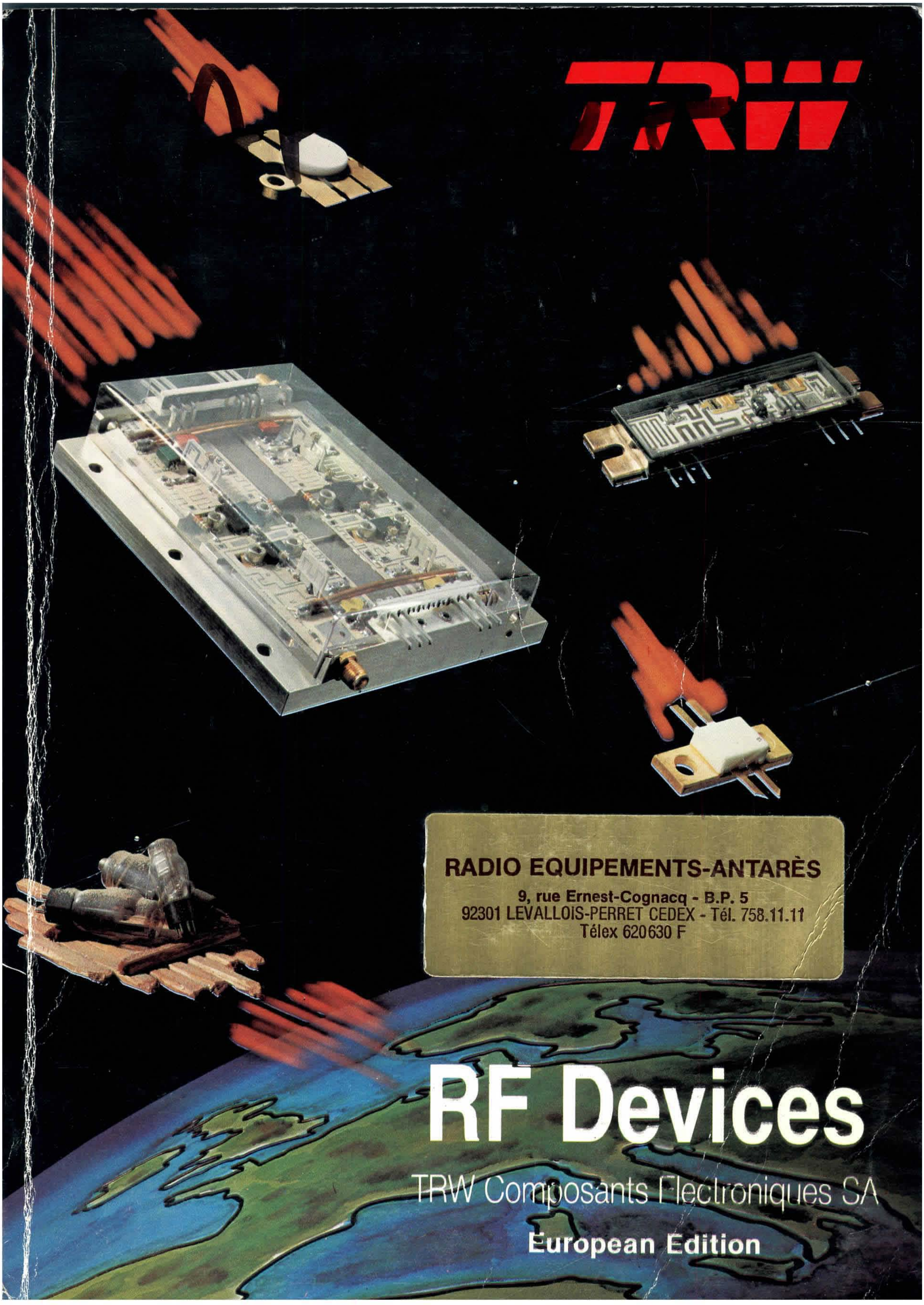


RADIO EQUIPEMENTS-ANTARÈS
9, rue Ernest-Cognacq - B.P. 5
92301 LEVALLOIS-PERRET CEDEX - Tél. 758.11.11
Télex 620630 F

RF Devices

TRW Composants Electroniques SA

European Edition

TRW
RF DEVICES

CATALOG
1985

EUROPEAN EDITION

SELECTION GUIDE

ALPHANUMERICAL INDEX

PART NUMBER	APPLICATION	FREQUENCY	POWER OR GAIN (dB)	SUPPLY VOLTAGE (V)	PACKAGE	PAGE
AMR 900-60	MOBILE	800-960 MHz	60 W	24	AMR	B 2
ATV 5030	TV BAND 4-5	860 MHz	20 W	26.5	ATV	D 65
ATV 5080	TV BAND 4-5	860 MHz	80 W	28	ATV	D 69
CA 2101	CATV	300 MHz	17 dB	24	CA	F 100
CA 2201	CATV	300 MHz	17 dB	24	CA	F 100
CA 2300	CATV	300 MHz	22 dB	24	CA	F 102
CA 2301	CATV	300 MHz	22 dB	24	CA	F 102
CA 2418	CATV	120 MHz	18 dB	24	CA	F 128
CA 2600	CATV	120 MHz	33 dB	24	CA	F 104
CA 2800	RF LINEAR	10-400 MHz	17 dB/800 mW	24	CA	F 6
CA 2810	RF LINEAR	10-350 MHz	33 dB/800 mW	24	CA	F 10
CA 2812	RF LINEAR	1-520 MHz	30 dB/300 mW	12	CA	F 14
CA 2813	RF LINEAR	40-300 MHz	34 dB/22 dBm	15	CA	F 18
CA 2818	RF LINEAR	1-200 MHz	18 dB/800 mW	24	CA	F 22
CA 2820	RF LINEAR	1-520 MHz	30 dB/400 mW	24	CA	F 26
CA 2830	RF LINEAR	5-200 MHz	34 dB/1 W	24	CA	F 30
CA 2832	RF LINEAR	1-200 MHz	35 dB/2 W	24	CA	F 34
CA 2840	RF LINEAR	30-300 MHz	22 dB/1 W	24	CA	F 38
CA 3101	CATV	330 MHz	17 dB	24	CA	F 106
CA 3201	CATV	330 MHz	17 dB	24	CA	F 106
CA 3600	CATV	330 MHz	34 dB	24	CA	F 108
CA 4101	CATV	400 MHz	17 dB	24	CA	F 110
CA 4201	CATV	400 MHz	17 dB	24	CA	F 110
CA 4411	CATV	200 MHz	13 dB	24	CA	F 130
CA 4412	CATV	200 MHz	13 dB	24	CA	F 130
CA 4418	CATV	200 MHz	18 dB	24	CA	F 132
CA 4422	CATV	200 MHz	22 dB	24	CA	F 134
CA 4600	CATV	400 MHz	34 dB	24	CA	F 112
CA 4800	RF LINEAR	10-1000 MHz	17 dB/400 mW	24	CA	F 42
CA 4812	RF LINEAR	10-1000 MHz	17 dB/400 mW	12	CA	F 46
CA 4815	RF LINEAR	10-1000 MHz	17 dB/400 mW	15	CA	F 50
CA 5101	CATV	450 MHz	18 dB	24	CA	F 114
CA 5180	CATV	450 MHz	14 dB	24	CA	F 122
CA 5201	CATV	450 MHz	18 dB	24	CA	F 114
CA 5280	CATV	450 MHz	18 dB	24	CA	F 122
CA 5300	CATV	450 MHz	22 dB	24	CA	F 116
CA 5301	CATV	450 MHz	22 dB	24	CA	F 116
CA 5600	CATV	450 MHz	34 dB	24	CA	F 118
CA 5700	CATV	450 MHz	38 dB	24	CA	F 120
CA 5800	RF LINEAR	10-1000 MHz	15 dB/1 W	28	CA	F 52
CA 5815	RF LINEAR	10-1000 MHz	15 dB/1 W	15	CA	F 56
CA 6101	CATV	550 MHz	19 dB	24	CA	F 126
CA 6201	CATV	550 MHz	19 dB	24	CA	F 126
FF 124	CATV	450 MHz	24 dB	24	FF	F 125
GPA 501	RF LINEAR	5-600 MHz	15 dB/4 dBm	15	TO 8	CONTACT FACTORY
GPA 502	RF LINEAR	5-600 MHz	15 dB/14 dBm	15	TO 8	
GPA 503	RF LINEAR	5-600 MHz	12 dB/19 dBm	15	TO 8	
GPA 504	RF LINEAR	5-500 MHz	25 dB/13 dBm	15	TO 8	
GPA 505	RF LINEAR	5-500 MHz	23 dB/20 dBm	15	TO 8	
GPA 510	RF LINEAR	5-600 MHz	15 dB/4 dBm	15	TO 8	
GPA 511	RF LINEAR	5-600 MHz	15 dB/14 dBm	15	TO 8	
GPA 512	RF LINEAR	5-600 MHz	12 dB/19 dBm	15	TO 8	
GPA 1006	RF LINEAR	5-1000 MHz	19 dB/13 dBm	15	TO 8	
GPA 1007	RF LINEAR	5-1000 MHz	17 dB/20 dBm	15	TO 8	
GPA 1501	RF LINEAR	5-1500 MHz	17 dB/10 dBm	15	TO 8	

ALPHANUMERICAL INDEX

* BV_{CBO}

ALPHANUMERICAL INDEX

PART NUMBER	APPLICATION	FREQUENCY	POWER OR GAIN (dB)	SUPPLY VOLTAGE (V)	PACKAGE	PAGE
PT 8809	MOBILE	470 MHz	2 W	12.5	SOE 280	B 25
PT 8810	MOBILE	470 MHz	5 W	12.5	SOE 280	B 25
PT 8811	MOBILE	470 MHz	10 W	12.5	SOE 280	B 25
PT 8828/F	MOBILE	175 MHz	10 W	12.5	SOE 380/F	B 29
PT 9700	MILITARY	400 MHz	1.5 W	28	SOE 280	C 10
PT 9701B	MILITARY	400 MHz	5 W	28	SOE 280	C 12
PT 9702B	MILITARY	400 MHz	20 W	28	SOE 280	C 14
PT 9703B	MILITARY	400 MHz	10 W	28	SOE 280	C 13
PT 9704A/B	MILITARY	400 MHz	30 W	28	SOE 280	C 15
PT 9730	MILITARY	175 MHz	4 W	28	SOE 380	C 20
PT 9731	MILITARY	175 MHz	25 W	28	SOE 380	C 23
PT 9732	MILITARY	175 MHz	8 W	28	SOE 380	C 21
PT 9733	MILITARY	175 MHz	50 W	28	SOE 380	C 24
PT 9734	MILITARY	175 MHz	15 W	28	SOE 380	C 22
PT 9780/A	SSB	30 MHz	100 PEP	28	SOE 500/F	B 34
PT 9784/A	SSB	30 MHz	75 PEP	12.5	SOE 380/F	B 39
PT 9785	SSB	30 MHz	100 PEP	12.5	SOE 500	B 39
TP 212/S	MOBILE	88 MHz	1.5 W	7.5	SOE 280/SS	B 43
TP 251	MOBILE	470 MHz	0.2 W	7.5	SOE 200/SS	B 46
TP 252/S	MOBILE	470 MHz	1.5 W	7.5	SOE 280/SS	B 49
TP 1045	MOBILE	470 MHz	2 W	12.5	SOE 280/SS	B 52
TP 2180	MOBILE	88 MHz	80 W	12.5	J-ZERO	B 55
TP 2304	MOBILE	175 MHz	40 W	12.5	SOE 380	B 58
TP 2312	MOBILE	175 MHz	3 W	12.5	TO 39 GE	B 62
TP 2314	MOBILE	175 MHz	4 W	12.5	TO 39 GE	B 65
TP 2320	MOBILE	175 MHz	17 W	12.5	SOE 380	B 68
TP 2330/F	MOBILE	175 MHz	30 W	12.5	SOE 380/F	B 72
TP 2503	MOBILE	470 MHz	5 W	12.5	SOE 280/SS	B 75
TP 3020	MOBILE	960 MHz	2 W	24	SOE 280	B 78
TP 3022	MOBILE	960 MHz	15 W	24	230 F	B 82
TP 3024	MOBILE	960 MHz	30 W	24	BMA 2	B 86
TP 3093	RF LINEAR	FT 3 GHz	700 mW	15	TO 39	F 88
TP 3098	RF LINEAR	FT 3 GHz	700 mW	15	TO 117C	F 92
TP 3400	RF LINEAR	FT 3 GHz	1200 mW	18	SOE 200	F 96
TP 9380	FM	108 MHz	75 W	28	SOE 500 F	D 2
TP 9383	FM	108 MHz	150 W	28	SOE 500 F	D 5
TP 9386	MILITARY	175 MHz	150 W	28	J-ZERO	C 27
TPM 401	MILITARY	400 MHz	1 W	20	SOE 280	C 31
TPM 405	MILITARY	400 MHz	5 W	24	SOE 280	C 35
TPM 425	MILITARY	400 MHz	25 W	24	SOE 280	C 39
TPM 4040	MILITARY	400 MHz	40 W	28	MRP 7	C 41
TPM 4130	MILITARY	400 MHz	130 W	28	MRP 7	C 45
TPV 364	TV BAND 3	225 MHz	10 W	25	SOE 380	D 13
TPV 375	TV BAND 3	225 MHz	14 W	28	SOE 500	D 17
TPV 376	TV BAND 3	225 MHz	30 W	28	SOE 500	D 23
TPV 385	TV BAND 3	225 MHz	14 W	28	JO 500	D 21
TPV 394	TV BAND 3	225 MHz	5 W	28	SOE 280	D 9
TPV 3100	TV BAND 3	225 MHz	30 W	28	MRP 7	D 27
TPV 590	TV BAND 4-5	860 MHz	0.250 W	20	SOE 200	D 33
TPV 591	TV BAND 4-5	860 MHz	0.5 W	20	SOE 200	D 37
TPV 593	TV BAND 4-5	860 MHz	2 W	25	SOE 280	D 49
TPV 595A	TV BAND 4-5	860 MHz	8 W	25	BMA 2	D 55
TPV 596	TV BAND 4-5	860 MHz	0.5 W	20	SOE 280	D 41
TPV 597	TV BAND 4-5	860 MHz	1 W	20	SOE 280	D 45
TPV 598	TV BAND 4-5	860 MHz	4 W	25	SOE 280	D 53
TPV 5051	TV BAND 4-5	860 MHz	50 W	28	BMA 2	D 61

ALPHANUMERICAL INDEX

A

INTRODUCTION

— SCOPE

This catalog is issued by TRW Composants Electroniques.
It provides complete information on all the TRW high-frequency transistors, modules and integrated circuits available from our plant in Bordeaux.

The book is up-dated in timely intervals in order reflect the latest developments of new products. It has proven to be an excellent aid and reference to numerous project and design ngineers.

— MARKET SEGMENTS

1) HF-SSB

Market

2 to 30 MHz, high power linear transmitters.

Products

12, 28 and 50 V up to 200 watt linear transistors.

2) MOBILE

Market

VHF (88 and 175 MHz) and UHF (470 MHz) transmitters for use in commercial and industrial mobile radio applications.

Products

7.5, 12 and 28 volts discrete transistors.
12 V power modules.

3) FM

Market

High power FM transmitters (88-108 MHz).

Products

High power transistors up to 175 W.

4) VHF/UHF BROADBAND

Market

Airbone and ground VHF/UHF transmitters — Navigation aids (ILS, VOR, GLIDE).

Products

Discrete and internally matched (JO) broadband transistors up to 100 watts.

5) SMALL SIGNAL

Market

Telecommunication, Instrumentation, General Purpose up to 1 200 MHz.

Products

- Transistors in plastic and ceramic packages with RF output voltages up to 122 dBuV (DIN 4 500 4 B).
- HYBRID Broadband amplifiers :
  1-500 MHz ; 50 to 100 Ohm
  40-900 MHz ; 50 to 100 Ohm
  Low noise and high linearity.

6) CATV

Market

Community Antenna Television Amplifiers — 40-300 MHz : 75 ohm
— 40-900 MHz : 75 ohm

Products

High performance HYBRID amplifiers for super linearity and cascadability.

A

7) TV TRANSPOSERS AND TRANSMITTERS

Market

Equipment for TV land coverage : transposers and transmitters.

Products

High power linear transistors specified in two bands : VHF 170 to 225 MHz, UHF 470 to 860 MHz.

8) MICROWAVE

Market

1 to 4 GHz transmitters.

Products

1 to 4 GHz discretes and internally matched (MRA) transistors specified as :
— Linear (common ermitter).
— Class C, Pulse (common base).
— Oscillators (common collector).

— TRW COMPOSANTS ELECTRONIQUES

This european facility was established in 1971 in order to provide optimum service to the european market. The advantages to our customers are numerous :

- MARKETING — TRW Bordeaux has an experienced team of product managers ready to discuss your needs and to serve your interests.
- MANUFACTURING — Most TRW products supplied by TRW Bordeaux are manufactured locally. The plant is equipped with the most modern machinery and has complete DC and RF testing facilities including highly specialized test stations for ultra-linear devices.

  Manufacture and stocking in Bordeaux assures quick response to our customers needs.
- QUALITY ASSURANCE — An independant Quality Assurance Department polices the design, manufacturing and testing procedures and guarantees the highest possible product quality.
- SPECIAL PRODUCTS — Should the products listed in this catalog fail to match your requirements exactly, there is always the possibility of a specially designed or modified device.

  Once we have defined what the transistor should be for your application. a specification will be written by you, reviewed by TRW and a special part number assigned. This procedure will insure proper operation of the devices in your equipment.
- APPLICATION ENGINEERING — One of the most important functions of TRW Bordeaux is the applications assistance which can be rendered promptly, efficiently and in a professional manner. The plant houses a well-equiped applications laboratory, which is staffed by RF engineers specialized in all areas of solid-state circuitry, applications and systems. Computer aided design is widely used.

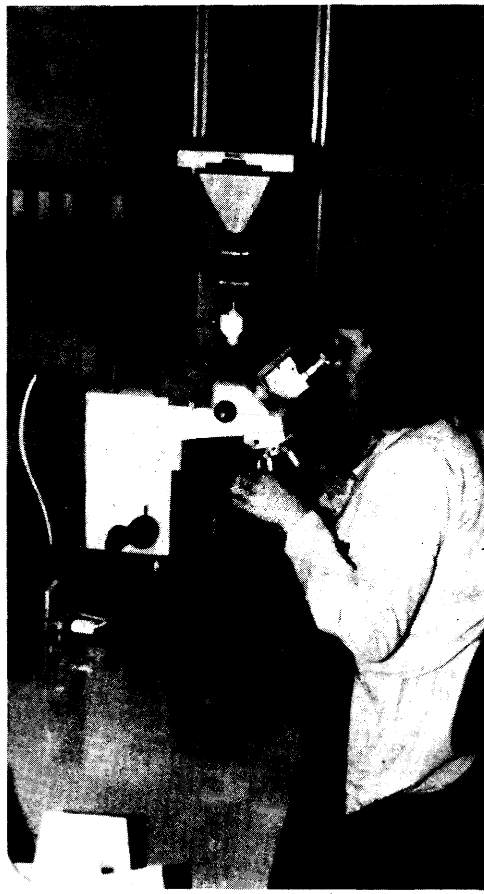
TRW RESERVES THE RIGHT TO MODIFY OR DISCONTINUE ANY OF THE PRODUCTS LISTED IN THIS EDITION

QUALITY AT TRW

TRW RF components are renowned for quality and reliability. A consequence of such quality is the dominant position of TRW in European communication equipments.

The primary objective of TRW is « to provide products and services of the highest possible quality ». Lets us see how such goal is achieved in the TRW Bordeaux plant.

This quality objective is realised by a permanent control of material from the beginning of raw material in-coming inspection to the assembly lines and final delivery to customers (as shown on the manufacturing flow chart.



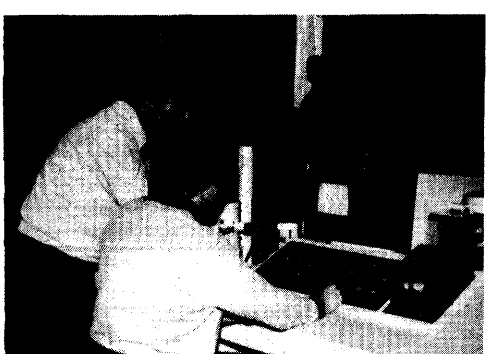
Optical microscope inspection

Quality dice lot

On arrival in the plant, each wafer is qualified by the evaluation of a sample of die, to measure quality of die solderability, wire bondability, DC and RF performances, current leakage, etc. and also to estimate the production yield we will achieve.

This wafer quality inspection has been recently further improved thanks to the scanning electronic microscopy. Since Jan. 1981, a SEM inspection is made on a 100 % basis for wafers intended for high reliability applications and on a sampling basis for all others.

The QA department can veto a wafer or a product at any stage of production if a failure is discovered.



SEM wafer analysis

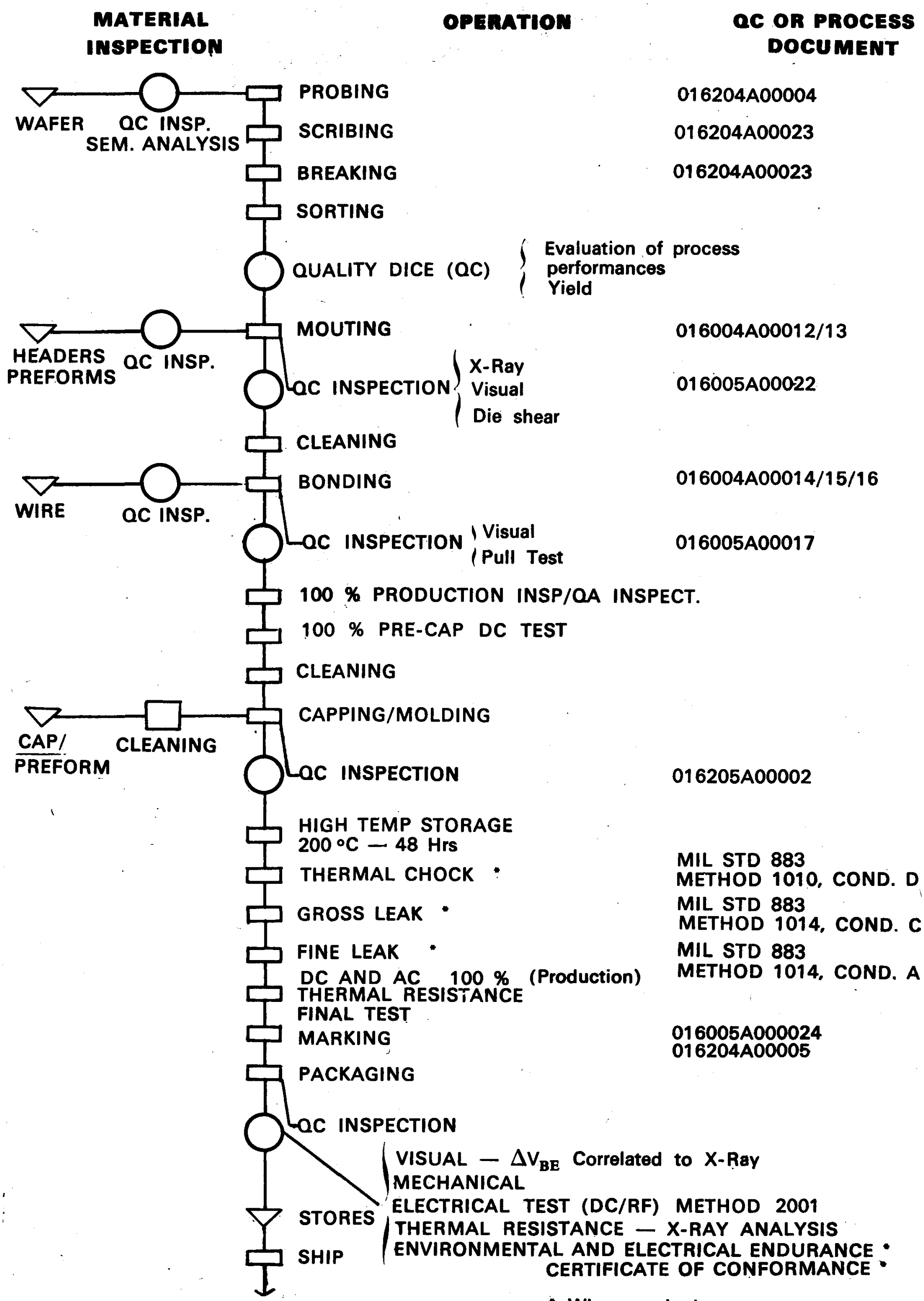
Assembly control — Quality lot card

During product assembly, die mounting and wire bonding machines are checked regurlarly every two hours to ensure that they are performing correctly.

Q.A. visual inspection, destructive tests and wire strenght are noted on a quality card which accompagnies each production lot from the beginning to final inspection in Q.A. department.

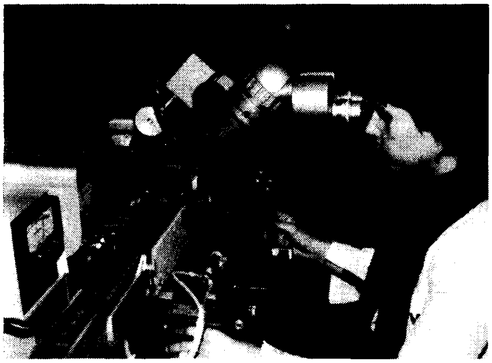
A

MANUFACTURING FLOW CHART

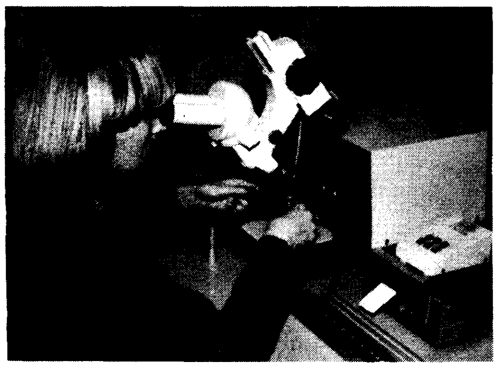


* When required

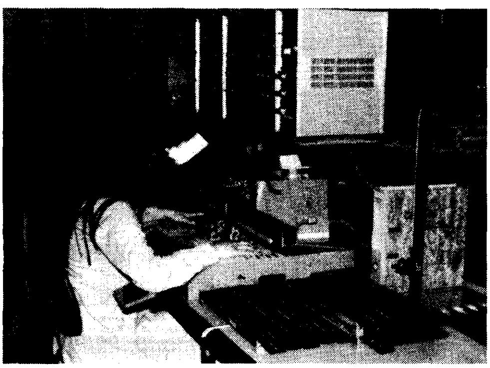
Soldering and visual inspection



Hard soldering die bonding



Wire bonding pull test



Wire bonding operation

X-Ray inspection

A good eutectic bond between the die and the header is fundamental, for the reliability of high power devices, so 2 years ago TRW Bordeaux introduced a X-Ray inspection of the die mounting operation. Depending on the method of construction of the transistor, either a 100 % or sampling only check is made on the quality of the die attach.

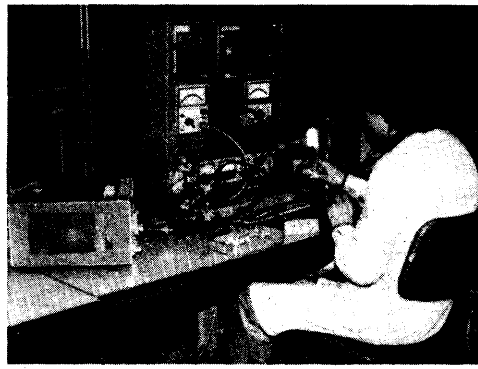
100 % Thermal resistance for super high reliability

In order to assure a maximum reliability, TRW-Bordeaux introduced 3 years ago a ΔV_{BE} measurment which is related to the thermal resistance by the following formula

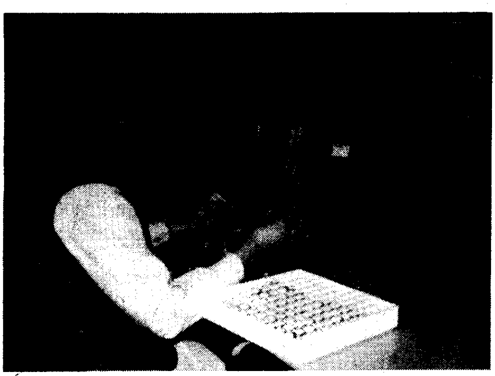
$$Rth_{JC} = \frac{I}{C} \frac{\Delta V_{BE}}{Pd}$$

This ΔV_{BE} measurment which is performed on 100 % basis for all RF high power devices, is then correlated to a X-Ray analysis for each production lot in order to determine the maximum value of ΔV_{BE} authorized for a certain part number. This is the best way to make sure of perfection of the die mount.

Die soldering X-Ray inspection.



Dynamic RF transistors testing



DC transistors final test inspection

Dynamic RF QA control

100 % visual inspection

All standart devices are 100 % visually inspected by production people prior to capping. High rel. components are submitted to a more stringent visual control under the responsability of the QA department with a high magnification microscope.

DC and RF testing

In order to assure the lowest possible failure level, each device is DC tested three times :

1. — Die probe prior to *input*
2. — prior to capping
3. — prior to final RF test.

All devices are then subjected to RF measurment on production line for conformity, to specification. After final production test and packaging, each lot passes to the quality department which tests again on a sample basis, DC and RF parameters. The percentage of pieces submitted to this final electrical control is 11 % for all discretes components and 18 % for hybrids circuits.

Reliability

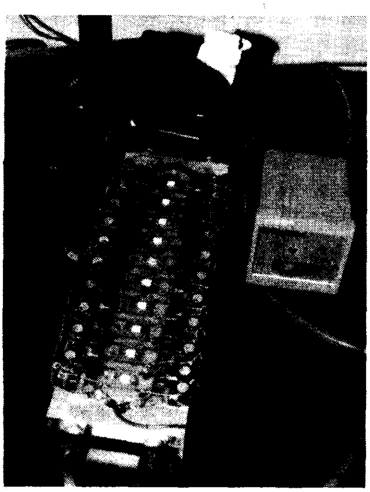
The quality department is also responsible for reliability which is assured by several environmental and electrical tests which are made to devices during assembly operations or at the final test level.

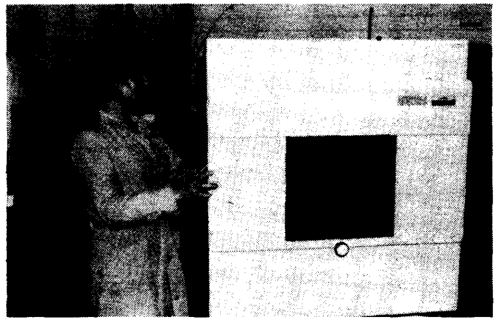
All moulded devices are subjected to a high Temperature DC test (+ 175 °C) in to order remove any possible infant mortalities.

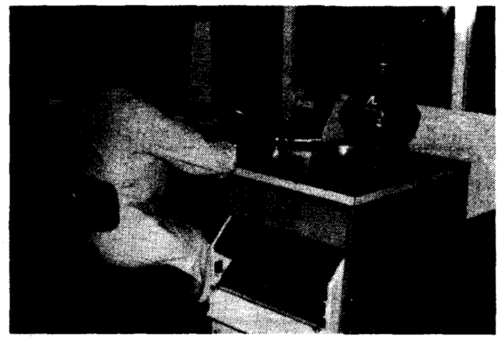
Other reliability tests include vibration, acceleration, thermal shock, humidity and DC or RF electrical endurance. These tests are performed either because of customer special requirement or as a routine reliability check.

Many high power — high quality devices binlt in Bordeaux for professionnal applications have been already submitted to a 3 000 or 5 000 hours electrical endurance test. Reports are available on request.

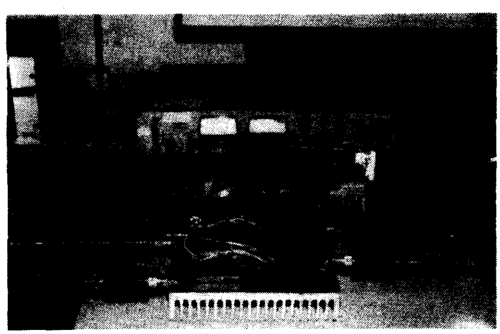

Acceleration test


DC burn-in life test


Environmental test


Fine leak test


Vibration test


RF burn-in life test

Quality Assurance Standard

TRW RF components are classified in three reliability classes depending on the level of screening needed to produce the quality and reliability required by each application as shown on table n° 1

RELIABILITY GRADE	APPLICATIONS
SH — Super High Reliability	— Space - system requiring super high reliability
H — High reliability	Military - Avionic - Systems requiring high reliability
I — Industrial	Industrial application - consumer

All class of transistor are screened in accordance to MIL STD 19 500/750/883 or CECC 50 007 or NFC 96 621 specification. However particular customer specification are also used as « a special customer requirement ».

TABLE A

SCREENING CONDITIONS

TEST	METHOD	INSPECTION REQUIREMENT		
		SH	H	I
1 SEM wafer inspection	TRW Specification	100 %	sampling	
2 Precap. visual inspection	MILSTD 750-2072	100 %	100 %	100 %
3 High Rel. Prec. vis. insp.	TRW Specification	100 %	(1)	
4 Die-soldering X-Ray test	TRW specification	100 %	sampling	
5 Wire-bonding test	TRW specification	sampling	sampling	sampling
6 Precap. BV - test	CECC 50 000/4.3.4	100 %	100 %	100 %
7 High storage	CECC 50 000/4.4.1	100 %	(1)	
8 Thermal Shock	CECC 50 000/4.4.4	100 %	(1)	
9 DC Electrical Test BV_{CBO} BV_{CEO} BV_{EBO} I_{CBO} I_{CEO} I_{EBO} h_{FE}	CECC 50 000/4.3.4	100 %	100 %	100 %
10 Thermal Imped. (ΔV_{BE})	TRW Specification	100 %	100 %	
11 RF test P_{out} - IMD - Ft. TOS	NFC 96.621	100 %	100 %	sampling
12 Ballast-Resist. control	TRW specification	100 %	sampling	
13 Vibration	CECC 50 000/4.4.6	100 %	(1)	
14 Acceleration	CECC 50 000/4.4.11	100 %	(1)	
15 Gross Leak	CECC 50 000/4.4.10/Qc only hermetic devices	100 %	100 %	sampling
16 Fine Leak	only hermetic devices CECC 50 000/4.4.10/Qk	100 %	100 %	
17 High temp. wire bonding test	only molded devices	100 %	sampling	
18 Electrical Endurance	NFC 96-621 CECC 50 000/4.5	100 %	sampling	
19 External - Visual - Mechanical	CECC 50 000/4.2.1.	100 %	sampling	sampling
20 QA Final Inspection	TRW specification	sampling	sampling	sampling

(1) On special request.

TABLE B

QA INSPECTION — GROUP A

LOT PER LOT

EXAMINATION OR TEST	CONDITION	INSPECTION REQUIREMENT	
		sampling level	AQL
Sub-group A1			
Visual inspection - Dimen/hours	CECC 50 000/4.2.1	I	1,5
Sub-group A2			
Breakdown Voltage	CECC 50 000/4.3.4	II	0,4
Leakage current	CECC 50 000/4.3.4	II	0,4
h_{FE} — Cob	CECC 50 000/4.3.4	II	0,4
RF dynamic characteristic	NFC 96 621	I	1

TABLE C

QA — INSPECTION GROUP A & B

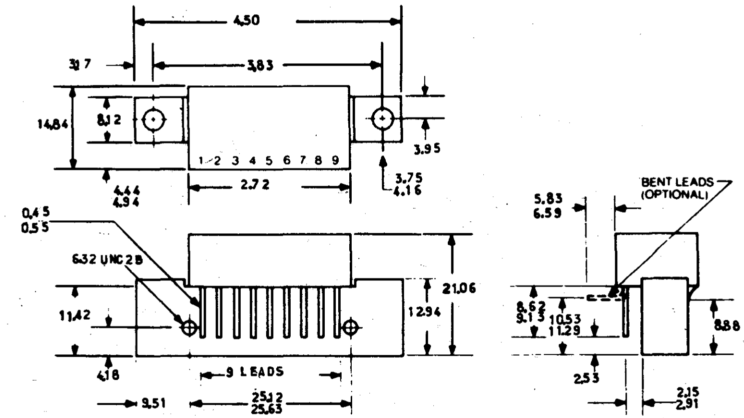
LOT PER LOT

EXAMINATION OR TEST	CONDITIONS	INSPECTION REQUIREMENT	
		sampling level	AQL
Sub-Group B2 to B5			
Solderability	CECC 50 000/4.4.7	S 4	1,5 %
Thermal shock (1)	CECC 50 000/4.4.4	S 4	1 %
Damp heat (1)	CECC 50 000/4.4.2	S 4	1,5 %
Gross leak	CECC 50 000/4.4.10.Qc	S 4	1 %
Fine leak	CECC 50 000/4.4.10.Qk	II	1 %
Sub-Group B8			
168 Hrs Electrical Endurance (1)	CECC 50 000/4.5 NFC 96 621	S 4	1,5 %
Sub-Group C3 to C6			
Tensile	CECC 50 000/4.4.9	I	1,5 %
Vibration (1)	CECC 50 000/4.4.6	I	1,5 %
Constant Acceleration (1)	CECC 50 000/4.4.11	I	1,5 %
Sub-Group C8			
1 000 Hrs Electrical Endurance (1)	CECC 50 000/4.5 NFC 96 621	S 4	1 %
Sub-Group C9			
High temp. storage (1)	CECC 50 000/4.4.1	S 4	1 %
Post measurment	$\Delta h_{FE} — \Delta I_{CBO}$		

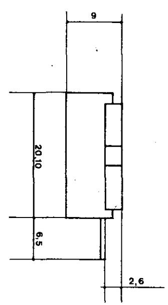
(1) On special request from QA or from customes.

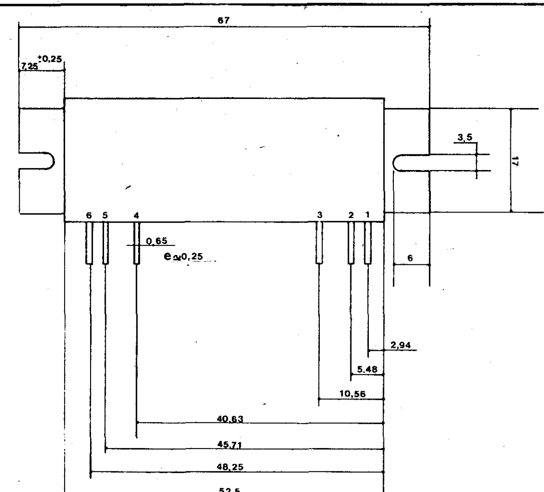
package designs (Dimensions Given in mm)

CA



MV/MX



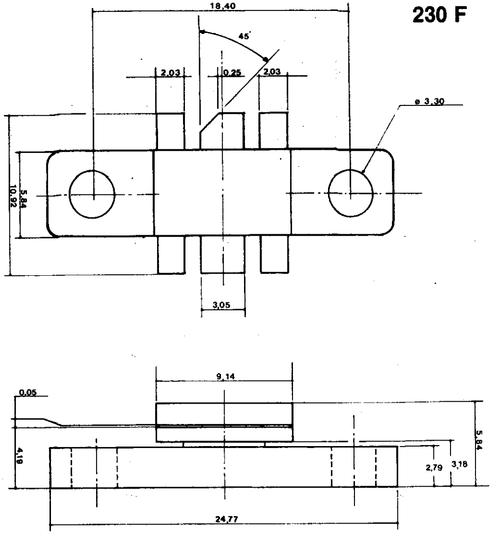


Pin 1 — RFout
Pin 2 — Ground
Pin 3 — Vcc 2
Pin 4 — Vcc 1
Pin 5 — Ground
Pin 6 — RF in

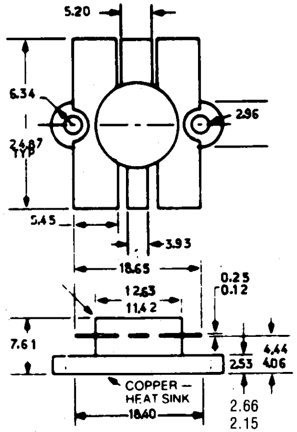
TOLERENCE ± 0,1 mm

ALL DIMENSIONS IN MILLIMETER

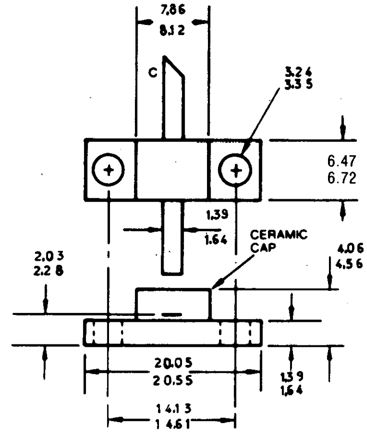
230 F



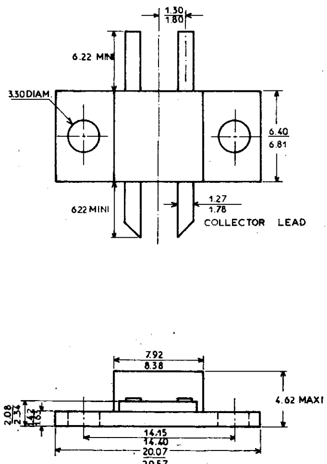
J-Zero-C



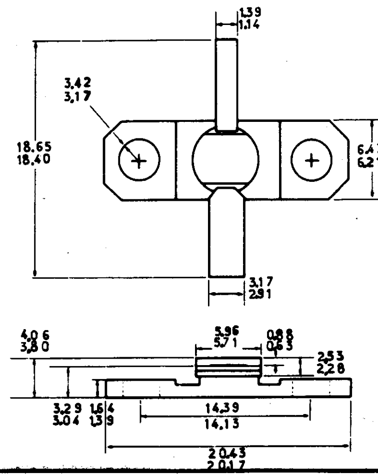
MRA



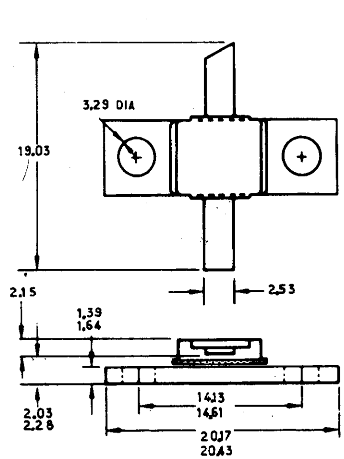
BMA 2



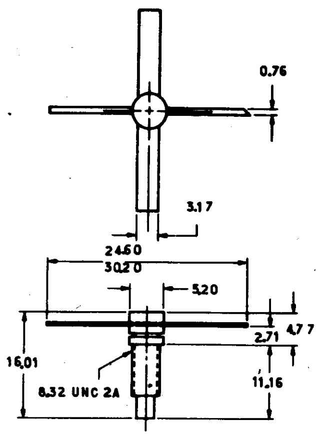
HLP-8/GP 13



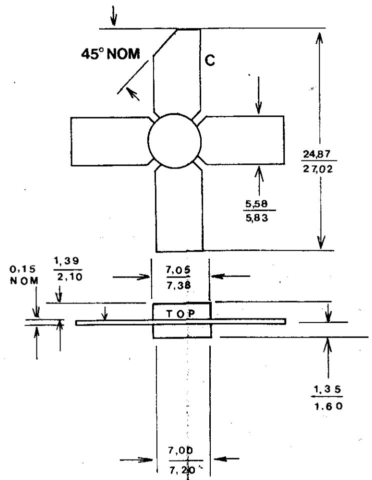
HLP-11



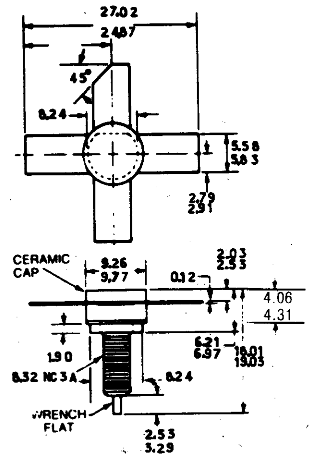
200 SOE



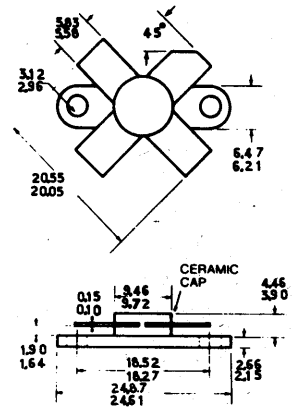
280 SOE STUDLESS



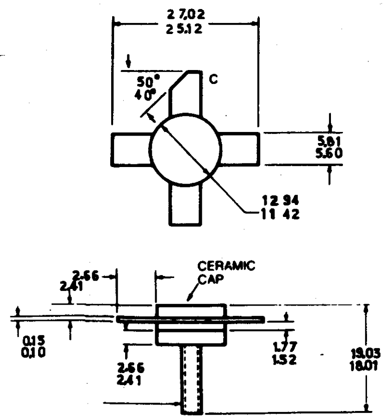
.380 SOE



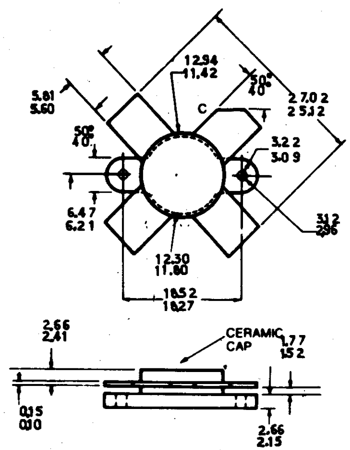
.380 SOE F



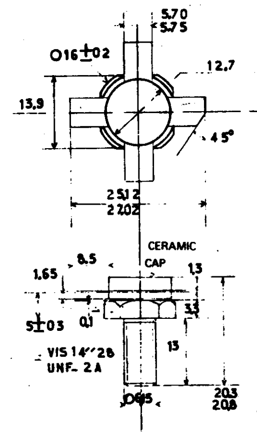
.500 SOE



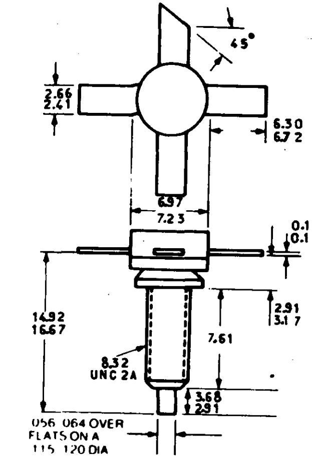
.500 SOE F



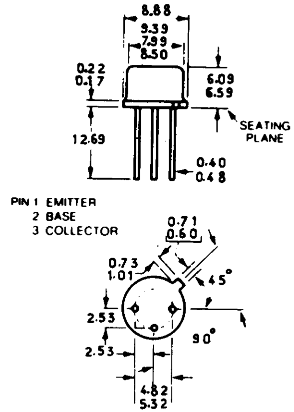
500 SOE 1/4" STUD



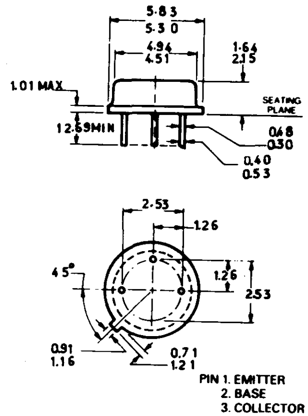
RT-3



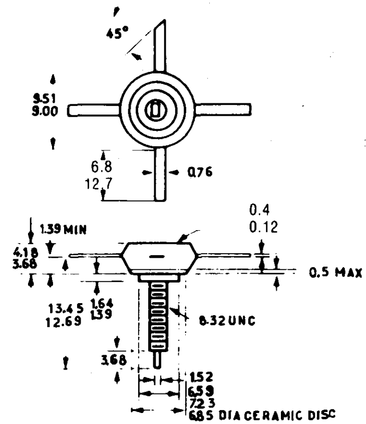
TO 39/TO 39 GE



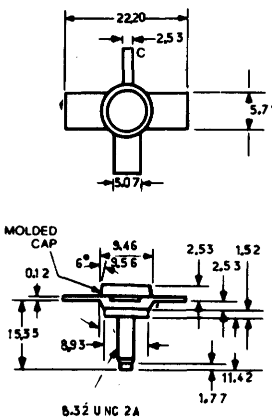
TO46



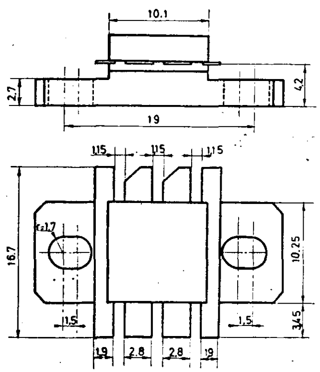
TO-117/TO-131



B-Band-2

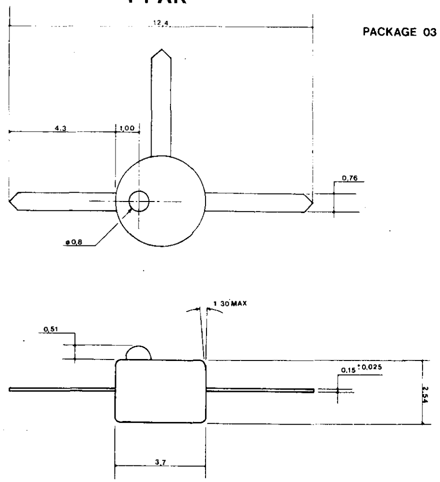


MRP 7

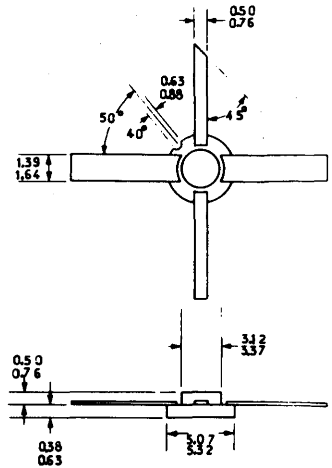


T-PAK

PACKAGE 03



TW-200



MOBILE VHF/UHF
900 MHz

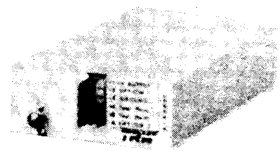
B

PRODUCT SUMMARY

PART NUMBER	APPLICATION	FREQUENCY	POWER OR GAIN (dB)	SUPPLY VOLTAGE (V)	PACKAGE	PAGE
AMR 900-60	MOBILE	800-960 MHz	60 W	24	AMR	B 2
JO 3020	MOBILE	470 MHz	20 W	12,5	J-ZERO	B 6
JO 3037	MOBILE	470 MHz	37 W	12,5	J-ZERO	B 9
JO 4036	MOBILE	175 MHz	36 W	12,5	J-ZERO	B 10
JO 4045	MOBILE	175 MHz	45 W	12,5	J-ZERO	B 14
ML 20	MOBILE	66-88 MHz	20 W	12.5	MVM	B 18
MV 20	MOBILE	140-175 MHz	20 W	12.5	MVM	B 19
MV 30	MOBILE	150-160 MHz	30 W	12.5	MVM	B 19
MX 20	MOBILE	400-470 MHz	20 W	12.5	MVM	B 23
PT 8809	MOBILE	470 MHz	2 W	12.5	SOE 280	B 25
PT 8810	MOBILE	470 MHz	5 W	12.5	SOE 280	B 25
PT 8811	MOBILE	470 MHz	10 W	12.5	SOE 280	B 25
PT 8828/F	MOBILE	175 MHz	10 W	12.5	SOE 380/F	B 29
PT 9780/A	SSB	30 MHz	100 PEP	28	SOE 500/F	B 34
PT 9784/A	SSB	30 MHz	75 PEP	12.5	SOE 380/F	B 39
PT 9785	SSB	30 MHz	100 PEP	12.5	SOE 500	B 39
TP 212/S	MOBILE	88 MHz	1.5 W	7.5	SOE 280/SS	B 43
TP 251	MOBILE	470 MHz	0.2 W	7.5	SOE 200/SS	B 46
TP 252/S	MOBILE	470 MHz	1.5 W	7.5	SOE 280/SS	B 49
TP 1045	MOBILE	470 MHz	2 W	12.5	SOE 280/SS	B 52
TP 2180	MOBILE	88 MHz	80 W	12.5	J-ZERO	B 55
TP 2304	MOBILE	175 MHz	40 W	12.5	SOE 380	B 58
TP 2312	MOBILE	175 MHz	3 W	12.5	TO 39 GE	B 62
TP 2314	MOBILE	175 MHz	4 W	12.5	TO 39 GE	B 65
TP 2320	MOBILE	175 MHz	17 W	12.5	SOE 380	B 68
TP 2330/F	MOBILE	175 MHz	30 W	12.5	SOE 380/F	B 72
TP 2503	MOBILE	470 MHz	5 W	12.5	SOE 280/SS	B 75
TP 3020	MOBILE	960 MHz	2 W	24	SOE 280	B 78
TP 3022	MOBILE	960 MHz	15 W	24	230 F	B 82
TP 3024	MOBILE	960 MHz	30 W	24	BMA 2	B 86

Linear RF Power Amplifier

- 60 W
- 800-960 MHz
- Class "AB"

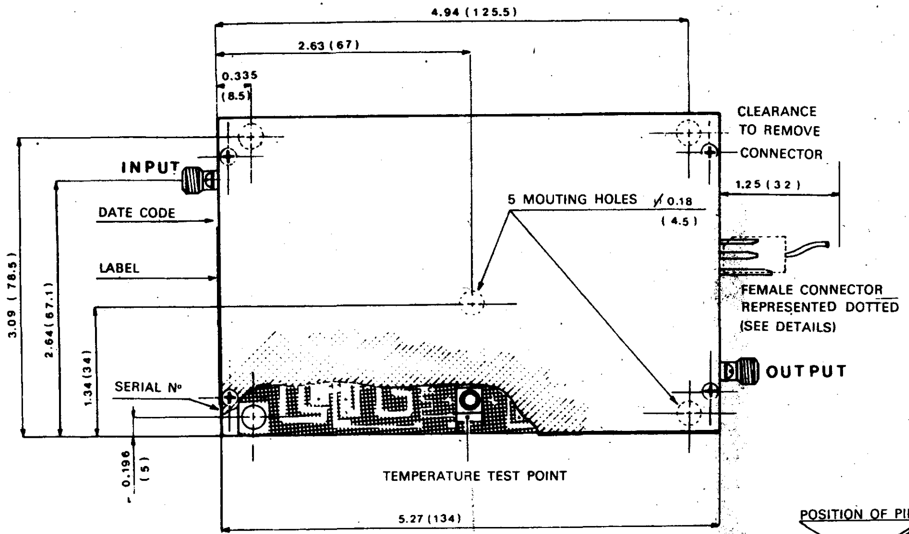


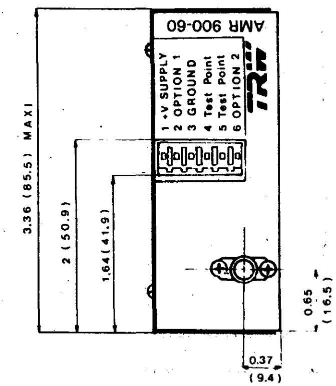
The AMR 900-60 solid state class B amplifier is specifically designed for cellular radio base stations.

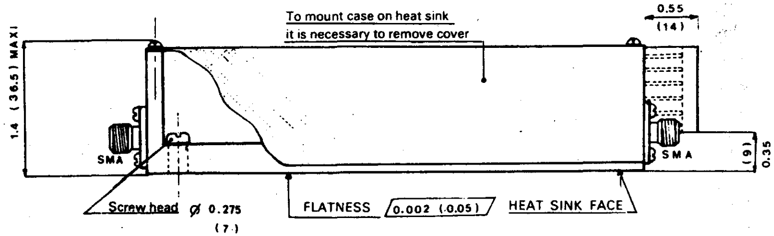
This amplifier incorporates microstrip technology and reliable TRW linear push-pull transistors.

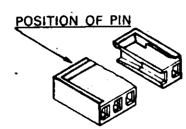
Electrical Characteristics (T_{case} = 50 °C)

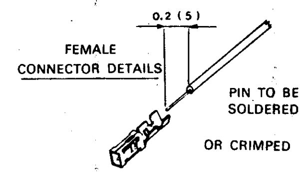
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
GENERAL OPERATING	R_L	Source and load Return loss	50 ohms reference			−20	dB
	BW	Bandwith	Continuous without Retuning	800		960	MHz
	Vcc	Supply voltage	Nominal		24		V
RF TEST	P_G	Power gain	P. ref. = 50 W		7		dB
	I_{typ}	Typical current consumption	P_{out} = 50 W Vcc = 24 V		4		A
	R_L	Input/output Return loss	50 ohms reference		−15	−10	dB
	VSWR	Output mismatch	P_{out} = 50 W Vcc = 24 V		5:1		
RATINGS	Vcc	Supply voltage		–	24	25	V
	I_{max}	Max DC current	Vcc = 24.0 V			6	A
	T_{op}	Operating temper.	Base plate (test point)	−20		+70	°C
	T_{STG}	Storage temperat.		−40		+100	°C











PLUS IN LAYOUT

PIN 1	+V supply 26.5 volts
PIN 2	Do not use
PIN 3	Ground
PIN 4-5	Collector current test point
PIN 6	Optionnal

VOLTAGE MEASUREMENT

V supply (Between pin 1 and 3)

COLLECTOR CURRENT MEASUREMENT

Voltmeter must have an input impedance greater than 10 K Ω

TRANSISTOR Nº 1

$$I_1\ (A) = \frac{1}{0.47} \times V\ (V)$$ Between Pin 1-5

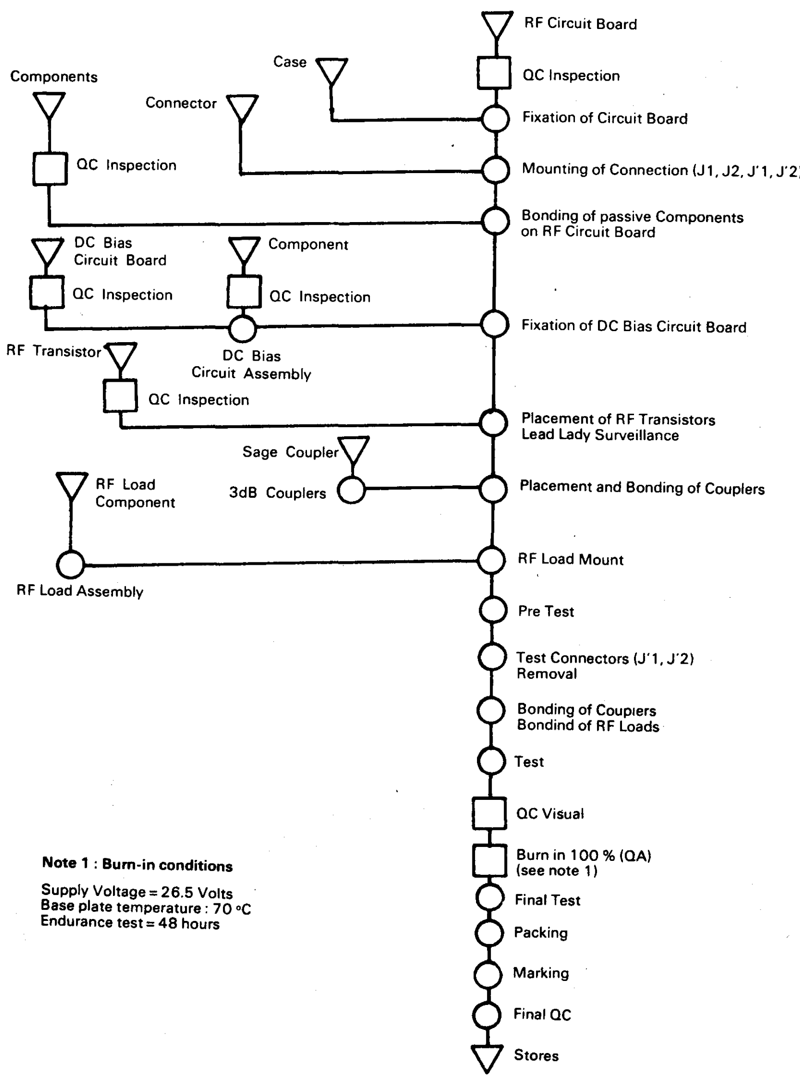
TRANSISTOR Nº 1

$$I_2\ (A) = \frac{1}{0.47} \times V\ (V)$$ Between Pin 1-4

DIMENSIONS IN INCHES mm IN BRACKETS

TOL. GENE. ±0.008 (0.2)

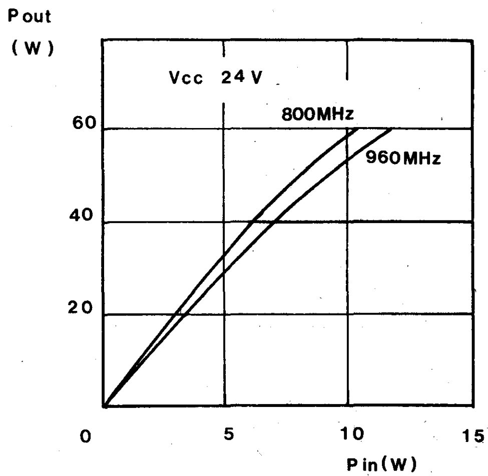
MANUFACTURING FLOW CHART OPERATION

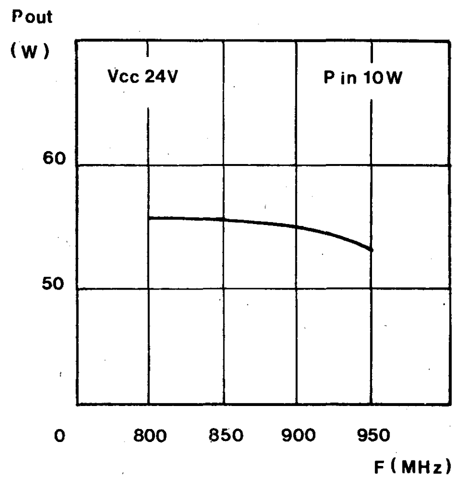


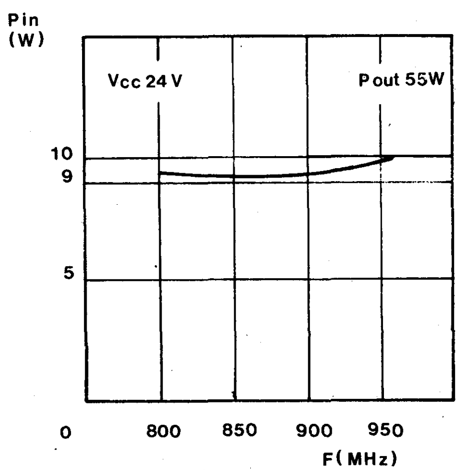
Note 1 : Burn-in conditions

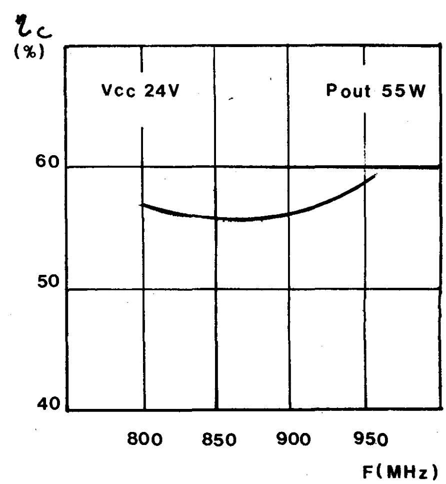
Supply Voltage = 26.5 Volts
Base plate temperature : 70 °C
Endurance test = 48 hours

TYPICAL CHARACTERISTICS





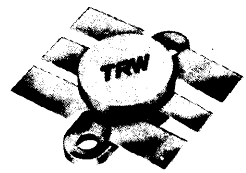




TRW

UHF RF Power Transistor

- 20 W
- 12.5 V
- 450-512 MHz
- Diffused Ballast Resistors
- Internally Matched
- Common Emitter
- Isolated Package
- 20:1 VSWR



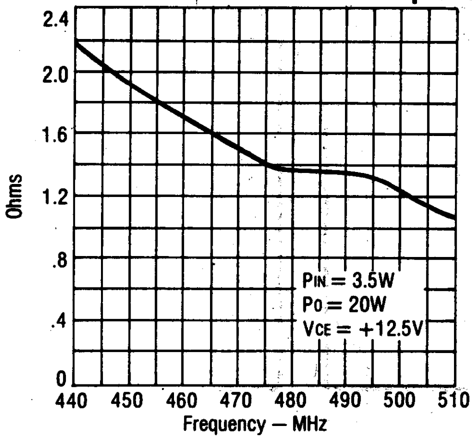
.500 J Zero

B

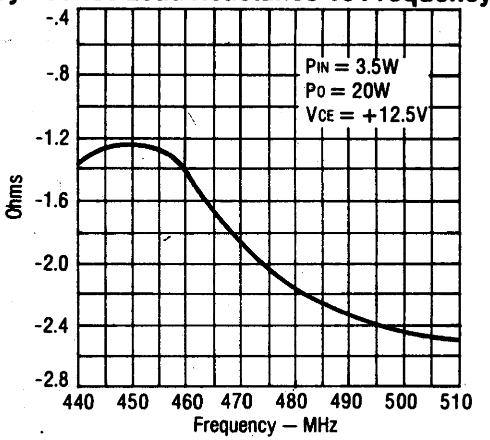
Electrical Characteristics (T_{CASE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CBO}	Collector Base Voltage	I_C = 50mA	36			V
	BV_{CEO}	Collector Emitter Voltage	I_C = 50mA	16			V
	I_{CES}	Collector Emitter Leakage	V_{CE} = 15V			10	mA
	BV_{EBO}	Emitter Base Voltage	I_E = 5mA, I_C = 0	4			V
	h_{FE}	D.C. Current Gain	V_{CE} = 5V, I_C = 1A	20		200	
RF TEST	P_{gain}	Power Gain	V_{CE} = 12.5V, f = 470MHz P_{IN} = 3.5W	7.6			dB
	$VSWR_L$	Collector Load	V_{CE} = 15.5V, f = 470MHz P_{IN} = 3.5W	20:1			VSWR
	η	Collector Efficiency	At P_O = 20W		60		%
THERMAL	θ_{jc}	Thermal Resistance	25°C Case		4.5		°C/W
	T_{STG}	Storage Temperature		−65		150	°C
	$I_{C(MAX)}$	Maximum Collector Current	T_C = 25°C			3	A
	$P_{D(MAX)}$	Total Dissipation	T_C = 25°C			39	W

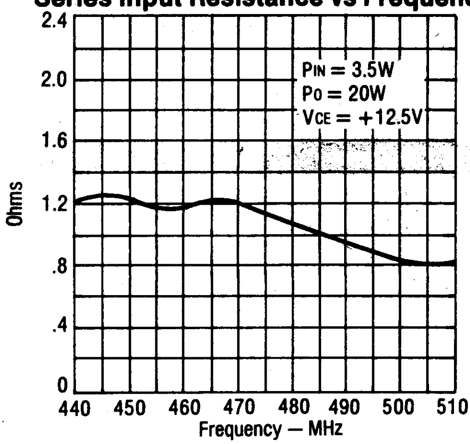
Series Load Resistance vs Frequency



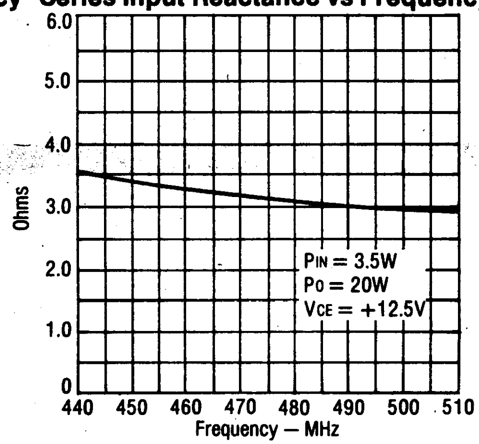
Series Load Reactance vs Frequency



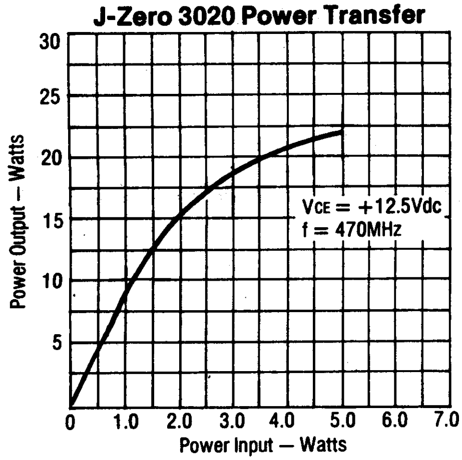
Series Input Resistance vs Frequency

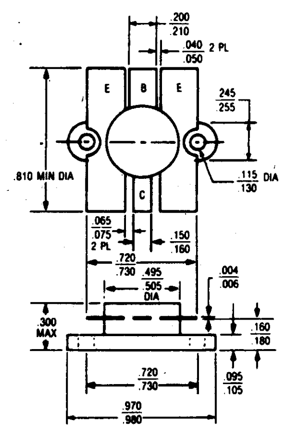


Series Input Reactance vs Frequency



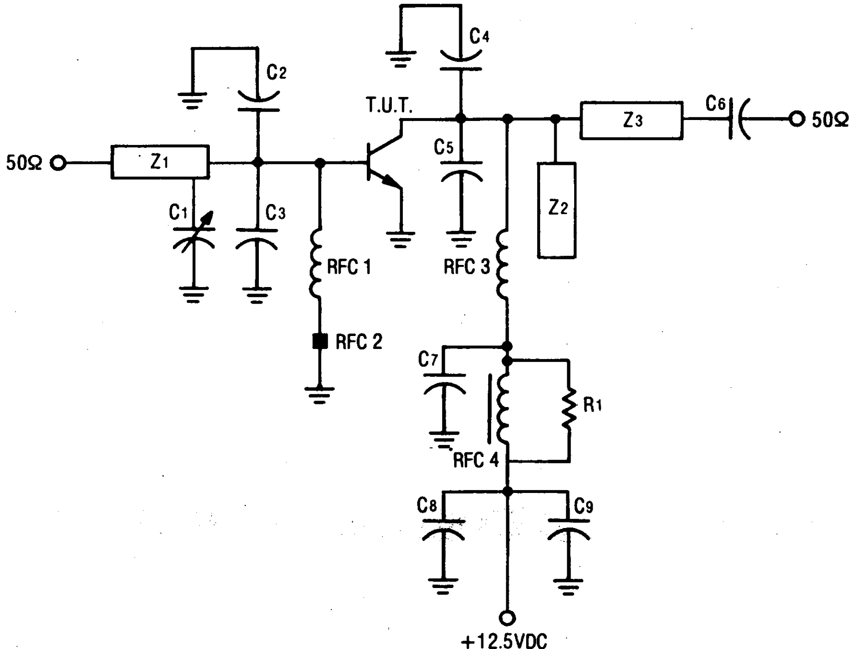
J-Zero 3020 Power Transfer





.500 J ZERO:

TEST CIRCUIT



PARTS LIST:

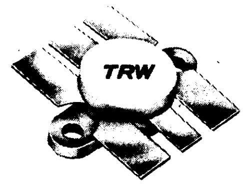
C_1	1-10pf piston trimmer, located 0.4" from device end on Z_1.
$C_{2,4}$	30pf uncased mica capacitor.
C_3	20pf uncased mica capacitor.
C_5	40pf uncased mica capacitor.
C_6	30pf miniature uncased mica capacitor.
C_7	220pf uncased mica capacitor.
C_8	5μf @ 25 volts.
C_9	0.1μfD @ 50 volts disc ceramic.
RFC 1	6 T. #18 AWG., 1/4" dia., 1/2" long.
RFC 2	Ferrite bead.
RFC 3	4 T. #18 AWG., 3/8" dia., 1/2" long.
RFC 4	3 T. #18 AWG. on 1/2" "H" toroid
R_1	10 ohms @ 1/2 watt.
Z_1	Microstripline, Z_0 = 30 ohms, W = 0.37", L = 3.02"
Z_2	Microstripline capacitor, Z_0 = 24 ohms, W = 0.46", L = 1.62
Z_3	Microstripline, Z_0 = 20 ohms, W = 0.56", L = 2.34"

Board material — 1/16" Teflon-glass

TRW

UHF RF Power Transistor

- 37 W
- 12.5 V
- 450-512 MHz
- High Gain
- 20:1 VSWR
- Common Emitter
- Isolated Package
- Internally Matched



.500 J Zero

Electrical Characteristics (T_{CASE} = 25°C)

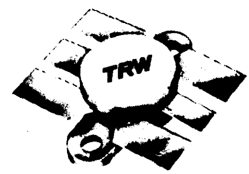
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{CBO}	Collector-Base Voltage	I_C = 50mA	36			V
	BV_{CEO}	Collector-Emitter Voltage	I_C = 50mA	16			V
	BV_{EBO}	Emitter-Base Voltage	I_E = 5mA, I_C = 0	4			V
	I_{CES}	Collector Emitter Leakage	V_{CE} = 15V		10		mA
	h_{FE}	D.C. Current Gain	V_{CE} = 5V, I_C = 1A	10		200	
RF TEST	P_G	Power Gain	V_{CE} = +12.5V, f = 470MHz P_{IN} = 12W	4.9			dB
	$VSWR_L$	Collector Load	V_{CE} = +15.5V, f = 470MHz P_{IN} = 12W	20:1			VSWR
	η	Collector Efficiency	P_O = 37W, f = 470MHz		60		%
THERMAL	θ_{jc}	Thermal Resistance	25 deg C case		2.1		°C/W
	T_{stg}	Storage Temperature		−65		+150	°C
	$I_{C(MAX)}$	Maximum Collector Current	T_C = 25°C			5	A
	$P_{D(MAX)}$	Total Dissipation	T_C = 25°C			83	W

JO 4036

TRW

RF Power Transistors

- 36 W
- 12.5 V
- 175 MHz
- Gold Metalization
- Diffused Ballast Resistors
- Low Thermal Resistance
- Common Emitter
- Isolated Package
- Internally Matched
- 20:1 VSWR
- Class C

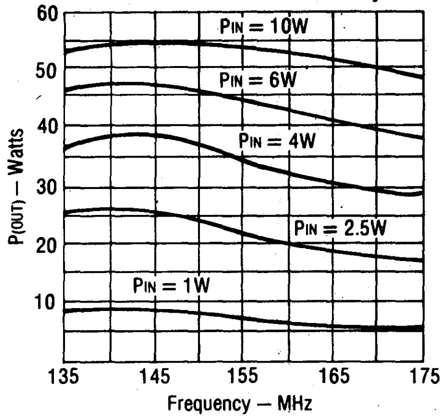


.500 Jo

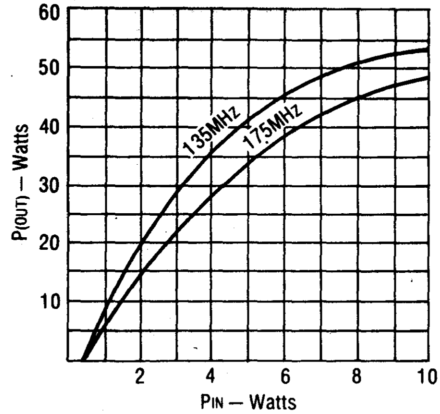
B

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 5mA	4			V
DC TEST	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 50mA	16			V
DC TEST	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 50mA	36			V
DC TEST	I_{CES}	Collector Cutoff Current	V_{CE} = 15V			10	mA
RF TEST	P_{GAIN}	Power Gain	V_{CE} = 12.5V, f = 175MHz P_{IN} = 6W	7.8			dB
RF TEST	P_{REF}	Power Reflected	V_{CE} = 12.5V, f = 175MHz P_{IN} = 6W			0.60	W
RF TEST	Load VSWR	Mismatch Tolerance	V_{CE} = 15.5V, f = 175MHz P_{IN} = 6W	20:1			VSWR
THERMAL	I_C	Continuous Collector Current	T_C = 25°C			6.5	A
THERMAL	P_T	Total Dissipation	T_C = 25°C			100	W
THERMAL	θ_{JC}	Thermal Resistance Junction to Flange			1.75		°C/W
THERMAL	T_{STG}	Storage Temperature		-65		150	°C

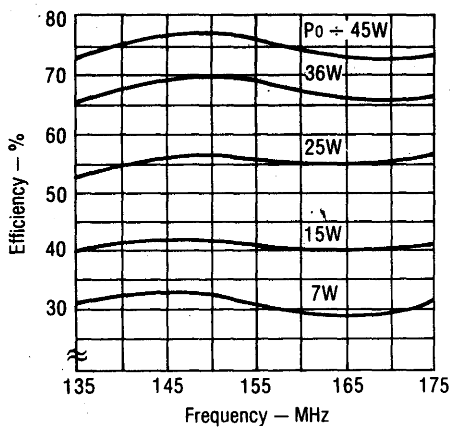
Broadband P(OUT) vs. Frequency



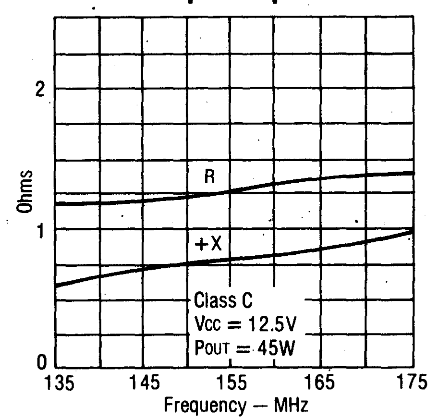
Broadband Power Transfer



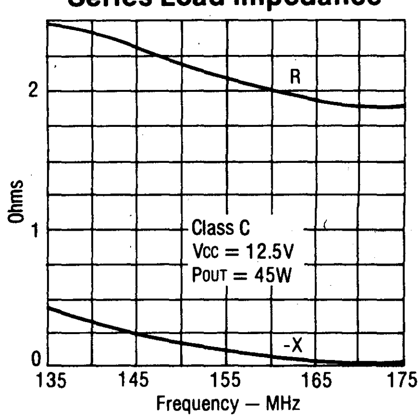
Broadband Collector Efficiency



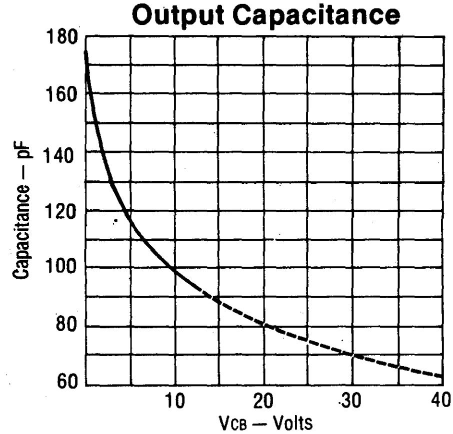
Series Input Impedance



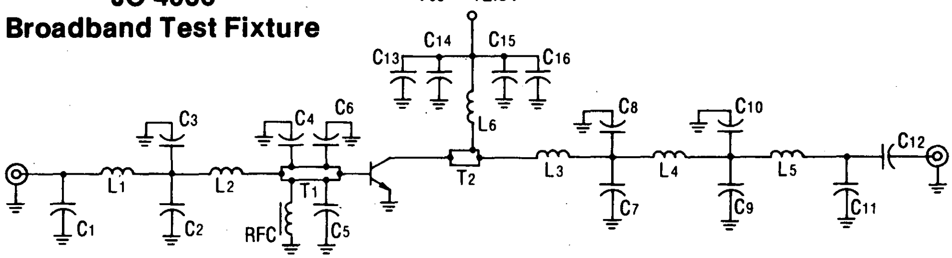
Series Load Impedance



Output Capacitance



JO 4036
Broadband Test Fixture

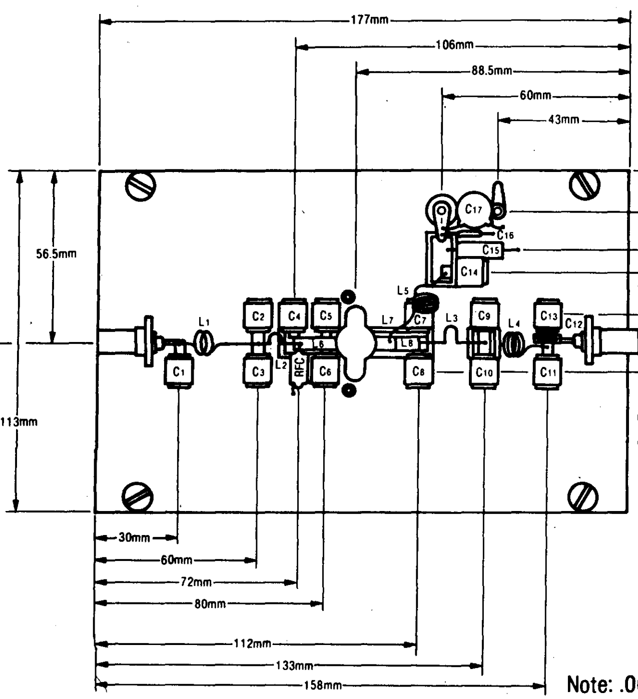


COMPONENTS LIST:

$C_{1,2}$	25pf
$C_{3,4}$	80pf
C_5	250pf
C_6	200pf
C_7	150pf
C_8	100pf
$C_{9,10}$	40pf
C_{11}	25pf
$C_{12,13}$	1000pf
C_{14}	.001μf
C_{15}	.01μf
C_{16}	25μf
L_1	2T 18 AWG .2" dia.
L_2	.2" hairpin .125" wide x .025 thick copper strip
L_3	.1" x .2" wide x .005" thick copper loop
L_4	.3" hairpin 18 AWG.
L_5	3 T. 18 AWG. .2" dia.
L_6	4 T. 18 AWG. .2" dia.
RFC	2½ T. on VK-211-07/38 ferrox cube
T_1	.2" width .5" length from package as ref.
T_2	.2" width .4" length from package as ref.

NOTES:

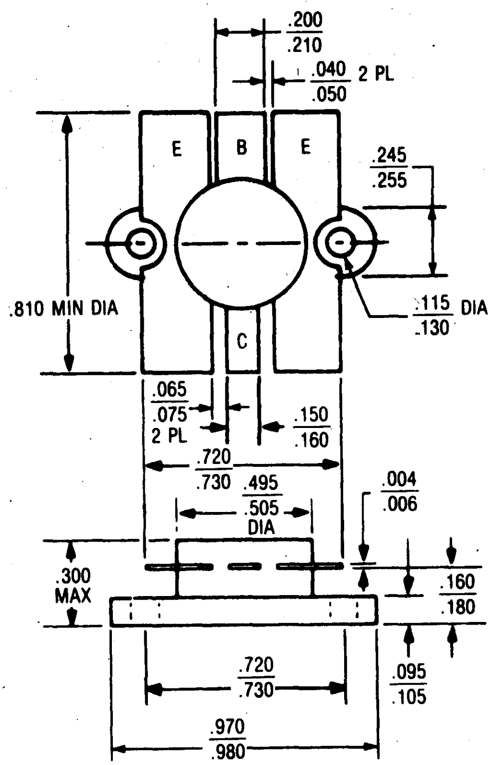
1. All capacitors in signal path are Underwood Electric Corp. Case Type J101.
2. Position C_5 and C_6 as close to pkg. as possible.



C_1	25pf
$C_{2,4}$	80pf
C_3	30pf
C_5	250pf
C_6	200pf
C_7	150pf
C_8	100pf
$C_{9,10}$	40pf
C_{11}	10pf
$C_{12,14}$	1000pf
C_{13}	15pf
C_{15}	5μf 25V
C_{16}	.001K Disc
C_{17}	.01μ 1KV Disc
L_1	2T .2" dia. 18 AWG .250" long
L_2	.2" hairpin .125" wide x .025 thick
RFC_1	2½ T on VK-211-07/3B ferrox cube
L_3	.3" hairpin #18 AWG
L_4	3T .2" dia. #10 AWG .500" long
L_5	4T .2" dia. #18 AWG .400 long
L_6	.5" x .2"
L_7	.4" x .2"
L_8	.1" x .2" wide x .005" thick

Note: .062 Epoxy Board Copper Clad — 2 Sides

B


.200
.210
.040
.050
2 PL
E
B
E
.245
.255
.810 MIN DIA
.115
.130
DIA
C
.065
.075
2 PL
.150
.160
.720
.730
.495
.505
DIA
.004
.006
.300
MAX
.160
.180
.720
.730
.095
.105
.970
.980

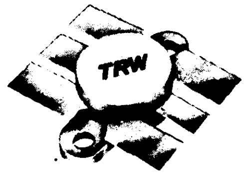
.500 J ZERO:

JO 4045

B

RF Power Transistors

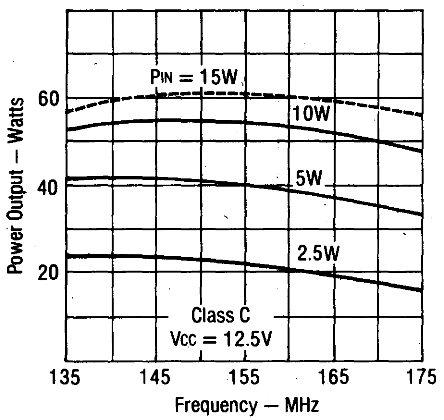
- **45 W**
- **12.5 V**
- **175 MHz**
- **Gold Metalization**
- **Diffused Ballast Resistors**
- **Low Thermal Resistance**
- **Common Emitter**
- **Isolated Packages**
- **Class C Operation**
- **20:1 VSWR**
- **Internally Matched**



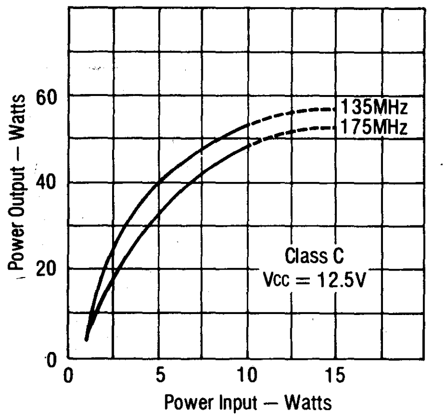
.500 J Zero

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CES}	Collector-Emitter Breakdown Voltage	$I_C = 50mA$	36			Vdc
	BV_{CEO}	Collector-Emitter Breakdown Voltage	$I_C = 50mA$	16			Vdc
	I_{CES}	Collector Cutoff Current	$V_{CE} = 15V$			10	mAdc
	h_{FE}	DC Current Gain	$V_{CE} = 5V, I_C = 1A$	10		200	—
RF TEST	P_G	Power Gain	$V_{CE} = 12.5V$, f = 175MHz $P_{IN} = 10W$	6.5			dB
	P_{REF}	Power Reflected	$V_{CE} = 12.5V$, f = 175MHz $P_{IN} = 10W$			1.0	W
	Load VSWR	Load Mismatch Tolerance	$V_{CE} = 15.5V$, f = 175MHz $P_{IN} = 10W$	20:1			VSWR
THERMAL	$I_{C(MAX)}$	Collector Current	$T_C = 25°C$			6.5	A
	$P_{D(MAX)}$	Total Dissipation	$T_C = 25°C$			100	W
	T_{STG}	Operating and Storage Temperature		-65		150	°C
	θ_{JC}	Thermal Resistance			1.75		°C/W

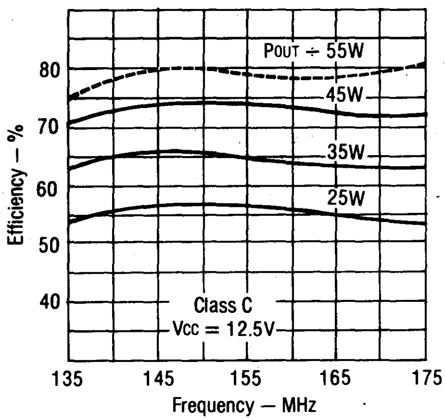
Broadband P(OUT) vs. Frequency



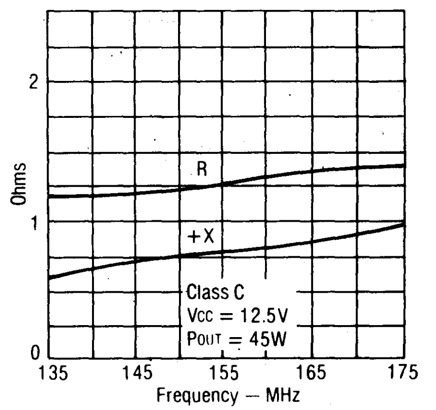
Broadband Power Transfer



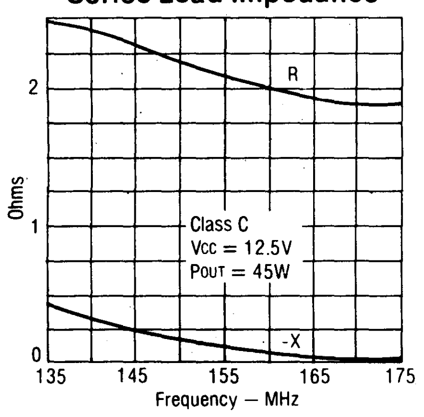
Broadband Collector Efficiency



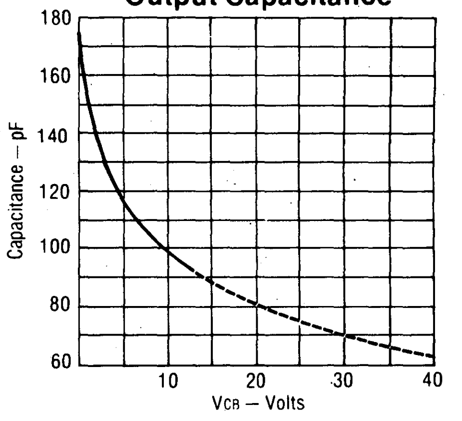
Series Input Impedance



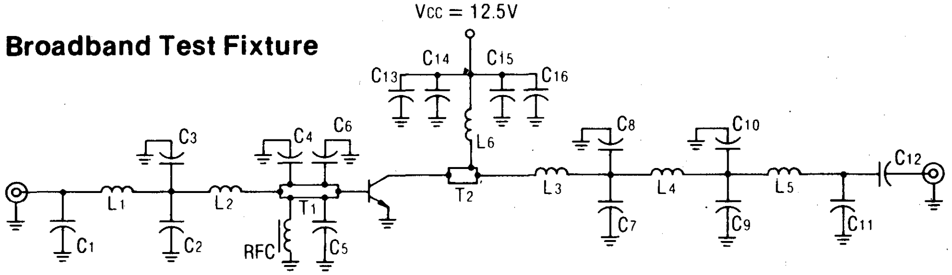
Series Load Impedance



Output Capacitance



Broadband Test Fixture

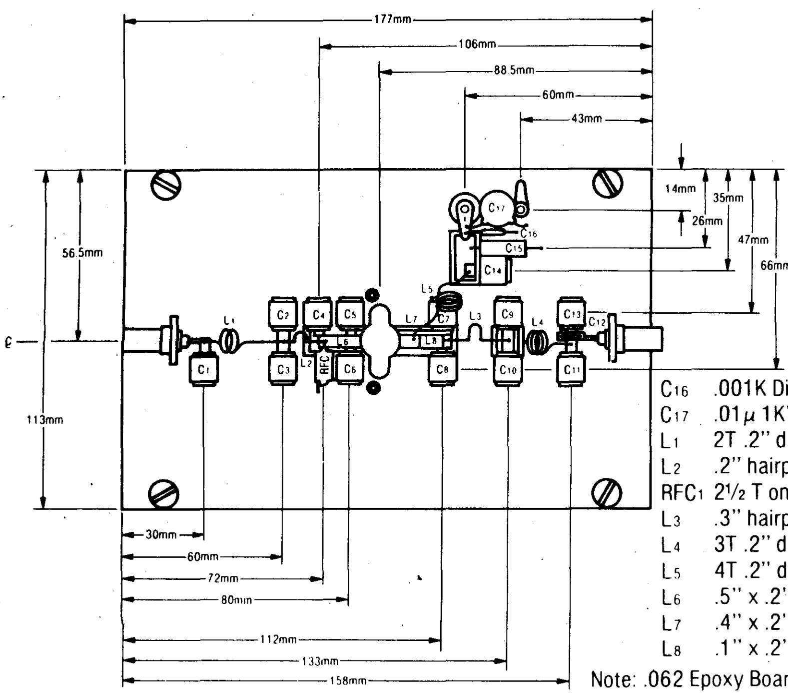


COMPONENTS LIST:

$C_{1,2}$	25pf
$C_{3,4}$	80pf
C_5	250pf
C_6	200pf
C_7	150pf
C_8	100pf
$C_{9,10}$	40pf
C_{11}	25pf
$C_{12,13}$	1000pf
C_{14}	.001μf
C_{15}	.01μf
C_{16}	25μf
L_1	2T 18 AWG .2" dia.
L_2	.2" hairpin .125" wide x .025 thick copper strip
L_3	.1" x .2" wide x .005" thick copper loop
L_4	.3" hairpin 18 AWG.
L_5	3 T. 18 AWG. .2" dia.
L_6	4 T. 18 AWG. .2" dia.
RFC	2½ T. on VK-211-07/38 ferrox cube
T_1	.2" width .5" length from package as ref.
T_2	.2" width .4" length from package as ref.

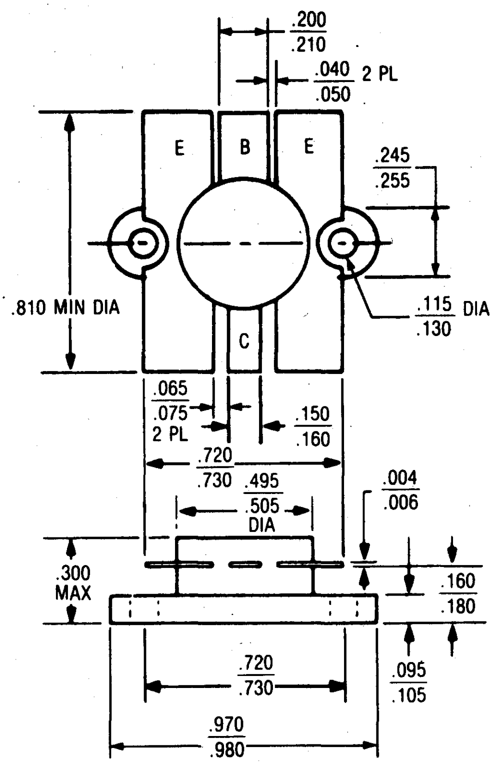
NOTES:

1. All capacitors in signal path are Underwood Electric Corp. Case Type J101.
2. Position C_5 and C_6 as close to pkg. as possible.



C_1	25pf
$C_{2,4}$	80pf
C_3	30pf
C_5	250pf
C_6	200pf
C_7	150pf
C_8	100pf
$C_{9,10}$	40pf
C_{11}	10pf
$C_{12,14}$	1000pf
C_{13}	15pf
C_{15}	5μf 25V
C_{16}	.001K Disc
C_{17}	.01μ 1KV Disc
L_1	2T .2" dia. 18 AWG .250" long
L_2	.2" hairpin .125" wide x .025 thick
RFC_1	2½ T on VK-211-07/3B ferrox cube
L_3	.3" hairpin #18 AWG
L_4	3T .2" dia. #10 AWG .500" long
L_5	4T .2" dia. #18 AWG .400 long
L_6	.5" x .2"
L_7	.4" x .2"
L_8	.1" x .2" wide x .005" thick

Note: .062 Epoxy Board Copper Clad — 2 Sides

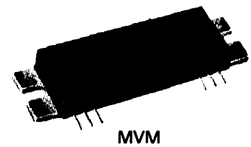

.200
.210
.040 2 PL
.050
E
B
E
.245
.255
.810 MIN DIA
C
.115 DIA
.130
.065
.075
2 PL
.150
.160
.720
.730
.495
.505
DIA
.004
.006
.300
MAX
.160
.180
.720
.730
.095
.105
.970
.980

.500 J ZERO:

TRW

RF Power Module

- 20 W
- 12.5 V
- 68-88 MHz


MVM

B

The ML modules are rugged power amplifier functions designed for battery powered mobile and marine applications in the 68-88 MHz band. The modules feature 50 Ω input and output impedances, highly repeatable broadband gain, and will withstand infinite load VSWR at 16 volts with overdrive and uncontrolled output power.

Compared to discrete components, these modules offer significant savings in size as well as cost of design, production and repair.

SPECIFICATIONS (T_{flange} = 25 °C, unless otherwise noted)

Characteristic	[illegible]	[illegible]	[illegible]
Frequency Range		68-88	MHz
Supply Voltage, V_{CC}		12.5	Vdc, Nom.
Power Output	Rated V_{CC} Any in-Band Frequency $P_{IN} \leq 0.15$ W	20	W, Min.
Efficiency	Rated P_O, V_{CC}	40	%, Min.
Harmonic Outputs	Rated P_O, V_{CC}	−30	dB, Max.
Input Return Loss	Z_O = 50 Ω	−10	dB, Max.
Output Impedance		50	Ω, Nom.
Quiescent Current	V_{CC} = 16 V, P_{IN} = 0 W	0.1	Adc, Max.
Power Slump	Rated P_O, V_{CC} 25 °C −30 °C to +80 °C	1	dB, Max.
Load VSWR, 0-360° (Degradation)	V_{CC} = 16 V, $P_{IN} \leq 0.3$ W Lowest Frequency P_{OUT} = 30 W Max.	20:1	No Degradation
Load VSWR, 0-360° (Stability)	10 V $\leq V_{CC} \leq$ 16 V $0 < P_{IN} \leq 0.2$ W Any in-Band Frequency P_{OUT} 30 W Max.	3:1	Min.
Temperature Range	Operating, T_{FLANGE}	−30 +100	°C Min. °C Max.

RF Power Modules

- 140-175 MHz
- ∞ VSWR at 16 V

MVM

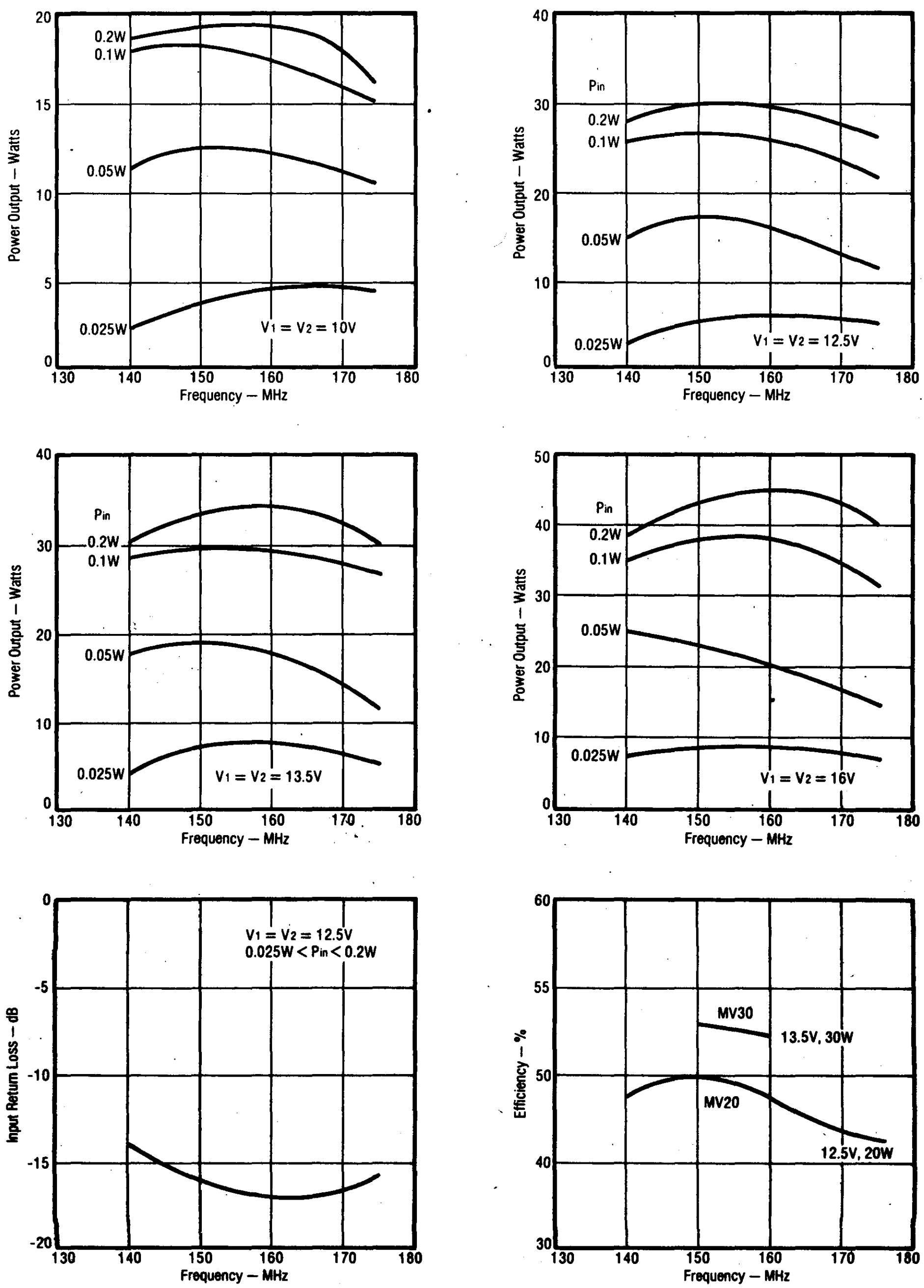
The MV modules are rugged power amplifier functions designed for battery powered mobile and marine applications in the 140-175 MHz band. The modules feature 50 Ω input and output impedances, highly repeatable broadband gain, and will withstand infinite load VSWR at 16 volts with overdrive and uncontrolled output power (typically more than 40 watts).

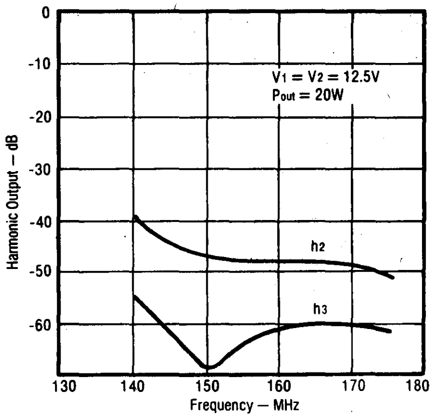
Compared to discrete components, these modules offer significant savings in size as well as cost of design, production and repair.

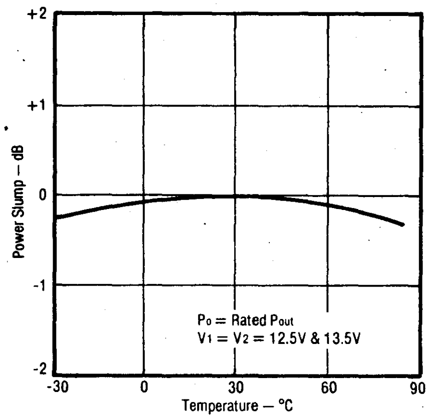
Electrical Characteristics (T_{flange} = 25 °C)

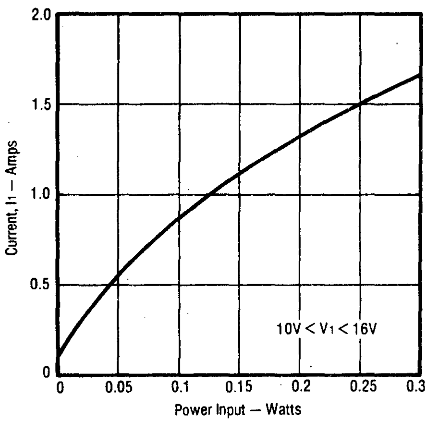
Characteristic	Test Conditions	MV 20	MV 30	Unit
Frequency Range		140-175	150-160	MHz
Supply Voltage, V_{CC}		12.5	13.5	Vdc, Nom.
Power Output	Rated V_{CC} Any in-Band Frequency $P_{IN} \leq 0.2$ W	20	30	W, Min.
Efficiency	Rated P_O, V_{CC}	40	45	%, Min.
Harmonic Outputs	Rated P_O, V_{CC}	−35	−40	dB, Max.
Input Return Loss	Z_O = 50 Ω	−10	−10	dB, Max.
Output Impedance		50	50	Ω, Nom.
Quiescent Current	V_{CC} = 16 V, P_{IN} = 0 W	0.1	0.1	Adc, Max.
Power Slump	Rated P_O, V_{CC} 25 °C −30 °C to +80 °C	1.0	1.0	dB, Max.
Load VSWR, 0-360° (Degradation)	V_{CC} = 16 V, $P_{IN} \leq 0.3$ W Lowest Frequency P_{OUT} = 30 W Max.	20:1	20:1	No Degradation
Load VSWR, 0-360° (Stability)	10 V ≤ V_{CC} ≤ 16 V 0 < P_{IN} ≤ 0.3 W Any in-Band Frequency	3:1	3:1	Min.
Temperature Range	Operating, T_{FLANGE}	−30 +100	−30 +100	°C Min. °C Max.

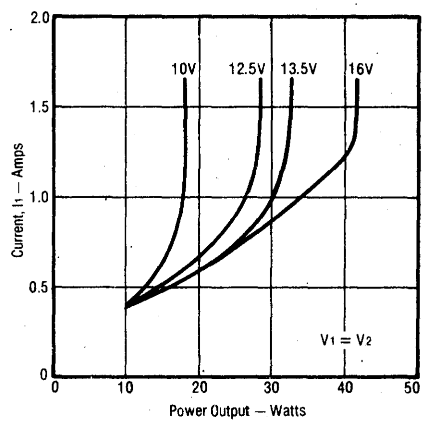
TYPICAL CHARACTERISTICS

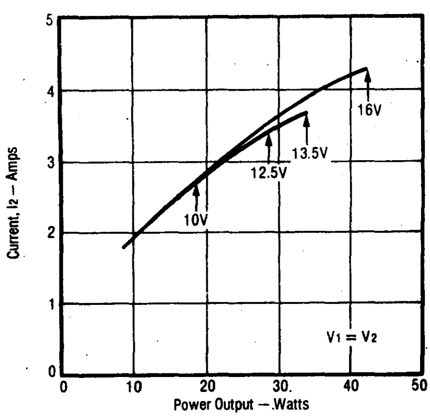


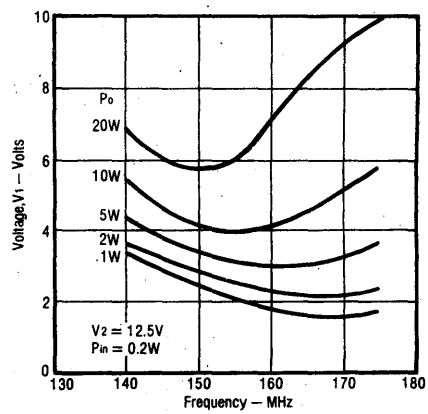

V1 = V2 = 12.5V
Pout = 20W
h2
h3
Harmonic Output – dB
0
-10
-20
-30
-40
-50
-60
130
140
150
160
170
180
Frequency — MHz


Po = Rated Pout
V1 = V2 = 12.5V & 13.5V
Power Slump – dB
+2
+1
0
-1
-2
-30
0
30
60
90
Temperature — °C


10V < V1 < 16V
Current, I1 — Amps
2.0
1.5
1.0
0.5
0
0
0.05
0.1
0.15
0.2
0.25
0.3
Power Input — Watts

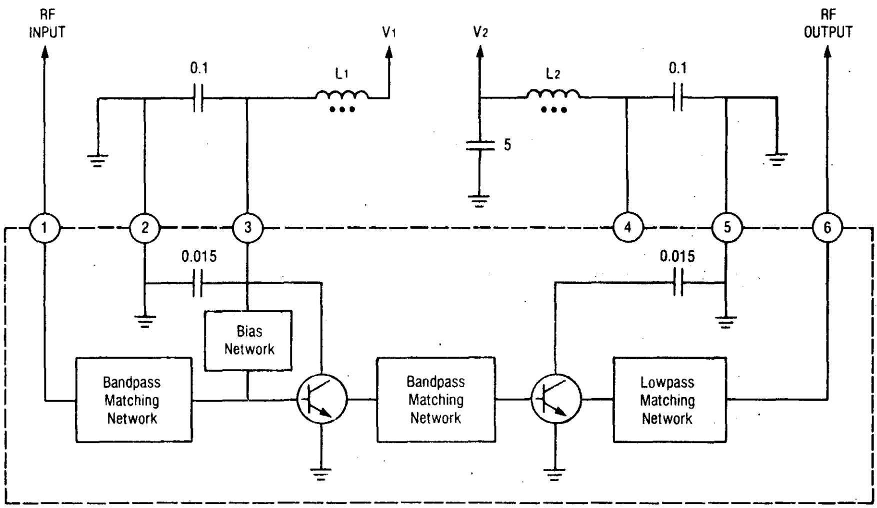

10V
12.5V
13.5V
16V
V1 = V2
Current, I1 — Amps
2.0
1.5
1.0
0.5
0
0
10
20
30
40
50
Power Output — Watts


16V
13.5V
12.5V
10V
V1 = V2
Current, I2 – Amps
5
4
3
2
1
0
0
10
20
30.
40
50
Power Output — Watts


Po
20W
10W
5W
2W
.1W
V2 = 12.5V
Pin = 0.2W
Voltage, V1 — Volts
10
8
6
4
2
0
130
140
150
160
170
180
Frequency — MHz

B

CIRCUIT DIAGRAM FOR MV 20 AND MV 30



L1, L2: Ferroxcube VK211173B, 2½ turns
All capacitor values in μF

TRW

RF Power Modules

- 400-440 MHz / 440-470 MHz
- 20 W
- 12.5 V


MVM

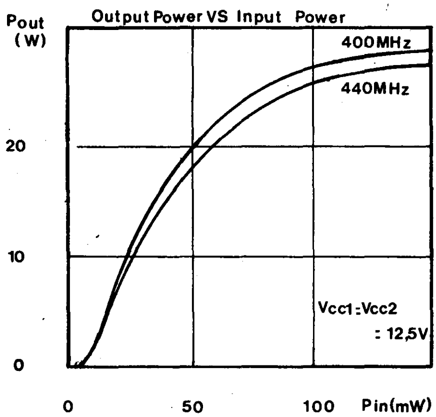
TRW's MX modules are rugged power amplifier functions designed for 12 volt broadband UHF applications. The modules feature 50 Ω input and output impedances, broadband gain, and can withstand infinite VSWR. They are stable under all operating conditions and provide excellent harmonic rejection. The modules also feature gain control capability, providing insensitivity to severe overdrive, surge voltages, and excessive currents induced by high VSWR levels.

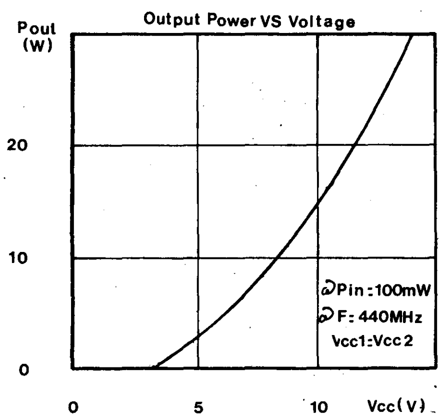
Compared to discrete components, these modules offer significant savings in size as well as in design, production, and repair costs.

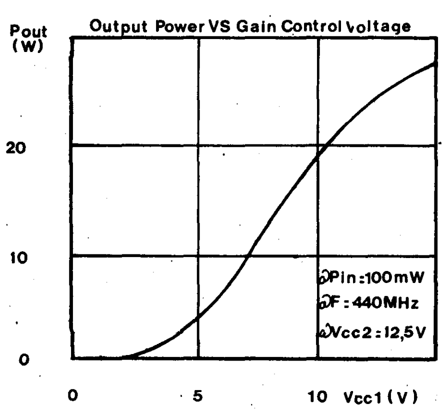
Electrical Characteristics (T_{FLANGE} = 25 °C, V_{cc} = 12.5 V)

Characteristic	Test Conditions		Units
Frequency Ranges	MX 20-1, MX 20-2	400-440, 440-470	MHz
Supply Voltage		12.5	Vdc nominal
Power Gain	$P_{IN} \leq 150$ mW	20	W
Efficiency	Rated P_O	35 min/40 typ.	% min.
Harmonic Content	Rated P_O	−40	dB min.
Load VSWR	V_{CC} = 15.6 V P_{OUT} max. : 30 W $P_{IN} \leq 200$ mW	20:1	
Power Derating	−30 °C to +70 °C	1	dB max.
Stability	Any frequency VSWR 4:1	0-15.6 0-200 20	Vdc mW W max.
Input Impedance Return Loss		50 −10	Ω nominal dB max.
Output Impedance		50	Ω nominal
ϕ JF		4	°C/W Typical
Operating Mode		B	Class
Temperature Range	Operating	− 30 + 100	°C min., °C max.
Gain Control Range	Operating	30	dB min.

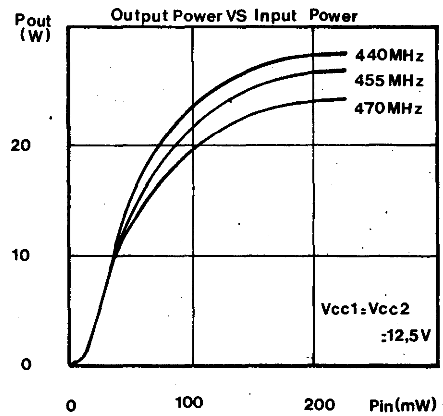
MX 20 - 1

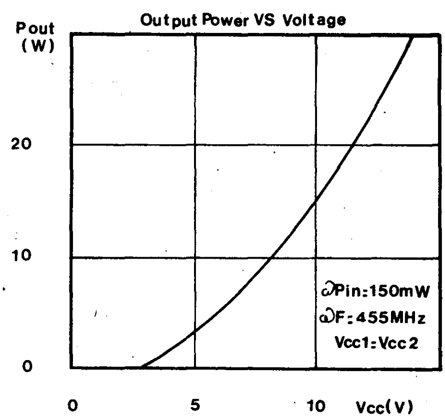

Output Power VS Input Power
Pout (W)
0
10
20
400MHz
440MHz
Vcc1:Vcc2
: 12,5V
0
50
100
Pin(mW)

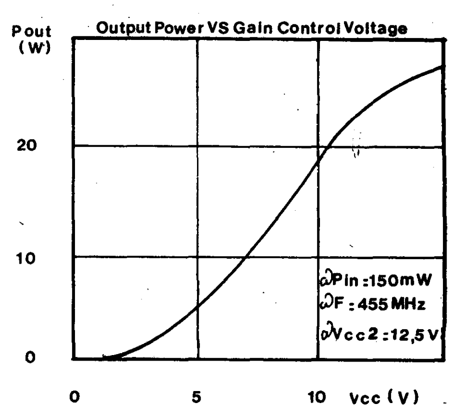

Output Power VS Voltage
Pout (W)
0
10
20
@Pin:100mW
@F: 440MHz
Vcc1:Vcc2
0
5
10
Vcc(V)


Output Power VS Gain Control Voltage
Pout (W)
0
10
20
@Pin:100mW
@F:440MHz
@Vcc2:12,5V
0
5
10
Vcc1 (V)

MX 20 - 2

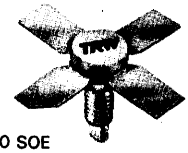

Output Power VS Input Power
Pout (W)
0
10
20
440MHz
455MHz
470MHz
Vcc1:Vcc2
:12,5V
0
100
200
Pin(mW)


Output Power VS Voltage
Pout (W)
0
10
20
@Pin:150mW
@F:455MHz
Vcc1:Vcc2
0
5
10
Vcc(V)


Output Power VS Gain Control Voltage
Pout (W)
0
10
20
@Pin:150mW
@F:455MHz
@Vcc2:12,5V
0
5
10
Vcc (V)

RF Power Transistors

- **PT 8809 : 2 W**
- **PT 8810 : 5 W**
- **PT 8811 : 10 W**
- **12.5 V**
- **470 MHz**



280 SOE

The PT 8809, 10 and 11 are designed for 12.5 volt, UHF applications. Power output is usable to the top of their ratings and they are able to withstand infinite VSWR at all phase angles at rated output power.

Electrical Characteristics (T_{CASE} = 25 °C)

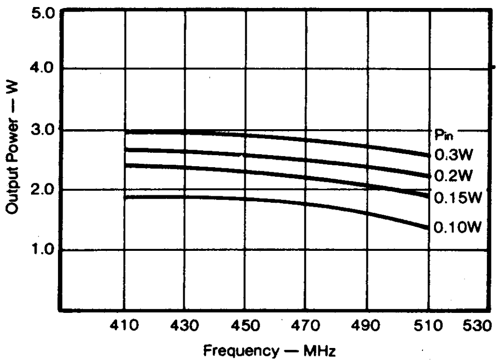
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	PT 8809	PT 8810	PT 8811	UNIT
DC Test	BV_{EBO}	Min. Emitter - Base Breakdown	I_E = 1 mA I_C = 0; I_E = 2 mA I_C = 0; I_E = 5 mA I_C = 0	4	4	4	V
DC Test	BV_{CES}	Min. Collector - Emitter Breakdown	I_C = 5 mA V_{BE} = 0; I_C = 10 mA V_{BE} = 0; I_C = 20 mA V_{BE} = 0	36	36	36	V
DC Test	BV_{CEO}	Min. Collector - Emitter Breakdown	I_C = 25 mA I_B = 0; I_C = 50 mA I_B = 0	16	16	16	V
DC Test	I_{CBO}	Max. Collector Cutoff Current	V_{CB} = 15 V I_E = 0	1	1	2	mA
DC Test	H_{FE}	Min. D.C Current Gain	V_{CE} = 5 V I_C = 100 mA; V_{CE} = 5 V I_C = 200 mA; V_{CE} = 5 V I_C = 500 mA	20	20	20	—
RF Test	P_{GAIN}	Min. Power Gain	V_{CE} = 12.5 V, F = 470 MHz; P_{in} = 0.2 W; P_{in} = 0.7 W; P_{in} = 2.5 W	2	5	10	W
RF Test	η	Min. Collector Efficiency	V_{CE} = 12.5 V, F = 470 MHz; P_{out} = 2 W; P_{out} = 5 W; P_{out} = 10 W	60	55	55	%
RF Test	VSWR	Mismatch Tolerance	V_{CE} = 12.5 V, F = 470 MHz; P_{out} = 2 W; P_{out} = 5 W; P_{out} = 10 W	∞ : 1	∞ : 1	∞ : 1	
RF Test	C_{OB}	Max. Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz I_E = 0	8	17	30	pF
Operating	I_C	Continous Collector Current		0.75	1.7	3.4	A
Operating	θ_{j-c}	Thermal Resistance	T_C = 25 °C	10	5	3.5	°C/W
Operating	T_{STG}	Storage Temperature and Junction Temperature		— 65° to + 200°			°C
Operating	P_D	Power Dissipation	T_C = 25 °C	17.5	35	50	W

TYPICAL POWER GAIN PERFORMANCE IN BROADBAND CIRCUIT

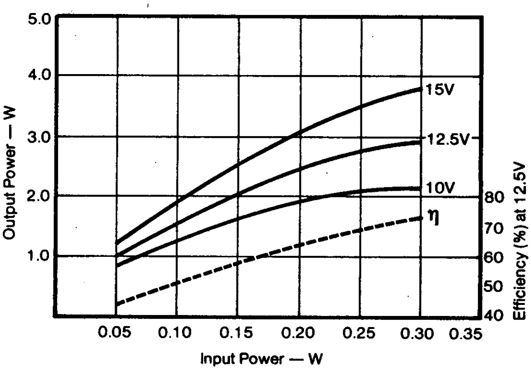
Power Output Frequency
V_{CE} = 12.5 V

Power Output vs Power Input
f = 470 MHz

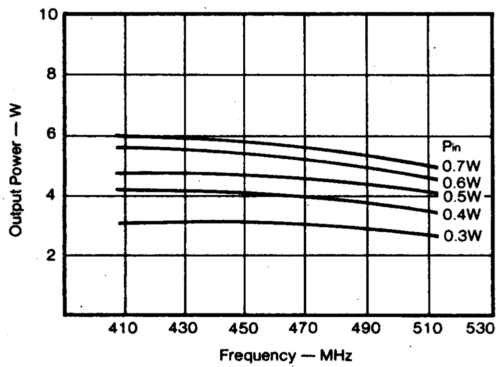
PT 8809



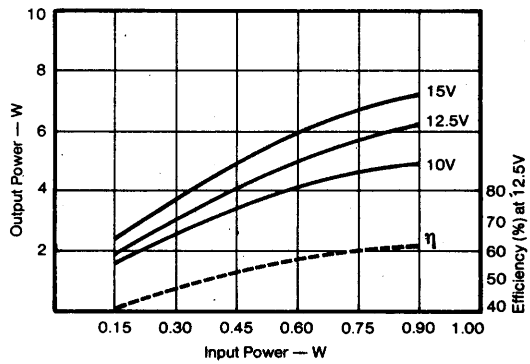
PT 8809



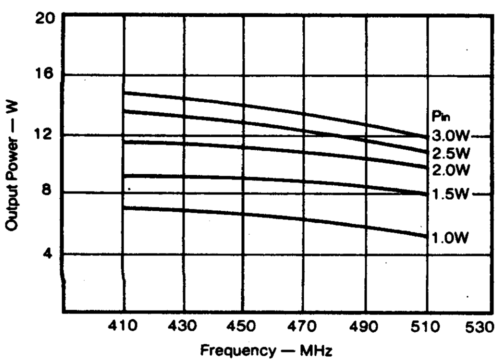
PT 8810



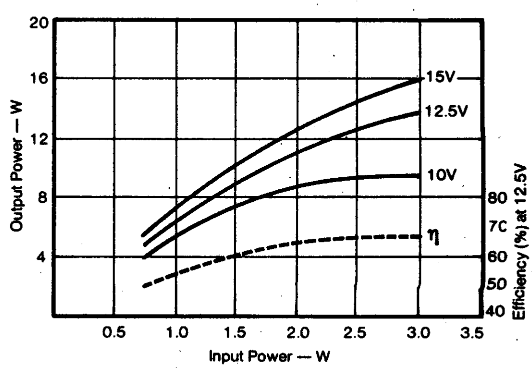
PT 8810



PT 8811



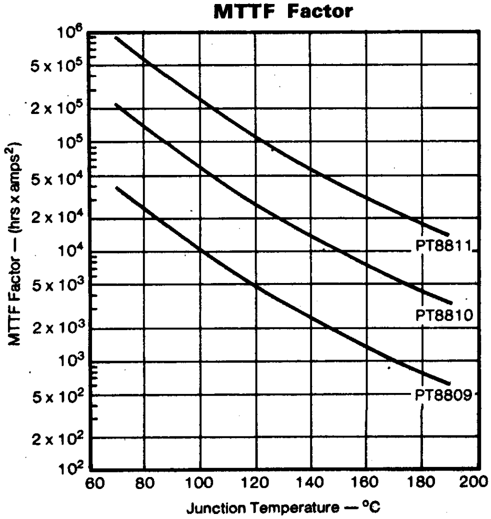
PT 8811



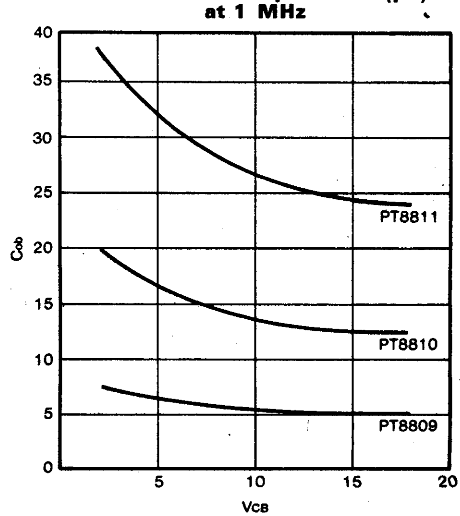
DEVICE IMPEDANCE PARAMETERS AT 12.5 V AND RATED INPUT POWER

DEVICE	FREQUENCY (MHz)	Z_n (Ω)	Z_{out} (Ω)
PT 8809	410	1.70 + j 1.92	15.7 — j 20.4
	430	1.79 + j 2.09	15.5 — j 19.7
	450	1.87 + j 2.26	15.4 — j 18.9
	470	1.96 + j 2.44	15.2 — j 18.2
	490	2.03 + j 2.61	15.1 — j 17.5
	510	2.11 + j 2.77	14.9 — j 16.7
PT 8810	410	1.49 + j 2.60	9.95 — j 6.20
	430	1.52 + j 2.90	9.80 — j 6.05
	450	1.56 + j 3.20	9.65 — j 5.90
	470	1.60 + j 3.50	9.55 — j 5.75
	490	1.63 + j 3.80	9.40 — j 5.60
	510	1.67 + j 4.10	9.30 — j 5.45
PT 8811	410	1.25 + j 2.65	6.00 — j 1.70
	430	1.24 + j 2.77	5.85 — j 1.64
	450	1.23 + j 2.89	5.70 — j 1.58
	470	1.22 + j 3.00	5.55 — j 1.62
	490	1.21 + j 3.12	5.40 — j 1.46
	510	1.20 + j 3.24	5.25 — j 1.40

MTTF Factor



Collector Base Capacitance (pF) at 1 MHz



MTTF factor is derived from calculations based on metal migration theory. The following example will serve to demonstrate the use of the MTTF factor charts shown above. Consider the PT 8810 operating at 470 MHz under normal conditions.

P_o = 5 W
V_C = 12.5 V
P_{in} = 0.6 W
η = 60 %

From this we calculate I_C = 0.67 A; therefore, the total power dissipated is 4 watts.

The junction temperature can then be calculated from :

$$T_j = T_{stud} + Pd \times \theta_{JC}$$

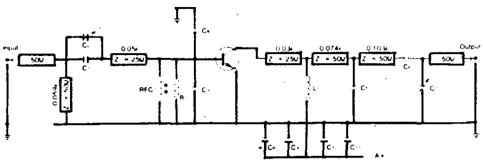
In this example $P_d \times \theta_{JC}$ is 20 °C.

For a stud temperature of 100 °C, T_j is 120 °C. From the chart above, we find the PT 8810 has an MTTF factor of 2.75 × 10^4 hours amps² at 120 °C. We calculate MTTF as follows :

$$MTTF = \frac{2.75 \times 10^4 \text{ hrs.amps}^2}{(0.67 \text{ amps})^2}$$

MTTF = 61,300 hours

PT 8809 TEST CIRCUIT BROADBAND (450-510 MHz)



COMPONENT AND MATERIAL LIST

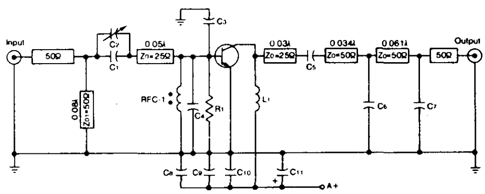
C_1 3.9 pF, ceramic chip
$C_{2,7}$ 0.8-10 pF, Voltronics AP 10, variable
$C_{3,4}$ 27 pF, ceramic chip
C_5 15 pF, ceramic chip
C_6 470 pF, ceramic chip
C_8 5 μF, electrolytic
C_9 1000 pF, Underwood
C_{10} 0.1 μF, disc-ceramic
C_{11} 0.1 μF, disc-ceramic

L_1 2 turns # 22 enameled, 0.1" I.D.

R_1 270 Ω, 1/2 watt, carbon
RFC_1 2 1/2 turns # 22 AWG on Ferroxcube VK 211/17-4 B

All transmission lines reference at 480 MHz

PT 8810 TEST CIRCUIT BROADBAND (450-510 MHz)

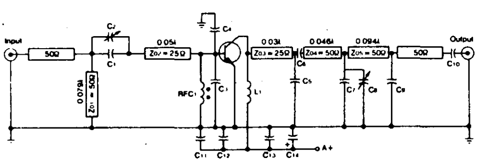


COMPONENT AND MATERIAL LIST

C_1 3.9 pF, ceramic chip
C_2 0.8-10 pF, Voltronics AP 10, variable
$C_{3,4}$ 25 pF, ceramic chip
C_5 1500 pF, ceramic chip
C_6 10 pF, Underwood
C_7 5 pF, Underwood
C_8 0.01 μF, disc-ceramic
C_9 0.10 μF, disc-ceramic
C_{10} 1000 pF, Underwood
C_{11} 5 μF, electrolytic
L_1 4 turns, # 22 enameled, 0.1" I.D.
R_1 750 Ω, 1/2 watt, carbon
RFC_1 2 1/2 turns # 22 AWG on Ferroxcube VK 211/17-4 B

All transmission lines reference at 480 MHz

PT 8811 TEST CIRCUIT BROADBAND (450-510 MHz)

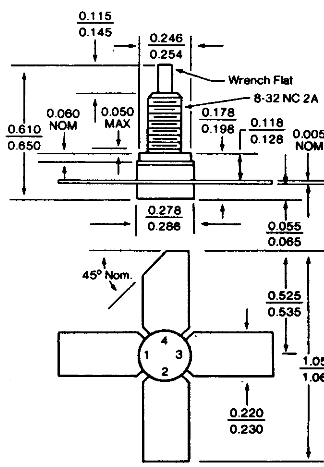


COMPONENT AND MATERIAL LIST

C_1 3.9 pF, ceramic chip
$C_{2,8}$ 0.8-10 pF, Voltronics AP 10, variable
$C_{3,4}$ 27 pF, ceramic chip
C_5 20 pF, Underwood
C_6 81 pF, ceramic chip
C_7 10 pF, Underwood
C_9 5 pF, Underwood
C_{10} 470 pF, ceramic chip
C_{11} 1000 pF, Underwood
C_{12} 0.1 μF, disc-ceramic
C_{13} 0.01 μF, disc-ceramic
C_{14} 5 μF, electrolytic
L_1 4 turns, # 22 enameled, 0.1" I.D.
RFC_1 2 1/2 turns # 22 AWG on Ferroxcube VK 211/17-4 B

All transmission lines reference at 480 MHz

CASE OUTLINE



To convert inches to millimeters multiply by 25.4

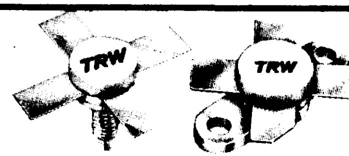
STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

PT 8828 /F

TRW

RF Transistor

- 10 W
- 12.5 V
- 175 MHz
- NPN Silicon



380 SOE 380 SOE F

Designed for 12.5 V VHF amplifiers. Class B or C operation.

12.5 V characteristics :

Output power 175 MHz - 9 W min.

Minimum gain at 175 MHz - 11 dB.

Available in either stud or flange package.

Power output useable to the top ratings and capable of whithstanding infinite VSWR at all phase angles at rated output power.

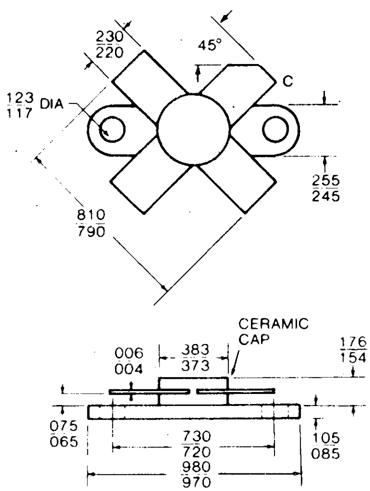
Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	16			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 20 mA I_E = 0	36			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			2	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 500 mA	20			—
RF Test	P_{GAIN}	Power Gain	V_{CB} = 12.5 V P_{in} = 0.7 W F = 175 MHz	9			W
	η	Efficiency	V_{CB} = 12.5 V P_{out} = 9 W F = 175 MHz	60			%
	Load VSWR	Mismatch Tolerance	V_{CE} = 12.8 V P_{out} = 9 W F = 175 MHz		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CB} = 12.5 V P_{in} = 0.7 W F = 175 MHz		1.8 − j 0.1		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CB} = 12.5 V P_{out} = 9 W F = 175 MHz		8.29 + j 2.55		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz			30	pF
Operating	I_C	Continous Collector Current				3.4	A
	θ_{j-c}	Thermal Resistance	T_C = 25 °C			3.5	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			50	W

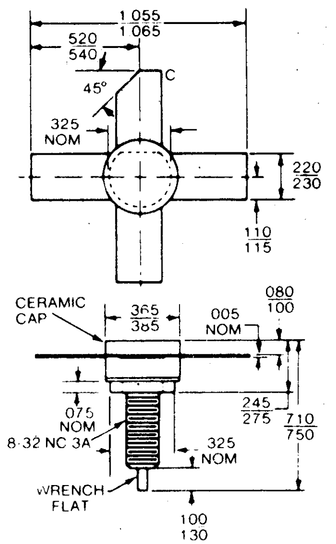
B

PACKAGE OUTLINE

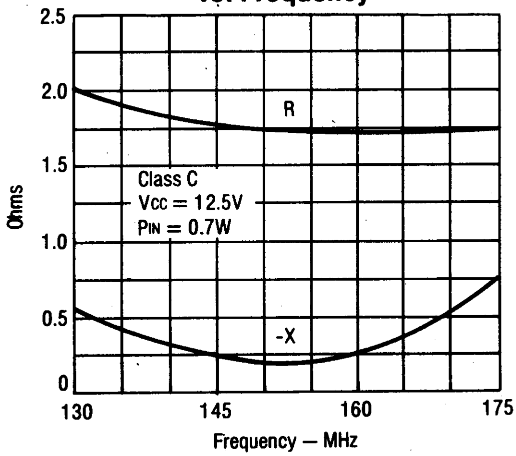
.380 SOE F



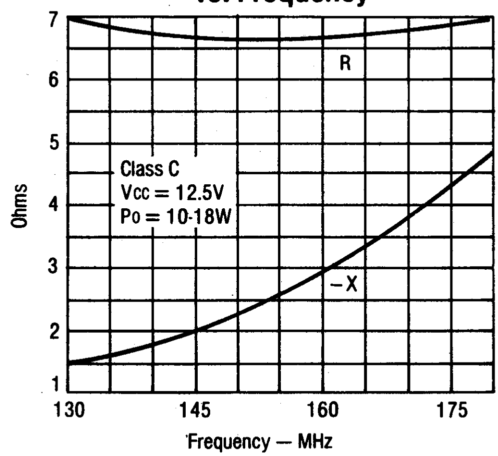
.380 SOE



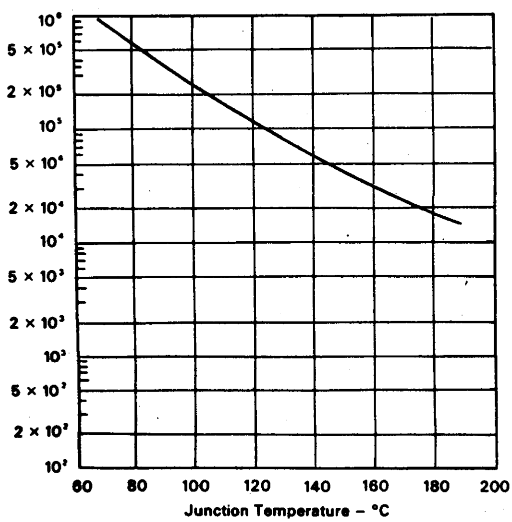
Series Input Impedance vs. Frequency



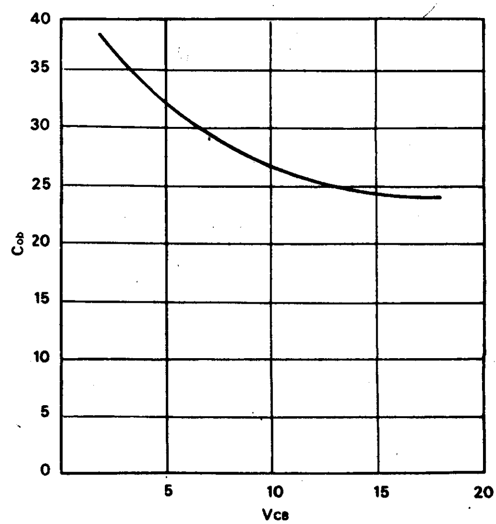
Series Load Impedance vs. Frequency



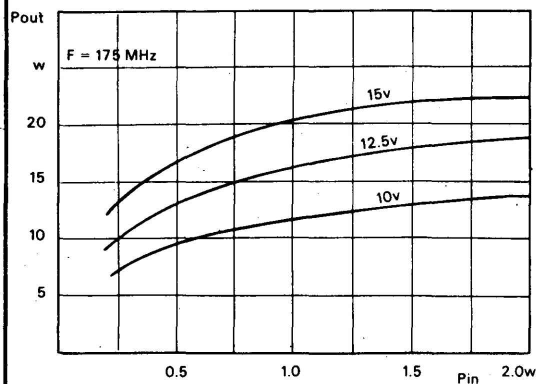
MTTF Factor



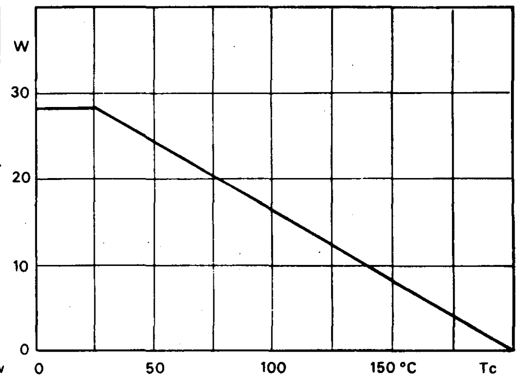
Collector Base Capacitance (pF) at 1 MHz



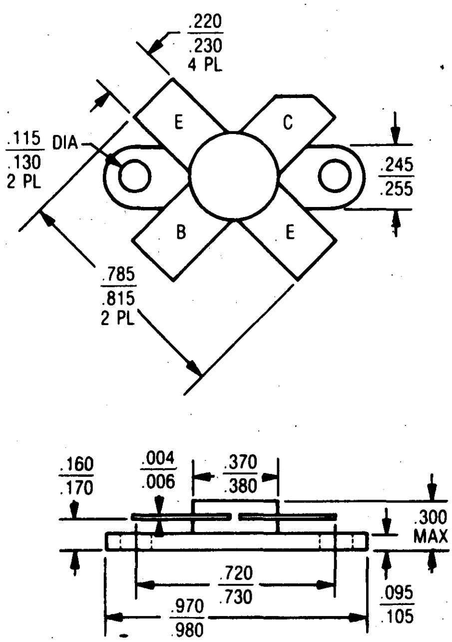
Typical characteristics



Power - Temperature Derating Curve

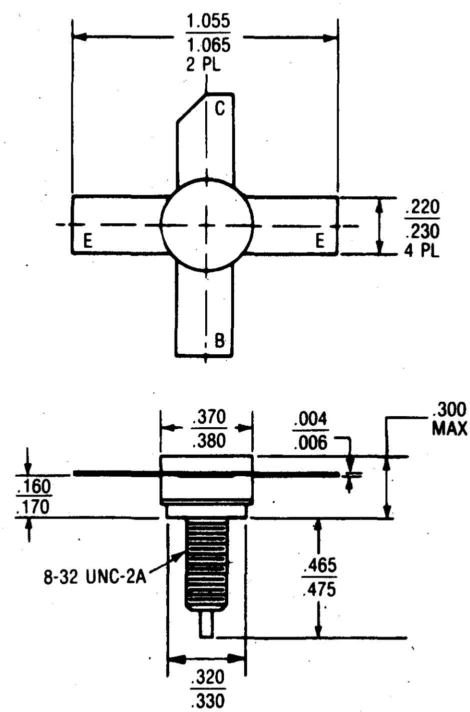


.380 SOE F



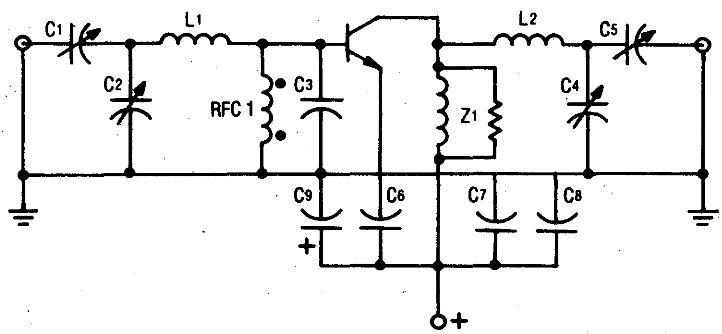
PT 8828/F

.380 SOE



PT 8828

TEST CIRCUIT



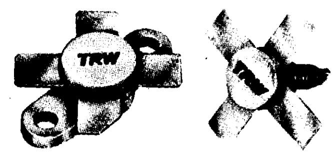
PARTS LIST:

$C_{1,2,4,5}$	Trimmer car, ARCO #462, 5-80pf.
C_3	120pf Underwood Mfg.
C_6	1000pf Underwood Mfg.
C_7	0.01μf disc ceramic.
C_8	0.02μf disc ceramic.
C_9	25μf, electrolytic, 35 WVDC.
L_1	2 T., #18 AWG., 0.25" I.D.
L_2	2 T., #18 AWG., 0.25" I.D.
Z_1	8 T., #18 AWG., wound on 330 ohms 1/2 W. resistor.
RFC 1	2-1/2 T., #22 AWG. on Ferrox cube VK211-17/4B Core.

TRW

SSB Power Transistors

- 100 W
- 28 V
- ∞ VSWR



B

The PT 9780 SSB/VHF Series features both high gain and high power, providing the desired power output with fewer devices. These power transistors are ballasted for ruggedness and will withstand infinite VSWR at all phase angles. A unique emitter structure provides high gain with wider emitter and base fingers resulting in high reliability. Diffused ballast resistors design enables operation at Class A, AB, and C. These rugged units are suitable for both narrow band and broadband SSB and VHF communications and instrumentation service. They are suitable for the following applications :

2-30 MHz	SSB, FM, AM
2-76 MHz	SSB, FM, AM
2-100 MHz	Linear Class A, SSB, FM, AM

Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	CONDITIONS	PT 9780 A	UNIT
DC Tests	BV_{CBO}	Collector to Base Breakdown Voltage	I_C = 100 mA, I_E = O	70	V Min.
	BV_{CEO}	Collector to Emitter Breakdown Voltage	I_C = 50 mA, I_B = O	40	V Min.
	I_{CES}	Collector - Emitter Cutoff Current	V_{CE} = 28 V	100	mA Max.
	I_{EBO}	Emitter - Base Leakage Current	V_{BE} = 4 V	5.0	mA Max.
	H_{FE}	D.C. Current Gain	V_{CE} = 5 V	10-100	
RF Tests	ΔH_{FE}	Matched Pairs	I_C = 1 A	Δ 5	
	G_P	Power Gain	V_{CE} = 28 V, F = 28 MHz, PEP 100 W	14	dB Min.
	IMD	Intermodulation Distortion	V_{CE} = 28 V, F = 28 MHz, PEP 100 W	−32	dB Max.
	VSWR	Mismatch Tolerance	V_{CE} = 28 V, F = 28 MHz, PEP 100 W	∞	—

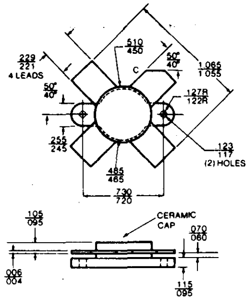
Absolute Maximum Ratings (T_{CASE} = 25°C)

Part Number*	V_{CBO} Volts	V_{CEO} Volts	V_{EBO} Volts	I_C Max Amps	P_T @ 25°C Watts	θ_{jc} °C/W	$T_{STORAGE}$ °C
PT9780	70	40	4.0	20.0	350	0.50	-65 to 200
PT9780A	70	40	4.0	20.0	250	0.70	-65 to 200

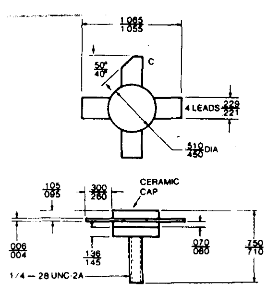
*The "A" suffix on part number denotes stud package.

Package Outlines

PT9780



PT9780A



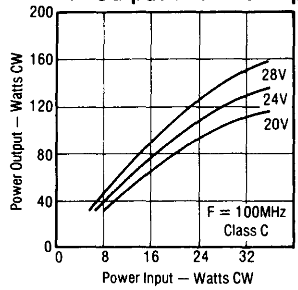
Mechanical Specifications

- Stud Torque, 10 in. lbs., max.
- Lead Soldering, 300°C, 15 sec. max.
- Lead Fatique, 3 bends @ 90°
- Flange Flatness, 0.0008 in. typ.

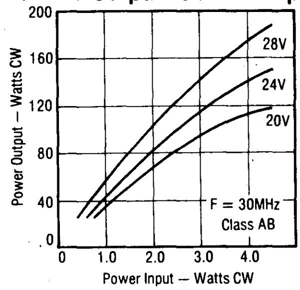
B

PT9780 and PT9780A

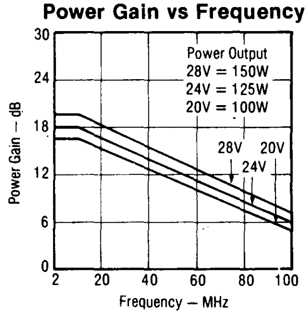
Power Output vs Power Input



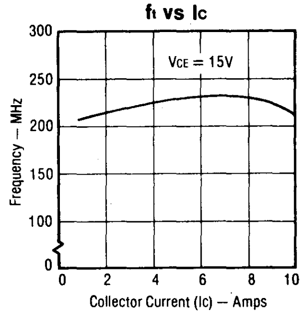
Power Output vs Power Input



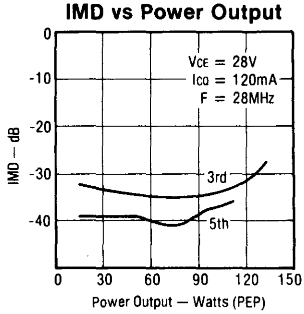
Power Gain vs Frequency



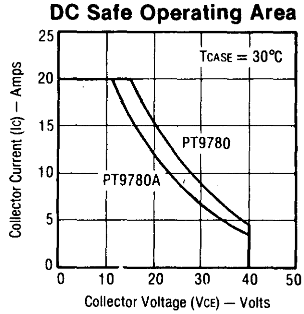
fₜ vs Iᴄ



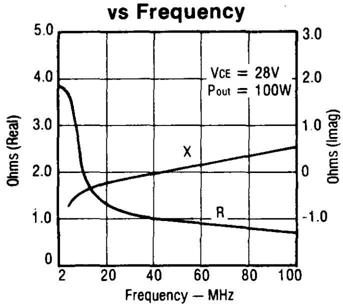
IMD vs Power Output



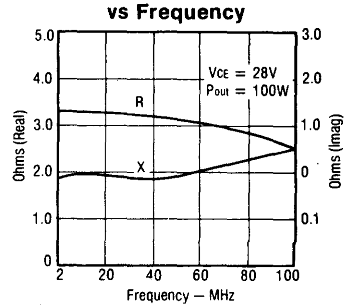
DC Safe Operating Area



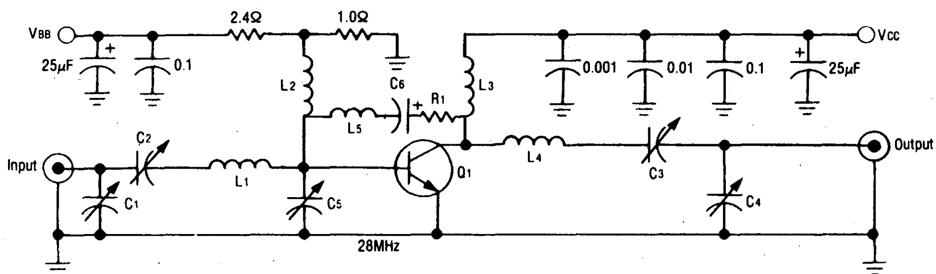
Series Input Impedance vs Frequency



Series Load Impedance vs Frequency

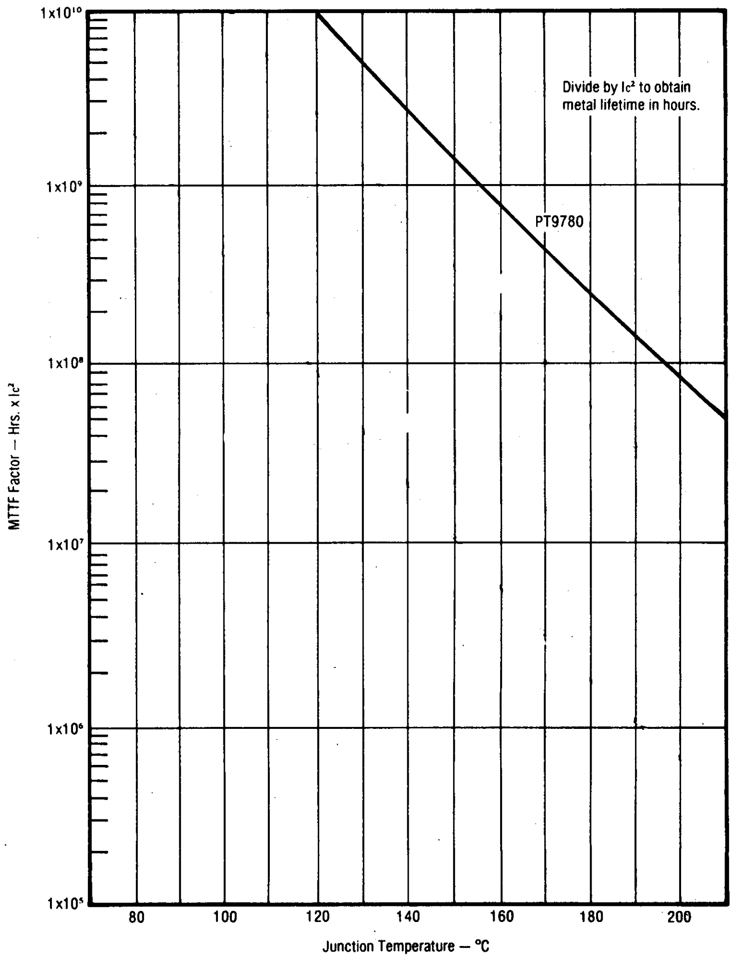


28MHz Test Circuit for PT9780/A.



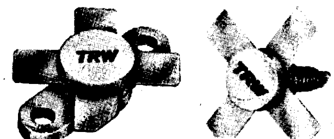
C_1	ARCO #467, 110-580pF
$C_{2,3,4}$	ARCO #466, 80-480pF
C_5	ARCO #469, 170-780pF
C_6	5μF, 50V ELE
R_1	50Ω, 2W
$L_{1,4}$	5 turns #14 tinned copper, 0.5" mean diameter, 1 equals 1.0"
L_2	10 turns #18AWG, 0.5" mean diameter
L_3	4 turns #20AWG through two Stackpole #23-1838 cores
L_5	6.8μH molded
V_{CC}	28V
V_{BB}	1.6 volts (I_C[Quies] = 100mA)

MTTF Factor vs Junction Temperature



SSB Power Transistors

- **PT 9785 - 100 W**
- **PT 9784/A - 75 W**
- **13.5 V**
- **∞ VSWR**



380 SOE F 380 SOE

This Series features both high gain and high power, providing the desired power output with fewer devices. These power transistors are ballasted for ruggedness and will withstand infinite VSWR at all phase angles. A unique emitter structure provides high gain with wider emitter and base fingers resulting in high reliability. Ballast resistor design enables operation at Class A, AB and C. These rugged units are suitable for both narrow band and broadband HF communications and instrumentation service.

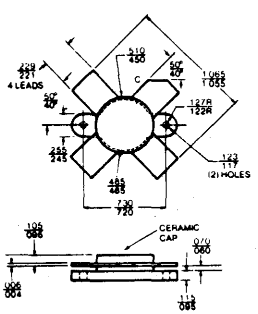
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	PT 9784/A	PT 9785	UNIT
DC TESTS	BV_{CBO}	Collector - Base Breakdown	I_C = 100 mA I_C = 200 mA	50	50	V Min.
	BV_{EBO}	Emitter - Base Breakdown	I_E = 6 mA I_E = 10 mA	4.0	4.0	V Min.
	I_{CES}	Collector - Emitter Cutoff Current	V_{CE} = 13,5 V	20	20	mA Max.
	HF_E	DC Current Gain	V_{CE} = 5 V	20-100	20-100	–
	ΔHF_E	Matched Pairs	I_C = 1 A	Δ 5	Δ 5	–
RF TESTS	P_{OUT}	Output Power PEP	V_{CE} = 13,5 V P = 28 MHz	75	100	W PEP
	P_G	Power Gain	V_{CE} = 13,5 V F = 28 MHz P_{OUT} = Rated PEP	15	13	dB *Min.*
	IMD	Intermodulation Distortion	V_{CE} = 13,5 V F = 28 MHz P_{OUT} = Rated PEP	−32	−32	dB Max.
	VSWR	Mismatch Tolerance	V_{CE} = 13,5 V F = 28 MHz P_{OUT} = Rated PEP	∞	∞	–
THERMAL	Rth	Thermal Resistance Jonction to Heatsink (Including Contact)	V_{CE} = 13,5 V th = 40 °C Pd = 50 W Pd = 60 W	1,4	0,9	°C/W

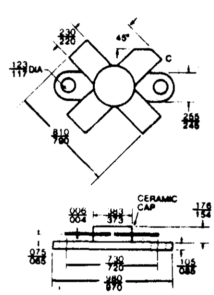
Absolute Maximum Ratings (T_{case} = 25 °C)

Part number	V_{CBO} V	V_{CEO} V	V_{CBO} V	$T_{storage}$ °C
PT 9784/A	50	20.0	4.0	— 65 to 200
PT 9785	50	20.0	4.0	— 65 to 200
The « A » suffix on part number denotes stud package				

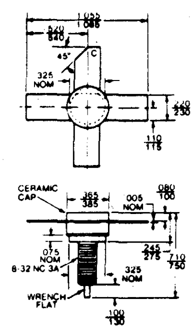
PT 9785



PT 9784



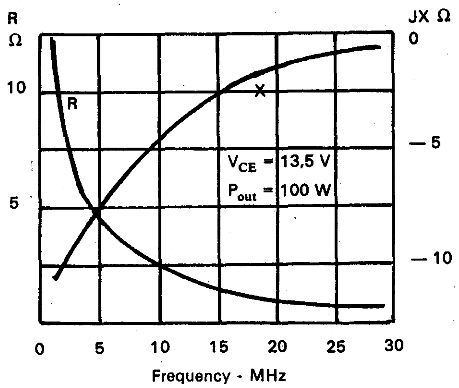
PT 9784 A



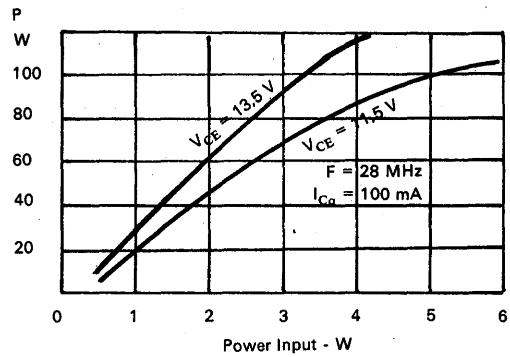
Mechanical Specifications

- Stud Torque, 10 in. lbs., max.
- Lead Soldering, 300°C, 15 sec. max.
- Lead Fatique, 3 bends @ 90°
- Flange Flatness, 0.0008 in. typ.

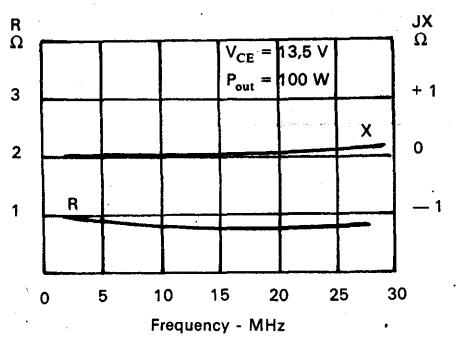
Series Input Impedance vs Frequency



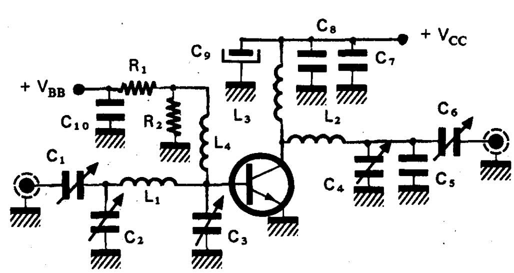
Power Output vs Power Input



Series Load Impedances vs Frequency



28 MHz Test Circuit



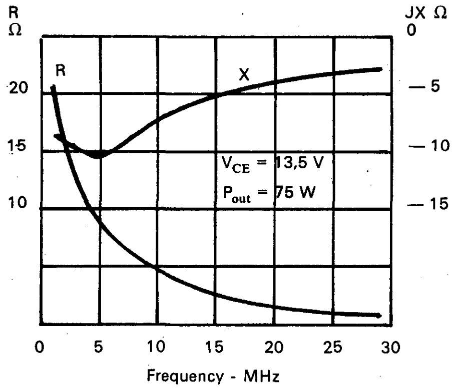
Test Circuit Ports List

C_1 ARCO 423 7-100 pF
C_2 ARCO 467 110-680 pF
C_3 ARCO 469 170-780 pF
C_4 ARCO 466 80-480 pF
C_5 400 pF UNELCO
C_6 ARCO 423 7-100 pF
C_7 1000 pF UNELCO
C_8 0,1 μF
C_9 470 μF Electrolytic
C_{10} 0,1 μF

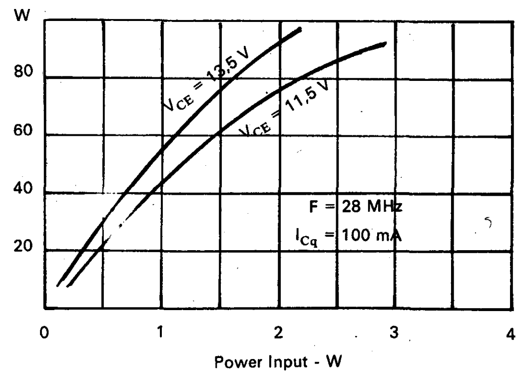
L_1 3 turns ⌀ 11 mm 1 mm wire L = 15 mm
L_2 3 turns ⌀ 15 mm 1,8 mm wire L = 20 mm
L_3 Sturns ⌀ 12 mm 1,8 mm wire
L_4 VK 200 ferrite choke

R_1 1,5 Ω
R_2 10 Ω/5 W

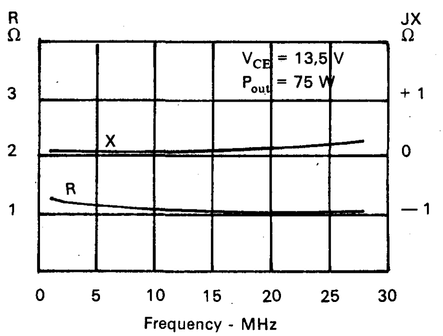
Series Input Impedance vs Frequency



Power Output vs Power Input



Series Load Impedance vs Frequency



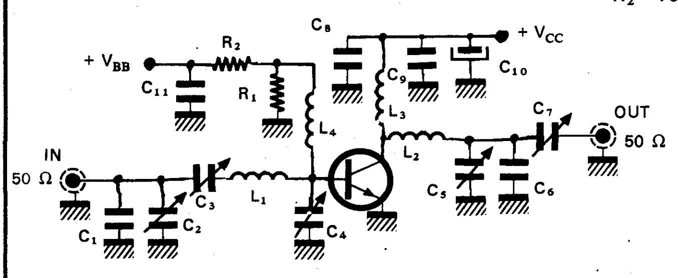
Test Circuit Parts List

L_1 3 turns ⌀ 12 mm 1,4 mm wire
L_2 2 turns ⌀ 13 mm 1,8 mm wire L = 10 mm
L_3 8 turns ⌀ 12 mm 1,2 mm wire
L_3 VK 200 ferrite choke

C_1 400 pF UNELCO
C_2 ARCO 427 55-300 pF
C_3 ARCO 469 170-780 pF
C_4 ARCO 469 170-780 pF
C_5 ARCO 427 55-300 pF
C_6 300 pF UNELCO
C_7 ARCO 425 24-200 pF
C_8 1000 pF UNELCO
C_9 0,1 μF
C_{10} 470 μF Electrolytic
C_{11} 0,1 μF

R_1 1,5 Ω
R_2 10 Ω/5 W

28 MHz Test Circuit

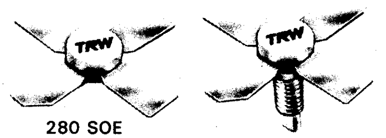


TP 212 - TP 212 S

TRW

7.5 Volts Transistor

- 1.5 W
- 88 MHz
- 13 dB Gain



280 SOE STUDLESS — 280 SOE

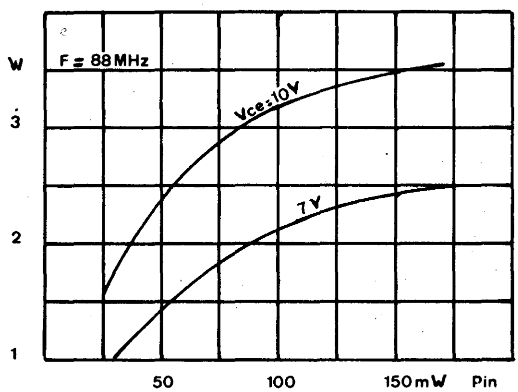
Using the latest in TRW technology, this device has been specifically designed and characterized for 7.5 V operation.

It is ideally suited for use in pocketphone where low battery voltage is used.

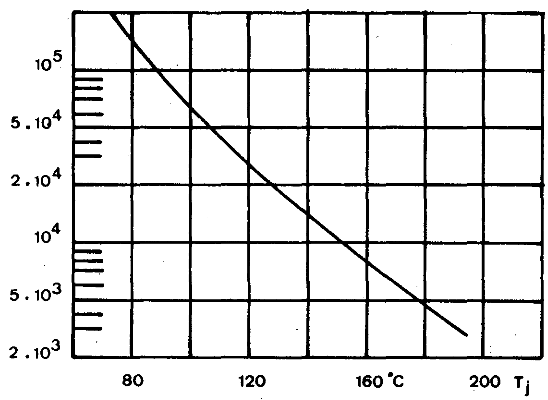
Preliminary Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 2 mA I_C = 0	4			V
DC TEST	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	16			V
DC TEST	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 10 mA I_B = 0	36			V
DC TEST	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_B = 0			1	mA
DC TEST	H_{FE}	DC Current Gain	V_{CE} = 5 V I_C = 200 mA	20			—
RF TEST	P_{GAIN}	Power Gain	V_{CE} = 7.5 V F = 88 MHz P_{in} = 0.075 W	1.5			W
RF TEST	η	Efficiency	V_{CE} = 7.5 V F = 88 MHz P_{out} = 1.5 W	50			%
RF TEST	Load VSWR	Mismatch Tolerance	V_{CE} = 10 V F = 88 MHz P_{out} = 1.5 W		all phase angles : 1		
RF TEST	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 7.5 V F = 88 MHz P_{in} = 0.075 W		2.54 — j 3.5		Ω
RF TEST	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CB} = 7.5 V F = 88 MHz P_{out} = 1.5 W		21.38 + j 10.3		Ω
RF TEST	C_{OB}	Collector Base Capacitance	V_{CB} = 15 V F = 1 MHz		13	17	pF
OPERATING THERMAL	I_C	Continuous Collector Current				1.7	A
OPERATING THERMAL	$\theta_{j.C}$	Thermal Resistance	T_C = 25 °C			10	°C/W
OPERATING THERMAL	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
OPERATING THERMAL	P_D	Power Dissipation	T_C = 25 °C			17.5	W

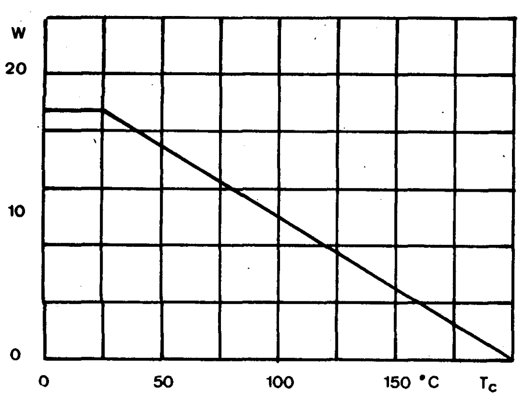
Output Power vs Input Power and Voltage Supply



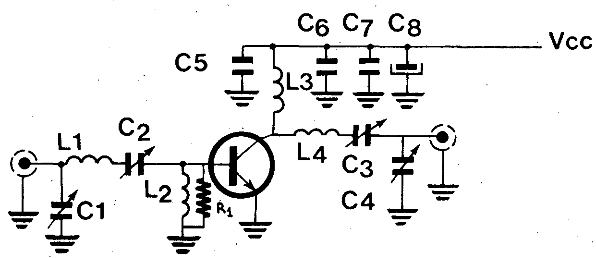
MTTF Factor vs Junction Temperature



Power - Temperature Operating Curve



88 MHz TEST CIRCUIT



C_1 = C_2 = C_3 = 24-200 pF ARCO 425
C_4 = 7-100 pF ARCO 423
C_5 = 1000 pF mica capacitor UNELCO
C_6 = 10 nF ceramic disc
C_7 = 0.1 μF ceramic disc
C_8 = 100 μF/35 V electrolytic

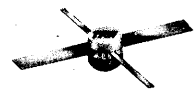
L_1 = L_4 = 4 turns 14 AWG 1/2″ I.D.
L_2 = 0.47 μH
L_3 = 6 turns 14 AWG 1/2″ I.D. Close Wound

R_1 = 47 ohms

TRW

7.5 Volts Transistor

- 0.2 W
- 400-512 MHz
- 13 dB Gain



200 SOE STUDLESS

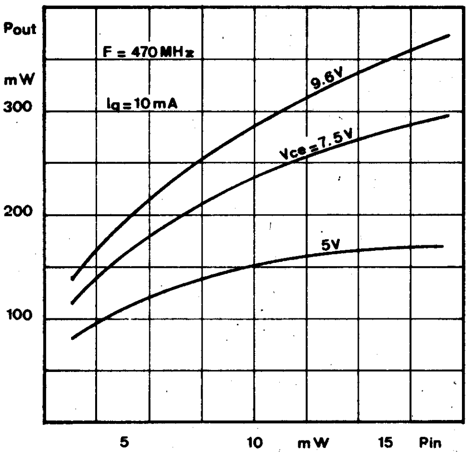
B

The latest in the TRW RF transistor, this device has been specifically designed and characterized for 7.5 V operation. It is ideally suited for use in pocketphones where low battery voltage is used.

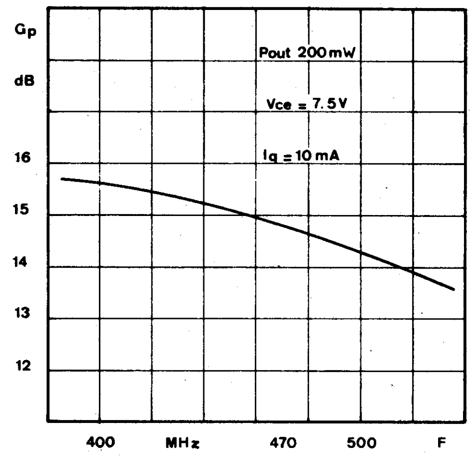
PRELIMINARY

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 5 mA I_B = 0	18			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2 mA I_B = 0	40			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			0.5	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 50 mA	20			—
RF Test	P_{GAIN}	Power Gain	F = 470 MHz Iq = 10 mA V_{CE} = 7.5 V P_{in} = 10 mW V_{CE} = 9.6 V P_{in} = 10 mW	0.175 0.200	0.230 0.290		W
	η	Efficiency	F = 470 MHz Iq = 10 mA V_{CE} = 7.5 V Rated Output Power	35	40		%
	Z_{in}	Common Emitter Amplifier Input Impedance	F = 470 MHz AB Class V_{CE} = 7.5 V P_{in} = 10 mW		5 + j 0.5		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	F = 470 MHz AB Class V_{CE} = 7.5 V P_{out} = 0.2 W		47 + j 45		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 10 V F = 1 MHz		1.6	2.5	pF
Operating	I_C	Continous Collector Current				0.2	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			60	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			2.9	W

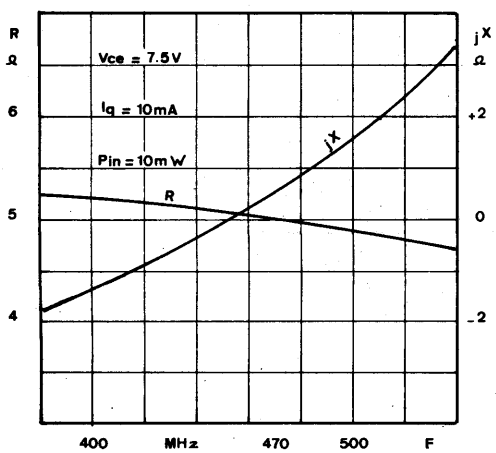
Output Power vs Input Power and V_{CE}



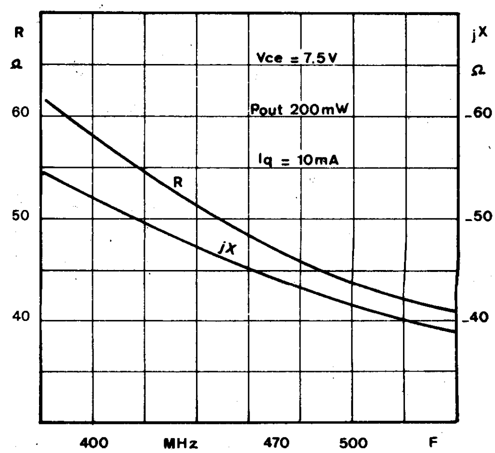
Power Gain vs Frequency



Input Impedance vs Frequency

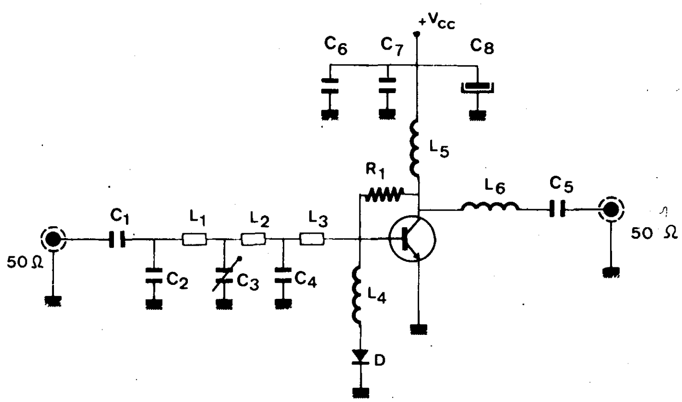


Output Impedance vs Frequency



B

400-512 MHz TEST CIRCUIT



C_1 =		27 pF Ceramic 632 RTC
C_2 =		8.2 pF Ceramic 632 RTC
C_3 =		3-20 pF Trimmer Capacitor
C_4 =		22 pF Ceramic 632 RTC
C_5 =	C_6 =	1000 pF Ceramic 629 RTC
C_7 =		10 nF Ceramic 629 RTC
C_8 =		10 μF/25 V Electrolytic

L_1 =	Stripline	Z_0 = 70 ohms	l = 0.061 λ	F_{REF} = 480 MHz
L_2 =	Stripline	Z_0 = 70 ohms	l = 0.026 λ	
L_3 =	Stripline	Z_0 = 50 ohms	l = 0.031 λ	

L_4 = L_5 = 0.15 μH Molded Coil

L_6 = 3 turns - Silvered Wire 6/10 mm - 4 mm I.D - 8 mm length

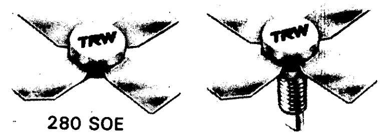
R_1 = 5 10 Ω Carbon Composition 1/4 W

TP 252/S

TRW

7.5 Volts Transistor

- **1.5 W**
- **400-512 MHz**
- **10 dB Gain**



280 SOE STUDLESS

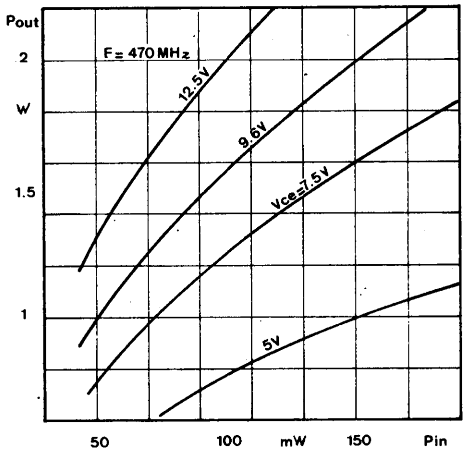
280 SOE

The latest in the TRW RF transistor, this device has been specifically designed and characterized for 7.5 V operation. It is ideally suited for use in pocketphone where low battery voltage is used.

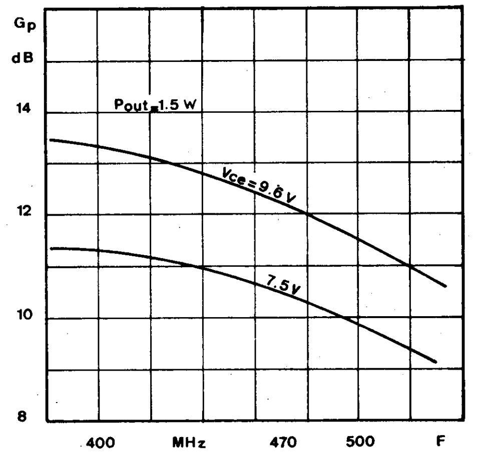
PRELIMINARY

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	[illegible]	4			[illegible]
	BV_{CEO}	Collector - Emitter Breakdown Voltage	[illegible]	14			[illegible]
	BV_{CBO}	Collector - Base Breakdown Voltage	[illegible]	30			[illegible]
	I_{CBO}	Collector Cutoff Current	[illegible]			0.5	[illegible]
	H_{FE}	D.C Current Gain	[illegible]	20			[illegible]
R F Test	P_{GAIN}	Power Gain	[illegible]	1.5 1.5	1.8 2		[illegible]
	η	Efficiency	F = 470 MHz V_{CE} = 7.5 V [illegible]	50	60		[illegible]
	Load VSWR	Mismatch Tolerance	F = 470 MHz V_{CE} = 10 V P_{out} = 1.5 W		∞ : 1 All phases		[illegible]
	Z_{in}	Common Emitter Amplifier Input Impedance	F = 470 MHz V_{CE} = 7.5 V P_{in} = 150 mW		1.8 + j 3.5		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	F = 470 MHz V_{CE} = 7.5 V P_{out} = 1.5 W		11 + j 6		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 10 V F = 1 MHz		5.5	7	pF
Operating	I_C	Continous Collector Current				1	A
	θ_{j-c}	Thermal Resistance	T_C = 25 °C			10	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	[illegible]			17.5	[illegible]

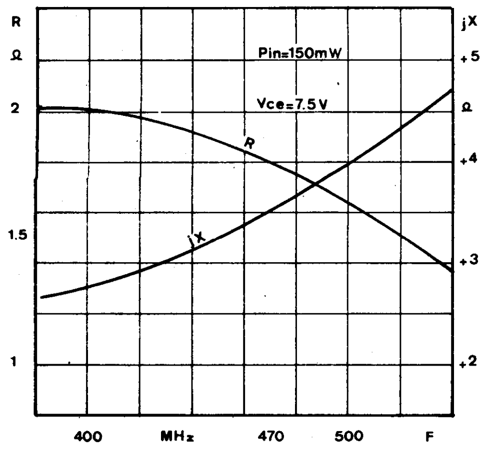
Output Power vs Input Power and V_{CE}



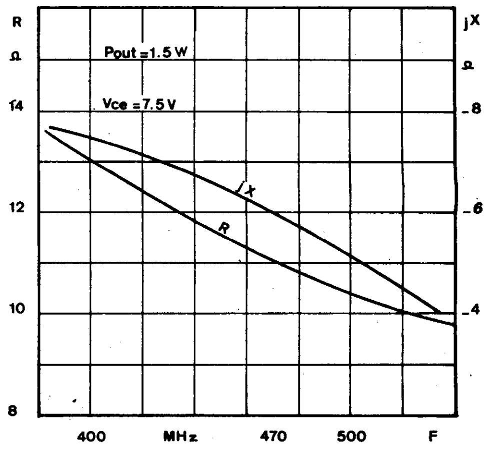
Power Gain vs Frequency and V_{CE}



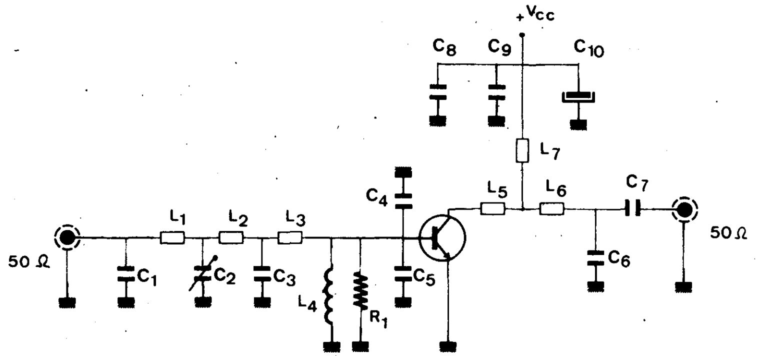
Input Impedance vs Frequency



Output Impedance vs Frequency



400-512 MHz TEST CIRCUIT



C_1 =	4.7 pF Ceramic 632 RTC
C_2 =	2-10 pF Trimmer Capacitor
C_3 =	15 pF Ceramic 632 RTC
$C_4 = C_5$ =	39 pF Ceramic Chip ATC
C_6 =	10 pF Ceramic Chip ATC
$C_7 = C_8$ =	1000 pF Ceramic 629 RTC
C_9 =	10 nF Ceramic 629 RTC
C_{10} =	10 μF/25 V Electrolytic

L_1 =	Stripline	Z_0 = 70 ohms	l = 0.032 λ	F_{REF} = 480 MHz
L_2 =	Stripline	Z_0 = 70 ohms	l = 0.029 λ	
L_3 =	Stripline	Z_0 = 25 ohms	l = 0.031 λ	
L_5 =	Stripline	Z_0 = 25 ohms	l = 0.006 λ	
L_6 =	Stripline	Z_0 = 70 ohms	l = 0.052 λ	
L_7 =	Stripline	Z_0 = 70 ohms	l = 0.064 λ	

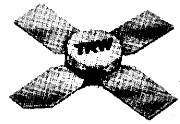
L_4 = 0.15 μH Molded Coil

R_1 = 47 ohms Carbon Composition - 1/4 W

TRW

RF Power Transistor

- 2W
- 12.5 V
- 470 MHz



280 SOE STUDLESS

B

The TP 1045 is designed for 12.5 V VHF and UHF amplifiers.

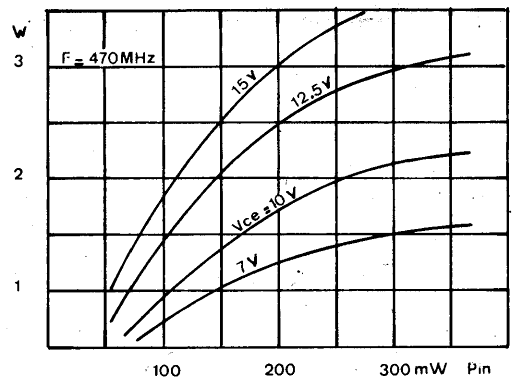
Its high gain at reduced voltage and stripline package make it suitable for use in pocketphone applications.

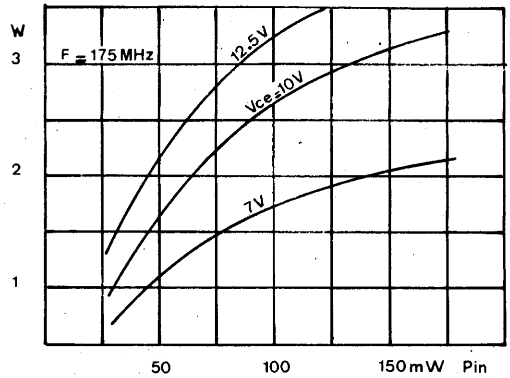
The power output is useable to the top of its ratings and it is able to withstand an infinite VSWR at all phase angles at rated output power.

Electrical Characteristics (T_{case} = 25 °C)

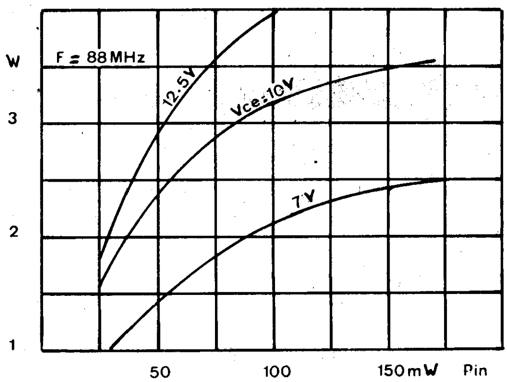
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0	4			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 25 mA I_B = 0	16			V
DC Test	BV_{CBO}	Collector - Base Beakdown Voltage	I_C = 5 mA I_E = 0	36			V
DC Test	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
DC Test	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 100 mA	20			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 470 MHz P_{in} = 0.2 W V_{CE} = 9.5 V F = 175 MHz P_{in} = 0.1 W V_{CE} = 9.5 V F = 88 MHz P_{in} = 0.1 W	2 1.5 1.5	 2.2 2.9		W
RF Test	η	Efficiency	V_{CE} = 12.5 V F = 470 MHz P_{out} = 2 W	60			%
RF Test	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 470 MHz P_{out} = 2 W		∞ : 1		
RF Test	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 470 MHz P_{in} = 0.2 W		1.96 + j 2.44		Ω
RF Test	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 470 MHz P_{out} = 2 W		15.2 + j 18.2		Ω
RF Test	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz		5	8	pF
Operating	I_C	Continous Collector Current				0.75	A
Operating	θ_{j-C}	Thermal Resistance	T_C = 25 °C			12	°C/W
Operating	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
Operating	P_D	Power Dissipation	T_C = 25 °C			14.5	W

Output Power vs Input Power and Voltage Supply

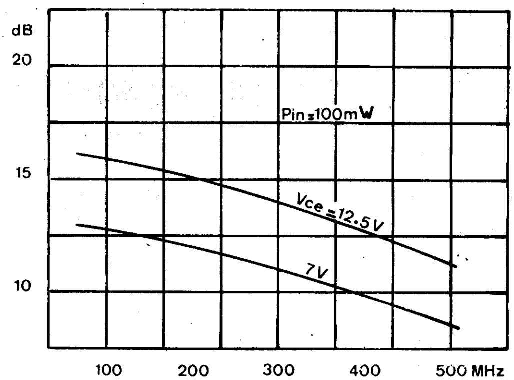




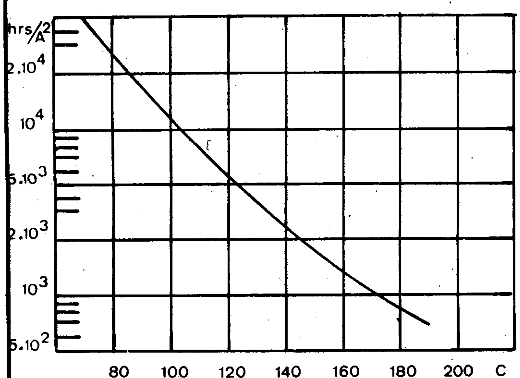
Output Power vs Input Power and Voltage Supply



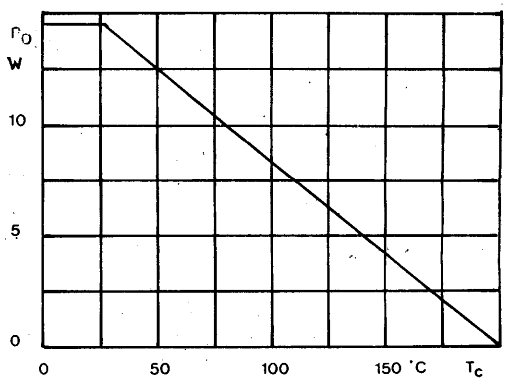
Power Gain vs Frequency and Voltage Supply



MTTF Factor vs Junction Temperature

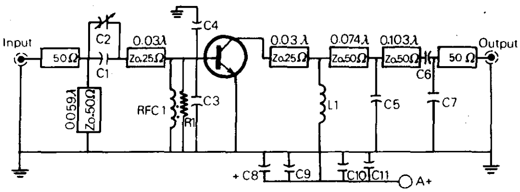


Power - Temperature Derating Curve



B

TEST CIRCUIT
BROADBAND (450-510 MHz)

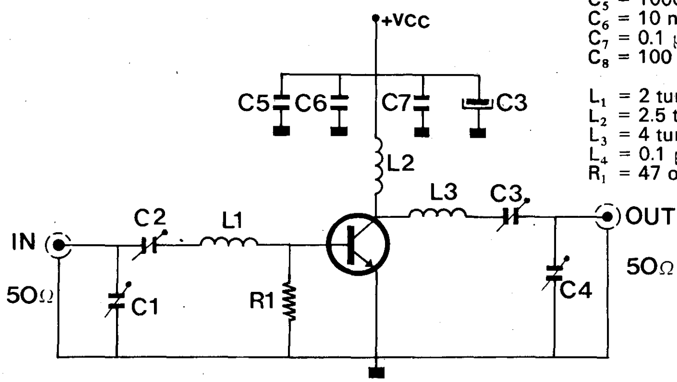


COMPONENT AND MATERIAL LIST

C_1	3.9 pF, ceramic chip
C_2, C_7	0.8-10 pF, Vol ronics AP 10, variable
C_3, C_4	27 pF, ceramic chip
C_5	15 pF, ceramic chip
C_6	470 pF, ceramic chip
C_8	5 μF, electrolytic
C_9	1000 pF, Underwood
C_{10}	0.1 μF, disc-ceramic
C_{11}	0.01 μF, disc-ceramic
L_1	2 turns # 22 enameled, 0.1" I.D.
R_1	270 Ω, ½ watt, carbon
RFC-1	2 ½ turns # 22 AWG on Ferroxcube VK211/17-4B

All transmission lines reference at 480 MHz

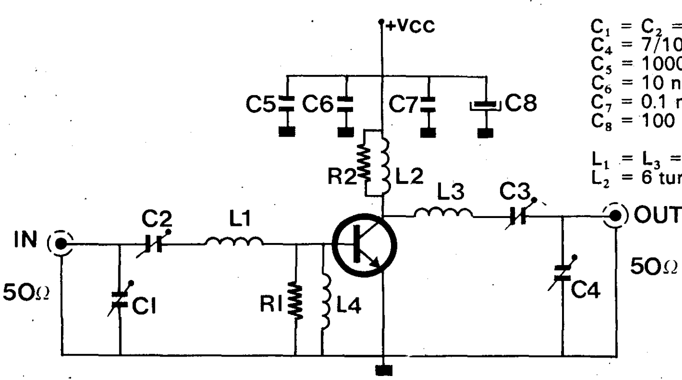
175 MHz TEST CIRCUIT



C_1 = 2-60 pF ARCO 404
C_2 = 24-200 pF ARCO 425
C_3 = 7-100 pF ARCO 425
C_4 = 4-40 pF ARCO 423
C_5 = 1000 pF UNELCO
C_6 = 10 nF ceramic disc
C_7 = 0.1 μF ceramic disc
C_8 = 100 μF/35 V electrolytic

L_1 = 2 turns - 8/10 mm wire - 4 mm I.D.
L_2 = 2.5 turns - 8/10 mm wire on ferrite core
L_3 = 4 turns - 8/10 mm wire - 4 mm I.D.
L_4 = 0.1 μH Molded Coil
R_1 = 47 ohms - 1/2 W carbon

88 MHz TEST CIRCUIT

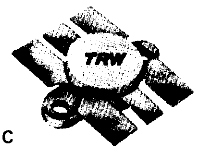


C_1 = C_2 = C_3 = 24/200 pF ARCO 425
C_4 = 7/100 pF ARCO 423
C_5 = 1000 pF UNELCO
C_6 = 10 nF ceramic disc
C_7 = 0.1 nF ceramic disc
C_8 = 100 μF/35 V electrolytic

L_1 = L_3 = 4 turns 14 AWG - 1/2" I.D.
L_2 = 6 turns - 14 AWG - 1/2" I.D. close wound

RF Power Transistor

- **80 W**
- **12.5 V**
- **88 MHz**



J zéro C

The TP 2180 is designed for use in 12.5 V VHF amplifiers operating under class A, B or C conditions.

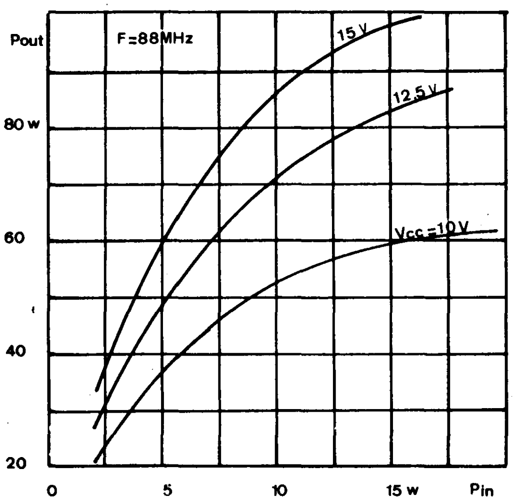
Its construction which incorporates gold metalization and diffused ballast resistors for longer life, enables the part to be used at its maximum ratings and be able to withstand an infinite VSWR at all phase angles.

Electrical Characteristics (T_{case} = 25 °C)

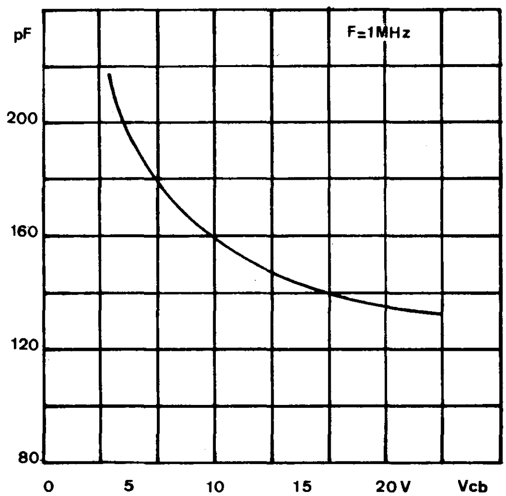
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 10 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 200 mA I_B = 0	18			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 100 mA I_E = 0	40			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 20 V I_E = 0			5	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1000 mA	10			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 88 MHz P_{in} = 16 W	80			W
	η	Efficiency	V_{CE} = 12.5 V F = 88 MHz P_{out} = 80 W	60	70		%
	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 88 MHz P_{out} = 80 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 88 MHz P_{in} = 16 W		0.3—j 0.4		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 88 MHz P_{out} = 80 W		0.6+j 0.44		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz			180	pF
Operating	I_C	Continous Collector Current				16	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			1.25	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			140	W

TYPICAL CHARACTERISTICS

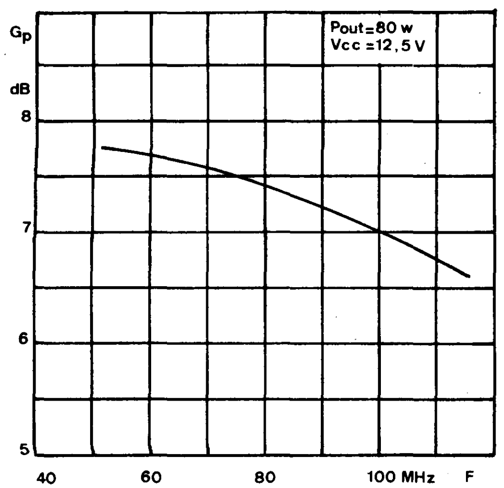
Output power vs input power and voltage supply



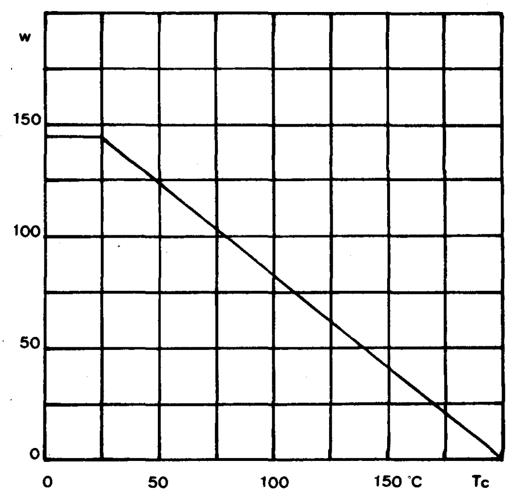
Collector base capacitance



Power gain vs frequency

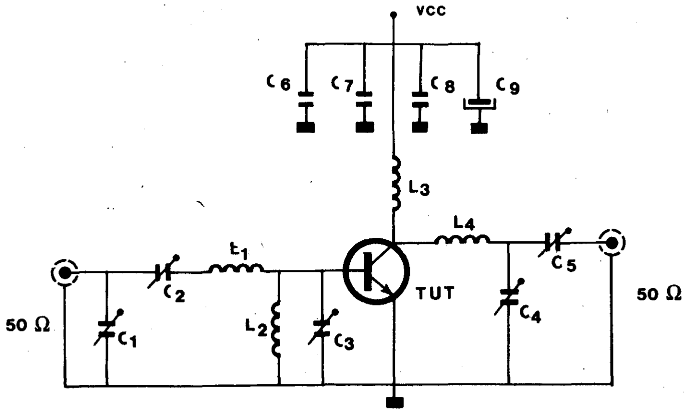


Power - Temperature operating curve



B

88 MHz TEST CIRCUIT

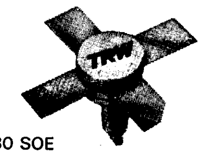


$C_1 = C_4$ = 24-200 pF trimmer capacitor ARCO 425
$C_2 = C_3$ = 55-300 pF trimmer capacitor ARCO 427
C_5 = 7-100 pF trimmer capacitor ARCO 423
C_6 = 1000 pF mica capacitor UNELCO
C_7 = 10 nF ceramic disc
C_8 = 0.1 μF ceramic disc
C_9 = 470 μF/40 V

L_1 = 3 turns - 12/10 mm silvered wire - 5 mm I.D.
L_2 = 0.68 μH molded coil
L_3 = 5 turns - 12/10 mm silvered wire - 12 mm I.D.
L_4 = 1 turn - 12/10 mm silvered wire - 6 mm I.D.

RF Power Transistor

- 40 W
- 12.5 V
- 175 MHz



380 SOE

B

The TP 2304 is designed for use in 12.5 V VHF amplifiers operating under class A, B or C conditions.

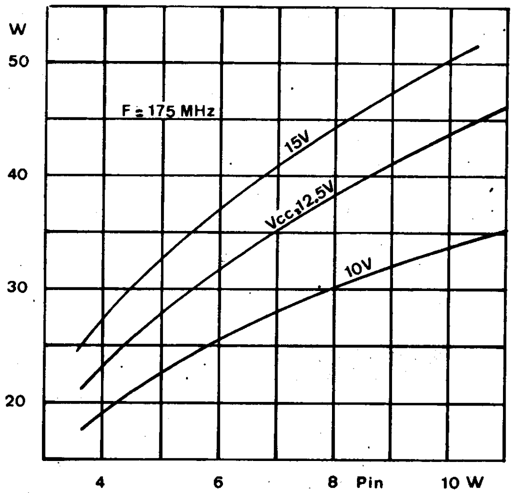
Its construction which incorporates gold metalization and diffused ballast resistors for longer life, enables the part to be used at its maximum ratings and be able to withstand an infinite VSWR at all phase angles.

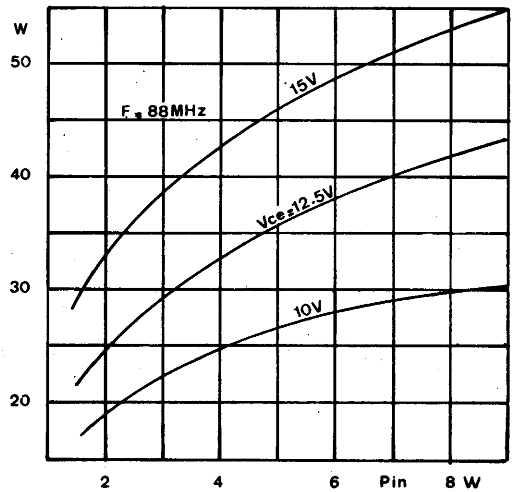
Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA I_C = 0	4			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	18			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA I_E = 0	40			V
DC Test	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			2	mA
DC Test	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1000 mA	10			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 175 MHz P_{in} = 12 W V_{CE} = 12.5 V F = 88 MHz P_{in} = 8 W	40 40			W
RF Test	η	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 40 W	60			%
RF Test	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 175 MHz P_{out} = 40 W		∞ : 1		
RF Test	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{in} = 10 W		1.5 + j 1.6		Ω
RF Test	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 40 W		2.25+j0.1		Ω
RF Test	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz		70	100	pF
Operating	I_C	Continous Collector Current				8	A
Operating	θ_{j-c}	Thermal Resistance	T_C = 25 °C			2.2	°C/W
Operating	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
Operating	P_D	Power Dissipation	T_C = 25 °C			80	W

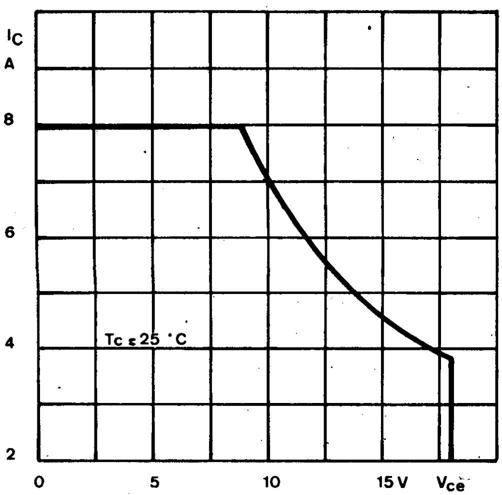
TYPICAL CHARACTERISTICS

Output Power vs Input Power and Voltage Supply

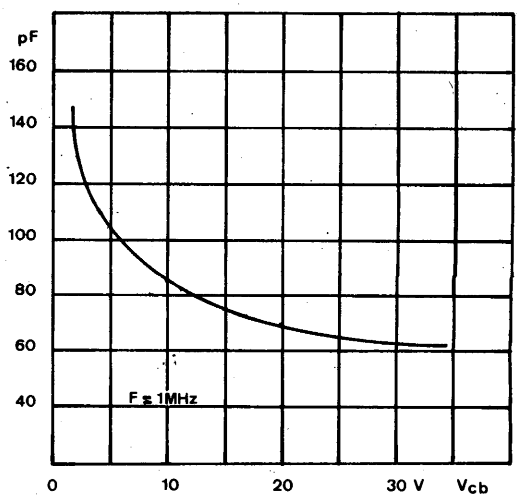




Safe Operating Area

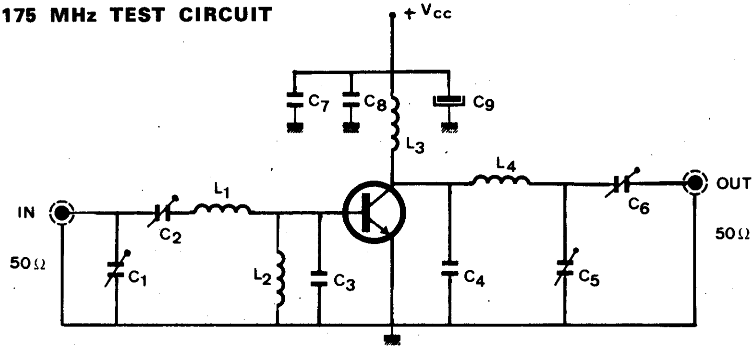


Collector Base Capacitance



B

175 MHz TEST CIRCUIT



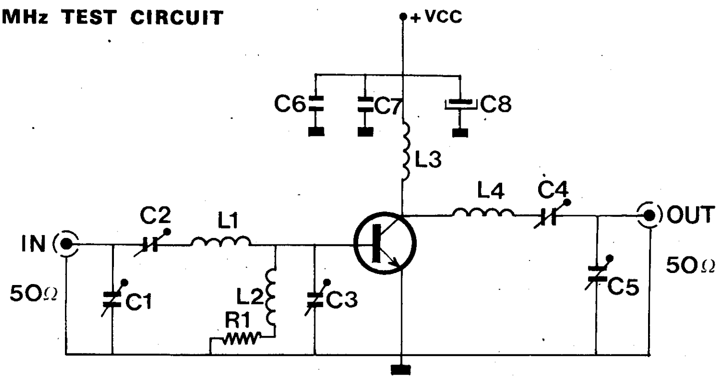
C_1 = ARCO 403 trimmer capacitor
C_2 = C_5 = ARCO 423 trimmer capacitor
C_3 = 200 pF mica capacitor UNELCO
C_4 = 150 pF mica capacitor UNELCO
C_6 = ARCO 425 trimmer capacitor
C_7 = 1000 pF mica capacitor UNELCO
C_8 = 0.1 μF ceramic disc
C_9 = 47 μF/63 V electrolytic

L_1 = 3 turns 15/10 mm silvered wire 6 mm I.D.
L_2 = 0.47 μH molded coil
L_3 = 6 turns 10/10 mm enameled wire wound on R_1

L_4 = 1 turns 15/10 mm silvered wire 6 mm I.D.

R_1 = 380 ohms 2 W carbon composition

88 MHz TEST CIRCUIT

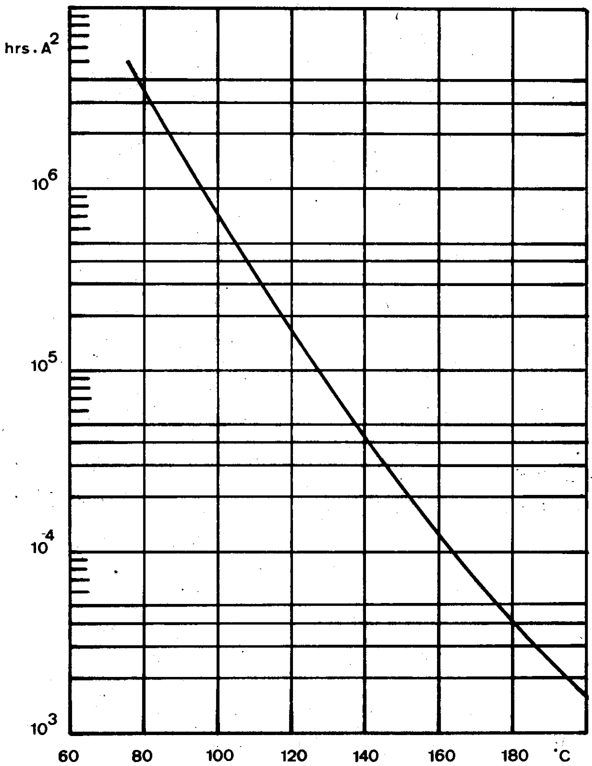


C_1 = C_4 = ARCO 425 24-200 pF trimmer capacitor
C_2 = ARCO 423 7-100 pF trimmer capacitor
C_3 = C_5 = ARCO 427 55-300 pF trimmer capacitor
C_6 = 1000 pF mica capacitor
C_7 = 10 nF ceramic
C_8 = 100 μF/35 V electrolytic

L_1 = 5 turns # 14 AWG 3/8" I.D.
L_2 = 1 μH
L_3 = 9 turns # 16 AWG 5/16" I.D.
L_4 = 4 turns # 14 AWG 3/8" I.D.

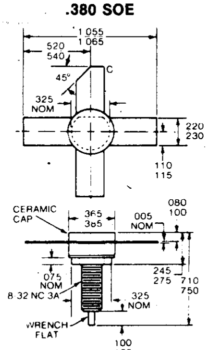
R_1 = 2.4 Ω

MTTF Factor vs Junction Temperature



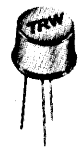
PACKAGE OUTLINE

.380 SOE



RF Power Transistor

- 3 W
- 12.5 V
- 175 MHz



TO 39 GE

B

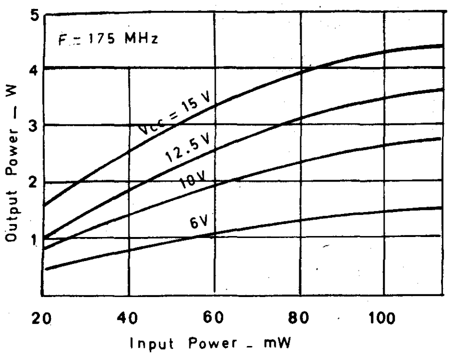
The TP 2312 is designed for 6 V to 12 V VHF applications and is intended for class A, B or C medium power amplifiers, frequency multipliers or oscillator circuits.

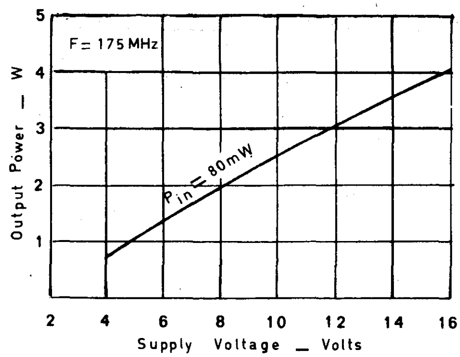
Its grounded emitter construction gives excellent thermal dissipation and the ability of providing further heatsinking where necessary the case also acts as a good RF screen.

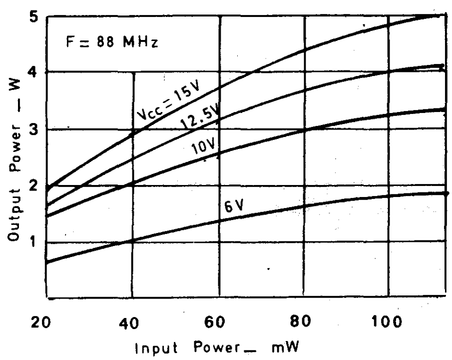
This device features high gain and an infinite VSWR rating at all phase angles at rated power output.

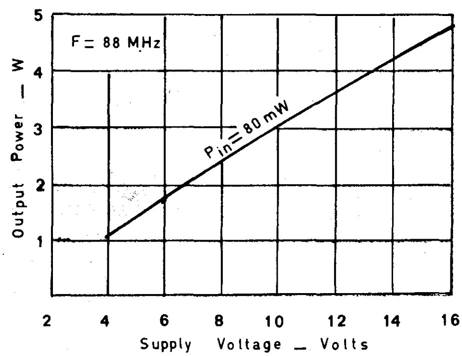
Electrical Characteristics (T_{case} = 25 °C)

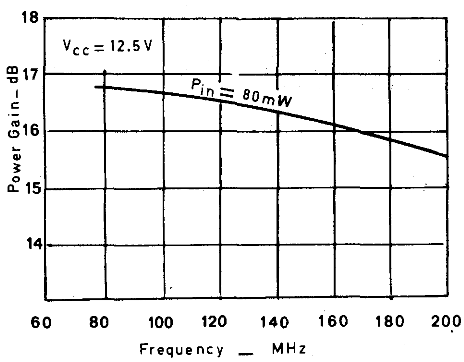
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 25 mA I_B = 0	16			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 5 mA I_E = 0	35			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 100 mA	20	70		—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 175 MHz P_{in} = 80 mW V_{CE} = 6 V F = 175 MHz P_{in} = 80 mW V_{CE} = 12.5 V F = 88 MHz P_{in} = 80 mW	2.75 1 3	3 1.3 3.5		W
	η	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 3 W	60	68		%
	Load VSWR	Mismatch Tolerance	All Phase Angles V_{CE} = 12.5 V F = 175 MHz P_{out} = 2.75 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{in} = 80 mW F = 88 MHz		2.9 + j 4.36 2.94 — j 7.67		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 3 W F = 88 MHz		25.1 + j 10.2 29 + j 18.4		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz		5.5	7	pF
Operating	I_C	Continous Collector Current				0.7	A
	θ_{j-c}	Thermal Resistance	T_C = 25 °C			25	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			7	W

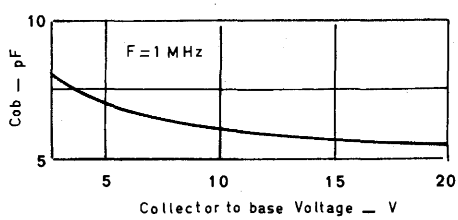


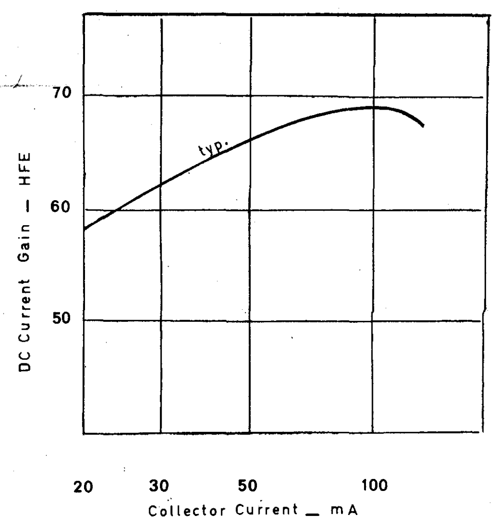






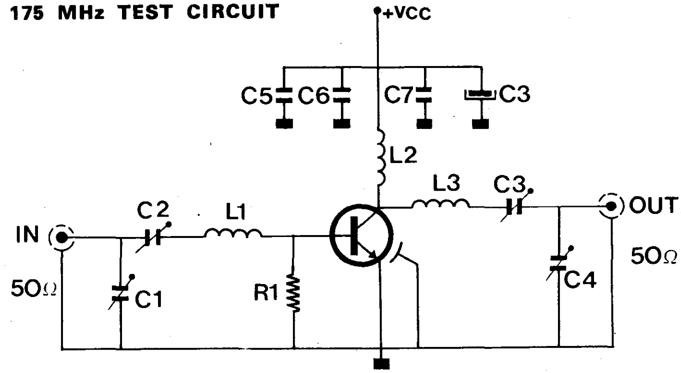






NOTA : TYPICAL CHARACTERISTICS

175 MHz TEST CIRCUIT



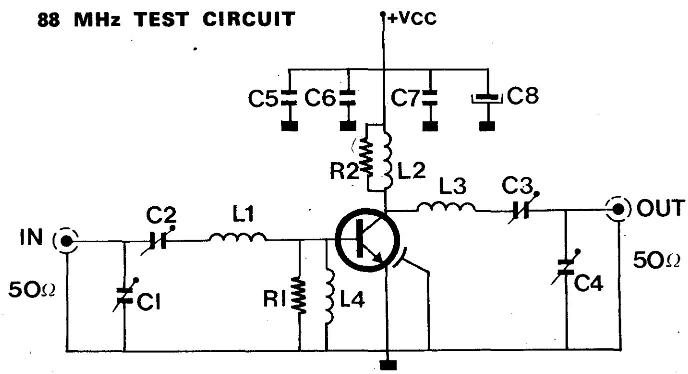
$C_1 = C_2 = C_3 = C_4$ = ARCO 404 7-60 pF trimmer capacitor
C_5 = 1000 pF mica capacitor
C_6 = 10 nF ceramic disc
C_7 = 0.1 μF ceramic disc
C_8 = 47 μF electrolytic

$L_1 = L_3$ = 2.5 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_2 = 3 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.

R_1 = 47 ohms - 1/2 W - carbon composition

NOTA : CASE MUST BE GROUNDED

88 MHz TEST CIRCUIT



$C_1 = C_2 = C_3 = C_4$ = ARCO 404 7-60 pF trimmer capacitor
C_5 = 1000 pF mica capacitor
C_6 = 10 nF ceramic disc
C_7 = 0.1 μF ceramic disc
C_8 = 47 μF electrolytic

$L_1 = L_3$ = 2.5 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_2 = 3 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_4 = 0.45 μH - molded coil
R_1 = 47 ohms - 1/2 W

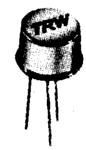
R_2 = 220 ohms - 1/2 W

NOTA : CASE MUST BE GROUNDED

TRW

RF Power Transistor

- 4 W
- 12.5 V
- 175 MHz



TO 39 GE

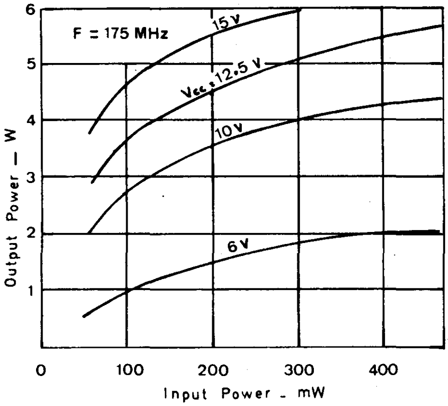
The TP 2314 is designed for 6 V to 12 V VHF applications and is intended for class A, B or C medium power amplifiers, frequency multipliers or oscillator circuits.

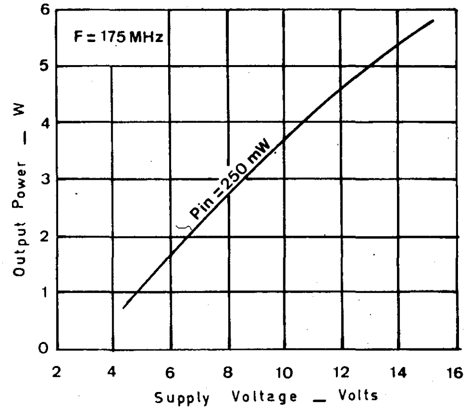
Its grounded emitter constructions gives excellent thermal dissipation and the ability of providing further heatsinking where necessary.

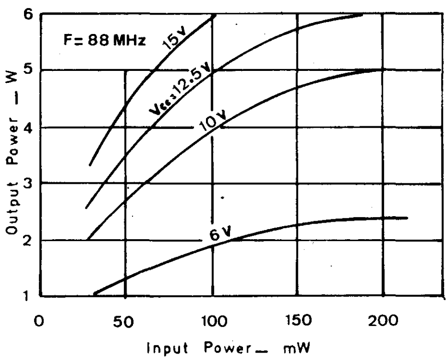
The case also acts as a good RF screen this device features high gain and an infinite VSWR rating at all phase angles at rated power output.

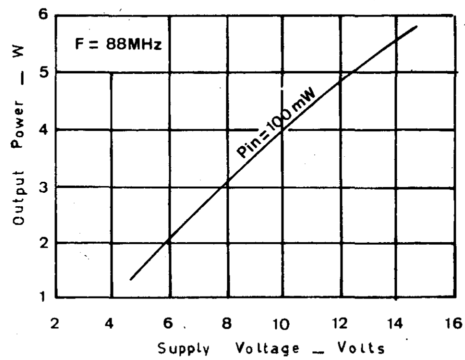
Electrical Characteristics (T_{case} = 25 °C)

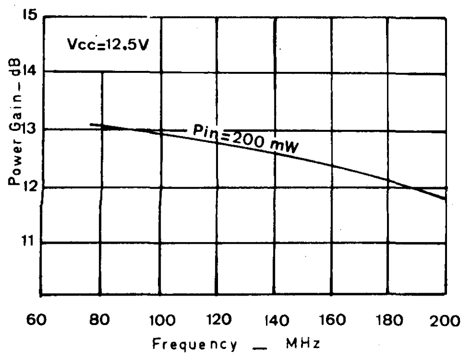
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdwon Voltage	I_E = 2 mA I_C = 0	4			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	16			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA I_E = 0	36			V
DC Test	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
DC Test	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 200 mA	20	40		—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 175 MHz P_{in} = 250 mW V_{CE} = 6 V F = 175 MHz P_{in} = 250 mW V_{CE} = 12.5 V F = 88 MHz P_{in} = 250 mW	4 1 4	4.8 1.6 4.8		W
RF Test	η	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 4 W	55	64		%
RF Test	Load VSWR	Mismatch Tolerance	All Phase Angles V_{CE} = 12.5 V F = 175 MHz P_{out} = 4 W		∞ : 1		
RF Test	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{in} = 250 mW F = 88 MHz		4.33 — j 3.69 4.5 — j 4.8		Ω
RF Test	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 4 W F = 88 MHz		15.96 + j 4.13 18.74 + j 6.44		Ω
RF Test	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz		12	15	pF
Operating	I_C	Continous Collector Current				1	A
Operating	θ_{j-C}	Thermal Resistance	T_C = 25 °C			20	°C/W
Operating	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
Operating	P_D	Power Dissipation	T_C = 25 °C			8	W

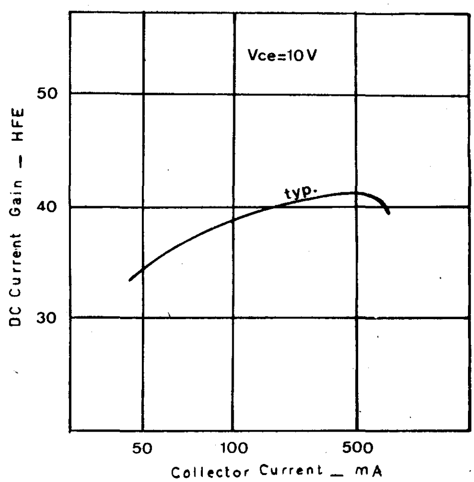


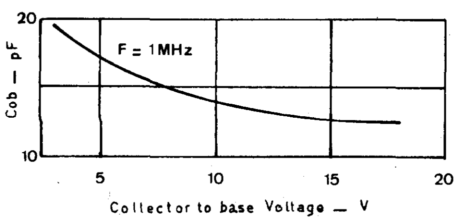








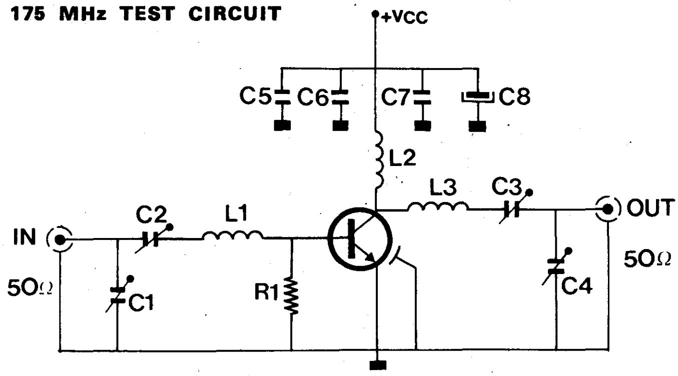




NOTA : TYPICAL CHARACTERISTICS

B

175 MHz TEST CIRCUIT



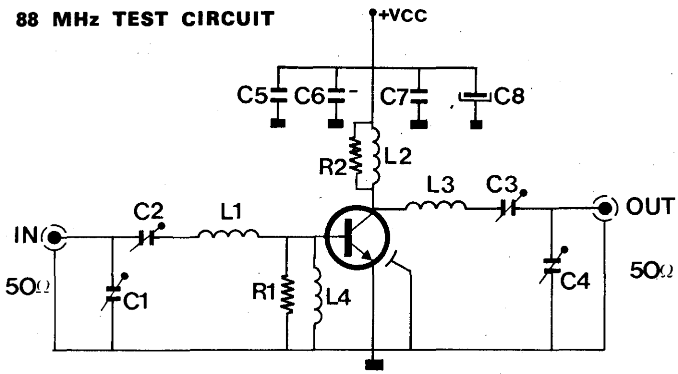
$C_1 = C_2 = C_3 = C_4$ = ARCO 404 7-60 pF trimmer capacitor
C_5 = 1000 pF mica capacitor
C_6 = 10 nF ceramic disc
C_7 = 0.1 μF ceramic disc
C_8 = 47 μF electrolytic

$L_1 = L_3$ = 2.5 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_2 = 3 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.

R_1 = 47 ohms - 1/2 W - carbon composition

NOTA : CASE MUST BE GROUNDED

88 MHz TEST CIRCUIT



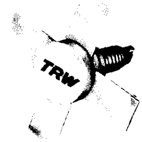
$C_1 = C_2 = C_3 = C_4$ = ARCO 404 7-60 pF trimmer capacitor
C_5 = 1000 pF mica capacitor
C_6 = 10 nF ceramic disc
C_7 = 0.1 μF ceramic disc
C_8 = 47 μF electrolytic
$L_1 = L_3$ = 2.5 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_2 = 3 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_4 = 0.47 μF - molded coil
R_1 = 47 ohms - 1/2 W
R_2 = 220 ohms - 1/2 W

NOTA : CASE MUST BE GROUNDED

TRW

RF Power Transistor

- 20 W
- 12.5 V
- 175 MHz



380 SOE

B

The TP 2320 is designed for use in 12.5 V VHF amplifiers operating under class A, B or C conditions.

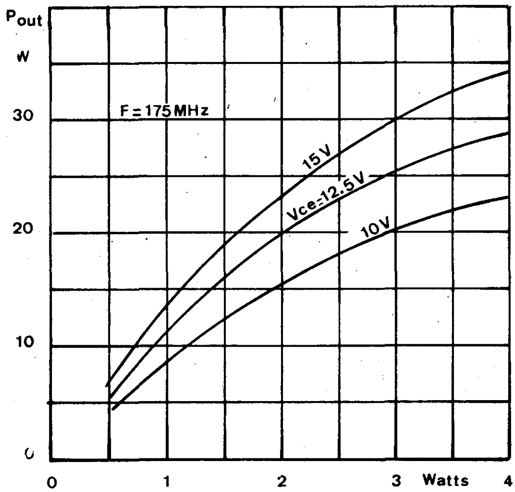
Its construction which incorporates gold metalization and diffused ballast resistors for longer life, enables the part to be used at its maximum ratings and be able to withstand an infinite VSWR at all phase angles.

Electrical Characteristics (T_{CASE} = 25 °C)

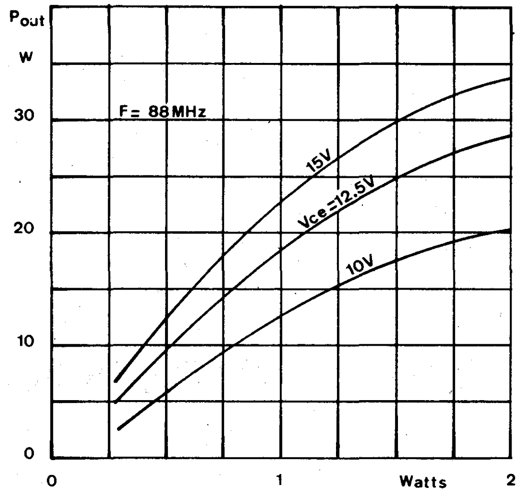
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA I_C = 0	4			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	18			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA I_E = 0	40			V
DC Test	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			2	mA
DC Test	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 500 mA	20			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 175 MHz P_{in} = 3 W V_{CE} = 12.5 V F = 88 MHz P_{in} = 1.5 W	17 17	20 20		W
RF Test	η	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 20 W	50			%
RF Test	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 175 MHz P_{out} = 17 W		∞ : 1		
RF Test	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{in} = 3 W		2 + j 1.5		Ω
RF Test	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 20 W		4.2 + j 0.7		Ω
RF Test	C_{OB}	Collector - Base Capacitance	V_{CE} = 20 V F = 1 MHz I_E = 0		55	70	pF
Operating	I_C	Continous Collector Current				6	A
Operating	θ_{j-C}	Thermal Resistance	T_C = 25 °C			3.5	°C/W
Operating	T_{STG}	Storage Temperature and Junction Temperature		— 65°		+200°	°C
Operating	P_D	Power Dissipation	T_C = 25 °C			50	W

TYPICAL CHARACTERISTICS

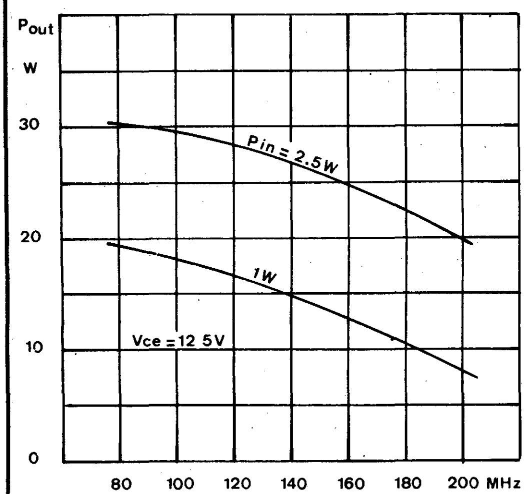
Output power vs input power and voltage supply



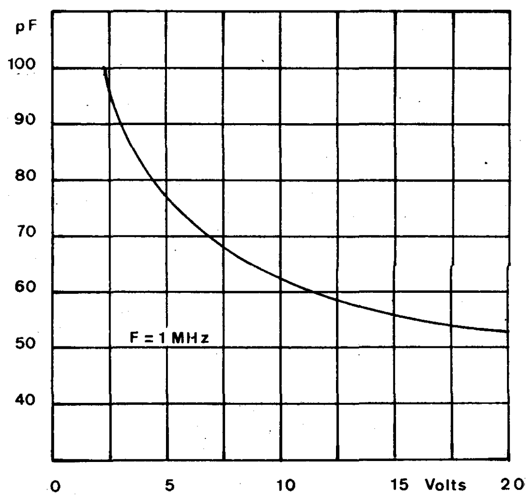
Output power vs input power and voltage supply



Output power vs frequency and input power

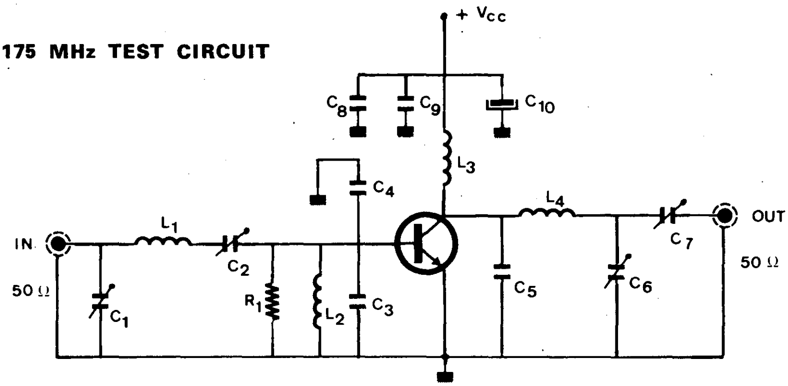


Coll. base capacitance



B

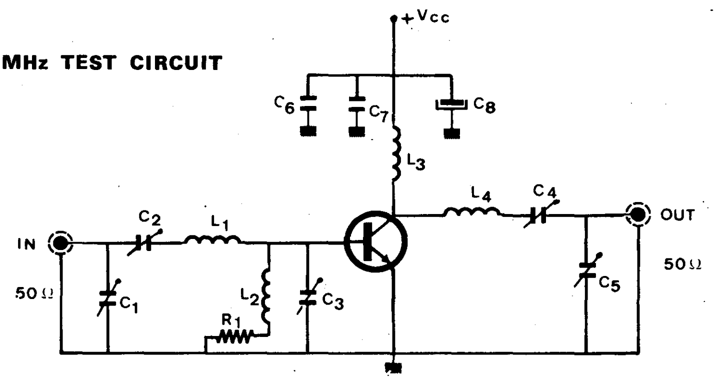
175 MHz TEST CIRCUIT



C_1 = ARCO 423 - 7-100 pF trimmer capacitor
C_2 = ARCO 423
C_3 = C_4 = 80 pF mica capacitor UNELCO
C_5 = 100 pF mica capacitor UNELCO
C_6 = C_7 = ARCO 423
C_8 = 1000 pF mica capacitor UNELCO
C_9 = 1000 pF ceramic disc
C_{10} = 47 μF electrolytic

L_1 = 3 turns 12/10 mm silvered wire - 6 mm I.D.
L_2 = 1 μH molded coil
L_3 = 3 turns 12/10 mm silvered wire - 6 mm I.D.
L_4 = 2 turns 12/10 mm silvered wire - 6 mm I.D.
R_1 = 150 ohms

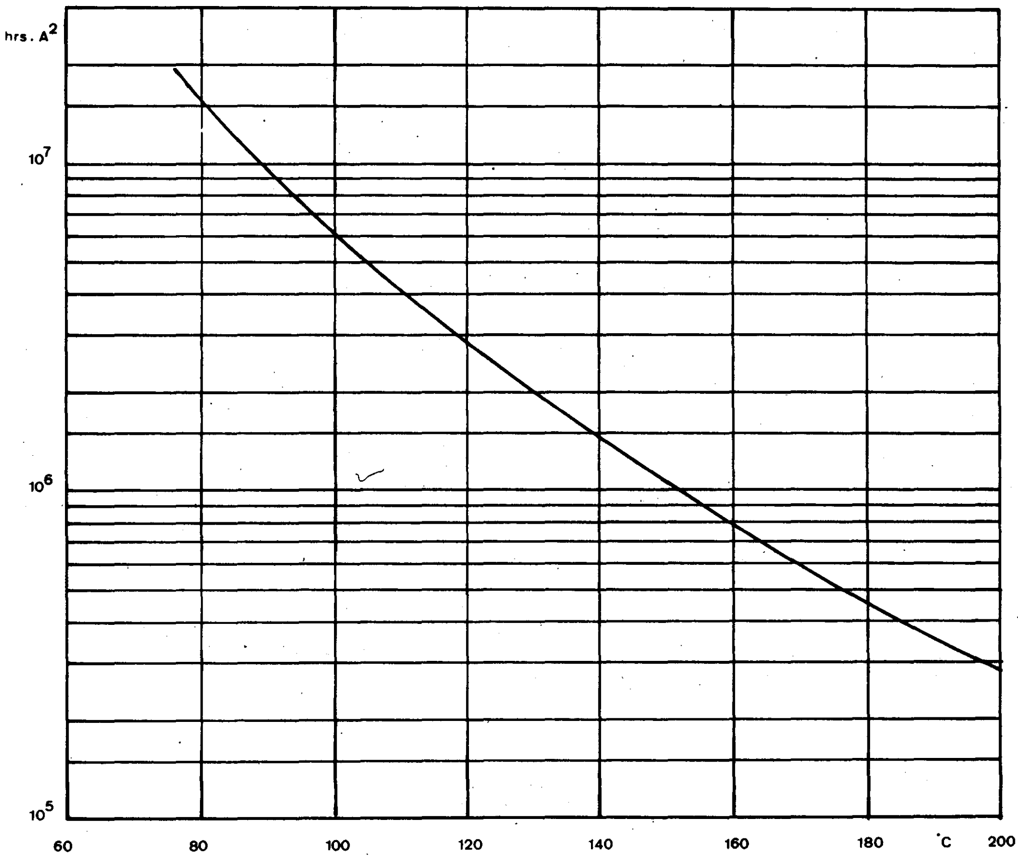
88 MHz TEST CIRCUIT



C_1 = C_4 = ARCO 425 24-200 pF trimmer capacitor
C_2 = ARCO 423 7-100 pF trimmer capacitor
C_3 = C_5 = ARCO 427 55-300 pF trimmer capacitor
C_6 = 1000 pF mica capacitor
C_7 = 10 nF ceramic
C_8 = 100 μF/35 V electrolytic

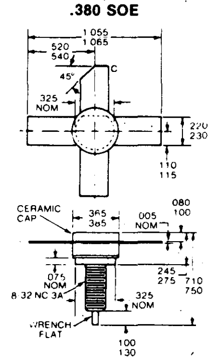
L_1 5 turns # 14 AWG 3/8" ID
L_2 1 μH
L_3 9 turns # 16 AWG 5/16" ID
L_4 4 turns # 14 AWG 3/8" ID
R_1 2.4 Ω

MTTF factor vs junction temperature



PACKAGE OUTLINE

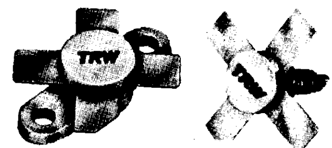
.380 SOE



TP 2330/F

RF Power Transistor

- **30 W**
- **12.5 V**
- **175 MHz**
- **10 dB**



380 SOE 380 SOEF

B

The TP 2330 is device intended for use in VHF transmitter output stages where a high gain is necessary.

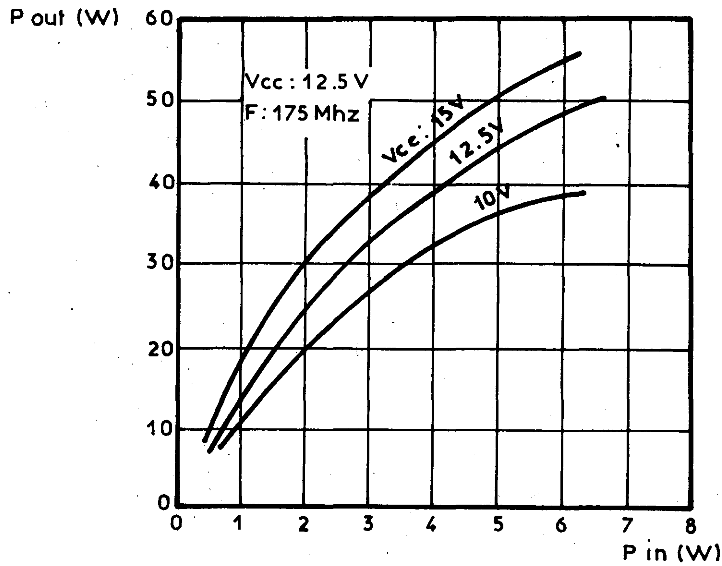
Using the latest in technology and manufacturing processes from TRW, excellent gain and high saturated output power has been achieved enabling a 30 W transmitter to be designed using only a TO 39 as driver.

Electrical Characteristics (T_{case} = 25 °C)

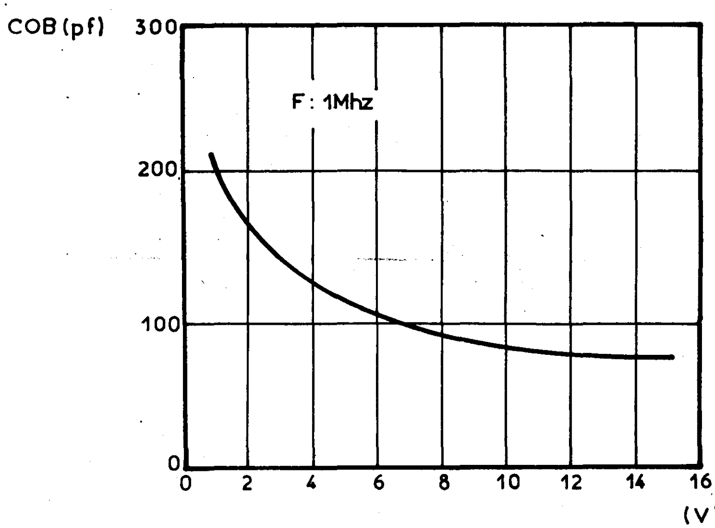
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA I_c = 0	4			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_c = 50 mA I_B = 0	16			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_c = 50 mA I_E = 0	36			V
DC Test	I_{CES}	Collector - Emitter Cutoff - Current	V_{CE} = 15 V			10	mA
DC Test	H_{FE}	DC Current Gain	V_{CE} = 5 V I_c = 1 A	20		150	
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V P_{in} = 3 W F = 175 MHz P_{in} = 3.8 W (F)	30 30			W
RF Test	η	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 30 W	60			%
RF Test	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 175 MHz P_{out} = 30 W		∞ : 1		
RF Test	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 30 W		1.05 + j 0.5		
RF Test	Z_{LOAD}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 30 W		2.7 + j 0.2		
RF Test	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz		70	100	pF
RF Test	I_c	Continuous Collector Current				8	A
Thermal	θ_{j-c}	Thermal Resistance	T_c = 25 °C			2.2	°C/W
Thermal	T_{STG}	Storage Temperature and Junction Temperature		— 65		+ 200	°C
Thermal	P_D	Power Dissipation	T_C = 25 °C			80	W

TYPICAL CHARACTERISTICS

TP 2330 Output Power vs Frequency

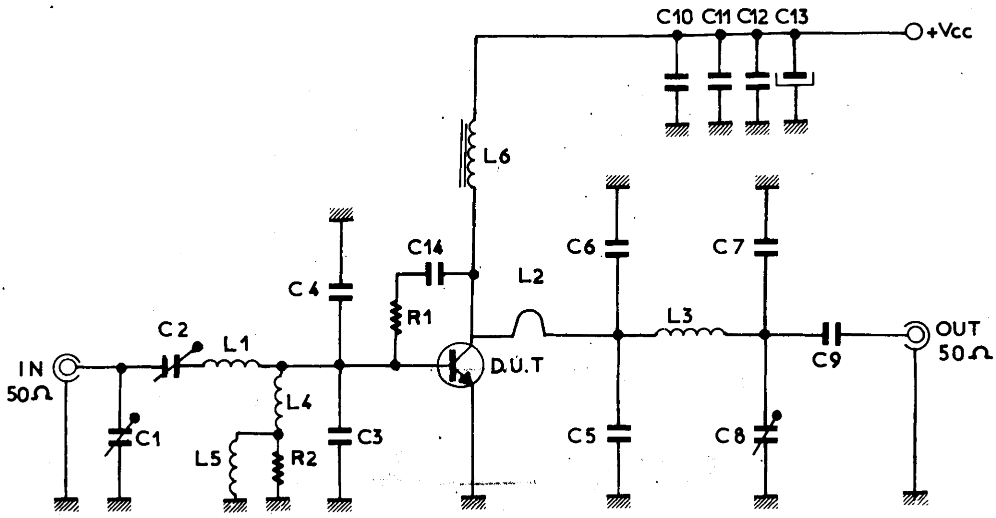


Collector base capacitance vs voltage



B

TP 2330 (F) 175 MHz test circuit



Components List

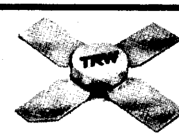
C_1 = C_2 = 100 pF ARCO 423 trimmer capacitor
C_3 = 200 pF UNELCO mica capacitor
C_4 = 150 pF UNELCO mica capacitor
C_5 = 120 pF UNELCO mica capacitor
C_6 = 100 pF UNELCO mica capacitor
C_7 = 25 pF UNELCO mica capacitor
C_8 = 40 pF ARCO 403 trimmer capacitor
C_9 = 1 000 pF ceramic disc capacitor
C_{10} = 1 000 pF UNELCO mica capacitor
C_{11} = C_{14} = 100 nF ceramic capacitor
C_{12} = 10 nF ceramic capacitor
C_{13} = 47 μF 25 V electrolytic capacitor

L_1 = 3 turns — 1 mm enameled wire. ID = 6 mm
L_2 = Copper lead 8 × 6 mm
L_3 = 1 .5 mm wire — 30 mm length
L_4 = 6 turns — 1 mm enameled wire. ID = 6 mm
L_5 = 10 uH molded coil
L_6 = 8 turns enameled wire wound on ferrite core 4C6 9 × 15 mm. ur = 120

R_1 = 100 Ω 1 W Carbon composition resistor.
R_2 = 10 Ω 1/2 W Carbon composition resistor

RF Power Transistor

- 5 W
- 12.5 V
- 470 MHz



280 SOE STUDLESS

The TP 2503 is designed for 12.5 V VHF and UHF amplifiers.

Its high gain at reduced voltage and stripline package make it suitable for use in pocketphone applications.

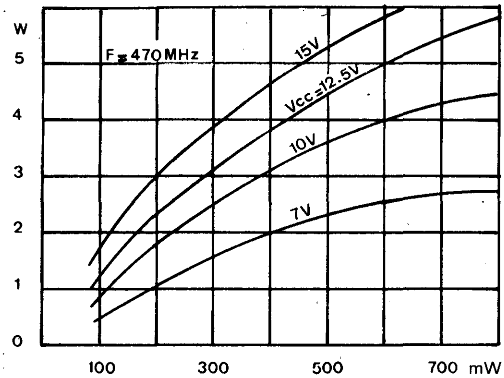
The power output is useable to the top of its ratings and it is able to withstand an infinite VSWR at all phase angles at rated output power.

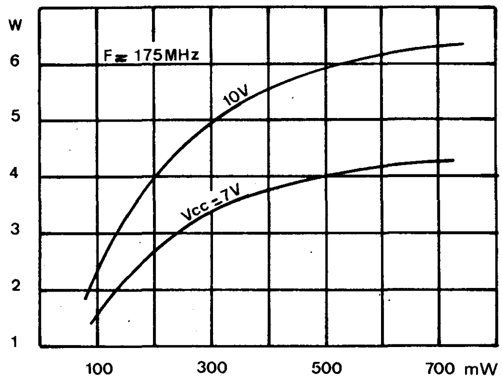
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 2 mA I_C = 0	4			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	16			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA I_E = 0	36			V
DC Test	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
DC Test	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 200 mA	20			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 470 MHz P_{in} = 0.7 W V_{CE} = 9.5 V F = 175 MHz P_{in} = 0.4 W V_{CE} = 9.5 V F = 88 MHz P_{in} = 0.2 W	5 5 5	5.5 5.5 6		W
RF Test	η	Efficiency	V_{CE} = 12.5 V F = 470 MHz P_{out} = 2 W	55			%
RF Test	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 470 MHz P_{out} = 5 W		∞ : 1		
RF Test	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 470 MHz P_{in} = 0.7 W		1.6 + j 3.5		Ω
RF Test	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 470 MHz P_{out} = 5 W		9.55 + j 5.75		Ω
RF Test	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz		13	17	pF
Operating	I_C	Continous Collector Current				1.7	A
Operating	θ_{j-c}	Thermal Resistance	T_C = 25 °C			10	°C/W
Operating	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
Operating	P_D	Power Dissipation	T_C = 25 °C			17.5	W

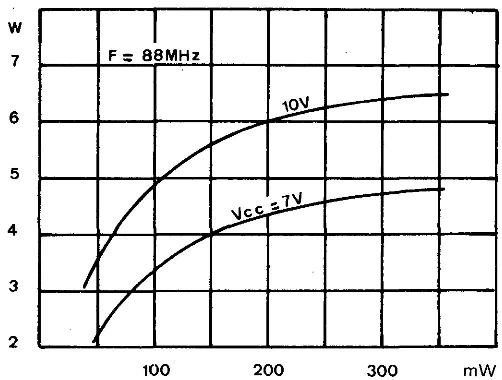
B

Output Power vs Input Power and Voltage Supply

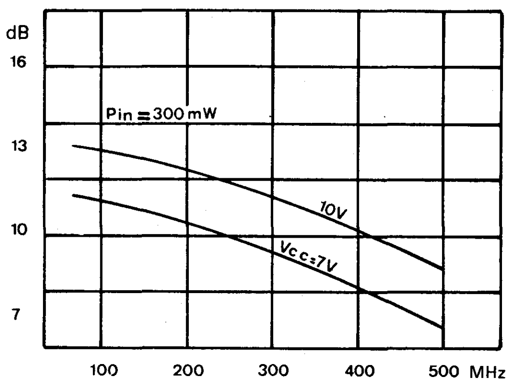




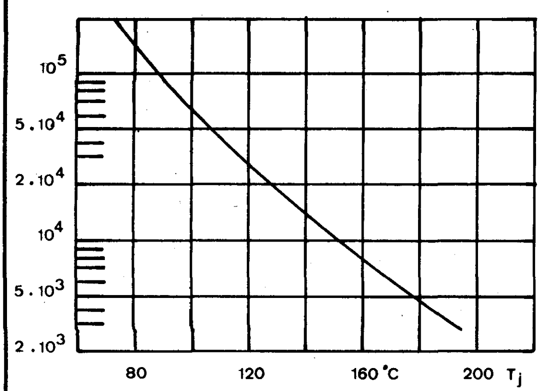
Output Power vs Input Power and Voltage Supply



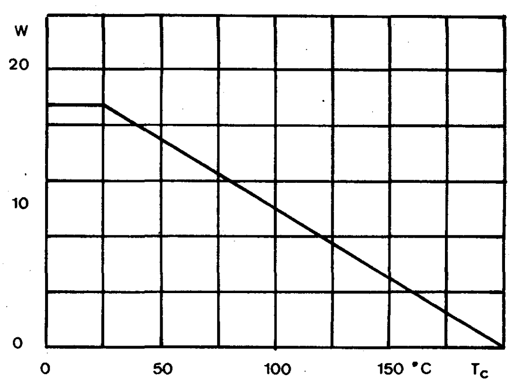
Power Gain vs Frequency and Voltage Supply



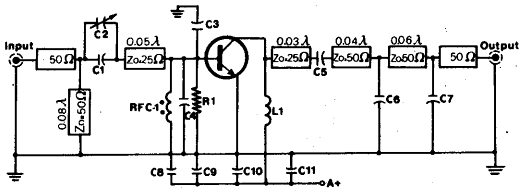
MTTF Factor vs Junction Temperature



Power - Temperature Operating Curve



TEST CIRCUIT
BROADBAND (450-510 MHz)

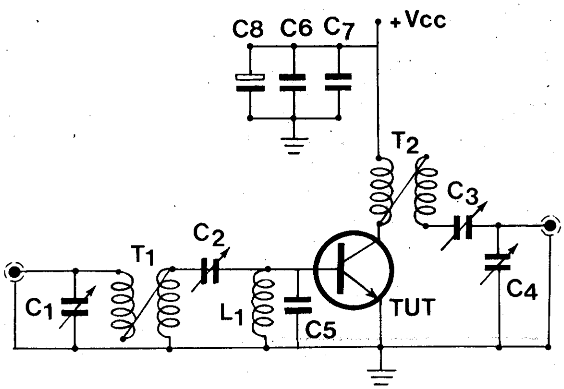


COMPONENT AND MATERIAL LIST

C_1	3,9 pF, ceramic chip
C_2	0.8-10 pF, Voltronics AP 10, variable
C_3, C_4	25 pF, ceramic chip
C_5	1500 pF, ceramic chip
C_6	10 pF, Underwood
C_7	5 pF, Underwood
C_8	0.01 μF, disc-ceramic
C_9	0.10 μF, disc-ceramic
C_{10}	1000 pF, Underwood
C_{11}	5 μF, electrolytic
L_1	4 turns, # 22 enameled, 0.1" I.D.
R_1	750 Ω, ½ watt, carbon
RFC-1	2½ turns # 22 AWG on Ferroxcube VK211/17-4B

All transmission lines reference at 480 MHz

175 MHz TEST CIRCUIT

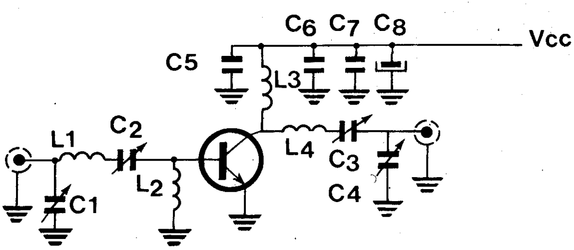


$C_1 = C_2 = C_4$ = 7-100 pF ARCO 423
C_3 = 24-200 pF ARCO 425
C_5 = 150 pF mica capacitor UNELCO
C_6 = 1000 pF mica capacitor UNELCO
C_7 = 10 nF ceramic disc
C_8 = 47 μF/63 V electrolytic

L_1 = 10 μH Molded Coil

$T_1 = T_2$ = Transmission Line Transformers 2 wires 8/10 mm twisted - 5 cm length

88 MHz TEST CIRCUIT

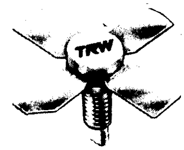


$C_1 = C_2 = C_3$ = 24-200 pF ARCO 425
C_4 = 7-100 pF ARCO 423
C_5 = 1000 pF mica capacitor UNELCO
C_6 = 10 nF ceramic disc
C_7 = 0.1 μF ceramic disc
C_8 = 100 μF/35 V electrolytic

$L_1 = L_4$ = 4 turns 14 AWG 1/2" I.D.
L_2 = 0.47 μH
L_3 = 6 turns 14 AWG 1/2" I.D. Close Wound

TP 3020

- **1.5 W**
- **24 V**
- **960 MHz**
- **9 dB Gain**
- **Class "A"**



280 SOE

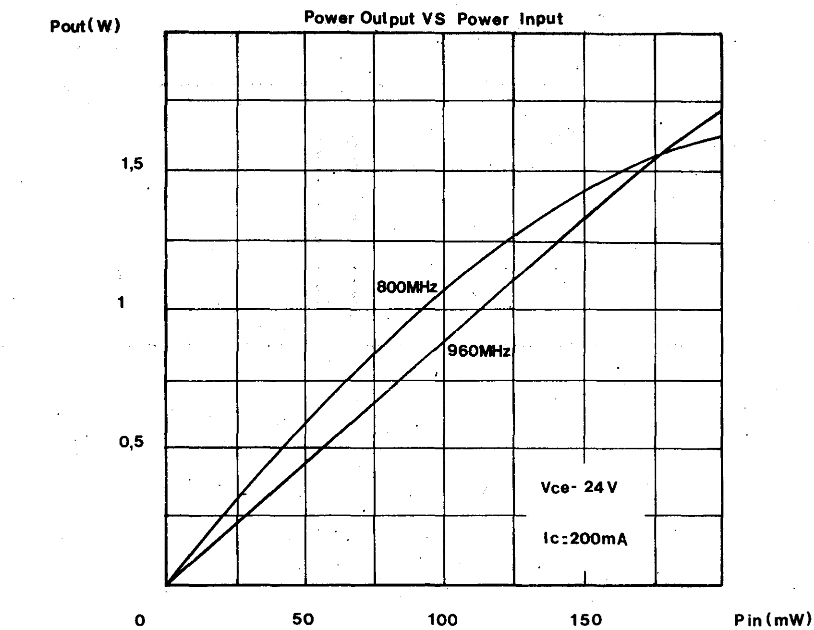
B

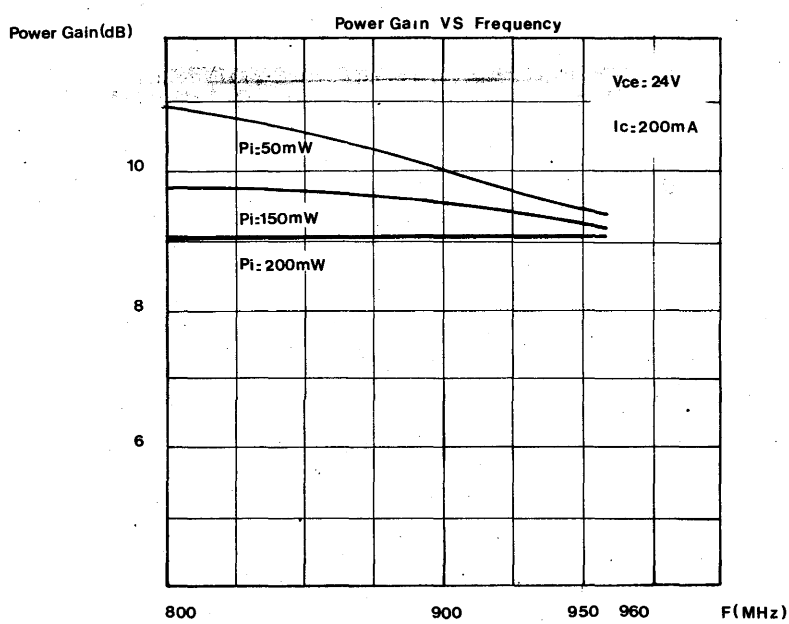
The TP 3020 is designed for use on the 900 MHz mobile band.

This device which is specified as a low power drive device, offering high gain, enables operation in class A, B or C circuits.

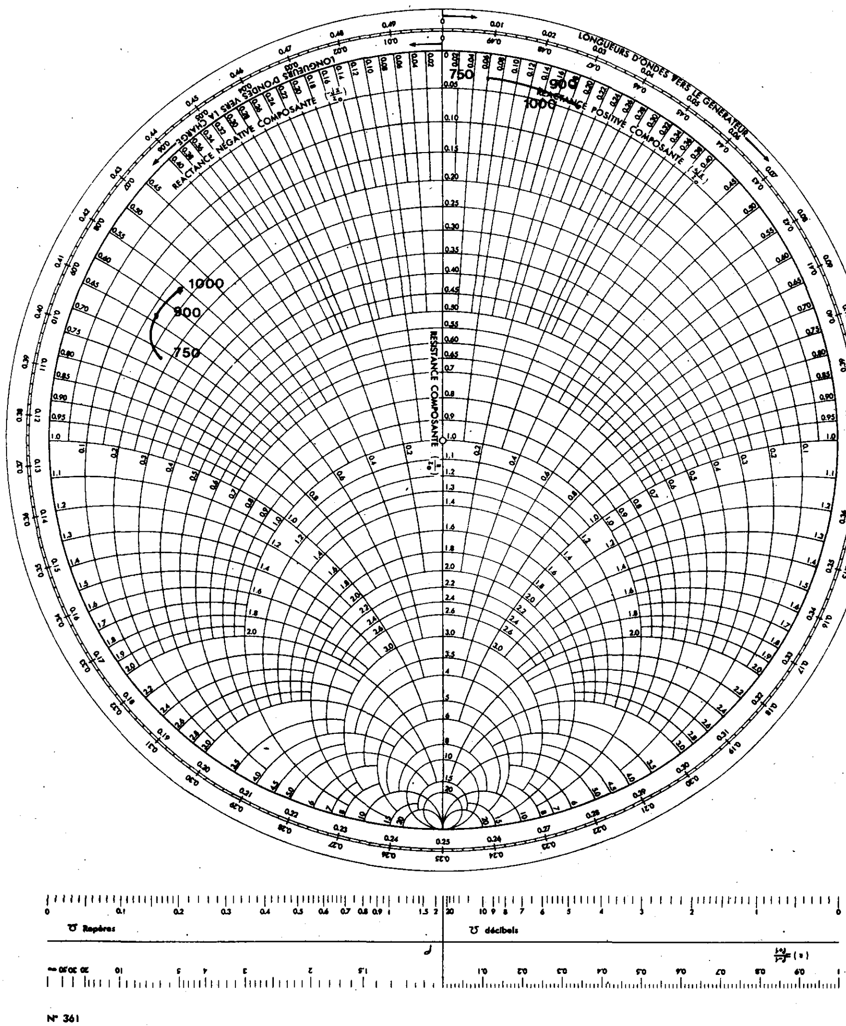
Electrical Characteristics (T_{case} = 25 °C)

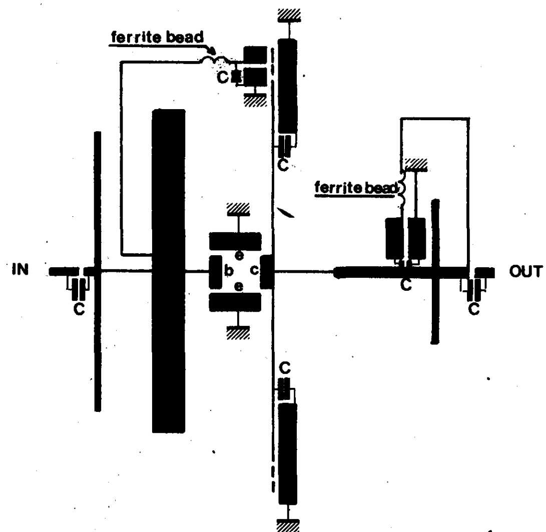
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Volt.	I_E = 0.25 mA	3.5			V
DC TEST	BV_{CER}		I_C = 20 mA, R_{BE} = 10	50			V
DC TEST	BV_{CBO}	Collector - Base Breakdown Volt.	I_C = 1 mA V_{CB} = 24 V	45		 0.5	V mA
DC TEST	I_{CBO} H_{FE}	Col. Base leakage DC fwd Cur. gain	V_{CE} = 5 V, I_C = 100 mA	20		120	—
RF TEST	P_{OUT}	Output Power	V_{CE} = 24 V, F = 960 MHz I_Q = 0.2 A, P_{IN} = 185 mW	1.5			W
RF TEST	C_{OB}	Collector base capacitance (Each side)	V_{CB} = 28 V, F = 1 MHz			5	pF
THERMAL	I_C θ_{JC} P_T T_{STG}/T_J		T case = 70 °C T Heatsink = 25 °C	 −65		0.7 20 8.75 +200	A °C/W W °C


Power Output VS Power Input
Pout(W)
1,5
1
0,5
0
50
100
150
Pin(mW)
800MHz
960MHz
Vce- 24V
Ic:200mA


Power Gain VS Frequency
Power Gain(dB)
10
8
6
800
900
950
960
F(MHz)
Vce: 24V
Ic:200mA
Pi:50mW
Pi:150mW
Pi: 200mW

IMPEDANCE DATA NORMALIZED TO 50 OHMS
V_{CE} = 24 V, I_C = 200 mA

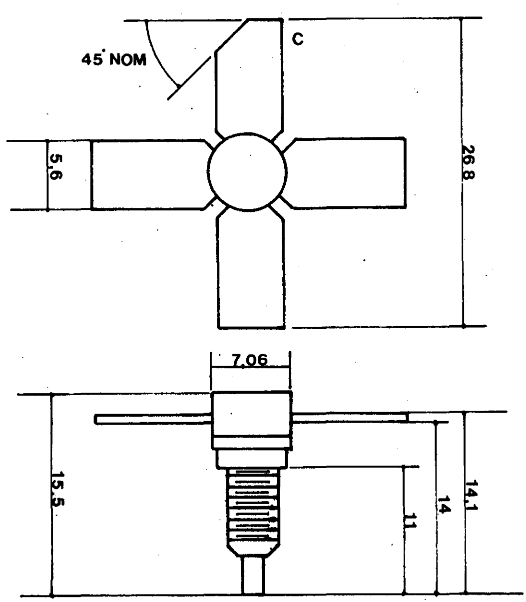




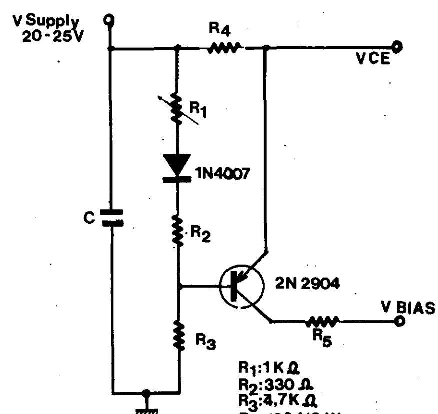
C : 100 Pf

Substrate : Epoxy Glass
20 m/m thick $\mathcal{E}$: 2,43

Foil wrap to ground plane



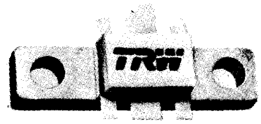
CLASS A BIAS CIRCUIT



R_1 : 1 KΩ
R_2 : 330 Ω
R_3 : 4,7 KΩ
R_4 10Ω 1/2 W
R_5 : 50 Ω
C : 100 F + 10 n F + 1nF

TP 3022

- 15 W
- 24 V
- 960 MHz
- 8 dB Gain
- Class "AB"



230 F

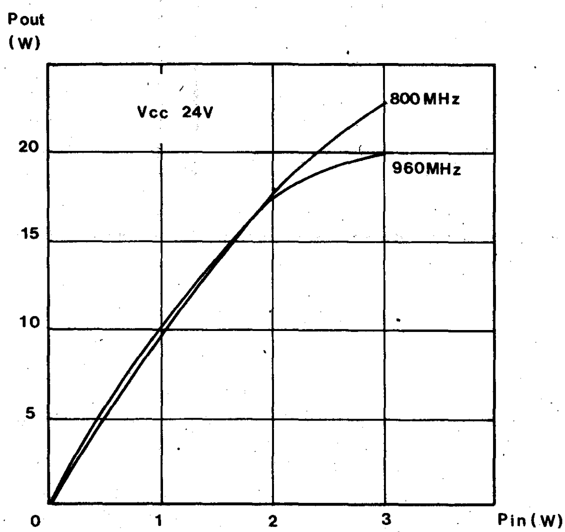
The TP 3022 is designed for operation in the 900 MHz mobile band and has been specifically conceived for use either as a medium power output device or driver for the TP 3024.

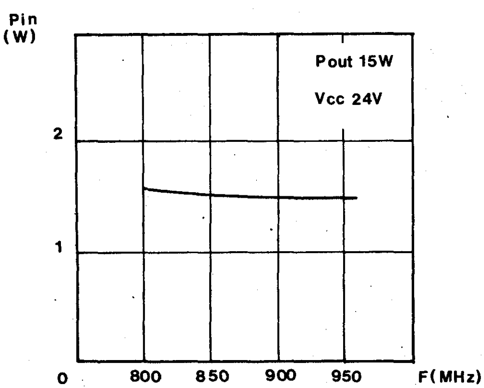
Using the latest in technology from TRW, this device offers a high degree of reliability and ruggedability.

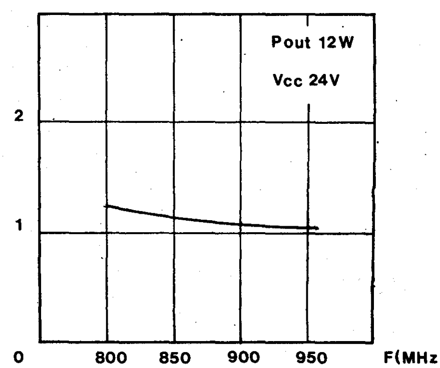
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Volt.	I_B = 5 mA	4			V
DC TEST	BV_{CEO}	Collector - Emit. Beakdown Volt.	I_E = 20 mA	25	28		V
DC TEST	BV_{CBO}	Collector - Base Breakdown Volt.	I_{CB} = 50 mA	48	50		V
DC TEST	I_{CBO}	Col. Base leakage	V_{CB} = 24 V			10	mA
DC TEST	H_{FE}	DC fwd Cur. gain	V_{CE} = 10 V, I_E = 100 mA	20		100	
RF TEST	P_{OUT}	Output power	V_{CE} = 24 V, F = 960 MHz P_{IN} = 2.38 W	15			W
RF TEST	η_C	Collector efficiency	V_{CE} = 24 V, F = 960 MHz P_{OUT} = 15 W		50 %		
RF TEST	C_{OB}	Collector - Base capacitance	V_{CB} = 24 V, F = 1 MHz		17	25	pF
THERMAL	R_{TH} J_C T_{STG}	Thermal resist. Junction-case Storage	T case = 70 °C measured under DC conditions hottest point.	 −65	6	 +200	°C/W

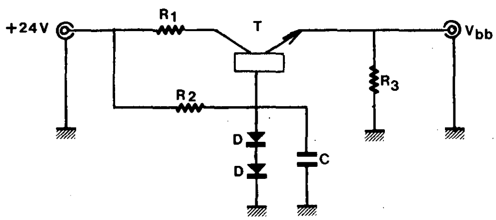
TYPICAL CHARACTERISTICS







CLASS AB BIAS CIRCUIT



COMPONENTS LIST

R_1 = 82 Ω (1 W)
R_2 = 5.6 K Ω (1/4 W)
R_3 = 150 Ω (1/4 W)

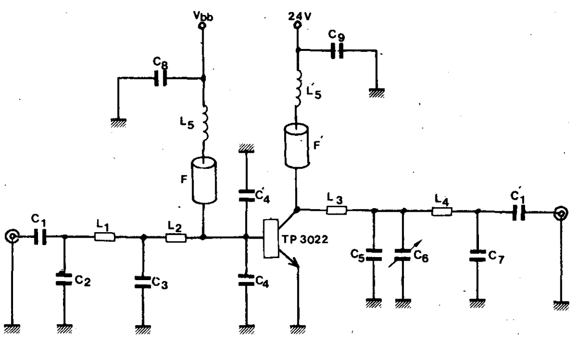
C = 1 nF

D = 1 N 4148 (or equivalent)

T = B D 135 (or equivalent)

CIRCUIT DIAGRAM

BROADBAND AMPLIFIER



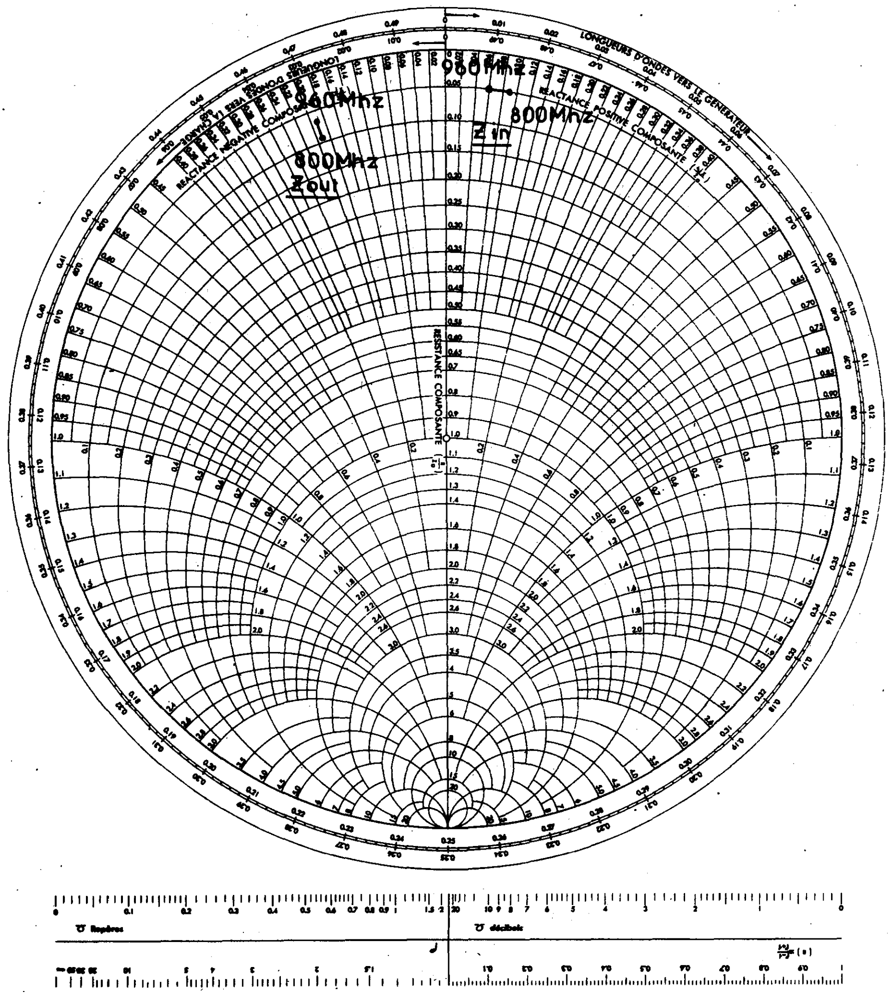
COMPONENTS LIST

L_1 = L_2 = 50 Ω line (1.45 mm wide), 13 mm long
L_3 = 50 Ω line (1.45 mm wide), 9 mm long
L_4 = 50 Ω line (1.45 mm wide), 17 mm long
L_5 = L'_5 = 2 turns - 10/10 mm enameled wire, 5 mm I.D.
F = F' = Ferrite bead
C_1 = C'_1 = 330 pF chip capacitor
C_2 = 3.3 pF chip capacitor
C_3 = 3.9 pF chip capacitor
C_4 = C'_4 = 15 pF chip capacitor
C_5 = 15 pF ATC chip capacitor
C_6 = O – 4 pF Johanson variable capacitor
C_7 = 6.8 pF ATC chip capacitor
C_8 = 330 pF + 1000 pF + 15nF
C_9 = 330 pF + 1000 pF + 15 nF + 10μF

Substrate material:

Teflon glass 1/50 inch. ϵ_r = 2.43

IMPEDANCES

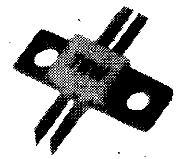


N° 361

TP 3024

TRW

- **30 W**
- **24 V**
- **960 MHz**
- **7.5 dB Gain**
- **Push Pull**



BMA-2

The TP 3024 is a balanced transistor designed specifically for used in cellular radio systems.

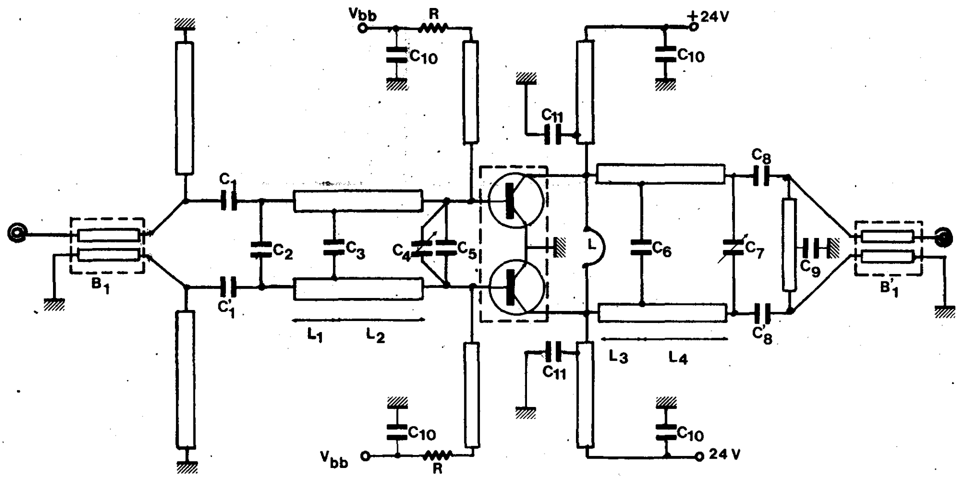
This device permits the design of a class AB push-pull, high gain, broadband amplifier having the high degree of linearity necessary in the latest systems, without the need for very complicated biasing circuitry.

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Each side. DC TEST	BV_{EBO}	Emitter - Base Breakdown Volt.	I_B = 5 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Volt.	I_E = 20 mA	25	28		V
	BV_{CBO}	Collector - Base Breakdown Volt.	I_{CB} = 50 mA	48	50		V
	I_{CBO}	Col. Base leakage	V_{CB} = 24 V			10	mA
	H_{FE}	DC fwd Cur. gain	V_{CE} = 10 V, I_E = 100 mA	20		100	
RF TEST	P_{OUT}	Output Power	V_{CE} = 24 V, F = 960 MHz P_{IN} = 5,3 W I_Q (TOT) ≃ 150 mA	30			W
	η_C	Collector efficiency	V_{CE} = 24 V, F = 960 MHz P_{OUT} = 30 W		50 %		
	C_{OB}	Collector base capacitance (Each side)	V_{CB} = 24 V F = 1 MHz		17	25	pF
THERMAL	R_{TH} JC	Thermal Resistance Junction-Case	T_{CASE} = 70° Measured under DC conditions hottest point		3		°C/W
	T_{STG}	Storage		−65		+200	

B

BROADBAND PUSH-PULL AMPLIFIER

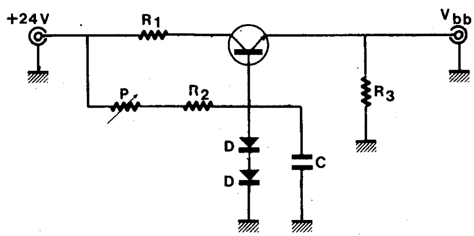


COMPONENTS LIST

C_1 = C'_1 = 15 pF ATC chip capacitor
C_2 = 2.2 pF ATC chip capacitor
C_3 = 4.7 pF ATC chip capacitor
C_4 = C_7 = 0 – 4 pF Johanson variable capacitor
C_5 = 12 pF ATC chip capacitor
C_6 = 5.6 pF ATC chip capacitor
C_8 = C'_8 = 27 pF ATC chip capacitor
C_9 = 12 pF ATC chip capacitor
C_{10} = 0.1 μF chip capacitor
C_{11} = 330 pF chip capacitor
B_1 = B'_1 = 50 Ω Balun stripline
L = 3 nH line on one side coated printed circuit.
l_1 = l_3 = 5 mm
l_2 = l_4 = 10 mm

Material: teflon glass 1/50 inch. ϵ_r = 2.43

CLASS AB BIAS CIRCUIT

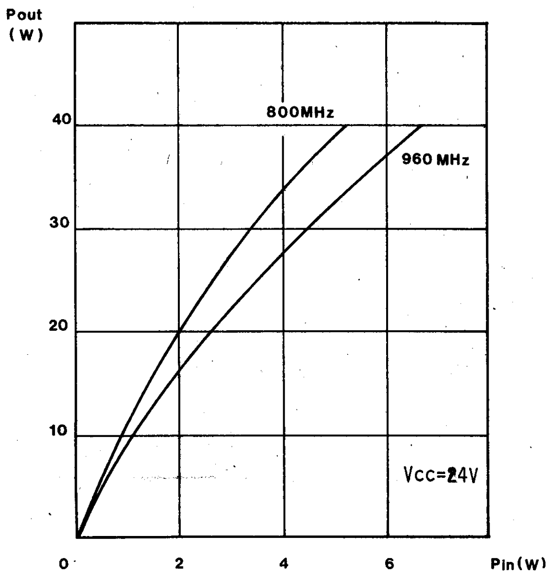


COMPONENTS LIST

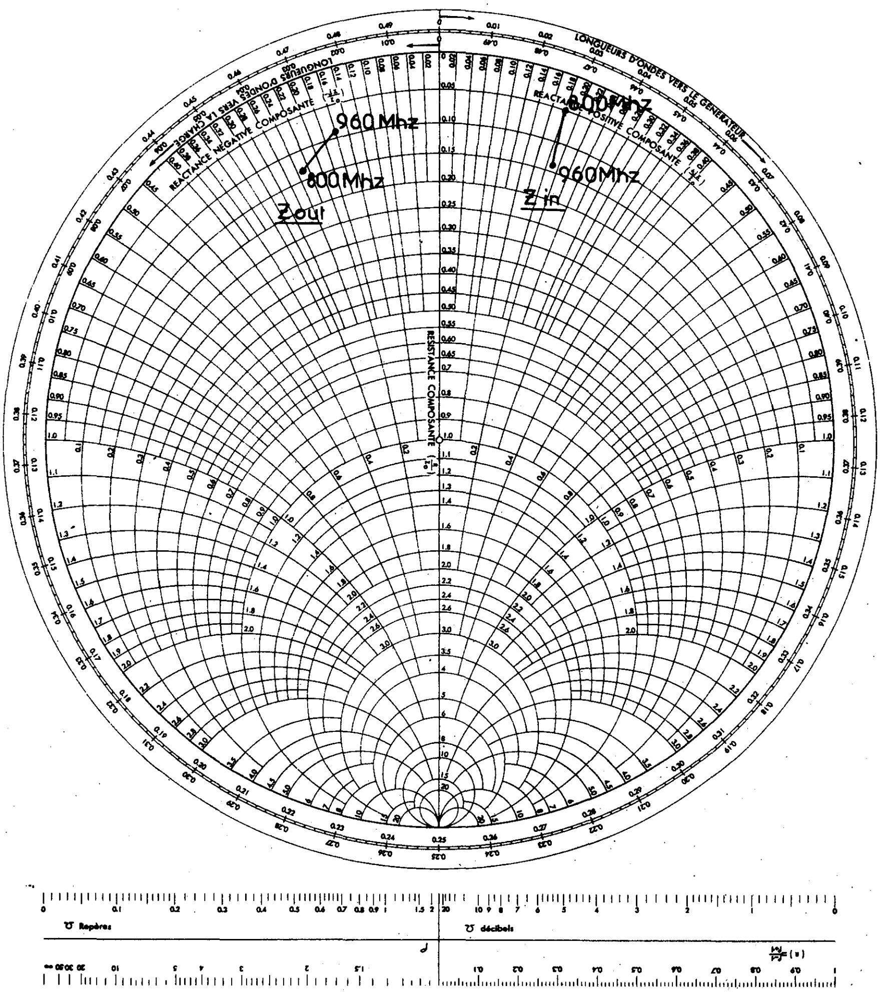
R_1 = 100 Ω (3 W)
R_2 = 5. KΩ (1/4 W)
R_3 = 75 Ω (1/4 W)

P = 1 KΩ
C = 1 nF
D = 1 N 4148 (or equivalent)
T = BD 135 (or equivalent)

TYPICAL TRANSFER CHARACTERISTICS



IMPEDANCES



N° 361

MILITARY COMMUNICATIONS HF/VHF/UHF

C

PRODUCT SUMMARY

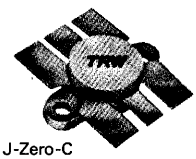
PART NUMBER	APPLICATION	FREQUENCY	POWER OR GAIN (dB)	SUPPLY VOLTAGE (V)	PACKAGE	PAGE
JO 2015A	MILITARY	400 MHz	70 W	28	J-ZERO	C2
JO 2058	MILITARY	450 MHz	100 Pulse	28	HLP 12	C6
PT 9700	MILITARY	400 MHz	1.5 W	28	SOE 280	C10
PT 9701B	MILITARY	400 MHz	5 W	28	SOE 280	C12
PT 9702B	MILITARY	400 MHz	20 W	28	SOE 280	C14
PT 9703B	MILITARY	400 MHz	10 W	28	SOE 280	C13
PT 9704A/B	MILITARY	400 MHz	30 W	28	SOE 280	C15
PT 9730	MILITARY	175 MHz	4 W	28	SOE 380	C19
PT 9731	MILITARY	175 MHz	25 W	28	SOE 380	C23
PT 9732	MILITARY	175 MHz	8 W	28	SOE 380	C21
PT 9733	MILITARY	175 MHz	50 W	28	SOE 380	C24
PT 9734	MILITARY	175 MHz	15 W	28	SOE 380	C22
TP 9386	MILITARY	175 MHz	150 W	28	J-ZERO	C27
TPM 401	MILITARY	400 MHz	1 W	20	SOE 280	C31
TPM 405	MILITARY	400 MHz	5 W	24	SOE 280	C35
TPM 425	MILITARY	400 MHz	25 W	24	SOE 280	C39
TPM 4040	MILITARY	400 MHz	40 W	28	MRP 7	C41
TPM 4130	MILITARY	400 MHz	130 W	28	MRP 7	C45

JO 2015 A

TRW

UHF Power Transistor

- 70 W
- 28 V
- 225-400 MHz
- ∞VSWR
- Broadband



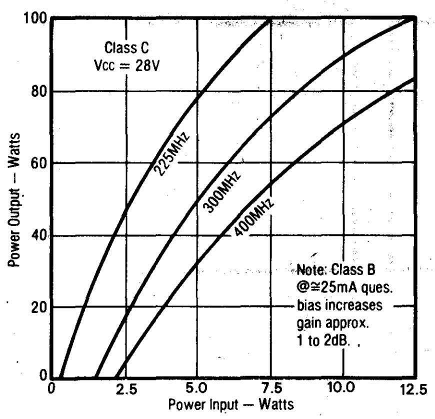
J-Zero-C

The JO 2015 A is an internally matched NPN silicon UHF power transistor. Its multicell design allows optimum heat dissipation and operating efficiency. A slotted-grid finger structure assures uniform current injection. Ruggedability and long-term reliability is guaranteed by unique, diffused silicon ballasting resistors coupled with TRW's refractory-gold-passivated metalization system.

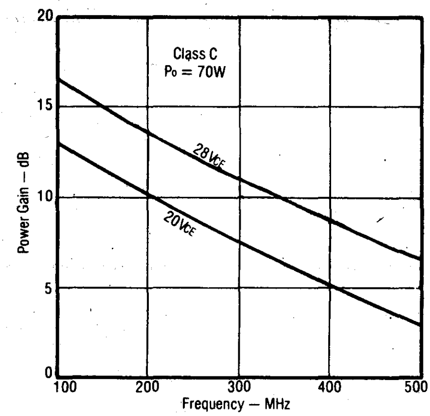
Electrical Characteristics (25 °C)

	Symbol	Characteristics	Condition	Value
D C Tests	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100 mA	65 Vdc Min
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 5.0 mA	3.5 Vdc Min
	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 50 mA	30 Vdc Min
	VSWR	Mismatch Tolerance	V_{CE} = 28 V, f = 400 MHz, P_o = 50 W	(All Angles) 10:1
	C_{ob}	Collector-Base Capacitance	V_{CB} = 28 V, f = 1 MHz	80 pF Max
	h_{FE}	DC Current Gain	V_{CE} = 10 V, I_C = 1 A	10-100
R F Tests	P_{gain}	Power Gain, CW Broadband	V_{CE} = 28 V, P_o = 50 W f = 225-400 MHz	10 dB Min
	P_{sat}	Saturated Power Output	V_{CE} = 28 V, f = 400 MHz	70 W Min
	η	Narrowband Collector Efficiency	V_{CE} = 28, f = 400 MHz, P_o = 50 W	55 % Min
Operating	T_{stg}	Max Storage Temperature		− 65 °C to + 200 °C
	θ_{jC}	Thermal Resistance	25 °C	1.25 °C/W
	I_C	Continuous Collector Current	V_{CE} = 10 V	10 A Max

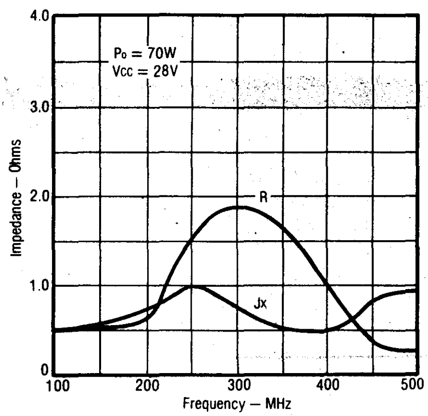
Power Output vs Power Input



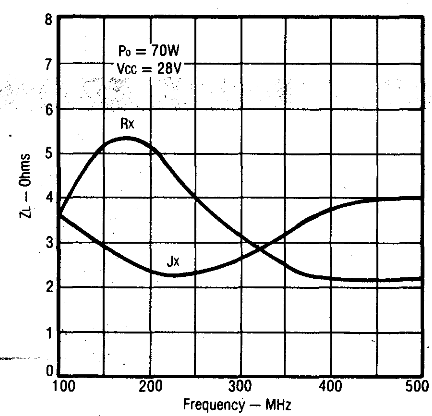
Power Gain vs Frequency



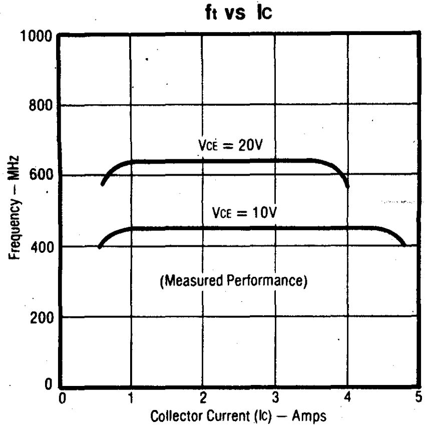
Series Input Impedance vs Frequency



Series Load Impedance vs Frequency



ft vs Ic



Safe Operating Area

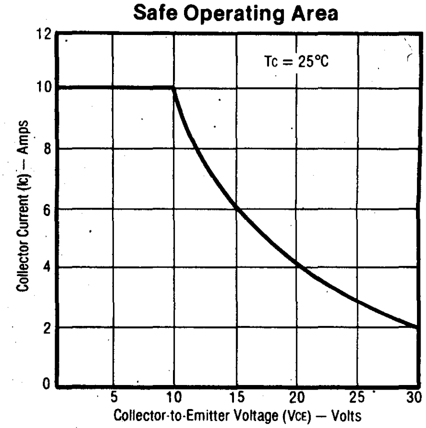
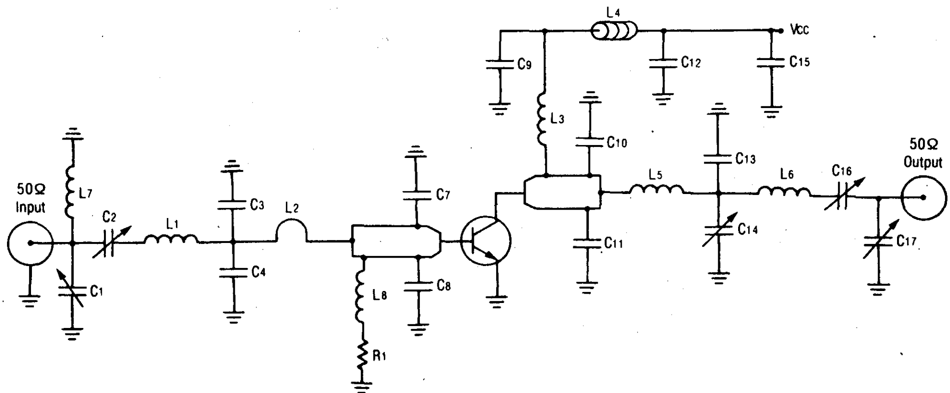


Figure 1. Narrowband Test Circuit



$C_{1,2,14,17}$	1.5-20pF ARCO #402	L_1	2 turns #22AWG, 0.1" form
$C_{3,4}$	10pF UNELCO	L_2	0.2" hairpin, 0.1" wide ribbon
$C_{7,8}$	60pF UNELCO	L_3	#22AWG, 1" diameter
$C_{10,11}$	40pF UNELCO	L_4	3 Ferrite beads on #22AWG
C_{13}	15pF UNELCO	L_5	#22AWG, 0.25" hairpin
$C_{9,12}$	1000pF UNELCO	L_6	1 turn #22AWG, 0.1" form
C_{15}	5μF electrolytic	L_7	6 turns #22AWG, 0.1" form
C_{16}	8-60pF ARCO #404	L_8	8 turns #22AWG, 0.1" form

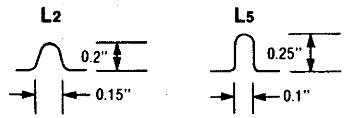
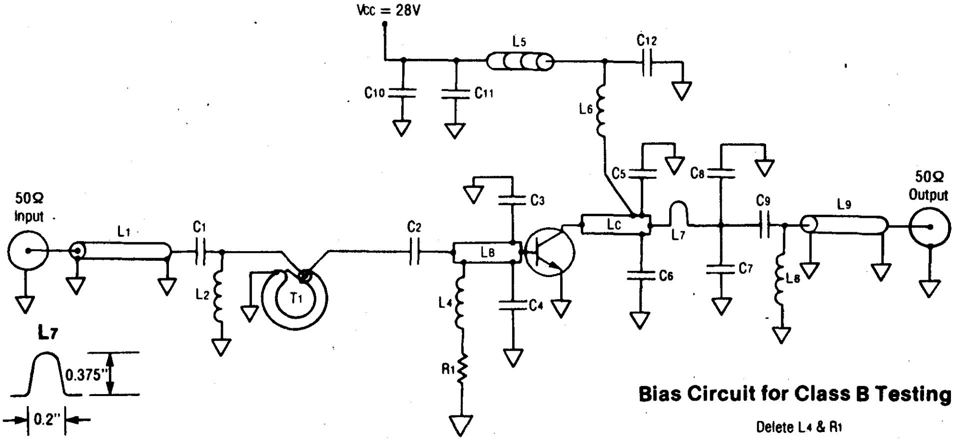


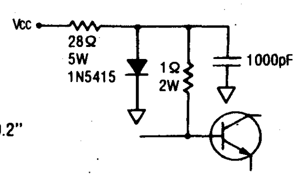
Figure 2. 70 Watt Broadband Test Circuit (225-400MHz)



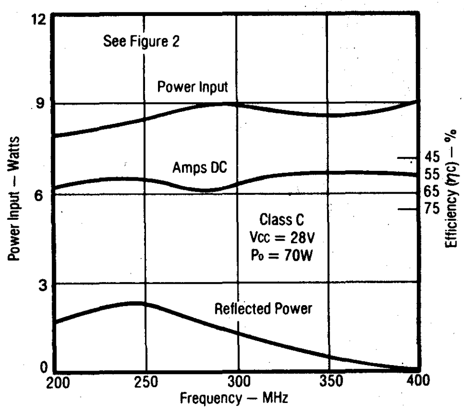
C_1	20pF JFD	$L_{2,4}$	4 turns #20AWG, 0.125" form
C_2	68pF JFD	L_5	3 Ferrite beads
$C_{3,4}$	60pF UNELCO	L_6	#20AWG, 1" diameter
$C_{5,6}$	40pF UNELCO	L_7	3/8" hairpin
$C_{7,9}$	15pF UNELCO	L_8	3 turns #20AWG, 0.125" form
C_8	10pF UNELCO	L_B	Base Inductance Pad, 0.5" x 0.2"
C_{10}	5μF electrolytic	L_C	Collector Inductance Pad, 0.5" x 0.2"
$C_{11,12}$	1000pF UNELCO	R_1	0.5Ω, 1W
$L_{1,9}$	50Ω semirigid (length to suit circuit)	T_1	1", 25Ω semirigid coax

Bias Circuit for Class B Testing

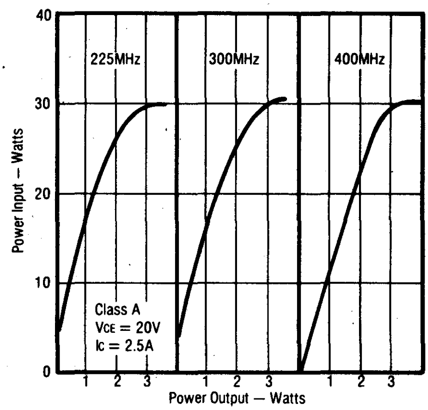
Delete L_4 & R_1



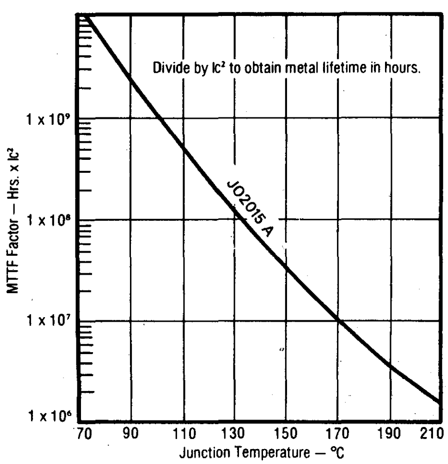
70W Broadband Performance



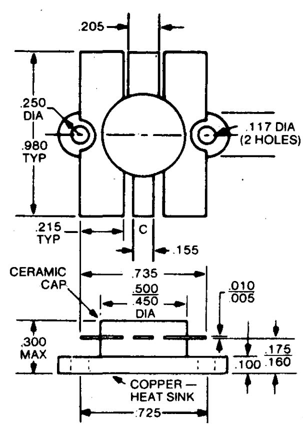
Typical Class A Linear Transfer Characteristics



MTTF Factor vs Tj



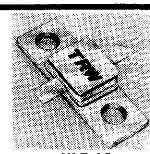
J-Zero-C Package Outline



TRW

High Power UHF Pulse Transistor

- 100 W (Pulse)
- 75 W (CW)
- Low θ_{JC}
- 0.88 °C/W



HLP-12

C

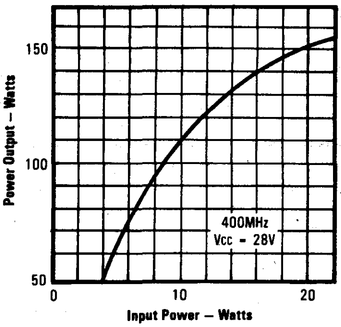
The JO 2058 Transistor is intended for use in military UHF CW and Pulse RF transmitters. The combination of all-gold metallization with state-of-the-art die technology and an inorganic hermetic seal enables reliable operation in hostile environments. Common base mode operation utilizes the multi-octave bandwidth capability of this device.

Electrical Characteristics (T_{case} = 25°C)

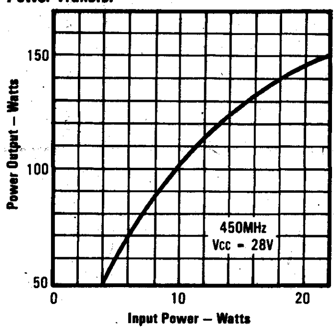
	Symbol	Characteristics	Test Conditions	Min.	Typ.	Max.	Unit
DC TEST	BV_{EBO}	Emitter Base Voltage	I_E = 5mA	3.5			Volts
	BV_{CEO}	Collector Emitter Voltage	I_C = 50mA	30			Volts
	BV_{CES}	Collector Emitter Voltage	I_C = 50mA	60			Volts
	I_{CES}	Collector Emitter Leakage	V_{CE} = 50V			5	mA
RF TEST	P_{OUT}	Power Output (Pulse)	V_{CC} = 28V, f = 450MHz, P_{IN} = 16W, 1msec. 10% Duty Cycle	100			Watts
	η	Efficiency (Pulse)	V_{CC} = 28V, f = 450MHz, P_{OUT} = 100W, 1msec, 10% Duty Cycle	60			%
	$VSWR_L$	Collector Load	V_{CC} = 28V, f = 450HMz, P_{OUT} = 100W, 1msec. 10% Duty Cycle Phase angle varied > 360° during 3-second test.	3:1			–
MAX. RATINGS	θ_{JC}	Thermal Resistance	25°C Flange			0.88	°C/W
	T_J	Junction Temperature				200	°C
	T_{STG}	Storage Temperature		-65		200	°C
	I_C	Collector Current	25°C Flange			14	A
	P_D	Total Dissipation	25°C Flange			200	W

Typical Pulse Characteristics
(1 millisecond pulse-width, 10% duty cycle)

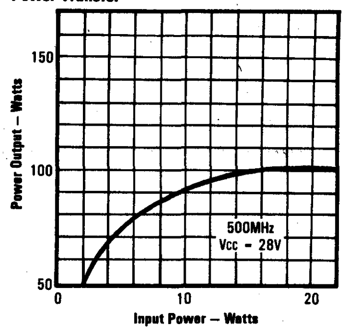
Power Transfer



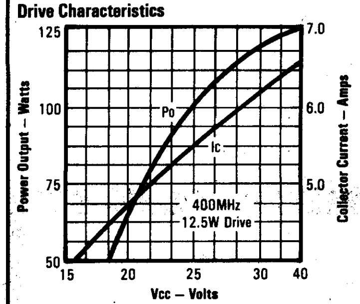
Power Transfer



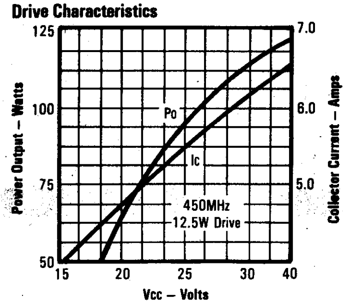
Power Transfer



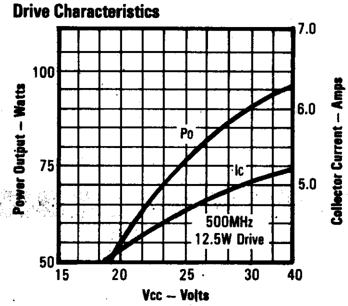
Drive Characteristics



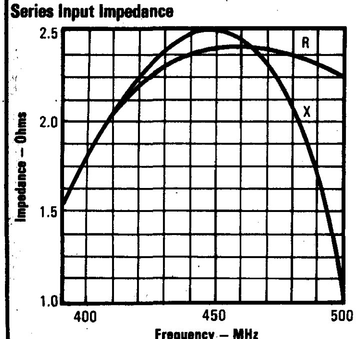
Drive Characteristics



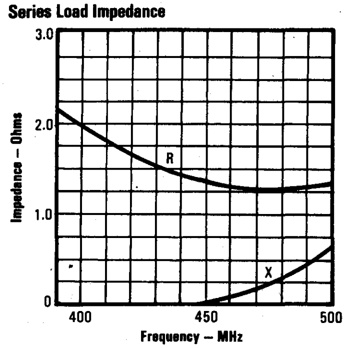
Drive Characteristics



Series Input Impedance

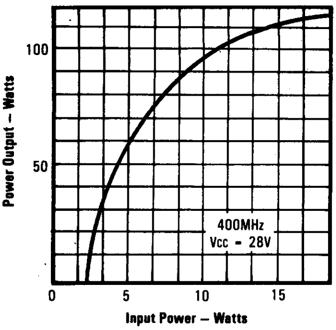


Series Load Impedance

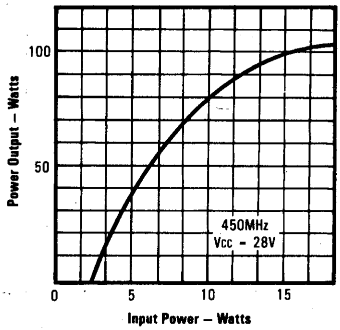


Typical CW (Class C) Characteristics

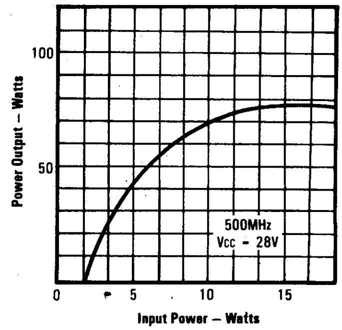
Power Transfer



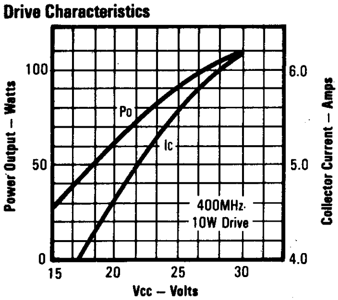
Power Transfer



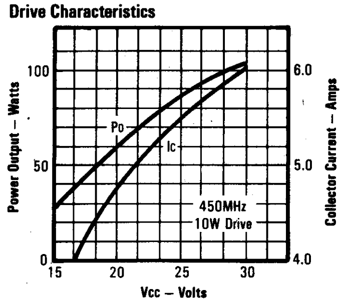
Power Transfer



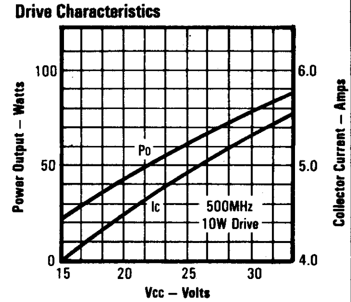
Drive Characteristics



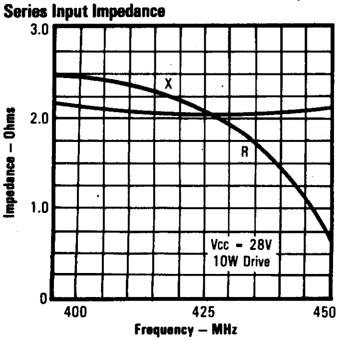
Drive Characteristics



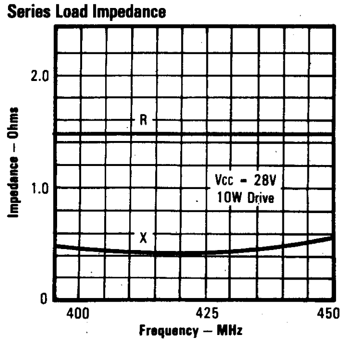
Drive Characteristics



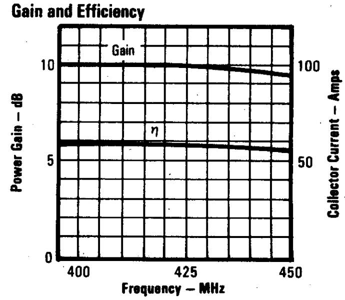
Series Input Impedance



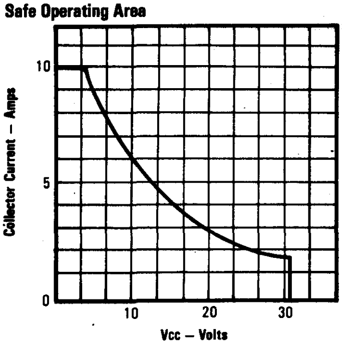
Series Load Impedance



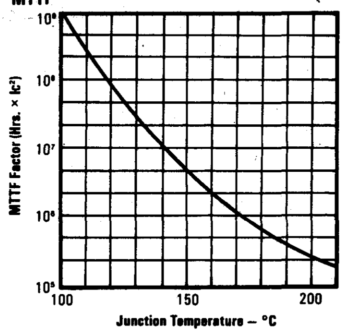
Gain and Efficiency



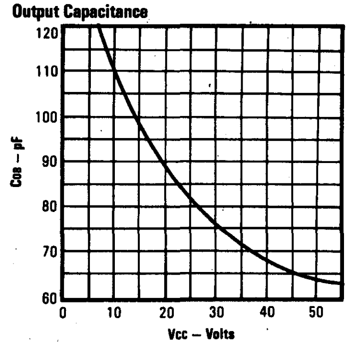
Safe Operating Area



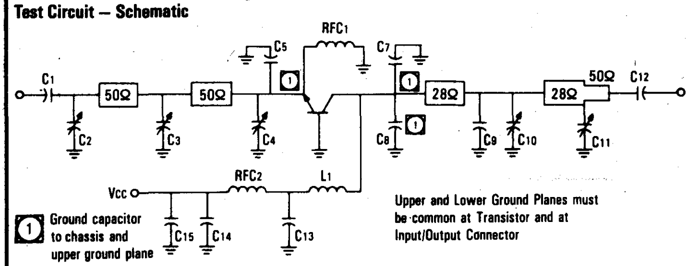
MTTF



Output Capacitance



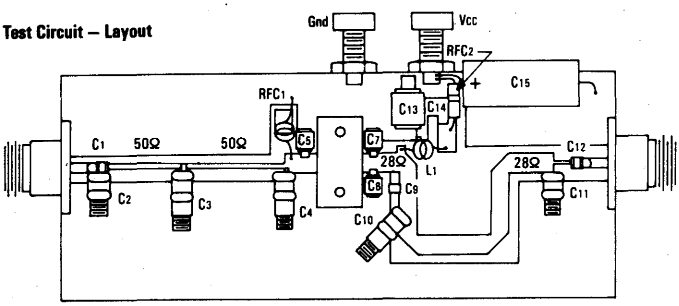
Test Circuit – Schematic



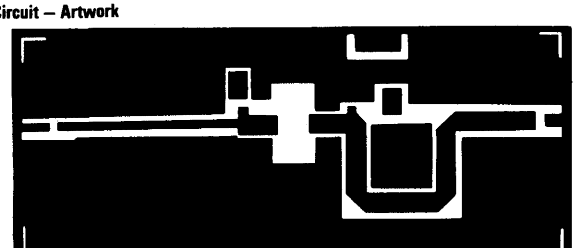
COMPONENTS LIST:

$C_{1, 12}$	420pF	C_{14}	470pF
$C_{2, 11}$	0-10pF	C_{16}	100μF 50VDC
$C_{3, 4, 10}$	0-20pF	RFC_1	13T, AWG. 20, 1/4" dia.
$C_{5, 9}$	33pF	RFC_2	3 ferrite beads on AWG. 20 wire.
$C_{7, 8}$	35pF	L_1	3T, #20 AWG., .125 dia.
C_{13}	1000pF	CKT	Brd. Matl. 0.032 Teflon-Glass

Test Circuit – Layout



Test Circuit – Artwork



Circuit is reduced. Contact factory for actual size.

TRW

UHF Power Transistors

- 1.5 to 30 W
- 28 V
- 400 MHz
- Gold Metalized
- Diffused Ballast Resistors
- Class A, AB or C Operation
- Common Emitter
- Isolated Package
- ∞ VSWR

280 SOE

The PT 9700 UHF Series features both high gain and high power, providing the desired power output with fewer devices. Microwave cellular geometries processed for UHF application provide both high performance and ruggedness. Diffused ballast resistors in the higher power units enable these devices to withstand infinite VSWR at all phase angles. Ballast resistor design enables operation at Class A, AB and C. These rugged units are suitable for both narrow band and broad band UHF communications and instrumentation service. All are gold metalized for long life and incorporate ceramic stripline packages.

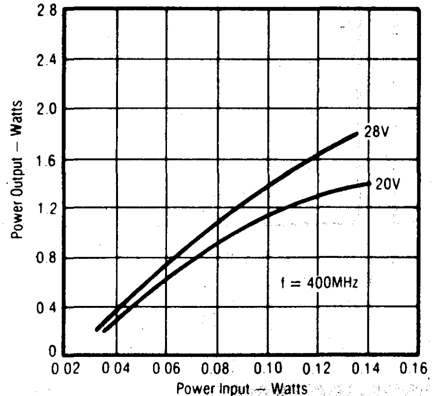
Electrical Characteristics (T_{FLANGE} = 25°C)

SYMBOL	CHARACTERISTICS	TEST CONDITIONS	PT 9700	PT 9701B	PT 9703B	PT 9702B	PT 9704A	UNIT
BV_{EBO}	Min. Emitter-Base Breakdown	I_E = 0.1mA, I_C = 0 I_E = 0.5mA, I_C = 0 I_E = 1mA, I_C = 0 I_E = 2mA, I_C = 0 I_E = 3mA, I_C = 0	3.5	4	4	4	4	V
BV_{CES}	Min. Collector-Emitter Breakdown	I_C = 1mA, V_{BE} = 0 I_C = 5mA, V_{BE} = 0 I_C = 10mA, V_{BE} = 0 I_C = 20mA, V_{BE} = 0 I_C = 30mA, V_{BE} = 0	55	60	60	60	55	V
BV_{CEO}	Min. Collector-Emitter Breakdown	I_C = 2.0mA, I_B = 0 I_C = 5mA, I_B = 0 I_C = 10mA, I_B = 0 I_C = 20mA, I_B = 0 I_C = 50mA, I_B = 0	35	30	30	30	30	V
I_{CBO}	Max. Collector-Base Leakage Current	V_{CB} = 30V	0.25	0.5	1.0	2.0	3.0	mA
H_{FE}	Min. D.C. Current Gain	I_C = 0.1A, V_{CE} = 5V	20-150	10-150	10-150	10-150	10-150	—
P_{GAIN}	Min. Power Gain	V_{CE} = 28V, P_{IN} = 0.12W P_{IN} = 0.62W P_{IN} = 1.5W f = 400 MHz, P_{IN} = 4W P_{IN} = 5W	1.5	5	10	20	30	W
η	Min. Collector Efficiency	V_{CE} = 28V, f = 400 MHz Rated Output Power	55	55	60	60	60	%
VSWR	Mismatch Tolerance	V_{CE} = 28V, f = 400 MHz 360° Rated Output Power	∞	∞	∞	∞	∞	
P_{SAT}	Min. Saturated Power Output	V_{CE} = 28V, f = 400 MHz	2	6	12	24	36	W
C_{OB}	Max. Collector-Base Capacitance	V_{CB} = 28V, f = 1 MHz I_E = 0	3.5	6	12	24	36	pF
I_C	Continuous Collector Current (Max. Rating)		0.5	0.75	1.25	2	5	A
$Θ_{J-C}$	Thermal Resistance	T_C = 25°C	35	17.5	8.8	4.4	2.5	°C/W
T_{STG}	Storage Temperature		−65 to +150					°C
T_J	Junction Temperature		+200° Maximum					°C
P_D	Power Dissipation	T_C = 25°C	5	10	20	40	70	W

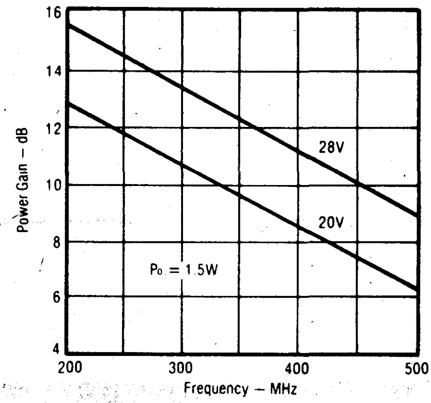
PT 9704 B Power Gain = 7 dB - Power Out/Power In = 30 W/6 W

PT 9700 — 1.5 Watts

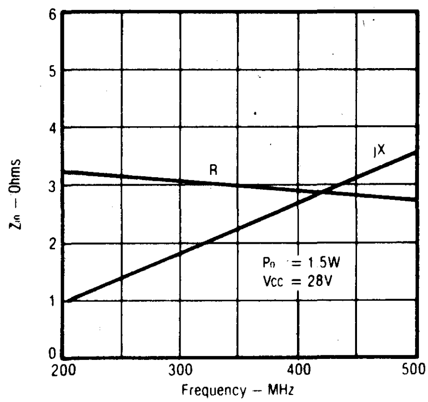
Power Output vs Power Input



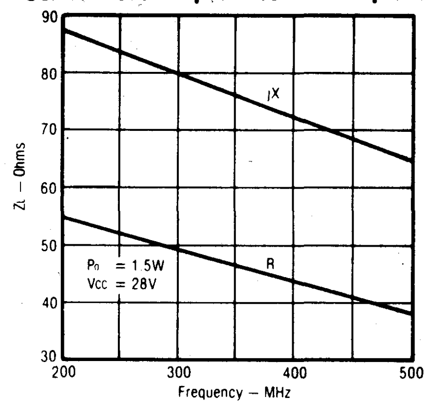
Power Gain vs Frequency



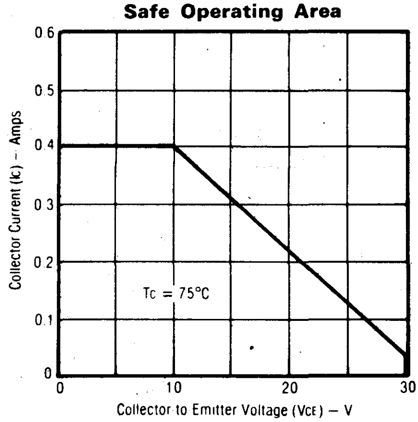
Series Input Impedance vs Frequency



Series Load Impedance vs Frequency

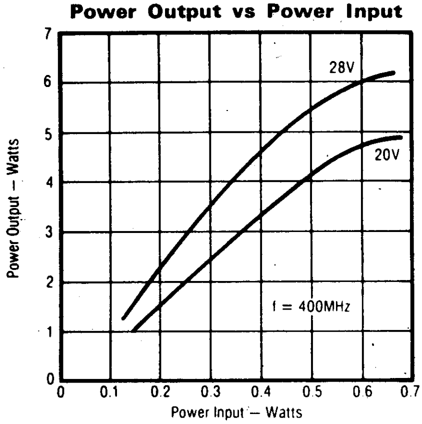


Safe Operating Area

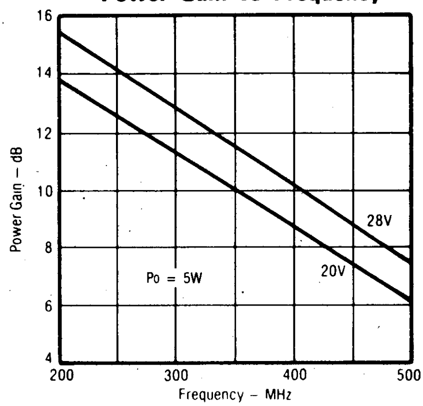


PT9701B — 5 Watts

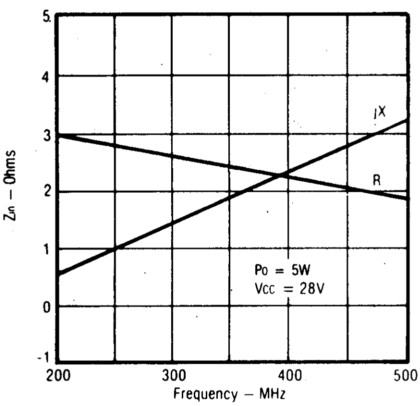
Power Output vs Power Input



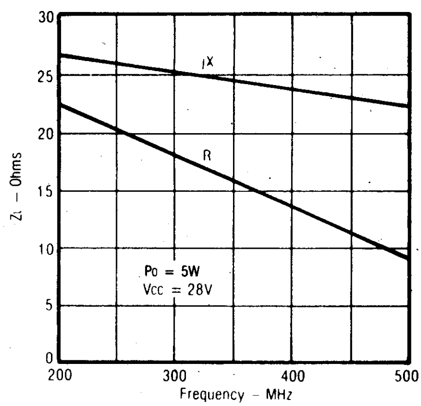
Power Gain vs Frequency



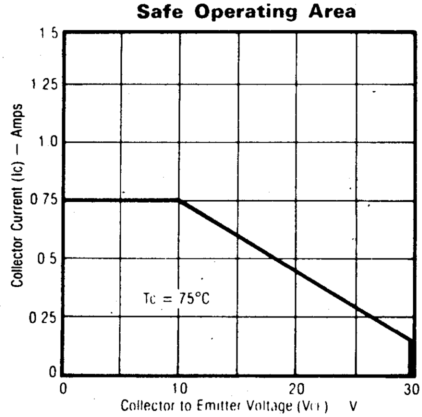
Series Input Impedance vs Frequency



Series Load Impedance vs Frequency



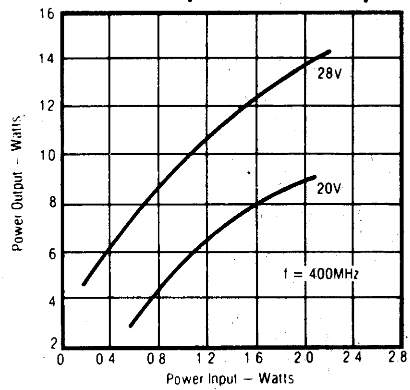
Safe Operating Area



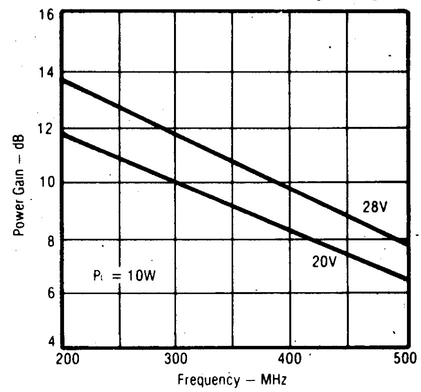
C

PT9703B — 10 Watts

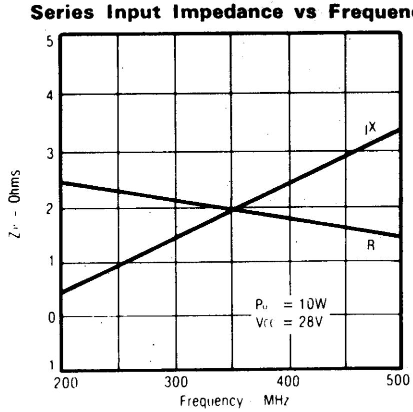
Power Output vs Power Input



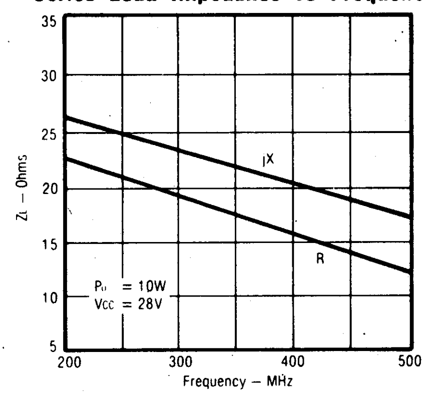
Power Gain vs Frequency



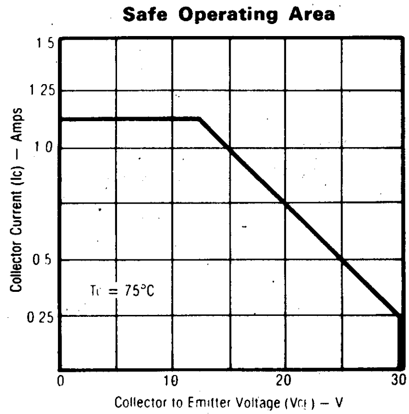
Series Input Impedance vs Frequency



Series Load Impedance vs Frequency



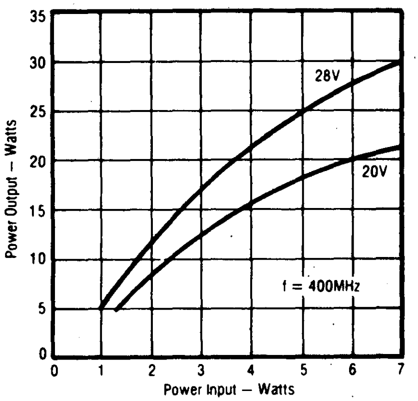
Safe Operating Area



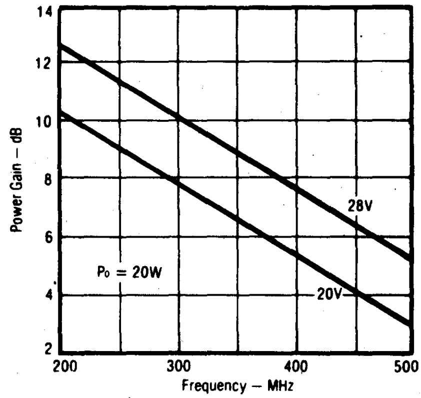
C

PT9702B — 20 Watts

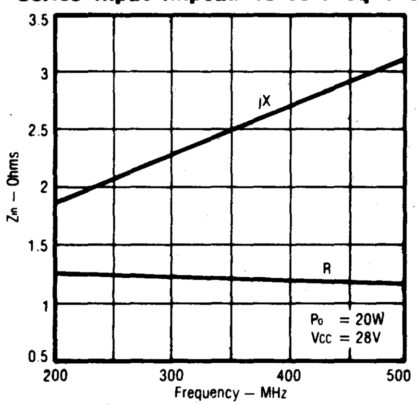
Power Output vs Power Input



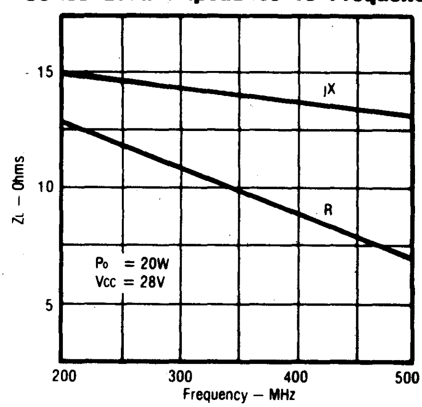
Power Gain vs Frequency



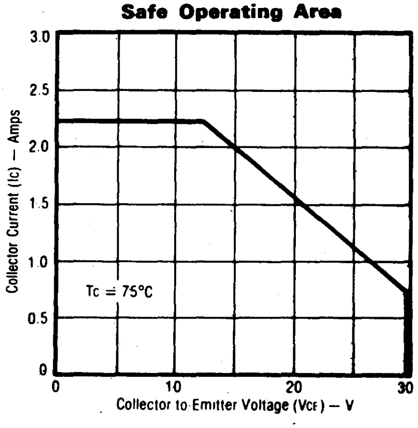
Series Input Impedance vs Frequency



Series Load Impedance vs Frequency

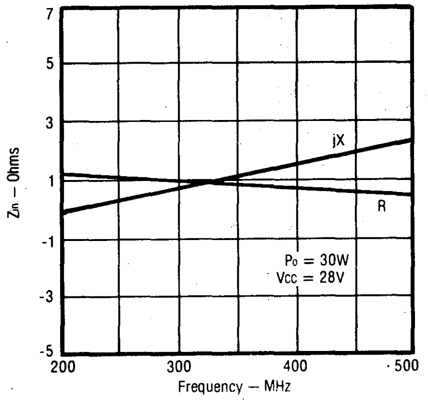


Safe Operating Area

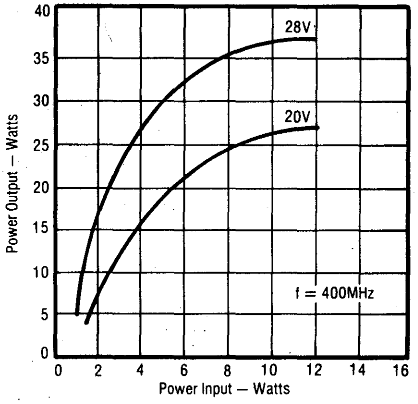


PT 9704 A — 30 Watts

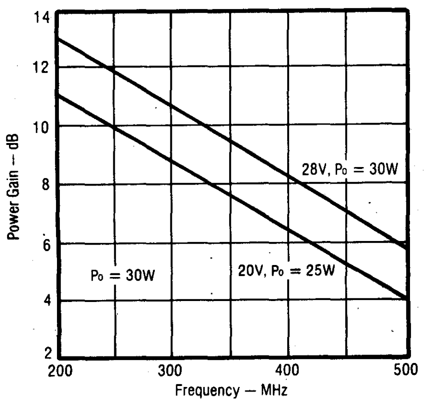
PT 9704 A Series Input Impedance vs Frequency



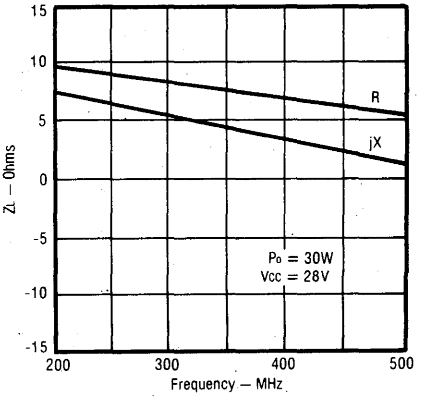
PT 9704 A Power Output vs Power Input



PT 9704 A Power Gain vs Frequency

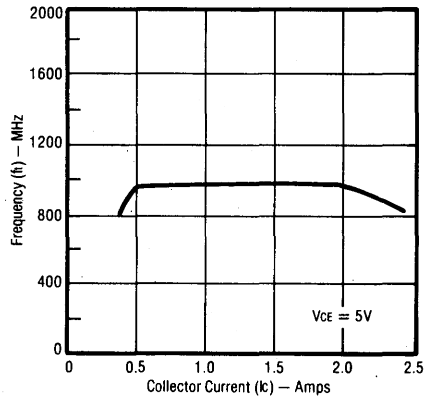


PT 9704 A Series Load Impedance vs Frequency

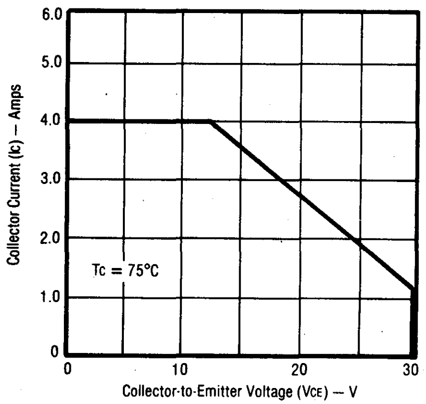


C

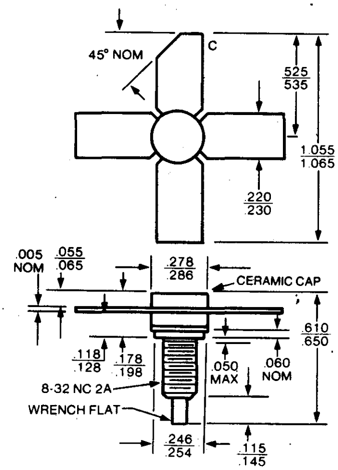
PT 9704 A f_t vs I_C



PT 9704 A Safe Operating Area

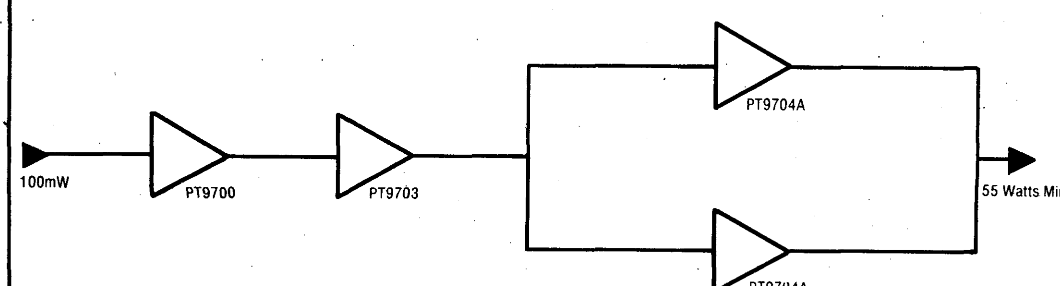


Package Outline



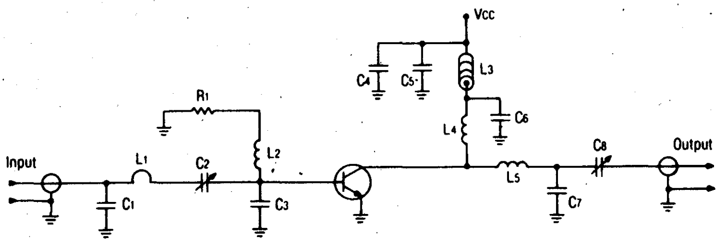
To convert inches to millimeters multiply by 2.54.

Typical Application
55 Watt UHF 28 V Power Amplifier
225-400 MHz



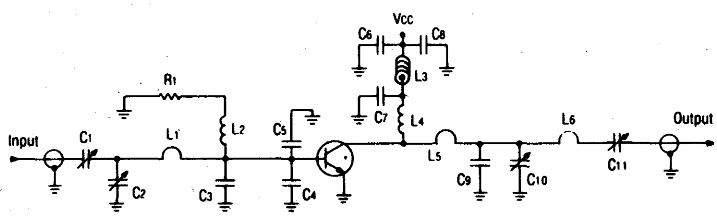
PT9700, 400 MHz TEST CIRCUIT

$C_{1,7,8}$ 0.9-7pF ARCO #400
C_2 3-35pF ARCO #403
C_3 30pF UNELCO
$C_{4,6}$ 1000pF UNELCO
C_5 1000μF electrolytic
L_1 1 loop #22AWG, 3/4"
$L_{2,5}$ 4 turns #22AWG, 0.1" I.D.
L_3 3 Ferrite beads
L_4 6 turns #22AWG, 0.1" I.D.
R_1 1 ohm, 1/4 watt carbon resistor



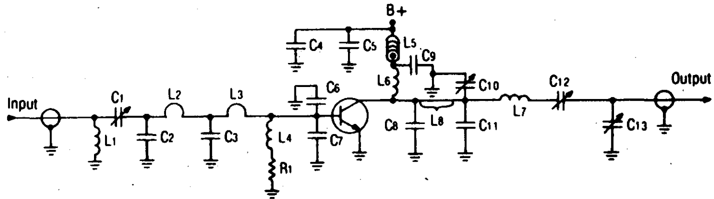
PT9701B and PT9703B, 400 MHz TEST CIRCUIT

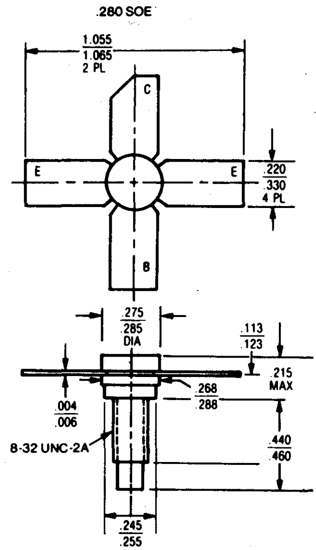
C_1 3-35pF ARCO #403
$C_{2,10}$ 0.9-7pF ARCO #400
$C_{3,9}$ 10pF UNELCO
$C_{4,5}$ 30pF UNELCO
$C_{6,7}$ 1000pF UNELCO
C_8 100μF electrolytic
C_{11} 0-18pF ARCO #402
L_1 #22AWG, 1/2"
L_2 4 turns #22AWG, 0.1" I.D.
L_3 3 Ferrite beads
L_4 2 turns #22AWG, 0.1" I.D.
L_5 #22AWG, 0.5" hairpin
L_6 3 turns #22AWG, 0.1" I.D.
R_1 1 ohm, 1/4 watt carbon resistor



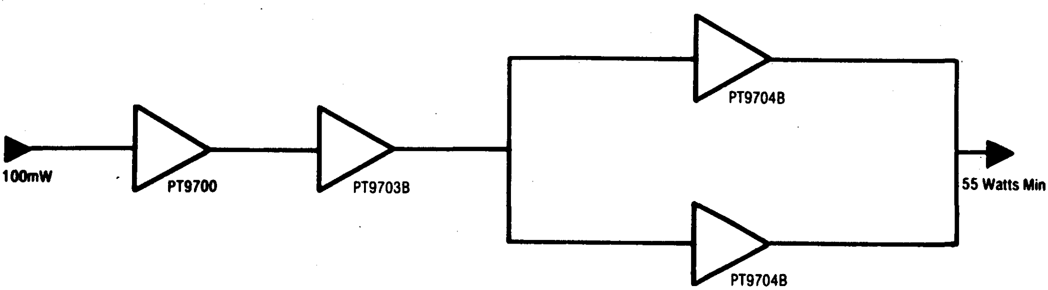
PT9702B and PT9704A, 400 MHz TEST CIRCUIT

$C_{1,12}$ 1.5-20pF ARCO #402
C_2 15pF UNELCO
$C_{3,6,7}$ 30pF UNELCO
$C_{4,9}$ 1000pF UNELCO
C_5 100μF electrolytic
C_8 35pF UNELCO
$C_{10,13}$ 0.9-7pF ARCO #400
C_{11} 10pF UNELCO
L_1 6 turns #22AWG, 1/8" I.D.
L_2 #22AWG, 3/8" hairpin
L_3 1/8" by 1/4" strap
L_4 2 turns on resistor lead
L_5 3 Ferrite beads
$L_{6,7}$ 2 turns #22AWG, 1/8" I.D.
L_8 #22AWG, 0.3"
R_1 1 ohm, 1/2 watt carbon resistor



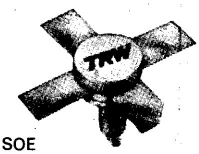


Typical Application
55 Watt UHF 28 V Power Amplifier
225-400 MHz



VHF Power Transistors

- PT 9730 4 W
- PT 9732 8 W
- PT 9734 15 W
- PT 9731 25 W
- PT 9733 50 W
- 28 V
- 175 MHz



380 SOE

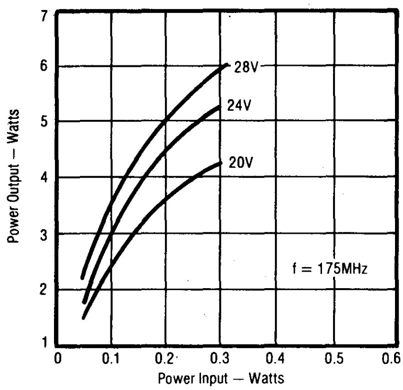
The PT9730 VHF Series feature both high gain and high power, providing the desired power output with fewer devices. These power transistors are ballasted for ruggedness and will withstand infinite VSWR at all phase angles. A unique emitter structure provides high gain with wider emitter and base fingers resulting in high reliability. Ballast resistor design enables operation at Class A, AB, and C. These rugged units are suitable for both narrow band and broadband VHF communications and instrumentation service.

Electrical Characteristics (T_{flange} = 25 °C)

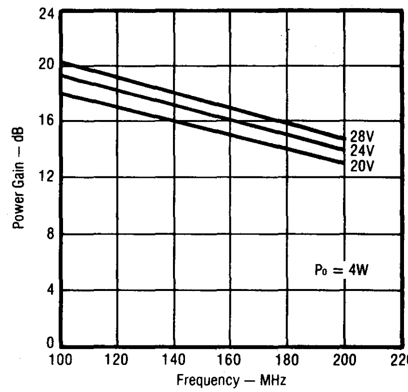
	Symbol	Characteristic	Test Conditions	PT 9730	PT 9732	PT 9734	PT 9731	PT 9733	Unit
DC Test	BV_{EBO}	Min. Emitter - Base Breakdown	I_E = 1 mA / = 2 mA / = 3 mA / = 4 mA / = 8 mA; I_C = 0	4	4	4	4	4	V
	BV_{CES}	Min. Collector - Emitter Breakdown	I_C = 50 mA V_{BE} = 0	60	60	60	60	60	V
	BV_{CEO}	Min. Collector - Emitter Breakdown	I_C = 25 mA I_B = 0	35	35	35	35	35	V
	I_{CES}	Max. Collector - Emitter Cutoff Current	V_{CE} = 25 V	0.5	0.5	0.75	1	2	mA
	H_{FE}	Min. D.C Current Gain	I_C = 500 mA V_{CE} = 10 V	20 to 150	20 to 150	20 to 150	20 to 150	20 to 150	—
RF Test	P_{GAIN}	Min. Power Gain	V_{CE} = 28 V, F = 175 MHz; P_{in} = 0.2 W / P_{in} = 0.5 W / P_{in} = 1 W / P_{in} = 2.5 W / P_{in} = 10 W	4	8	15	25	50	W
	η	Min. Collector Efficiency	V_{CE} = 28 V, F = 175 MHz, Rated Output Power	60	60	60	60	60	%
	VSWR	Mismatch Tolerance	V_{CE} = 28 V, F = 175 MHz, Rated Output Power	∞	∞	∞	∞	∞	
	P_{SAT}	Min. Saturated Power Output	V_{CE} = 28 V F = 175 MHz	6	10	18	30	60	W
	C_{OB}	Max. Collector - Base Capacitance	V_{CB} = 28 V F = 1 MHz I_E = 0	12	18	24	40	90	pF
Operating	I_C	Continous Collector Current		1	1.25	2.5	4	8	A
	θ_{j-c}	Thermal Resistance	T_C = 25 °C	17.5	8.8	5.8	3.9	2.1	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65 to + 200					°C
	P_D	Power Dissipation	T_C = 25 °C	10	20	30	45	85	W

PT 9730 — 4 Watts

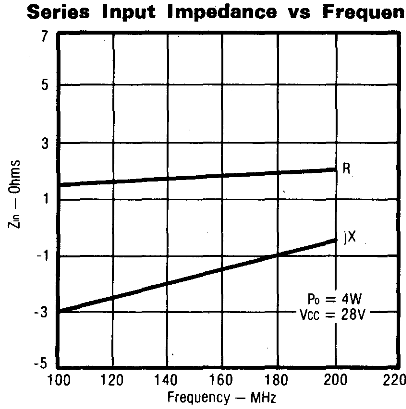
Power Output vs Power Input



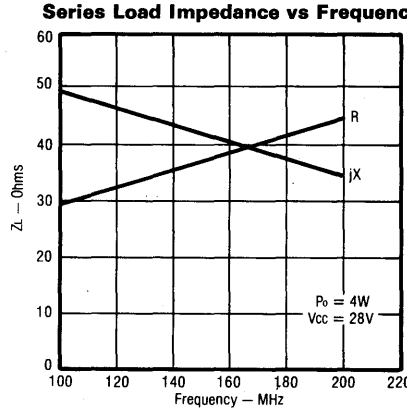
Power Gain vs Frequency



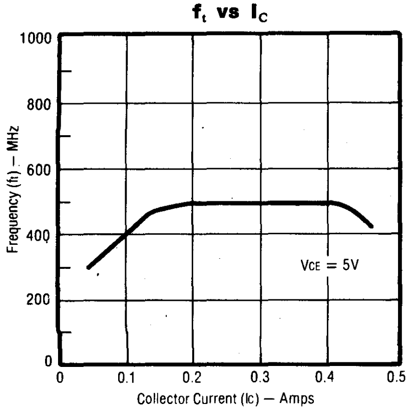
Series Input Impedance vs Frequency



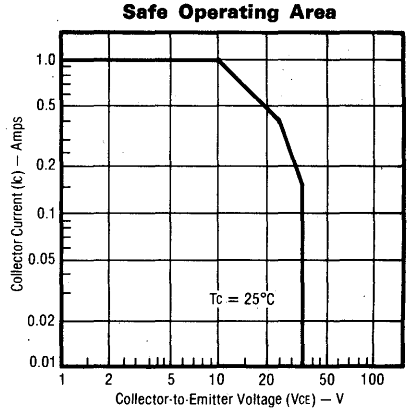
Series Load Impedance vs Frequency



f_t vs I_C

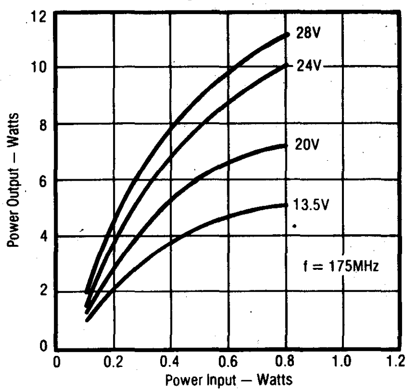


Safe Operating Area

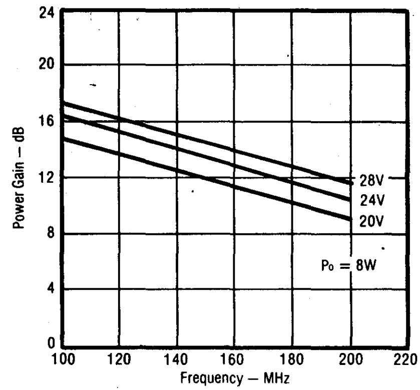


PT 9732 — 8 Watts

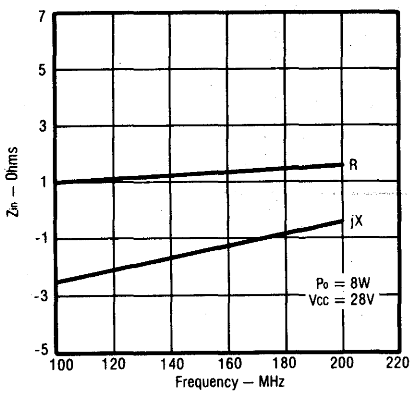
Power Output vs Power Input



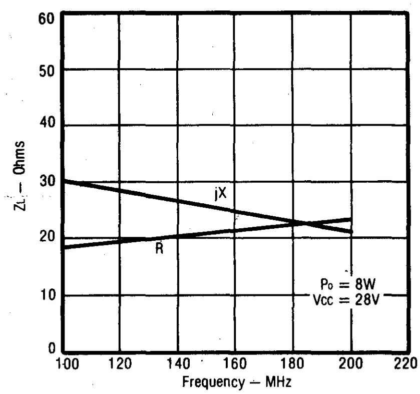
Power Gain vs Frequency



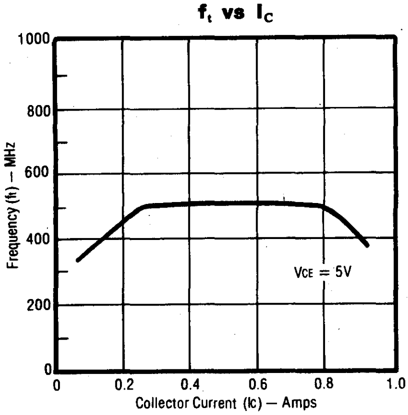
Series Input Impedance vs Frequency



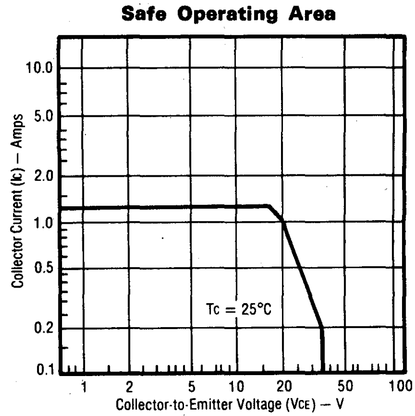
Series Load Impedance vs Frequency



f_t vs I_C

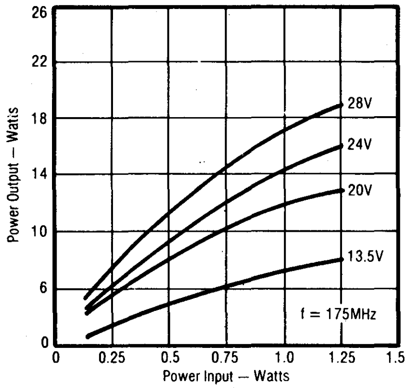


Safe Operating Area

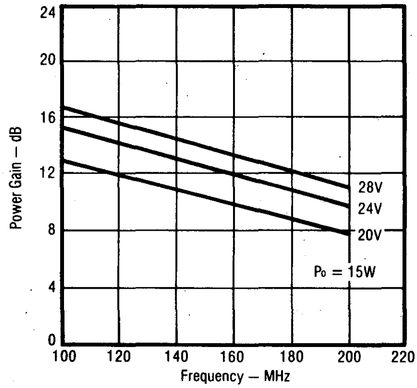


PT 9734 — 15 Watts

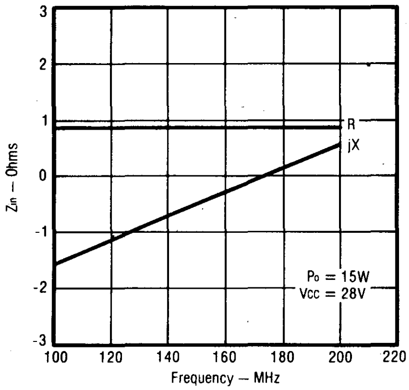
Power Output vs Power Input



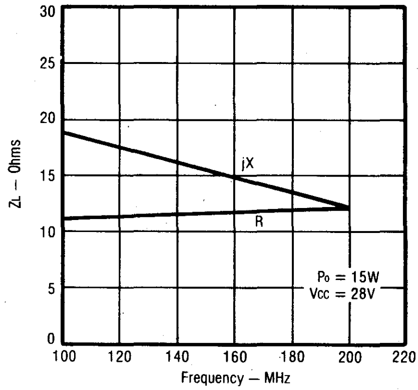
Power Gain vs Frequency



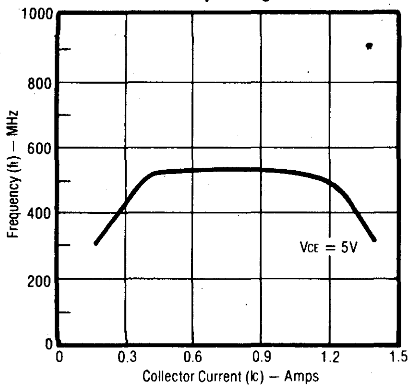
Series Input Impedance vs Frequency



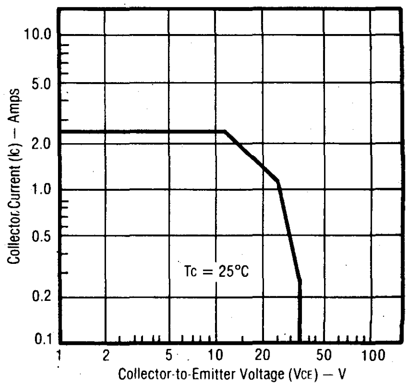
Series Load Impedance vs Frequency



f_t vs I_C

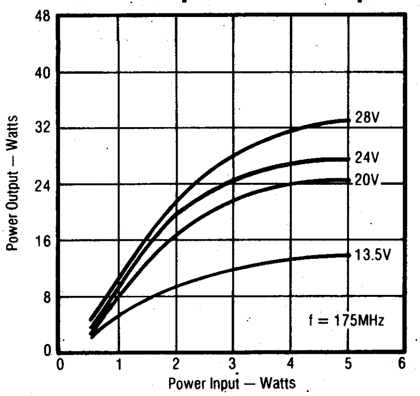


Safe Operating Area

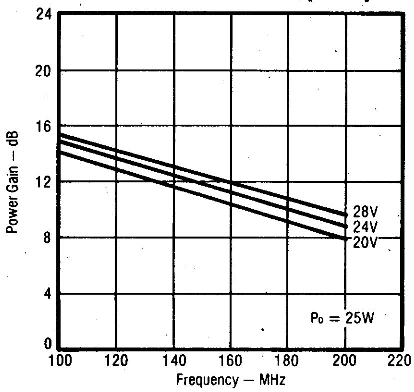


PT 9731 — 25 Watts

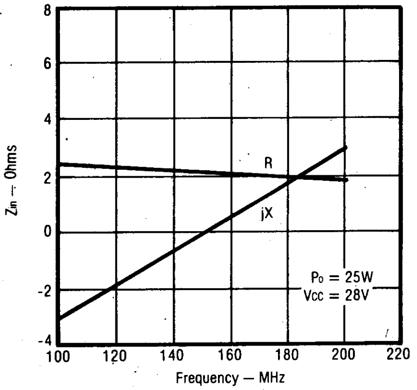
Power Output vs Power Input



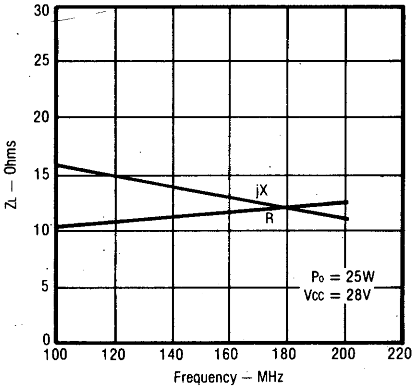
Power Gain vs Frequency



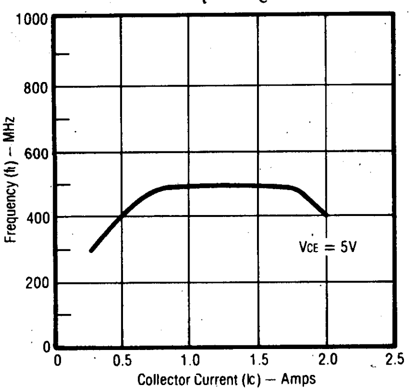
Series Input Impedance vs Frequency



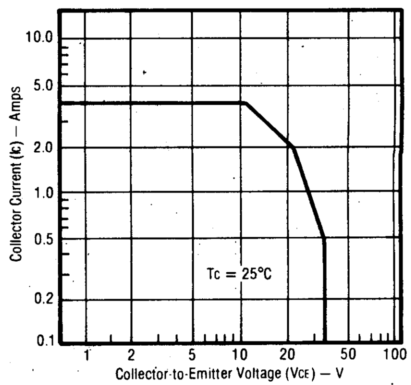
Series Load Impedance vs Frequency



f_t vs I_C

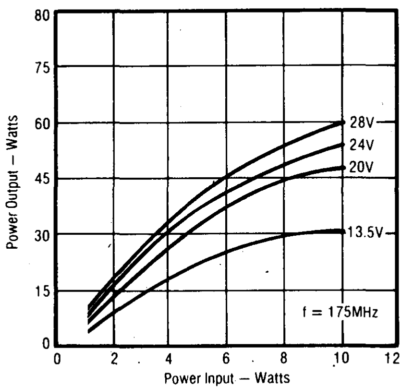


Safe Operating Area

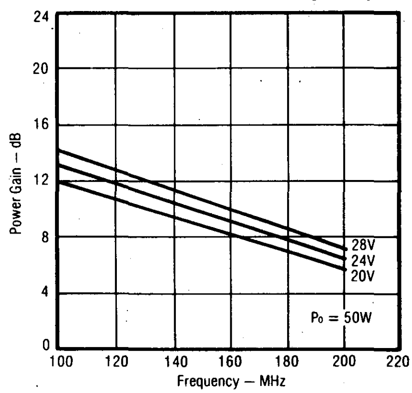


PT 9733 — 50 Watts

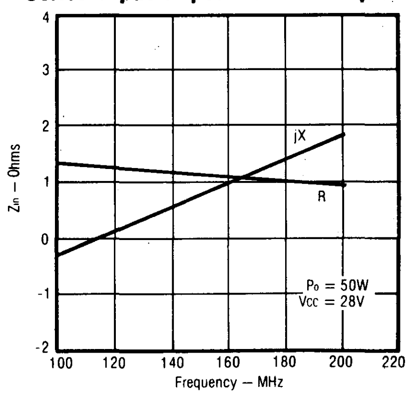
Power Output vs Power Input



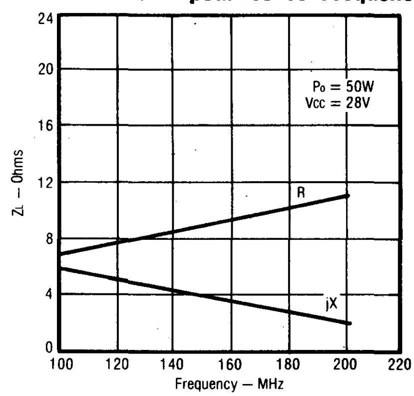
Power Gain vs Frequency



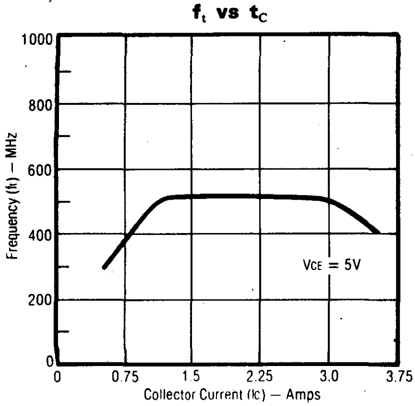
Series Input Impedance vs Frequency



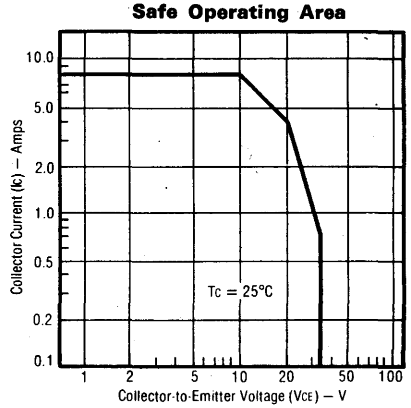
Series Load Impedance vs Frequency



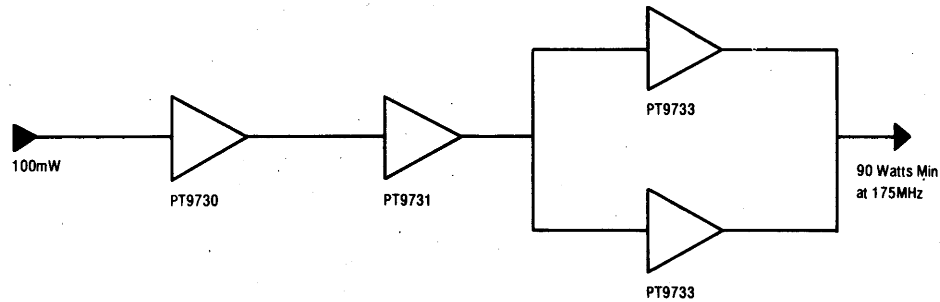
f_t vs t_C



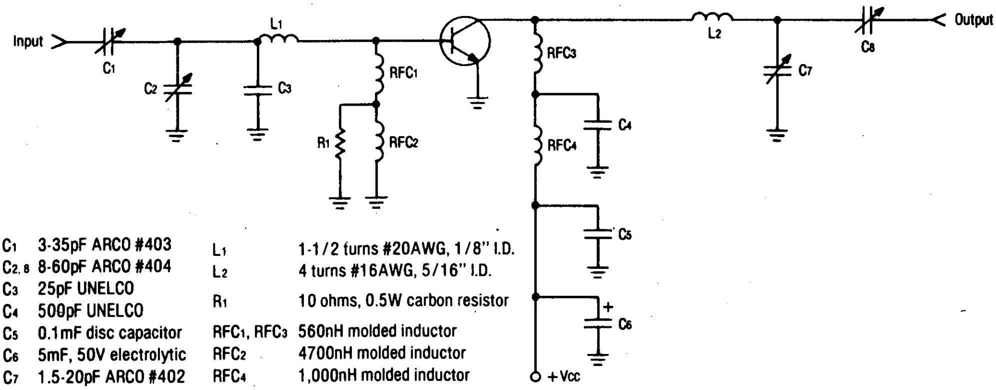
Safe Operating Area



TYPICAL APPLICATION
90 Watt VHF 28 V Power Amplifier

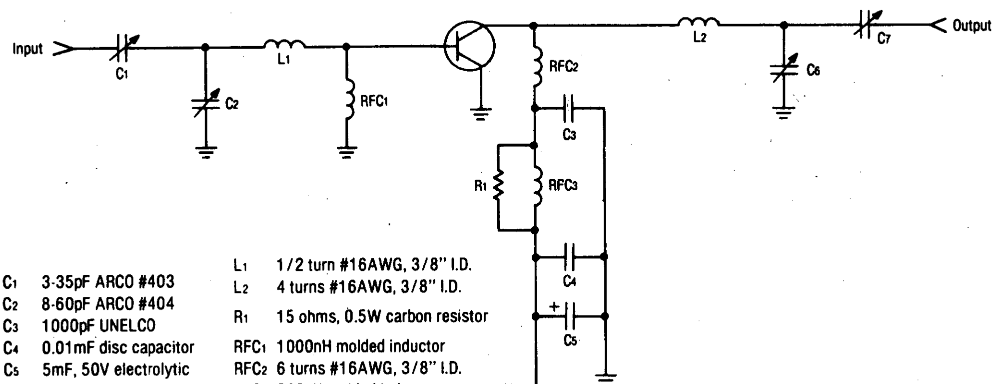


PT 9730 and PT 9732 175 MHz TEST CIRCUIT



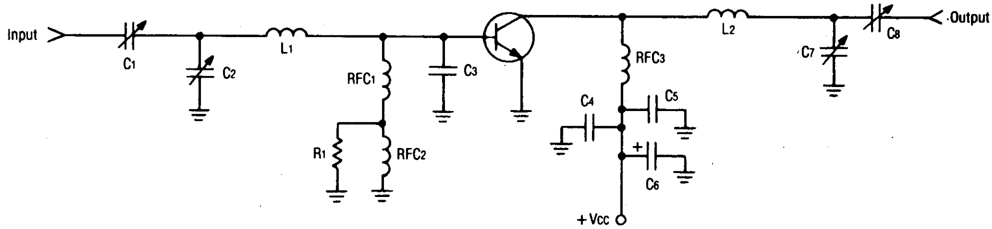
C_1	3-35pF ARCO #403	L_1	1-1/2 turns #20AWG, 1/8" I.D.
$C_{2,8}$	8-60pF ARCO #404	L_2	4 turns #16AWG, 5/16" I.D.
C_3	25pF UNELCO		
C_4	500pF UNELCO	R_1	10 ohms, 0.5W carbon resistor
C_5	0.1mF disc capacitor	RFC_1, RFC_3	560nH molded inductor
C_6	5mF, 50V electrolytic	RFC_2	4700nH molded inductor
C_7	1.5-20pF ARCO #402	RFC_4	1,000nH molded inductor

PT 9734 175 MHz TEST CIRCUIT



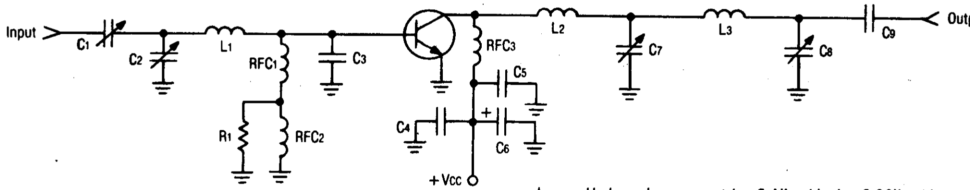
		L_1	1/2 turn #16AWG, 3/8" I.D.
C_1	3-35pF ARCO #403	L_2	4 turns #16AWG, 3/8" I.D.
C_2	8-60pF ARCO #404		
C_3	1000pF UNELCO	R_1	15 ohms, 0.5W carbon resistor
C_4	0.01mF disc capacitor	RFC_1	1000nH molded inductor
C_5	5mF, 50V electrolytic	RFC_2	6 turns #16AWG, 3/8" I.D.
$C_{6,7}$	1.5-20p-F ARCO #402	RFC_3	560nH molded inductor

PT 9731 175 MHz TEST CIRCUIT



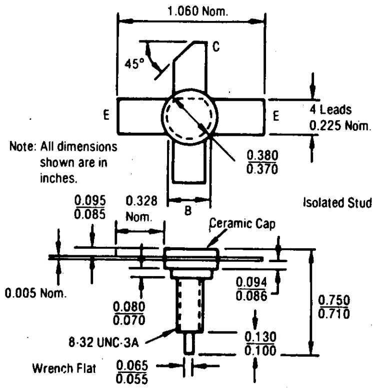
$C_{1,8}$	7-100pF ARCO #423
C_2	8-60pF ARCO #404
C_3	90pF UNELCO
C_4	1000pF UNELCO
C_5	0.1mF disc capacitor
C_6	5mF, 50V electrolytic
C_7	5-80pF ARCO #462
L_1	2 turns, 0.1" wide by 0.02" thick copper strip, 1/4" I.D.
L_2	4 turns, 0.1" wide by 0.02" thick copper strip, 1/4" I.D.
R_1	10 ohms, 0.5W carbon resistor
RFC_1	150nH molded inductor
RFC_2	10,000nH molded inductor
RFC_3	4 turns #16AWG, 5/16" I.D.

PT 9733 175 MHz TEST CIRCUIT



$C_{1,2,8}$	8-60pF ARCO #404
C_3	150pF UNELCO
C_4	500pF UNELCO
C_5	0.1mF disc capacitor
C_6	5mF, 50V electrolytic
C_7	5-80pF ARCO #462
C_9	0.001mF disc capacitor
L_1	1 turn, 0.1" wide by 0.02" thick copper strip, 5/16" I.D.
L_2	U-shaped copper strip, 0.1" wide by 0.02" wide thick, 0.25" high by 0.675" long
L_3	1-1/2 turns, 0.1" wide by 0.02" thick copper strip, 5/16" I.D.
R_1	10 ohms, 0.5W carbon resistor
RFC_1	150nH molded inductor
RFC_2	10,000nH molded inductor
RFC_3	4 turns #16AWG, 5/16" I.D.

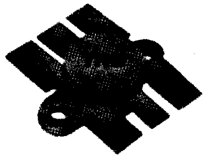
PACKAGE OUTLINE



TRW

VHF Power Transistor

- **150 W**
- **100 - 175 MHz**
- **High Gain**
- **RF Power Transistor**
- **Silicon**



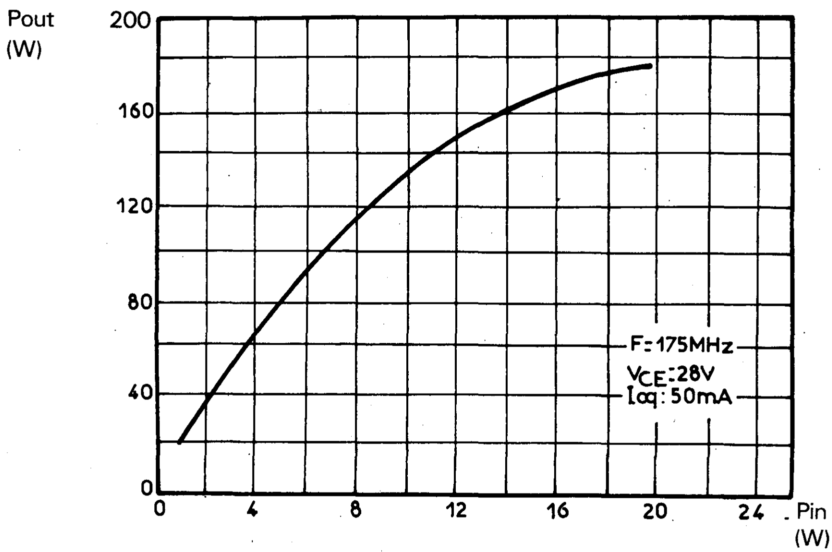
JØ 500

The TP 9386 is designed for use in the new generation of VHF transmitters. It operates in class A, B or C from a 28 V supply. Its construction, which now incorporates the new standard TRW process of gold metallisation and diffused ballast resistors, ensures a long operational life even when run at its maximum ratings.

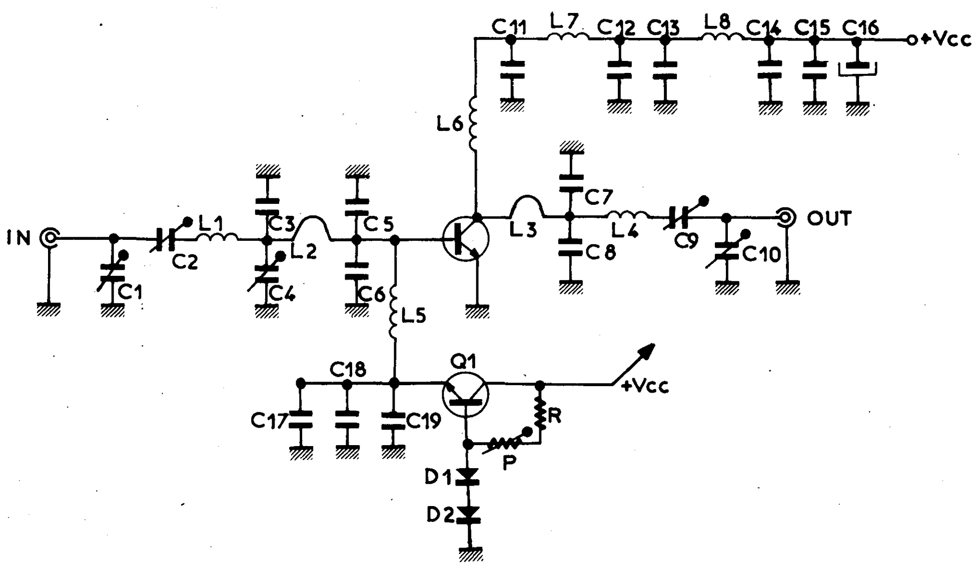
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 20 mA	4			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
DC Test	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10 Ω	60			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
DC Test	h_{FE}	D.C Current Gain	V_{CE} = 5V I_C = 1 A	15		150	—
RF Test	P_{out}	Common Emitter Amplifier output power	V_{CE} = 28 V I_{cq} = 50 mA F = 175 MHz P_{in} = 15 W	150			W
RF Test	η_c	Collector Efficiency	V_{CE} = 28 V I_{cq} = 50 mA F = 175 MHz P_{out} = 150 W	60			%
RF Test	C_{ob}	Output Capacitance	V_{CB} = 28 V F = 1 MHz			150	pF
Thermal	P_d	Maximum Power dissipation				250	W
Thermal	I_c	Maximum Collector Current				15	A
Thermal	R_{thjc}	Thermal resistance Junction case				0,7	°C/W

TYPICAL POWER OUTPUT VERSUS POWER INPUT



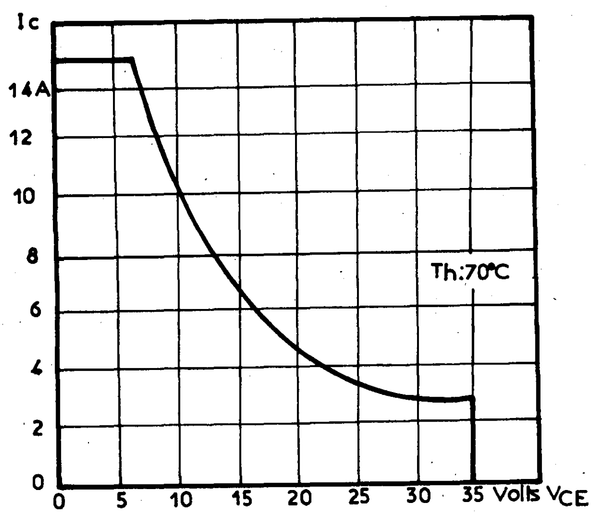
TEST FIXTURE (Narrow band)



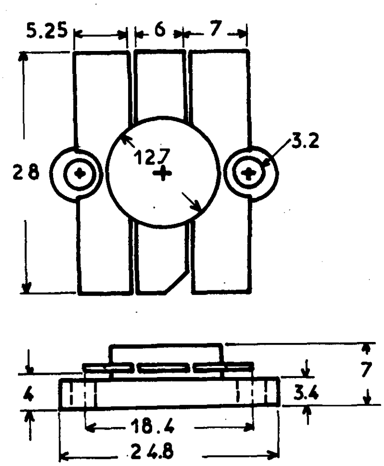
COMPONENTS PART LIST

C_1 C_2	ARCO 403	
C_3	30 pF	
C_4	ARCO 404	
C_5 C_6	80 pF	
C_7 C_8	100 pF	
C_9 C_{10}	ARCO 425	(24-200 pF)
C_{11} C_{12} C_{14} C_{17}	1 000 pF	
C_{13} C_{15} C_{18}	10 nF	
C_{16} C_{19}	47 µF	
L_1	2turns	∅ 8 mm 1 mm wire
L_2	Hair pin	Copper foil 15 × 3 mm 0,3 mm thick
L_3	Hair pin	Copper foil 12 × 5 mm 0,3 mm thick
L_4	3 turns	∅ 5 mm 1,5 mm wire
L_5	10 turns	∅ 5 mm 0,5 mm wire
L_6	3 turns	∅ 6 mm 1,5 mm wire
L_7	3 turns	∅ 6 mm 1,5 mm wire
L_8	10 turns	1 mm wire on core (µi = 120)
R	1,5 Ω	1/2 W
P	5 KΩ	
D_1 D_2	IN 4007	
Q_1	BD 135	

DC SAFE OPERATING AREA

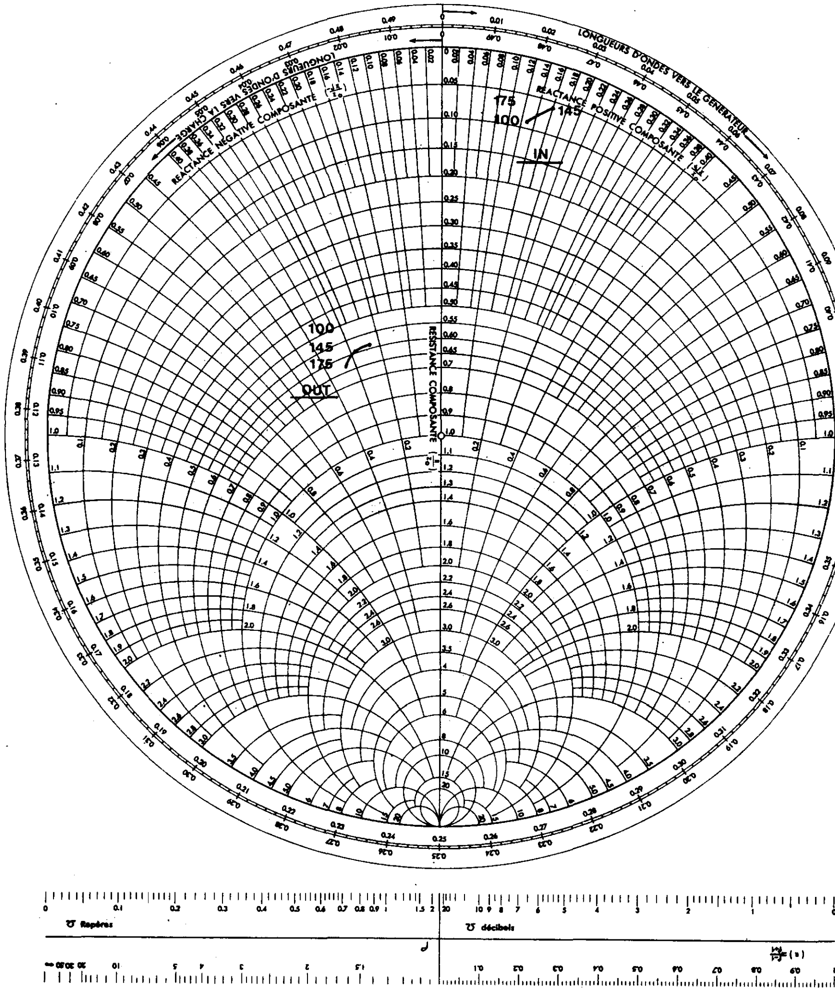


PACKAGE



Dimensions given in mm

TYPICAL VALUES



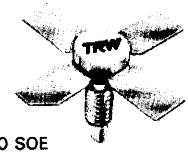
TP 9386 at 28 V   Icq = 50 mA   Pout = 150 W

	Zin (Ω)	*Zout* (Ω)
100 MHz	0.43+j0.65	2.88−j1.13
145 MHz	0.40+j0.7	2.88−j1.22
175 MHz	0.29+j0.87	3.16−j1.39

TRW

UHF Power Transistor

- 1 W
- 20 V
- 100 - 400 MHz
- 16 dB Gain
- Narrow Band
- Gold Reliability



280 SOE

The TM 401 is a NPN gold metallized transistor using diffused emitter ballast resistor design for operation in class A, B or C conditions.

The high gain reduces the need for complex broadband circuits and is ideally suited for 100-400 MHz broadband amplifier applications.

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 0.3 mA	3.5			V
	BV_{CER}	Collector Emitter Breakdown Voltage	R_{BE} = 10 Ω I_C = 20 mA	50			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 20 mA	24			V
	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 1 mA	45			V
	I_{CBO}	Collector Base Leakage	V_{CB} = 28 V			0.4	mA
	h_{FE}	DC Current Gain	V_{CE} = 5 V I_C = 100 mA	20		120	
RF TEST	P_G	Power Gain Class A Broad Band	F = 400 MHz V_{CE} = 20 V I_E = 200 mA P_O = .5 W	13			dB
	P_{sat}	Broad Band Min Saturated Output Power Class A	F = 400 MHz V_{CE} = 20 V I_E = 200 mA	1.3			W
	VSWR	Mismatch Tolerance	F_O = 400 MHz V_{CE} = 20 V I_C = 220 mA P_{out} = 1.0 WCW		∞		
	C_{ob}	Collector Base Capacitance	V_{CB} = 24 V F = 1 MHz			5	pF
	F_T	Cutoff Frequency	V_{CE} = 20 V I_E = 200 mA	2.2			GHz
THERMAL	I_C	Maximum Collector Current				0.7	A
	$\theta_{j.c}$	Thermal Resistance Junction Case	T_{case} = 70 °C			20	°C/W
	P_T	Power Dissipation	T_{case} = 25 °C			8.75	W
	T_{STG} T_J	Storage temperature Junction temperature		— 65		+ 200	°C

V_{CE} = 20 V - I_C = 200 mA - Class A

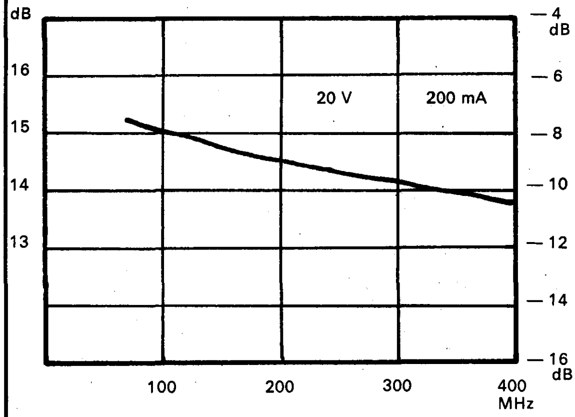
POLAR S-PARAMETERS IN 50 OHM SYSTEM								
F	S 11		S 21		S 12		S 22	
MHz	Magn	Angl°	Magn	Angl°	Magn	Angl°	Magn	Angl°
100 MHz	0.67	203°	12.6	112°	0.037	32°	0.41	— 90°
200 MHz	0.78	186°	7.6	93°	0.042	31°	0.33	— 122°
300 MHz	0.79	183°	5.5	82.5°	0.047	30°	0.34	— 135°
400 MHz	0.78	170°	4.21	72°	0.053	30°	0.34	— 137°
500 MHz	0.76	165°	3.39	66°	0.061	35°	0.33	— 138°

C

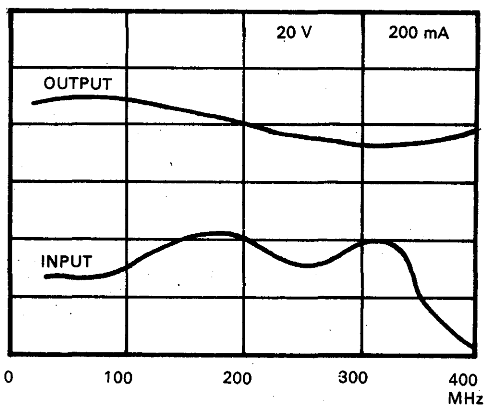
100-400 MHz AMPLIFIER PERFORMANCES

Class A 20 V 200 mA

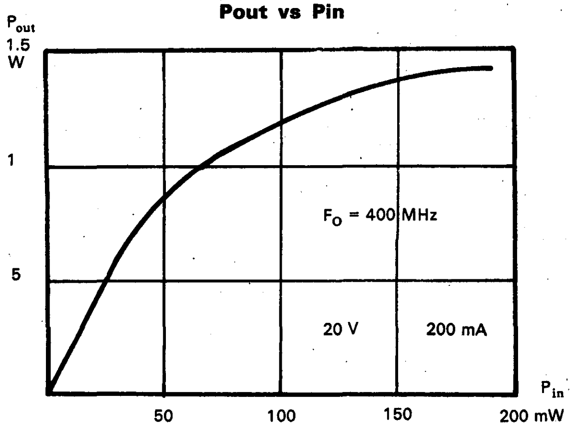
Small Signal Gain Variation



Input and Output VSWR

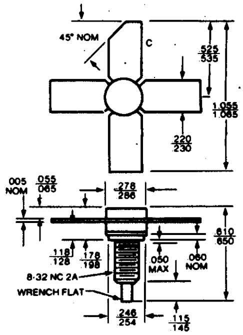


Pout vs Pin

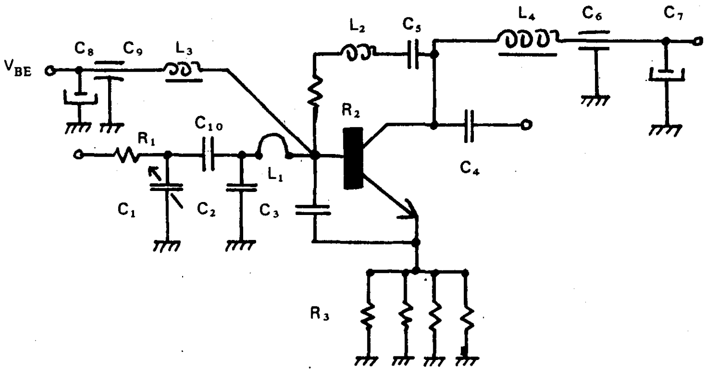


Package

.280 SOE



1 W - 100-400 MHz Class A AMPLIFIER



C_1 = 1-9 pF variable RTC
C_2 = 8.2 pF RTC C 330
C_3 = 2 × 2.2 pF RTC C 632
C_4 = 10 nF RTC C 331
C_5 = C_{10} = 1 nF C 331
C_6 = C_9 = 1 nF by-pass
C_7 = C_8 = 10 μF 25 V

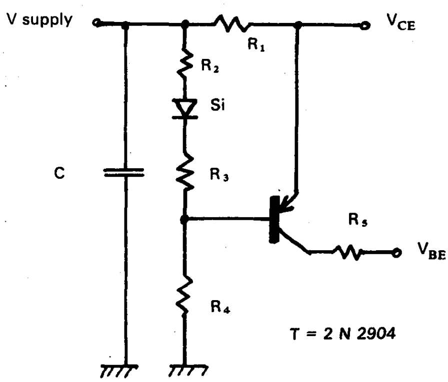
R_1 = 15 Ω carbon composition
R_2 = 300 Ω carbon composition
R_3 = 4 × 3.9 Ω 1/4 W
Carbon composition

L_1 = ∩ ↕ 5 mm wire 5/10 mm
5 mm

L_2 = 4 turns ID 4 mm wire 5/10 mm

L_3 = L_4 = choke

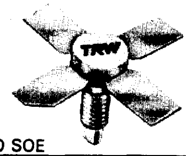
Bias Circuit



R_1 = 11 Ω 1/2 W
R_2 = 500 Ω
R_3 = 220 Ω
R_4 = 4.7 kΩ
R_5 = 22 Ω

UHF Power Transistor

- 5 W
- 400 MHz
- 16 dB Gain
- Gold Reliability



280 SOE

The TPM 405 is a NPN gold metallized transistor using diffused emitter ballast resistors for operation at class A, AB and C.

Its high gain reduces the complexity of the broadband stages and make the TPM 405 ideal for 100-400 MHz applications.

A 100-400 MHz push-pull amplifier is described in the two last pages of this data sheet.

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
DC TEST	BV_{CER}	Collector Emitter Breakdown Voltage	I_C = 40 mA R_{BE} = 10 Ω	50			V
DC TEST	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 2 mA	45			V
DC TEST	I_{CBO}	Collector Base Leakage	V_{CB} = 28 V			0.450	mA
DC TEST	h_{FE}	DC Current Gain	V_{CE} = 5 V I_C = 200 mA	20		120	
RF TEST	P_{GAIN}	Power Gain Class AB	V_{CF} = 24 V P_{out} = 5 W F_O = 400 MHz I_Q = 50 mA	16			dB
RF TEST	η	Min Collector Efficiency	V_{CE} = 24 V P_{out} = 5 W F_O = 400 MHz I_Q = 50 mA	50			%
RF TEST	VSWR	Mismatch Tolerance	V_{CE} = 24 V P_{out} = 3 W F_O = 400 MHz I_Q = 50 mA		∞		
RF TEST	P_{SAT}	Min Saturated Power output	V_{CE} = 24 V F_O = 400 MHz I_Q = 50 mA	7			W
RF TEST	C_{ob}	Collector Base Capacitance	V_{CB} = 24 V F = 1 MHz			7	pF
THERMAL	I_C	Maximum Collector Current				1.4	A
THERMAL	$\theta_{J.C}$	Thermal Resistance Junction Case	T_{case} = 70 °C			9.5	°C/W
THERMAL	T_{STG} T_j	Storage and Junction Temperature		— 65 °C		+ 200	°C

CLASS A - V_{CE} = 20 V - I_C = 440 mA - Small Signal

POLAR S-PARAMETERS IN 50 OHM SYSTEM								
F	S 11		S 21		S 12		S 22	
MHz	Magn	Angl°	Magn	Angl°	Magn	Asgl°	Magn	Angl°
100 MHz	0.871	190	6.130	108	0.028	17	0.537	205
200 MHz	0.902	182	4.9	90	.03	18	0.562	191
300 MHz	0.907	178	3.35	80	0.033	20	0.562	189
400 MHz	0.902	175	2.66	72	0.035	22	0.562	188
500 MHz	0.905	175	2.21	71	0.034	30	.540	192

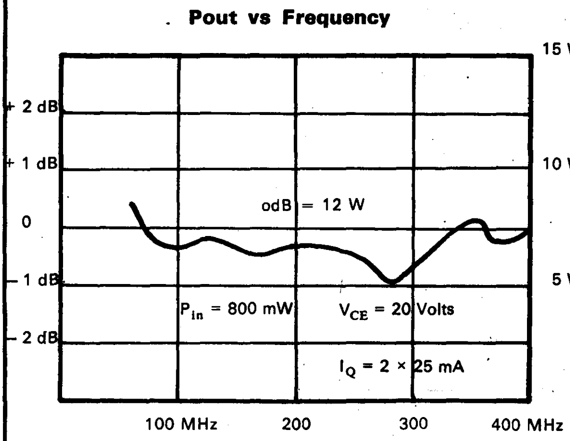
Large Signal Impedances

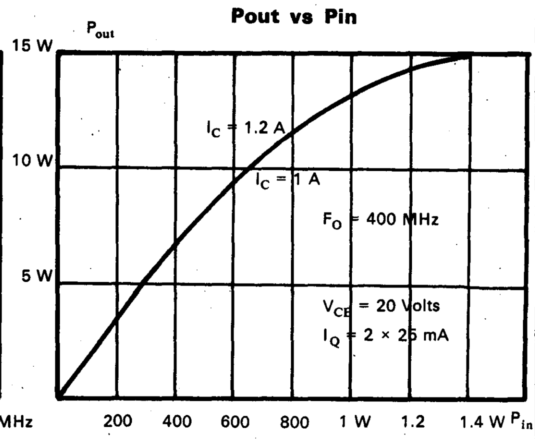
Class AB I_Q = 50 mA F_O = 400 MHz

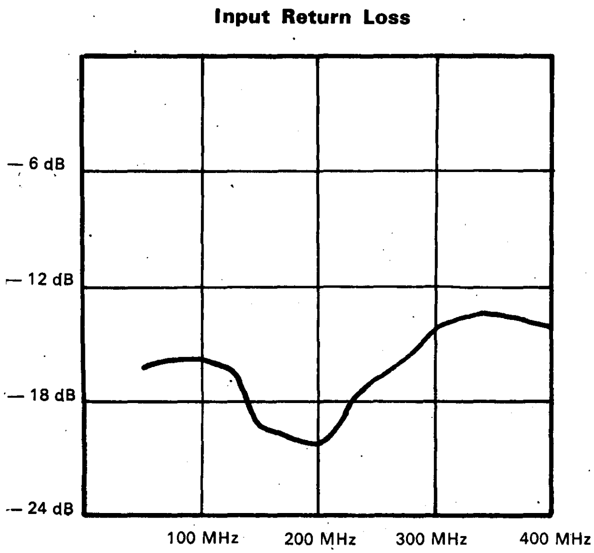
P_{out} = 5 W V_{CE} = 20 V

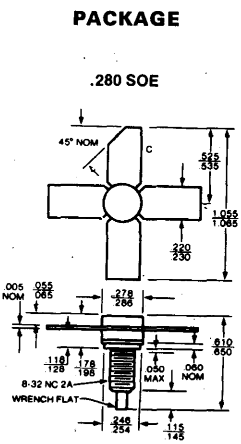
Z_{in}	Z_{out}
(1,5 — J 1) ohm	(15,5 — J 21,4) ohm

PUSH-PULL PERFORMANCE

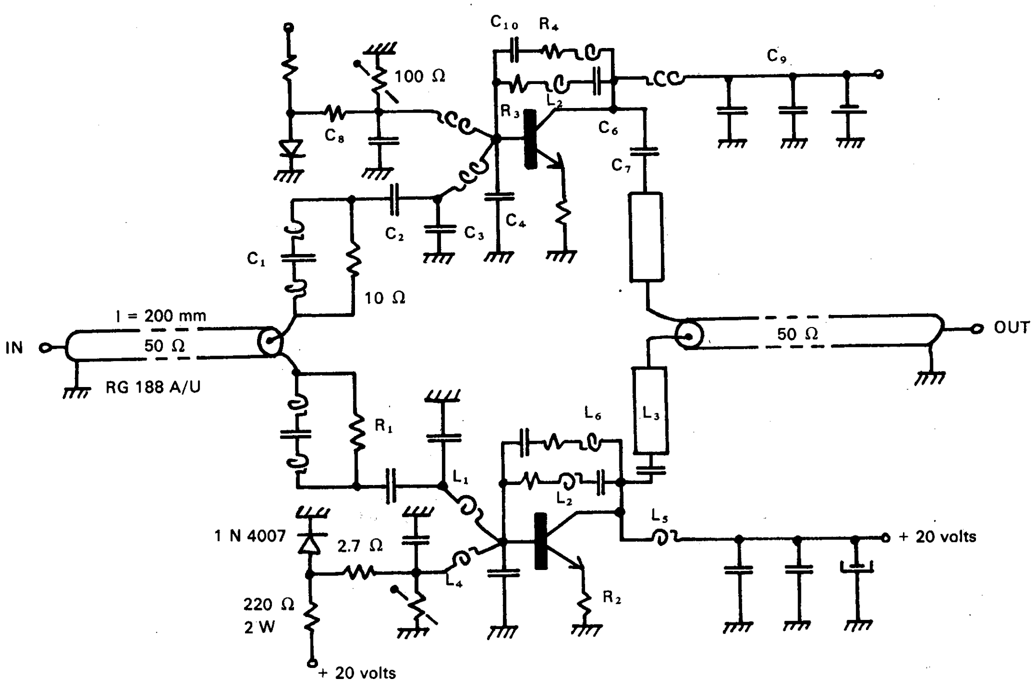








PUSH-PULL AMPLIFIER 100-400 MHz



L_1 : 1/2 turn ↕ 5 mm 5/10 mm
5 mm

L_2 : 6 turns ⌀ 3 mm 5/10 mm
L_3 : 25 Ω line 2 % λg at 400 MHz
L_4 : Moiled coil .47 μF
L_5 : Moiled coil 4.7 μH
L_6 : 17 turns ⌀ 3 mm 5/10 mm

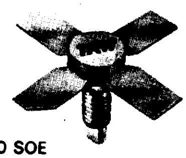
C_1 : 27 pF C 300 RTC with 12 mm leads
C_2 : C_7 = 10 nF chip
C_3 : 27 pF ATC 100 A
C_4 : 2 × 1.3 pF ATC 100 A
C_6 : C_{10} = 10 nF RTC C 331
C_8 : C_9 = 1 nF + 10 nF + 0.1 μF + 10 μF decoupling

R_1 = 10 Ω 1/4 W carbon
R_2 = 4 × 1 Ω 1/4 W carbon
R_3 = R_4 = 300 Ω 1/4 W carbon

TRW

UHF Power Transistor

- 25 W
- 400 MHz
- 9 dB Gain
- Gold Reliability

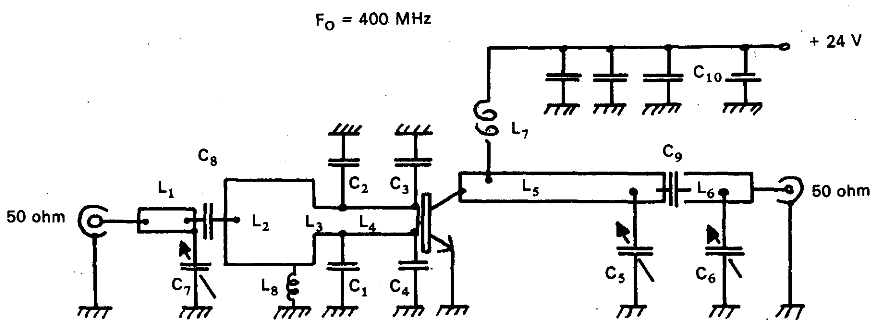


280 SOE

The TPM 425 is a high gain UHF transistor which has been specially designed for use in 100-400 MHz broadband amplifiers.
Its construction utilizes the new standard, gold metallization and diffused emitter ballast resistors, allowing class A, B or C operation and a high degree of ruggedability.

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 3 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_E = 20 mA	25			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA	45			V
	H_{FE}	D.C Current Gain	V_{CE} = 20 V I_C = 500 mA	10			
RF TEST	P_{out}	Power Output	V_{CE} = 24 V F_O = 400 MHz P_{in} = 3 W	25			W
	η_C	Collector Efficiency	V_{CE} = 24 V F_O = 400 MHz P_{out} = 25 W	60	70		%
	C_{OB}	Collector - Base Capacitance	V_{CE} = 24 V F = 1 MHz			20	pF
	I_C	Maximum Collector Current				2	A
THERMAL	θ_{J-C}	Thermal Resistance Junction - Case	T_{case} = 25 °C			5	°C/W
	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C



L_1 = 50 ohm line
L_2 = 22 ohm line 3 % λg at 400 MHz
L_3 = 30 ohm line 0.5 % λg at 400 MHz
L_4 = 30 ohm line 1 % λg at 400 MHz
L_5 = 50 ohm line 5.5 % λg at 400 MHz
L_6 = 50 ohm line 3.5 % λg at 400 MHz

L_7 = 2 turns — ID 7 mm — wire 1 mm
L_8 = 0.68 μH - Molded — RFC

C_1 = C_2 = 18 pF — ATC — 100 A
C_3 = C_4 = 10 pF — ATC — 100 A
C_5 = AT 5501 — 1-20 pF — Tekelec
C_6 = C_7 = AT 5601 — 1-30 pF — Tekelec
C_8 = C_9 = 1 nF
C_{10} = 1 nF + 10 nF + .1 μF + 10 μF Decoupling.

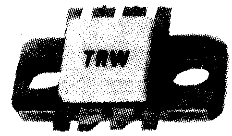
POLAR S-PARAMETERS 50 OHM SYSTEM

FREQ. MHz	S 11		S 21		S 12		S 22	
	Magn	Angl°	Magn	Angl°	Magn	Angl°	Magn	Angl
100	0.957	181	3.89	99	0.019	35	0.707	190
200	0.957	178	1.97	95	0.019	45	0.724	186
300	0.957	176	1.29	75	0.025	45	0.741	184
400	0.957	174	1.06	68	0.032	50	0.749	184
500	0.957	172	0.86	63	0.035	57	0.746	183

V_{CE} = 25 V I_C = 850 mA

TPM 4040

- **40 W**
- **28 V**
- **30 - 400 MHz**
- **RF Power**
- **Push-Pull Transistor**
- **NPN Silicon**



MRP7 Push-pull package.

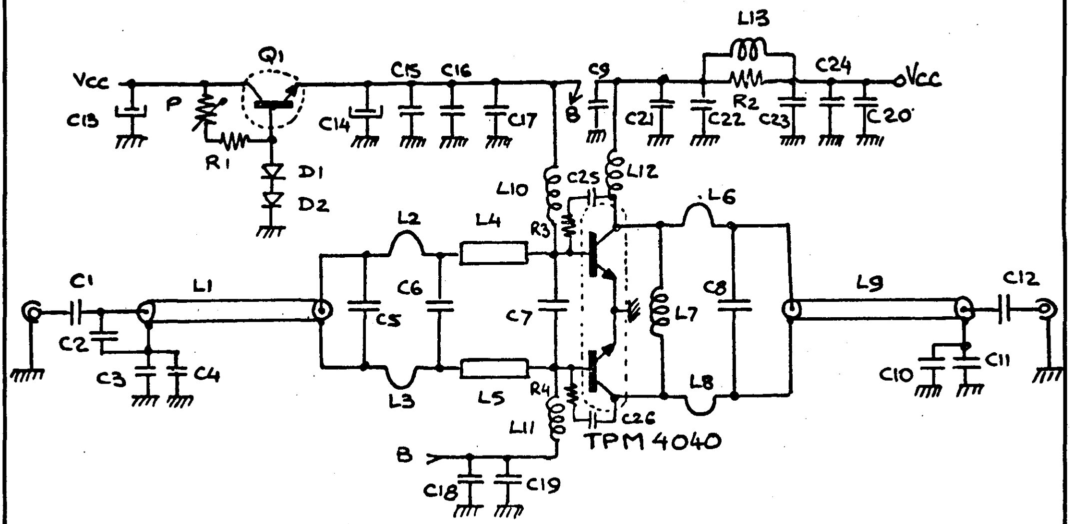
The TPM 4040 is an internally matched transistor on a push-pull package specially designed for multioctave bandwith high gain and power applications. Its internal matching and package configuration lead to high input and output impedances.

Multicell die design and ultra thin beryllium oxide header allow optimum heat dissipation and operating efficiency. Long term reliability and ruggedness are garanteed by diffused silicon ballast resistors and the TRW gold metallization process.

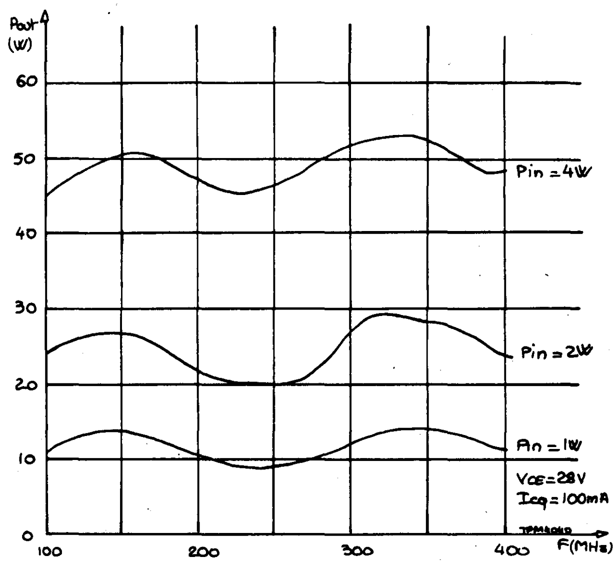
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emetter - Base Breakdown Voltage	I_E = 6 mA	4			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 40 mA	30			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 20 mA	45			V
DC Test	H_{FE}	D.C. Current Gain	V_{CE} = 20 I_C = 500 mA	10			—
RF Test	P_G	RF Power Gain	V_{CE} = 28 V	10			dB
RF Test	η_C	Collector Efficiency	F = 400 MHz	50			%
RF Test	VSWR	Mismatch Tolerance	P_{out} = 40 W I_{cq} = 2 X 50 mA	∞			—
RF Test	C_{OB}	Collector - Base Capacitance (Each Side)	V_{CB} = 28 V F = 1 MHz			20	pF
Thermal	θ_{JC}	Thermal Resistance Junction Case	T° $_{case}$ = 70 °C			2	°C/W
Thermal	P_D	Power dissipated	T° $_{case}$ = 70 °C			65	W

100-400 MHz 40 W AMPLIFIER (Class AB)



Typical Pout vs Pin, F

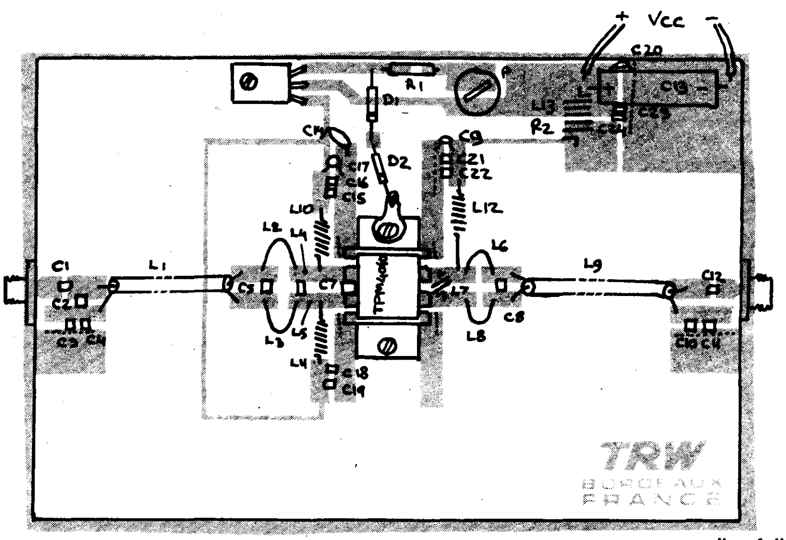


COMPONENTS PART LIST

C_1, C_6, C_{12}	= 39 pF chip capacitor
C_2	= 3.9 pF chip capacitor
C_3, C_{10}, C_{15}, C_{18}, C_{21}, C_{23}	= 1000 pF chip capacitor
C_4, C_{11}, C_{16}, C_{19}, C_{22}, C_{24}	= 15 nF chip capacitor
C_5	= 22 pF chip capacitor
C_7	= 68 pF chip capacitor
C_8	= 15 pF chip capacitor
C_{25}, C_{26}	= 10 nF ceramic disc capacitor
C_{14}	= 10 μF/ 5 V Electrolytic capacitor
C_{13}	= 100 μF/40 V Electrolic capacitor
C_9, C_{13}, C_{17}, C_{20}	= 0.1 μF Tantal
L_1, L_9	= 100 mm, 50 ohms teflon coaxial cable
L_2, L_3	= hair pin L = 17 mm, 0.8 mm wire
L_4, L_5	= 6 mm X 3 mm line on substrate
L_6, L_8	= hair pin L = 12 mm, 0.8 mm wire
L_7	= 3 turns ∅ 5 mm, 0.8 mm wire
L_{10}, L_{11}, L_{12}	= 15 turns ∅ 3 mm 0.5 mm craneled wire
L_{13}	= 6 turns ∅ 5 mm 1.2 mm wire
R_1	= 1.2 K ohms 1/2 W
R_2	= 15 ohms 1/2 W
R_3, R_4	= 1 K ohms 1/4 W
D_1, D_2	= 1 N 4007 or equivalent
Q_1	= BD 135 or equivalent

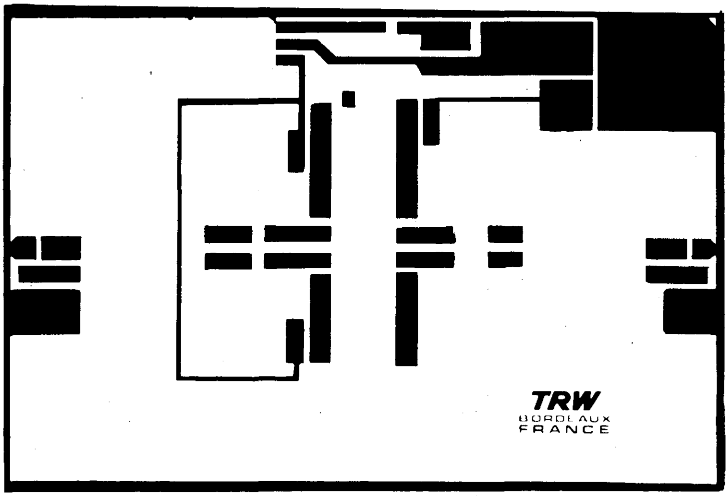
Substrate : teflon glass 1/50"

COMPONENTS LAYOUT

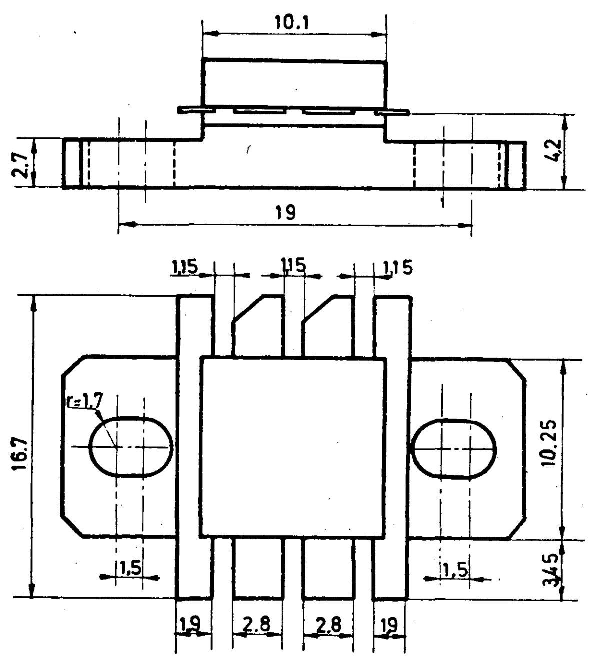


- - - - - = grounding foil

PRINTED CIRCUIT BOARD



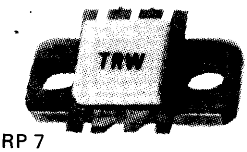
PACKAGE



TPM 4130

Push-Pull Transistor

- **130 W**
- **28 V**
- **225 - 400 MHz**
- **RF Power**
- **Push-Pull Transistor**
- **NPN Silicon**



MRP 7

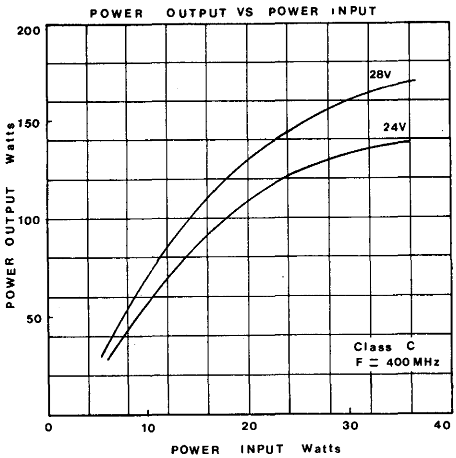
Push-pull package

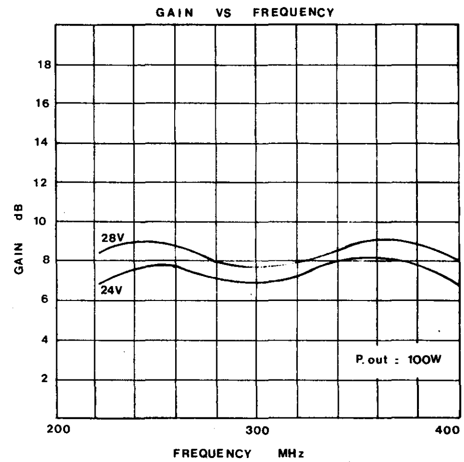
The TPM 4130 is an internally matched transistor on a push-pull package specially designed for multioctave bandwidth high power applications. Its internal matching and package configuration lead to high input and output impedances. Multicell die design and ultra thin beryllium oxide header allow optimum heat dissipation and operating efficiency. Long term reliability and ruggedness are garanteed by diffused silicon ballast resistors and the TRW gold metallization process.

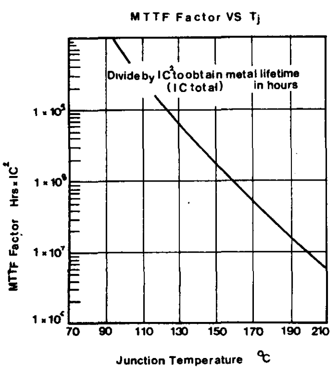
Electrical Characteristics (T_{CASE} = 25 °C)

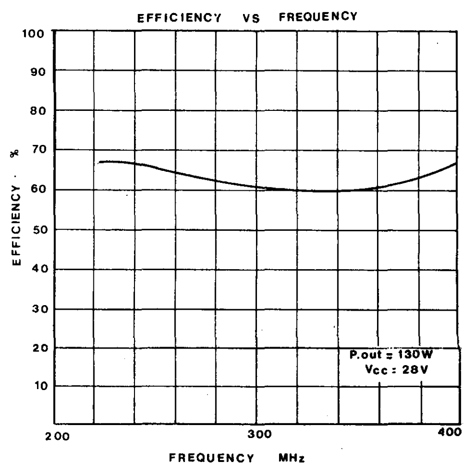
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA	3.5			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	30			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 100 mA	65			V
	H_{FE}	D.C. Current Gain	V_{CE} = 5 V, I_C = 1 A	20		150	–
RF TEST	P_G	Power Gain	V_{CE} = 28 V, P_{OUT} = 130 W F = 400 MHz	7.2			dB
	η_C	Collector Efficiency	V_{CE} = 28 V, P_{OUT} = 130 W F = 400 MHz	60			%
	C_{OB}	Collector Base Capacitance (each side)	V_{CB} = 28 V, F = 1 MHz		60	70	pF
THERMAL	P_D	Maximal Total Dissipation	t_C = 25 °C			210	W
	I_C	Maximal Collector Current (each side)				10	A
	R_{TH}	Thermal Resistance Junction - Case	T-Case = 60 °C			0.85	°C/W

TYPICAL PERFORMANCE

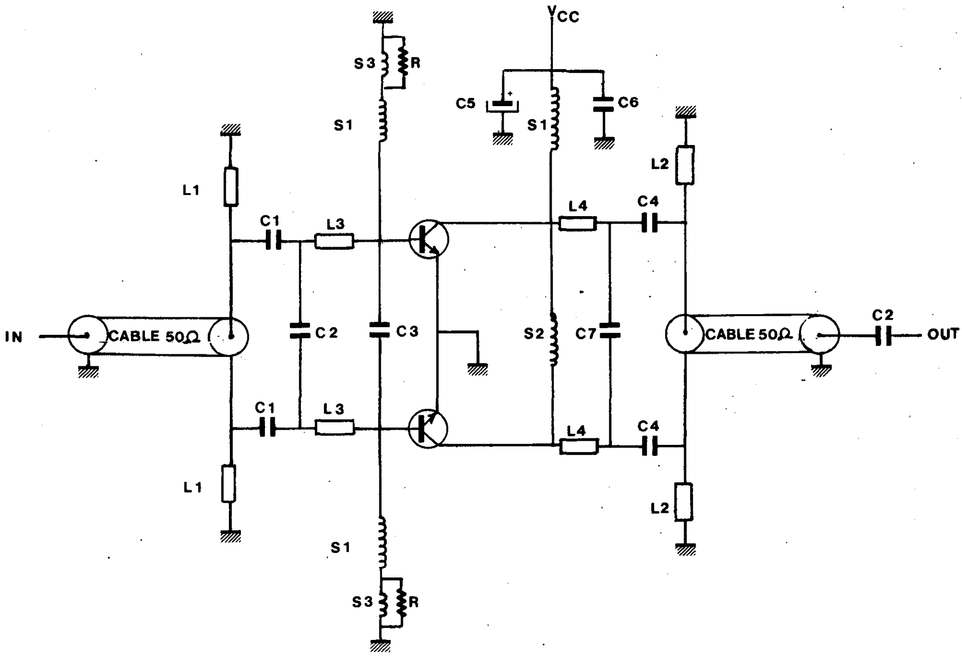








SCHEMATIC TPM 4130



$L_1 = L_4$ = 30 mm 50 Ω teflon coaxial cable soldered on L_2 and L_{12}.
$L_2 = L_3$ = 24 mm × 1,5 mm on substrate.
$L_4 = L_5$ = 6 × 2,5 mm on substrate.
L_9 = hair pin made with 24 mm of 5 mm wire (as close to the collectors as possible).
L_8 = 0.1 uH.
$L_{10} = L_{11}$ = 8 × 1,5 mm on substrate.
$L_{12} = L_{13}$ = 30 mm × 2,5 mm on substrate.

Substrate teflon-glass 1/16''. (ϵ_r = 2.55).

C_1 ATC 100B 39pF capacitors.
C_2 ATC 100B 27pF capacitors.
C_3 ATC 100B 47pF capacitor.
C_4 ATC 100B 33pF capacitor.
C_5 Electrolytic capacitor 10 μF 63V.
C_6 Chip capacitor 100 nf.
C_7 ATC 100B 22pF capacitor.
S_1 Inductor 0.8 mm wire 3.6 mm id.
S_2 Inductor 0,5 mm wire 24 mm long.
S_3 Inductor 1μH.
R Resistor 10Ω ± 10 % 1/4 W.
L_1 Microstrip lines 28.5 mm × 1.5 mm.
L_2 Microstrip lines 30 mm × 2.5 mm.
L_3 Microstrip lines 11 mm × 2.5 mm.
L_4 Microstrip lines 12 mm × 2 mm.

Teflon *coaxial* 50 Ω ∅ 1.8 mm 27.5 mm.

TV AND FM BROADCASTING

D

PRODUCT SUMMARY

PART NUMBER	CLASS	POWER (W)	LIN.* (dB)	GAIN (dB)	PACKAGE	PAGE
FM BAND II 88-108 MHz						
TP 9380	C	75	—	10	SOE 500F	D2
TP 9383	C	150	—	9	SOE 500F	D5
TV BAND III 170-230 MHz						
TPV 394	A	5	−58	15	SOE 280	D9
TPV 364	A	10	−54	10	SOE 380	D13
TPV 375	A	14	−55	8.5	SOE 500	D17
TPV 385	A	14	−53	14	JØ 500	D21
TPV 376	A	30	−53	7.5	SOE 500	D23
TPV 3100	A	30	−52	14	MRP 7	D27
TPV 3100	AB	100	1	11	MRP 7	D30
TV BAND IV-V 470-860 MHz						
TPV 590	A	0.250	−60	14	SOE 200	D33
TPV 591	A	0.5	−60	13	SOE 200	D37
TPV 596	A	0.5	−60	12	SOE 280	D41
TPV 597	A	1	−60	11	SOE 280	D45
TPV 593	A	2	−60	8.5	SOE 280	D49
TPV 598	A	4	−60	7	SOE 280	D53
TPV 595A	A	8	−58	8.5	BMA 2	D55
TPV 5051	AB	50	1	6	BMA 2	D61
ATV 5030	A	20	−51	7.5	ATV	D65
ATV 5080	AB	80	1	6	ATV	D69
TPVA 5060	A	50	−51	17	TPVA	D73

* Linearity specification

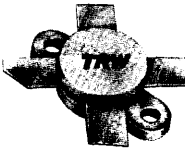
— Devices in Class A : 3 TONES TEST PRef
VISION − 8 dB
SOUND − 7 dB
SIDEBAND − 17 dB
} TRW Document N° 05001

— Devices in Class AB : GAIN COMPRESSION

TRW

FM Power Transistor

- 75 W
- 28 V
- 108 MHz
- High Gain
- RF Power Transistor
- NPN Silicon



500 SOE F

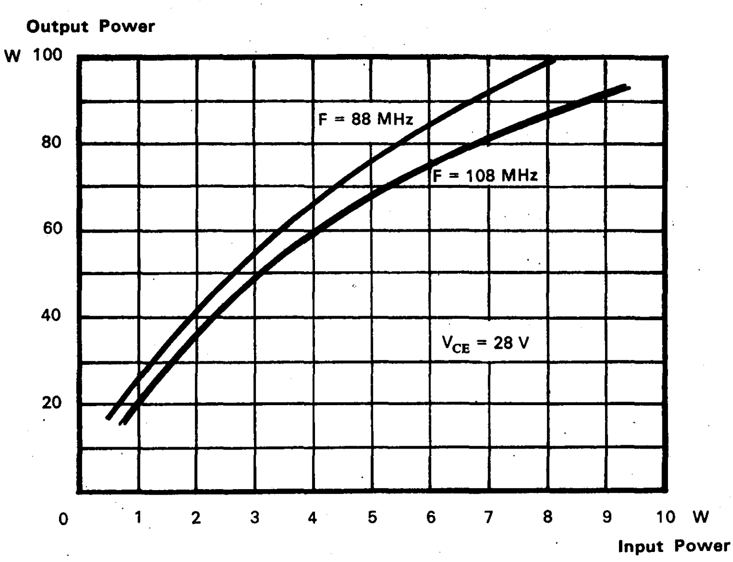
The TP 9380 is designed for use in the new generation of VHF-FM broadcast transmitters operating from a 28 V supply in class A, B or C.

Its construction, which now incorporates the new standard TRW process of gold metallization and diffused ballast resistors, ensures a long operational life even when run at its maximum ratings.

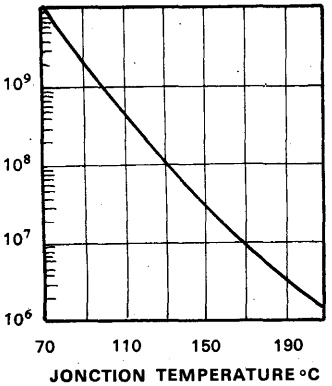
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_B = 10 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10 Ω	60			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
	H_{FE}	DC Current Gain	V_{CE} = 5 V I_C = 1 A	20		150	—
RF TEST	P_G	RF Power Gain	V_{CB} = 28 V P_{in} = 7 W F = 108 MHz	75			W
	η_C	Collector Efficiency	V_{CE} = 28 V P_{out} = 75 W F = 108 MHz	70	75		%
	C_{OB}	Output Capacitance	V_{CB} = 30 V F = 1 MHz			85	pF
	VSWR	Mismatch Tolerance (All phases)	V_{CB} = 28 V P_{out} = 75 W F = 108 MHz All phases	4 : 1			—
THERMAL	I_C	Maximum Collector Current				10	A
	θ_{jc}	Thermal Resistance Junction Case	T case = 70 °C			1.5	°C/W
	θ_{CH}	Thermal Resistance Case Heatsink				0.25	°C/W
	P_S	Power Dissipated	T heatsink = 25 °C			100	W
	T_{STG}	Storage and Junction Temperature		— 65		+ 200	°C

TYPICAL POWER OUTPUT vs POWER INPUT

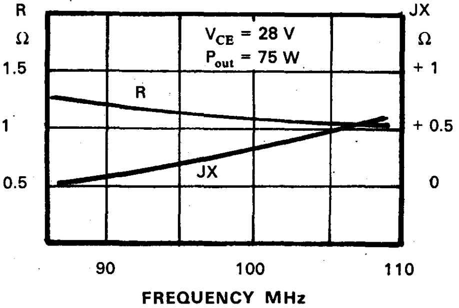


MTTF FACTOR vs Tj

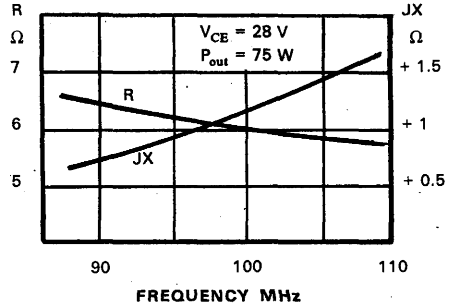


DIVIDE BY Ic2 TO OBTAIN METAL LIFETIME IN HOURS

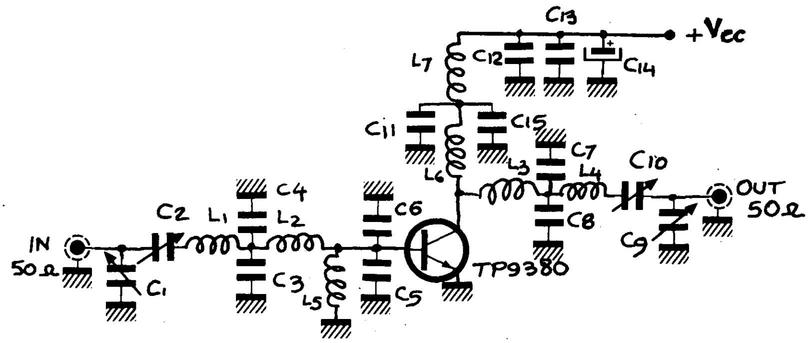
SERIES INPUT IMPEDANCE vs FREQUENCY



SERIES LOAD IMPEDANCE vs FREQUENCY



88-108 MHz NARROW BAND TEST FIXTURE

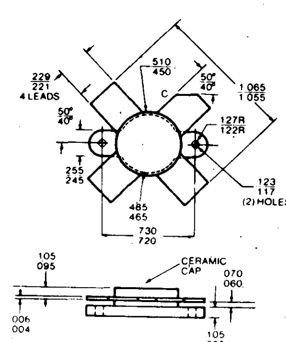


D

C₁ Arco 425 Variable capacitor (24 - 200 pF).

C_1	Arco 425 Variable capacitor (24 - 200 pF).
C_2	Arco 425 Variable capacitor (24 - 200 pF).
C_3	60 pF UNELCO.
C_4	60 pF UNELCO (108 MHz).
	100 pF UNELCO (88 MHz).
C_5	330 pF chip capacitor (closed to the transistor).
C_6	330 pF chip capacitor (closed to the transistor).
C_7	40 pF UNELCO.
C_8	40 pF UNELCO (108 MHz).
	80 pF UNELCO (88 MHz).
C_9	Arco 423 variable capacitor (7 - 100 pF).
C_{10}	Arco 425 variable capacitor (24 - 200 pF).
C_{11}	1 000 pF UNELCO.
C_{12}	1 000 pF UNELCO.
C_{13}	0.1 μF disc capacitor.
C_{14}	100 μF/40 V capacitor.
C_{15}	10 nF disc capacitor.

L_1	3 turns ID = 6 mm 1 mm wire.	
L_2	« Hair pin » made with a 1.4 mm wire	L = 15 mm
L_3	« Hair pin » made with a 2 mm wire	L = 20 mm for 108 MHz.
	« Hair pin » made with a 2 mm wire	L = 30 mm for 88 MHz.
L_4	3 turns ID = 8 mm 1.4 mm wire.	
L_5	0.7 μH chocke.	
L_6	6 turns ID = 6 mm 1.2 mm wire	L = 15 mm.
L_7	4 turns 1.2 mm wire on ferrite.	



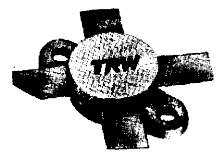
Use an ultra flat heatsink.

Use a few of silicon thermal grease.

PACKAGE 500 SOE F

FM Power Transistor

- 150 W
- 28 V
- 108 MHz
- High Gain
- RF Power Transistor
- NPN Silicon



500 SOE F

The TP 9383 is designed for use in the new generation of VHF-FM broadcast trasmitters operating from a 28 V supply in class A, B, or C.

Its construction, which now incorporates the new standard TRW process of gold metallization and diffused ballast resistors, ensures a long operational life even when run at its maximum ratings.

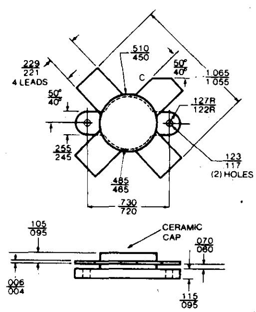
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 20 mA	4			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 100 mA	25			V
	BV_{CER}	Collector Emitter Breakdown Voltage	I_C = 100 mA R_{BE} = 10 Ω	55			V
	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 100 mA	60			V
	h_{FE}	DC current gain	V_{CE} = 6 V I_C = 1 A	20		150	—
RF TEST	P_{out}	Commun Emitter Amplifier output power	V_{CB} = 28 V P_{in} = 18 W F = 108 MHz	150			W
	η_C	Collector Efficiency	V_{CB} = 28 V P_{out} = 150 W F = 108 MHz	70	75		%
	C_{ob}	Output Capacitance	V_{CB} = 28 V F = 1 MHz			150	pF
	VSWR	Voltage Standing wave Ratio	V_{CE} = 28 V P_{out} = 100 W F = 108 MHz P_{out} = 150 W All phases	∞ 4 : 1			— —
THERMAL	$Rth_{J.C}$	Thermal Resistance Junction - Case	Pd = 100 W t = 25 °C t = 70 °C		0,75 0,9	1	°C/W
	$Rth_{C.H}$	Thermal Resistance Case - Heatsink			0,15		°C/W

Absolute Maximum Ratings

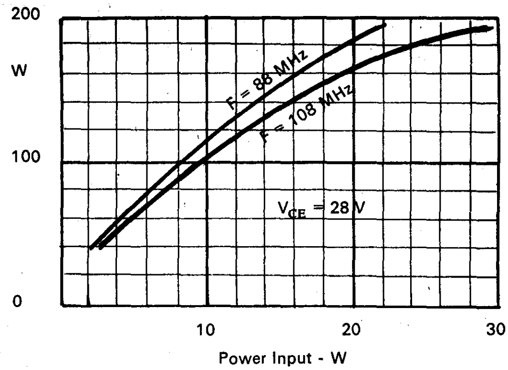
Emitter Base Voltage	V_{EB}	4 V
Collector Emitter Voltage	V_{CE}	35 V
Collector Base Voltage	V_{CB}	60 V
Collector Current	I_C	16 A
Total device power dissipation t_{case} = 25 °C	P_d	150 W
Storage and junction temperature	T_{STG}	— 65 to + 200 °C

TP 9383
500 SOE Flange

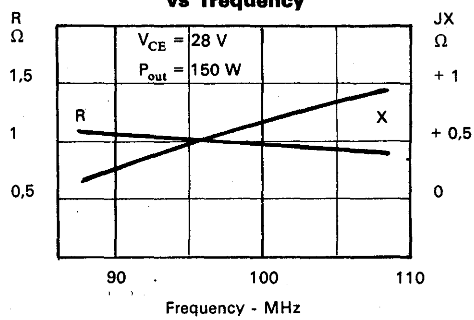


Use ultra flat heatsink. Make Stud hole as small as possible.
Use a few of silicon grease.

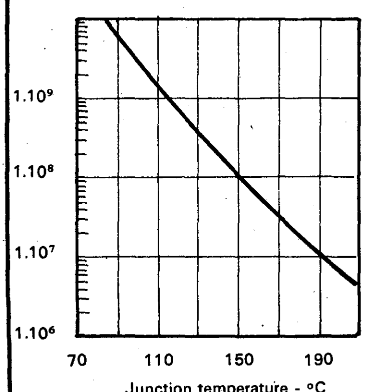
Power Output vs Power Input



Series Input Impedance vs frequency

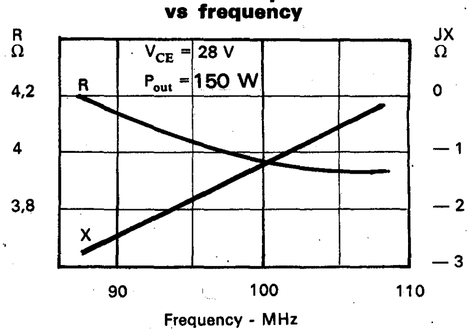


MTTF factor vs Tj

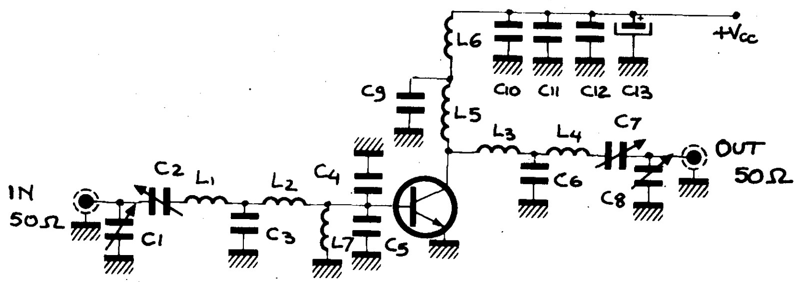


Divide by Ic^2 to obtain metal lifetime in hours.

Series load impedance vs frequency



Test circuit 88-108 MHz
Narrow band



C_1 ARCO 425 Variable capacitor 24-200 pF
C_2 ARCO 425
C_3 150 pF UNELCO
C_4 470 pF Chip capacitor (very close to the transistor) ATC
C_5 470 pF Chip capacitor (very close to the transistor) ATC
C_6 300 pF UNELCO
C_7 ARCO 425
C_8 ARCO 425
C_9 1000 pF UNELCO
C_{10} 1000 pF UNELCO
C_{11} 10000 pF
C_{12} 0.1 μF
C_{13} 100 μF/40 V electrolytic

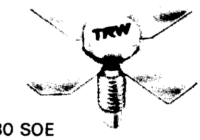
L_1 3 turns 6 mm ID 1.2 mm wire
L_2 2 cm wire 1.2 mm Ω (hair pin)
L_3 1.2 cm wire 1.2 mm Ω (hair pin)
L_4 3 turns 6 mm ID 1.2 mm wire
L_5 6 turns 8 mm ID 1.5 mm wire
L_6 6 turns 1.5 mm wire on ferrite core
L_7 10 μF chocke

D

TRW

VHF Linear Transistor

- 5 W at - 58 dB IMD
- 16 dB Gain
- TV Transposer and Transmitter
- Band 3



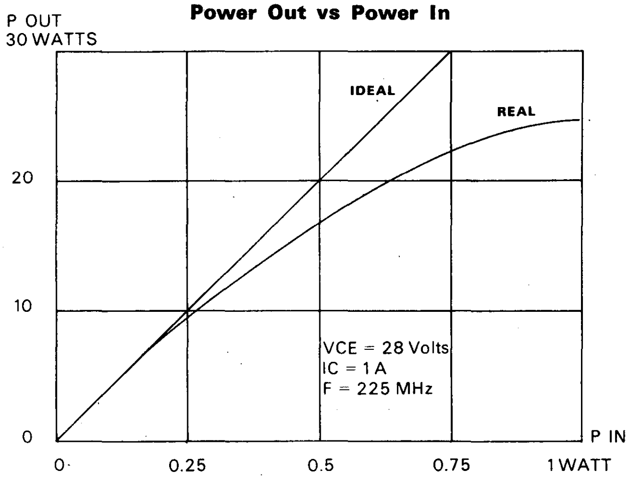
280 SOE

The TPV 394 is a NPN gold metallized transistor using diffused ballast resistors for super linearity. This transistor is designed for **medium power band 3 TV transposers.** The TPV 394 is used in the output stage of 10 W transposers or in the driver stages of higher power transposers and transmitters. Its exceptional **high gain** reduces the complexity of driver stages.

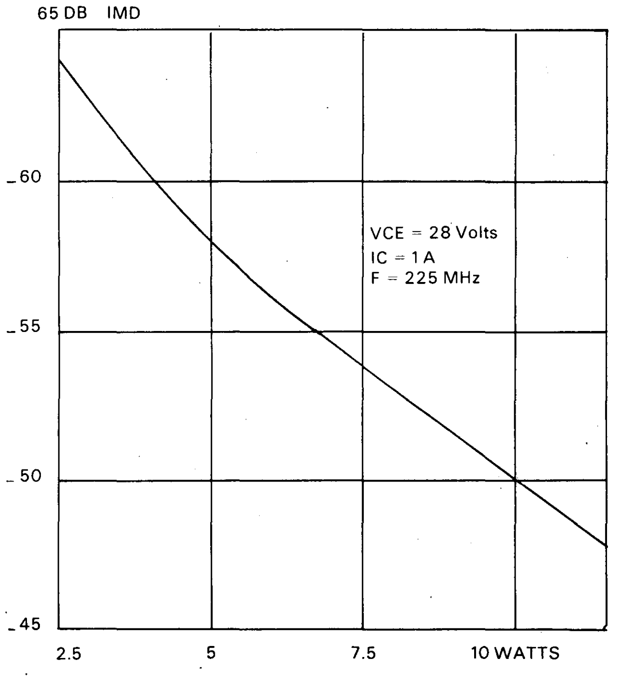
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	[redacted]	4			[redacted]
	BV_{CEO}	Collector - Emitter Breakdown Voltage	[redacted]	30			[redacted]
	BV_{CER}	Collector - Emitter Breakdown Voltage	[redacted]	55			[redacted]
	BV_{CBO}	Collector - Base Breakdown Voltage	[redacted]	55			[redacted]
	h_{FE}	D.C. Current Gain	[redacted]	10			[redacted]
RF Test	IMD 1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband Carrier = Reference - 16 dB	[redacted]			— 58	[redacted]
	IMD 2	Idem	[redacted]			— 50	[redacted]
	P_G	Power Gain	[redacted]	15	16		[redacted]
	VSWR	Mismatch Tolerance	[redacted]		∞		[redacted]
	C_{OB}	Collector - Base Capacitance	[redacted]			35	[redacted]
Thermal	I_C	Maximum Collector Current	[redacted]			4	[redacted]
	θ_{JC}	Thermal Resistance Junction - Case	[redacted]			2.5	[redacted]
	θ_{CH}	Thermal Resistance Case - Heatsink	[redacted]			1.0	[redacted]
	P_T	Dissipated Power	[redacted]			50	[redacted]
	T_{STG} T_J	Storage Temperature Junction Temperature	[redacted]	— 65		+ 200	[redacted]

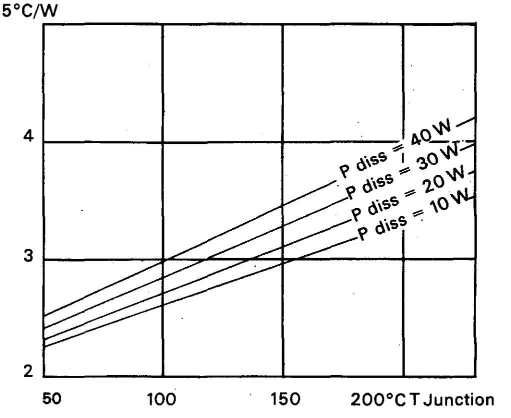
Power Out vs Power In



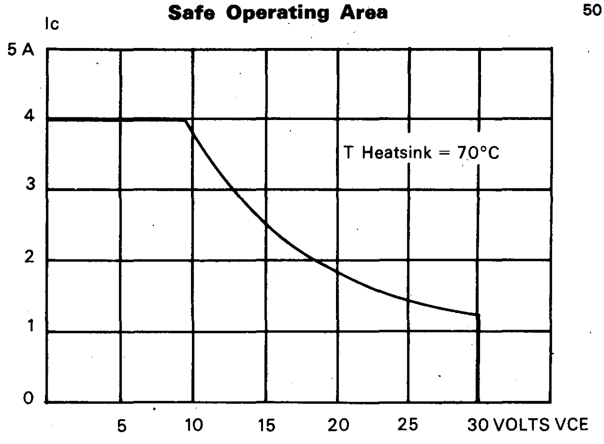
Intermodulation Distortion vs Power Out



Thermal Resistance Junction Heatsink vs Temperature of Junction for Various Power's Dissipated

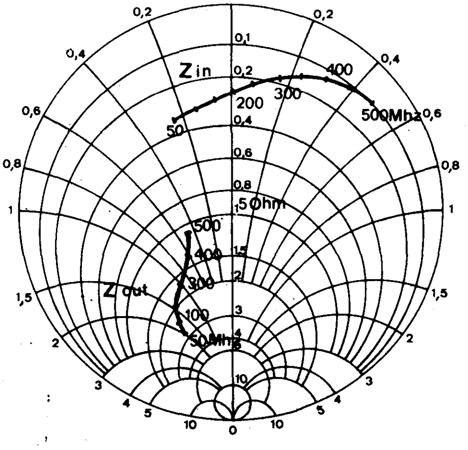


Safe Operating Area

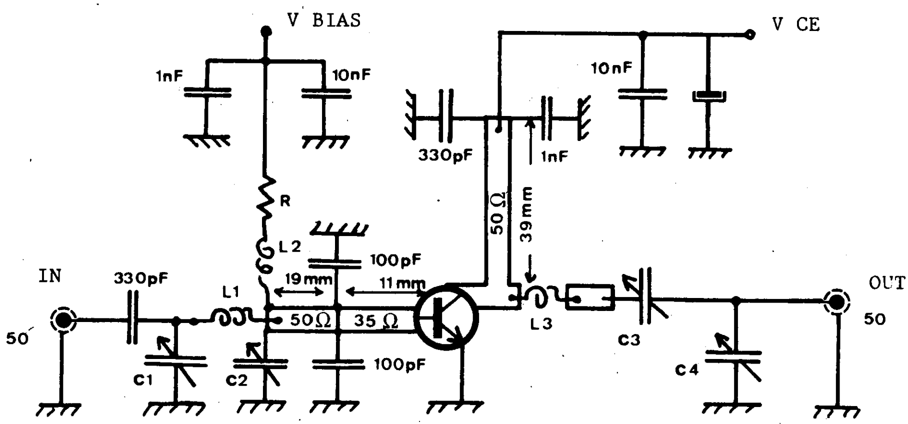


Large Signal Impedances vs Frequency

V_{CE} = 28 V - I_C = 1 A



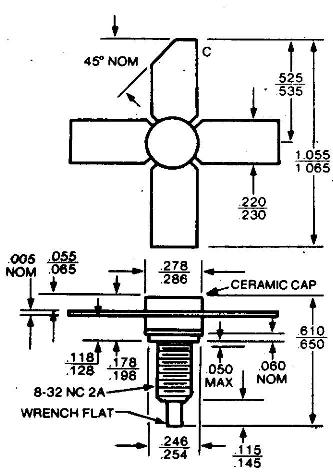
TEST CIRCUIT AT F = 225 MHz



Lines are printed on G 10 epoxy glass material

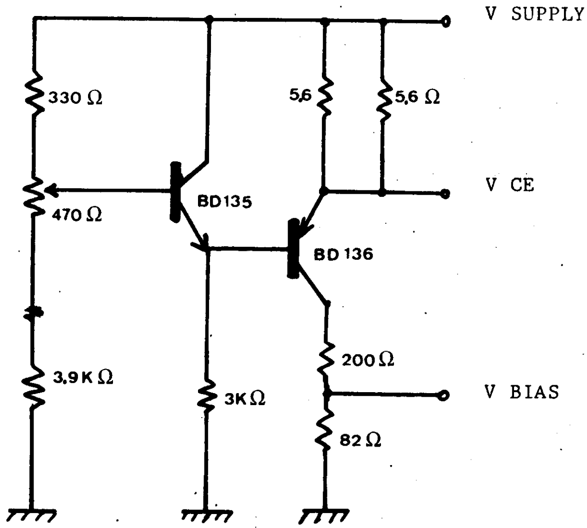
$C_{1,4}$	ARCO 403
C_2	ARCO 404
C_3	ARCO 423
L_1	1 turn 1/2 I.D. = 5 mm
L_2	RFC 10 turns I.D. = 5 mm
L_3	1.5 mm shaped :

Package Outline



To convert inches to millimeters multiply by 2.54.

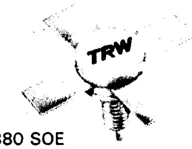
CLASS A BIAS CIRCUIT



TRW

VHF Linear Transistor

- 10 W at - 55 dB IMD
- 10 dB Gain
- TV Transposer and Transmitter
- Band 3



380 SOE

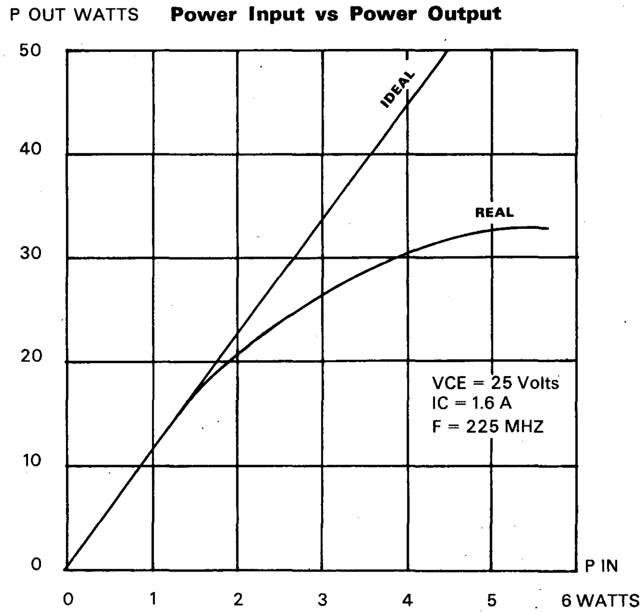
The TPV 364 is a NPN gold metallized transistor using diffused ballast resistors for super linearity. This transistor is designed for high power band 3 TV transposers and transmitters.

The TPV 364 is used in the final stages of 20 W transposers or in the driver stages of 100 W plus transposers and transmitters. Its high gain allows to reduce the complexity of lower power stages.

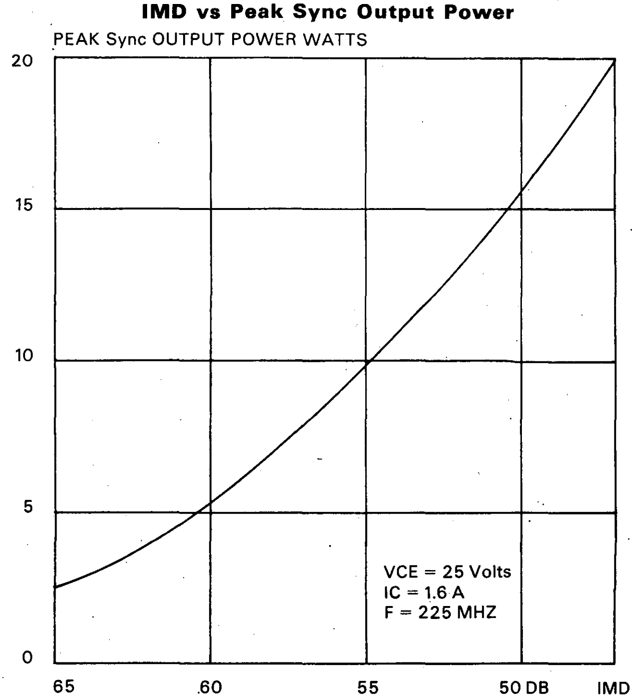
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP.	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 10 mA	4			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
DC Test	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10 ohms	65			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
DC Test	h_{FE}	D.C Current Gain	V_{CE} = 6 V I_C = 1000 mA	20		120	
RF Test	IDM_1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband Carrier = Reference - 16 dB	F = 225 MHz V_{CE} = 25 V I_C = 1.6 A P_{REF} = 10 W TRW DOCUMENT 05001			- 54	dB
RF Test	IMD 2	Idem	F = 225 MHz V_{CE} = 25 V I_C = 1.6 A P_{REF} = [illegible] W			— 52	dB
RF Test	P_G	Power Gain 10 REF	F = 225 MHz V_{CE} = 25 V I_C = 1.6 A	10			dB
RF Test	VSWR	Mismatch Tolerance	P_{REF} = 20 W F = 225 MHz V_{CE} = 25 V I_C = 1.6 A P_{REF} = 15 W		∞		
RF Test	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz		58	85	[illegible]
Thermal	I_C	Maximum collector current				9	A
Thermal	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C			2.0	°C/W
Thermal	θ_{CH}	Thermal Resistance Case - Heatsink				0.5	°C/W
Thermal	P_T	Dissipated Power	[illegible] = 25 °C			70	W
Thermal	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	[illegible]

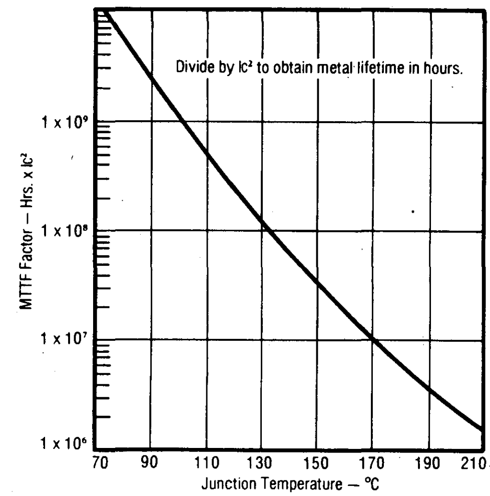
Power Input vs Power Output



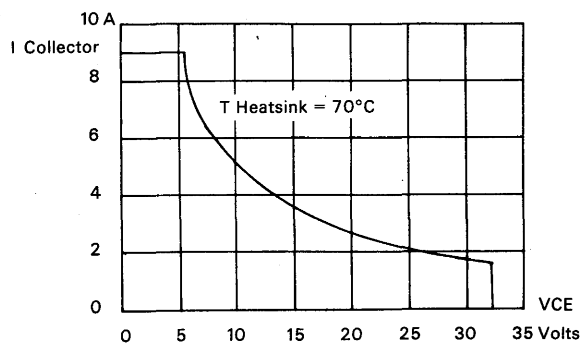
IMD vs Peak Sync Output Power



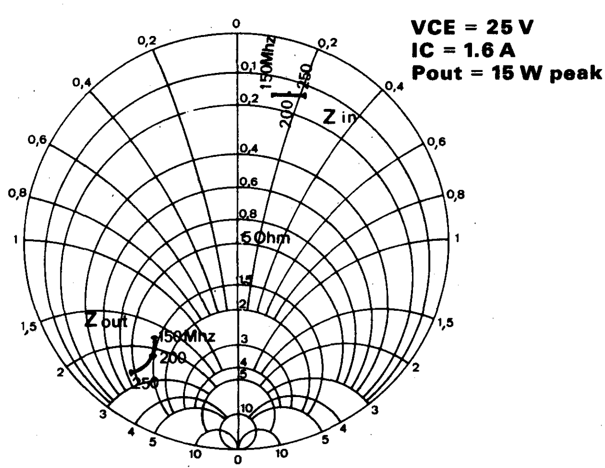
MTTF Factor vs Tj



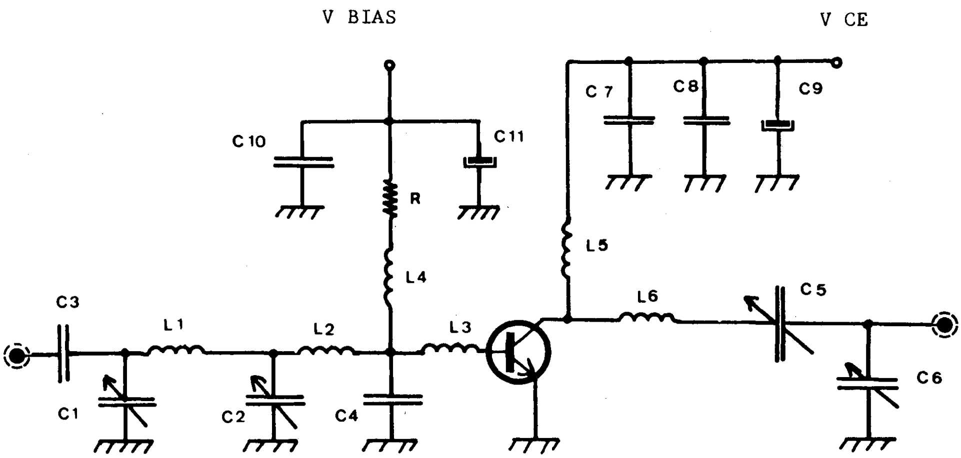
Safe Operating Area



Large Signal Impedances vs Frequency

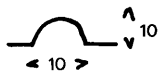


TEST CIRCUIT FOR 225 MHz

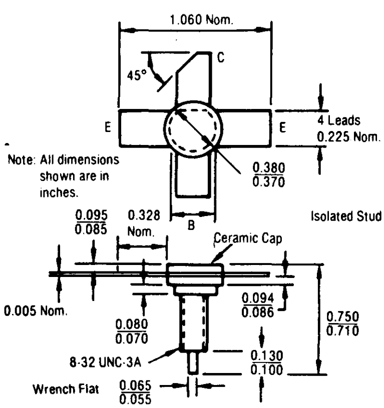


C_1	ARCO 403
$C_{2,6}$	ARCO 404
C_5	ARCO 423
$C_{3,7}$	chip capacitor 470 pF
C_4	UNELCO-capacitor 80 pF
$C_{8,10}$	UNELCO-capacitor 1000 pF
$C_{9,11}$	100 μF electrolytic - 63 V
R	4.7 ohms - 1/2 W

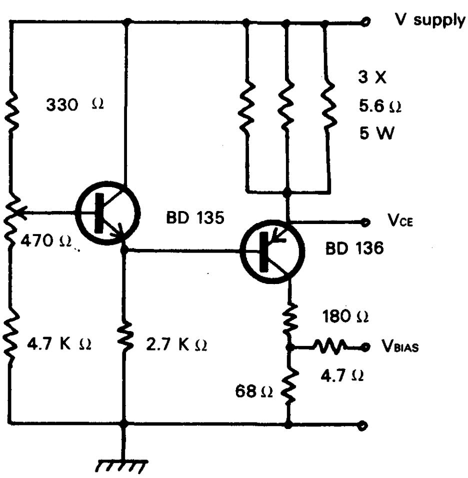
L_1	1.5 turns closely wound - Cu wire 1 mm - I.D. 5 mm
L_2	2.5 cm - 50 ohms line
L_3	length of the base lead
L_6	Cu wire 1.5 mm
L_5	3 cm - 50 ohms line
L_4	5 turns closely wound - Cu wire 8 mm - I.D. 5 mm



380 SOE



BIAS CIRCUIT

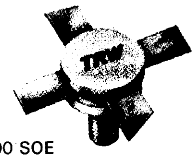


TPV 375

TRW

VHF Linear Transistor

- 20 W at - 51 dB IMD
- 14 W at - 55 dB IMD
- High Saturation Power
- TV Transposer and Transmitter
- Band 3



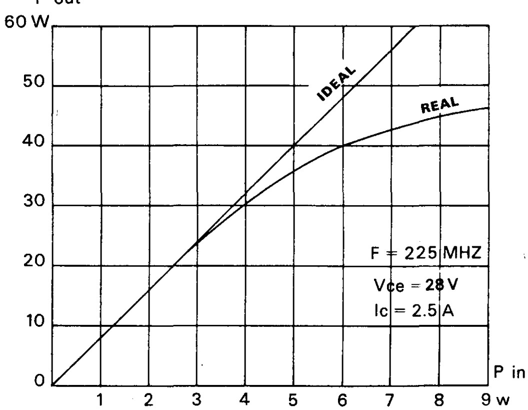
500 SOE

The TPV 375 is a NPN gold metallized transistor using diffused ballast resistors for super linearity. The TPV 375 is specifically designed for **high power band 3. TV transposers and transmitters amplifiers.** Due to its high saturation power (over 70 watts), the TPV 375 shows good linearity characteristics at powers over 25 W. This performance allows to build a 50 W transposer using 2 TPV 375 in parallel with linearity correction circuit.

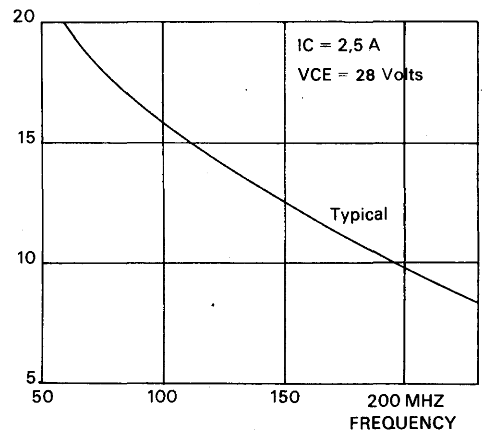
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP.	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 10 mA	4			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
DC Test	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10 ohms	60			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
DC Test	h_{FE}	D.C. Current Gain	V_{CE} = 5 V I_C = 1000 mA	20		120	
RF Test	IMD 1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband Carrier = Reference - 16 dB	F = 225 MHz V_{CE} = 28 V I_B = 2.5 A P_{REF} = 14 W TRW DOCUMENT 08001			— 55	dB
RF Test	IMD 2	Idem	F = 225 MHz V_{CE} = 28 V I_B = 2.5 A P_{REF} = 20 W			— 51	dB
RF Test	P_G	Power Gain	F = 225 MHz V_{CE} = 28 V I_B = 2.5 A P_{REF} = 20 W	8	9		dB
RF Test	VSWR	Mismatch Tolerance	F = 225 MHz V_{CE} = 28 V I_B = 2.5 A P_{REF} = 20 W		∞		
RF Test	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz		58	85	pF
Thermal	I_C	Maximum Collector Current				10	A
Thermal	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C			1.5	°C/W
Thermal	θ_{CH}	Thermal Resistance Case - Heatsink				0.25	°C/W
Thermal	P_T	Dissipated Power	$T_{HEATSINK}$ = 25 °C			100	W
Thermal	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C

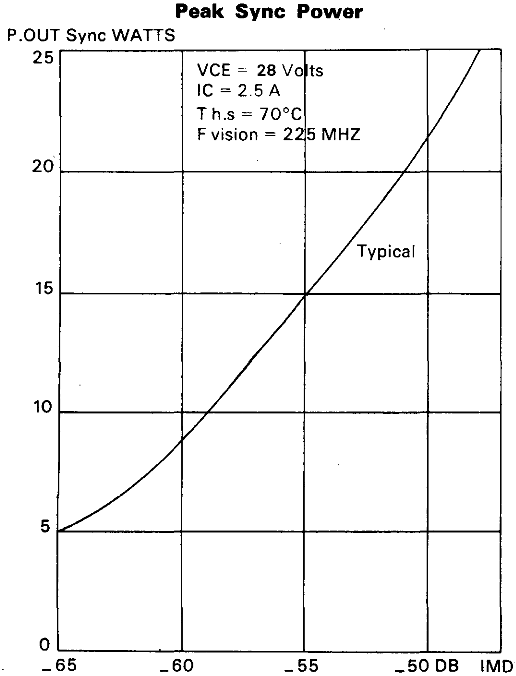
Power Output vs Power Input



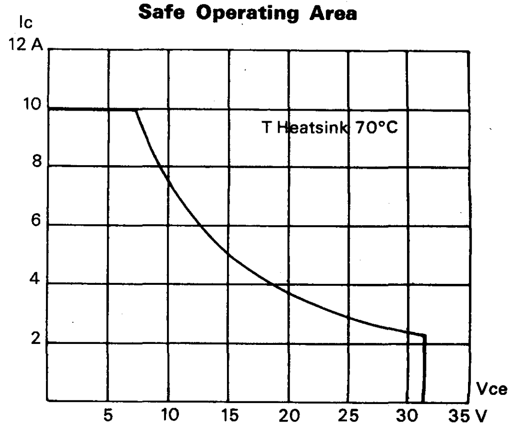
Power Gain vs Frequency



Intermodulation Distortion vs Peak Sync Power

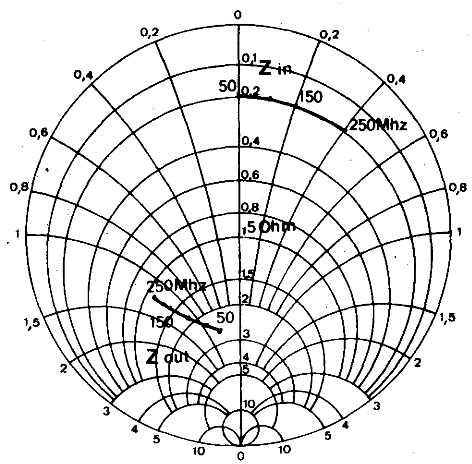


Safe Operating Area

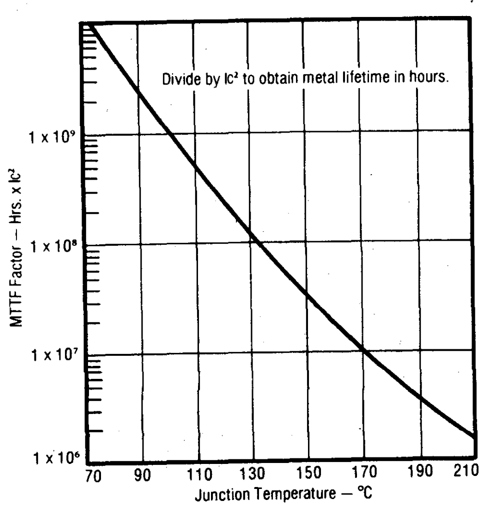


Large signal Impedances vs Frequency

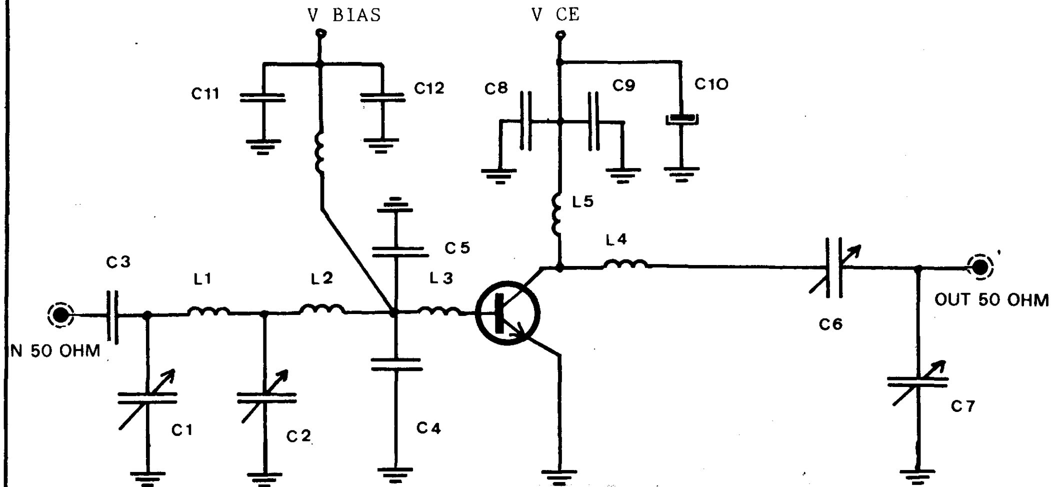
V_{CE} = 28 V - I_C = 2.5 A



MTTF Factor vs Tj



TEST CIRCUIT FOR F = 225 MHz

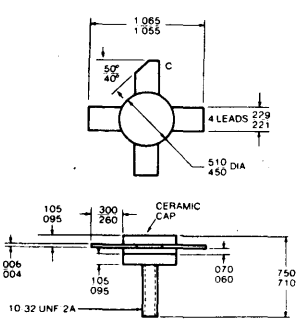


$C_{1,7}$	ARCO 403
C_2	ARCO 404
$C_{3,8}$	chip capacitor 470 pF
$C_{4,5}$	UNELCO 80 pF
C_6	ARCO 423
$C_{9,11}$	UNELCO 1000 pF
C_{10}	470 μF electrolytic
C_{12}	10 nF

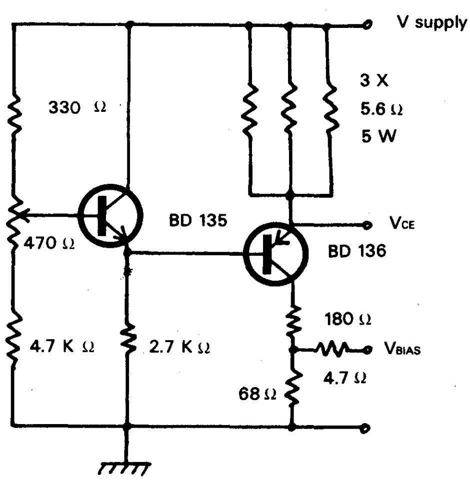
L_1	1.5 turns closely wound. Cu wire 0.7 mm I.D. 4.5 mm
L_2	2.1 cm - 50 ohms - line
L_3	length of the base lead
L_4	Cu wire 1.6 mm (10, 8)
L_5	3.5 cm - 50 ohms line
L_6	4 turns closely wound Cu wire 0.8 mm I.D. 4.5 mm

PACKAGE OUTLINE

.500 SOE



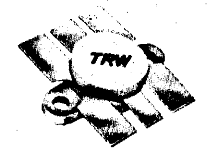
BIAS CIRCUIT



TRW

UHF Linear Transistor

- 14 W at - 53 dB
- 14 dB Gain
- TV Transposer and Transmitter
- Band 3



J⌀ 500

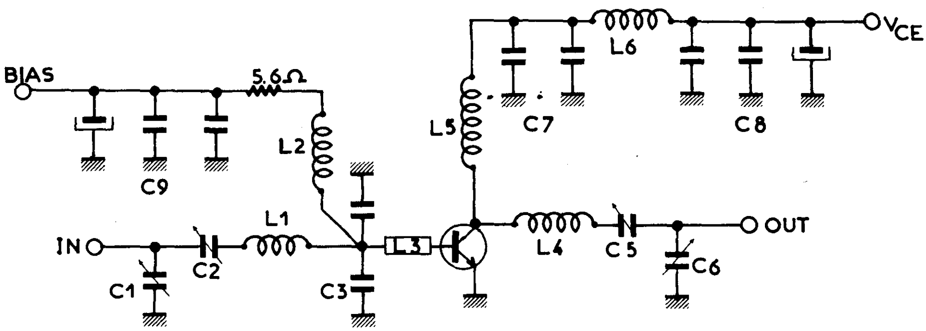
The TPV 385 is a NPN gold metallized transistor using diffused ballast resistors for super linearity. The TPV 385 is specifically designed for high power band III TV transposers and transmitters amplifiers. Due to its very high gain, the number of transistors per line-up is reduced.

Its internal matching makes easier a band III broadband circuit.

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 10 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10	60			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1 A	20		100	
RF Test	IMD	Intermodulation Distortion 3 tone vision = -- 8 dB sound = — 7 dB sideband = — 16 dB	**TRW DOCUMENT 05001** F_O = 225 MHz V_{CE} = 28 V I_E = 2.5 A			— 53	dB
	P_G	Power Gain	P_{REF} = 14 W	14	15		dB
	VSWR	Mismatch Tolerance			∞		
	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz		65	85	pF
Thermal	I_C	Maximum Collector Current				10	A
	θ_{JC}	Thermal Resistance Junction Case	T_{case} = 70 °C			1.5	°C/W
	T_{STG}	Storage Temperature		— 65		+ 200	°C

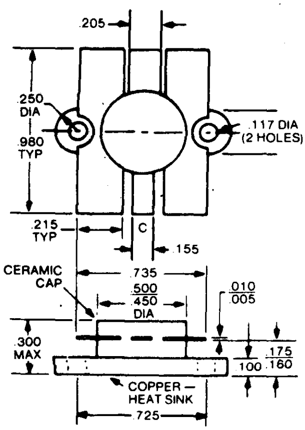
TEST CIRCUIT FOR 225 MHz CLASS A

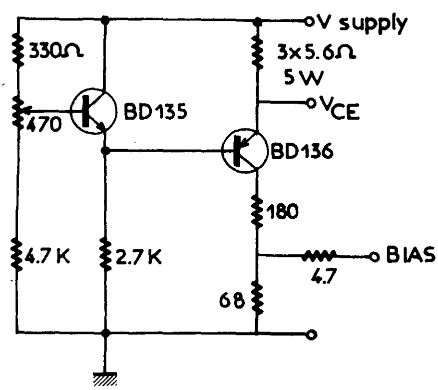


C_1 = C_6 = ARCO 404
C_2 = C_5 = ARCO 423
C_3 = C_4 = UNELCO 80 pF
C_7 = 1 nF + 47 nF
C_8 = C_9 = 1 nF + 0.1 μF + 47 μF

L_1 = 2 turns - ID 6 mm - wire 1 mm
L_1 = 1 turn - ID 10 mm - wire 1 mm
L_2 = 6 turns - ID 6 mm - wire .6 mm
L_3 = base inductance PAD - L = 10 mm W = 5 mm
L_5 = 1 turn - ID 6 mm - wire 1.5 mm
L_6 = 2 turns on ferrite core - wire 1.5 mm

J-Zero-C Package Outline

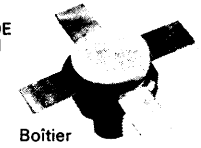




TRW

UHF Linear Transistor

- 30 W at - 53 dB IMD
- 8 dB Gain
- Class A or AB
- Band 3

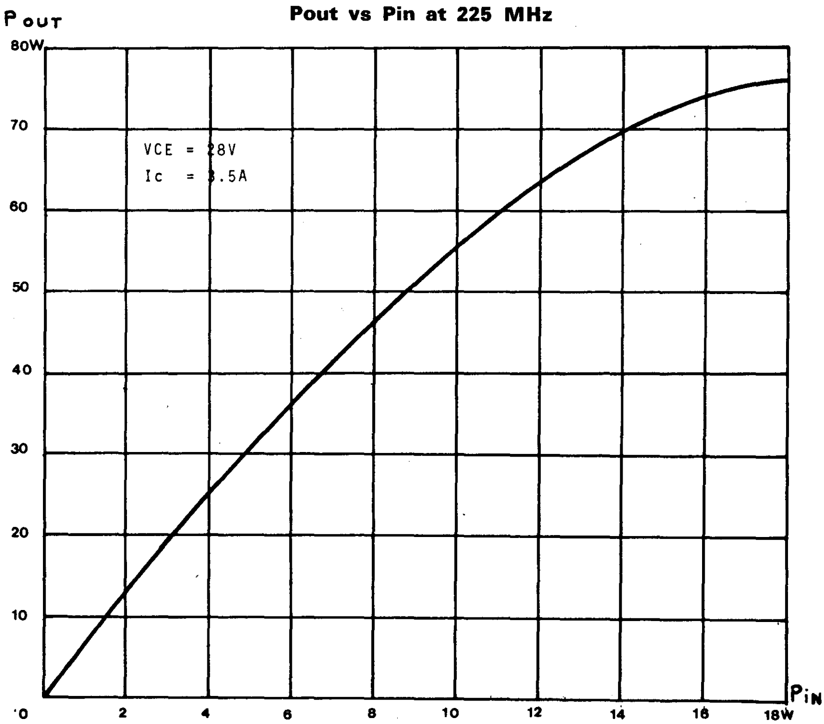


TPV 376 is a gold metallized NPN silicon transistor using high value diffused emitter ballast resistors. It is packaged in a low thermal resistance header. A combination of state of the art die mounting technique and on-line 100 percent thermal resistance testing ensures unsurpassed long term reliability. The above features make TPV 376 the highest Power transistor available for **class A and class AB band 3 TV transmitters and transposers** applications.

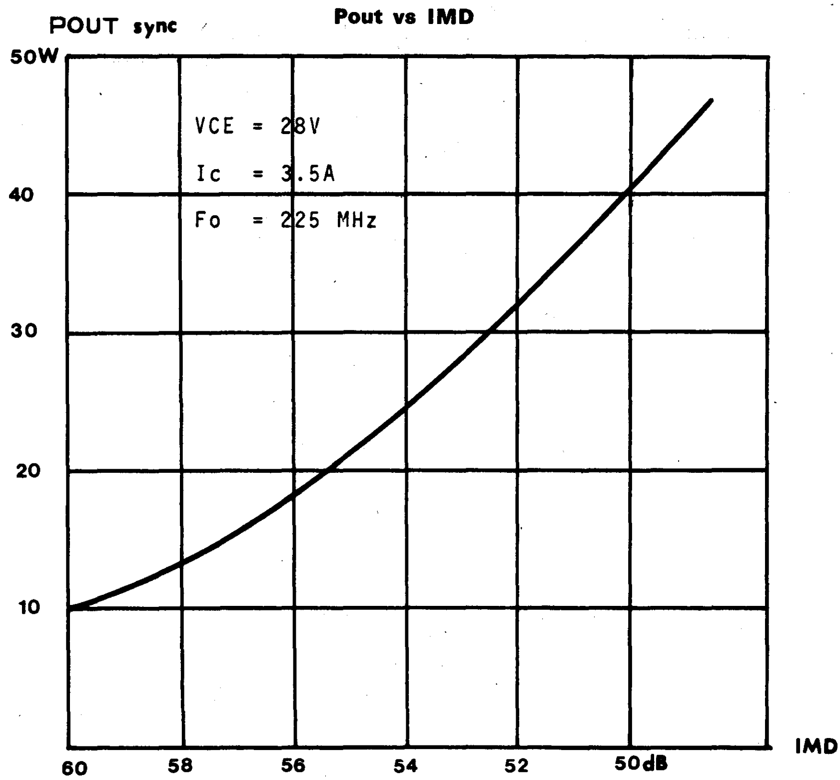
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
D C Test	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 20 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 100 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 100 mA R_{BE} = 10 ohms	60			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100 mA	65			V
	h_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1000 mA	20		120	
R F Test	IMD 1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband = Reference - 16 dB	F = 225 MHz V_{CE} = 28 V I_E = 3.5 A P_{REF} = 30 W TRW DOCUMENT 08001			– 53	dB
	P_G	Power Gain	F = 225 MHz V_{CE} = 28 V I_E = 3.5 A P_{REF} = 20 W	7.5		8	dB
	VSWR	Mismatch Tolerance	F = 225 MHz V_{CE} = 28 V I_E = 3.5 A P_{REF} = 20 W	∞			
	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz		100	150	pF
Thermal	I_C	Maximum Collector Current			16		A
	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C		0.9	1	°C/W
	θ_{CH}	Thermal Resistance Case - Heatsink					°C/W
	P_T	Dissipated Power	$T_{HEATSINK}$ = 25 °C		150		W
	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C

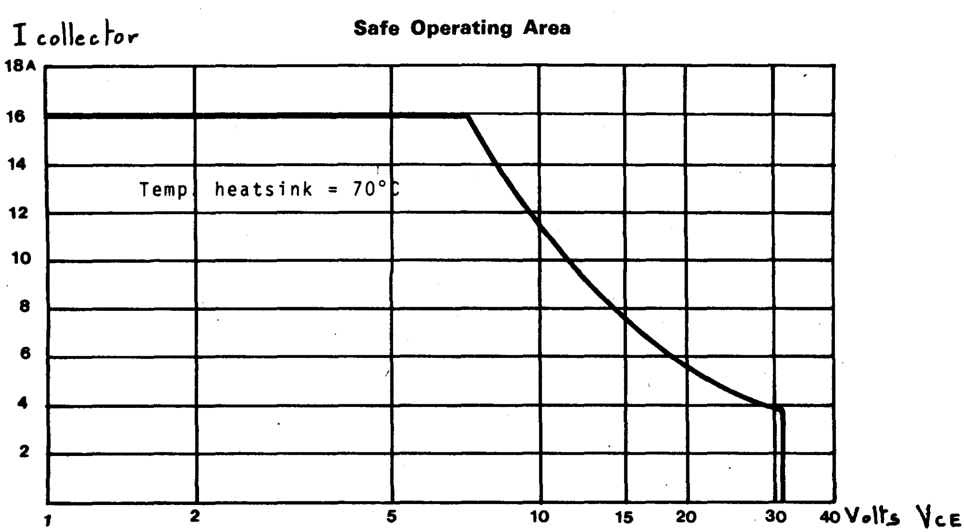
Pout vs Pin at 225 MHz



Pout vs IMD



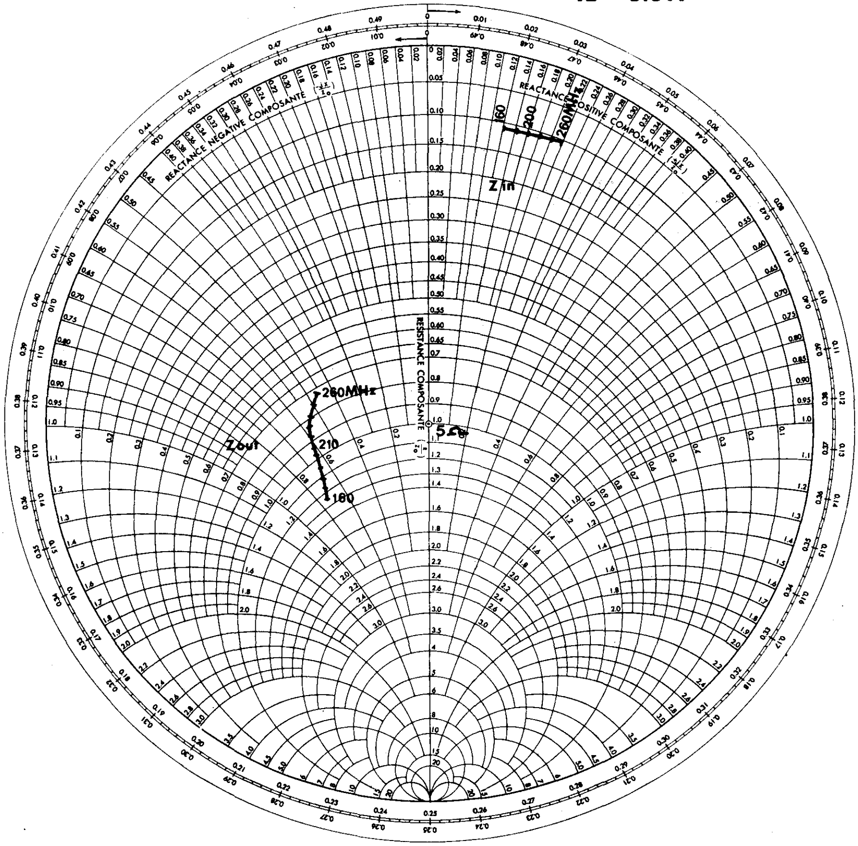
Safe Operating Area



D

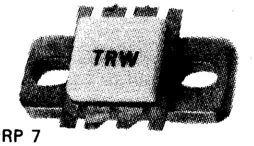
Large Signal Zout Zin

VCE = 28 V
IE = 3.5 A



VHF Linear Power Transistor

- Band 3
- TV Transmitter
- High Gain
- Class A - AB
- Push-Pull Transistor


MRP 7

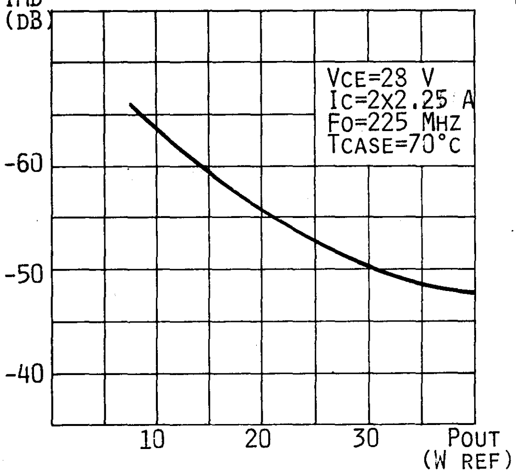
TPV 3100 is a gold metallized NPN silicon push-pull transistor packaged on a very low thermal resistance header.
The use of high value diffused emitter ballast resistors, state of the art die mounting technology and 100 % mechanical thermal and electrical test ensures long term reliability. This devide combines very high gain, easy circuit design, ruggedness and linearity.
It is an ideal candidate for VHF Band III vision and/or sound amplifiers.

Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_C = 5 mA	3.5			V
DC TEST	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
DC TEST	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 15 Ohms	60			V
DC TEST	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 50 mA	65			V
DC TEST	H_{FE}	DC Current Gain	V_{CE} = 28 V, I_C = 0.5 A	20		150	–
RF TEST	P_G	Power Gain	V_{CE} = 28 V, I_C = 4 A 2×2.25 A	14			dB
RF TEST	I_{MD}	Intermodulation Dist. 3 tones	F = 225 MHz (−8, −7, −16 dB Tones)			−51	dB
RF TEST	VSWR	Mismatch Tolerance	Pref = 28 W			∞	–
RF TEST	P_{OUT}	Output Power Class AB 1 dB Gain Compression	V_{CE} = 28 V, F = 225 MHz I_Q = 2×100 mA	100			W
RF TEST	C_{OB}	Collector Base Capacitance Each side	V_{CB} = 28 V, F = 1 MHz		60		pF
THERMAL	I_C	Maximum Collector Current Each side				8	A
THERMAL	θJ_C	DC Thermal Resistance Junction Case	T_{CASE} = 70 °C			0.8	°C/W
THERMAL	T_{STG}	Storage temperature		−65		+200	°C

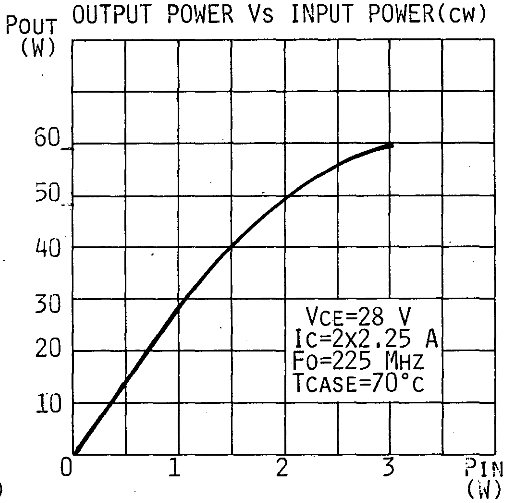
TYPICAL VALUES CLASS A

IMD Vs OUTPUT POWER



IMD: 3 TONES (-8 -7 -16dB)

OUTPUT POWER Vs INPUT POWER(cw)



LARGE SIGNAL IMPEDANCES

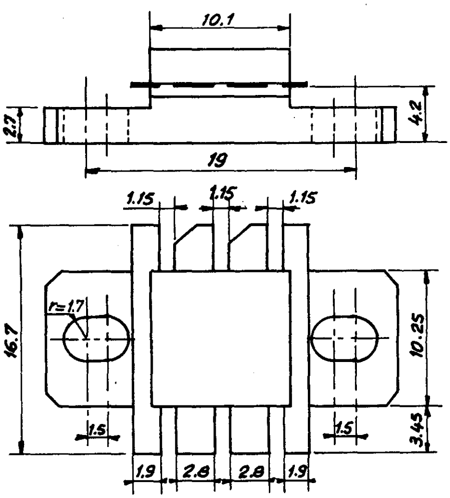
FO(MHZ)	ZIN(OHMS)	ZLOAD(OHMS)
170	1+J0.6	14.5+J10
200	.9+J1	12.5+J7
230	1.2+J2	10.5+J8.2

__NOTES:__ VCE=28V IC=2x2.25 A

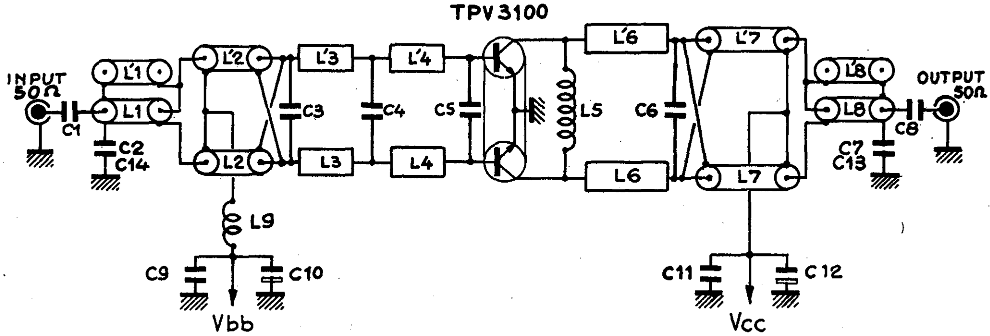
ZIN: VALUES FOR OPTIMUM INPUT RETURN LOSS.

ZLOAD: VALUES FOR BEST IMD AT 28 W REF.

PACKAGE OUTLINE

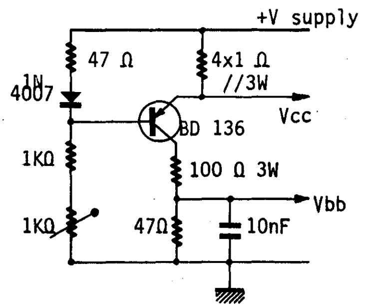


TEST FIXURE CLASS A OPERATION



L_1, L_8	80 mm teflon coaxial cable 50 ohms
L_2, L_7	80 mm teflon coaxial cable 25 ohms
L_3	25 mm line W = 1.5 mm on substrate
L_4	5 mm line W = 1.5 mm on substrate
L_5	5 turns dia 5 mm - 0.8 mm wire - L = 5 mm
L_6	33 mm line W = 2 mm on substrate
L_9	10 turns dia 3 mm - 0.5 mm wire
C_1, C_2	4700 pF chip capacitor
C_7, C_8	4700 pF chip capacitor
C_3	68 pF chip capacitor
C_4	100 pF chip capacitor
C_5	220 pF + 22 pF chip capacitor
C_6	33 pF chip capacitor
C_9, C_{11}	1000 pF + 10 nF + 0.1 μF chip capacitor
C_{10}	1000 μF 5 V
C_{12}	1000 μF 6 V
C_{13}, C_{14}	0.1 μF chip capacitor substrate teflon-glass 1/50 inch.

BIASING CIRCUIT



LARGE SIGNAL IMPEDANCES

CLASS AB

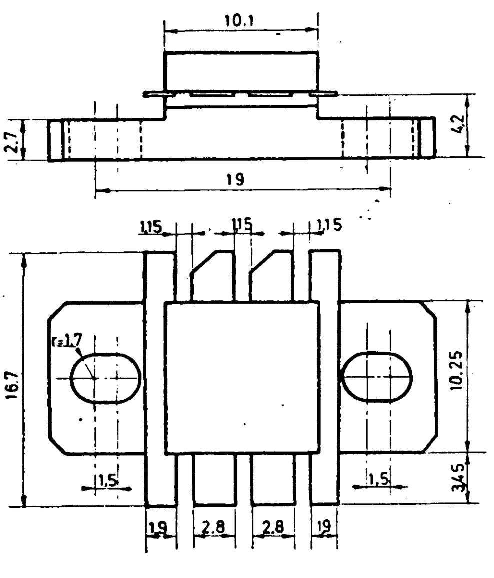
FREQUENCY (MHz)	Z_{in} (Ω)	Z_{Load} (Ω)
170	1.25 + j 0.5	10 + j 10
200	0.9 + j 0.9	9.5 + j 7
230	1 + j 2	6.5 + j 6.5

NOTES : V_{CE} = 28 Volts I_q = 2 × 100 mA P_{out} = 100 W

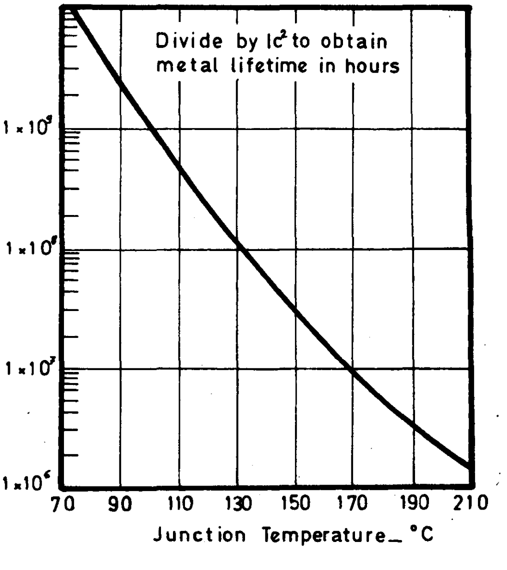
— Z_{in} values to get optimum input return loss

— Z_{Load} values to get optimum output power and efficiency

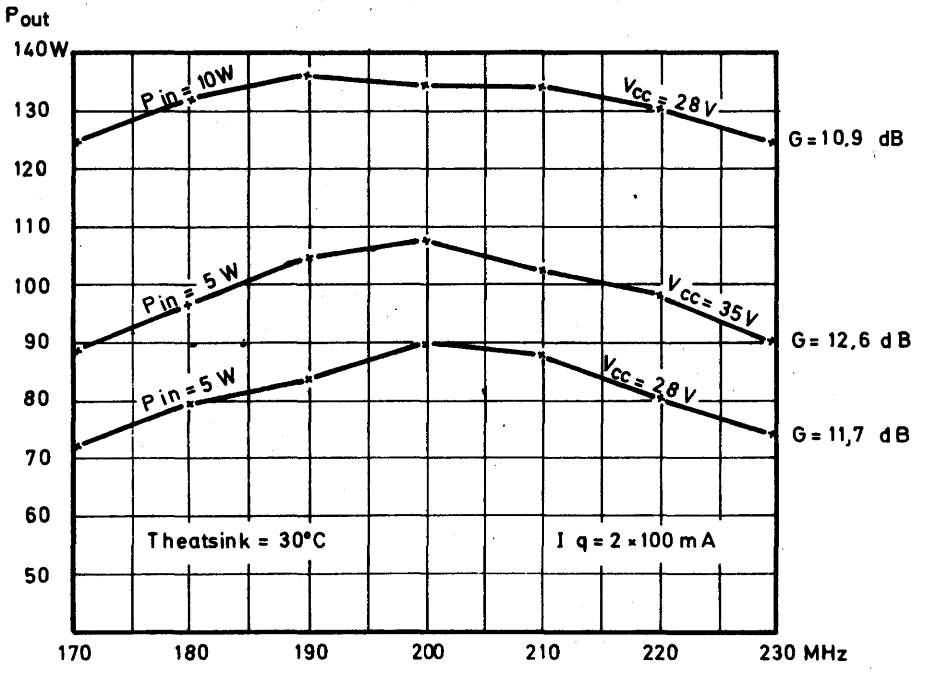
Package Outline



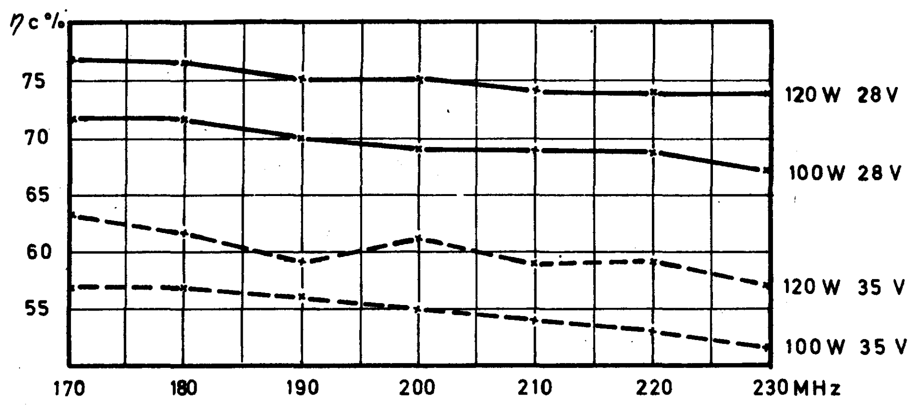
MTTF vs Junction Temperature



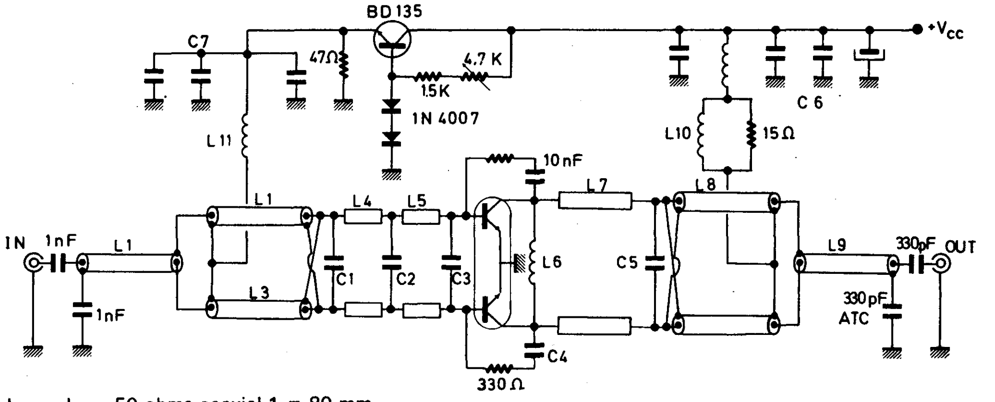
Typical Performances Class AB



Collector Efficiency vs Frequency



170-230 MHz BROADBAND AMPLIFIER CLASS AB

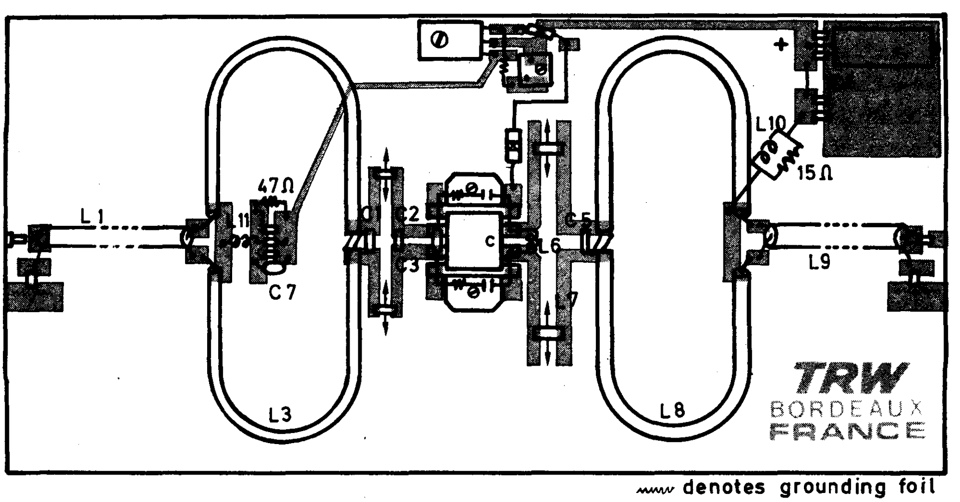


L_1 = L_9 = 50 ohms coaxial 1 = 80 mm
L_2 = L_3 = L_8 = 25 ohms coaxial cable or semi-rigid 1 = 80 mm
L_4 = 40 ohms line 2.5 % of λg 225 MHz or 1 = 23 mm sub 1/50 inch teflon glass
L_5 = 40 ohms line 65 % λg 225 MHz or 1 = 6 mm
L_6 = 3 turns ID 4 mm wire 1 mm ⌀ leads 5 mm long
L_7 = 40 line 3.5 % λg 225 MHz or 1 = 32 mm 1/50 teflon glass
L_{10} = 11 turns ID 4 mm wire 1 mm ⌀
L_{11} = .22 μH molded inductor

C_1 = 68 pF ATC 100B
C_2 = 100 pF ATC 100B
C_3 = 220 pF ATC 100B
C_5 = 27 pF + 33 pF ATC 100A
C_6 = C_7 = 1 nF + 10 nF + .1 μF + ELECTROLYTIC

L_4 has to be adjusted for Gain
L_6 and L_7 have to be adjusted for the best lead

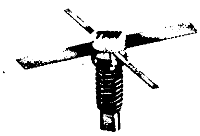
Components Layout



denotes grounding foil

UHF Linear Transistor

- **0.25 W - Band 5**
- **14 dB Gain at 860 MHz**
- **Gold Reliability**
- **TV Transposer**


.200 SOE

The TPV 590 is a NPN gold metallized transistor using emitter ballast resistors for super linearity. The fine chip geometry gives typical gain in excess of 14 dB at 860 MHz.

These characteristics make TPV 590 an ideal candidate for very efficient low power stages in UHF transposers applications.

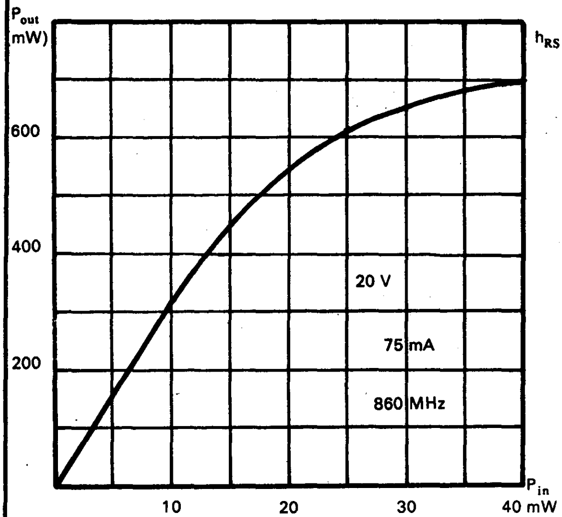
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	[illegible]	3.5			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	[illegible]	24			V
	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 1 mA	45			V
	BV_{CER}	Collector Emitter Breakdown Voltage	R_{BE} = 10 I_C = 10 mA	50			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.25	mA
	H_{FE}	DC Current Gain	V_{CE} = 5V I_C = 100 mA	20		120	[illegible]
RF TEST	I_{MD}	Intermodulation Distortion — 8 dB — 16 dB — 7 dB	f = 860 MHz		— 60	— 58	dB
	P_G	Power Gain	V_{CE} = 20 V [illegible]	14	14.5		dB
	VSWR	Mismatch Tolerance	[illegible]		∞		[illegible]
	C_{ob}	Collector Base Capacitance	[illegible]			3	pF
	F_T	Cutoff Frequency	[illegible]	3			GHz
THERMAL	I_C	Maximum Collector Current	[illegible]			.4	A
	θ_{JF}	Thermal Resistance Junction Heatsink	[illegible]			30	°C/W
	T_J T_{STG}	Max Junction and Storage Temper	[illegible]	— 65		+ 200	°C

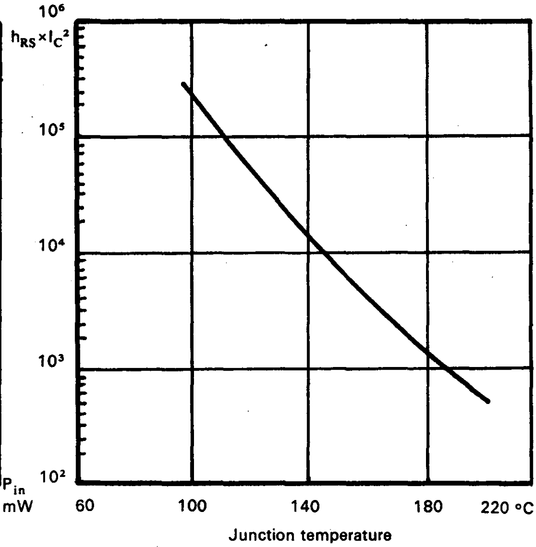
TPV 590 V_{CE} = 20 V I_C = 100 mA

POLAR S-PARAMETERS IN 50 OHM SYSTEM								
F	S 11		S 21		S 12		S 22	
MHz	Magn	Angl°	Magn	Angl°	Magn	Angl°	Magn	Angl°
100 MHz	0.613	226°	17.78	126°	0.0199	35°	0.530	320°
200 MHz	0.732	203°	12.88	103°	0.028	33°	0.316	305°
300 MHz	0.767	192.5°	9.22	93°	0.029	33°	0.266	297°
400 MHz	0.767	185°	6.91	84°	0.033	33°	0.266	295°
500 MHz	0.754	179.5°	5.16	79°	0.033	38°	0.266	300°
600 MHz	0.776	174°	4.67	72°	0.035	42°	0.237	300°
700 MHz	0.776	170°	4.02	66°	0.039	43°	0.237	290°
800 MHz	0.767	167°	3.34	61°	0.044	44°	0.266	285°
900 MHz	0.767	163°	3.16	56°	0.047	44°	0.237	290°
1 GHz	0.776	160°	2.786	52°	0.053	45°	0.266	280°

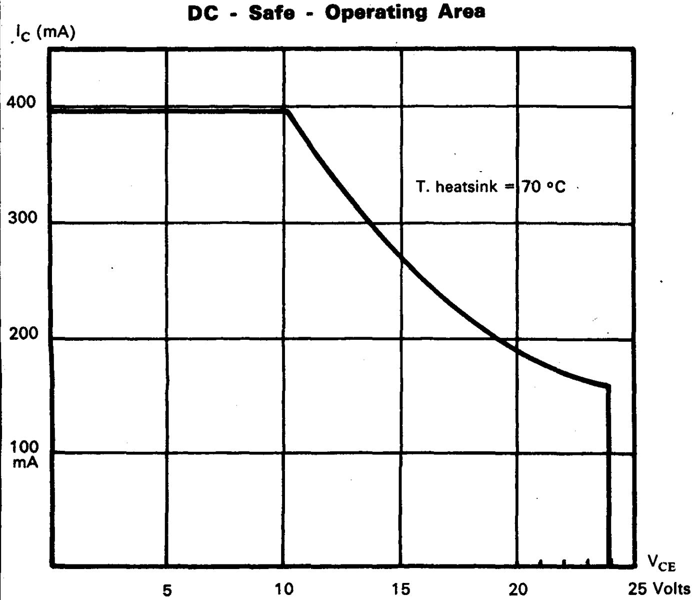
Power Output vs Power Input



MTTF Factor vs Junction Temperature

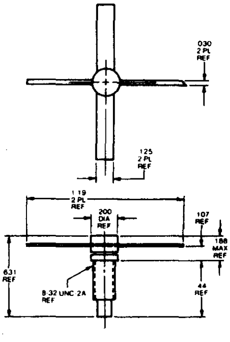


DC - Safe - Operating Area

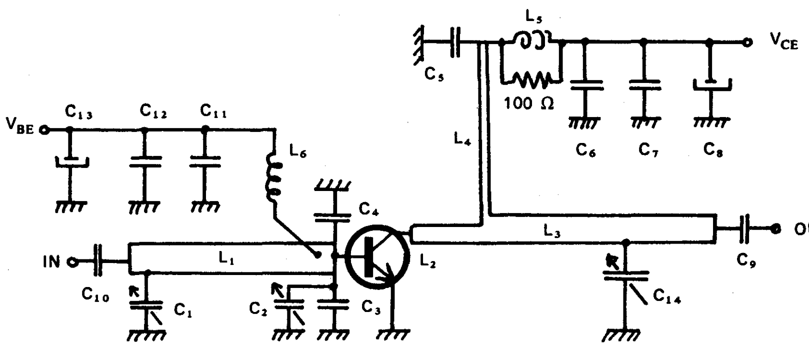


Package

.200 SOE STUD



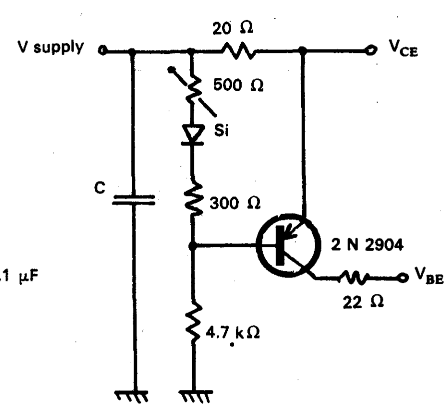
V_{CE} = 20 V I_C = 75 mA F_O = 860 MHz



L_1 : 50 Ω line l = 10 % λg at 860 MHz
L_2 : 100 Ω line l = 12 % λg at 860 MHz
L_3 : 50 Ω 'ine l = 7 % λg at 860 MHz
L_4 : 120 Ω line l = 10 % λg at 860 MHz
L_5 : 6 turns ID 3 mm wire .5 mm
L_6 : 6 turns ID 3 mm wire .5 mm

C_1 = C_2 = C_{14} = variable AIRTRONIC C max 4.7 pF AT 7275
C_3 = C_4 = ATC chip 10 pF
C_5 = 680 pF ATC chip
C_6 = C_{11} = 1 nF
C_7 = C_{12} = 10 nF
C_8 = 10 μF 63 V
C_{13} = 10 μF 25 V
C_9 = C_{10} = 1 nF chip

C = 1 μF + .1 μF
+ 10 nF

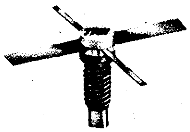


Bias Circuit

TRW

UHF Linear Transistor

- 0.5 W Band 5
- 14 dB Gain at 860 MHz
- High Efficiency
- Gold Reliability
- TV Transposer



200 SOE

The TPV 591 is a NPN gold metallized transistor using diffused emitter ballast resistors.

The sophisticated chip geometry allows the TPV 591 to expand the gain-efficiency frontier.

Its characteristics make the TPV 591 the best device available for very efficient low power stages in UHF transposers applications.

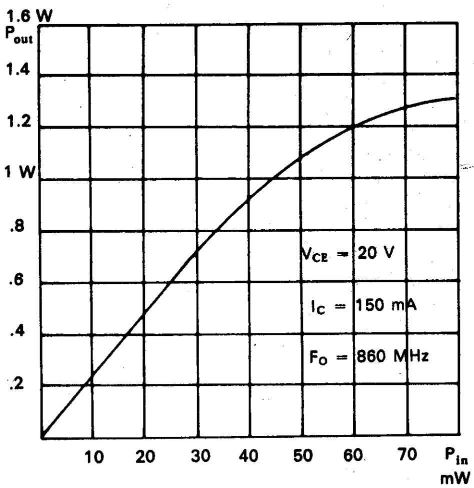
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	24			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω I_C = 20 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.5	mA
	H_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 200 mA	20		120	
RF TEST	IMD	Intermodulation Distortion — 8 dB, — 16 dB, — 7 dB	F_O = 860 MHz TRW DOCUMENT 05001		— 60	— 58	dB
	P_G	Power Gain	V_{CE} = 20 V I_C = 150 mA	13	14		dB
	VSWR	Mismatch tolerance	P_{REF} = 0.5 W		∞		
	F_T	Cutoff Frequency	V_{CE} = 20 V I_E = 75 mA	3			GHz
	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz			5.5	pF
THERMAL	I_C	Maximum Collector Current				.8	A
	θ_{JF}	Thermal Resistance Junction - Heatsink	$T_{Heatsink}$ = 70 °C			16	°C/W
	T_J T_{STG}	Maximum Junction and Storage Temperature		— 65		+ 200	°C

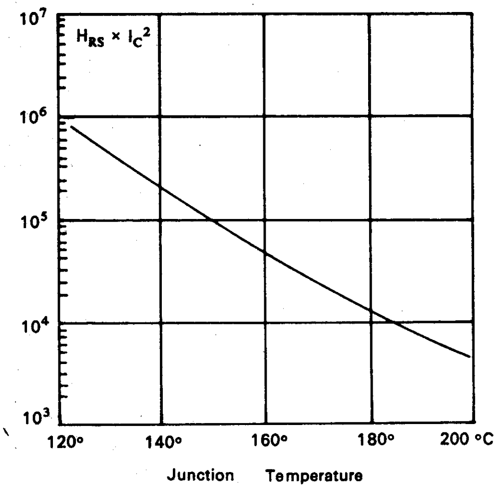
V_{CE} = 20 V I_C = 150 mA

POLAR S-PARAMETERS IN 50 OHM SYSTEM								
F	S 11		S 21		S 12		S 22	
MHz	Magn	Angl°	Magn	Angl°	Magn	Angl°	Magn	Angl°
100	0.733	190	13.8	117	0.025	27	0.365	280
200	0.841	187	8.13	100	0.028	27	0.266	241
300	0.861	181	5.62	88	0.033	27	0.266	241
400	0.861	177	4.27	79	0.035	30	0.282	225
500	0.861	173	3.47	72	0.040	36	0.282	225
600	0.865	169	2.82	68	0.045	36	0.282	218
700	0.865	167	2.44	61	0.045	37	0.316	214
800	0.866	163	2.15	54	0.050	40	0.316	216
860	0.866	162	2.03	54	0.050	43	0.331	218
900	0.866	160	1.94	52	0.053	44	0.331	217
1 000	0.876	158	1.66	46	0.056	44	0.376	214

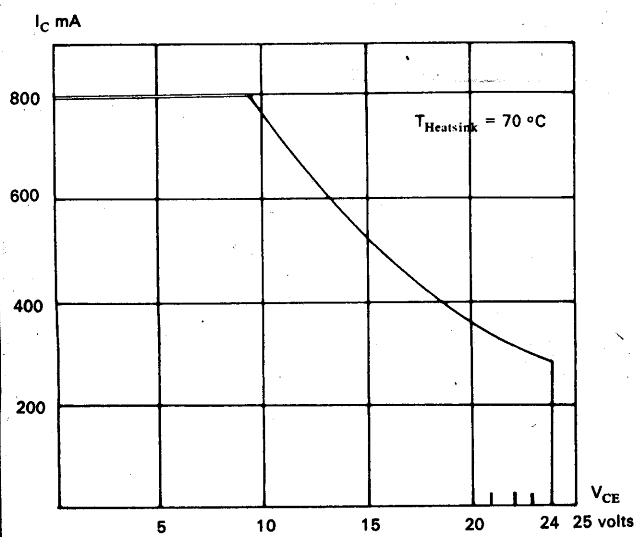
Power Output vs Power Input



MTTF Factor vs Junction Temperature

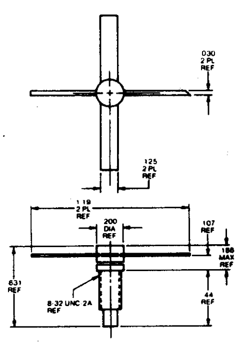


D.C Safe Operating Area

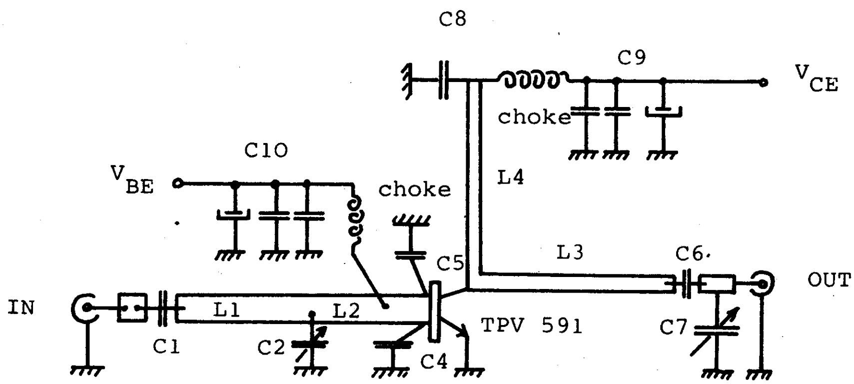


Package

.200 SOE STUD



F_O = 860 MHz — V_{CE} = 20 V — I_C = 150 mA



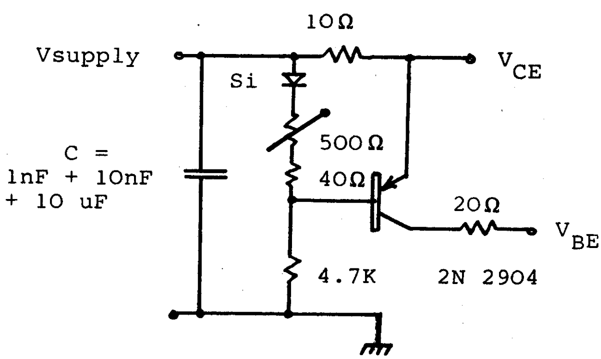
C_1 = C_6 = 1 nF
C_2 = C_7 = Variable Airtronic AT 7285 - max. 2.5 pF
C_4 = ATC 100 A 10 pF
C_5 = ATC 100 A 6.8 pF + 4.7 pF
C_8 = 1 nF
C_9 = C_{10} = 1 nF + 10 nF + 10 µF

Choke : 8 turns — ID 6 mm — wire .5 mm

L_1 = 50 line — ℓ = 10 % λg at 860 MHz
L_2 = 50 line — ℓ = 5 % λg at 860 MHz
L_3 = 80 line — ℓ = 13 % λg at 860 MHz
L_4 = 100 line — ℓ = 8 % λg at 860 MHz

BIAS CIRCUIT

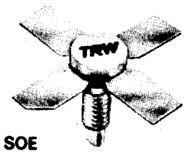
C = 1nF + 10nF + 10 uF



TRW

UHF Linear Transistor

- 0.5 W Band 5
- MATV 1.5 V
- 860 MHz
- 12 dB Gain
- Gold Reliability
- TV Transposer



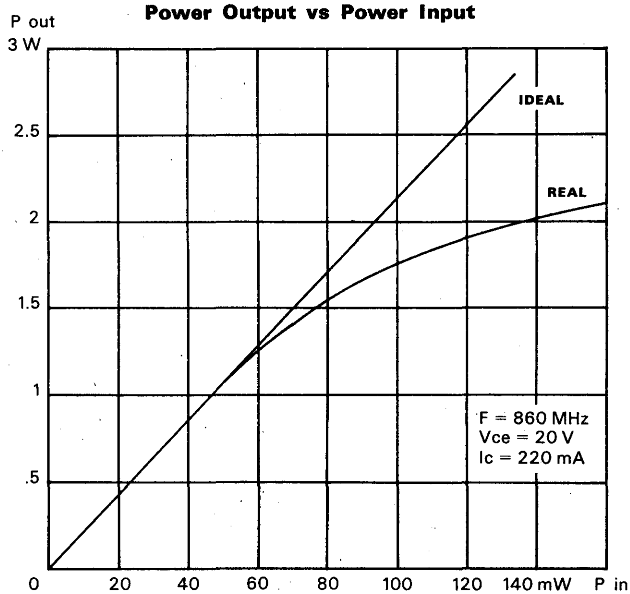
280 SOE

The TPV 596 is a NPN gold metallized transistor using diffused emitter ballast resistors for super linearity. The chip design using microwave techniques provides more than 12 dB gain at 860 MHz thereby reducing the complexity of the lower amplifier stages. The TPV 596 is specifically designed for very high output **1.5 volt MATV** amplifier up to 860 MHz and **500 mW band 5 TV transposers** stages.

Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	24			V
DC Test	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 20 mA R_{BE} = 10 ohms	50			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1 mA	45			V
DC Test	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			0.45	mA
DC Test	h_{FE}	D.C. Current Gain	V_{CE} = 5 V I_C = 100 mA	15		120	
RF Test	IMD 1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband Carrier = Reference - 16 dB	F = 860 MHz V_{CE} = 20 V I_E = 0.22 A P_{REF} = 1 W **TRW DOCUMENT 05001**			— 50	dB
RF Test	IMD 2	Idem	F = 860 MHz V_{CE} = 20 V I_E = 0.22 A P_{REF} = 0.5 W		— 60	— 58	dB
RF Test	P_G	Power Gain	F = 860 MHz V_{CE} = 20 V I_E = 0.22 A P_{REF} = 0.5 W	11.5	12		dB
RF Test	VSWR	Mismatch Tolerance	F = 860 MHz V_{CE} = 20 V I_E = 0.22 A P_{REF} = 1 W		∞		
RF Test	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F = 1 MHz			5	pF
RF Test	f_T	Cutoff Frequency	V_{CE} = 20 V I_E = 220 mA	2.2	2.5		GHz
Thermal	I_C	Maximum Collector Current				0.7	A
Thermal	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C			20	°C/W
Thermal	P_T	Dissipated Power	$T_{HEATSINK}$ = 25 °C			8.75	W
Thermal	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C

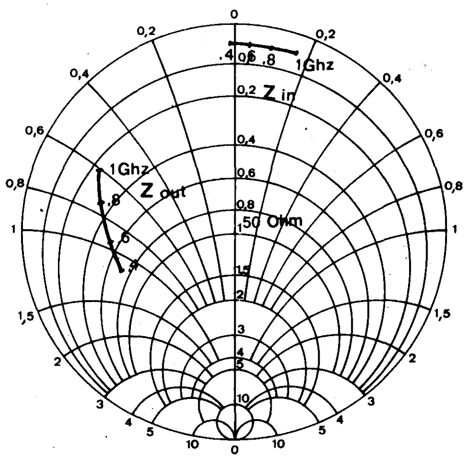
Power Output vs Power Input



LARGE SIGNAL IMPEDANCES

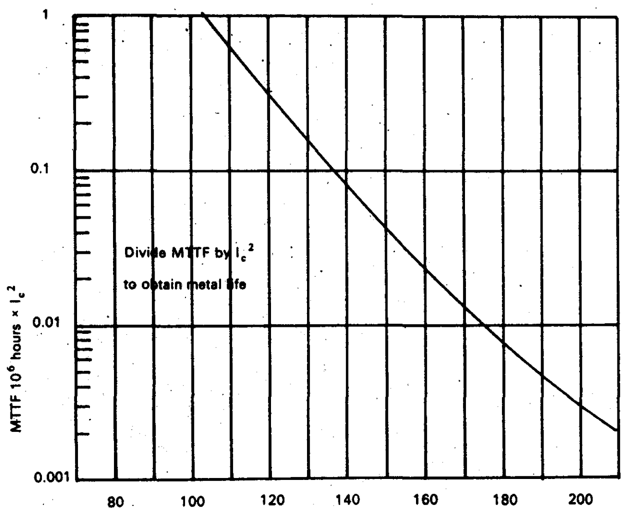
Vce = 20 v

Ic = 220 mA



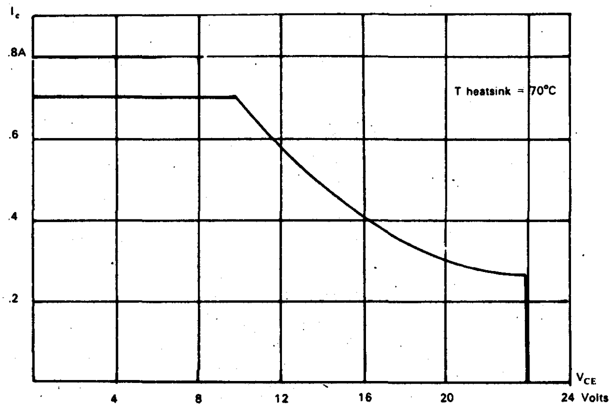
D

MTTF FACTOR vs JUNCTION TEMPERATURE

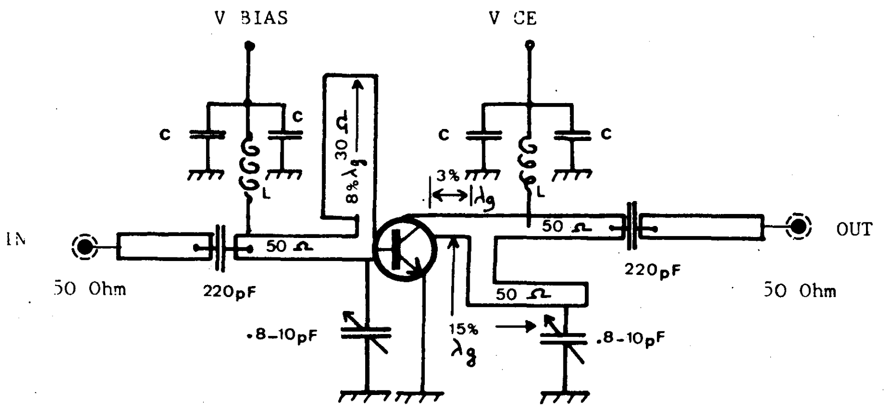


JUNCTION TEMPERATURE — °C

DC-SAFE OPERATING AREA



TEST CIRCUIT AT 860 MHz

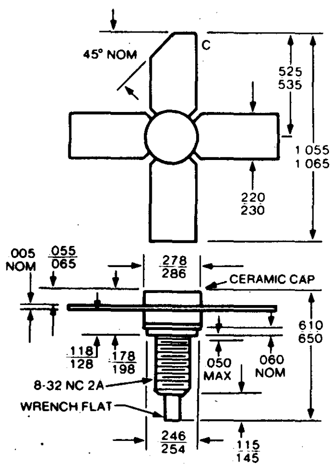


L = 6 turns ID = 1 mm Wire diameter = 0.6 mm

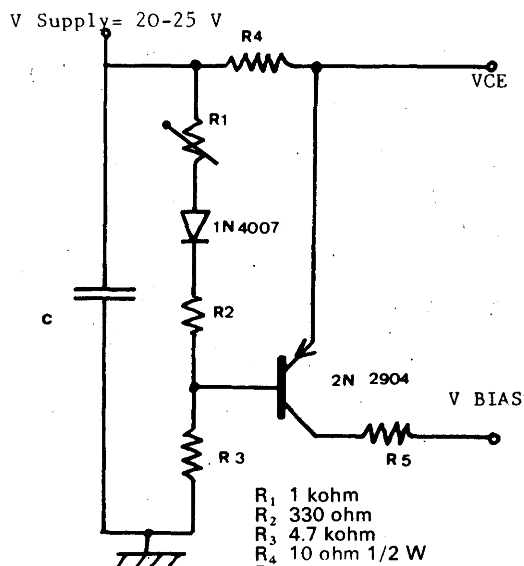
The lengths are given for F = 860 MHz

CLASS A BIAS CIRCUIT

Package Outline



To convert inches to millimeters multiply by 2.54



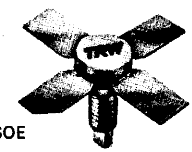
R_1 1 kohm
R_2 330 ohm
R_3 4.7 kohm
R_4 10 ohm 1/2 W
R_5 50 ohm
C 100 F + 10 nF + 1 nF

D

TRW

UHF Linear Transistor

- 1 W
- 11 dB Gain
- Gold Reliability
- TV Transposer
- Band 5



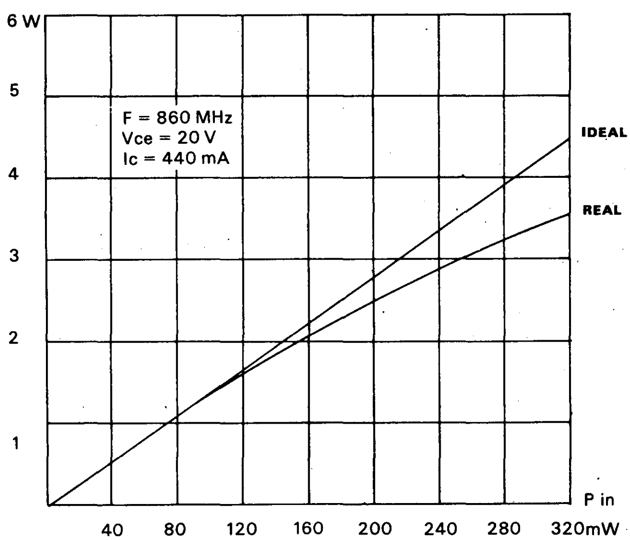
280 SOE

The TPV 597 is a NPN gold metallized transistor using diffused emitter ballast resistors for super linearity. The chip design using microwave techniques provides more than 11 dB gain at 860 MHz thereby reducing the complexity of the lower amplifier stages. The TPV 597 is specifically designed for **1 W - band 5 - TV transposers** stages.

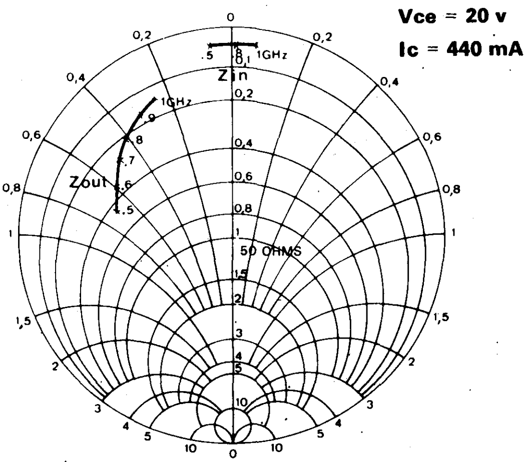
Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 40 mA	24			V
DC Test	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 40 mA R_{BE} = 10 ohms	50			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2 mA	45			V
DC Test	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			0.45	mA
DC Test	h_{FE}	D.C. Current Gain	V_{CE} = 5 V I_C = 200 mA	15		120	
RF Test	IMD 1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband Carrier = Reference - 16 dB	F = 860 MHz V_{CE} = 20 V I_E = 0.44 A P_{REF} = 1 W **TRW DOCUMENT 05001**		— 60	— 58	dB
RF Test	IMD 2	Idem	F = 860 MHz V_{CE} = 20 V I_E = 0.44 A P_{REF} = 2 W			— 51	dB
RF Test	P_G	Power Gain	F = 860 MHz V_{CE} = 20 V I_E = 0.44 A P_{REF} = 1 W	10.5	11		dB
RF Test	VSWR	Mismatch Tolerance	F = 860 MHz V_{CE} = 20 V I_E = 0.44 A P_{REF} = 2 W		∞		
RF Test	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F = 1 MHz			7	pF
RF Test	f_T	Cutoff Frequency	V_{CE} = 20 V I_E = 440 mA	2.2	2.5		GHz
Thermal	I_C	Maximum Collector Current				1.4	A
Thermal	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C			9	°C/W
Thermal	P_T	Dissipated Power	$T_{HEATSINK}$ = 25 °C			19	W
Thermal	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C

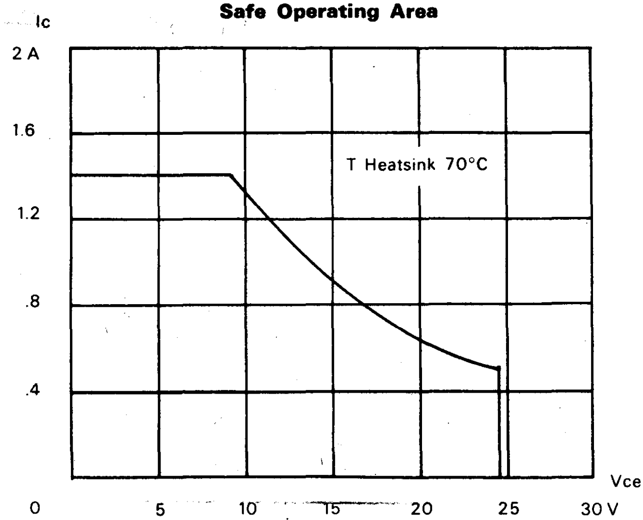
Power Output vs Power Input



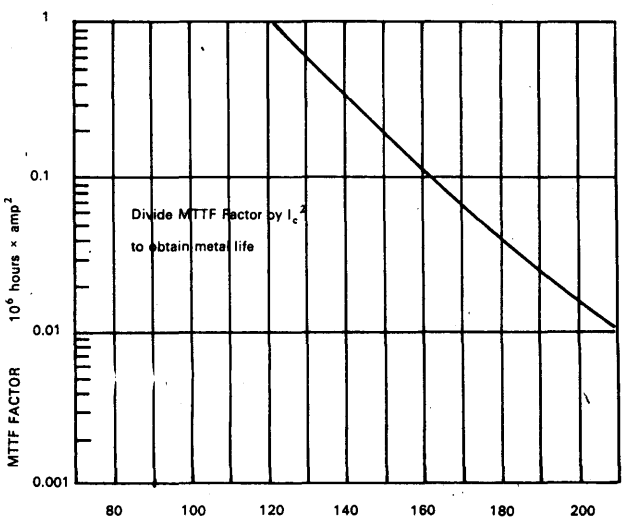
LARGE SIGNAL IMPEDANCES



Safe Operating Area

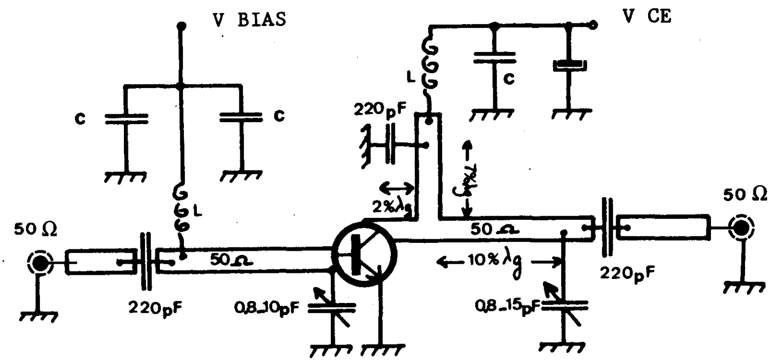


MTTF FACTOR vs
JUNCTION TEMPERATURE



JUNCTION TEMPERATURE — °C

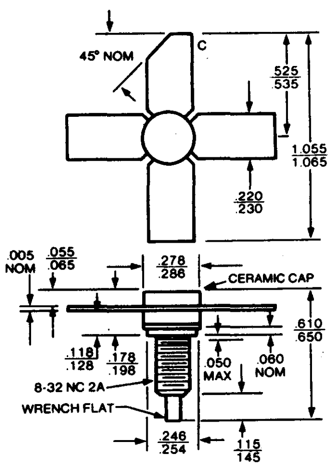
TEST CIRCUIT AT 860 MHz



L = 6 turns ID = 1 mm Wire diameter = 0.6 mm

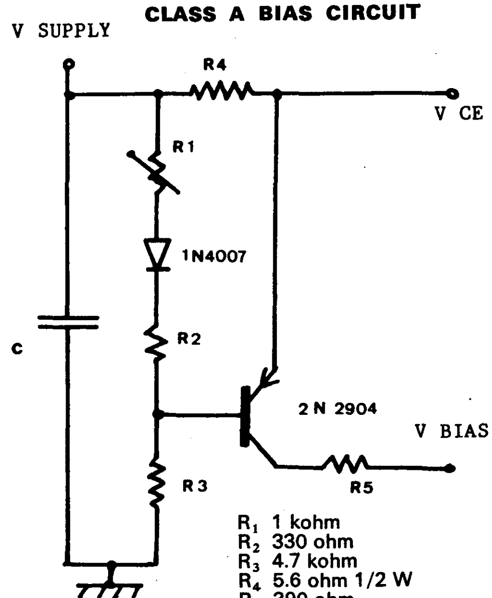
The lengths are given for F = 860 MHz

Package Outline



To convert inches to millimeters multiply by 2.54.

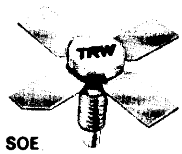
CLASS A BIAS CIRCUIT



R_1 1 kohm
R_2 330 ohm
R_3 4.7 kohm
R_4 5.6 ohm 1/2 W
R_5 390 ohm
C 100 μF + 10 nF + 1 nF

UHF Linear Transistor

- 2 W
- 9 dB Gain
- Band 4 & 5
- TV Transposer



280 SOE

The TPV 593 is a NPN gold metallized transistor using diffused emitter ballast resistors for super linearity.

Its characteristics make the TPV 593 the best device available for very efficient medium power stages in UHF transposers applications.

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 80 mA	25			V
DC TEST	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA	45			V
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA	4			V
DC TEST	H_{FE}	D.C. Current Gain	V_{CE} = 20 V I_C = 250 mA	10			—
RF TEST	IMD	Intermodulation distortion vision = — 8 dB sound = — 7 dB Sideband = — 16 dB	**TRW DOCUMENT 05001** F = 860 MHz P_{REF} = 2 W V_{CE} = 25 V I_C = 450 mA			— 60	dB
RF TEST	P_G	Power Gain		8.5	9		dB
RF TEST	C_{OB}	Collector Base Capacitance	V_{CB} = 25 V F = 1 MHz			10	pF
THERMAL	θ_{j-c}	Thermal Resistance Junction Case	T_{case} 70 °C			11	°C/W
THERMAL	T_{STG}	Storage Temperature		— 65		+ 200	°C
THERMAL	T_J	Junction Temperature		— 65		+ 200	°C

POLAR « S » PARAMETERS IN 50 OHMS SYSTEM

F	S11		S21		S12		S22		S21	K
MHz	MAGN	ANGL	MAGN	ANGL	MAGN	ANGL	MAGN	ANGL	dB	FACTOR
470	0.93	170°	1.5	63	0.04	50°	0.55	— 166°	3.52	1.01
650	0.93	165°	1.06	50	0.05	54°	0.60	— 169°	0.51	1.04
860	0.92	162°	0.79	38	0.06	54°	0.65	— 169°	— 2	1.15

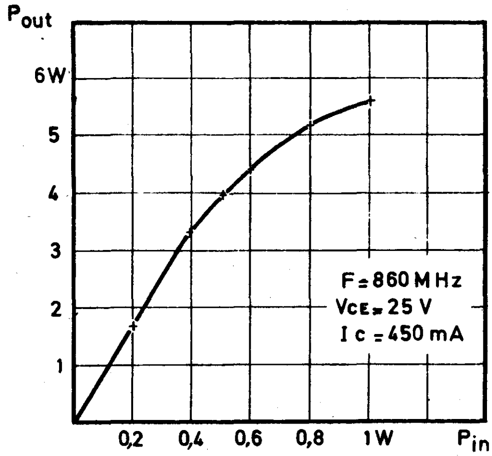
NOTE : V_{CE} = 25 Volts — I_C = 450 mA — Class A

POLAR COORDINATES OF SIMULTANEOUS CONJUGATE MATCH IN 50 OHMS SYSTEM

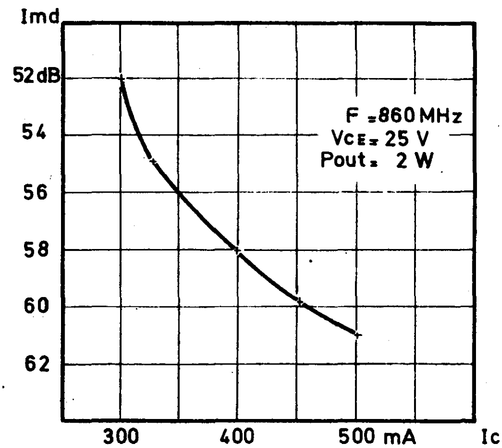
F	SOURCE REFL. COEFF.		LOAD REFL. COEFF.		G MAX
MHz	MAGN	ANGLE	MAGN	ANGLE	dB
470	0.99	— 173°	0.91	124°	15.2
650	0.99	— 168°	0.83	134°	12.0
860	0.95	— 165°	0.79	146°	9.2

NOTE : V_{CE} = 25 Volts — I_C = 450 mA — Class A

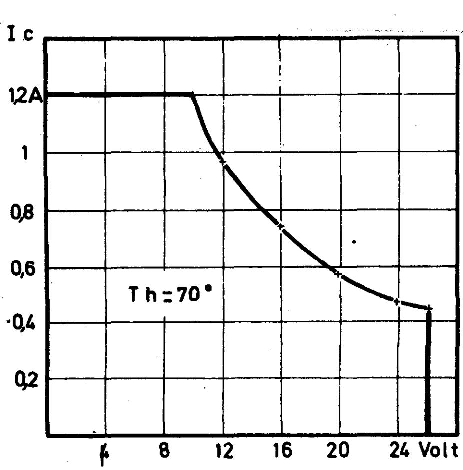
Output Power vs Input Power



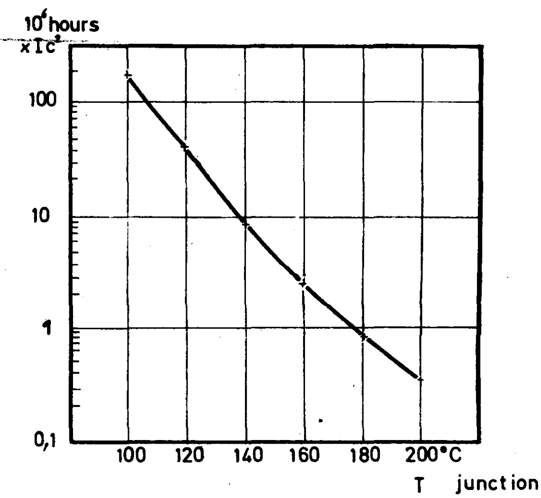
IMD vs Collector Current



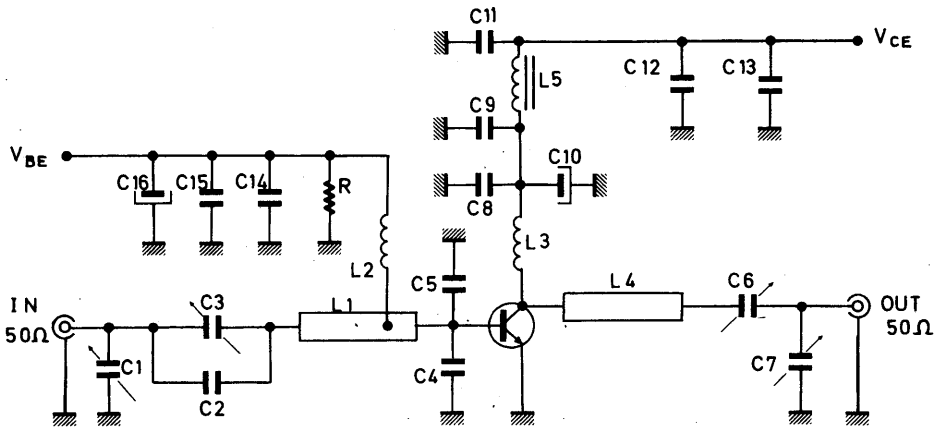
DC Safe Operating Area



MTTF vs Junction Temperature



TEST CIRCUIT AT 860 MHz

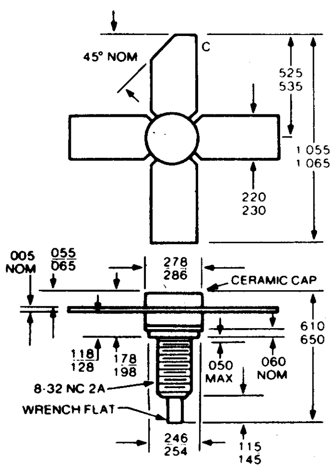


Components Part List

C_1 = AIR TRIMMER AT 5201 0.8 - 10 pF TEKELEC
C_2 = CHIP ATC 4.7 pF
C_3 = AIR TRIMMER AT 5751 0.6 - 6 pF TEKELEC
C_4 = C_5 = CHIP ATC 3.3 pF
C_6 = C_7 = AIR TRIMMER AT 5501 1 - 20 pF TEKELEC
C_8 = C_{13} = C_{14} = 1 nF CHIP CAPACITOR
C_9 = C_{11} = C_{15} = 10 nF RTC
C_{12} = 0.1 μF RTC
C_{10} = C_{16} = 10 μF 63 V electrolytic

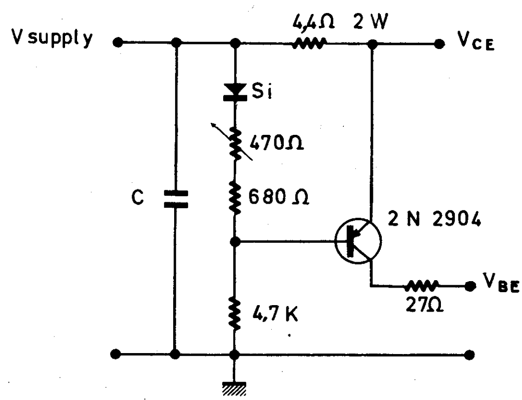
L_1 = 30 Ω line 1 = 6.5 % λg
L_2 = choke 0.47 μH
L_3 = 1 turn - ID 6 mm - wire 10/10
L_4 = 30 Ω line 1 = 19 % λg
L_5 = 8 turns on a CN 20 FERRITE BEAD - CERAMICL - MAGNETICS
R = 43 Ω 1/4 Watt

Package Outline



To convert inches to millimeters multiply by 2 54

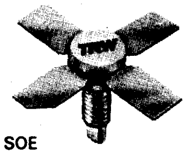
Class a Bias Circuit



TRW

UHF Linear Transistor

- 4 W
- 7 dB Gain
- TV Transposer
- Band 4 & 5



280 SOE

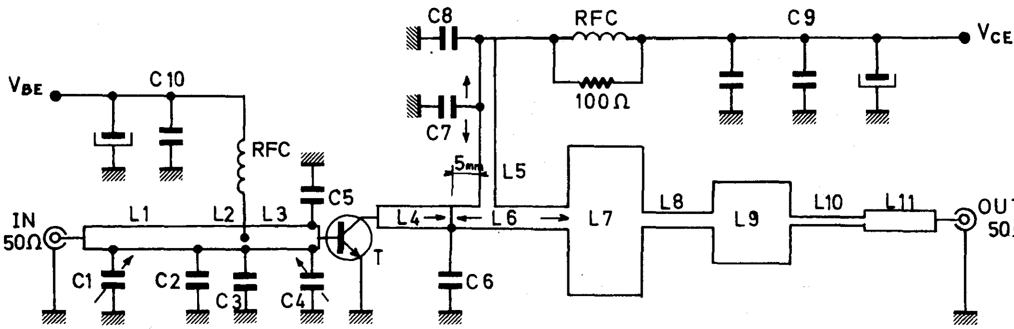
The TPV 598 is a NPN gold metallized transistor using diffused emitter ballast resistors for super linearity. The chip design using microwave techniques provides over 7 dB gain at 860 MHz.

The TPV 598 is specifically designed for high power band 4 and 5 TV Transposers.

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA	4			V
DC TEST	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	27			V
DC TEST	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA	45			V
DC TEST	H_{FE}	D.C. Current Gain	V_{CE} = 20 V I_C = 500 mA	10			
RF TEST	IMD	Intermodulation distortion 3 tones : — 8 dB vision — 7 dB sound — 16 dB Sideband	F = 860 MHz V_{CE} = 25 V I_C = 850 mA **TRW DOCUMENT 05001**			— 60	dB
RF TEST	P_G	Power Gain	P_{REF} = 4 W	7			dB
RF TEST	C_{OB}	Collector Base Capacitance	V_{CB} = 25 V F = 1 MHz			20	pF
RF TEST	F_T	Cutoff Frequency	V_{CE} = 25 V I_C = 850 mA		2		GHz
THERMAL	θ_{JC}	Thermal Resistance Junction Case	DC Dissipation Average Temperature T_{case} = 70 °C			5	°C/W
THERMAL	θ_{JC}	Thermal Resistance Junction Case	High Resolution DC Dissipation T_{case} = 70 °C			6.2	°C/W
THERMAL	θ_{CH}	Thermal Resistance Case Heatsink			0.4		°C/W
THERMAL	T_{STG}	Storage Temperature		— 65		+ 200	°C

BROADBAND TEST CIRCUIT

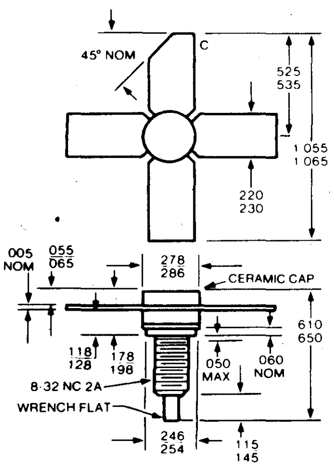


C_1 = VARIABLE .5 - 4.7 pF AIRTRONIC
C_2 = C_3 = ATC 4.7 pF
C_4 = ATC 10 pF + VARIABLE .5 - 4.7 pF AIRTRONIC
C_5 = ATC 10 pF + ATC 5.6 pF
C_6 = ATC 18 pF + .5 - 4.7 pF VARIABLE AIRTRONIC
C_7 = 470 pF CHIP CAPACITOR
C_8 = 1 nF + 10 nF DECOUPLING
C_9 = 1 nF + 10 nF + .1 μF + 10 μF
C_{10} = 10 nF + 1 μF + 10 μF

RFC = 8 turns ID 2.5 mm Wire = .5 mm

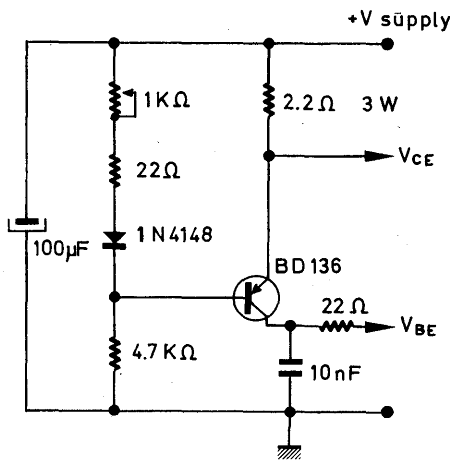
L_1 = 50 Ω line 6.2 % λg at 860 MHz
L_2 = 50 Ω line 4.2 % λg at 760 MHz
L_3 = 50 Ω line 4.9 % λg at 860 MHz
L_4 = 20 Ω line 6.5 % λg at 860 MHz
L_5 = 50 Ω line 5 % λg at 860 MHz
L_6 = 20 Ω line 9.5 % λg at 860 MHz
L_7 = 4 Ω line 8 % λg at 860 MHz
L_8 = 55 Ω line 7.5 % λg at 860 MHz
L_9 = 7.5 Ω line 8 % λg at 860 MHz
L_{10} = 100 Ω line 8 % λg at 860 MHz
L_{11} = 20 Ω line 8 % λg at 860 MHz

Package Outline



To convert inches to millimeters multiply by 2 54

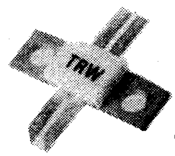
Class a Bias Circuit



D

High Linear Transistor

- 8 W
- 8.5 dB Gain
- Gold Reliability
- TV Transposers
- Band 4 & 5



BMA-2

The TPV 595 A is a push-pull device incorporating gold metallized dice and diffused emitter ballast resistors for linearity and ruggedness.

The chip design using microwave techniques provides over 8.5 dB gain at 860 MHz.

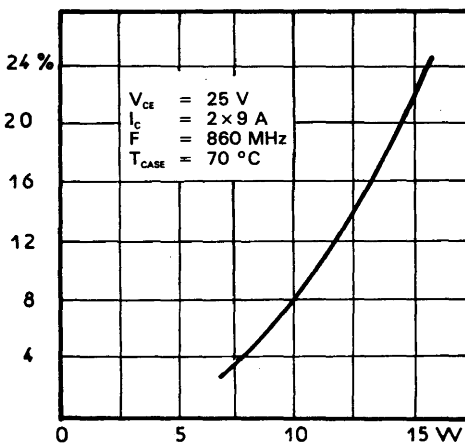
The TPV 595 A is specifically designed for high power band 4 & 5 TV transposers and solid state transmitters.

Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST EACH SIDE	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 3 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 60 mA	28			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA	45			V
	BV_{CER}	Collector Emitter Breakdown Voltage	I_C = 10 mA, RBE = 51 Ohms	40			V
	IC_{EO}	Collector Emitter cut-off Current	V_{CE} = 20 V			5	mA
	H_{FE}	DC Current Gain	V_{CE} = 20 V, I_C = 500 mA	10			
RF TEST	I_{MD}*	Intermodulation	F_O = 860 MHz, Pref = 8 W V_{CE} = 25 V, I_C = 2×900 mA			−58	dB
	P_G	Power Gain	**TRW DOCUMENT 05001**	8.5			dB
	P_{IN}	Pin Overdrive (no degradation)	F_O = 470 MHz, V_{CE} = 25 V I_C = 2×900 mA	8.5			W
	C_{OB}	Collector - Base Capacitance	F_O = 1 MHz, V_{CB} = 28 V		20		pF
THERMAL	$\theta_J C$	Thermal Resistance Junction Case	$T°_{CASE}$ = 70 °C DC DISSIP High resolution			2.5	°C/W
	P_{DISS}	Maximum Total Power Dissipat.	$T°_{CASE}$ = 70 °C			50	W
	IC_{MAX}	Maximum Collector Current				5	
	T_{CASE}	Maximum Mini Case Temperature		−15		+70	°C
	T_{STG}	Storage Temperature		−50		+200	

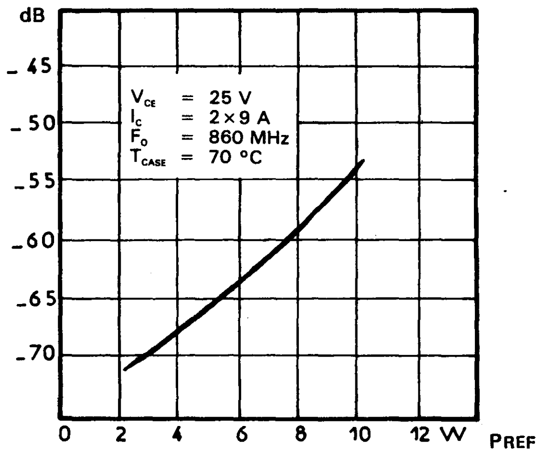
TYPICAL VALUES

Cross-mod* vs Output Power



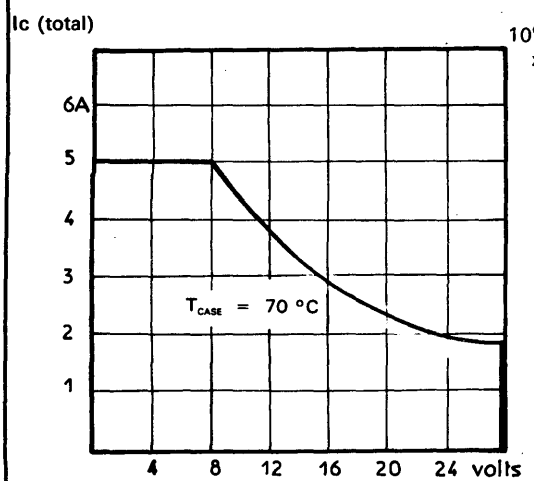
* Cross-mod : Δ % sound (— 7 dB)
— vision O ——→ PEAK

IMD* vs Output Power

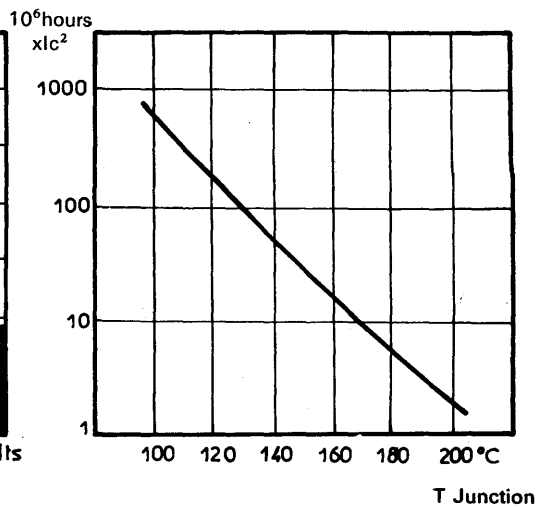


* IMD : 3 tones — 7 dB, — 8 dB, — 16 dB

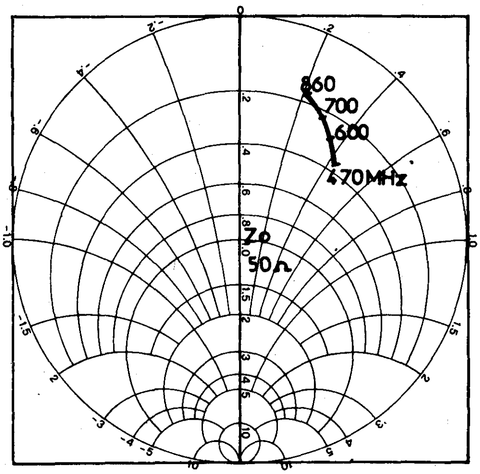
DC Safe Operating Area



MTTF vs Junction Temperature

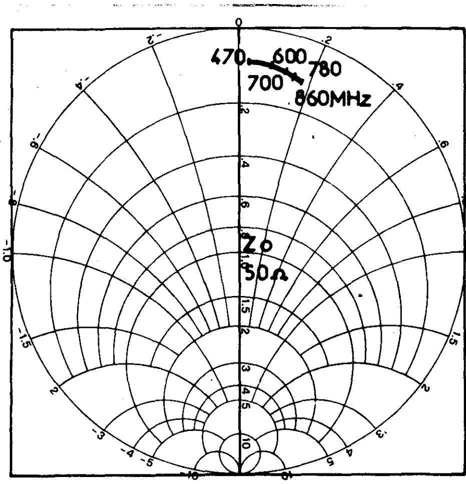


Z LOAD FOR BEST IMD (8 W) and CROSS-MODULATION (12 W)
Collector to collector



V_{CE} = 25 V
I_C = 2 X 0.9 A

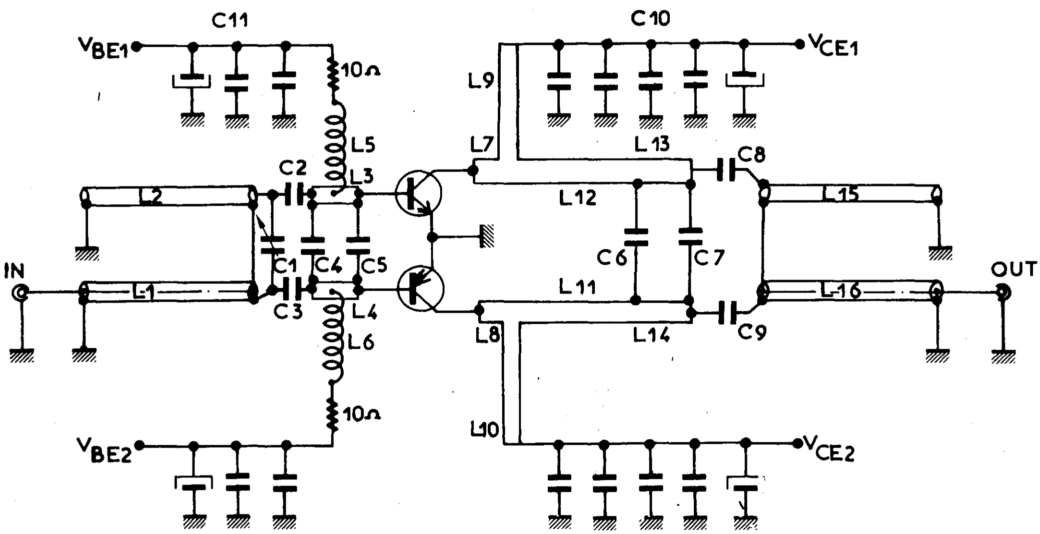
ZIN FOR BEST INPUT VSWR
Base to base



V_{CE} = 25 V
I_C = 2 X 0.9 A

TPV 595 A BROADBAND AMPLIFIER 470-860 MHz

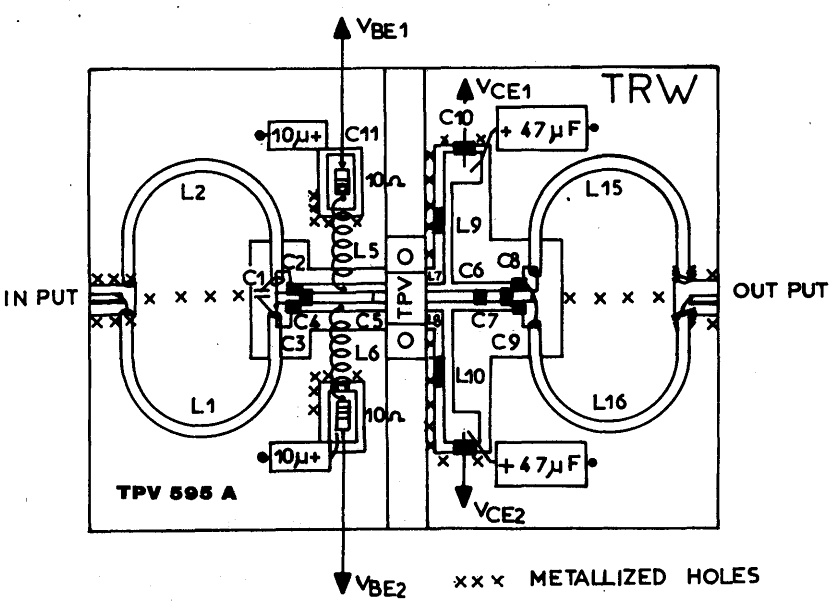
Class A

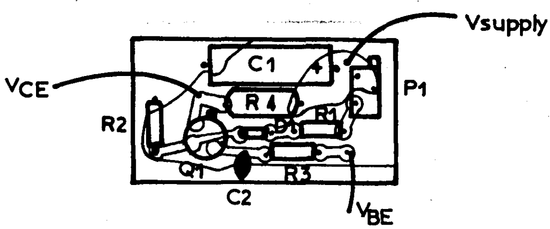


$L_1 = L_2 = L_{15} = L_{16}$	=	60 mm of 50 Ω - 2.2 mm semi rigid coax
$L_3 = L_4$	=	50 Ω line - 5.5 % λ g at 860 MHz
$L_5 = L_6$	=	3 turns ID 2 mm
$L_7 = L_8$	=	50 Ω line - 1.5 % λ g at 860 MHz
$L_9 = L_{10}$	=	50 Ω line - 4.9 % λ g at 860 MHz
$L_{11} = L_{12}$	=	50 Ω line - 2 % λ g at 860 MHz
$L_{13} = L_{14}$	=	50 Ω line - 1.5 % λ g at 860 MHz
C_1	=	.5 — 4.5 pF GIGATRIM TRIMMER
$C_2 = C_3$	=	27 pF ATC 100 A
C_4	=	6.8 pF ATC 100 A
C_5	=	18 pF ATC 100 A
C_6	=	3.3 pF ATC 100 A
C_7	=	4.7 pF ATC 100 A
$C_8 = C_9$	=	27 pF ATC 100 A
C_{10}	=	+ 330 pF ATC 100 B + 1 nF + 10 nF + 47 μF
C_{11}	=	1 nF + 10 nF + 10 μF

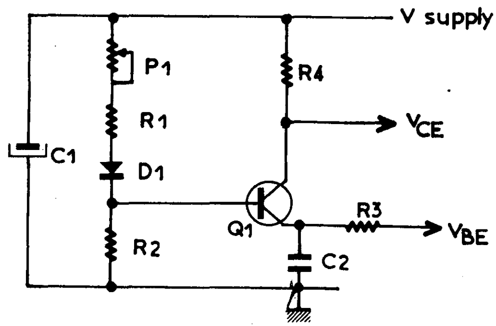
470-860 MHz BROADBAND AMPLIFIER

Class A





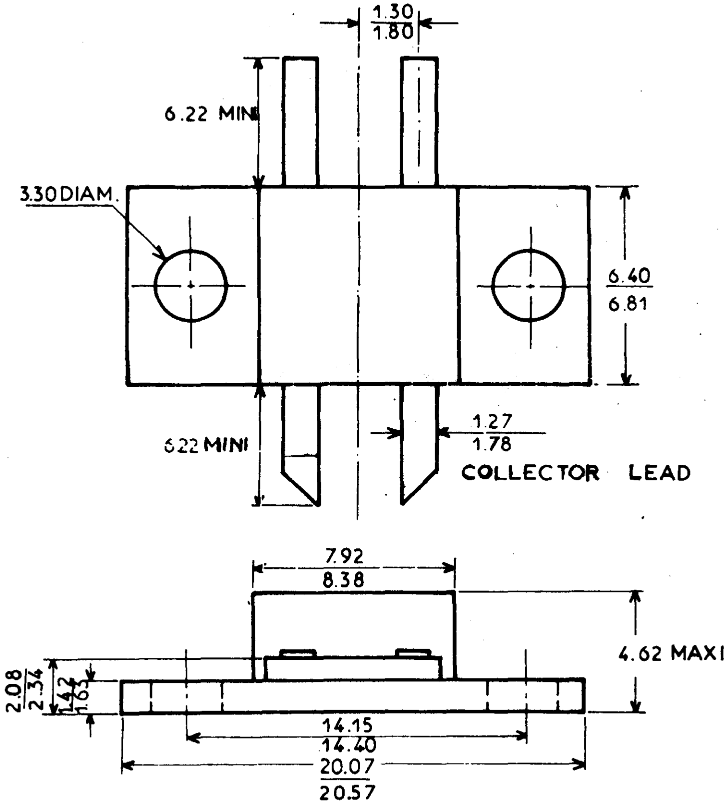
BIAS



PART LIST

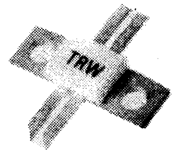
C_1 = 100 MF	R_2 = 5.6 KΩ	D_1 = 1 N 4148
C_2 = 10 nF	R_3 = 100 Ω	Q_1 = 2 N 2904
R_1 = 150 Ω	R_4 = 2.7 Ω 2 W.	P_1 = 1 K Ω

PACKAGE OUTLINE



UHF Linear Transistor

- 50 W Class AB
- TV Transmitter
- Band 4 & 5
- Push-Pull
- Gold Reliability


BMA-2

The TPV 5051 is a push-pull device incorporating gold mettalized dice and diffused emitter ballast resitors for linearity and ruggedness.

It provides 6.5 dB gain at 50 W and 860 MHz.

The TPV 5051 is specifically designed for high power vision only TV amplifiers operating in Bands IV or V.

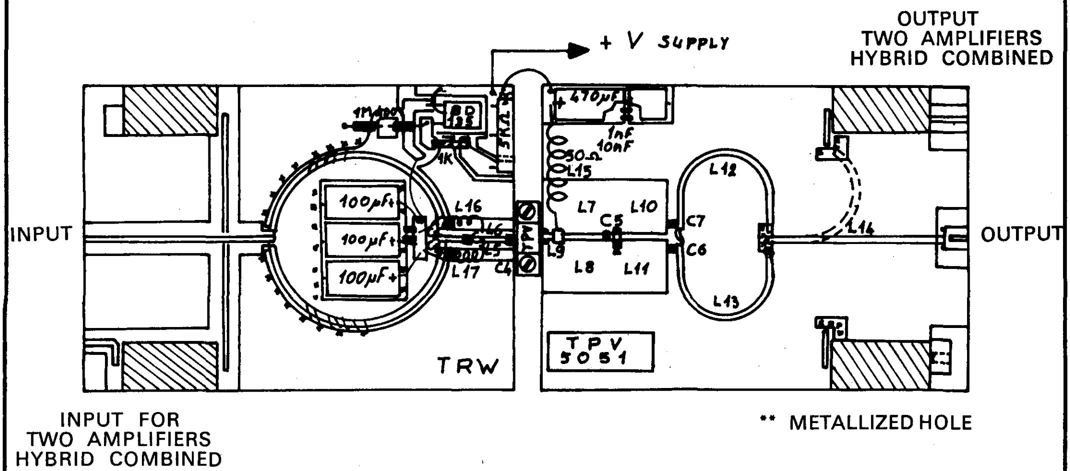
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test each side	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 6 mA	4			V
	BV_{ECO}	Collector Emitter Breakdown Voltage	I_C = 40 mA	30			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 20 mA	45			V
	H_{FE}	D.C Current Gain	V_{CE} = 20 V I_C = 800 mA	10			
RF Test	P_G	Power Gain	V_{CE} = 28 V I_q = 2 X 100 mA F = 860 MHz P_{out} = 50 W	6.5	7		dB
	η_C	Collector Efficiency		45	50		%
Thermal	Cob/Side	Collector - Base Capitance	V_{CB} = 28 V F = 1 MHz			40	pF
	θ_{JC}	Thermal Resistance Junction - Case	— High resolution — T_{case} = 70 °C — Rated output power			1.8	°C/W
	θ_{CH}	Thermal Resistance Case Heatsink			0.2		°C/W
	T_{STG}	Storage Temperature		— 65		+ 200	°C

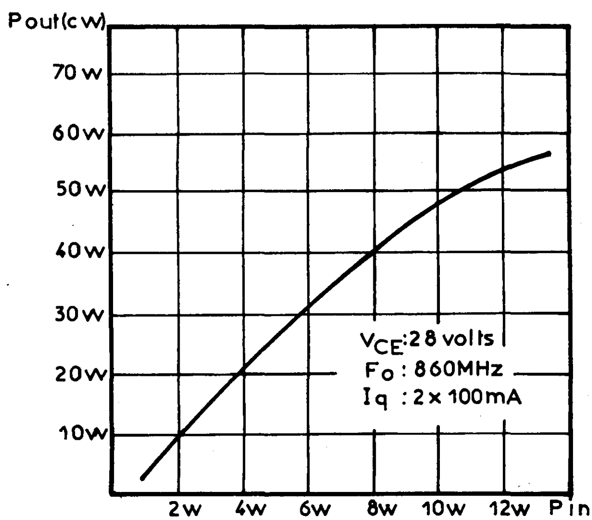
TYPICAL APPLICATION

600-860 MHz BROADBAND AMPLIFIER CLASS A-B

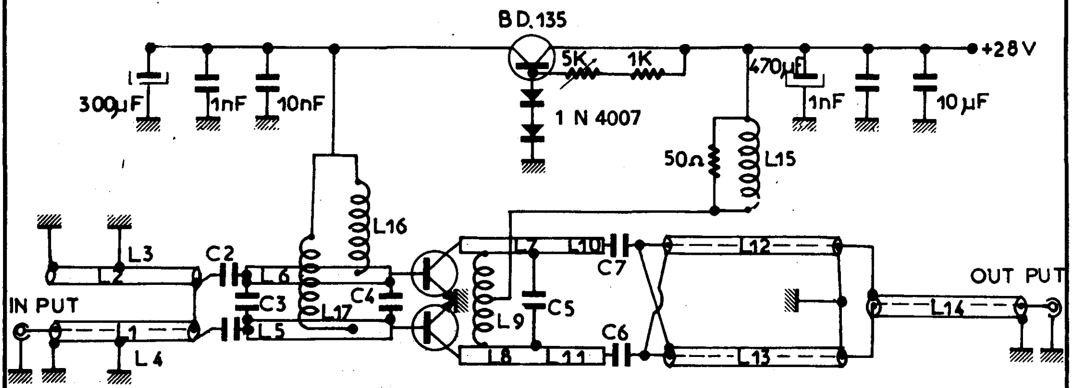
CIRCUIT LAYOUT



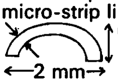
TYPICAL OUTPUT POWER US INPUT POWER



600-860 MHz CIRCUIT DIAGRAM



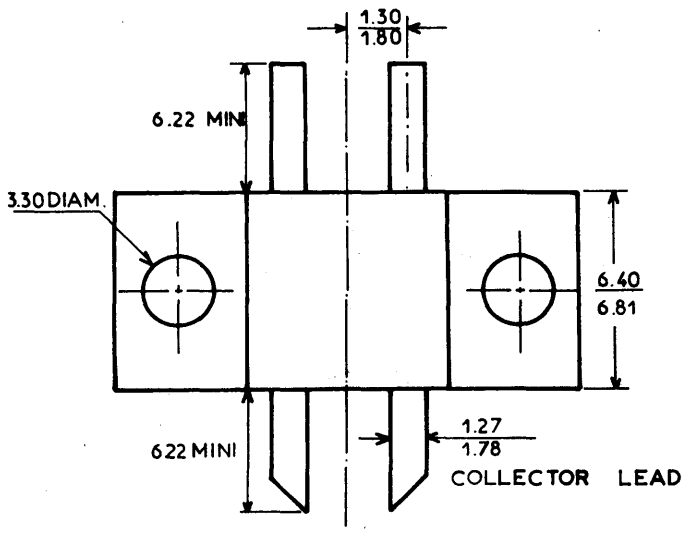
L_1 = L_2 = 70 mm of 50 Ω semi rigid coax — ⌀ 2.2 mm
L_3 = L_4 = 50 Ω micro-strip line — 17 % λ g at 860 MHz
L_5 = L_6 = 40 Ω micro-strip line — 6 % λ g at 860 MHz
L_7 = L_8 = 10 Ω micro-strip line — 6 % λ g at 860 MHz

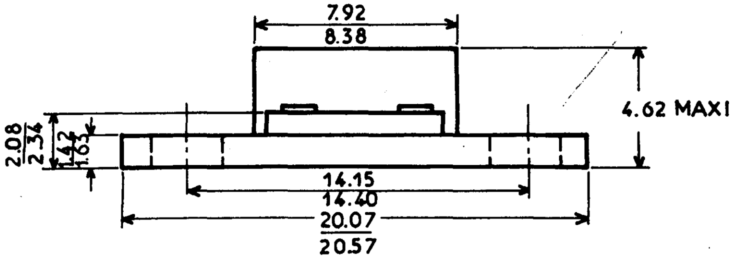
L_9 = 2 mm  6 mm ←2 mm→ cooper ribbon

L_{10} = L_{11} = 12 Ω micro-strip line — 6 % λ g at 860 MHz
L_{12} = L_{13} = 25 Ω semi-rigid — 50 mm long
L_{14} = 50 Ω semi-rigid — 47 mm long

C_1 = C_2 = 8.2 pF ATC 100 A
C_3 = 2.2 pF ATC 100 A + .5 — 4.5 pF GIGATRIM TRIMMER
C_4 = 12 pF + 4.7 pF ATC 100 A
C_5 = 10 pF ATC 100 A + .5 — 4.5 pF GIGATRIM TRIMMER
C_6 = C_7 = 100 pF ATC 100 A
L_{15} = 3 turns — wire 1 mm — ID 5 mm
L_{16} = L_{17} = 6 turns — wire .5 mm — ID 2 mm

PACKAGE OUTLINE





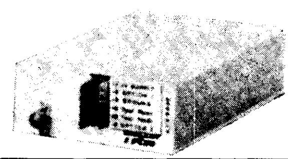
DIMENSIONS GIVEN IN mm

D

TRW

Linear RF Power Amplifier

- 20 W
- 470-860 MHz
- Class "A"



The ATV 5030 solid state class A amplifier is specifically designed for TV transposers and transmitters. This amplifier incorporates microstrip technology and reliable TRW linear push-pull transistors.

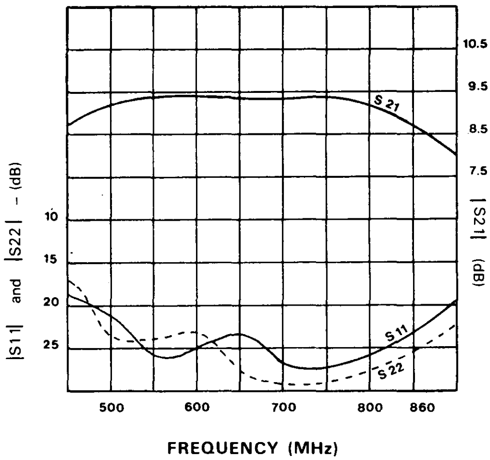
Electrical Characteristics (T_{case} = 50 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
GENERAL OPERATING	R_L	Source and load Return loss	50 Ω reference			− 20	dB
	BW	Bandwith	Continuous without Retuning	470		860	MHz
	Vcc	Supply voltage	Nominal		26.5		V
RF TEST	P_G	Power gain	3 tones IMD2 test	7.5	8.5		dB
	G_R	Gain ripple	Pref = 20 W		± .5	± .8	dB
	IMD1	Intermodulation	Pref = 20 W (− 8, − 7, − 16 dB) **TRW DOCUMENT 05001**		− 52	− 51	dB
	IMD2	3 tones	Pref = 20 W (− 8, − 10, − 16 dB)		− 55	− 54	dB
	P_{out}	Output power at 1 dB compression	Continuous wave	25	28		W
	R_L	Input/output Return loss	50 Ω reference			− 15	dB
	VSWR	Output mismatch Tolerance	3 tones IMD2 test Pref = 20 W any phase		∞ : 1		
RATINGS	Vcc	Supply voltage		26	26.5	27	V
	I_{max}	Max DC current	Vcc = 26.5 V		3.8	4	A
	T_{op}	Operating temper.	Base plate (test point)	− 20		+ 70	°C
	T_{STG}	Storage temperat.		− 40		+ 100	°C

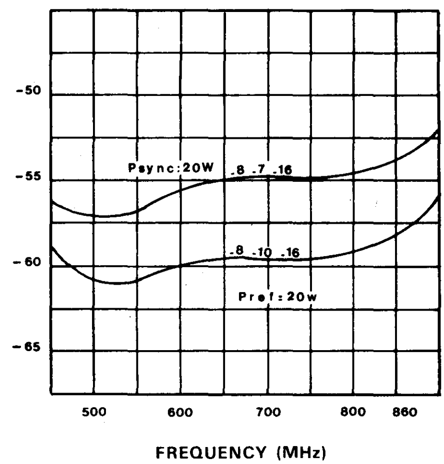
TYPICAL CHARACTERISTICS

SMALL SIGNAL

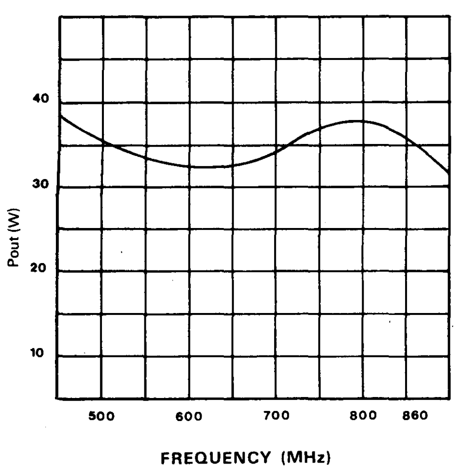
« S » parameter magnitude Vs Frequency



INTERMODULATION Vs FREQUENCY



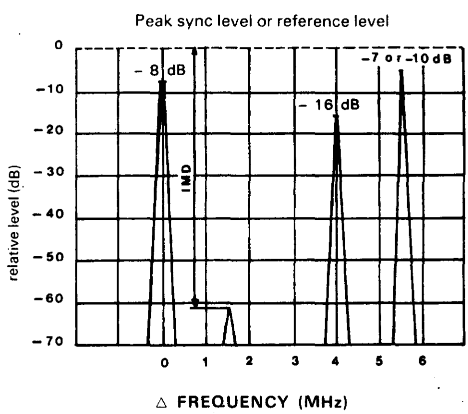
Output power at 1 dB
gain compression Vs frequency



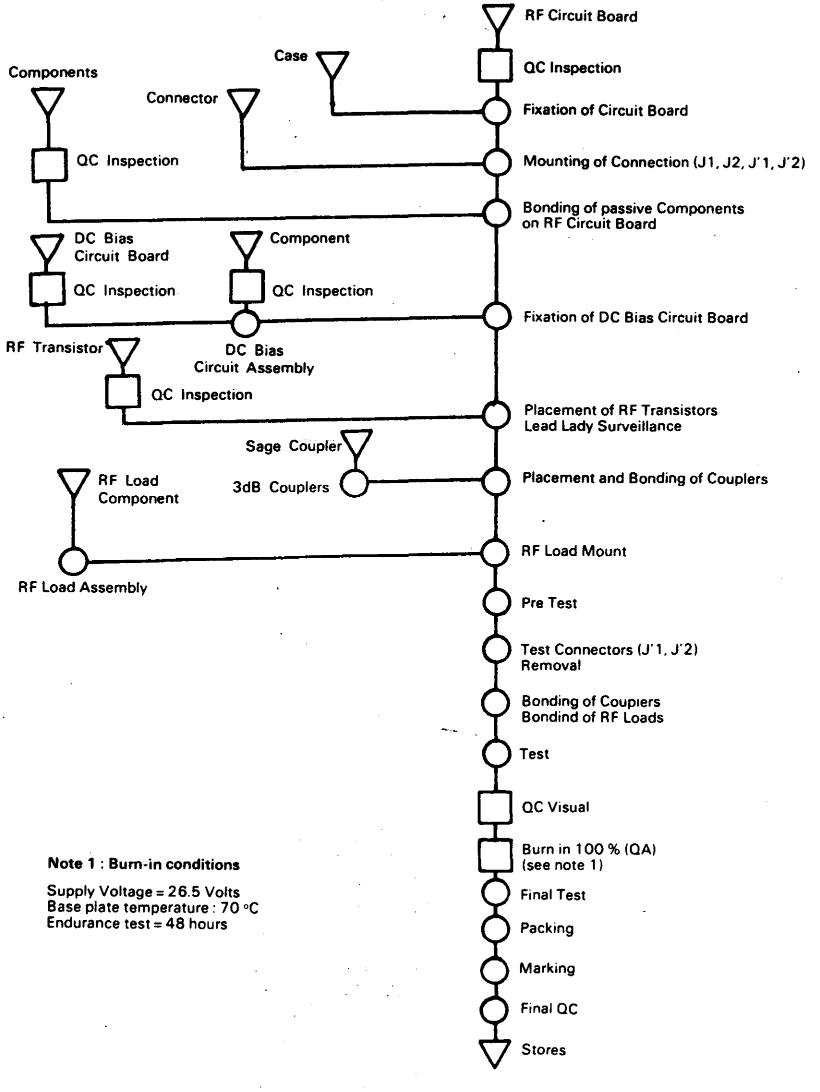
* **3 tones test methode** :

IMD1 : Vision carrier – 8 dB, sound carrier – 7 dB Sideband signal – 16 dB ; Zero dB corresponds to peak sync level.

IMD2 : Vision carrier – 8 dB, sound carrier – 10 dB Sideband signal – 16 dB ; Zero corresponds to reference level.

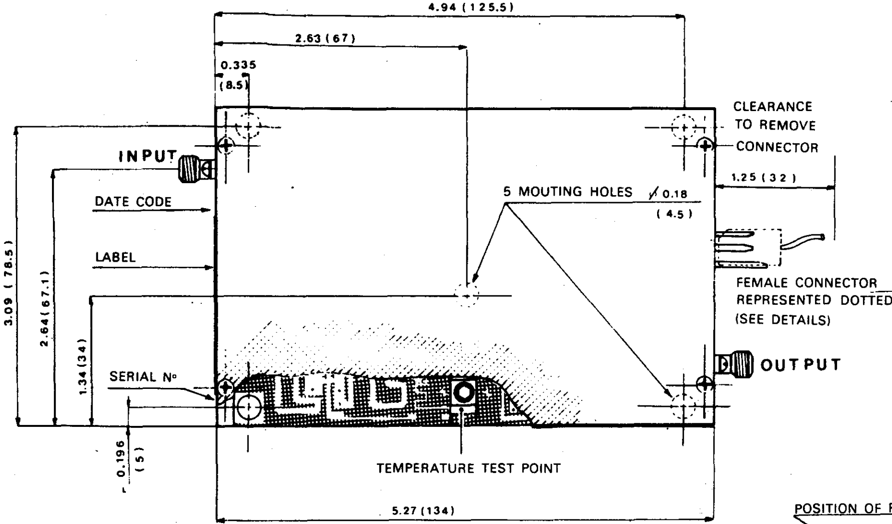


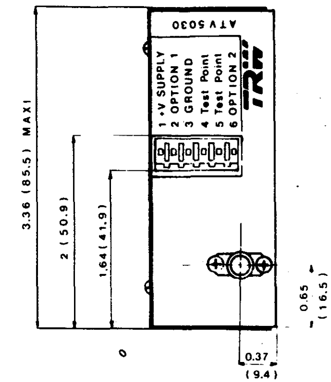
MANUFACTURING FLOW CHART OPERATION

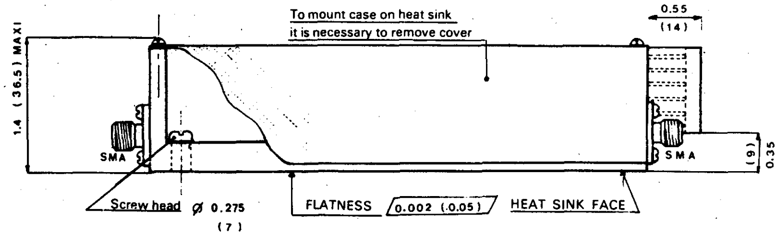


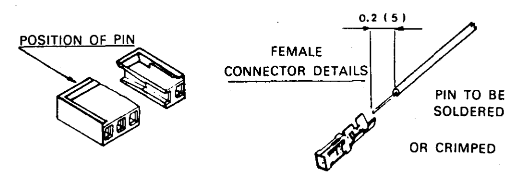
Note 1 : Burn-in conditions

Supply Voltage = 26.5 Volts
Base plate temperature : 70 °C
Endurance test = 48 hours









PLUS IN LAYOUT

PIN 1	+V supply 26.5 volts
PIN 2	Do not use
PIN 3	Ground
PIN 4-5	Collector current test point
PIN 6	Optionnal

VOLTAGE MEASUREMENT

V supply (Between pin 1 and 3)

COLLECTOR CURRENT MEASUREMENT

Voltmeter must have an input impedance greater than 10 KΩ

TRANSISTOR N° 1

$I_1\ (A) = \frac{1}{0.47} \times V\ (V)$ Between Pin 1-5

TRANSISTOR N° 1

$I_2\ (A) = \frac{1}{0.47} \times V\ (V)$ Between Pin 1-4

DIMENSIONS IN INCHES mm IN BRACKETS

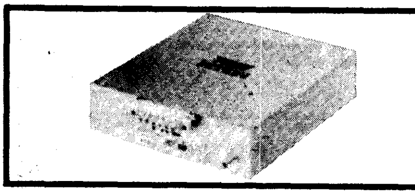
TOL. GENE. ±0.008 (0.2)

ATV 5080

TRW

Linear RF Power Amplifier

- **80 W**
- **470-860 MHz**
- **Class "AB"**



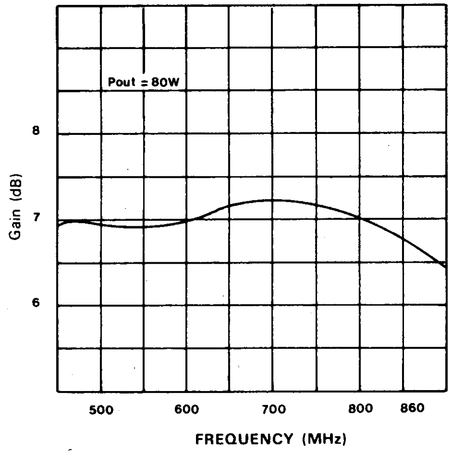
The ATV 5080 solid state class AB amplifier is specifically designed for TV transmitters. This amplifier incorporates microstrip technology and reliable TRW linear push-pull transistors.

Electrical Characteristics (T_{case} = 50 °C)

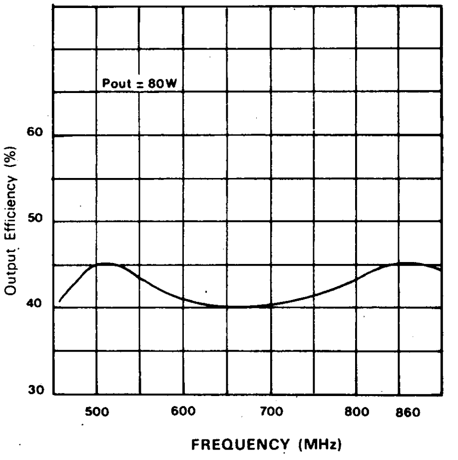
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
GEN. OPER.	R_L	Source and load Return loss	50 Ω reference			−20	dB
	BW	Bandwith	Continuous without retuning	470		860	MHz
	Vcc	Supply voltage	Nominal		28		V
RF TEST	P_G	Power gain	P_{OUT} = 80 W CW	6	6.8		dB
	G_R	Gain ripple	P_{OUT} = 80 W CW			±.8	dB
	P_{out}	Output power at 1 dB Gain compression	Continuous wave	80	85		W
	I	DC current total Amplifier	P_{OUT} = 80 W CW		7	7.5	A
	VSWR	Output mismatch tolerance	P_{out} = 80 W, CW, t ⩽ 1 S Any phase		2 : 1		
RATINGS	R_L	Input return loss	50 Ω reference			−15	dB
	H_R	Harmonics rejection	P_{OUT} = 80 W CW	30	35		dB
	Vcc	Supply voltage		27.5		28.5	V
	I_{max}	Max DC current	Vcc = 28 V			9	A
	T_{op}	Operating temperature	Base plate (Test point)	0		+70	°C
	T_{STG}	Storage temperature		−40		+100	°C

TYPICAL CHARACTERISTICS

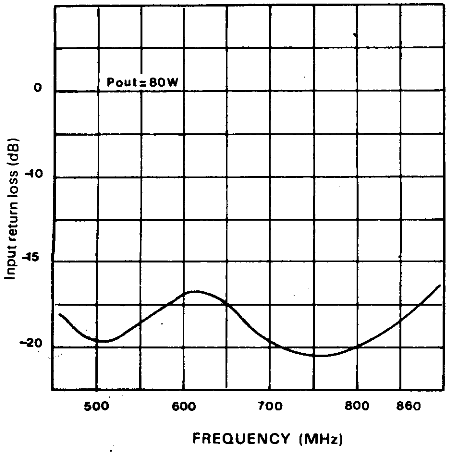
Power Gain Vs Frequency



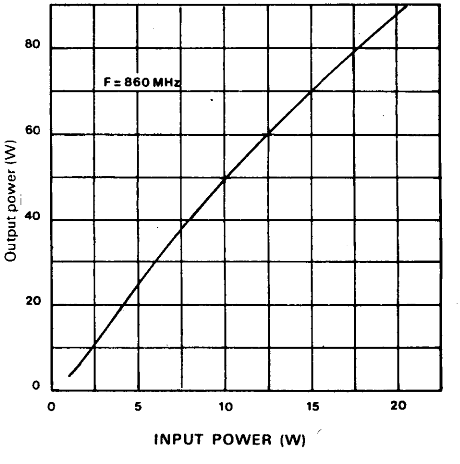
Efficiency Vs Frequency



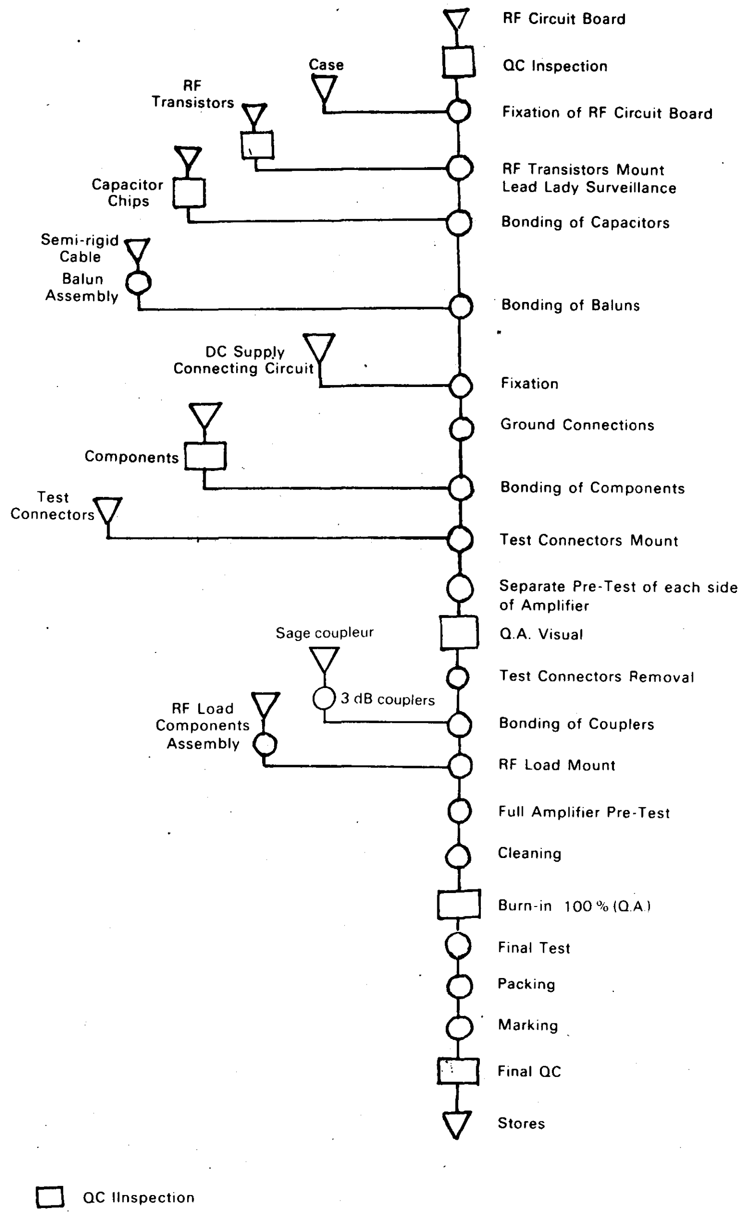
Input Return Loss Vs Frequency



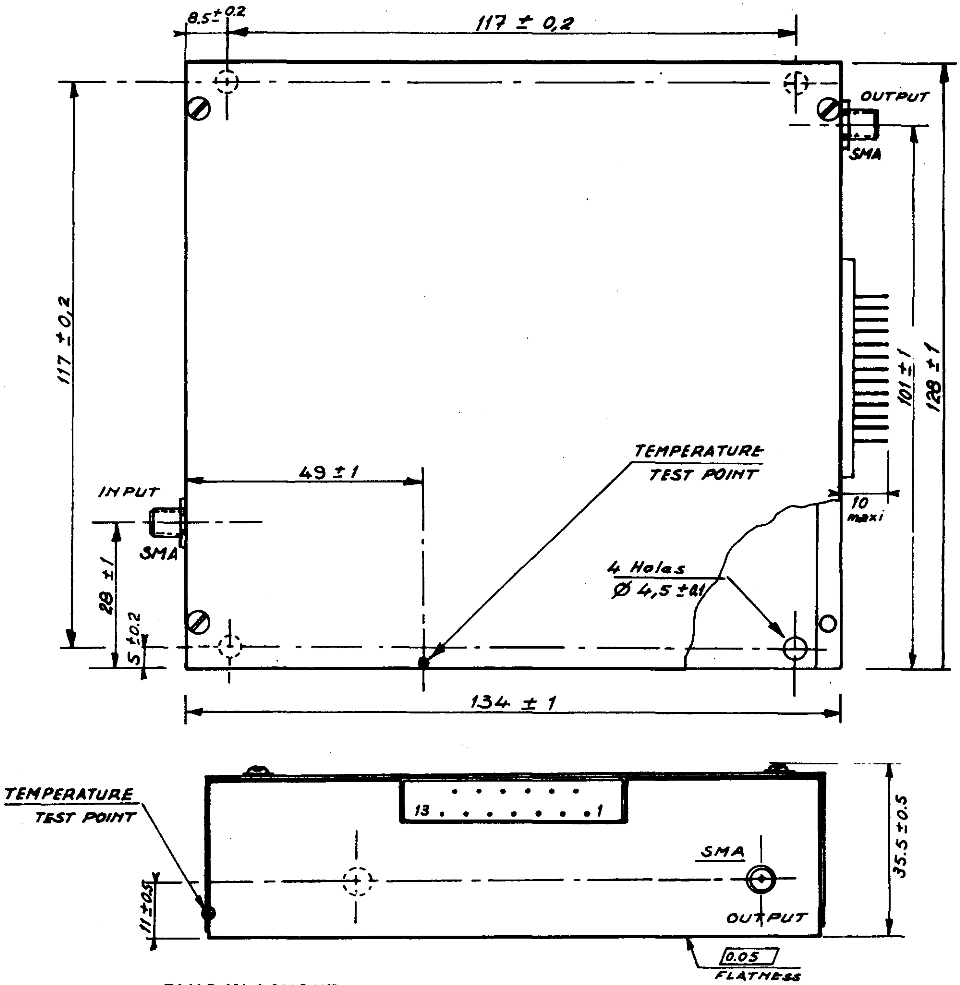
Output Power Vs Input Power



MANUFACTURING FLOW CHART OPERATION



ATV PACKAGE OUTLINE



PLUG-IN LAYOUT

Pin 5-6-7-8-9	V_{SUPPLY}
Pin 1-2-12-13	GROUND
Pin 3-4-10-11	TEST POINT

VOLTAGE MEASUREMENT

- V_{SUPPLY} (between Pin 4 and 1)

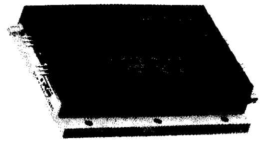
COLLECTOR CURRENT MEASUREMENT

Voltmeter must have an input impedance greater than 10 kΩ.

- Transistor N° 1
  $I1_{AMP}$ = 10 × V (between Pin 4 and 3)
- Transistor N° 2
  $I2_{AMP}$ = 10 × V (between Pin 10 and 11)

Linear RF Power Module

- 50 W
- 470 - 860 MHz
- Class "A"



This module incorporates microstrip technology and reliable TRW linear Semiconductors.

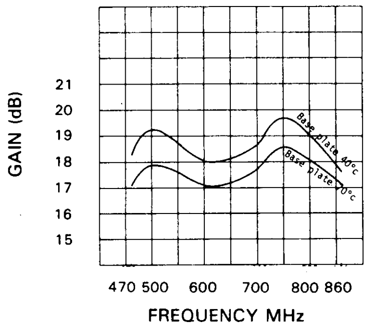
The TPVA 5060 is specifically designed for high power Band 4 et 5 TV transposers and solid state transmitters.

Electrical Characteristics

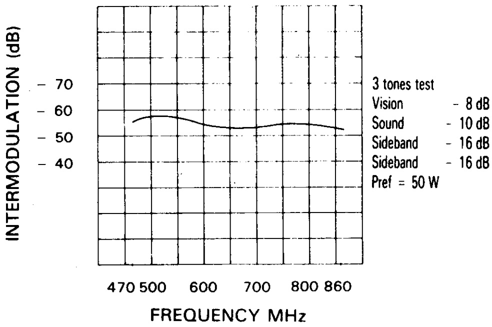
- BASE PLATE TEMPERATURE AT DEFINED TEST POINT (T) = 50 °C (see mechanical drawing)
- BIASING CONDITIONS (see circuit diagram)
  Voltage : $V_{CD1} = V_{CF1} = V_{CD2} = V_{CF2}$ = 26 volts
  Current : $I_{CD1} = I_{CD2}$ = 1.7 A
  $I_{CF1} = I_{CF2}$ = 3.6 A

Characteristic	Specified	Typical	Test conditions
DC power supply	280 W maxi.		See biasing conditions
Frequency range	470 to 860 MHz		
Output power at 1 dB gain compression point	65 W min.	70 W	Continous wave
Input source/output load impedance	50 Ω		
Input and output return loss	15 dB min.	17 dB	470 MHz to 860 MHz
Gain (S21)	17 dB min.		
Gain variation over frequency range	17 dB to 20 dB		Small signal
Gain variation over any 6 MHz segment	0.3 dB max.		
Gain variation Vs temperature	1 dB max.		40 °C to 70 °C base plate at temperature test point (T)
3rd order intermodulation products	– 51 dB max.		3 tone tests : Vision – 8 dB Sound – 10 dB Sideband – 16 dB At Pref = 50 watts
Harmonic level	> 20 dB	30 dB	Below fundamental at 50 watts CW
Output VSWR mismatch capability	>10 : 1		No damage to occur with any output power from 0 to 50 watts pref. 470 – 860 MHz any phase angle
Overdrive capability	3 dB		Over input power required for 50 W sync. output
Operating temperature range	0 °C ; + 70 °C		Base plate temperature
Storage temperature range	- 20 °C ; + 100 °C		Base plate temperature

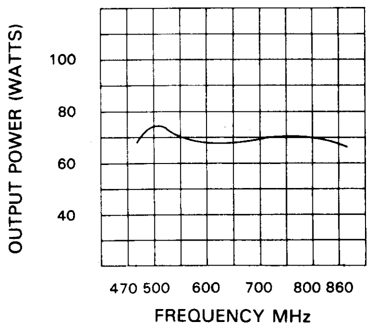
SMALL SIGNAL GAIN
Typical values

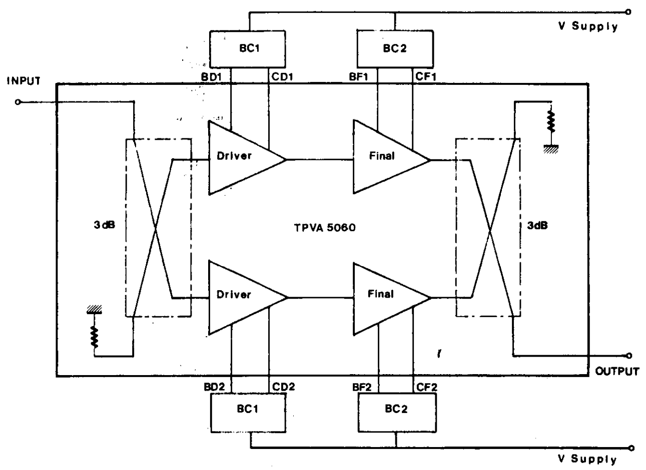


INTERMODULATIONS 3 TONES
Typical values



OUTPUT POWER AT 1 dB
GAIN COMPRESSION
Typical values





CIRCUIT DIAGRAM

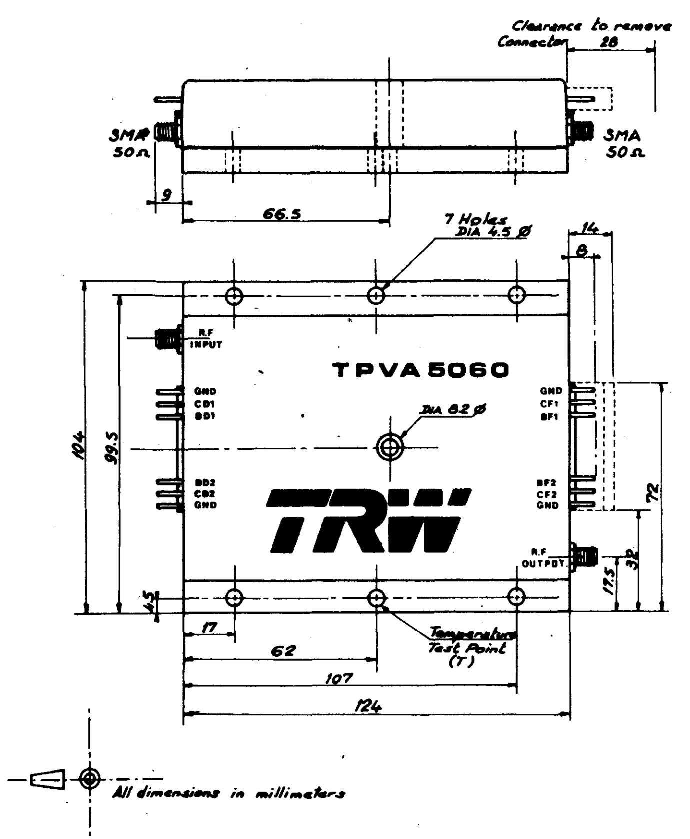
BD = Base driver
CD = Collector driver
BF = Base final
CF = Collector final

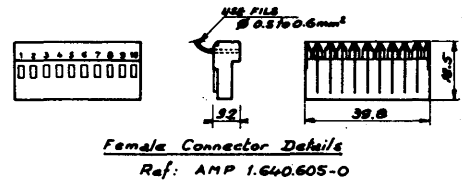
BIASING CONDITIONS

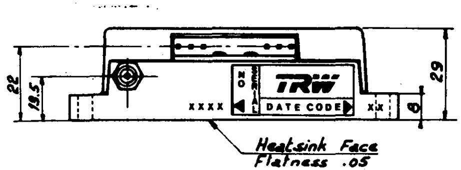
Voltage current : $V_{CD1} = V_{CF1} = V_{CD2} = V_{CF2}$ = 26 volts

Current : $I_{CD1} = I_{CD2}$ = 1.7 A
$I_{CF1} = I_{CF2}$ = 3.6 A

MECHANICAL DRAWINGS







PRIOR TO SWITCHING ON,
REFER TO OPERATING INSTRUCTIONS :
SEE TV 005-83 APPLICATION NOTE

3 TONES INTERMODULATION TEST

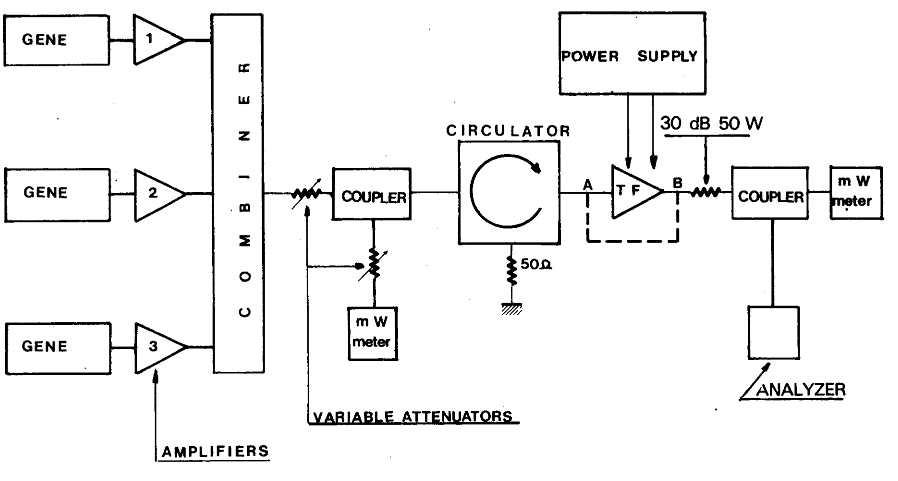
(SPECIFICATION TV 05001)

1. PURPOSE

Measure the intermodulation of the device with the following conditions :

Pref	:	rated value
Vision	:	-8 dB (F_0)
Sound	:	-7 dB ($F_0 + 5.5$ MHz)
Side band	:	-16 dB ($F_0 + 4.4$ MHz)
IMD	:	$F_0 + 1.1$ MHz rated value

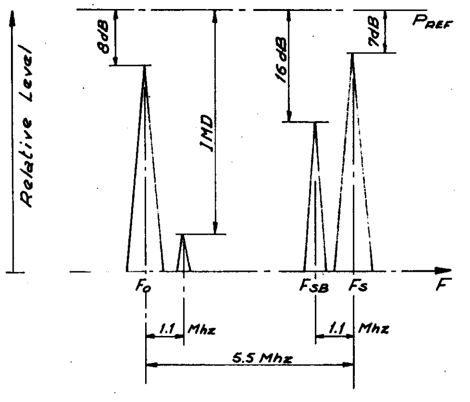
2. MEASURING CIRCUIT



3. EQUIPMENTS

- Generator
- Amplifier
- Circulator
- Bi-directional coupler
- Attenuator 30 dB; 50 W
- Power Supply
- Milliwattmeter
- Spectrum Analyser

4. EXECUTION



F_o = Vision carrier
F_{SB} = Side band carrier
F_s = Sound carrier

MICROWAVE

E

PRODUCT SUMMARY

PART NUMBER	APPLICATION	FREQUENCY	POWER OR GAIN (dB)	SUPPLY VOLTAGE (V)	PACKAGE	PAGE
MRA 0610-3	MICROWAVE	600-1000 MHz	3 W	28	MRA .25	E 5
MRA 0610-9	MICROWAVE	600-1000 MHz	9 W	28	MRA .25	E 6
MRA 0610-18	MICROWAVE	600-1000 MHz	18 W	28	MRA .25	E 7
MRA 0610-40	MICROWAVE	600-1000 MHz	40 W	28	MRA .25	E 8
MRA 1014-2	MICROWAVE	1.0-1.4 GHz	2 W	28	MRA .25	E 13
MRA 1014-6	MICROWAVE	1.0-1.4 GHz	6 W	28	MRA .25	E 14
MRA 1014-12	MICROWAVE	1.0-1.4 GHz	12 W	28	MRA .25	E 15
MRA 1014-35	MICROWAVE	1.0-1.4 GHz	35 W	28	MRA .25	E 16
MRA 1214-55H	MICROWAVE	1.2-1.4 GHz	55 W	28	MRA .4	E 19
MRA 1417-2	MICROWAVE	1.4-1.7 GHz	2 W	28	MRA .25	E 23
MRA 1417-6	MICROWAVE	1.4-1.7 GHz	6 W	28	MRA .25	E 24
MRA 1417-11	MICROWAVE	1.4-1.7 GHz	11 W	28	MRA .25	E 25
MRA 1417-25	MICROWAVE	1.4-1.7 GHz	25 W	28	MRA .25	E 26
MRA 1720-2	MICROWAVE	1.7-2.0 GHz	2 W	28	MRA .25	E 31
MRA 1720-5	MICROWAVE	1.7-2.0 GHz	5 W	28	MRA .25	E 32
MRA 1720-9	MICROWAVE	1.7-2.0 GHz	9 W	28	MRA .25	E 33
MRA 1720-20	MICROWAVE	1.7-2.0 GHz	20 W	28	MRA .25	E 34
MRAL 1417-2	MICROWAVE	1.4-1.7 GHz	2 W	22	MRA .25	E 37
MRAL 1417-6	MICROWAVE	1.4-1.7 GHz	6 W	22	MRA .25	E 37
MRAL 1417-11	MICROWAVE	1.4-1.7 GHz	11 W	22	MRA .25	E 37
MRAL 1417-25	MICROWAVE	1.4-1.7 GHz	25 W	22	MRA .25	E 37
MRAL 1720-2	MICROWAVE	1.7-2.0 GHz	2 W	22	MRA .25	E 39
MRAL 1720-5	MICROWAVE	1.7-2.0 GHz	5 W	22	MRA .25	E 40
MRAL 1720-9	MICROWAVE	1.7-2.0 GHz	9 W	22	MRA .25	E 41
MRAL 1720-20	MICROWAVE	1.7-2.0 GHz	20 W	22	MRA .25	E 42
MRAL 2023-1,5	MICROWAVE	2.0-2.3 GHz	1.5 W	22	MRA .25	E 46
MRAL 2023-3	MICROWAVE	2.0-2.3 GHz	3 W	22	MRA .25	E 47
MRAL 2023-6	MICROWAVE	2.0-2.3 GHz	6 W	22	MRA .25	E 48
MRAL 2023-12	MICROWAVE	2.0-2.3 GHz	12 W	22	MRA .25	E 49
MRAL 2023-1,5H	MICROWAVE	2.0-2.3 GHz	1.5 W	22	HLP 11	E 53
MRAL 2023-3H	MICROWAVE	2.0-2.3 GHz	3 W	22	HLP 11	E 54
MRAL 2023-6H	MICROWAVE	2.0-2.3 GHz	6 W	22	HLP 11	E 55
MRAL 2023-12H	MICROWAVE	2.0-2.3 GHz	12 W	22	HLP 11	E 56
TRW 2001	MICROWAVE	2 GHz	1 W	28	HLP 8	E 59
TRW 2003	MICROWAVE	2 GHz	3 W	28	HLP 8	E 61
TRW 2005	MICROWAVE	2 GHz	5 W	28	HLP 8	E 63
TRW 2010	MICROWAVE	2 GHz	10 W	28	HLP 8	E 65
TRW 2015	MICROWAVE	2 GHz	15 W	28	HLP 11	E 67
TRW 2020	MICROWAVE	2 GHz	20 W	28	HLP 11	E 68
TRW 2301	MICROWAVE	2.3 GHz	1.5 W	20	HLP 8	E 70
TRW 2304	MICROWAVE	2.3 GHz	4 W	20	HLP 8	E 71
TRW 2307	MICROWAVE	2.3 GHz	7 W	20	HLP 8	E 72
TRW 3001	MICROWAVE	3 GHz	1 W	28	HLP 8	E 75
TRW 3003	MICROWAVE	3 GHz	3 W	28	HLP 8	E 77
TRW 3005	MICROWAVE	3 GHz	5 W	28	HLP 8	E 79
TRW 52001	MICROWAVE	2 GHz	1.5 W	20	TW 200	E 82
TRW 52002	MICROWAVE	2 GHz	3 W	20	TW 200	E 87
TRW 52004	MICROWAVE	2 GHz	6 W	20	TW 200	E 91
TRW 52101	MICROWAVE	2 GHz	1.5 W	20	HLP 8F	E 83
TRW 52201	MICROWAVE	2 GHz	1.5 W	20	GP 14S	E 83
TRW 52501	MICROWAVE	2 GHz	1.5 W	20	GP 14	E 83
TRW 52502	MICROWAVE	2 GHz	3 W	20	GP 14	E 88
TRW 52504	MICROWAVE	2 GHz	6 W	20	GP 14	E 93
TRW 52601	MICROWAVE	2 GHz	1.5 W	20	HPL 8	E 83
TRW 52602	MICROWAVE	2 GHz	3 W	20	HLP 8	E 88
TRW 52604	MICROWAVE	2 GHz	6 W	20	HLP 8	E 93
TRW 53001	MICROWAVE	3 GHz	0.8 W	20	TW 200	E 95

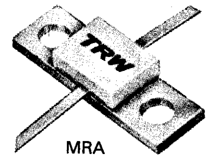
PRODUCT SUMMARY

PART NUMBER	APPLICATION	FREQUENCY	POWER OR GAIN (dB)	SUPPLY VOLTAGE (V)	PACKAGE	PAGE
TRW 53002	MICROWAVE	3 GHz	1.6 W	20	TW 200	E 99
TRW 53101	MICROWAVE	3 GHz	0.8 W	20	HLP 8F	E 96
TRW 53201	MICROWAVE	3 GHz	0.8 W	20	GP 14S	E 96
TRW 53501	MICROWAVE	3 GHz	0.8 W	20	GP 14	E 96
TRW 53502	MICROWAVE	3 GHz	1.6 W	20	GP 14	E 100
TRW 53601	MICROWAVE	3 GHz	0.8 W	20	HLP 8	E 96
TRW 53602	MICROWAVE	3 GHz	1.6 W	20	HLP 8	E 100
TRW 54001	MICROWAVE	2 GHz-4 GHz	0.5 W	20	TW 200	E 103
TRW 54101	MICROWAVE	2 GHz-4 GHz	0.5 W	20	HLP 8F	E 104
TRW 54201	MICROWAVE	2 GHz-4 GHz	0.5 W	20	GP 14S	E 104
TRW 54501	MICROWAVE	2 GHz-4 GHz	0.5 W	20	GP 14	E 104
TRW 54601	MICROWAVE	2 GHz-4 GHz	0.5 W	20	HLP 8	E 104
TRW 62601	MICROWAVE	2 GHz	1.2 W	20	HLP 8	E 107
TRW 62602	MICROWAVE	2 GHz	2.5 W	20	HLP 8	E 111
TRW 63601	MICROWAVE	3 GHz	0.45 W	20	HLP 8	E 115
TRW 63602	MICROWAVE	3 GHz	0.85 W	20	HLP 8	E 119
TRW 64601	MICROWAVE	4 GHz	0.3 W	20	HLP 8	E 123
TRW 64602	MICROWAVE	4 GHz	0.6 W	20	HLP 8	E 127

TRW

MICroAMP

- **3-9-18-40 W**
- **Broadband 600-1000 MHz**
- **Internally Compensated***
- **Gold Metalized**
- **Diffused Ballast Resistors**
- **MTTF Data**



Electrical Characteristics (T_{flange} = 25 °C)

Symbol	Characteristic	MRA0610-3	MRA0610-9	MRA0610-18	MRA0610-40
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 20 mA 50 V Min	I_C = 60 mA 50 V Min	I_C = 100 mA 50 V Min	I_C = 200 mA 50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA 3.5 V Min	I_B = 0.5 mA 3.5 V Min	I_B = 1.25 mA 3.5 V Min	I_E = 2.5 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 28 V 0.5 mA V_{CB} = 45 V 1.0 mA	V_{CB} = 28 V 1.5 mA V_{CB} = 45 V 3.0 mA	V_{CB} = 28 V 2.5 mA V_{CB} = 45 V 5.0 mA	V_{CB} = 28 V 5.0 mA V_{CB} = 45 V 10.0 mA
I_C	Max Continuous Collector Current V_{CE} = 4 V	0.5 A	1.5 A	5.0 A	10.0 A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V	I_C = 0.1 A 10-100	I_C = 0.3 A 10-100	I_C = 0.5 A 10-100	I_C = 1.0 A 10-100
θ_{jF}	Thermal Resistance Junction to Flange	15 °C/W	6 °C/W	4 °C/W	2.5 °C/W
P_o	Min Broadband Power Output	3.0 W	9.0 W	18.0 W	40.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 28 V, f = 1 MHz	4.5 pF	10 pF	14 pF	28 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 28 V	P_o = 3.0 W 7.8 dB	P_o = 9.0 W 7.8 dB	P_o = 18.0 W 7.8 dB	P_o = 40.0 W 7.0 dB
MTTF	Metal Failure Factor Hrs × Amps^2 T_j = 150 °C*	60,692	546,227	1,517,298	6,069,192
η_c	Min Broadband Collector Efficiency	P_o = 3.0 W 50 %	P_o = 9.0 W 55 %	P_o = 18.0 W 50 %	P_o = 40.0 W 55 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : —.65 to + 200 °C				

* Based on Black's equation and using φ = 0.96 EV, β = 1.07 × 10^{-12} for unpassivated Au. Empirical data indicates a 3-10 times improvement for glass passivated units. These units are glass passivated.

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, inc. (US ≠ 3,713,006).

The TRW MRA0610 series offers a complete family of broadband, high-gain transistors for applications in the 600-1000MHz band.

Using internal compensation (a patented* technique developed and first offered for sale by TRW), the MRA0610 series is intended for use in a variety of military and industrial applications including ECM, radio relay and the "960" mobile band for fixed station use.

The smooth, broadband transfer characteristics of the MRA0610 series makes it attractive for semi-linear applications without the need for bias. Power leveling within a broad range can be accomplished simply through control of low-level drive, thus eliminating brute force control of collector voltage.

Device output power levels of 3, 9, 18 and 40 watts allow a wide choice of lineup configurations. Excellent device-to-device phase tracking characteristics permit hybrid combination for higher powers with negligible combining loss.

Complete data and broadband circuitry, suitable to photograph for circuit boards, are contained herein.

DIFFUSED BALLASTING AND RELIABILITY

Microwave transistor devices are universally constructed using multiple cell combinations for higher power. A number of advantages are obtained using the cellular concept including better thermal balance and the ability to adjust power output capability using more or less cells to construct a device. Unless proper ballasting techniques are employed, some difficulty can be encountered in the act of combining cells. Ballasting makes cell combining practical. The alternative to ballasted cells is an operator-dependent assembly technique called "contour-bonding." Herein, bond wires of varying lengths are employed to adjust inductance and thereby achieve the expected balance. TRW has decided in favor of ballasting rather than contour-bonding because it is a controlled, repeatable and totally reliable technique.

While ballasting is desirable, certain techniques for creating ballast resistors in fine geometry microwave transistors have proven unreliable. Such an example is "metal" ballast resistors. Such resistors are incorporated by introducing an exposed section of barrier metal between the emitter finger and feeder bar. This type of resistor, of necessity, lies on top of an oxide layer. Because the metal resistor is required to dissipate as much as $10KW/CM^2$, extreme temperatures are generated in the resistor material. With this construction there is no adequate means of removing heat from the metal resistor. Therefore, the ballast resistor undergoes radical changes in physical dimension during its operating profile. This results in separation from the oxide layer or micro-cracking, or both.

Given that ballasting is desirable, a better solution, **diffused ballast resistors**, is incorporated in the MRA0610 series. Several advantages accrue from this approach. It is integral in the silicon carrier, has the same coefficient of expansion and is heat sinked. Experience has shown that the diffused ballast resistor has none of the metal resistor disadvantages, yet offers an additional advantage. In the MRA0610 series, the diffused resistor is designed to current limit (because of limited carriers) before destructive current levels at the junction occur. Diffused ballast resistors are definitely superior in performance and reliability. Test data is available to verify this fact.

METALIZATION AND RELIABILITY

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200°C	30

For this reason, TRW RF Semiconductors uses a gold metalization system on all microwave transistors including the MRA0610 series.

TRW'S PATENTED* MICroAMP

Since power microwave transistors became feasible, the bandwidth limiting problem of excessively high input "Q's" has vexed the solid state microwave amplifier designer.

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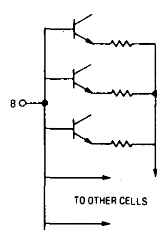
Note that all components of the input impedance are in parallel, which compounds the "Q" and bandwidth problem as more cells are used to achieve power, or the operating frequency is raised (or both). Figure 2 illustrates a more acceptable solution which combines inputs after an impedance transformation at the input of each device cell. It is convenient to do this all or partially within the package.



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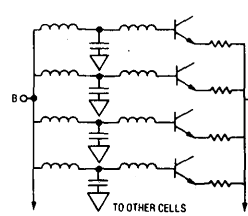


Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

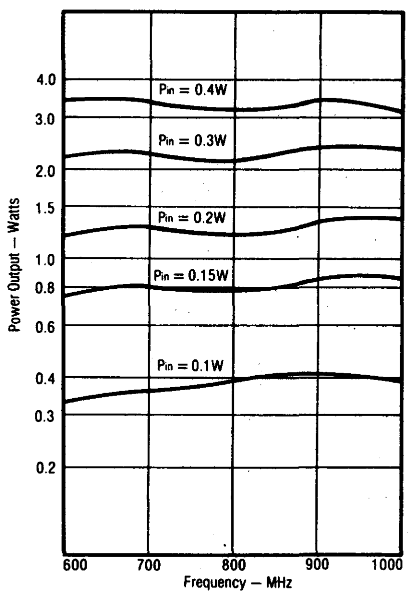
Because of the nature of source impedance driving the transistor cell (essentially a voltage source), as much as 10dB additional usable dynamic range without noticeably altering bandwidth or tuning is possible with the MICroAMP.

Additional gain and bandwidth advantage can be obtained by operation of the MICroAMP device cells in a common base configuration. The devices described therein are so configured.

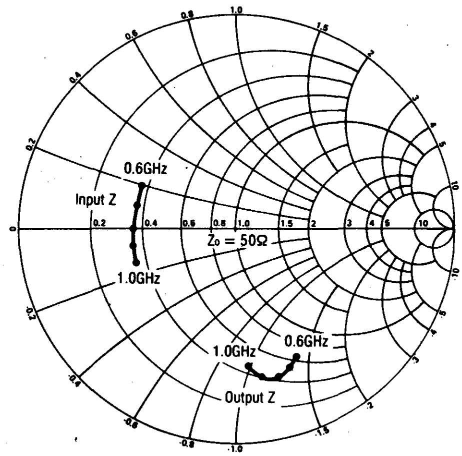
*TRW U.S. Patent #3,713,006

MRA0610-3 — 3 WATTS BROADBAND

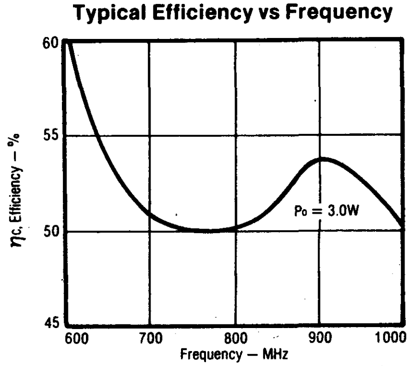
Typical Power Output vs Frequency



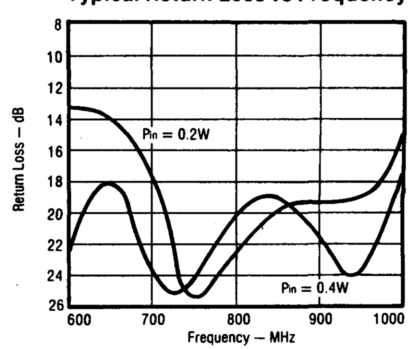
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

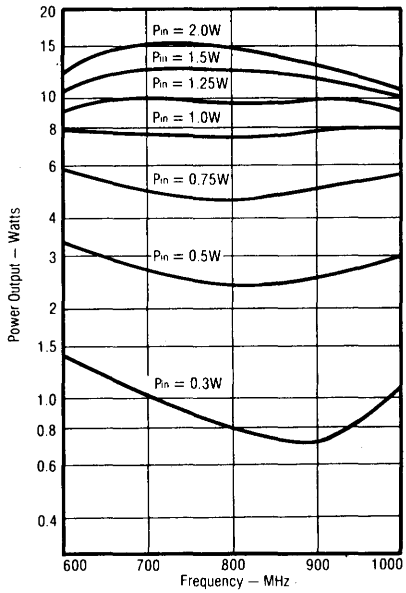


Typical Return Loss vs Frequency

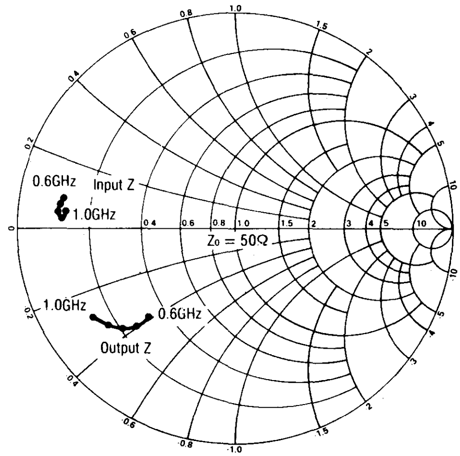


MRA0610-9 — 9 WATTS BROADBAND

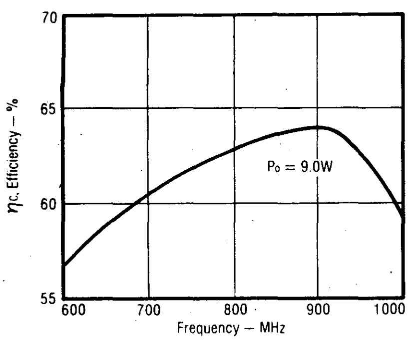
Typical Power Output vs Frequency



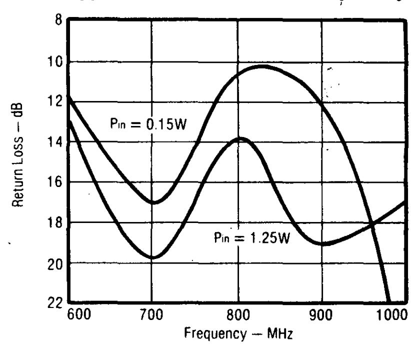
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

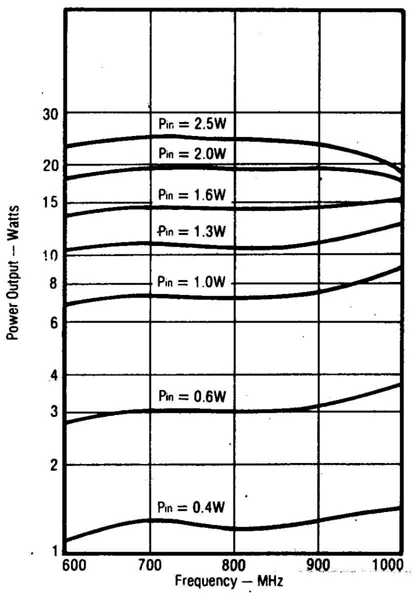


Typical Return Loss vs Frequency

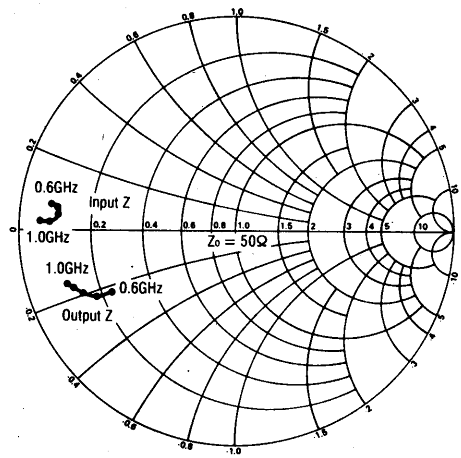


MRA0610-18 — 18 WATTS BROADBAND

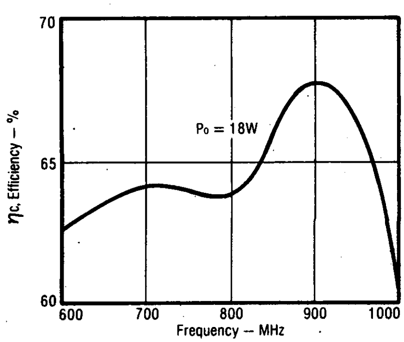
Typical Power Output vs Frequency



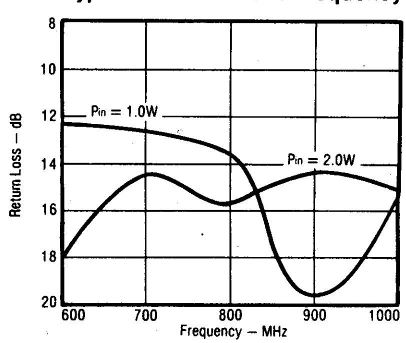
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

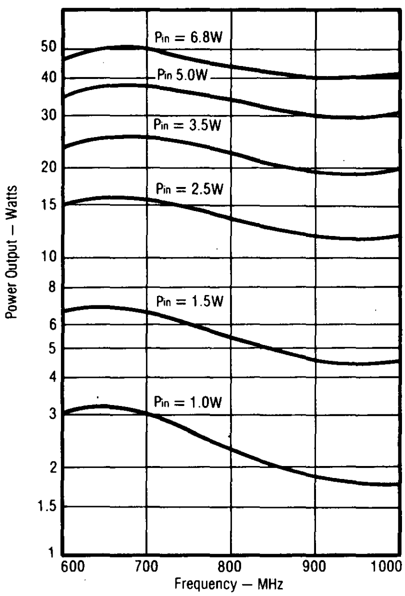


Typical Return Loss vs Frequency

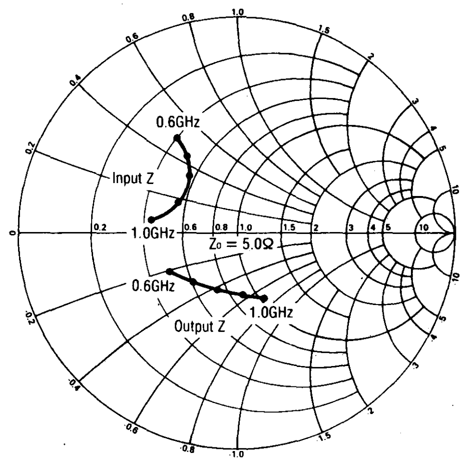


MRA0610-40 — 40 WATTS BROADBAND

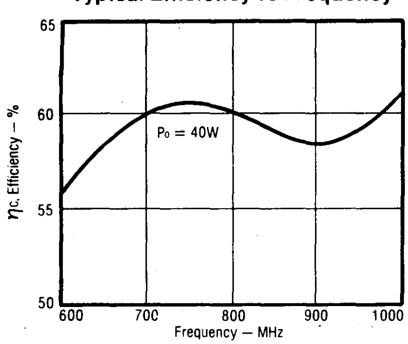
Typical Power Output vs Frequency



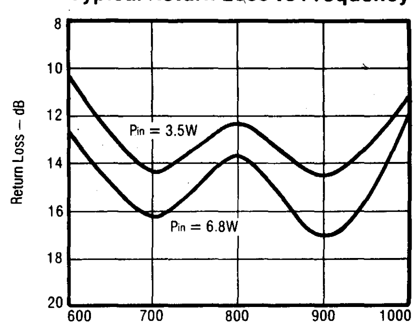
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

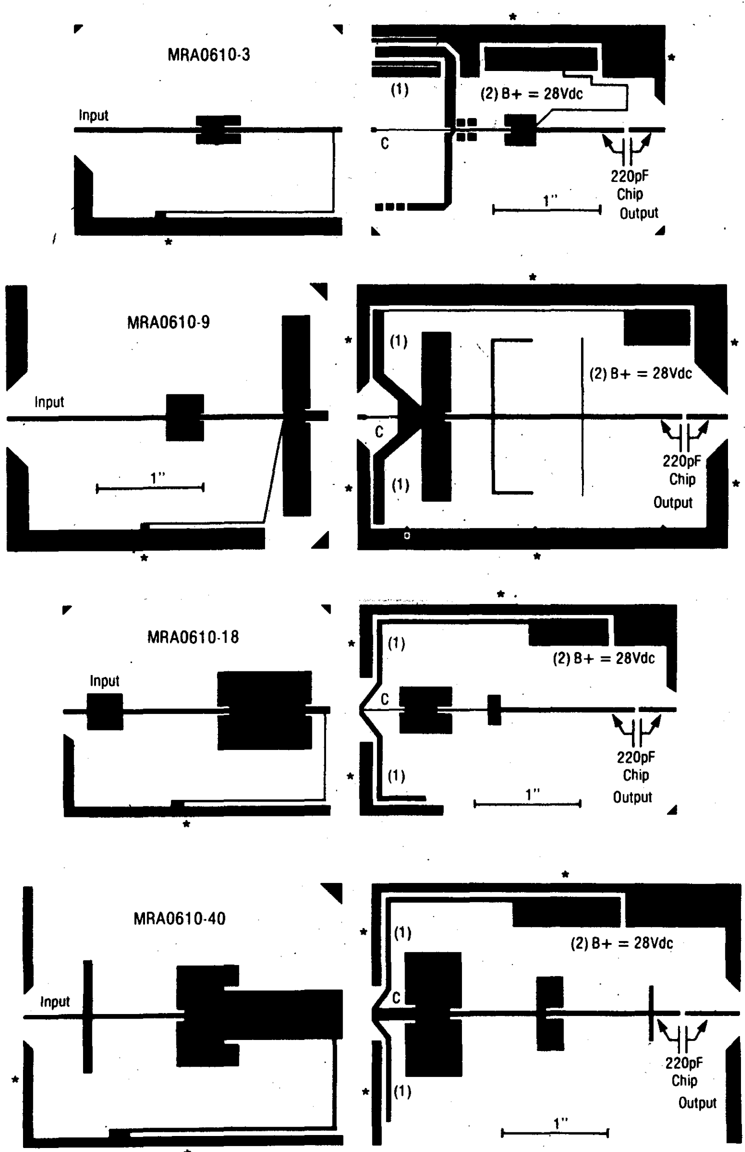


Typical Return Loss vs Frequency



TEST CIRCUIT BOARDS FOR MRA0610 SERIES

NOTE: Scale is not 1:1.



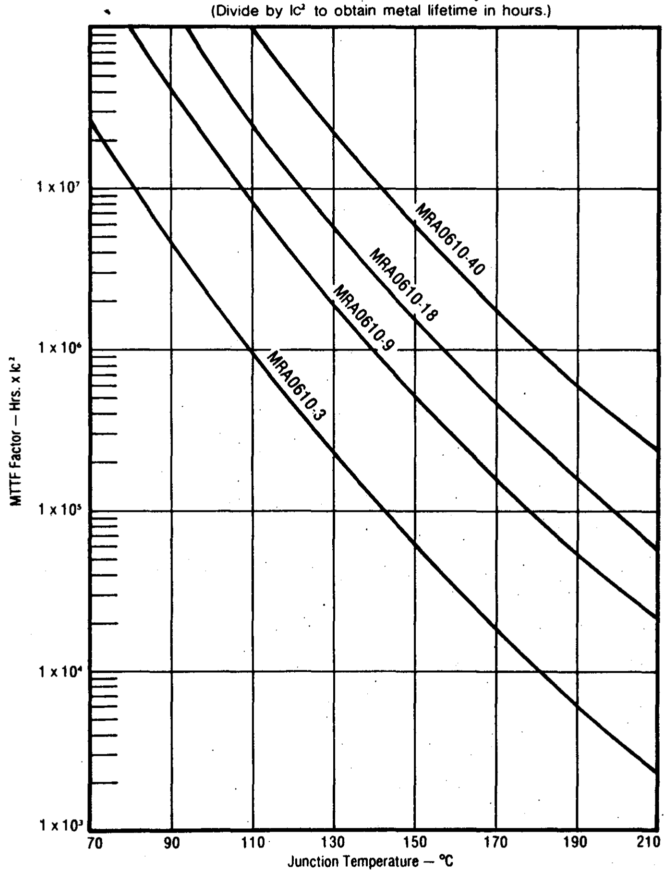
*Foil wrap or plate around to ground plane. Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

(1) Bypass capacitor to ground for shunt inductor (220pF chip).

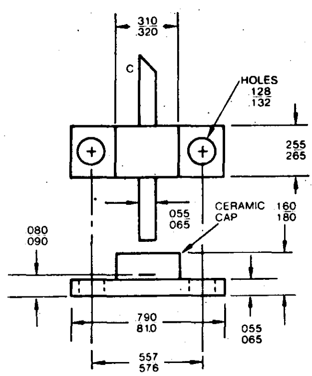
(2) Use B+ bypass of 0.01 and 1μF capacitors at this point.

MTTF FACTOR vs Tj

(Divide by Ic² to obtain metal lifetime in hours.)



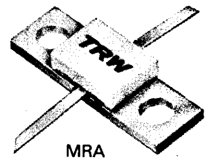
MRA Series Package



TRW

MICroAMP

- 2-6-12-35 W
- Broadband 1000-1400 MHz
- Internally Compensated*
- Gold Metalized
- Diffused Ballast Resistors
- MTTF Data



Electrical Characteristics (T_{flange} = 25 °C)

Symbol	Characteristic	MRA1014 2	MRA1014 6	MRA1014 12	MRA1014 35
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 20 mA 50 V Min	I_C = 40 mA 50 V Min	I_C = 80 mA 50 V Min	I_C = 200 mA 50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA 3.5 V Min	I_E = 0.5 mA 3.5 V Min	I_E = 1.0 mA 3.5 V Min	I_E = 2.5 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 28 V 0.5 mA V_{CB} = 45 V 1.0 mA	V_{CB} = 28 V 1.0 mA V_{CB} = 45 V 2.0 mA	V_{CB} = 28 V 2.0 mA V_{CB} = 45 V 4.0 mA	V_{CB} = 28 V 5.0 mA V_{CB} = 45 V 10.0 mA
I_C	Max Continuous Collector Current V_{CE} = 4 V	0.5 A	1.5 A	5.0 A	10.0 A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V	I_C = 0.1 A 10-100	I_C = 0.2 A 10-100	I_C = 0.4 A 10-100	I_C = 1.0 A 10-100
θ_{jF}	Thermal Resistance Junction to Flange	15 °C/W	8 °C/W	4.5 °C/W	2 °C/W
P_o	Min Broadband Power Output	3.0 W	6.0 W	12.0 W	35.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 28 V, f = 1 MHz	4.5 pF	8 pF	12 pF	28 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 28 V	P_o = 2.0 W 8.2 dB	P_o = 6.0 W 7.4 dB	P_o = 12.0 W 7.8 dB	P_o = 35.0 W 7.0 dB
η_c	Min Broadband Collector Efficiency	P_o = 2.0 W 45 %	P_o = 6.0 W 50 %	P_o = 12.0 W 50 %	P_o = 35.0 W 50 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : — 65 to + 200 °C				

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, Inc. (US # 3,713,006).

The TRW MRA1014 series offers a complete family of broadband, high-gain transistors for applications in the 1000-1400MHz band.

Using internal compensation (a patented* technique developed and first offered for sale by TRW), the MRA1014 series is intended for use in a variety of military and industrial applications including ECM, radio relay and telemetry for fixed station use.

The smooth, broadband transfer characteristics of the MRA1014 series makes it attractive for semi-linear applications without the need for bias. Power leveling within a broad range can be accomplished simply through control of low-level drive, thus eliminating brute force control of collector voltage.

Device output power levels of 2, 6, 12 and 35 watts allow a wide choice of lineup configurations. Excellent device-to-device phase tracking characteristics permit hybrid combination for higher powers with negligible combining loss.

Complete data and broadband circuitry, suitable to photograph for circuit boards, are contained herein.

DIFFUSED BALLASTING AND RELIABILITY

Microwave transistor devices are universally constructed using multiple cell combinations for higher power. A number of advantages are obtained using the cellular concept including better thermal balance and the ability to adjust power output capability using more or less cells to construct a device. Unless proper ballasting techniques are employed, some difficulty can be encountered in the act of combining cells. Ballasting makes cell combining practical. The alternative to ballasted cells is an operator-dependent assembly technique called "contour-bonding." Herein, bond wires of varying lengths are employed to adjust inductance and thereby achieve the expected balance. TRW has decided in favor of ballasting rather than contour-bonding because it is a controlled, repeatable and totally reliable technique.

While ballasting is desirable, certain techniques for creating ballast resistors in fine geometry microwave transistors have proven unreliable. Such an example is "metal" ballast resistors. Such resistors are incorporated by introducing an exposed section of barrier metal between the emitter finger and feeder bar. This type of resistor, of necessity, lies on top of an oxide layer. Because the metal resistor is required to dissipate as much as $10KW/CM^2$, extreme temperatures are generated in the resistor material. With this construction there is no adequate means of removing heat from the metal resistor. Therefore, the ballast resistor undergoes radical changes in physical dimension during its operating profile. This results in separation from the oxide layer or micro-cracking, or both.

Given that ballasting is desirable, a better solution, **diffused ballast resistors**, is incorporated in the MRA1014 series. Several advantages accrue from this approach. It is integral in the silicon carrier, has the same coefficient of expansion and is heat sinked. Experience has shown that the diffused ballast resistor has none of the metal resistor disadvantages, yet offers an additional advantage. In the MRA1014 series, the diffused resistor is designed to current limit (because of limited carriers) before destructive current levels at the junction occur. Diffused ballast resistors are definitely superior in performance and reliability. Test data is available to verify this fact.

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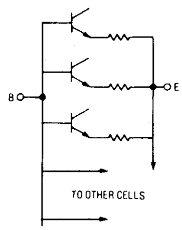

Figure 1. Elementary Method of Cell Combining

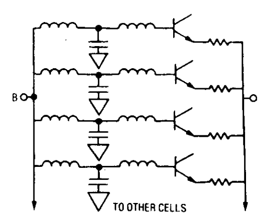

Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

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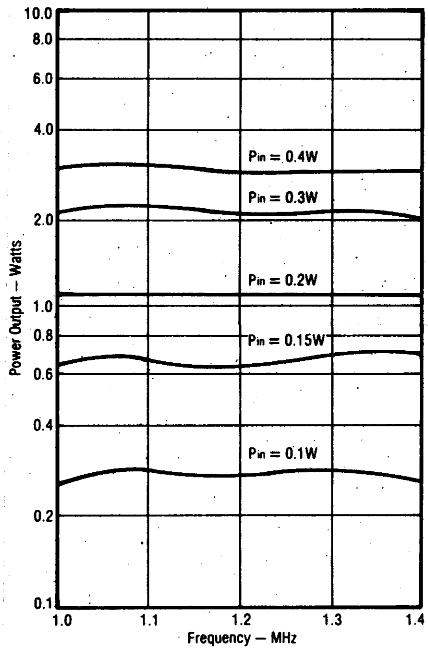
*TRW U.S. Patent #3,713,006

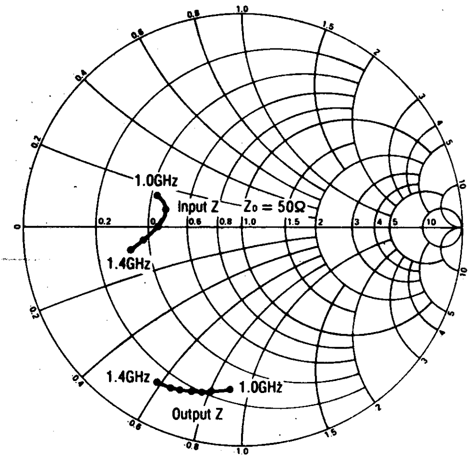
E

MRA1014-2 — 2 WATTS BROADBAND

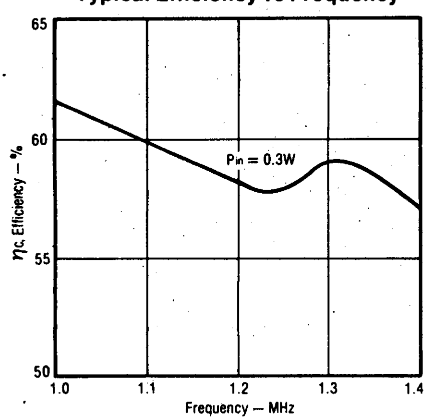
Typical Power Output vs Frequency



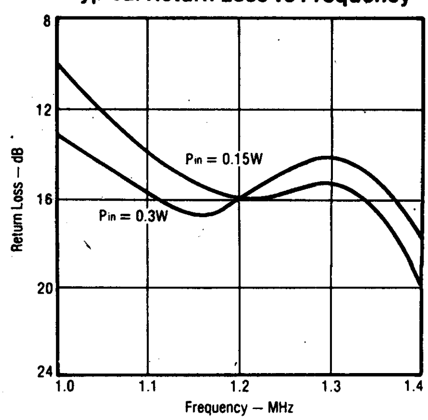
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

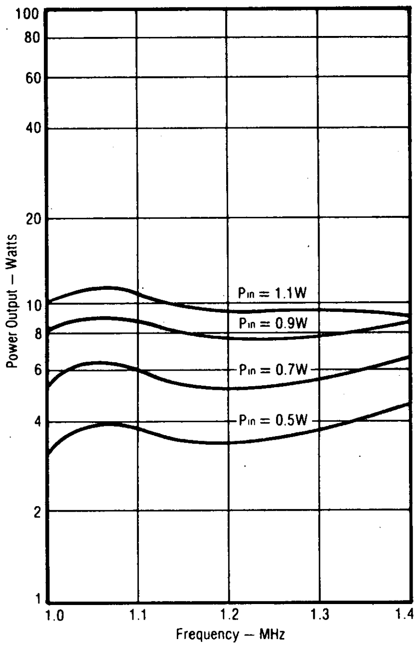


Typical Return Loss vs Frequency

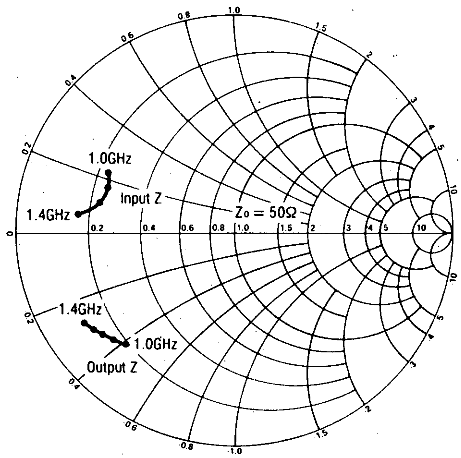


MRA1014-6 — 6 WATTS BROADBAND

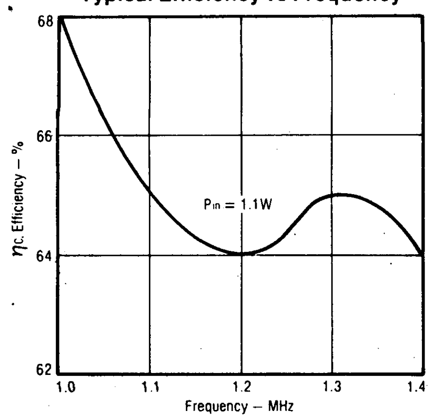
Typical Power Output vs Frequency



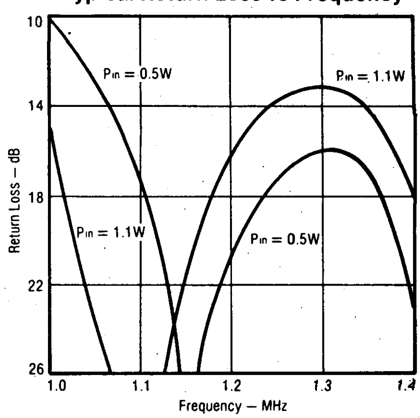
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

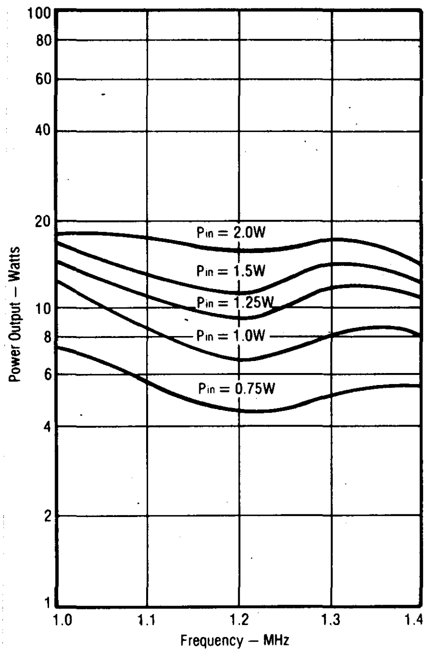


Typical Return Loss vs Frequency

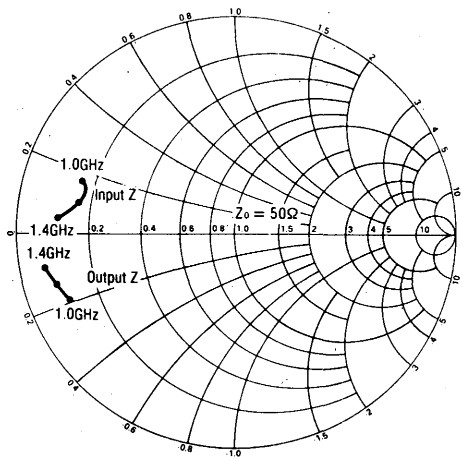


MRA1014-12 — 12 WATTS BROADBAND

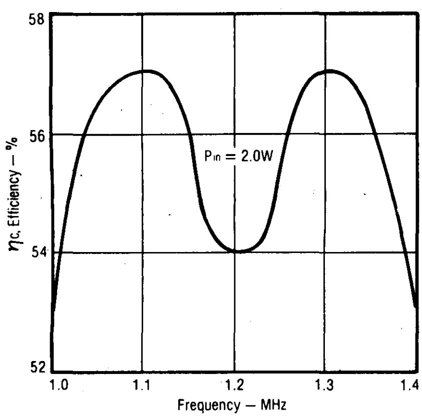
Typical Power Output vs Frequency



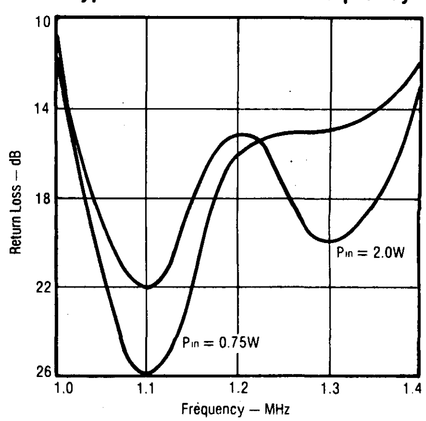
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

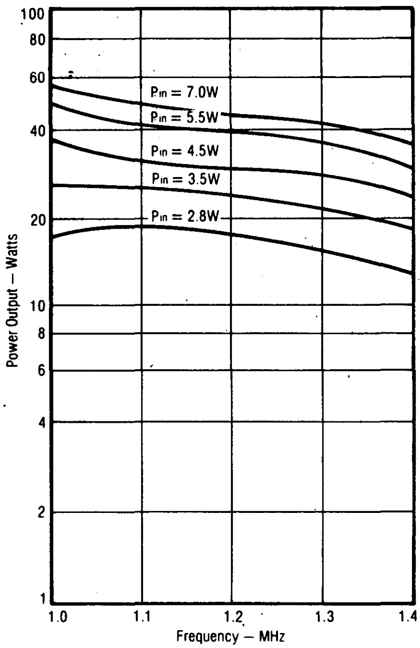


Typical Return Loss vs Frequency

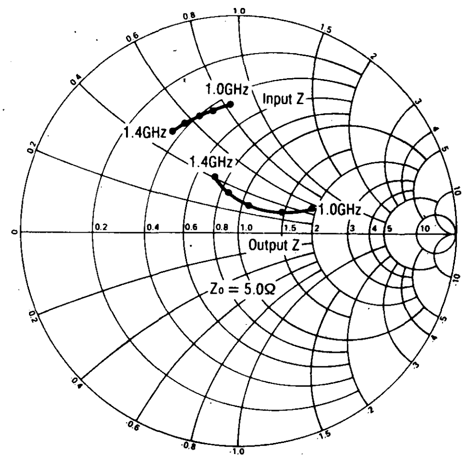


MRA1014-35 — 35 WATTS BROADBAND

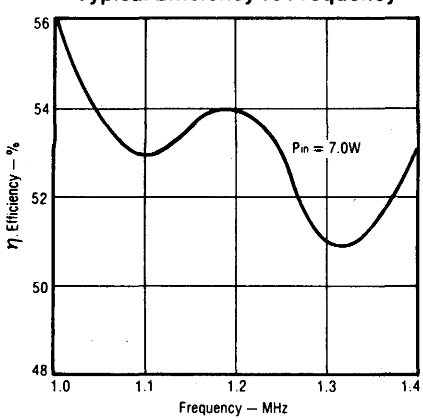
Typical Power Output vs Frequency



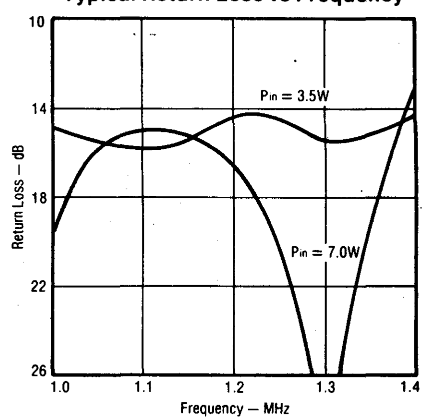
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

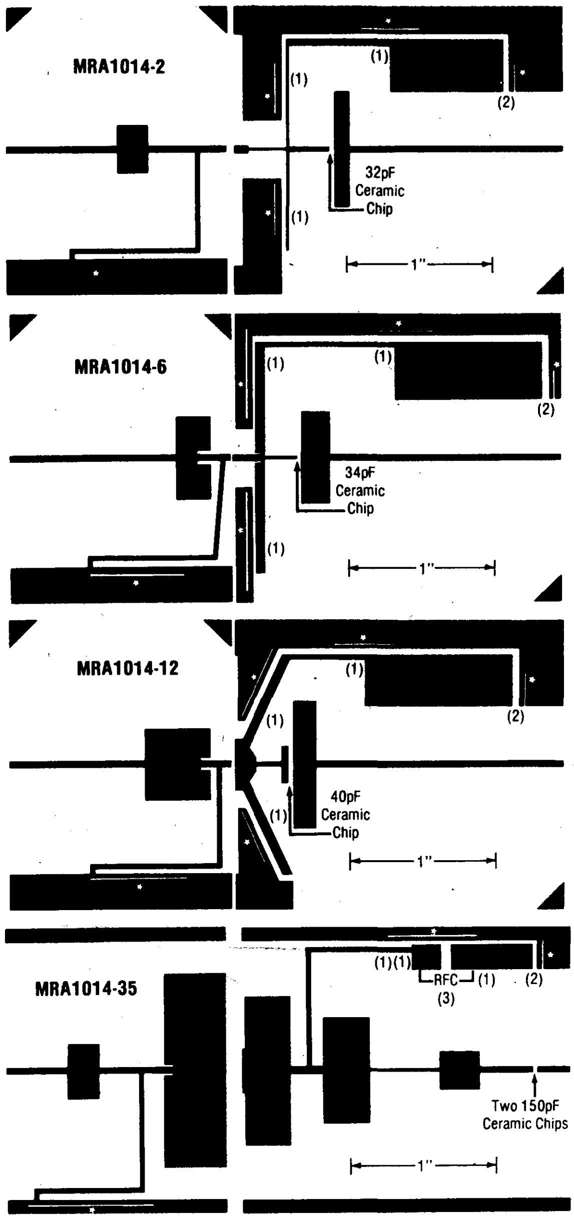


Typical Return Loss vs Frequency



TEST CIRCUIT BOARDS FOR MRA1014 SERIES

NOTE: Scale is not 1:1.



*Foil wrap or plate around to ground plane. Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

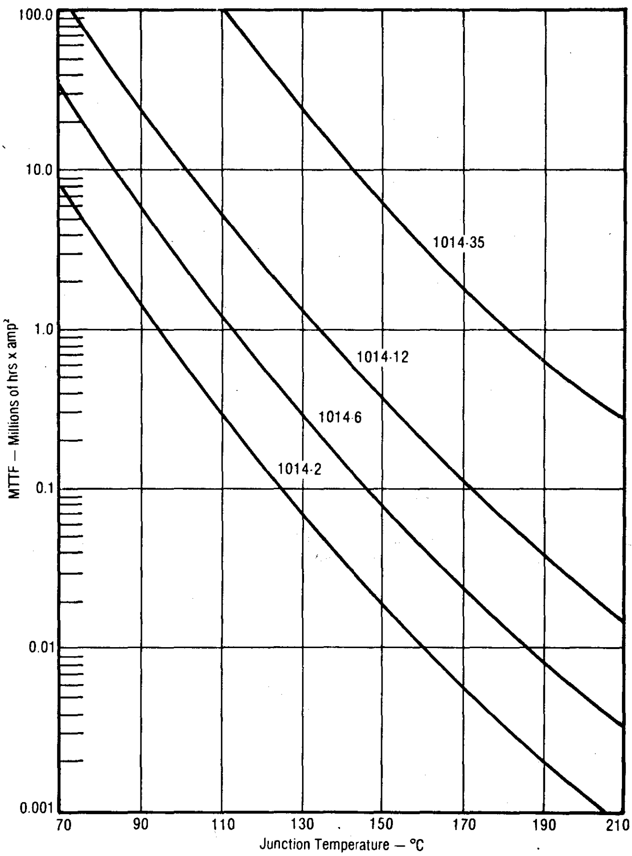
(1) Bypass capacitor to ground (150pF chip).

(2) Use B+ bypass of 0.01 and 1μF capacitors at this point.

(3) 10 turns #20 enamel close wound on 0.040 mandril.

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.



Example of MTTF for MRA1014-12 Conditions

where:

$P_o = 12W$

$P_{in} = 2W$

$V_{CC} = 28V$

$\eta_c = 50\%$

$T_{flange} = 70°C$

$$I_C \cong I_E = \frac{100 P_o}{\eta_c \times V_{CC}} = 0.857A$$

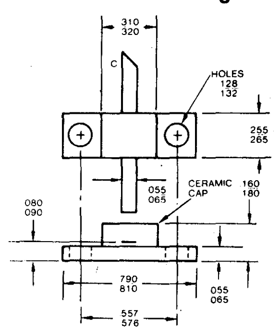
$$P_{diss} = P_{in} + V_{CC} I_C - P_o = 14.0W$$

$$T_{junc} = T_{flange} + \theta_{JF} \times P_{diss} = 133°C$$

$$MTTF = \frac{1.2 \times 10^6 \text{ hrs amp}^2}{I_C^2} = 1{,}400{,}200 \text{ hrs}$$

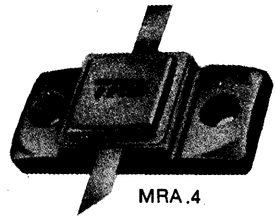
$$= 159 \text{ yrs}$$

MRA Series Package



L-Band High Power

- **55 W**
- **1200-1400 MHz**



The TRW MRA 1214-55H* is an NPN silicon power RF transistor which is intended for military and industrial use in the 1200-1400 MHz range. It provides a minimum of 55 watts output power at 28 VDC collector potential.

In a pulsed mode (100 μs, modest duty) as much as 100 watts output power is available.

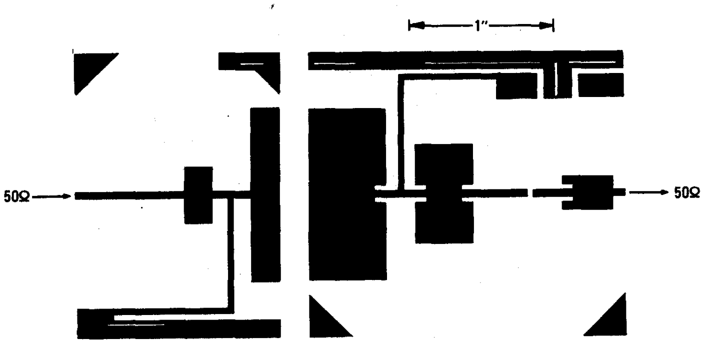
The devices feature TRW-pioneered advantages such as PtSi-TiWAu metalization and diffused silicon ballast resistors.

These high power microwave transistors find use in radar systems, ECM systems and other L-Band systems. 6.5 dB of power gain allows hybrid combining of multiple devices. The high power output of the MRA 1214-55H assures combining of a minimum number of devices to achieve desired power output.

Electrical Characteristics (25°C unless otherwise noted)

Test	Characteristic	Test Conditions	Min	Max	Units
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 2.0mA	3.5		Volts
BV_{CES}	Collector-Base Breakdown Voltage	I_C = 6.0mA I_C = 12.0mA I_C = 120.0mA	28 45 58		Volts
P_O	Min. Broadband Power Output	P_{IN} = 12.3W 1.2-1.4 GHz (@ 6.5dB Gain)	55		Watts
η_C	Min. Broadband Collector Efficiency	P_O = 55W 1.2-1.4 GHz V_{CC} = 28V	45	50 (typ.)	Percent
Θ_{JF}	Thermal Resistance Junction to Flange	T_{FLANGE} = 25°C	1.5		0°C/W

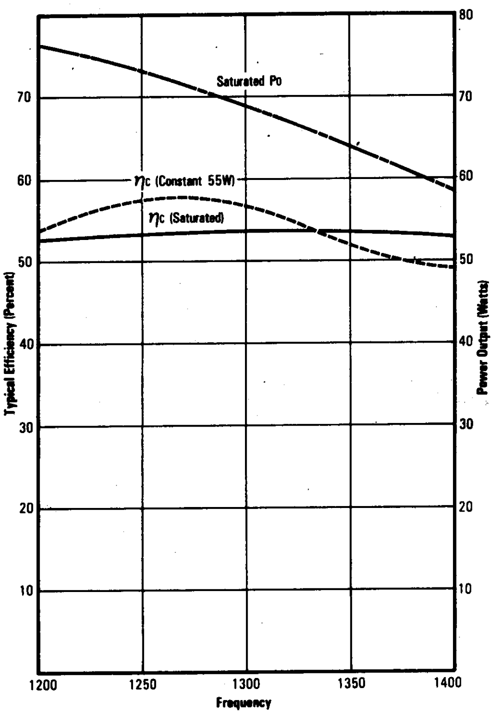
MRA1214-55H stripline circuit for .020" glass-Teflon

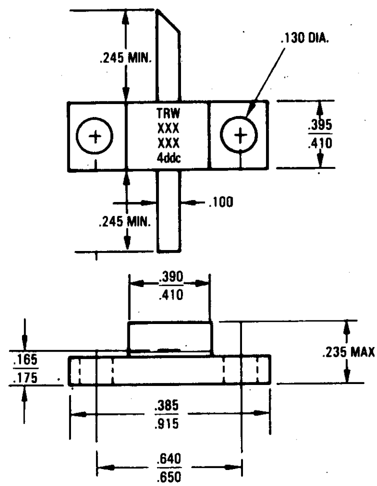


NOTE: Foil bond all slots to ground plane (back).

MRA 4

Typical Efficiency vs. Frequency
Power Output vs. Frequency



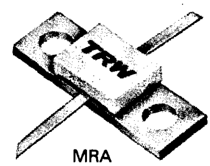


E

MRA 1417 Series

MICroAMP

- 2-6-11-25 W
- Broadband 1400-1700 MHz
- Internally Compensated*
- Gold Metalized
- Diffused Ballast Resistors
- MTTF Data



MRA

Electrical Characteristics at T_{flange} = 25 °C

Symbol	Characteristic	MRA1417-2	MRA1417-6	MRA1417-11	MRA1417-25
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 20 mA 50 V Min	I_C = 40 mA 50 V Min	I_C = 80 mA 50 V Min	I_C = 160 mA 50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA 3.5 V Min	I_E = 0.5 mA 3.5 V Min	I_E = 1.0 mA 3.5 V Min	I_E = 2.0 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 28 V 0.5 mA	V_{CB} = 28 V 1.0 mA	V_{CB} = 28 V 2.0 mA	V_{CB} = 28 V 4.0 mA
		V_{CB} = 45 V 1.0 mA	V_{CB} = 45 V 2.0 mA	V_{CB} = 45 V 4.0 mA	V_{CB} = 45 V 8.0 mA
I_C	Max Continuous Collector Current V_{CE} = 4 V	0.5 A	1.0 A	4.0 A	8.0 A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V	I_C = 0.1 A 10-100	I_C = 0.2 A 10-100	I_C = 0.4 A 10-100	I_C = 0.8 A 10-100
θ_{jF}	Thermal Resistance Junction to Flange	15 °C/W	8 °C/W	4.5 °C/W	2.5 °C/W
P_o	Min Broadband Power Output	2.0 W	6.0 W	11.0 W	25.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 28 V, f = 1 MHz	4.5 pF	8 pF	12 pF	24 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 28 V	P_o = 2.0 W 8.0 dB	P_o = 6.0 W 7.4 dB	P_o = 11.0 W 7.4 dB	P_o = 25.0 W 7.0 dB
η_c	Min Broadband Collector Efficiency	P_o = 2.0 W 40 %	P_o = 6.0 W 45 %	P_o = 11.0 W 45 %	P_o = 25.0 W 45 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : — 65 to + 200 °C				

* Based on Black's Equation and using φ = 0.96 EV, β = 1.07 × 10^{-12} for unpassivated A_u. Empirical data indicates a 3-10 times improvement for glass passivated units. These units are glass passivated.

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, Inc. (US # 3,713,006).

The TRW MRA1417 series offers a complete family of broadband, high-gain transistors for applications in the 1.4-1.7GHz band.

Using internal compensation (a patented* technique developed and first offered for sale by TRW), the MRA1417 series is intended for use in a variety of military and industrial applications including ECM, radio relay and telemetry.

The smooth, broadband transfer characteristics of the MRA1417 series makes it attractive for semi-linear applications without the need for bias. Power leveling within a broad range can be accomplished simply through control of low-level drive, thus eliminating brute force control of collector voltage.

Device output power levels of 2, 6, 11 and 25 watts allow a wide choice of lineup configurations. Excellent device-to-device phase tracking characteristics permit hybrid combination for higher powers with negligible combining loss.

Complete data and broadband circuitry, suitable to photograph for circuit boards, are contained herein.

DIFFUSED BALLASTING AND RELIABILITY

Microwave transistor devices are universally constructed using multiple cell combinations for higher power. A number of advantages are obtained using the cellular concept including better thermal balance and the ability to adjust power output capability using more or less cells to construct a device. Unless proper ballasting techniques are employed, some difficulty can be encountered in the act of combining cells. Ballasting makes cell combining practical. The alternative to ballasted cells is an operator-dependent assembly technique called "contour-bonding." Herein, bond wires of varying lengths are employed to adjust inductance and thereby achieve the expected balance. TRW has decided in favor of ballasting rather than contour-bonding because it is a controlled, repeatable and totally reliable technique.

While ballasting is desirable, certain techniques for creating ballast resistors in fine geometry microwave transistors have proven unreliable. Such an example is "metal" ballast resistors. Such resistors are incorporated by introducing an exposed section of barrier metal between the emitter finger and feeder bar. This type of resistor, of necessity, lies on top of an oxide layer. Because the metal resistor is required to dissipate as much as $10KW/CM^2$, extreme temperatures are generated in the resistor material. With this construction there is no adequate means of removing heat from the metal resistor. Therefore, the ballast resistor undergoes radical changes in physical dimension during its operating profile. This results in separation from the oxide layer or micro-cracking, or both.

Given that ballasting is desirable, a better solution, **diffused ballast resistors**, is incorporated in the MRA1417 series. Several advantages accrue from this approach. It is integral in the silicon carrier, has the same coefficient of expansion and is heat sinked. Experience has shown that the diffused ballast resistor has none of the metal resistor disadvantages, yet offers an additional advantage. In the MRA1417 series, the diffused resistor is designed to current limit (because of limited carriers) before destructive current levels at the junction occur. Diffused ballast resistors are definitely superior in performance and reliability. Test data is available to verify this fact.

***METALIZATION* AND RELIABILITY**

Metal migration is the main concern when considering a metal system. In fine geometry devices common to all microwave transistors, the use of aluminum having sufficiently large grain size to provide an activation energy equal to that of gold is not possible since geometrical definition would be impossible. In order to adequately define small geometries, one must use aluminum with a grain size (1 micron or less) which has a very unattractive activation energy. Activation energy has an exponential relationship to metal migration.

A fair comparison of two metal systems (aluminum versus gold) would be to construct the same transistor using both metal systems and calculate the anticipated metal failure point using Black's equation. The following example is based upon the same transistor cell as is used in the TRW MRA1417 series.

Junction Temperature	Times Improvement of MTTF with Gold vs Aluminum
100°C	691
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150°C	168
175°C	56
200°C	30

For this very obvious reason TRW RF Semiconductors uses a gold metalization system on all microwave transistors including the MRA1417 series.

TRW'S PATENTED* MICroAMP

Since power microwave transistors became feasible, the bandwidth limiting problem of excessively high input "Q's" has vexed the solid state microwave amplifier designer.

Parasitic reactances (primarily due to the package) become increasingly more significant past 200MHz and impose severe limitations on band width past 1GHz. Additionally, the real component of input $Z(R_{bb})$ becomes smaller as higher drive power and higher power outputs are achieved.

Microwave power transistors generally employ several emitter ballasted cells in parallel to obtain power outputs required with the small cell geometry necessary to realize a microwave transistor. Figure 1 shows the schematic representation of such a device.

Note that all components of the input impedance are in parallel, which compounds the "Q" and bandwidth problem as more cells are used to achieve power, or the operating frequency is raised (or both). Figure 2 illustrates a more acceptable solution which combines inputs after an impedance transformation at the input of each device cell. It is convenient to do this all or partially within the package.

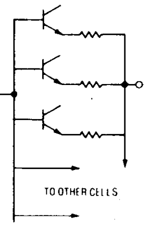


Figure 1. Elementary Method of Cell Combining

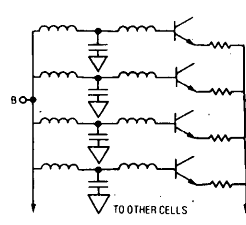


Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

Because of the nature of source impedance driving the transistor cell (essentially a voltage source), as much as 10dB additional usable dynamic range without noticeably altering bandwidth or tuning is possible with the MICroAMP.

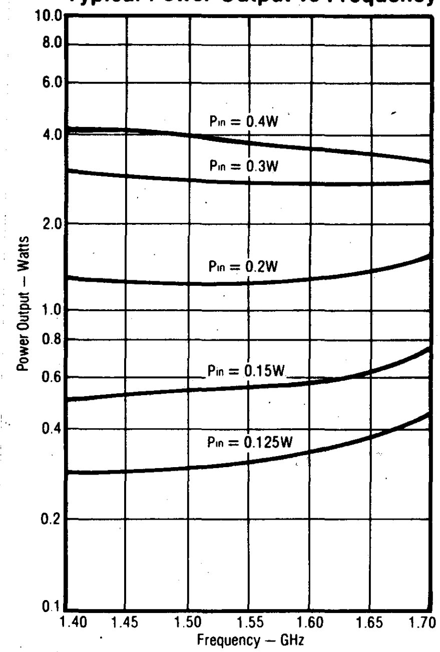
Additional gain and bandwidth advantage can be obtained by operation of the MICroAMP device cells in a common base configuration. The devices described therein are so configured.

*TRW U.S. Patent #3,713,006

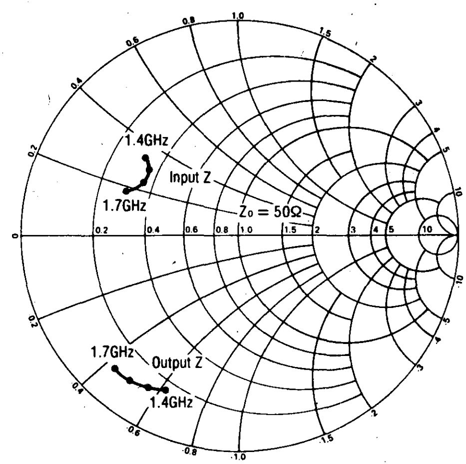
E

MRA1417-2 — 2 WATTS BROADBAND

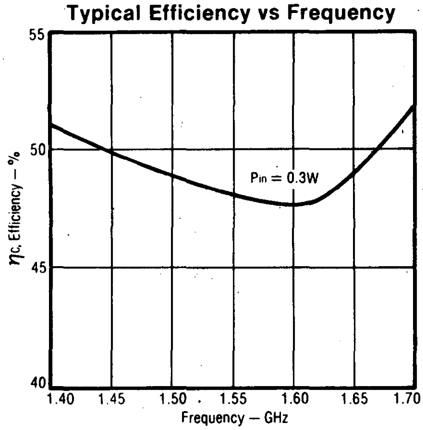
Typical Power Output vs Frequency



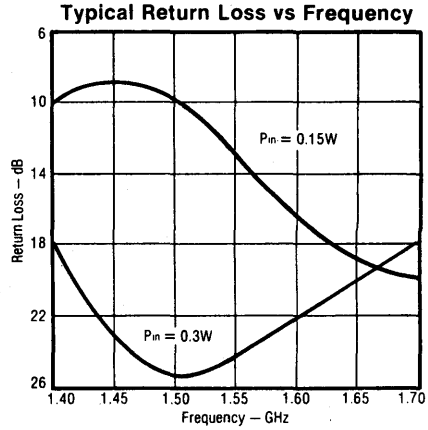
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

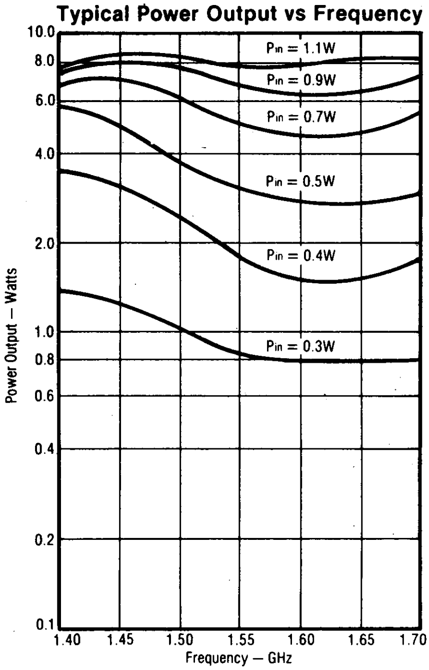


Typical Return Loss vs Frequency

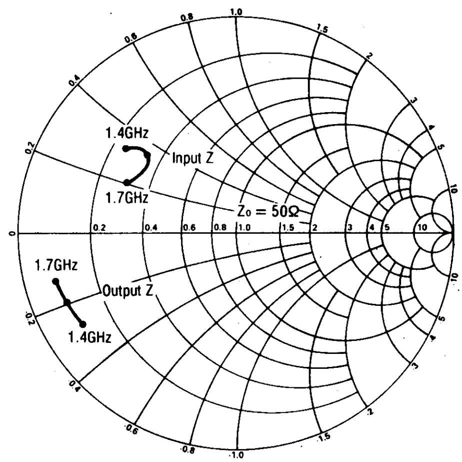


MRA1417-6 — 6 WATTS BROADBAND

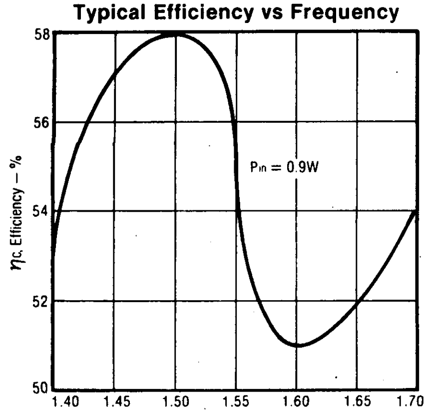
Typical Power Output vs Frequency



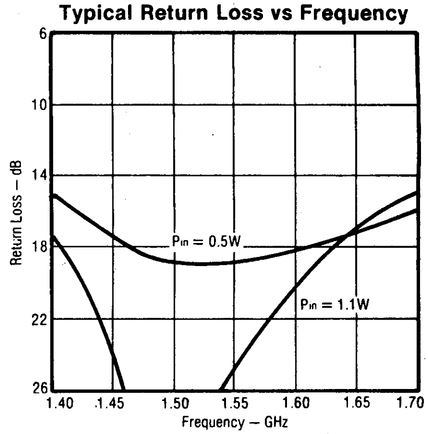
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

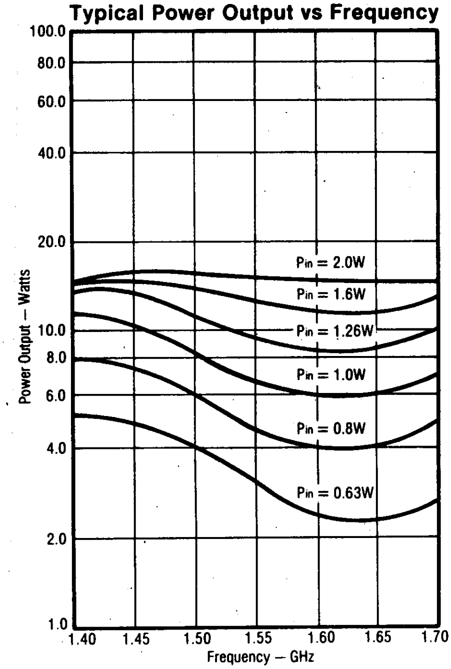


Typical Return Loss vs Frequency

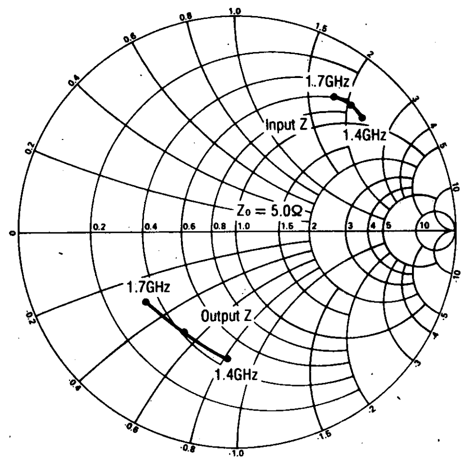


MRA1417-11 — 11 WATTS BROADBAND

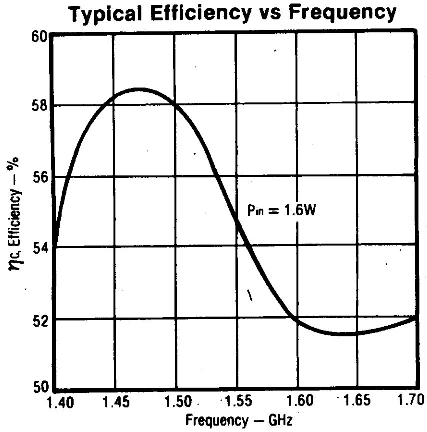
Typical Power Output vs Frequency



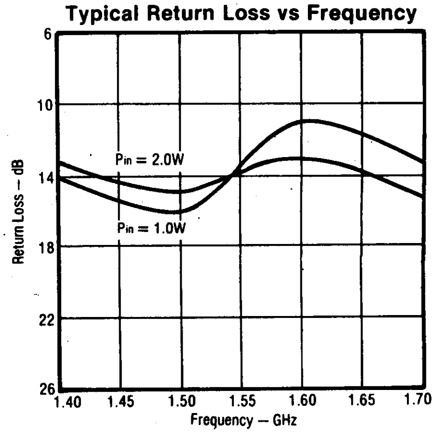
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

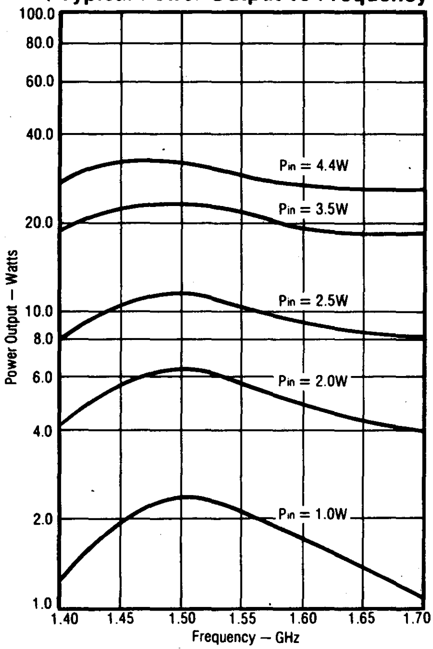


Typical Return Loss vs Frequency

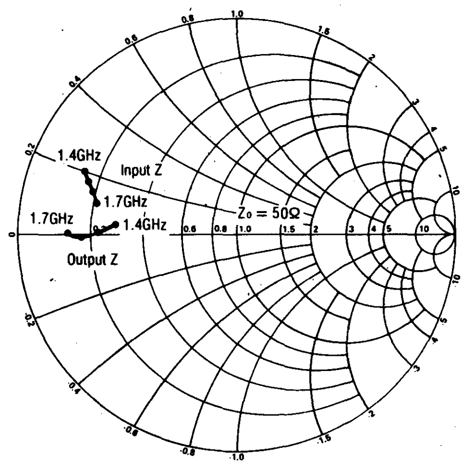


MRA1417-25 — 25 WATTS BROADBAND

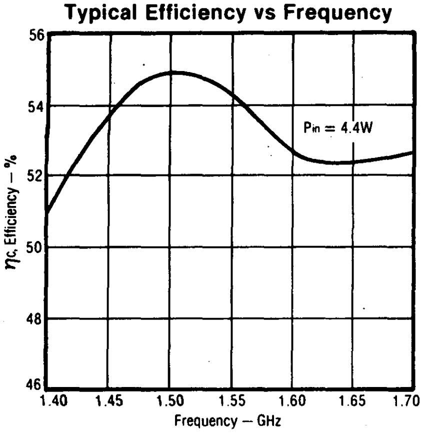
Typical Power Output vs Frequency



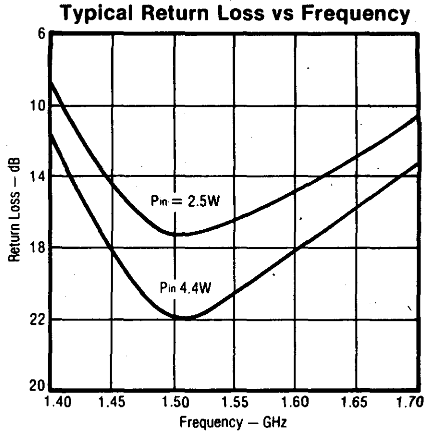
Impedance Data
Vcc = 28V



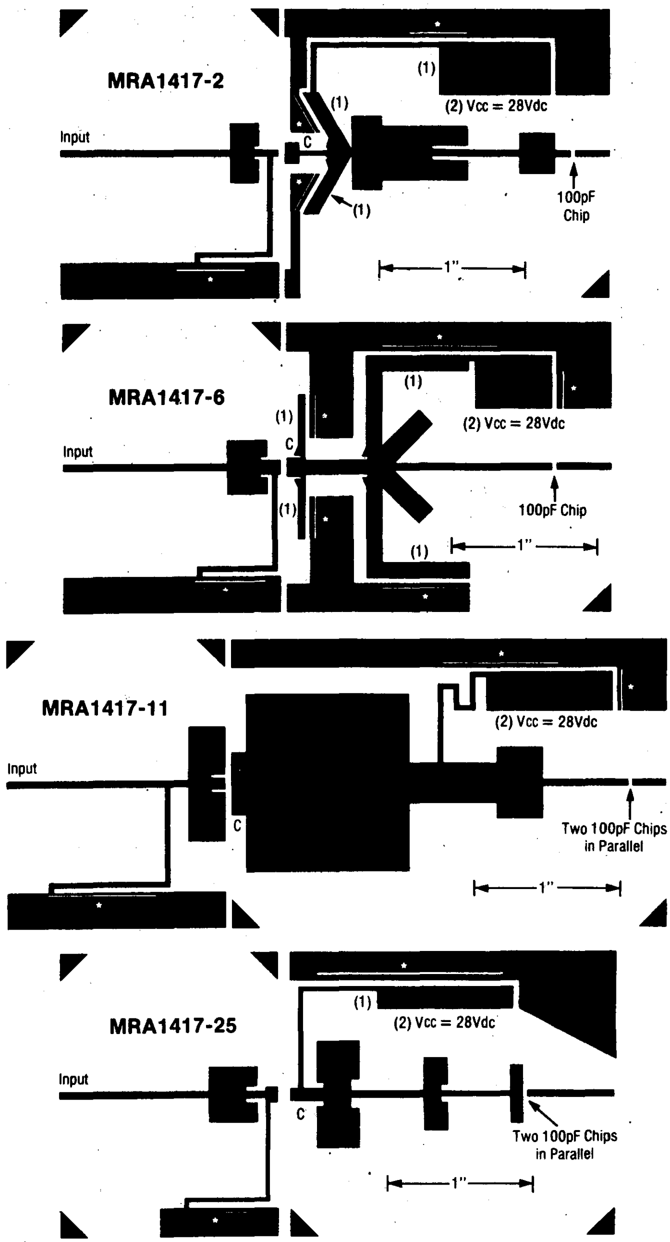
Typical Efficiency vs Frequency



Typical Return Loss vs Frequency



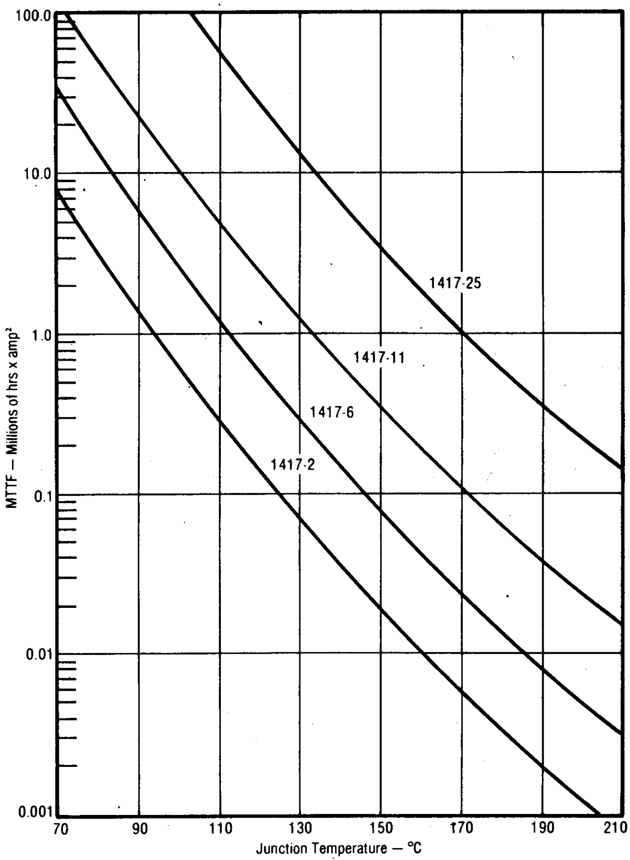
TEST CIRCUIT BOARDS FOR MRA1417 SERIES



*Foil wrap or plate around to ground plane.
(1) Bypass capacitor to ground (220pF chip).
(2) Use Vcc bypass of 220pF chip, 0.1μF chip and 5μF.
Board material 0.020 inch glass-teflon $\varepsilon r = 2.55$.

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.



Example of MTTF for MRA1417-11 Conditions

where:

$P_o = 11W$
$P_{in} = 2W$
$V_{CC} = 28V$
$\eta_c = 45\%$
$T_{flange} = 70°C$

$$I_C \cong I_E = \frac{P_o}{\eta_c \times V_{CC}} = 0.873A$$

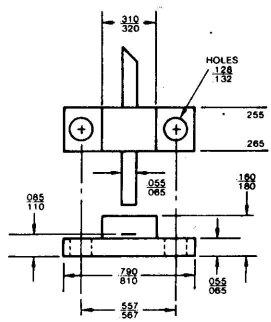
$$P_{diss} = P_{in} + V_{CC}\, I_C - P_o = 15.4W$$

$$T_{junc} = T_{flange} + \theta_{JF} \times P_{diss} = 132°C$$

$$MTTF = \frac{1.1 \times 10^6 \text{ hrs amp}^2}{I_C^2} = 1{,}443{,}328 \text{ hrs}$$

$$= 164 \text{ yrs}$$

MRA Series Package

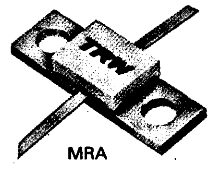


E

TRW

MICroAMP

- 2-5-9-20 W
- Broadband 1700-2000 MHz
- Internally Compensated*
- Gold Metalized
- Diffused Ballast Resistors
- MTTF Data



MRA

Electrical Characteristics at T_{flange} = 25 °C

Symbol	Characteristic	MRA1720-2	MRA1720-5	MRA1720-9	MRA1720-20
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 20 mA 50 V Min	I_C = 40 mA 50 V Min	I_C = 80 mA 50 V Min	I_C = 160 mA 50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA 3.5 V Min	I_E = 0.5 mA 3.5 V Min	I_E = 1.0 mA 3.5 V Min	I_E = 2.0 mA 3.5 V Min
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Microwave power transistors generally employ several emitter ballasted cells in parallel to obtain power outputs required with the small cell geometry necessary to realize a microwave transistor. Figure 1 shows the schematic representation of such a device.

Note that all components of the input impedance are in parallel, which compounds the "Q" and bandwidth problem as more cells are used to achieve power, or the operating frequency is raised (or both). Figure 2 illustrates a more acceptable solution which combines inputs after an impedance transformation at the input of each device cell. It is convenient to do this all or partially within the package.

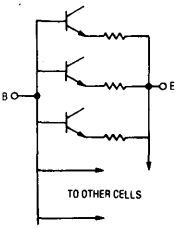


Figure 1. Elementary Method of Cell Combining

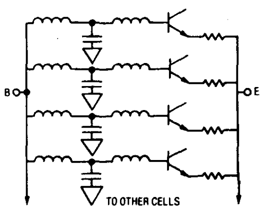


Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

Because of the nature of source impedance driving the transistor cell (essentially a voltage source), as much as 10dB additional usable dynamic range without noticeably altering bandwidth or tuning is possible with the MICroAMP.

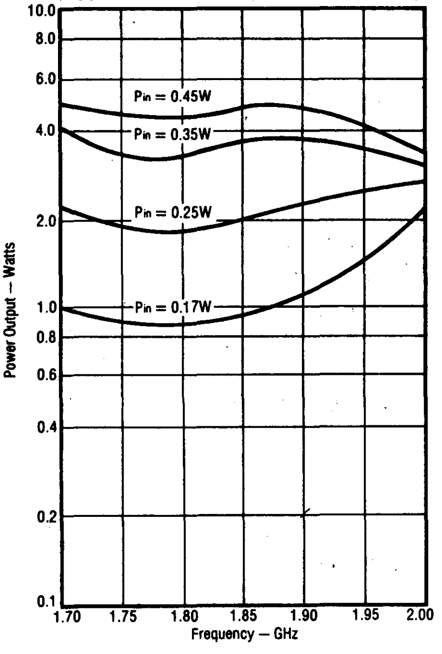
Additional gain and bandwidth advantage can be obtained by operation of the MICroAMP device cells in a common base configuration. The devices described therein are so configured.

*TRW U.S. Patent #3,713,006

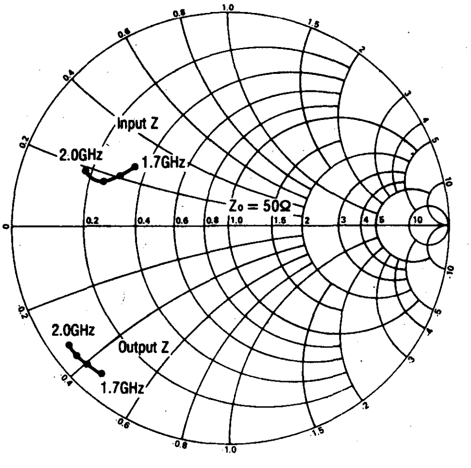
E

MRA 1720-2 WATTS BROADBAND

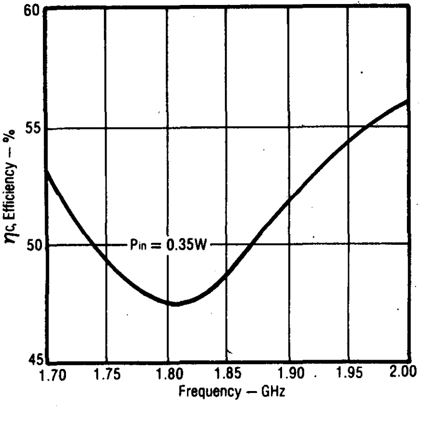
Typical Power Output vs Frequency



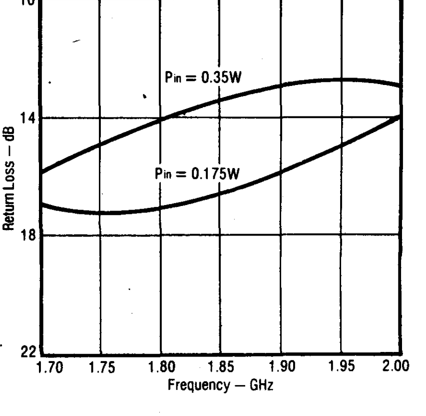
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency



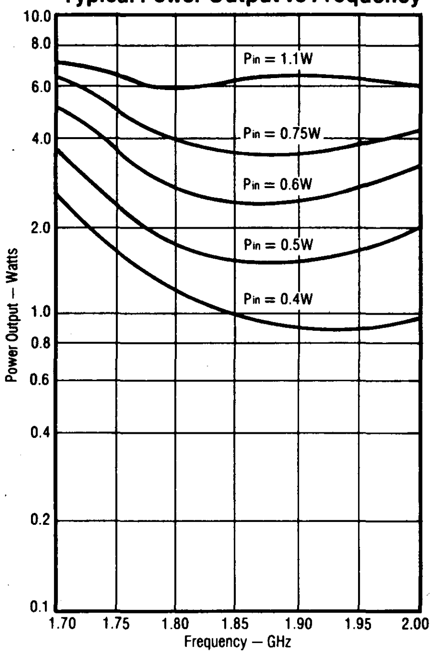
Typical Return Loss vs Frequency



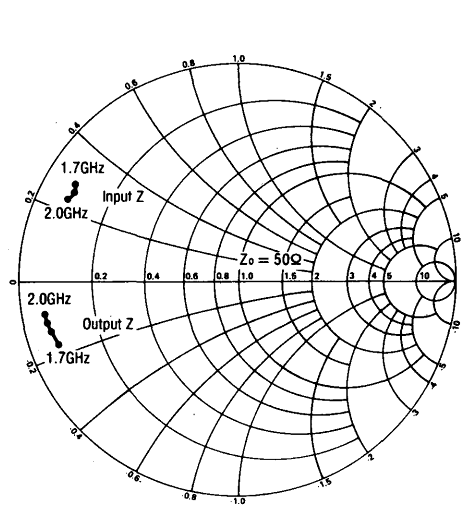
E

MRA 1720-5 — 5 WATTS BROADBAND

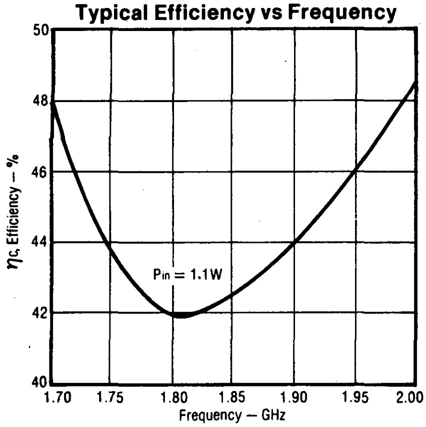
Typical Power Output vs Frequency



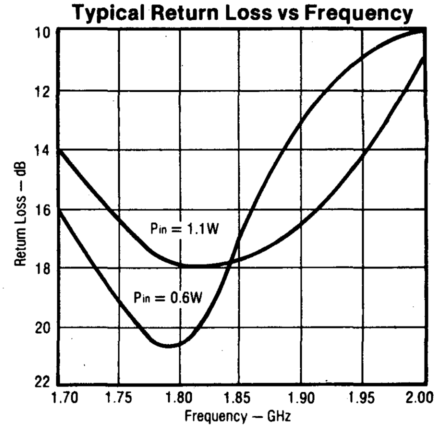
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

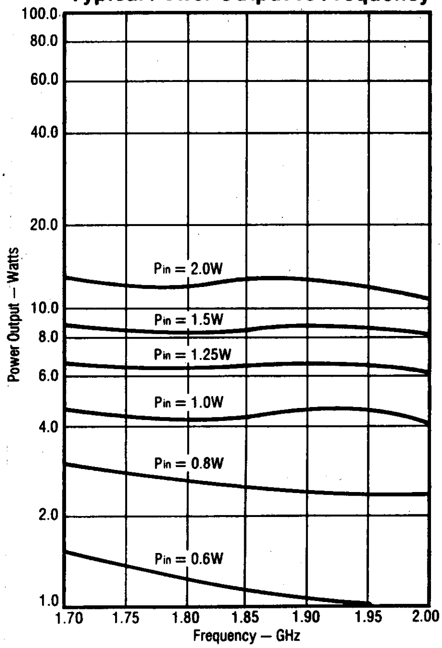


Typical Return Loss vs Frequency

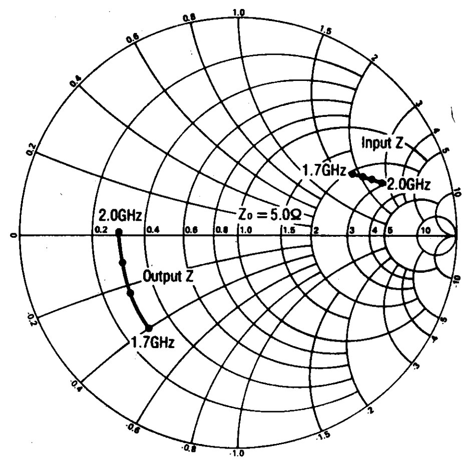


MRA 1720-9 — 9 WATTS BROADBAND

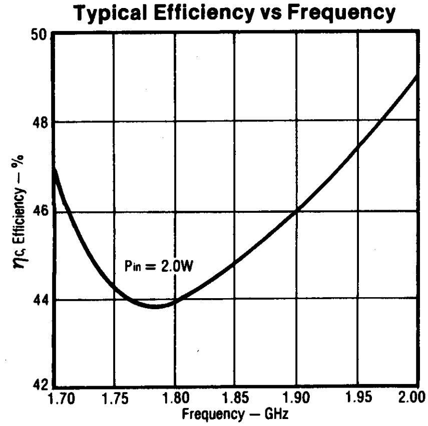
Typical Power Output vs Frequency



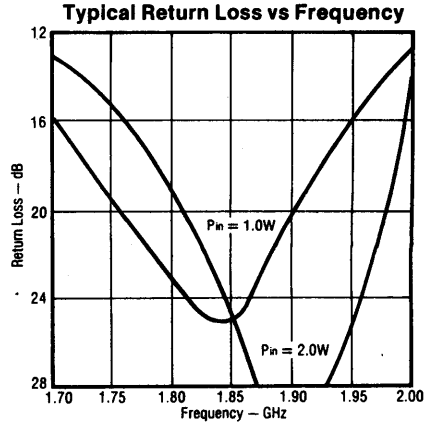
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

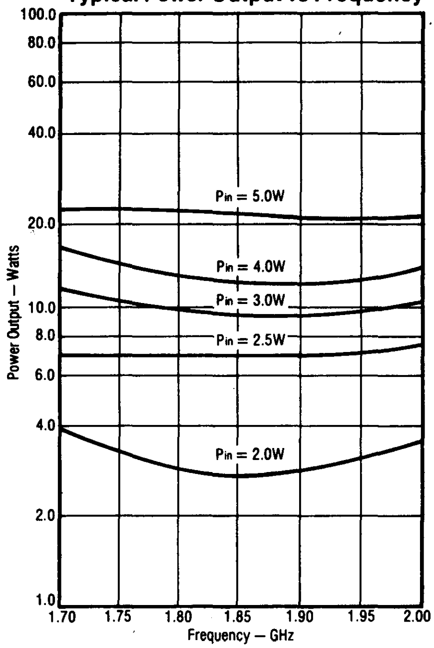


Typical Return Loss vs Frequency

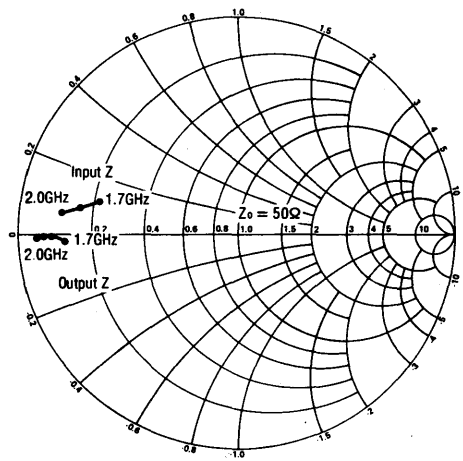


MRA 1720-20 — 20 WATTS BROADBAND

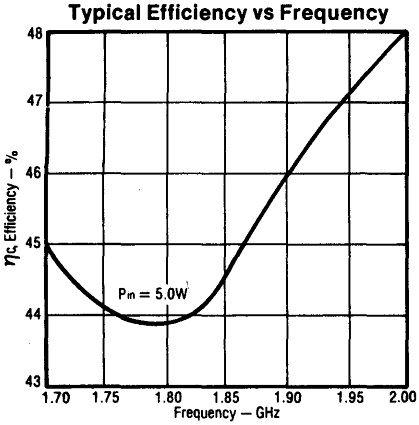
Typical Power Output vs Frequency



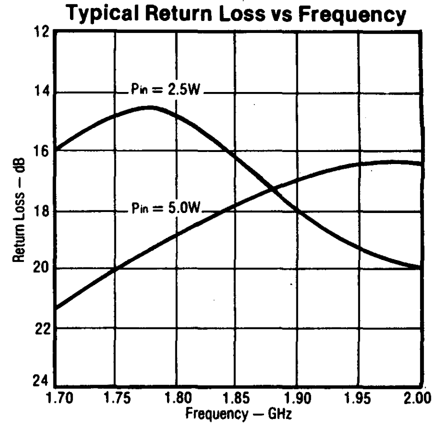
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

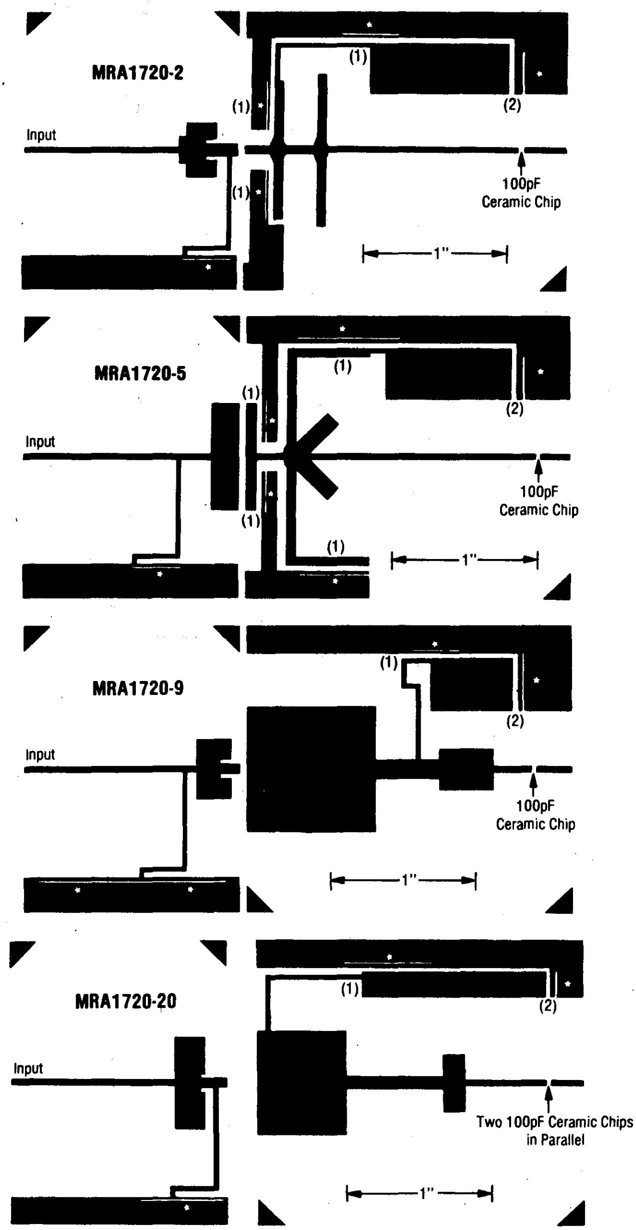


Typical Return Loss vs Frequency



E

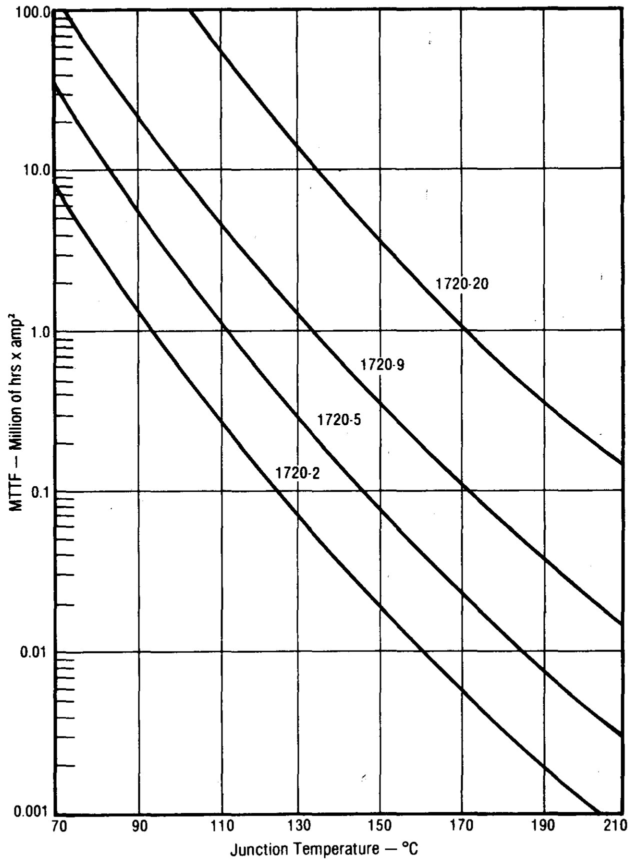
TEST CIRCUIT BOARDS FOR MRA1720 SERIES



*Foil wrap or plate around to ground plane.
(1) Bypass capacitor to ground (100pF ceramic chip).
(2) Use Vcc bypass of 100pF chip, 0.1μF chip and 5μF.
Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.



Example of MTTF for MRA1720-9 Conditions

where:

$P_o = 9W$

$P_{in} = 2W$

$V_{CC} = 28V$

$\eta_C = 40\%$

$T_{flange} = 70°C$

$$I_C \cong I_E = \frac{100\,P_o}{\eta_C \times V_{CC}} = 0.800A$$

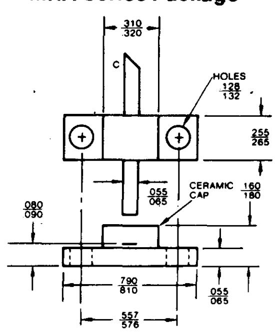
$$P_{diss} = P_{in} + V_{CC}\,I_C - P_o = 15.4W$$

$$T_{junc} = T_{flange} + \theta_{JF} \times P_{diss} = 139.3°C$$

$$MTTF = \frac{0.7 \times 10^5 \text{ hrs amp}^2}{I_C^2} = 109{,}380 \text{ hrs}$$

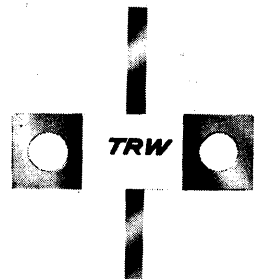
$$= 12.46 \text{ yrs}$$

MRA Series Package



MICROAMP

- 1400-1700 MHz
- Full “MRA” performance at 22 volts V_{CC}
- Gold metalization
- Diffused ballast resistors
- Common Base
- ∞ VSWR
- 2 to 25 W



MRA .25

Electrical Characteristics at T_{FLANGE} = 25°C

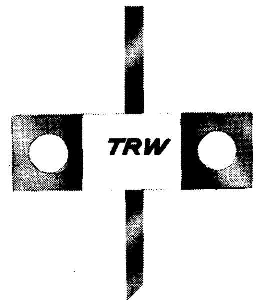
SYMBOL	CHARACTERISTICS	MRAL1417-2	MRAL1417-6	MRAL1417-11	MRAL1417-25
BV_{CES}	Collector-Base Breakdown Voltage	I_C = 20mA 42V Min	I_C = 40mA 42V Min	I_C = 80mA 42V Min	I_C = 160mA 42V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25mA 3.5V Min	I_E = 0.5mA 3.5V Min	I_E = 1.0mA 3.5V Min	I_E = 2.0mA 3.5V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 22V 0.5mA	V_{CB} = 22V 1.0mA	V_{CB} = 22V 2.0mA	V_{CB} = 22V 4.0mA
		V_{CB} = 38V 1.0mA	V_{CB} = 38V 2.0mA	V_{CB} = 38V 4.0mA	V_{CB} = 38V 8.0mA
I_C	Max. Continuous Collector Current V_{CE} = 4V	0.5A	1.0A	4.0A	8.0A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5V	I_C = 0.1A 10-100	I_C = 0.2A 10-100	I_C = 0.4A 10-100	I_C = 0.8A 10-100
P_O	Min. Broadband Power Output	2.0W	6.0W	11.0W	25.0W
$P_{G(dB)}$	Min. Power Gain in dB V_{CB} = 22V	P_O = 2.0W 8.0dB	P_O = 6.0W 7.4dB	P_O = 11.0W 7.4dB	P_O = 25.0W 7.0dB
η_C	Min. Broadband Collector Efficiency	P_O = 2.0W 40%	P_O = 6.0W 45%	P_O = 11.0W 45%	P_O = 25.0W 45%
T_j	−65 to +200°C				
T_{STG}	−65 to +150°C				

*The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, Inc. (US # 3,713,006).

MRAL 1720 Series

MICROAMP

- Internally Compensated*
- Gold Metalized
- Diffused Ballast Resistors
- MTTF Data
- 22 V Operation
- 1700-2000 MHz
- 2 to 20 W
- ∞ VSWR
- Common Base



MRA .25

E

Electrical Characteristics at T_{FLANGE} = 25°C

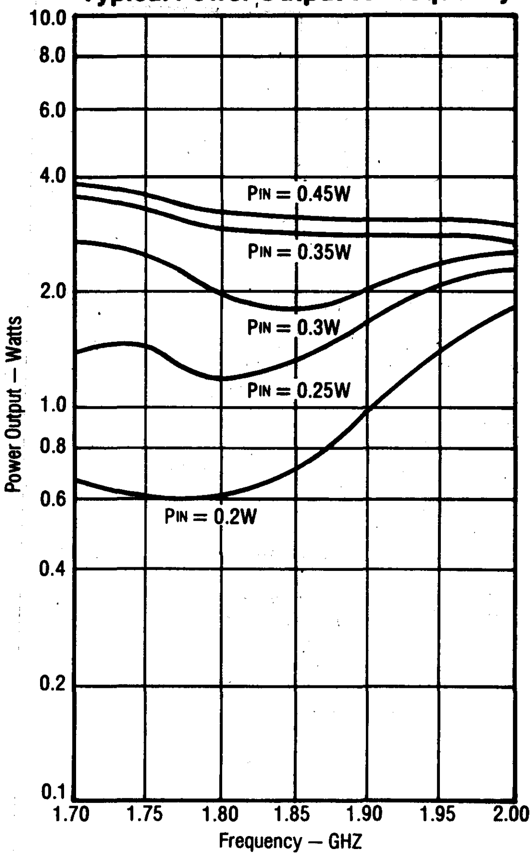
SYMBOL	CHARACTERISTICS	MRAL1720-2	MRAL1720-5	MRAL1720-9	MRAL1720-20
BV_{CES}	Collector-Base Breakdown Voltage	I_C = 20mA 42V Min	I_C = 40mA 42V Min	I_C = 80mA 42V Min	I_C = 160mA 42V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25mA 3.5V Min	I_E = 0.5mA 3.5V Min	I_E = 1.0mA 3.5V Min	I_E = 2.0mA 3.5V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 22V 0.5mA	V_{CB} = 22V 1.0mA	V_{CB} = 22V 2.0mA	V_{CB} = 22V 4.0mA
		V_{CB} = 38V 1.0mA	V_{CB} = 38V 2.0mA	V_{CB} = 38V 4.0mA	V_{CB} = 38V 8.0mA
I_C	Max. Continuous Collector Current V_{CE} = 4V	0.5A	1.0A	4.0A	8.0A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5V	I_C = 0.1A 10-100	I_C = 0.2A 10-100	I_C = 0.4A 10-100	I_C = 0.8A 10-100
θ_{jF}	Thermal Resistance Junction to Flange	15°C/W	8°C/W	4.5°C/W	2.5°C/W
P_O	Min. Broadband Power Output	2.0W	5.0W	9.0W	20.0W
C_{OB}	Max. Collector-Base Capacitance V_{CB} ≙ 28V; f ≙ 1MHz	4.5pF	8pF	12pF	24pF(1)
$P_{G(dB)}$	Min. Power Gain in dB V_{CB} = 22V	P_O = 2.0W 7.5dB	P_O = 5.0W 6.5dB	P_O = 9.0W 6.5dB	P_O = 20.0W 6.0dB
η_C	Min. Broadband Collector Efficiency	P_O = 2.0W 35%	P_O = 5.0W 40%	P_O = 9.0W 40%	P_O = 20.0W 40%
T_{STG}	Maximum Storage Temperature: -65 to +150°C				
T_j	Maximum Junction Temperature: -65 to +200°C				

*The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, Inc. (US #3,713,006).

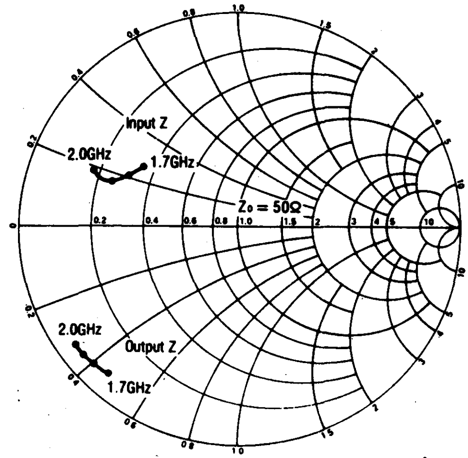
(1)Nominal value, not measurable due to shunt inductor bypass.

MRAL 1720-2, 2 WATTS BROADBAND

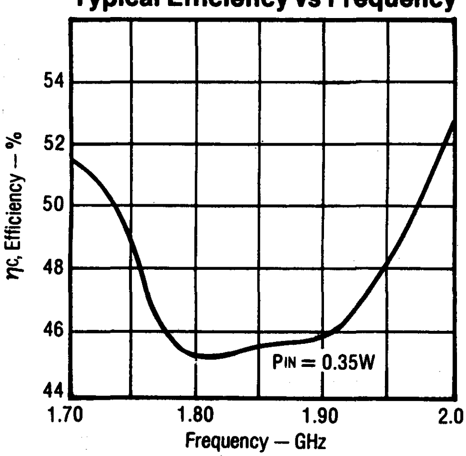
Typical Power Output vs Frequency



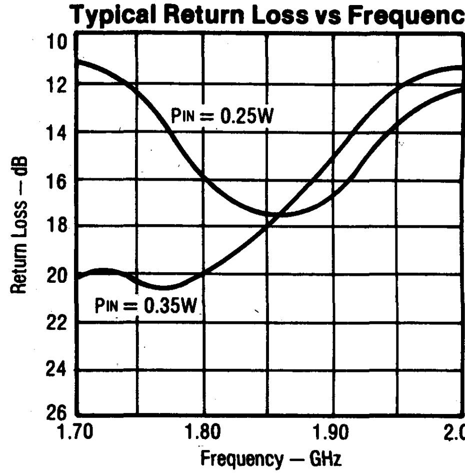
Impedance Data
Vcc = 22V



Typical Efficiency vs Frequency



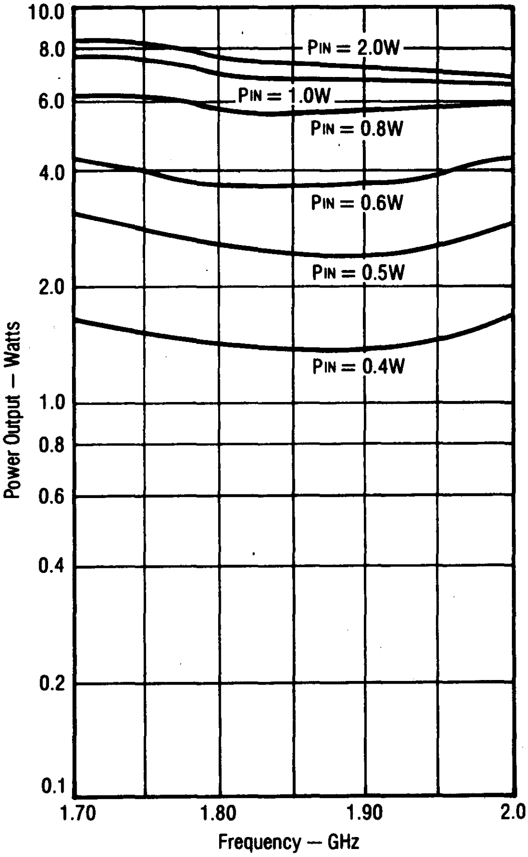
Typical Return Loss vs Frequency



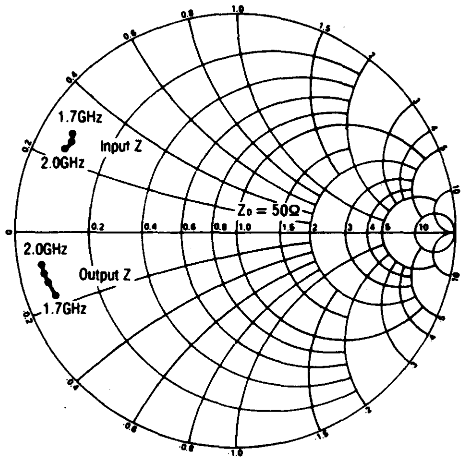
E

MRAL 1720-5, 5 WATTS BROADBAND

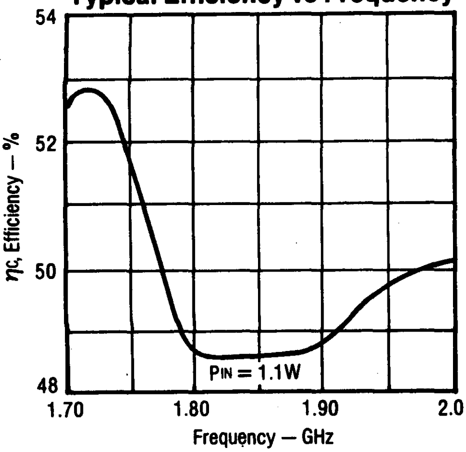
Typical Power Output vs Frequency



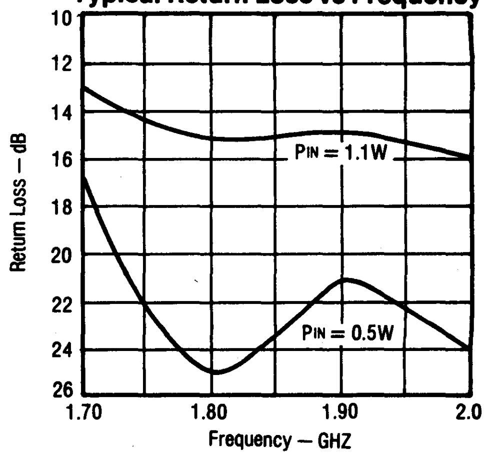
Impedance Data
Vcc = 22V



Typical Efficiency vs Frequency

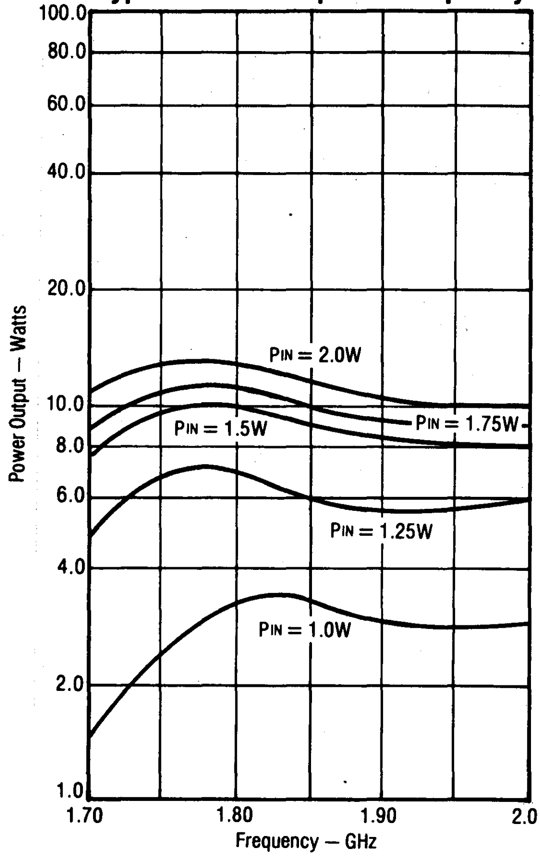


Typical Return Loss vs Frequency

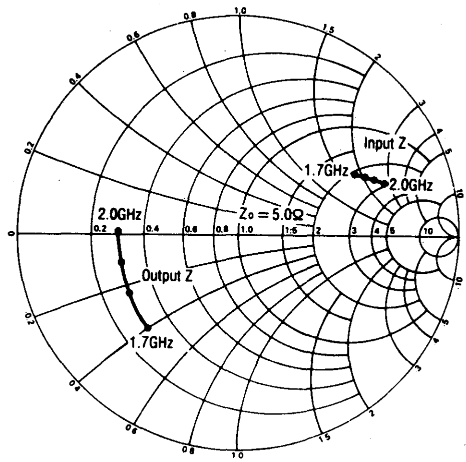


MRAL 1720-9, 9 WATTS BROADBAND

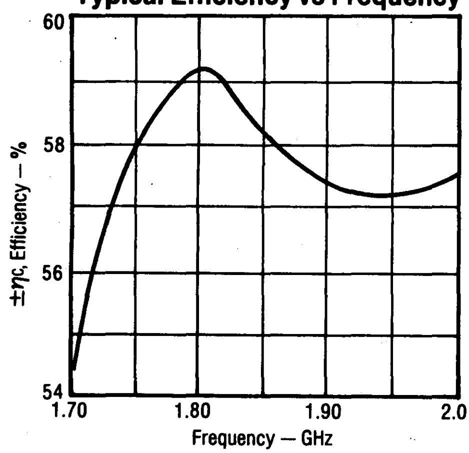
Typical Power Output vs Frequency



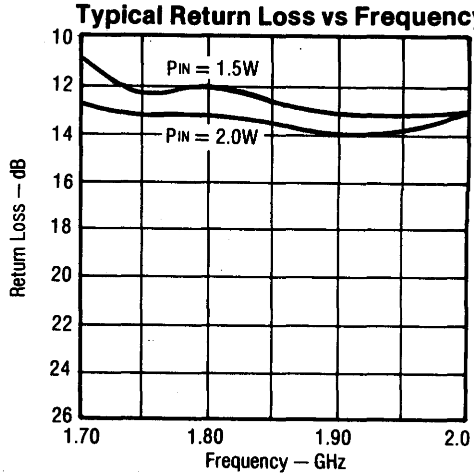
Impedance Data
Vcc = 22V



Typical Efficiency vs Frequency

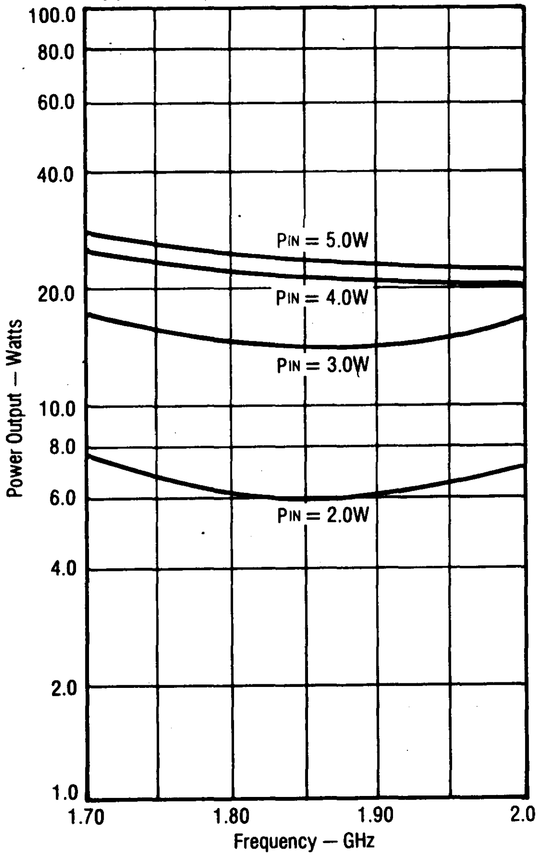


Typical Return Loss vs Frequency

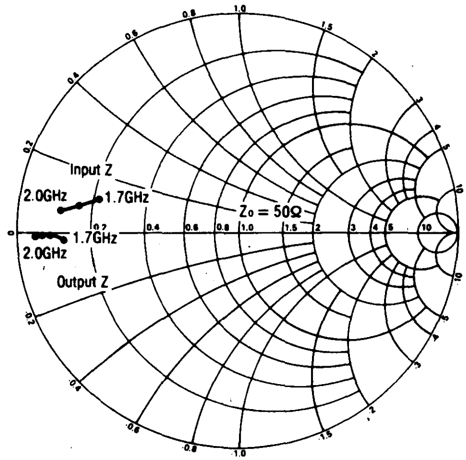


MRAL 1720-20, 20 WATTS BROADBAND

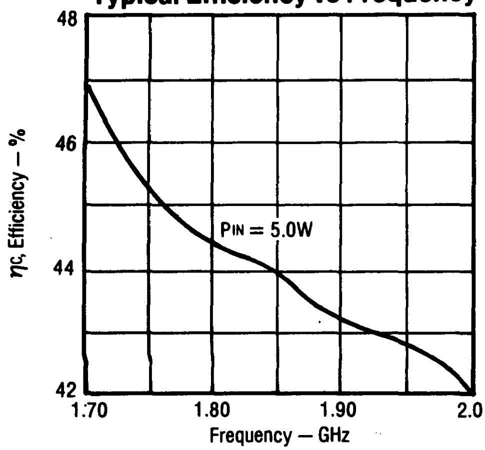
Typical Power Output vs Frequency



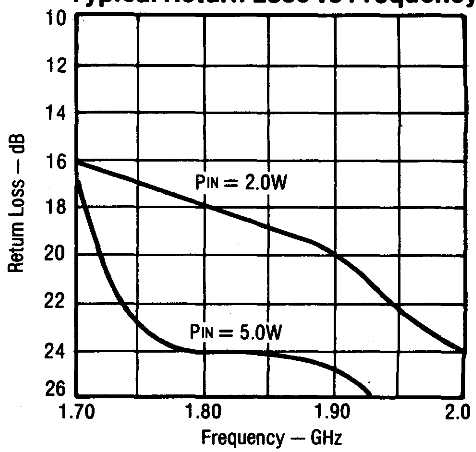
Impedance Data
Vcc = 22V



Typical Efficiency vs Frequency



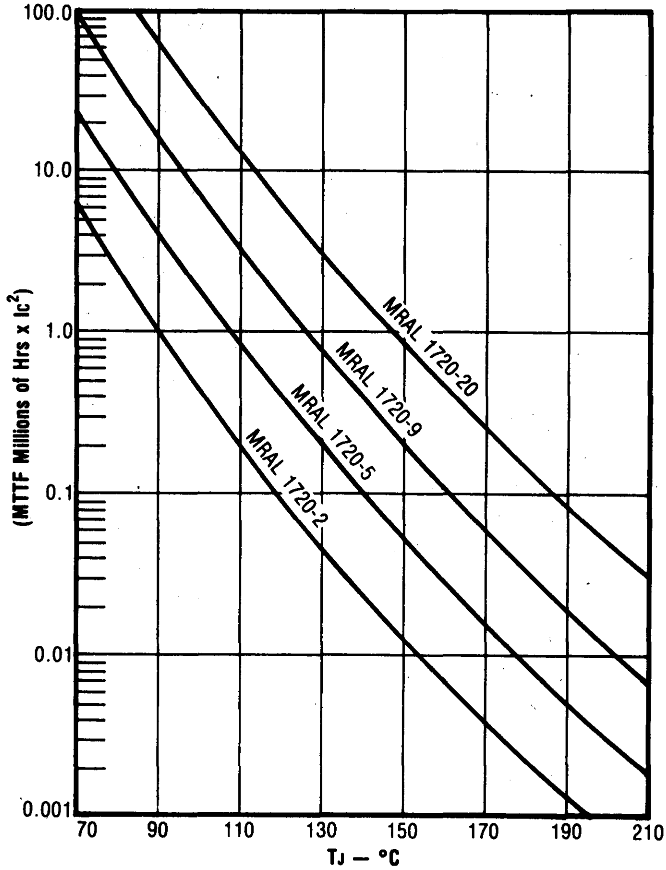
Typical Return Loss vs Frequency



Note: Test circuit details are available from TRW Semiconductors.

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.



Example of MTTF for MRA1720-9 Conditions

$P_O = 9.0W$

$P_{IN} = 2.0W$

$V_{CC} = 28V$

$\eta_C = 40\%$

$T_{FLANGE} = 70°C$

$$I_C \simeq I_E = \frac{100\ P_O}{\eta_C \times V_{CC}} = 0.803A$$

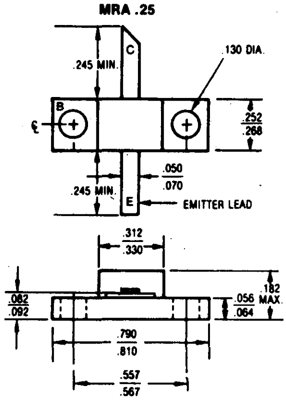
$P_{DISS} = P_{IN} + V_{CC}.\ I_C - B = 15.48W$

$T_{JUNC} = T_{FLANGE} + \theta JF \times 15.48 = 139.6\ °C$

$$MTTF = \frac{0.4 \times 10^6\ \text{Hrs Amp}^2}{I_C^2} = 620{,}338\ \text{Hrs}$$

$MTTF = 70.8\ \text{Yrs}$

MRA .25

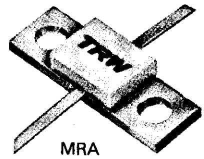


MRAL 2023 Series

TRW

MICroAMP

- 1.5-3-6-12 W
- 22 V Operation
- Broadband 2000-2300 MHz
- Internally Compensated*
- Gold Metalized
- Diffused Ballast Resistors
- MTTF Data



E

Electrical Characteristics at T_{flange} = 25 °C

Symbol	Characteristic	MRAL2023 1.5	MRAL2023 3	MRAL2023 6	MRAL2023 12
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 10 mA 42 V Min	I_C = 20 mA 42 V Min	I_C = 50 mA 42 V Min	I_C = 100 mA 42 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.2 mA 3.5 V Min	I_E = 0.4 mA 3.5 V Min	I_E = 1.0 mA 3.5 V Min	I_E = 2.0 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 22 V 0.25 mA	V_{CB} = 22 V 0.5 mA	V_{CB} = 22 V 1.25 mA	V_{CB} = 22 V 2.5 mA
		V_{CB} = 38 V 0.5 mA	V_{CB} = 38 V 1.0 mA	V_{CB} = 38 V 2.5 mA	V_{CB} = 38 V 5.0 mA
I_C	Max Continuous Collector Current V_{CE} = 4 V	0.25 A	0.5 A	1.25 A	2.5 A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V	I_C = 0.1 A 10-90	I_C = 0.2 A 10-90	I_C = 0.5 A 10-90	I_C = 1.0 A 10-90
θ_{jF}	Thermal Resistance Junction to Flange	30 °C/W	16 °C/W	8 °C/W	4.5 °C/W
P_o	Min Broadband Power Output	1.5 W	3.0 W	6.0 W	12.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 22 V, f = 1 MHz	3.5 pF	5 pF	10 pF	18 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 22 V	P_o = 1.5 W 8.0 dB	P_o = 3.0 W 8.0 dB	P_o = 6.0 W 7.0 dB	P_o = 12.0 W 7.0 dB
η_c	Min Broadband Collector Efficiency	P_o = 1.5 W 35 %	P_o = 3.0 W 40 %	P_o = 6.0 W 40 %	P_o = 12.0 W 40 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : — 65 to + 200 °C				

* Based on Black's Equation and using φ = .96 EV, $\beta = 1.07 \times 10^{-12}$ for unpassivated A_u. Empirical data indicates a 3-10 times improvement for glass passivated units. These units are glass passivated.

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, In. (US # 3,713,006).

The TRW MRAL2023 series offers a complete family of broadband, high-gain transistors for applications in the 2.0-2.3GHz band.

Using internal compensation (a patented* technique developed and first offered for sale by TRW), the MRAL2023 series is intended for use in a variety of military and industrial applications including ECM, radio relay and telemetry.

The smooth, broadband transfer characteristics of the MRAL2023 series makes it attractive for semi-linear applications without the need for bias. Power leveling within a broad range can be accomplished simply through control of low-level drive, thus eliminating brute force control of collector voltage.

Device output power levels of 1.5, 3, 6 and 12 watts allow a wide choice of lineup configurations. Excellent device-to-device phase tracking characteristics permit hybrid combination for higher powers with negligible combining loss.

Complete data and broadband circuitry, suitable to photograph for circuit boards, are contained herein.

DIFFUSED BALLASTING AND RELIABILITY

Microwave transistor devices are universally constructed using multiple cell combinations for higher power. A number of advantages are obtained using the cellular concept including better thermal balance and the ability to adjust power output capability using more or less cells to construct a device. Unless proper ballasting techniques are employed, some difficulty can be encountered in the act of combining cells. Ballasting makes cell combining practical. The alternative to ballasted cells is an operator-dependent assembly technique called "contour-bonding." Herein, bond wires of varying lengths are employed to adjust inductance and thereby achieve the expected balance. TRW has decided in favor of ballasting rather than contour-bonding because it is a controlled, repeatable and totally reliable technique.

While ballasting is desirable, certain techniques for creating ballast resistors in fine geometry microwave transistors have proven unreliable. Such an example is "metal" ballast resistors. Such resistors are incorporated by introducing an exposed section of barrier metal between the emitter finger and feeder bar. This type of resistor, of necessity, lies on top of an oxide layer. Because the metal resistor is required to dissipate as much as $10KW/CM^2$, extreme temperatures are generated in the resistor material. With this construction there is no adequate means of removing heat from the metal resistor. Therefore, the ballast resistor undergoes radical changes in physical dimension during its operating profile. This results in separation from the oxide layer or micro-cracking, or both.

Given that ballasting is desirable, a better solution, **diffused ballast resistors**, is incorporated in the MRAL2023 series. Several advantages accrue from this approach. It is integral in the silicon carrier, has the same coefficient of expansion and is heat sinked. Experience has shown that the diffused ballast resistor has none of the metal resistor disadvantages, yet offers an additional advantage. In the MRAL2023 series, the diffused resistor is designed to current limit (because of limited carriers) before destructive current levels at the junction occur. Diffused ballast resistors are definitely superior in performance and reliability. Test data is available to verify this fact.

METALIZATION AND RELIABILITY

Metal migration is the main concern when considering a metal system. In fine geometry devices common to all microwave transistors, the use of aluminum having sufficiently large grain size to provide an activation energy equal to that of gold is not possible since geometrical definition would be impossible. In order to adequately define small geometries, one must use aluminum with a grain size (1 micron or less) which has a very unattractive activation energy. Activation energy has an exponential relationship to metal migration.

A fair comparison of two metal systems (aluminum versus gold) would be to construct the same transistor using both metal systems and calculate the anticipated metal failure point using Black's equation. The following example is based upon the same transistor cell as is used in the TRW MRAL2023 series.

Junction Temperature	Times Improvement of MTTF with Gold vs Aluminum
100°C	691
125°C	370
150°C	168
175°C	56
200°C	30

For this very obvious reason TRW RF Semiconductors uses a gold metalization system on all microwave transistors including the MRAL2023 series.

TRW'S PATENTED* MICroAMP

Since power microwave transistors became feasible, the bandwidth limiting problem of excessively high input "Q's" has vexed the solid state microwave amplifier designer.

Parasitic reactances (primarily due to the package) become increasingly more significant past 200MHz and impose severe limitations on band width past 1GHz. Additionally, the real component of input $Z(R_{bb})$ becomes smaller as higher drive power and higher power outputs are achieved.

Microwave power transistors generally employ several emitter ballasted cells in parallel to obtain power outputs required with the small cell geometry necessary to realize a microwave transistor. Figure 1 shows the schematic representation of such a device.

Note that all components of the input impedance are in parallel, which compounds the "Q" and bandwidth problem as more cells are used to achieve power, or the operating frequency is raised (or both). Figure 2 illustrates a more acceptable solution which combines inputs after an impedance transformation at the input of each device cell. It is convenient to do this all or partially within the package.

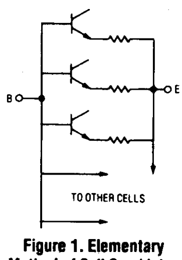


Figure 1. Elementary Method of Cell Combining

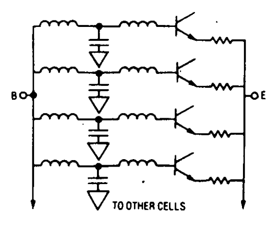


Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

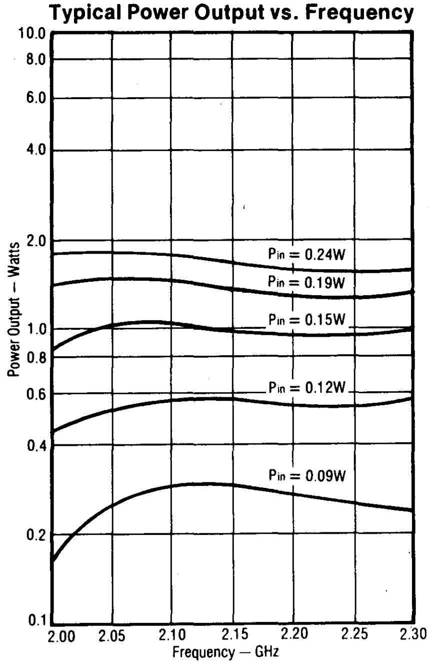
Because of the nature of source impedance driving the transistor cell (essentially a voltage source), as much as 10dB additional usable dynamic range without noticeably altering bandwidth or tuning is possible with the MICroAMP.

Additional gain and bandwidth advantage can be obtained by operation of the MICroAMP device cells in a common base configuration. The devices described therein are so configured.

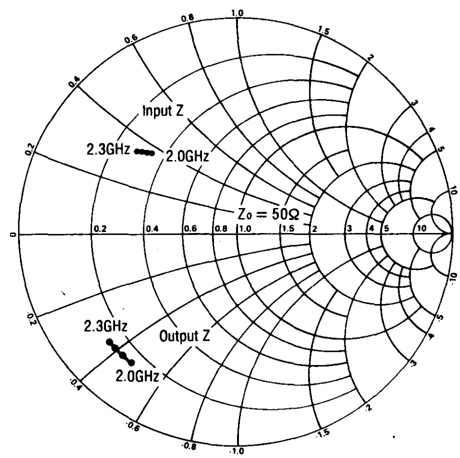
*TRW U.S. Patent #3,713,006

MRAL2023-1.5 WATTS BROADBAND

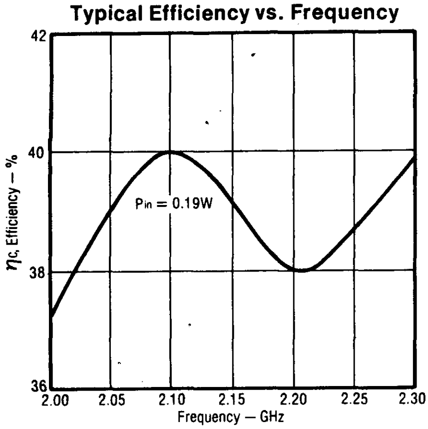
Typical Power Output vs. Frequency



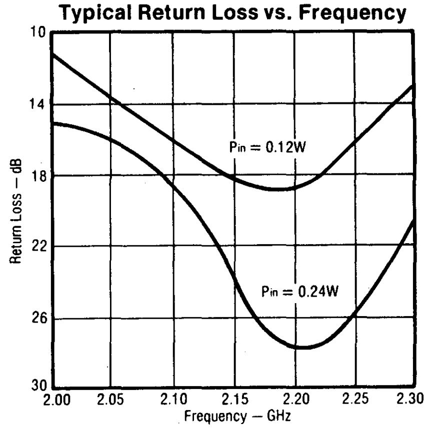
Impedance Data
Vcc = 22V



Typical Efficiency vs. Frequency



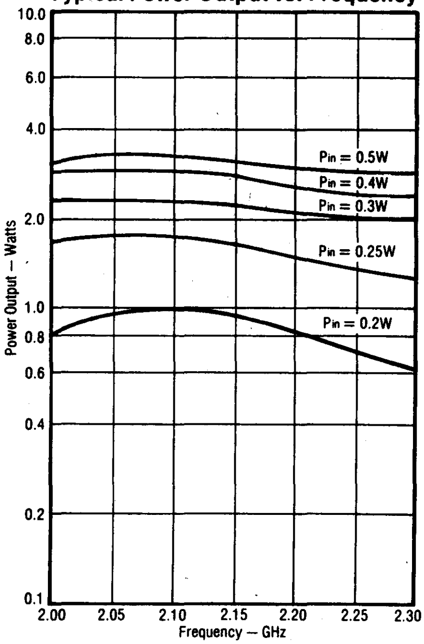
Typical Return Loss vs. Frequency



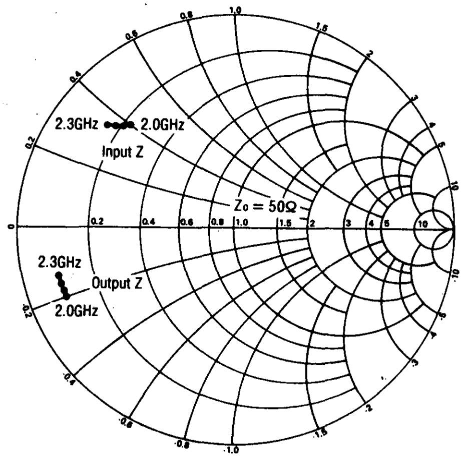
E

MRAL2023-3 — 3 WATTS BROADBAND

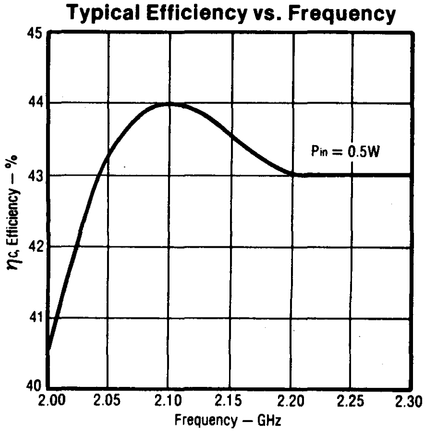
Typical Power Output vs. Frequency



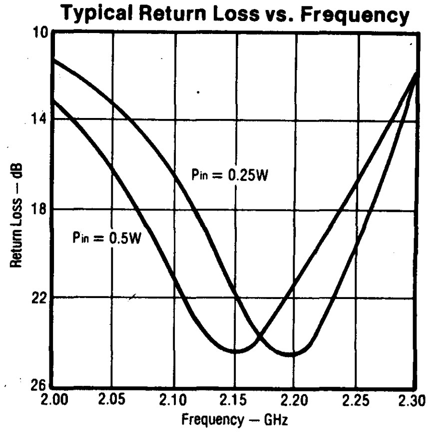
Impedance Data
Vcc = 22V



Typical Efficiency vs. Frequency

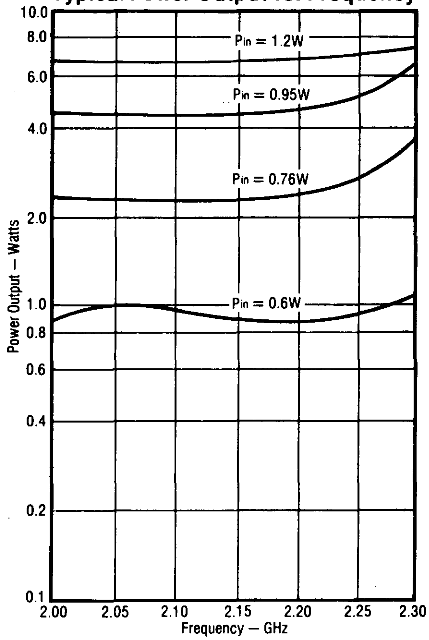


Typical Return Loss vs. Frequency

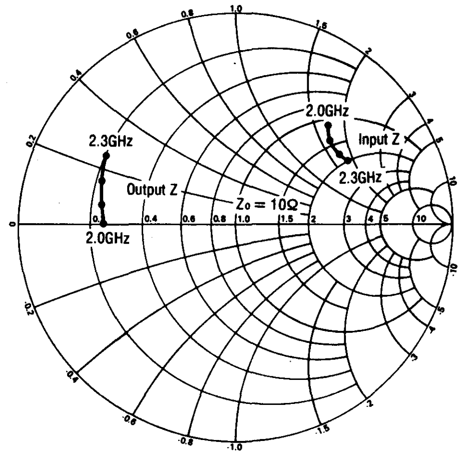


MRAL2023-6 — 6 WATTS BROADBAND

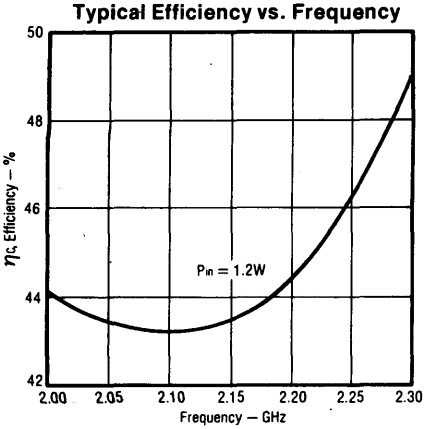
Typical Power Output vs. Frequency



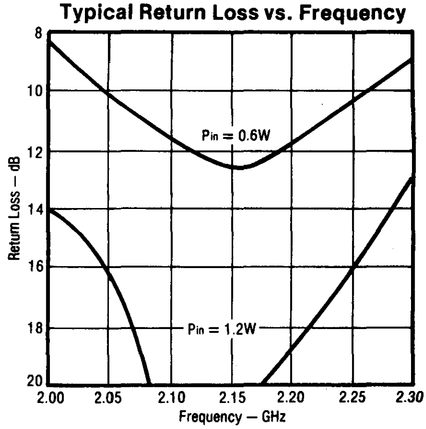
Impedance Data
Vcc = 22V



Typical Efficiency vs. Frequency

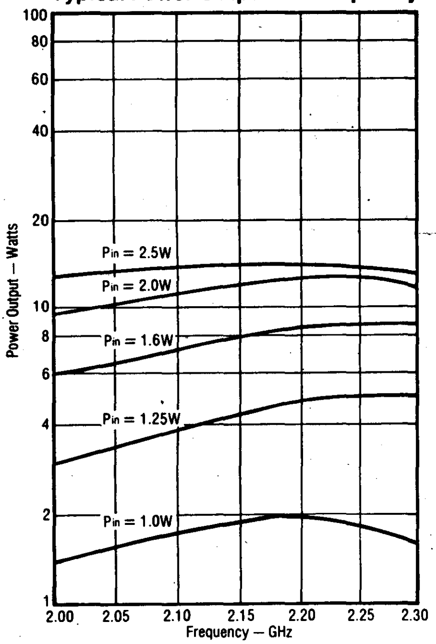


Typical Return Loss vs. Frequency

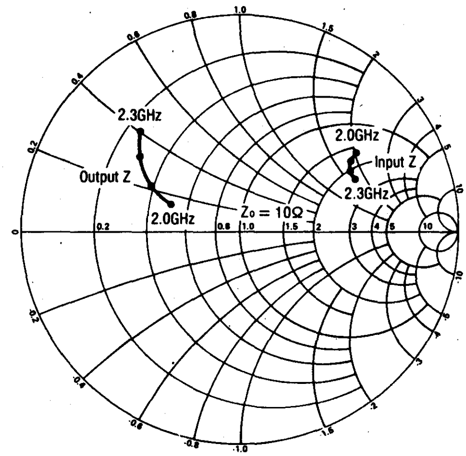


MRAL2023-12 — 12 WATTS BROADBAND

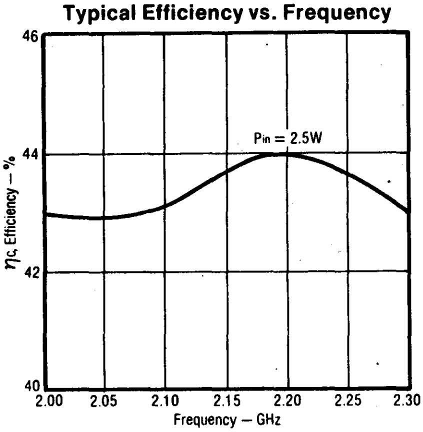
Typical Power Output vs. Frequency



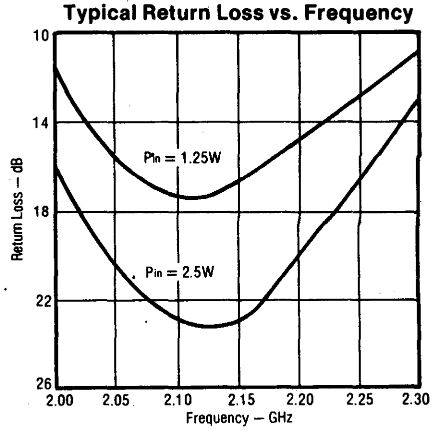
Impedance Data
Vcc = 22V



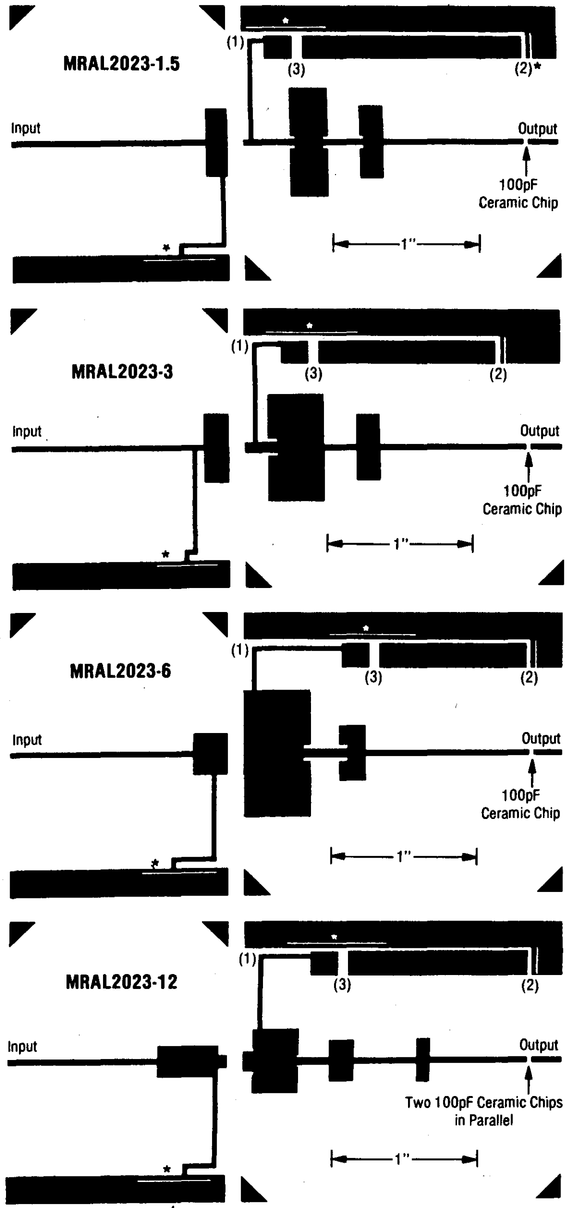
Typical Efficiency vs. Frequency



Typical Return Loss vs. Frequency



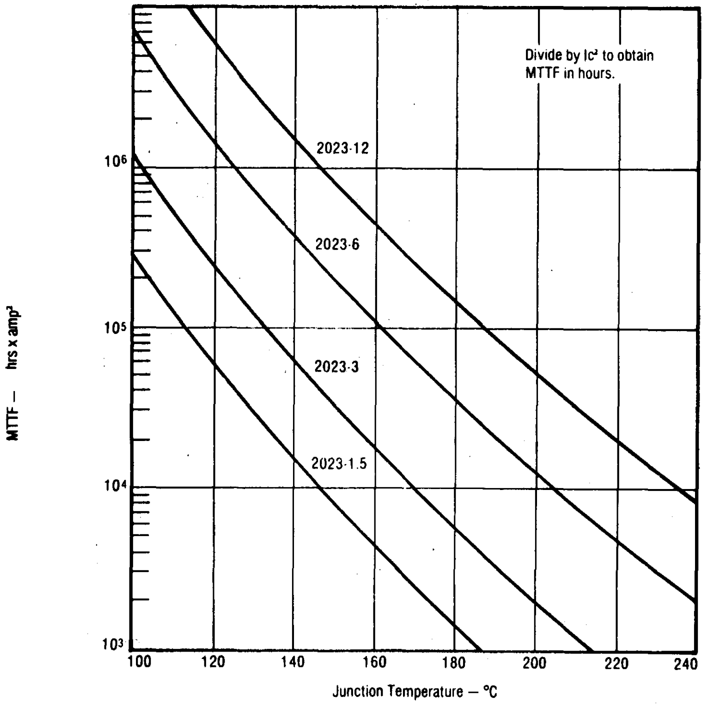
TEST CIRCUIT BOARDS FOR MRAL2023 SERIES



*Foil wrap or plate around to ground plane.
(1) Bypass capacitor to ground (100pF ceramic chip).
(2) Use Vcc bypass of 100pF chip, 0.1μF chip and 5μF.
(3) RF choke 10 turns #28 enam. close bound.
Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.



Example of MTTF for MRAL2023 Conditions

where:

$P_o = 12W$
$P_{in} = 2.4W$
$V_{CC} = 22V$
$\eta_C = 40\%$
$T_{flange} = 70°C$

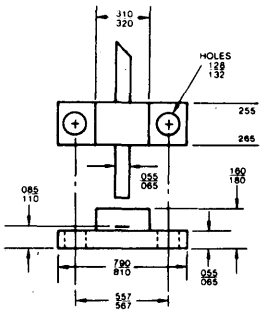
$$I_C \cong I_E = \frac{100\,P_o}{\eta_C \times V_{CC}} = 1.36A$$

$$P_{diss} = P_{in} + V_{CC}\,I_C - P_o = 20.40W$$

$$T_{junc} = T_{flange} + \theta_{JF} \times P_{diss} = 161.4°C$$

$$MTTF = \frac{4.3 \times 10^5 \text{ hrs amp}^2}{I_C^2} = 232{,}482 \text{ hrs} = 26.5 \text{ yrs}$$

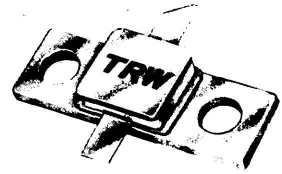
MRA Series Package



TRW

MICroAMP

- 1.5-3-6-12 W, 22 V Operation
- Broadband 2000-2300 MHz
- Internally Compensated*
- Gold Metalized
- Diffused Ballast Resistors
- MTTF Data



HLP-11

E

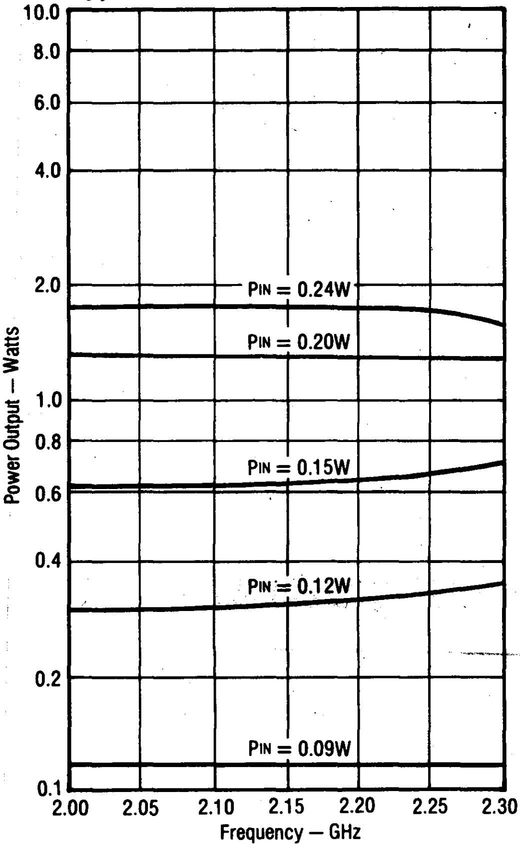
Electrical Characteristics at $T_{FLANGE} = 25°C$

SYMBOL	CHARACTERISTICS	MRAL2023-1.5H	MRAL2023-3H	MRAL2023-6H	MRAL2023-12H
BV_{CES}	Collector-Base Breakdown Voltage	$I_C = 10mA$ 42V Min	$I_C = 20mA$ 42V Min	$I_C = 50mA$ 42V Min	$I_C = 100mA$ 42V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = 0.2mA$ 3.5V Min	$I_E = 0.4mA$ 3.5V Min	$I_E = 1.0mA$ 3.5V Min	$I_E = 2.0mA$ 3.5V Min
I_{CBO}	Collector Cutoff Current $I_E = 0$	$V_{CB} = 22V$ 0.25mA	$V_{CB} = 22V$ 0.5mA	$V_{CB} = 22V$ 1.25mA	$V_{CB} = 22V$ 2.5mA
		$V_{CB} = 38V$ 0.5mA	$V_{CB} = 38V$ 1.0mA	$V_{CB} = 38V$ 2.5mA	$V_{CB} = 38V$ 5.0mA
I_C	Max. Continuous Collector Current $V_{CE} = 4V$	0.25A	0.5A	1.25A	2.5A
h_{FE}	Forward Current Transfer Ratio $V_{CE} = 5V$	$I_C = 0.1A$ 10-90	$I_C = 0.2A$ 10-90	$I_C = 0.5A$ 10-90	$I_C = 1.0A$ 10-90
θ_{jF}	Thermal Resistance Junction to Flange	30°C/W	16°C/W	8°C/W	4.5°C/W
P_O	Min. Broadband Power Output	1.5W	3.0W	6.0W	12.0W
C_{OB}	Max. Collector-Base Capacitance $V_{CB} = 22V$; f = 1MHz	3.5pF	5pF	Internal Shunt L	Internal Shunt L
$P_{G(dB)}$	Min. Power Gain in dB $V_{CB} = 22V$	$P_O = 1.5W$ 8.0dB	$P_O = 3.0W$ 8.0dB	$P_O = 6.0W$ 7.0dB	$P_O = 12.0W$ 7.0dB
η_C	Min. Broadband Collector Efficiency	$P_O = 1.5W$ 35%	$P_O = 3.0W$ 40%	$P_O = 6.0W$ 40%	$P_O = 12.0W$ 40%
T_j & T_{STG}	Maximum Junction and Storage Temperatures: -65 to +200°C				
Based on Black's Equation and using $\phi = .96EV$, $\beta = 1.07 \times 10^{-12}$ for unpassivated Au. Empirical data indicates a 3-10 times improvement for glass passivated units. These units are glass passivated.					

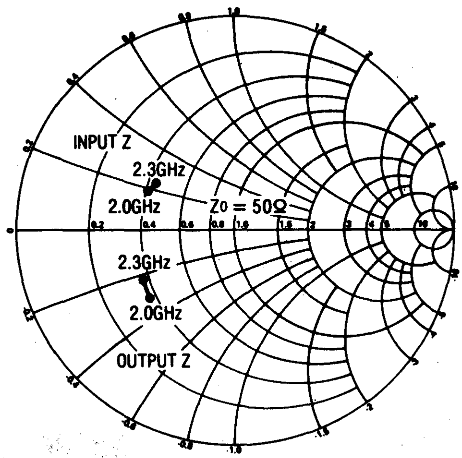
*The concept of input and/or matching using MOS capacitors, wire bonds and other techniques is patented by TRW, Inc. (US #3,713,006).

MRAL 2023-1.5H, 1.5 Watts Broadband Hermetic

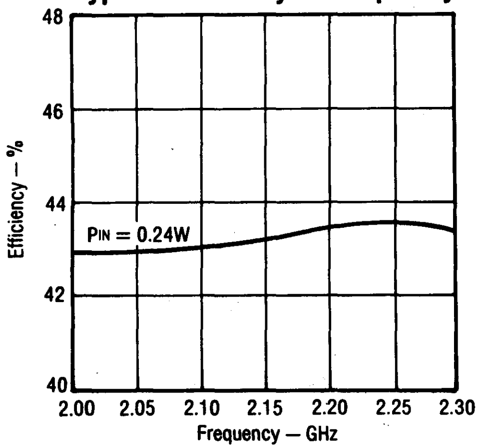
Typical Power Output vs Frequency



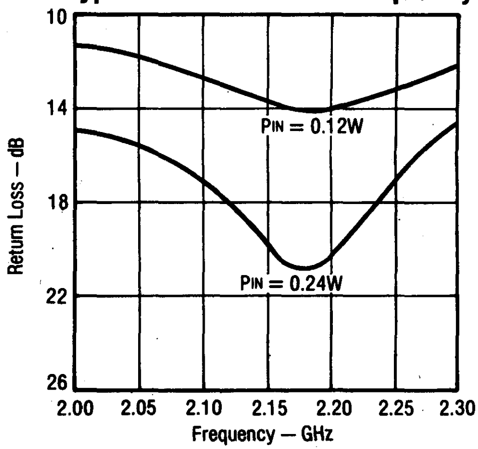
Impedance Data



Typical Efficiency vs Frequency

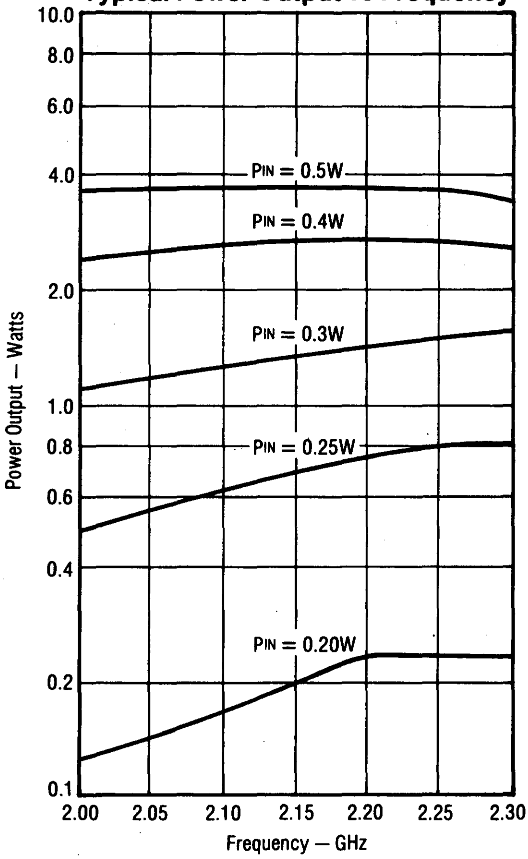


Typical Return Loss vs Frequency

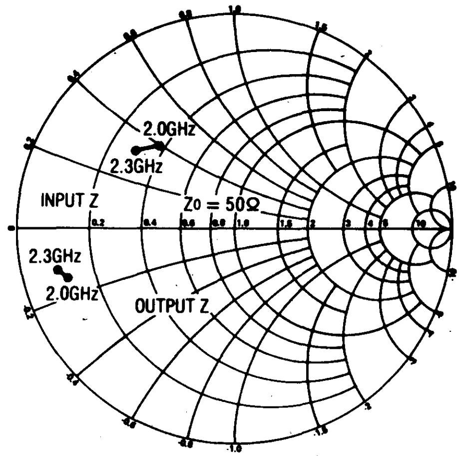


MRAL 2023-3H, 3 Watts Broadband Hermetic

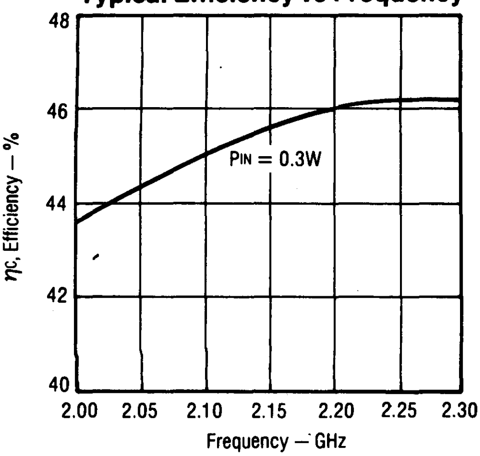
Typical Power Output vs Frequency



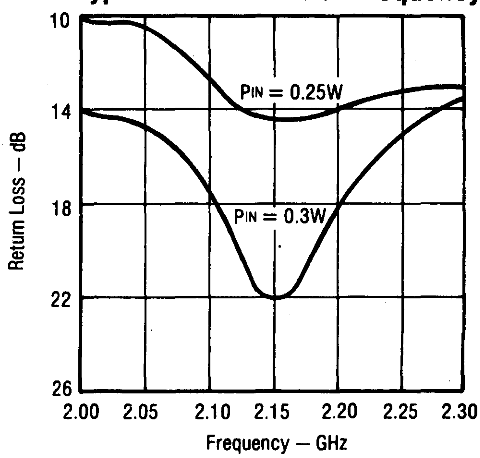
Impedance Data



Typical Efficiency vs Frequency

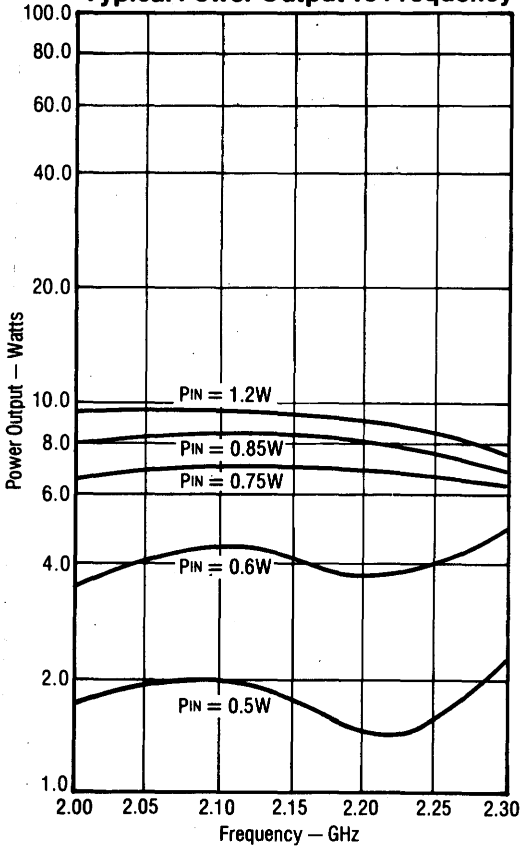


Typical Return Loss vs Frequency

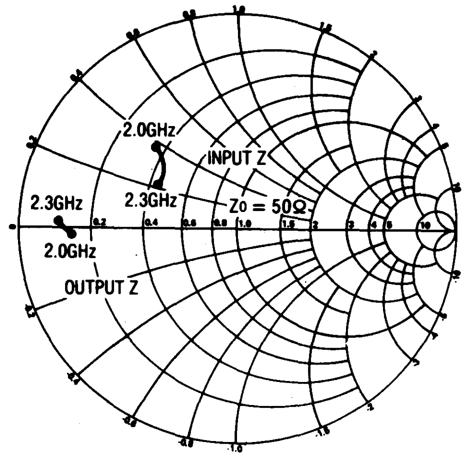


MRAL 2023-6H, 6 Watts Broadband Hermetic

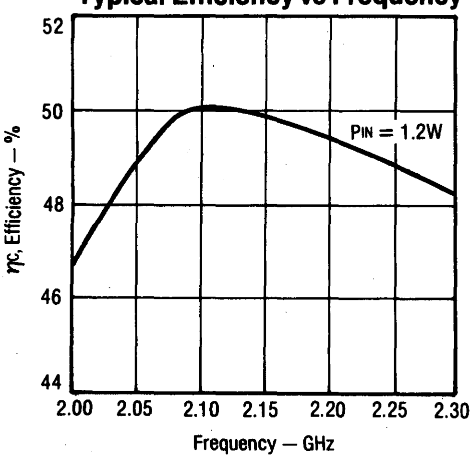
Typical Power Output vs Frequency



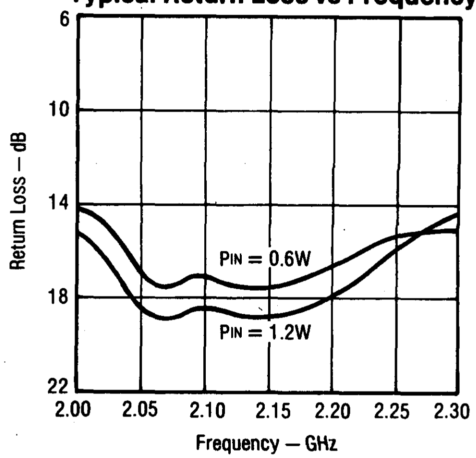
Impedance Data



Typical Efficiency vs Frequency

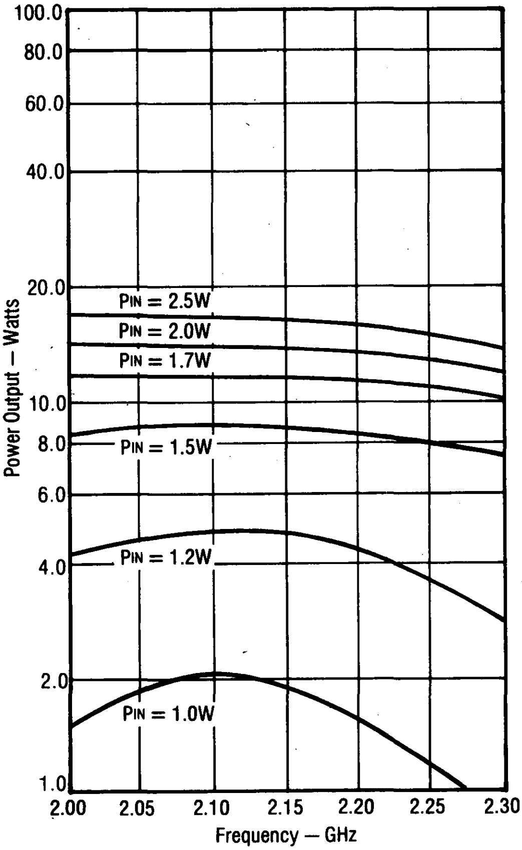


Typical Return Loss vs Frequency

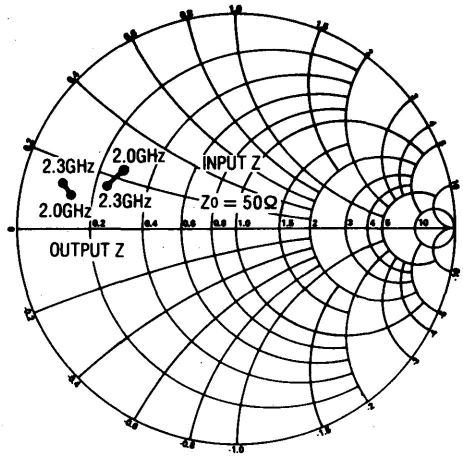


MRAL 2023-12H, 12 Watts Broadband Hermetic

Typical Power Output vs Frequency

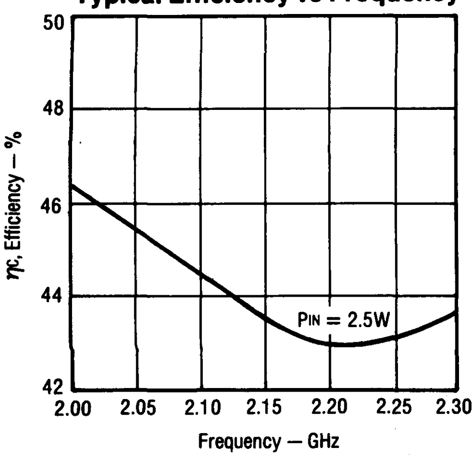


Impedance Data

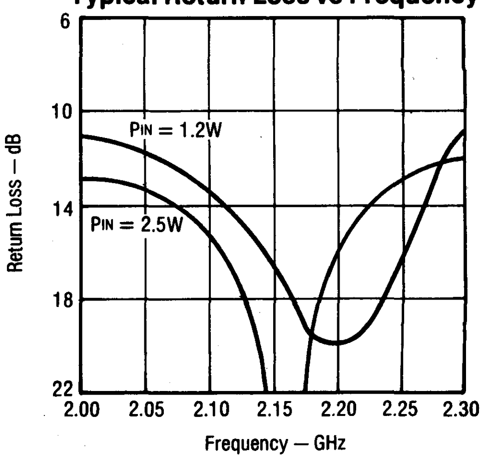


Test circuit details available from TRW Semiconductors.

Typical Efficiency vs Frequency

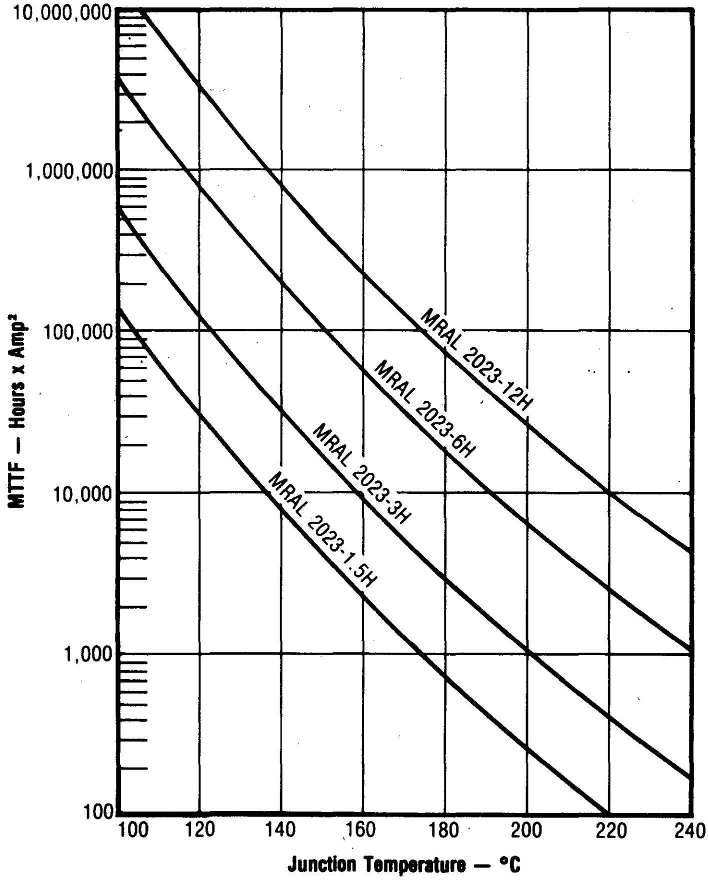


Typical Return Loss vs Frequency

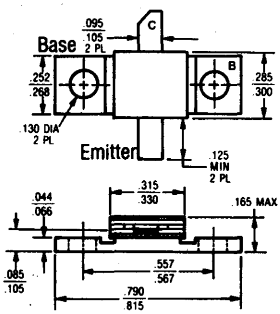


MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.



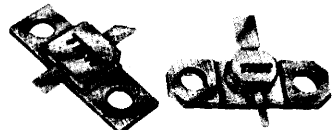
HLP-11 Series Package



TRW

Microwave Power Transistors

- **TRW 2001 1 W, 9 dB**
- **TRW 2003 3 W, 8 dB**
- **TRW 2005 5 W, 8 dB**
- **TRW 2010 10 W, 6 dB**
- **TRW 2015 15 W, 6 dB**
- **TRW 2020 20 W, 5.2 dB**
- **∞VSWR**



HLP-11 HLP-8

The TRW « Super 2 GHz » series is the first group of GHz, common base devices offering unqualified tolerance of **complete mismatch** (∞VSWR, any phase) conditions. This feature is particularly desirable in military and space applications where multi million dollar investments (and even human lives) can be jeopardized by device failure. The « Super 2 GHz » series is characterized to 2.3 GHz and is priced to be attractive in industrial service. All units are **gold metallized** for longevity and resistance to metal migration. They are emitter ballasted with heat sinked, diffused, rather than deposited metal resistors. This series is housed in TRW's true hermetic, MIL acceptable, HLP package. The package is available with or without flange.
The « Super 2 GHz » series can be adapted readily to circuits designed around older, less reliable devices with a minimum of circuit adjustment. They are mechanically interchangeable with other similar 2 GHz devices.

Electrical Characteristics (T_{CASE} = 25 °C)

Mechanical Specifications

The following are mechanical specifications for this transistor.

Dimensions : Per outline drawing.

Solderability : Per MIL-STD-750.

Marking : Per MIL-S-19500, « TRW », 4-digit date code, type number.

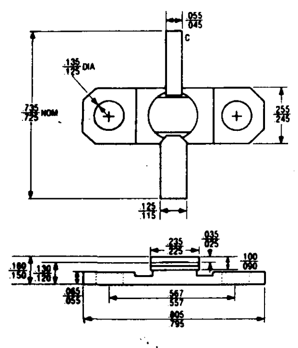
Hermaticity : Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration : Per MIL-STD-750, 20.000 G in any plane.

Bond Pull : Per MIL-STD-750, 3 grams min.

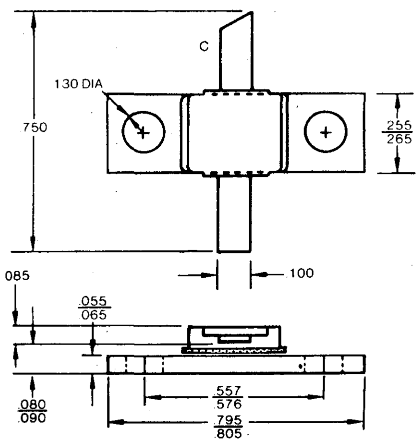
Package HLP-11 HLP-8 : A glass-free, brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 micro-inches of gold plating.

HLP-8 Normal Package



Flangeless HLP-8
Specify « F » Suffix

HLP-11 Package



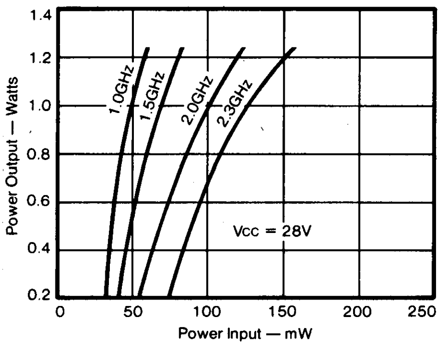
Flangeless HLP-11
Specify « F » Suffix

TRW 2001

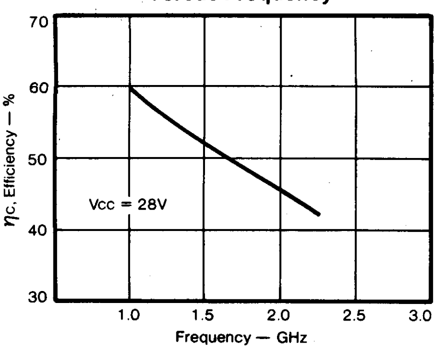
Electrical Characteristics (T_{flange} = 25°C)

Symbol	Characteristic	Condition	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10Ω	I_C = 10mA	50V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1mA I_C = 0	4.0V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28V I_E = 0 V_{CB} = 45V	500μA 1mA
I_C	Continuous Collector Current (Max)	V_{CE} = 4V	0.250A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V I_C = 100mA	10-120
θ_{JF}	Thermal Resistance (Junction to Flange)	—	28°C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28V	3.0pF
P_o	Power Output @ 2000MHz	P_{in} = 0.125W	1W Min
$P_{o(sat)}$	Power Output @ 2300MHz	V_{CE} = 28Vdc	1.0W (Typ)
	Power Output @ 1500MHz		1.2W (Typ)
	Power Output @ 1000MHz		1.3W (Typ)
P_{gain}	Power Gain (dB) @ 2000MHz	P_o = 1.0W	9dB Min
VSWR	Mismatch Tolerance @ Vcc = 28V	P_o = 1.0W f = 2.0GHz	∞
MTTF	Mean-Time-to-Metal Failure (Hrs x Amps²)	T_j = 150°C	4,661
η_C	Collector Efficiency (Min)	P_o = 1.0W f = 2.0GHz	40%
T_j & T_{stg}	Max Junction and Storage Temperatures	-65 to 200°C	

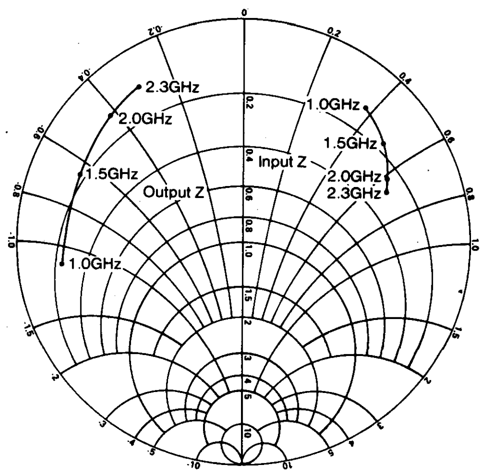
Typical Transfer Characteristics Versus Frequency



Typical ηc Versus Frequency



Impedance Data Vcc = 28V

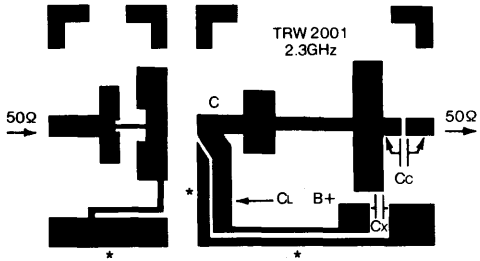


PC BOARD LAYOUT FOR TRW 2001 TEST CIRCUITS

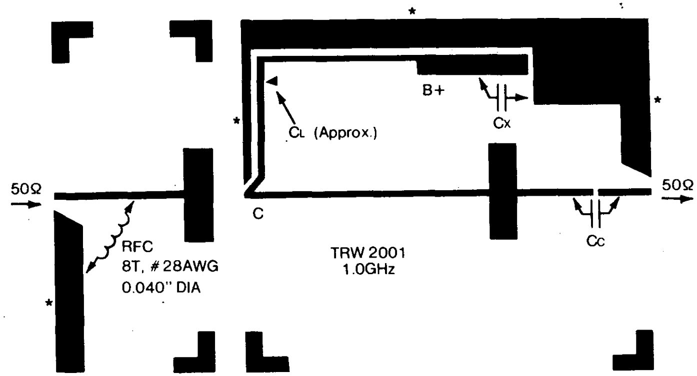
PART DETAILS

*	=	Foil-wrap asterisked edge to ground plane
Cc	=	220pF chip on all circuits
Cx	=	A combination of two 220pF chips, one 0.1 chip and a 25μF tantalum capacitor (35V min)
CL	=	Used as an AC bypass on the shunt inductor line (220pF chip) whose position can be varied

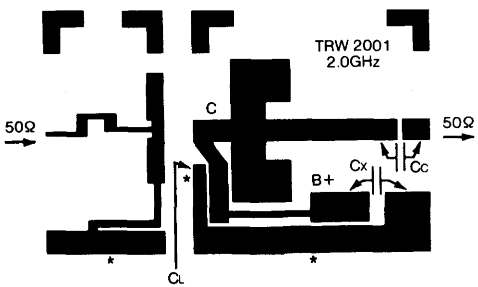
RFC	=	1000MHz	8 turns, #28AWG, 0.040 dia
RFC	=	1500MHz	6 turns, #28AWG, 0.040 dia
RFC	=	2000 and 2300MHz	4 turns, #28AWG, 0.040 dia



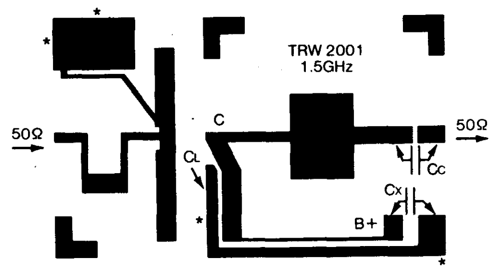
Board Material = 0.062" Glass-Teflon ε_r = 2.55



Board Material = 0.020" Glass-Teflon ε_r = 2.55



Board Material = 0.062" Glass-Teflon ε_r = 2.55



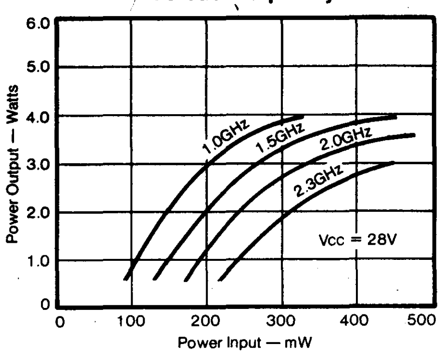
Board Material = 0.062" Glass-Teflon ε_r = 2.55

TRW 2003

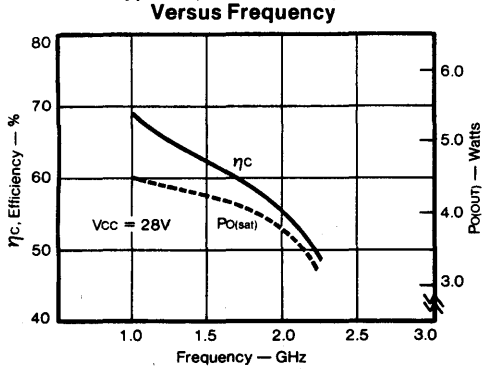
Electrical Characteristics (T_{flange} = 25°C)

Symbol	Characteristic	Conditon	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10Ω	I_C = 20mA	50V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25mA I_C = 0	3.5V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28V I_E = 0 V_{CB} = 45V	500μA 1mA
I_C	Continuous Collector Current (Max)	V_{CE} = 4V	0.50A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V I_C = 100mA	10-100
θ_{jF}	Thermal Resistance (Junction to Flange)	—	15°C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28V	5.0pF
P_o	Power Output @ 2000MHz	P_{in} = 0.47W	3.0W Min
$P_{o(sat)}$	Power Output @ 2300MHz	V_{CE} = 28Vdc	3.0W (Typ)
	Power Output @ 1500MHz		3.7W (Typ)
	Power Output @ 1000MHz		4.0W (Typ)
P_{gain}	Power Gain (dB) @ 2000MHz	P_o = 3.0W	8dB Min
VSWR	Mismatch Tolerance @ V_{CC} = 28V	P_o = 3.0W f = 2.0GHz	∞
MTTF	Mean-Time-to-Metal Failure (Hrs x Amps²)	T_j = 150°C	20,300
η_C	Collector Efficiency (Min)	P_o = 3.0W f = 2.0GHz	40%
T_j & T_{stg}	Max Junction and Storage Temperatures	-65 to 200°C	

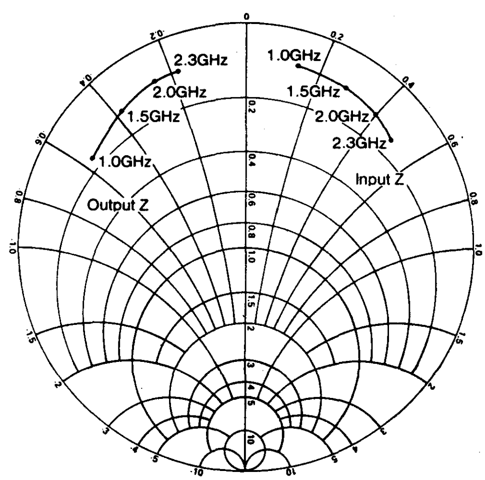
Typical Transfer Characterics Versus Frequency



Typical η_C, Power Output Versus Frequency



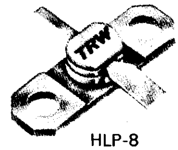
Impedance Data Vcc = 28V



TRW

Microwave Power Transistors

- **850 mW at 3 GHz**
- **Up to 3.5 GHz**
- **∞VSWR**


HLP-8

The TRW 63602 is designed for use up to 3.5 GHz with a typical Pout of 850 mW at 3 GHz.

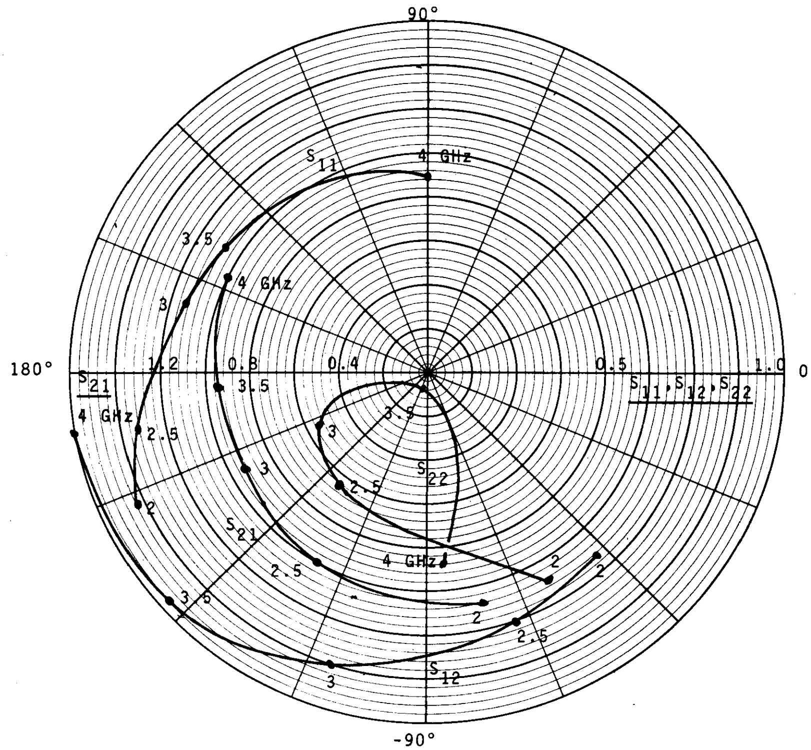
TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	20			V
	BV_{CER}	Collector - Emitter Breakdwon Voltage	R_{BE} = 10 Ω, I_C = 20 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.5	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 200 mA	15		120	
R F Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V, F = 1 MHz			5.5	pF
	F_T	Frequency Cutoff	V_{CE} = 20 V, I_E = 230 mA	3	3.3		GHz
	P_o	Power output	F = 2.3 GHz, V_{CE} = 20 V, I_E = 230 mA	1.2			W
	VSWR	Mismatch Tolerance	P_o = 1.2 W, V_{CE} = 20 V, I_E = 230 mA			∞ : 1	
Operating	θ_{jF}	Thermal Resistance (junction to Flange)				17	°C/W
	T_{STG}	Max Junction and Storage Temperature		— 65		200	°C

Small Signal S-Parameters
(V_{CE} = 20 V, I_E = 120 mA)



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

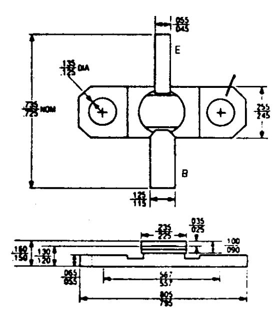
Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

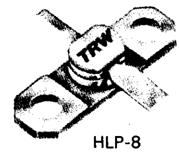
Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Package Outlines



Microwave Power Transistors

- 850 mW at 3 GHz
- Up to 3.5 GHz
- ∞VSWR



HLP-8

The TRW 63602 is designed for use up to 3.5 GHz with a typical Pout of 850 mW at 3 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

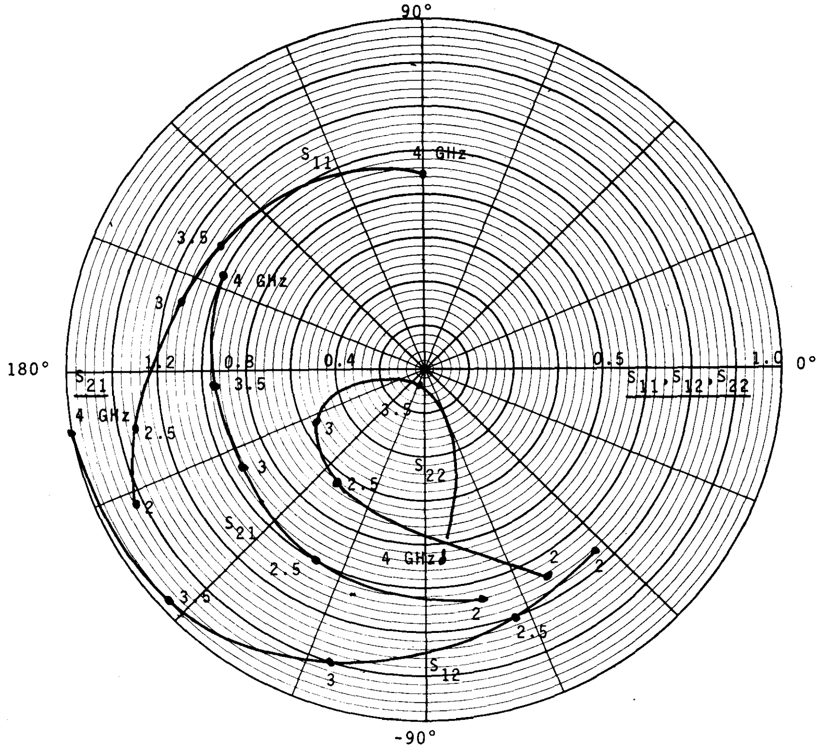
Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	20			V
	BV_{CER}	Collector - Emitter Breakdwon Voltage	R_{BE} = 10 Ω I_C = 20 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.5	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V I_C = 200 mA	15		120	
R F Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V F = 1 MHz			5.5	pF
	F_T	Frequency Cutoff	V_{CE} = 20 V I_E = 230 mA	3	3.3		GHz
	P_o	Power output	F = 2.3 GHz V_{CE} = 20 V I_E = 230 mA	1.2			W
	VSWR	Mismatch Tolerance	P_o = 1.2 W V_{CE} = 20 V I_E = 230 mA			∞ : 1	
Operating	θ_{jF}	Thermal Resistance (junction to Flange)				17	°C/W
	T_{STG}	Max Junction and Storage Temperature		— 65		200	°C

Small Signal S-Parameters

(V_{CE} = 20 V, I_E = 120 mA)

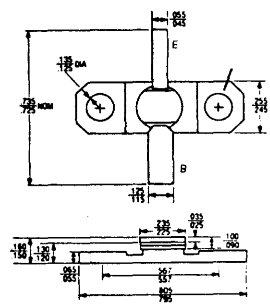


Mechanical Specifications

The following are mechanical specifications for this transistor series.

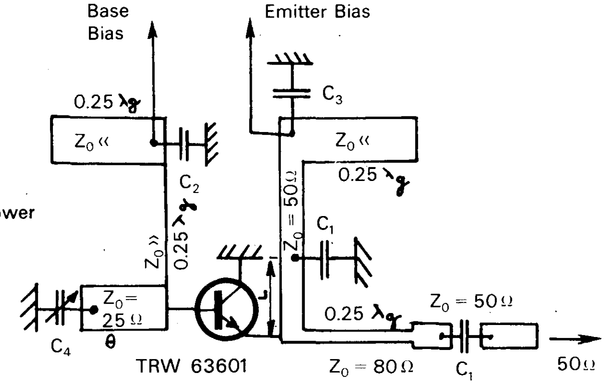
Dimensions:	Per outline drawing.
Solderability:	Per MIL-STD-750.
Marking:	Per MIL-S-19500, "TRW," 4-digit date code, type number.
Hermaticity:	Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)
Acceleration:	Per MIL-STD-750, 20,000G in any plane.
Bond Pull:	Per MIL-STD-750, 3 grams min.
Package:	A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Package Outlines

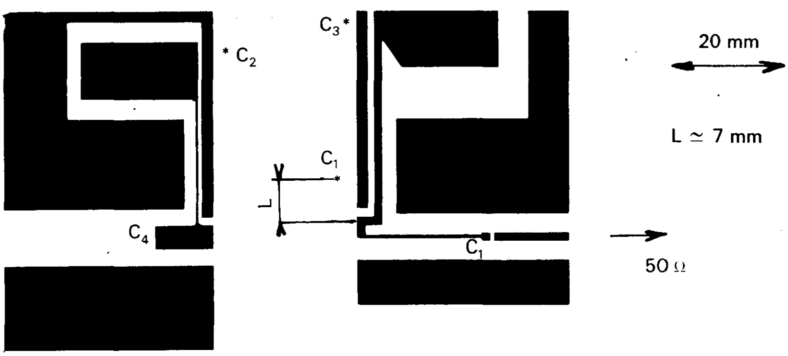


TEST CIRCUIT

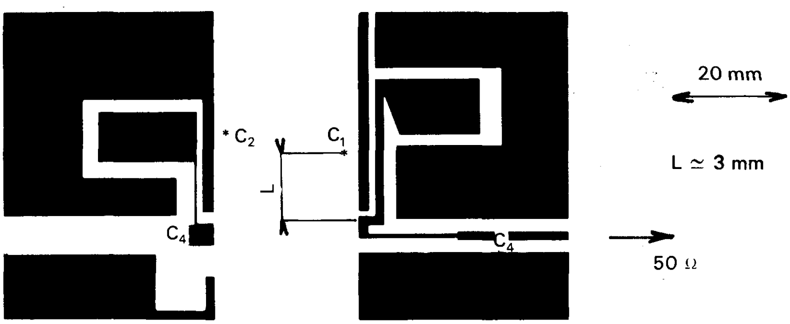
C_1: 220 pF (chip)
C_2: 220 pF (chip) + 10 nF
C_3: 220 pF (chip) + 10 nF + 10 μF
C_4: 0.6-4.5 pF (Frequency tuning)
L : adjust to obtain the maximum output power
θ = 0.115 λg for Fo = 2.3 GHz
θ = 0.06 λg for Fo = 3 GHz



PC Board Layout for Fo = 2.3 GHz (BW = 500 MHz)



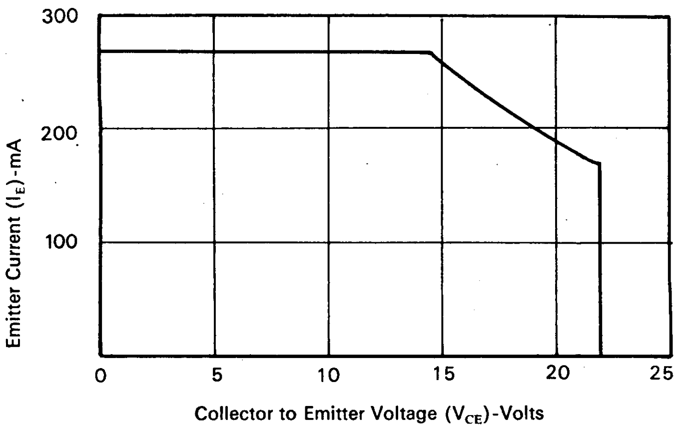
PC Board Layout for Fo = 3 GHz (BW = 500 MHz)



* Foil-wrap asterisked edge to ground plane.
Board material :- 0.020" Glass teflon (Er = 2.55)
Adjust L to obtain the maximum output power

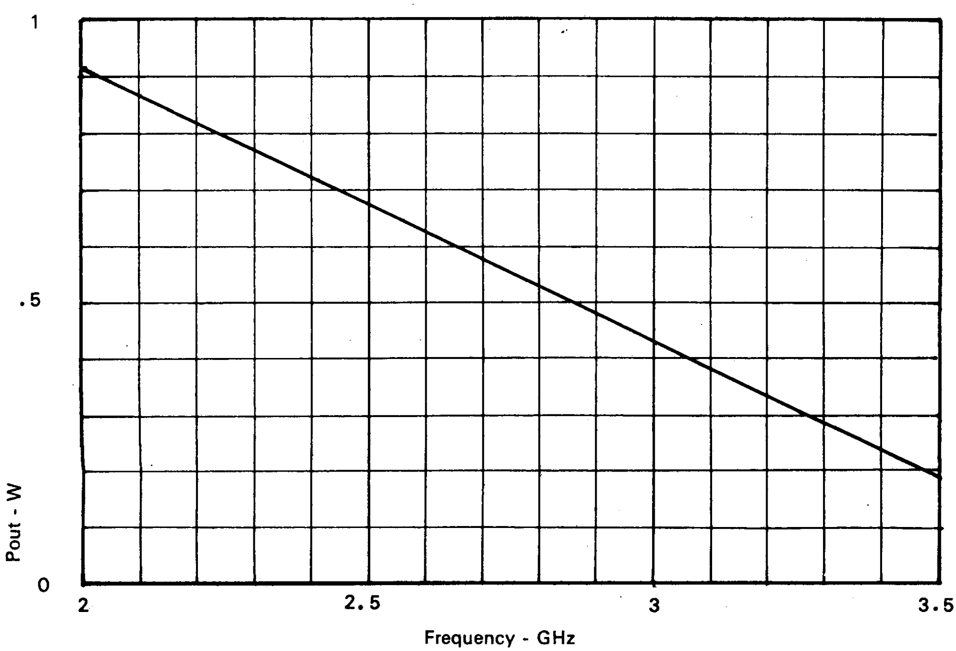
D.C. Safe Operating Area

T_{flange} = **75** °C



Output Power vs. Frequency

(V_{CE} = 20 V, I_E = 120 mA)

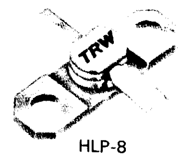


E

TRW

Microwave Power Oscillator Transistors

- 430 mW at 3 GHz
- Up to 3.5 GHz
- ∞VSWR



HLP-8

The TRW 63601 is designed for use up to 3.5 GHz with a typical Pout of 430 mW at 3 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

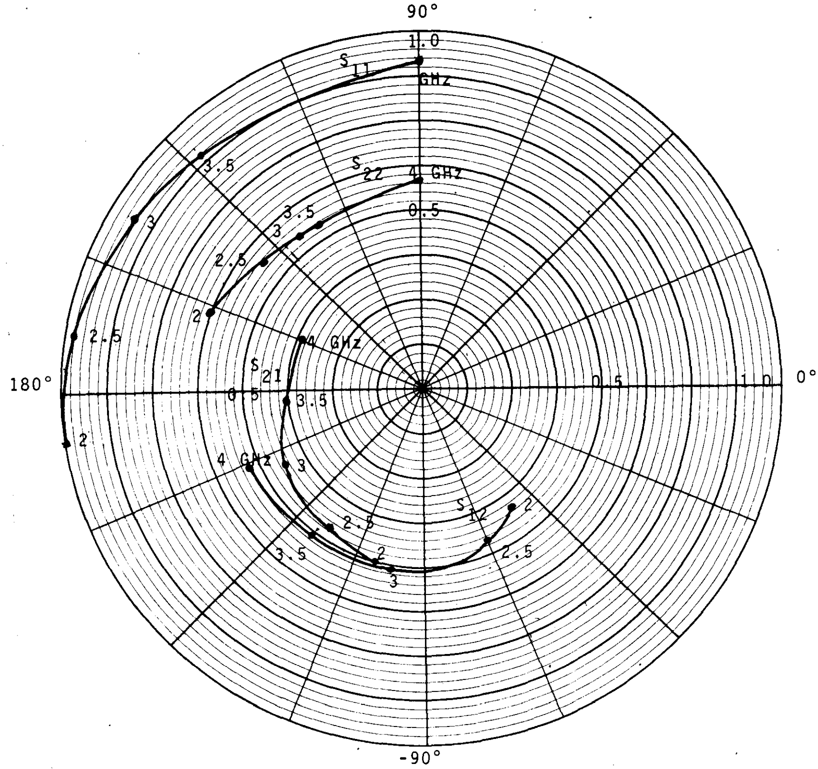
Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	20			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω I_C = 10 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.250	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V I_C = 100 mA	15		120	
R F Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V F = 1 MHz			3.5	pF
	F_T	Frequency Cutoff	V_{CE} = 20 V I_E = 120 mA	3.0	3.3		GHz
	P_o	Power output	F = 2.3 GHz V_{CE} = 20 V I_E = 120 mA	0.6			W
	VSWR	Mismatch Tolerance	P_o = 0.6 W V_{CE} = 20 V I_E = 120 mA		∞ : 1		
Operating	θ_{jF}	Thermal Resistance (junction to Flange)				32	°C/W
	T_{STG}	Max Junction and Storage Temperature		— 65		200	°C

Small Signal S-Parameters

(V_{CE} = 20 V, I_E = 440 mA)



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

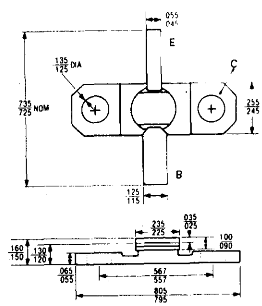
Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

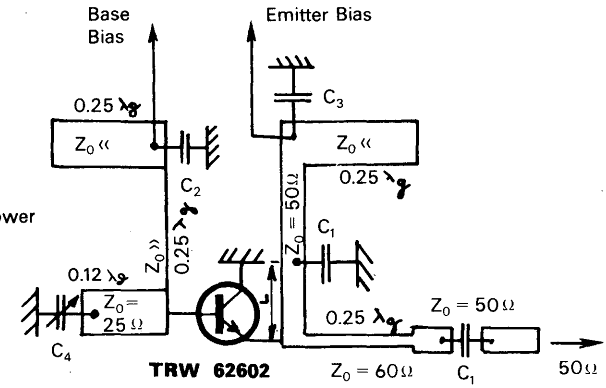
Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

PACKAGE OUTLINE

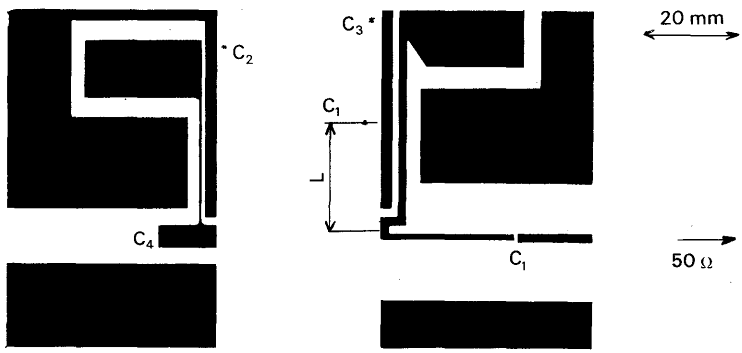


C_1: 220 pF (chip)
C_2: 220 pF (chip) + 10 nF
C_3: 220 pF (chip) + 10 nF + 10 μF
C_4: 0.6-4.5 pF (Frequency tuning)
L : adjust to obtain the maximum output power

TEST CIRCUIT



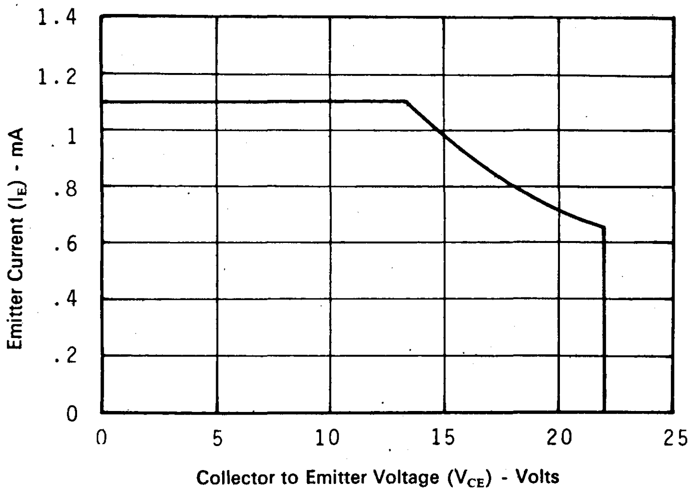
PC Board Layout for Fo = 2.3 GHz (BW = 500 MHz)



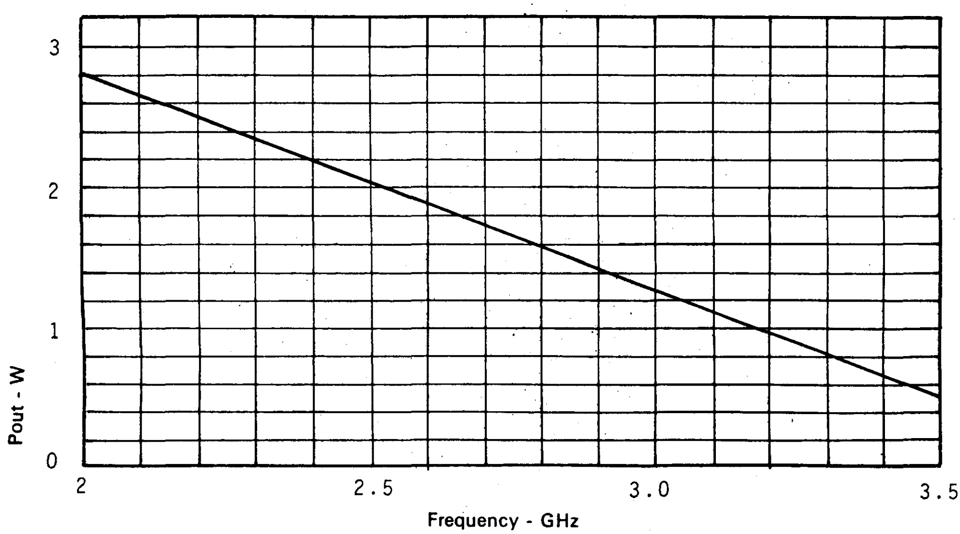
* Foil-wrap asterisked edge to ground plane.
Board material :- 0.020" Glass teflon (Er = 2.55)
Adjust L to obtain the maximum output power

For F = 2 GHz	L = 24 mm
F = 2.3 GHz	L = 19 mm
F = 2.5 GHz	L = 14 mm

D.C. Safe Operating Area

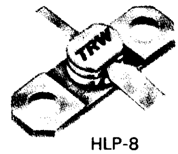


Output Power vs. Frequency
(V_{CE} = 20 V, I_E = 440 mA)



Microwave Power Oscillator Transistors

- 2 W at 2.5 GHz
- Up to 3 GHz
- ∞VSWR



HLP-8

The TRW 62602 is designed for use upt to 3 GHz with a typical Pout of 2 W at 2.5 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

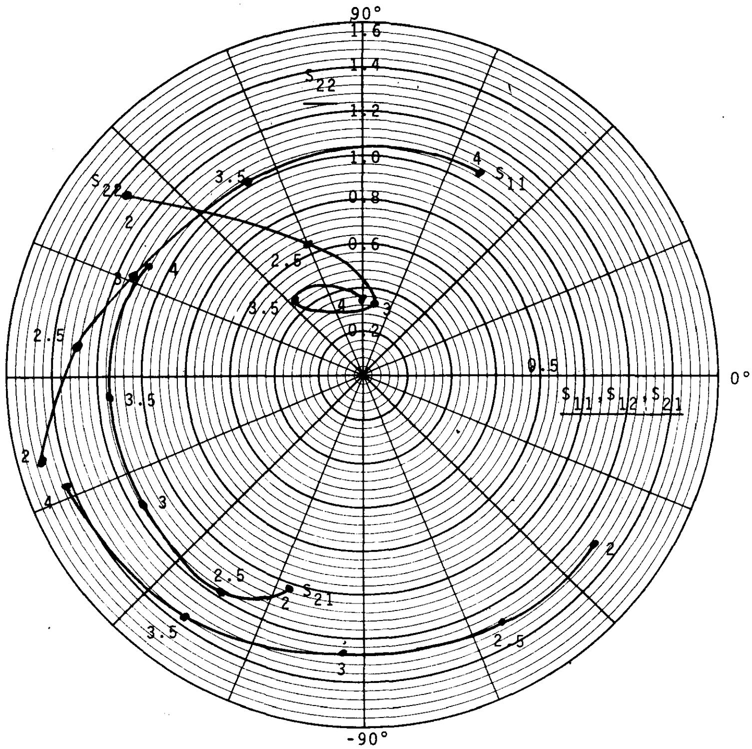
Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 40 mA	22			V
DC Test	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω I_C = 40 mA	50			V
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2.0 mA	45			V
DC Test	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.25	mA
DC Test	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V I_C = 200 mA	20		120	
RF Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V F = 1 MHz			7.0	pF
RF Test	F_T	Frequency Cutoff	V_{CE} = 20 V I_E = 440 mA	2.7	3.0		GHz
RF Test	P_O	Power output	F = 2.00 GHz V_{CE} = 20 V I_E = 440 mA	2.5			W
RF Test	VSWR	Mismutch Tolerance	P_o = 2.5 W V_{CE} = 20 V I_E = 440 mA		∞ : 1		
Operating	θ_{jF}	Thermal Resistance (junction to Flange)				8.5	°C/W
Operating	T_{STG}	Max Junction and Storage Temperature		−65		200	°C

Small Signal S-Parameters

(V_{CE} = 20 V, I_E = 220 mA)



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

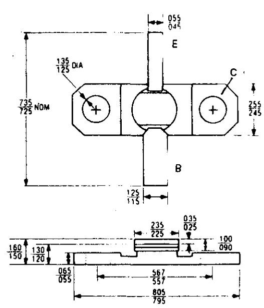
Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

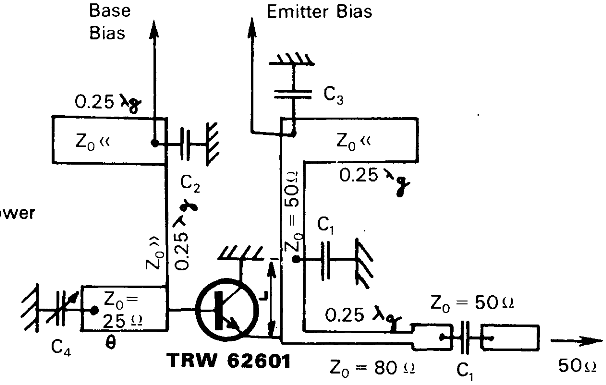
Package Outlines



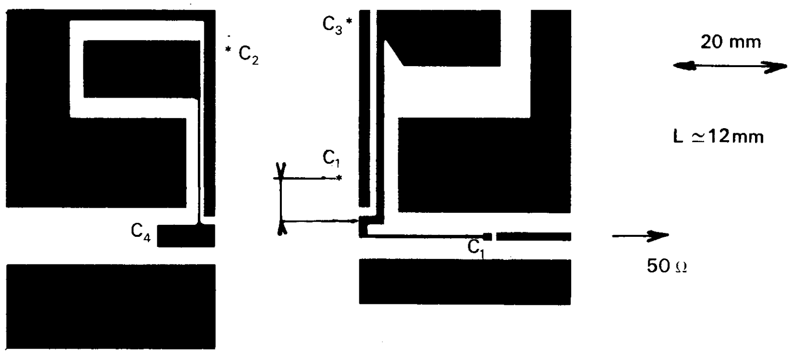
E

TEST CIRCUIT

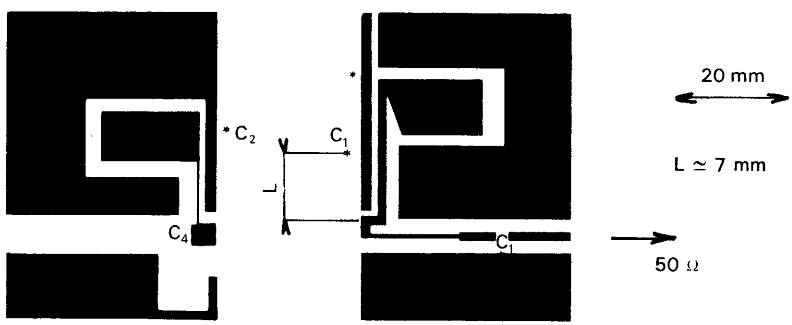
C_1: 220 pF (chip)
C_2: 220 pF (chip) + 10 nF
C_3: 220 pF (chip) + 10 nF + 10 μF
C_4: 0.6-4.5 pF (Frequency tuning)
L : adjust to obtain the maximum output power
$\theta = 0.115\ \lambda g$ for Fo = 2.3 GHz
$\theta = 0.06\ \lambda g$ for Fo = 3 GHz



PC Board Layout for Fo = 2.3 GHz (BW = 500 MHz)

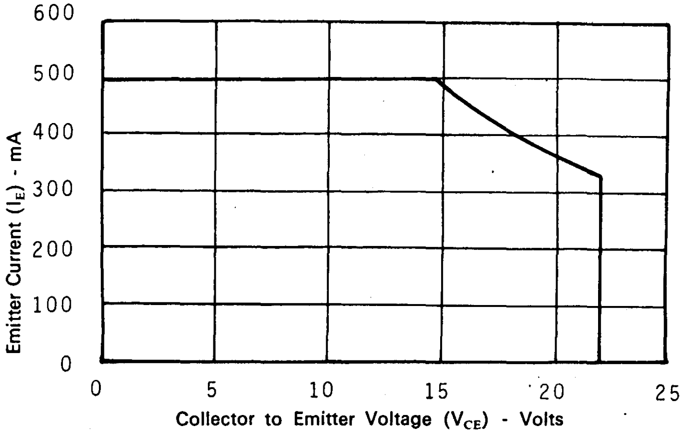


PC Board Layout for Fo = 3 GHz (BW = 500 MHz)

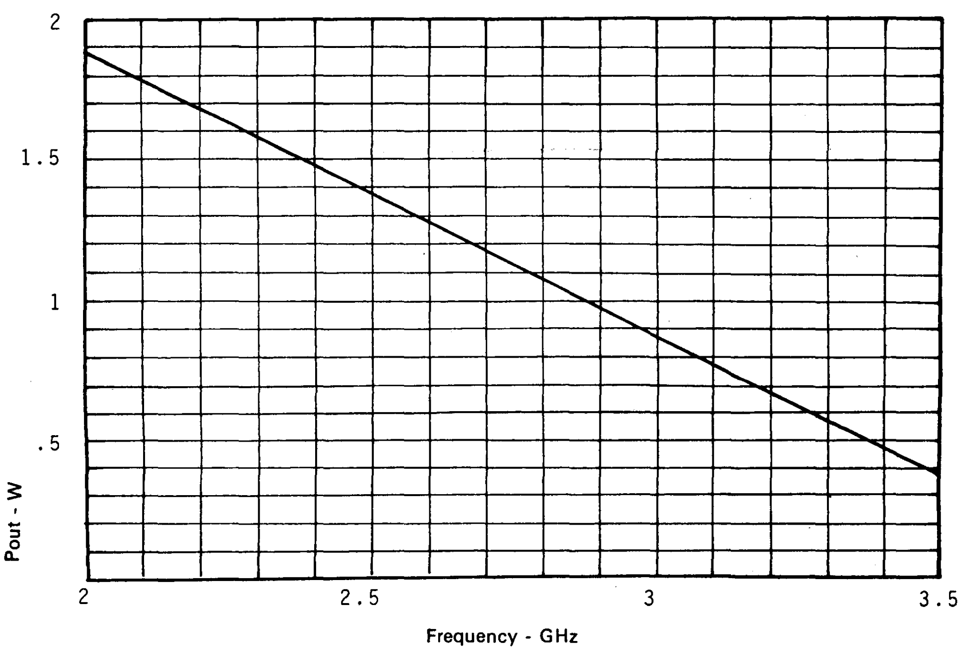


* Foil-wrap asterisked edge to ground plane.
Board material :- 0.020" Glass teflon (Er = 2.55)
Adjust L to obtain the maximum output power

D.C. Safe Operating Area



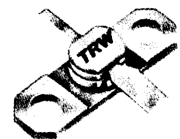
Output Power vs. Frequency
(V_{CE} = 20 V, I_E = 220 mA)



TRW 62601

Microwave Power Oscillator Transistors

- 1.2 W at 2.5 GHz
- Up to 3 GHz
- ∞VSWR



HLP-8

The TRW 62601 is designed for use up to 3 GHz with a typical Pout of 1.2 W at 2.5 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

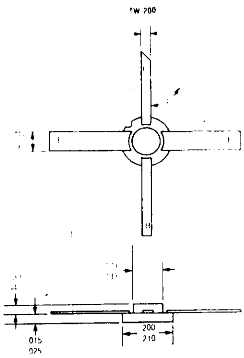
Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

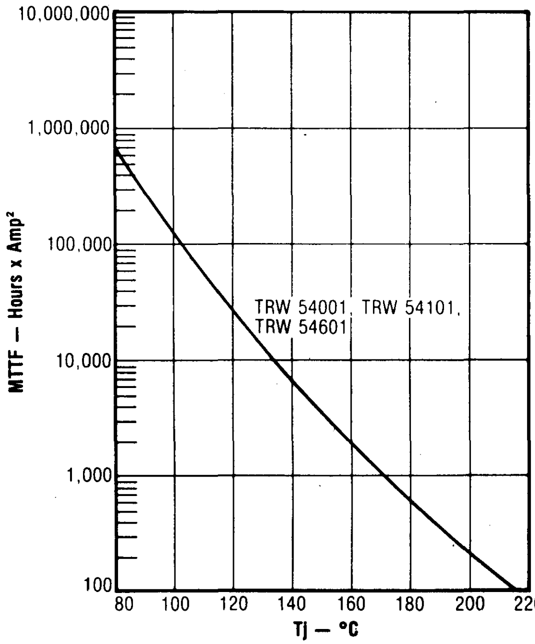
Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
D C Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	22			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω, I_C = 20 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28			0.125	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 100 mA	20		120	
R F Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V, F = 1 MHz			5.0	pF
	F_T	Frequency Cutoff	V_{CE} = 20 V, I_E = 220 mA	2.7	3.0		GHz
	P_o	Power output	F = 2.0 GHz, V_{CE} = 20 V, I_E = 220 mA	1.25			W
	VSWR	Mismatch Tolerance	P_o = 1.25 W, V_{CE} = 20 V, I_E = 220 mA		∞ : 1		
Operating	θ_{jF}	Thermal Resistance (junction to Flange)				15	°C/W
	T_{STG}	Max Junction and Storage Temperature		— 65		200	°C

Note: Test circuit details are available from TRW Semiconductors.

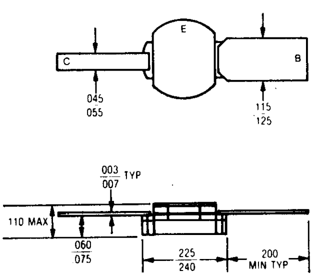
TRW54001





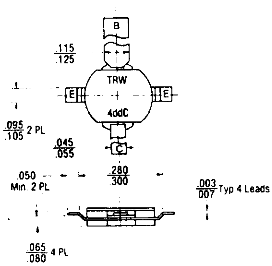
TRW54101

HLP-8 / F



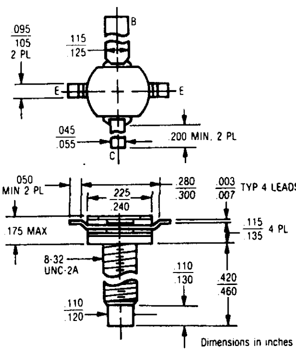
TRW54201

GP-14S



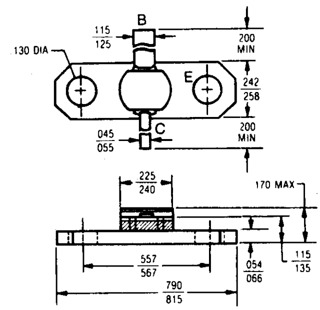
TRW54501

GP-14



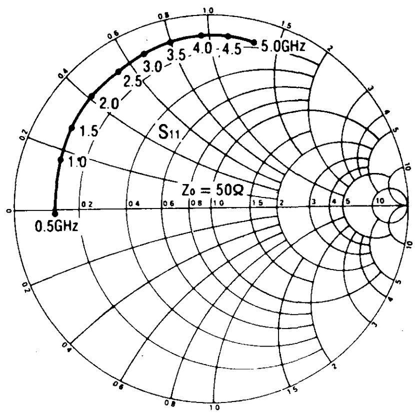
TRW54601

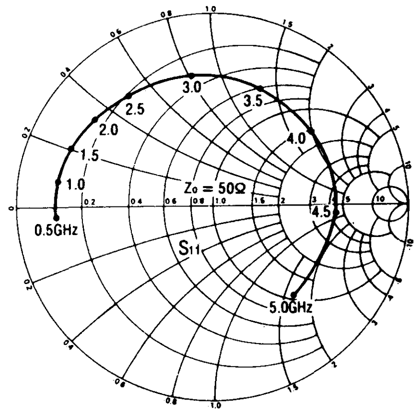
HLP-8

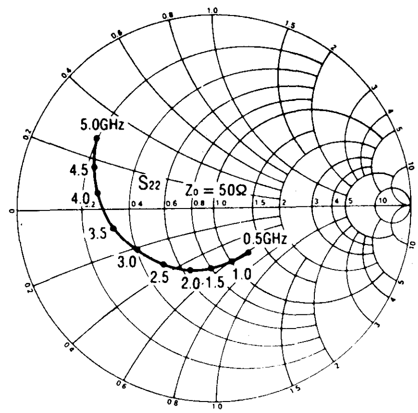


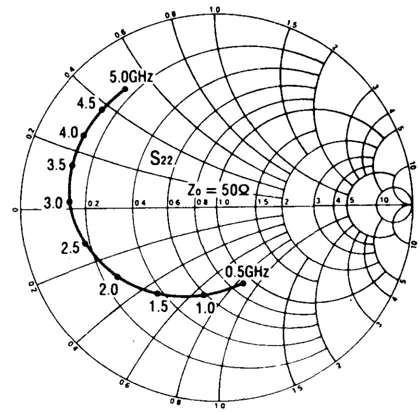
S-Parameters
V_{CE} = 20V, I_E = 120mA, T_{FLANGE} = 25°C

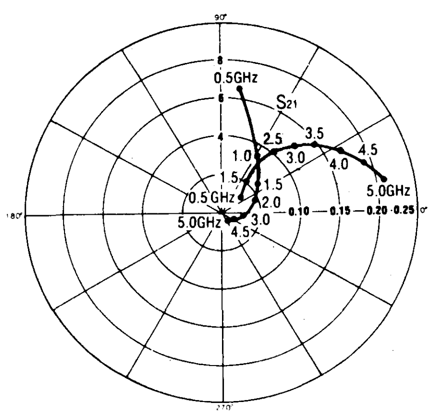
TRW54001 | **TRW54101, TRW54601**

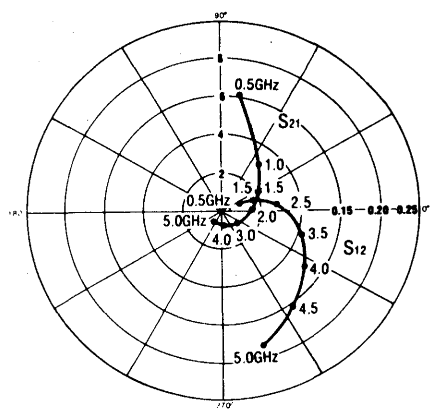






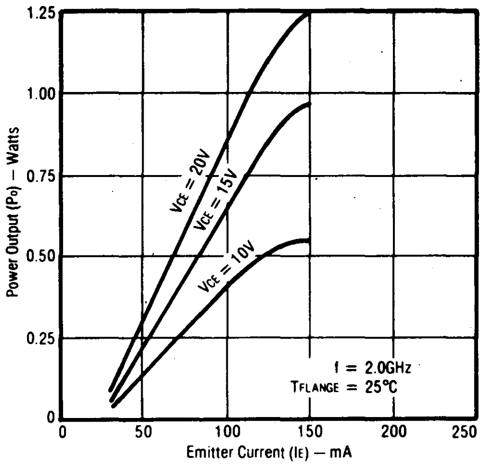




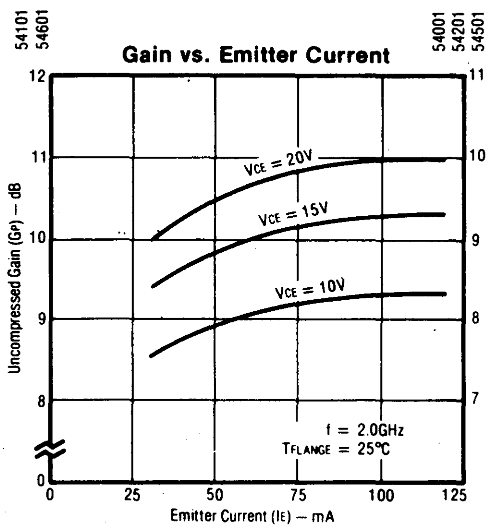


ELECTRICAL CHARACTERISTICS
TRW54001, TRW54101, TRW54201, TRW54501, TRW54601

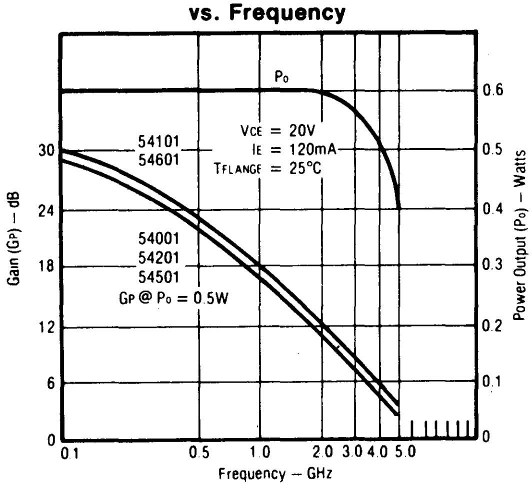
1dB Compression Point vs. Emitter Current



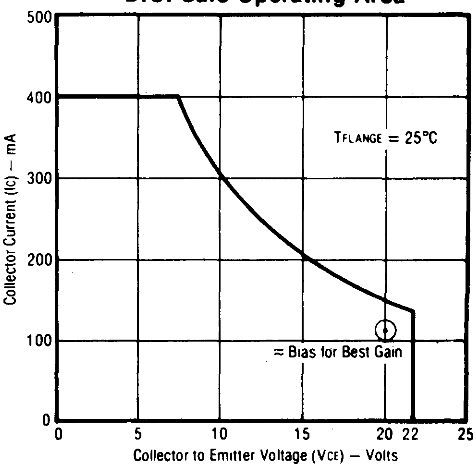
Gain vs. Emitter Current



Gain and 1dB Compressed Power vs. Frequency



D.C. Safe Operating Area



Mechanical Design Specifications

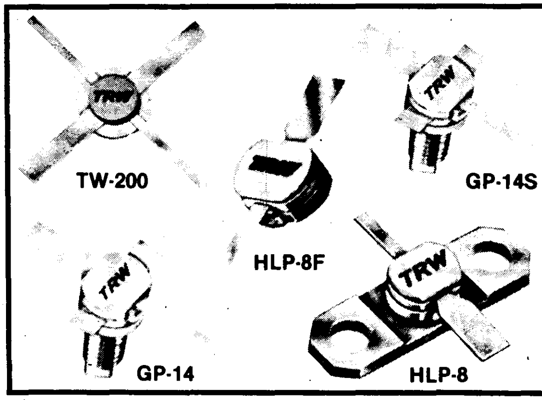
The following are design specifications for this transistor series.

Dimensions:	Per outline drawing.
Solderability:	Per MIL STD 750.
Marking:	Per MIL S 19500. "TRW," 4 digit date code, type number
Hermeticity:	Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)
Acceleration:	Per MIL-STD-750, 20,000G in any plane.
Bond Pull:	Per MIL-STD-750, 3 grams min.
Package:	A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

E

Microwave Linear Transistors

- 0.5 Watts
- 4 GHz
- Gold Metalized
- Diffused Ballast Resistors
- Linear per DIN 45004K
- Common Emitter
- Package Options
- Hermetic
- ∞ VSWR



Electrical Characteristics (T_{CASE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 10mA	22			V
DC TEST	BV_{CES}	Collector-Emitter Breakdown Voltage	I_C = 10mA	50			V
DC TEST	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25mA	3.5			V
DC TEST	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 1.0mA	45			V
DC TEST	I_{CBO}	Collector Cutoff Current	V_{CB} = 28V			0.25	mA
DC TEST	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0V, I_C = 100mA	20		120	—
RF TEST	C_{ob}	Collector-Base Capacitance	V_{CB} = 28V, f = 1MHz			3.5	pF
RF TEST	P_O	Power Output	V_{CE} = 20V, I_E = 120mA, f = 2.0GHz P_{in} = .05W f/54001 & 54201 & 54501 *P_{in} = .04W all others	.5			W
RF TEST	f_t	Frequency Cutoff	V_{CE} = 20V, I_E = 120mA	4.0	4.5		GHz
RF TEST	VSWR	Mismatch Tolerance	P_O = 0.5W, I_E = 120mA, V_{CE} = 20V	∞			
RF TEST	IMD	Third Order Intermodulation Distortion	V_{CE} = 20V, I_E = 120mA $P_{O(PEP)}$ = 0.5W Tones at 2.000GHz and 2.005GHz		-30		dB
RF TEST	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20V, I_E = 75mA, f = 1.0GHz, P_{REF} = 0.15W		-60		dB
RF TEST	L_G	Gain Linearity	V_{CE} = 20V, I_E = 120mA f = 2.0GHz, P_{O1} = 0.5W, P_{O2} = 0.5mW			-0.2 +1.0	dB
OPER.	T_j & T_{stg}	Max. Junction & Storage Temperature		-65		+200	°C
OPER.	θ_{jC}	Thermal Resistance	T_C = 25°C			40	°C/W

Mechanical Design Specifications

The following are design specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermeticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

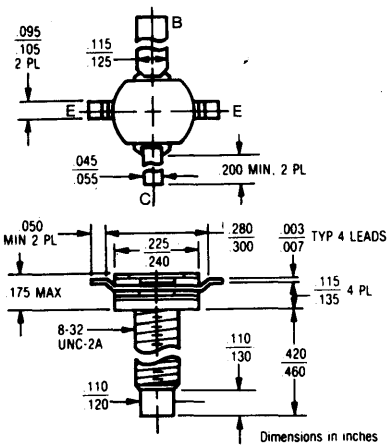
Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of NICKEL base material with minimum 60 microinches of gold plating.

TRW53502

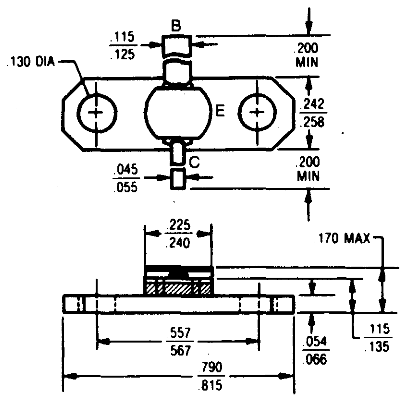
GP-14



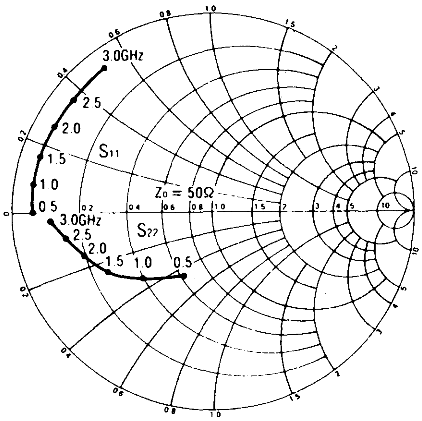
Dimensions in inches

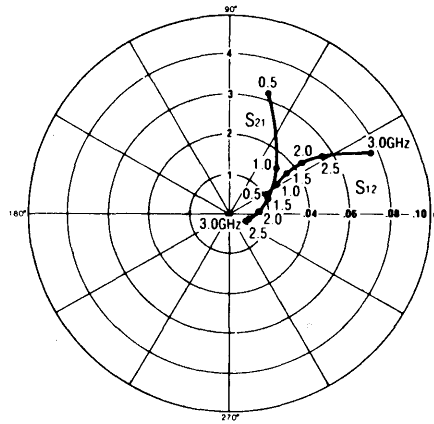
TRW53602

HLP-8

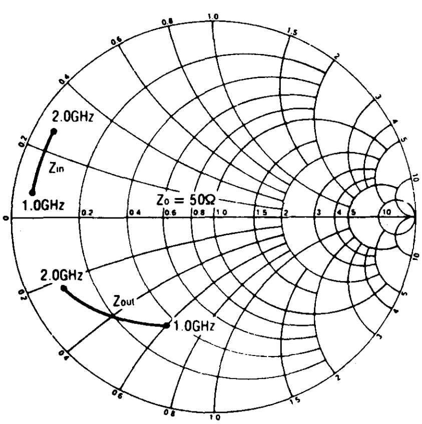


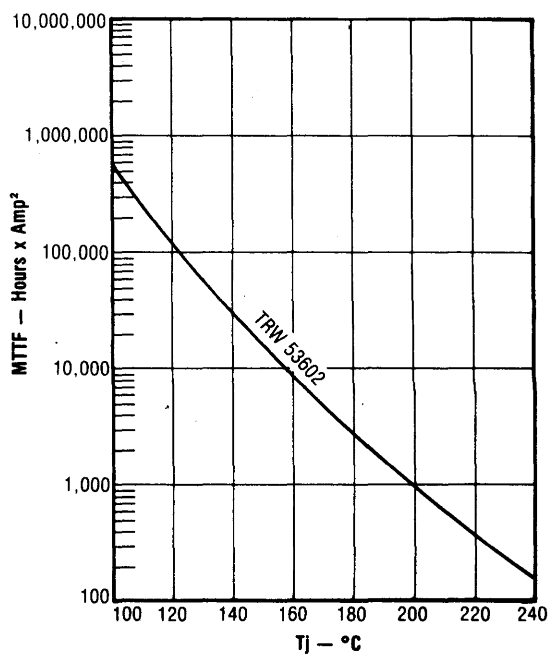
S-PARAMETERS
V_{CE} = 20V, I_E = 230mA, T_{FLANGE} = 25°C





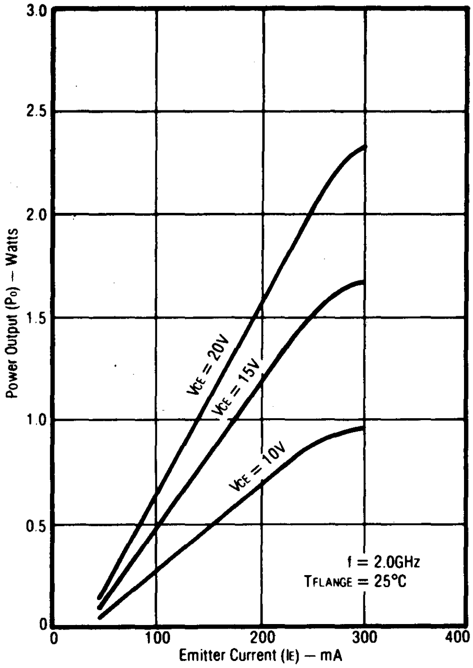
Large Signal Impedance Data



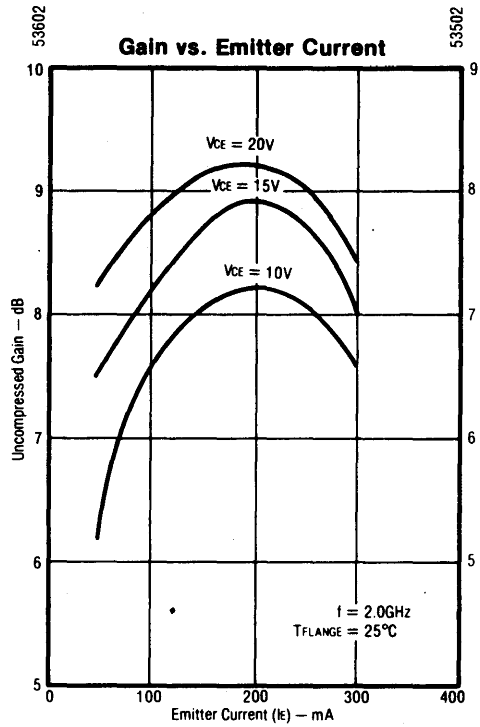


ELECTRICAL CHARACTERISTICS
TRW53502, TRW53602

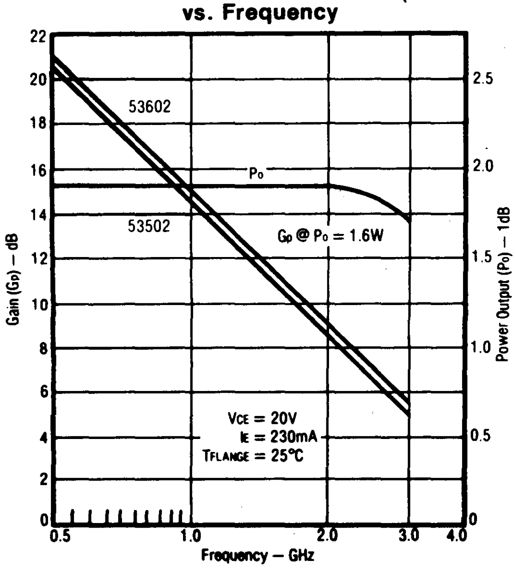
1dB Compression Point vs. Emitter Current



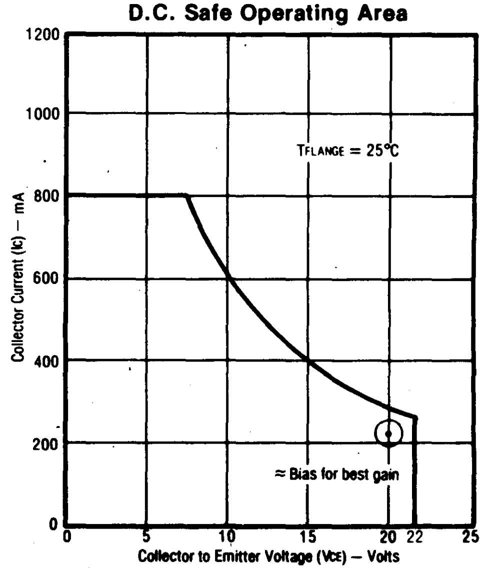
Gain vs. Emitter Current



Gain and 1dB Compressed Power vs. Frequency



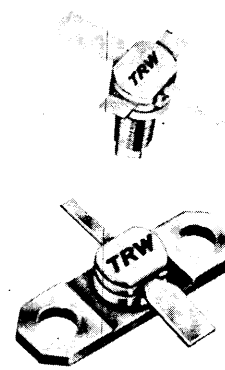
D.C. Safe Operating Area



E

Microwave Linear Transistors

- 1.6 Watts
- 3 GHz
- Gold Metalized
- Diffused Ballast Resistors
- Linear per DIN 45004K
- Common Emitter
- Package Options
- Hermetic
- ∞ VSWR



GP-14

HLP-8

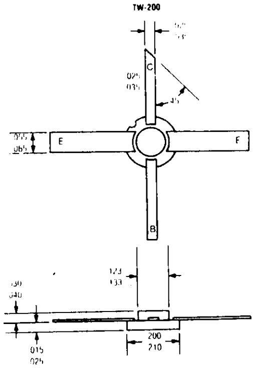
Electrical Characteristics (T_{CASE} = 25°C)

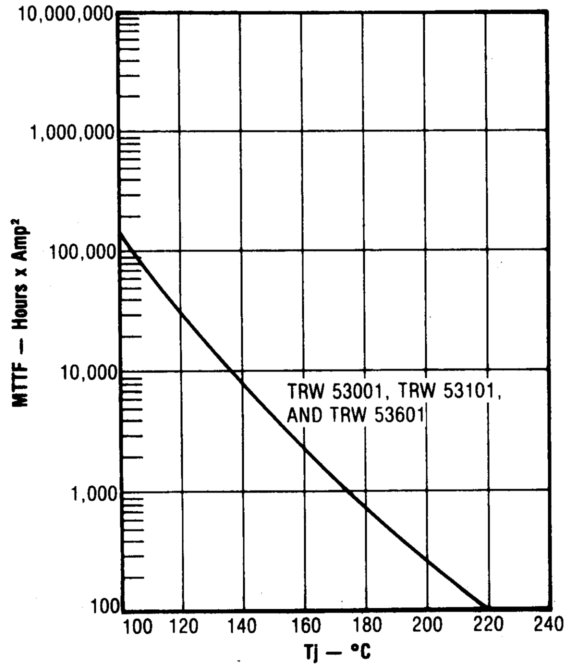
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 20mA	20			V
	BV_{CES}	Collector-Emitter Breakdown Voltage	I_C = 20mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.50mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 2.0mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28V			0.5	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0V, I_C = 200mA	15		120	—
RF TEST	C_{ob}	Collector-Base Capacitance	V_{CB} = 28V, f = 1MHz			5.5	pF
	P_O	Power Output	V_{CE} = 20V, I_E = 230mA, f = 2.0GHz P_{in} = 0.253W f/53602 P_{in} = .319W f/53502	1.6			W
	f_t	Frequency Cutoff	V_{CE} = 20V, I_E = 230mA	3.0	3.3		GHz
	VSWR	Mismatch Tolerance	P_O = 1.6W, I_E = 230mA, V_{CE} = 20V	∞			
	IMD	Third Order Intermodulation Distortion	V_{CE} = 20V, I_E = 230mA $P_{O(PEP)}$ = 1.6W Tones at 2.000GHz and 2.005GHz		-30		dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20V, I_E = 150mA, f = 1.0GHz, P_{REF} = 0.5W		-60		dB
	L_G	Gain Linearity	V_{CE} = 20V, I_E = 230mA f = 2.0GHz, P_{O1} = 1.6W, P_{O2} = 1.6mW			-0.2 +1.0	dB
OPER.	T_j & T_{stg}	Max. Junction & Storage Temperature		-65		+200	°C
	θ_{jC}	Thermal Resistance	T_C = 25°C			17	°C/W

Note: Test circuit details are available from TRW Semiconductors.

TRW53001

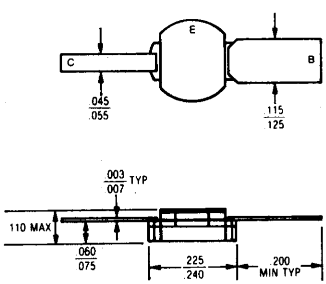
TW-200





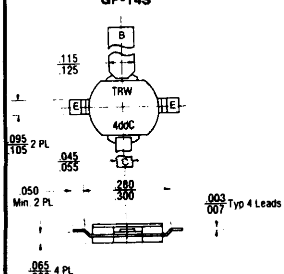
TRW53101

HLP-8 / F



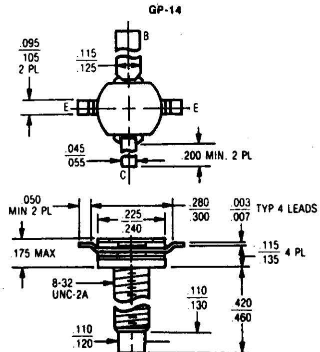
TRW53201

GP-14S



TRW53501

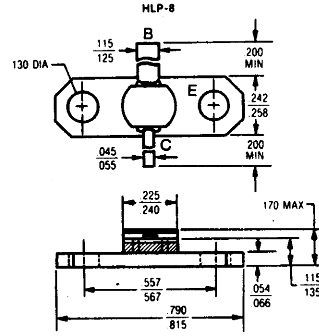
GP-14



Dimensions in inches

TRW53601

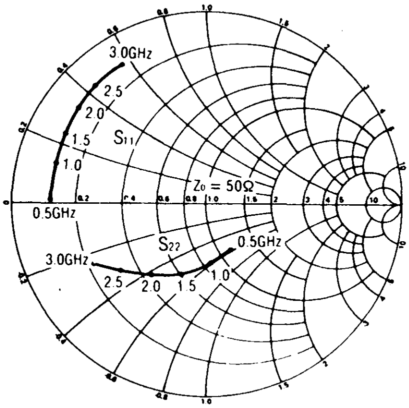
HLP-8

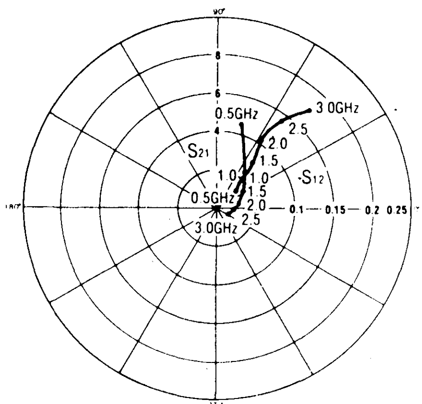


S-Parameters

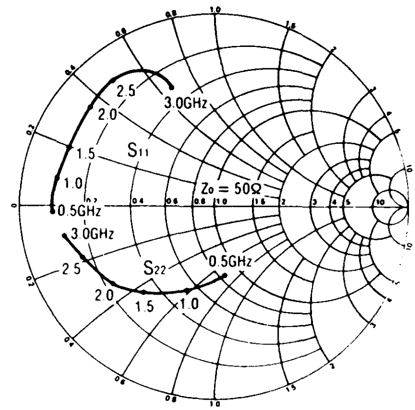
V_{CE} = 20V, I_E = 120mA, T_{FLANGE} = 25°C

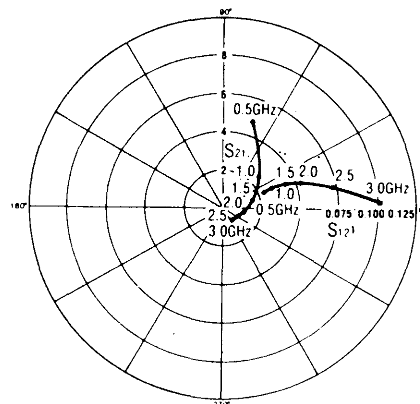
TRW53001





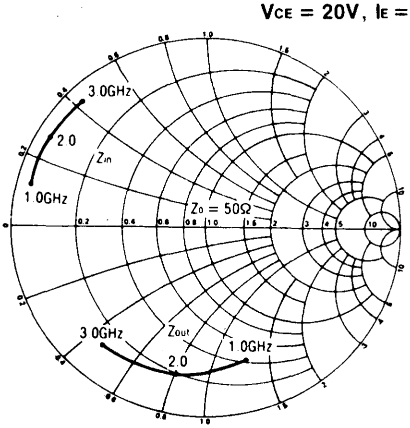
TRW53101, TRW53601

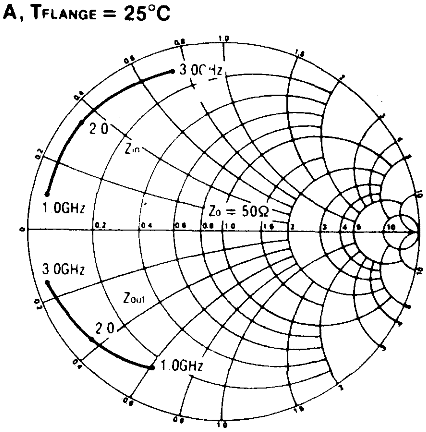




Large Signal Impedance Data

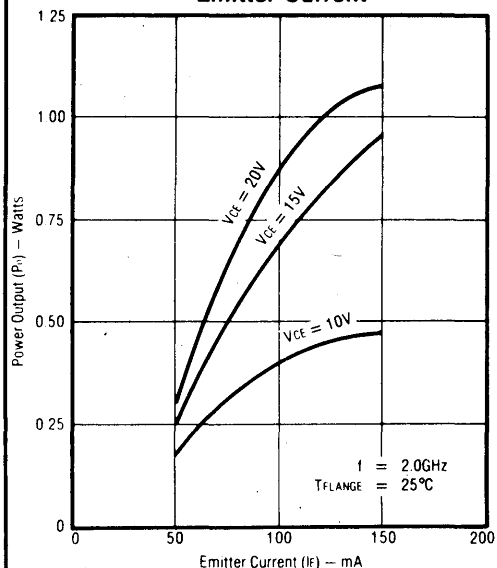
V_{CE} = 20V, I_E = 120mA, T_{FLANGE} = 25°C



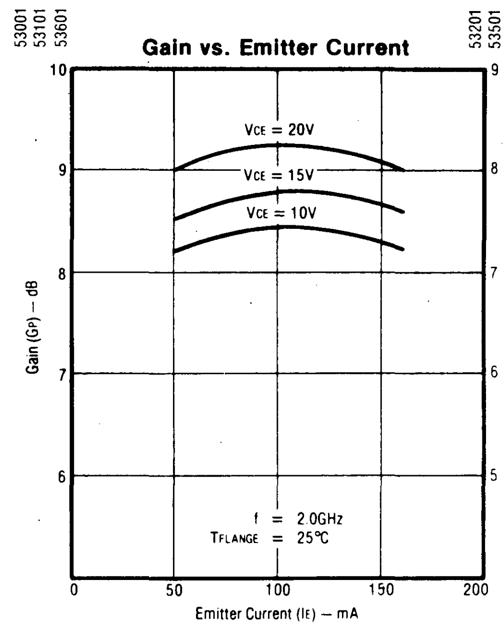


ELECTRICAL CHARACTERISTICS
TRW53001, TRW53101, TRW53201, TRW53501, TRW53601

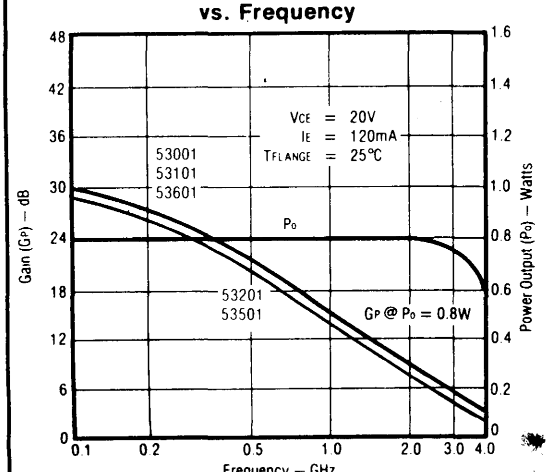
1dB Compression Point vs. Emitter Current



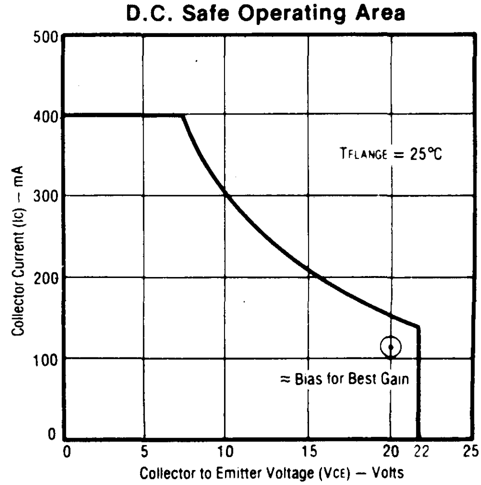
Gain vs. Emitter Current



Gain and 1dB Compressed Power vs. Frequency



D.C. Safe Operating Area



Mechanical Design Specifications

The following are design specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermeticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

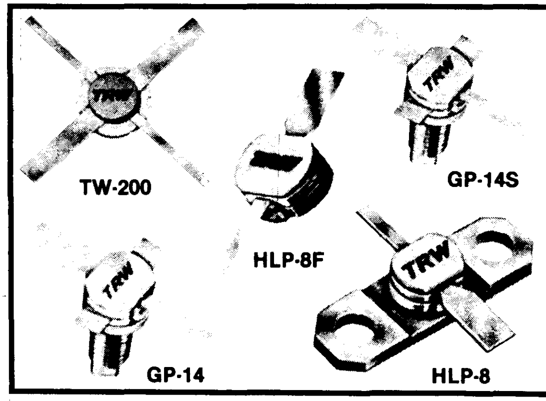
Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Microwave Linear Transistors

- 0.8 Watts
- 3 GHz
- Gold Metalized
- Diffused Ballast Resistors
- Linear per DIN 45004K
- Common Emitter
- Package Options
- Hermetic
- ∞VSWR



Electrical Characteristics (T_{CASE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 10mA	20			V
	BV_{CES}	Collector-Emitter Breakdown Voltage	I_C = 10mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 1.0mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28V			0.25	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0V, I_C = 100mA	15		120	—
RF TEST	C_{ob}	Collector-Base Capacitance	V_{CB} = 28V, f = 1MHz			3.5	pF
	P_O	Power Output	V_{CE} = 20V, I_E = 120mA, f = 2.0GHz *P_{in} = .100W f/53101 & 53601 P_{in} = 0.142W f/53201 & 53501 P_{in} = .142WF/53001	.8			W
	f_t	Frequency Cutoff	V_{CE} = 20V, I_E = 120mA	3.0	3.3		GHz
	VSWR	Mismatch Tolerance	P_O = 0.8W, I_E = 120mA, V_{CE} = 20V	∞			
	IMD	Third Order Intermodulation Distortion	V_{CE} = 20V, I_E = 120mA f = 2.0GHz, $P_{O(PEP)}$ = 0.8W Tones at 2.000GHz and 2.005GHz		-30		dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20V, I_E = 75mA, f = 1.0GHz, P_{REF} = 0.25W		-60		dB
	L_G	Gain Linearity	V_{CE} = 20V, I_E = 120mA f = 2.0GHz, P_{O1} = .8W, P_{O2} = .8mW			-0.2 +1.0	dB
OPER.	T_j & T_{stg}	Max. Junction & Storage Temperature		-65		+200	°C
	θ_{jC}	Thermal Resistance	T_C = 25°C			31	°C/W

Mechanical Design Specifications

The following are design specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermeticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

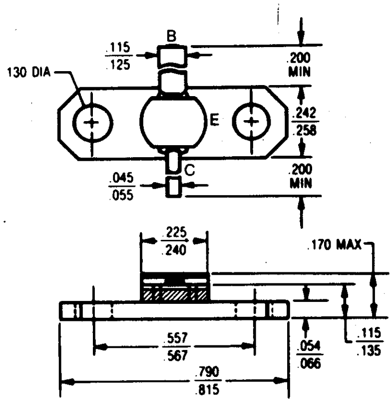
Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of NICKEL base material with minimum 60 microinches of gold plating.

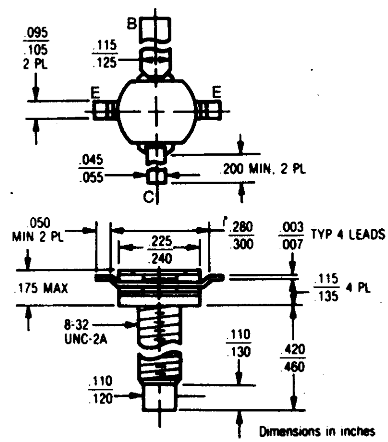
Package Outlines

TRW52604



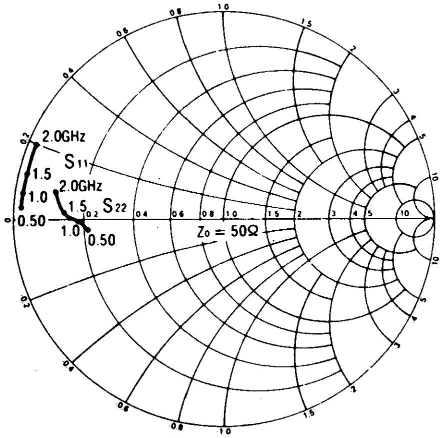
HLP-8

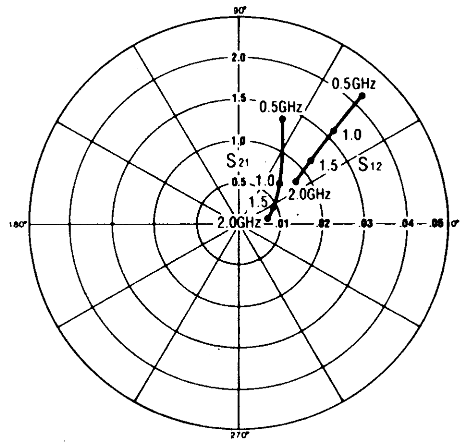
TRW52504



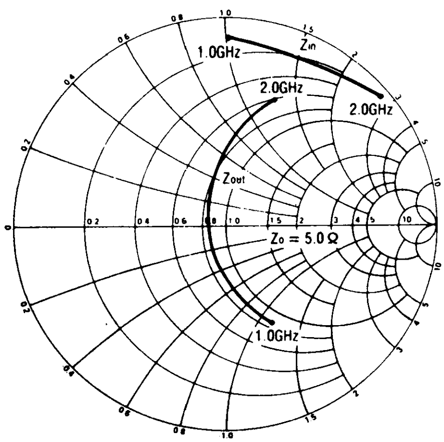
GP-14

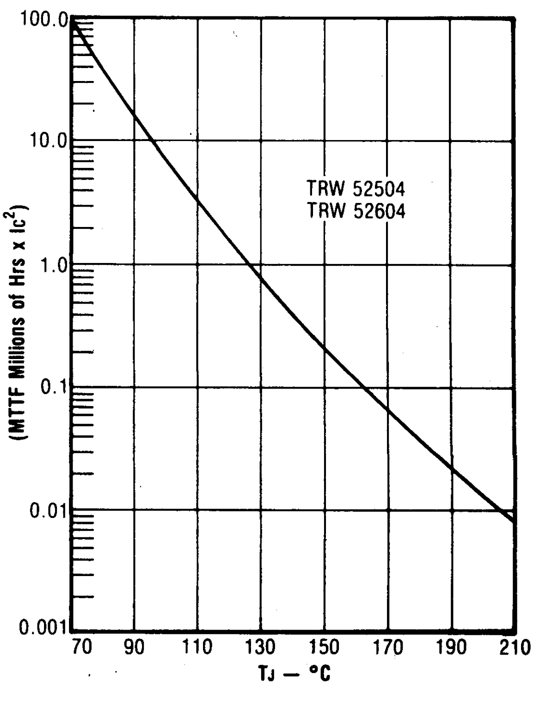
S-Parameters
VCE = 20V, IE = 880mA, TFLANGE = 25°C





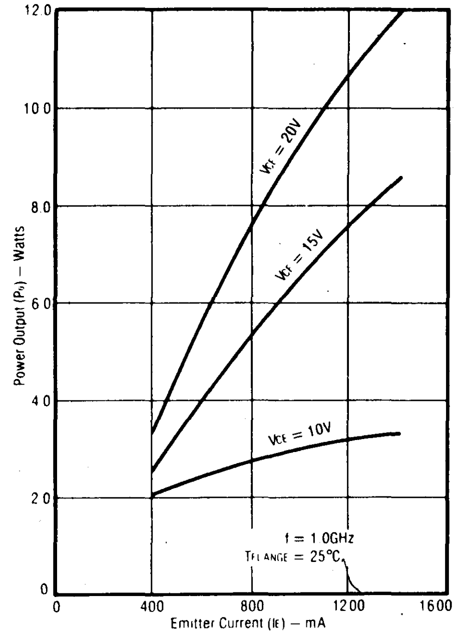
Large Signal Impedance Data



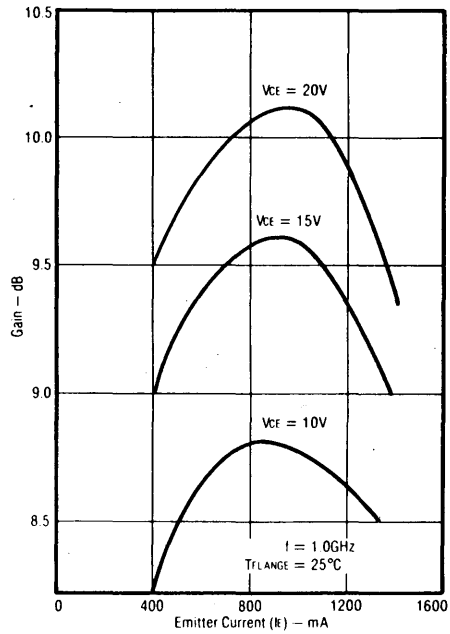


ELECTRICAL CHARACTERISTICS

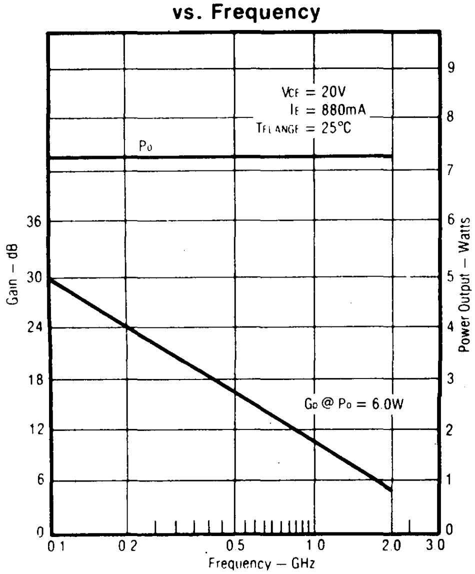
1dB Compression Point vs. Emitter Current



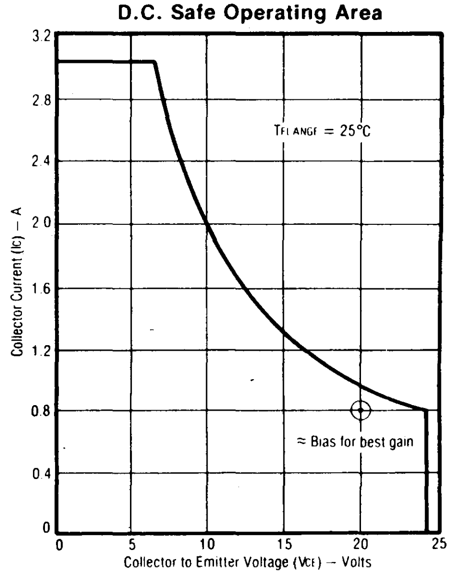
Gain vs. Emitter Current



Gain and 1dB Compressed Power vs. Frequency

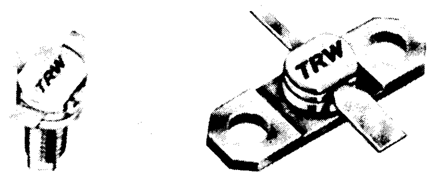


D.C. Safe Operating Area



Microwave Linear Transistors

- Gold Metalized
- Diffused Ballast Resistors
- Linear per DIN 45004K
- Common Emitter
- Package Options
- 6 Watts
- 2 GHz
- ∞ VSWR
- Hermetic



GP-14 HLP-8

Electrical Characteristics (T_{CASE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP	MAX.	UNIT
DC TEST	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 80mA	24			V
DC TEST	BV_{CES}	Collector-Emitter Breakdown Voltage	I_C = 80mA	50			V
DC TEST	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0mA	3.5			V
DC TEST	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 4.0mA	45			V
DC TEST	I_{CBO}	Collector Cutoff Current	V_{CB} = 28V			0.5	mA
DC TEST	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0V, I_C = 400mA	20		120	—
RF TEST	C_{ob}	Collector-Base Capacitance	V_{CB} = 28V, f = 1MHz			12	pF
RF TEST	P_O	Power Output	V_{CE} = 20V, I_E = 880mA f = 2.0GHz, P_{in} = 2.0W	6.0			W
RF TEST	f_t	Frequency Cutoff	V_{CE} = 20V, I_E = 880mA	2.4	2.6		GHz
RF TEST	VSWR	Mismatch Tolerance	P_O = 6.0W, I_E = 880mA, V_{CE} = 20V	3:1			
RF TEST	IMD	Third Order Intermodulation Distortion	V_{CE} = 20V, I_E = 880mA $P_{O(PEP)}$ = 6.0W Tones at 1.000GHz and 1.005GHz		-30		dB
RF TEST	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20V, I_E = 600mA, f = 1.0GHz, P_{REF} = 2.0W		-60		dB
RF TEST	L_G	Gain Linearity	V_{CE} = 20V, I_E = 880mA f = 2.0GHz, P_{O1} = 6W, P_{O2} = 6mW			-0.2 +1.0	dB
OPER.	T_j & T_{stg}	Max. Junction & Storage Temperature		-65		+200	°C
OPER.	θ_{jC}	Thermal Resistance	P_O = 5W, V_{CE} = 20V, I_E = 880mA			6.0	°C/W

Mechanical Design Specifications

The following are design specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermeticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

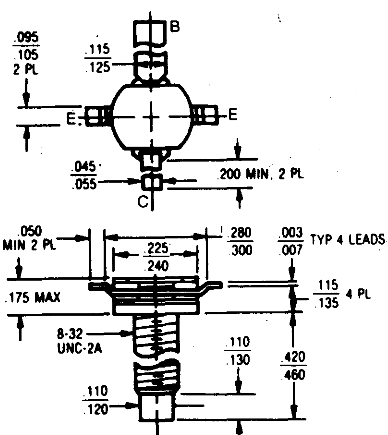
Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of NICKEL base material with minimum 60 microinches of gold plating.

TRW52502

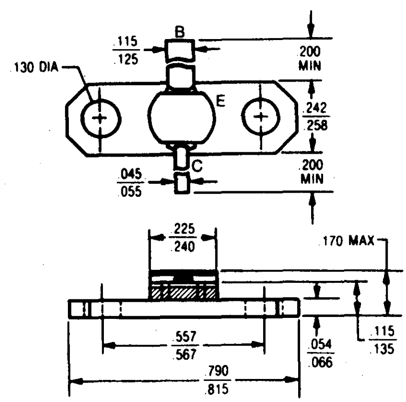
GP-14



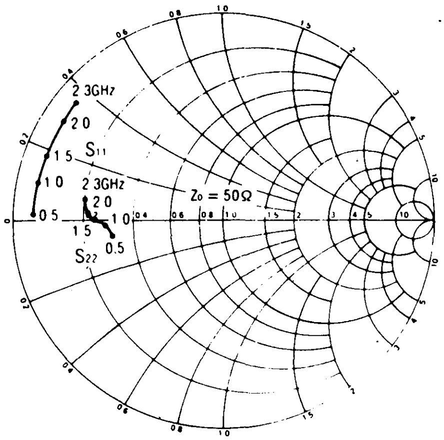
Dimensions in inches

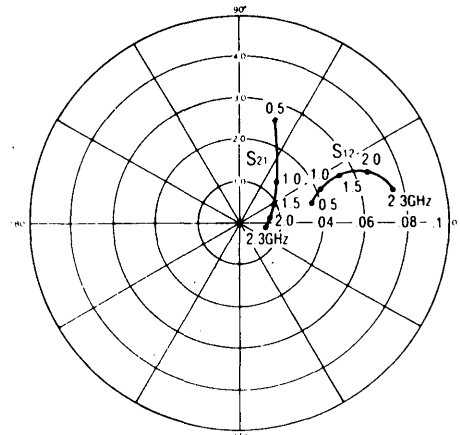
TRW52602

HLP-8

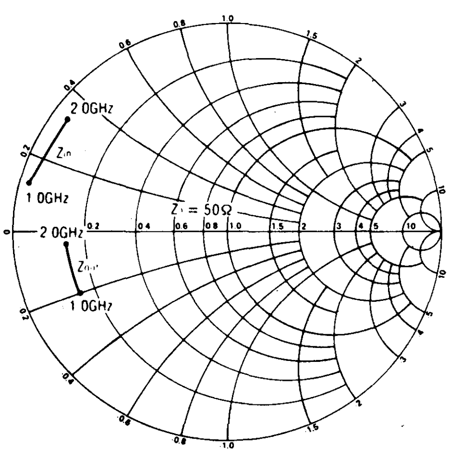


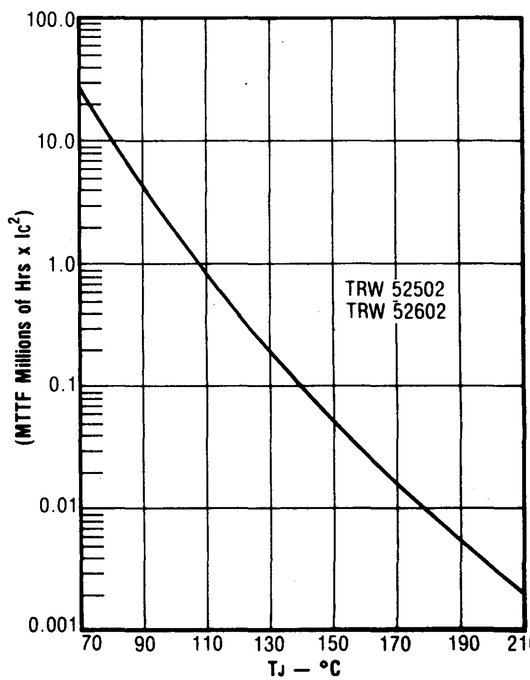
S-PARAMETERS
V_{CE} = 20V, I_E = 440mA, T_{FLANGE} = 25°C





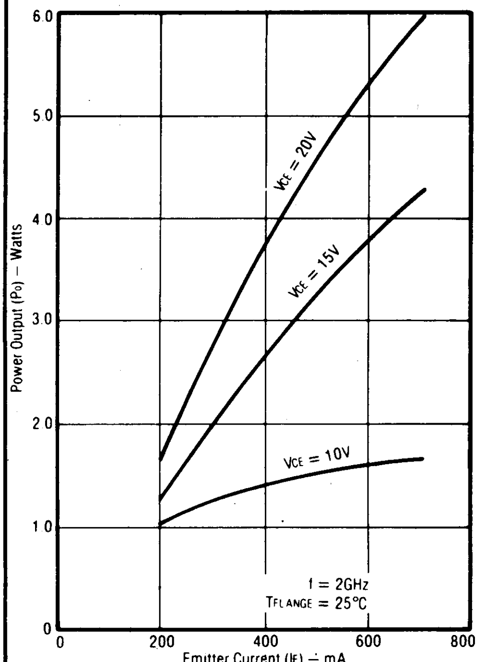
Large Signal Impedance Data



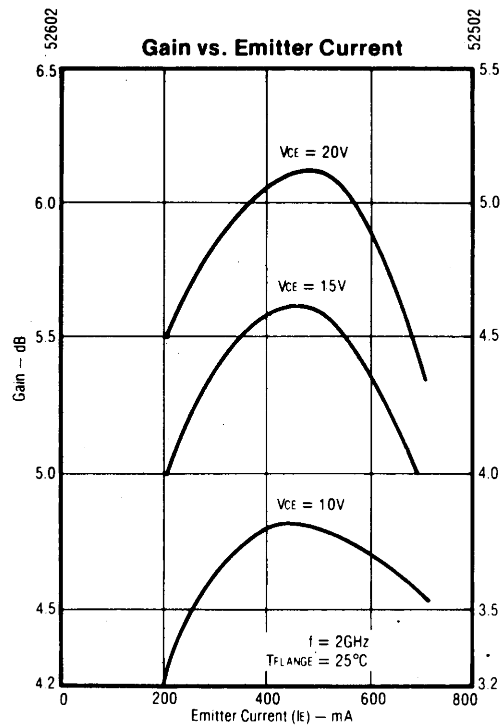


ELECTRICAL CHARACTERISTICS
TRW52502, TRW52602

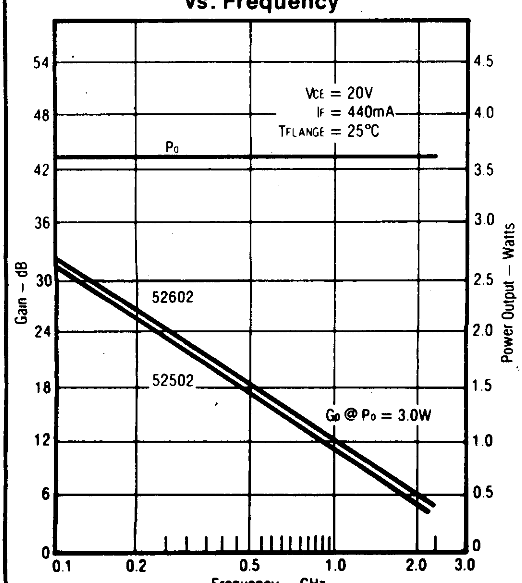
1dB Compression Point vs. Emitter Current



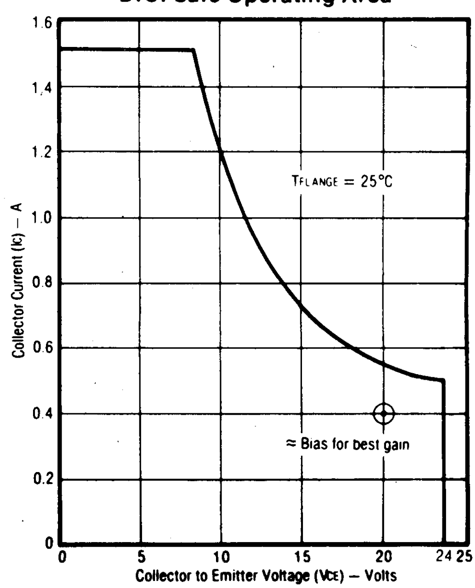
Gain vs. Emitter Current



Gain and 1dB Compressed Power vs. Frequency



D.C. Safe Operating Area

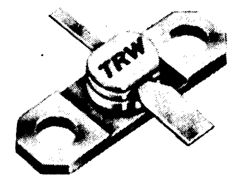


TRW

Microwave Linear Transistors

- Gold Metalized
- Diffused Ballast Resistors
- Linear per DIN 45004K
- Common Emitter
- Package Options
- 3 Watts
- 2 GHz
- Hermetic
- ∞ VSWR

GP-14



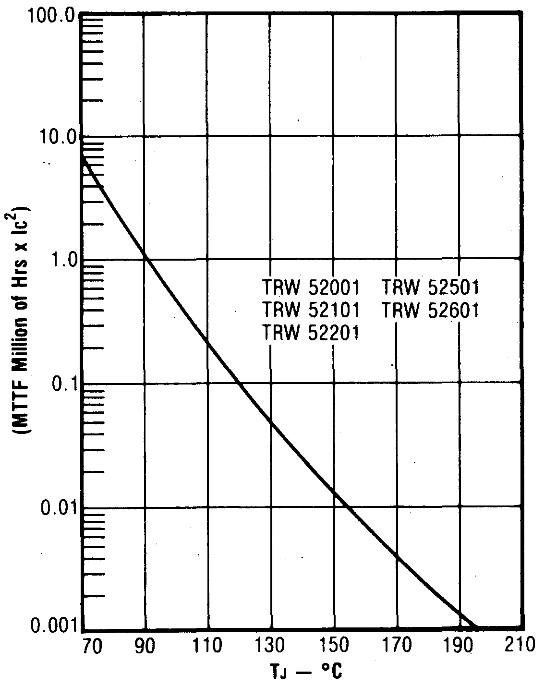
HLP-8

Electrical Characteristics (T_{CASE} = 25°C)

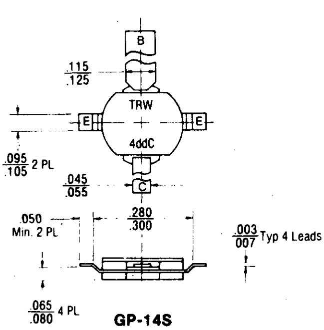
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 40mA	24			V
	BV_{CES}	Collector-Emitter Breakdown Voltage	I_C = 40mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.50mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 2.0mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28V			0.25	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0V, I_C = 200mA	20		120	—
RF TEST	C_{ob}	Collector-Base Capacitance	V_{CB} = 28V, f = 1MHz			7	pF
	P_O	Power Output	V_{CE} = 20V, I_E = 440mA f = 2.0GHz, P_{in} = 0.75W (52602) P_{in} = .95W f/(52502)	3.0			W
	f_t	Frequency Cutoff	V_{CE} = 20V, I_E = 440mA	2.7	3.0		GHz
	VSWR	Mismatch Tolerance	P_O = 3.0W, I_E = 440mA, V_{CE} = 20V	∞			
	IMD	Third Order Intermodulation Distortion	V_{CE} = 20V, I_E = 440mA $P_{O(PEP)}$ = 3.0W Tones at 2.000GHz and 2.005GHz		-30		dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20V, I_E = 300mA, f = 1.0GHz, P_{REF} = 1.0W		-60		dB
	L_G	Gain Linearity	V_{CE} = 20V, I_E = 440mA f = 2.0GHz, P_{O1} = 3.0W, P_{O2} = 3.0mW			-0.2 +1.0	dB
OPER.	T_j & T_{stg}	Max. Junction & Storage Temperature		-65		+200	°C
	θ_{jC}	Thermal Resistance	T_C = 25°C			8.5	°C/W

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.

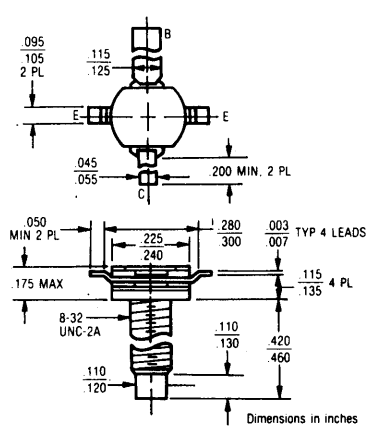


TRW52201



GP-14S

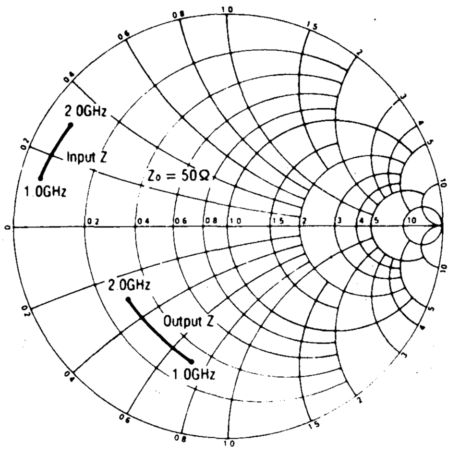
TRW52501



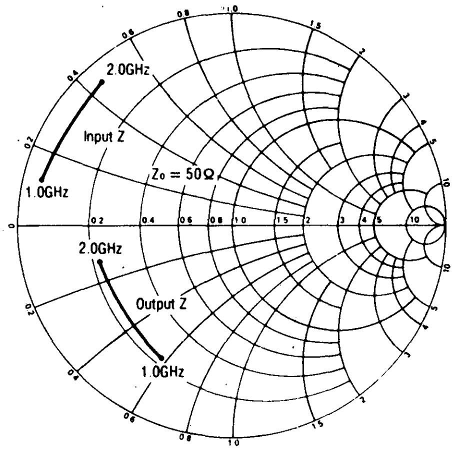
GP-14

LARGE SIGNAL IMPEDANCE DATA
V_{CE} = 20V, I_E = 220mA, T_{FLANGE} = 25°C

TRW52001

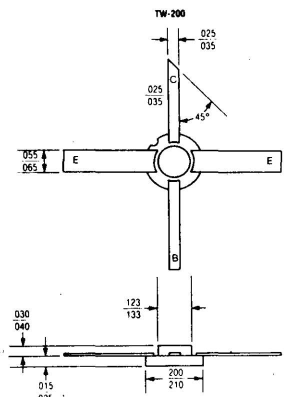


TRW52101, TRW52601

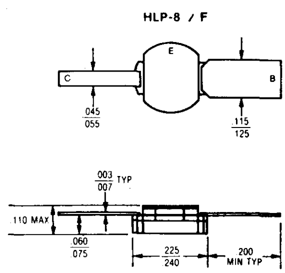


Package Outlines

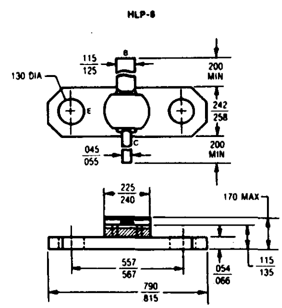
TRW52001



TRW52101



TRW52601



Mechanical Design Specifications

The following are design specifications for this transistor series:

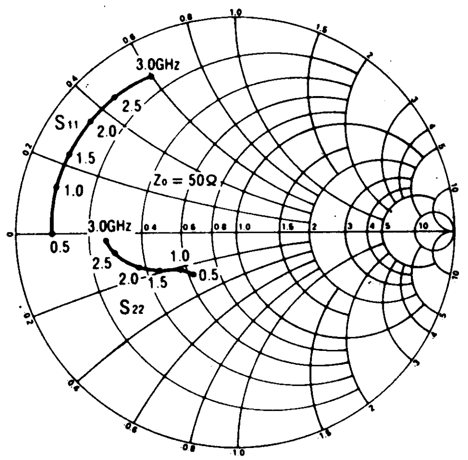
Dimensions: Per outline drawing.
Solderability: Per MIL STD 750.
Marking: Per MIL S 19500. "TRW," 4 digit date code, type number.
Hermeticity: Per MIL STD 750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL STD 750, 20,000 G in any plane.
Lead Pull: Per MIL STD 750, 3 grams min.
Package: A brazed ceramic package assuring long term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

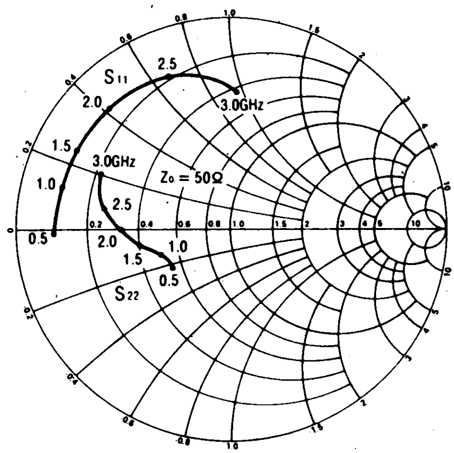
S-PARAMETERS

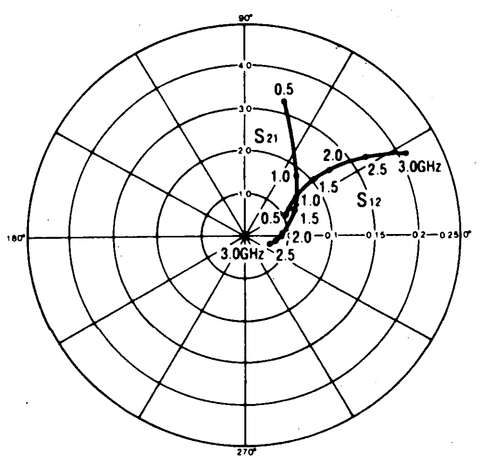
V_{CE} = 20V, I_E = 220mA, T_{FLANGE} = 25°C

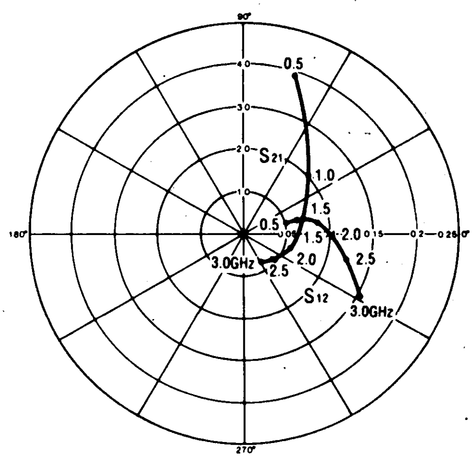
TRW52001



TRW52101, TRW52601



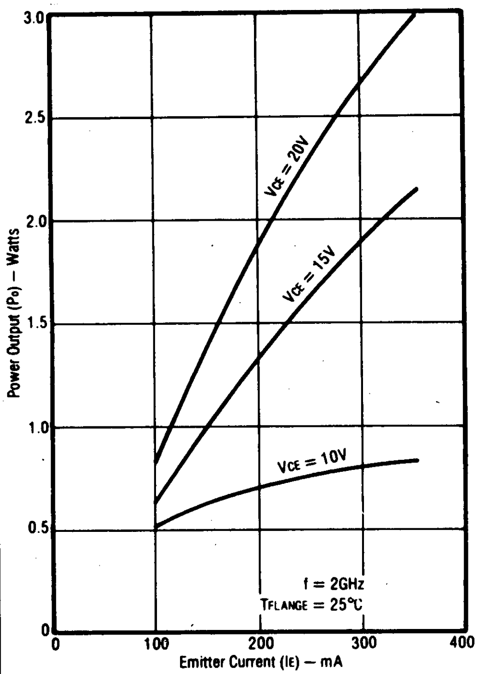




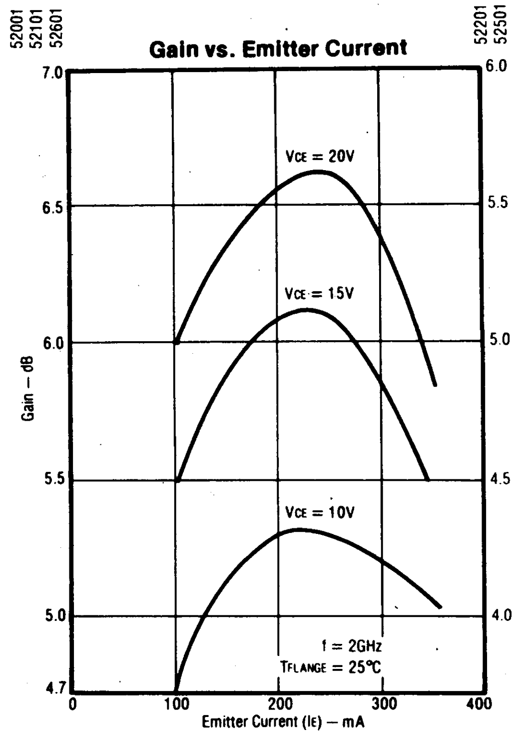
E

ELECTRICAL CHARACTERISTICS
TRW52001, TRW52101, TRW52201, TRW52501, TRW52601

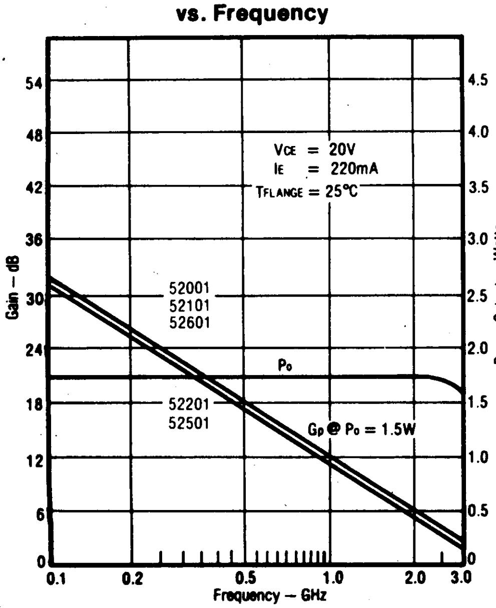
1dB Compression Point vs. Emitter Current



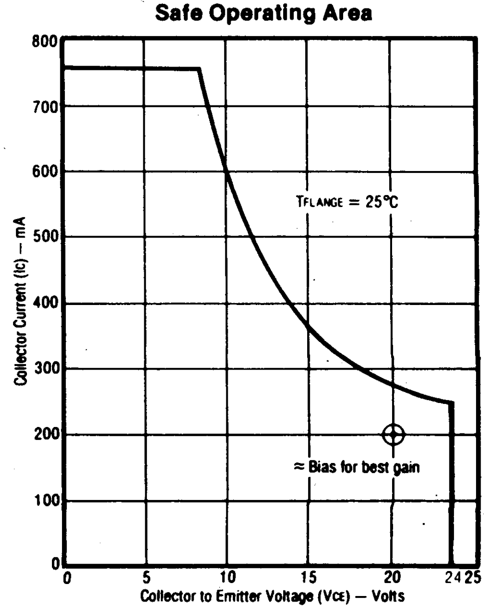
Gain vs. Emitter Current



Gain and 1dB Compressed Power vs. Frequency

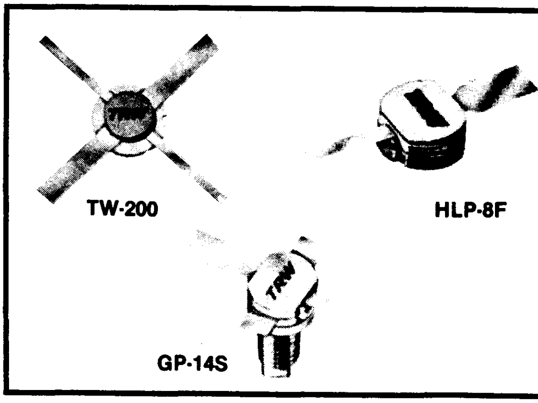


Safe Operating Area



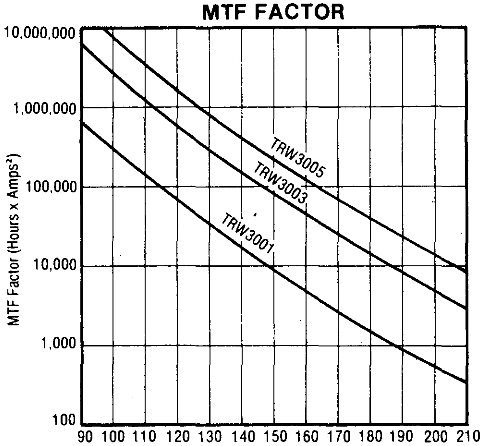
Microwave Linear Transistors

- Gold Metalized
- Diffused Ballast Resistors
- Linear per DIN-45004K
- Common Emitter
- 5 Package Options
- 2 GHz
- 1.5 W
- ∞ VSWR



Electrical Characteristics (T_{CASE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 20mA	24			V
DC TEST	BV_{CES}	Collector-Emitter Breakdown Voltage	I_C = 20mA	50			V
DC TEST	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25mA	3.5			V
DC TEST	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 1.0mA	45			V
DC TEST	I_{CBO}	Collector Cutoff Current	V_{CB} = 28V			0.125	mA
DC TEST	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0V, I_C = 100mA	20		120	–
RF TEST	C_{ob}	Collector-Base Capacitance	V_{CB} = 28V, f = 1MHz			5	pF
RF TEST	P_O	Power Output	V_{CE} = 20V, I_E = 220mA f = 2.0GHz, P_{in} = 0.375W *P_{in} = 0.474W f/52201 & 52501	1.5			W
RF TEST	f_t	Frequency Cutoff	V_{CE} = 20V, I_E = 220mA	2.7	3.0		GHz
RF TEST	VSWR	Mismatch Tolerance	P_O = 1.5W, I_E = 220mA, V_{CE} = 20V	∞			
RF TEST	IMD	Third Order Intermodulation Distortion	V_{CE} = 20V, I_E = 220mA f = 2.0GHz, $P_{O(PEP)}$ = 1.5W Tones at 2.05GHz and 2.1GHz		-30		dB
RF TEST	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20V, I_E = 150mA, f = 1.0GHz, P_{REF} = 0.5W		-60		dB
RF TEST	L_G	Gain Linearity	V_{CE} = 20V, I_E = 220mA f = 2.0GHz, P_{O1} = 1.5W, P_{O2} = 1.5mW			-0.2 +1.0	dB
OPER.	T_j & T_{stg}	Max. Junction & Storage Temperature		-65		+200	°C
OPER.	θ_{jC}	Thermal Resistance	T_C = 25°C			16	°C/W



MTTF FACTOR

(Normalized to 1 ampere² Continuous Duty)

The graph shown displays MTTF in hours x ampere² emitter current for each of the 3 GHz devices. Life tests at elevated temperatures have correlated to better than ± 10 % to the theoretical prediction for metal failure. **CAUTION** ε A calculation is required to obtain actual metal life. Sample MTTF calculations based on operating conditions are shown below.

Junction Temperature — °C

To calculate metal lifetime under any set of conditions, obtain actual data or estimate from typical performance curves. Solve for T_J (°C):

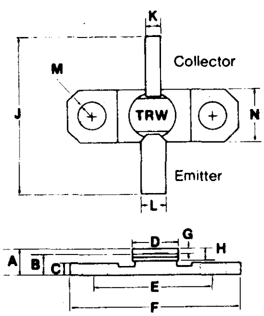
(1)
$$T_j = \theta_{jF}\left(\frac{P_{OUT} \times 100}{\eta c\,\%} + P_{IN} - P_{OUT}\right) + T_{FLANGE}$$

Enter graph of MTF factor vs. T_j. Obtain MTF factor. Calculate metal life by:

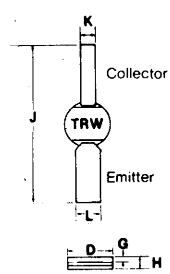
(2)
$$\text{Metal Life in Hours} = \frac{\text{MTF Factor}}{Ic^2\ (\text{Amps})}$$

Mechanical Dimensions

HLP-8 Normal Package

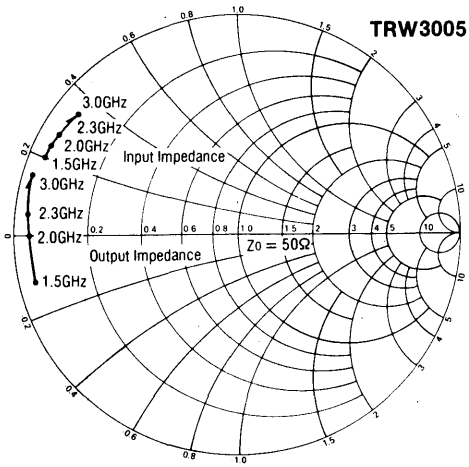


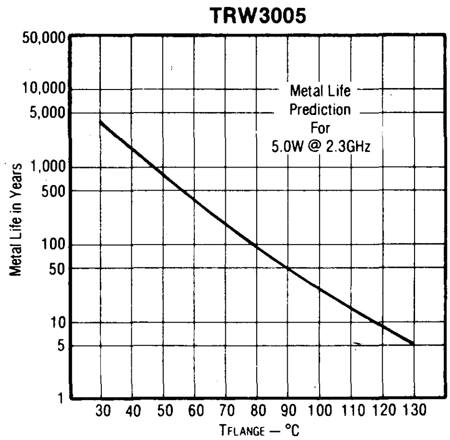
Flangeless HLP-8 (Specify « F » Suffix)



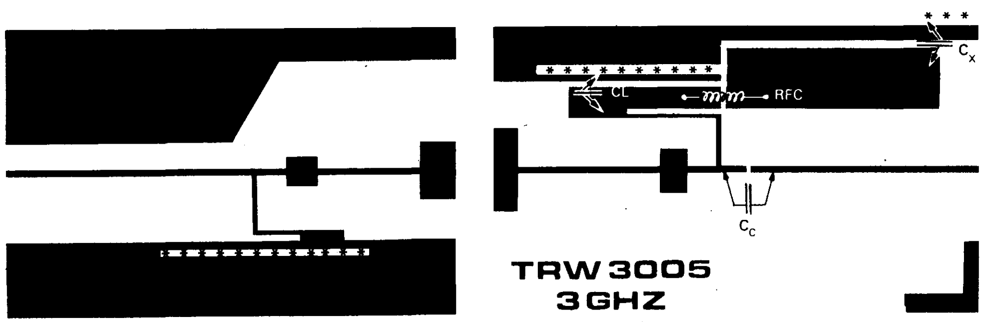
Dimension	U.S. (Inches ± 0.005)	Metric (Centimeters ± 0.0127)
A	0.155	0.3937
B	0.125	0.3175
C	0.060	0.1524
D	0.230	0.5842
E	0.562	1.4270
F	0.800	2.030
G	0.030	0.0762
H	0.095	0.2413
J	0.730 nom	1.85 nom
K	0.050	0.127
L	0.120	0.3048
M	0.130 dia	0.3302 dia
N	0.250	0.6350

TYPICAL CHARACTERISTICS





PC BOARD LAYOUT F = 3 GHz



1 inch = 19,48 mm

PARTS DETAILS

Board material : 0.020″ Glass Teflon (ε_r = 2.55)

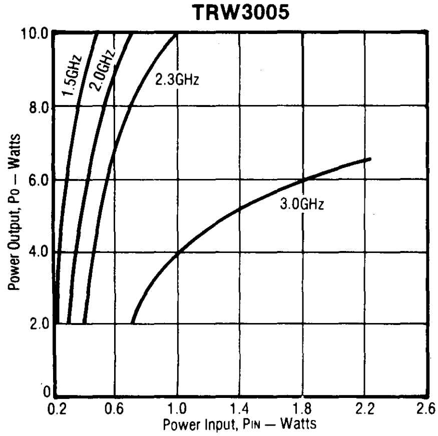
- * = Foil wrap asterisked edge to ground plane.
- C_C = 100 pF chip.
- C_X = 100 pF, 1 nF, 10 nF chip capacitors and 10 μF.
- C_L = 100 pF chip capacitor. The capacitor position can be tuned.
- R_{FC} = 8 turns # 28AWG, 0.010 dia.

Electrical Characteristics (T_{case} = 25 °C)

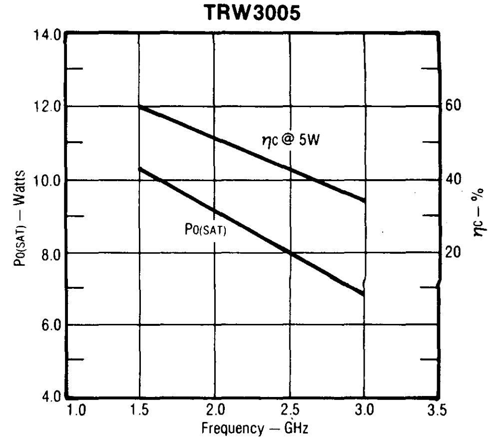
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5			V
DC TEST	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 5.0 mA	45			V
DC TEST	BV_{CES}	Collector - Emitter Breakdown Voltage (EB Shorted)	I_C = 50.0 mA	50			V
DC TEST	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			1.25	mA
RF TEST	H_{FE}	DG Current Gain	V_{CE} = 5.0 V I_C = 500 mA	10		120	
RF TEST	P_{Gain}	Power Gain	F_O = 3 GHz P_O = 5 W V_{CC} = 28 V	5.0			dB
RF TEST	η_C	Collector Efficiency	F_O = 3 GHz P_O = 5 W V_{CC} = 28 V	30			%
RF TEST	VSWR	Mismatch Tolerance (Without Damage)	F_O = 3 GHz P_O = 5 W V_{CC} = 28 V	∞			
RF TEST	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F_O = 1 MHz		8.4	10	pF
THERMAL	θ_{JC}	Thermal Impedance Junction to Case	—			8.5	°C/W
THERMAL	T_{STG} & T_J	Junction & Storage Temperature Range	—	— 65		+ 200	°C

TYPICAL CHARACTERISTICS

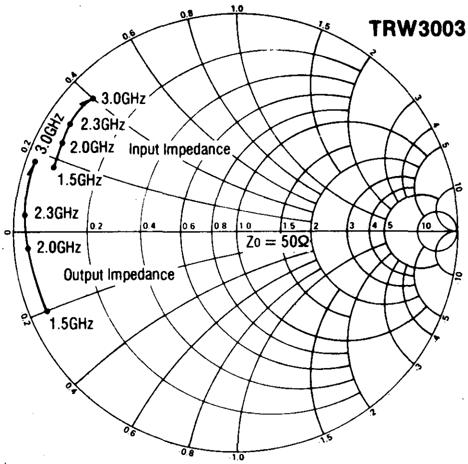
TRW3005

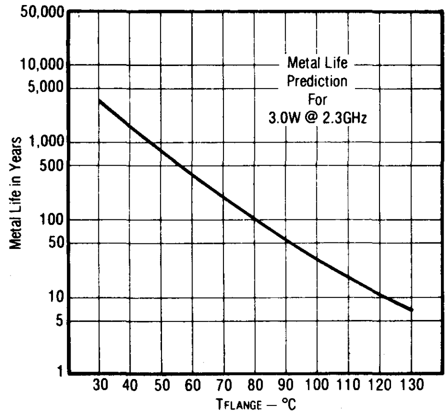


TRW3005

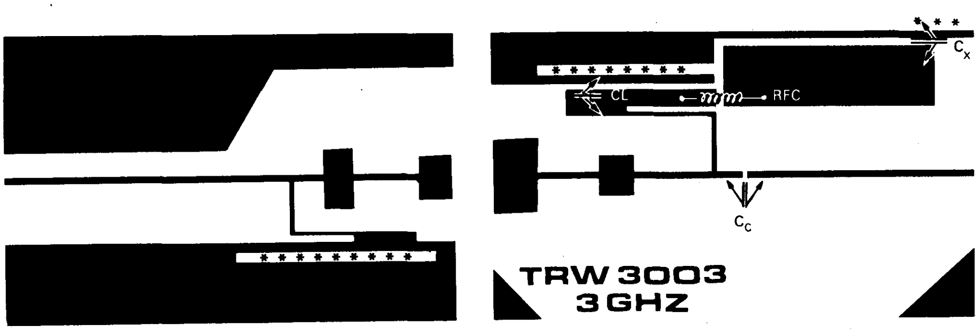


TYPICAL CHARACTERISTICS





PC BOARD LAYOUT F = 3 GHz



1 inch = 19,48 mm

PARTS DETAILS

Board material : 0.020″ Glass Teflon (ε_r = 2.55)

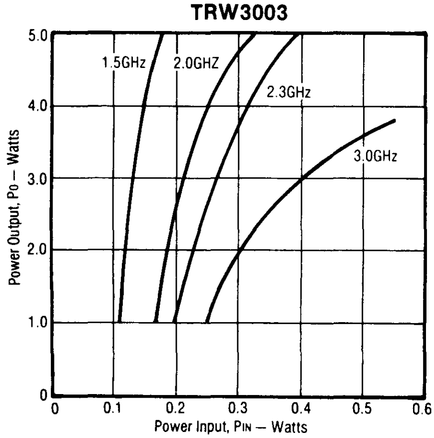
- * = Foil wrap asterisked edge to ground plane.
- C_C = 100 pF chip.
- C_X = 100 pF, 1 nF, 10 nF chip capacitors and 10 μF.
- C_L = 100 pF chip capacitor. The capacitor position can be tuned.
- R_{FC} = 8 turns # 28AWG, 0.010 dia.

Electrical Characteristics (T_{case} = 25 °C)

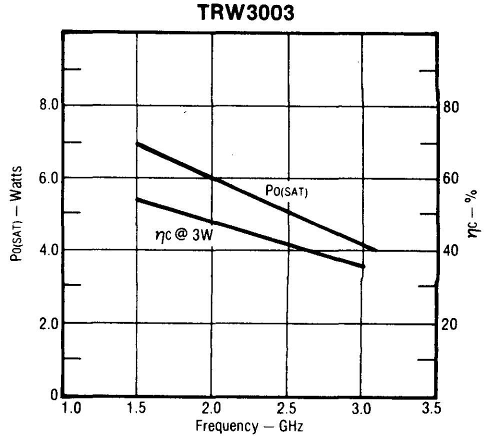
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 3.0 mA	45			V
	BV_{CES}	Collector - Emitter Breakdown Voltage (EB Shorted)	I_C = 30.0 mA	50			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			0.75	mA
RF TEST	H_{FE}	DC Current Gain	V_{CE} = 5.0 V I_C = 300 mA	10		120	
	P_{Gain}	Power Gain	F_O = 3 GHz P_O = 3.0 W V_{CC} = 28 V	6.0			dB
	η_C	Collector Efficiency	F_O = 3 GHz P_O = 3.0 W V_{CC} = 28 V	30			%
	VSWR	Mismatch Tolerance (Without Damage)	F_O = 3 GHz P_O = 3.0 W V_{CC} = 28 V	∞			
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F_O = 1 MHz		5.7	7.0	pF
THERMAL	θ_{JC}	Thermal Impedance Junction to Case	—			17	°C/W
	T_{STG} & T_J	Junction & Storage Temperature Range	—	— 65		+ 200	°C

TYPICAL CHARACTERISTICS

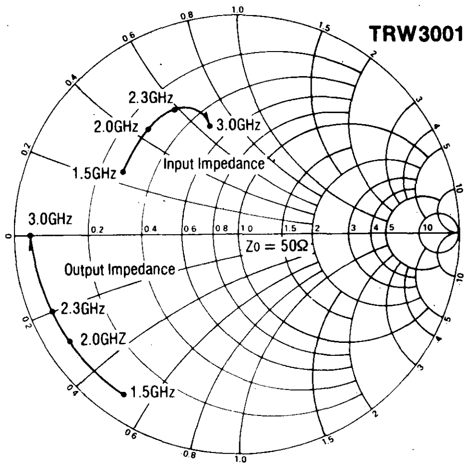
TRW3003

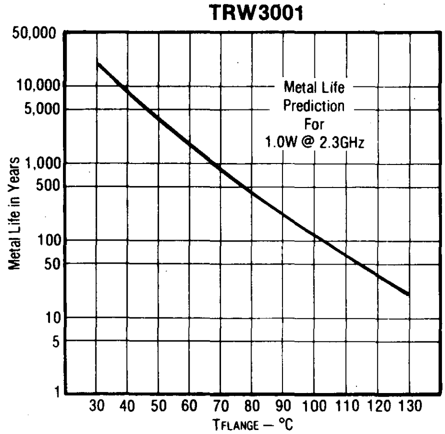


TRW3003

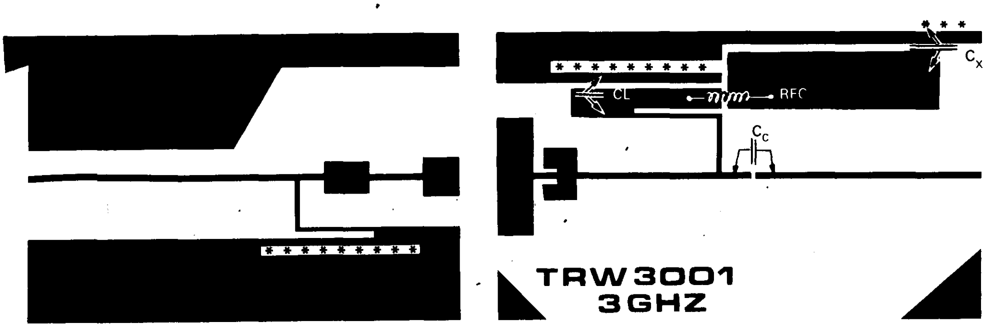


TYPICAL CHARACTERISTICS





PC BOARD LAYOUT F = 3 GHz



1 inch = 19,48 mm

PARTS DETAILS

Board material ≃ 0.020″ Glass teflon (ε_r = 2.55).

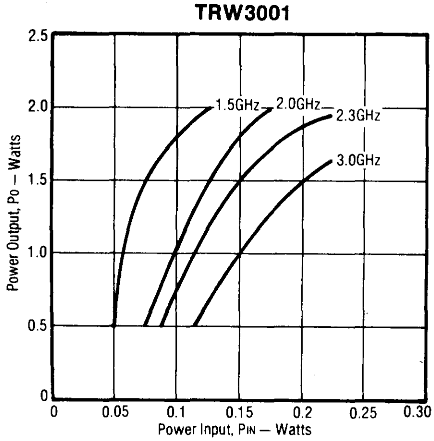
- * = Foil wrap asterisked edge to ground plane.
- C_C = 100 pF chip.
- C_X = 100 pF, 1 nF, 10 nF chip capacitors and 10 μF.
- C_L = 100 pF chip capacitor. The capacitor position can be tuned.
- R_{FC} = 8 turns # 28AWG, 0.010 dia.

Electrical Characteristics (T_{case} = 25 °C)

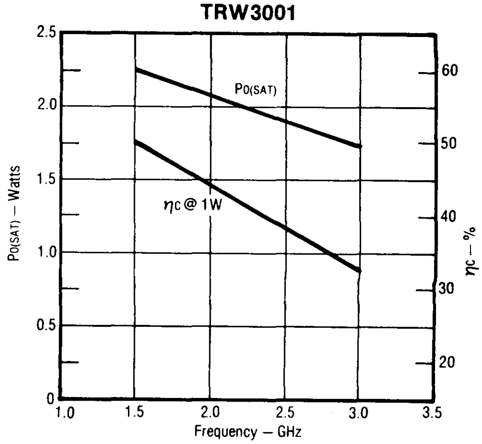
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1.0 mA b	45			V
	BV_{CES}	Collector - Emitter Breakdown Voltage (EB Shorted)	I_C = 10 mA	50			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			0.5	mA
	H_{FE}	DC Current Gain	V_{CE} = 5.0 V I_C = 100 mA	10		120	
RF TEST	P_{gain}	Power Gain	F_O = 3 GHz P_O = 1.0 W V_{CC} = 28 V	7.0			dB
	η_C	Collector Efficiency	F_O = 3 GHz P_O = 1.0 W V_{CC} = 28 V	30			%
	VSWR	Mismatch Tolerance (Without Damage)	F_O = 3 GHz P_O = 1.0 W V_{CC} = 28 V	∞			
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F_O = 1 MHz		3.5	4.0	pF
THERMAL	θ_{JC}	Thermal Impedance Junction to Case	—			35	°C/W
	T_{STG} & T_J	Junction & Storage Temperature Range	—	− 65		+ 200	°C

TYPICAL CHARACTERISTICS

TRW3001



TRW3001

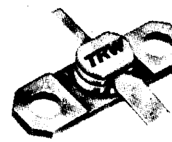


SUPER 3 GHz Series

TRW

- **TRW 3001 - 1 W**
- **TRW 3003 - 3 W**
- **TRW 3005 - 5 W**

- **∞VSWR**



HLP-8

E

This data describes TRW's SUPER 3GHz transistors. The etchless gold die metallization, the diffused ballast resistors, and the avalanche protection are available exclusively from TRW.

∞ VSWR Tolerance. A TRW first. Every SUPER 3GHz transistor is tested to guarantee each device is capable of withstanding all mismatch conditions (any magnitude, any phase angle). This guarantee precludes costly failures due to an inadvertent impedance mismatch in the laboratory, on the production line or in the field. A 100% production line test for ∞ VSWR capability also assures the die mount integrity. This is not possible with less rugged transistors.

Diffused Ballast Resistors. Another TRW first. Only TRW offers this major technological advance in microwave transistors (patents pending). High resistance ballast resistors are diffused directly into the silicon die totally avoiding the primary failure mechanism of peeling and microcracking associated with conventional thin film, metal ballast resistors. Also, diffused ballasting safely allows much higher resistance values to be achieved (25Ω-100Ω) than does thin film metal ballasting (8Ω-10Ω). Higher ballast levels preclude "hot spotting" since near perfect finger-to-finger and cell-to-cell current sharing is realized. The positive temperature coefficient of the diffused resistor further equalizes uneven temperature distribution.

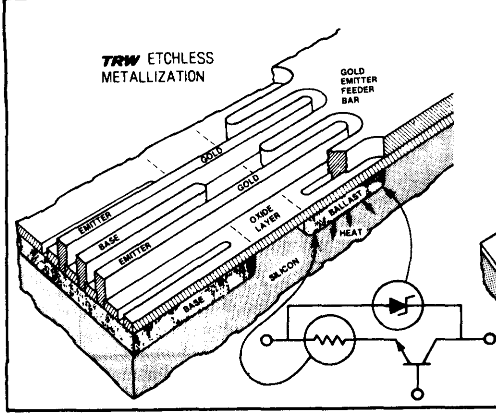
Avalanche Protection. Yet another TRW first. TRW's exclusive avalanche protection mechanism (patent pending) precludes the failure mode not handled by ballasting alone — secondary breakdown. The voltage across the transistor junction is never allowed to reach breakdown. The P-N diode of the ballast resistor is diffused to avalanche several volts less than the transistor junctions. Under severe mismatch conditions when voltages in excess of breakdown occur, the diode conducts the full avalanche current, thus, protecting the transistor junction. True "full-circle" VSWR protection is achieved with these devices.

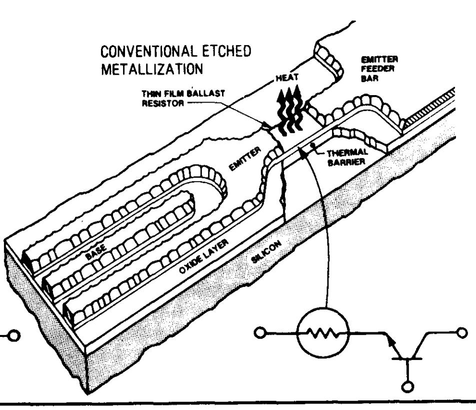
Gold Die Metallization. One more TRW first. TRW's etchless, gold metallization process (patent pending) provides exact finger definition. This process is capable of defining sub-micron finger spacing in the interdigitated geometry even though the cross sectional dimension of each gold finger is deeper than it is wide. The etchless process precludes finger scalloping characteristic of all etching processes and eliminates resultant current crowding where metal fingers are necked down. With TRW's gold die metallization original design values are not compromised in the manufacturing process for the primary wear-out mechanism in RF transistors — metal migration. Thus, TRW's etchless, gold metallization system not only capitalizes on the vast improvement in electromigration properties of gold over aluminum but it also assures that the metal lifetime design criteria is retained in the manufacturing process. This achievement cannot be accomplished with any etch-dependent metal system.

Mono-Metal System. TRW's use of gold metallized die, gold wire bonds, and gold package metal on all SUPER 3GHz transistors precludes intermetallic formations and resultant failures. Gold bonding wire does not work-harden and is thousands of times more resistant to fatigue than is the more brittle aluminum wire alternative. Fatigue tests have verified that TRW's thermal-compression bonding technique provides bond-to-pad mechanical integrity, not possible with aluminum, ultra-sonic bonding systems.

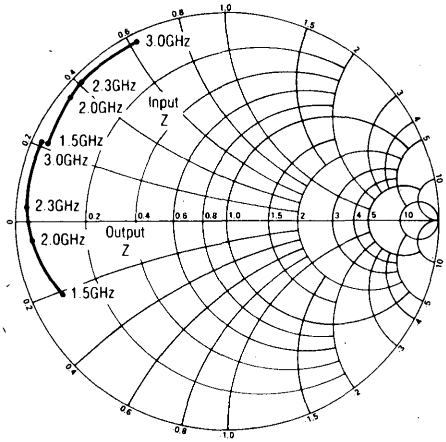
Mil-Package. The Space Qualified HLP-8 is a fully hermetic, glass-free, co-fired ceramic package. It is available with or without a flange.

TRW DIFFUSED BALLAST RESISTORS WITH ETCHLESS GOLD METALLIZATION vs. CONVENTIONAL THIN FILM BALLAST RESISTORS WITH ETCHED METALLIZATION

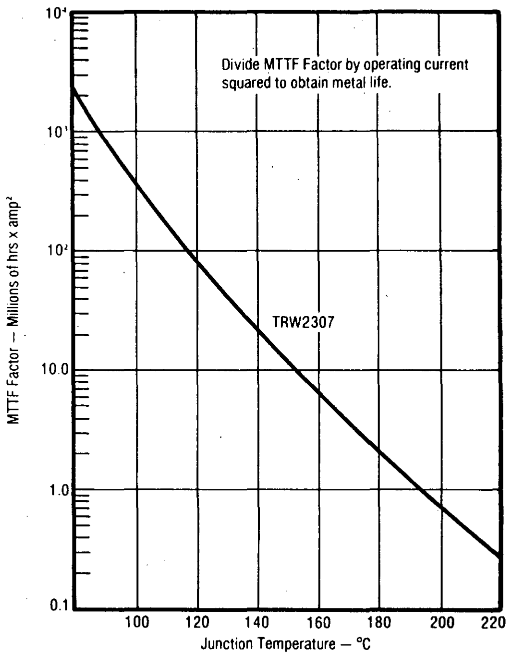




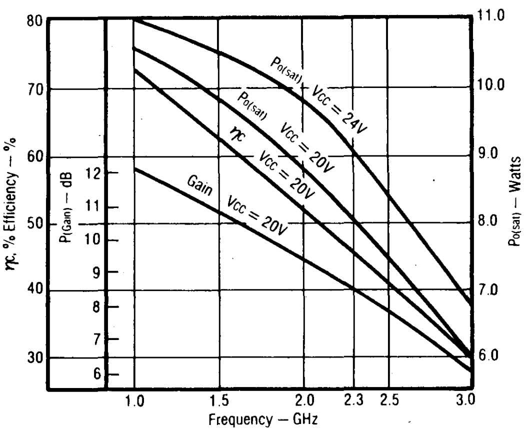
Impedance Data
Vcc = 20V



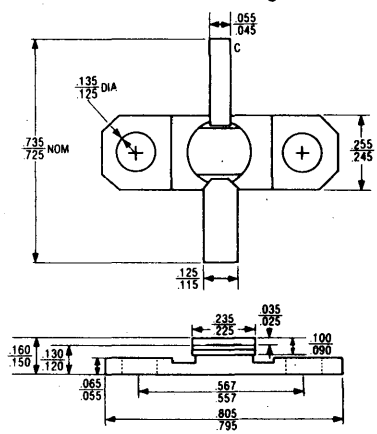
Metal Failure



Typical Performance Characteristics



HLP-8 Package



Mechanical Specifications

The following are mechanical specifications for this transistor.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

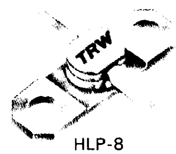
Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A glass-free, brazed ceramic package *assuring* long-term integrity of hermetic seals. Leads of HLP-8, KOVAR base material with minimum 60 microinches of gold plating.

Microwave Power Transistor

- 7 W
- 20 V
- 2.3 GHz
- ∞VSWR



HLP-8

E

Latest in the TRW « Super 2 GHz » Series, the TRW 2307 offers a sturdy transistor which is ideally suited to space, military, radio relay and other applications in the 1 to 3.0 GHz region.

The device is capable of withstanding any mismatch load condition at any phase angle up to, and including, open and short circuit (∞**VSWR**) under full rated conditions. The unit is **gold metalized,** thereby eliminating metal migration problems common with aluminum parts (metal failure predictions are included herein). Further, the transistor is emitter ballasted with **diffused silicon resistors** rather than deposited metal film resistors for reliability and ruggedness.

The TRW 2307 is housed in the HLP-8, glass free, **full hermetic** package which is available with or without mounting flange. Full mechanical specifications are guaranteed.

Electrical Characteristics (T_{flange} = 25 °C)

	Symbol	Characteristics	Condition	Value
D C Tests	BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 50 mA	42 V Min
D C Tests	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5 V Min
D C Tests	I_{CBO}	Collector Cutoff Current	V_{CB} = 22 V I_E = 0 V_{CB} = 38 V	1.25 mA 2.5 mA
D C Tests	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 500 mA	10-120
R F Tests	C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 20 V	10 pF
R F Tests	P_o	Power Output	f = 2.3 GHz V_{CE} = 20 V V_{CE} = 24 V	7.0 W Min 9.0 W Min
R F Tests	P_{gain}	Power Gain (dB)	f = 2.3 GHz P_o = 7.0 W V_{CE} = 20 V	8.4 dB Min
R F Tests	VSWR	Mismatch Tolerance	P_o = 7.0 W f = 2.3 GHz V_{CE} = 20 V	∞
R F Tests	η_C	Collector Efficiency	P_o = 7.0 W f = 2.3 GHz V_{CE} = 20 V	40 % Min
Operating	T & T_{stg}	Max Junction and Storage Temperature	— 65 to + 200 °C	
Operating	θ_{jF}	Thermal Resistance		8.5 °C/W
Operating	I_C	Continuous Collector Current	V_{CE} = 5 V	2.5 A Max

Microwave Power Transistor

- 4 W
- 20 V
- 2.3 GHz
- ∞ VSWR

HLP-8

Latest in the TRW « Super 2 GHz » Series, the TRW 2304 offers a sturdy transistor which is ideally suited to space, military, radio relay and other applications in the 1 to 3.0 GHz region.

The device is capable of withstanding any mismatch load condition at any phase angle up to, and including, open and short circuit (∞ **VSWR**) under full rated conditions. The unit is **gold metalized,** thereby eliminating metal migration problems common with aluminum parts (metal failure predictions are included herein). Further, the transistor is emitter ballasted with **diffused silicon resistors** rather than deposited metal film resistors for reliability and ruggedness.

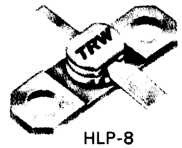
The TRW 2304 is housed in the HLP-8, glass-free, **full hermetic** package which is available with or without mounting flange. Full mechanical specifications are guaranteed.

Electrical Characteristics (T_{flange} = 25 °C)

	Symbol	Characteristics	Condition	Value
D C Tests	BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 50 mA	42 V Min
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5 V Min
	I_{CBO}	Collector Cutoff Current	V_{CB} = 22 V I_E = 0	0.75 mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 250 mA	10-120
R F Tests	C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 20 V	7 pF
	P_o	Power Output	f = 2.3 GHz V_{CE} = 20 V V_{CE} = 24 V	4 W Min 5 W Typ
	P_{gain}	Power Gain (dB)	f = 2.3 GHz P_o = 4 W V_{CE} = 20 V	8.0 dB Min
	VSWR	Mismatch Tolerance	P_o = 4 W f = 2.3 GHz V_{CE} = 20 V	∞
	η_C	Collector Efficiency	P_o = 4 W f = 2.3 GHz V_{CE} = 20 V	40 % Min
Operating	T_j & T_{stg}	Max Junction and Storage Temperature	— 65 to + 200 °C	
	θ_{jF}	Thermal Resistance		17 °C/W
	I_C	Continuous Collector Current	V_{CE} = 5 V	1.5 A Max

Microwave Power Transistor

- 1.5 W
- 20 V
- 2.3 GHz
- ∞ VSWR



HLP-8

Latest in the TRW « Super 2 GHz » Series, the TRW 2301 offers a sturdy transistor which is ideally suited to space, military, radio relay and other applications in the 1 to 3.0 GHz region.

The device is capable of withstanding any mismatch load condition at any phase angle up to, and including, open and short circuit (∞ **VSWR**) under full rated conditions. The unit is **gold metalized,** thereby eliminating metal migration problems common with aluminum parts (metal failure predictions are included herein). Further, the transistor is emitter ballasted with **diffused silicon resistors** rather than deposited metal film resistors for reliability and ruggedness.

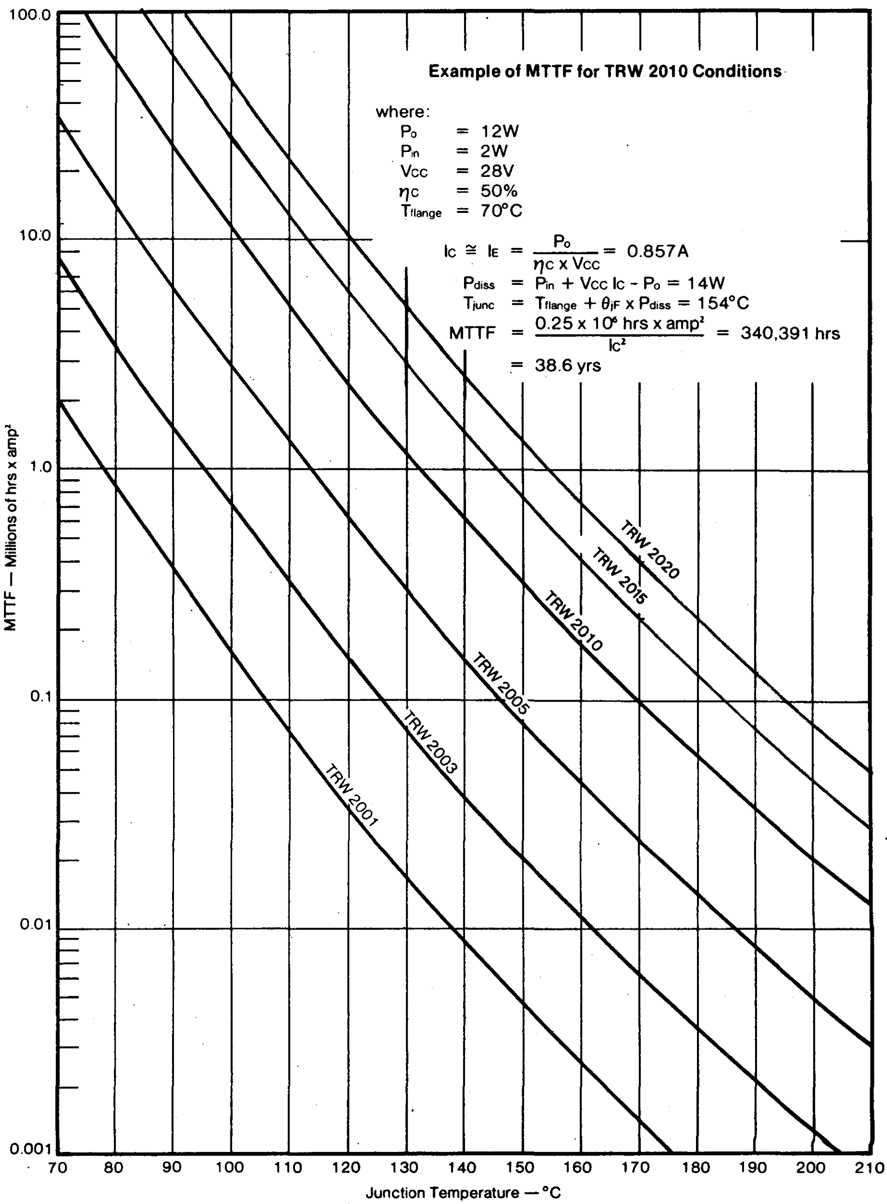
The TRW 2301 is housed in the HLP-8, glass-free, **full hermetic** package which is available with or without mouning flange. Full mechanical specifications are guaranteed.

Electrical Characteristics (T_{flange} = 25 °C)

	Symbol	Characteristics	Condition	Value
D C Tests	BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 50 mA	42 V Min
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0 mA I_c = 0	3.5 V Min
	I_{CBO}	Collector Cutoff Current	V_{CB} = 22 V I_E = 0	0.5 mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 100 mA	10-120
R F Tests	C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 20 V	4 pF
	P_o	Power Output	f = 2.3 GHz V_{CE} = 20 V V_{CE} = 24 V	1.5 W Min 2 W Typ
	P_{gain}	Power Gain (dB)	f = 2.3 GHz P_o = 1.5 W V_{CE} = 20 V	8.0 dB Min
	VSWR	Mismatch Tolerance	P_o = 1.5 W f = 2.3 GHz V_{CE} = 20 V	∞
	η_C	Collector Efficiency	P_o = 1.5 W f = 2.3 GHz V_{CE} = 20 V	40 % Min
Operating	T_j & T_{stg}	Max Junction and Storage Temperature	— 65 to + 200 °C	
	θ_{jF}	Thermal Resistance		35 °C/W
	I_C	Continuous Collector Current	V_{CE} = 5 V	0.5 A Max

MTTF FACTOR (Normalized to 1 ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the "Super 2GHz" devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included on the graph.

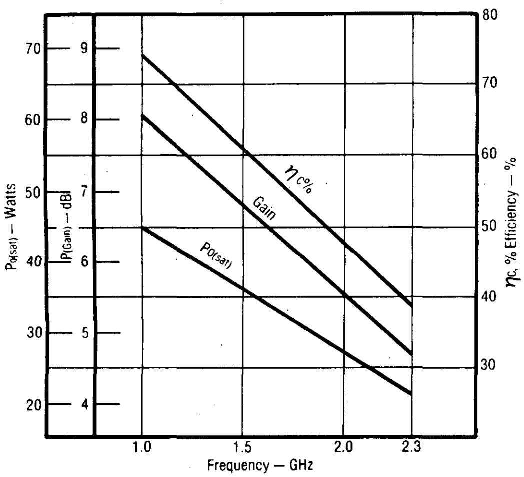


TRW 2020

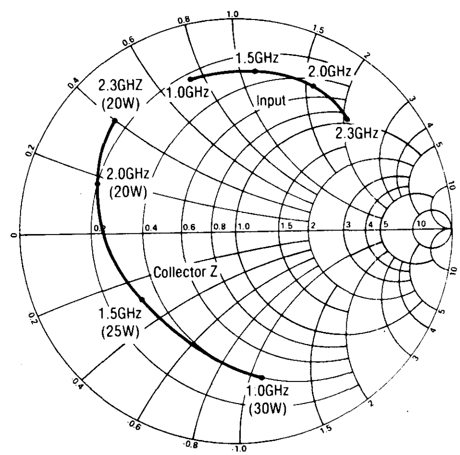
Electrical Characteristics (T_{FLANGE} = 25°C)

Symbol	Characteristic	Condition	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10Ω	I_C = 160mA	50V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 2.0mA I_C = 0	3.5V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28V I_E = 0 V_{CB} = 45V	1.0mA 8mA
I_C	Continuous Collector Current (Max)	V_{CE} = 4V	4.0A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V I_C = 800mA	10-100
θ_{JF}	Thermal Resistance (Junction to Flange)	—	3°C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28V	24.0pF
P_O	Power Output @ 2000MHz	P_{in} = 6.0W	20.0W Min
$P_{O(sat)}$	Power Output @ 1500MHz	V_{CE} = 28Vdc	30.0W (Typ)
	Power Output @ 1000MHz		40.0W (Typ)
P_{gain}	Power Gain (dB) @ 2000MHz	P_O = 20W	5.2dB Min
VSWR	Mismatch Tolerance @ V_{CC} = 28V	P_O = 20.0W f = 2.0GHz	∞
MTTF	Mean-Time-to-Metal Failure (Hrs x Amps²)	T_j = 150°C	1,588,000
η_C	Collector Efficiency (Min)	P_O = 20.0W f = 2.0GHz	40%
T_j & T_{stg}	Max Junction and Storage Temperature	-65 to 200°C	

Typical Performance Characteristics



Impedance Data
V_{CC} = 28V Z_O = 5.0Ω

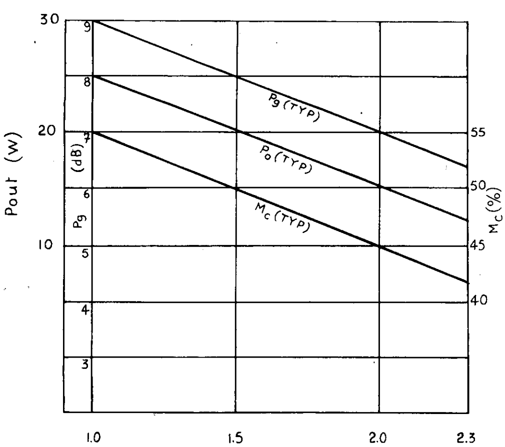


TRW 2015

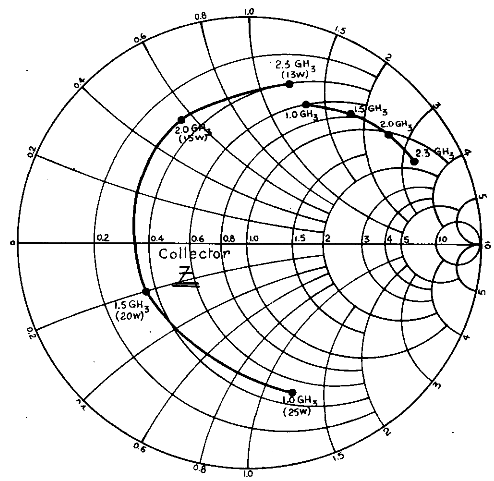
Electrical Characteristics ($T_{FLANGE} = 25°C$)

Symbol	Characteristic	Condition	Value
BV_{CER}	Collector-Base Breakdown Voltage $R_{BF} = 10\ \Omega$	I_C = 120 mA	50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1,5 mA I_C = 0	3.5 V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V I_E = 0	1.0 mA Max
I_C	Continuous Collector Current (Max)	V_{CE} = 4 V	3.0 A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 600 mA	10-100
θ_{jF}	Thermal Resistance (Junction to Flange)	—	4 °C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28 V	21 pF
P_o	Power Output 2000 MHz	P_{in} = 3.75 W	15.0 W Min
$P_{o(sat)}$	Power Output 1500 MHz	V_{CE} = 28 V	22 W Typ
	Power Output 1000 MHz		30 W Typ
P_{gain}	Power Gain (dB) 2000 MHz	P_o = 15 W	6 dB Min
VSWR	Mismatch Tolerance V_{CC} = 28 V	P_o = 15 W f = 2 GHz	∞
MTTF	Mean Time-to-Metal Failure (Hrs × $Amps^2$)	T_j = 150 °C	780,000
η_C	Collector Efficiency (Min)	P_o = 15 W f = 2 GHz	40 %
T_j & T_{stg}	Max Junction and Storage Temperature	— 65 °C to + 200 °C	

Typical Performance Characteristics

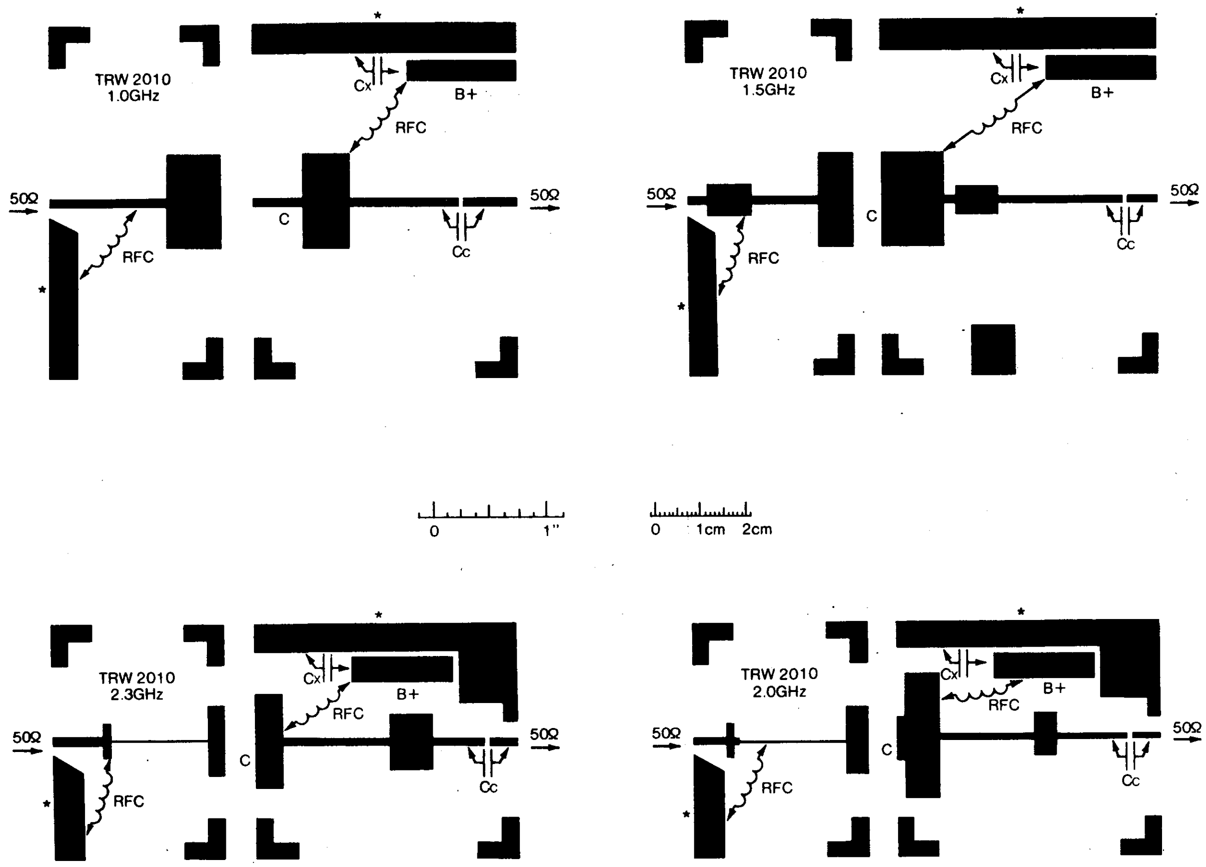


Impedance Data
Vcc = 28V Zo = 5.0Ω



PC BOARD LAYOUT FOR TRW 2010 TEST CIRCUITS

See page 3 for parts details



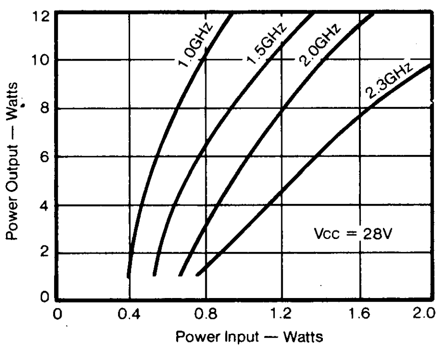
Board Material = 0.020" Glass-Teflon ε_r = 2.55

TRW 2010

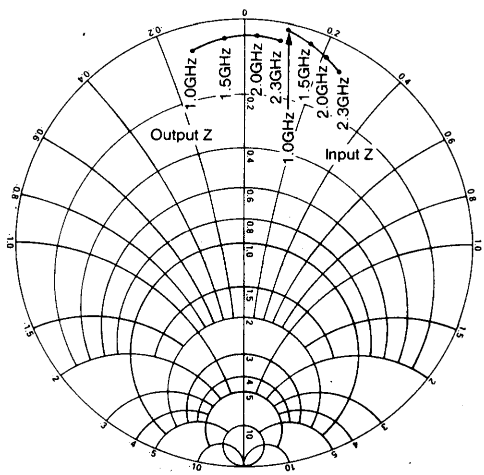
Electrical Characteristics (T_{flange} = 25°C)

Symbol	Characteristic	Conditon	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10Ω	I_C = 80mA	50V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0mA I_C = 0	3.5V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28V I_E = 0 V_{CB} = 45V	500μA 4mA
I_C	Continuous Collector Current (Max)	V_{CE} = 4V	2.0A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V I_C = 400mA	10-100
θ_{jF}	Thermal Resistance (Junction to Flange)	—	6°C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28V	12.0pF
P_o	Power Output @ 2000MHz	P_{in} = 2.5W	10.0W Min
$P_{o(sat)}$	Power Output @ 2300MHz	V_{CE} = 28Vdc	10.0W (Typ)
	Power Output @ 1500MHz		13.0W (Typ)
	Power Output @ 1000MHz		15.0W (Typ)
P_{gain}	Power Gain (dB) @ 2000MHz	P_o = 10W	6dB Min
VSWR	Mismatch Tolerance @ Vcc = 28V	P_o = 10.0W f = 2.0GHz	∞
MTTF	Mean-Time-to-Metal Failure (Hrs x Amps²)	T_j = 150°C	324,800
η_C	Collector Efficiency (Min)	P_o =10.0W f = 2.0GHz	40%
T_j & T_{stg}	Max Junction and Storage Temperatures	-65 to 200°C	

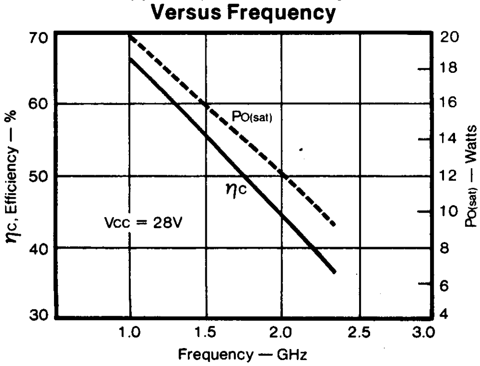
Typical Transfer Characteristics Versus Frequency



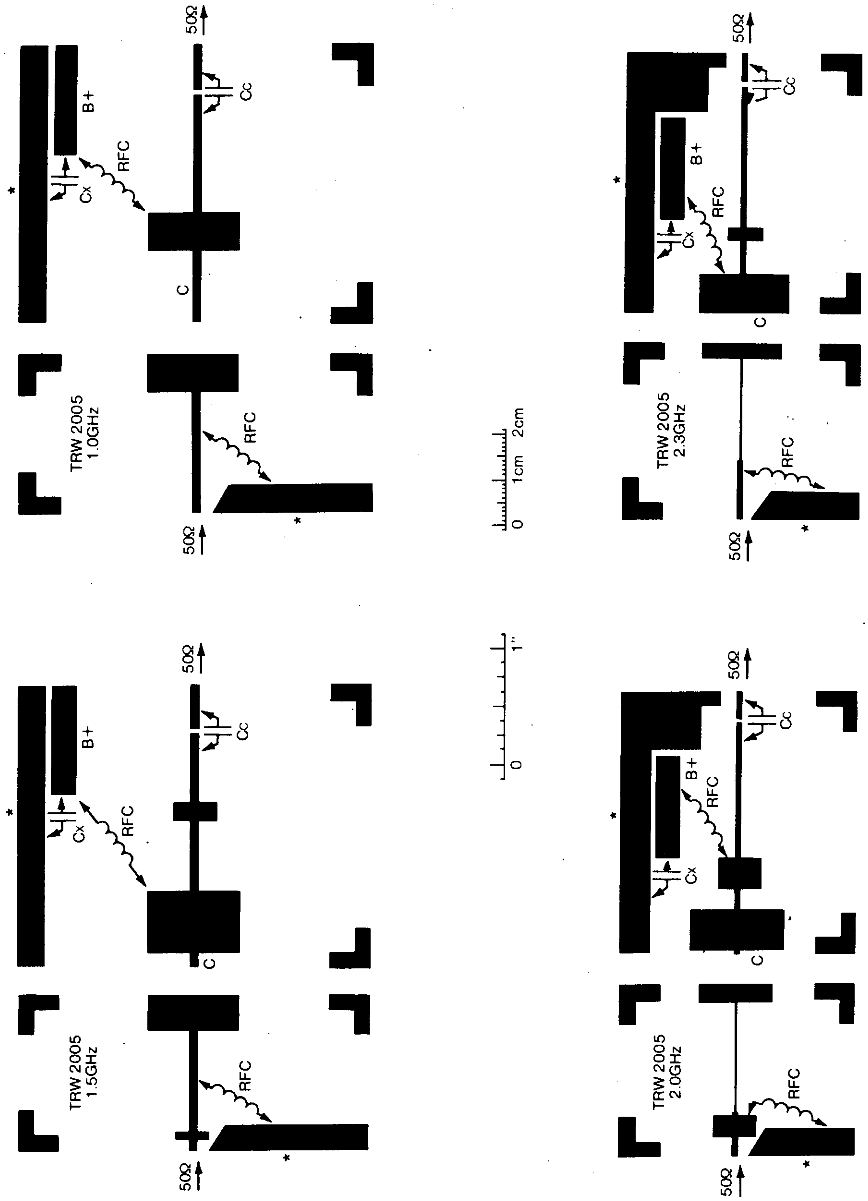
Impedance Data Vcc = 28V



Typical η_C, Power Output Versus Frequency



PC BOARD LAYOUT FOR TRW 2005 TEST CIRCUITS



Board Material = 0.020" Glass-Teflon ε_r = 2.55

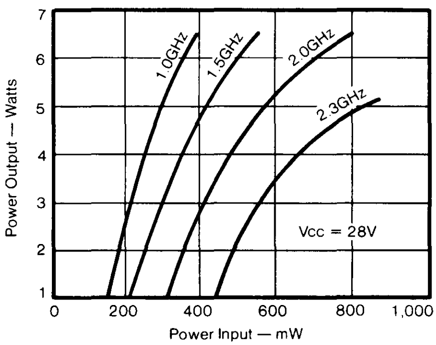
See page 3 for parts details

TRW 2005

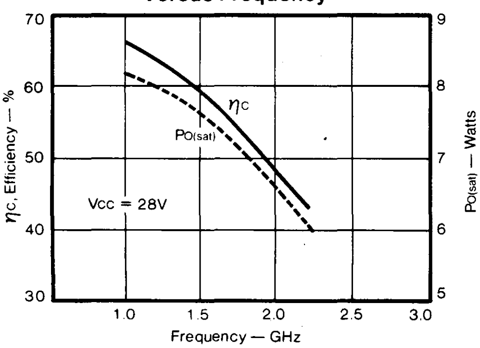
Electrical Characteristics (T_{flange} = 25°C)

Symbol	Characteristic	Conditon	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10Ω	I_C = 40mA	50V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.5mA, I_C = 0	3.5V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28V, I_E = 0 / V_{CB} = 45V	500µA / 2mA
I_C	Continuous Collector Current (Max)	V_{CE} = 4V	1.0A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V, I_C = 200mA	10-100
θ_{jF}	Thermal Resistance (Junction to Flange)	—	8.5°C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28V	7.0pF
P_o	Power Output @ 2000MHz	P_{in} = 0.80W	5W Min
$P_{o(sat)}$	Power Output @ 2300MHz	V_{CE} = 28Vdc	5.0W (Typ)
	Power Output @ 1500MHz		6.5W (Typ)
	Power Output @ 1000MHz		7.5W (Typ)
P_{gain}	Power Gain (dB) @ 2000MHz	P_o = 5.0W	8dB Min
VSWR	Mismatch Tolerance @ Vcc = 28V	P_o = 5.0W, f = 2.0GHz	∞
MTTF	Mean-Time-to-Metal Failure (Hrs x Amps²)	T_j = 150°C	81,200
η_C	Collector Efficiency (Min)	P_o = 5.0W, f = 2.0GHz	40%
T_j & T_{stg}	Max Junction and Storage Temperatures	-65 to 200°C	

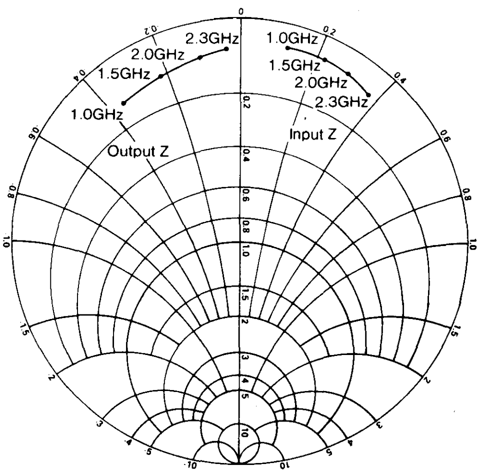
Typical Transfer Characteristics Versus Frequency



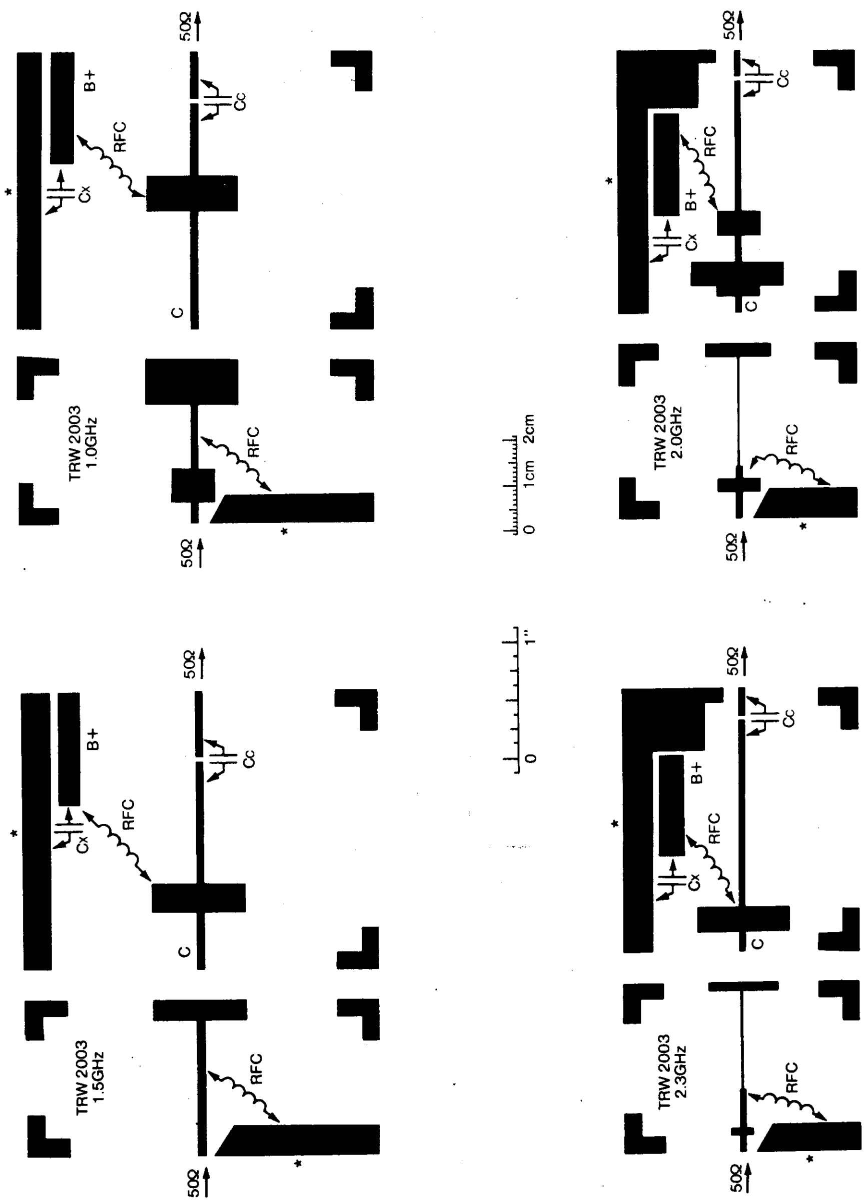
Typical η_C, Power Output Versus Frequency



Impedance Data Vcc = 28V



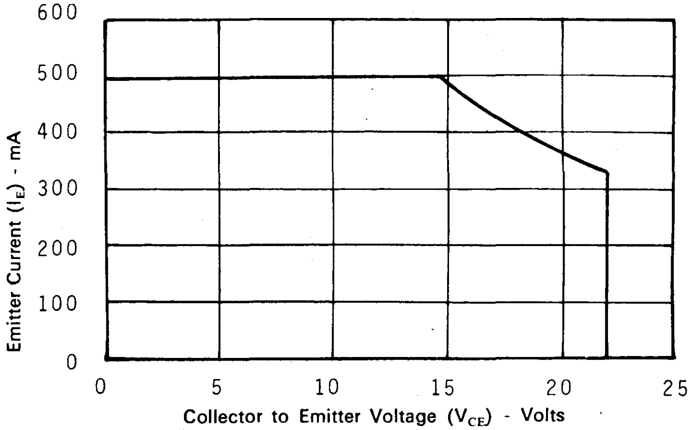
PC BOARD LAYOUT FOR TRW 2003 TEST CIRCUITS



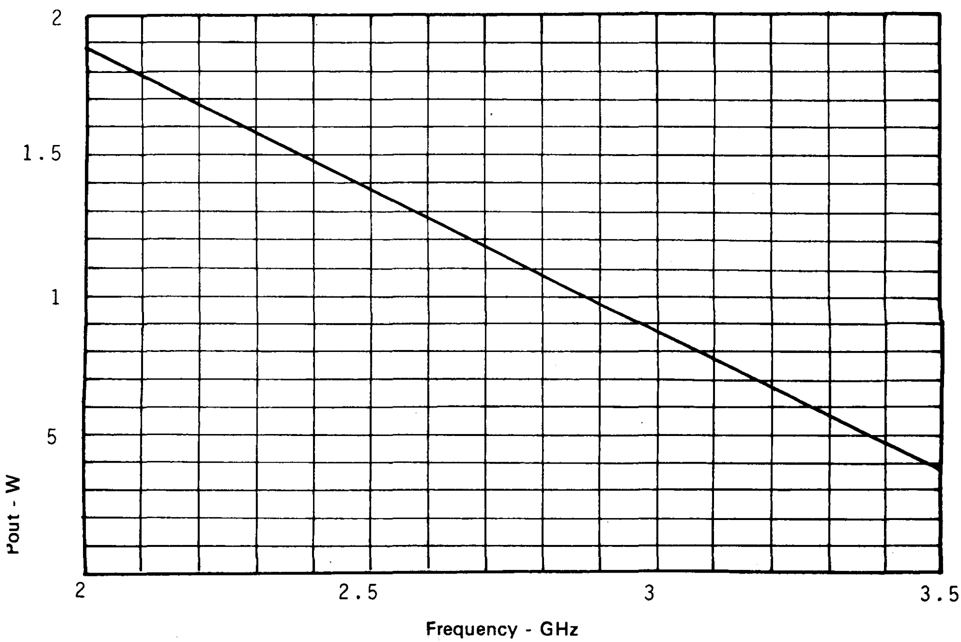
Board Material = 0.020" Glass-Teflon ε_r = 2.55

See page 3 for parts details

D.C. Safe Operating Area



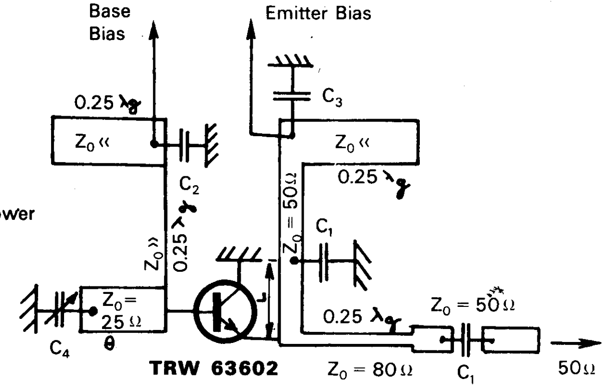
Output Power vs. Frequency
(V_{CE} = 20 V, I_E = 230 mA)



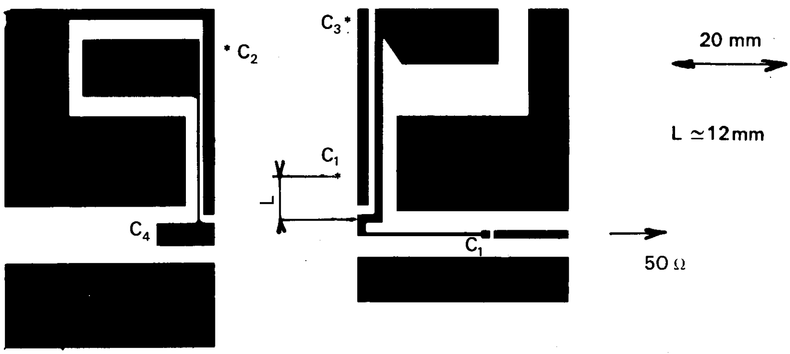
E

TEST CIRCUIT

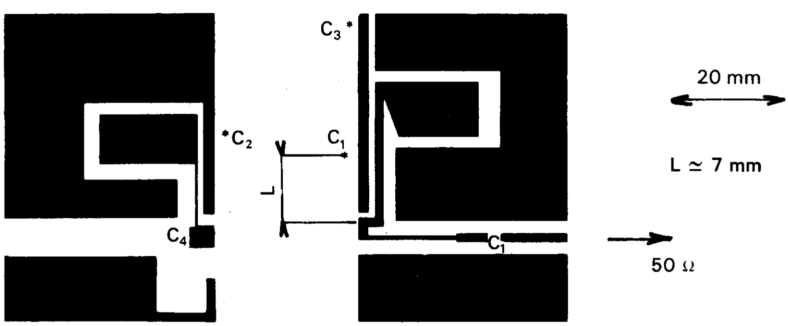
C_1: 220 pF (chip)
C_2: 220 pF (chip) + 10 nF
C_3: 220 pF (chip) + 10 nF + 10 μF
C_4: 0.6-4.5 pF (Frequency tuning)
L : adjust to obtain the maximum output power
$\theta = 0.115\ \lambda g$ for Fo = 2.3 GHz
$\theta = 0.06\ \lambda g$ for Fo = 3 GHz



PC Board Layout for Fo = 2.3 GHz (BW = 500 MHz)



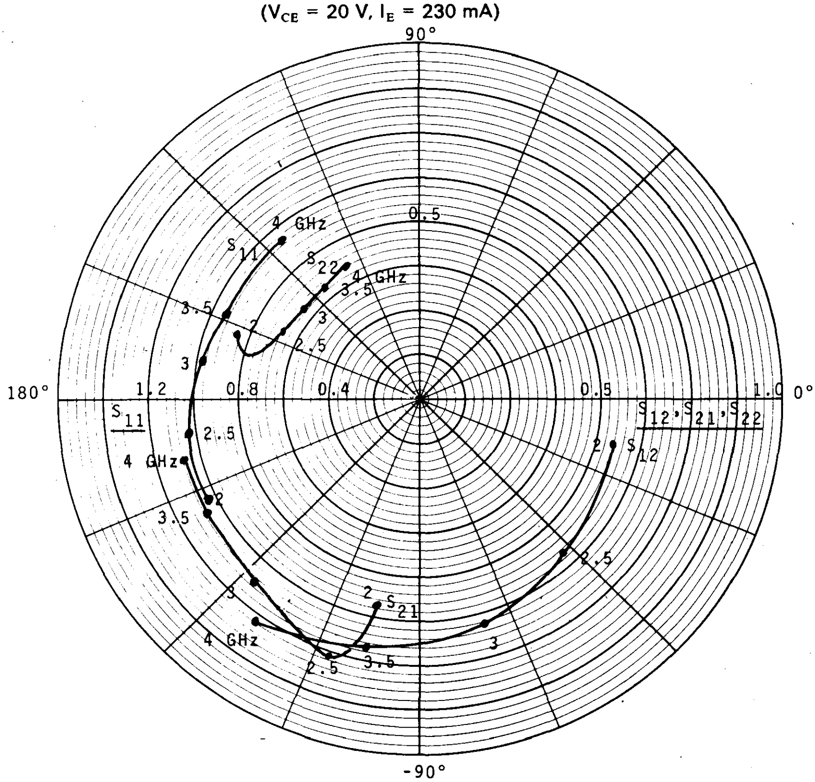
PC Board Layout for Fo = 3 GHz (BW = 500 MHz)



* Foil-wrap asterisked edge to ground plane.
Board material :- 0.020" Glass teflon (Er = 2.55)
Adjust L to obtain the maximum output power

Small Signal S-Parameters

(V_{CE} = 20 V, I_E = 230 mA)

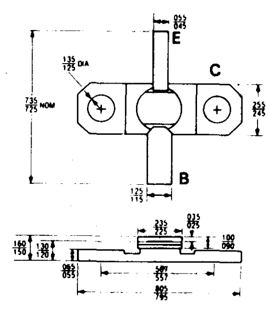


Mechanical Specifications

The following are mechanical specifications for this transistor series.

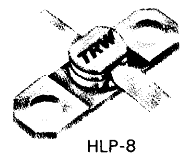
Dimensions:	Per outline drawing.
Solderability:	Per MIL-STD-750.
Marking:	Per MIL-S-19500, "TRW," 4-digit date code, type number.
Hermaticity:	Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)
Acceleration:	Per MIL-STD-750, 20,000G in any plane.
Bond Pull:	Per MIL-STD-750, 3 grams min.
Package:	A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Package Outlines



Microwave Power Oscillator Transistors

- 350 mW at 4 GHz
- Up to 5 GHz
- ∞VSWR



HLP-8

The TRW 64601 is designed for use up to 5 GHz with a typical Pout of 350 mW at 4 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

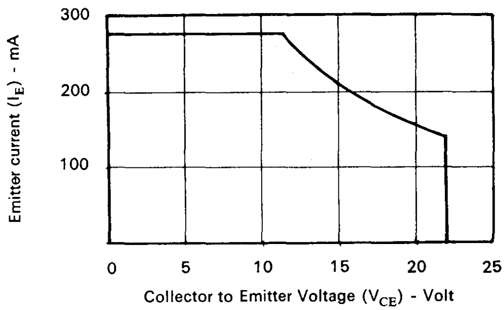
Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
D C Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	22			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω I_C = 10 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28			0.25	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V I_C = 100 mA	20		120	
R. F. Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V F = 1 MHz			3.5	pF
	F_T	Frequency Cutoff	V_{CE} = 20 V I_E = 120 mA	4.0	4.5		GHz
	P_o	Power output	F = 4 GHz V_{CE} = 20 V I_E = 120 mA	0.300	0.350		W
	VSWR	Mismatch Tolerance	P_o = 0.300 W V_{CE} = 20 V I_E = 120 mA		∞ : 1		
Operating	θ_{JF}	Thermal Resistance (junction to Flange)				40	°C/W
	T_{STG}	Max Junction and Storage Temperature		— 65		100	°C

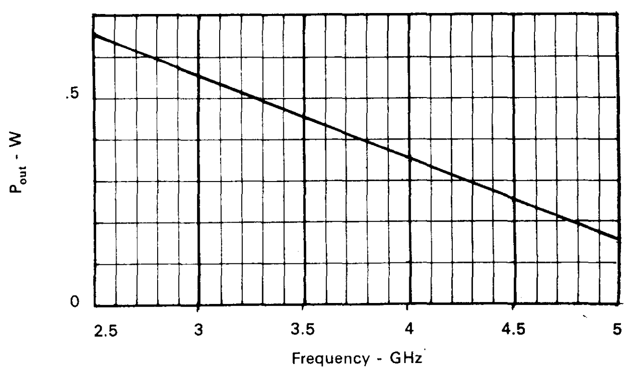
DC Safe Operating Area

T_{Flange} = 75 °C



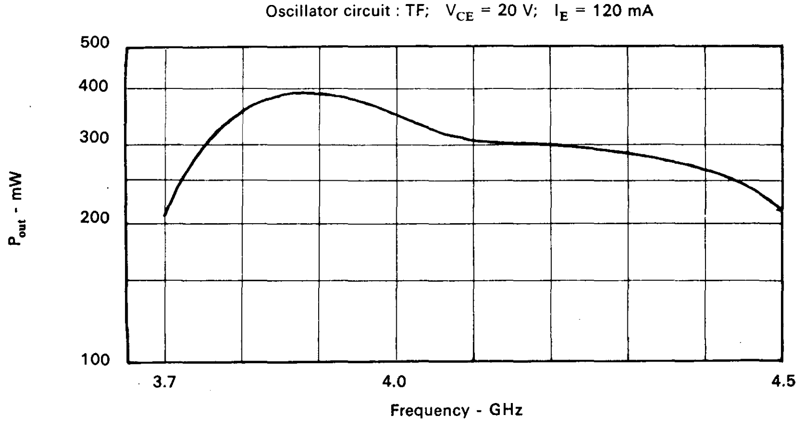
Output Power V_S Frequency

(V_{CE} = 20 V, I_E = 120 mA)



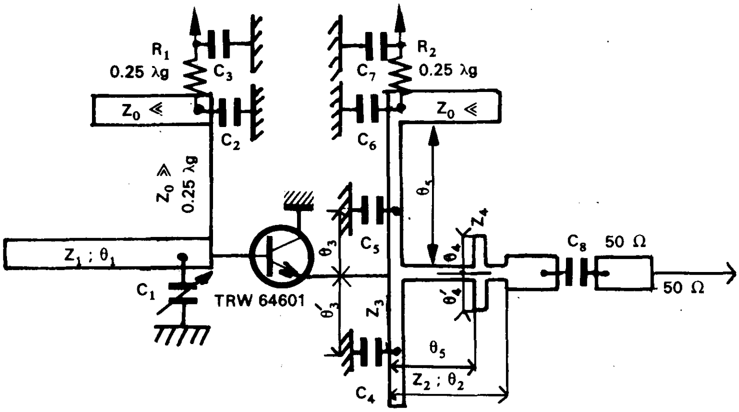
P_{out} V_S Frequency with a Fixed tuned output circuit

Oscillator circuit : TF; V_{CE} = 20 V; I_E = 120 mA



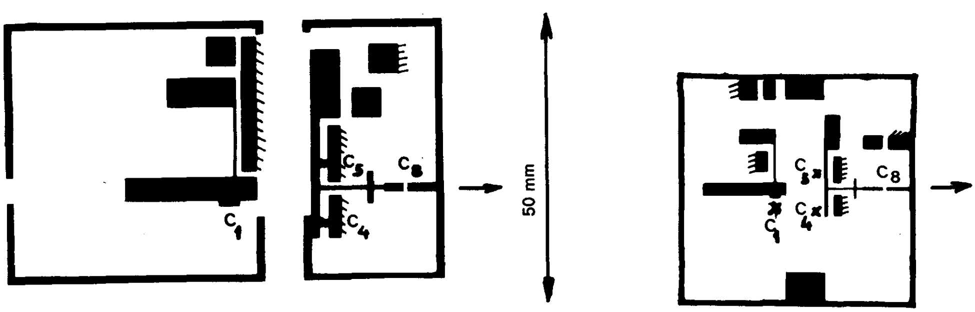
Test circuit

F_0 = 4 GHz



Z_1 = 23.5 Ω θ_1 = 0.52 λg
Z_2 = 80/67 Ω θ_2 = 0.25 λg
Z_3 = 50 Ω { θ_3 = 0.095 λg; θ'_3 = 0.140 λg
Adjust θ_3 and θ_3 to obtain the maximum output power
Z_4 = 62 Ω θ_4 = 0.05 λg
θ_5 = 0.18 λg
R_1 = 160 Ω
R_2 = 1 Ω
C_1 = 0.4 - 2.5 pF
$C_2 = C_6$ = 100 pF (chip) + 10 nF
$C_3 = C_7$ = 10 nF
$C_4 = C_5 = C_8$ = 33 pF (chip)

P_C Board layout For F_0 = 4 GHz (BW = 700 MHz)

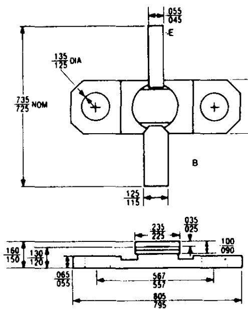


//// Foil wrap edge to ground plane

Board Material : 0.020″ Glass teflon;
E_r = 2.55

Board Material : 0.025″
Epsilan 10 ; E_r = 10.2

Package Outlines



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

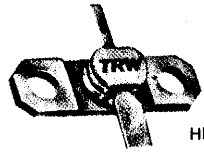
Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

TRW

Microwave Power Oscillator Transistors

- 650 mW at 4 GHz
- Up to 4 GHz
- ∞VSWR



HLP-8

The TRW 64602 is designed for use up to 5 GHz with a typical P_{out} of 650 mW at 4 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

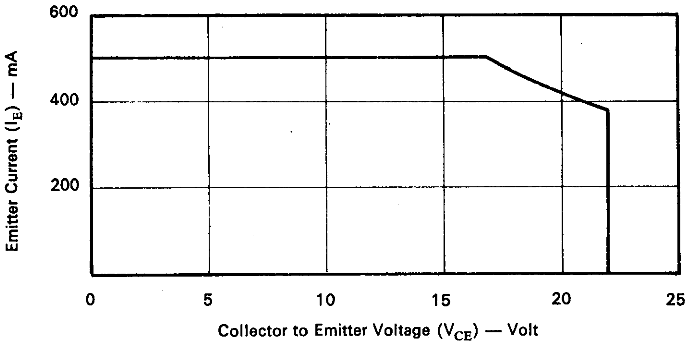
Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP	MAX.	UNIT
DC TEST	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	22			V
DC TEST	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 20 mA R_{BE} = 10 Ω	50			V
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 V	3.5			V
DC TEST	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2 mA	45			V
DC TEST	I_{CBO}	Collector Cutoff Current	V_{CE} = 28 V			0.5	mA
RF TEST	H_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 200 mA	20		120	
RF TEST	C_{OB}	Collector Base Capacitance	V_{CB} = 28 V F = 1 MHz			5.5	pF
RF TEST	P_O	Power output	V_{CE} = 20 V I_C = 240 mA F = 4 GHz	550	650		mW
RF TEST	VSWR	Mismatch Tolerance	V_{CE} = 20 V I_C = 240 mA F = 4 GHz		∞ : 1		
THERMAL	θ_{JF}	Thermal Resistance Junction to Flange				20	°C/W
THERMAL	T_{STG} & T_J	Max Junction & Storage Temperature		— 65		+ 200	°C

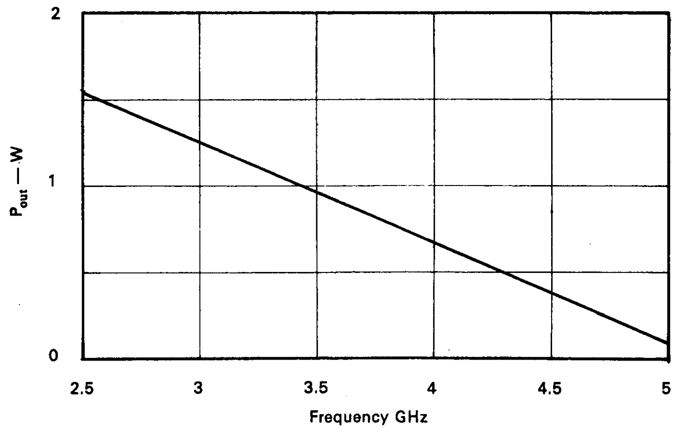
DC Safe Operating Area

T_{flange} = 75 °C

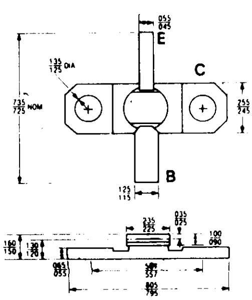


Output Power vs Frequency

(V_{CE} = 20 V, I_E = 240 mA)



Package Outlines



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions	: Per outline drawing.
Solderability	: Per MIL-STD-750.
Marking	: Per MIL-S-19500, « TRW », 4-digit date code, type number.
Hermaticity	: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak (Available on special order screened to 10^{-8} atmospheres.)
Acceleration	: Per MIL-STD-750, 20.000G in any plane.
Bond Pull	: Per MIL-STD-750, 3 grams min.
Package	: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

RF LINEAR AND CATV

F

PRODUCT SUMMARY

PART. NUMBER	FREQUENCY	PACKAGE	PAGE
LT 1001A	3.0 GHz	TO-39	F 58
LT 3203	3.0 GHz	T-PACK	F 72
LT 3703	3.5 GHz	T-PACK	F 74
LT 4700	6.0 GHz	100 MIL	F 76
PT 4572A	1.2 GHz	TO-117	F 80
PT 4579	1.2 GHz	TO-39	F 84
TP 3093	3.0 GHz	TO-39	F 88
TP 3098	3.0 GHz	TO-117	F 92
TP 3400	3.0 GHz	SOE 200	F 96

RF LINEAR - HYBRIDS

PRODUCT SUMMARY

PART. NUMBER	FREQUENCY	GAIN	PAGE
CA 2800	10-400 MHz	17 dB, 0.8 W	F 6
CA 2810	10-350 MHz	33 dB, 0.8 W	F 10
CA 2812	CA 2820 FOR 12 V SUPPLY		F 14
CA 2813	40-300 MHz	34 dB, 0.15 W	F 18
CA 2818	1-200 MHz	18.5 dB, 0.8 W	F 22
CA 2820	1-520 MHz	30 dB, 0.4 W	F 26
CA 2830	5-200 MHz	34.5 dB, 0.8 W	F 30
CA 2832	1-200 MHz	35.5 dB, 2.0 W	F 34
CA 2840	30-300 MHz	22 dB, 75Ω	F 38
CA 4800	10-1000 MHz	17 dB, 26 V	F 42
CA 4812	CA 4800 FOR 12 V SUPPLY		F 46
CA 4815	5-1000 MHz	17 dB, 15 V	F 50
CA 5800	10-1000 MHz	16 dB, 28 V	F 52
CA 5815	10-1000 MHz	16 dB, 15 V	F 56
GPA 501	5-600 MHz	15 dB, +4 dBm	CONTACT FACTORY
GPA 502	5-600 MHz	15 dB, +14 dBm	
GPA 503	5-600 MHz	12 dB, +19 dBm	
GPA 504	5-600 MHz	25 dB, +13 dBm	
GPA 505	5-500 MHz	23 dB, +14 dBm	
GPA 510	5-600 MHz	15 dB, +4 dBm	
GPA 511	5-600 MHz	15 dB, +14 dBm	
GPA 512	5-600 MHz	12 dB, +12 dBm	
GPA 1006	5-1000 MHz	19 dB, +13 dBm	
GPA 1007	5-1000 MHz	17 dB, +20 dBm	
GPA 1501	5-1000 MHz	17 dB, +10 dBm	

VIDEO DISPLAY APPLICATIONS

PRODUCT SUMMARY

PART. NUMBER	APPLICATION		PACKAGE	PAGE
LT 1817	CRT DRIVER	NPN	TO-117	F 64
LT 1820	CRT DRIVER	NPN	TO-220	F 66
LT 1839	CRT DRIVER	NPN	TO-39	F 68
LT 5817	CRT DRIVER	PNP	TO-117	F 70
LT 5839	CRT DRIVER	PNP	TO-39	F 71

CATV HYBRID AMPLIFIERS

PRODUCT SUMMARY

PREAMP	POST AMP.	LINE EXTENDER	GAIN (50MHz)	STATUS	PAGE
35 CHANNELS (40-300 MHz)					
CA 2101	CA 2201		17 dB	D	F 100
CA 2300	CA 2301		22 dB	D	F 102
		CA 2600	33 dB	D	F 104
40 CHANNELS (40-330 MHz)					
CA 3101	CA 3201		17 dB	D	F 106
		CA 3600	34 dB	D	F 108
52 CHANNELS (40-400 MHz)					
CA 4101	CA 4201		17 dB	D	F 110
		CA 4600	34 dB	C	F 112
60 CHANNELS (40-450 MHz)					
CA 5101	CA 5201		18 dB	D	F 114
CA 5300	CA 5301		22 dB	D	F 116
		CA 5600	34 dB	ND	F 118
		CA 5700	38 dB	ND	F 120
60 CHANNELS SUPER TRUNKS					
CA 5180	CA 5280		14 dB	ND	F 122
		FF 124	24 dB	ND	F 124
77 CHANNELS (40-550 MHz)					
CA 6101	CA 6201		19 dB	ND	F 126

CATV RETURN AMPLIFIERS

PRODUCT SUMMARY

PREAMP	POST AMP.	LINE EXTENDER	GAIN (10MHz)	STATUS	PAGE
12 CHANNELS (5-120 MHz)					
CA 2418			18 dB	C	F 128
26 CHANNELS (5-200 MHz)					
CA 4411			13 dB	D	F 130
CA 4412			13 dB	D	F 130
CA 4418			18 dB	D	F 132
CA 4422			22 dB	D	F 134

STATUS GUIDE

D = DESIGN TYPE
Recommended for equipment design, production quantities available at date of publication.

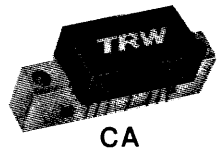
ND = NEW DESIGN TYPE
Recommended for new equipment design, production quantities available after date of publication.

C = CURRENT TYPE
No longer recommended for equipment design, available for equipment production and for use in existing equipment.

TRW

Wide Bandwidth Linear Hybrid Amplifier

- **Instantaneous Bandwidth, 10-400 MHz**
- **17 dB Gain**
- **400 mW PEP @ - 32 Db IMD**



CA

The CA2800 is a high-reliability thin-film hybrid amplifier utilizing an all gold metalization system. Units are designed for wide bandwidth linear operation in 50 to 100 ohm systems. This hybrid provides excellent gain stability with temperature and very low distortion due to push-pull amplifier circuitry. This module is recommended for wide bandwidth, low noise and linear applications.

F

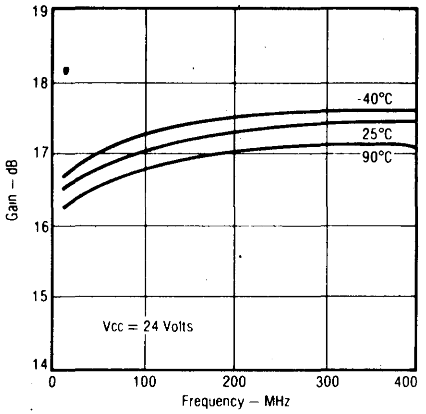
Absolute Maximum Ratings

V_{CC}	RF Power Input	Storage Temperature	Operating Temperature
28 Volts	+16dBm	-40°C to +100°C	-20°C to +90°C

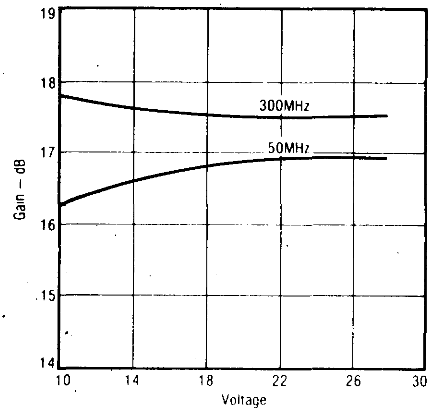
Electrical Characteristics for 50Ω Systems (T_{CASE} = 25°C and 24V)

Symbol	Characteristic	Conditions	Value
P_G	Power Gain	f = 50MHz	17 ±0.75dB
NF	Noise Figure, Broadband	f = 60MHz f = 300MHz	5.0dB Typ 8.5dB Typ
I_{TO}	Third Order Intercept, See Figure 1	f_1 = 300MHz	+44dBm Typ
VSWR	Input/Output VSWR for 50Ω Systems	f = 10-400MHz	2:1 Typ
I_{CC}	Supply Current	24V	220mA Max
P_O	Power Output — 1dB Compression	f = 200MHz	800mW
P_{RI}	Reverse Isolation	f = 10-400MHz	25dB Typ
F_R	Frequency Response	f = 30-300MHz f = 10-400MHz	±0.5dB Max ±1dB Max
d_{SO}	Second Harmonic Distortion	Tone at 10mW f_{2H} = 10-300MHz	-66dB Typ
PEP	Peak Envelope Power for Two Tone Distortion Test See Figure 1	f = 10-300MHz at -32dB	400mW Typ

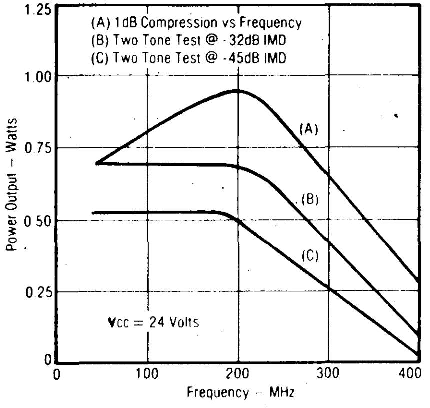
Gain vs Frequency



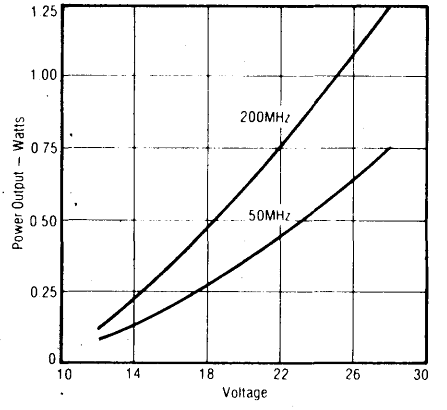
Gain vs Voltage



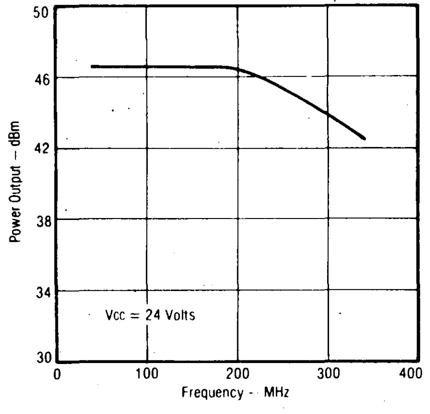
Power Output vs Frequency



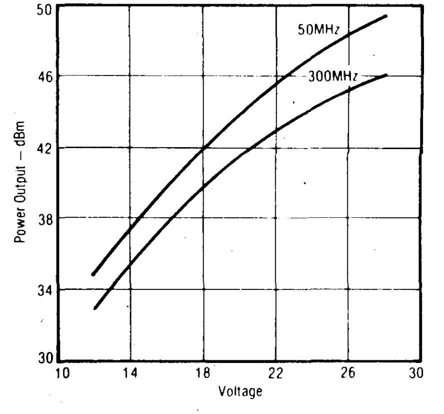
1dB Compression vs Voltage



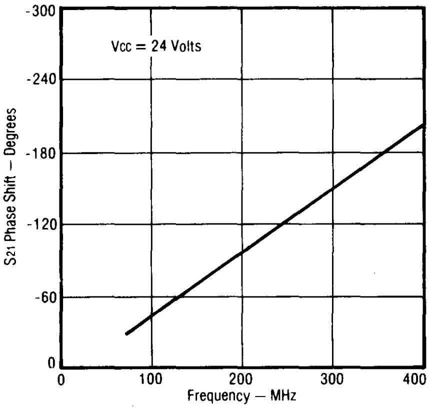
Third Order Intercept vs Frequency



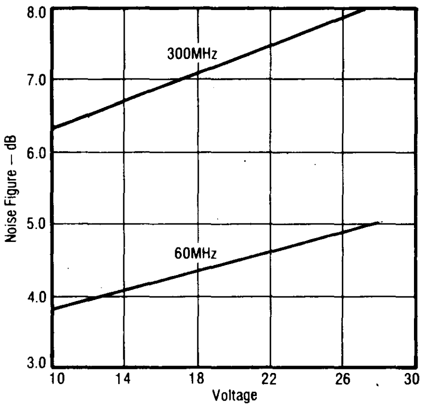
Third Order Intercept vs Voltage



Phase Shift vs Frequency

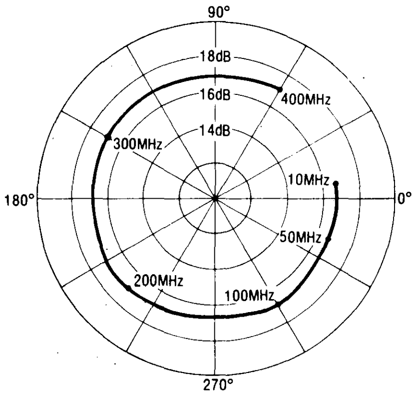


Noise Figure vs Voltage

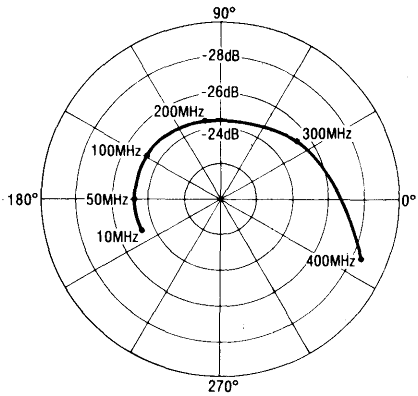


S-Parameters
Vcc = 24V, Zo = 50Ω

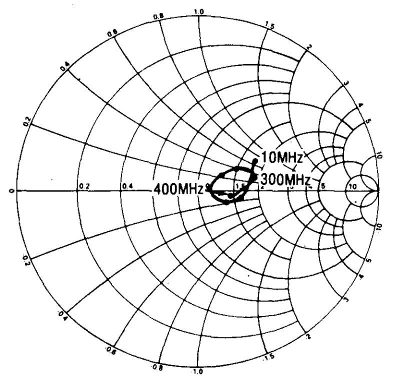
S21



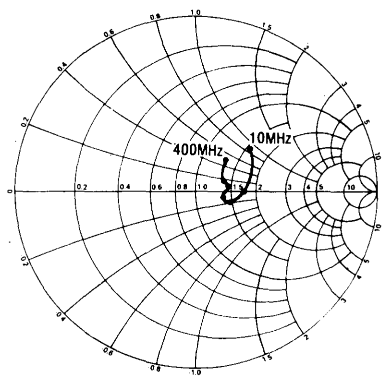
S12



S11



S22



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CA Package Outline

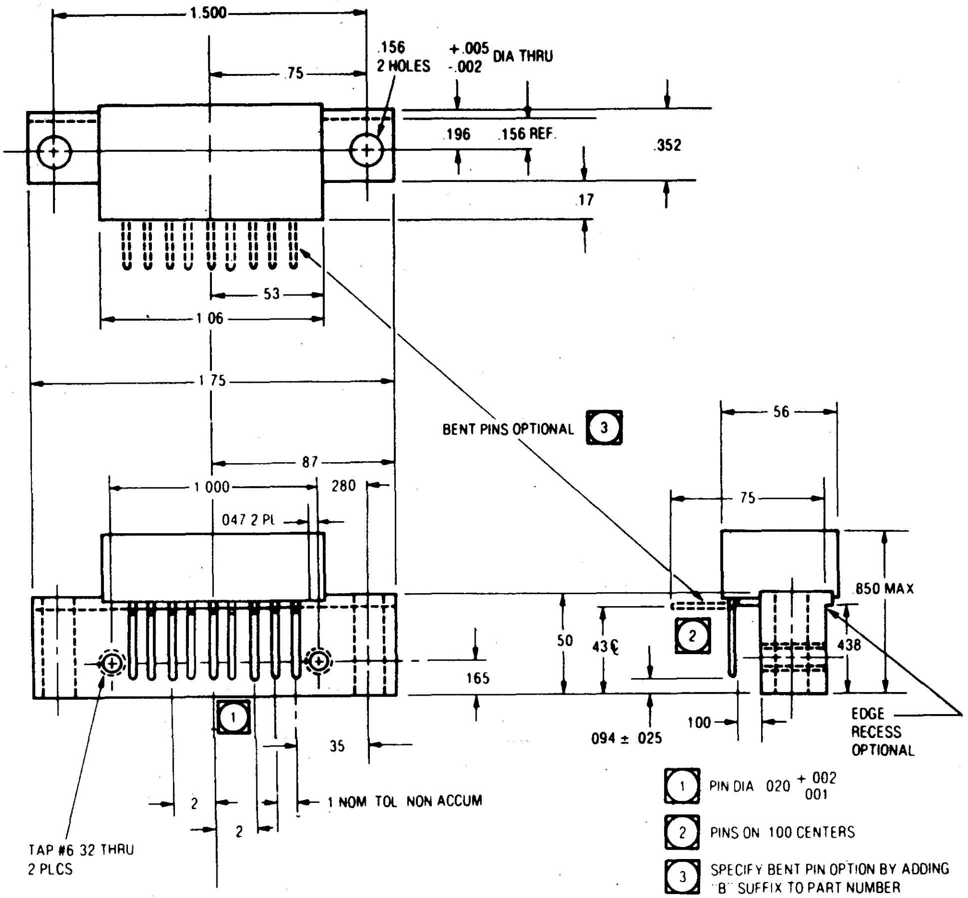
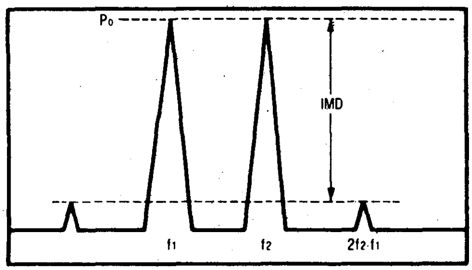


FIGURE 1. INTERMODULATION TEST



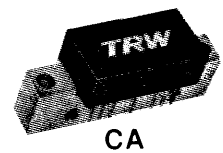
$$I_{TO} = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X P_o @ IMD = -32dB

TRW

Wide Bandwidth Linear Hybrid Amplifier

- **Instantaneous Bandwidth, 10-350 MHz**
- **33 dB Gain**
- **Power Output, 800 mW**



CA

The CA2810 is a high-reliability thin-film hybrid amplifier utilizing an all gold metalization system. Units are designed for wide bandwidth linear operation in 50 to 100 ohm systems. This hybrid provides excellent gain stability with temperature and very low distortion due to push-pull amplifier circuitry. This module is recommended for wide bandwidth, low noise and linear applications.

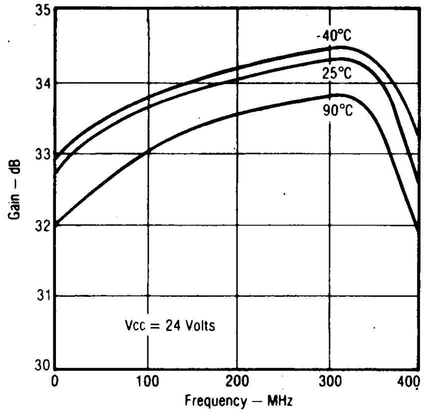
Absolute Maximum Ratings

V_{CC}	RF Power Input	Storage Temperature	Operating Temperature
28 Volts	+5dBm	-40°C to +100°C	-20°C to +90°C

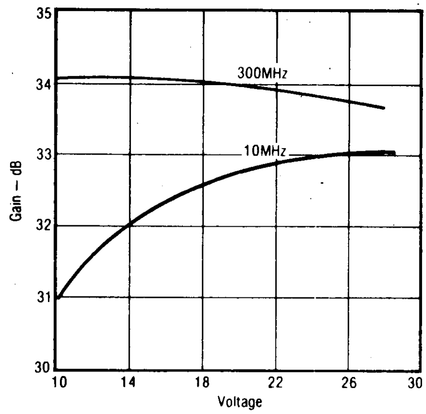
Electrical Characteristics for 50Ω Systems (T_{CASE} = 25°C and 24V)

Symbol	Characteristic	Conditions	Value
P_G	Power Gain	f = 50MHz	33 ±1dB
NF	Noise Figure, Broadband	f = 60MHz f = 300MHz	4.5dB Typ 8.0dB Max
I_{TO}	Third Order Intercept, See Figure 1	f_1 = 300MHz	+43dBm Typ
VSWR	Input/Output VSWR for 50Ω Systems	f = 10-350MHz	2:1 Typ
I_{CC}	Supply Current	24V	330mA Max
P_O	Power Output — 1dB Compression	f = 200MHz	800mW
P_{RI}	Reverse Isolation	f = 10-350MHz	40dB Typ
F_R	Frequency Response	f = 30-300MHz f = 10-350MHz	±1.0dB Max ±1.5dB Max
d_{SO}	Second Harmonic Distortion	Tone at 10mW f_{2H} = 10-300MHz	-66dB Typ
PEP	Peak Envelope Power for Two Tone Distortion Test See Figure 1	f = 10-300MHz at -32dB	400mW Typ

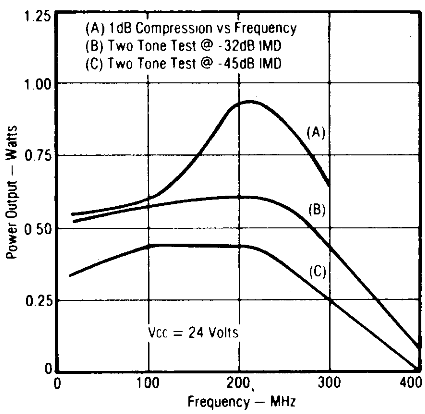
Gain vs Frequency



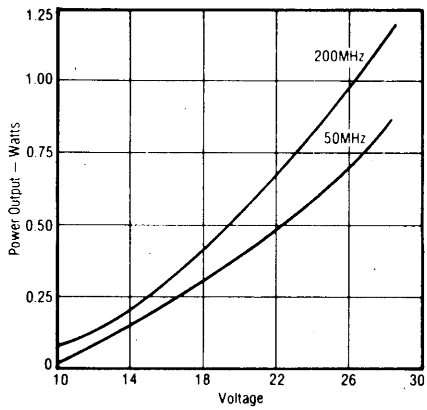
Gain vs Voltage -



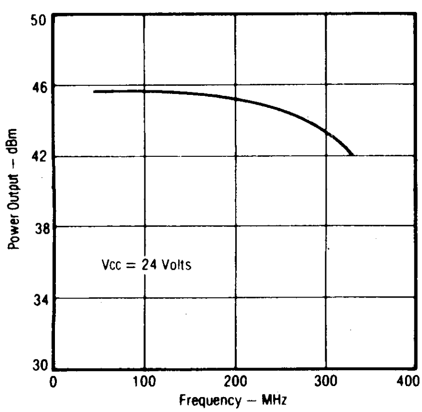
Power Output vs Frequency



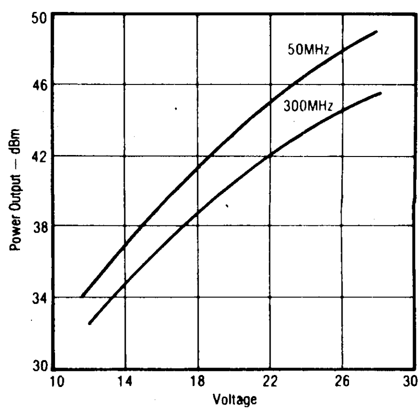
1dB Compression vs Voltage



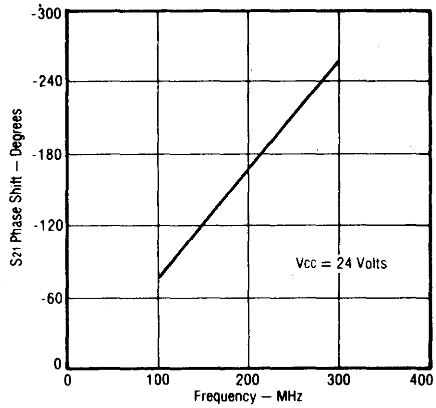
Third Order Intercept vs Frequency



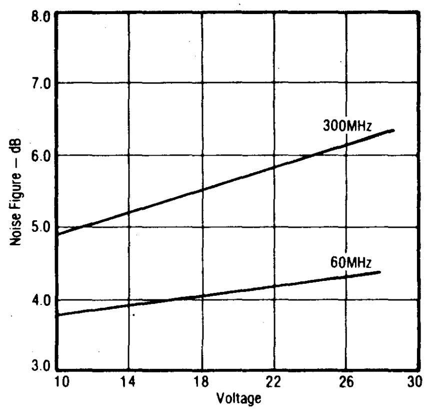
Third Order Intercept vs Voltage



Phase Shift vs Frequency

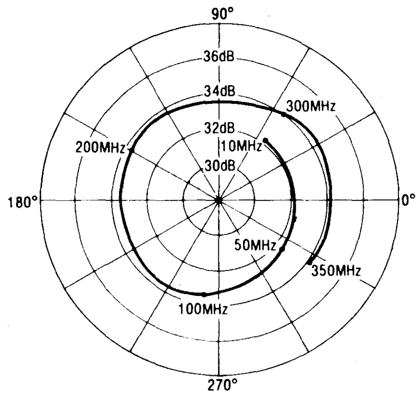


Noise Figure vs Voltage

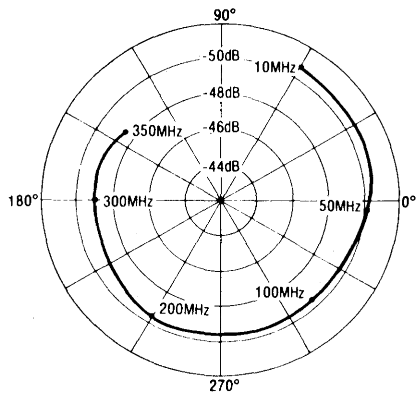


S-Parameters
Vcc = 24V, Zo = 50Ω

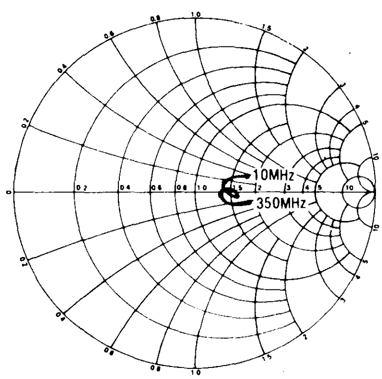
S21



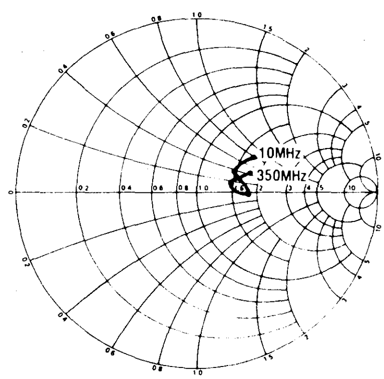
S12



S11



S22



F

PACKAGE OUTLINE

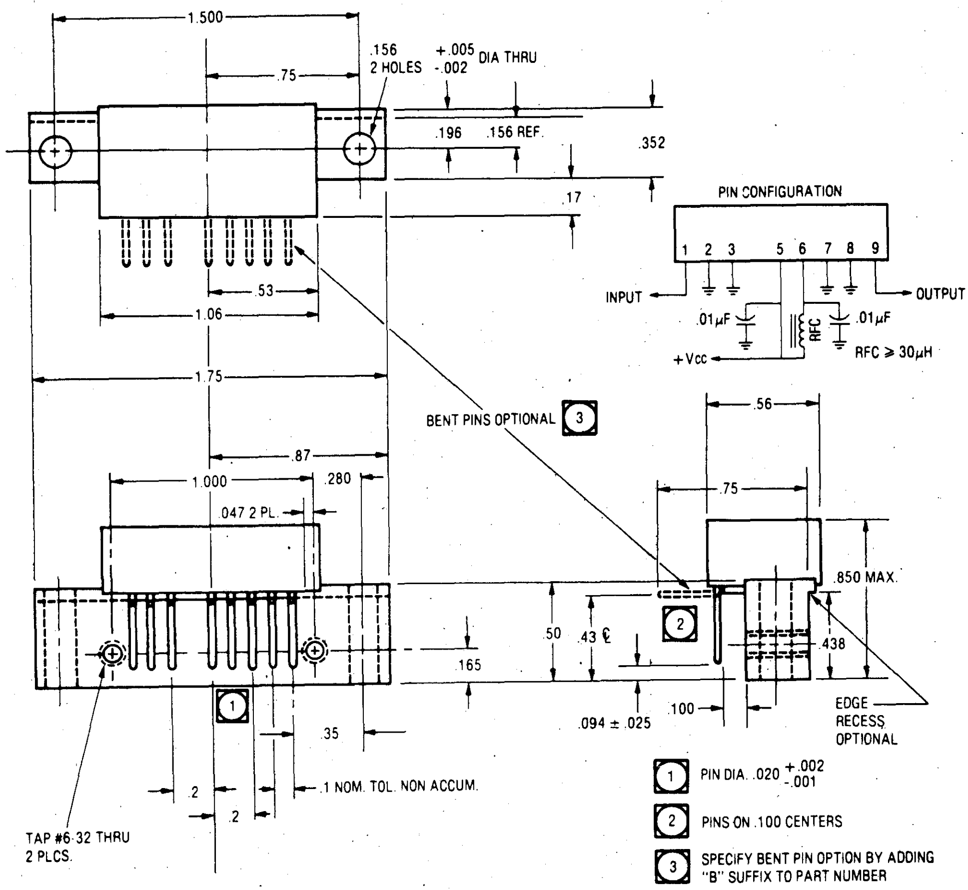
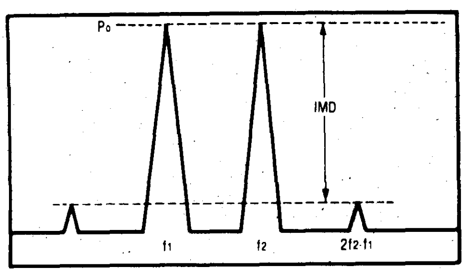


FIGURE 1. INTERMODULATION TEST



$$I_{TO} = P_o + \frac{IMD}{2} \text{ @ } IMD > 60dB$$

$$PEP = 4X\ P_o \text{ @ } IMD = -32dB$$

TRW

Wide Bandwidth Linear Hybrid Amplifier

- **Instantaneous Bandwidth, 1-520 MHz**
- **30 dB Gain**
- **Power Output, 250 mW Minimum**
- **Optimized for 12 V Operation**

CA

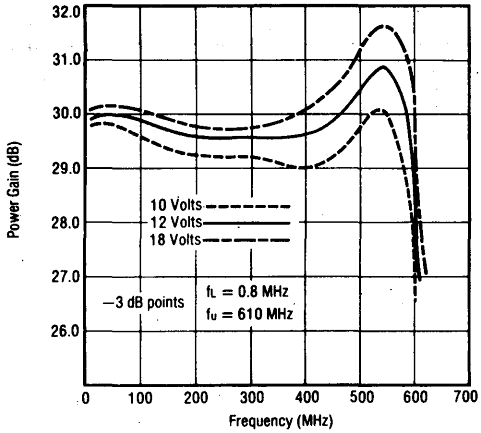
- Low cost single ended design
- Unconditional stability under all mismatch conditions

The CA2812 is a high-reliability thin-film hybrid amplifier utilizing an all gold metallization system. Units are designed for widest bandwidth linear operation in 50 ohm systems. The linear class A bias enables the CA2812 to drive highly reactive loads at large signal levels over its frequency range. Low end frequency response can be extended to 500KHz by increasing the value of the external RF chokes. This module is recommended for wide bandwidth, low cost and linear applications in 25 to 75 ohm systems over a wide range of supply voltages.

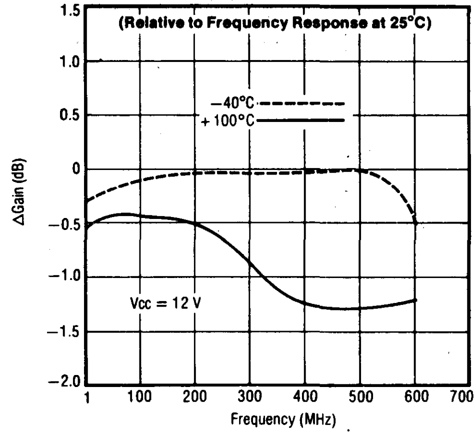
Electrical Characteristics For 50Ω Systems (T_{CASE} = 25°C and 12V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
MAX RATINGS	V_{CC}	Supply Voltage				18	volts
	P_{IN}	RF Power Input				+10	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS	P_G	Power Gain	f = 100MHz	29	30	31	dB
	NF	Noise Figure, Broadband	f = 30MHz f = 500MHz	— —	5.5 8	7 10	dB
	I_{TO}	Third Order Intercept, See Figure 1	f = 520MHz	+32	+34	—	dBm
	VSWR	Input VSWR for 50 Ohm Systems Output VSWR for 50 Ohm Systems	f = 1-520MHz	—	1.5:1 1.8:1	2.0:1 2.0:1	N/A
	I_{CC}	Supply Current	12V	300	330	360	mA
	P_O	Power Output — 1dB Compression	f = 1-520MHz	250	300	—	mW
	P_{RI}	Reverse Isolation	f = 1-520MHz	49	52	—	dB
	F_R	Frequency Response	f = 1-520MHz	—	± 0.8	± 1.5	dB
	dso	Second Harmonic Distortion	P_O = 10mW f_{2H} = 1-520MHz	-40	-50	—	dB

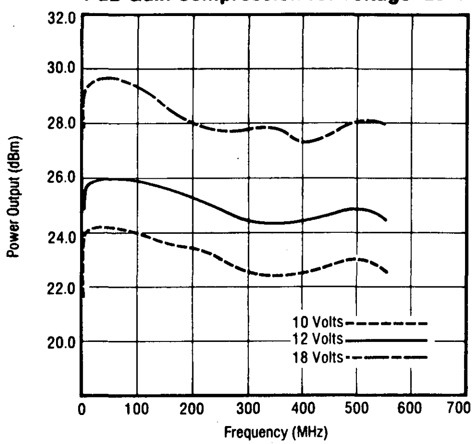
Frequency Response 25°C



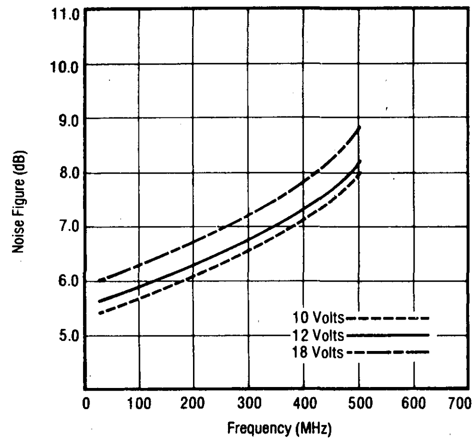
Frequency Response vs. Temperature



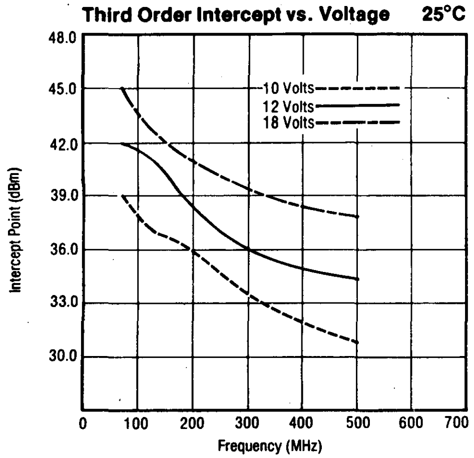
1 dB Gain Compression vs. Voltage 25°C



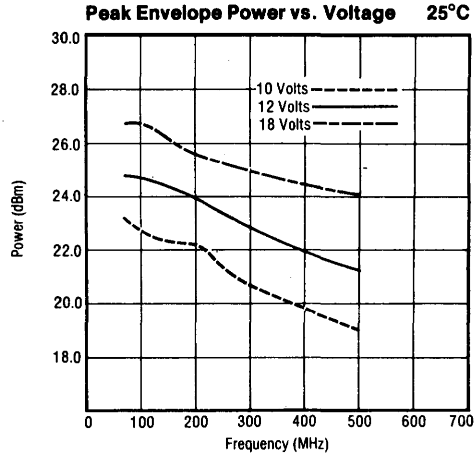
Noise Figure vs. Voltage 25°C

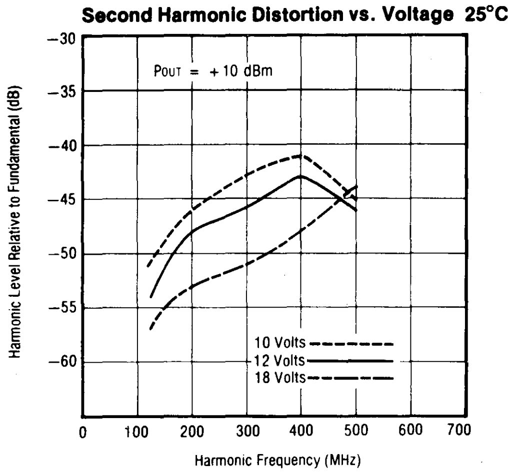


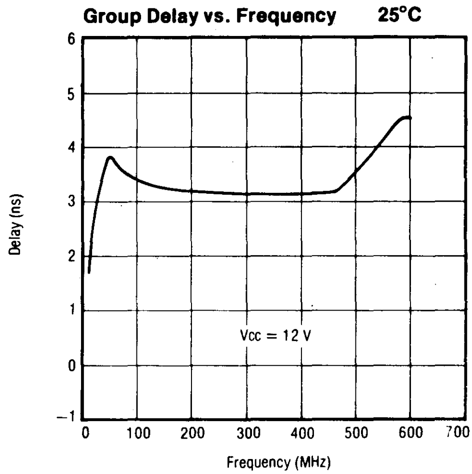
Third Order Intercept vs. Voltage 25°C



Peak Envelope Power vs. Voltage 25°C







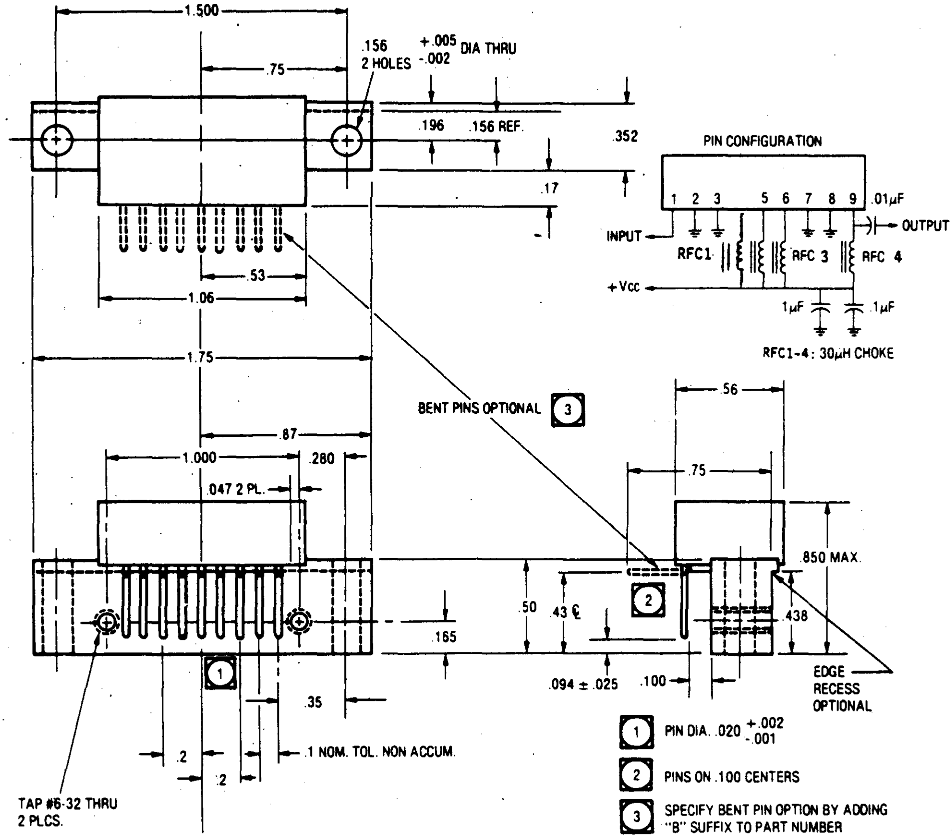
S-Parameters

Biased at 12 Volts T = 25°C Zo = 50Ω

Frequency (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
1	-9.0	-52.7	29.7	170	-50.2	167	-4.0	145
10	-25.0	-26.0	29.9	3.7	-54.5	8.6	-25.5	54.0
100	-20.8	-12.0	29.9	-122	-55.5	-36.8	-22.2	59.0
200	-17.0	-53.7	29.5	117	-58.0	-77.8	-14.8	37.0
300	-14.7	-99	29.5	-6.4	-60.4	-140	-16.8	26.0
400	-14.5	-159	29.5	-131	-56.9	151	-13.1	2.8
500	-17.6	111	30.1	98.2	-51.7	93	-19.9	-135
600	-17.5	-83	27.5	-79.9	-56.2	17.9	-3.1	82

Magnitude in dB, Phase Angle in degrees.

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

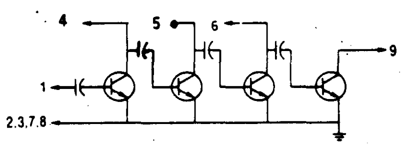
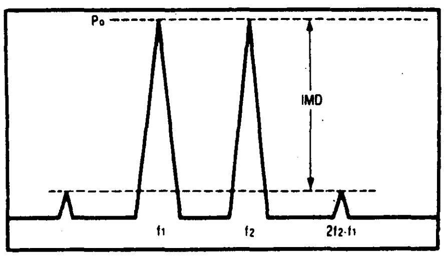


FIGURE 1. INTERMODULATION TEST

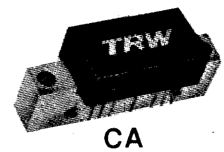


$$I_{TO} = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

$$PEP = 4X\ P_o \text{ @ IMD} = -32dB$$

Wide Band RF Linear Hybrid Amplifier

- **34 dB Gain**
- **15 volt operation, low power consumption**
- **Instantaneous Bandwidth, 40-300 MHz**
- **Low VSWR for 75 Ω system**
- **Low noise figure, 3.5 dB**



CA

The CA 2813 is a high reliability thin-film hybrid amplifier utilizing an all gold metallization system. This hybrid provides excellent gain stability and very low distortion due to push-pull amplifier circuitry. The CA 2813 is recommended for driver applications requiring good linearity and noise performance.

Excellent performance can be obtained with a supply voltage from 12 to 28 volts.

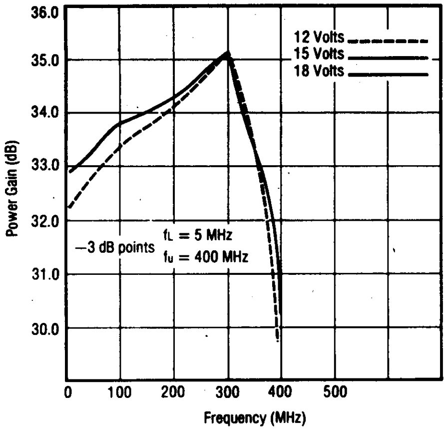
Absolute Maximum Ratings

Supply Voltage	RF Power Input	Storage Temperature	Case Operating Temperature
+28 Volts	+5 dBm	−40 °C to +100 °C	−20 °C to +90 °C

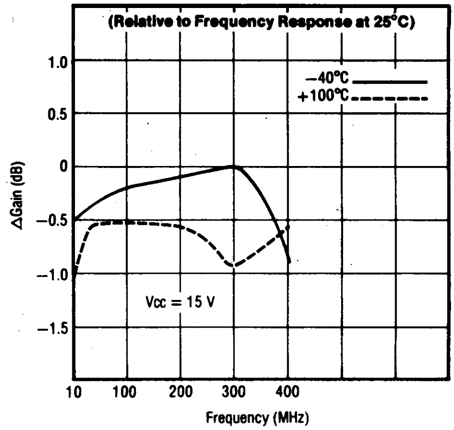
Electrical Characteristics for 75Ω Systems (T_{CASE} = +25°C and +15V Supply Voltage)

Symbol	Characteristics	Conditions	Min.	Typ.	Max.	Units
P_G	Power Gain	f = 50 MHz	33.0	34.0	35.0	dB
F_R	Frequency Response	f = 40-300 MHz		±0.75	±1.25	dB
P_O	Power Output, 1dB Compression	f = 300 MHz		+22		dBm
P_{ri}	Reverse Isolation	f = 40-300 MHz		40		dB
PEP	Peak Envelope Power for Two Tone Distortion Test, *See Figure 1*	f = 40-300 MHz @ −32dB IMD	125	150		mW
I_{TO}	Third Order Intercept, See Figure 1	f = 300 MHz	+38	+40		dBm
d_{so}	Second Harmonic Suppression	Po = 100mW f_{2h} = 300 MHz	−47	−50		dB
NF	Noise Figure, Broadband	f = 50 MHz f = 300 MHz		3.5 5.0	4.5 6.0	dB
VSWR	Input/Output VSWR (75Ω)	f = 40-300 MHz		1.2:1	1.3:1	N/A
I_{CC}	Supply Current	15V	150	170	190	mA

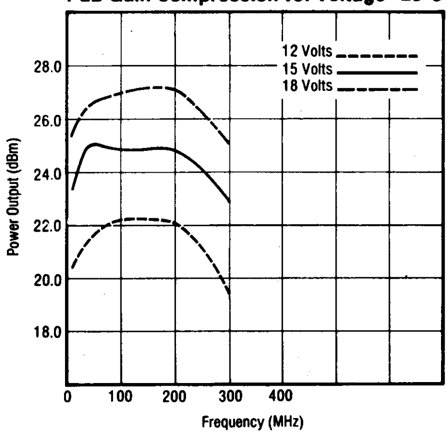
Frequency Response 25°C



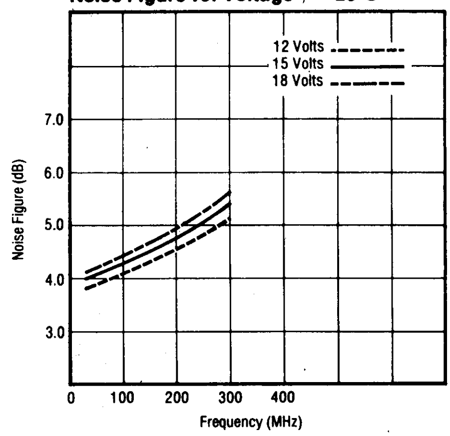
Frequency Response vs. Temperature



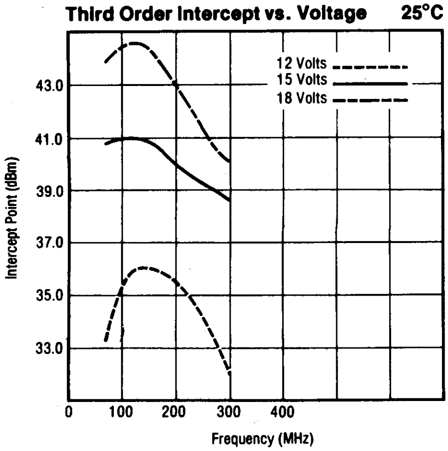
1 dB Gain Compression vs. Voltage 25°C



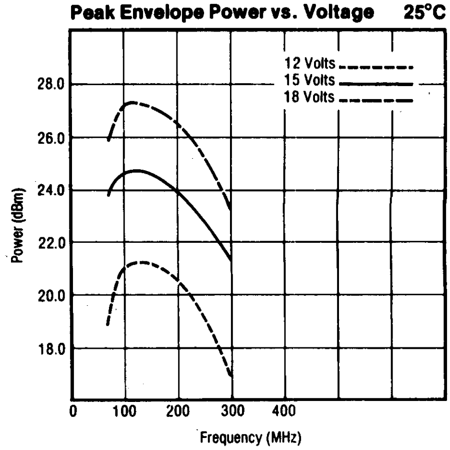
Noise Figure vs. Voltage 25°C

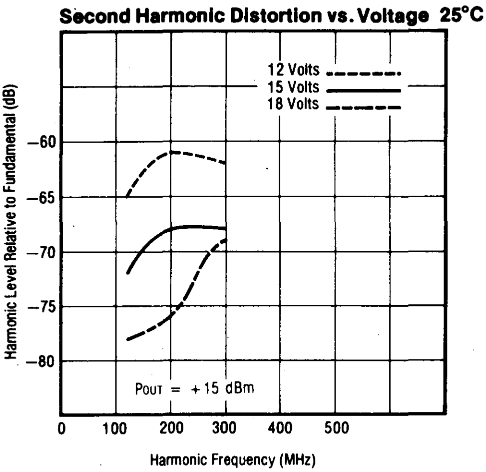


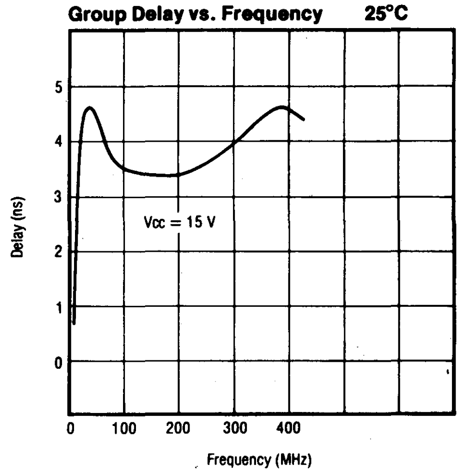
Third Order Intercept vs. Voltage 25°C



Peak Envelope Power vs. Voltage 25°C







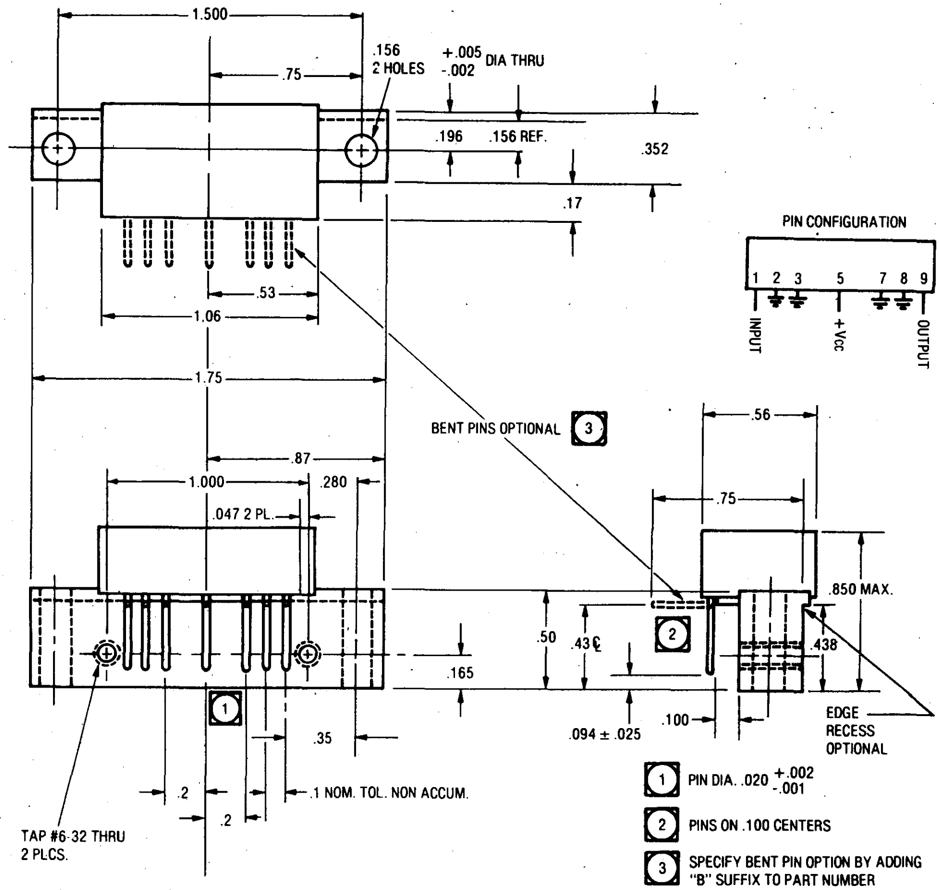
S-Parameters

Biased at 15 Volts T = 25°C Zo = 75Ω

Frequency (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
10	-16.6	53.0	33.1	35.0	-48.1	39.1	-21.2	48.7
50	-32.3	-2.0	33.6	-44.9	-47.8	-21.0	-30.9	65.0
100	-41.4	119	34.2	-107	-47.7	-58.0	-30.3	22.6
200	-27.8	62.0	34.5	130	-48.6	-140	-38.5	-105
300	-26.1	-177	35.3	-10.2	-47.1	126	-23.3	84.5

Magnitude in dB, Phase Angle in degrees.

CA2813
PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

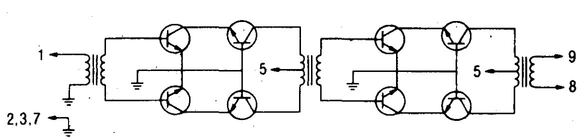
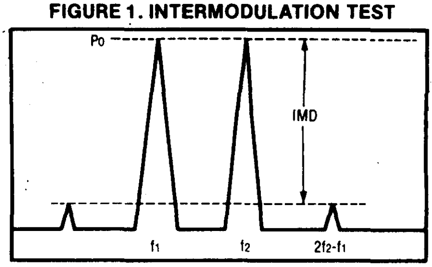


FIGURE 1. INTERMODULATION TEST

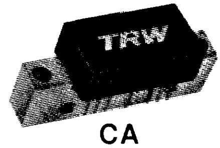


$I_{TO} = P_o + \frac{IMD}{2}$ @ IMD > 60dB

PEP = 4X P_o @ IMD = -32dB

Wide Bandwidth Linear Hybrid Amplifier

- Instantaneous Bandwidth, 1-200 MHz
- 18.5 dB Gain
- Power Output, 800 mW



CA

The CA2818 is a high-reliability thin-film hybrid amplifier utilizing an all gold metalization system. This hybrid provides excellent gain stability and very low distortion due to push-pull amplifier circuitry. The CA2818 is recommended for driver applications requiring high power capability and for "gain blocks" that demand maximum linearity. Excellent performance can be obtained with a supply voltage from 12 to 28 volts. For 75 ohm performance, refer to CATV equivalent model CA2418.

F

ABSOLUTE MAXIMUM RATINGS

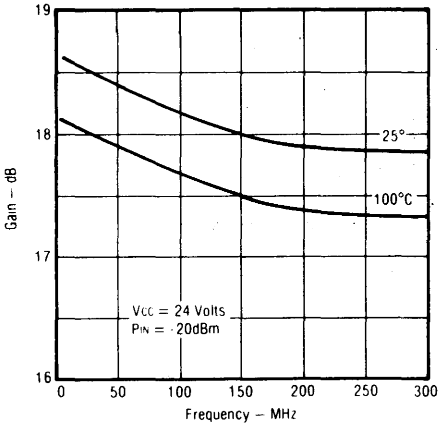
V	RF Power Input	Storage Temperature	Operating Temperature (Case)
28 Volts	+14dBm	-55°C to +125°C	-40°C to +100°C

ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS *(T_{CASE} = 25°C and 24V)

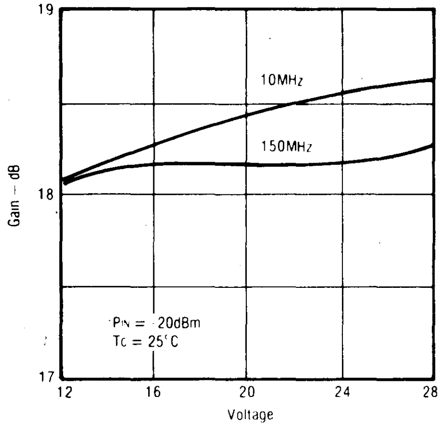
Symbol	Characteristic	Conditions	Min.	Typ.	Max.	Units
P_G	Power Gain	f = 50MHz	17.75	18.5	19.25	dB
NF	Noise Figure, Broadband	f = 30MHz f = 150MHz	— —	4.5 5.5	6.0 7.0	dB
I_{TO}	Third Order Intercept, See Figure 1	f = 150MHz	+44	+47	—	dBm
VSWR	Input/Output VSWR for 50Ω Systems Input/Output VSWR for 75Ω Systems	f = 1-200MHz	— —	1.7:1 1.2:1	2.0:1 1.3:1	N/A
I_{CC}	Supply Current	24V	190	205	220	mA
P_O	Power Output — 1dB Compression	f = 150MHz	800	900	—	mW
P_{RI}	Reverse Isolation	f = 1-200MHz	—	25	—	dB
F_R	Frequency Response	f = 5-150MHz f = 1-200MHz	— —	±0.2 ±0.5	±0.5 ±1.0	dB
d_{SO}	Second Harmonic Distortion	P_O = 100mW f_{2H} = 1-200MHz	-55	-60	—	dB
PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 1-200MHz at -32dB	600	800	—	mW

*Except for VSWR as noted.

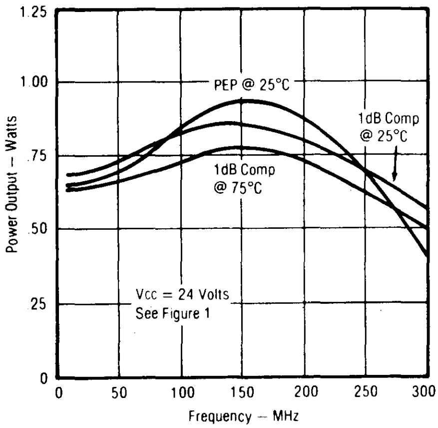
GAIN VS. FREQUENCY



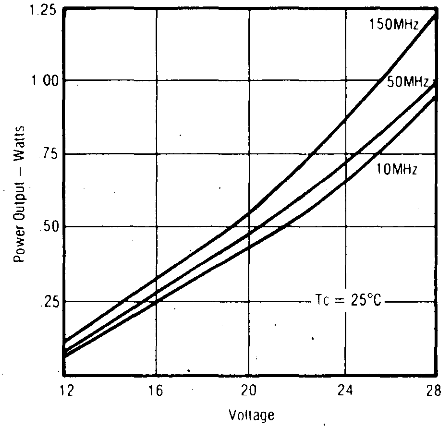
GAIN VS. VOLTAGE



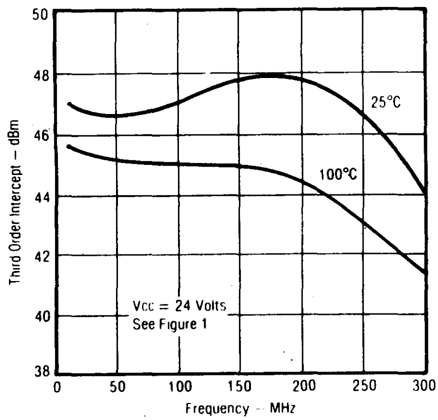
POWER OUTPUT VS. FREQUENCY



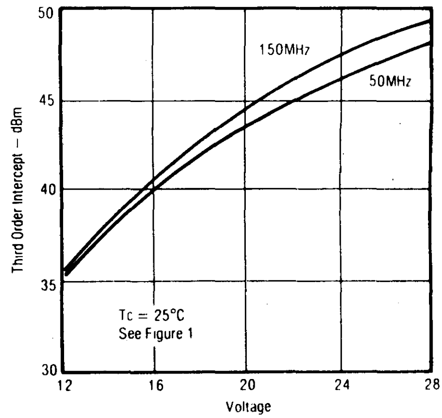
1dB COMPRESSION VS. VOLTAGE



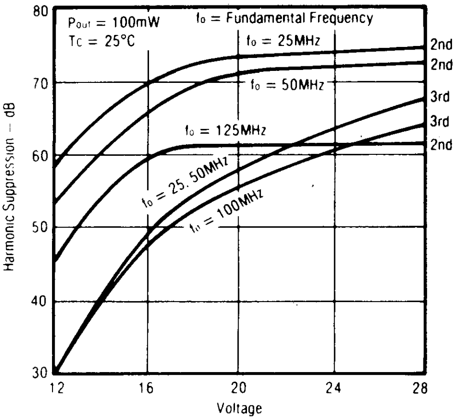
THIRD ORDER INTERCEPT VS. FREQUENCY



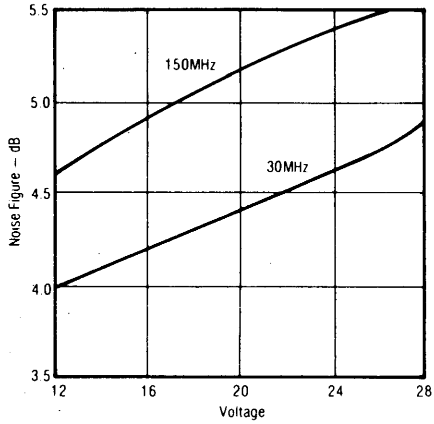
THIRD ORDER INTERCEPT VS. VOLTAGE



SECOND AND THIRD HARMONIC SUPPRESSION VS. VOLTAGE

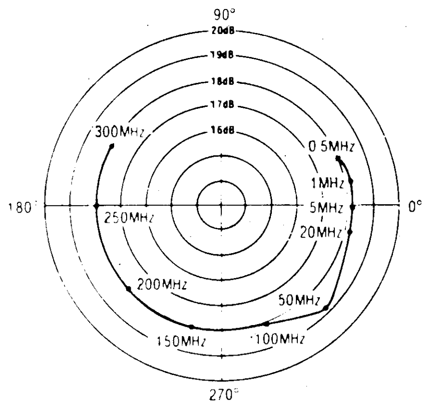


NOISE FIGURE VS. VOLTAGE

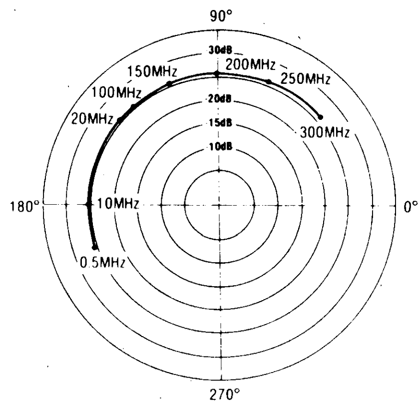


S-PARAMETERS
Zo = 50Ω, Vcc = 24V

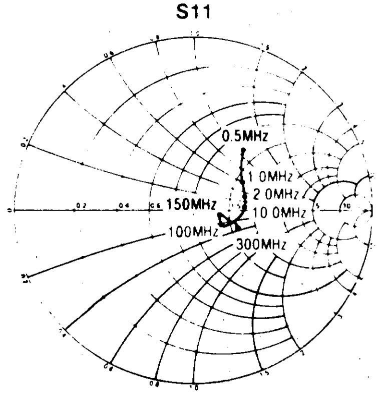
S21



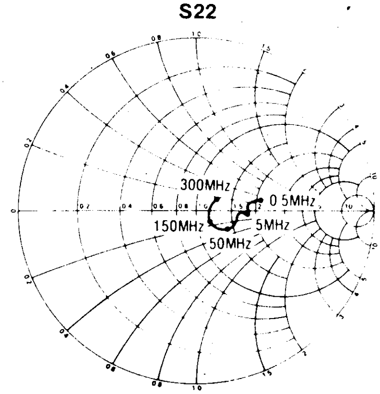
S12



S11



S22



PACKAGE OUTLINE

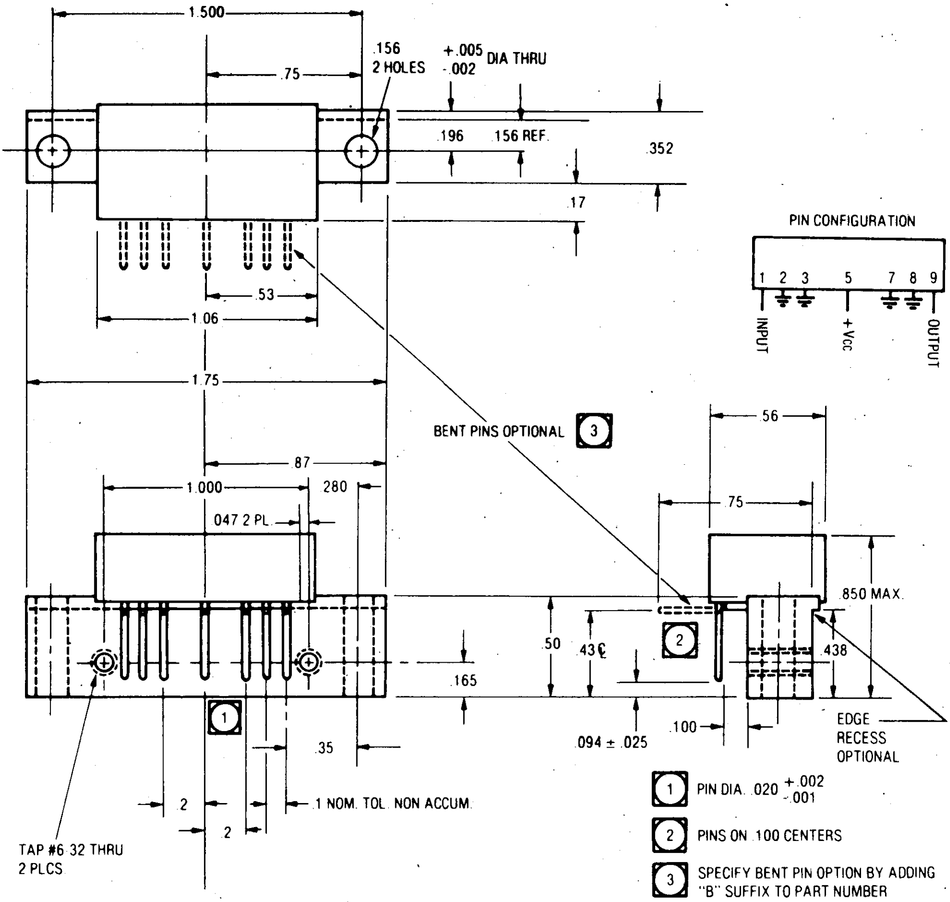
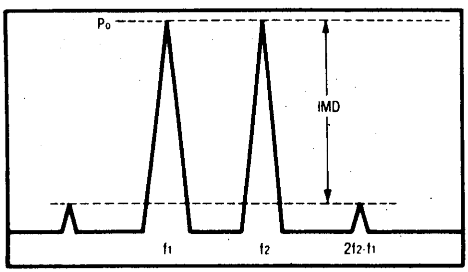


FIGURE 1. INTERMODULATION TEST



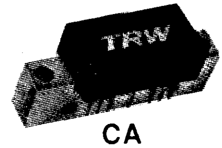
$$I_{TO} = P_o + \frac{IMD}{2} \ @ \ IMD > 60dB$$

$$PEP = 4X \ P_o \ @ \ IMD = -32dB$$

TRW

Wide Bandwidth Linear Hybrid Amplifier

- **Instantaneous Bandwidth, 1-520 MHz**
- **30 dB Gain**
- **Power Output, 400 mW Minimum**



CA

The CA2820 is a high-reliability thin-film hybrid amplifier utilizing an all gold metalization system. Units are designed for widest bandwidth linear operation in 50 ohm systems. The linear class A bias enables the CA2820 to drive highly reactive loads at large signal levels over its frequency range. Low end frequency response can be extended to 500KHz by increasing the value of the external RF chokes. This module is recommended for wide bandwidth, low cost and linear applications in 25 to 75 ohm systems over a wide range of supply voltages.

F

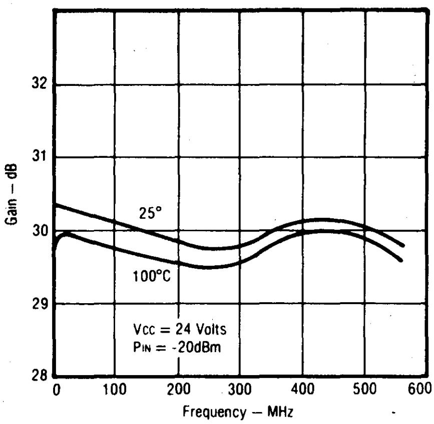
ABSOLUTE MAXIMUM RATINGS

V..	RF Power Input	Storage Temperature	Operating Temperature (Case)
28 Volts	+10dBm	-55°C to +125°C	-40°C to +100°C

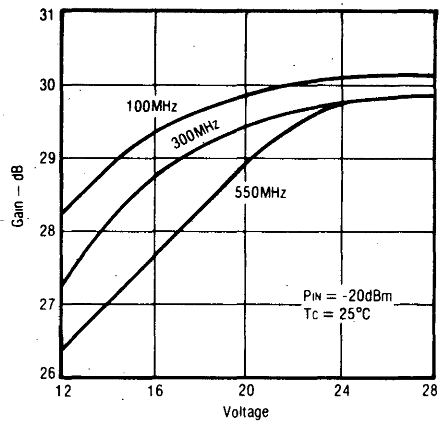
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE} = 25°C and 24V)

Symbol	Characteristic	Conditions	Min.	Typ.	Max.	Units
P_G	Power Gain	f = 100MHz	29	30	31	dB
NF	Noise Figure, Broadband	f = 30MHz f = 500MHz	— —	6.0 8.3	8 10	dB
I_{TO}	Third Order Intercept, See Figure 1	f = 520MHz	+35	+37	—	dBm
VSWR	Input VSWR for 50 Ohm Systems Output VSWR for 50 Ohm Systems	f = 1-520MHz	—	1.5:1 1.8:1	2.0:1 2.0:1	N/A
I_{CC}	Supply Current	24V	300	330	360	mA
P_O	Power Output — 1dB Compression	f = 1-520MHz	400	440	—	mW
P_{RI}	Reverse Isolation	f = 1-520MHz	49	52	—	dB
F_R	Frequency Response	f = 1-520MHz	—	±0.8	±1.5	dB
d_{SO}	Second Harmonic Distortion	P_O = 10mW f_{2H} = 1-520MHz	-45	-55	—	dB
PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 1-520MHz at -32dB	300	400	—	mW

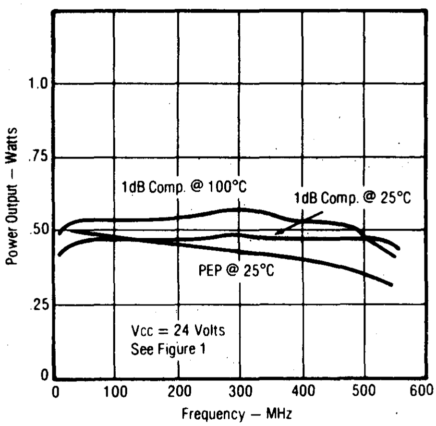
GAIN VS. FREQUENCY



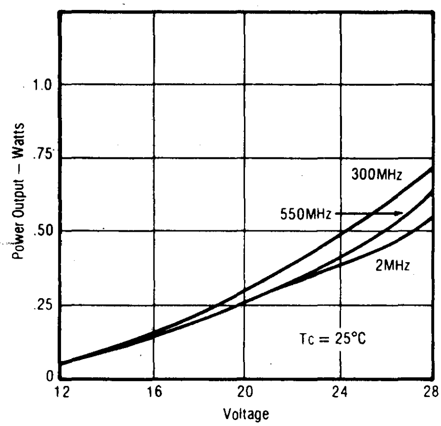
GAIN VS. VOLTAGE



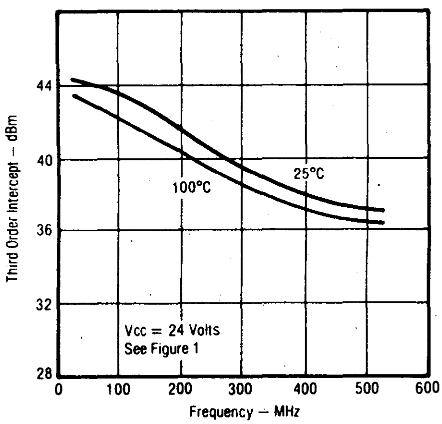
POWER OUTPUT VS. FREQUENCY



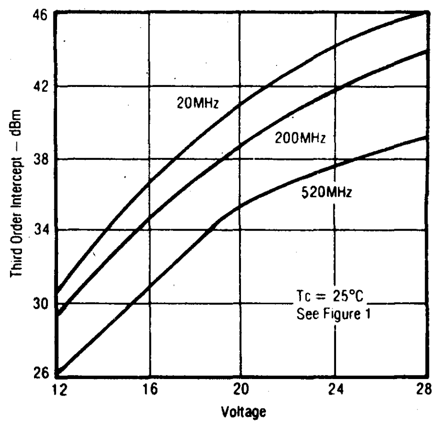
1dB COMPRESSION VS. VOLTAGE



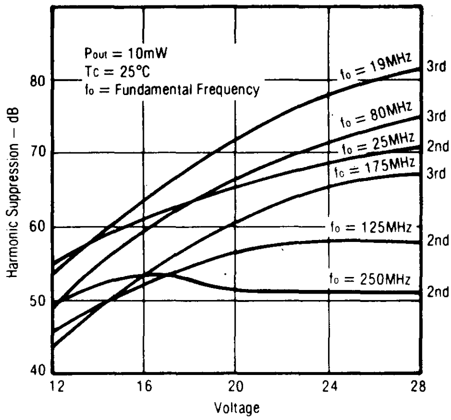
THIRD ORDER INTERCEPT VS. FREQUENCY



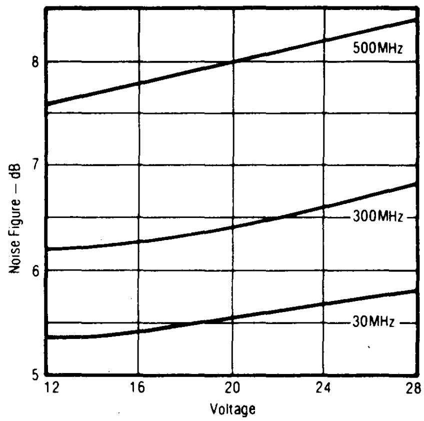
THIRD ORDER INTERCEPT VS. VOLTAGE



SECOND AND THIRD HARMONIC SUPPRESSION VS. VOLTAGE



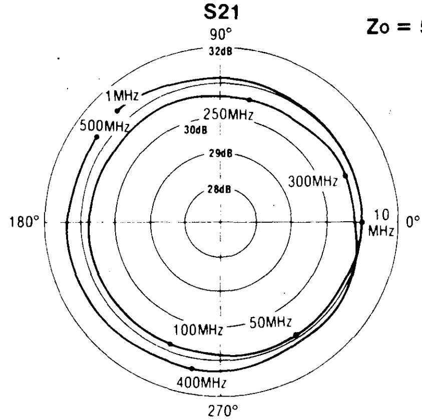
NOISE FIGURE VS. VOLTAGE



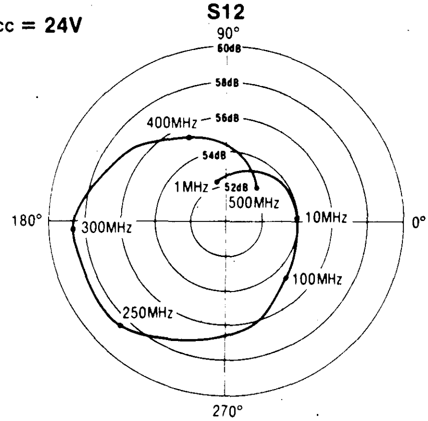
S-PARAMETERS

Zo = 50Ω, Vcc = 24V

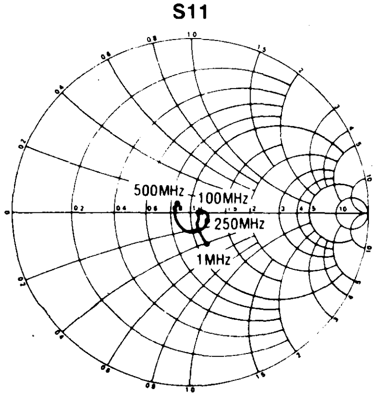
S21



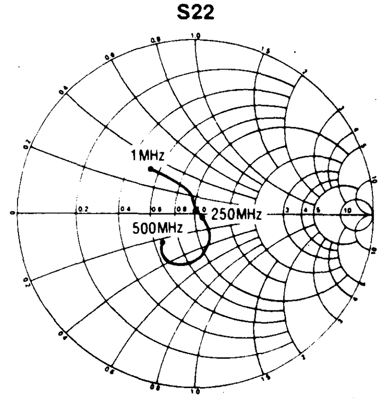
S12



S11

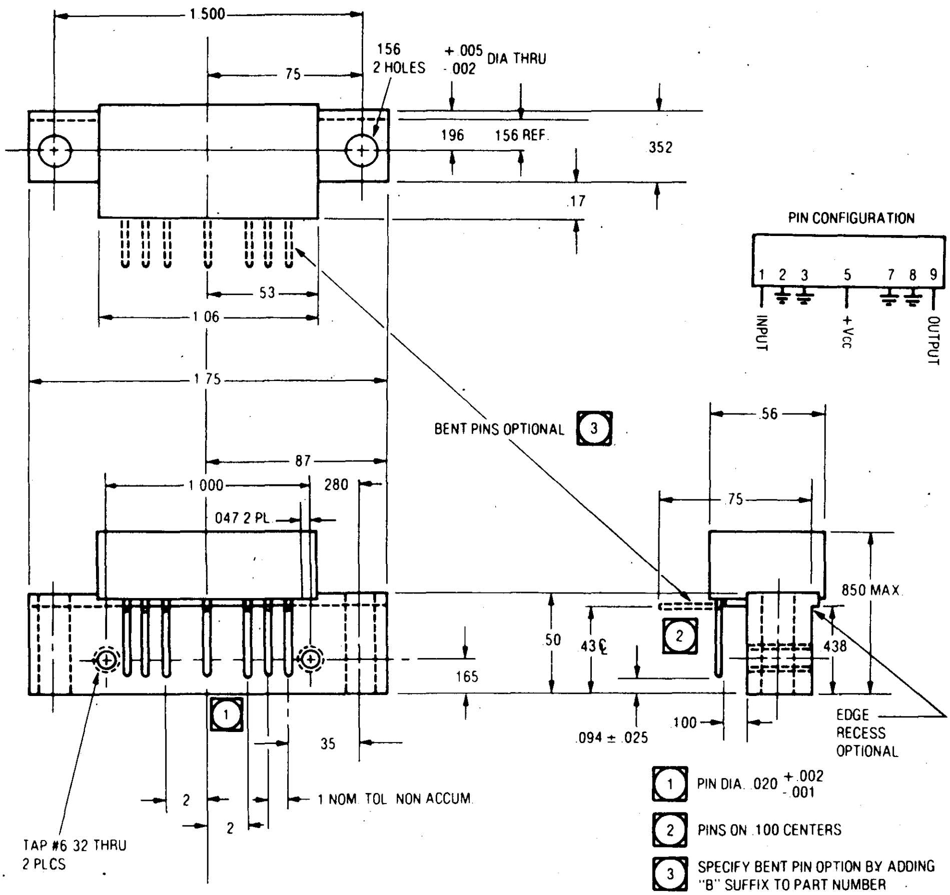


S22



F

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

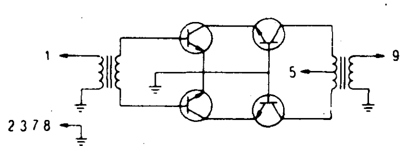
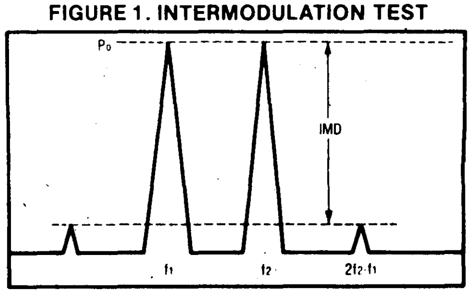


FIGURE 1. INTERMODULATION TEST



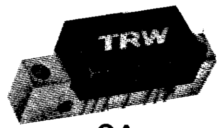
$$I_{TO} = P_o + \frac{IMD}{2} \text{ @ } IMD > 60dB$$

$$PEP = 4X\ P_o \text{ @ } IMD = -32dB$$

TRW

Thin Film RF Linear Hybrid Amplifier

- **High Gain (34.5dB), Low Distortion (Push-pull Circuitry)**
- **1W Output Power at 28V**



CA

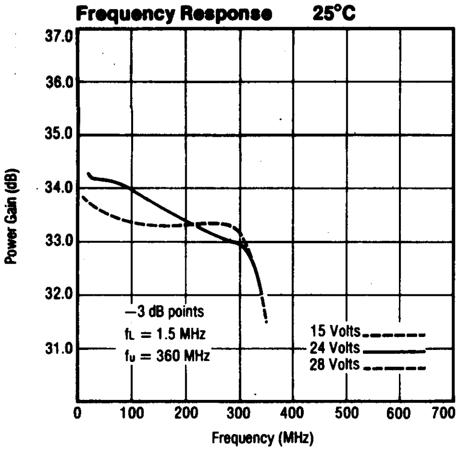
- Wide dynamic range: +46dBm third order intercept
- Unconditional stability under all load conditions
- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
- Transmitter driver for HF, VHF communications radios
- Fiber optic driver for laser/L.E.D. diodes
- Driver for acousto-optic modulators
- High performance linear amplifier for all types of analog/digital waveforms

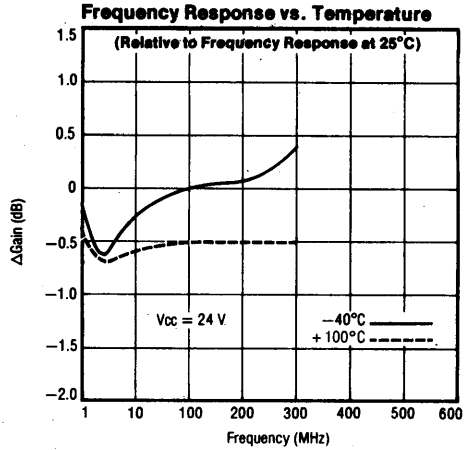
F

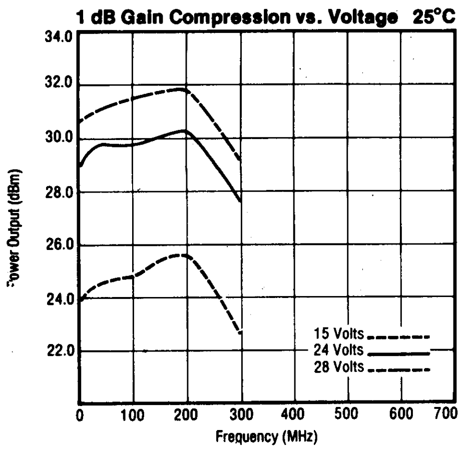
Electrical Characteristics For 50Ω Systems (T_{CASE} = +25°C and +24V*)

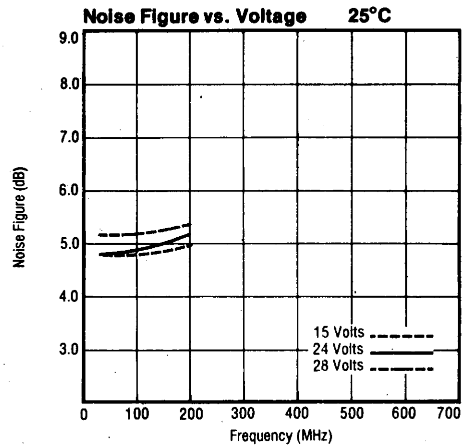
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				+28	volts
	P_{IN}	RF Power Input				+5	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE} = +25°C and +24V*)	P_G	Power Gain	f = 100MHz	33.5	34.5	35.5	dB
	F_R	Frequency Response	f = 5-200MHz	—	± 0.5	± 1.0	dB
	P_O	Power Output, 1dB Compression	f = 5-200MHz	+28	+29	—	dBm
	P_O	Power Output, 1dB Compression, V_{CC} = 28V	f = 5-200MHz	+30	+31	—	dBm
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 5-200MHz @ -32dB IMD	600	800	—	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 200MHz	+44	+46	—	dBm
	d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2H} = 150MHz	-50	-60	—	dB
	NF	Noise Figure, Broadband	f = 200MHz	—	4.7	5.5	dB
	VSWR	Input/Output VSWR (50Ω)	f = 5-200MHz	—	1.5:1	2.0:1	N/A
	I_{CC}	Supply Current	24V	270	300	330	mA

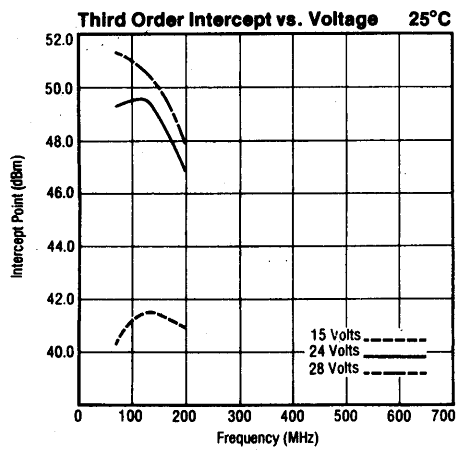
*Except for power output as noted.

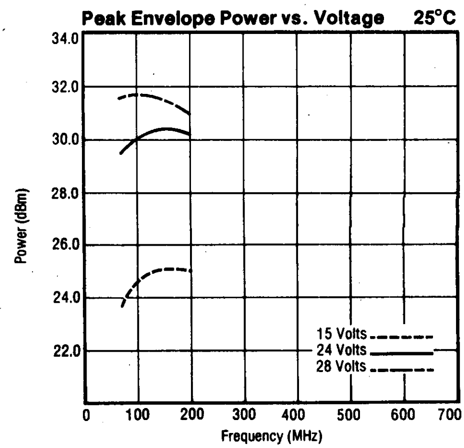

Frequency Response 25°C
Power Gain (dB)
37.0
36.0
35.0
34.0
33.0
32.0
31.0
−3 dB points
fL = 1.5 MHz
fu = 360 MHz
15 Volts
24 Volts
28 Volts
0
100
200
300
400
500
600
700
Frequency (MHz)

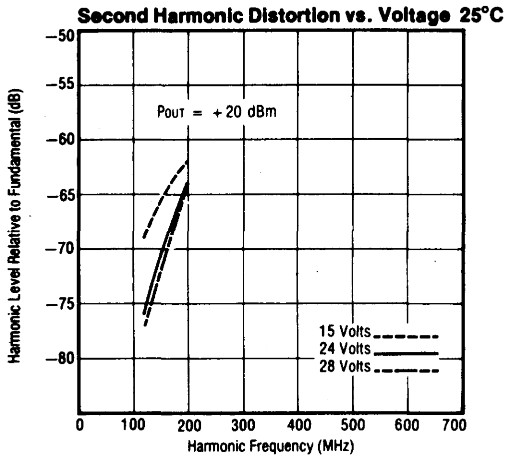

Frequency Response vs. Temperature
(Relative to Frequency Response at 25°C)
ΔGain (dB)
1.5
1.0
0.5
0
−0.5
−1.0
−1.5
−2.0
Vcc = 24 V
−40°C
+100°C
1
10
100
200
300
400
500
600
Frequency (MHz)

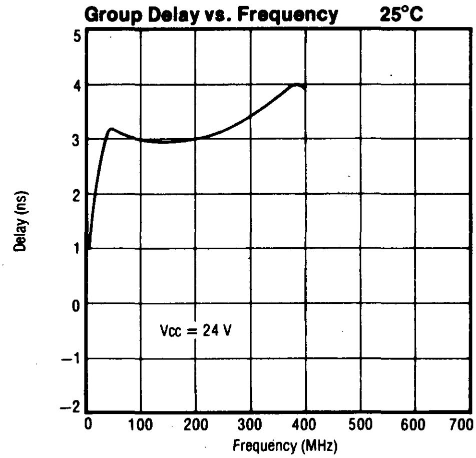

1 dB Gain Compression vs. Voltage 25°C
Power Output (dBm)
34.0
32.0
30.0
28.0
26.0
24.0
22.0
15 Volts
24 Volts
28 Volts
0
100
200
300
400
500
600
700
Frequency (MHz)


Noise Figure vs. Voltage 25°C
Noise Figure (dB)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
15 Volts
24 Volts
28 Volts
0
100
200
300
400
500
600
700
Frequency (MHz)


Third Order Intercept vs. Voltage 25°C
Intercept Point (dBm)
52.0
50.0
48.0
46.0
44.0
42.0
40.0
15 Volts
24 Volts
28 Volts
0
100
200
300
400
500
600
700
Frequency (MHz)


Peak Envelope Power vs. Voltage 25°C
Power (dBm)
34.0
32.0
30.0
28.0
26.0
24.0
22.0
15 Volts
24 Volts
28 Volts
0
100
200
300
400
500
600
700
Frequency (MHz)





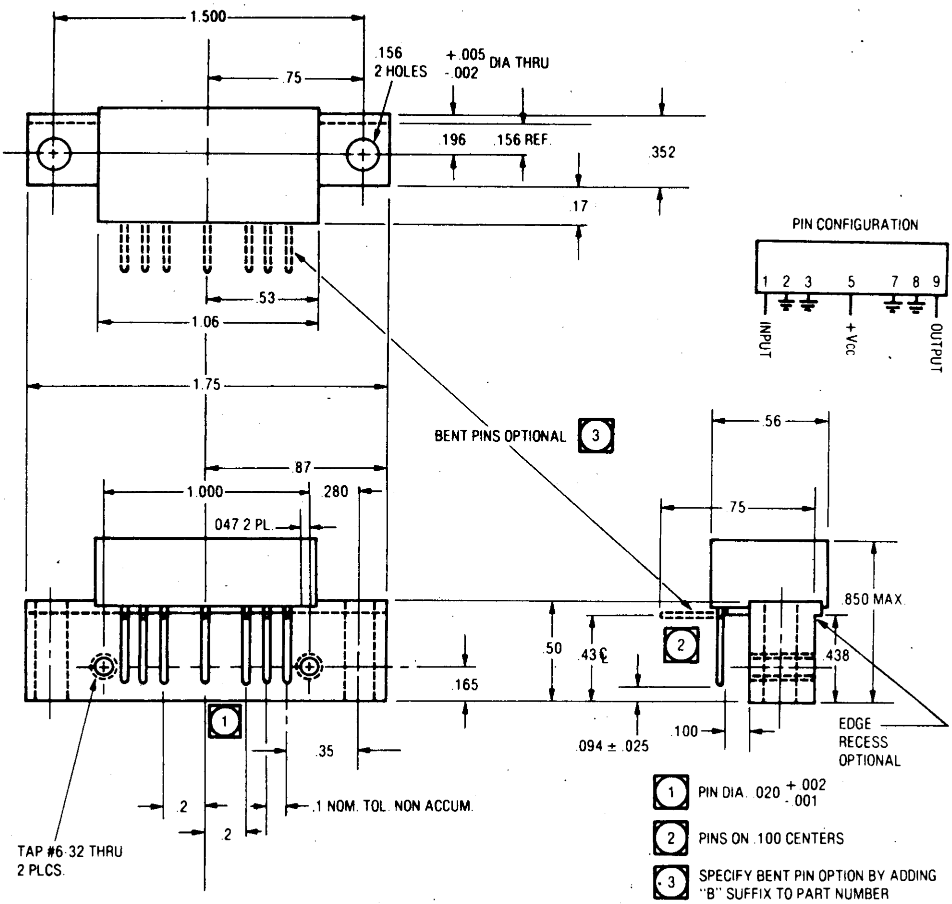
S-Parameters

Biased at 24 Volts T = 25°C Zo = 50Ω

Frequency (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
5	-18.3	66.2	34.6	15.2	-47.0	17.7	-9.8	87.4
10	-19.3	45.5	34.6	-0.6	-47.0	2.3	-14.5	76.8
50	-15.6	35.0	34.2	-56.7	-47.5	-30.3	-12.6	45.0
100	-13.2	34.4	33.9	-114	-47.9	-62.9	-10.8	10.7
200	-11.1	30.1	33.5	134	-48.3	-128	-14.9	-42.6

Magnitude in dB, Phase Angle in degrees.

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

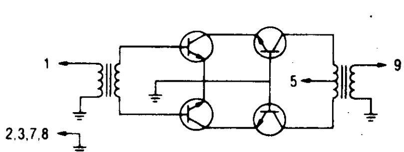
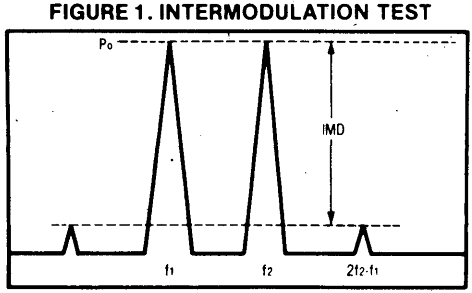


FIGURE 1. INTERMODULATION TEST



$I_{TO} = P_o + \frac{IMD}{2}$ @ IMD > 60dB

PEP = 4X P_o @ IMD = -32dB

TRW

Thin Film RF Linear Hybrid Amplifier

- **High Gain — 35.5dB**
- **Low Distortion**
- **2W Output @ 28V**

CA

- High gain (35.5dB), low distortion (push-pull circuitry)
- 2W output power at 28V
- Wide dynamic range: +47dBm third order intercept
- Unconditional stability under all load conditions
- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
- Transmitter driver for HF, VHF communications radios
- Fiber optic driver for laser/L.E.D. diodes
- Driver for acousto-optic modulators
- High performance linear amplifier for all types of analog/digital waveforms

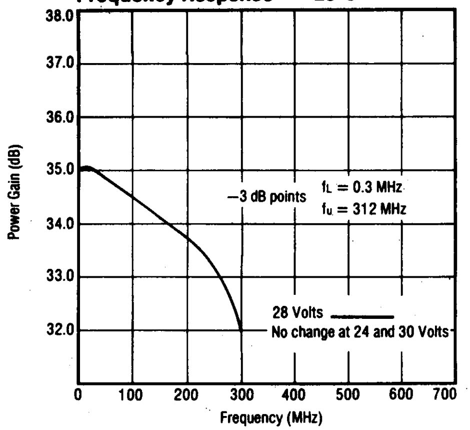
Absolute Maximum Ratings

Supply Voltage	RF Power Input	Storage Temperature	Case Operating Temperature
+30 Volts	+15dBm	−55°C to +125°C	-40°C to +100°C

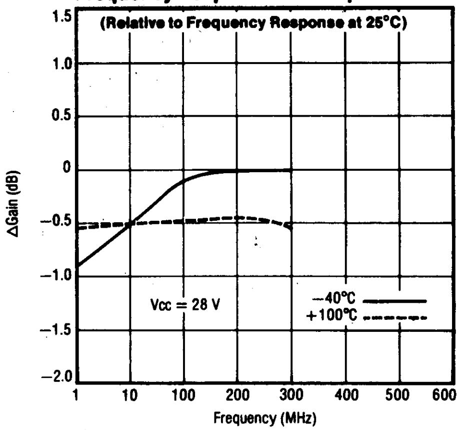
Electrical Characteristics for 50Ω Systems (T_{CASE} = +25°C and +28V)

Symbol	Characteristic	Conditions	Min.	Typ.	Max.	Units
P_G	Power Gain	f = 100MHz	34.0	35.5	37.0	dB
F_R	Frequency Response	f = 1-200MHz	—	±0.5	±1.0	dB
P_o	Power Output, 1dB Compression	f = 1-200MHz	+31	+32	—	dBm
P_o	Power Output, 1dB Compression	f = 150MHz	—	+33	—	dBm
PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 1-200MHz @ −32dB IMD	—	900	—	mW
I_{TO}	Third Order Intercept, See Figure 1	f = 200MHz	+45	+47	—	dBm
dso	Second Harmonic Suppression	P_o = 100mW f_{2H} = 150MHz	−60	−70	—	dB
NF	Noise Figure, Broadband	f = 200MHz	—	6	7	dB
VSWR	Input/Output VSWR (50Ω)	f = 1-200MHz	—	1.5:1	2.0:1	N/A
I_{CC}	Supply Current	28V	400	435	470	mA

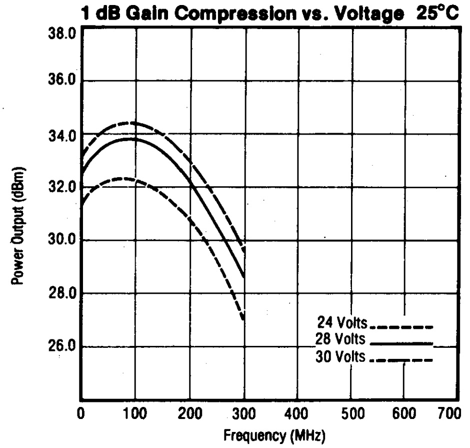
Frequency Response 25°C



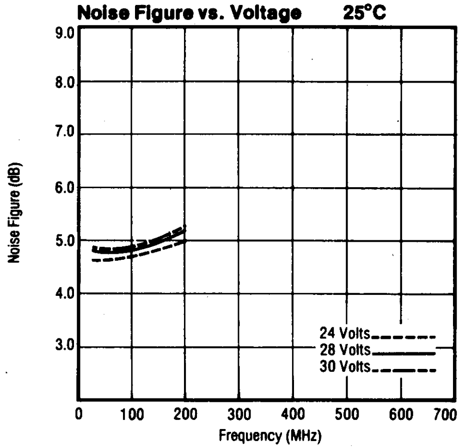
Frequency Response vs. Temperature



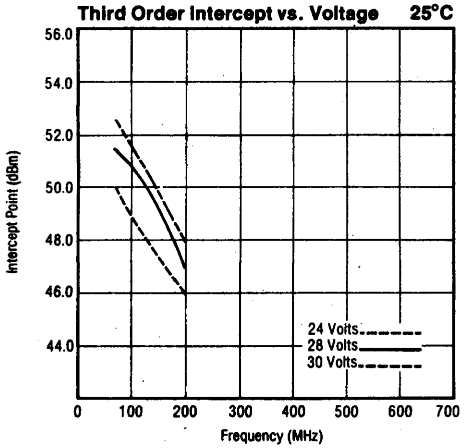
1 dB Gain Compression vs. Voltage 25°C



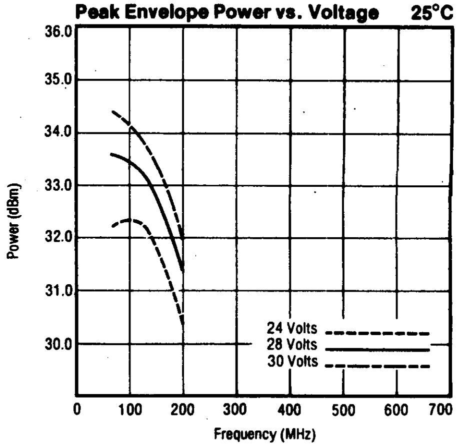
Noise Figure vs. Voltage 25°C

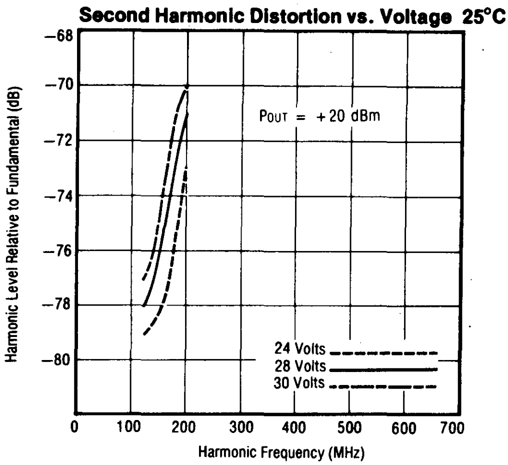


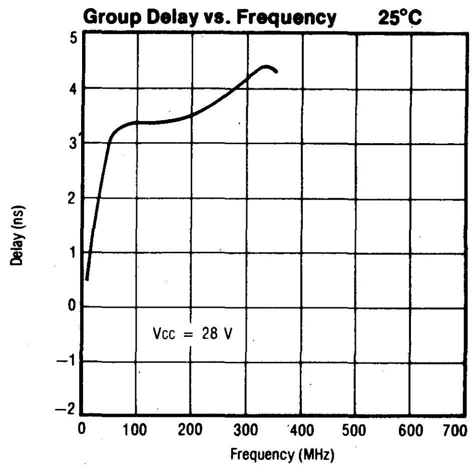
Third Order Intercept vs. Voltage 25°C



Peak Envelope Power vs. Voltage 25°C







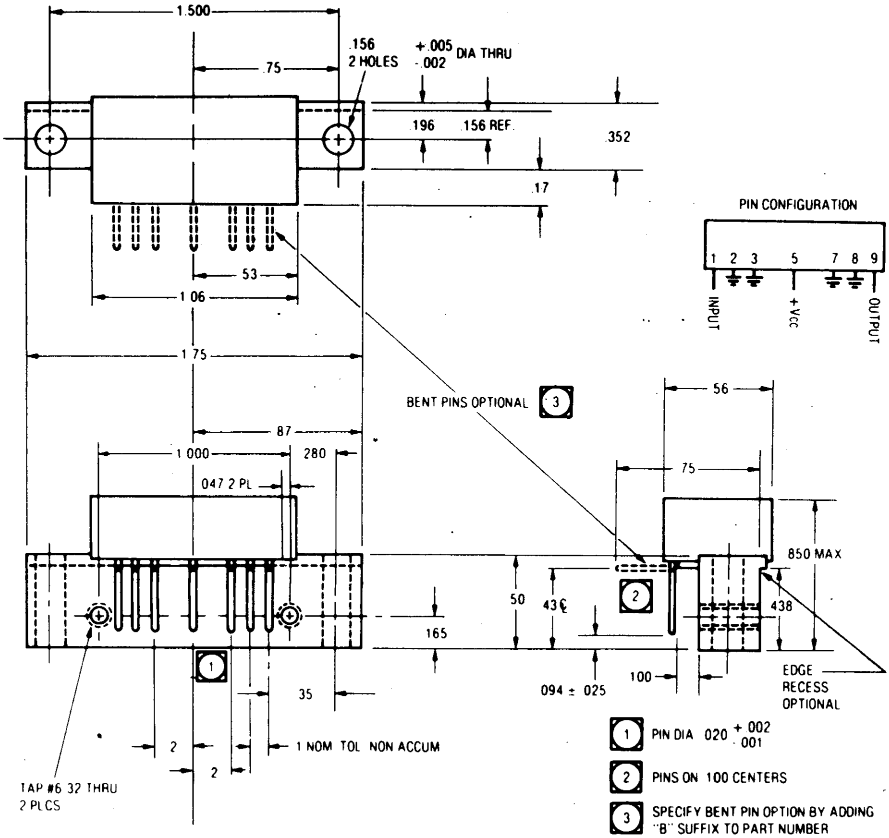
S-Parameters

Biased at 28 Volts T = 25°C Zo = 50Ω

Frequency (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
1	-17.6	79.3	35.2	23.5	-48.0	28.1	-12.6	60.5
10	-19.7	31.2	35.7	-9.1	-47.3	-4.9	-16.4	25.0
50	-16.0	30.6	35.5	-63.6	-48.0	-37.7	-11.8	9.8
100	-13.3	37.4	35.0	-126	-48.7	-75.0	-10.7	-34.2
200	-10.0	27.6	34.3	110	-50.5	-154	-9.8	-136

Magnitude in dB, Phase Angle in degrees.

CA2832 PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

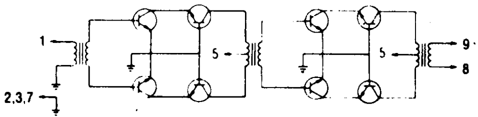
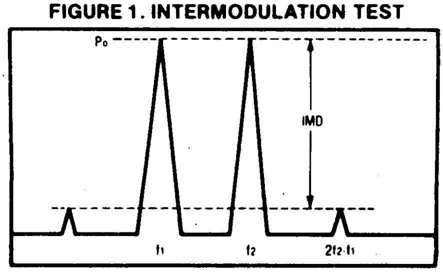


FIGURE 1. INTERMODULATION TEST

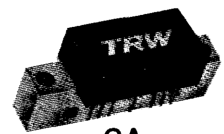


$$I_{TO} = P_o + \frac{IMD}{2} \text{ @ } IMD > 60dB$$

$$PEP = 4X\ P_o \text{ @ } IMD = -32dB$$

Thin Film RF Linear Hybrid Amplifier

- **22dB Gain, Low Distortion (Push-pull Circuitry)**
- **1W Output Power at 28V**
- **Matched for 75Ω Applications**



CA

- Unconditional stability under all load conditions
- All gold (monometallic) metallization system featuring gold transistor die with diffused ballast resistors for the ultimate in reliability
- Local oscillator buffer amp for high level mixer
- 75 ohm IF post amplifier
- High performance linear amplifier for all types of analog/digital waveforms

ABSOLUTE MAXIMUM RATINGS

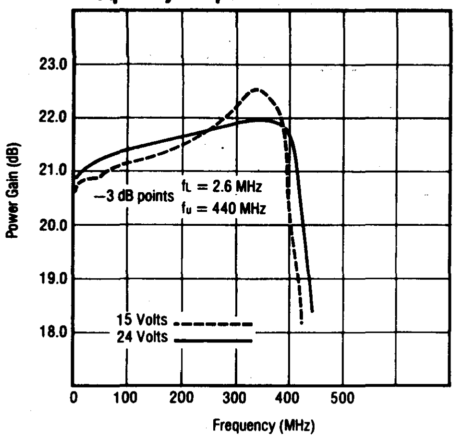
Supply Voltage	RF Power Input	Storage Temperature	Case Operating Temperature
+28 Volts	+14dBm	-55°C to +125°C	-40°C to +100°C

ELECTRICAL CHARACTERISTICS FOR 75Ω SYSTEMS (T_{CASE} = +25°C and +24V*)

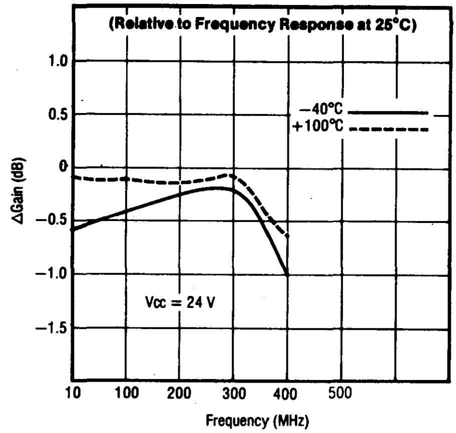
Symbol	Characteristics	Conditions	Min.	Typ.	Max.	Units
P_G	Power Gain	f = 100MHz	21	22	23	dB
F_R	Frequency Response	f = 30-300MHz	—	±0.5	±1.0	dB
P_O	Power Output, 1dB Compression	f = 30-200MHz	+29	+30	—	dBm
P_O	Power Output, 1dB Compression, V_{CC} = 28V	f = 30-200MHz	+30	+31	—	dBm
PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 200MHz @ -32dB IMD	550	650	—	mW
I_{TO}	Third Order Intercept, See Figure 1	f = 30-300MHz	+43	+46	—	dBm
d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2h} = 300MHz	-50	—	—	dB
NF	Noise Figure, Broadband	f = 100MHz	—	5	6	dB
VSWR	Input/Output VSWR (75Ω)	f = 30-300MHz	—	1.2:1	1.3:1	N/A
I_{CC}	Supply Current	24V	210	230	250	mA

*Except for power output as noted.

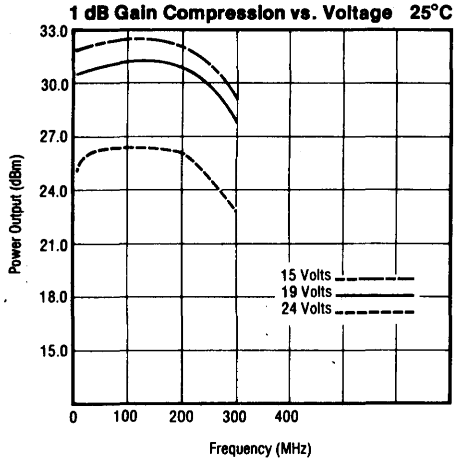
Frequency Response 25°C



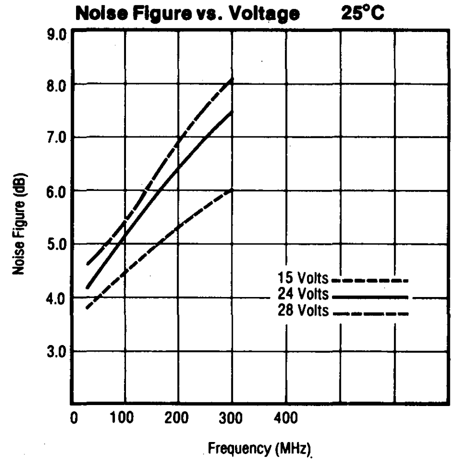
Frequency Response vs. Temperature



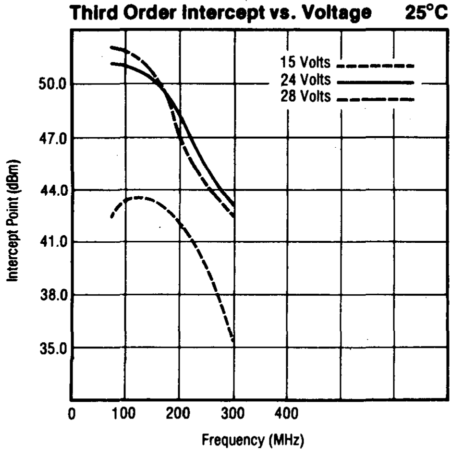
1 dB Gain Compression vs. Voltage 25°C



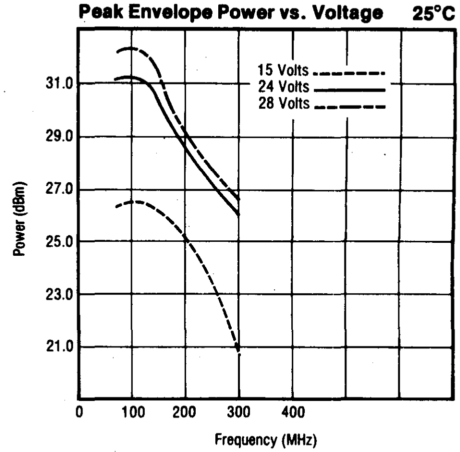
Noise Figure vs. Voltage 25°C



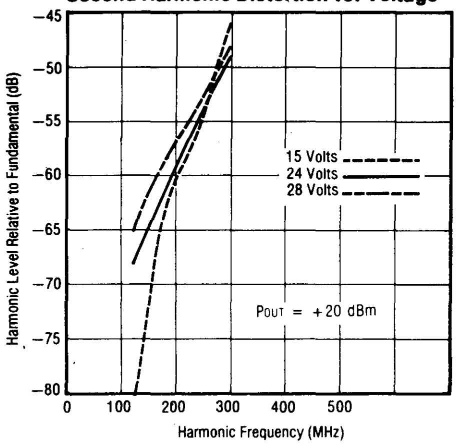
Third Order Intercept vs. Voltage 25°C



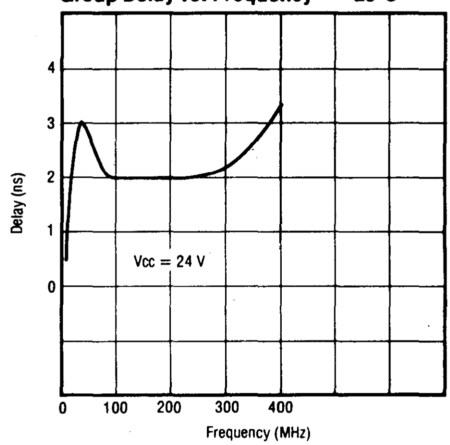
Peak Envelope Power vs. Voltage 25°C



Second Harmonic Distortion vs. Voltage 25°C



Group Delay vs. Frequency 25°C



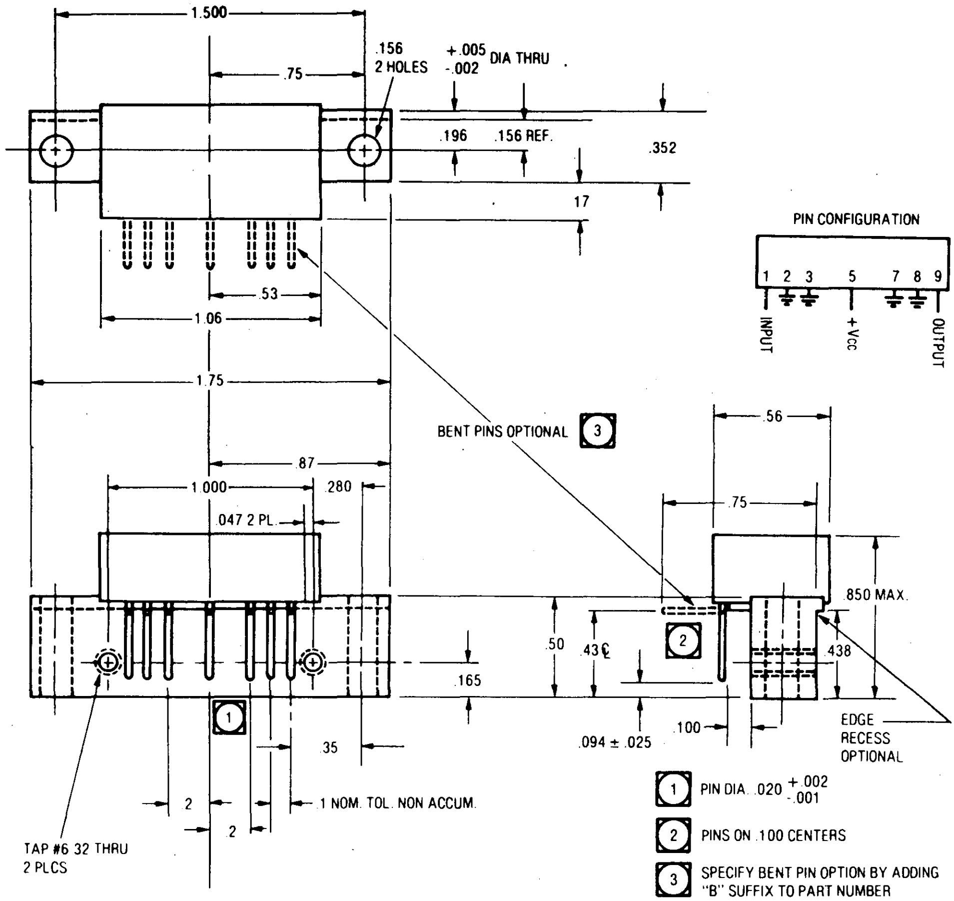
S-Parameters

Biased at 24 Volts T = 25°C Zo = 50Ω

Frequency (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
10	-8.21	21.5	20.9	11.4	-27.1	-168	-9.34	21.5
50	-10.8	-8.5	21.1	-33.1	-27.1	156	-11.3	-9.0
100	-13.5	-12.2	21.4	-73.3	-26.9	125	-14.7	-35.8
200	-12.6	40.9	21.5	-152	-27.5	65.5	-15.4	47.9
300	-10.6	10.7	21.9	123	-29.1	-0.2	-12.4	20.6

Magnitude in dB, Phase Angle in degrees.

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

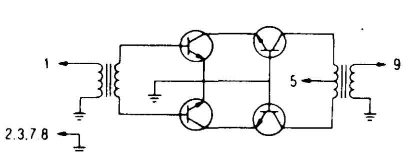
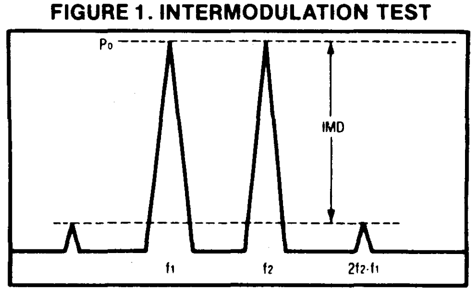


FIGURE 1. INTERMODULATION TEST



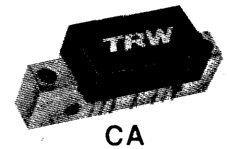
$$I_{TO} = P_o + \frac{IMD}{2} \text{ @ } IMD > 60dB$$

$$PEP = 4X\ P_o \text{ @ } IMD = -32dB$$

TRW

VHF-UHF Linear Amplifier

- **Wide Bandwidth: 10 MHz-1000 MHz**
- **17 dB Gain**
- **Wide Dynamic Range: 7 dB Noise Figure**
- **40 dBm Third Order Intercept**
- **Low Second Order Distortion: Push Pull Circuitry**
- **Optimized for 24 V Power Supply**
- **400 mW Output Power**



CA

F

The CA 4800 RF amplifier is a low cost, push-pull hybrid circuit offering low second and third harmonic distortion. Production techniques used in the CA 4800 have been proven in the manufacture of millions of TRW CATV amplifiers.
Uses include IF and preamplifier service for Electronic Counter Measures (ECM), Radar and communications, a "total coverage" TV preamplifier, cable driver, driver for TV transposers, general instrumentation, broad band sweep generators, plus numerous other applications requiring 17 dB of gain, 400 mW power output and low distortion over the 10-1000 MHz bandwidth.
For Military and other special applications, the CA 4800 is available in a hermetic package (CA 4800 H).

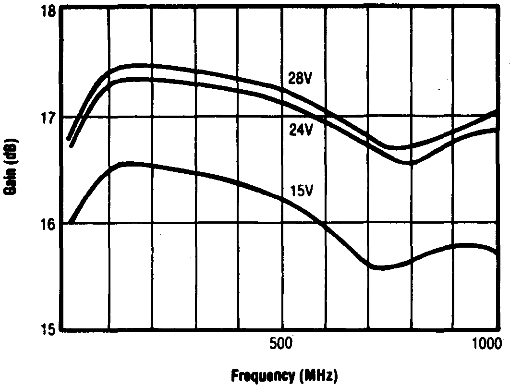
Electrical Characteristics For 50Ω Systems (T_{case} = 25°C and 24V Supply)

Symbol	Characteristics	Conditions	Min.	Typ.	Max.	Units
P_G	Power Gain	f = 100MHz	16	17	18	dB
F_R	Frequency Response	10-1000MHz		±0.5	±1	dB
P_o	Power Output, 1dB Compression	f = 500MHz	300	400		mW
I_{TO}	Third Order Intercept see Figure 1	10-1000MHz	38	40		dBm
d_{SO}	Second Harmonic Suppression	P_o = 100mW f_{2h} = 1000MHz	−40	−50		dB
N_F	Noise Figure	f = 500MHz f = 1000MHz		6.5 7.5	8 9	dB
VSWR	Input/Output (50Ω)	40-860MHz 10-1000MHz			2:1 2.5:1	N/A
I_{CC}	Supply Current	24V	200	220	240	mA
PEP	Peak Envelope Power — For 2 Tone Distortion Test, see Fig. 1	f = 500MHz		25		dBm
IMD	Intermodulation Distortion TV Test (−8 −17 −10) See Fig. 2	f = 860MHz P_{sync} = 200mW		−60		dB

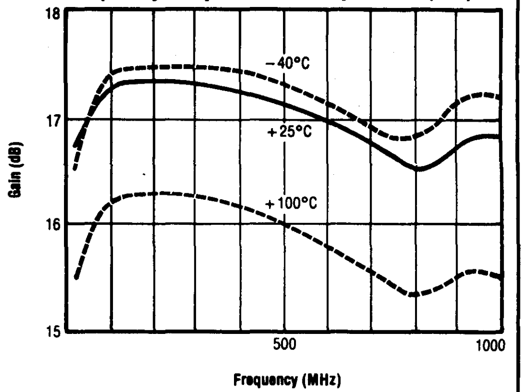
Absolute Maximum Ratings

Supply Voltage	RF Power Input	Storage Temperature	Case Operating Temp.
+28 Volts	+14dBm	−55°C to +125°C	−40°C to +100°C

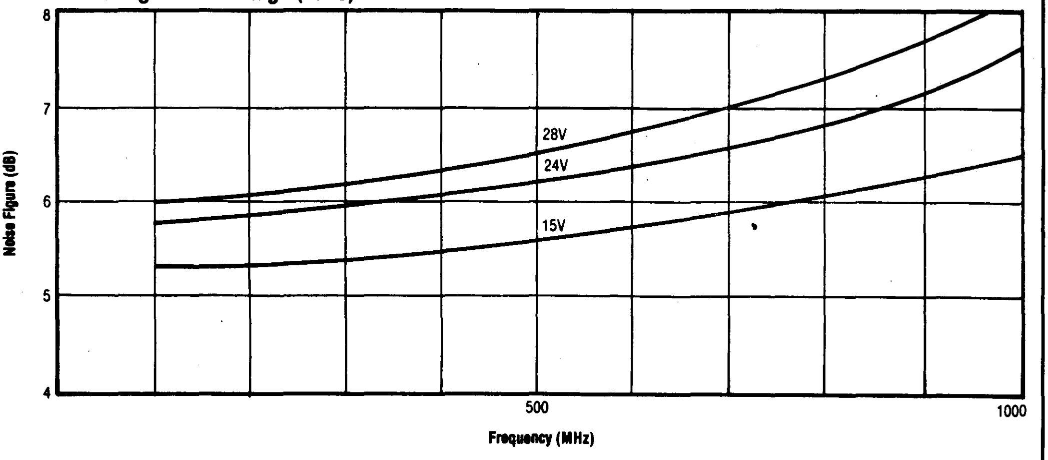
Frequency Response vs. Voltage (+25°C)



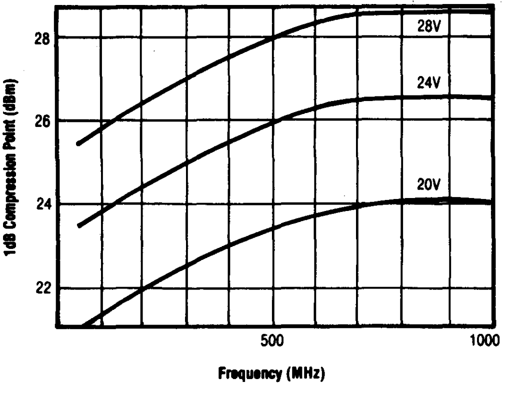
Frequency Response vs. Temperature (24V)



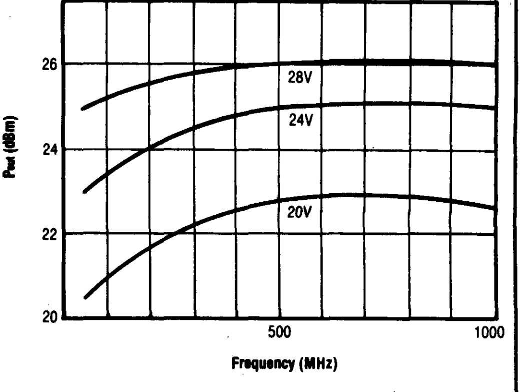
Noise Figure vs. Voltage (25°C)



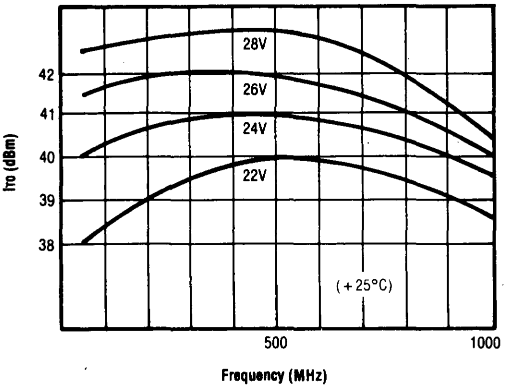
1dB Compression vs. Voltage (25°C)



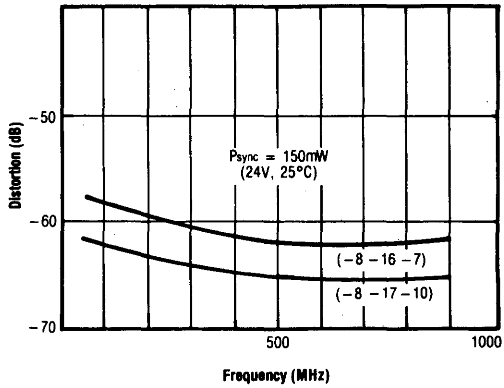
Peak Envelope Power vs. Voltage (+25°C)



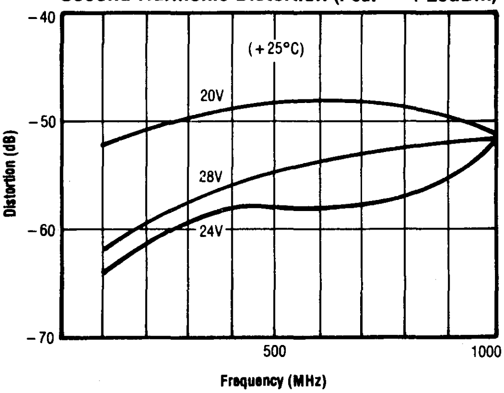
Third Order Intercept vs. Frequency vs. Voltage



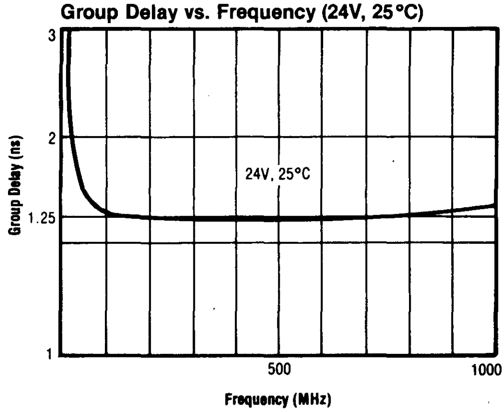
Intermodulation: TV Test



Second Harmonic Distortion (Pout = +20dBm)



Group Delay vs. Frequency (24V, 25°C)



CA4800 S PARAMETERS

Biased at 24 Volts
220mA
Zo = 50 Ohms

Frequency (MHz)	S11		S21		S12		S22		k
10	−25.26	116.3	16.71	13.8	−43.08	−34.0	−12.00	95.3	9.766
110	−39.97	117.8	17.35	−47.1	−42.15	−8.6	−18.41	33.7	8.596
210	−31.20	130.0	17.35	−92.1	−41.04	−99.1	−17.27	22.1	7.534
310	−27.75	117.0	17.29	−138.1	−39.80	−18.4	−16.91	9.4	6.568
410	−27.26	114.0	17.24	177.3	−38.31	−28.4	−17.64	−4.2	5.588
510	−25.39	125.3	17.14	132.2	−36.36	−39.7	−18.85	−19.7	4.547
610	−21.39	125.2	16.87	88.3	−34.46	−56.3	−19.92	−43.8	3.784
710	−18.22	104.8	16.66	44.3	−32.66	−74.2	−20.26	−85.4	3.146
810	−16.08	71.8	16.50	1.4	−30.48	−94.0	−18.80	−137.1	2.488
910	−12.87	29.5	16.74	−42.7	−28.03	−117.4	−15.81	166.5	1.794
1010	−8.59	−20.8	16.79	−92.1	−25.74	−146.5	−12.71	104.8	1.253

Package Outline

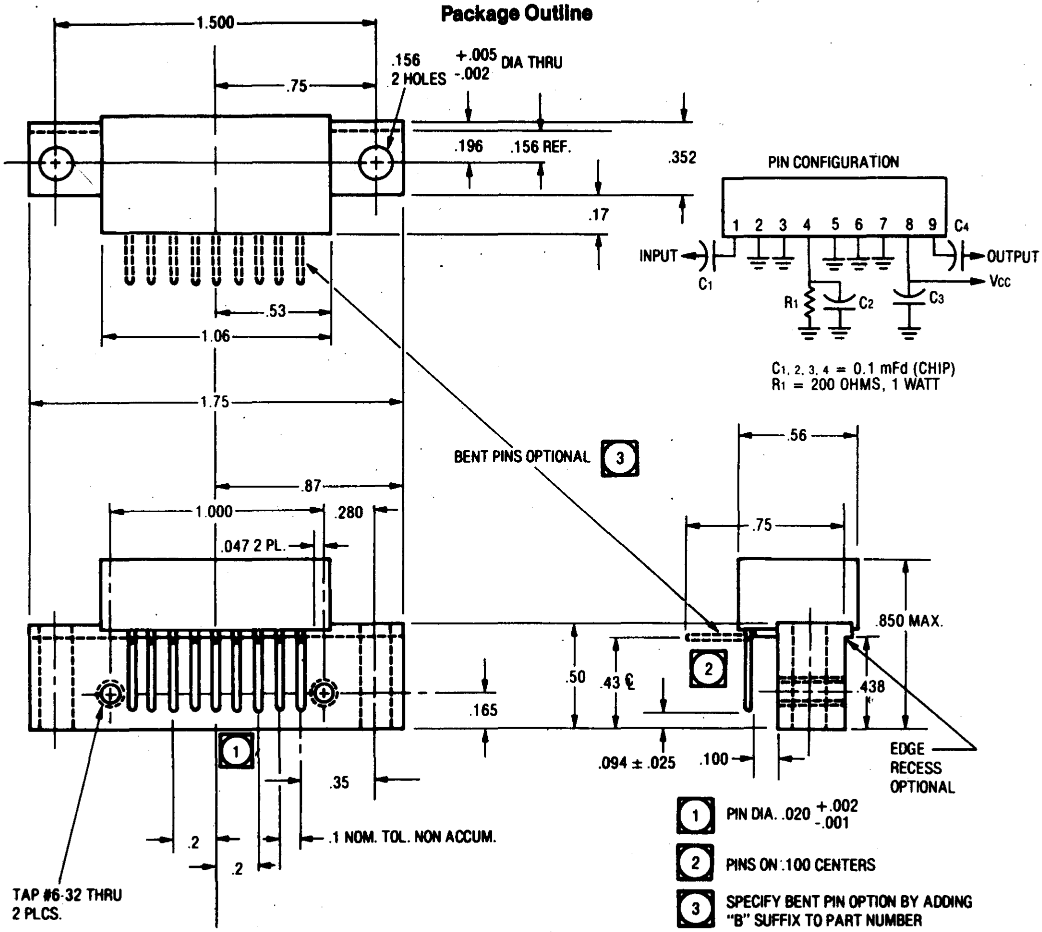
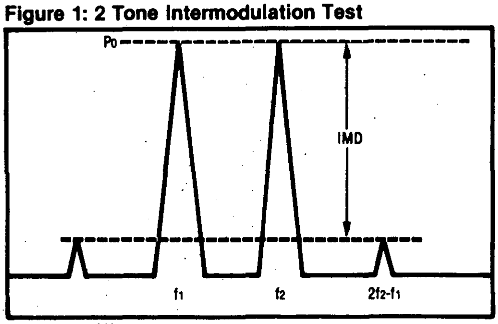


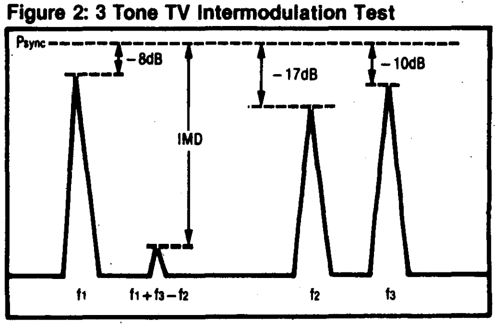
Figure 1: 2 Tone Intermodulation Test



$I_{TO} = P_o + \frac{IMD}{2}$ @ IMD > 60dB

PEP = 4X Po @ IMD = −32dB

Figure 2: 3 Tone TV Intermodulation Test

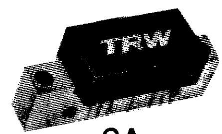


f1: video
f2: sideband
f3: sound

TRW

VHF-UHF Linear Amplifier

- Wide Bandwidth: 10 MHz-1000 MHz
- 17 dB Gain
- Wide Dynamic Range: 7 dB Noise Figure
- 40 dBm Third Order Intercept
- Low Second Order Distortion: Push Pull Circuitry
- Optimized for 12 V Power Supply
- 400 mW Output Power



CA

F

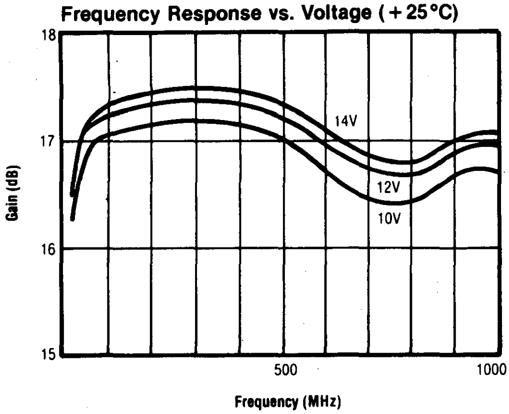
The CA 4812 RF amplifier is a low cost, push-pull hybrid circuit offering low second and third harmonic distortion. Production techniques used in the CA 4812 have been proven in the manufacture of millions of TRW CATV amplifiers.
Uses include IF and preamplifier service for Electronic Counter Measures (ECM), Radar and communications, a "total coverage" TV preamplifier, cable driver, driver for TV transposers, general instrumentation, broad band sweep generators, plus numerous other applications requiring 17 dB of gain, 400 mW power output and low distortion over the 10-1000 MHz bandwidth.
For Military and other special applications, the CA 4812 is available in a hermetic package (CA 4812H).

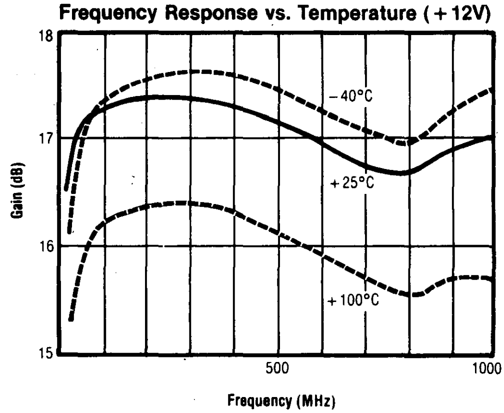
Electrical Characteristics For 50Ω Systems (T_{case} = 25°C and 12V Supply)

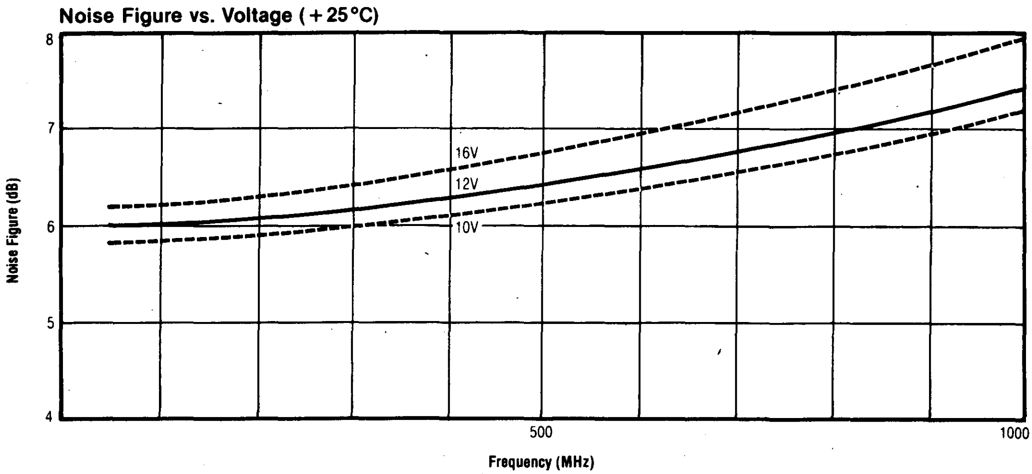
Symbol	Characteristics	Conditions	Min.	Typ.	Max.	Units
P_G	Power Gain	f = 100MHz	16	17	18	dB
F_R	Frequency Response	10-1000MHz		±0.5	±1	dB
P_o	Power Output, 1dB Compression	f = 500MHz	300	400		mW
I_{TO}	Third Order Intercept see Figure 1	10-1000MHz	38	40		dBm
dso	Second Harmonic Suppression	P_o = 100mW f_{2h} = 1000MHz	−40	−50	dB	
N_F	Noise Figure	f = 500MHz f = 1000MHz		6.5 7.5	8 9	dB
VSWR	Input/Output (50Ω)	40-860MHz 10-1000MHz			2:1 2.5:1	N/A
Icc	Supply Current	+12V	360	380	400	mA
PEP	Peak Envelope Power — For 2 Tone Distortion Test, see Fig. 1	f = 500MHz		25		dBm
IMD	Intermodulation Distortion TV Test (−8 −17 −10) See Fig. 2	f = 860MHz P_{sync} = 200mW		−60		dB

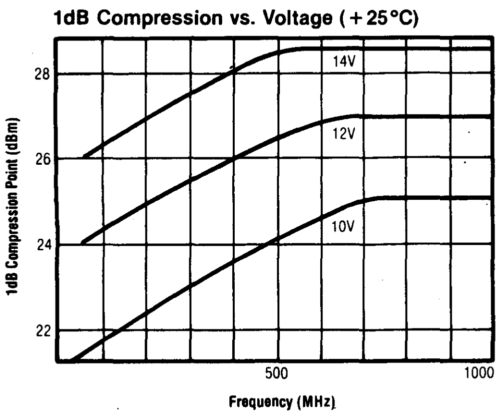
Absolute Maximum Ratings

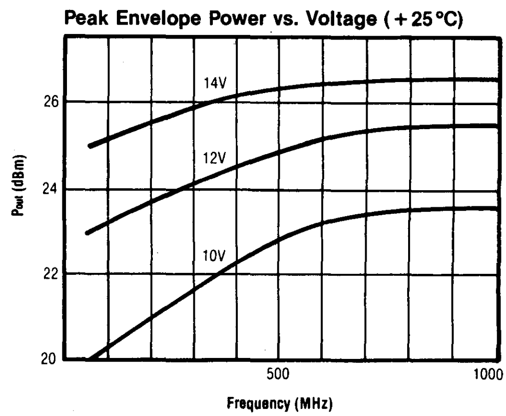
Supply Voltage	RF Power Input	Storage Temperature	Case Operating Temp.
+14 Volts	+14dBm	−55°C to +125°C	−40°C to +100°C


Frequency Response vs. Voltage (+25°C)
18
17
16
15
Gain (dB)
14V
12V
10V
500
1000
Frequency (MHz)

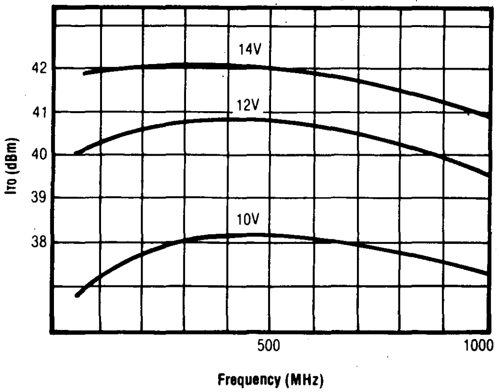

Frequency Response vs. Temperature (+12V)
18
17
16
15
Gain (dB)
−40°C
+25°C
+100°C
500
1000
Frequency (MHz)


Noise Figure vs. Voltage (+25°C)
8
7
6
5
4
Noise Figure (dB)
16V
12V
10V
500
1000
Frequency (MHz)

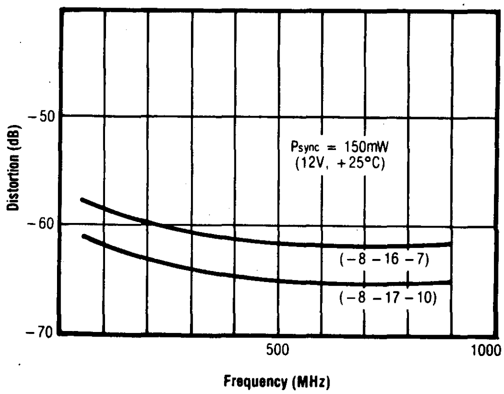

1dB Compression vs. Voltage (+25°C)
28
26
24
22
1dB Compression Point (dBm)
14V
12V
10V
500
1000
Frequency (MHz)


Peak Envelope Power vs. Voltage (+25°C)
26
24
22
20
Pout (dBm)
14V
12V
10V
500
1000
Frequency (MHz)

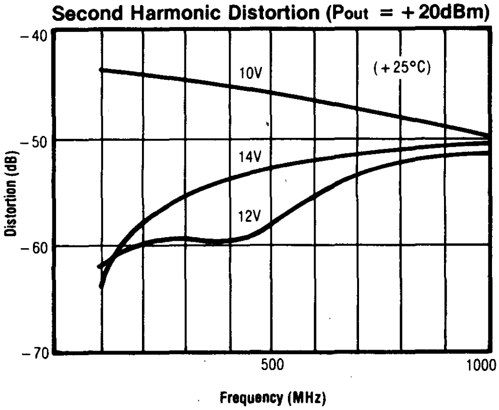
Third Order Intercept vs. Voltage (+25°C)



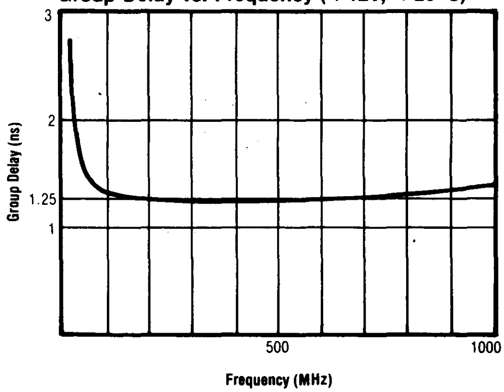
Intermodulation: TV Test



Second Harmonic Distortion (Pout = +20dBm)



Group Delay vs. Frequency (+12V, +25°C)



CA4812 S PARAMETERS

Biased at 12 Volts
378mA
Zo = 50 Ohms

Frequency (MHz)	S11		S21		S12		S22		k
10	−26.45	120.1	16.50	14.2	−43.49	16.8	−11.58	98.1	10.425
110	−39.42	132.5	17.24	−47.2	−42.25	−0.5	−18.18	39.2	8.802
210	−31.22	133.7	17.15	−92.3	−41.15	−4.7	−16.72	29.3	7.787
310	−27.72	118.8	17.39	−138.6	−39.61	−13.4	−16.22	20.5	6.325
410	−27.24	119.2	17.33	176.2	−37.91	−24.1	−16.30	−13.6	5.249
510	−24.56	139.6	17.22	130.5	−36.08	−38.2	−16.64	−5.6	4.329
610	−19.41	136.4	16.97	86.1	−34.27	−55.2	−17.26	−6.6	3.622
710	−15.98	113.6	16.76	41.6	−32.16	−74.7	−19.19	−27.0	2.926
810	−14.04	76.9	16.66	−1.7	−30.01	−95.6	−25.19	−55.8	2.339
910	−11.66	31.1	16.93	−46.4	−27.63	−120.2	−25.82	119.3	1.728
1010	−7.98	−24.7	16.99	−97.3	−25.33	−150.7	−13.13	66.2	1.208

Package Outline

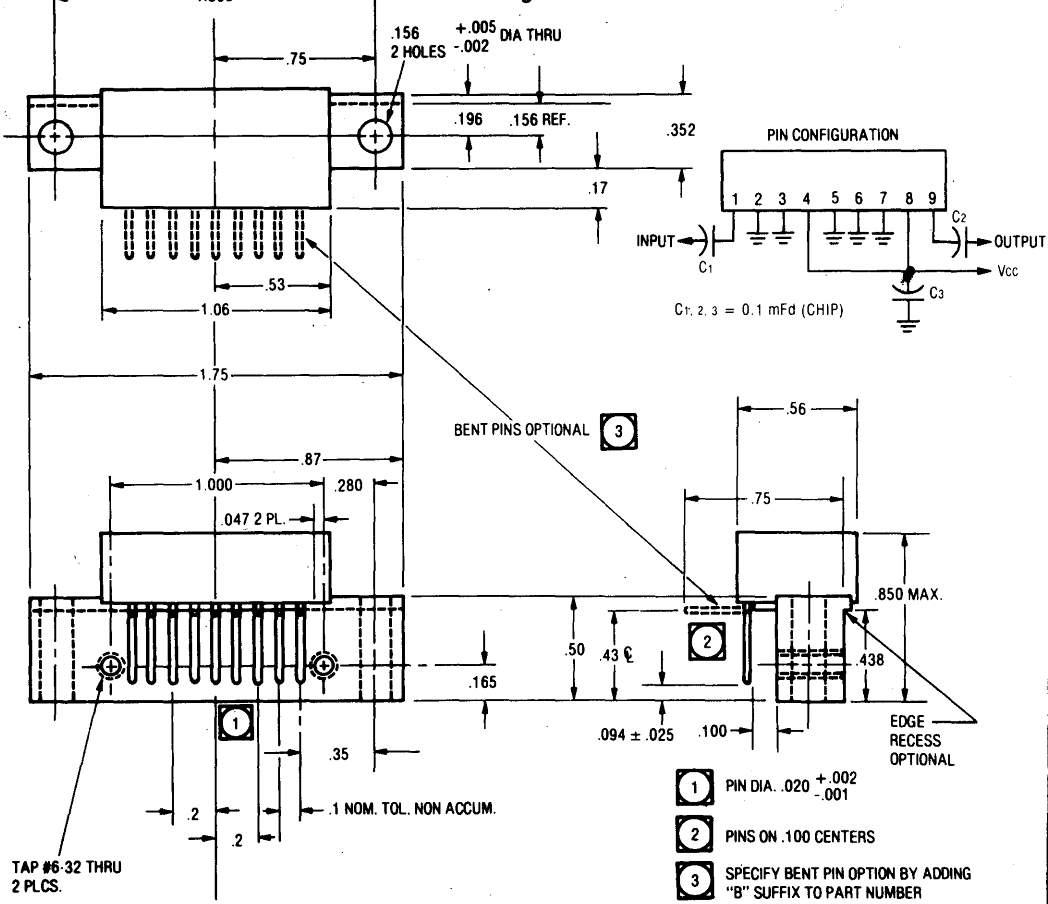
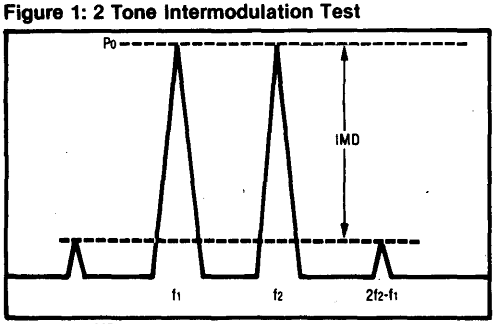


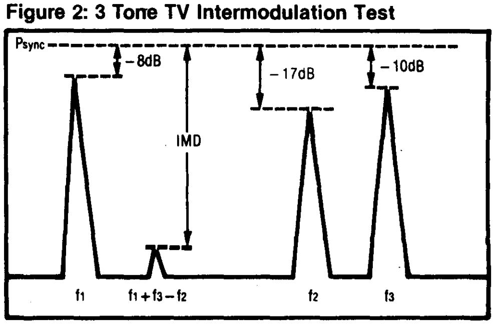
Figure 1: 2 Tone Intermodulation Test



$I_{TO} = P_O + \frac{IMD}{2}$ @ IMD > 60dB

PEP = 4X P_O @ IMD = −32dB

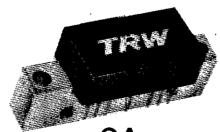
Figure 2: 3 Tone TV Intermodulation Test



f_1: video
f_2: sideband
f_3: sound

VHF-UHF Linear Amplifier

- Wide Bandwidth: 10 MHz-1000 MHz
- 17 dB Gain
- Wide Dynamic Range: 7.5 dB Noise Figure
- 40 dBm Third Order Intercept
- Low Second Order Distortion: Push Pull Circuitry
- Optimized for 15 V Power Supply
- 400 mW Output Power



CA

F

Electrical Characteristics For 50Ω Systems (T_{case} = 25°C and 15V Supply)

Symbol	Characteristics	Conditions	Min.	Typ.	Max.	Units
P_G	Power Gain	f = 100MHz	16	17	18	dB
F_R	Frequency Response	10-1000MHz		±0.5	±1	dB
P_O	Power Output, 1dB Compression	f = 500MHz	300	400		mW
I_{TO}	Third Order Intercept see Figure 1	10-1000MHz	38	40		dBm
d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2h} = 1000MHz	-40	-50		dB
NF	Noise Figure	f = 500MHz f = 1000MHz		6.5 7.5	8 9	dB
VSWR	Input/Output (50Ω)	40-860MHz 10-1000MHz			2:1 2.5:1	N/A
I_{CC}	Supply Current	+15V	360	380	400	mA
PEP	Peak Envelope Power — For 2 Tone Distortion Test, see Fig. 1	f = 500MHz		25		dBm
IMD	Intermodulation Distortion TV Test (-8 -17 -10) See Fig. 2	f = 860MHz P_{sync} = 200mW		-60		dB

Absolute Maximum Ratings

Supply Voltage	RF Power Input	Storage Temperature	Case Operating Temp.
+18 Volts	+14dBm	-55°C to +125°C	-40°C to +100°C

Package Outline

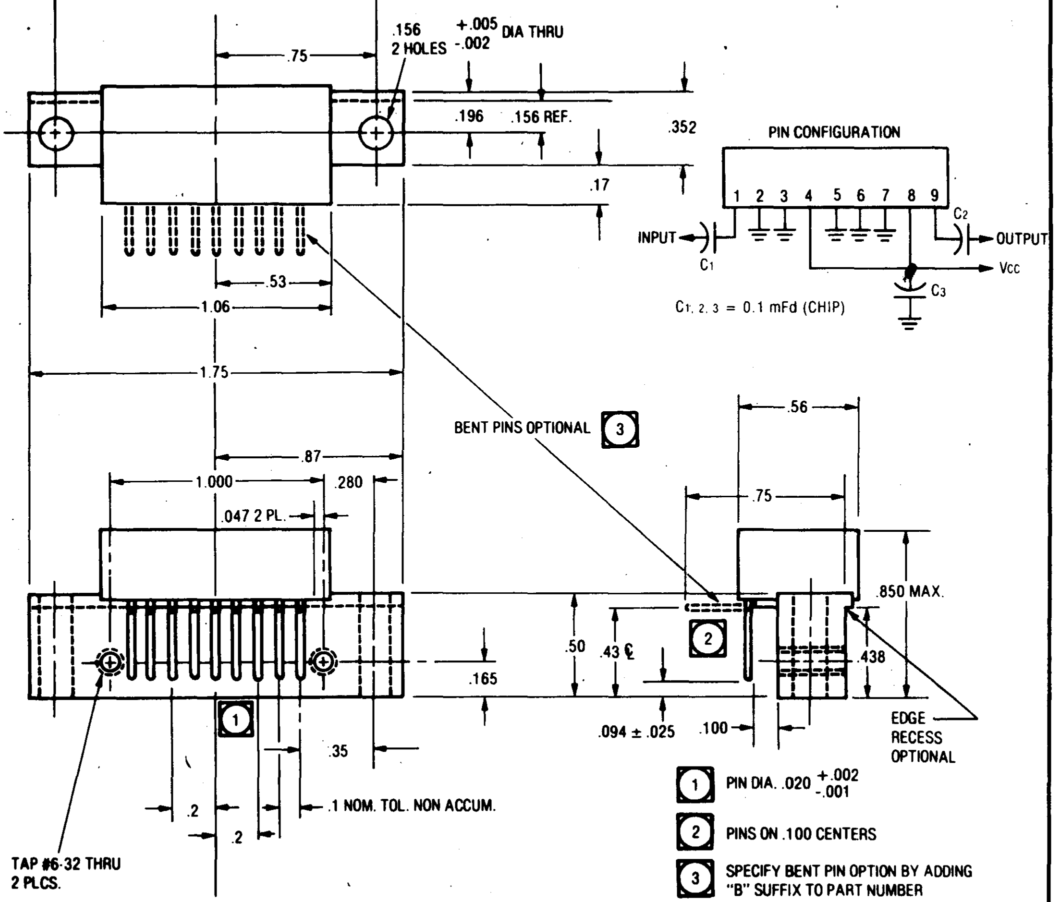
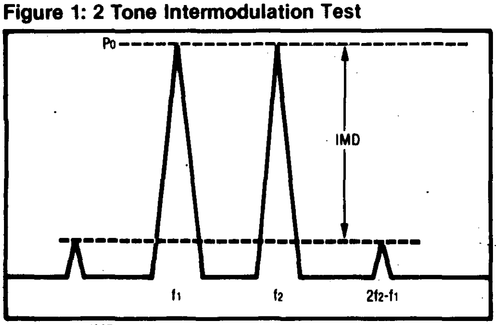


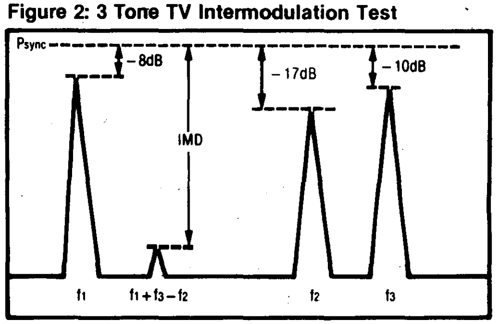
Figure 1: 2 Tone Intermodulation Test



$I_{TO} = P_O + \frac{IMD}{2}$ @ IMD > 60dB

PEP = 4X Po @ IMD = −32dB

Figure 2: 3 Tone TV Intermodulation Test

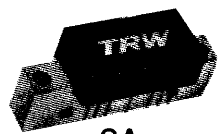


f_1: video
f_2: sideband
f_3: sound

TRW

VHF-UHF Linear Amplifier

- **Wide Bandwidth: 10 MHz-1000 MHz**
- **15 dB Gain**
- **Wide Dynamic Range: 8 dB Noise Figure**
- **43 dBm Third Order Intercept**
- **Low Second Order Distortion: Push Pull Circuitry**
- **Optimized for 28 V Power Supply**
- **1 W Output Power**



CA

F

The CA 5800 RF amplifier is a low cost, push-pull hybrid circuit offering low second and third harmonic distortion. Production techniques used in the CA 5800 have been proven in the manufacture of millions of TRW CATV amplifiers.
Uses include IF and preamplifier service for Electronic Counter Measures (ECM), Radar and communications, a "total coverage" TV preamplifier, cable driver, driver for TV transposers, general instrumentation, broad band sweep generators, plus numerous other applications requiring 15 dB of gain, 1 W power output and low distortion over the 10-1000 MHz bandwidth.
For Military and other special applications, the CA 5800 is available in a hermetic package (CA 5800 H).

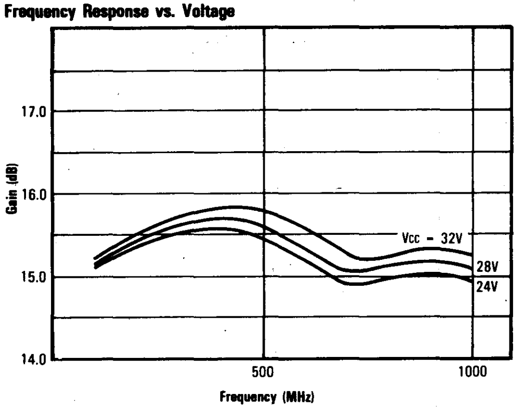
Electrical Characteristics For 50Ω Systems (T_{case} = 25°C and 28V Supply)

Symbol	Characteristics	Conditions	Min.	Typ.	Max.	Units
P_G	Power Gain	f = 100MHz	14	15		dB
F_R	Frequency Response	10-1000MHz		±0.5	±1	dB
P_O	Power Output, 1dB Compression	f = 500MHz	630	1000		mW
I_{TO}	Third Order Intercept see Figure 1	10-1000MHz	41	43		dBm
d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2h} = 1000MHz	-45	-55		dB
N_F	Noise Figure	f = 500MHz f = 1000MHz		7.5 8.5	8.5 9.5	dB
VSWR	Input/Output (50Ω)	40-860MHz 10-1000MHz			2:1 2.5:1	N/A
Icc	Supply Current	28V	360	400	440	mA
PEP	Peak Envelope Power – For 2 Tone Distortion Test, see Fig. 1	f = 500MHz		29		dBm
IMD	Intermodulation Distortion TV Test (-8 -17 -10) See Fig. 2	f = 860MHz P_{sync} = 400mW		-58		dB

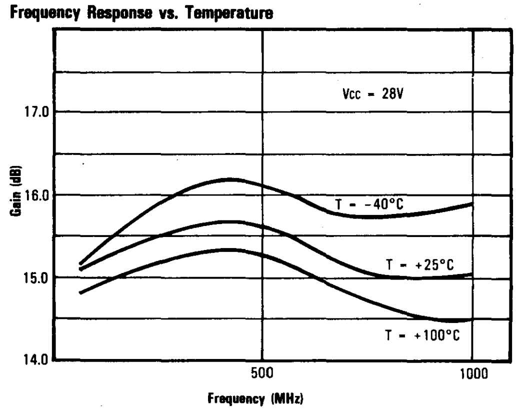
Absolute Maximum Ratings

Supply Voltage	RF Power Input	Storage Temperature	Case Operating Temp.
+32 Volts	+20dBm	-55°C to +125°C	-40°C to +100°C

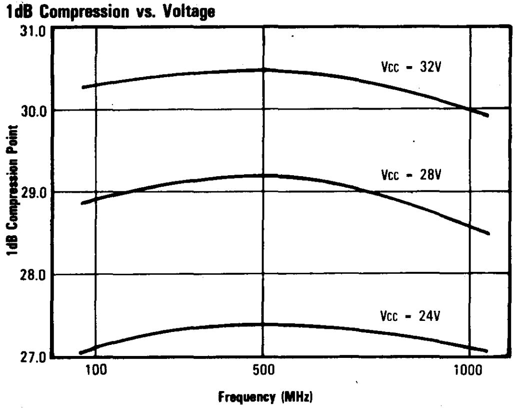
Frequency Response vs. Voltage



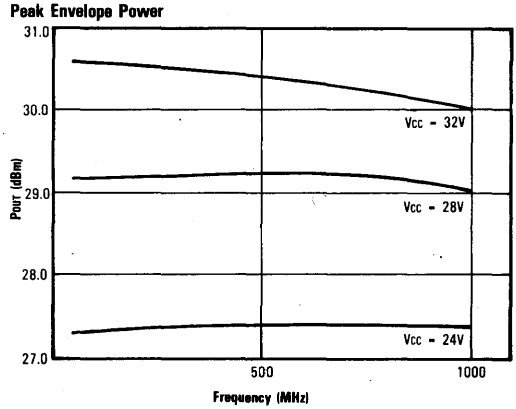
Frequency Response vs. Temperature



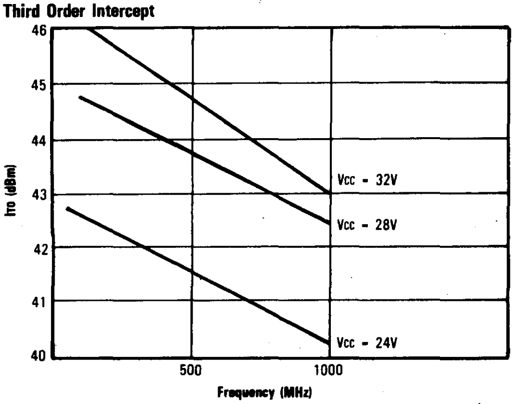
1dB Compression vs. Voltage



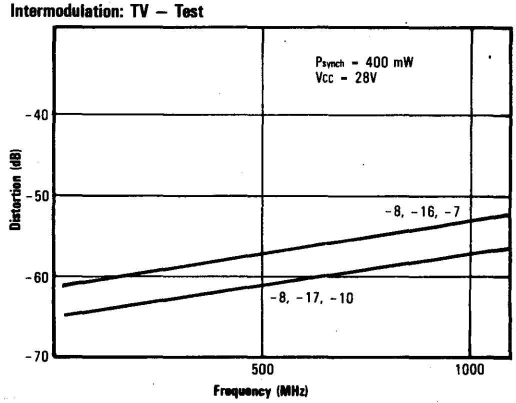
Peak Envelope Power



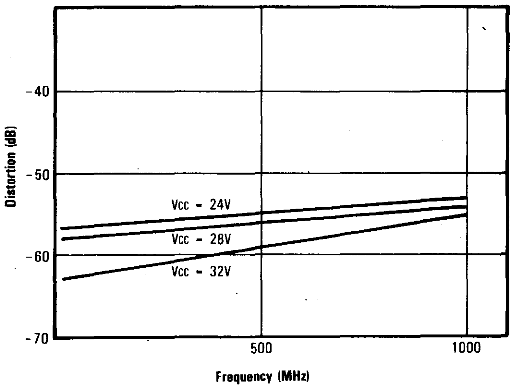
Third Order Intercept



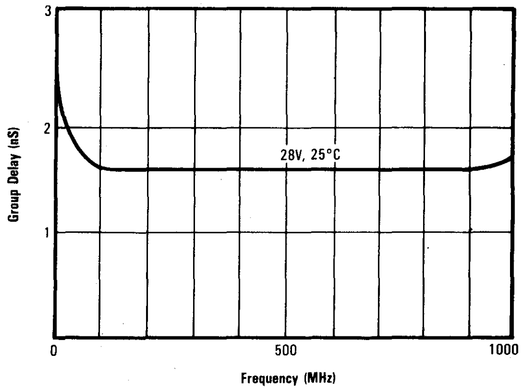
Intermodulation: TV – Test



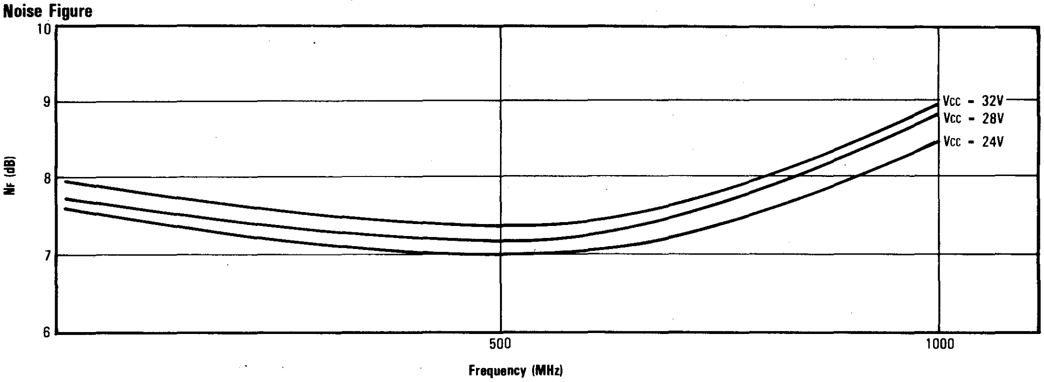
Second Harmonic Distortion



Delay Time ns/Div.



Noise Figure

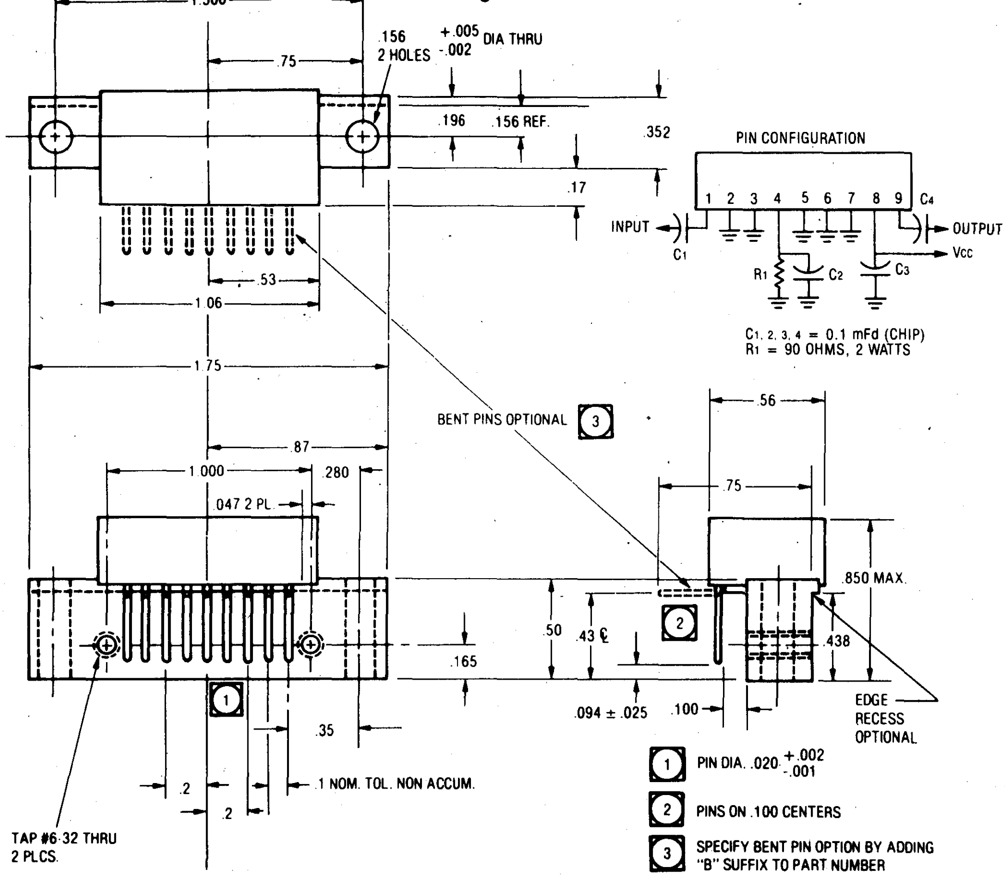


CA5800 S PARAMETERS

Biased at 28 Volts
392mA
Zo = 50 Ohms

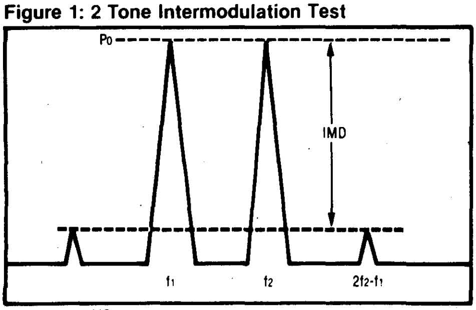
Frequency (MHz)	S11		S21		S12		S22		k
10	-44.08	129.3	14.50	13.4	-44.03	11.4	-12.47	111.0	14.153
110	-25.25	23.4	15.00	-80.6	-42.68	-33.5	-24.69	90.9	12.064
210	-20.84	-15.0	15.19	-156.9	-41.07	-68.3	-23.79	55.6	9.753
310	-18.72	-63.8	15.39	125.4	-38.94	-110.7	-21.01	23.1	7.392
410	-19.06	-123.4	15.51	47.7	-36.84	-157.2	-18.36	-17.6	5.699
510	-22.14	158.8	15.37	-30.6	-35.16	151.4	-17.49	-66.9	4.805
610	-23.19	50.2	15.09	-107.3	-33.51	99.0	-19.32	-116.5	4.152
710	-19.89	-41.0	14.89	176.7	-31.78	45.8	-25.26	-144.3	3.516
810	-17.89	-116.1	14.88	100.9	-29.89	-8.3	-23.18	-129.9	2.839
910	-16.70	156.5	15.15	22.7	-27.62	-66.3	-16.90	167.0	2.114
1010	-13.61	47.2	15.08	-61.5	-25.63	-129.7	-12.69	67.4	1.645

Package Outline



1. PIN DIA. .020 +.002 -.001
2. PINS ON .100 CENTERS
3. SPECIFY BENT PIN OPTION BY ADDING "B" SUFFIX TO PART NUMBER

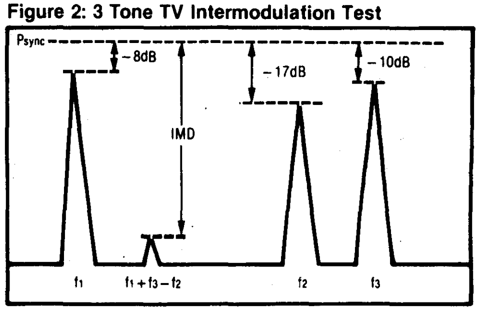
Figure 1: 2 Tone Intermodulation Test



$I_{TO} = P_O + \frac{IMD}{2}$ @ IMD > 60dB

PEP = 4X Po @ IMD = −32dB

Figure 2: 3 Tone TV Intermodulation Test



f1: video
f2: sideband
f3: sound

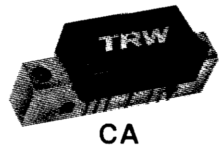
RF Devices Division, TRW Electronic Components Group, 14520 Aviation Blvd., Lawndale, CA 90260

Form No. 728/983

TRW

VHF-UHF Linear Amplifier

- 16 dB Gain
- 10-1000 MHz
- 1 W, 1 dB Compression
- +43 dBm Third Order Intercept



CA

F

Electrical Characteristics For 50Ω Systems (T_{case} = 25°C and 15V Supply)

Symbol	Characteristics	Conditions	Min.	Typ.	Max.	Units
P_G	Power Gain	f = 100MHz	15	16	17	dB
F_R	Frequency Response	10-1000MHz			±1.5	dB
P_O	Power Output, 1dB Compression	f = 500MHz	0.6	1		W
I_{TO}	Third Order Intercept see Figure 1	10-1000MHz	40	43		dBm
d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2h} = 1000MHz	-46	-56		dB
NF	Noise Figure	f = 500MHz f = 1000MHz		7 8	8.5 9.5	dB
VSWR	Input/Output (50Ω)	10-1000MHz	–	–	2:1	N/A
I_{CC}	Supply Current	+15V	650	700	750	mA

Absolute Maximum Ratings

Supply Voltage	RF Power Input	Storage Temperature	Case Operating Temp.
+17 Volts	+18dBm	-55°C to +125°C	-40°C to +100°C

Package Outline

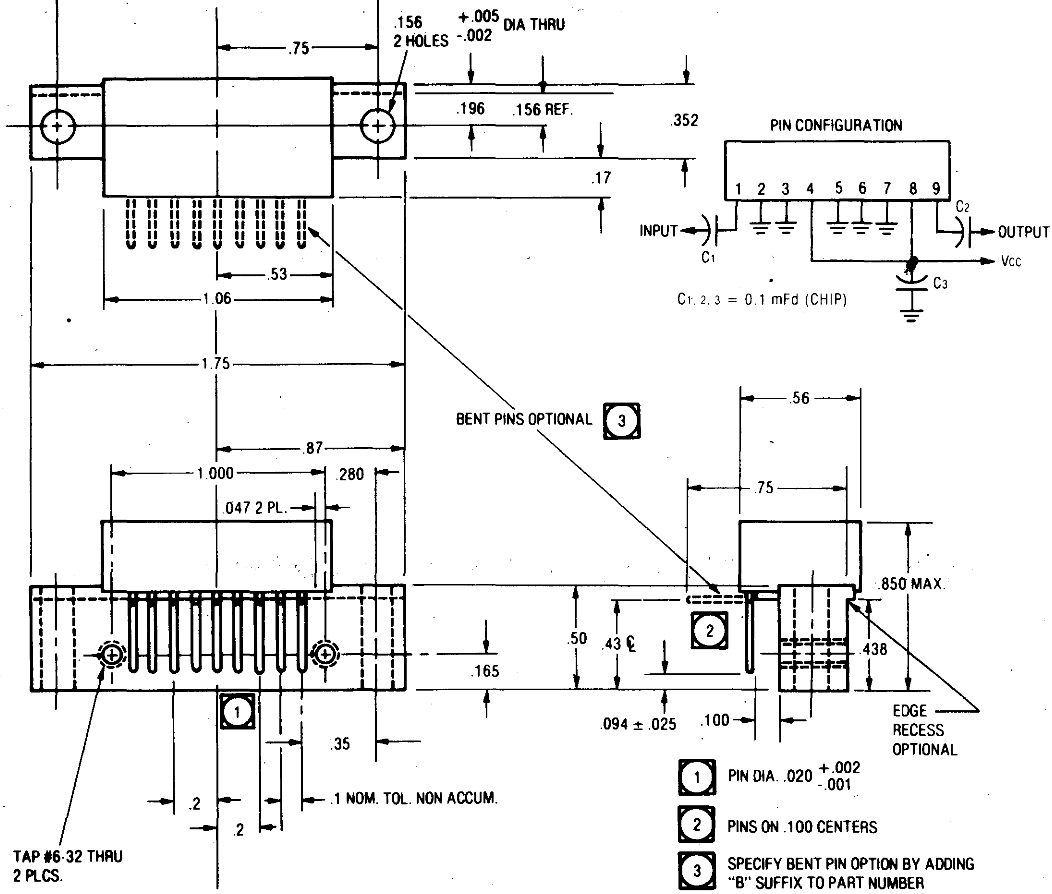
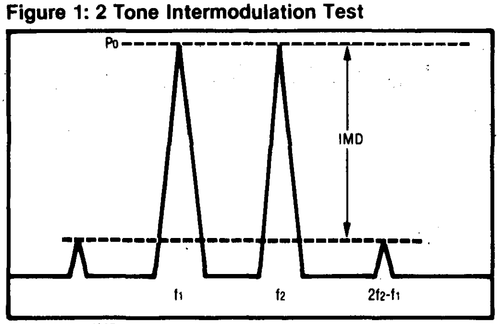


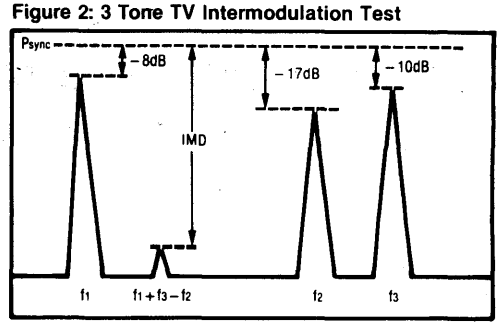
Figure 1: 2 Tone Intermodulation Test



$I_{TO} = P_O + \frac{IMD}{2}$ @ IMD > 60dB

PEP = 4X Po @ IMD = −32dB

Figure 2: 3 Tone TV Intermodulation Test

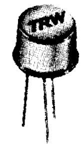


f1: video
f2: sideband
f3: sound

TRW

RF Transistor

- **High fT - 3.0 GHz**
- **Low Distortion**
- **Low Noise Figure, 2,5 dB @ 300 MHz**



TO 39

The LT1001 is a high-output NPN silicon TO-39-mounted transistor designed for ultra-linear communications or instrumentation applications. Low noise figure combined with high-output capability gives this device an exceptional dynamic range. Gold metallization and diffused emitter ballasting are combined to achieve the high reliability demanded by the most severe communications requirements. High gain makes this transistor ideal for broadband applications.

F

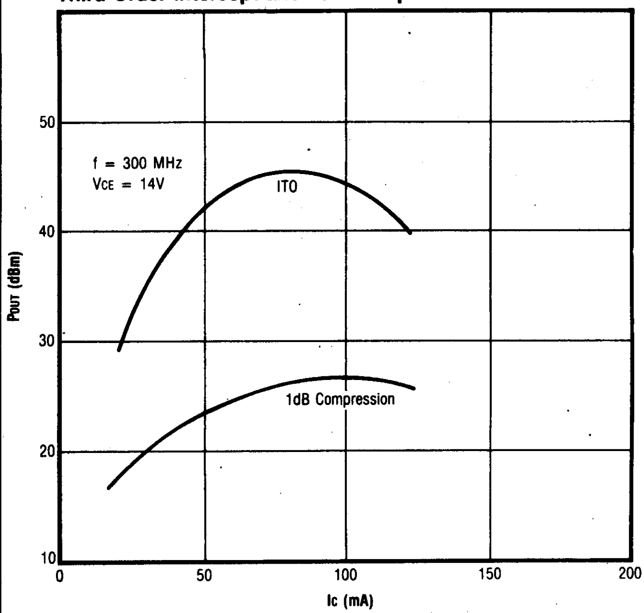
Electrical Characteristics

Symbol	Description	Conditions	Min.	Typ.	Max.	Units
BV_{EBO}	Emitter-Base Breakdown-Voltage	I_E = 0.1mA	3.5			V
BV_{CEO}	Collector-Emitter Breakdown-Voltage	I_C = 5.0mA	20			V
BV_{CBO}	Collector-Base Breakdown-Voltage	I_C = 1.0mA	40			V
I_{CBO}	Collector-Base Leakage	V_{CB} = 10V		50		μA
$V_{CE\ (SAT)}$	Collector-Emitter Saturation Voltage	I_C = 50mA I_C/I_B = 10		500		mV
h_{FE}	DC Current Gain	V_{CE} = 5V I_C = 50mA	70	100	300	
C_{CB}	Collector-Base Capacitance	V_{CB} = 8V f = 1 MHz		1.6		pF
NF_{min}	Minimum Noise Figure	V_{CE} = 8V I_C = 50mA f = 300 MHz		2.5		dB
G_{Umax}	Maximum Unilateral Gain	V_{CE} = 14V I_C = 90mA f = 300 MHz		15		dB
$[S_{21}]^2_E$	Common Emitter Insertion Gain	V_{CE} = 14V I_C = 90mA f = 300 MHz		13.5		dB
F_T	Gain Bandwidth Product	V_{CE} = 14V I_C = 90mA		3.0		GHz
P_{OUT}	Power out @ 1dB Compression	V_{CE} = 14V I_C = 90mA f = 300 MHz		26		dBm
ITO	Third Order Intercept	V_{CE} = 14V I_C = 90mA f = 300 MHz		45		dBm

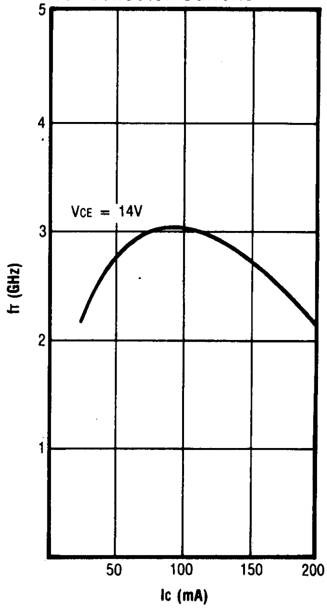
Absolute Maximum Ratings @ 25°C Case

Collector Current (I_C)	Collector Base Voltage (V_{CBO})	Junction Temperature (T_j)	Storage Temperature (T_{STG})
200mA	40V	200°C	−65°C to 200°C

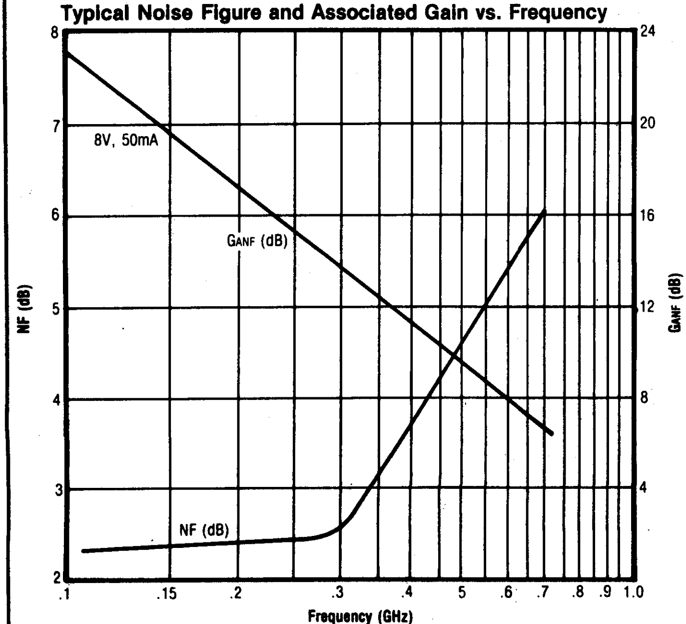
Third Order Intercept and 1dB Compression



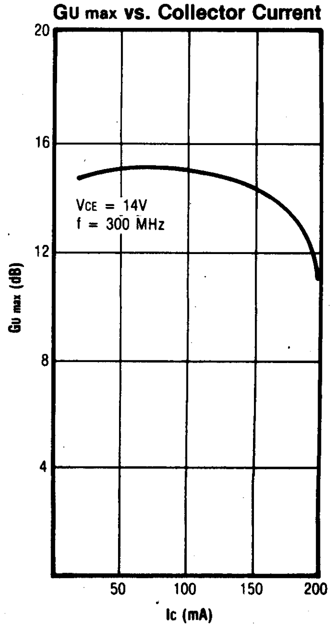
Gain-Bandwidth Product vs. Collector Current



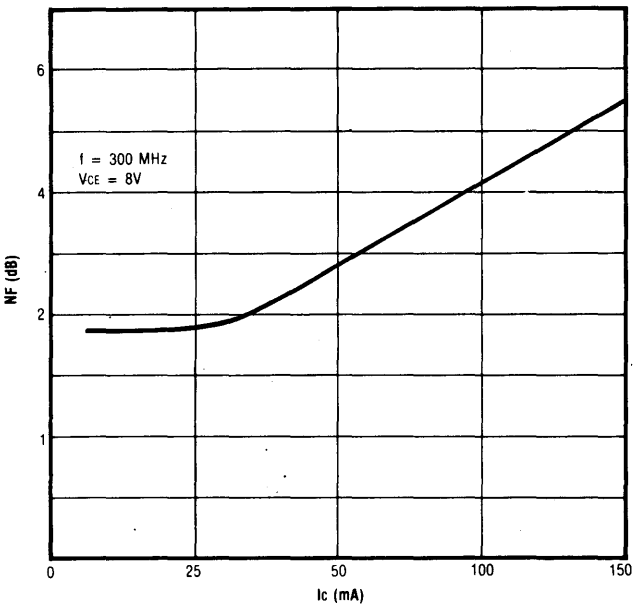
Typical Noise Figure and Associated Gain vs. Frequency



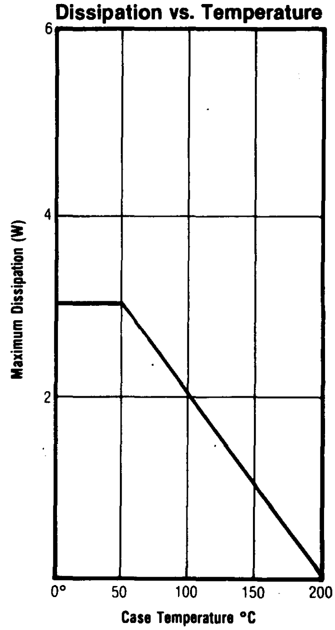
GU max vs. Collector Current



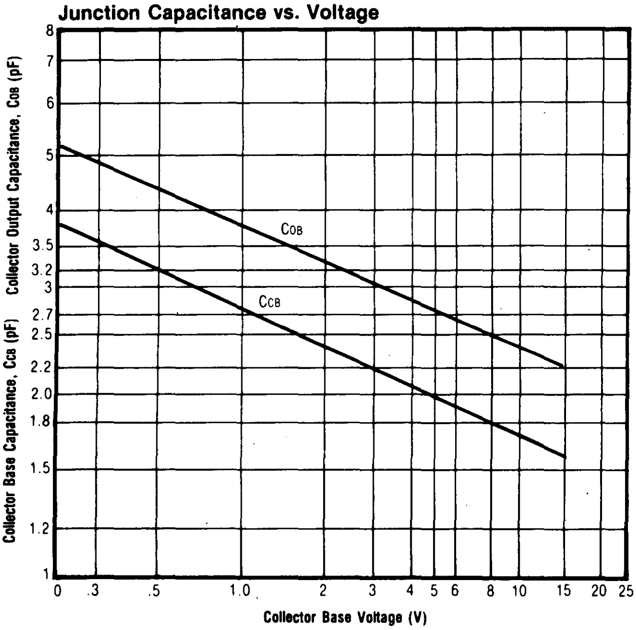
NF vs. Collector Current



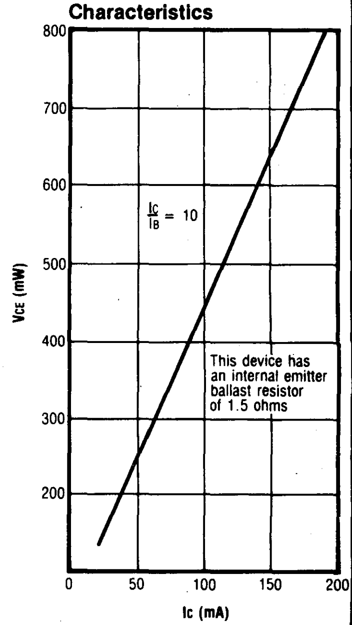
Dissipation vs. Temperature



Junction Capacitance vs. Voltage

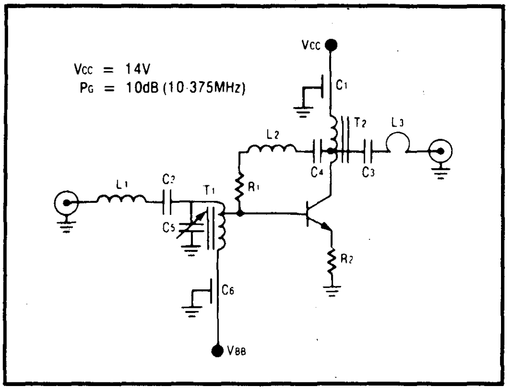


Collector Saturation Characteristics



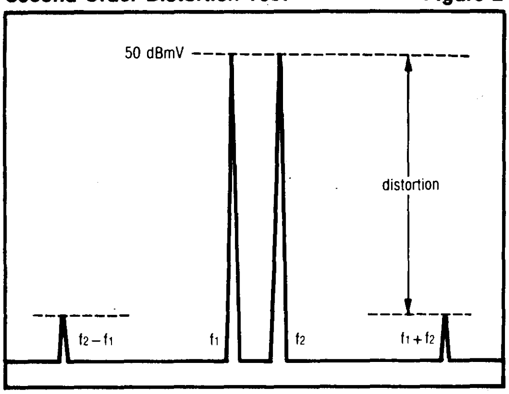
CATV/MATV Characterization

Broadband Test Circuit **Figure 1**

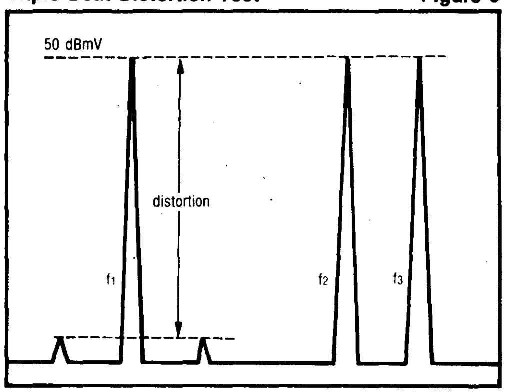


$C_{1,2,3,4}$	0.001μF
C_5	5-10pF
C_6	0.01μF
L_1	2 turns 1/8'' I.D. #20AWG
L_2	3 turns 3/16'' I.D. #20AWG
L_3	1 turn 1/8'' I.D. #20AWG
T_{12}	2x8 #30AWG, Q1 Core
R_1	24Ω, 1/8W
R_2	13Ω, 1/2W

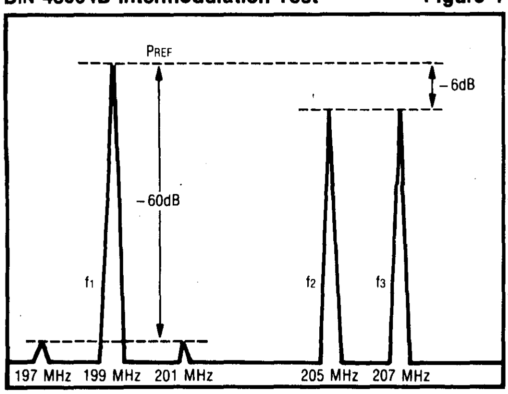
Second Order Distortion Test **Figure 2**



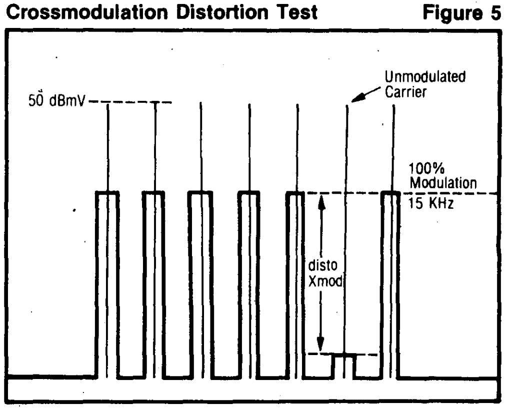
Triple Beat Distortion Test **Figure 3**



DIN 45004B Intermodulation Test **Figure 4**

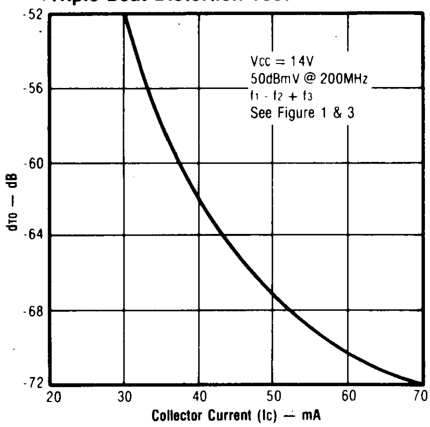


Crossmodulation Distortion Test **Figure 5**

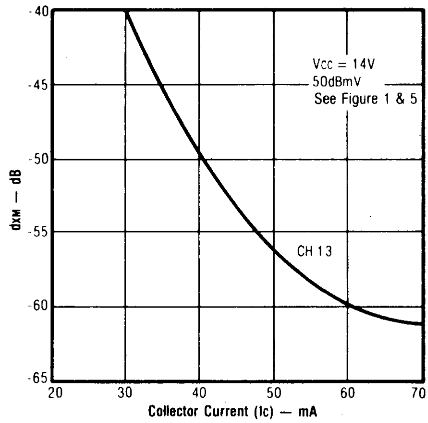


CATV/MATV Characterization

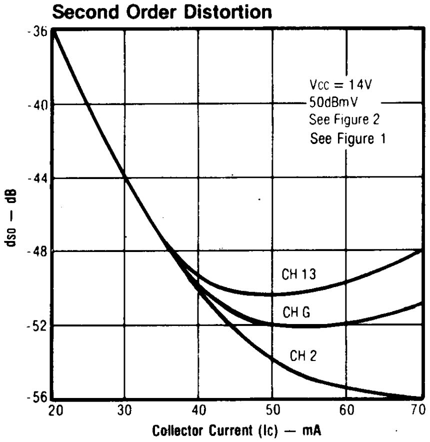
Triple Beat Distortion Test



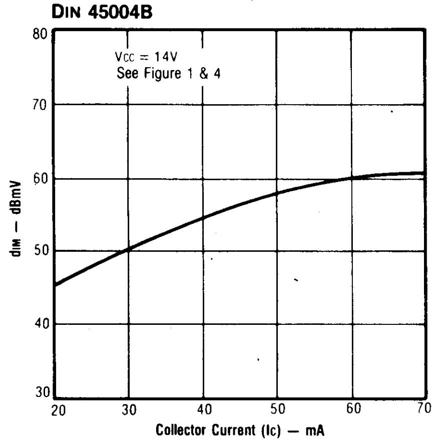
7 Channel X-Modulation Distortion



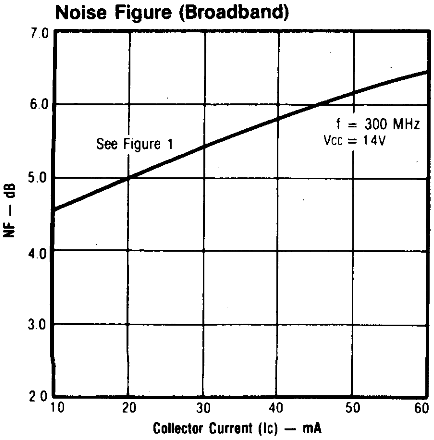
Second Order Distortion



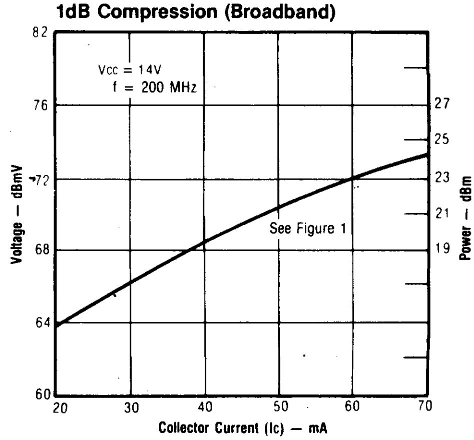
DIN 45004B



Noise Figure (Broadband)



1dB Compression (Broadband)



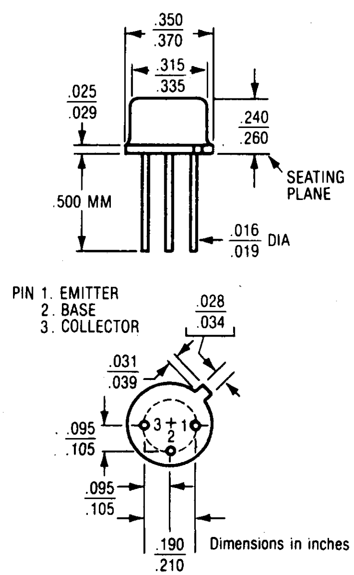
LT 1001A S PARAMETERS

S-dB and Angles:
V_{CE} = 8V, I_C = 50mA

Frequency (MHz)	S11		S21		S12		S22		k
100	−7.23	−131.8	21.95	101.3	−25.33	58.8	−7.08	−78.4	0.631
200	−9.06	−167.6	16.02	85.4	−21.46	65.6	−11.85	−86.2	0.969
300	−9.06	175.3	12.69	75.7	−18.49	68.9	−12.58	−93.5	1.025
400	−8.90	160.9	10.33	67.5	−16.21	69.7	−12.74	−102.7	1.049
500	−8.87	145.8	8.53	60.8	−14.42	69.7	−12.55	−110.4	1.071
600	−8.67	136.0	7.14	54.8	−12.90	69.3	−11.66	−119.7	1.068
700	−8.70	124.0	6.12	49.6	−11.50	68.3	−10.72	−126.6	1.059
800	−8.94	114.2	5.13	43.7	−10.37	66.4	−9.85	−136.3	1.065
900	−8.91	105.3	4.28	39.1	−9.34	65.0	−9.39	−143.9	1.066
1000	−9.16	93.6	3.63	34.6	−8.42	62.8	−3.70	−152.1	1.064

V_{CE} = 14V, I_C = 90mA

Frequency (MHz)	S11		S21		S12		S22		k
100	−7.74	−126.6	22.66	103.0	−28.85	57.6	−6.82	−47.5	0.748
200	−8.33	−157.8	17.08	86.3	−25.01	62.6	−8.40	−56.7	0.965
300	−8.28	−172.6	13.71	75.6	−22.37	65.8	−8.25	−66.4	1.026
400	−8.31	−177.5	11.25	66.7	−20.31	66.9	−7.58	−75.0	1.037
500	−8.18	173.9	9.61	61.2	−17.69	70.4	−7.33	−78.9	0.938
600	−8.12	167.5	8.08	55.5	−16.35	71.2	−6.81	−85.1	0.932
700	−8.19	161.2	6.83	48.9	−15.21	70.2	−6.22	−91.6	0.913
800	−8.16	−155.6	5.60	43.6	−14.22	70.9	−5.44	−96.4	0.883
900	−8.07	149.9	4.58	38.0	−13.28	70.0	−4.84	−102.4	0.844
1000	−7.86	143.8	3.70	34.4	−12.40	70.2	−4.54	−105.1	0.824

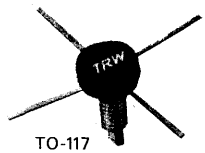


TO-39

TRW

High Frequency, High Voltage Transistor for CRT Driver Applications

- High Voltage
- High Frequency
- Low Capacitance
- Rugged
- All Gold Metallization



TO-117

F

These rugged NPN silicon transistors are specifically designed for CRT driver applications requiring high voltage and high frequency, such as high resolution color graphics video monitors. A new process in wafer fabrication enables high breakdown voltage without sacrificing high frequency capability. Utilizing ion implantation techniques coupled with microwave processing, the LT1817 sets new standards for bipolar transistors in these applications. Gold metallization insures high reliability for these rugged devices.

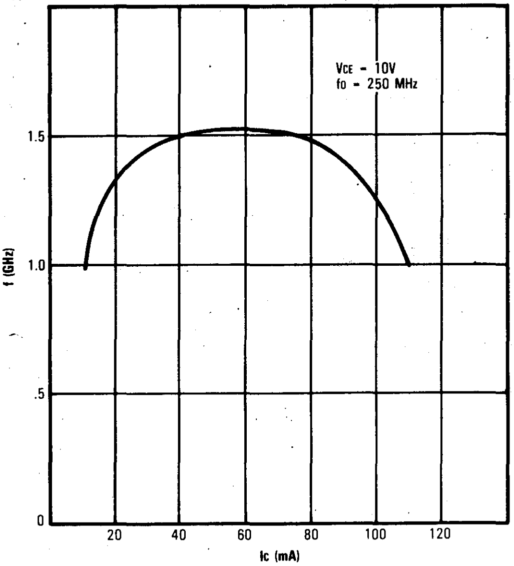
Electrical Characteristics (25°C Unless otherwise noted.)

Symbol	Description	Conditions	Min.	Max.	Units
BV_{EBO}	Emitter-Base Breakdown-Voltage	I_E = .1mA	3.0		V
BV_{CBO}	Collector-Base Breakdown-Voltage	I_C = .1mA	120		V
BV_{CEO}	Collector-Emitter Breakdown-Voltage	I_C = 1mA	70		V
I_{CES}	Collector-Emitter Leakage	V_{CE} = 80V		100	μA
I_{CBO}	Collector-Base Leakage	V_{CB} = 80V		20	μA
h_{FE}	DC Current Gain	V_{CE} = 5V I_C = 50mA	15	45	
C_{CB}	Collector-Base Capacitance	V_{CB} = 10V		2.0	pF
$V_{CE\,(SAT)}$	Collector-Emitter Saturation Voltage	I_C = 50mA I_B = 5mA		800	mV
F_T	Gain Bandwidth Product	V_{CE} = 10V I_C = 80mA fo = 250MHz	1.0		GHz
F_{max}	Maximum Oscillation Frequency	V_{CE} = 10V I_C = 80mA fo = 250MHz	2.0		GHz
S_{21}	Common Emitter Insertion Gain	V_{CE} = 10V I_C = 50mA f = 200MHz	15		dB

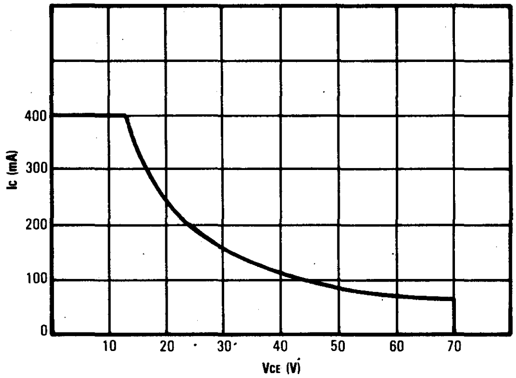
Absolute Maximum Ratings @ 25°C Case

Collector Current (I_C)	Collector Base Voltage (V_{CBO})	Junction Temperature (T_J)	Storage Temperature (T_{STG})
400mA	120V	+200°C	-65°C to +200°C

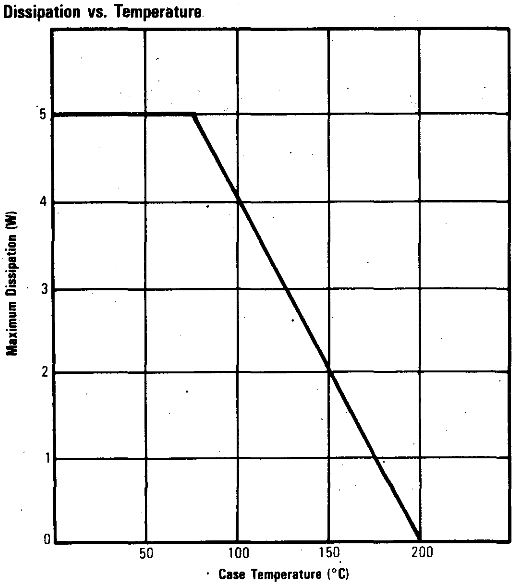
Typical Gain Bandwidth Product vs. Collector Current



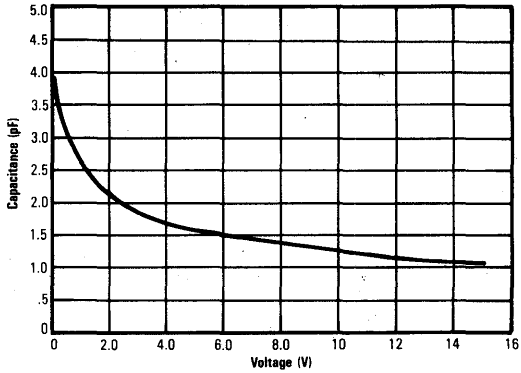
Safe Operating Area

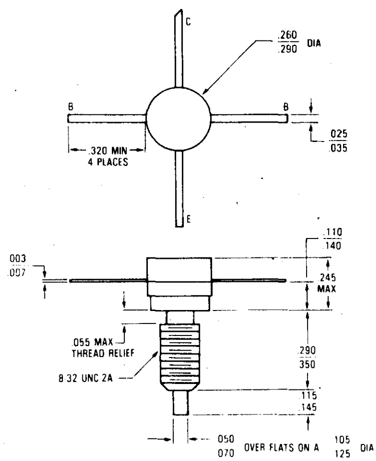


Dissipation vs. Temperature



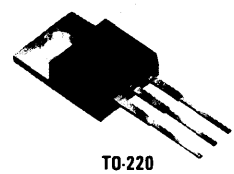
Typical Junction Capacitance vs. Voltage





High Frequency, High Voltage Transistor for CRT Driver Applications

- High Voltage
- High Frequency
- Low Capacitance
- Rugged
- All Gold Metallization



TO-220

These rugged NPN silicon transistors are specifically designed for CRT driver applications requiring high frequency and high voltage, such as high resolution color graphics video monitors. A new process in wafer fabrication enables high breakdown voltage without sacrificing high frequency capability. Utilizing ion implantation techniques coupled with microwave processing, the LT1820 sets new standards for bipolar transistors in these applications. Gold metallization insures high reliability for these rugged devices.

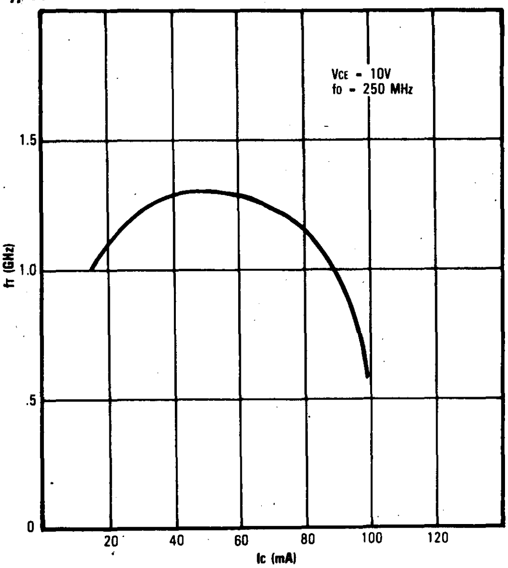
Electrical Characteristics (25°C Unless otherwise noted.)

Symbol	Description	Conditions	Min.	Max.	Units
BV_{EBO}	Emitter-Base Breakdown-Voltage	I_E = .1mA	3.0		V
BV_{CBO}	Collector-Base Breakdown-Voltage	I_C = .1mA	120		V
BV_{CEO}	Collector-Emitter Breakdown-Voltage	I_C = 1mA	70		V
I_{CES}	Collector-Emitter Leakage	V_{CE} = 80V		100	μA
I_{CBO}	Collector-Base Leakage	V_{CB} = 80V		20	μA
h_{FE}	DC Current Gain	V_{CE} = 5V I_C = 50mA	15	45	
C_{CB}	Collector-Base Capacitance	V_{CB} = 10V		2.5	pF
$V_{CE\ (SAT)}$	Collector-Emitter Saturation Voltage	I_C = 50mA I_B = 5mA		800	mV
F_T	Gain Bandwidth Product	V_{CE} = 10V I_C = 80mA f_O = 250MHz	1.0		GHz
S_{21}	Common Emitter Insertion Gain	V_{CE} = 10V I_C = 50mA f = 200MHz	13		dB

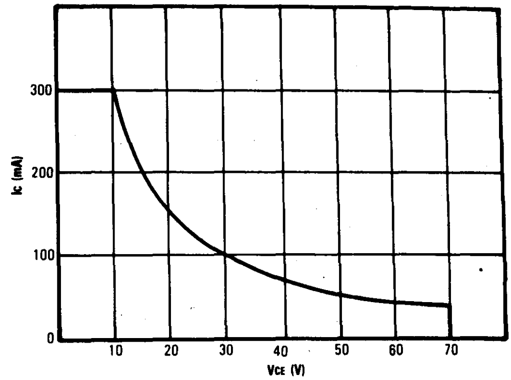
Absolute Maximum Ratings @ 25°C Case

Collector Current (I_C)	Collector Base Voltage (V_{CBO})	Junction Temperature (T_J)	Storage Temperature (T_{STG})
300mA	120V	+200°C	-65°C to +200°C

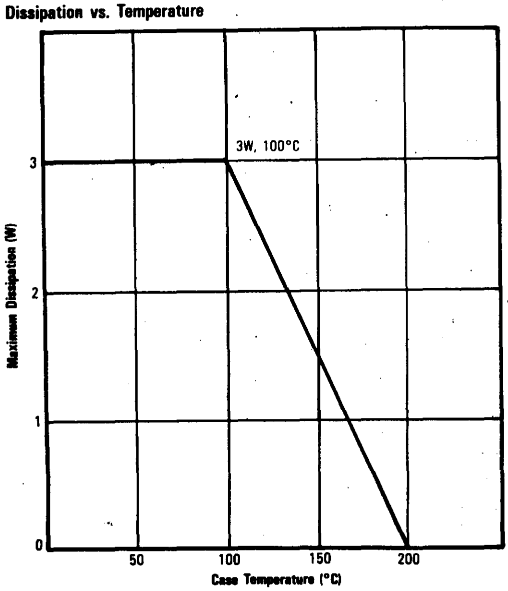
Typical Gain Bandwidth Product vs. Collector Current



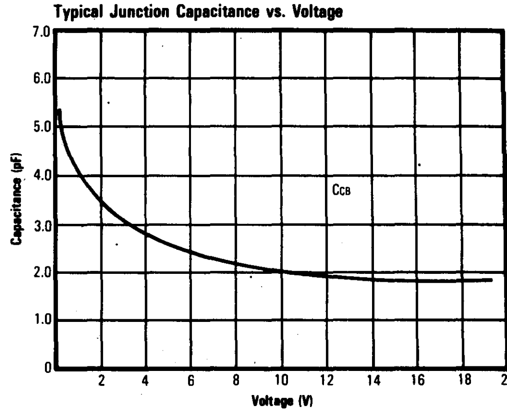
Safe Operating Area



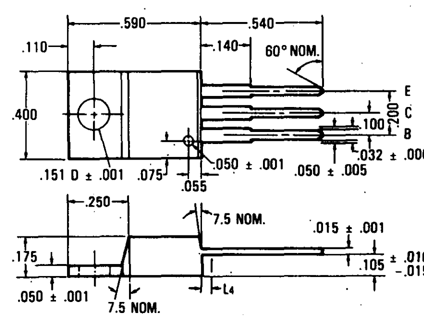
Dissipation vs. Temperature



Typical Junction Capacitance vs. Voltage



TO-220



NOTE:
1. DIMENSIONS IN INCHES
2. TOLERANCE OF ±.010 APPLIED UNLESS OTHERWISE SPECIFIED
3. MOLD FLASH ALLOWED WITHIN L4 MAX .020

High Frequency, High Voltage Transistor for CRT Driver Applications

- High Voltage
- High Frequency
- Low Capacitance
- Rugged
- All Gold Metallization

TO-39

F

These rugged NPN silicon transistors are specifically designed for CRT driver applications requiring high frequency and high voltage, such as high resolution color graphics video monitors. A new process in wafer fabrication enables high breakdown voltage without sacrificing high frequency capability. Utilizing ion implantation techniques coupled with microwave processing, the LT1839 sets new standards for bipolar transistors in these applications. Gold metallization insures high reliability for these rugged devices.

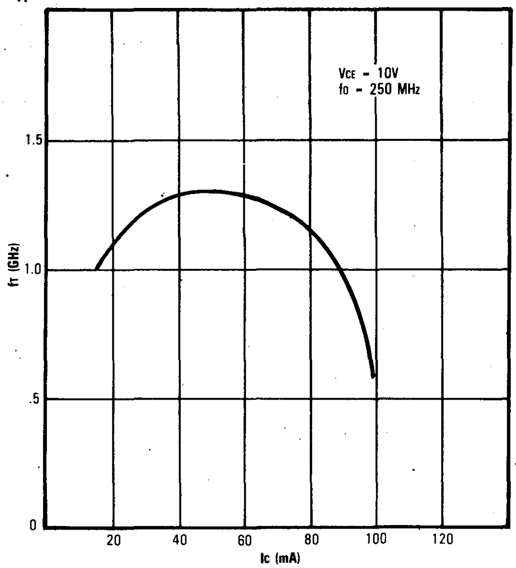
Electrical Characteristics (25°C Unless otherwise noted.)

Symbol	Description	Conditions	Min.	Max.	Units
BV_{EBO}	Emitter-Base Breakdown-Voltage	I_E = .1mA	3.0		V
BV_{CBO}	Collector-Base Breakdown-Voltage	I_C = .1mA	120		V
BV_{CEO}	Collector-Emitter Breakdown-Voltage	I_C = 1mA	70		V
I_{CES}	Collector-Emitter Leakage	V_{CE} = 80V		100	μA
I_{CBO}	Collector-Base Leakage	V_{CB} = 80V		20	μA
h_{FE}	DC Current Gain	V_{CE} = 5V I_C = 50mA	15	45	
C_{CB}	Collector-Base Capacitance	V_{CB} = 10V		2.0	pF
$V_{CE\,(SAT)}$	Collector-Emitter Saturation Voltage	I_C = 50mA I_B = 5mA		800	mV
F_T	Gain Bandwidth Product	V_{CE} = 10V I_C = 80mA f_0 = 250MHz	1.0		GHz
S_{21}	Common Emitter Insertion Gain	V_{CE} = 10V I_C = 50mA f = 200MHz	13		dB

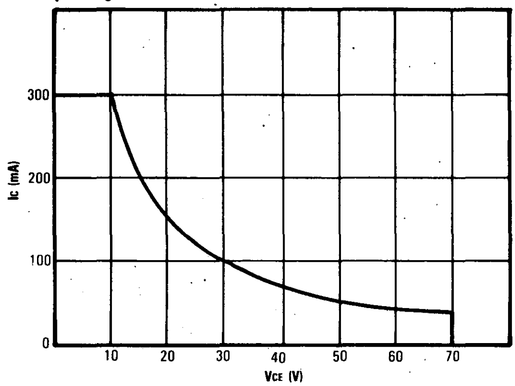
Absolute Maximum Ratings @ 25°C Case

Collector Current (I_C)	Collector Base Voltage (V_{CBO})	Junction Temperature (T_J)	Storage Temperature (T_{STG})
300mA	120V	+200°C	-65°C to +200°C

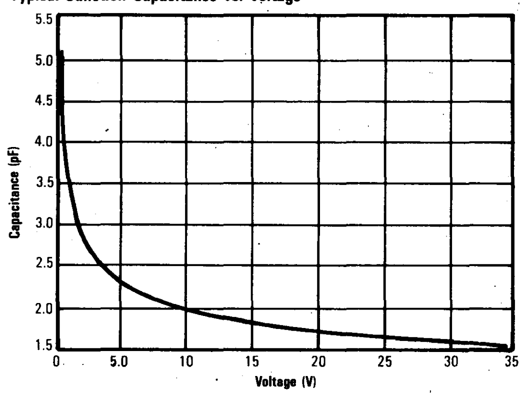
Typical Gain Bandwidth Product vs. Collector Current



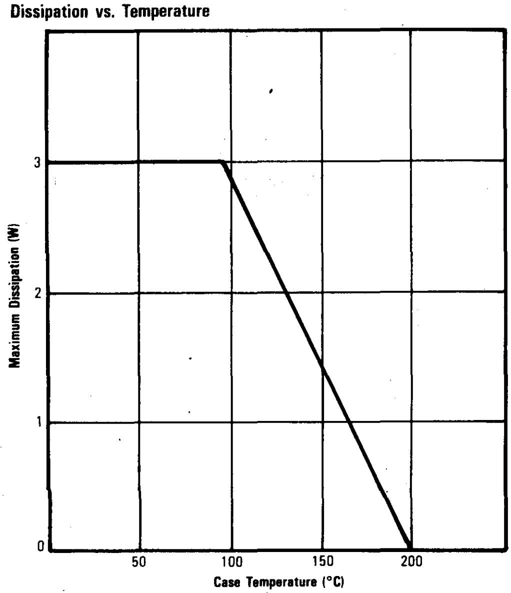
Safe Operating Area



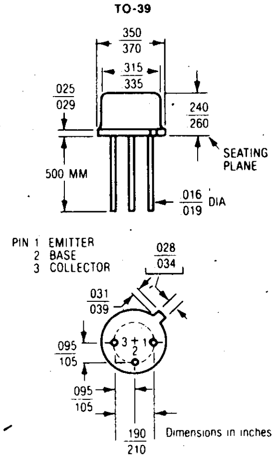
Typical Junction Capacitance vs. Voltage



Dissipation vs. Temperature



TO-39



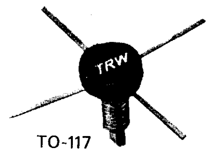
Semiconductor Division
TRW Electronic Components Group
14520 Aviation Blvd.
Lawndale, CA 90260

NEW

TRW

PNP Bipolar Transistor
High Frequency, High Voltage Transistor for CRT Driver Applications

- High Voltage
- High Frequency
- Low Capacitance
- Rugged
- All Gold Metallization



TO-117

F

These rugged PNP silicon transistors are specifically designed for CRT driver applications requiring high frequency and high voltage, such as high resolution color graphics video monitors. A new process in wafer fabrication enables high breakdown voltage without sacrificing high frequency capability. Utilizing ion implantation techniques coupled with microwave processing, the LT 5817 sets new standards for bipolar transistors in these applications. Gold metallization insures high reliability for these rugged devices.

Electrical Characteristics (25 °C Unless otherwise noted)

TEST	TEST CONDITIONS*	LIMIT Min.	LIMIT Max.	UNITS
BVE_{BO}	I_E = .1 mA,	3.0		V
BV_{CEO}	I_E = 1 mA	65		V
BV_{CBO}	I_C = .1 mA,	75		V
I_{CES}	V_{CE} = 50 V		100	μA
IC_{BO}	V_{CB} = 50 V		20	μA
H_{FE}	V_{CE} = 5 V, I_C = 50 mA	20	60	
C_{CB}	V_{CB} = 10 V, 1 MHz		2.0	pF
V_{CE} (SAT)	I_C = 50 mA, I_B = 5 mA		800	mV
$(S21)^2$	V_{CE} = 10 V, I_C = 50 mA, 200 MHz	13		dB
F_T	V_{CE} = 10 V, I_C = 50 mA	1.5		GHz

* Puise width 300 μ sec 2 % duty cycle

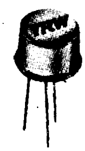
LT 5839

NEW

TRW

PNP Bipolar Transistor
High Frequency, High Voltage Transistor for CRT Driver Applications

- High Voltage
- High Frequency
- Low Capacitance
- Rugged
- All Gold Metallization



TO 39

These rugged PNP silicon transistors are specifically designed for CRT driver applications requiring high frequency and high voltage, such as high resolution color graphics video monitors. A new process in wafer fabrication enables high breakdown voltage without sacrificing high frequency capability. Utilizing ion implantation techniques coupled with microwave processing, the LT 5839 sets new standards for bipolar transistors in these applications. Gold metallization insures high reliability for these rugged devices.

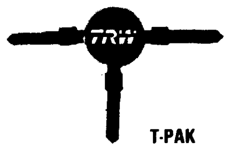
Electrical Characteristics (25 °C Unless otherwise noted)

TEST	TEST CONDITIONS*	LIMIT Min	LIMIT Max	UNITS
BVE_{BO}	I_E = .1 mA,	3.0		V
BV_{CEO}	I_E = 1 mA	65		V
BV_{CBO}	I_C = .1 mA,	75		V
I_{CES}	V_{CE} = 50 V		100	μA
IC_{BO}	V_{CB} = 50 V		20	μA
H_{FE}	V_{CE} = 5 V, I_C = 50 mA	20	60	
C_{CB}	V_{CB} = 10 V, 1 MHz		2.0	pF
V_{CE} (SAT)	I_C = 50 mA, I_B = 5 mA		800	mV
$(S21)^2$	V_{CE} = 10 V, I_C = 50 mA, 200 MHz	13		dB
F_T	V_{CE} = 10 V, I_C = 50 mA	1.5		GHz

* Pulse width 300 μ sec 2 % duty cycle

UHF Linear Transistor

- High Output
- Low Cost
- Gold Reliability
- 2.5 GHz F_T



T-PAK

The LT3203 is a NPN transistor, gold metalized for reliability, using diffused ballast resistors for super linearity at currents compatible with the power dissipation capability of a T-Pack. LT3203 is the ideal candidate for up to **0.8 V MATV** amplifiers from **40** to **860 MHz**. The LT3203 has applications in driver stages of 12 volts VHF/UHF transmitters and broadband instrumentation equipment.

Electrical Characteristics

Symbol	Description	Conditions	Min.	Typ.	Max.	Units
BV_{EBO}	Emitter-Base Breakdown-Voltage	I_E = 0.1mA	3.5			V
BV_{CEO}	Collector-Emitter Breakdown-Voltage	I_C = 5.0mA	20			V
BV_{CBO}	Collector-Base Breakdown-Voltage	I_C = 1.0mA	40			V
I_{CBO}	Collector-Base Leakage	V_{CB} = 10V		50		μA
$V_{CE\ (SAT)}$	Collector-Emitter Saturation Voltage	I_C = 50mA, I_C/I_B = 10		300		mV
h_{FE}	DC Current Gain	V_{CE} = 5V I_C = 50mA	70	100	300	
C_{CB}	Collector-Base Capacitance	V_{CB} = 8V f_o = 1.0 MHz		1.2		pF
NF_{min}	Minimum Noise Figure	V_{CE} = 8V I_C = 40mA, f = 300 MHz		2.5		dB
GU_{max}	Maximum Unilateral Gain	V_{CE} = 14V I_C = 40mA, f = 500 MHz		15		dB
$\|S_{21}\|_E^2$	Common Emitter Insertion Gain	V_{CE} = 14V I_C = 40mA, f = 500 MHz		13		dB
F_T	Gain Bandwidth Product	V_{CE} = 14V I_C = 40mA		3.0		GHz
P_{out}	Power out @ 1dB Compression	V_{CE} = 14V I_C = 40mA		23		dBm
ITO	Third Order Intercept	V_{CE} = 14V I_{CE} = 40mA		45		dBm

Absolute Maximum Ratings @ 25°C Case

Collector Current (I_C)	Collector Base Voltage (V_{CBO})	Junction Temperature (T_j)	Storage Temperature (T_{STG})
150mA	40V	+150°C	-65°C to +150°C

*Replaces TP394

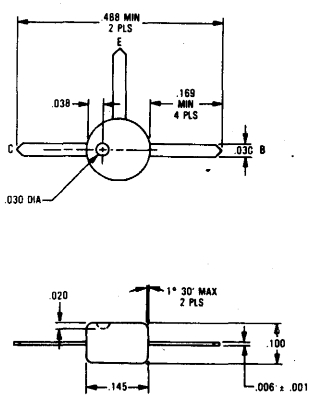
LT3203 S PARAMETERS

S-dB and Angles:
VCE = 8V, IC = 20mA

Frequency (MHz)	S11		S21		S12		S22		k
100	-3.04	-114.1	24.22	116.2	-29.57	42.2	-4.81	- 42.1	0.298
200	-3.39	-148.3	19.22	95.8	-27.76	39.6	-7.87	- 47.6	0.554
300	-3.53	-162.8	15.87	83.9	-26.71	45.0	-9.06	- 50.9	0.768
400	-3.56	-171.6	13.51	76.1	-25.55	49.9	-9.50	- 55.2	0.897
500	-3.57	-177.7	11.60	68.9	-24.39	55.7	-9.53	- 60.5	0.981
600	-3.57	177.7	10.01	62.5	-23.14	59.9	-9.38	- 65.7	1.012
700	-3.51	173.7	8.78	56.3	-21.94	63.1	-9.24	- 72.4	1.003
800	-3.42	169.4	7.61	50.9	-20.87	66.6	-8.89	- 77.9	0.984
900	-3.38	166.9	6.64	45.3	-19.61	68.6	-8.59	- 84.2	0.932
1000	-3.27	162.9	5.79	39.9	-18.47	69.2	-8.23	- 90.3	0.870
1100	-3.15	159.7	4.96	34.7	-17.44	69.9	-7.89	- 96.5	0.817
1200	-3.05	155.8	4.19	29.6	-16.33	70.6	-7.52	-103.4	0.764
1300	-3.00	153.3	3.52	24.9	-15.24	69.2	-7.15	-108.7	0.704

VCE = 14V, IC = 40mA

Frequency (MHz)	S11		S21		S12		S22		k
100	-3.49	-115.7	25.61	114.0	-31.18	44.2	-5.31	-39.2	0.385
200	-3.98	-149.1	20.41	94.8	-29.27	45.4	-8.17	-41.2	0.670
300	-4.11	-163.0	17.08	83.5	-27.50	51.2	-9.19	-42.2	0.842
400	-4.14	-171.4	14.72	76.4	-26.04	55.0	-9.59	-45.2	0.943
500	-4.13	-177.2	12.82	69.4	-24.67	59.2	-9.68	-49.2	0.996
600	-4.14	178.5	11.21	63.3	-23.44	62.3	-9.57	-53.3	1.033
700	-4.06	174.7	9.96	57.4	-22.26	64.5	-9.41	-59.1	1.018
800	-3.95	170.7	8.83	51.9	-21.05	66.8	-9.15	-64.0	0.979
900	-3.88	168.1	7.83	46.6	-20.12	68.8	-8.84	-69.5	0.958
1000	-3.78	164.4	6.96	41.4	-18.97	69.7	-8.50	-75.0	0.894
1100	-3.64	161.4	6.16	36.2	-18.04	69.9	-8.15	-81.0	0.837
1200	-3.50	157.7	5.38	31.0	-16.97	70.5	-7.88	-87.4	0.780
1300	-3.42	155.2	4.72	26.4	-16.00	70.0	-7.57	-92.7	0.727



T-PAK

TRW

Small Signal Low Noise Transistor for Receiver Applications

- Front End Amplifier
- Low Noise Oscillator
- High Frequency Multiplier
- Low Noise
- High Gain
- Wide Dynamic Range
- Plastic Package

T-PAK

The prime applications of this Silicon NPN transistor include satellite down conversion links, microwave radio relay communication links, ECM receivers, oscillators, mixers, and multipliers. Processes in wafer fabrication make this transistor effective in applications up to 3.5 GHz, with a very wide dynamic range.

The LT3703 sets new standards for low noise figure, high gain, and dynamic range. Gold metallization insures high reliability for low noise amplifier applications.

Electrical Characteristics

Symbol	Description	Conditions	Min.	Typ.	Max.	Units
BV_{EBO}	Emitter-Base Breakdown-Voltage	I_C = .1mA	3.0			V
BV_{CEO}	Collector-Emitter Breakdown-Voltage	I_C = 1mA	14			V
I_{CBO}	Collector-Base Leakage	V_{CB} = 10V			1	μA
h_{FE}	DC Current Gain	V_{CE} = 5V I_E = 25mA	50	150	300	
C_{CB}	Collector-Base Capacitance	V_{CB} = 8V f = 1.0 MHz		.6		pF
NF_{min}	Minimum Noise Figure	V_{CE} = 8V, I_C = 5mA f = .3 GHz f = .5 GHz f = 1.0 GHz		1.5 1.8 3.4	2.8	dB dB dB
G_{ANF}	Gain @ Associated Noise Figure	V_{CE} = 8V, I_C = 5mA f = .3 GHz f = .5 GHz f = 1.0 GHz		21 16.0 11.0		dB dB dB
$\lvert S_{21}\rvert_E^2$	Common Emitter Insertion Gain	V_{CE} = 8V, I_C = 25mA f = .3 GHz f = .5 GHz f = 1.0 GHz	13	20 15.5 9.5		dB dB dB
G_{Umax}	Maximum Unilateral Gain	V_{CE} = 8V, I_C = 25mA f = .3 GHz f = .5 GHz f = 1.0 GHz		24 19.5 13.5		dB dB dB
F_T	Gain Bandwidth Product	V_{CE} = 8V I_C = 25mA		3.5		GHz

Absolute Maximum Ratings

Collector Current (I_C)	Collector Base Voltage (V_{CBO})	Junction Temperature (T_j)	Storage Temperature (T_{STG})
50mA	25V	150°C	−65°C to +150°C

***Replaces TP491**

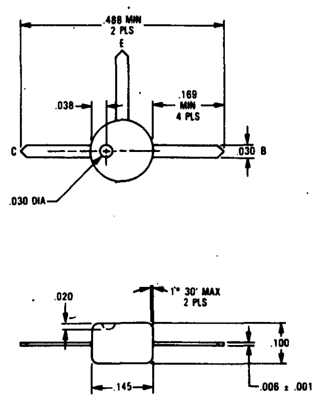
LT3703 S PARAMETERS

S-dB and Angles:
VCE = 8V, Ic = 5mA

Frequency (MHz)	S11		S21		S12		S22		k
100	-2.41	- 52.7	22.86	144.3	-33.03	62.4	-1.04	-15.7	0.242
200	-4.10	- 89.9	20.15	120.8	-29.13	51.6	-2.48	-21.7	0.439
300	-5.31	-114.5	17.71	105.8	-27.67	47.3	-3.45	-23.9	0.634
400	-6.02	-131.9	15.66	96.7	-26.60	47.2	-4.02	-25.1	0.778
500	-6.49	-144.5	13.96	89.0	-25.83	48.1	-4.36	-26.1	0.916
600	-6.78	-153.9	12.44	83.0	-25.11	49.9	-4.54	-27.7	1.029
700	-6.92	-161.9	11.19	77.5	-24.23	51.3	-4.72	-29.0	1.097
800	-7.03	-168.9	10.17	72.5	-23.61	52.6	-4.72	-30.6	1.143
900	-7.12	-173.7	9.16	67.9	-22.79	54.7	-4.74	-32.4	1.172
1000	-7.11	-179.4	8.31	63.8	-21.99	55.0	-4.74	-35.0	1.167
1100	-7.10	175.9	7.67	59.7	-21.55	56.0	-4.74	-37.1	1.189
1200	-7.09	170.9	6.91	55.2	-20.87	57.4	-4.78	-39.8	1.196
1300	-7.11	166.8	6.30	51.6	-20.19	57.9	-4.69	-42.0	1.169

VCE = 8V, Ic = 25mA

Frequency (MHz)	S11		S21		S12		S22		k
100	-6.83	- 99.5	27.84	121.8	-36.55	56.4	-3.27	-22.0	0.600
200	-7.78	-136.8	23.07	102.1	-33.01	58.2	-5.03	-21.3	0.886
300	-8.07	-153.6	19.80	91.5	-30.48	63.0	-5.68	-20.3	1.024
400	-8.07	-163.5	17.53	85.5	-28.43	63.8	-5.97	-20.7	1.070
500	-8.06	-170.2	15.59	79.8	-26.90	64.7	-6.12	-21.7	1.128
600	-8.07	-175.4	14.00	75.0	-25.55	65.5	-6.15	-23.1	1.158
700	-7.91	-179.7	12.77	70.8	-24.45	65.8	-6.24	-24.5	1.172
800	-7.85	175.8	11.60	66.4	-23.38	65.6	-6.16	-26.5	1.169
900	-7.77	173.0	10.56	62.3	-22.39	65.7	-6.10	-28.4	1.161
1000	-7.63	169.2	9.73	58.8	-21.57	65.6	-6.05	-31.2	1.143
1100	-7.50	166.0	8.90	55.1	-20.84	64.7	-6.03	-33.1	1.141
1200	-7.42	162.0	8.18	51.1	-20.14	65.3	-5.99	-35.8	1.131
1300	-7.36	159.7	7.57	47.7	-19.38	64.4	-5.83	-38.0	1.086

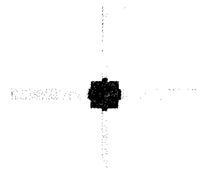


T-PAK

TRW

Small Signal Low Noise Transistor for High Performance Receiver Applications

- **Front End Amplifier**
- **Low Noise Oscillator**
- **High Frequency Multiplier**
- **Low Noise**
- **High Gain**
- **Wide Dynamic Range**
- **Hermetic Package**



100 MIL

The prime applications of this Silicon NPN transistor include satellite down conversion links, microwave radio relay communication links, ECM receivers, oscillators, mixers, and multipliers. A new process in wafer fabrication helps make this new transistor effective in applications up to as high as 6 GHz, with a very wide dynamic range.

Utilizing ion implantation techniques coupled with arsenic emitters, the LT4700 sets new standards for low noise figure, high gain, and wide dynamic range. Gold metallization insures high reliability for low noise amplifier applications.

F

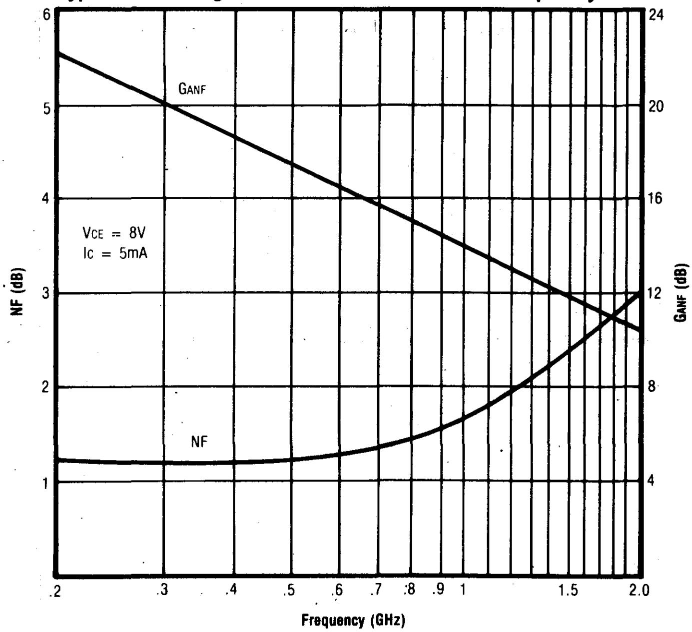
Electrical Characteristics

Symbol	Description	Conditions	Min.	Typ.	Max.	Units
BV_{EBO}	Emitter-Base Breakdown-Voltage	I_E = .1mA	3			V
BV_{CEO}	Collector-Emitter Breakdown-Voltage	I_C = 1mA	12			V
I_{CBO}	Collector-Base Leakage	V_{CB} = 10V			1	μA
h_{FE}	DC Current Gain	V_{CE} = 5V I_C = 25mA	70	150	300	
C_{CB}	Collector-Base Capacitance	V_{CB} = 8V f = 1 MHz			.6	pF
NF_{min}	Minimum Noise Figure	V_{CE} = 8V, I_C = 5mA f = 0.5 GHz f = 1.0 GHz f = 2.0 GHz		1.2 1.6 3.0	2.5	dB dB dB
G_{ANF}	Gain @ Associated Noise Figure	V_{CE} = 8V, I_C = 5mA f = 0.5 GHz f = 1.0 GHz f = 2.0 GHz		18.0 14.0 11.0		dB dB dB
$\|S_{21}\|_E^2$	Common Emitter Insertion Gain	V_{CE} = 8V, I_C = 25mA f = 0.5 GHz f = 1.0 GHz f = 2.0 GHz	13.0	21.0 15.0 10.0		dB dB dB
$G_{U(max)}$	Maximum Unilateral Gain	V_{CE} = 8V, I_C = 25mA f = 0.5 GHz f = 1.0 GHz f = 2.0 GHz		26.0 21.0 16.0		dB dB dB
F_t	Gain Bandwidth Product	V_{CE} = 8V I_C = 25mA		6.0		GHz
F_{max}	Maximum Oscillation Frequency	V_{CE} = 8V I_C = 25mA		7.0		GHz

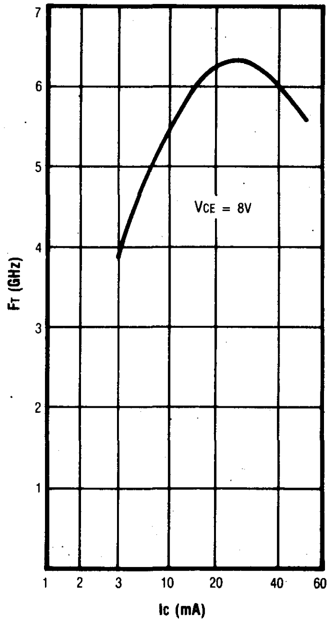
Absolute Maximum Ratings

Collector Current (I_C)	Collector Base Voltage (V_{CBO})	Junction Temperature (T_J)	Storage Temperature (T_S)
50mA	20V	200°C	−65°C to 200°C

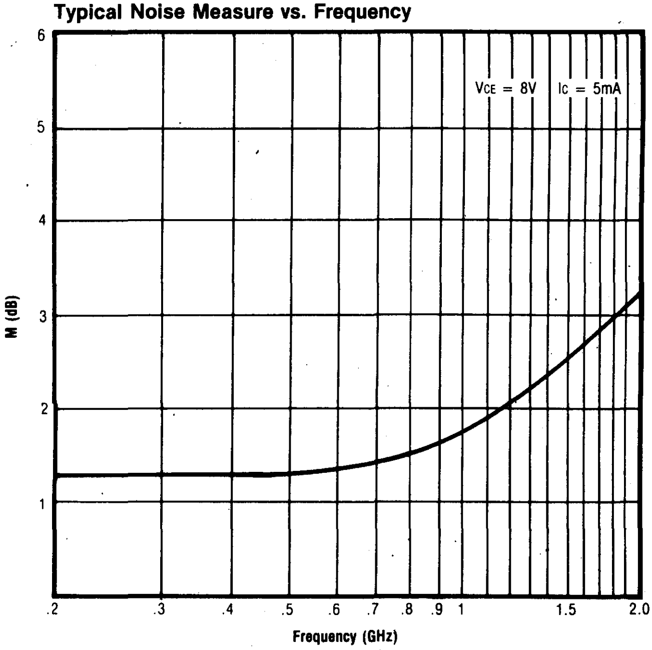
Typical Noise Figure and Associated Gain vs. Frequency



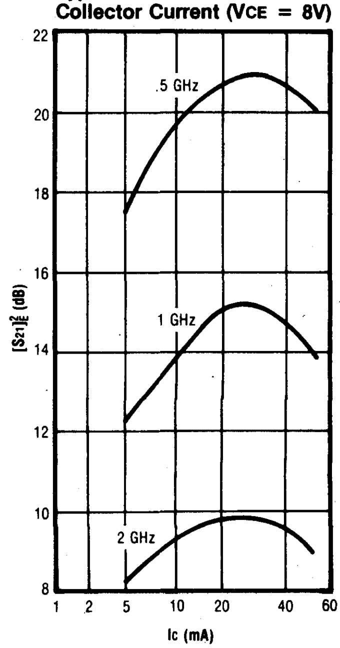
Typical Gain Bandwidth Product vs. Collector Current



Typical Noise Measure vs. Frequency



Typical Insertion Gain vs. Collector Current (VCE = 8V)



LT 4700 S PARAMETERS

S-dB and Angles:
V_{CE} = 8V, I_C = 5mA

Frequency (MHz)	S11		S21		S12		S22		k
100	−2.09	−35.4	24.61	149.8	−33.54	71.3	−0.28	−18.5	0.14632
150	−2.70	−48.2	23.37	153.7	−32.03	66.7	−0.42	−14.5	0.08388
200	−3.17	−61.0	21.27	143.5	−30.61	56.5	−2.11	−17.4	0.38362
250	−3.62	−73.5	19.86	133.3	−29.07	51.8	−2.20	−28.6	0.34603
400	−3.66	−106.1	18.67	113.0	−26.98	40.3	−3.23	−29.9	0.43098
500	−3.91	−119.4	17.34	107.3	−26.32	37.3	−3.69	−30.4	0.48277
600	−4.00	−130.2	16.13	100.2	−25.82	34.5	−4.15	−32.8	0.54641
700	−4.07	−139.1	15.05	94.4	−25.56	32.7	−4.56	−33.2	0.62994
800	−4.11	−146.6	14.04	89.9	−25.20	31.1	−4.75	−35.7	0.67527
900	−4.14	−152.9	13.06	85.1	−25.04	30.8	−5.10	−37.1	0.76699
1000	−4.76	−161.3	12.15	79.1	−25.02	34.9	−5.10	−36.8	0.91025
1100	−4.79	−166.5	11.41	75.5	−24.88	35.2	−5.33	−37.9	0.99839
1200	−4.81	−171.3	10.70	71.9	−24.55	35.8	−5.34	−39.0	1.03922
1300	−4.81	−175.7	10.03	68.3	−24.34	36.4	−5.42	−41.8	1.09306
1400	−4.80	−179.6	9.41	65.1	−24.19	37.7	−5.55	−43.1	1.16138
1500	−4.77	176.8	8.82	61.6	−23.92	36.9	−5.50	−45.4	1.19230
1600	−4.77	173.2	8.24	58.6	−23.73	38.9	−5.53	−47.3	1.24361
1700	−4.82	171.1	7.70	57.1	−23.50	40.0	−5.54	−49.1	1.29489
1800	−4.72	167.4	7.25	52.6	−23.31	40.4	−5.54	−51.3	1.31465
1900	−4.70	164.6	6.92	50.1	−22.96	41.3	−5.57	−54.0	1.30445
2000	−4.68	161.8	6.48	47.3	−22.74	42.8	−5.55	−56.0	1.32750

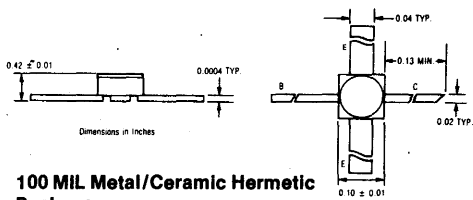
V_{CE} = 8V, I_C = 25mA

Frequency (MHz)	S11		S21		S12		S22		k
100	−5.83	−88.2	30.87	131.0	−37.23	55.3	−2.18	−27.5	0.33256
150	−5.77	−107.6	29.28	125.3	−35.66	56.8	−3.33	−28.6	0.38799
200	−5.54	−121.6	27.32	119.5	−34.93	52.9	−4.67	−30.6	0.52604
250	−5.43	−132.5	25.47	112.9	−34.55	53.8	−5.39	−32.4	0.64475
400	−4.86	−152.7	22.60	96.7	−32.75	45.9	−7.29	−34.6	0.82367
500	−4.77	−160.5	20.82	92.8	−31.90	47.6	−7.79	−33.2	0.92234
600	−4.72	−166.2	19.35	87.7	−31.00	49.6	−8.18	−33.6	0.99615
700	−4.66	−170.7	18.07	83.4	−30.21	50.8	−8.47	−32.9	1.06180
800	−4.63	−174.6	16.93	80.0	−29.45	51.7	−8.64	−34.9	1.10767
900	−4.58	−177.9	15.94	76.7	−29.79	52.7	−8.84	−35.3	1.15458
1000	−5.29	176.5	14.85	72.4	−27.18	59.5	−8.36	−34.0	1.16067
1100	−5.27	−173.3	14.02	69.5	−26.60	59.4	−8.50	−35.3	1.19985
1200	−5.22	−170.4	13.20	66.3	−25.95	59.5	−8.48	−36.3	1.21402
1300	−5.17	167.7	12.50	63.2	−25.28	59.8	−8.55	−39.2	1.21229
1400	−5.13	−165.3	11.84	61.0	−24.82	60.2	−8.61	−40.4	1.24004
1500	−5.08	163.0	11.23	57.8	−24.24	58.8	−8.54	−42.8	1.23090
1600	−5.05	160.8	10.65	55.2	−23.81	59.7	−8.52	−44.9	1.24442
1700	−5.10	159.4	10.07	54.4	−23.36	59.6	−8.53	−46.5	1.27095
1800	−4.97	156.4	9.62	50.1	−22.93	58.9	−8.52	−49.1	1.25286
1900	−4.97	154.5	9.22	48.1	−22.44	58.9	−8.57	−51.2	1.24397
2000	−4.96	152.6	8.78	45.0	−22.10	59.2	−8.47	−54.0	1.24979

NOISE PARAMETERS

Freq.	N.F. OPT	Γs OPT	Rn
0.5 GHz	1.2 dB	.244 /80°	.72Ω
1.0 GHz	1.6 dB	.337 / −97°	.63Ω
1.5 GHz	2.3 dB	.353 / −158°	.31Ω
2.0 GHz	3.0 dB	.345 / −146°	1.15Ω

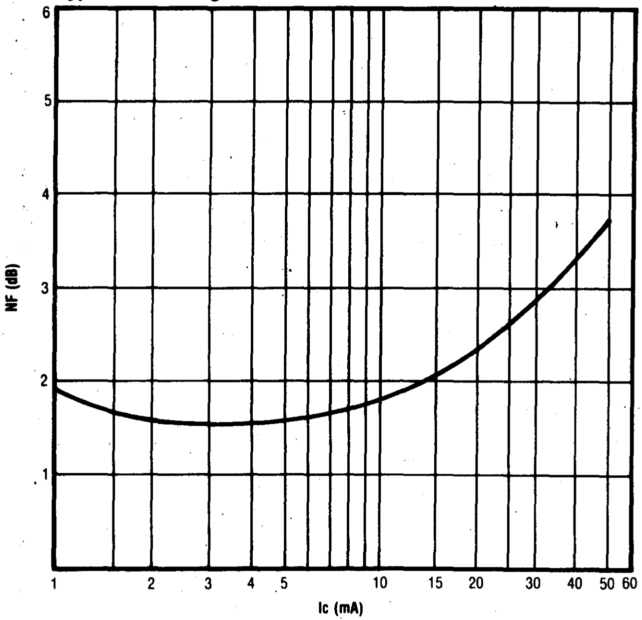
Reflection coefficient of source and the noise resistance at optimum noise figure for V_{CE} = 8V, I_C = 5mA



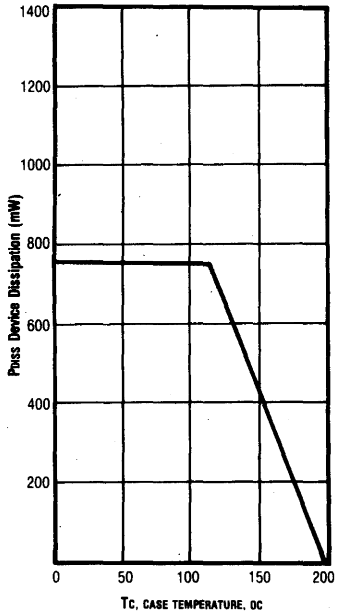
100 MIL Metal/Ceramic Hermetic Package

F

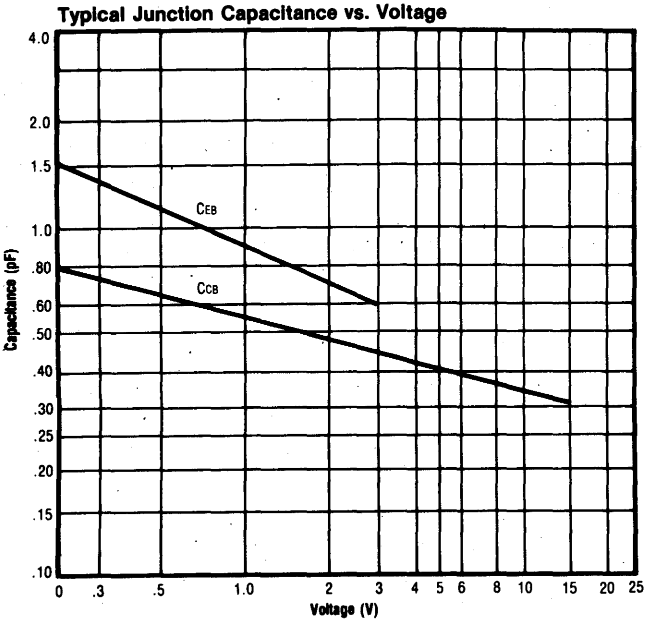
Typical Noise Figure vs. Collector Current



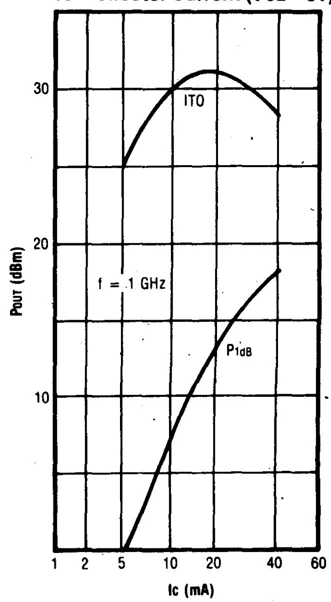
Device Dissipation Operating Range



Typical Junction Capacitance vs. Voltage



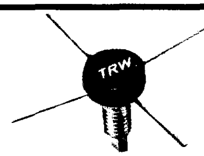
Typical Third Order Intercept vs. Collector Current ($V_{CE} = 8V$)



TRW

Broadband Class A Linear Applications

- High Output
- Low Noise
- Low Distortion



TO-117A

These rugged NPN silicon transistors are specifically designed for broadband Class A applications requiring low distortion and low noise figure. Ceramic capped and stud mounted, these high power devices are ideally suited for CATV and MATV amplifiers. The PT4572A is used as an intermediate or output stage transistor.

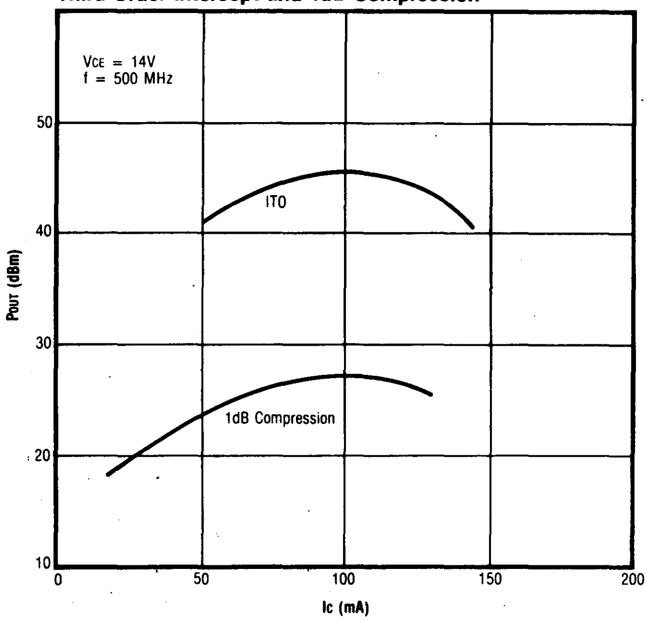
Electrical Characteristics

Symbol	Description	Conditions	Min.	Typ.	Max.	Units
BV_{EBO}	Emitter-Base Breakdown-Voltage	I_E = 0.1mA	3.0			V
BV_{CEO}	Collector-Emitter Breakdown-Voltage	I_C = 5.0mA	25			V
BV_{CBO}	Collector-Base Breakdown-Voltage	I_C = 1.0mA	40			V
I_{CBO}	Collector-Base Leakage	V_{CB} = 10V			200	μA
$V_{CE\,(SAT)}$	Collector-Emitter Saturation Voltage	I_C = 100mA, I_C/I_B = 2		400		mV
h_{FE}	DC Current Gain	V_{CE} = 5V, I_C = 50mA	20	100	150	
C_{CB}	Collector-Base Capacitance	V_{CB} = 8V, f = 1 MHz		2.2		pF
NF_{min}	Minimum Noise Figure	V_{CE} = 8V, I_C = 50mA, f = 300 MHz		2.3		dB
G_{Umax}	Maximum Unilateral Gain	V_{CE} = 14V, I_C = 90mA, f = 300 MHz		16		dB
$\|S_{21}\|^2$	Common Emitter Insertion Gain	V_{CE} = 14V, I_C = 90mA, f = 300 MHz		14		dB
F_T	Gain Bandwidth Product	V_{CE} = 14V, I_C = 90mA		2.5		GHz
P_{OUT}	Power out @ 1dB Compression	V_{CE} = 14V, I_C = 90mA, f = 500 MHz		27		dBm
ITO	Third Order Intercept	V_{CE} = 14V, I_C = 90mA, f = 500 MHz		45		dBm

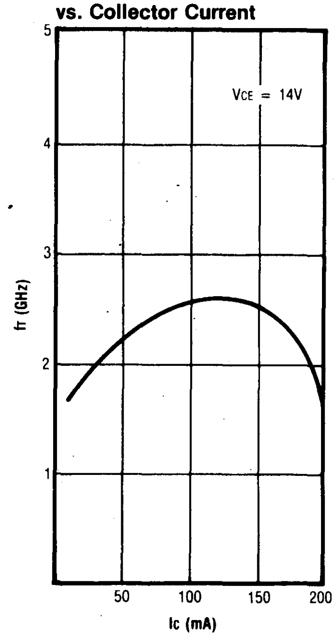
Absolute Maximum Ratings @ 25°C Case

Collector Current (I_C)	Collector Base Voltage (V_{CBO})	Junction Temperature (T_J)	Storage Temperature (T_{STG})
200mA	40V	200°C	−65°C to +200°C

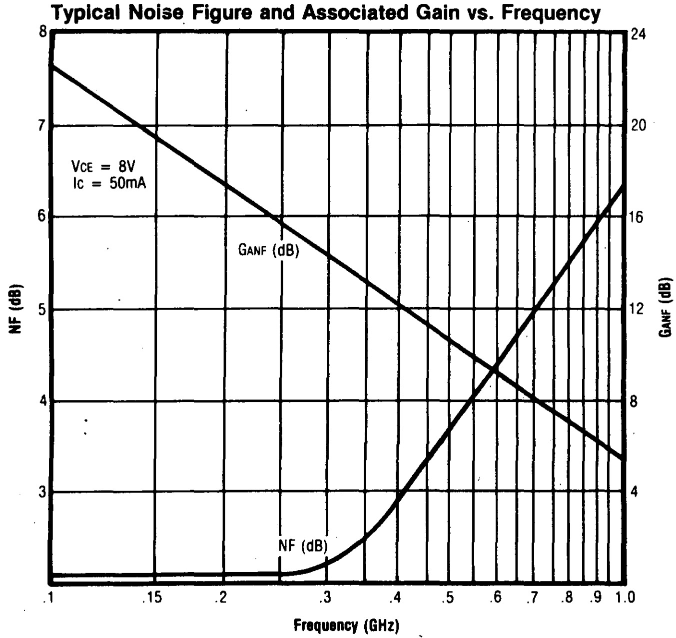
Third Order Intercept and 1dB Compression



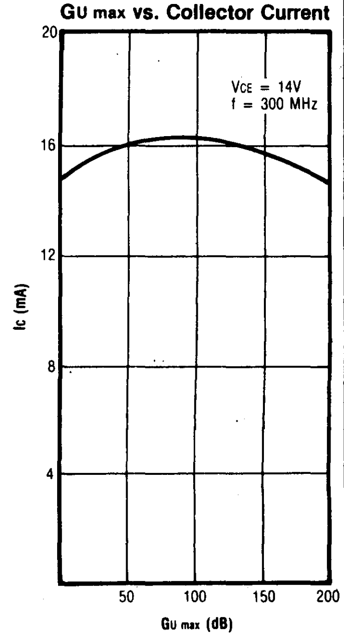
Gain-Bandwidth Product vs. Collector Current



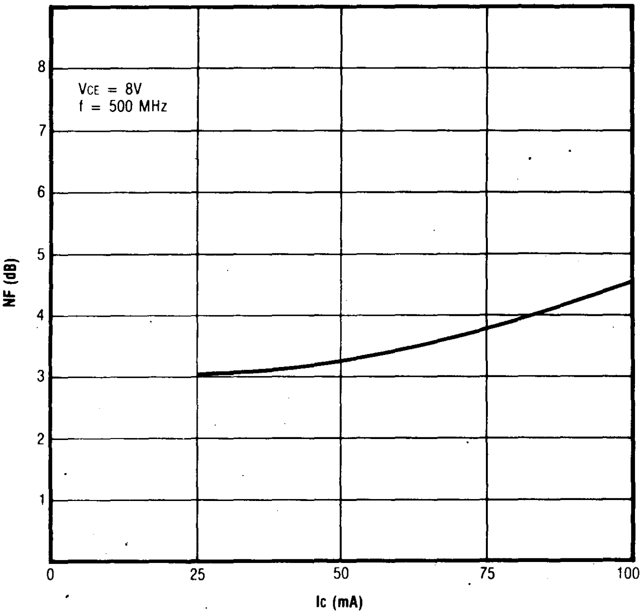
Typical Noise Figure and Associated Gain vs. Frequency



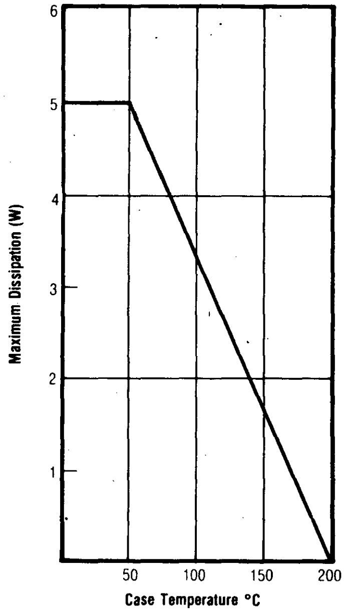
GU max vs. Collector Current



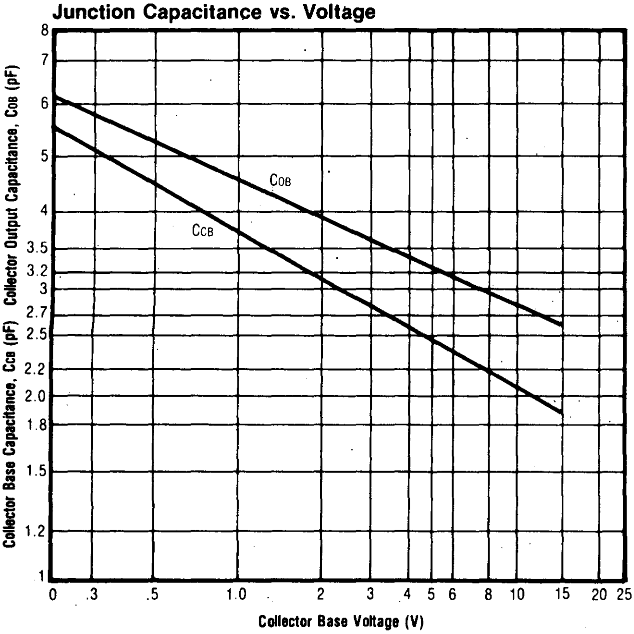
NF vs. Collector Current



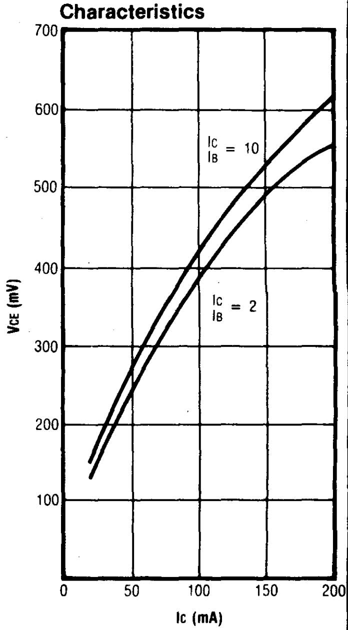
Dissipation vs. Temperature



Junction Capacitance vs. Voltage



Collector Saturation Characteristics



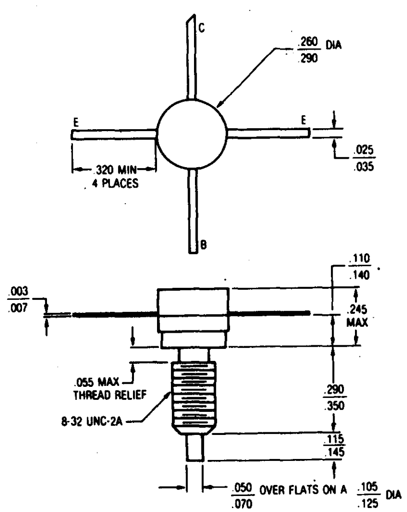
PT 4572 A S PARAMETERS

S-dB and Angles:
VCE = 8V, IC = 50mA

Frequency (MHz)	S11		S21		S12		S22		k
100	−4.58	−172.6	22.07	96.2	−31.41	60.7	−16.48	−108.4	1.085
200	−4.47	169.5	17.14	84.5	−26.24	67.2	−20.29	−124.3	1.101
300	−4.29	156.2	13.79	74.2	−22.99	67.3	−18.02	−132.3	1.100
400	−4.32	146.8	11.42	65.4	−20.62	65.6	−18.23	−128.8	1.098
500	−4.30	136.9	9.43	57.6	−18.96	63.5	−16.01	−129.2	1.123
600	−4.04	128.1	7.90	49.7	−17.55	60.3	−15.84	−143.4	1.119
700	−4.20	121.3	6.47	43.5	−16.45	58.1	−14.73	−141.8	1.164
800	−4.10	113.1	5.23	36.5	−15.67	55.5	−12.53	−158.0	1.216
900	−4.00	105.5	4.08	30.9	−14.82	53.2	−12.23	−166.1	1.245
1000	−4.11	99.9	3.07	25.6	−14.12	51.4	−12.14	−170.1	1.295

VCE = 14V, IC = 90mA

Frequency (MHz)	S11		S21		S12		S22		k
100	−4.49	−177.2	24.66	83.6	−32.32	66.1	−16.41	− 86.9	0.914
200	−4.61	167.1	17.94	75.5	−26.89	70.9	−19.88	− 92.7	1.066
300	−4.49	157.1	14.31	69.1	−23.68	71.1	−19.75	− 99.9	1.100
400	−4.25	147.5	11.78	62.7	−21.31	69.7	−18.35	−110.1	1.094
500	−4.16	138.0	9.76	56.5	−19.44	67.5	−17.36	−117.7	1.105
600	−4.01	130.3	8.14	50.2	−18.02	65.6	−15.80	−127.3	1.115
700	−3.97	123.5	6.80	44.7	−16.86	63.0	−14.36	−137.5	1.139
800	−4.07	115.2	5.43	38.9	−15.97	60.8	−13.31	−146.4	1.214
900	−3.99	107.8	4.23	34.1	−15.12	58.6	−12.54	−153.3	1.248
1000	−4.12	101.5	3.19	30.5	−14.40	57.2	−11.78	−161.1	1.312

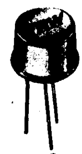


TO-117A

TRW

RF Transistor

- **High fT - 2.0 GHz**
- **Low Distortion**
- **Low Noise Figure: 2.3 dB @ 200 MHz**



TO-39

The PT4579 is a high-output NPN silicon TO-39-mounted transistor designed for ultra-linear communications or instrumentation applications. Low noise figure combined with high-output capability gives this device an exceptional dynamic range. Gold metalization is used to achieve the high reliability demanded by the most severe communications requirements. High gain makes this transistor ideal for broadband applications.

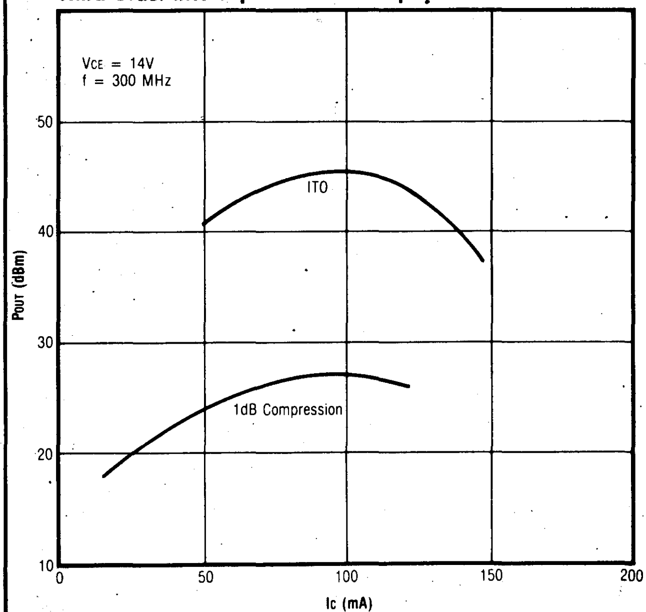
Electrical Characteristics

Symbol	Description	Conditions	Min.	Typ.	Max.	Units
BV_{EBO}	Emitter-Base Breakdown-Voltage	I_E = 0.1mA	3.0			V
BV_{CEO}	Collector-Emitter Breakdown-Voltage	I_C = 25mA	25			V
BV_{CBO}	Collector-Base Breakdown-Voltage	I_C = 1.0mA	40			V
I_{CBO}	Collector-Base Leakage	V_{CB} = 13V		100		μA
$V_{CE\,(SAT)}$	Collector-Emitter Saturation Voltage	I_C = 100mA, I_C/I_B = 2		400		mV
h_{FE}	DC Current Gain	V_{CE} = 5V, I_C = 50mA	50	150	300	
C_{CB}	Collector-Base Capacitance	V_{CB} = 8V, f = 1 MHz		2.5		pF
NF_{min}	Minimum Noise Figure	V_{CE} = 8V, I_C = 50mA, f = 300 MHz		2.3		dB
G_{Umax}	Maximum Unilateral Gain	V_{CE} = 14V, I_C = 90mA, f = 300 MHz		13.5		dB
$\|S_{21}\|^2_E$	Common Emitter Insertion Gain	V_{CE} = 14V, I_C = 90mA, f = 300 MHz		12.0		dB
F_T	Gain Bandwidth Product	V_{CE} = 14V, I_C = 90mA		2.5		GHz
P_{OUT}	Power out @ 1dB Compression	V_{CE} = 14V, I_C = 90mA, f = 300 MHz		26		dBm
ITO	Third Order Intercept	V_{CE} = 14V, I_C = 90mA, f = 300 MHz		46		dBm

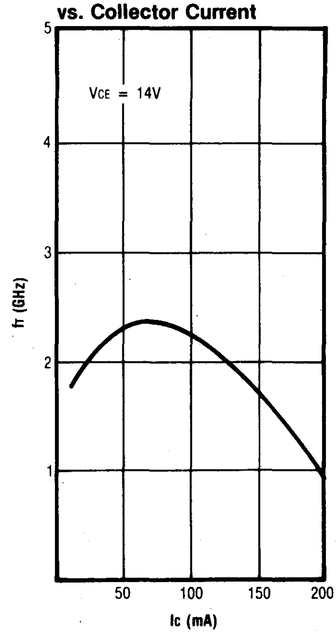
Absolute Maximum Ratings @ 25°C Case

Collector Current (I_C)	Collector Base Voltage (V_{CBO})	Junction Temperature (T_j)	Storage Temperature (T_{STG})
200mA	40V	+200°C	−65°C to +200°C

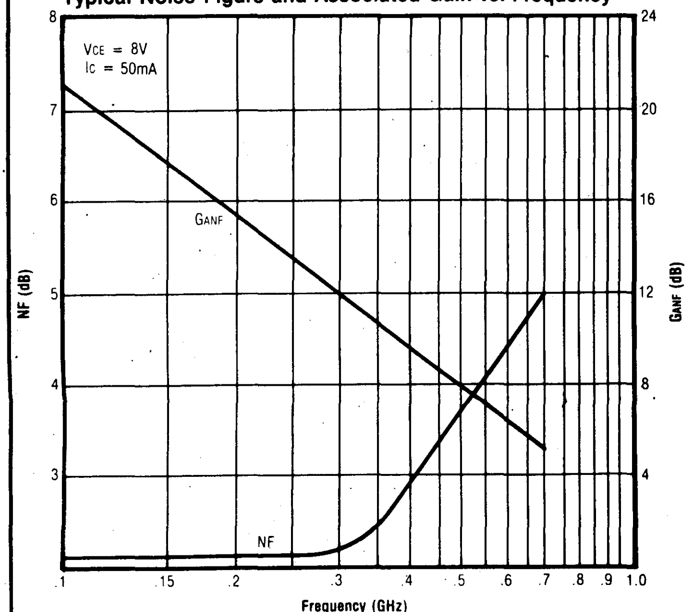
Third Order Intercept and 1dB Compression



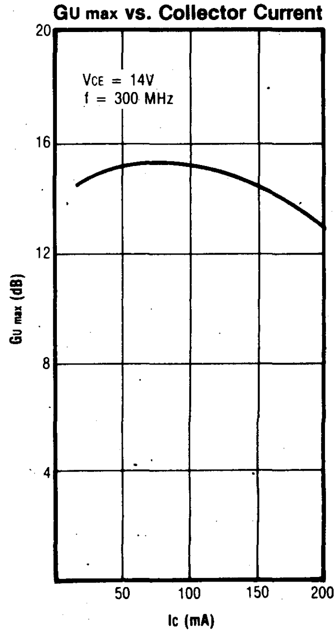
Gain-Bandwidth Product vs. Collector Current



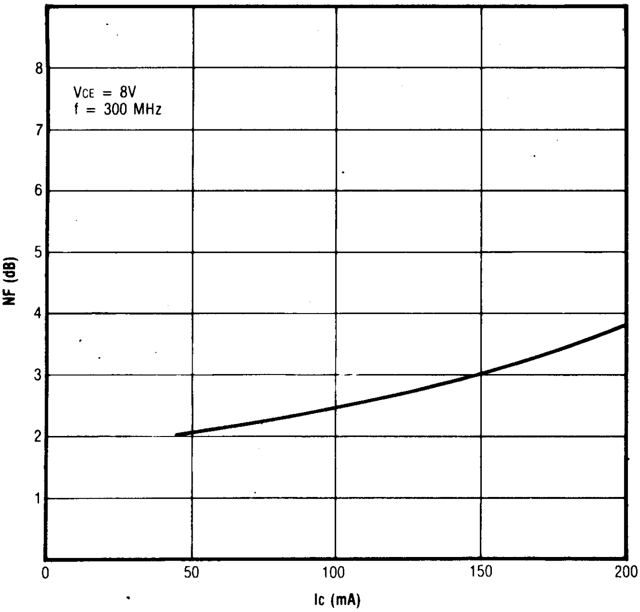
Typical Noise Figure and Associated Gain vs. Frequency



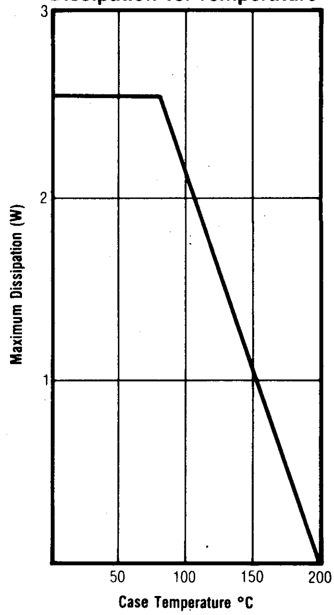
GU max vs. Collector Current



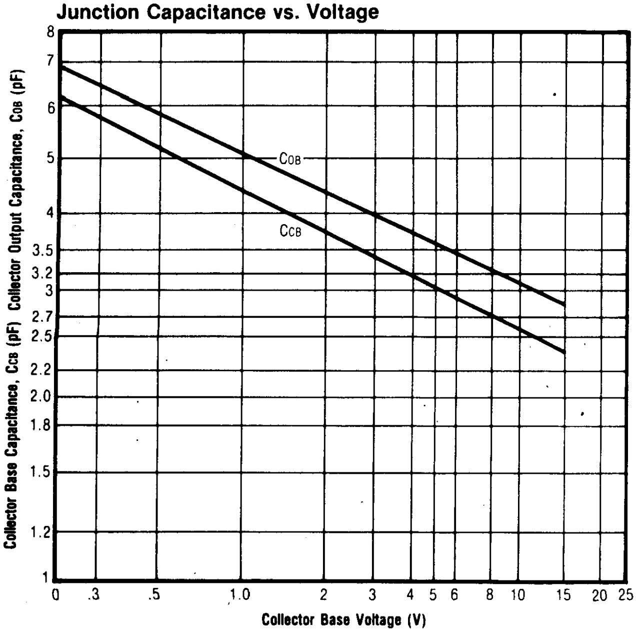
NF vs..Collector Current



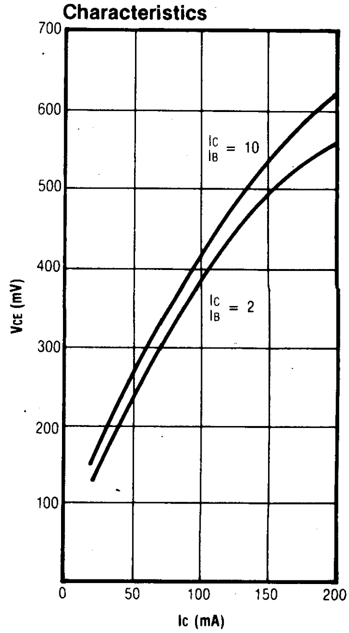
Dissipation vs. Temperature



Junction Capacitance vs. Voltage



Collector Saturation Characteristics



F

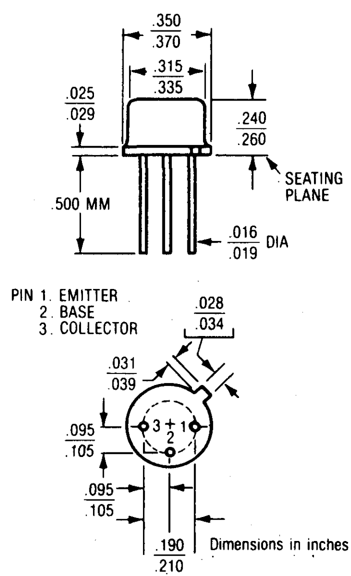
PT 4579 S PARAMETERS

S-dB and Angles:
V_{CE} = 8V, I_C = 50mA

Frequency (MHz)	S11		S21		S12		S22		k
100	– 5.90	– 170.7	19.47	96.2	– 26.71	66.7	– 15.48	– 113.1	1.043
200	– 5.73	170.6	14.39	83.4	– 21.49	71.2	– 17.43	– 129.8	1.064
300	– 5.60	158.7	11.21	73.6	– 18.27	71.4	– 16.90	– 134.9	1.061
400	– 5.65	148.4	8.97	65.5	– 15.95	70.4	– 15.46	– 140.3	1.067
500	– 5.53	137.7	7.21	58.2	– 14.17	68.9	– 15.41	– 144.0	1.065
600	– 5.33	128.4	5.85	51.4	– 12.75	67.2	– 14.00	– 148.0	1.057
700	– 5.38	117.8	4.69	46.2	– 11.49	65.3	– 12.82	– 149.6	1.064
800	– 5.59	109.5	3.83	39.8	– 10.50	62.9	– 11.50	– 156.7	1.078
900	– 5.49	101.0	2.99	34.6	– 9.56	60.8	– 10.80	– 162.2	1.076
1000	– 5.69	90.5	2.27	29.5	– 8.76	58.5	– 10.01	– 169.2	1.091

V_{CE} = 14V, I_C = 90mA

Frequency (MHz)	S11		S21		S12		S22		k
100	– 6.12	– 164.8	21.44	92.0	– 28.07	64.6	– 14.71	– 99.9	0.972
200	– 5.94	– 179.1	15.65	82.1	c23.14	69.6	– 15.64	– 112.7	1.060
300	– 5.83	173.2	12.20	74.6	– 20.09	70.3	– 14.63	– 116.3	1.082
400	– 5.88	167.3	9.81	67.8	– 17.96	69.6	– 13.38	– 115.2	1.091
500	– 5.91	161.9	8.05	62.0	– 16.34	69.2	– 12.22	– 114.4	1.086
600	– 6.03	156.8	6.55	56.1	– 14.99	68.5	– 11.15	– 113.1	1.082
700	– 6.15	151.4	5.33	51.1	– 13.89	67.1	– 10.21	– 113.6	1.078
800	– 6.26	146.4	4.23	46.3	– 12.96	67.0	– 9.44	– 115.0	1.084
900	– 6.33	140.6	3.33	41.9	– 12.18	66.2	– 8.60	– 115.9	1.076
1000	– 6.24	134.0	2.45	37.9	– 11.42	65.7	– 8.00	– 118.6	1.073

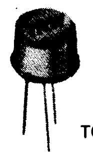


TO-39

TRW

UHF Linear Transistor

- 3 GHz FT
- 1 Volt output DIN 45004 B
- 3.5 dB at 500 MHz

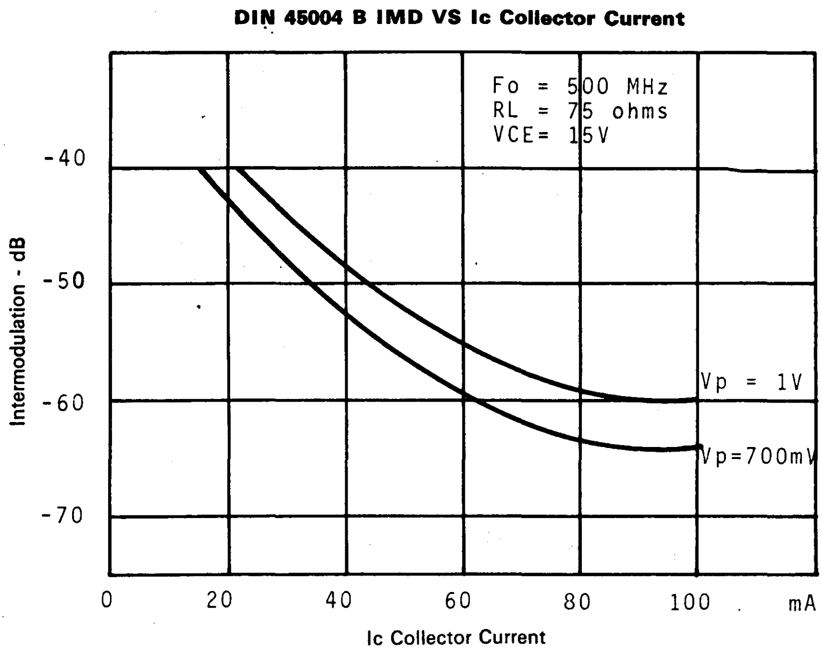


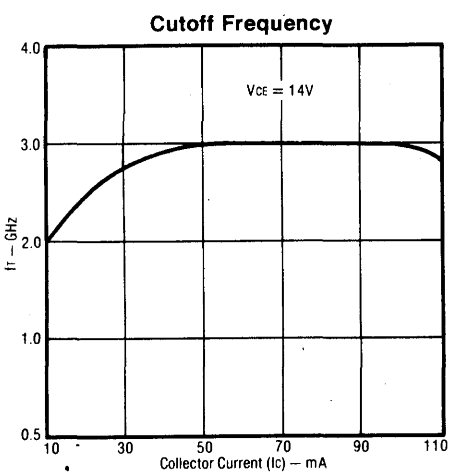
TO 39

The TP 3093 is an NPN silicon transistor using gold metallization and diffused emitter ballast resistors for long term reliability. Its mains characteristics are high output level, low noise figure and high Ft. These features make TP 3093 an ideal candidate for broadband linear amplifier up to 1 GHz (MATV), oscillators, mixers, multipliers and others.

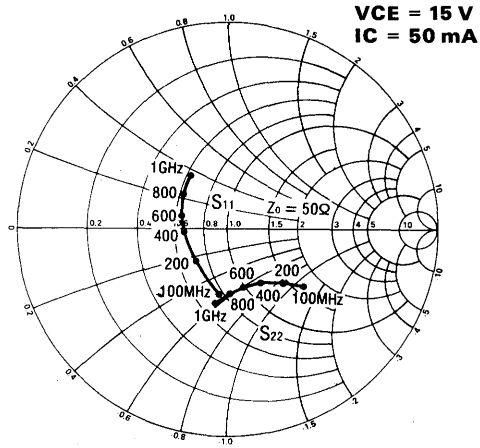
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.1 mA	3			V
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	20			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1 mA	30			V
DC Test	h_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 50 mA	20			
RF Test	NF	Noise Figure	V_{CE} = 15 V I_C = 20 mA F = 500 MHz		3.5		dB
RF Test	f_T	Cutoff Frequency	V_{CE} = 15 V I_C = 50 mA F = 500 MHz		3		GHz
RF Test	G_{Umax}	Maximum Unilaterilized Gain	V_{CE} = 15 V I_C = 50 mA F = 500 MHz		9.5		dB
RF Test	$\|S_{21}\|$	Forward Gain 50 Ω/50 Ω	V_{CE} = 15 V I_C = 50 mA F = 500 MHz		8.5		dB
RF Test	IMD	Intermodulation Distortion 3 Tone - DIN 45004/B F = 500 MHz R_{Load} = 75 ohms	V_{CE} = 15 V V_{out} = 700 mV I_C = 60 mA V_{out} = 1000 mV		— 65 — 56		dB dB
RF Test	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V f = 1 MHz			4	pF
Thermal	I_{Cmax}	Maximum Collector Current			200		mA
Thermal	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 25 °C		50°		°C/W
Thermal	P_T	Dissipated Power	T_{CASE} = 25 °C		3.5		W
Thermal	T_{STG}	Storage Temperature		— 65		+ 200	°C

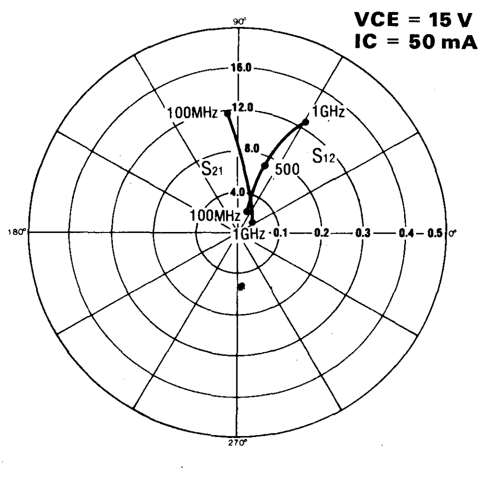

DIN 45004 B IMD VS Ic Collector Current
Fo = 500 MHz
RL = 75 ohms
VCE= 15V
-40
-50
-60
-70
Intermodulation - dB
Vp = 1V
Vp=700mV
0
20
40
60
80
100
mA
Ic Collector Current


Cutoff Frequency
VCE = 14V
4.0
3.0
2.0
1.0
0.5
fT — GHz
10
30
50
70
90
110
Collector Current (Ic) — mA

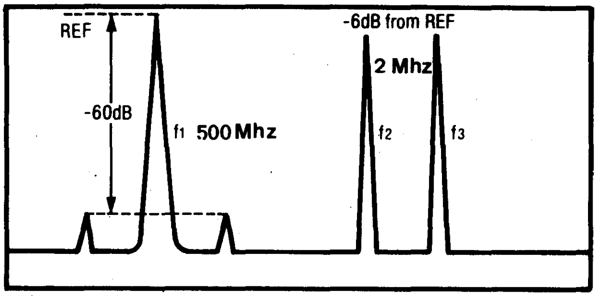
S 22 - S 11 Parameters vs Frequency



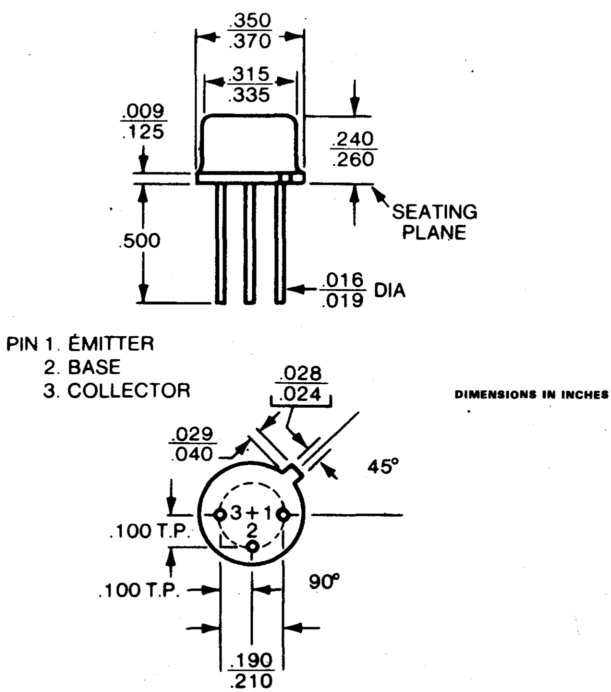
S 21 - S 12 Parameters vs Frequency



Intermodulation Distortion Test



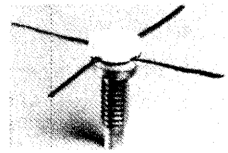
Package Outline
TO-39



TRW

UHF Linear Transistor

- High Output
- 1 V (DIN 45004/B)
- 200 MW (DIN 45004/K)
- 10 dB Gain at 860 MHz
- Gold Reliability



TO 117 C

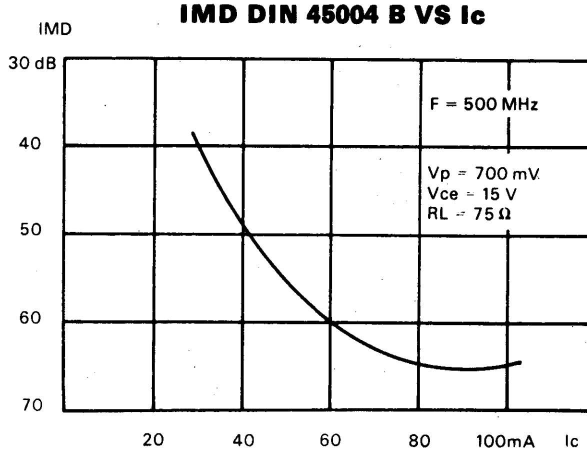
The TP 3098 is a NPN transistor gold metallized for reliability.

It uses diffused emitter ballast resistors for super linearity, The transition frequency of 3 GHz makes these transistor ideal for UHF broadband linear amplification such as in high level 1 VOLT MATV Amplifiers up to 860 MHz or low power 200 mW TV TRANSPOSER stages.

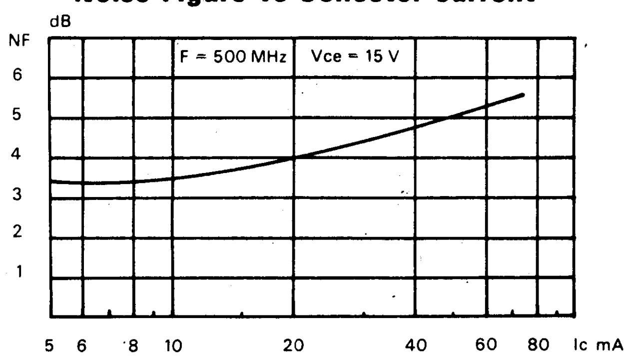
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{BEO}	Emitter - Base Breakdown Voltage	I_E = 0.1 mA	3.0			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	20			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 10 mA R R_{BE} = 10	25			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1 mA	30			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 15 V			0.2	mA
	H_{FE}	D.C. Current Gain	V_{CE} = 10 V I_C = 90 mA	60			
RF Test	N_F	Noise Figure	V_{CE} = 15 V I_C = 40 mA F = 500 MHz			6.5	dB
	F_T	Cutoff Frequency	V_{CE} = 15 V I_C = 100 mA F = 500 MHz		2.6		GHz
	G_{Umax}	Maximum Gain	V_{CE} = 15 V I_C = 100 mA F = 500 MHz		13.5		dB
	$\|S_{21}\|$	Forward Gain 50 ohms/50 ohms	V_{CE} = 15 V I_C = 100 mA F = 500 MHz		11.5		dB
	IMD	Intermodulation Distortion 3 tone — DIN 45004/B F = 500 MHz R_{Load} = 75 ohms	V_{CE} = 15 V V_{out} = 700 mV I_C = 100 mA		— 65	— 60	dB
	C_{OB}	Collector Base Capacitance	V_{CB} = 10 V F = 1 MHz		2.5		pF
Thermal	I_{Cmax}	Maximum Collector Current				200	mA
	Θ_{JC}	Thermal Resistance	T_{case} = 25 °C			35	°C/W
	P_T	Dissipated Power				5.0	W
	T_{STG}	Storage Temperature		— 65		+ 200	°C
	T_J	Junction Temperature					

IMD DIN 45004 B VS Ic

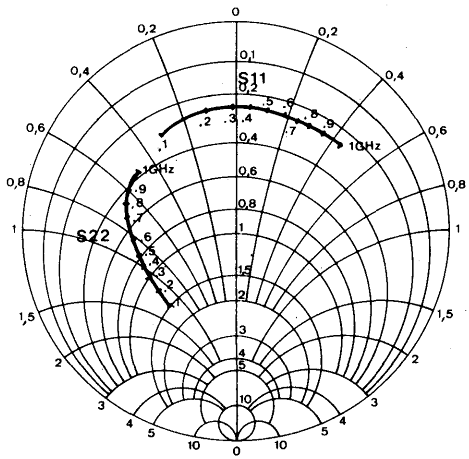


Noise Figure vs Collector current



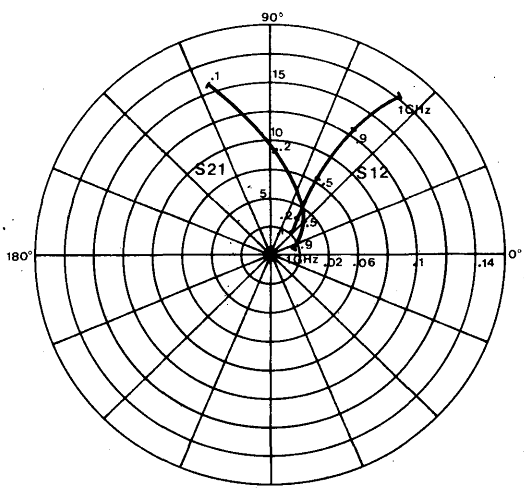
S11 and S22 vs Frequency

V_{CE} = 15 V - I_C = 100 mA

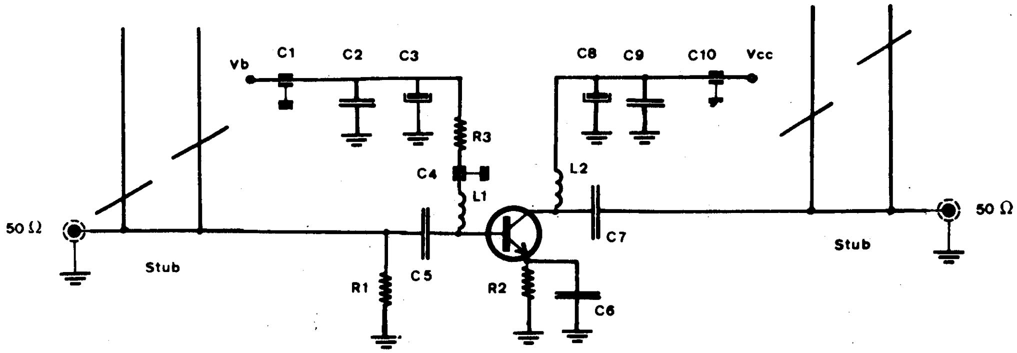


S21 - S 12 Parameters vs Frequency

V_{CE} = 15 V - I_C = 100 mA

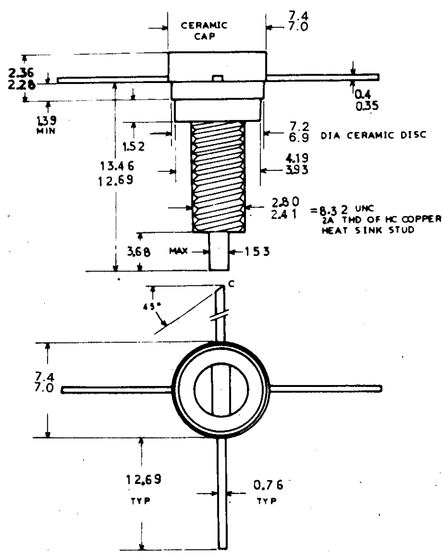


IMD AND NF TEST CIRCUIT AT 500 MHz



$L_{1,2}$	0.1 nH molded coil
$C_{1,4,10}$	1000 pF by pass
$C_{2,9}$	470 pF ceramic disc
$C_{5,7}$	220 pF ceramic chip
$C_{3,8}$	47 μF 40 V electrolytic
C_6	2 × 220 pF chip one at each emitter lead
R_1	100 ohms 1/4 W carbon resistor
R_2	39 ohms 1/4 W carbon resistor
R_3	1.5 K ohms 1/4 W carbon resistor

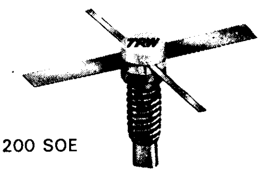
Package Outline To 117 G



TP 3400

TRW

- **0.20 W**
- **960 MHz**
- **12 dB Gain**
- **24 V**
- **Class A**



200 SOE

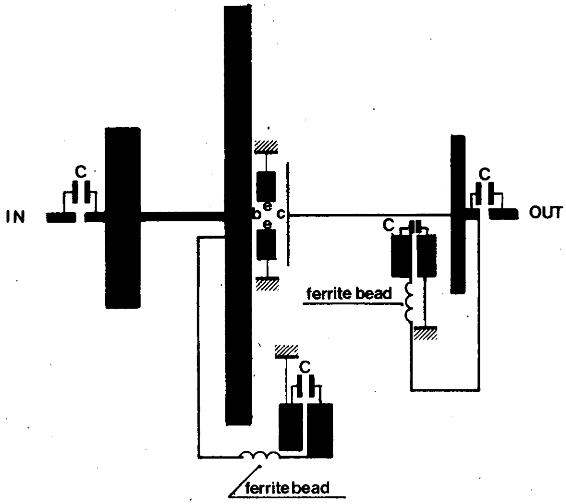
The TP 3400 is designed for use on the 900 MHz mobile band.

This device which is specified as a low power drive device, offering high gain, enables operation in class A, B or C circuits.

F

Electrical characteristics (Tcase = 25 °C)

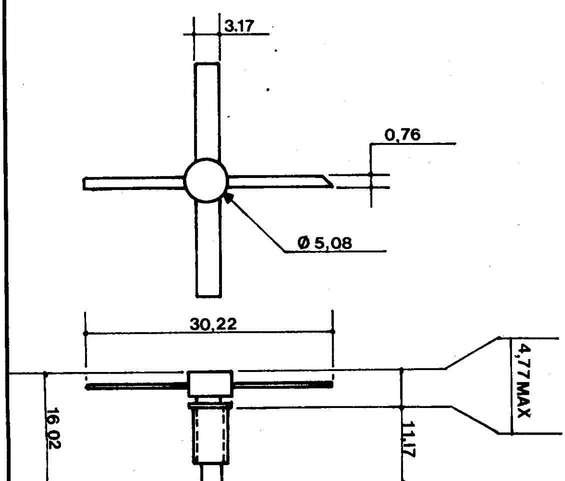
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
DC Test	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 10 mA, R_{BE} = 10	50			V
DC Test	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1 mA	45			V
DC Test	I_{CBO}	Collector Cutoff Current	V_{CB} = 24 V			0.25	mA
DC Test	H_{FE}	D.C. Current Gain	V_{CE} = 5 V, I_C = 100 mA	20		120	–
RF Test	P_{OUT}		V_{CE} = 24 V, F = 960 MHz IQ = 74 mA ; Pin = 12.5 mW	200			mW
RF Test	C_{OB}	Collector Base Capacitance	V_{CB} = 20 V, F = 1 MHz			3	pF
Thermal	I_C	Maximum Collector Current				0.4	A
Thermal	θ_{jc}	Thermal Resistance Junction Case	T case = 70 °C			30	°C/W
Thermal	P_T		T Heatsink = 25 °C			5.8	W
Thermal	T_{STG}/T_J	Maximum Junction and Storage Temperature		– 65		+ 200	°C



C=100 Pf

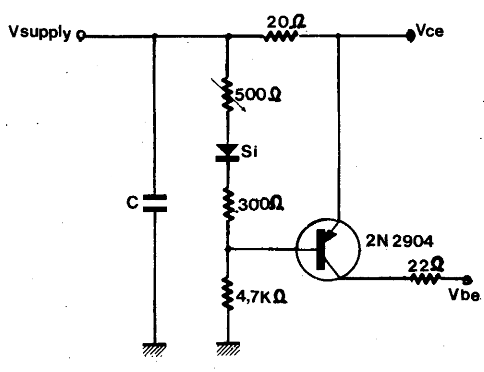
Substrate Epoxy Glass 20 m/m thick $\mathcal{E}r$ = 2,43

: Foil wrap to ground plane



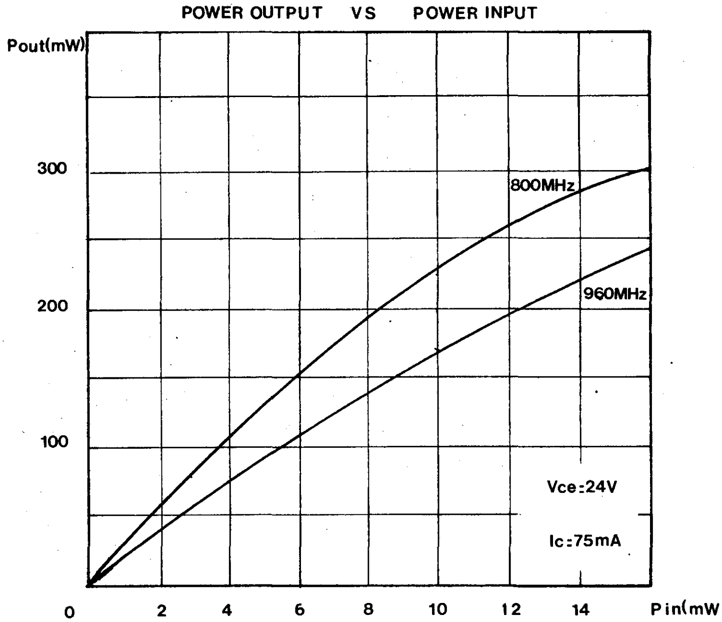
PACKAGE 200 SOE STUD

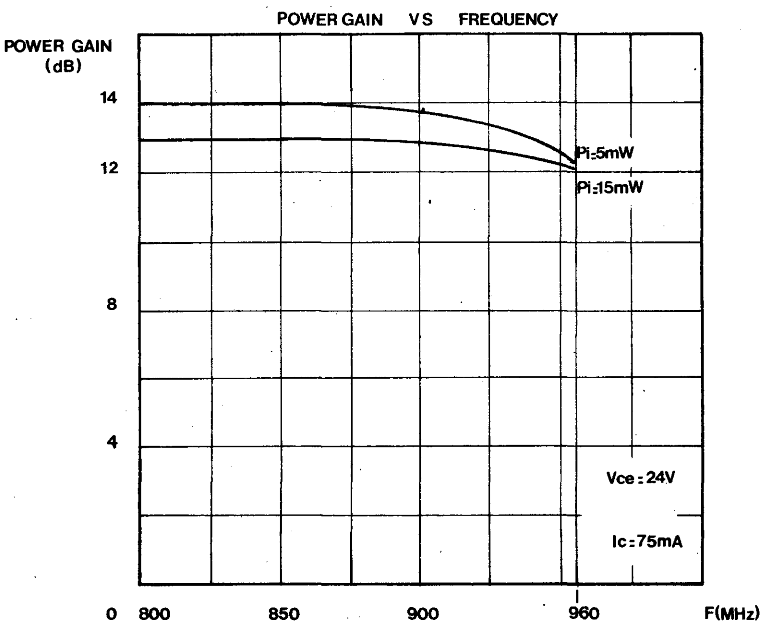
Dimensions Given in m/m



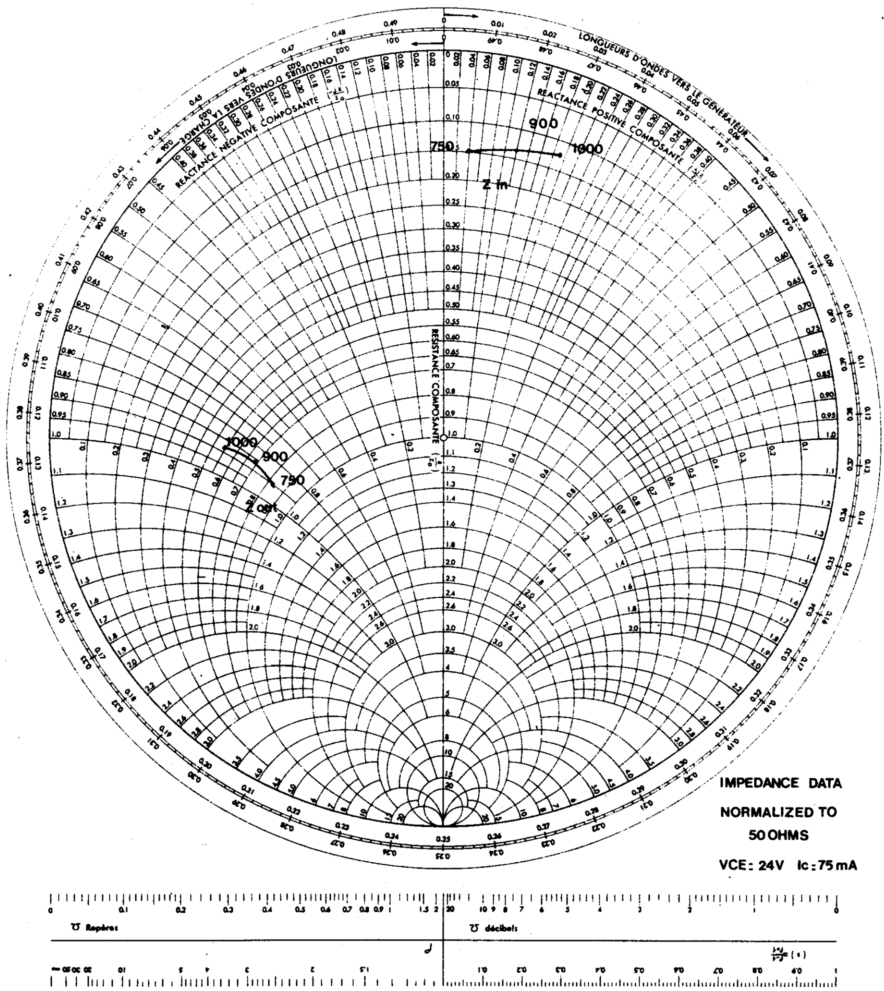
C=1 µF+0,1 µF+10nF

BIAS CIRCUIT


POWER OUTPUT VS POWER INPUT
Pout(mW)
300
200
100
0
2
4
6
8
10
12
14
Pin(mW)
800MHz
960MHz
Vce:24V
Ic:75mA


POWER GAIN VS FREQUENCY
POWER GAIN (dB)
14
12
8
4
0
800
850
900
960
F(MHz)
Pi:5mW
Pi:15mW
Vce:24V
Ic:75mA

F



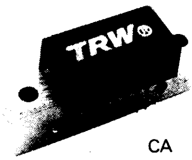
IMPEDANCE DATA
NORMALIZED TO
50 OHMS
VCE: 24V Ic: 75 mA

N° 361

CA 2101 - CA 2201

CATV Hybrid Amplifiers

- 300 MHz
- 17 dB



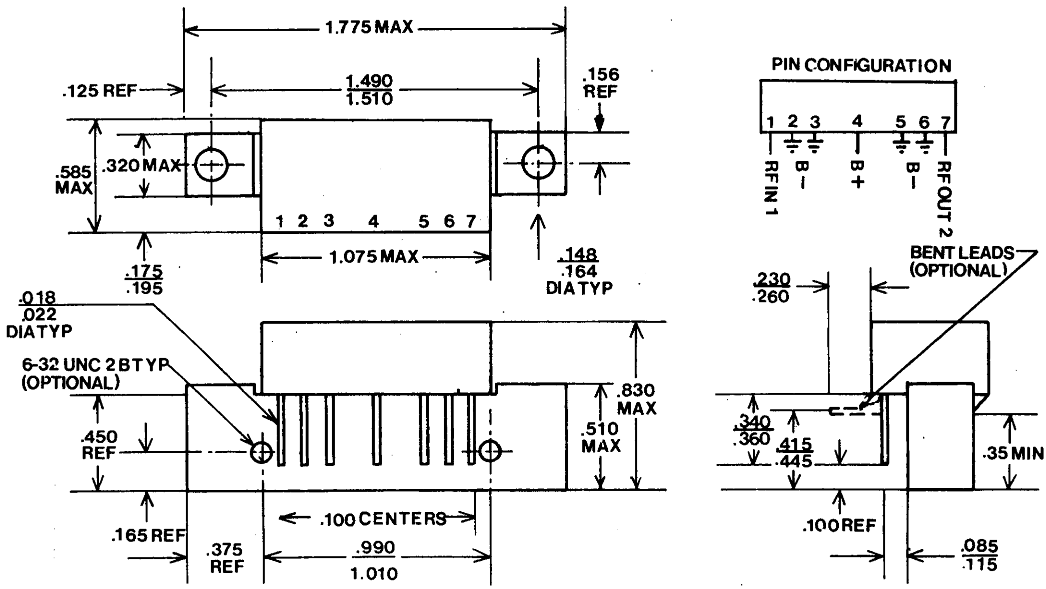
CA

F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

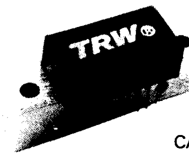
PARAMETER	CA 2101	CA 2201
Gain @ 50 MHz	17.1 ± 0.5 dB	17.1 ± 0.5 dB
Frequency Response	40-300 MHz (± 0.1 dB)	40-300 MHz (± 0.1 dB)
Slope Cable Equivalent	0.0. to + 1.0 dB	0.0 to + 1.0 dB
Output Capability @ −57 dB X-MOD 35 Channel Flat	48.0 dBmV	50.5 dBmV
35 Channel Composite Triple Beat @ +46 dBmV on Channel W	−61 dB	−66 dB
Second Order Beat @ 50 dBmV	−69 dB	−71 dB
Triple Beat @ 50 dBmV on CH W	−74 dB	−79 dB
Noise Figure on Channel W	7.0 dB Maximum	7.5 dB Maximum
Return Loss Input/Output	18 dB Minimum	18 dB Minimum
Power Requirement	165 mA (Typ) @ 24 Vdc	200 mA (Typ) @ 24 Vdc
Operating Temperature (Sink)	−20 °C to + 100 °C	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C	−40 °C to + 100 °C

CA PACKAGE OUTLINE



CATV Hybrid Amplifiers

- **450 MHz**
- **22 dB**

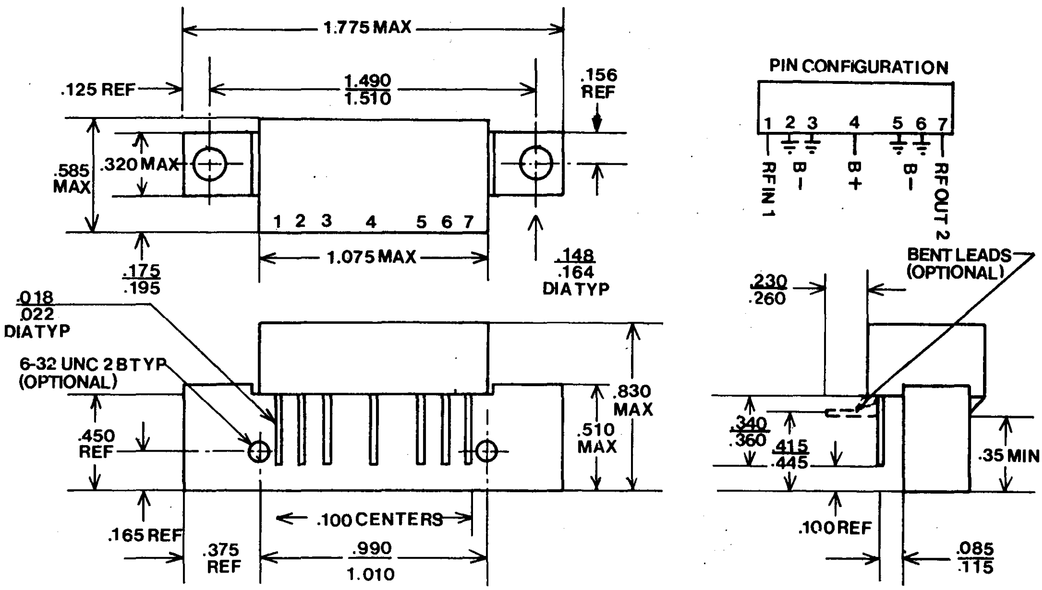


CA

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

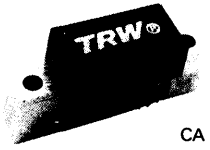
PARAMETER	CA 2300	CA 2301
Gain @ 50 MHz	22.0 ± 0.6 dB	22.0 ± 0.6 dB
Cable Equivalent Slope (50-300 MHz)	0 to + 1.0 dB	0 to + 1.0 dB
Frequency Response	40-300 MHz (± 0.2 dB)	40-300 MHz (± 0.2 dB)
Composite Triple Beat (@ 46 dBmV)		
35 Ch on CH 13	− 77 dB Max.	− 82 dB Max.
35 Ch on CH W	− 73 dB Max.	− 78 dB Max.
X-MOD @ 46 dBmV		
12 Channel	−69 dB Max.	−74 dB Max.
20 Channel	−64 dB Max.	−69 dB Max.
35 Channel	−59 dB Max.	−64 dB Max.
Second Order Beat @ 50 dBmV		
Ch 2, 13, R	−64 dB	−66 dB
Triple Beat @ 50 dBmV		
On Ch H-14	−72 dB	−76 dB
On Ch H-22	−68 dB	−72 dB
Noise Figure on CH W	6.0 dB Max.	7.0 dB Max.
Return Loss Input/Output	18 dB Min.	18 dB Min.
Power Requirement	180 mA (Typ) @ 24 V	215 mA (Typ) @ 24 V
Operating Temperature (Sink)	−20 °C to + 100 °C	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C	−40 °C to + 100 °C

CA PACKAGE OUTLINE



CATV Hybrid Amplifier

- **300 MHz**
- **33 dB**



CA

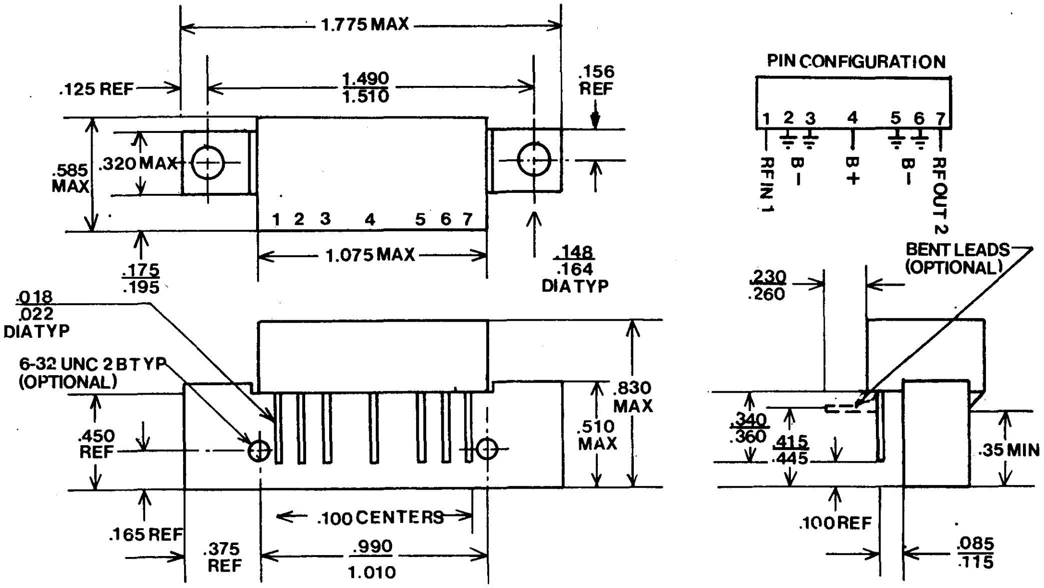
The CA 2600 amplifier is optimized for 75 Ω CATV applications where signature free flat response, excellent impedance match and low distortion and noise figure are required.

High reliability is achieved through a monometalic gold assembly process using state-of-the-art gold transistors. These hybrids utilizing push-pull circuitry provide low distortion and superior thermal stability.

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 2600
Gain @ 50 MHz	33.5 ± 1 dB
Frequency Response	40-300 MHz ± 0.3 dB
Slope Cable Equivalent	+0.5 to +1.5 dB
Output Capability @ −57 dB NCTA	
12 CH Flat	53.5 dBmV
20 CH Flat	51.0 dBmV
35 CH Flat	48.5 dBmV
Second Order Beat @ 50 dBmV CH 2, 13, R	−68 dB
Triple Beat @ 50 dBmV	
$F_1 \pm F_2 \pm F_3$ on 13	−80 dB
$F_1 \pm F_2 \pm F_3$ on W	−76 dB
Composite Triple Beat 35 Channels Flat @ 46 dBmV	
CH 13	−65
CH W	−62
Noise Figure CH W	7.0 dB Max.
Return Loss Input/Output	18 dB Min.
Power Requirement 24 Volts	290 mA (Typ)
Operating Temperature	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C

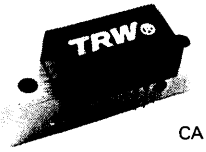
CA PACKAGE OUTLINE



TRW

CATV Hybrid Amplifiers

- 330 MHz
- 17 dB

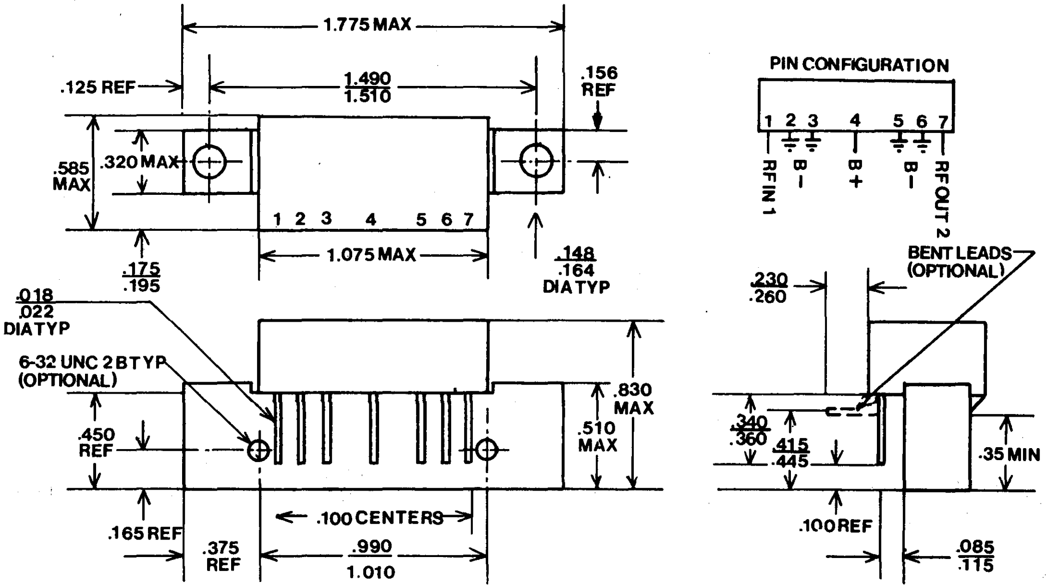


F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 3101	CA 3201
Gain @ 50 MHz	17.1 ± 0.5 dB	17.1 ± 0.5 dB
Frequency Response	40-330 MHz (± 0.1 dB)	40-330 MHz (± 0.1 dB)
Slope Cable Equivalent	0.0 to + 1.0 dB	0.0 to + 1.0 dB
Output Capability @ − 57 dB X-MOD 40 Channel Flat	47.0 dBmV	49.5 dBmV
40 Channel Composite Triple Beat @ + 46 dBmV on Channel W	− 58 dB	− 63 dB
Second Order Beat @ 50 dBmV	− 68 dB	− 70 dB
Triple Beat @ 50 dBmV on CH W	− 74 dB	− 79 dB
Noise Figure @ 330 MHz	7.0 dB Maximum	7.5 dB Maximum
Return Loss Input/Output	18 dB Minimum	18 dB Minimum
Power Requirement	175 mA (Typ) @ 24 Vdc	210 mA (Typ) @ 24 Vdc
Operating Temperature (Sink)	− 20 °C to + 100 °C	− 20 °C to + 100 °C
Storage Temperature	− 40 °C to + 100 °C	− 40 °C to + 100 °C

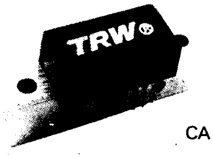
CA PACKAGE OUTLINE



TRW

CATV Hybrid Amplifier

- 330 MHz
- 34 dB

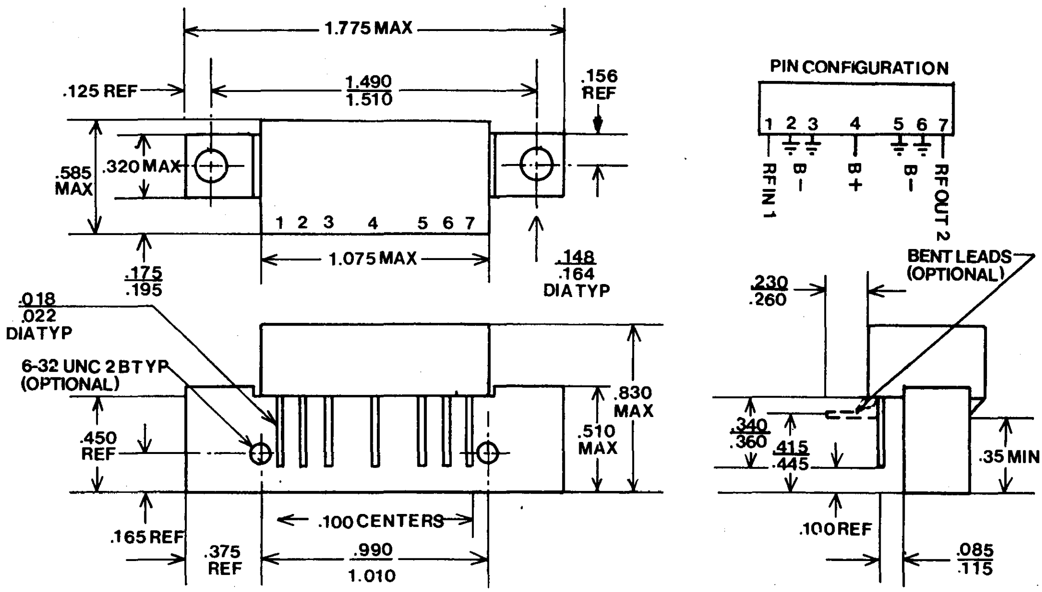


CA

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

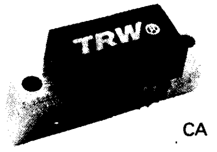
PARAMETER	CA 3600
Gain @ 50 MHz	34.0 ± 1 dB
Frequency Response	40-330 MHz (± 0.3 dB)
Slope Cable Equivalent (50-330 MHz)	+0.4 to +1.5 dB
Output Capability @ −57 dB X-MOD 40 Channel Flat	+48.5 dBmV
40 Channel Composite Triple Beat @ +46 dBmV on Ch W	−60 dB
Second Order Beat @ 50 dBmV CH 2, 13, R	−66 dB
Triple Beat @ 50 dBmV on CH W	−77 dB
Noise Figure on CH W	7.0 dB Max.
Return Loss Input/Output	18 dB Minimum
Power Requirement	320 mA (typ) @ 24 Vdc
Operating Temperature	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C

CA PACKAGE OUTLINE



CATV Hybrid Amplifiers

- 400 MHz
- 17 dB

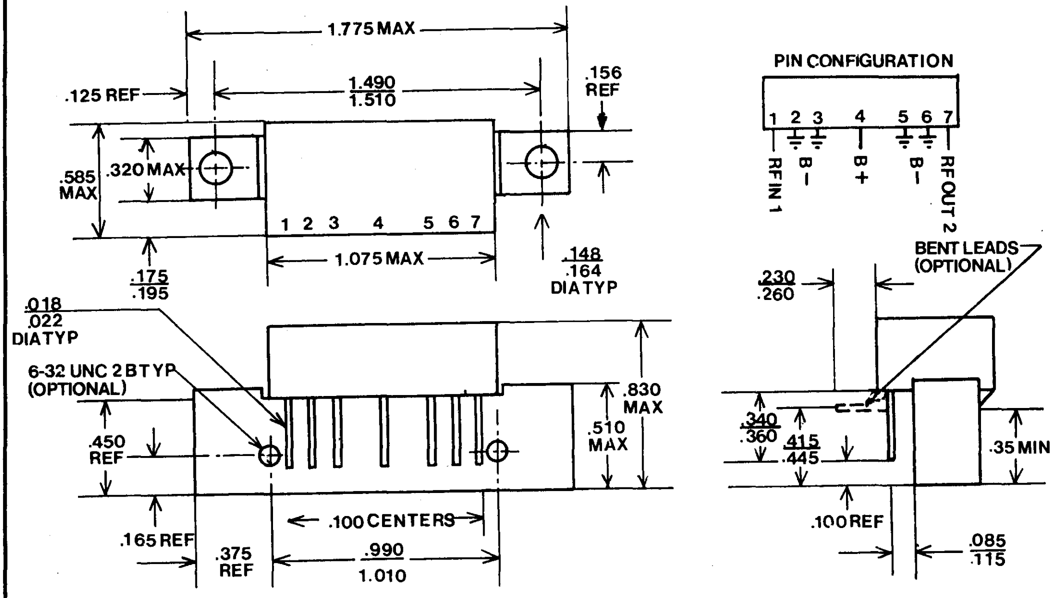


F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 4101	CA 4201
Gain @ 50 MHz	16.7-17.7 dB	16.7-17.7 dB
Gain @ 400 MHz	17.4-18.6 dB	17.4-18.6 dB
Frequency Response	40-400 MHz (± 0.2 dB)	40-400 MHz (± 0.2 dB)
Output Capability @ −57 dB X-MOD 52 Channel Flat	+47 dBmV	+49 dBmV
52 Channel Composite Triple Beat @ + 46 dBmV on H14	−54 dB	−58 dB
Second Order Beat @ 50 dBmV		
CH 2, 13, R	−69 dB	−71 dB
CH G, N, H14	−66 dB (Typ)	−68 dB (Typ)
Triple Beat @ 50 dBmV on CH H14	−68 dB	−72 dB
Noise Figure on CH H14	8 dB Max. (7.5 dB Typ)	9 dB Max. (8 dB Typ)
Return Loss Input/Output	18 dB Min.	18 dB Min.
Power Requirement	170 mA (Typ) @ 24 V	210 mA (Typ) @ 24 V
Operating Temperature (Sink)	−20 °C to + 100 °C	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C	−40 °C to + 100 °C

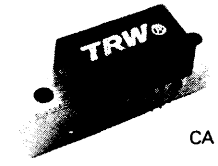
CA PACKAGE OUTLINE



TRW

CATV Hybrid Amplifier

- 400 MHz
- 34 dB



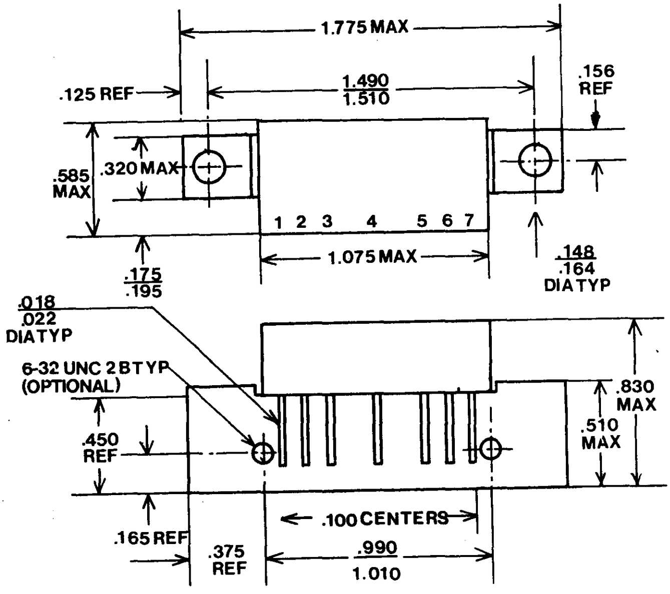
CA

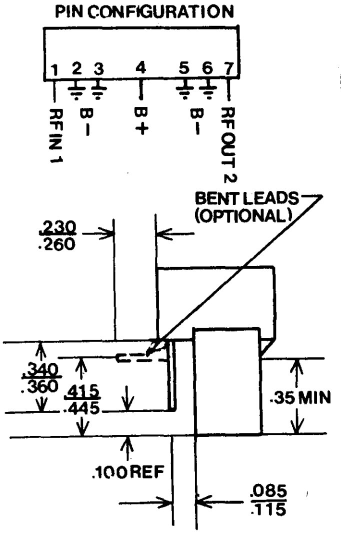
F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 4600
Gain @ 50 MHz	34.0 ± 1 dB
Frequency Response	40-400 MHz (± 0.4 dB)
Slope Cable Equivalent (50-400 MHz)	+0.6 to +2.0 dB
Output Capability @ −57 dB X-MOD 40 Channel Flat	+48.5 dBmV
40 Channel Composite Triple Beat @ +46 dBmV on Ch W	−66 dB
Second Order Beat @ 50 dBmV CH 2, 13, R	−66 dB
Triple Beat @ 50 dBmV on CH H-14	−71 dB
Noise Figure on CH H-14	7.5 dB Max.
Return Loss Input/Output	18 dB Minimum
Power Requirement	320 mA (typ) @ 24 Vdc
Operating Temperature	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C

CA PACKAGE OUTLINE



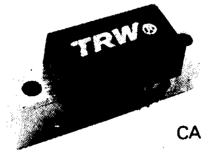


CA 5101 - CA 5201

TRW

CATV Hybrid Amplifiers

- 450 MHz
- 18 dB



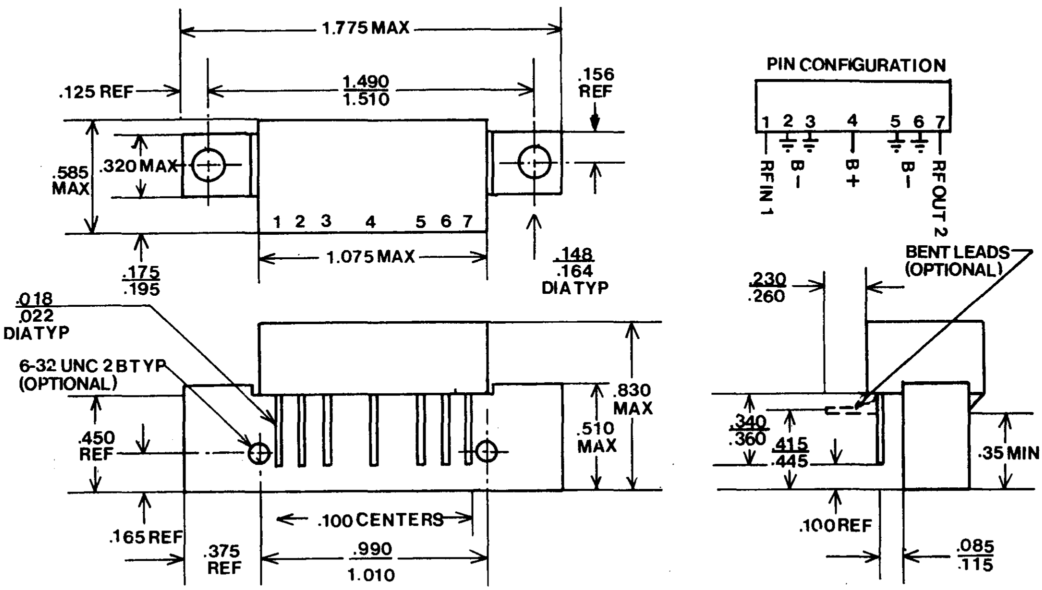
CA

F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 5101	CA 5201
Gain @ 450 MHz	18.5-19.7 dB	18.5-19.7 dB
Gain Equivalent Slope (50-450 MHz)	.3-1.4 dB	.3-1.4 dB
Frequency Response	40-450 MHz (± 0.2 dB)	40-450 MHz (± 0.2 dB)
Composite Triple Beat (@ 46 dBmV)		
52 Ch on H-14	−58 dB Max.	−62 dB Max.
60 Ch on H-22	−55 dB Max.	−59 dB Max.
X-MOD @ 46 dBmV		
52 Channel	−57 dB Max.	−60 dB Max.
60 Channel	−55 dB Max.	−58 dB Max.
Second Order Beat @ 50 dBmV		
Ch 2, H-5, H-14	−65 dB	−69 dB
Triple Beat @ 50 dBmV		
On Ch H-14	−74 dB	−78 dB
On Ch H-22	−70 dB	−74 dB
Noise Figure on 50 MHz	4.5 dB Max.	5.0 dB Max.
400 MHz	6.0 dB Max.	6.5 dB Max.
450 MHz	6.5 dB Max.	7.0 dB Max.
Return Loss Input/Output	18 dB Min.	18 dB Min.
Power Requirement	180 mA (Typ) @ 24 V	215 mA (Typ) @ 24 V
Operating Temperature (Sink)	−20 °C to + 100 °C	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C	−40 °C to + 100 °C

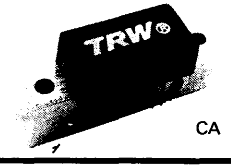
CA PACKAGE OUTLINE



TRW

CATV Hybrid Amplifiers

- 450 MHz
- 22 dB



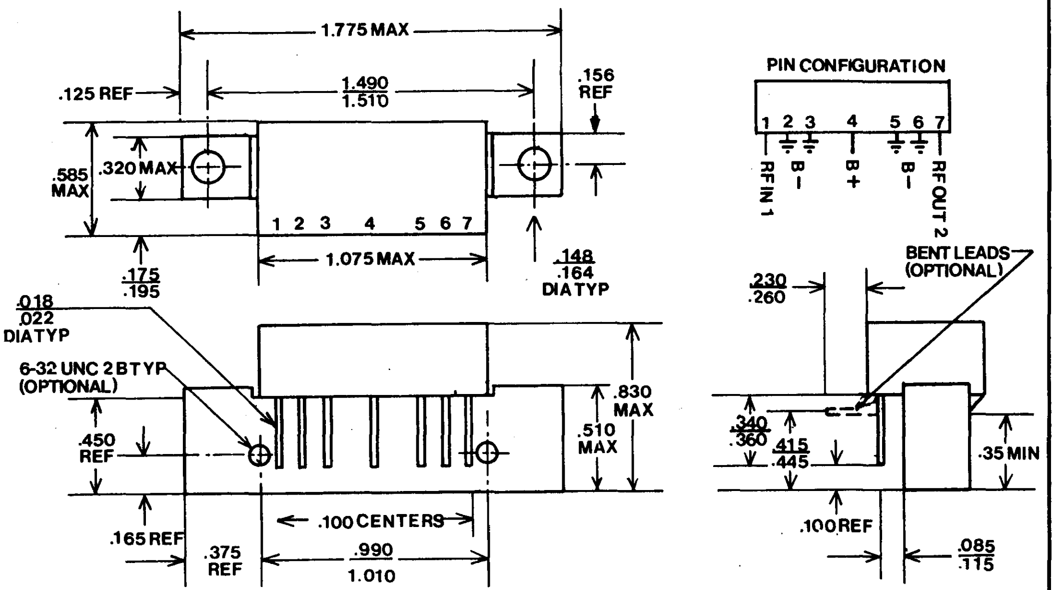
CA

F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

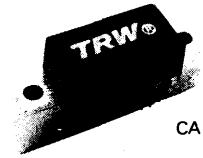
PARAMETER	CA 5300	CA 5301
Gain @ 50 MHz	21.4-22.6 dB	21.4-22.6 dB
Gain @ 450 MHz	22-5.-23.8 dB	22.5-23.8 dB
Cable Equivalent Slope (50-450 MHz)	.5-1.8 dB	.5-1.8 dB
Frequency Response	40-450 MHz (± 0.2 dB)	40-450 MHz (± 0.2 dB)
Composite Triple Beat (@ 46 dBmV)		
52 Ch on H-14	−57 dB Max.	−61 dB Max.
60 Ch on H-22	−53 dB Max.	−57 dB Max.
X-MOD @ 46 dBmV 60 Ch on Ch 2	−54 dB	−58 dB
Second Order Beat @ 50 dBmV On Ch H-5, H-14	−63 dB	−67 dB
Triple Beat @ 50 dBmV		
On Ch H-14	−72 dB	−76 dB
On Ch H-22	−68 dB	−72 dB
Noise Figure on 50 MHz	4.5 dB Max.	5.0 dB Max.
400 MHz	6.0 dB Max.	6.5 dB Max.
450 MHz	6.5 dB Max.	7.0 dB Max.
Return Loss Input/Output	18 dB Min.	18 dB Min.
Power Requirement	180 mA (Typ) @ 24 V	225 mA (Typ) @ 24 V
Operating Temperature (Sink)	−20 °C to + 100 °C	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C	−40 °C to + 100 °C

CA PACKAGE OUTLINE



CATV Hybrid Amplifier

- 450 MHz
- 34 dB

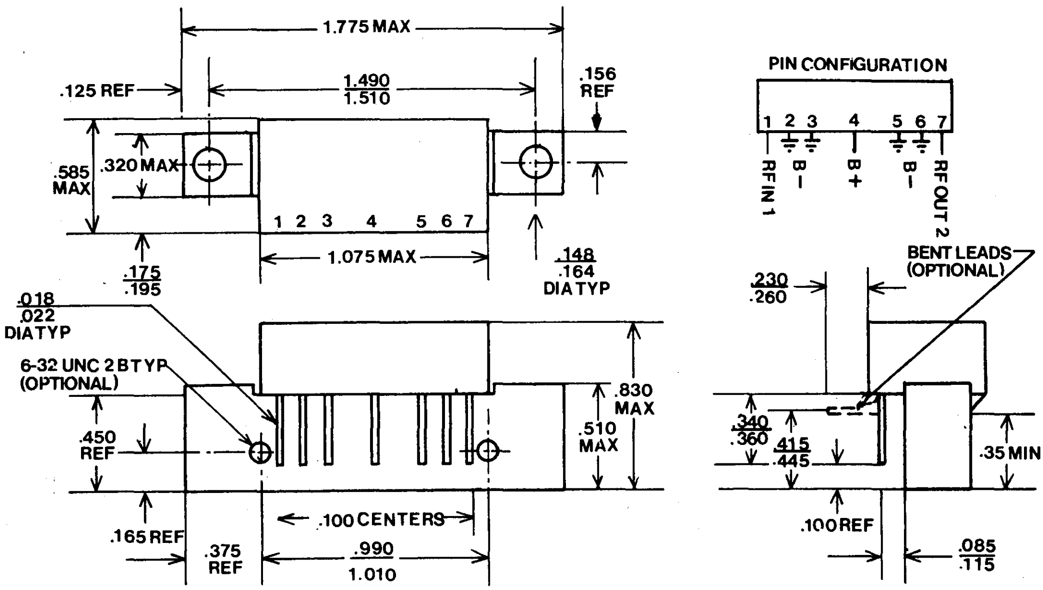


CA

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

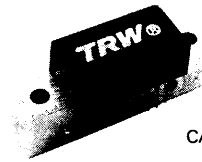
PARAMETER	CA 5600
Gain @ 50 MHz	34.0 ± 1.0 dB
Frequency Response	40-450 MHz (± 0.4 dB)
Slope Cable Equivalent (50-450 MHz)	+0.5 to +2.0 dB
Composite Triple Beat (@ 46 dBmV)	
52 Channel on H-14	−61 dB Max.
60 Channel on H-22	−58 dB Max.
X-MOD @ 46 dBmV	
52 Channel	−60 dB
60 Channel	−58 dB
Second Order Beat @ 50 dBmV Ch 2, H-5, H-14	−64 dB
Triple Beat @ 50 dBmV	
On Ch H-14	−76 dB
On Ch H-22	−72 dB
Noise Figure on 50 MHz	4.5 dB Max.
400 MHz	5.5 dB Max.
450 MHz	6.0. dB Max.
Return Loss Input/Output	18 dB Min.
Power Requirement	340 mA (Typ) @ 24 V
Operating Temperature (Sink)	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C

CA PACKAGE OUTLINE



CATV Hybrid Amplifier

- 450 MHz
- 38 dB



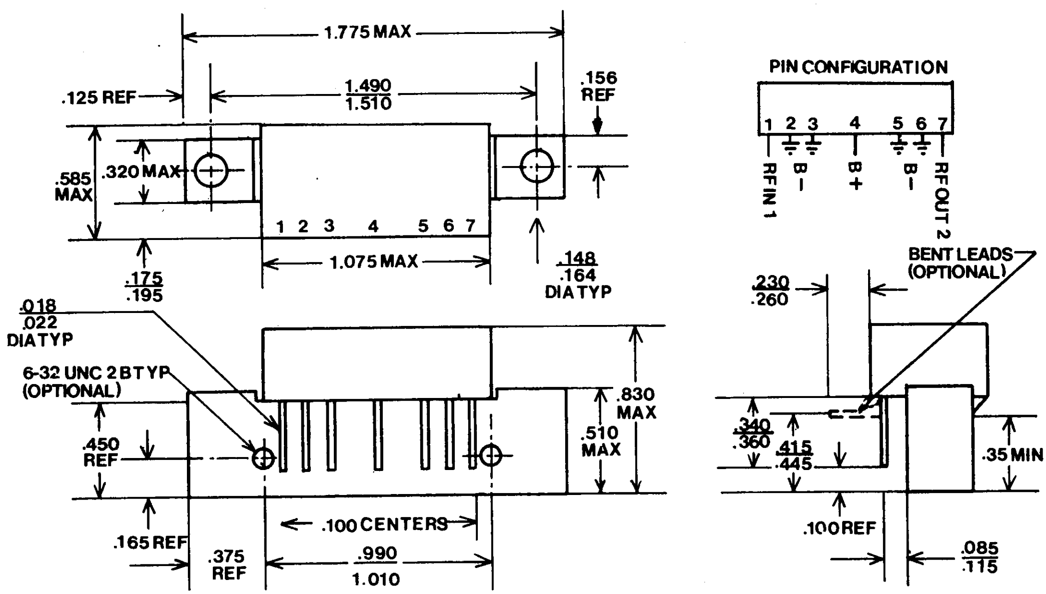
CA

F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 5700
Gain @ 50 MHz	38.0 ± 1.0 dB
Frequency Response	40-450 MHz (± 0.4 dB)
Slope Cable Equivalent (50-450 MHz)	+0.5 to +2.0 dB
Composite Triple Beat (@ 46 dBmV)	
52 Channel on H-14	−60 dB Max.
60 Channel on H-22	−57 dB Max.
X-MOD @ 46 dBmV	
52 Channel	−57 dB
60 Channel	−55 dB
Second Order Beat @ 50 dBmV	
Ch 2, H-5, H-14	−64 dB
Noise Figure on 50 MHz	4.5 dB Max.
400 MHz	5.5 dB Max.
450 MHz	6.0. dB Max.
Return Loss Input/Output	18 dB Min.
Power Requirement	340 mA (Typ) @ 24 V
Operating Temperature (Sink)	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C

CA PACKAGE OUTLINE

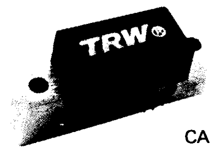


CA 5180 — CA 5280

TRW

CATV Hybrid Amplifiers

- 450 MHz
- 14 dB
- Driver For Feedforward



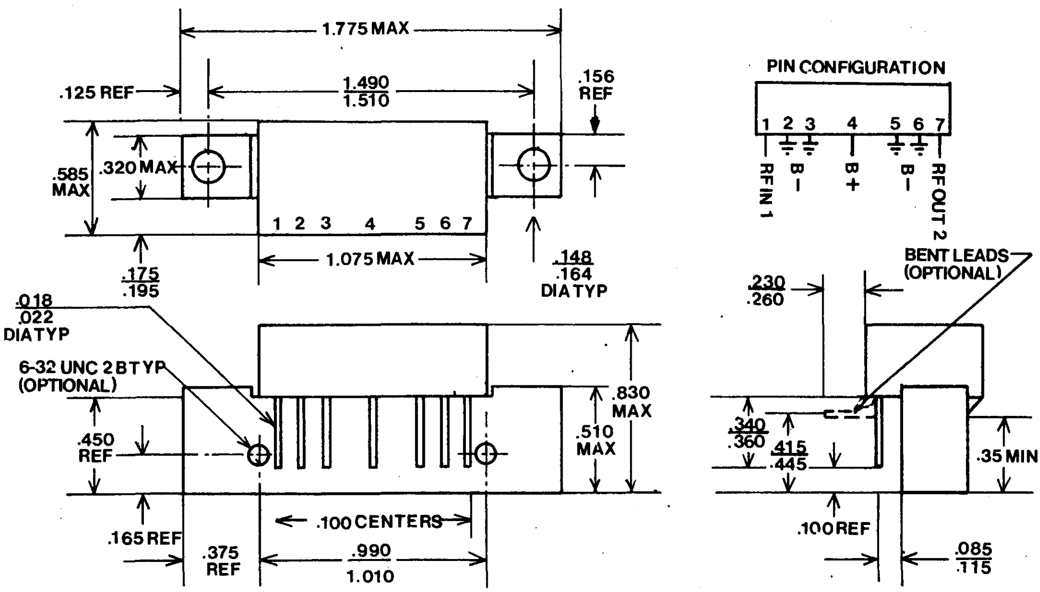
CA

F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 5180	CA 5280
Gain @ 50 MHz	13.5-14.5 dB	13.5-14.5 dB
Gain @ 450 MHz	14.2-15.4 dB	14.2-15.4 dB
Cable Equivalent Slope (50-450 MHz)	+0.3-1.3 dB	+0.3-1.3 dB
Frequency Response	40-400 MHz(±0.2 dB)	40-450 MHz(±0.2 dB)
Composite Triple Beat (@ 46 dBmV)		
52 Ch on H-14	−58 dB Max.	−62 dB Max.
60 Ch on H-22	−56 dB Max.	−60 dB Max.
X-MOD @ 46 dBmV		
52 Channel	−58 dB Max.	−62 dB Max.
60 Channel	−55 dB Max.	−59 dB Max.
Second Order Beat @ 50 dBmV Ch 2, H-5, H-14	−64 dB	−68 dB
Triple Beat @ 50 dBmV		
On Ch H-14	−72 dB	−76 dB
On Ch H-22	−68 dB	−72 dB
Noise Figure on 50 MHz	5.0 dB Max.	5.5 dB Max.
400 MHz	6.0 dB Max.	6.5 dB Max.
450 MHz	6.5. dB Max.	7.0 dB Max.
Return Loss Input/Output	18 dB Min.	18 dB Min.
Power Requirement	190 mA (Typ) @ 24 V	220 (Typ) @ 24 V
Operating Temperature (Sink)	−20 °C to + 100 °C	−20 °C to +100 °C
Storage Temperature	−40 °C to + 100 °C	−40 °C to +100 °C

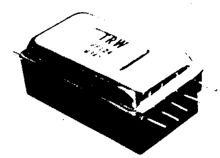
CA PACKAGE OUTLINE



TRW

CATV Feedforward Hybrid Amplifier

- 450 MHz
- 24 dB Gain
- 22 dB Composite Triple Beat Reduction
- Fully Shielded Metal Package



Absolute Maximum Ratings

Symbol	Characteristics	FF124
V_{CC}	Supply Voltage	28V
P_{in}	RF Power Input	+55dBmV
T_{st}	Storage Temperature	−40°C to +100°C
T_{op}	Operating Temperature	−20°C to +100°C

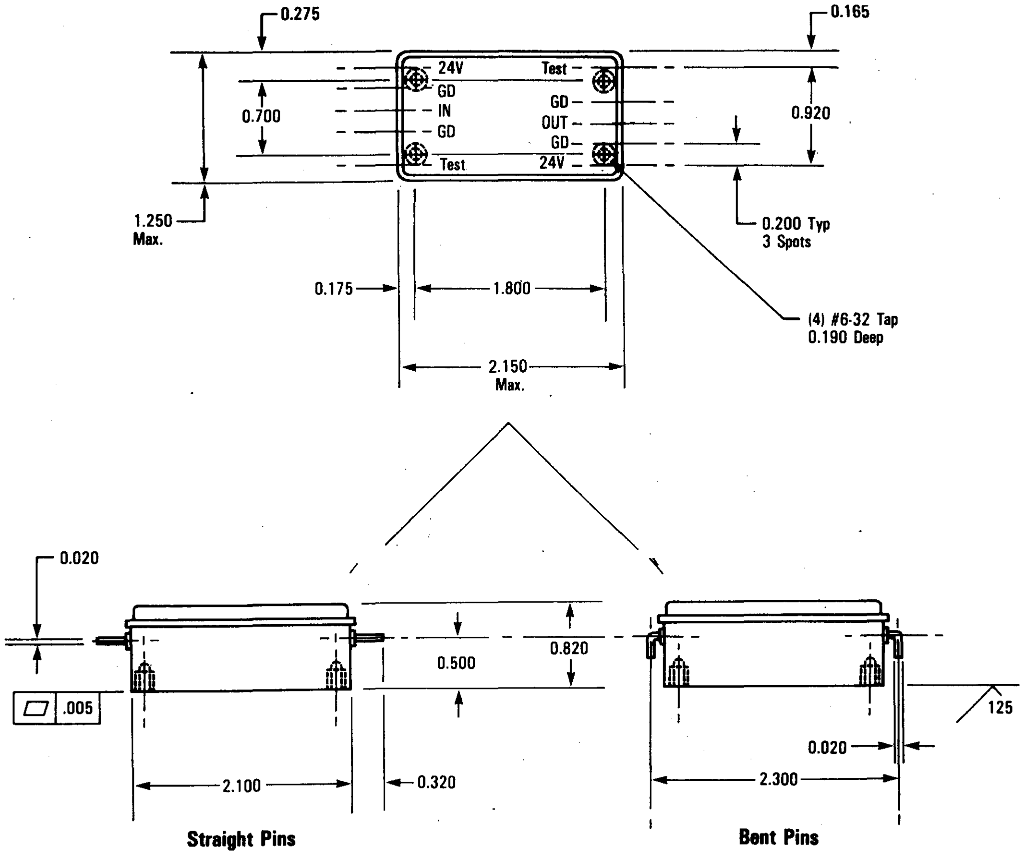
Electrical Characteristics for 75Ω Systems (V_{CC} = 24V, T_{CASE} = +65°C)

Symbol	Characteristics	Test Conditions	FF124
PRequ.	Power Requirement	24V	660mA (Typ)
G	Gain	50MHz	24dB ± 0.6dB
S.C.E.	Slope Cable Equivalent	50 - 450MHz	+0.2 to +1.4dB
BW	Flatness	50 - 450MHz	±0.25dB
R.L.	Return Loop Input/Output	50 - 450MHz	18dB
CTB	Composite Triple Beat 60 Channels +46dBmV	2 H-22	−85dB −80dB
X-Mod	Cross Modulation 60 Channels +46dBmV	2 H-22	−80dB −75dB
S.O.	Second Order +50dBmV	A, H-14, H-22	−80dB
N.F.	Noise Figure	50MHz 450MHz	8.5dB 9.5dB

Performance Derate vs. Temperature

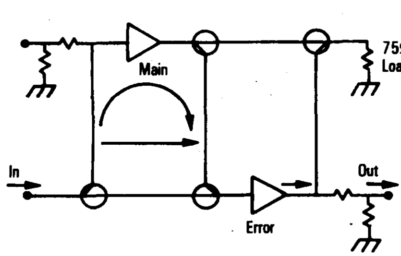
Symbol	Characteristics	Test Conditions	−20 +80°C	−20 +100°C
G	Gain	50 - 450MHz	±0.3dB	±0.5dB
CTB	Composite Triple Beat 60 Ch. +46dBmV	Ch 2 Ch H-22	−84dB −77dB	−83dB −75dB

Package Outline



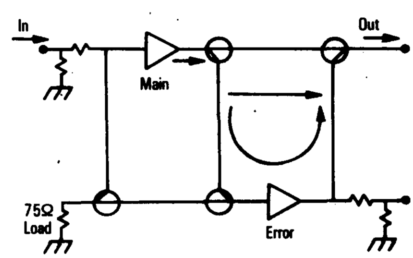
Loop Cancellation Measurement*

First Loop Cancellation



- Loop Cancellation is zeroed with main amplifier off.
- Typical Cancellation is 26dB across the band.

Second Loop Cancellation



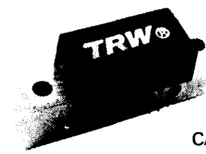
- Loop Cancellation is zeroed with error amplifier off.
- Typical Cancellation is 26dB across the band.

* Microstrip connections from feedforward package to test fixture are necessary for accurate loop cancellation measurement.

CA 6101 — CA 6201

CATV Hybrid Amplifiers

- 550 MHz
- 19 dB



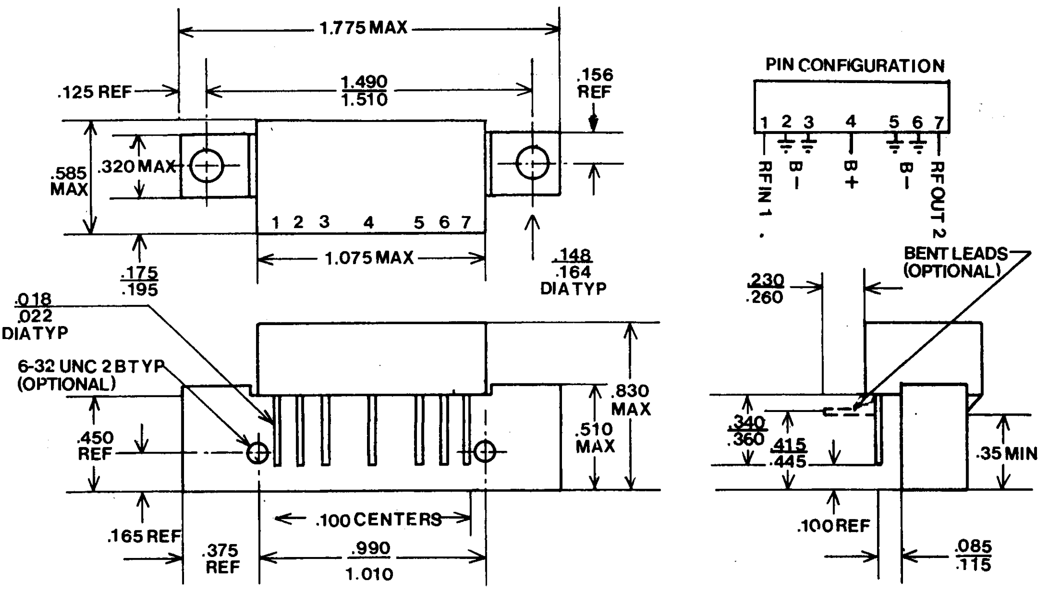
CA

F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 6101	CA 6201
Gain @ 50 MHz	17.7-18.7 dB	17.7-18.7 dB
Gain @ 550 MHz	18.4-19.6 dB	18.4-19.6 dB
Cable Equivalent Slope (50-550 MHz)	.3-1.6 dB	.3-1.6 dB
Frequency Response	40-550 MHz (±0.2 dB)	40-550 MHz (± 0.2 dB)
Composite Triple Beat (@ 44 dBmV)		
60 Ch on Ch 61	−61 dB Max.	−65 dB Max.
77 Ch on Ch 78	−54 dB Max.	−58 dB Max.
X-MOD @ 44 dBmV		
77 Ch on Ch 2	−58 dB	−62 dB
Second Order Beat @ 50 dBmV	−64 dB	−68 dB
Noise Figure on 50 MHz	4.5 dB Max.	5.0 dB Max.
400 MHz	6.0 dB Max.	6.5 dB Max.
550 MHz	7.5. dB Max.	8.0 dB Max.
Return Loss Input/Output	18 dB Min.	18 dB Min.
Power Requirement	180 mA (Typ) @ 24 V	225 mA (Typ) @ 24 V
Operating Temperature (Sink)	−20 °C to + 100 °C	−20 °C to +100 °C
Storage Temperature	−40 °C to + 100 °C	−40 °C to +100 °C

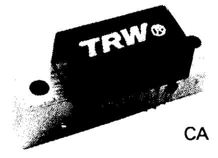
CA PACKAGE OUTLINE



TRW

CATV Hybrid Amplifier

- 5-120 MHz
- 18 dB
- Return Amp

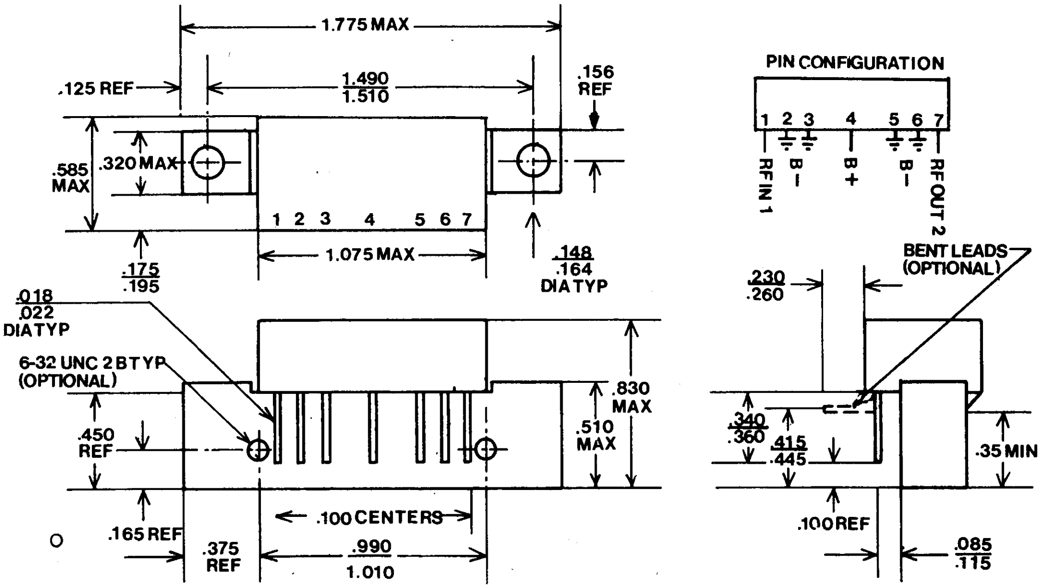

CA

F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 2418
Gain @ 10 MHz	18.5 ± 0.5 dB
Frequency Response	5 - 120 MHz (± 0.25 dB)
Slope Cable Equivalent	+0.2 to −0.5 dB
Output Capability (@ −57 dB X-MOD 12 Channel Flat	54.5 dBmV
Second Order Beat @ 50 dBmV	−72 dB
Triple Beat @ 50 dBmV	−84 dB
Noise Figure (100 MHz)	6.5 dB
Return Loss Input/Output	20 dB Minimum
Power Requirement	200 mA (Typ) @ 24 Vdc
Operating Temperature (Sink)	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C

CA PACKAGE OUTLINE

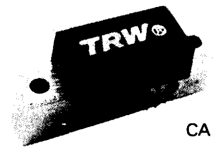


CA 4411 · CA 4412

TRW

CATV Hybrid Amplifiers

- 13 dB
- 5-200 MHz
- Return Amp

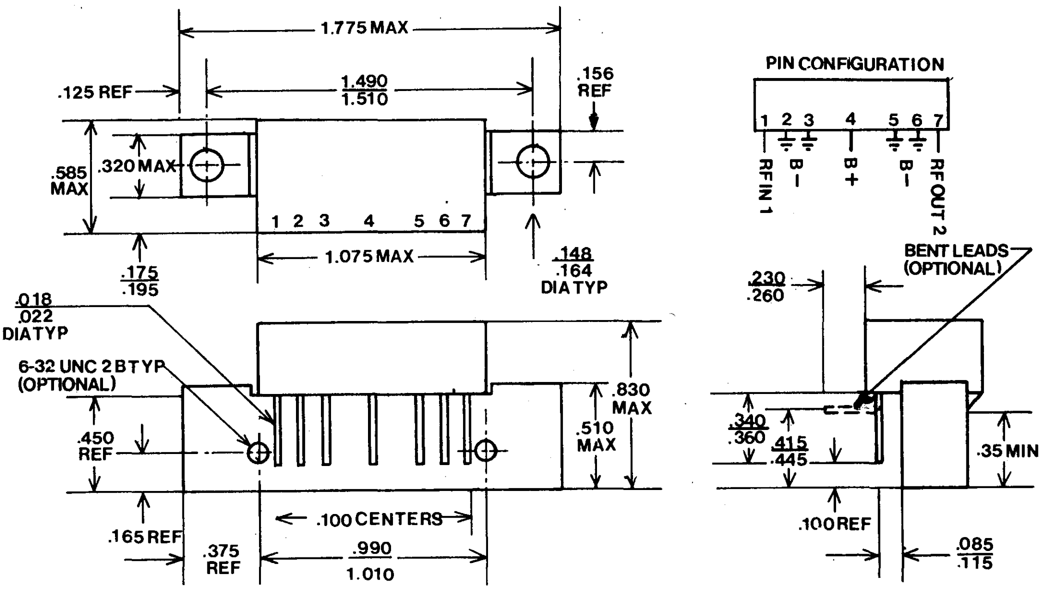


CA

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 4411	CA 4412
Gain @ 10 MHz	13.0 ± 0.5 dB	13.0-0.5 dB
Frequency Response	5-200 MHz (±0.25 dB)	5-200 MHz (± 0.25 dB)
Slope Cable Equivalent	+0.2 to −0.5 dB	+0.2 to −0.5 dB
Composite Triple Beat (@ 50 dBmV) 26 Channel Flat	−61 dB	−66 dB Max.
X-MOD @ 50 dBmV 26 Channel Flat	−55 dB	−60 dB Max.
Second Order @ 50 dBmV	−70 dB	−72 dB
Triple Beat @ 50 dBmV (120 MHz)	−79 dB	−84 dB
(200 MHz)	−77 dB	−82 dB
Noise Figure (200 MHz)	6.5 dB	7.0 dB Max.
Return Loss 5-150 MHz	20 dB	20 dB
150-200 MHz	18 dB	18 dB
Power Requirements 24 Volts	165 mA (Typ)	200 mA Typ
	185 mA Max.	220 mA Max.
Operation Temperature (Heatsink)	−20 °C to + 100 °C	−20 °C to +100 °C
Storage Temperature	−40 °C to + 100 °C	−40 °C to +100 °C

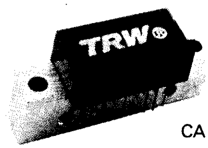
CA PACKAGE OUTLINE



TRW

CATV Hybrid Amplifier

- 18 dB
- 5-200 MHz
- Return Amp



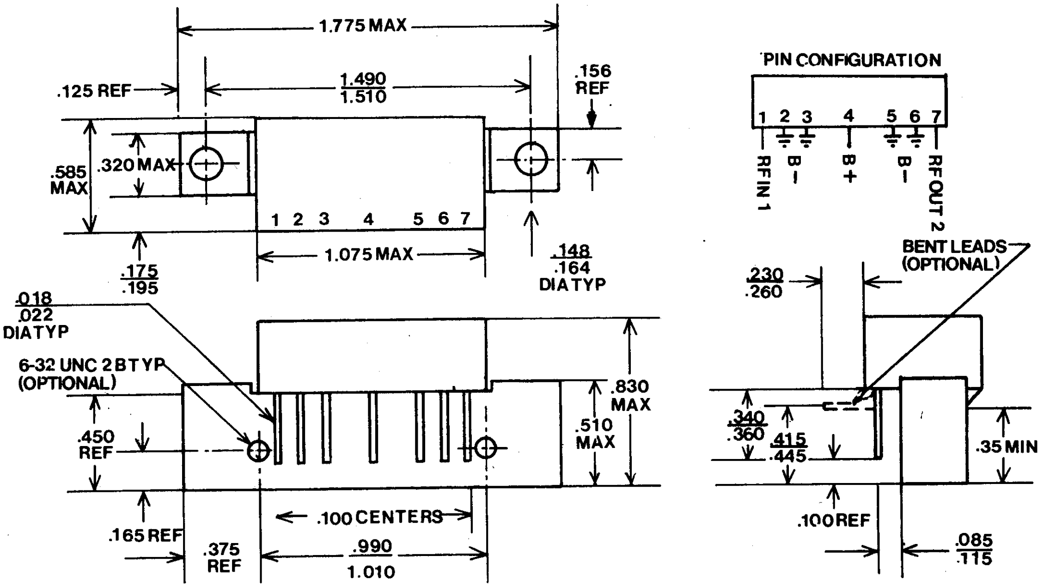
CA

F

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 4418
Gain @ 10 MHz	18.5 ± 0.5 dB
Frequency Response	5-200 MHz (± 0.25 dB)
Slope Cable Equivalent	+0.2 to −0.5 dB
Composite Triple Beat @ 50 dBmV 26 Channel Flat	−66 dB
X-MOD @ 50 dBmV 26 Channel Flat	−60 dB
Second Order @ 50 dBmV	−72 dB
Triple Beat @ 50 dBmV (120 MHz) (200 MHz)	−84 dB −82 dB
Noise Figure (200 MHz)	5.5 dB
Return Loss 5-150 MHz 150-200 MHz	20 dB 18 dB
Power Requirements, 24 Volts	200 mA Typ 220 mA Max.
Operation Temperature (Heatsink)	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C

CA PACKAGE OUTLINE

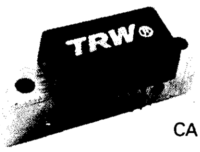


CA 4422

TRW

CATV Hybrid Amplifier

- 22 dB
- 5-200 MHz
- Return Amp

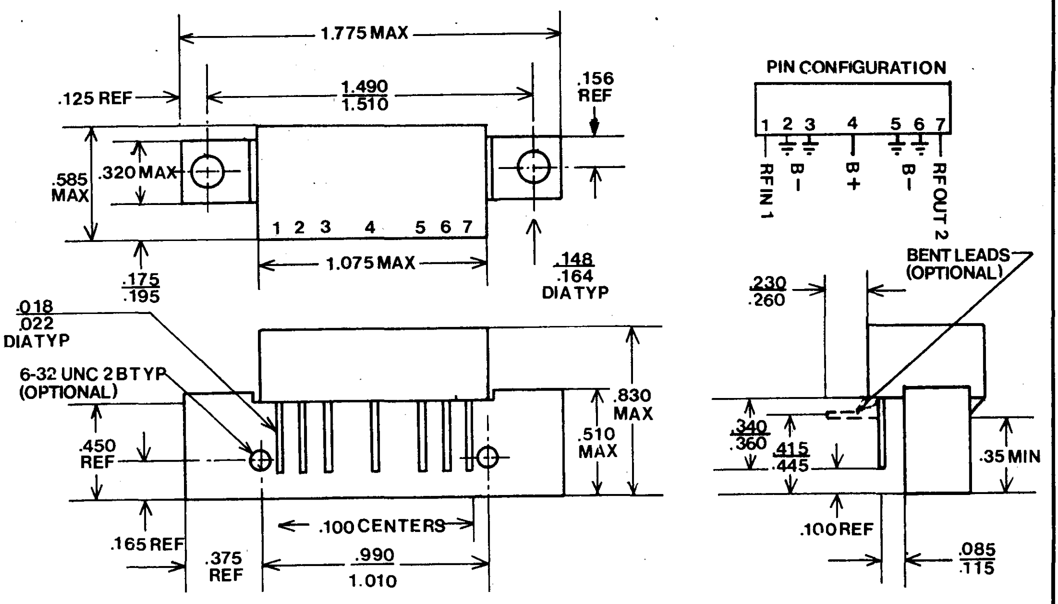


CA

Electrical Characteristics at T_{CASE} = 25 °C, V_{CC} = 24 V

PARAMETER	CA 4422
Gain @ 10 MHz	22.0 ± 0.6 dB
Frequency Response	5-200 MHz (± 0.25 dB)
Slope Cable Equivalent	+0.5 to −0.5 dB
Composite Triple Beat @ 50 dBmV 26 Channel Flat	−64 dB
X-MOD @ 50 dBmV 26 Channel Flat	−60 dB
Second Order @ 50 dBmV	−70 dB
Triple Beat @ 50 dBmV (120 MHz)	−84 dB
(200 MHz)	−82 dB
Noise Figure (200 MHz)	5.0 dB
Return Loss 5-150 MHz	20 dB
150-200 MHz	18 dB
Power Requirement, 24 Volts	200 mA Typ
	220 mA Max.
Operating Temperature (Heatsink)	−20 °C to + 100 °C
Storage Temperature	−40 °C to + 100 °C

CA PACKAGE OUTLINE



APPLICATIONS NOTES

MOUNTING OF TRANSISTORS AND MODULES

MOUNTING OF STUDDED RF POWER TRANSISTORS

I) Preparing of heat-sink

The majority of thermal energy generated in the chip is dissipated downward to the heat sink through the package in a circular cone of 45° from the bottom of the chip (See drawing).

Since efficiency, power gain and life expetency is inversly proportional to the chip temperature, care must be taken in getting the most heat transferred from the package to the heat-sink.

A) The hole in the heat-sink for the transistor stud must not be larger than absolutely necessary, i.e. : Nr 8-32 UNC-2 A stud, Nr. 10-32 UNC-2 A studs, etc.

B) Do not chamfer hole, but remove any burr left by drill with a file — to keep as much of the heat sink as possible in direct contact with the header flange.

C) Keep the heat-sink which is in direct contact with the header flange as flat as possible and clean of any foreign material.

II) Mounting the transistor.

The transistor leads are not made to give mechanical support nor should they be used in holding the transistor when screwing the nut down:

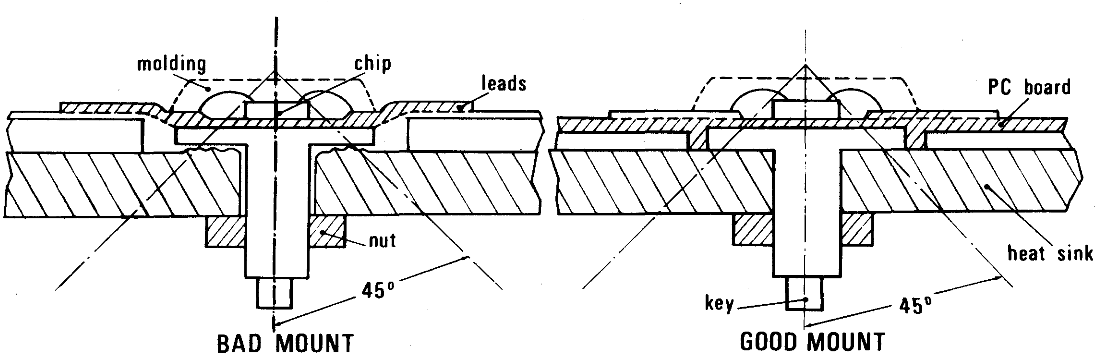
A) Make sure the distance from the flange of the header to the bottom of the electrical leads is observed (See drawing).

B) Coat the heat-sink surface with a small amount of thermal contact grease.

C) Put transistor in place making sure emitter, base and collector are aligned property.

D) Lock the nut into place by holding transistor in place with fingers or by gripping the key provided on the stud of the transistor with a tool.
Torque
6 kgcm SOE 200 - 280 - 380.
9 kgcm SOE 500
23 kgcm SOE 500 1/4 inch.

E) The solder leads into place.



MOUNTING OF FLANGE RF POWER TRANSISTORS

I. Preparation of heat sink

To ensure maximum heat transfer from the transistor to the heat sink it is imperative that the heat sink be made as flat as possible. Ideally one should target for a flatness of the mounting surface to 0.02 mm by careful machining.

It is also important to ensure that the fixing holes do not have any burrs around them, which may prevent the transistor from sitting firmly on the heat sink.

II. Mounting proceedure

A) Prior to mounting, the transistor flange should be lapped to 0.01 mm flatness using a 400 grit carborundum paper on a flat surface, and then cleaned of any small particles.

B) Apply the absolute minimum of thermal grease to the flange base of the transistor and then rub lightly on a flat surface to remove any excess. TOO MUCH THERMAL GREASE IS WORSE THAN USING NONE.

C) Bolt the transistor in place using the appropriate screws plan washers and lock washers.

If at any time it is found necessary to remove the transistor and then replace it once more in the circuit, the device should be lapped again before mounting. This will be necessary since the flange will almost certainly have been distorted by mounting and removal.

MOUNTING OF RF POWER MODULES - (MOBILE MX/MV)

A similar proceedure to that for the mounting of lange transistors should be adhered to. However the degree of flatness to be acheived is as follows.

a) Heat sink - 0.1 mm.

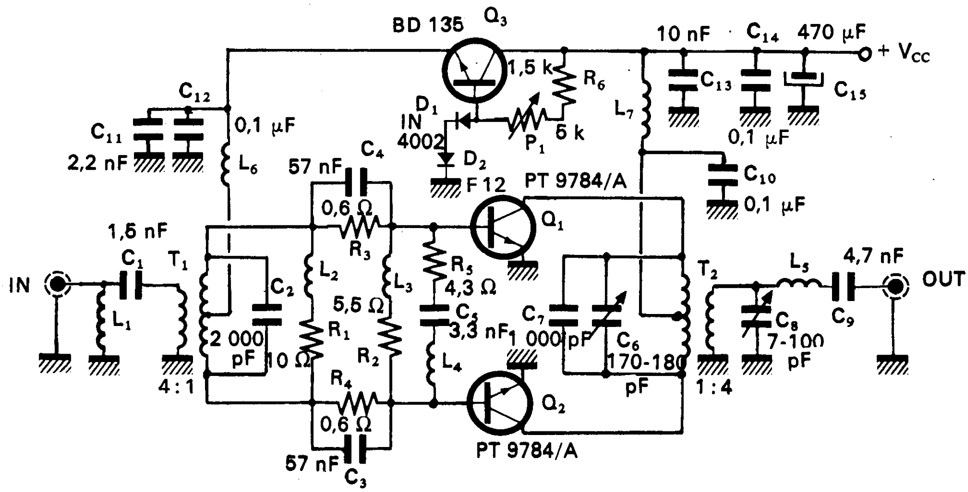
b) Module - This is already delivered to a flatness guaranteed to be better than 0.15 mm.

Again, the absolute minimum of heat sink compound should be used.

150 WATT LINEAR AMPLIFIER 2 TO 28 MHz, 13.5 VOLT D.C.

This application note describes the design of a push-pull linear 150 W solid state power amplifier intended for SSB transmitter applications.
The broadband amplifier operates directly from a 13.5 V DC source and covers the 2 — 28 MHz band.

The circuit calculation, the major performance characteristics and the complete construction details are presented.
Devices used : Two PT 9784/A.



1. — BASIC AMPLIFIER SPECIFICATION

V_{CE} = 13.5 V

Bandwidth : 2 to 28 MHz

Pgain at 150 W : 15 ± 1.3 dB

IMD at 28 MHz and 150 W PEP ⩽ — 30 dB

INPUT VSWR ⩽ 1.6 : 1

2. — GENERAL DESIGN CONSIDERATION

The principal aims were :

— employ a relatively simple solution permitting us to obtain optimal performance from two PT 9784/A,

— use components available on European market.

In order to comply with our self imposed criteria, we chose a push-pull configuration to improve even harmonic suppression and to simplify the matching problems due to very low input and output transistor impedances.

In push-pull configuration, the transistor input or output impedances are in series, making the required transformation ratio one quarter of that required for parallel operation.
We also chose a ferrite manufacturer whose product is freely available on the European market.

The circuit calculation was made as follows :

— choice of the input and output transformer ratio,

— choice of the transformer type,

— estimation of the transformer volumes,

— calculation of the transformer compensation,

— calculation of an input network between the input transformer and the transistors to match 2 Zin to 3 Ω and to stabilize the gain-frequency characteristic.

The figure 1 shows the schematic of the amplifier.

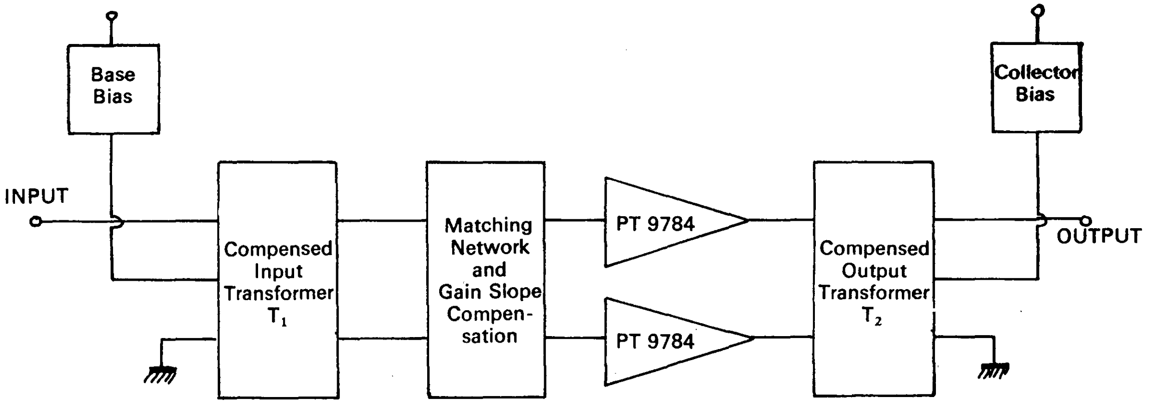


Fig. 1

3. — IMPEDANCE TRANSFORMATION CHOICE

3. — 1. Input voltage transformation ratio

Zin = R + JX (Ω) typical values :

F (MHz)	2	5	10	15	20	25	30
R (Ω)	15	8	5	3	2	1.5	1.2
X (Ω)	— 8	— 11	— 7.5	— 5	— 4	— 3.5	— 3

In order to obtain a good match at high frequency, we consider Zin at 25 MHz. The real part at this frequency is 1.5 Ω, which means for a push-pull configuration the real part is 3 Ω between the two bases.

The voltage transformation ratio is determined by :

$$n = \sqrt{\frac{50}{3}} \simeq 4 \qquad \boxed{n_{IN} = 4}$$

3. — 2. Output voltage transformation ratio

The transistor equivalent output circuit is :

With :

$C_C \simeq 270$ pF

$$R_C = \frac{(V_{CC} - V_{sat})^2}{2 P_o}$$

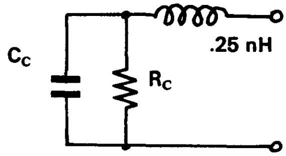


Fig 2.

Where :

- V_{CC} : collector supply voltage = 13.5 V
- V_{sat} : RF saturation voltage = 1.0 V
- P_o : Output power for one transistor = 75 W
- $R_C \simeq 1.1\ \Omega$

The output transformer matches 2 Z_{out} to 50 Ω for push-pull configuration. The voltage transformation ratio is defined by :

$$n = \sqrt{\frac{50}{2.2}} = 4.7 \simeq 5$$

In fact we found empirically that the best ratio is n = 4.

$$\boxed{n_{out} = 4}$$

4. — TRANSFORMER TYPES USED

Since the input and output voltage transformation ratios are 4, we can use the small pratical transformer show by figures 3 and 4.

The low impedance winding always consists of one turn, which limits the available impedance transformation ratio to 1, 4, 9...

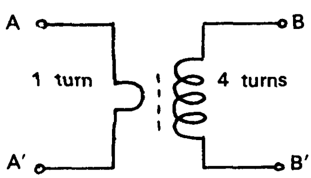


Fig. 3.

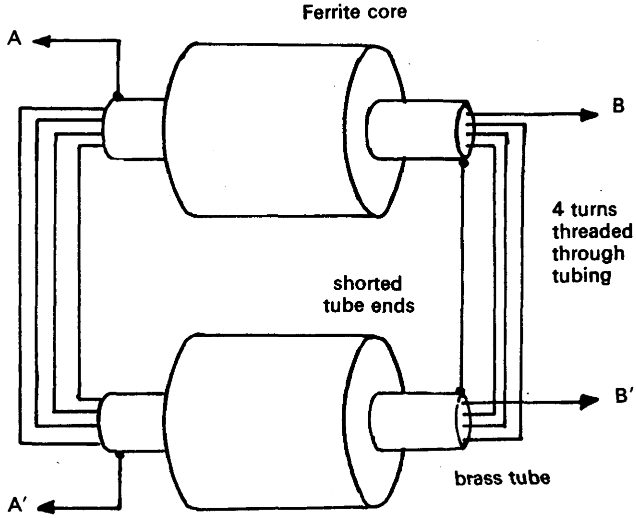


Fig. 4.

5. — TRANSFORMER VOLUME ESTIMATION

5. — 1. Output transformer

Ferrite used : 4 C 6 material made by RTC.
Reference : Tore 14/9/5 — 4 C 6
4322 020 97 180

$\mu_r = 120 \pm 20\ \%$

Toroid dimensions.

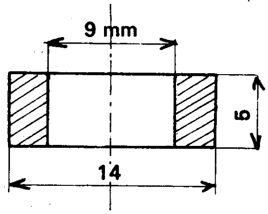


Fig. 5.

The primary inductance can be calculated with the following formula :

$$L_p = \mu_o \, \mu_r \, n^2 \frac{S}{l} \qquad (5\text{-}1\text{-}1)$$

Where :

- L_p : inductance (H)
- $\mu_o = 4\pi\,10^{-7}$
- μ_r : Relative permeability
- s : ferrite cross section (m^2)
- l : average lenght of the lines force (m)
- n : number of turns.

The value of L_p must be chosen high, but not higher than really necessary, because otherwise the performance at the high end of the band will be degraded.

We take :

$$2\pi\, L_p\, F\ min \simeq 3\, R$$

in which :

- R : load impedance = 50 Ω
- F mini = 2 MHz

$$L_p = \frac{150}{2\pi\, 2\, 10^6} = 12\ \mu H$$

The ferrite cross section is :

$$S = Nh\,\frac{(D - d)}{2}$$

in which N is the number of toroids.

$$S = N\, 5\, 10^{-3}\, 2.5\, 10^{-3} = 1.25\, 10^{-5}\, N\ (m^2)$$

From 5 — 1 — 1 we can calculate N :

$$N = \frac{L_p l}{\mu_o\, \mu_r\, n^2\, 1.25\, 10^{-5}} = \frac{12\, 10^{-6}\, 36.1\, 10^{-3}}{4\pi\, 10^{-7}\, 120\, 16\, 12.5\, 10^{-5}}$$

$N \simeq 14$ toroids.

In fact we use 16 cores, which gives :

Lp = 13.7 μ H and S = 2 10^{-4} (m^2)

The highest toroid losses occur in this case at 2 MHz under large signal conditions. RTC give the power loss density, i.e. the power loss related to the unit of volume versus the maximum induction and the frequency. The maximum induction $\hat{B}$ can be calculated with the following formula :

$$\hat{B} = \frac{\hat{V}}{2\pi FSn} \qquad (5\text{-}1\text{-}2)$$

in which :

- $\hat{B}$: maximum induction (T)
- S : ferrite cross section (m^2)
- n : number of turns
- $\hat{V}$: maximum value of voltage accross n turns (V)
- F : frequency

$\hat{V}$ is given by :

$$\hat{V} = \sqrt{2\, P_o\, R_L} \qquad (5\text{-}1\text{-}3)$$

where :

- P_o : output power
- $R_L = 50\ \Omega$

$$\hat{V} = \sqrt{2\ 150\ 50} = 122.5\ \text{V}$$

$$\hat{B} = \frac{122.5}{2\pi\ 2\ 10^6\ 2\ 10^{-4}\ 4} = 1.2\ 10^{-2}\ \text{T}$$

for $\hat{B}$ = 12 mT and F = 2 MHz the power loss density is $2\ 10^2\ \text{mW}\cdot\text{cm}^{-3}$.

The ferrite volume is :

$$v = \frac{\pi}{4}(D^2 - d^2)\, hN = \frac{\pi}{4}(14^2 - 9^2)\ 5\ 16\ 10^{-3} = 7.2\ \text{cm}^3$$

This gives a loss α :

$$\alpha = 2\ 10^2\ 7.2 = 1440\ \text{mW or } \frac{1.4}{150} = 1\ \%$$

<u>This 0.05 dB loss in the ferrite is acceptable.</u>

Toroid dimensions.

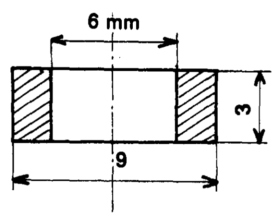


Fig. 6.

5. — 2. Input transformer

Ferrite used : 4 C 6 material made by RTC
Reference : Tore 9/6/3 — 4 C 6
4322 020 97170

$\mu_r = 120 \pm 20\ \%$

In order to reduce the transformer dimensions we use a transformer with a primary inductance at 2 MHz given by :

$$2\pi L_p F \text{ mini} \simeq R_s \qquad (5\text{-}2\text{-}1) \qquad \text{where } R_s = 50\ \Omega$$

this inductance is compensated at low frequencies by the following circuit (figure 7) :

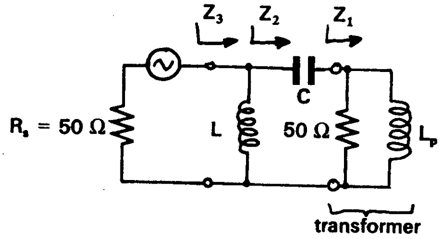


Fig. 7.

Smith chart :

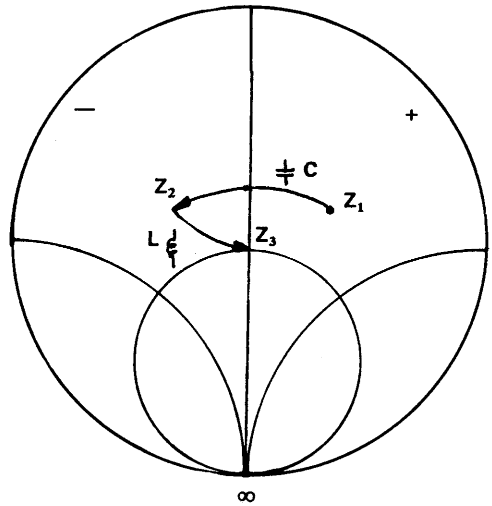


Fig. 8.

From 5-2-1 :

$$L_p \simeq \frac{50}{2\,\pi\,2\,10^6} = 4\,\mu\,H$$

The ferrite cross section S is :

$$S = N\,\frac{D - d}{2}\,h = N\,1.5\,10^{-3}\,3\,10^{-3} = 4.5\,N\,10^{-6}\ (m^2)$$

where N is the number of toroids.

The average length of the line force l is :

$$l = \pi\,\frac{D + d}{2} = \pi\,7.5\,10^{-3} = 23.6\,10^{-3}\ (m)$$

N can be calculated from 5-1-1 :

$$N = \frac{L_p l}{\mu_o\,\mu_r\,n^2\,4.5\,10^{-6}} = \frac{4\,10^{-6}\,23.6\,10^{-3}}{4\,\pi\,10^{-7}\,120\,16\,4.5\,10^{-6}}$$

$N = 8.7 \simeq 9.$

In fact we use $\boxed{N = 10}$ toroids, which means :

$$\boxed{L_p = 4.6\,\mu H}$$

By using the same reasoning and formula as the output transformer :

$P_{in} \simeq 3$ W at 2 MHz

$$\hat{V} = \sqrt{2\,P_{in}\,R} = \sqrt{2\,.\,3\,.\,50} = 17.3\ V$$

$$\hat{B} = \frac{\hat{V}}{2\,\pi\,FSn} = \frac{17.3}{2\,\pi\,2\,10^6\,4.5\,10^{-5}\,4} = 7.6\,10^{-3}\ T$$

for $\hat{B}$ = 8 mT and F = 2 MHz the power loss density is 70 $mW.cm^{-3}$.

The ferrite volume is:

$$v = \frac{\pi}{4}(D^2 - d^2)\, hN = \frac{\pi}{4}(9^2 - 6^2)\, 3\; 10\; 10^{-3} = 1\ cm^3$$

This gives a loss α :

$$\alpha = 70 \times 1 = 70\ mW \text{ or } \frac{70}{3000} = 2.3\ \%$$

This 0.1 dB loss in the ferrite is acceptable.

6. — OUTPUT CIRCUIT

Figure 9 shows the RF equivalent output circuit :

— Resistor AA, capacitor AA and inductor BB are the equivalent circuit to 2 Zout in series.

— Capacitor CC, capacitor EE and inductor FF are the transformer HF compensation.

— Capacitor FF is for low frequency compensation.

— The transformer is a black box described by its S-parameters.

The compensation elements are optimized with the aid of an analysis and optimization computer programme COMPACT.

Figure 10 shows the programme with final values and the final analysis :

The maximum output VSWR is lower than 1.6 : l.

ELEMENTS		CALC. VALUE	EMPIRICAL VALUE
CC	CAP (pF)	1474	1000 + 100/700*
EE	CAP (pF)	136	20/100*
FF	IND (nH)	256	90
	CAP (pF)	2993	4700

* variable capacitor.

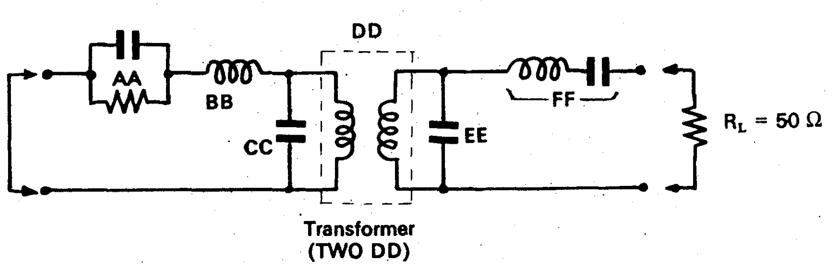


Fig. 9.

OUTPUT CIRCUIT

COMPACT PROGRAM

```
PRC  AA SE    3.000        135.0      )
IND  BB SE    .5000                   |
CAP  CC PA — 1474.                    |
TWØ  DD S1 — 50.00                    |  DEFINITIONS + INTERCONNECTIONS
CAP  EE PA — 136.0                    |
SLC  FF SE — 251.4       — 2993.      |  THE ELEMENT VALUES ARE THE FINAL VALUES
CAX  AA FF                            |
PRI  AA ØR   50.00                    |
END                                   )

2  5  10  15  20  25  30              )  FREQUENCY (MHz)
END                                   )

.909 176.5  .409     26   .390   20.5  .881   57.5  )
.884 177    .449     9.5  .435   10    .877   23    |
.884 176    .458     2    .439   2     .865   9     |
.877 174.5  .460 —   2.5  .437 — 1.5   .858   3     |  POLAR S-PARAMETERS FOR
.884 173    .453 —   6    .439 — 4     .871 — 0.5   |  THE TRANSFORMER (TWØ DD)
.885 172    .453 —   8    .437 — 6.5   .870 — 4.    |
.886 170    .456 — 10     .432 — 9     .867 — 8     |
END                                                 )

1                                     )
0 1 0 0                               |  OPTIMIZATION DATA
END                                   )
```

FINAL ANALYSIS

ØUTPUT REFL. CØEF. AND VSWR IN 50. ØHM. SYSTEM WITH 0.0 ØHM SOURCE

F (MHZ)	RHØ (MAGN. < ANGLE)		VSWR	RET L/G (DB)	Z (R + JX) ØHM	
2.000	0.107	— 167.8	1.24 : 1	— 19.08	40.46	— 1.85
5.000	0.051	— 24.1	1.11 : 1	— 25.79	54.86	2.31
10.000	0.053	59.3	1.11 : 1	— 25.57	52.54	4.77
15.000	0.076	52.0	1.16 : 1	— 22.44	54.46	6.52
20.000	0.107	27.5	1.24 : 1	— 19.41	60.15	6.02
25.000	0.047	— 9.8	1.10 : 1	— 26.62	54.81	— 0.88
30.000	0.232	— 148.8	1.60 : 1	— 12.68	32.60	— 8.30

Fig. 10.

Z

7. — **INPUT CIRCUIT**

Figure 11 shows the RF equivalent input circuit :

— IMP JJ is the two transistor input impedances in series,

— inductor AA and capacitor BB are for transformer compensation at low frequency,

— capacitor DD is for high frequency transformer compensation,

— circuits EE, FF, GG and HH have two functions :

- form a selective attenuator with 3 Ω input impedance to stabilize the gain-frequency characteristic ;
- match the two transistors input impedance which are in series to 3 Ω, with the minimum of loss at the highest frequency.

Figure 12 shows the programme with final values and the final analysis : the maximum input VSWR is lower than 1.6 : 1.

ELEMENTS		CAL. VALUE	EMPIRICAL VALUE
AA	IND (nH)	5732	4000
BB	CAP (pF)	1294	1680
DD	CAP (pF)	1146	2000
EE	RES (Ω)	13.4	10
	IND (nH)	189	200
FF	RES (Ω)	1.3	1.2
	CAP (pF)	33350	57000
GG	RES (Ω)	7.2	5.5
	IND (nH)	93.3	95
HH	RES (Ω)	6.8	4.3
	IND (nH)	31.5	45
	CAP (pF)	3040	3300

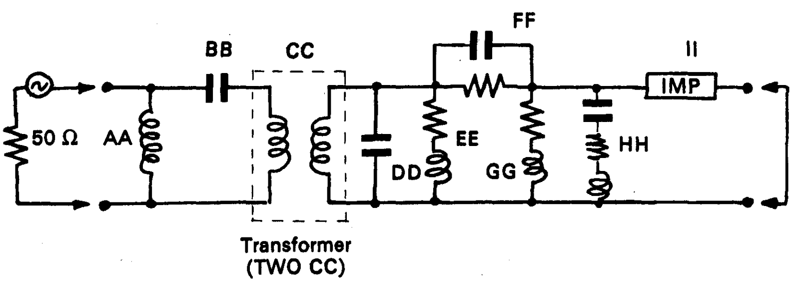


Fig. 11.

INPUT CIRCUIT

COMPACT PROGRAM

DEFINITIONS + INTERCONNECTIONS

THE ELEMENT VALUES ARE THE FINAL VALUES

```
IND  AA PA  —5732.
CAP  BB SE  —1294.
TWØ  CC S1   50.00
CAP  DD PA  —1146.
SRL  FE PA  —13.43      —189.0
PRC  FF SE  —1.325      —.3335 E + 05
SRL  GG PA  —7.161      —93.26
SRX  HH PA  —6.817      —01.50        —3040.
IMP  II SE
CAX  AA II
PRI  AA IR   50.00
END
```

FREQUENCY (MHz)

```
2 5 10 15 20 25 30
END
```

POLAR S-PARAMETERS FOR THE TRANSFORMER (TWØ CC)

```
.917 87.5  .321 —139  .337 —139  .949 176
.891 41.5  .414 —161  .428 —161  .909 177
.868 19    .430 —172  .452 —172  .891 176
.863 11    .437 —176  .453 —177  .883 172
.861  6.5  .439 —179  .455  180  .883 175
.854  2.5  .441  178  .452  177  .884 174
.852  0    .445  175  .443  175  .885 174
END
```

2 ZIN IN SERIES R + JX (Ω)

```
30  —16
16  —22
10  —15
 6  —10
 4  — 8
 3  — 7
 2.4— 6
END
```

OPTIMIZATION DATA

```
1
0 1 0 0
END
```

FINAL ANALYSIS

INPUT REFL. CØEF. AND VSWR IN 50. ØHM SYSTEM WITH 0.0 ØHM LØAD

F (MHZ)	RHØ (MAGN<ANGLE)		VSWR	RET L/G (DB)	Z (R + JX) ØHM	
2.000	0.129	— 93.6	1.30 : 1	— 17.79	47.60	— 12.46
5.000	0.186	55.7	1.46 : 1	— 14.60	58.51	13.64
10.000	0.108	45.6	1.24 : 1	— 19.36	57.41	8.93
15.000	0.248	74.0	1.66 : 1	— 12.10	50.76	25.80
20.000	0.083	48.6	1.18 : 1	— 21.66	55.32	6.91
25.000	0.054	87.5	1.11 : 1	— 25.33	49.95	5.42
30.000	0.115	159.0	1.26 : 1	— 18.78	40.18	3.35

Fig 12.

8. — BIAS CIRCUIT

The transistors which heat up during operation, need a thermally compensated bias current.

The circuit used is an emitter follower giving a low output resistance, in which the base voltage is fixed through a thermally variable component : a diode.

The diode is thermally connected with the heatsink (D2).

D1 is needed to compensate the VBE of the transistor.

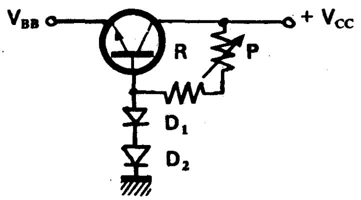


Fig. 13.

With the potentiometer, we adjust the current through the diodes, changing the voltage accross them.

We could have made a more sophisticated circuit, but this one is enough for our purpose.

9. — AMPLIFIER PERFORMANCE

The test set up used is the following (figure 14) :

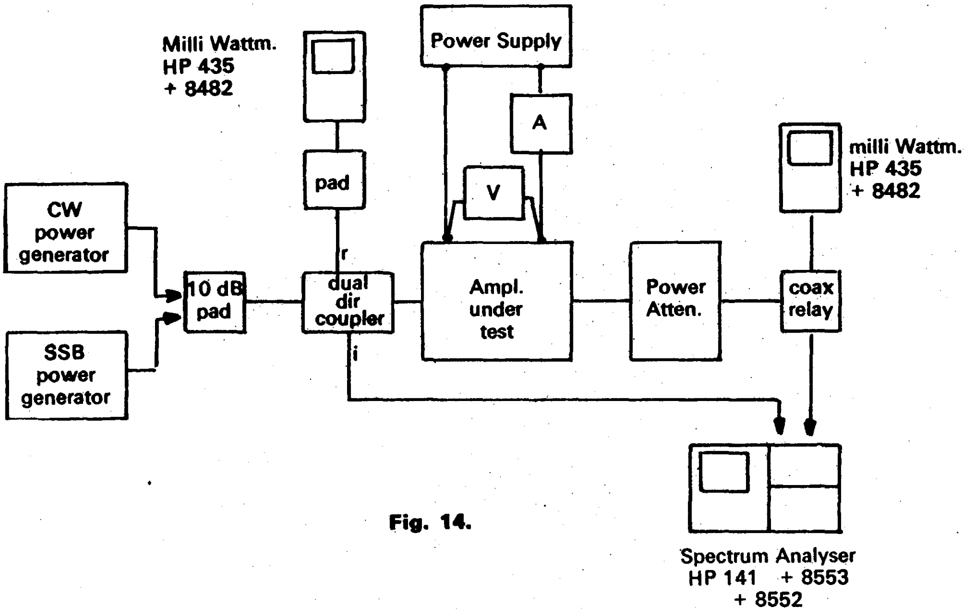


Fig. 14.

The performance is given in the following figures :

Power output versus frequency : Figure 15
Input VSWR versus frequency : Figure 16
IMD versus power output : Figure 17
Gain output versus power input and frequency : Figure 18

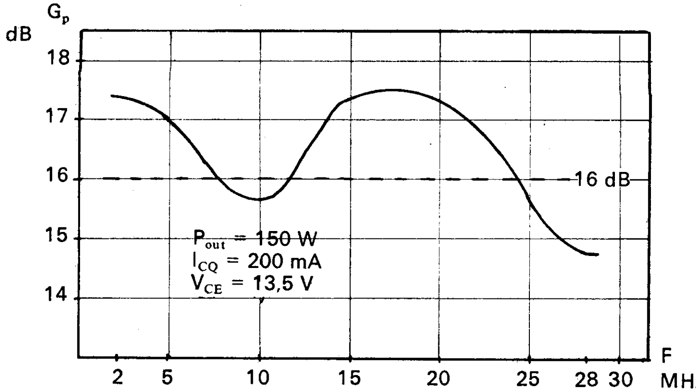


Fig. 15.

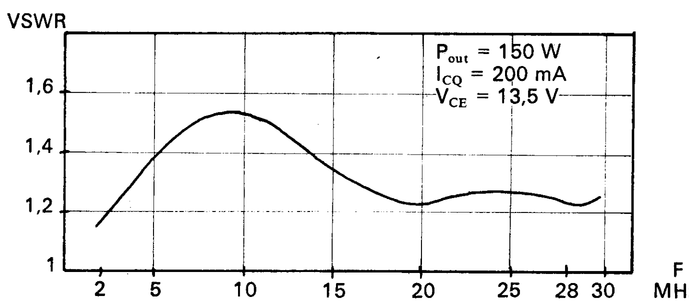


Fig. 16.

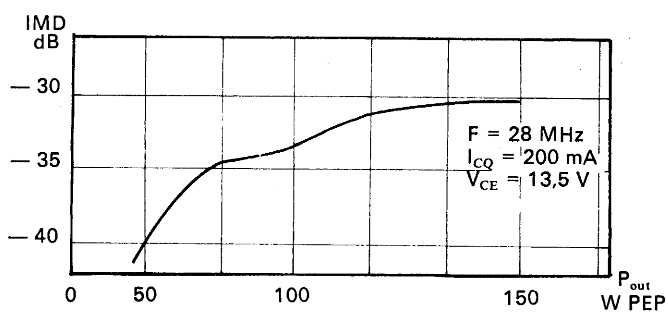


Fig. 17.

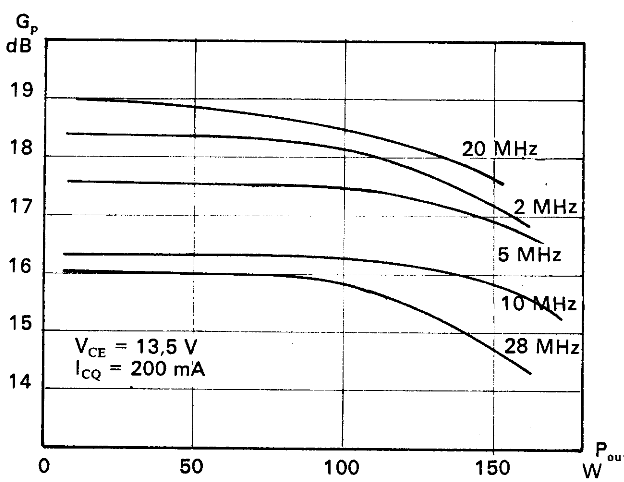


Fig. 18.

AMPLIFIER SCHEMATIC

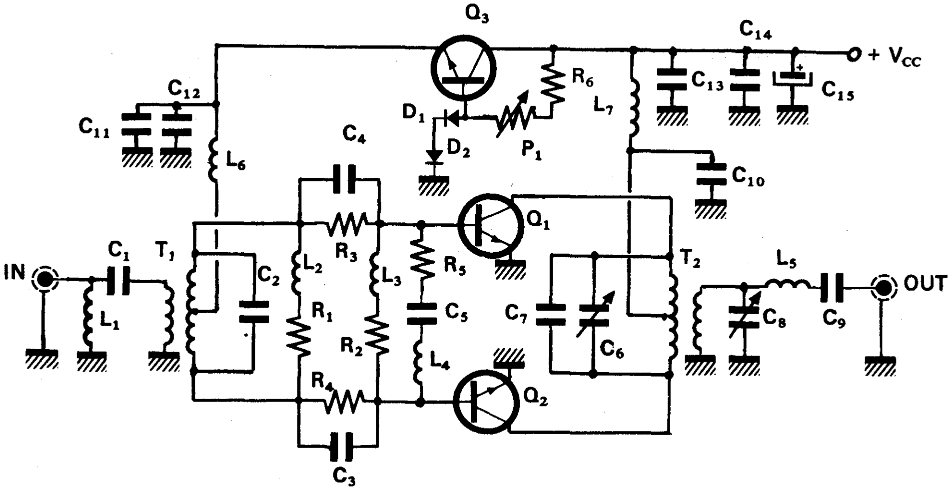


Fig. 19.

COMPONENTS PART LIST

CAPACITORS

C 1	1000 pF + 560 pF	
C 2	1000 pF + 1000 pF	
C 3	47 nF + 10 nF	
C 4	47 nF + 10 nF	
C 5	3300 pF	
C 6	ARCO 469	170 — 780 pF
C 7	1000 pF Mica	
C 8	ARCO 423	7 — 100 pF
C 9	4700 pF	
C 10	0.1 μ F	
C 11	2200 pF	
C 12	0.1 μ F	
C 13	10 nF	
C 14	0.1 μ F	
C 15	470 μ F/25 V	

RESISTORS

R 1	10 Ω made by 20 Ω + 20 Ω ½ W in parallel
R 2	5.5 Ω made by 10 Ω + 12 Ω ½ W in parallel
R 3	0.6 Ω made by 1.2 Ω + 1.2 Ω ½ W in parallel
R 4	0.6 Ω made by 1.2 Ω + 1.2 Ω ½ W in parallel
R 5	4.3 Ω 1/2 W
R 6	1.5 K Ω ½ W
P 1	2 K Ω

SEMICONDUCTORS

D 1	1N 4002
D 2	F 12 metallic case (cathode to case)
Q 1	PT 9784/A
Q 2	PT 9784/A
Q 3	BD 135

INDUCTORS

L1	15 turns 0.5 mm wire wound on a ferrite core same as used for T1
L2	6 turns Ø 7 mm 0.8 mm wire
L3	4 turns Ø 7 mm 1 mm wire
L4	4 turns Ø 6 mm 0.8 mm wire 6 mm length
L5	4 turns Ø 8 mm 1.4 mm wire 9 mm length
L6	1 μ H molded choke
L7	10 turns 1.4 mm wire wound on a ferrite core same as used for T 2.

TRANSFORMERS

Refer to figure 20 for complete view of the transformers.

T 1

PRIMARY : 2 times 5 ferrite cores 9 × 6 × 3 mm μ_r = 120 material 4 C 6 reference RTC 4322 020 97170, on 2 brass tubes ø 5 mm, 22 mm length, with a 10 × 20 mm PCB piece on each side (figure 21).

SECONDARY : 4 turns of 0.5 mm² insulated wire wound through the 2 brass tubes.

T 2

PRIMARY : 2 times 8 ferrite cores 14 × 9 × 5 mm μ_r = 120 material 4 C 6 reference RTC 4322 020 97180 on 2 brass tubes ø 8 mm, 49 mm lenght, with a 15 × 30 mm PCB piece on each side (figure 22).

SECONDARY : 4 turns of 1.8 mm² insulated wire wouhd through the 2 brass tubes.

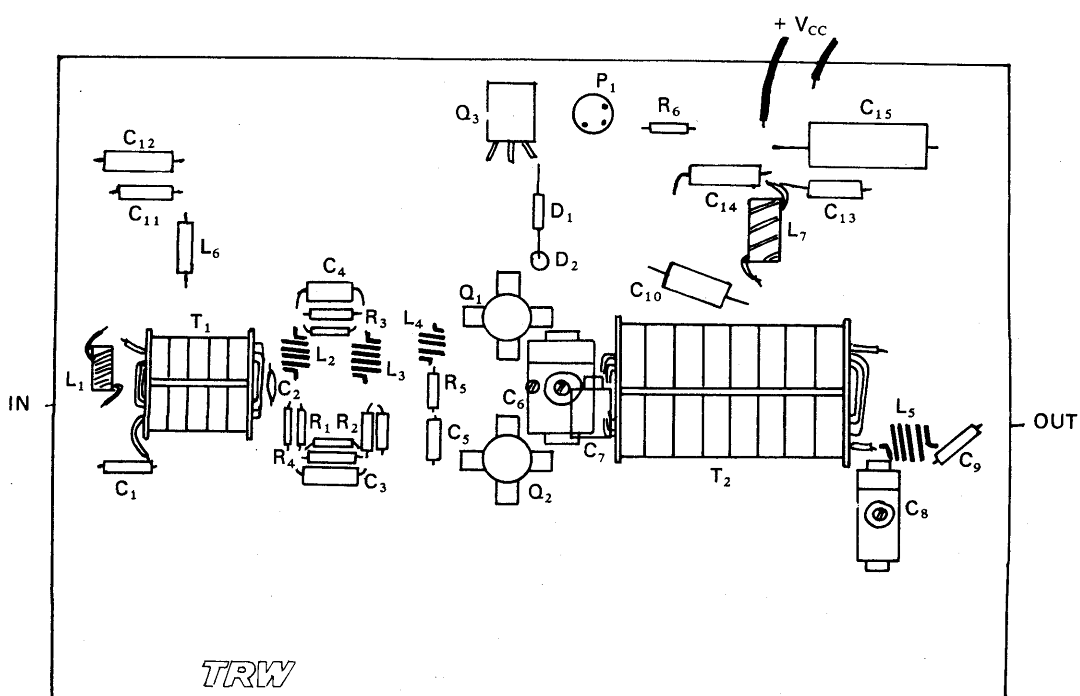


Fig. 24

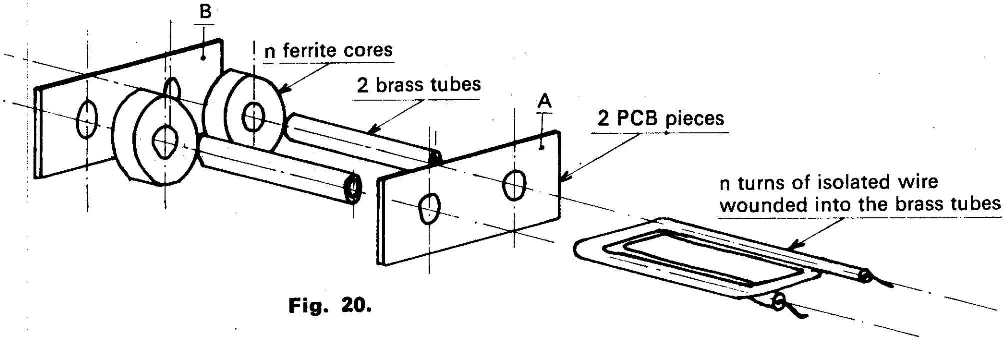
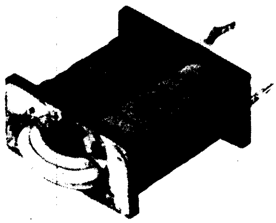


Fig. 20.



INPUT TRANSFORMER

PARTS A AND B FOR T1 (INPUT)

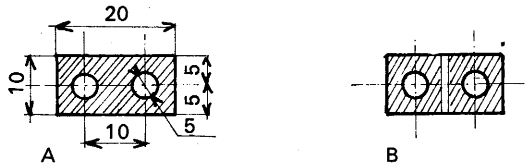
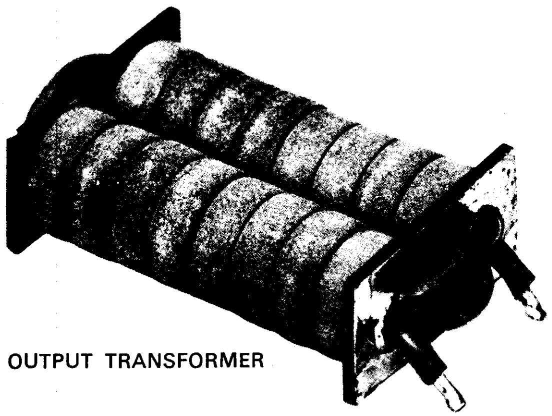


Fig. 21.



OUTPUT TRANSFORMER

PARTS A AND B FOR T2 (OUTPUT)

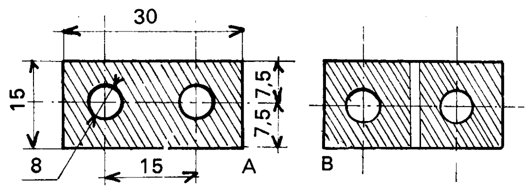
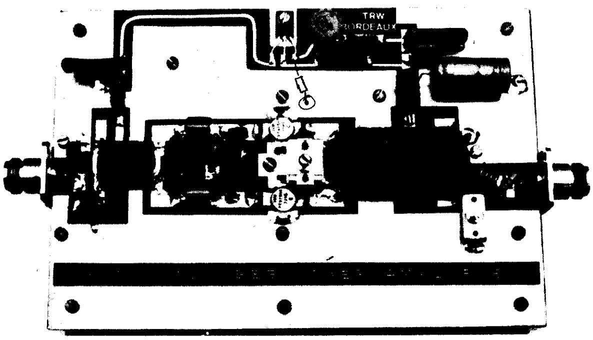


Fig. 22.



PRINTED CIRCUIT
FULL SCALE

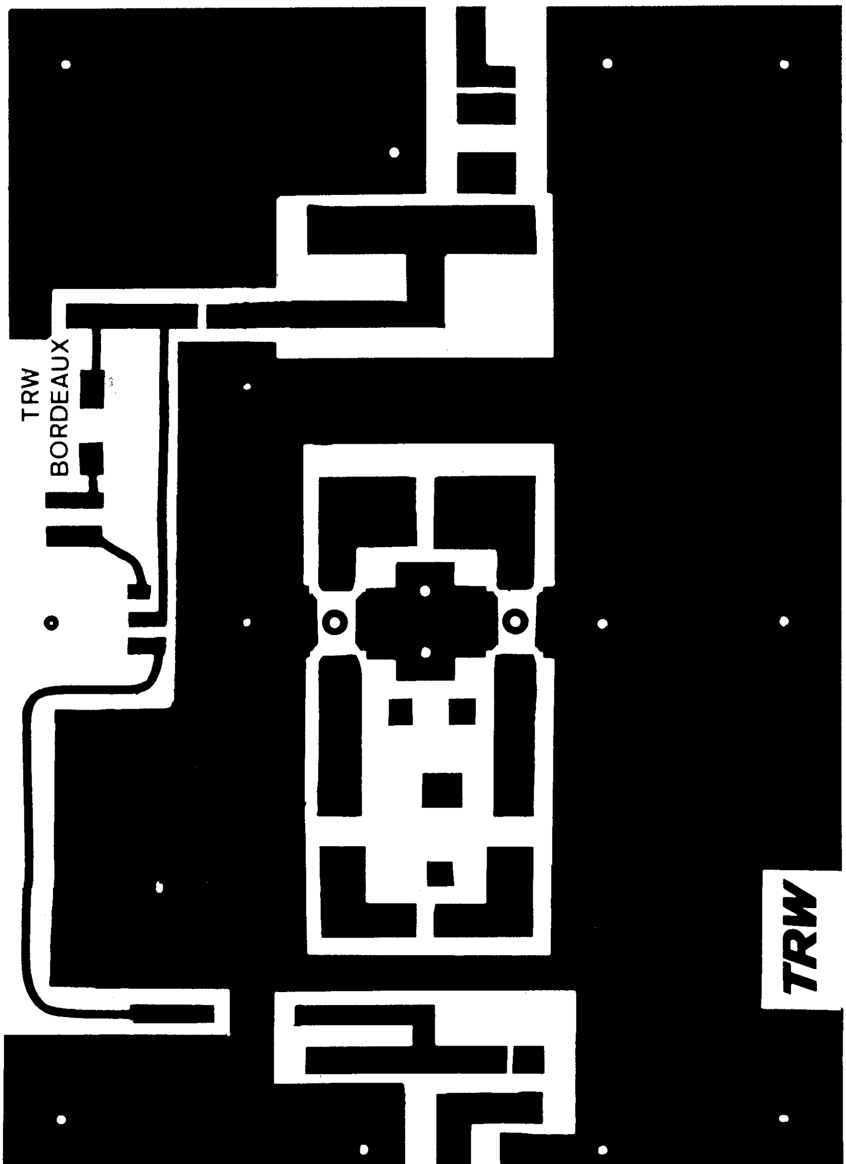
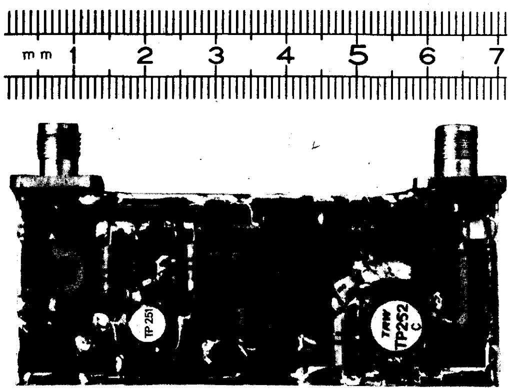


Fig. 23.

7,5 V - BROADBAND AMPLIFIER
1.5 W — 20 dB — 400 - 512 MHz



Introduction

For portable FM equipment, it is necessary to design RF power amplifiers supplied by low voltage batteries. The typical voltages used are 7.5 V to 9.6 V. Output power required is about 1.5 watts out of the amplifier. The most important problem is to provide very good efficiency in order to have a longer battery operating time. Small size is also required.

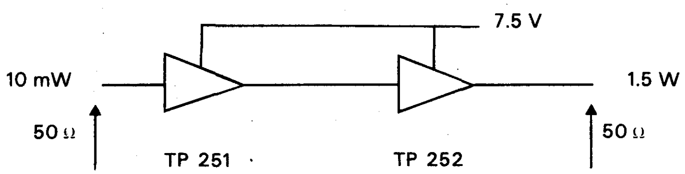
General design considerations

The design of a broadband power amplifier that will operate from a 7.5 V source and provide 1.5 W output with 50 % typical efficiency requires that careful attention be paid to impedance matching.

Performance constraints :

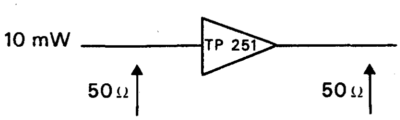
V_{CC} = 7.5 V.
P_{out} = 1.5 watts min. with 20 dB gain.
Frequency range = 400-512 MHz broadband.
Efficiency = 40 % min. 45 % to 50 % typical.
Input return loss = — 10 dB max.
Input and output load impedance = 50 ohms.

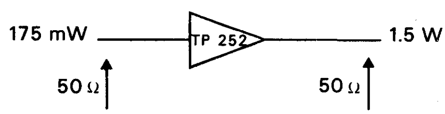
TRW's new 7.5 V transistor family offers the capability of meeting this specification with only 2 stages.



Looking at the TP 251 data sheet we can see that the real part of the output impedance is ≃ 50 ohms for 175 mW output.

For this reason we have taken the approach of designing the matching networks around each device such that each transistor is matched 50 Ω in/50 Ω out. This gives us the added advantage that, during early design, each stage may be looked at on an individual basis.





Analysis and optimization of circuits was made by computer (compact program).

Example of calculation

Since it is necessary to have a very good efficiency, as one example, we will describe the design of the output matching for the final stage TP 252.

The TP 252 data sheet gives us :

Frequency	Z_{out} (Ω)	
400 MHz	13 — j 7.5	V_{CC} = 7.5 V
470 MHz	11 — j 6	
520 MHz	10 — j 4.5	P_{out} = 1.5 W

In order to facilitate easy connection of the transistor collector lead to the circuit, it is necessary to start with a short length of line with sufficient width. For this reason a stripline L_{11} (Z_0 = 25 Ω, l = 4 mm for εr = 1) is connected at the output of the TP 252 (fig. 1). The resulting transformation of the output impedance is the following :

f^- 400 MHz	12.75 — j 6.82 (Ω)
f_0 470 MHz	Z = 10.81 — j 5.15 (Ω)
f^+ 520 MHz	9.86 — j 3.55 (Ω)

After normalization to Z_0 = 70 Ω (We have chosen 70 ohms transmission line in order to realize a small mechanical size). Fig. 2.

f^- 400 MHz	0.18 — j 0.1		4.24 + j 2.35		
f_0 470 MHz	z_1 = 0.15 — j 0.07	or	y_1 = 5.30 + j 2.51	with	$Y_0 = \frac{1}{70}$ ℧
f^+ 520 MHz	0.14 — j 0.05		6.31 + j 2.30		

If we connect in parallel an admittance value — j 2.51 this improves the real impedance at f_0.
The Smith chart shows this is possible using a line L_{12} (Z_0 = 70 Ω - l = 0.06 λ) connected in parallel and with short circuit termination - fig. 2.

	4.24 — j 0.68	f^-
y_1 → y_2 =	5.30 + j 0	f_0
	6.31 + j 0.03	f^+

For f_0, the intersection with the circle y = 1.4 — jX is possible if we connect a line L_{13} (Z_0 = 70 Ω, l = 0.052 λ).

	1.60 — j 1.94	f^-
y_2 → y_3 =	1.41 — j 2.18	f_0
	1.09 — j 2.21	f^+

Admittance C_{11} y = j 2.18, Y = 31 mV (10.5 pF for f_0 = 470 MHz) completes the matching to y = 1.4 or Z = 50 Ω.

	1.60 — j 0.12	f^-	
y_3 → y_4 =	1.41 + j 0	f_0	$Y_0 = \frac{1}{70}$ ℧
	1.09 + j 0.17	f^+	

After normalization to Z_0 = 50 ohms, we can write :

f^- = 400 MHz	0.87 + j 0.066		43.5 — j 3.3 (Ω)
f_0 = 470 MHz	z_4 = 1 + j 0	or	Z_4 = 50 + j 0 (Ω)
f^+ = 520 MHz	1.25 — j 0.19		63.5 — j 9.5 (Ω)

The final circuit is the following :

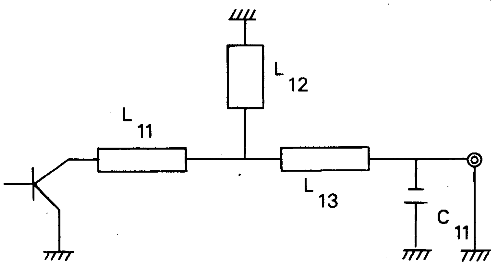


Fig. 1

L_{11}	Z_0 = 25 Ω	l = 0.006 λ	εr = 1
L_{12}	Z_0 = 70 Ω	l = 0.06 λ	εr = 1
L_{13}	Z_0 = 70 Ω	l = 0.052 λ	εr = 1
F_{REF} = 470 MHz			
C_{11} = 10.5 pF			

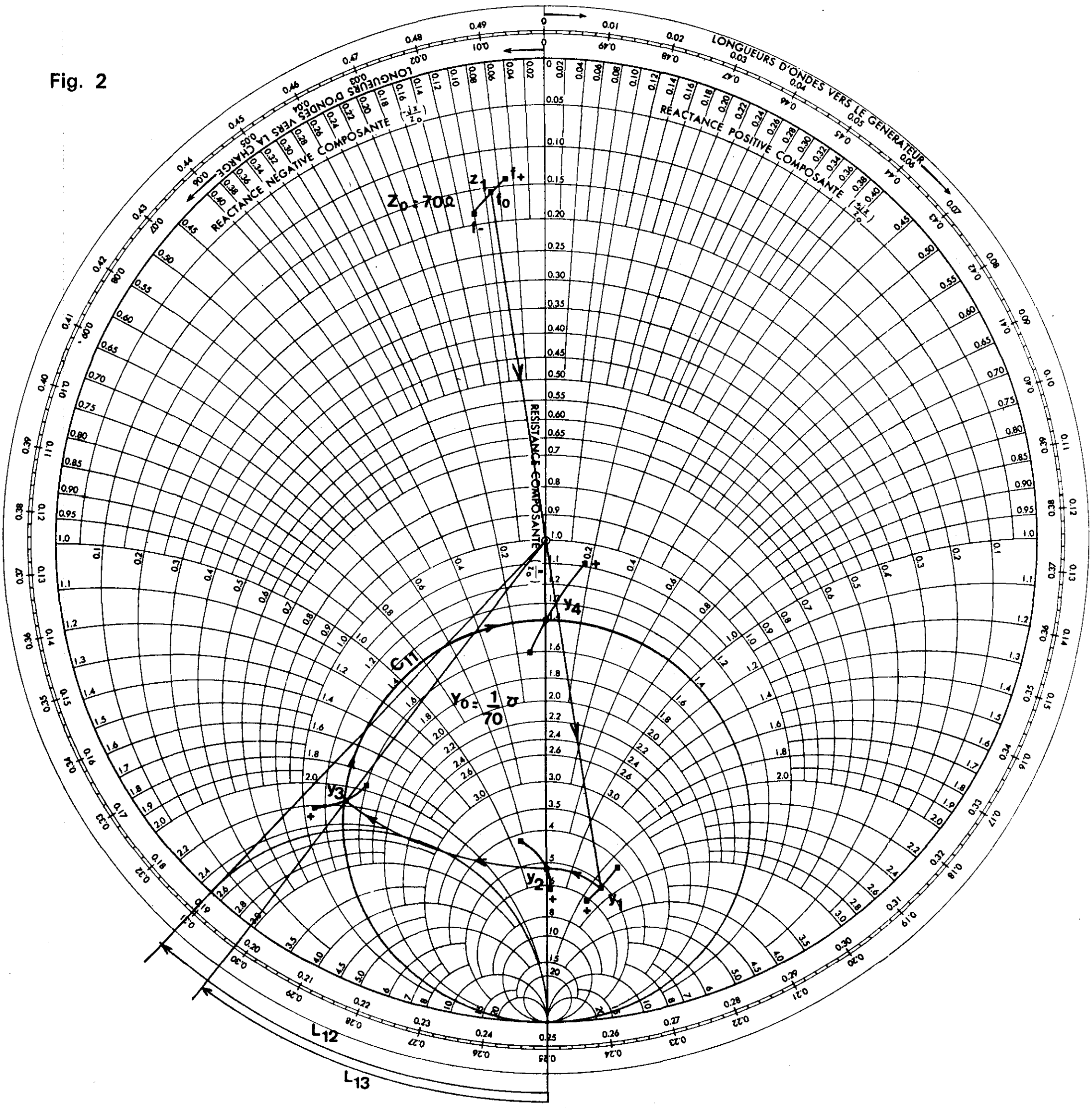
Analysis of this circuit by computer gives the following results :

Output refl. coef. and VSWR in 50. ohm system

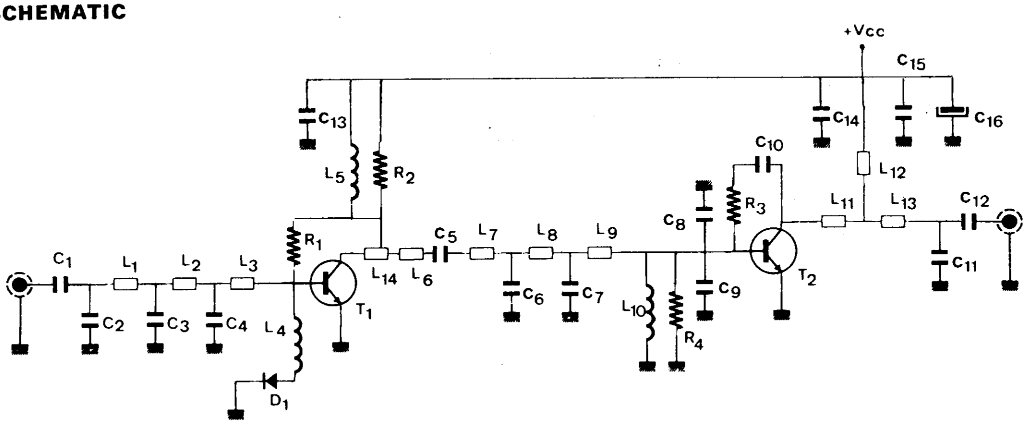
F (MHz)	Rho (magn. < angle)		VSWR	Ret L/G (dB)	Z (R + jX) ohm	
400.000	0.067	150.2	1.14 : 1	— 23.47	44.4	3.0
470.000	0.002	— 172.2	1.00 : 1	— 53.25	49.8	— 0.0
520.000	0.149	— 37.9	1.35 : 1	— 16.56	62.1	— 11.6

N.B. —
- Line L_{12} is a convenient point to supply the transistor but it is necessary to realize a good RF short circuit at this end.
- L_{12} provides a low load impedance for the transistor at low frequencies (stability).
- The good matching over the frequency range ensures that we acheive optimum efficiency.

Fig. 2



SCHEMATIC



List of components

C_1 = 27 pF Ceramic 632 RTC
C_2 = 8.2 pF Ceramic 632 RTC
C_3 = 18 pF Ceramic 632 RTC
C_4 = 22 pF Ceramic 632 RTC
C_5 = C_{10} = C_{12} = C_{13} = C_{14} = 1 nF Ceramic 629 RTC
C_6 = 12 pF Ceramic 632 RTC
C_7 = 15 pF Ceramic 632 RTC
C_8 = C_9 = 39 pF Ceramic Chip ATC
C_{11} = 10 pF Ceramic Chip ATC
C_{15} = 10 nF Ceramic 629 RTC
C_{16} = 10 μF/25 V Electrolytic

L_1 = Stripline Z_0 = 70 ohms 0.061 λ
L_2 = Stripline Z_0 = 70 ohms 0.026 λ
L_3 = Stripline Z_0 = 50 ohms 0.031 λ
L_4 = L_5 = L_{10} = 0.15 μH Molded Coil
L_6 = Stripline Z_0 = 100 ohms 0.045 λ
L_7 = Stripline Z_0 = 70 ohms 0.043 λ
L_8 = Stripline Z_0 = 70 ohms 0.041 λ
L_9 = Stripline Z_0 = 25 ohms 0.031 λ
L_{11} = Stripline Z_0 = 25 ohms 0.006 λ
L_{12} = Stripline Z_0 = 70 ohms 0.064 λ
L_{13} = Stripline Z_0 = 70 ohms 0.052 λ
L_{14} = Stripline Z_0 = 50 ohms 0.009 λ

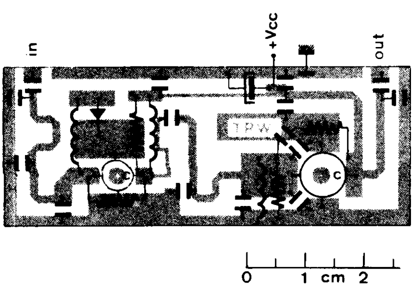
R_1 = 510 ohms 1/4 W carbon composition
R_2 = 270 ohms 1/4 W carbon composition
R_3 = 150 ohms 1/4 W carbon composition
R_4 = 10 ohms 1/4 W carbon composition

D_1 = 1 N 4001

T_1 = TP 251 TRW
T_2 = TP 252 TRW

F_{REF} = 480 MHz

Example of realisation with epoxy glass substrate



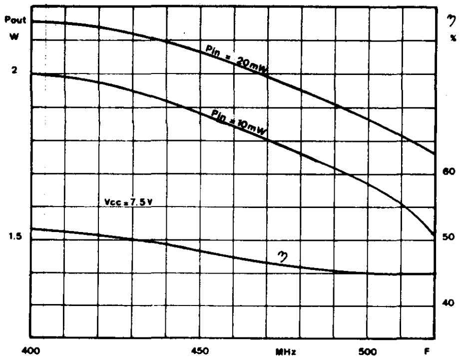
(h = 1/16″ and εr = 4.1)

Edge of the PC board must bemetallized and it is necessary to locate plated through holes underneath the emitter leads of transistors.

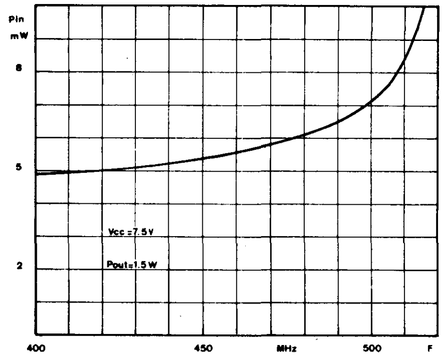
Components are mounted on the circuit side.

TYPICAL RESULTS

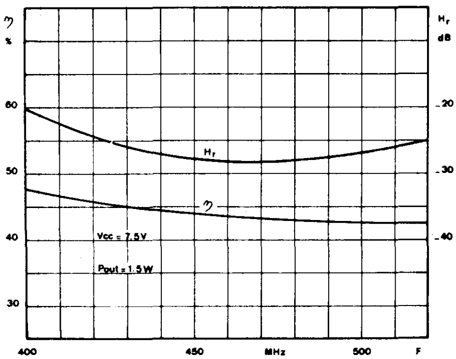
Output Power vs Frequency and Input Power



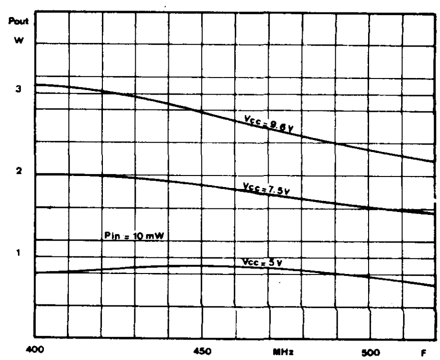
Input Power vs Frequency for 1.5 watts Output



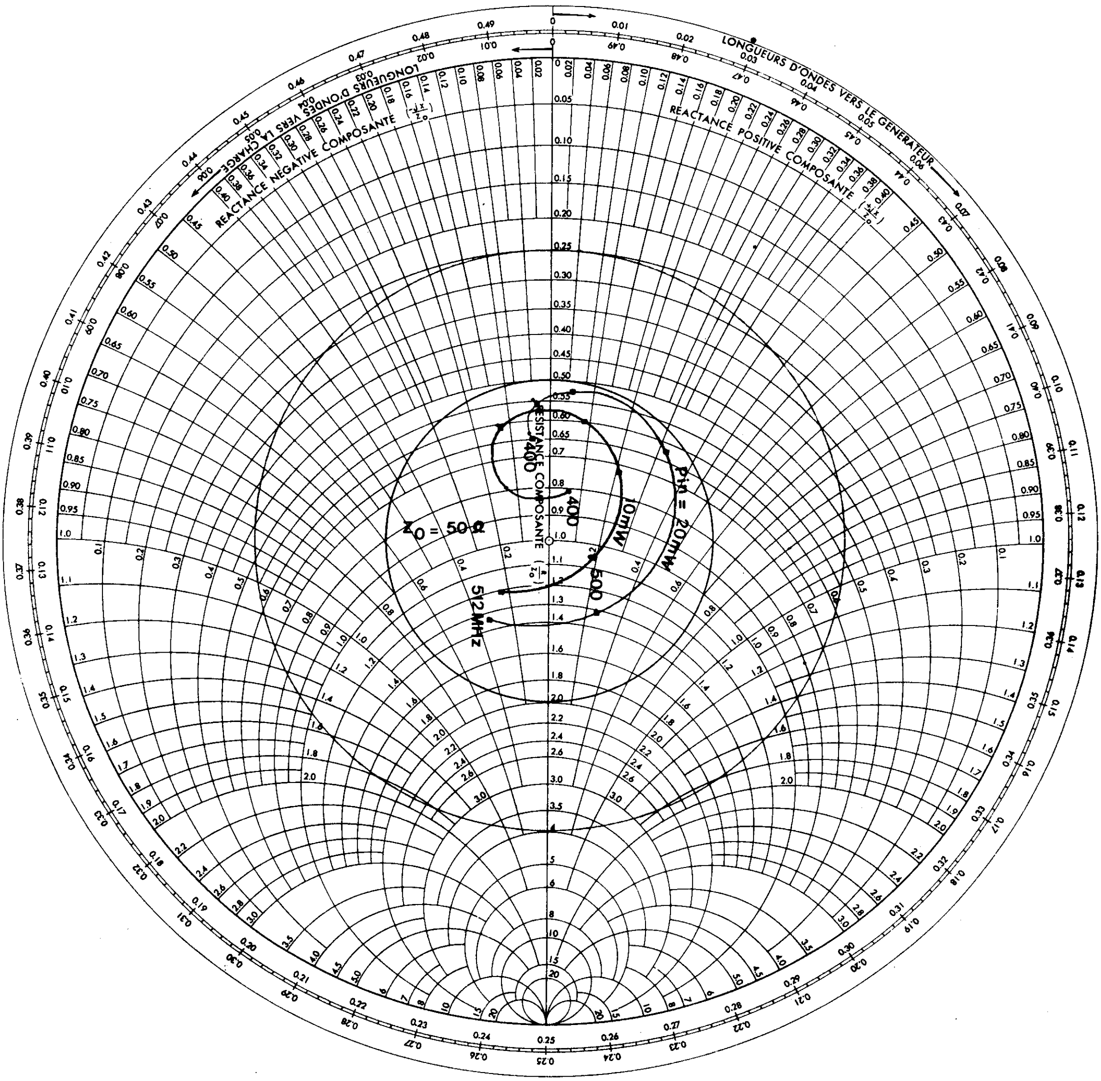
Efficiency and Harmonic Rejection vs Frequency



Output Power vs Frequency and Voltage Supply



Input Impedance vs Frequency and Input Power



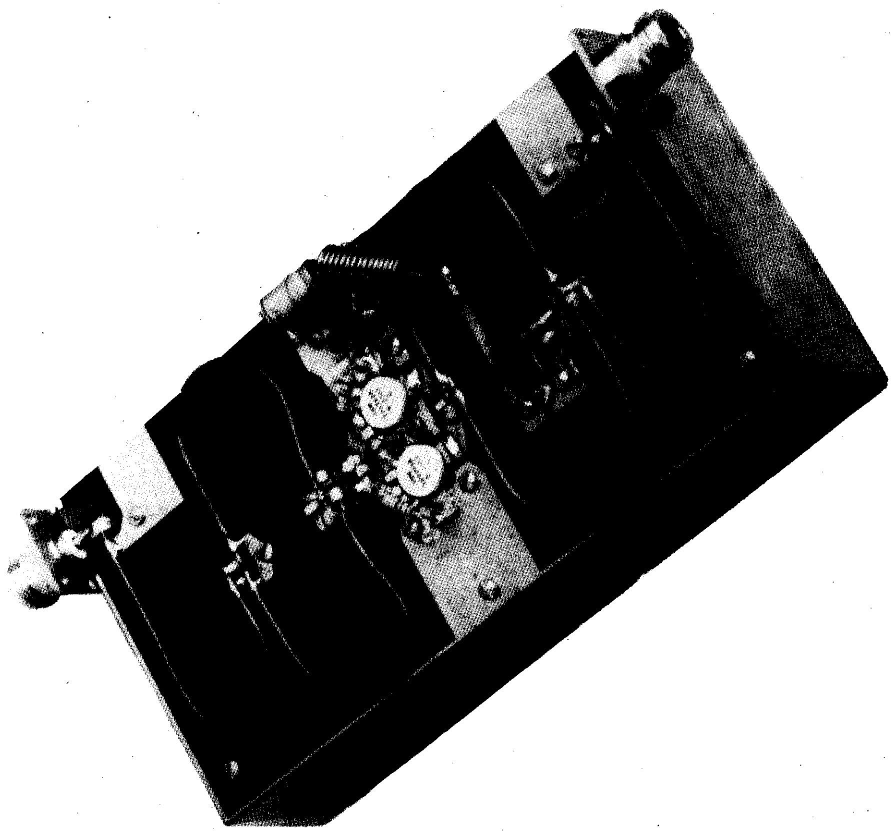
Z

Stability

To improve stability with VSWR at the output, it is necessary to put resistor (R_1 and R_3) between collector and base of transistors. In this condition, it is possible to guarantee stability with 3 : 1 VSWR all phases.

$5\ V \leqslant V_{CC} \leqslant 10\ V$ $\qquad$ P_{in} 0 to 20 mW

SOLID STATE POWER AMPLIFIER
300 W FM



BROADBAND 88 – 108 MHz

INTRODUCTION

High efficiency multikilowat FM transmitters with full solid state amplifiers are possible today. The power amplifier of these transmitters should be made by multiparalleling of a basic building block amplifier. This building block should have a high output power and a high gain, a good collector efficiency, broadband (88-108 MHz) frequency response and a simple, reproducible and reliable circuit design. This application note describes an FM building block amplifier that meets the requirements mentioned above and that can be successfully incorporated to a number of amplifier architectures.

The amplifier has been developed with a pair of TP 9383 transistors in push-pull configuration. TP 9383 is a double diffused silicon epitaxial transistor that makes use of gold metallization and diffused ballast resistors for long operationg life and ruggedness. Its basic specifications are :

$$V_{CC} = 28\ V \quad ; \quad \eta = 75\ \%\ \text{at 108 MHz and 150 W output power}$$

$$G = 9\ dB \qquad Po = 150\ W$$

DESIGN CONSIDERATIONS

When designing an FM amplifier the total efficiency must be the first goal.

Overall efficiency is the combination of good collect efficiency and high gain. To get a good collector efficiency the transistors must be operated in class C and the load impedance should match the transistors output impedance at the operation power level. Class C amplifiers are non-linear units. The harmonic content of the output signal of this type of amplifiers can be very high and their power wasted with an important reduction in the efficiency.

This fact made **advantageous** the use of balanced amplifiers. In such circuit arrangement all the even harmonic are largely suppressed and the waste of power minimized. Push-pull amplifiers have also the additional advantages of connecting in series for RF operation the input and output impedance of the 2 transistors. That makes considerably easier to match the input and output impedances of the transistor pair. However, as the impedance transformation is lower, the RF power losses are smaller and the gain and efficiency higher.

Another important consideration in the design of an FM amplifier is the ruggedness of the amplifier. FM transmitters are often operated 24 hours per day and sometimes remotly controlled and in difficult access sites. The operating point of the transistors should be choosen in a conservative way and the heat properly evacuated. A thermo switch should be incorporated to the system. The amplifier must also be able to withstand output VSWR. Although all transmitters use to incorporate VSWR protection in their interlocky systems, the amplifier must be designed with the capability of supporting VSWR of 3.1 as a minimum. This point can be very determinent when considering that on a high efficiency circuit the collector voltage swing can be close to 3 times the collector supply voltage.

CIRCUIT DESCRIPTION

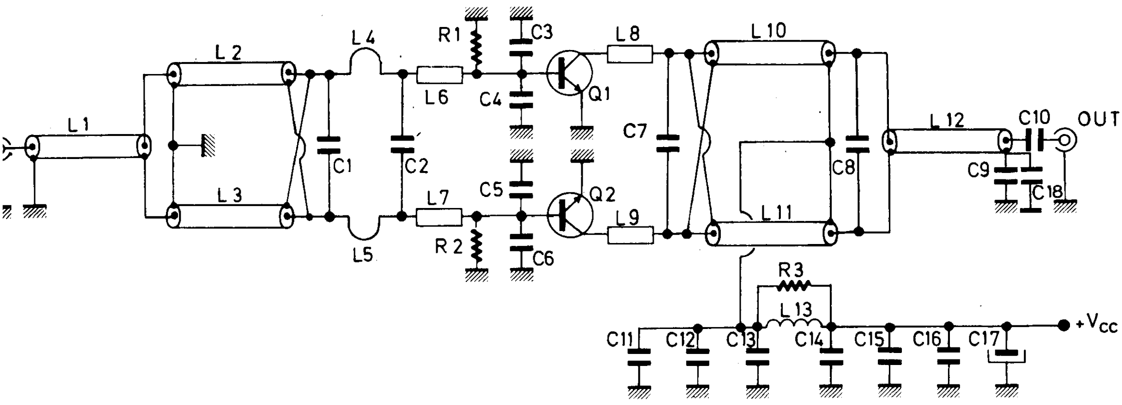
Circuit schematic is given in the Figure 1. At the amplifier input there is a two section balun. The first section, L_1, consists of a short lenght ($\simeq \lambda/20$) of 50 Ω coaxial semirigid cable. The outer conductor of the coaxial cable is grounded at the input side and floates at the output.

The second section of the balun consists of two identical coaxial cables, L_2 and L_3, of the same lenght that L_1 but with 25 Ω characteristic impedance. The ends of these two coaxials are interconnected in series at the input side (thus offering 50 Ω impedance to L_1) and in parallel at the output of the section.

The combined balanced impedance will be therefore 12.5 Ω at the output of the balun. The input impedance of the transistor pair Q_1 and Q_2 is transformed to 12.5 Ω (2 × 6.25) with the LC network represented in the schematic.

If this balun is well charged by 2 × 6.25 Ω it is well capable of multioctave operation. However in this case the LC network that transform the impedances of the transistor pair has been optimized only between 88 and 108 MHz.

A similar balun circuit is used at the output of the amplifier. The main difference with the input balun is that the coaxial cables are also used in the collect biasing circuit. Care has been taken with the decoupling of the collect bias in order to avoid low frequency oscillations. The collect impedance is higher than the base impedance and therefore the LC output transforming network is very simple, only L_8, L_9 and C_7.



88-108 MHz; 300 W 28 V

BROADBAND POWER AMPLIFIER FM

Figure 1

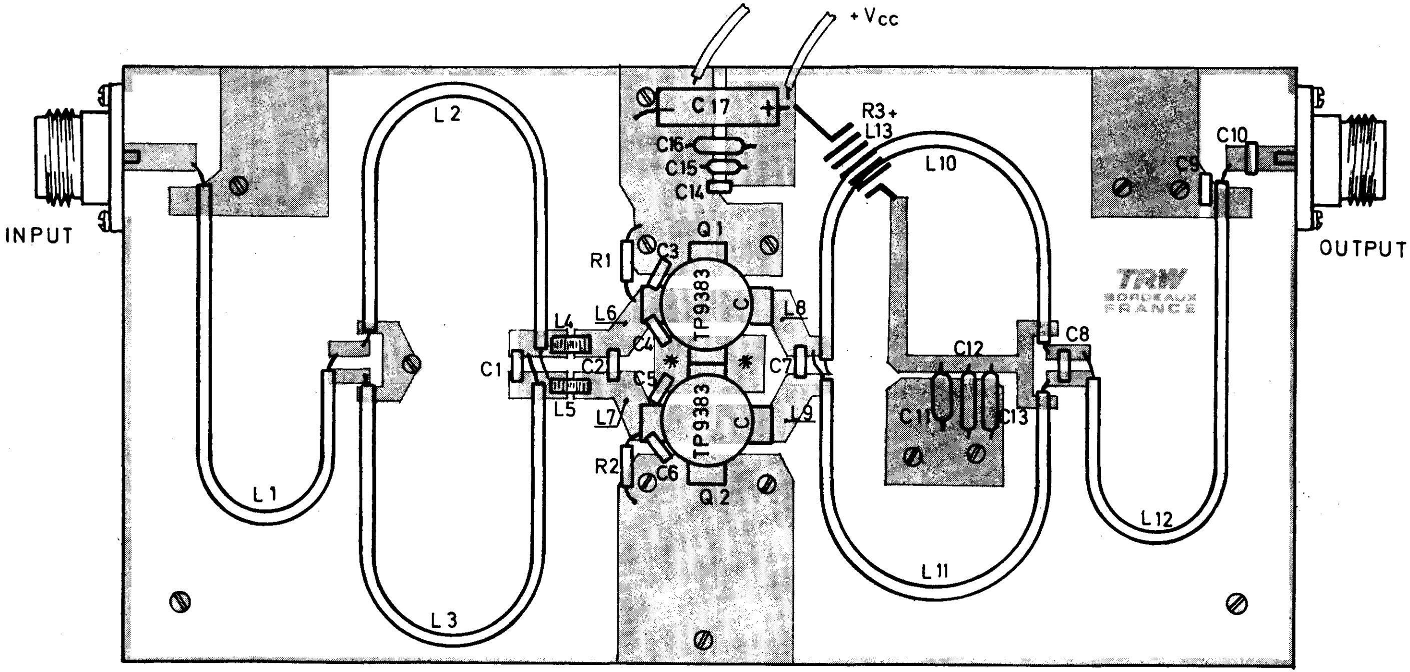
COMPONENTS LIST

C_1	= 120 + 80 pF Chip capacitor ATC 100 B
C_2	= 220 pF Chip capacitor ATC 100 B
C_3, C_4, C_5, C_6	= 470 pF Chip capacitor ATC 100 B
C_7	= 100 pF Chip capacitor ATC 100 B
C_8	= 27 pF Chip capacitor ATC 100 B
C_9, C_{10}, C_{11}, C_{14}	= 1 000 pF Disc capacitor
C_{12}, C_{15}	= 10 nF
C_{13}, C_{16}, C_{18}	= 0,1 μF
C_{17}	= 1 000 μF/63 V Electrolytic

L_1	= 50 Ω coaxial cable ∅ 3,2 mm (Teflon) L = 110 mm
L_2, L_3	= 25 Ω coaxial cable ∅ 3,2 mm (Teflon) L = 110 mm
L_4 L_5	= Hair pin : copper foil 18 × 3 mm 0,3 mm thickness
L_6, L_7	= Line on substrate : 15 × 5 mm
L_8, L_9	= Line on substrate : 10 × 5 mm
L_{10}, L_{11}	= 25 Ω coaxial cable ∅ 5 mm (Teflon) L = 110 mm
L_{12}	= 50 Ω coaxial cable ∅ 5 mm (Teflon) L = 110 mm
L_{13}	= 15 turns ∅ 8 mm 1,4 mm wire

R_1, R_2	= 22 Ω 1/2 W
R_3	= 47 Ω 2 W

Q_1, Q_2	= TP 9383

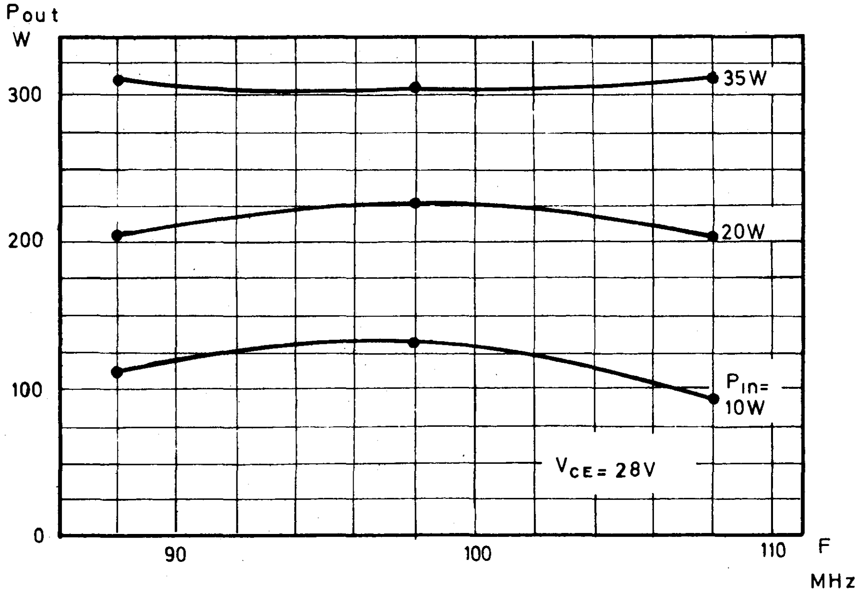


* Grouding eyelet.

Epoxy glass dual side coated

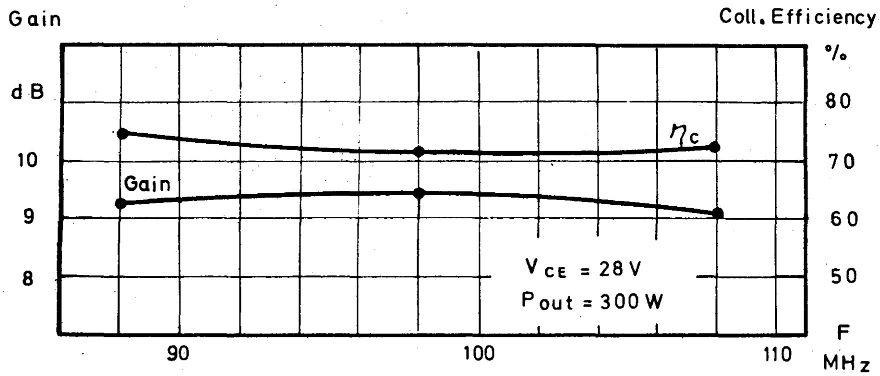
Figure 2

300 W PUSH-PULL FM TP 9383



Pin/Pout

Figure 3



Gain and Efficiency

Figure 4

1.2 V, 40-900 MHz BROADBAND AMPLIFIER WITH THE TP 3400 TRANSISTOR

INTRODUCTION

This application note describes a single stage broadband amplifier incorporating the TP 3400 transistor. The amplifier will deliver 1.2 V output signal from 40 to 900 MHz at an intermodulation level* of — 60 dB or less. The gain is 9.5 dB ± 0.5 dB. Although the amplifier has been designed for MATV use, its simplicity and versatility makes it suitable for use in many other applications. The circuit construction is straight forward and only standard components have been used.

TP 3400

The TP 3400 is a NPN gold metallized transistor with a transition frequency of more than 3 GHz. The transistor is housed in a SOE 200 package.

The TRW gold metallization process used on the manufacture of this transistor is etchless, providing exact finger definition with submicron resolution and avoids the finger scalloping characteristic of all etching processes, which eliminates therefore current crowding where metal fingers are necked down. Moreover this gold process improves on all the benefits of gold over aluminium regarding electromigration.

The TP 3400 also incorporates diffused ballast resistors. High resistance ballast resistors are diffused directly into the silicon avoiding therefore all the reliability problem associated with conventional thin film, metal ballast resistors. In addition the P-N diode of the ballast resistor is diffused to avalanche at a lower voltage than the transistor, thus protecting effectively the transistor against VSWR or transient damage. A diagram illustrating the above mentioned technological characteristic is given in fig. 1.

TRW DIFFUSED BALLAST RESISTORS WITH ETCHLESS GOLD METALLIZATION vs. **CONVENTIONAL THIN FILM BALLAST RESISTORS WITH ETCHED METALLIZATION**

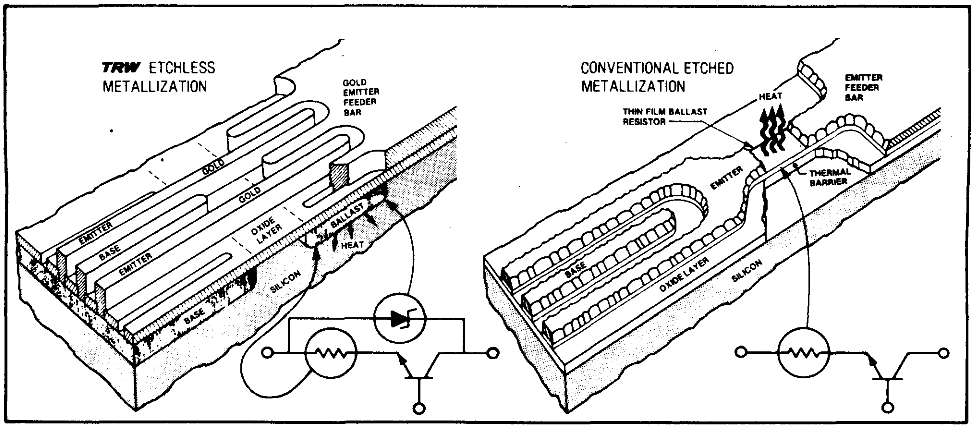


Figure 1

(*) Intermodulation measured with a test procedure in accordance with DIN 45004/B.

AMPLIFIER DESIGN

a) Calculations

The amplifier configuration choosen is given in figure 2. A combination of series and shunt feedback compensates the frequency gain slope of the transistor. Transmission line inductors are used on the shunt feedback network. The resistor in series with the base will improve the input VSWR at the cost of some gain, but this gain decrease is partially compensated by the fact that less series feddback is necessary in this way.

The calculation and optimization of the circuit was carried out with the aid of a computer using the COMPACT program. The program, the optimization data and the final expected results are given in table. 1. The expected gain is 9.5 dB plus/minus 0.5 dB, the amplifier is unconditionally stable over the required frequency range and input and output impedance matchings could be considered correct.

b) Amplifier assembly

Final amplifier is shown in fig. 3. The component values are given in table 2. The amplifier was built on standard Epoxy glass double clad printed circuit board and all the components are commonly used types. The resistors are carbon-composition type. Care was taken with all ground returns, made by wrapping copper foil between both planes. Plated trough holes may also be used. PC board and component layouts are given in figures 4 and 5 respectively.

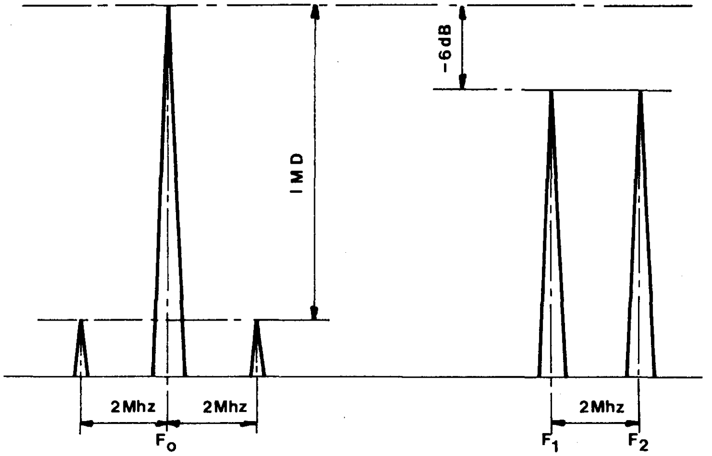
RESULTS

Several TP 3400 transistors, covering all the accepted production spread, were used and no significant differences in the amplifier performance were recorded.

Input and output matching are given in figures 6 and 7. Gain versus frequency is given in figure 8. It is similar to that calculated.

Figure 9 shows its behabiour as an MATV amplifier, measured according to the DIN 45004B test procedure. The — 60 dB IMD level is attained at 1.2 volt; 75 output.

INTERMODULATION MEASUREMENT ACCORDING DIN 45004/B



CIRCUIT DEFINITION

```
MET  AA  ZZ
CAP  AA  PA  —2.078
TRL  BB  SE   65.00   —19.96   1.000
RES  CC  SE  —12.44
TRL  DD  SE   65.00   —18.35   1.000
CAP  EE  PA  —2.101
TWO  HH  SI   50.00
CAS  EE  HH
RES  II  PA  —6.759
SER  EE  II
CAP  JJ  PA  —.8989
SRL  KK  PA   35.00    1000.
TRL  LL  SE   65.00   —10.15   1.000
CAX  JJ  LL
CAS  EE  JJ
RES  MM  SE  —204.7
TRL  NN  SE   65.00   —7.229   1.000
CAS  MM  NN
PAR  EE  MM
TRL  FF  SE   65.00   —14.60   1.000
CAP  GG  PA  —.9557
CAX  AA  GG
PRI  AA  SI   50.00
END
```

FREQUENCY (MHz)

```
100  200  300  400  500  600  700  800  900
END
```

POLAR S PARAMETERS FOR TWO HH (TP 3400)

```
.61  226  17.8  126  .0200  35  .53  320
.73  203  12.9  103  .0282  33  .32  305
.77  192  9.23   93  .0299  33  .27  297
.75  185  6.92   84  .0335  33  .27  295
.75  179  5.15   79  .0335  38  .27  300
.78  174  4.68   72  .0355  42  .24  300
.77  167  3.34   61  .0447  44  .27  285
.77  163  3.16   56  .0473  44  .24  290
END
```

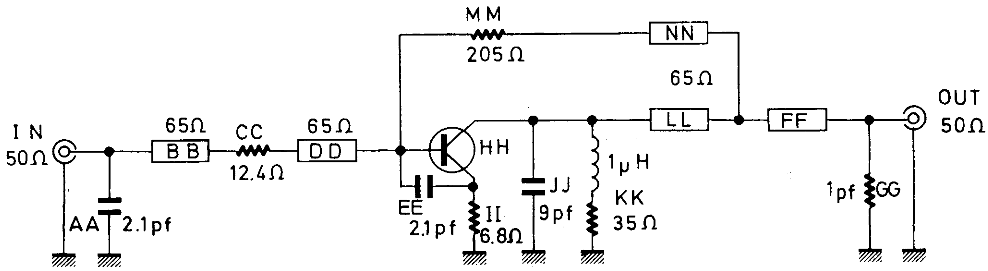
OPTIMIZATION DATA

```
.5
10  10  1  10
END
```

POLAR S-PARAMETERS IN 50.0 OHM SYSTEM

FREQ.	S11 (MAGN	ANGL)	S21 (MAGN	ANGL)	S12 (MAGN	ANGL)	S22 (MAGN	ANGL)	S21 dB	K FACT.
100.00	0.09	—132	2.99	157.1	0.139	—10.7	0.16	149	9.52	1.38
200.00	0.11	—140	3.14	135.2	0.139	—21.5	0.16	141	9.94	1.33
300.00	0.13	—152	3.13	113.4	0.136	—32.7	0.11	128	9.91	1.36
400.00	0.15	—166	3.14	89.7	0.133	—43.6	0.03	86	9.94	1.38
500.00	0.15	166	2.94	64.2	0.128	—53.5	0.07	—52	9.37	1.49
600.00	0.15	140	3.15	43.9	0.126	—63.6	0.10	—68	9.96	1.42
700.00	0.15	99	3.18	20.0	0.127	—72.3	0.16	—99	10.05	1.37
800.00	0.20	51	2.95	—6.8	0.128	—80.8	0.25	—120	9.38	1.34
900.00	0.26	18	3.06	—29.3	0.128	—93.0	0.25	—125	9.78	1.22

TP 3400 Amplifier 40-900 MHz



$9.4 \leqslant G \leqslant 10.1$ dB INPUT VSWR $\leqslant 1.8 : 1$

OUTPUT VSWR $\leqslant 1.7 : 1$

Figure 2

List of Components **Table 2**

C_1 = capacitor ceramic 2.8 pF 632 RTC
C_2 = capacitor chip 10 nF Eurofarad
C_3 = capacitor chip 8.2 pF Vitramon
C_4 = capacitor chip 2.2 pF Vitramon
C_5, C_7 = capacitor chip 1 nF Eurofarad
C_6, C_8 = capacitor chip 10 nF Eurofarad
C_9 = capacitor chip 22 pF Vitramon
C_{10} = capacitor chip 10 nF Eurofarad
C_{11} = capacitor electrolytic 25 MF 25 V

L_1 = 8 turns 5/10 mm Cu ID 2.5 mm
L_2 = printed 5 nH
L_3 = printed stripline 75 ohms 11.5 mm
L_4 = printed stripline 75 ohms 11 mm
L_5 = printed stripline 75 ohms 25 mm
F_1 = ferrite bead 1200082 TRW

R_1 = resistor 12 ohms 1/4 W carbon composition
R_2 = resistor 4.7 ohms 1/4 W carbon composition
R_3, R_4 = resistor 10 ohms 1/4 W carbon composition
R_5 = resistor 8.2 kohms 1/4 W carbon composition
R_6 = resistor 240 ohms 1/4 W carbon composition
R_7 = resistor 12 ohms 1/2 W carbon composition

T = transistor TRW TP 3400

Board Material

Epoxy glass (G 10) 1/16 inch $E_R = 4.2$

CIRCUIT DIAGRAM

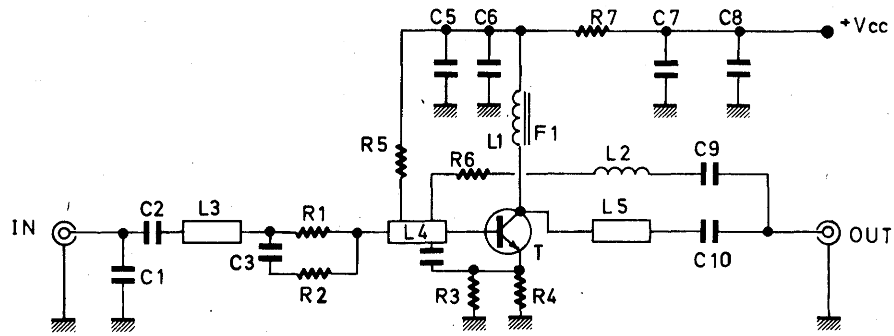


Figure 3

PC Board Layout

Epoxy glass (G 10)

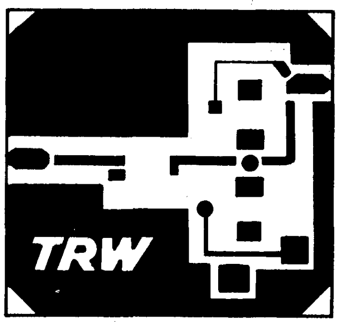
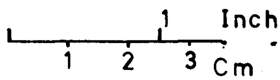


Figure 4



Component Layout

Double sided

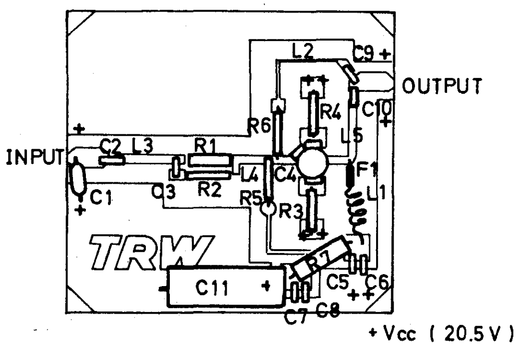


Figure 5

+++ FOIL WRAP OR PLATE AROUND PLANE

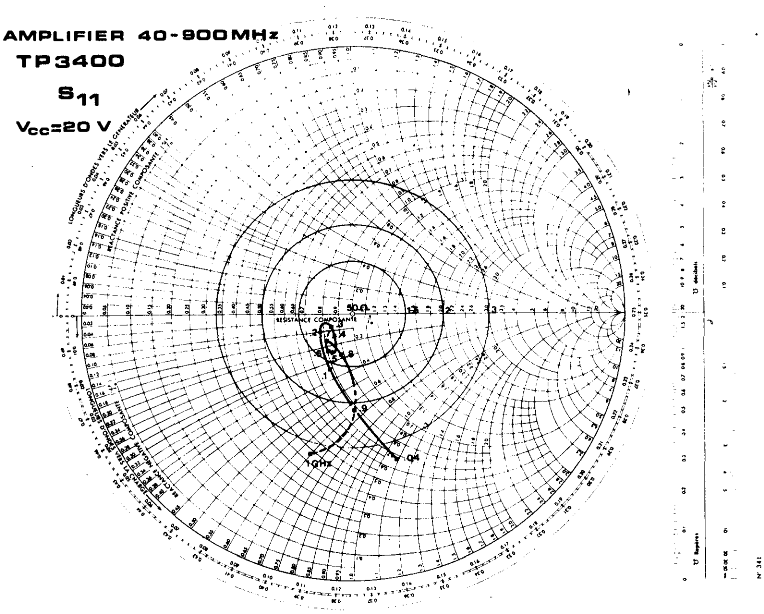


Figure 6

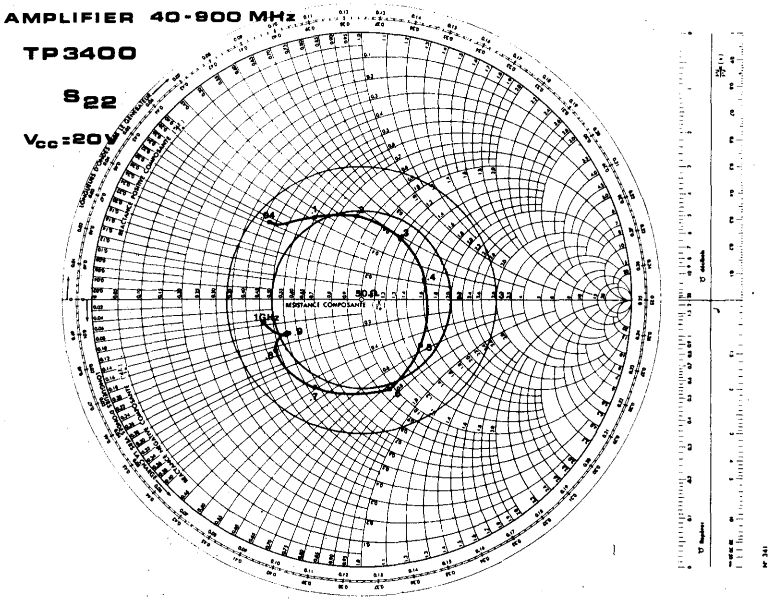


Figure 7

Gain vs Frequency

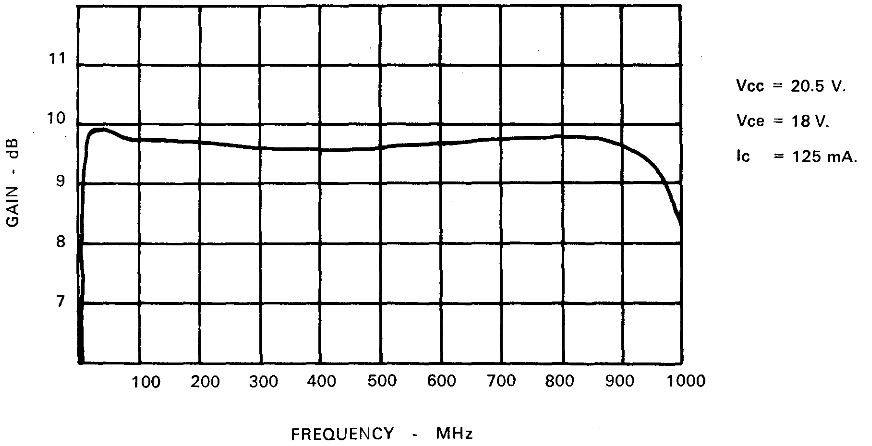


Figure 8

IMD (Din 45004 B) vs Output Voltage

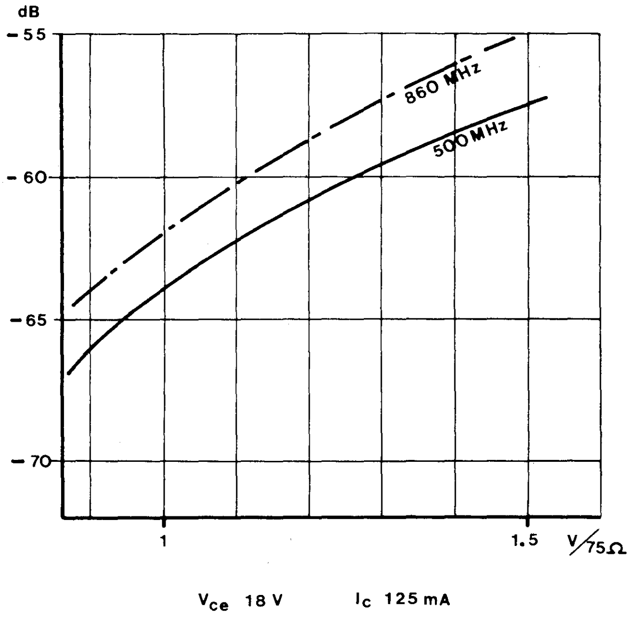


Figure 9

35/50 WATT BROADBAND (160-240 MHz) PUSH-PULL TV AMPLIFIER BAND III

This note describes the performance of a broadband ultra linear push pull amplifier designed for service in band III TV transposers and transmitters.

Devices used : two TPV 375.

Basic amplifier specifications :

IMD (1) = — 51 dB at P_0 = 35 W
IMD (1) = — 48 dB at P_0 = 50 W
V_{ce} = 28 volts ; Total = 4.4 A
P_{gain} = 10 dB
input VSWR : < 1.6
output VSWR : < 1.5

(1) vision carrier — 8 dB, sound carrier — 7 dB, sideband signal — 16 dB.

General design Consideration

The principal aims were :

— employ a relatively simple solution permitting us to obtain the optimal performances from TWO TPV 375.
— simplify the design and reduce the cost.

The main consideration was to obtain the maximum output power with the best IMD over the band. To obtain this requirement the output match and losses must be the best possible in all the band.

The second consideration was to obtain the maximum gain by reducing the input matching circuit losses to a minimum.

These factors led us to choose matching circuits using quarter-wavelength transformers at the input and output which permit us to :

— reduce the load and source impedances to low values with low losses
— couple two transistors in a push pull configuration.

Because the output and input transistor impedances are in series, due to the push-pull configuration, the required transformation ratio is one half of that required for a single ended stage.

The first approach for the circuit calculation was made from the input and output impedances given in the TPV 375 data sheet and matched to the proper impedance levels using a smith chart. The element values were then optimized with the aid of «COMPACT » program.

Amplifier Design

The basic block diagram for the amplifier is shown in Figure 1 and the circuit schematic is shown in Figure 2.

The input and output circuits are each composed of two networks : a quarter-wavelength transformer-balun and a matching network.

The quarter-wavelength transformer impedances have been chosen to be easily built using microstrip technology.

Input circuit

The input circuit is shown in Figure 3 and the input impedances are shown in Smith Chart 1.

The low transistor input impedances are transformed into higher impedances near the real axe by capacitors FF.

The (EE, DD) series elements and (CC, BB) parallel elements collapse the amplifier input impedances around 8,5 Ω.

Since the devices can be considered in series at this point the impedance is doubled to 17 Ω. The quarter-wavelength transformer balun (AA) completes the match to 50 Ω.

The transformation ratio is 2.8 : 1.

The maximum theoritical input VSWR is 1.80 : 1 and the maximum experimental VSWR is 1.60 : 1.

Output circuit

The output circuit is shown in Figure 4 and the output impedances on Smith Chart. II. Since the output impedances are higher than the input impedances, the output matching network is simpler and the quarter-wavelength transformer ratio is lower.

The inductors aid the matching but primarily provide for good stability at the low frequencies, and are used for collector bias. The output quarter-wave-length transformer ratio is 1.6 : 1.

The maximum theoritical VSWR is 1.16 : 1 and the maximum experimental VSWR is 1.44 : 1.

Amplifier Performances

— IMD versus output power : Figure 5

— Input and output return loss and VSWR = Figure 6

— Gain versus frequency : see Figure 7

— 1 dB gain point compression : 70 W

— Bias conditions : V_{ce} = 28 V ; Total = 4.4 A.

Technology and layout considerations

The epoxy-Glass 1/16 inch (ε_r = 4.1) is used as board material except for the input and ouput transformers.

The glass - Teflon 1/50 inch (ε_r = 2.55) is used for the transformers (see the details Figure 8).

We have considered for a microstrip line that after W (Width) from the conductor strip edge the fields are negligible and we can size the ground conductor to be 3 W without perturbing the propagation. This kind of transformer has the following characteristics :

— We can have any impedance values within realizable min-max limits.

— The vertical dimensions are small and the mechanical realibility is good.

— Good repeatibility.

The bias circuits are included with RF circuits in order to give a compact amplifier : Figures 10 and 11 show the layouts and the Figure 12 the physical layout of the push-pull amplifier.

Combined pairs of push-pull Amplifiers

— In general several push-pull amplifiers are used for the final stage of the TV transmitter amplifiers.

They can be combined by pair with quadrature combiners (see block diagram Figure 9).

The advantage of using this kind of coupler is that the input and output VSWR become good (> 20 dB rtn. loss) in comparison with the relatively high original VSWR of the push-pull amplifier.

General Conclusions

— Pushpull techniques simplify the required circuitry and associated losses.

— The problems associated with 3 dB hybrids in cascade — insertion loss and imbalance — when four devices in parallel are required are minimized.

— With additional effort both the input and output VSWR could be improved to 1.2 : 1.

— Good repeatability in production without variable components being required.

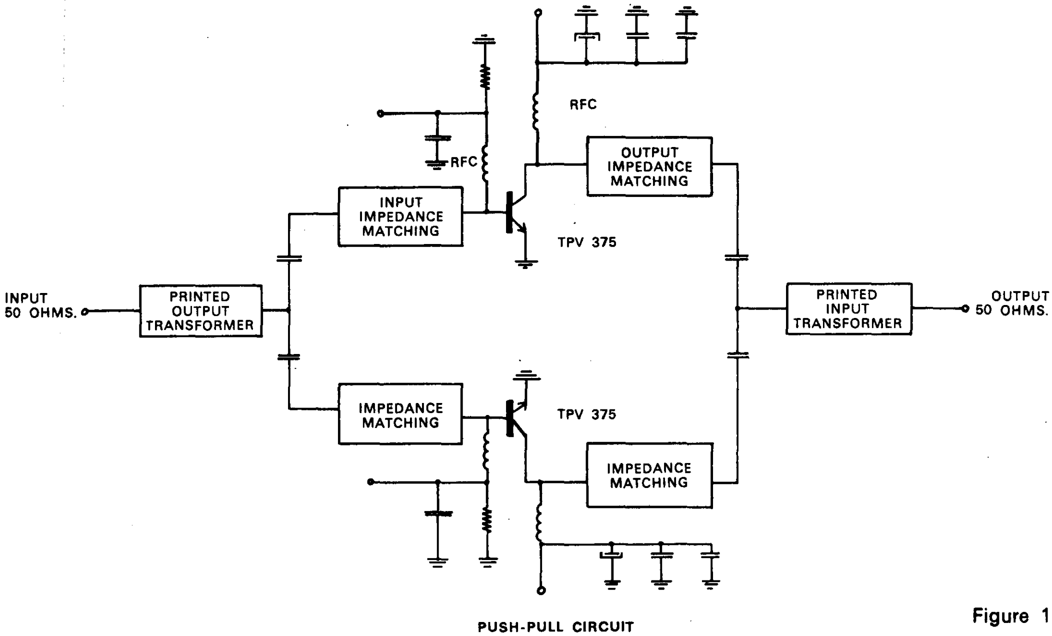


Figure 1

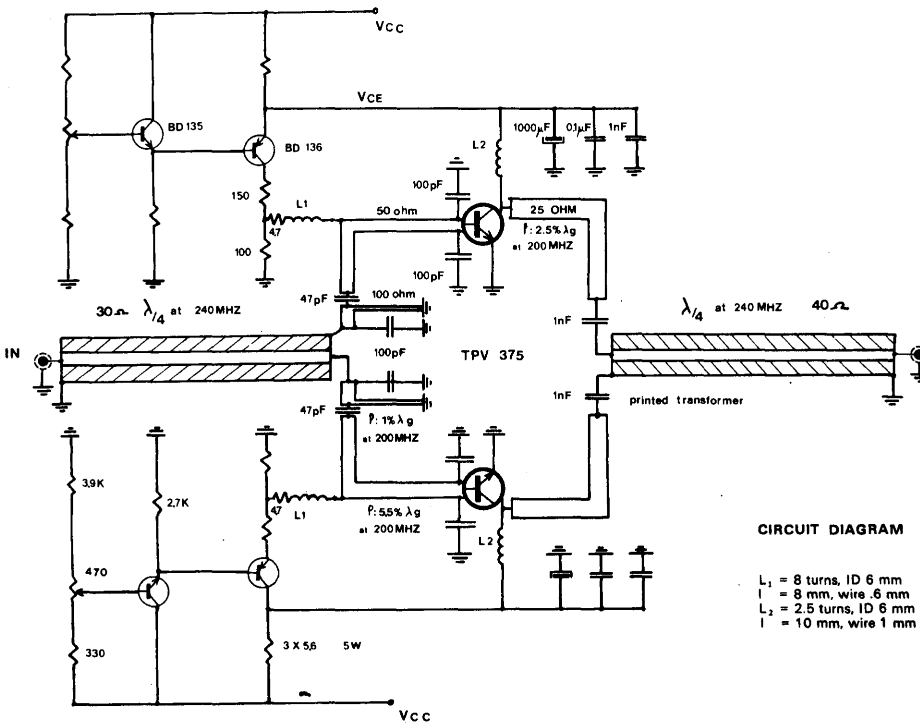
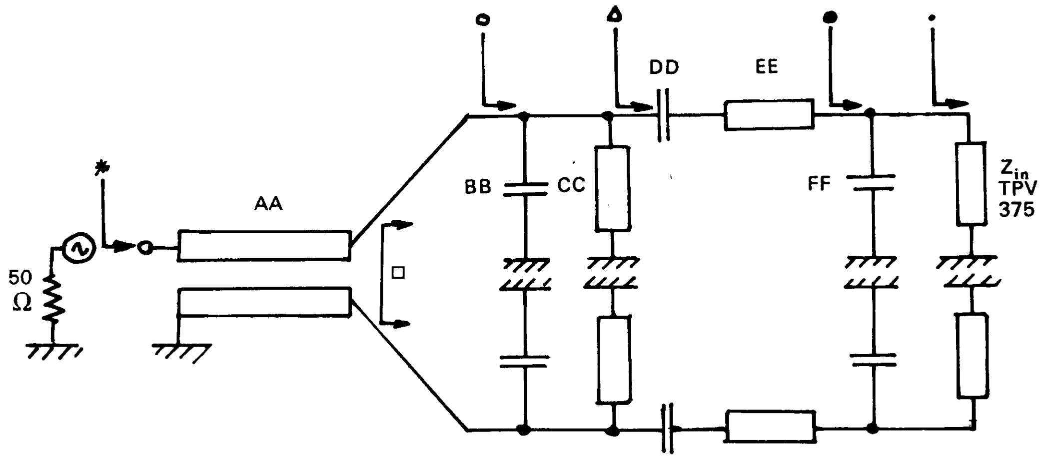


Figure 2

INPUT CIRCUIT

On the smith chart the impedances are represented by :



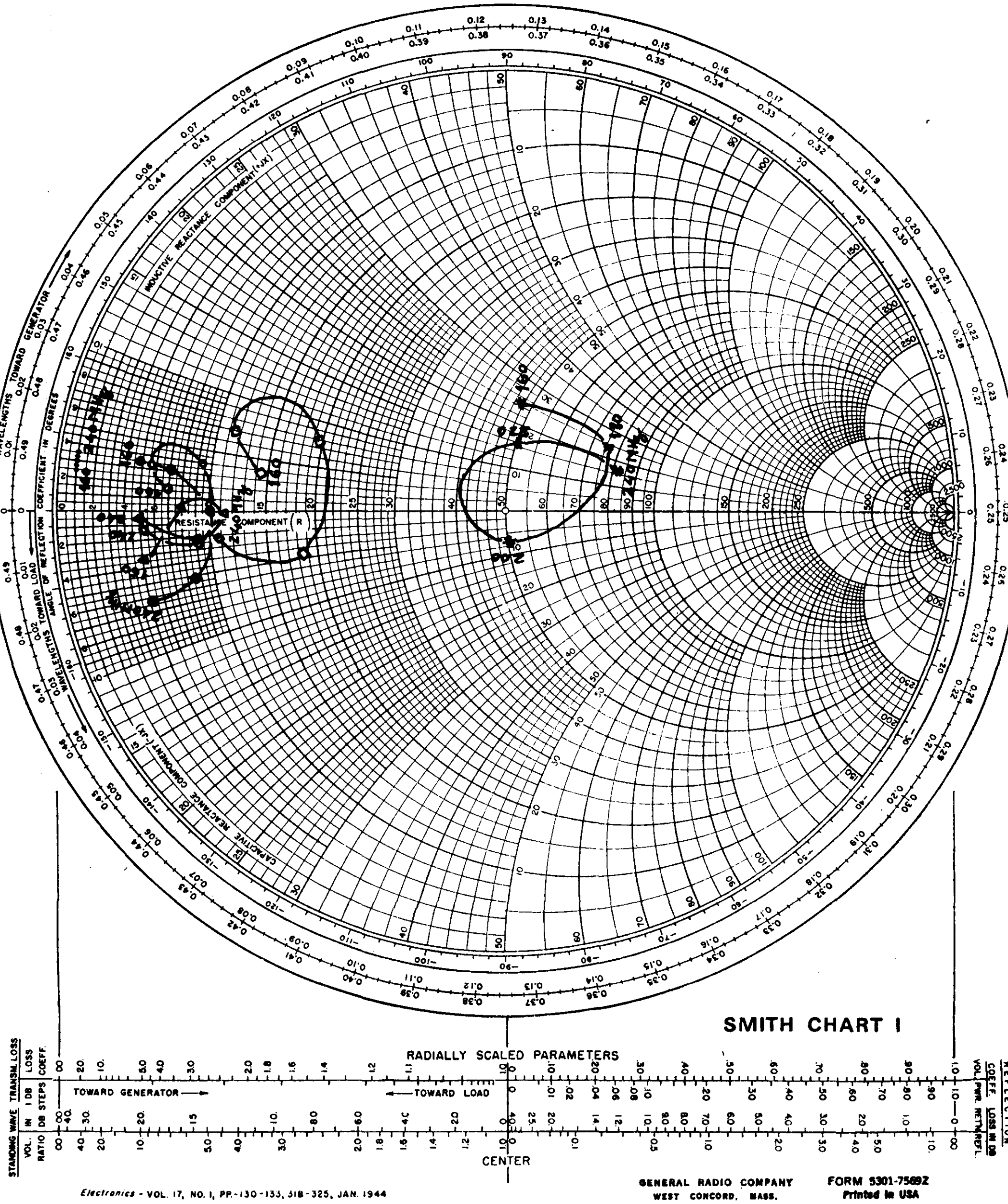
	AA		BB	CC		DD	EE		FF
	Z_0 (Ω)	L* (mm)	(pF)	Z_0 (Ω)	L* (mm)	(pF)	Z_0 (Ω)	L* (mm)	(pF)
Calc. value	30	313	139	100	11.3	47	50	80.8	238
Empirical value	30	313	100	100	15.0	47	50	82.5	200

* L is given for $\varepsilon_r = 1$

Figure 3

INPUT CIRCUIT

IMPEDANCE COORDINATES—50-OHM CHARACTERISTIC IMPEDANCE



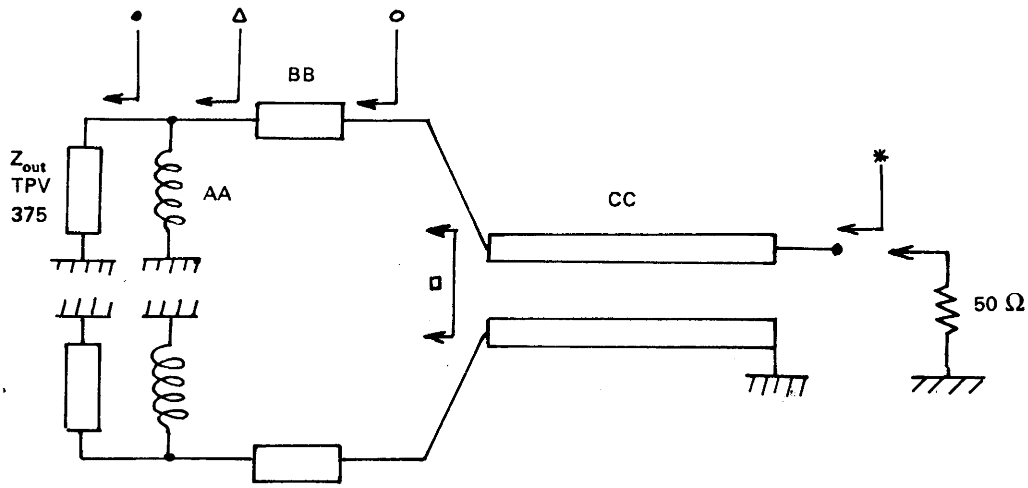
Electronics - VOL. 17, NO. 1, PP.-130-133, 318-325, JAN. 1944

GENERAL RADIO COMPANY
WEST CONCORD, MASS.

FORM 5301-7569Z
Printed in USA

OUPUT CIRCUIT

On the smith chart the impedances are represented by :

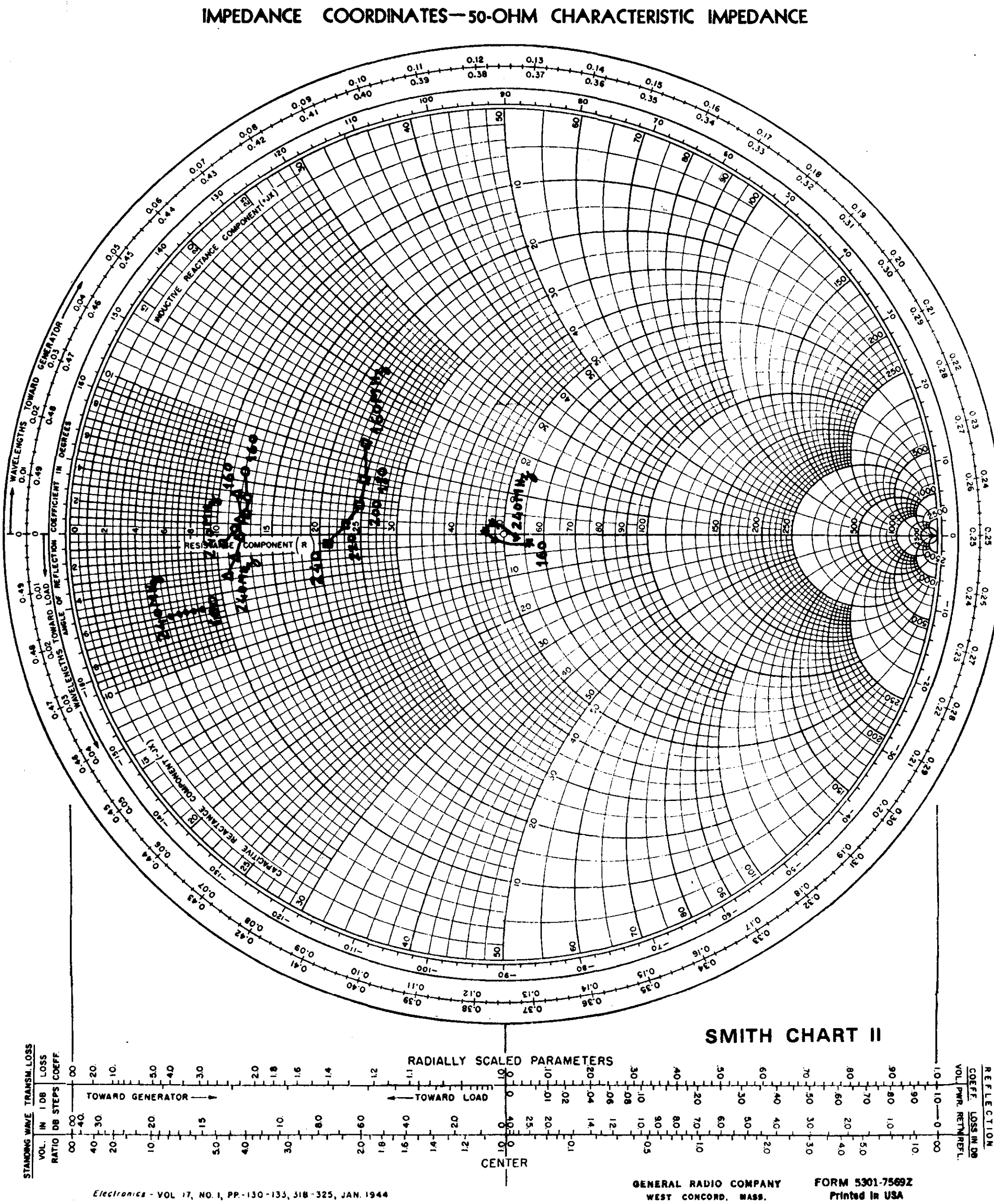


	AA	BB		CC	
	(nH)	Z_0 (Ω)	L* (mm)	Z_0 (Ω)	L* (mm)
Calc. value	11.7	21.6	37.5	33	312.5
Empirical value	53.1	25.0	37.5	40	312.5

* L is given for $\varepsilon_r = 1$

Figure 4

OUTPUT CIRCUIT



IMD VERSUS OUTPUT POWER

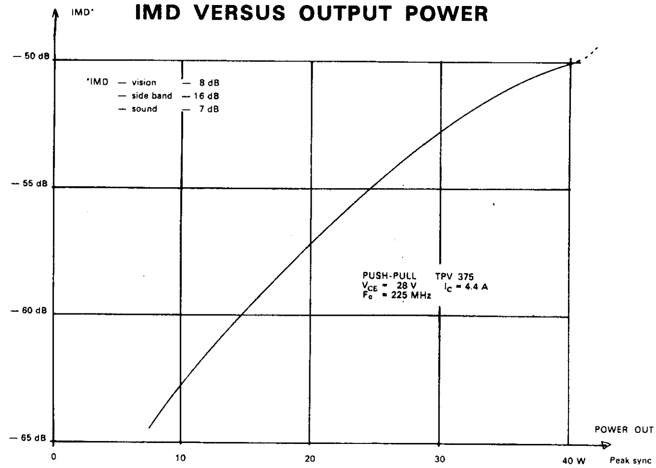


Figure 5

INPUT AND OUTPUT RETURN LOSS Vs FREQUENCY

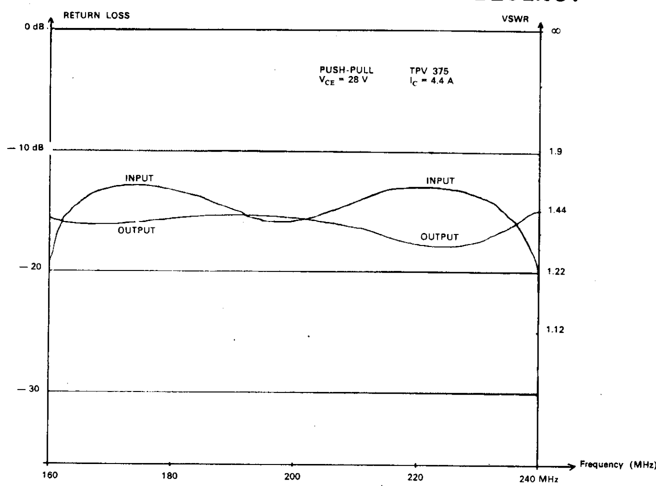


Figure 6

LOW LEVEL GAIN Vs FREQUENCY

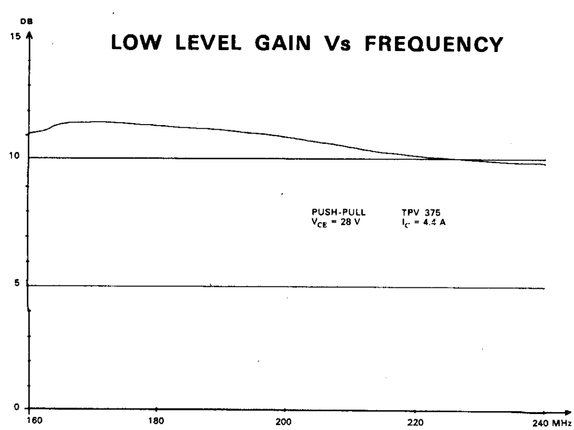
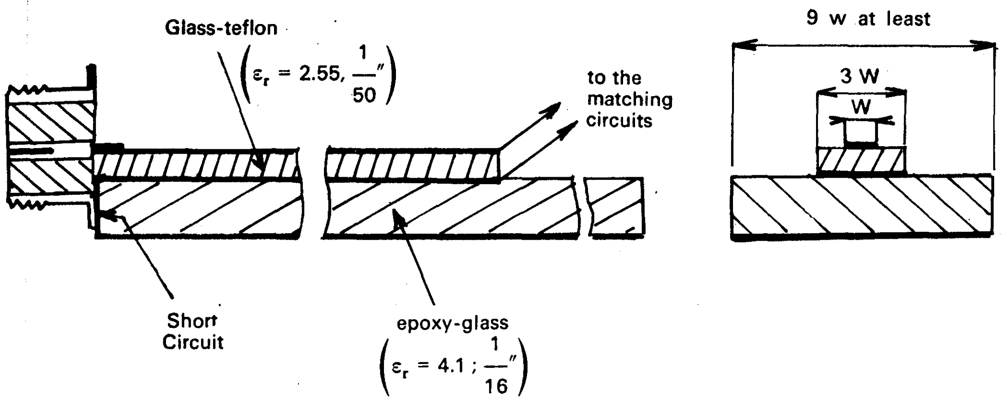


Figure 7

Z

QUATER WAVELENGTH BALUN



EQUIVALENT CIRCUIT

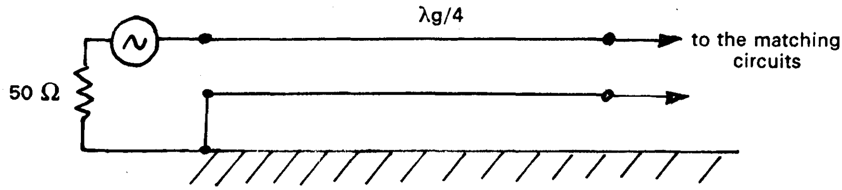


Figure 8

COMBINED PAIR OF PUSH-PULL AMPLIFIERS

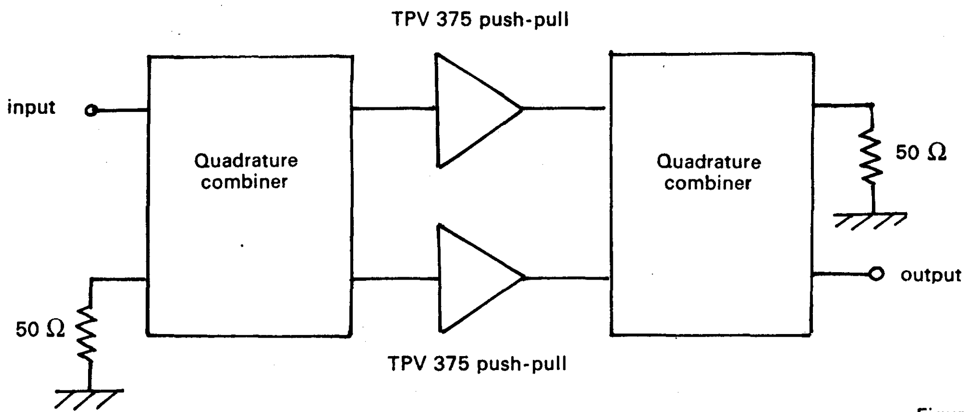


Figure 9

PC BOARD LAYOUT

Board material : epoxy-glass ; 1/16 inch ; ε_r = 4.1

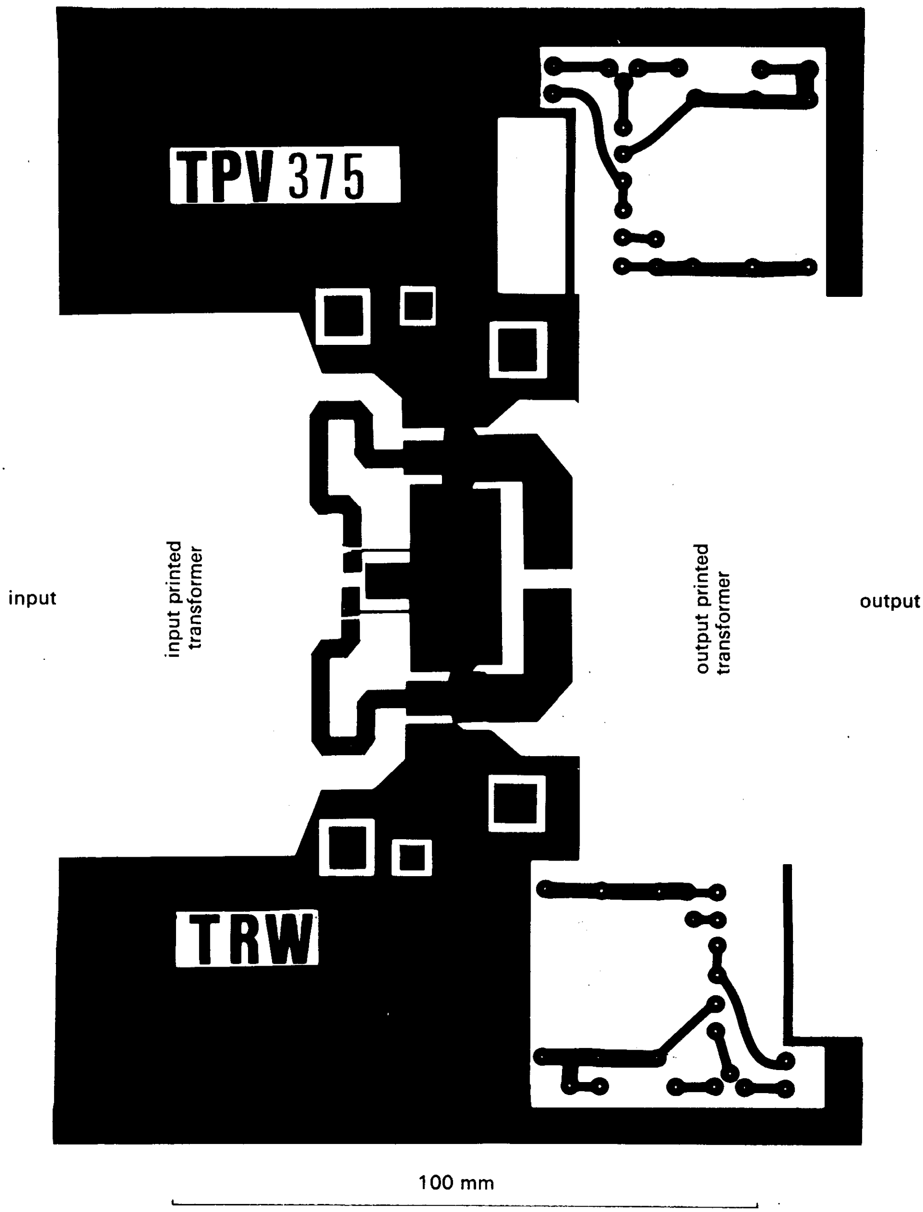


Figure 10

PC BOARD LAYOUT FOR INPUT AND OUTPUT QUATER-WAVELENGHT TRANSFORMER

Board material : glass teflon ; 1/50 inch ; $\varepsilon_r = 2.55$

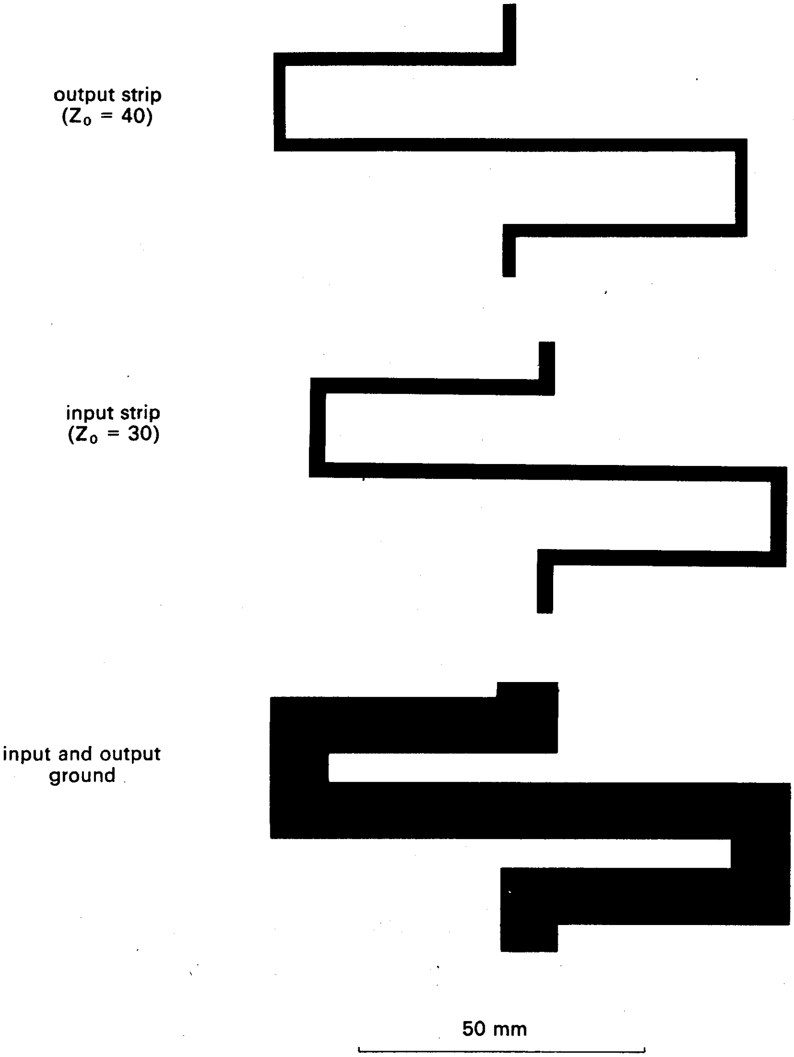


Figure 11

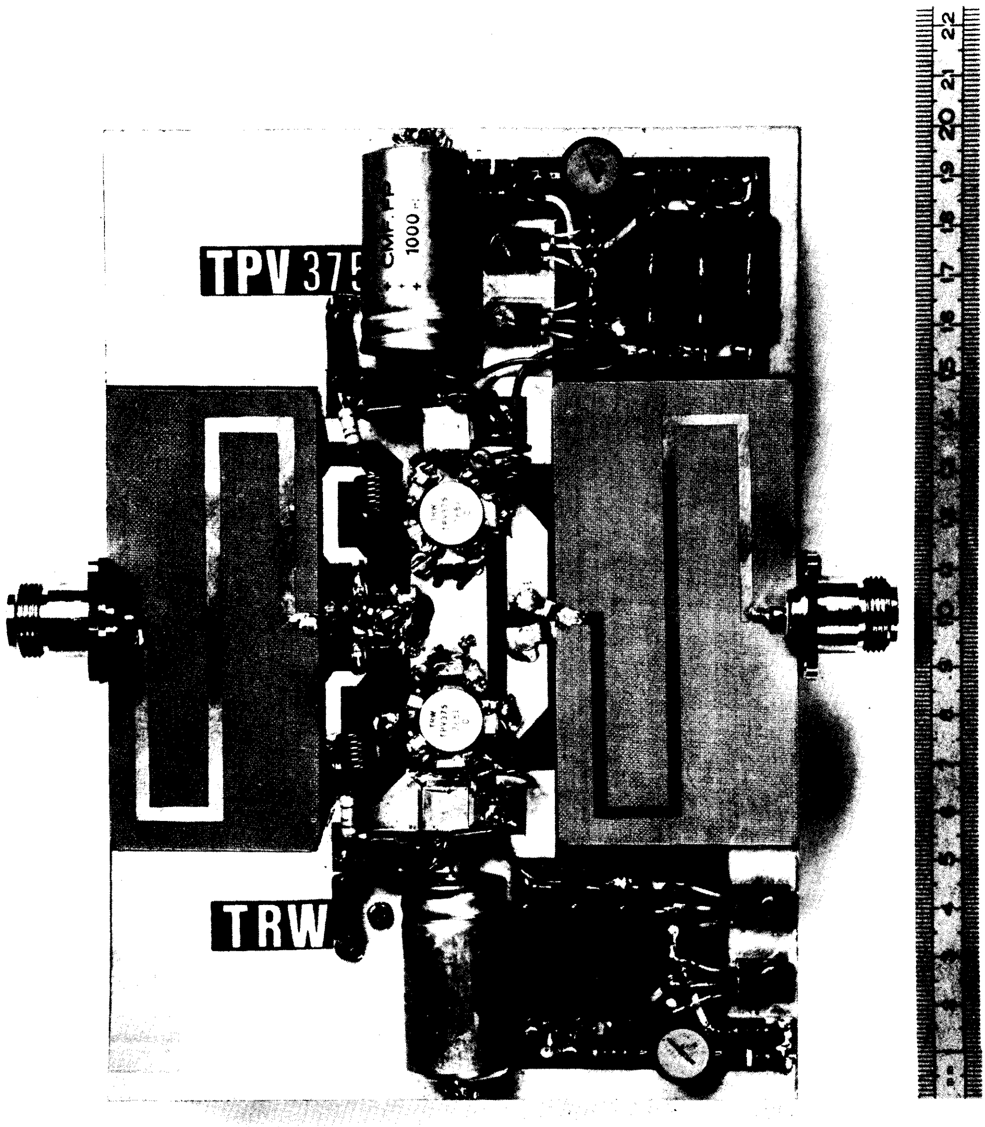


Figure 12

TV TRANSPOSERS BAND IV and V
P_0 = 0.5 W/1.0 W

This note describes the performance of a broadband (470-860 MHz) ultra linear amplifier designed for service in band IV and V T V transposers.
Device used :

TPV 596.

Basic specs :

I.M.D. — 60 dB max. at Po = 0.5 watts
Vce = 20 volts ; Ic = 200 mA
Pgain = 11.5 dB min.

The approach used is intended to be straight forward and inexpensive as follows.

1) The load line be defined to provide the correct match for peak power (P. sync).
2) The VSWR at the collector be less than 2 : 1.
3) The input match be designed to provide flat gain with decreasing frequency.
4) Use computer aided design.
5) Use a three tone norm
   Pvision = — 8 dB
   Psound = — 7 dB
   Psideband = — 16 dB
6) Circuit realization to be a distributed design built upon teflon glass copper clad circuit boards. However the design will be analized using Er = 1.0.

The input and output impedances were taken from the TPV 596 data sheet and plotted on a smith chart. First consider the input. To have flat gain with an optimum collector load, the basic physics of a class « A » biased device defines a gain slope of — 6 dB/octave which must be compensated for. The band of interest is 470-860 MHz which is .915 octaves which implies that 5.25 dB of gain must be compensated for if the device is perfectly matched at 860 MHz. This means that a transmission loss of 5.25 dB or a VSWR of 11.0 : 1 must be employed at 470 MHz. The input Z is converted to Y on smith chart (I). The point at 860 MHz will intersect the constant conductance line equal to 1.0 (20 m℧) if it is rotated 0.14 λ using a 20 m℧ (50 Ω) transmission line. After this rotation a capacitive stub or chip capacitor is used to resonate the susceptance at 860 MHz ; A capacitive stub or a chip capacitor equal to 16.7 pF can be used, and the result is shown on Smith chart (I). It is interesting to note that the VSWR vs : frequency can be adjusted for gain flatness by selecting an optimum Zo for the capacitive stub. It is also obvious that the locus of impedances at the circuit input can very between the locus of points defined by using a chip capacitor, and the imaginary axis by using a stub with Zo = ∞. Graph (II) is a plot of these results. Because infinite isolation doesn't exist between the output and input of any transistor, and because the required network is very simple, the input circuit will be optimized empirically. A computed aided circuit will be defined for the output only. It is also indicated that a combination chip capacitor and stub may provide the best results.

The output circuit considerations were first determined using a smith chart approach. It must be clearly understood that computer optimization is only as good as the circuit configuration and associated computer instructions.

The approach follows :

Smith Chart (II)

1) The device output impedances are first converted to admittances and plotted as the conjugate (Y load).
2) In order to allow easy collector lead soldering a Zo = 50 Ω, 3 mm long transmission line is used. Since the Smith chart is normalized to 20 m℧ (50 Ω) we can rotate toward the load directly as the chart is configured.
3) Since the balance of the circuit used Yo = 10 m℧ (100 Ω) we next normalize the chart to 10 m℧. 100 Ω transmission line was chosen as a good compromise between physical length requirements and ease of realization on Teflon Glass.

4) The next element, a shorted shunt transmission line less than λ/4 in length reduces the imaginary part by moving each point of admittance along a line of constant conductance. The length was chosen to locate the lowest frequency point (400 MHz) near the real axis so that the locus of points would be more equally distributed about a 2.0 : 1 VSWR circle.

5) The resultant locus of points are then rotated with a 10 m℧ (100 Ω) transmission line to a degree which locates the admittance point of 860 MHz near the line of constant conductance equal to 2.0 on Smith Chart (II). This conductance is exactely equal to 20 m℧ since the chart is normalized to 10 m℧.

6) The final step is to use a parallel resonant circuit which will reduce the imaginary pacts at both the upper and lower frequencies.

The following approach was used to calculate the element values for the antiresonant circuit.

By observation of the smith chart it was decided to place the 460 and 860 MHz points on or just inside the 2.0 : 1 VSWR circle.

It then follows that

at f_1 = 460 MHz $$W_1C - \frac{1}{W_1L} = -0.4$$

at f_2 = 860 MHz $$W_2C - \frac{1}{W_2L} = 1{,}7$$

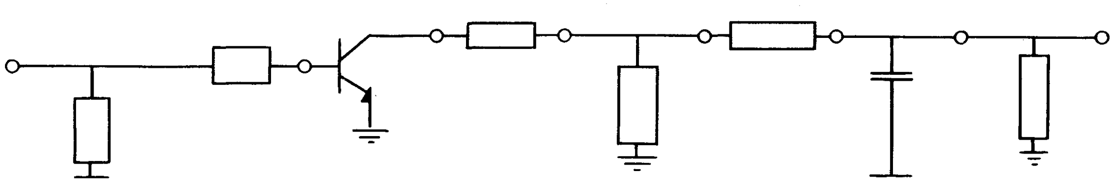
The 2 equations with 2 unknows are solved with the following result.

L = 0,189 nHy
C = 496.11 pFd

since we are normalized to 10 m℧

Lactual = 0.189/.01 nH = 18.9 nHy
Cactual = 496.11 × 0.1 pF = 4.96 pFd

7) The result is normalized to 20 m℧ with the final result shown.



Zo	10 Ω	50 Ω	TPV 596	50 Ω	100 Ω	100 Ω		100 Ω
Calc. Value	45.7 mm	3.78 mm		3 mm	76.1 mm	29,3 mm	4.9 pF	50.4 mm
Empirical Value	8.5 48.8 mm	1.5 mm	Opti-mized Value	3 mm	98.8 mm	39.62	5.5 pF	61.6 mm

Graph (III) shows the various VSWR calculated compared to the theoretical best curve and the actual VSWR measured.

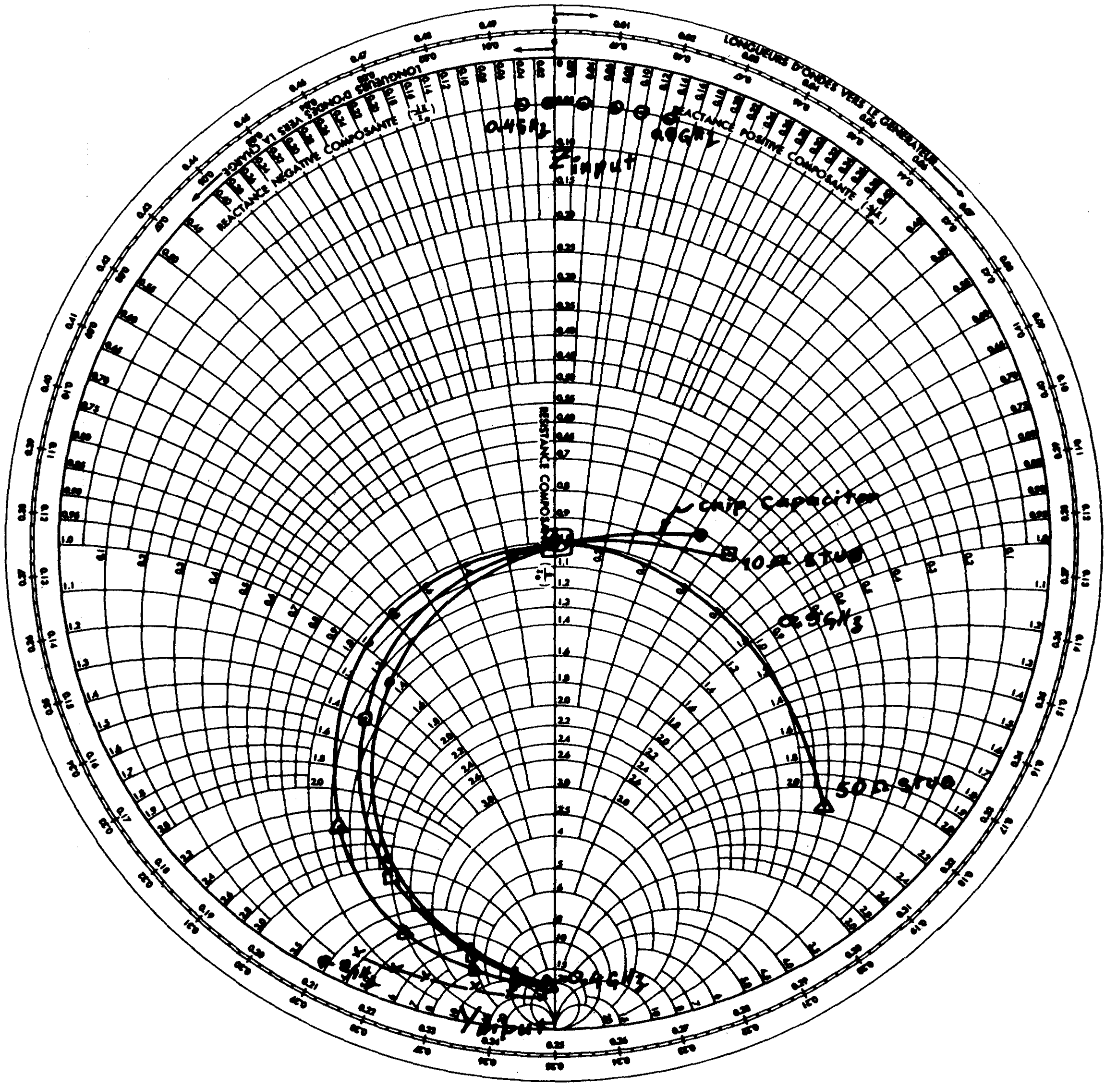
Graph (IV) shows the collector load VSWR for the calculated, optimized, and actual result.

Graph (V) is a plot of the single ended amplifier results taken with a network analyzer. No component losses were considered for the theoritical and optimized analysis. The final circuit was also optimized empirically from 470-860 MHz using a network analyzer.

The following results are a summary of performance, bias conditions circuit configuration and recommended hybrid adaptation.

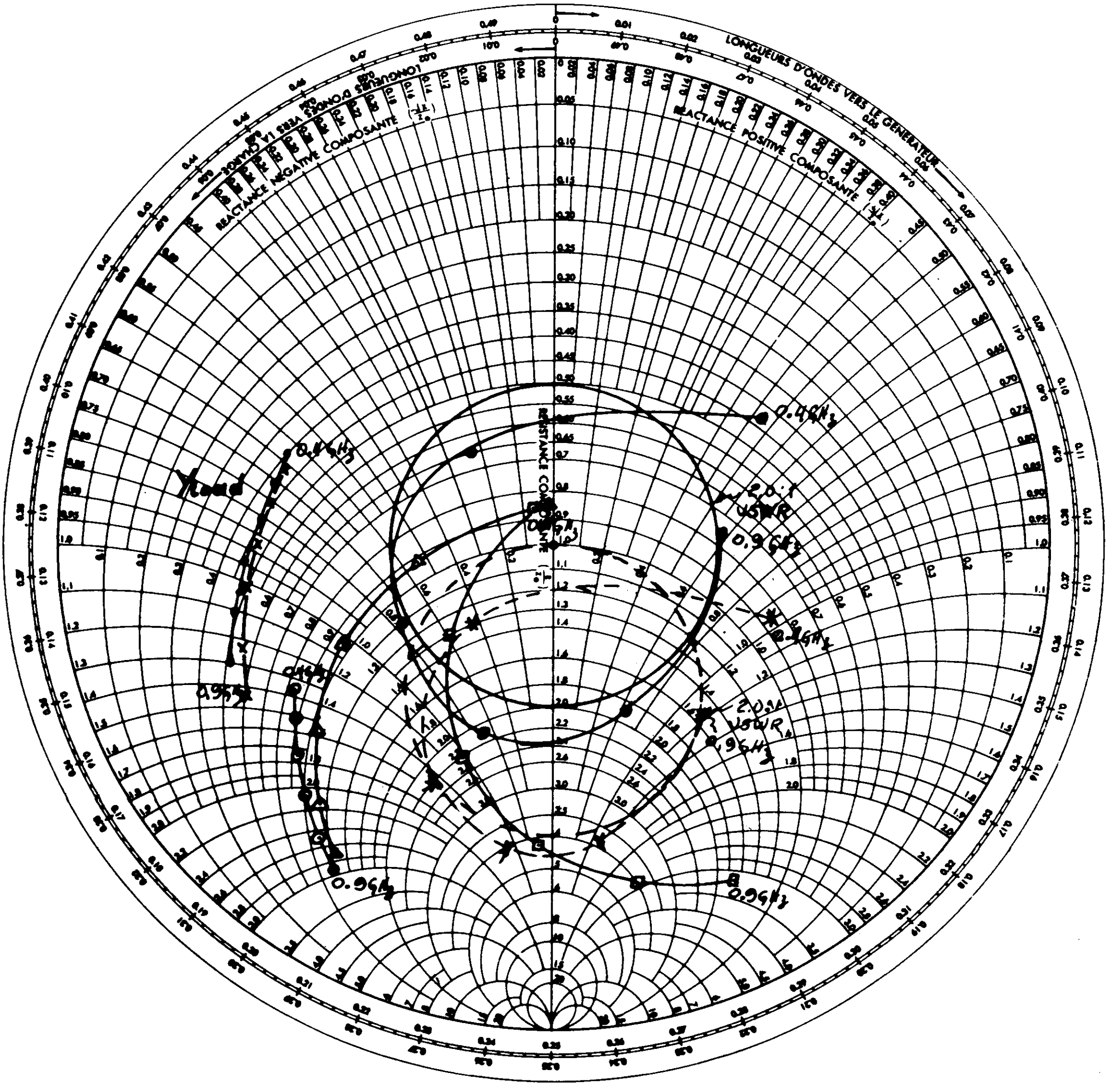
SMITH CHART (I)

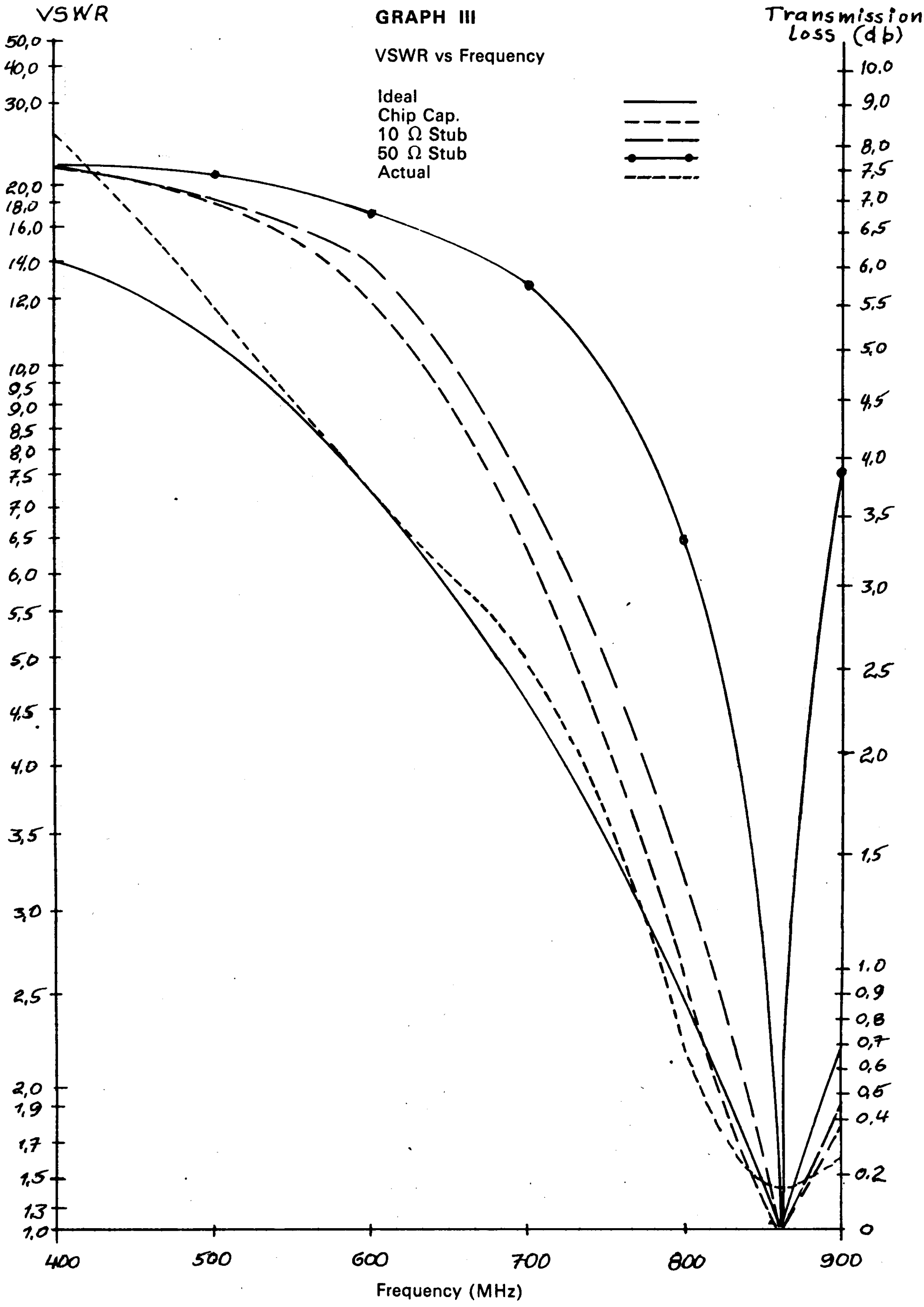
starting Imp.	⊙———⊙
rotated Adm.	×———×
final Adm. ω/Chip Cap.	●———●
final Adm. ω/10 Ω Stub	⊡———⊡
final Adm. ω/50 Ω Stub	△———△



SMITH CHART (II)

starting Adm.
50 Ω rotation
100 Ω translation
equiv. shunt Ind.
100 Ω rotation
parallel L-C
final Adm. 50 Ω translation

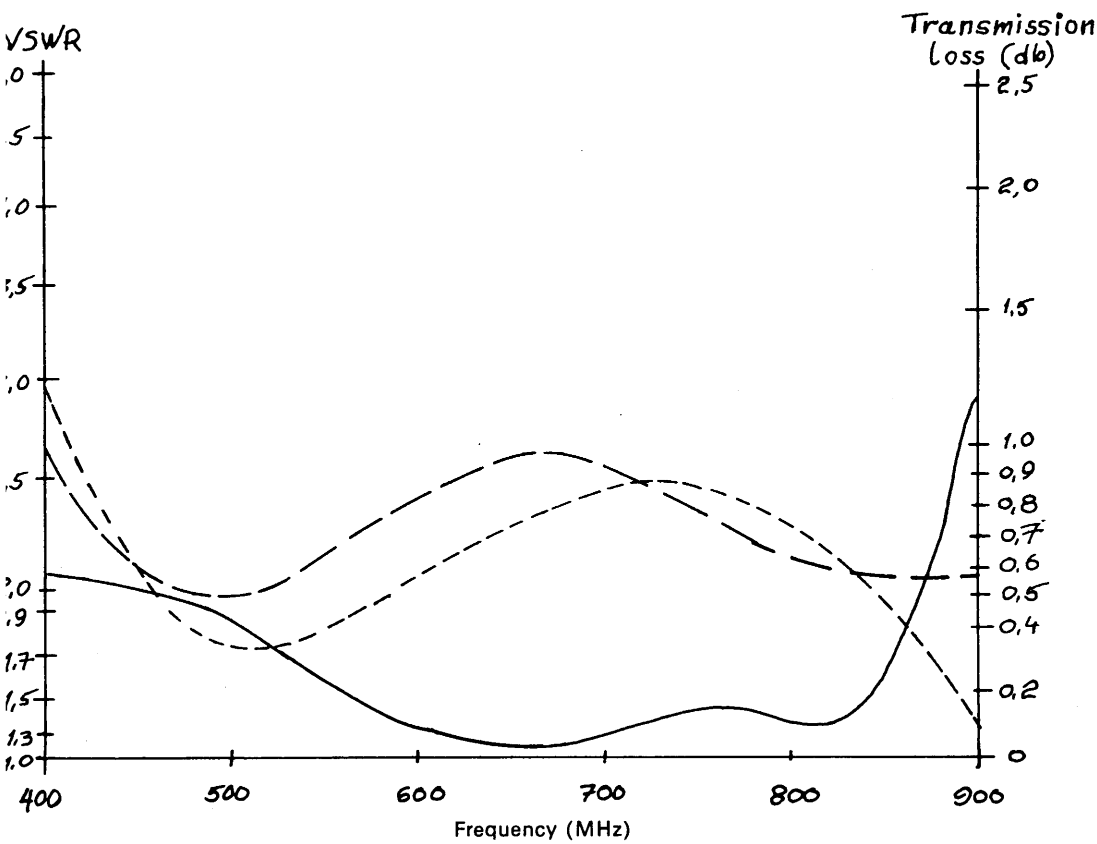



VSWR
GRAPH III
VSWR vs Frequency
Ideal
Chip Cap.
10 Ω Stub
50 Ω Stub
Actual
Transmission Loss (db)
50,0
40,0
30,0
20,0
18,0
16,0
14,0
12,0
10,0
9,5
9,0
8,5
8,0
7,5
7,0
6,5
6,0
5,5
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,9
1,7
1,5
1,3
1,0
10.0
9,0
8,0
7,5
7,0
6,5
6,0
5,5
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1.0
0,9
0,8
0,7
0,6
0,5
0,4
0.2
0
400
500
600
700
800
900
Frequency (MHz)

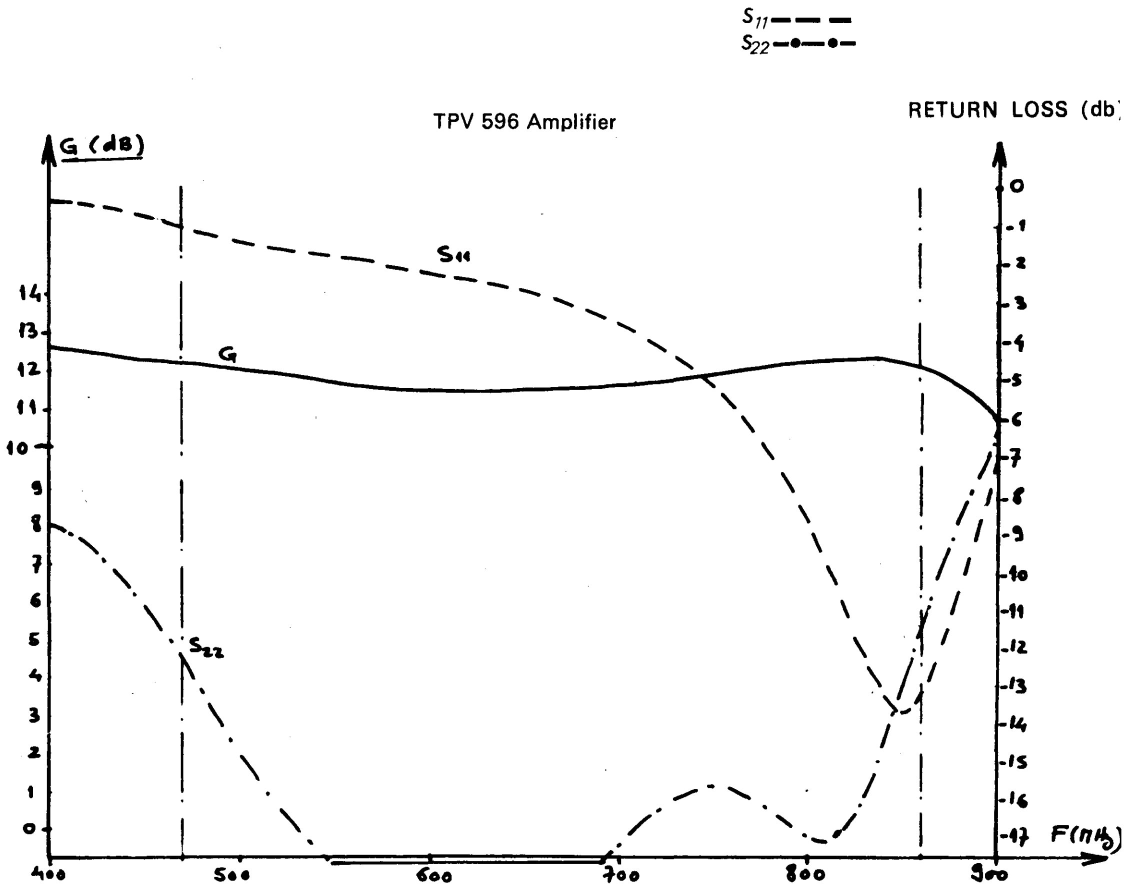
GRAPH IV

VSWR vs : Frequency

Preoptimization — — —
Postoptimization - - - - - -
Measured ———

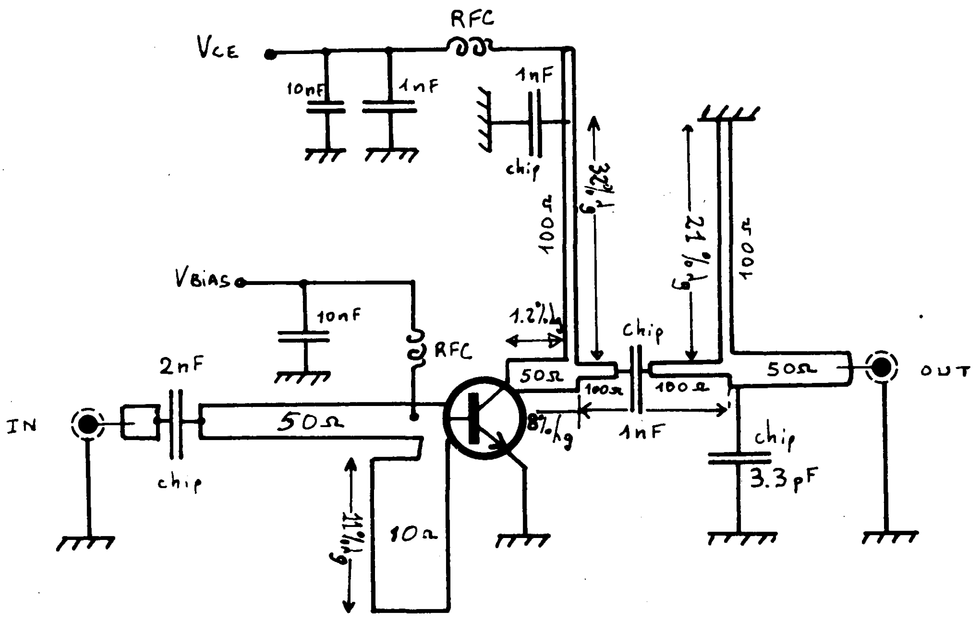


GRAPH V

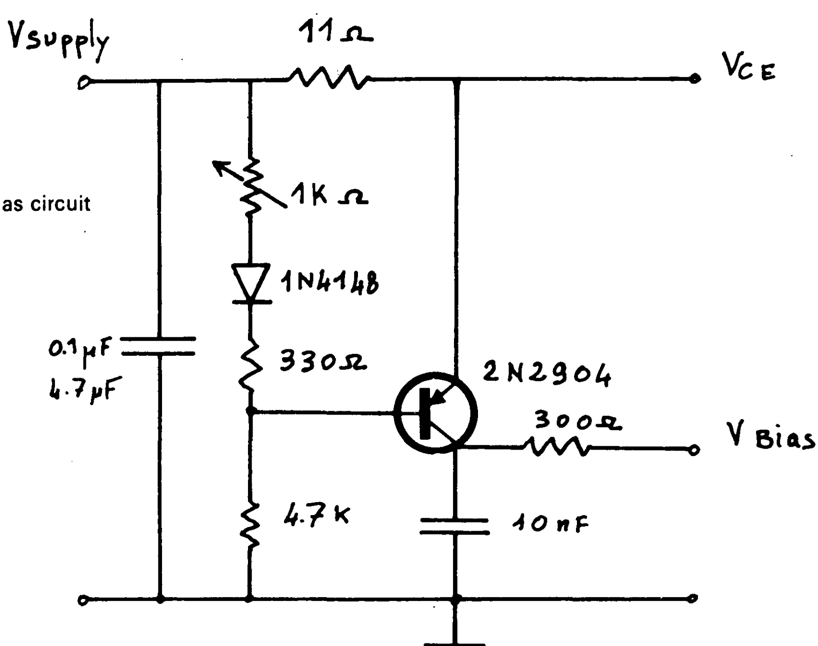


S11
S22
TPV 596 Amplifier
RETURN LOSS (db)
G (dB)
S11
G
S22
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
F(MHz)
400
500
600
700
800
900

470-860 MHz class A with TPV 596



V_{CE} = 20 V - I_C = 220 mA
F_0 = 860 MHz - WAVELENGTH (λg) at 860 MHz
(material : Glass teflon εr = 2.55 - 1/16″ used by TRW)



Class A bias circuit

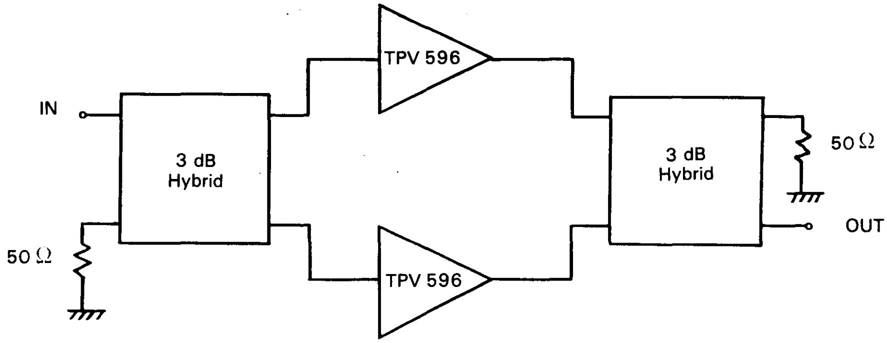
TPV 596 BROADBAND AMPLIFIER

FREQUENCY RANGE	: 470 MHz-860 MHz
POWER OUTPUT AT	: — 60 dB IMD* ⩾ 0.5 W
POWER GAIN	: 11.5 ⩽ G ⩽ 12.7 dB
INPUT RETURN LOSS*	: < — 1 dB
OUTPUT RETURN LOSS	: < — 11 dB
VOLTAGE SUPPLY	: ~ 23 V (V_{CE} = 20 V)
TOTAL CURRENT	: 220 mA

*IMD : Vision : — 8 dB ; Sound carried : — 7 dB ; Side band : — 16 dB

RECOMMENDED CONFIGURATION

*INPUT RETURN LOSS : This amplifier must be used by two connected together with two 3 dB quadrature hybrids to have a balance amplifier with a good input VSWR.



*3 dB - 90° Hybrid coupler from
- — AMAREN 10 264-3
- — SAGE wireline 3 dB Hybrid 4450 900

IMD VS OUTPUT FOR A SINGLE STAGE
VCE = 20 V-220 mA

F = 860 MHz ; Vision = — 8 dB ; Sound Carrier = — 7 dB ; Sideband = — 16 dB

Pout (W)	0.25 W	0.5 W	1 W
IMD (dB)	— 67 dB	— 61 dB	— 55 dB

F = 860 MHz ; IMD DIN 45004/B
RL = 75 ohms

1.5 V/75 ohms	IMD = — 66 dB
2 V/75 ohms	IMD = — 60 dB

APPLICATION NOTE TRW

1 W/2 W BROADBAND TV AMPLIFIER BAND IV and V

This note describes the performance of a broadband (470-860 MHz) ultra linear amplifier designed for service in band IV and V TV transposers.

Device used : TPV 597

Basic specifications

IMD (1) = — 60 dB at $P_0 = 1$ W
V_{ce} = 20 V ; $I_e = 440$ mA
P_{gain} = 11.5 dB.

(1) Vision carrier — 8 dB, sound carrier — 7 dB, sideband signal — 16 dB.

General design considerations

In general to obtain a flat gain for broadband amplifiers which use transistors with about — 6 dB power gain variation per octave we can use two techniques :

- feedback technique (eg emitter resistor and a negative feedback with a selective circuit between the collector and the base),
- or reflect the input or the output power selectivly to have an insertion loss of 6 dB per octave with 0 dB for the highest frequency.
  (There is also another technique which uses a selective attenuator).

With the feedback technique we can have a good input and output match. With the second technique we need to reflect the input power and have a good output match in order to obtain a good IMD. It means the input VSWR is very high for the low frequencies.

The second solution is simpler than the first and if we use two amplifiers connected together with 3 dB quadrature hybrids to have a balanced amplifier this inconvenience disappears. We have chosen for this amplifier this second solution. For the larger broadband amplifier (eg 170-860 MHz) this solution must be rejected and the only acceptable solution is to use the feedback technique.

Amplifier design

The first approach for the circuit calculation was made by using the Smith Chart from the input and output impedances given in the TPV 597 data sheet to have, at the input, a reflected power so that the gain will be flat and at the output to obtain the best match possible.

INPUT VSWR VERSUS FREQUENCY TO OBTAIN A FLAT GAIN :

The power gain can be approximated by :

$$G \simeq \left(\frac{F_{max}}{F}\right)^2$$

F_{max} is the frequency for which power gain drops to unity.

Z

The transmission loss due to the input reflection is :

$$\alpha = 1 - |\rho|^2$$

ρ is the reflection coefficient.

To have Gα constant we must have :

$$G\alpha \simeq \left(\frac{F_{max}}{F}\right)^2 [1 - |\rho|^2] = G_H = \left(\frac{F_{max}}{F_H}\right)^2$$

G_H is the gain at the highest frequency used (F_H)

or

$$|\rho| \simeq \left[1 - \left(\frac{F}{F_H}\right)^2\right]^{1/2}$$

$$VSWR = \frac{1 + |\rho|}{1 - |\rho|} \simeq \frac{1 + \left[1 - \left(\frac{F}{F_H}\right)^2\right]^{1/2}}{1 - \left[1 - \left(\frac{F}{F_H}\right)^2\right]^{1/2}}$$

Figure 1 shows the theoritical VSWR versus frequency with an insertion loss of 0 dB (implies $\rho = 0$) for 860 MHz. We have defined the input circuit from the TPV 597 input impedance to have an input VSWR as close as possible to this curve, and have assumed that output circuit losses versus frequency is negligeable.

After we have calculated separatly the input and the output circuits, we optimized some of the parameters by means of the global amplifier and the TPV 597 S-parameters, with the COMPACT Program.

— RF equivalent circuit : Figure 2
— Program : Figure 3
— Calculated gain and empirical gain : Figure 4
— Calculated and empirical input VSWR : Figure 5
— Calculated and empirical output VSWR : Figure 6

Amplifier Performance

— IMD versus output power : Figure 7
— IMD versus frequency : Figure 7′
— Input return loss and VSWR : Figure 5
— Output return loss and VSWR : Figure 6
— Gain versus frequency : Figure 4
— Bias conditions : V_{ce} = 20 V ; I_e = 440 mA

Technology and layout considerations

— The glass Teflon 1/16 inch (ε_r = 2.55) is used as board material. This substrat is soldered to the heat sink to have a good contact and repeatable results.

Figure 8 shows the circuit diagram and the bias circuit ; figure 9 shows the PC board layout.

Combined - Transistor Stage

In many instance the power output requirements of transposers exceed the capability of a single transistor, which forces the designer to use combinations of transistors. They can be combined by pair with quadrature combiners (See figure 10). Since quadrature combiners have the ability to channel the reflected power from the amplifier into the fourth port of the combiner it means the input and output VSWR become very low (VSWR < 1.2). The power gain is reduced due to the couplers insertion loss by 0.6 dB. Coupler imbalance should also be taken into account as causing some IMD degration.

INPUT VSWR

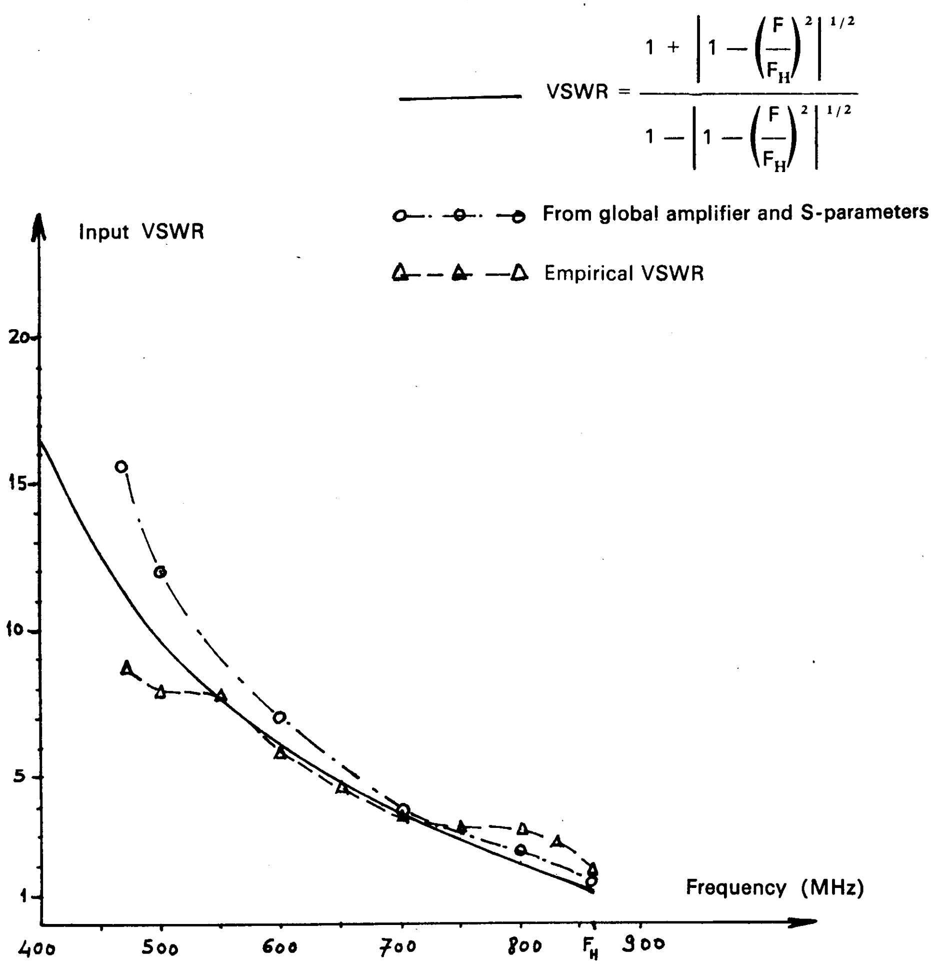
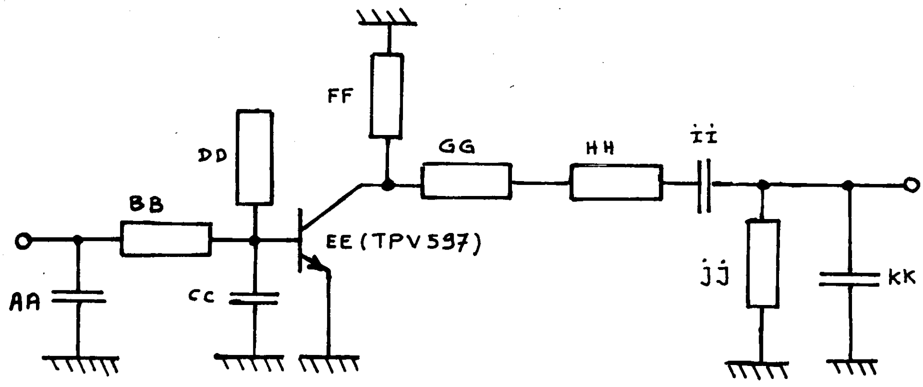


Figure 1

RF EQUIVALENT CIRCUIT
FOR COMPACT PROGRAM



	AA	BB		CC	DD		FF	
	pF	Z_0 (Ω)	L (mm)	pF	Z_0 (Ω)	L (mm)	Z_0 (Ω)	L (mm)
Calc. value	4.5	50	32.0	29.3	25	14	50	72.2
Empirical value	4.7	50	45.4	10.0	25	14	50	34.9

	GG		HH		II	JJ		KK
	Z_0 (Ω)	L (mm)	Z_0 (Ω)	L (mm)	pF	Z_0 (Ω)	L (mm)	pF
Calc. value	110	28.4	45	14	5.1	75	50	3.5
Empirical value	110	27.9	45	14	3.9	75	38.4	3.3

L are given for $\varepsilon_r = 1$.

Figure 2

COMPACT PROGRAM

```
MET  AA  ZZ
CAP  AA  PA   —4.61
TRL  BB  SE   50  —41.64  1
CAP  CC  PA   —25.39
ØST  DD  PA   25  14  1
TWØ  EE  S1   50
SST  FF  PA   50  —63.43  1
TRL  GG  SE   110  28.44  1
TRL  HH  SE   45  14  1
CAP  II  SE   —5.134
SST  JJ  PA   75  49.98  1
CAP  KK  PA   —4.129
CAX  AA  KK
PRI  AA  SI   50
END
```

CIRCUIT DEFINITION

```
470  500  600  700
800  860
END
```

FREQUENCY (MHz)

```
.92  176  2.38  72  .033  31  .55  —166
.91  175  2.21  71  .034  33  .54  —167
.93  171  1.80  63  .037  34  .56  —170
.93  170  1.57  59  .039  36  .59  —168
.92  169  1.40  54  .043  38  .58  —165
.91  167  1.30  52  .045  40  .58  —166
END
```

POLAR S PARAMETERS FOR TWØ EE (TPV 597)

```
.5
0  100  1  12
100  100  2  12
END
```

OPTIMIZATION DATA

```
VARIABLES (—)            GRADIENTS

  (1) : 4.51899          (1) : — .894864
  (2) : 32.0136          (2) :   .704452E-01
  (3) : 29.2938          (3) :   2.69282
  (4) : 72.2399          (4) :   .287748
  (5) : 5.16145          (5) :   1.68585
  (6) : 3.53445          (6) : — .267730
 ERR. F. =   7.809

HOW MANY ITERATIONS BEFORE NEXT STOP? , O ' RESULTS IN FINAL ANALYSIS.
WANT INTERMEDIATE PRINTS (YES = 1' NO = 0)? TYPE TWO NUMBERS : (I, J) : 0
SEARCH INTERRUPTED, FINAL ANALYSIS FOLLOWS :
```

POLAR S-PARAMETERS IN 50.0 OHM SYSTEM

FREQ.	S11 (MAGN < ANGL)	S21 (MAGN < ANGL)	S12 (MAGN < ANGL)	S22 (MAGN < ANGL)	S21 DB	K FACT.
470.00	0.88 < 134	3.53 < 86.3	0.049 < 45.3	0.11 < 105	10.97	0.75
500.00	0.85 < 128	3.46 < 68.4	0.053 < 30.4	0.12 < 109	10.79	0.90
600.00	0.75 < 92	4.19 < 12.2	0.086 < — 16.8	0.05 < 5	12.45	0.78
700.00	0.59 < 55	4.48 < — 39.2	0.111 < — 62.2	0.19 < — 127	13.02	0.78
800.00	0.43 < 11	4.34 < — 93.2	0.133 < — 109.2	0.26 < 180	12.75	0.86
860.00	0.20 < — 44	4.08 < — 135.2	0.141 < — 147.2	0.26 < 114	12.22	1.01

Figure 3

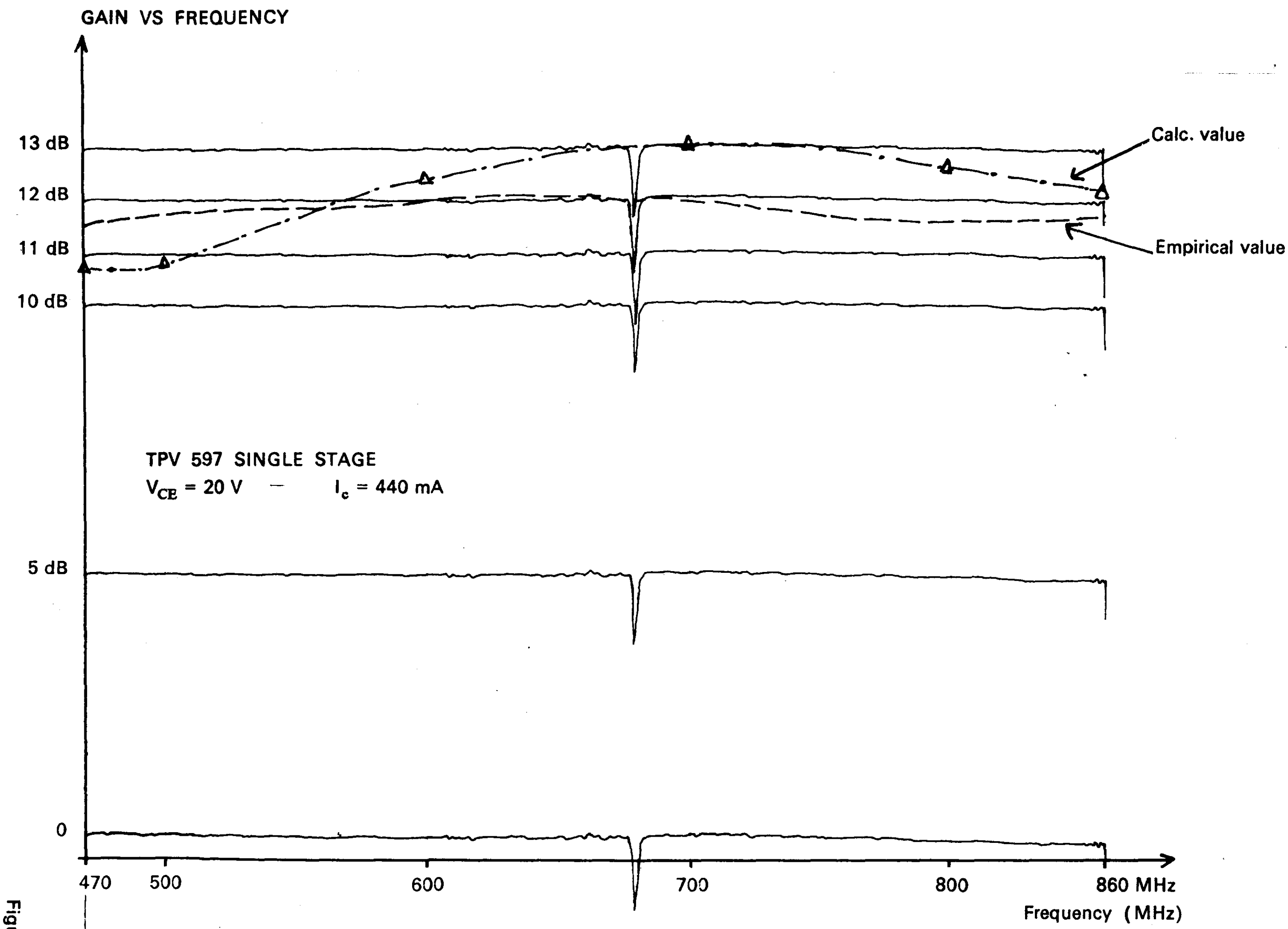
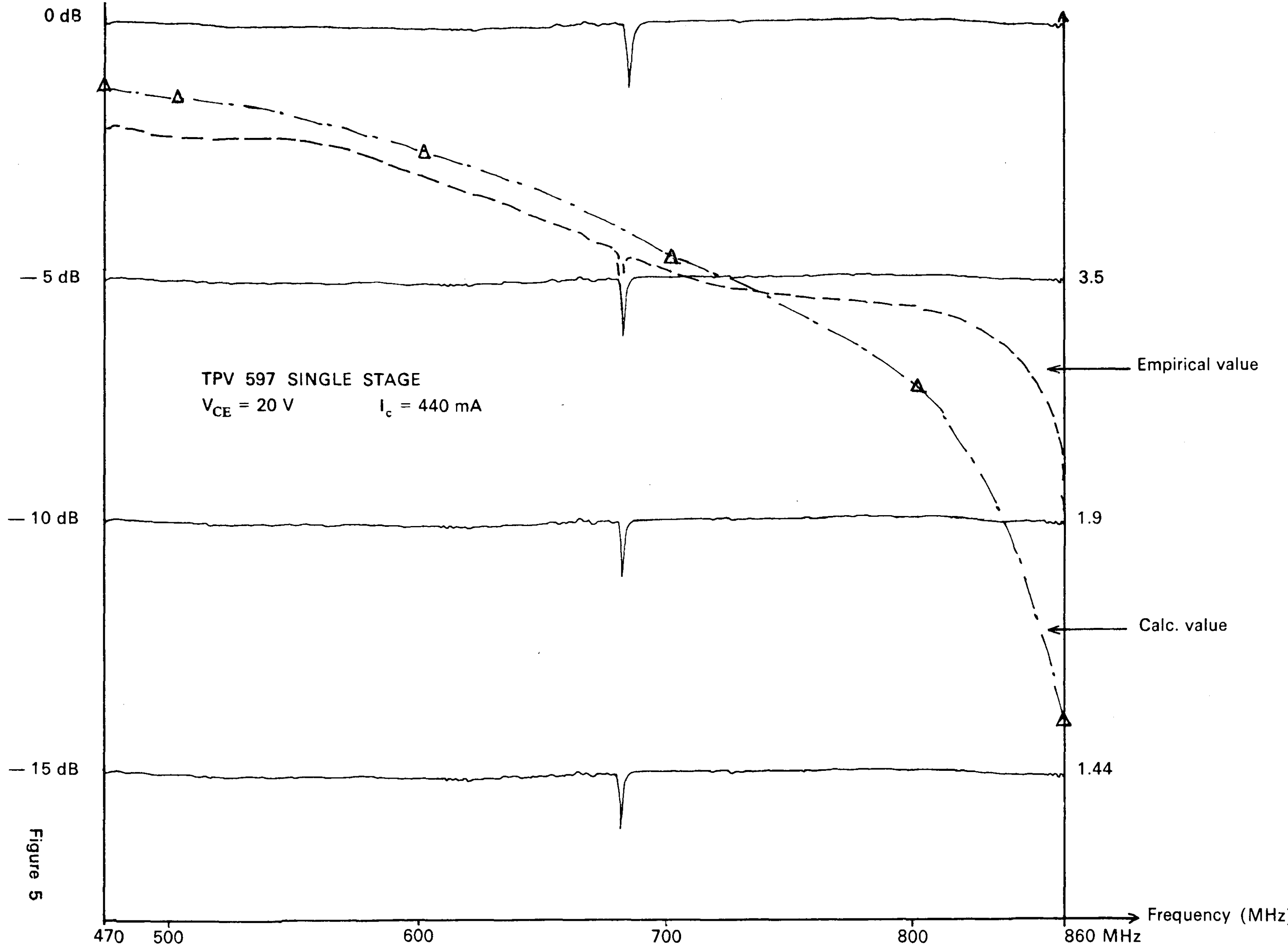

GAIN VS FREQUENCY
13 dB
12 dB
11 dB
10 dB
5 dB
0
Calc. value
Empirical value
TPV 597 SINGLE STAGE
V_CE = 20 V — I_c = 440 mA
470
500
600
700
800
860 MHz
Frequency (MHz)

Figure 4



0 dB
— 5 dB
— 10 dB
— 15 dB
3.5
1.9
1.44
Empirical value
Calc. value
TPV 597 SINGLE STAGE
V_{CE} = 20 V
I_c = 440 mA
470
500
600
700
800
860 MHz
Frequency (MHz)

Figure 5

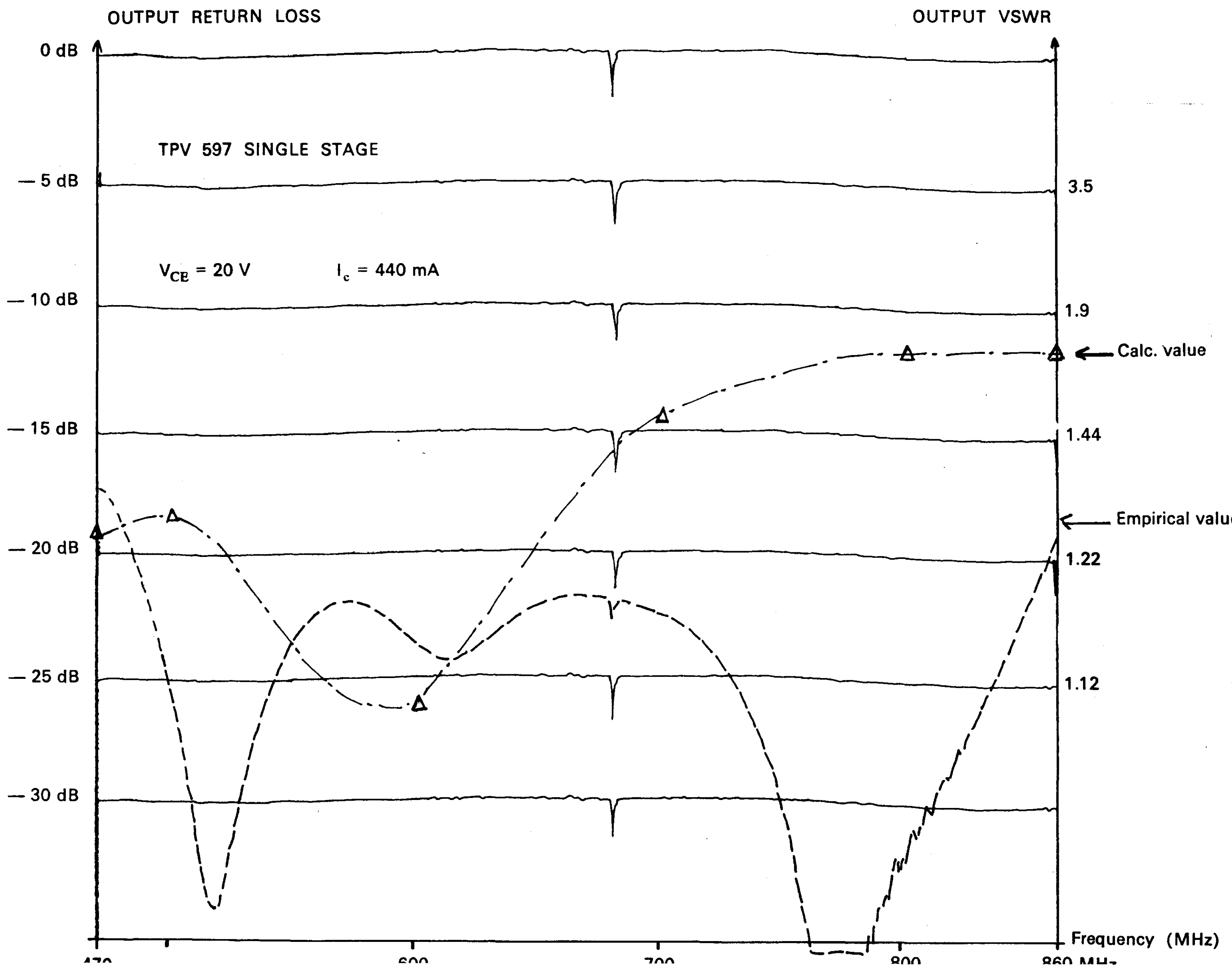

OUTPUT RETURN LOSS
OUTPUT VSWR
0 dB
TPV 597 SINGLE STAGE
− 5 dB
3.5
V_{CE} = 20 V
I_c = 440 mA
− 10 dB
1.9
Calc. value
− 15 dB
1.44
Empirical value
− 20 dB
1.22
− 25 dB
1.12
− 30 dB
Frequency (MHz)

Figure 6

IMD VS PEAK SYNCH OUTPUT

TPV 597 Single Stage

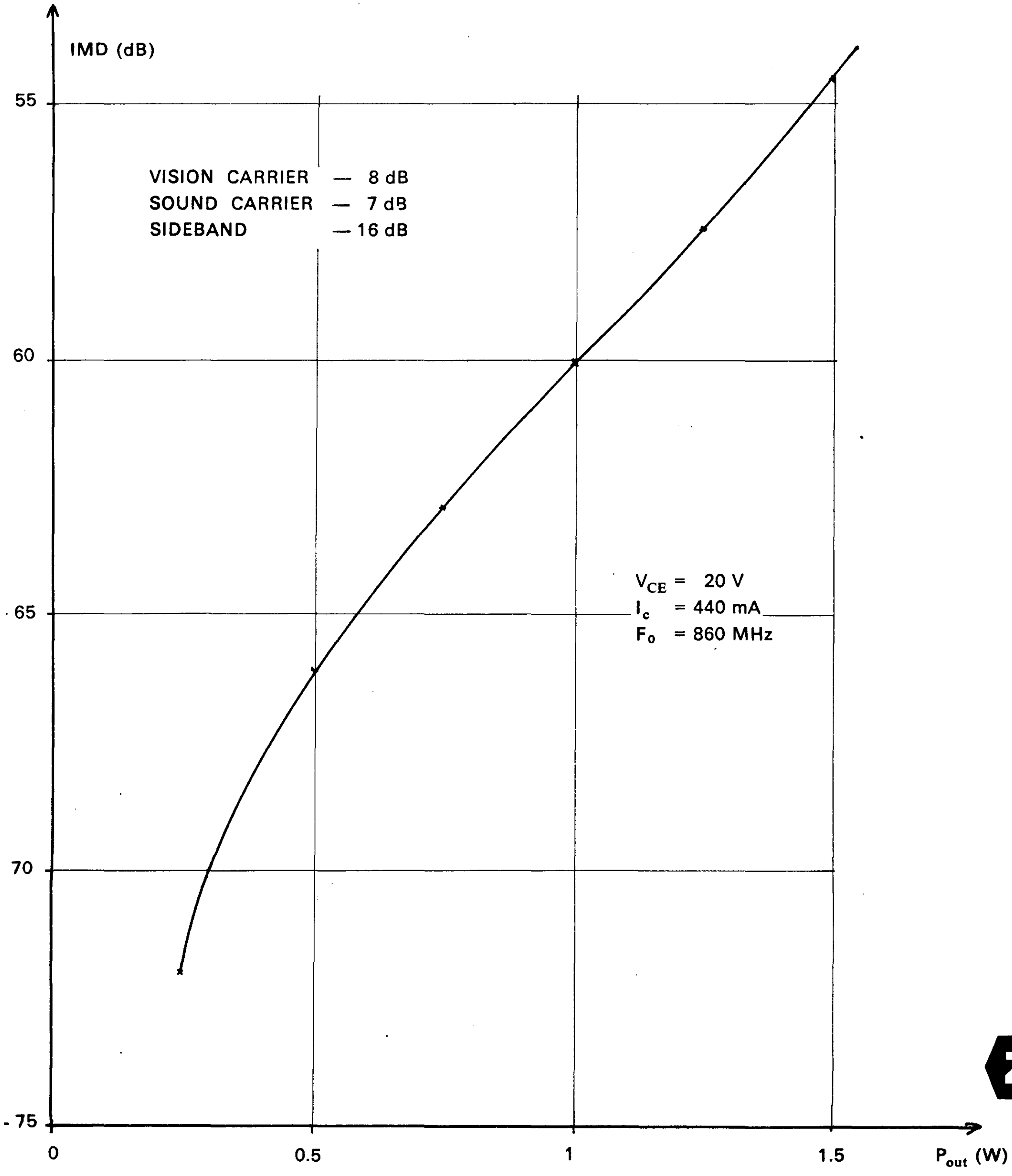


Figure 7

Z 69

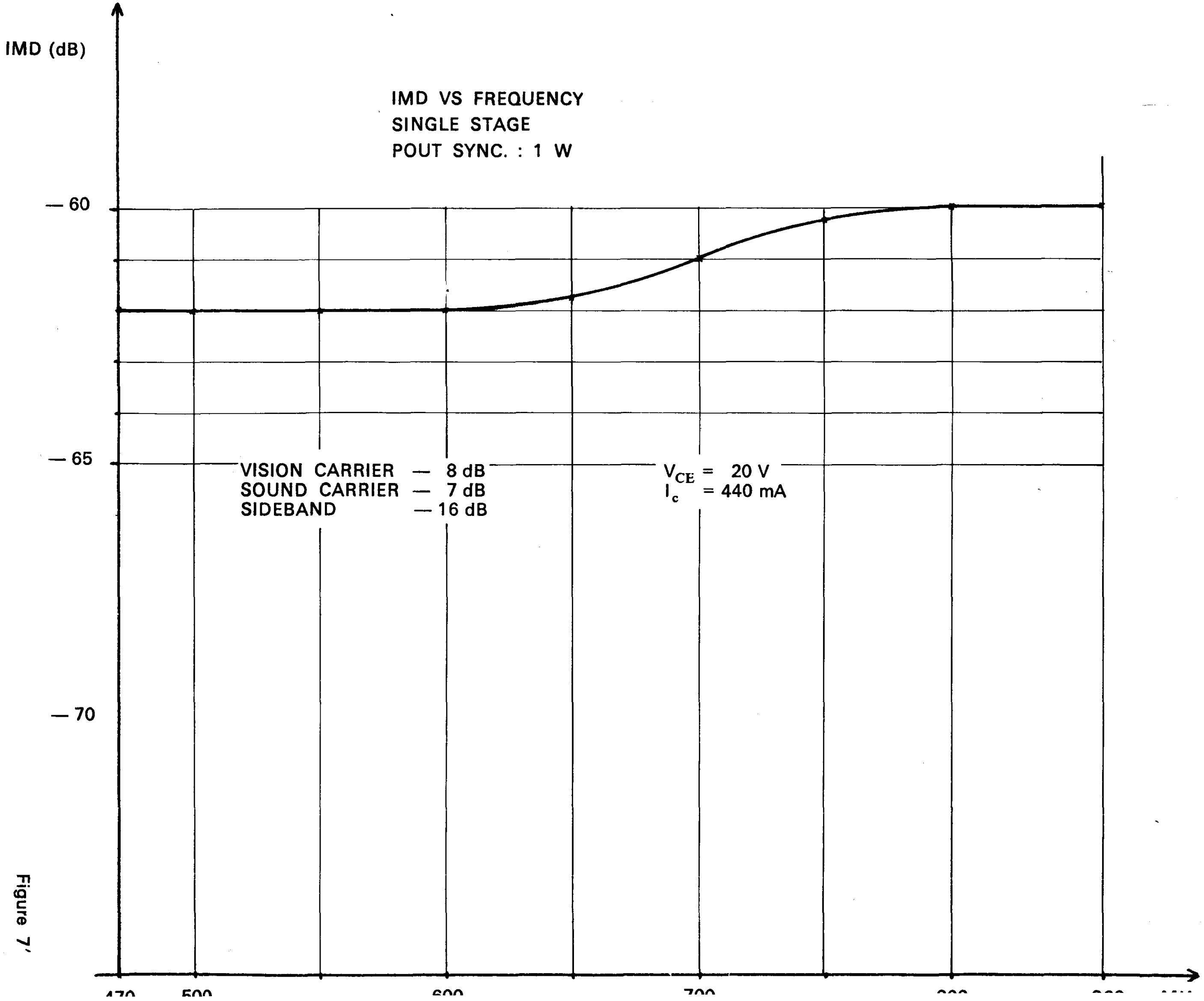
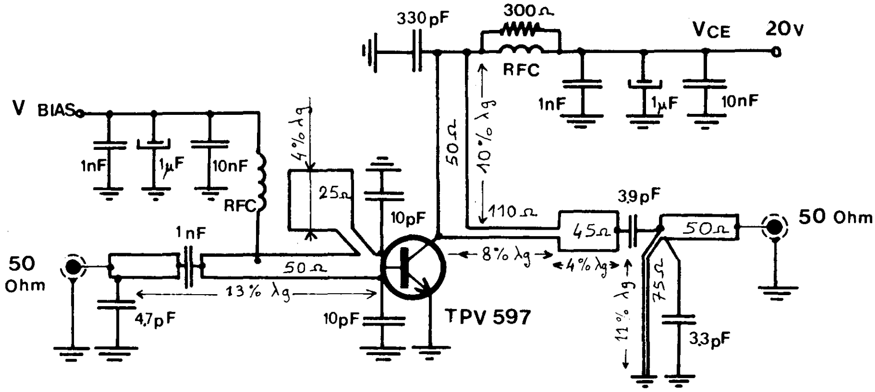

IMD (dB)
IMD VS FREQUENCY
SINGLE STAGE
POUT SYNC. : 1 W
— 60
— 65
— 70
VISION CARRIER — 8 dB
SOUND CARRIER — 7 dB
SIDEBAND — 16 dB
V_{CE} = 20 V
I_c = 440 mA

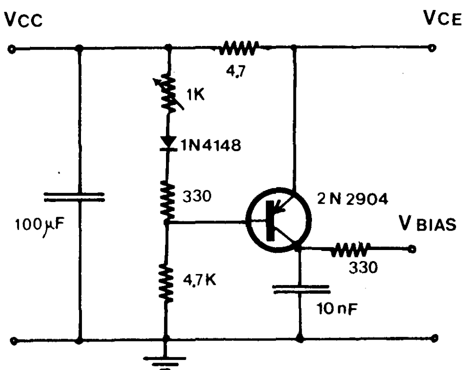
Figure 7

DIAGRAM CIRCUIT



Lengths are given at F_0 = 860 MHz $\left(\lambda g = \dfrac{3.10^8}{F_0 \sqrt{\varepsilon_{eff}}}\right)$

Glass teflon E_r = 2.55 1/16" used by TRW.



CLASS A BIAS CIRCUIT

Figure 8

PC BOARD LAYOUT

Board material : Glass Teflon ; 1/16 inch ; ε_r = 2.55

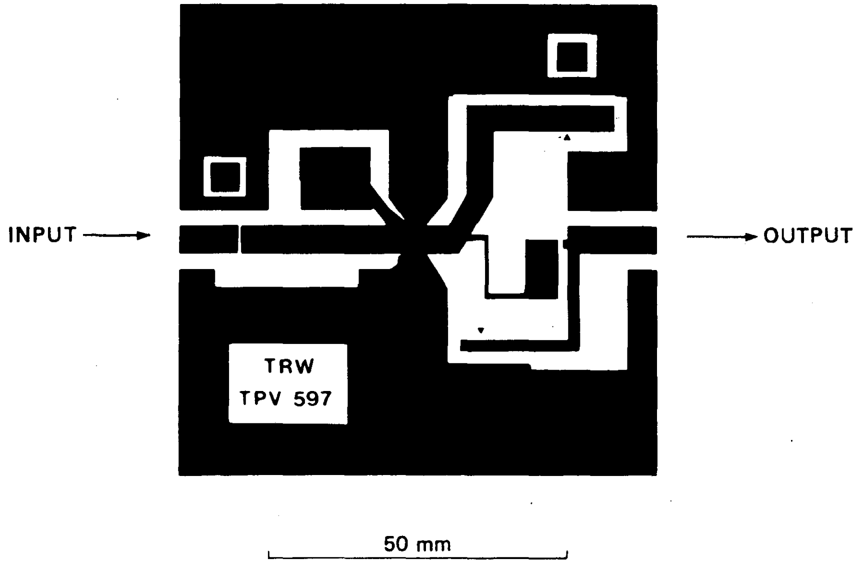
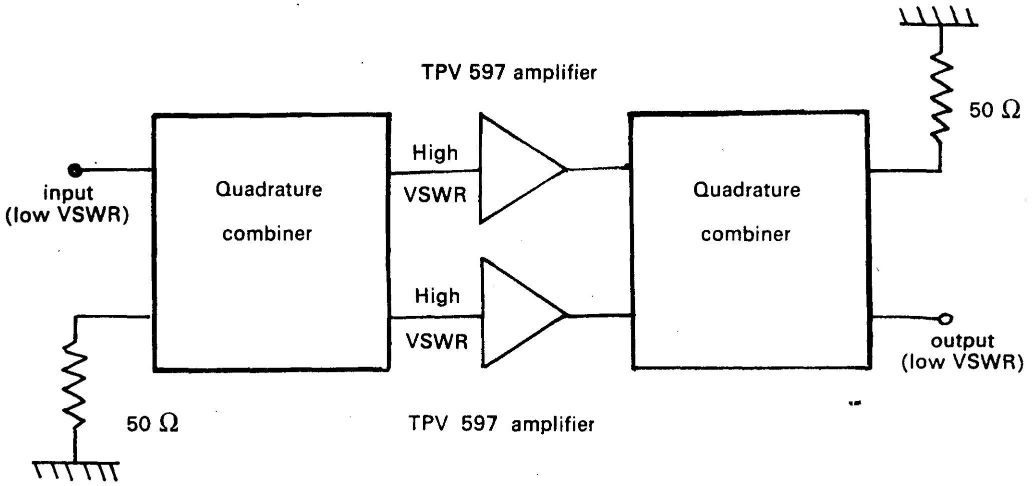


Figure 9

TWO BROADBAND AMPLIFIERS COMBINED WITH QUADRATURE COMBINERS



The 3 dB quadrature combiners can be supplied by :

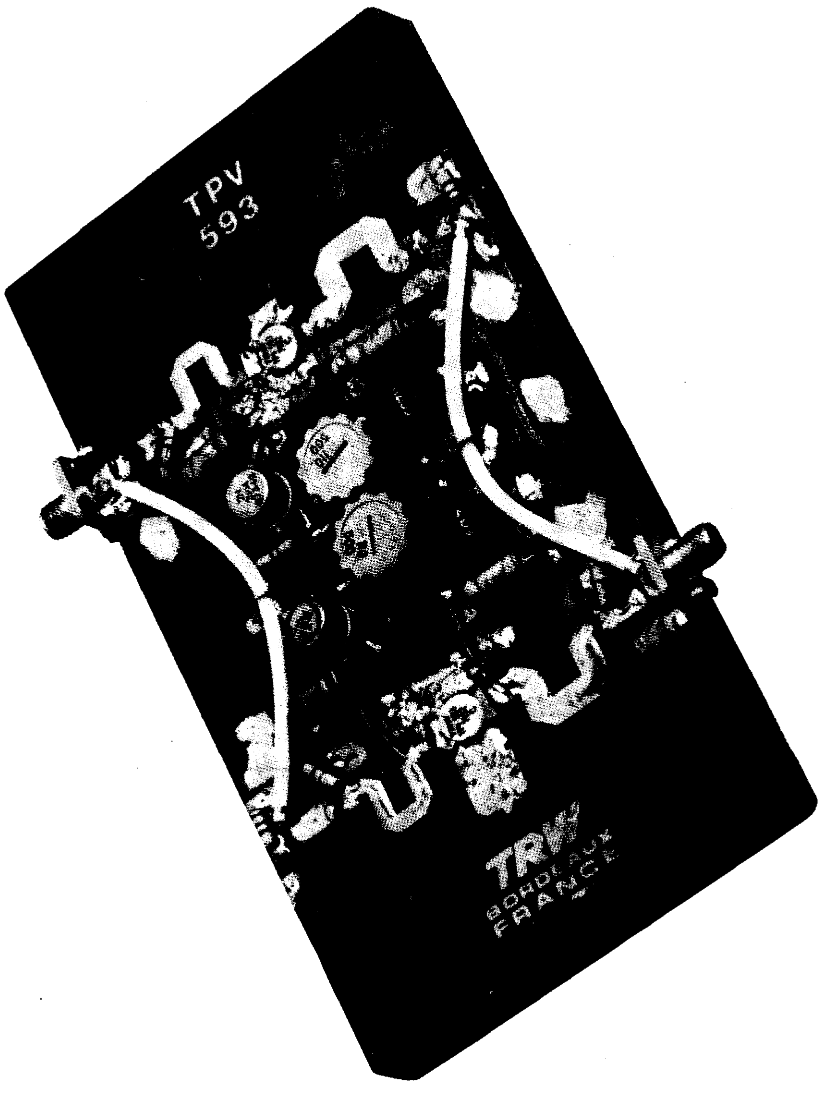
— ANAREN (10 264-3)
— SAGE wireline (4450900)

Figure 10

APPLICATION NOTE

TRW

470-860 MHz
BROADBAND AMPLIFIER
5 W



5 W UHF TV TRANSPOSER AMPLIFIER
WITH TWO TPV 593 TRANSISTORS

Z

INTRODUCTION

This application note describes an ultralinear broadband (470-860 MHz) amplifier, developed for TV transposer applications. The amplifier incorporates two TPV 593 transistors.

Each transistor is used to build a separate broadband amplifier. The two identical amplifiers are later combined with 3 dB hybrids.

The TPV 593 transistor has been developed for TV class A application. It incorporates gold metallization and diffused ballast resistors for ruggedness and linearity. Its DC current consumption is very low and makes it a good candidate for solar cell powered systems. Its basic specifications are :

V_{CC} = 25 V I_C = 450 mA

G = 9 dB at 860 MHz

IMD = — 60 dB at 860 MHz and 2 W output

The S parameters of the TPV 593 are given in the table below.

POLAR S-PARAMETERS IN 50.0 OHM SYSTEM

FREQ.	S11 (MAGN	ANGL)	S21 (MAGN	ANGL)	S12 (MAGN	ANGL)	S22 (MAGN	ANGL)	S21 dB	K FACT.
470.00	0.93	170	1.50	63.0	0.040	50.0	0.55	— 166	3.52	1.01
650.00	0.93	165	1.06	50.0	0.050	54.0	0.60	— 169	0.51	1.04
860.00	0.92	162	0.79	38.0	0.056	54.0	0.65	— 169	— 2.00	1.15

POLAR COORDINATES OF SIMULTANEOUS CONJUGATE MATCH

F MHz	SOURCE REFL. COEFF. MAGN.	ANGLE	LOAD REFL. COEFF. MAGN.	ANGLE	Gmax dB
470.0	0.99	— 173	0.91	124	15.23
650.0	0.97	— 168	0.83	134	12.01
860.0	0.95	— 165	0.79	146	9.16

DESIGN CONSIDERATIONS

Two identical single transistor class A amplifiers will be combined with 3 dB couplers. First the design of a single amplifier will be considered.

From the analysis of the variation of the TPV 593 S21 parameter with the frequency it may be seen that there is a difference of 5.52 dB between 470 and 860 MHz. If a flat gain is required this gain slope has to be compensated. The compensation can be implemented in two ways :

a) By placing a selective attenuator at the input of the transistor amplifier, with an insertion loss minimum at 860 MHz and wich increases to 5.52 dB at 470 MHz. The insertion loss increase should compensate the transistor gain slope.

b) By selective mistmatch at the input of the transistor. The input circuit will provide impedance matching at 860 MHz, in order to get a gain as close as possible to the GA max. Frequency dependent mistmatch will compensate the gain slope. At 470 MHz a VSWR as high as 11 : I will be necessary. It has been proved that impedance mistmatch at the base terminal of a transistor power amplifier do not modify the linearity behaviour of the device.

As it was decided to combine two amplifiers with 3 dB couplers the method b) was selected. 50 ohms 3 dB hybrid couplers when used with two identical loads provide a good VSWR at the common terminal even if the loads differ from 50 ohms. The reflected energy is dissipated as the 50 ohms load connected to the fourth terminal of the coupler. The coupler behaves as a selective attenuator. Figure 1 shows the amplifier arrangement. The use of a 3 dB coupler to split the input signal makes almost compulsory the use of the same type of circuit at the output.

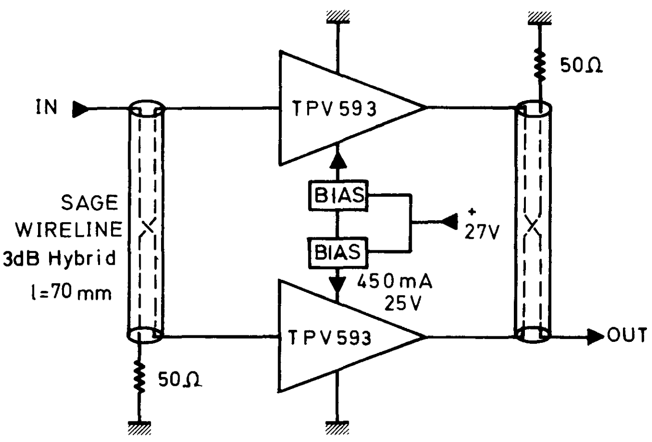


Figure 1

The amplifier must be as linear as possible over the complete UHF band. A transistor power amplifier usually requires impedance matching at the collector side for optimum intermodulation. Therefore the output circuitry has been designed for impedance matching all over the bands IV and V.

COMPONENTS PART LIST

L_1 = 65 line 11 % g at 860 MHz
L_2 = 50 line 1.5 % g at 860 MHz
L_3 = 50 line 17 % g at 860 MHz
L_4 = 7 turns ID 2 mm - Closely Wound - wire 5 mm
L_5 = 10 mm : 5 mm wire 1 mm

C_1-C_5 = Variable Airtronic AT 7275, .8-4.5 pF
C_2 = 6.8 pF ATC 100A
C_3-C_4 = 10 pF ATC 100A
C_6-C_7 = 1 nF + 10 nF + 1μ + 10 μF

Board Material: 1/16" Teflon Fiberglass

CIRCUIT DESCRIPTION

The circuit of a simple amplifier is given in Figure 2.

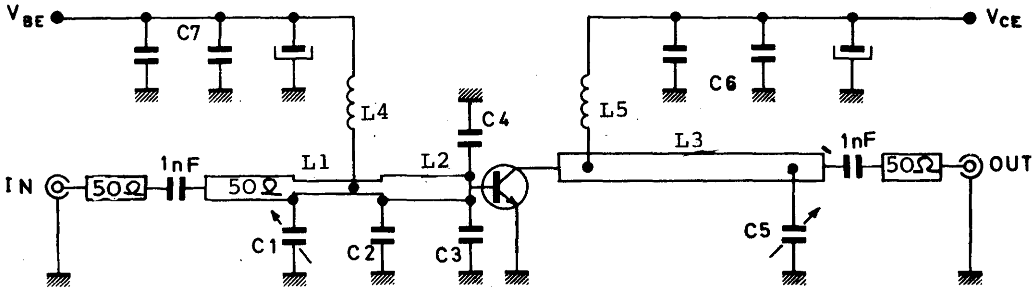


Figure 2

Class a Bias Circuit

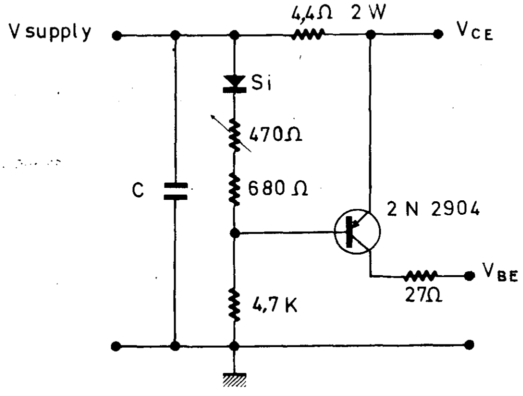


Figure 3

The input circuit consist of a three section low pass type matching network. To minimize power losses all the inpedance transformations are made at a low Q level. Variable capacitor C_1 is adjusted for optimum VSWR at 860 MHz. The tuning is straight forward and only a small retouch is necessary after the collector tuning.

The very constant S22 of the TPV 593 transistor makes extremely simple to match the collector to a 50 ohms load. L_8 tunes the output capacitance of the device and is determinant for good matching at the low end of the band. Only one low pass section is necessary. Capacitor C_5, variable, allows a good shaping of the output VSWR. Collector tuning should be done after tuning the input.

The bias control circuitry is classical and is given in figure 3.

. CONSTRUCTIONAL DETAILS

The printing circuit board lay-out of the complete amplifier is given in figure 4. Considerate attention should be paid to the ground returns. Platted through holes have been used to ensure low emitter inductance. Wrapped foils ensure proper grounding of parallel capacitors and connectors.

The couplers have been made with parallel wire cable.

This solution is as inexpensive as straigh forward.

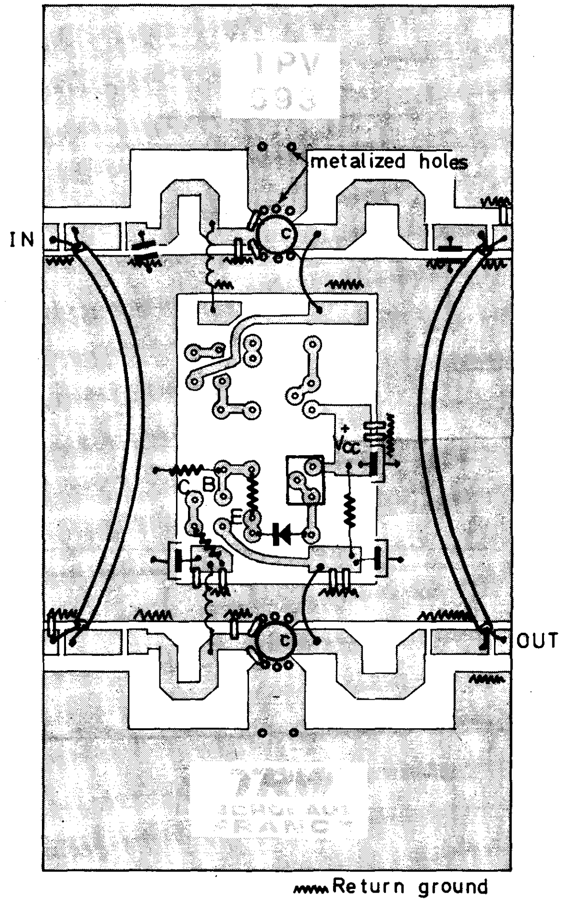


Figure 4

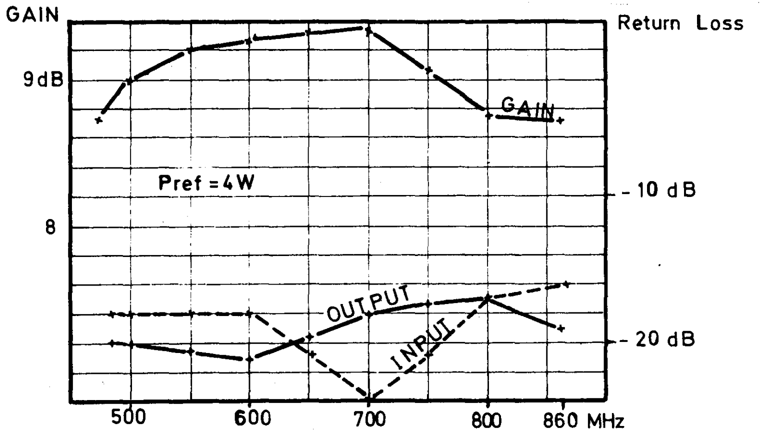


Figure 5

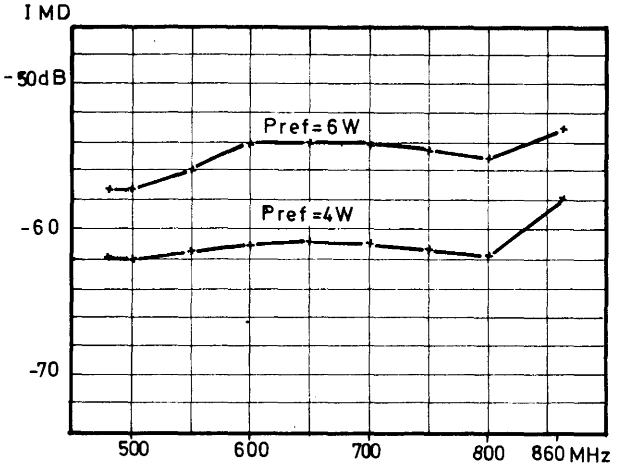
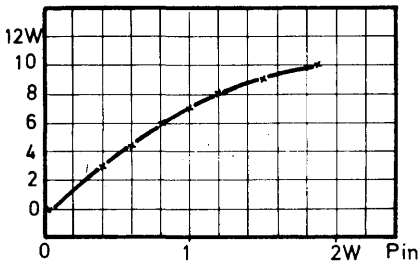
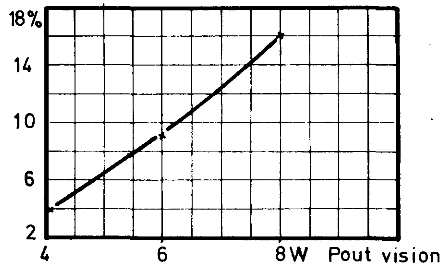


Figure 6

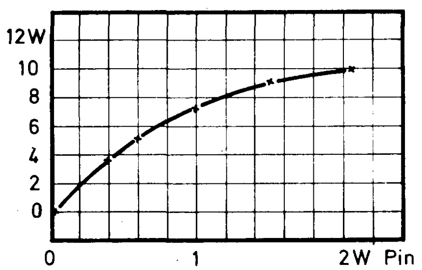
Output Power vs Input Power | **Vision to Sound Cross Modulation**

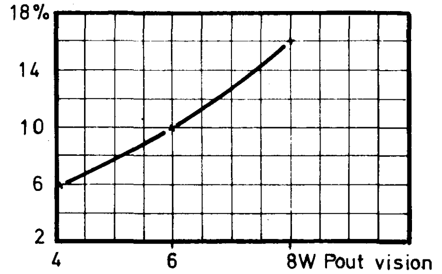
470 MHz



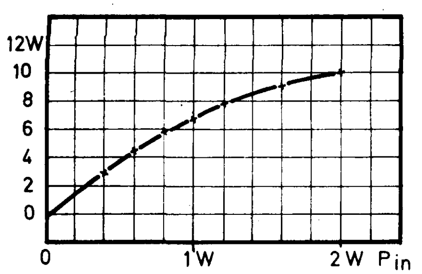


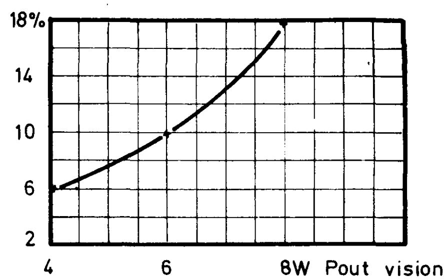
650 MHz





860 MHz





NOTA : Δ % of sound carrier (— 7 dB)
when vision carrier is switch ON/OFF

Figure 7

Z

MEASUREMENTS

The measurements results have been summarized in table. 2.

Figure 5 shows the frequency response of the amplifier as well as the input and output match. Figure 6 displays the linearity (IMD test ; — 8, — 16, — 7 dB) of the amplifier. Static transfer curves are given in the figure 7 that shows also the vision to sound cross modulation of the amplifier.

TABLE 2

TYPICAL RESULTS

BANDWIDTH	: 470 - 860 MHz
GAIN	: 8.7 dB min.
IMD* at — 4 W	: — 58 dB
— 5 W	: — 56 dB
INPUT RETURN LOSS	: — 16 dB
OUTPUT RETURN LOSS	: — 17 dB
BIAS CONDITIONS	: V_{CE} = 25 V ; I_C = 2 × 450 mA

* IMD : SOUND = REF. — 7 dB
VISION = REF. — 8 dB
SIDEBAND = REF. — 16 dB

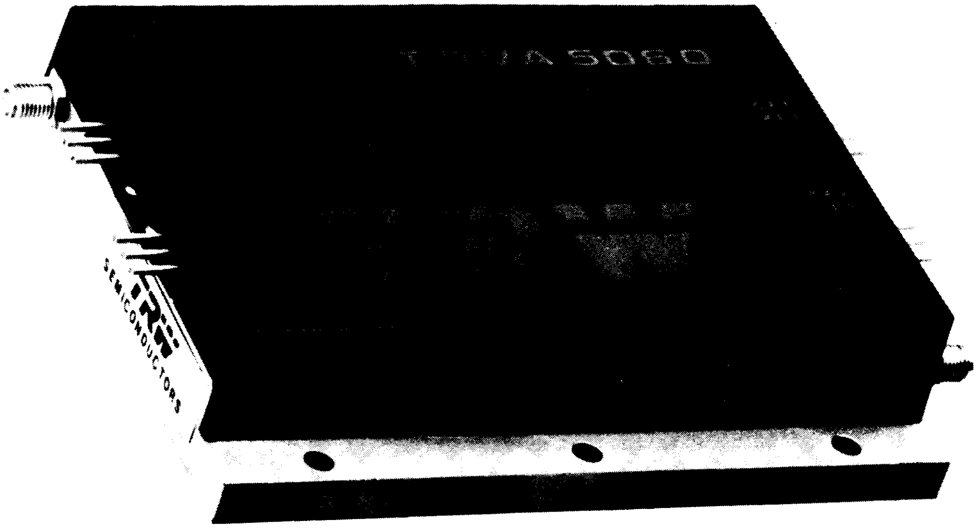
CONCLUSION

A high performance amplifier has been described as an example of the possibilities offered to the designer by the TPV 593. In particular the amplifier combines excellent frequency response and linearity with high efficient use of the DC power. This circuit may be of interest for output stages of low power TV transposers or drivers of higher power units.

APPLICATION NOTE

TRW

LINEAR RF POWER MODULE FOR 50 WATTS UHF TV AMPLIFIER



The TPVA 5060 is a high performance power amplifier which should prove invaluable in the design of TV transposers and transmitters.

The basic characteristics of this unit are :

- 65 watts output at the 1 dB gain compression point from 470 to 860 MHz.
- Small signal gain of 17 dB minimum.
- IMD products ≤ – 51 dB at 50 W (– 8 : – 10 : – 16)
- Cross modulation : 20 % typical at 50 W
- Small size.

Giving precise details for DC supply and cooling, this application note sets out to simplify the installation of the module and to ensure its optimal performance.

I. — PRESENTATION

With the aid of 3 dB couplers, the TPVA 5060 combines two separate amplifiers. As well as doubling the output power, this concept has the advantage of ensuring a reduced output in the unlikely event of failure of one of the channels.

Fig. 1 : shows the circuit of one amplifier channel. It can be seen that each amplifier stage is itself a class A amplifier in push-pull configuration.
It is with this well known concept that broadband operation and high degree of linearity may be achieved.

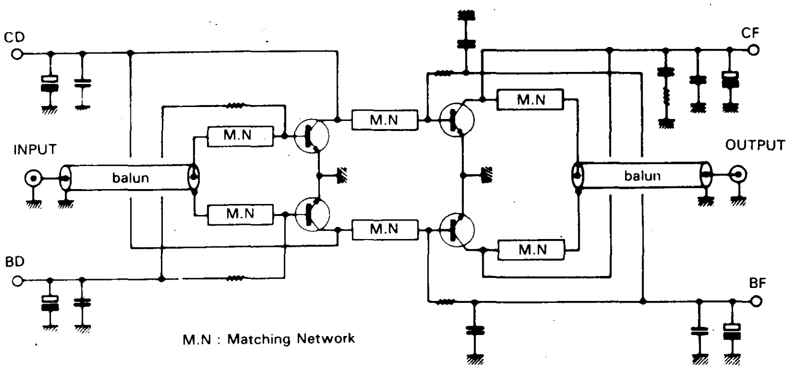


Figure 1

II. — BIASING THE TPVA 5060

II.1 — Introduction

The TPVA 5060 is a linear power module having :
- 50 ohms SMA connectors for RF input and output
- 2 DC connectors for supplies.

The biasing circuits which we shall call BC1 and BC2 feed the driver and final stage respectively. (See fig. 2)
They have been chosen for their reliability, simplicity and low cost but more sophisticated circuits could be used.
This module incorporates the RF and low frequency decoupling circuits.

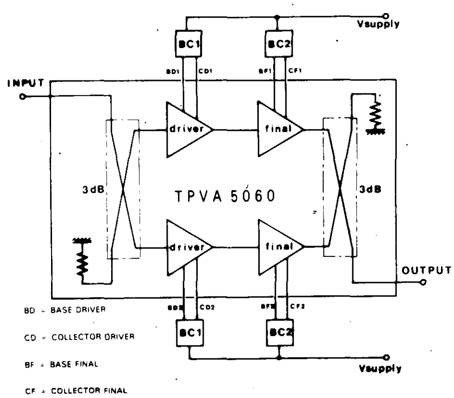


Figure 2

II.2 — BC1 and BC2 description

This para gives some details of suggested circuits for BC1 and BC2.

II.2.1 — Theory of operation

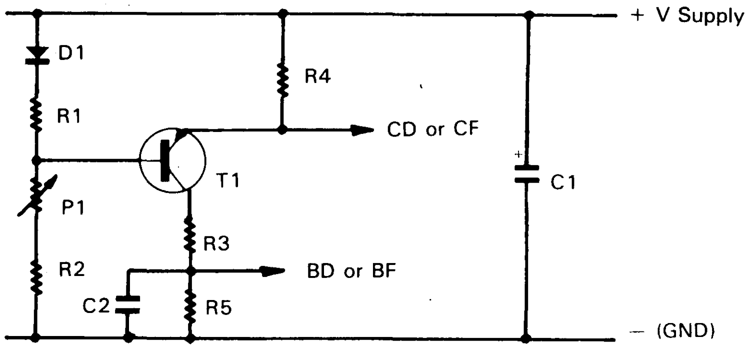
- BC1 and BC2 are current generators biasing the driver and final stages in class A. (Fig. 3)
- They also ensure the stability of the RF transistors quiescent currents versus temperature.
- Potentiometers P1 and P2 allow bias current adjustment.
- Collectors voltages and currents can be checked on test points TP1 and TP2 with an electronic millivoltmeter.

II.2.2 — Electrical circuit — Components list — PCB Layout

Fig. 3 et 4.

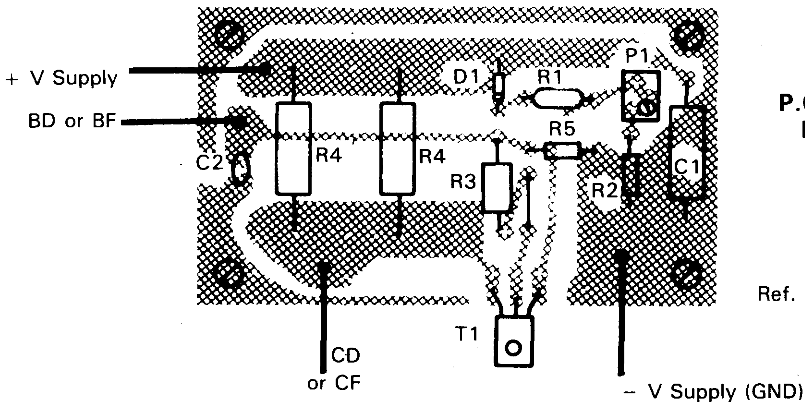
ELECTRICAL CIRCUIT

Figure 3



P.C. BOARD LAYOUT

Figure 4



Ref. : TRW B 5060

Four circuits are requested for one TPVA 5060 (2 circuits BC1 for driver)
(2 circuits BC2 for final)

COMPONENTS LIST

C1	Electrolytic capacitor	100 MF/40 volts
C2	Ceramic capacitor	1000 pF
R1	Resistor 1/4 W 5 %	47 ohms
R2	Resistor 1/4 W 5 %	1000 ohms
R3	Resistor 1 W 5 %	47 ohms
R4	Resistor 6 W 1 %	0.47 ohms {(2 parallel resistors each 0.47 on BC2 final circuits)}
R5	Resistor 1/4 W 5 %	47 ohms
D1	Diode	1N 4148
T1	Transistor	BD 136 with heatsink

III. — OPERATING INSTRUCTIONS

III.1 — Precautions

Before switching on be sure that :

— The heatsink used to evacuate the heat generated by the module is large enough to maintain a temperature below 70 °C on the module temperature test point.

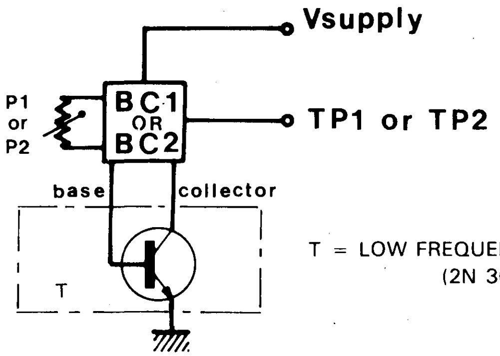
— RF input and output are terminated with a 50 ohms load.

— The power supply has been « current limited » to 12 amperes.

— There is no RF input.

— BC1 and BC2 have been tested.

The following test circuit can be used to « pre-test » each bias circuit and to « pre-set » potentiometer P1 and P2. (Fig. 5)



T = LOW FREQUENCY POWER TRANSISTOR (2N 3055 + HEATSINK)

Figure 5

III.2 — Measuring voltages and currents across the module

• All voltage measurements use the base plate as reference.

• Measuring I_{CD} (Collector Current of the Driver) and I_{CF} (Collector Current of the Final) :

If R3 and R4 of BC1 and BC2 have a tolerance of 1 % :

$$I_{CD}\ (A) = \frac{V\ \text{(volts) across R4}\ (\Omega)}{R4\ (\Omega)}$$

$$I_{CF}\ (A) = \frac{V\ \text{(volts) across R3}\ (\Omega)}{R3\ (\Omega)}$$

• Voltage supply is a function of the collector voltage and the collector current.

— V. supply to BC1 = V_{CD} + (R3 × I_{CD})

Example :

If V_{CD} = 26 volts ; I_{CD} = 1.7A ; R3 = 0.47 ohms

V. supply to BC1 = 26.8 volts

— V. supply to BC2 = V_{CF} + (R4 × I_{CF})

Example :

If F_{VF} = 26 volts ; I_{CF} = 3.6A ; R4 = 0.235 ohms

V. supply to BC2 = 26.5 volts.

III.3 — Switching on

• Apply first a voltage supply of + 5V and check the following voltages and currents :

For BC1 : V_{CD} ≈ 5 V ; V_{BD} ≈ 0.8 V ; I_{CD} ≈ 180 mA

For BC2 : V_{CF} ≈ 5 V ; V_{BF} ≈ 0.8 V ; I_{CF} ≈ 300 mA

• Then increase voltage supply :

— adjust P1 of BC1 to vary I_{CD1} or I_{CD2}

— adjust P2 of BC2 to vary I_{CF1} or I_{CF2}

• Following typical values are given below :

V_{CD} ≈ 5 V	V_{BD} ≈ 0.8 V	I_{CD} ≈ 180 mA
V_{CD} ≈ 10 V	V_{BD} ≈ 0.9 V	I_{CD} ≈ 500 mA
V_{CD} ≈ 20 V	V_{BD} ≈ 1.0 V	I_{CD} ≈ 1.25 A
V_{CD} ≈ 26 V	V_{BD} ≈ 1.1 V	I_{CD} ≈ 1.7 A

V_{CD} max = 26 volts, V_{BD} max = 1.3 volts, I_{CD} max = 1.8 A

V_{CF} ≈ 5V	V_{BF} ≈ 0.8 V	I_{CF} ≈ 300 mA
V_{CF} ≈ 10 V	V_{BF} ≈ 0.9 V	I_{CF} ≈ 950 mA
V_{CF} ≈ 20 V	V_{BF} ≈ 1.1 V	I_{CF} ≈ 2.5 A
V_{CF} ≈ 26 V	V_{BF} ≈ 1.2 V	I_{CF} ≈ 3.6 A

V_{CF} max = 26 volts, V_{BF} max = 1.4 volts, I_{CF} max = 3.7 A

III.4 — Recommended biasing conditions

V_{CD} = 26 volts ; I_{CD} = 1.7 A

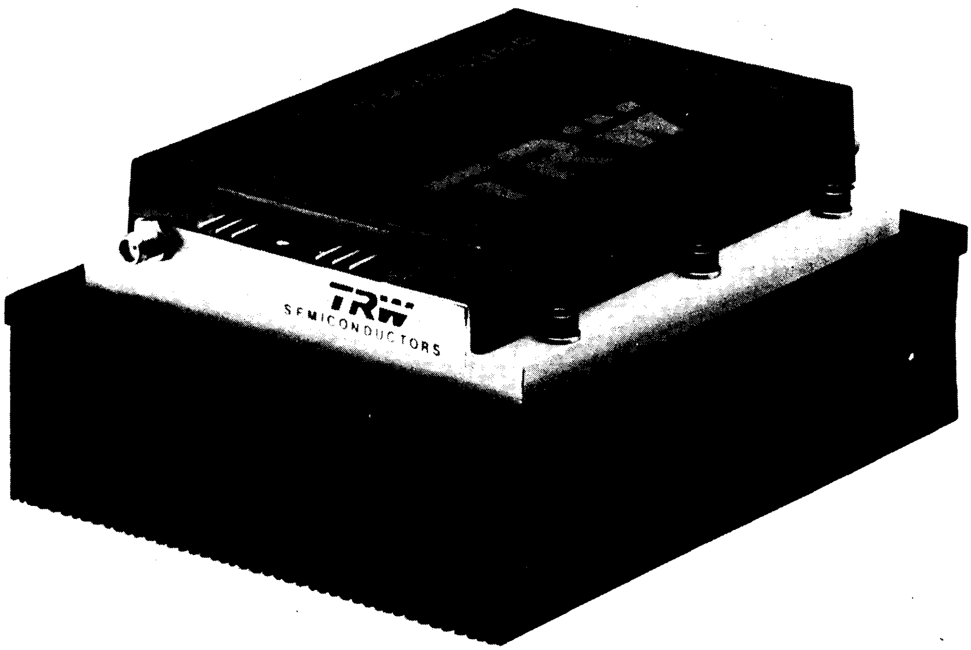
V_{CF} = 26 volts ; I_{CF} = 3.6 A

These biasing conditions have been chosen to give optimum RF performance (see specification) and ensure high reliability.

IV. — COOLING THE TPVA 5060

The user must take into consideration that, without RF drive, 280 W flows from the amplifier base plate. This implies that caution should be taken with thermal design so that the junction temperature does not exceed a prohibitive value.

Taking into account all thermal resistance encountered between the junction of the transistors and the base plate of the amplifier (junction-flange, flange-base plate, heat diffusion in the base plate), we do not advise exceeding a temperature of 70 °C at the reference point (T) defined in the figure 9.



Note that the optimal torque of the steel screws is 25 kg/cm.
Please refer to the graph below to make an estimate of the MTTF versus the flange temperature. (Fig. 6)

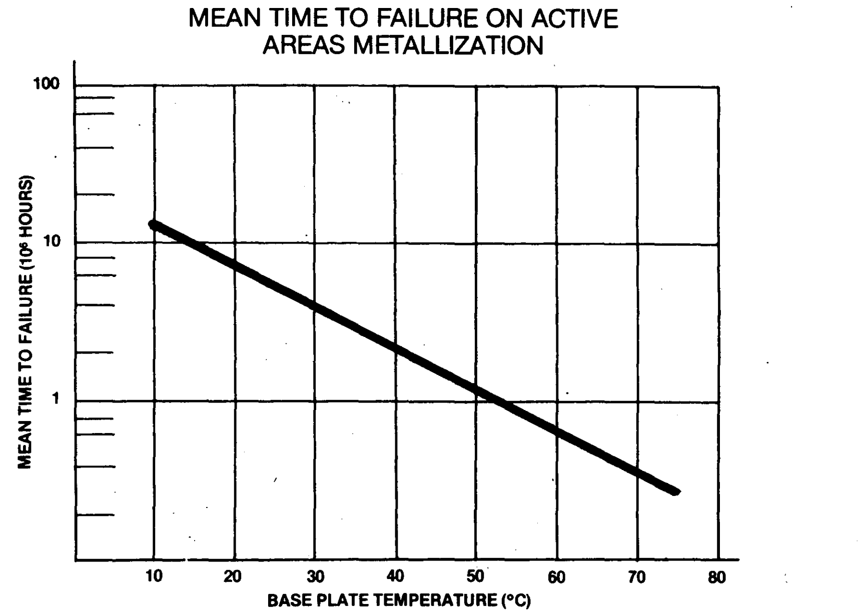


Figure 6

However, the user may meet rather severe environmental conditions when the ambient temperature goes up to 50 °C.
The rise in temperature allowed at the reference point is then 20 °C.
A conventional air-air exchanger is not sufficient to achieve this low temperature rise under realistic conditions of overall dimensions and air flow.
So we suggest the use of an aluminium heatsink, with base plate of 150 mm × 120 mm × 5 mm with 42 brazed finns of 3.5 cm eight, 0.035 cm thickness.
This will ensure a temperature rise of 20 °C when the air flow is 43 l/s at sea level. (Fig. 7)

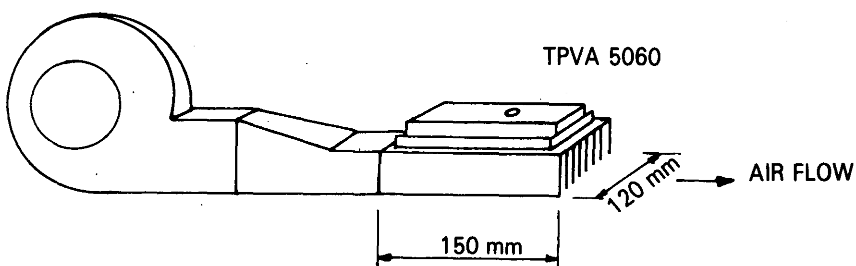


Figure 7

The size of this type of heatsink is relatively small.
Typical blower (characteristics at 50 Hz) :
Nominal speed : 2 800 rpm
Maximum flow at O static pressure : 80 l/s
Maximum static pressure : 32 mm H_2O
Static pressure at 43 l/s : 22 mm H_2O

Another configuration using helicoidal blower gives only 17 °C temperature rise at sea level. (Fig. 8).

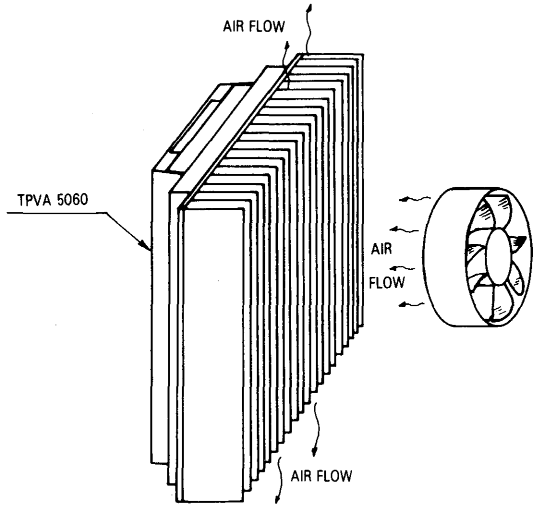


Figure 8

Typical blower (50 Hz)
Nominal speed : 2 850 r.p.m.
Maximal flow at 0 mm H_2O Static pressure 40 l/s
Maximal static pressure : 28 mm H_2O
Static pressure at 100 l/s : 12 mm H_2O

The user must however consider that the air density decreases according to the altitude i.e. :

$$\varrho = \varrho o \left(\frac{Po - 80\,h}{P} \times \frac{To}{To - 7{,}5\,h} \right)$$

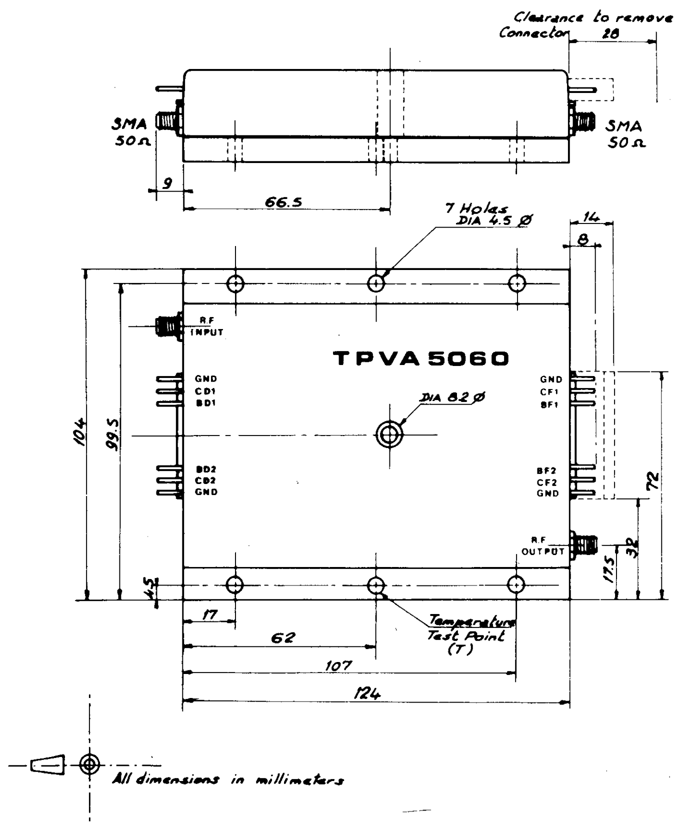
Po = pressure at sea level (760 mmHg)
To = initial temperature
h = altitude (km)

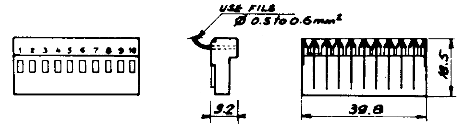
So, at 2000 m altitude, we obtain
$\varrho = \varrho o \times 0{,}828$
However, under the same conditions, it must be remembered that temperature at altitude is not so high as it would be at sea level.
It is considered that for 50 °C ambient at sea level, the temperature does not exceed 35 °C at an altitude of 2000 m.
Finally, if the available air is not filtered properly, it could obstruct the heatsink after a few hours.
The user will have to take this fact into consideration.

TRW composants electroniques consider the results that follow are typical and therefore they will not be taken in any case as contractual.

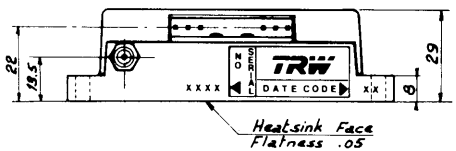
Z

MECHANICAL DRAWINGS





Female Connector Details
Ref: AMP 1.640.605-0



PRIOR TO SWITCHING ON,
REFER TO OPERATING INSTRUCTIONS :
SEE TV 005-83 APPLICATION NOTE

APPLICATION NOTE

TRW

MATCH IMPEDANCES IN MICROWAVE AMPLIFIERS

and you're on the way to successful solid-state designs. Here's how to analyze input/output factors and to create a practical design.

The key to successful solid-state microwave power-amplifier design is impedance matching.

In any high-frequency power-amplifier design, improper impedance matching will degrade stability and reduce circuit efficiency. At microwave frequencies, this consideration is even more critical, since the transistor's bond-wire inductance and base-to-collector capacitance become significant elements in input/output impedance network design.

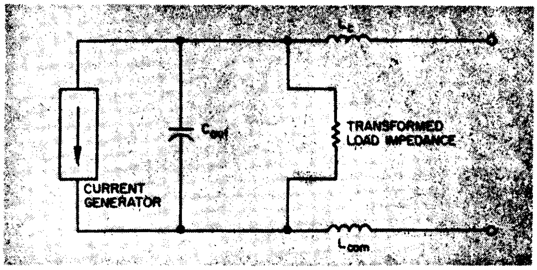
In selecting a suitable transistor, therefore, keep in mind that the input and output impedances are critical along with power output, gain and efficiency.

Unless the selected transistor is used at frequencies that are much lower than the maximum operating frequency, the input impedance is largely inductive with a small real part. The large inductance is due to bond wires that connect the transistor chip to the input lead of the package and to the common-element bond wires. The small real part of the input impedance is due to the large geometries required to generate high power *at high frequencies*; the base bulk resistance may be the predominant part of the real input impedance.

Use microstrip stubs at input network

The first and most important step in designing the input matching network for the selected device is to provide a shunt capacitance that will resonate the inductive component of the input impedance. This step forms the low-pass matching section of the network and should provide the smallest possible transformed impedance. To minimize the inductive component, the input and common-element lead lengths must be kept short.

The resonating capacitance is generally best provided by a microstrip stub. In some cases the stub producing the required capacitance is so large that a practical circuit size cannot be realized. It is best then to distribute as much of this capacitance as is physically practical and to provide the balance with high-quality chip capacitors.



1. **In this output equivalent circuit,** capacitance C_{OUT} is almost equal to the selected transistor's collector-to-base capacitance C_{ob}.

The first section of the impedance matching network is extremely important because it can degrade the stability of the amplifier if it is not well designed. Depending on the design frequency of the amplifier and the transistor selected, the resonated real impedance can range from less than 50 Ω to much higher. When it is below 50 Ω, an additional low-pass matching section can be conveniently added to achieve the required 50-Ω impedance at the input.

The higher-impedance case presents a special problem if microstrip techniques are used to build the matching network. The problem occurs because the resonated impedance may be as high as 300 Ω. Reducing this to 50 Ω by use of a low-pass network configuration requires a series-transmission line that will behave as an inductor. The rule of thumb is that the characteristic impedance of the transmission line must be at least twice the higher impedance before such behavior results. Examination of the accompanying table shows that characteristic impedance lines of greater than 100 Ω are very narrow. Narrow transmission lines (less than 0.01-inch wide) should be avoided wherever possible, because repeatability of width dimensions is poor. Also, the loss in a narrow line may become excessive. A better solution is to use a quarter-wave transmission-line transformer with a characteristic impedance

Roger DeBloois, Senior Applications Engineer, TRW Semiconductors, Lawndale, Calif. 90260.

equal to the square root of the 50-Ω impedance product: $Z_o = \sqrt{50 Z_R}$.

Make output bandwidth wider than input

The output impedance of a microwave power transistor is usually defined as the conjugate of the load impedance required to achieve the device performance. A typical output equivalent circuit is shown in Fig. 1. The capacitance C_{out} is nearly equal to the collector-base capacitance C_{ob} specified for the selected transistor. L_c is the inductance of the bond wires used to bridge from the collector metallization area to the package output lead, and L_{com} represents the inductive effects of the common element bond wires.

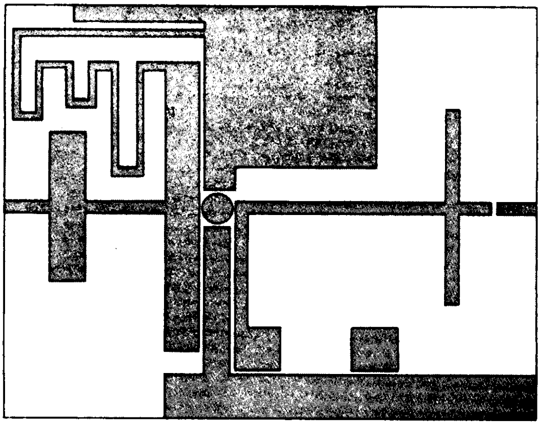
For correct operation of the transistor, the ultimate load impedance must be transformed to a real impedance across the current generator. This real impedance is determined by

$$R_L = \frac{[V_{cc} - V_{ce}\,(sat)]^2}{2P_{out}}.$$

The load impedance presented to the package terminals will contain the real impedance at the current generator, transformed to a lower value by the low-pass L section formed by C_{out} and the parasitic inductances L_c and L_{com}. Usually the reactive part of the load impedance is made inductive to tune out the residual capacitance of the device.

The output matching network should be designed so it has greater bandwidth than the input matching network. Providing a good collector match, both above and below the design frequency, ensures that the input power will be reflected before the collector VSWR rises to values that endanger the transistor. In this way the transistor is protected from off-frequency operation. The amount of additional bandwidth required for protection of the transistor depends on the ruggedness of the transistor used. The manufacturer's specifications for VSWR tolerance and input Q can be a guide for determining the bandwidth requirements of the input matching network.

One technique for obtaining the required bandwidth is to resonate a portion of the capacitive reactance of the transistor output impedance with a shunt inductor. The shunt inductor can also be used to feed the collector supply voltage to the transistor. Additional transformation may be obtained from a low-pass matching section. By adjusting the amount of shunt inductance and rematching with the low-pass section, the designer can create a truly broadband output match.



2. **With this typical microwave amplifier breadboard layout,** the entire board can be soldered to a metal plate to provide a path for thermal cooling.

Don't overlook base and collector paths

In addition to matching the device impedances, direct-current paths must be provided to the base and collector of the transistor. The collector path is provided by the shorted stub in the impedance-matching network. The base path requires the addition of a choke from the base to ground. The choke can be a lumped element or a distributed shorted stub of sufficient impedance to be negligible in the circuit. A quarter-wavelength stub is ideal. The narrowest practical line should be selected. In addition a dc blocking capacitor is required in the collector circuit. Also needed is a bypass capacitor to provide the proper ac shorting point for the inductive stub in the col-

Microstrip Z_0 and velocity factor vs width-to-height (W/H) ratio.

(Prepared by Don Schulz, Applications Engineer, TRW)

W/H	Air K = 1.0 Z_o	V_P	Teflon K = 2.55 Z_o	V_P	Epoxy K = 4.25 Z_o	V_P	Alumina K = 9.6 Z_o	V_P
0.630	168.425	1.000	110.683	0.657	87.986	0.522	60.977	0.362
0.695	161.878	1.000	106.258	0.656	84.414	0.521	58.441	0.361
0.766	155.370	1.000	101.865	0.656	80.870	0.521	55.927	0.360
0.844	148.909	1.000	97.509	0.655	77.360	0.520	53.440	0.359
0.931	142.506	1.000	93.199	0.654	73.888	0.518	50.985	0.358
1.026	136.171	1.000	88.941	0.653	70.463	0.517	48.566	0.357
1.131	129.916	1.000	84.745	0.652	67.090	0.516	46.187	0.356
1.247	123.753	1.000	80.616	0.651	63.775	0.515	43.853	0.354
1.375	117.692	1.000	76.565	0.651	60.524	0.514	41.568	0.353
1.516	111.746	1.000	72.597	0.650	57.345	0.513	39.337	0.352
1.672	105.926	1.000	68.721	0.649	54.243	0.512	37.164	0.351
1.843	100.242	1.000	64.944	0.648	51.223	0.511	35.053	0.350
2.032	94.706	1.000	61.273	0.647	48.291	0.510	33.007	0.349
2.240	89.327	1.000	57.714	0.646	45.451	0.509	31.030	0.347
2.470	84.115	1.000	54.271	0.645	42.709	0.508	29.123	0.346
2.723	79.076	1.000	50.951	0.644	40.066	0.507	27.289	0.345
3.002	74.218	1.000	47.757	0.643	37.527	0.506	25.531	0.344
3.310	69.546	1.000	44.692	0.643	35.094	0.505	23.849	0.343
3.649	65.065	1.000	41.759	0.642	32.768	0.504	22.244	0.342
4.023	60.779	1.000	38.959	0.641	30.550	0.503	20.716	0.341
4.435	56.689	1.000	36.292	0.640	28.440	0.502	19.266	0.340
4.890	52.796	1.000	33.760	0.639	26.439	0.501	17.892	0.339
5.391	49.100	1.000	31.360	0.639	24.544	0.500	16.594	0.338
5.944	45.600	1.000	29.091	0.638	22.755	0.499	15.370	0.337
6.553	42.291	1.000	26.952	0.637	21.069	0.498	14.218	0.336
7.224	39.173	1.000	24.938	0.637	19.485	0.497	13.138	0.335
7.965	36.233	1.000	23.047	0.636	17.998	0.497	12.125	0.335
8.781	33.484	1.000	21.275	0.635	16.606	0.496	11.179	0.334
9.681	30.904	1.000	19.618	0.635	15.305	0.495	10.295	0.333
10.674	28.491	1.000	18.071	0.634	14.091	0.495	9.472	0.332
11.768	26.240	1.000	16.629	0.634	12.961	0.494	8.707	0.332
12.974	24.143	1.000	15.288	0.633	11.911	0.493	7.996	0.331
14.304	22.192	1.000	14.043	0.633	10.937	0.493	7.338	0.331
15.770	20.381	1.000	12.888	0.632	10.033	0.492	6.728	0.330
17.387	18.702	1.000	11.818	0.632	9.198	0.492	6.164	0.330
19.169	17.148	1.000	10.830	0.632	8.425	0.491	5.644	0.329
21.133	15.172	1.000	9.917	0.631	7.713	0.491	5.164	0.329
23.300	14.385	1.000	9.074	0.631	7.056	0.490	4.722	0.328
25.688	13.162	1.000	8.299	0.630	6.451	0.490	4.315	0.328

Table continued

W/H	Air K = 1.0 Z_o	V_p	Teflon K = 2.55 Z_o	V_p	Epoxy K = 4.25 Z_o	V_p	Alumina K = 9.6 Z_o	V_p
28.321	12.036	1.000	7.585	0.630	5.894	0.490	3.942	0.327
31.224	10.999	1.000	6.929	0.630	5.383	0.489	3.598	0.327
34.424	10.047	1.000	6.326	0.630	4.914	0.489	3.284	0.327
37.953	9.172	1.000	5.773	0.629	4.483	0.489	2.995	0.327
41.843	8.370	1.000	5.266	0.629	4.089	0.489	2.731	0.326
46.132	7.634	1.000	4.801	0.629	3.727	0.488	2.489	0.326
50.860	6.960	1.000	4.376	0.629	3.397	0.488	2.267	0.326
56.073	6.343	1.000	3.987	0.629	3.094	0.488	2.065	0.326
61.821	5.779	1.000	3.632	0.628	2.818	0.488	1.880	0.325
68.157	5.264	1.000	3.307	0.628	2.566	0.487	1.711	0.325
75.144	4.792	1.000	3.010	0.628	2.335	0.487	1.557	0.325
82.846	4.362	1.000	2.739	0.628	2.125	0.487	1.417	0.325
91.337	3.969	1.000	2.492	0.628	1.933	0.487	1.289	0.325
100.700	3.611	1.000	2.267	0.628	1.758	0.487	1.172	0.324

lector-matching network.

Selection of a blocking capacitor is relatively straightforward. The capacitor should be chosen to provide low loss at the operating frequency while maintaining the capacitance at a value that inhibits low-frequency oscillation. The latter is caused by the series capacitor's tendency to display rising reactance with decreasing frequency.

Blocking capacitors must be large enough to preserve coupling characteristics down to a frequency where the shunt-feed chokes can effectively short the respective port to ground. Coupling capacitors should not be excessively large, or they may produce as much as 1-dB loss in gain with a corresponding decrease in efficiency in the case of collector coupling capacitors. The Q of the coupling capacitor determines the acceptable range of capacitance values and is generally inversely related to capacitance.

Bypass capacitors are selected by analysis of the same considerations as those for blocking capacitors. A large bypass capacitor (tantalum or electrolytic), placed from the dc feedpoint to ground, prevents tendencies toward low-frequency oscillation in the circuit. Also, it may be necessary to add smaller bypass capacitors to preserve stability over a wide range of frequencies.

Adjust for bandwidth and physical dimensions

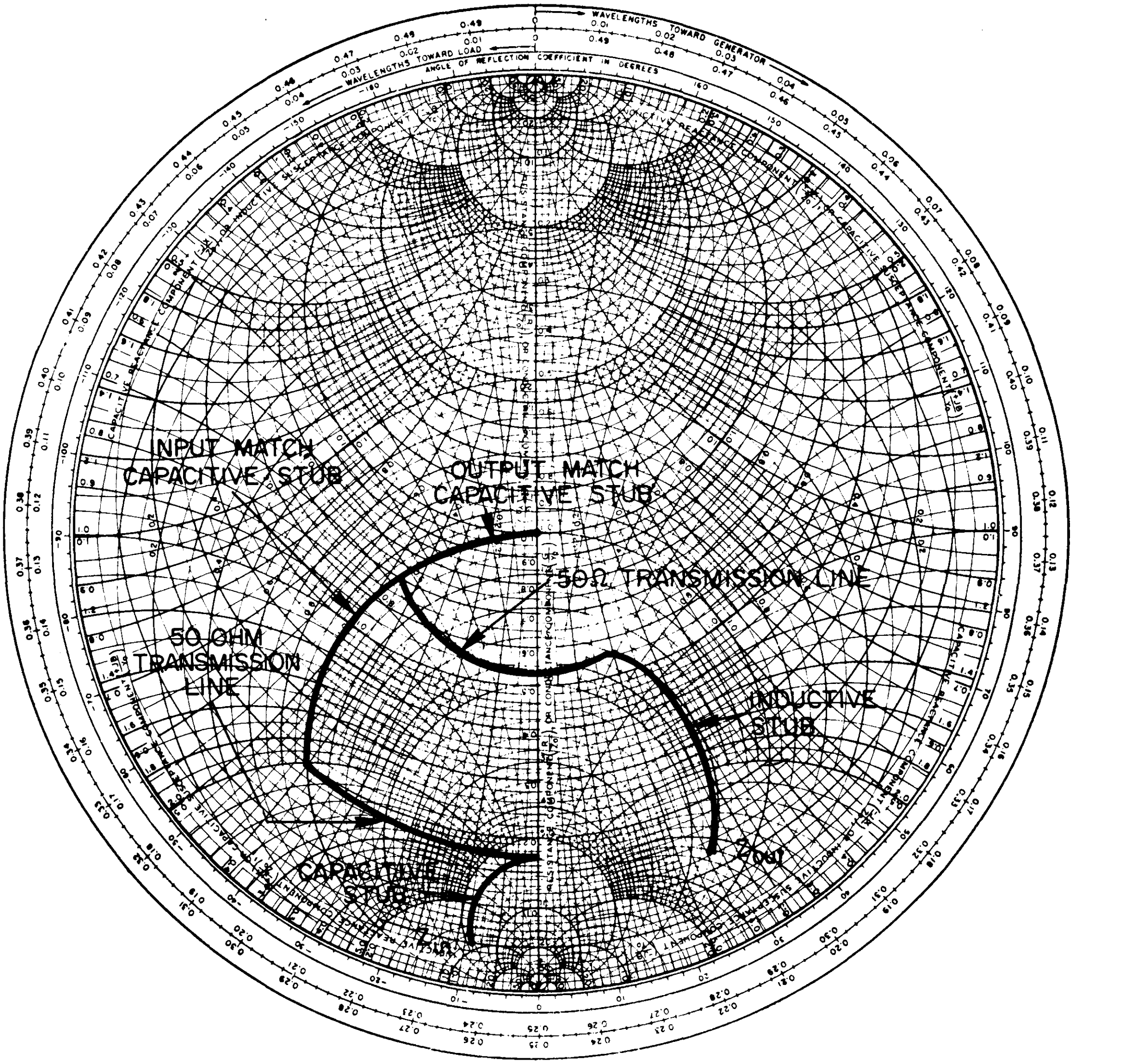
The circuit design may be adjusted quickly for bandwidth requirements through use of a computer optimization program such as Magic, offered by University Computing of Dallas, Tex. When that step is finished, electrical dimensions must be converted to physical dimensions.

At this point in the design sequence, the dielectric material must be chosen. Three commonly used materials are Teflon fiberglass, epoxy fiberglass and alumina. Above 500 MHz, epoxy fiberglass exhibits too many losses to be a good choice. Teflon fiberglass can be used up to several gigahertz; it has reasonable dielectric losses and is easy to process. Alumina, a ceramic, offers a high dielectric constant, good dimensional consistency and small circuit geometry.

When plastic materials are used, it's a good practice to measure the material thickness and dielectric constant, because variations are common. In a recent test the dielectric constant of a sheet of epoxy fiberglass material was measured at 4.55 at 1 MHz and 4.25 at 500 MHz. If the manufacturer's value of 5.5 had been used for the design of matching networks, considerable error would have resulted.

The physical dimensions of the matching circuitry may be calculated from the data in the table. The line lengths are scaled by the velocity factor, which is equal to $Z_o/Z_{o(air)}$ in air for a constant width-to-height ratio, W/H.

The final design of a typical breadboard microwave amplifier is shown in Fig. 2. The ground areas on the top of the board are connected to the microstrip ground plane by 2-mil-thick foil wrapped around the edges of the board and the areas directly under the emitter leads of the transistor. The foil is secured to the top and bot-



3. **The immittance chart,** with values specified for the design example, indicates the necessary inductive and capacitive stubs. Impedance transformations are achieved by 50-Ω series-transmission lines.

tom surfaces with solder. Plating may be used for production units. The entire board can be soldered to a metal plate to allow connector mounting and to provide a thermal path for the heat generated by the transistor.

The initial tune-up of the amplifier matching circuits can be expedited by use of a network analyzer and a precision load on the input or output connector. The circuit can be adjusted to match the nominal impedances supplied by the transistor manufacturer. Distributed stubs are purposely made longer than necessary and are adjusted to the correct length by trimming of the foil on the capacitive stubs. The inductive stub in the output network is adjusted by positioning of the bypass capacitor along the stub and the adjacent ground plane.

This procedure results in a load line that is fairly close to optimum. A transistor can now be inserted in the circuit and the collector matching network readjusted for maximum collector efficiency. Stub tuners are used to match the amplifier input impedance, so that only one variable at a time need be considered. Initially it may be necessary to operate the transistor at reduced collector voltage and power output to avoid excessive stress. When maximum efficiency is obtained, the stub tuner is removed and the input network adjusted for minimum input VSWR.

Now let's design an impedance-matching circuit

Let's consider a practical example of a procedure for the design of impedance-matching circuitry. The sample circuit uses a TRW 2N5596 at 700 MHz as the active device.

Specifications for the completed amplifier are:

$$Z_{in} = 50\ \Omega,$$
$$Z_{out} = 50\ \Omega,$$
$$P_{out} = 20\ \text{W},$$
$$G_p = 7\ \text{dB},$$
$$\eta = 55\%\ \text{minimum}.$$

Specifications for the TRW 2N5596 are:

$$P_{out} = 20\ \text{W at 1 GHz},$$
$$\eta = 55\%\ \text{minimum at 1 GHz},$$
$$G_p = 5\ \text{dB minimum at 1 GHz},$$
$$Z_{in} = 2.5 + J4.0\ \text{at 700 MHz},$$
$$Z_{out} = 6.0 - J12.5\ \text{at 700 MHz}.$$

In practice, the gain of a common-emitter amplifier decreases at a rate of 4 to 5 dB per octave. The 2N5596 at 700 MHz produces about 7 dB of gain. Therefore approximately 4 W of drive will be required to produce 20 W of output power. The collector efficiency can be expected to increase at the lower frequency, but it is difficult to estimate because it is a complex phenomenon. Manufacturers' curves of typical behavior are useful. Output power will not increase significantly with the decreased frequency.

The efficiency-frequency relationship depends on device f_T and ballasting. Heavily ballasted transistors tend to give increased efficiency as frequency is decreased. However, they level out at a lower efficiency than a nonballasted part because of I^2R losses in ballast resistors. The average increase in efficiency as a result of decreasing frequency is about 20% per octave. Values from 10 to 40% per octave have been measured.

The initial phase of the design is best accomplished on an immittance chart. The chart with appropriate values indicated for the sample design is shown in Fig. 3. The input match is achieved when the input impedance is resonated with a capacitive susceptance of 0.18 mhos. This susceptance is realized by use of a pair of capacitive microstrip stubs. Each stub must exhibit a reactance of 2 × 1/0.18 mhos, or 11.1 Ω. The length of the stub may be calculated by

$$\tan \Theta = \frac{Z_o}{X_c}.$$

For ease of adjustment, the length of the stubs should be less than 60 degrees. Because capacitive reactance is a tangential function, the reactive variations per unit length become increasingly severe past 60 degrees. It is better to decrease Z_o rather than to use longer stubs to achieve higher capacitance. Therefore $Z_o \leqq 1.732\ X_c \leqq 19.24\ \Omega$. Because it is easier to shorten a microstrip stub than to lengthen it, the Z_o of 15 Ω, for example, provides sufficient adjustment range to accommodate device variations.

The next step is to transform the resonated impedance to 50 Ω. This is accomplished by a series-transmission line with a characteristic impedance of 50 Ω. From Fig. 3, we see that the length of this line can be directly determined to be 0.062 wavelengths, or 22.3 degrees, long. A capacitive susceptance of 0.040 mhos completes the transformation. Again, a pair of capacitive stubs will provide the susceptance. For ease of converting the design to microstrip dimensions, it is convenient to choose a Z_o for the second stub that is equal to that selected for the first. Therefore:

$$\tan \Theta = \frac{Z_o}{X_c} = \frac{15}{50} = 0.3,$$
$$\text{or } \Theta = 16.7\ \text{degrees}.$$

In this case the length chosen is 20 degrees to allow for some adjustment.

The output match is achieved by partial resonating of the device's output impedance with an inductive susceptance. While the amount of susceptance chosen is arbitrary at this point, the output network bandwidth is affected by the value. From Fig. 3, we can determine that 0.05 mhos is required for the first matching element. This susceptance is achieved by use of a shorted microstrip stub. The length of the stub may be calculated from the equation

$$\tan \Theta = \frac{X_L}{Z_o}.$$

If Z_o of the stub is arbitrarily chosen to be 50 Ω,

$$\tan \Theta = \frac{20}{50} = 0.4,$$
$$\Theta = 21.8\ \text{degrees}.$$

Again, the stub is made somewhat longer because it can be adjusted by sliding the chip capacitor (ac short) up or down the line length. The remaining transformation is achieved by a 50-Ω series-transmission line of 0.15 wavelengths (54 degrees long) and a capacitive susceptance of 0.014 mhos. Selecting a pair of 50-ohm microstrip lines to provide the susceptance requires a stub length of

$$X_c = 2 \times \frac{1}{0.014} = 143\ \Omega.$$
$$\tan = \frac{Z_o}{X_c} = \frac{50}{143} = 0.350 = 19.3\ \text{degrees}.$$

A stub length of 25 degrees will provide an adequate allowance for adjustment of the circuit. ■■

APPLICATION NOTE

TRW

THREE BALUN DESIGNS FOR PUSH-PULL AMPLIFIERS

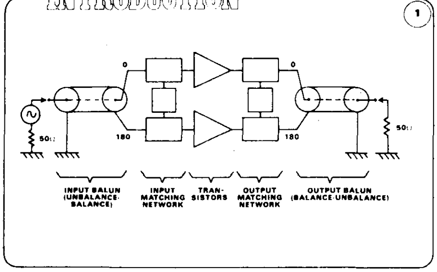
SINGLE RF power transistors seldom satisfy today's design criteria; several devices in separate packages[1] or in the same package (balanced, push-pull or dual transistors), must be coupled to obtain the required amplifier output power. Since high-power transistors have very low impedance, designers are challenged to match combined devices to a load. They often choose the push-pull technique because it allows the input and output impedances of transistors to be connected in series for RF operation.

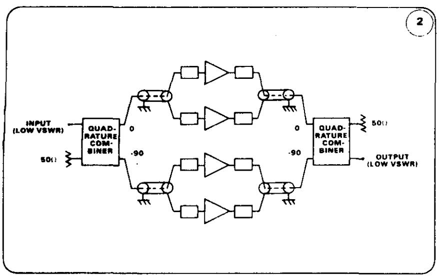
Balun-transformers provide the key to push-pull design, but they have not been as conspicuous in microwave circuits as at lower frequencies. Ferrite baluns[2] have been applied up to 30 MHz; others incorporating coaxial transmission lines operate in the 30-to-400-MHz range.[3]

The success of these two balun types should prompt the microwave designer to ask if balun-transformers can be included in circuits for frequencies above 400 MHz. Theory and experimental results lead to the emphatic answer: yes! Not only will baluns function at microwave frequencies, but a special balun can be designed in microstrip form that avoids the inherent connection problems of coax.

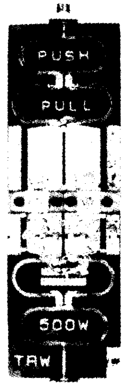
On the next six pages, you will observe the development of three balun-transformers—culminating with the microstrip version. None of the baluns was tuned nor were the parasitic elements compensated. In this way, the deviation of the experimental baluns from their theoretical performance could be evaluated more easily. The frequency limitations imposed by the parasitic elements also were observed more clearly.

INTRODUCTION





1. A balun transforms a balanced system that is symmetrical (with respect to ground) to an unbalanced system with one side grounded. Without balun-transformers, the minimum device impedance (real) that can be matched to 50 ohms with acceptable bandwidth and loss is approximately 0.5 ohms. The key to increasing the transistors' output power is reducing this impedance ratio. Although 3-dB hybrid combiners can double the maximum power output, they lower the matching ratio to only 50:1. Balun transformers can reduce the original 100:1 ratio to 6.25:1 or less. The design offers other advantages: the baluns and associated matching circuits have greater bandwidth, lower losses, and reduced even-harmonic levels.



A 500-W push-pull amplifier for DME band.

2. Baluns are not free of disadvantages. Coupling a pair of push-pull amplifiers with 3-dB hybrids avoids (for four-transistor circuits) one of these: the higher broadband VSWRs of balun-transformers. A second disadvantage, the lack of isolation between the two transistors in each push-pull configuration, is outweighed by the advantages of the balun design in reducing the critical impedance ratio.

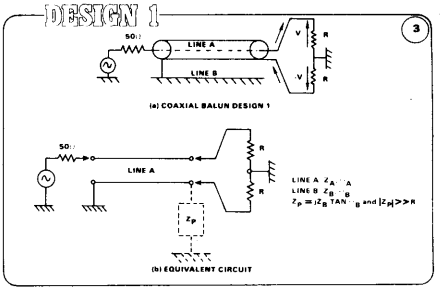
Z

DESIGN 1

3. In this simple balun that uses a coaxial transmission line, the grounded outer conductor makes an unbalanced termination, and the floating end makes a balanced termination. Charge conservation requires that the currents on the center and the outer conductors maintain equal magnitudes and a 180-degree phase relationship at any point along the line. By properly choosing the length and characteristic impedance, this balun can be designed to match devices to their loads. In the case shown, if θ_A = 90 degrees, the matching condition is:

Experimental version of a simple balun using coaxial lines.

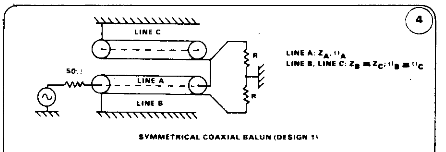
$$Z_A^2 = 2xRx50.$$



(a) COAXIAL BALUN DESIGN 1

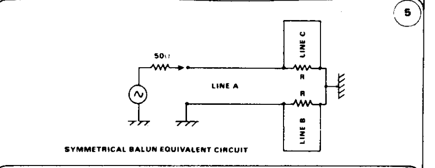
(b) EQUIVALENT CIRCUIT

4. By adding a second coaxial line, the basic balun can be made perfectly symmetrical. In this symmetrical coaxial balun, the bandwidth (in terms of the input VSWR) is limited by the transformation ratio, 50/2R, and the leakages, which are represented by lines B and C. If Z_A = 50 ohms and R = 25 ohms, the bandwidth is constrained only by the leakages.



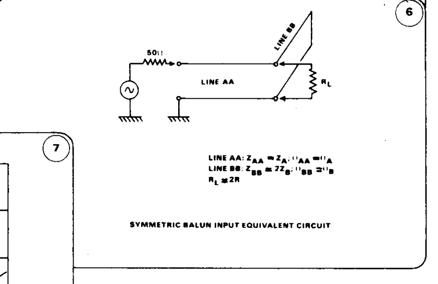
SYMMETRICAL COAXIAL BALUN (DESIGN 1)

5. The equivalent circuit for the symmetrical balun shows the effect of the leakages (lines B and C) on its performance. A broadband balun can be obtained by using a relatively high characteristic impedance for these leakage lines. In theory, the construction of the baluns insures perfect balance.



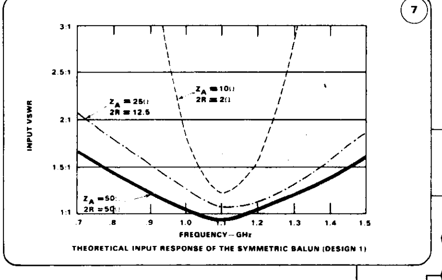
SYMMETRICAL BALUN EQUIVALENT CIRCUIT

6. The symmetric balun's input equivalent circuit further simplifies its configuration and allows the input VSWR to be calculated.[4] In this design, line A has a characteristic impedance of Z_A=50 ohms, a length of L_A=1799 mils, and a dielectric constant (relative) of ϵ_r=2.10. For lines B and C, Z_0=30 ohms, L=1799 mils, and ϵ_{eff}=2.23.



SYMMETRIC BALUN INPUT EQUIVALENT CIRCUIT

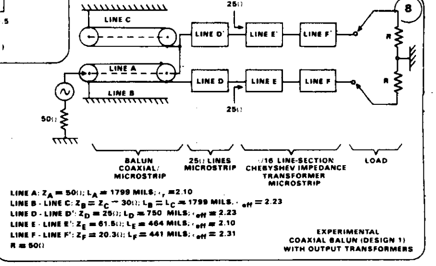
L=1799



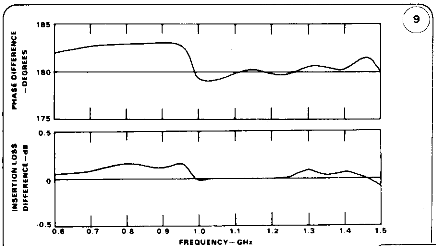
THEORETICAL INPUT RESPONSE OF THE SYMMETRIC BALUN (DESIGN 1)

7. The theoretical input VSWR has been calculated for 50-ohm values of Z_A and 2R, and for two other sets of values for these parameters. The performance of an experimental balun will be compared with these theoretical results.

8. Two λ/16 line-section Chebyshev impedance transformers match the experimental balun to a 50-ohm measurement system. The balun was tested from 0.6 to 1.5 GHz.



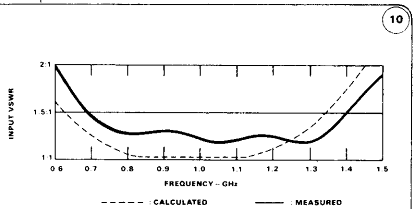
EXPERIMENTAL COAXIAL BALUN (DESIGN 1) WITH OUTPUT TRANSFORMERS



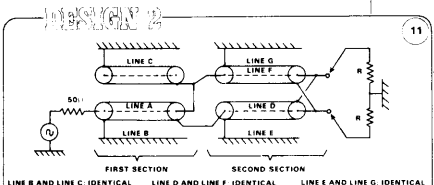
DESIGN 1 BALUN MEASURED PERFORMANCE

9. The measured phase difference and insertion loss difference, which indicate the maximum unbalance for the Design 1 experimental balun, are 3 degrees and 0.2 dB, respectively.

10. The maximum VSWR measured for the first design is 1.5:1. Note the comparison between the calculated and measured response. The performance shown can be considered valid for amplifier applications up to an octave range.

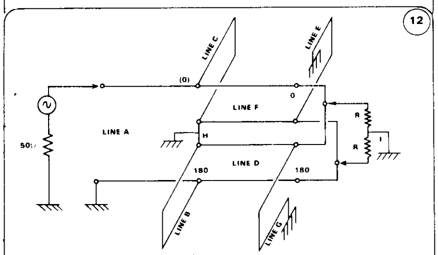


DESIGN 1 BALUN PERFORMANCE



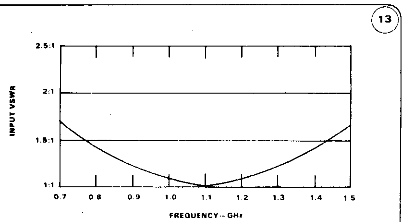
COAXIAL BALUN DESIGN 2

11. The second balun design adds two identical coax lines to the simple balun just described. The inputs of the identical lines are connected in series to the output of the first balun. By putting their outputs in parallel, the final output becomes symmetrical. The output impedance is halved.



DESIGN 2 BALUN EQUIVALENT CIRCUIT

12. The equivalent circuit for the Design 2 balun indicates that its bandwidth, in terms of input VSWR, is limited by the transformation ratios of the first and second sections and the leakages represented by lines B, C, E, and G. If the balun is designed with Z_A = 50 ohms, and $Z_D = Z_F$ = 25 ohms, and if the load, 2R, is set at 2×6.25 ohms, all of the transmission lines will be connected to their characteristic impedances. In this case, the bandwidth will be limited by the leakage alone, and a broadband balun can be obtained by choosing lines B, C, E, and G with relatively high impedance and $\lambda/4$ length for the center frequency. The balun achieves a transformation from 50 ohms to twice 6.25 ohms without causing a standing wave in the coaxial cables.

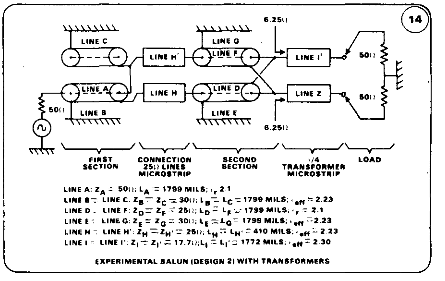


THEORETICAL INPUT RESPONSE OF THE COAXIAL BALUN (DESIGN 2)

13. The performance of the Design 2 balun can be calculated using its equivalent circuit. The calculated VSWR shows a response very close to the simple coaxial balun (Fig. 10) because the new second section has four times the bandwidth of the first section. This design and its two companions are intended to have octave bandwidths centered at 1.1 GHz, the central frequency used in distance measuring equipment (DME, 1.025 to 1.150 GHz) and tactical air navigation (TACAN, 0.960 to 1.215 GHz). For line A: Z_A = 50 ohms, L_A = 1799 mils, ϵ_r = 2.10; lines B, C, E, and G: Z_o = 30 ohms, L = 1799 mils, ϵ_{eff} = 2.23; lines E and F: Z_0 = 25 ohms, L = 1799 mils, ϵ_r = 2.10.

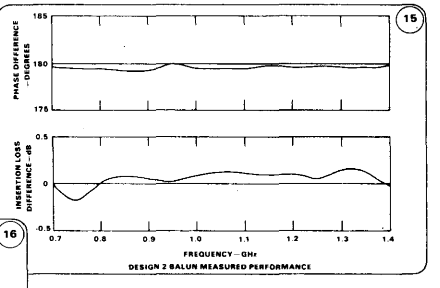
Two-section balun often used in the 100-to-400 MHz range.

14. Two λ/4 transformers match the experimental two-section coaxial balun's 6.26-ohm impedance to the 50-ohm load. Although these transformers drastically reduce the bandwidth (in terms of the VSWR), they don't affect the balance.



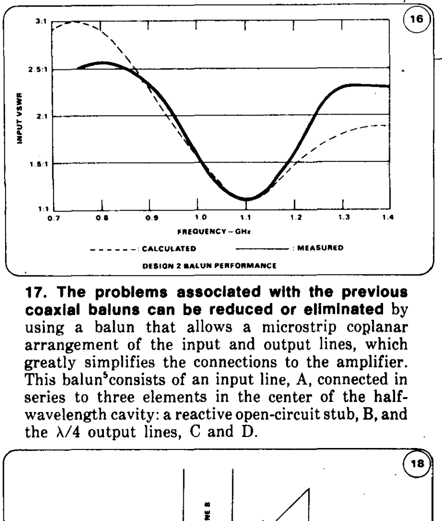
EXPERIMENTAL BALUN (DESIGN 2) WITH TRANSFORMERS

15. The measured phase difference and measured insertion loss difference are plotted for the two-section coaxial balun (Design 2). The maximum unbalances for these two measurements over the octave bandwidth are 1 degree and 0.2 dB.



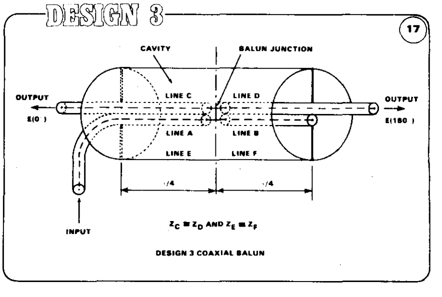
DESIGN 2 BALUN MEASURED PERFORMANCE

16. The calculated and measured values for the input VSWR for the Design 2 balun show close agreement between the experimental and predicted performances. This indicates that the parasitic inductors at the connections are negligible to at least 1.4 GHz. Moreover, the balun has excellent balance to 1.4 GHz and achieves the 4:1 transformation without causing a standing wave in the coaxial line. Despite the many excellent qualities of the Design 1 and Design 2 baluns, the necessary coaxial line connection limits them to approximately 2 GHz.

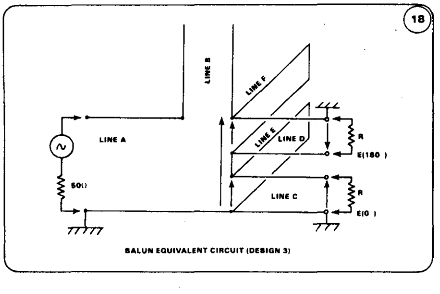


DESIGN 2 BALUN PERFORMANCE

17. The problems associated with the previous coaxial baluns can be reduced or eliminated by using a balun that allows a microstrip coplanar arrangement of the input and output lines, which greatly simplifies the connections to the amplifier. This balun[5] consists of an input line, A, connected in series to three elements in the center of the half-wavelength cavity: a reactive open-circuit stub, B, and the λ/4 output lines, C and D.



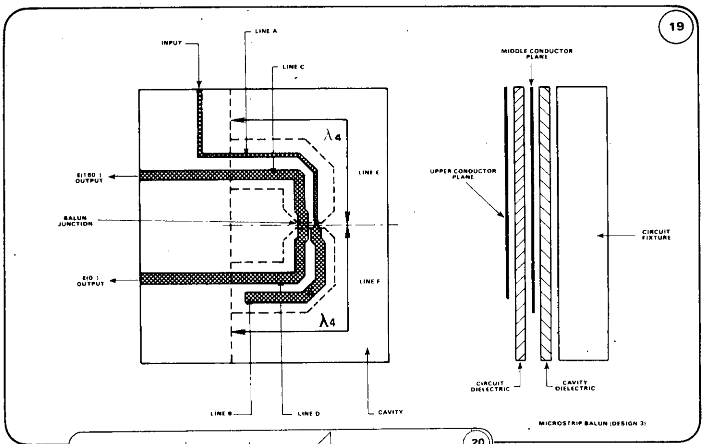
DESIGN 3 COAXIAL BALUN

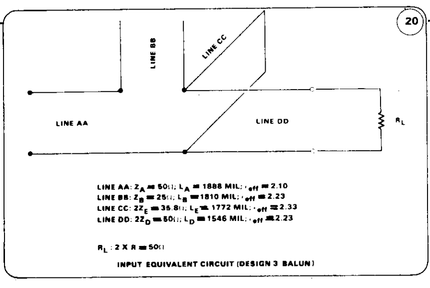


BALUN EQUIVALENT CIRCUIT (DESIGN 3)

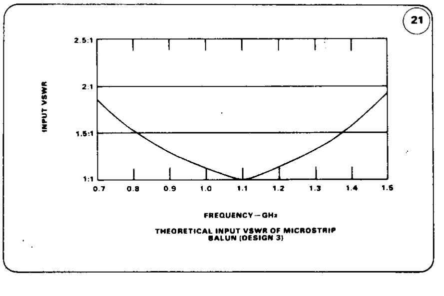
18. The equivalent circuit of the Design 3 coaxial version balun shows lines C and D connected to place their input signals in antiphase, thereby producing two antiphase signals at their outputs. Transmission line impedances and lengths are optimized to achieve the correct input/output transformation ratio and a good match across the desired bandwidth. If only one frequency or a narrow bandwidth is desired, and all lengths are λ/4, the matching condition $Z_A^2/50 = 2Z_C^2/R$, will occur. In this case, Z_E ($Z_E = Z_F$) and Z_B have no significance except for loss.

19. The coplanar arrangement of input and output lines can be accomplished with microstrip technology. The uppermost conductor plane contains input line A, output lines C and D, and the open stub B. Coupling between these lines is avoided by separating them by at least one line width. The middle conductor carries the ground plane for the lines. To avoid radiation loss, the center conductor must extend at least one line width to either side of the upper plane circuit line. The balun resonant cavity is formed by the region between the middle and the lower conductor planes. A hole for the cavity is cut in the circuit fixture, filled with dielectric, and covered with the middle conductor plane. The end-to-end length of the cavity is nominally a half-wavelength at midband. To avoid disturbance of the field distribution, the cavity width must be at least three times the width of the middle conductor plane. The arms of the balun cavity are folded to produce two parallel and proximate output transmission lines. This configuration is more suited to coupling two transistors than the original layout in which the two outputs were on opposite sides (Fig. 17).





20. The input equivalent circuit for the microstrip version of the Design 3 balun allows its theoretical performance to be calculated. The design parameters shown provide a microstrip circuit that can be compared with the coaxial baluns of Design 1 and Design 2. Transmission line A and lines C and D are loaded by their characteristic impedances—in this case, 50 and 25 ohms. The cavity and the stub impose the principal frequency limitation. The impedances of these elements are dictated by the properties of the available dielectric substrates (glass-Teflon 0.020 and 0.0625 inches thick).

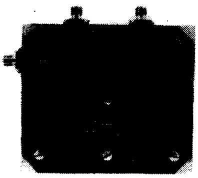


21. The input VSWR can be calculated based on the equivalent circuit for the microstrip balun. For a one-octave bandwidth, the input VSWR is lower than 1.75:1. This calculated performance is similar to that of the two previous balun designs. The design of the microstrip has theoretically perfect balance.

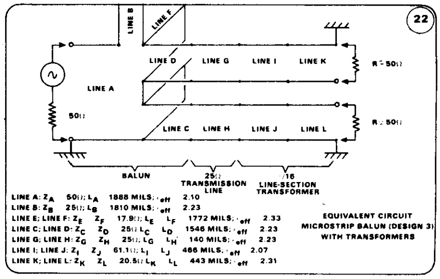
References

1. "35/50 Watt Broadband (160-240 MHz) Push-Pull TV Amplifier Band III," TRW Application Note, TRW RF Semiconductors Catalog No. 97, p. 84AN.
2. "150 W Linear Amplifier 2 to 28 MHz, 13.5 Volt DC," TRW Application Note, TRW RF Semiconductors Catalog No. 97, p. 108AN.
3. TRW Application Notes on the TPM-4100 (100 W, 100 - 400 MHz); the TPM-4040 (40 W, 100 - 400 MHz); the TPV-3100 (110 W, Band III); and the TPV-5050 (50 W, UHF), available from TRW RF Semiconductors.
4. The program used for the circuit calculation was COMPACT (Computerized Optimization of Microwave Passive and Active Circuits).
5. Gordon J. Laughlin, "New Impedance-Matched Wideband Balun and Magic Tee," *IEEE Transactions: Microwave Theory and Technology*, Vol. MTT-24, No. 3, (March 1976).

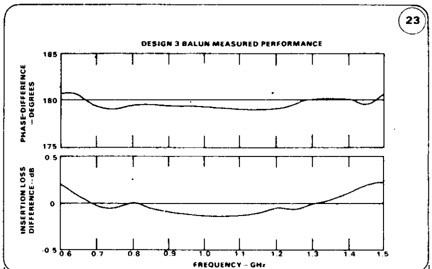
22. The equivalent circuit of the microstrip balun shows it during performance measurements with λ/16 matching lines. The experimental model uses 18-mil glass-Teflon (ϵ_r = 2.55) for the tap circuits and 62.5 mil glass-Teflon for the cavity. Balance properties were measured with a 50-ohm system, which was transformed to 25 ohms by the λ/16 line-section Chebyshev impedance transformers, which have a bandwidth from 0.960 to 1.215 GHz.



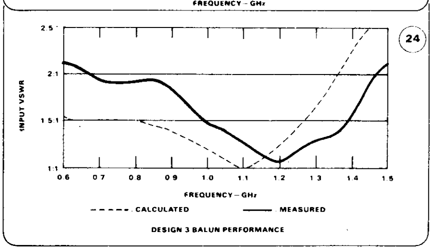
The experimental microstrip balun showing the uppermost conductor plane.



23. The unbalance between output ports for a one-octave bandwidth is shown in the measured 1.5-degree maximum phase difference and 0.15-dB maximum insertion loss difference.



24. The central frequency is 10 percent higher than expected, but response is close to the calculated values if relative frequency is considered. If the output transformers and their effect on input VSWR are disregarded, an octave bandwidth with a maximum input VSWR of around 2.0:1 can be obtained. The 100-MHz shift between the two curves may be caused by the improper determination of the folded cavity's electrical length. Similar calculation inaccuracies may arise from effects at the balun junction and from the electrical length of the stub. As in the calculated response, the experimental microstrip balun performs comparably to the two coaxial designs.



25. The similarity in the performance of the three balun designs within the considered frequency bands indicates that the parasitic elements do not significantly affect the theoretical properties. The frequency limit is higher than 1.5 GHz for all three. In the 0.960-to-1.215-GHz bandwidth (TACAN and DME applications), each performed with satisfactory balance. The table compares the main characteristics of the balun designs.

The phase differences (±1.5 degrees) for all three baluns are similar to those experienced with the miniature 3-dB hybrid couplers that are normally used to combine transistors for microwave balanced amplifiers. But the insertion loss differences of the baluns are better—0.2 dB for a one-octave bandwidth compared with 0.5 dB.

The physically simple microstrip balun eliminates the connection problem inherent in coaxial designs: physical variances that breed standing waves and unbalance. Microstripping the transmission lines allows a designer to choose any value of characteristic impedance of the lines. Consequently, the microstrip balun is both more manageable and more controllable.

Since the balun load impedance will vary with frequency, the best results will be obtained by simultaneously optimizing the balun parameters with those of the matching network. The transistor's internal prematching network must be considered.••

SUMMARY

Performance of the Three Balun Designs

(25)

Type of balun	Balun loads, R (ohms)	Maximum experimental unbalance for one-octave bandwidth		Theoretical input VSWR for:	
		$\Delta\phi$(°)	ΔMAG (dB)	960-1215 MHz	One-octave bandwidth
Coaxial I (Design 1)	25	3	0.2	1.15:1	1.6:1
Coaxial II (Design 2)	6.25	1	0.2	1.15:1	1.6:1
Microstrip (Design 3)	25	1.5	0.2	1.20:1	1.8:1

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