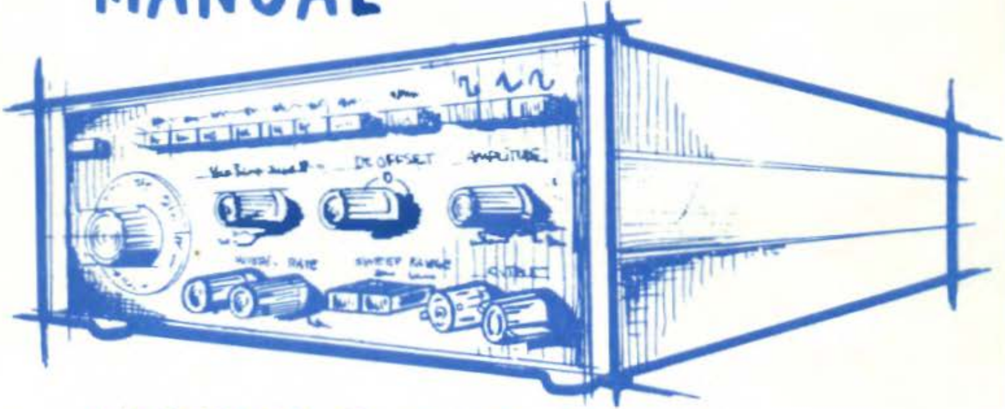
EXACT®

INSTRUCTION MANUAL



MODELS 119 & 121 FUNCTION GENERATOR

INSTRUCTION MANUAL

MODELS 119/121

FUNCTION GENERATORS

EXACT ELECTRONICS, INC.

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EXACT electronics, inc.

WARRANTY

Exact warrants its instruments to be free from defects in material and workmanship under normal use for a period of twelve months from the original date of shipment. Exact's obligation is limited to repair or replacement.

All repairs and replacements made under this warranty are F.O.B. Exact's factory or designated service depot unless otherwise authorized by Exact. This warranty is made on condition that prompt notice of defect is given to Exact, in writing, within the warranty period and that Exact shall have the sole right to determine whether in fact a defect exists.

This Warranty does not apply to any instrument which has been repaired or altered by other than Exact's own service representative so as, in Exact's judgment, to adversely affect it, nor which has been subject to misuse, negligence or accident or which has been operated contrary to sound practice or operating instructions.

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SECTION 1

GENERAL DESCRIPTION

INTRODUCTION

The Exact Models 119 and 121 Sweep-Function Generators provide square, triangle, sine, ramp, and pulse waveforms over a frequency range of 0.2 Hz to 2 MHz, (0.02 Hz to 200 kHz with option B) plus a VCF (voltage-controlled-frequency) input, variable DC Offset and TTL Pulse output. The MODEL 121 has an internal sweep generator that provides a linear sweep from 1 ms to 10 sec for sweeping the main generator over three decades (1000:1). A ramp sync output and auxiliary ramp output are also provided. The 119M includes an AM input for modulating or controlling the amplitude.

MECHANICAL DESCRIPTION

Case/Top and Bottom Covers

The instrument case is made of lightweight plastic. The top and bottom covers are made of ABS plastic for extreme ruggedness and flexibility. Front and rear bezels are made of Lexan 500 for maximum strength and rigidity. The instrument requires no ventilation holes because of its low power consumption.

Front Panel

The main output and all controls are on the front panel. They are: the pushbutton POWER switch, power ON indicator, seven frequency RANGE pushbutton switches, three pushbutton FUNCTION switches, RAMP/PULSE INVERT pushbutton switch, frequency MULTIPLIER (variable), VAR RAMP/PULSE potentiometer, DC OFFSET control, and output AMPLITUDE control, OUTPUT HI, and OUTPUT LO. The MODEL 121 includes a sweep WIDTH control, sweep RATE control, and two SWEEP RANGE pushbutton switches. The MODEL 119M includes an AM switch, MODULATION control, and a CARRIER control.

Rear Panel

On the rear panel are the power cord, fuse, VCF (Voltage-controlled-frequency) input, TTL pulse output, ramp sync output (121), aux ramp output (121), and AM input (119M).

Printed Circuit Boards

MAIN GENERATOR: All circuitry, the power supply, and power transformer are on the main P.C. board. All controls, the POWER switch, and ON indicator are also on the main P.C. board.

SWEEP GENERATOR: The internal sweep generator in the MODEL 121 is on a separate P.C. board mounted to the front bezel. All sweep controls are mounted on the sweep board.

AMPLITUDE MODULATOR: The amplitude modulator in the MODEL 119M is on a separate P.C. board mounted to the front bezel. All AM controls are mounted on this board.

SPECIFICATIONS

Specifications are listed below in Table 1-1. Test procedures for verification of specification are given in Section 3.

Table 1-1 Specifications

Main Generator:	
Frequency Range:	0.2 Hz to 2 MHz (7 ranges) Option B: 0.02 Hz to 200 kHz
Frequency Accuracy:	±5% of full scale
VCF (Voltage Controlled Frequency):	Approx. 0 to 10 volt input for 1000:1 (3 decades) frequency ratio. Input impedance – Approx. 10 KΩ

Main Output *(50Ω):

Waveforms – Sine, triangle, square, pulse, and ramp

Amplitude – $\geq$20V P-P open circuit
$\geq$10V P-P into *50Ω

**Attenuation – 30 dB continuously variable plus 30 dB for the *LO output

DC Offset – (variable)
+10 to −10 volts open circuit
+5 to −5 volts into *50Ω

NOTE: The output signal will be automatically clipped for protection if the DC offset plus the signal exceeds the maximum peak voltage.

Sine Distortion – <1% 0.2 Hz to 200 kHz, typically <0.5% −30 dB 200 kHz to 2 MHz (all harmonics) measured at full output, between 0.2 and 2.0 on the dial.

Sine Frequency Response – <0.1 dB 0.1 Hz to 200 kHz <0.5 dB 200 kHz to 2 MHz

Squarewave – Rise Time – <100 nsec

Abberations – <5% max P-P amplitude

*Option K is 600Ω and has no LO output.

**Option A is 30 dB continuously variable plus a 0-20-40 dB switch

Pulse Output:

TTL Compatible:

Amplitude Fixed, >+3V open circuit. <25 nsec rise time. Will sink 20 TTL loads.

AM: (119M)

AM

Approximately 100K input impedance. DC coupled.

Approximately 5V P-P for 100% AM. In the AM mode, other specifications are not valid.

Sweep Generator: (121)

Sweep Rate Range:
1 ms to 10 s (2 ranges)

Sweep Rate Accuracy:
±10% (Cal Position)
100:1 Variable

Sweep Width:
Continuously variable to 1000:1 (3 decades)

Ramp Reset Time:
Approximately 15% of range.

Power Requirements:
−115 VAC ±10% or 230 VAC ±10% 50/60 Hz. Approx. 5 watts. (can be wired for other voltages)

Physical Characteristics:
7⅜″ wide x 2⅞″ high x 8½″ deep. Weight – Approx. 2 lbs.

NOTE: (unless otherwise stated).
Specifications apply 10% to maximum output voltage, terminated into the rated load impedance, between 0.2 and 2 Multiplier settings.

Specifications are valid at 25°C ±5°C after 1 hour warmup time.

Specifications are NOT valid in AM mode.

SECTION 2

INSTALLATION AND OPERATION

UNPACKING AND INSPECTION

The MODEL 119 and 121 FUNCTION GENERATORS are packaged to absorb any reasonable shock encountered during shipping.

Carefully remove the instrument from the shipping container and inspect for shipping damage. If damage is found, SAVE THE SHIPPING CONTAINER and notify the carrier immediately.

AC POWER REQUIREMENTS

These Models operate on line voltages of 100, 115, 200, and 230 VAC ±10% 50-60 Hz. Power requirements are typically 5 watts.

Unless specifically ordered otherwise, the instrument is wired for 115 VAC.

To operate the instrument at a different line voltage, it is necessary to change one or two jumpers on the P.C. board. Perform the following steps:

A. With the instrument unplugged, remove the top and bottom covers as described under dissassembly steps, Section 5.

B. From Figure 6-3 select the jumper or jumpers corresponding to the desired line voltage of operation.

C. Remove the jumpers previously installed in the P.C. board (Fig. 6-2).

D. Install the jumpers corresponding to the desired line voltage.*

E. From Figure 6-3 select the proper terminal number for the white wire from the power cord (no. 5 or no. 6).

F. If the white wire needs to be moved, unsolder it and resolder to the appropriate eyelet indicated on Figure 6-3.

WARNING

***BE SURE TO INSULATE JUMPERS TO PREVENT SHOCK HAZARD.**

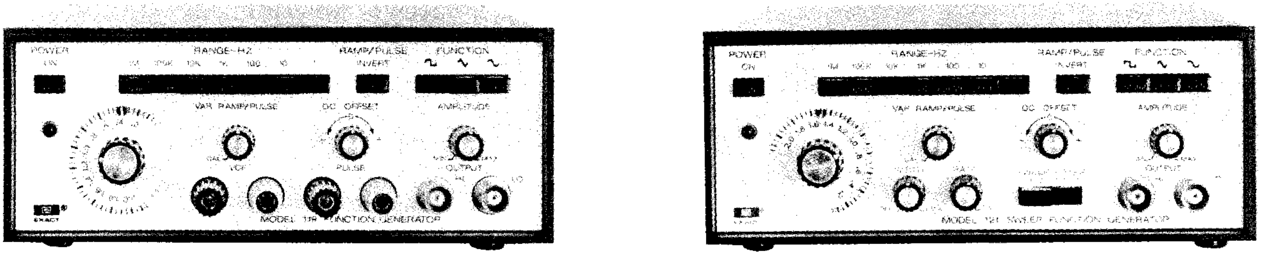


Fig. 2-1 Controls and Indicators

CONTROLS AND INDICATORS (Fig. 2-1)

POWER Switch

The power switch applies power.

Power ON Indicator

A light emitting diode (LED) indicates when power is applied. Because the LED is a solid-state device, its life expectancy, like most other solid-state devices, is indefinite.

RANGE Switch

Seven fixed decades of frequency are provided by the RANGE pushbutton switch. The seven switches are interlocking. Depressing one pushbutton will release all others.

FUNCTION Switch

Three interlocking pushbutton switches select the desired output waveform. Depressing one switch releases the switch previously depressed. Square, triangle, and sine waveforms are provided, satisfying most applications. By only partially depressing a switch, all three switches can be disengaged simultaneously. This allows using the generator output as a DC source controlled by the DC OFFSET pot.

MULTIPLIER

The MULTIPLIER is a variable potentiometer allowing frequency settings between fixed ranges. Although the dial skirt is calibrated from 0.2 to 2.0, the dynamic range of the MULTIPLIER dial is 1000:1 (three decades). For example, this allows frequency settings between 200 kHz and 200 Hz without changing ranges. NOTE: This is necessary when sweeping up in frequency over a three decade range 1000:1. For further information concerning sweeping refer to Section 4 (Summing Amplifier).

HI OUTPUT

Square, triangle, sine, ramp, and pulse waveforms are provided at up to 20V P-P amplitude (open circuit) at the HI OUTPUT.

LO OUTPUT

The LO OUTPUT is 30 dB down from the HI OUTPUT. In combination with the 30 dB provided by the amplitude control this provides a maximum attenuation of 60 dB.

Option A replaces the 2 outputs with one output and adds a 0-20-40 dB attenuator switch.

Option K changes the output impedance to 600Ω and replaces the 2 BNC outputs with a single output pair of 5-way binding posts.

AMPLITUDE

The AMPLITUDE control provides 30 dB attenuation of the output waveform.

DC OFFSET

A DC OFFSET control allows setting the DC level of the OUTPUT waveforms as desired. The OFF position disconnects the DC OFFSET control.

NOTE: If the amount of offset plus the waveform amplitude exceeds the maximum P-P amplitude, automatic clipping will occur. By disengaging all three waveforms, the DC OFFSET acts as a variable power supply control for the generator output.

VCF INPUT

A VCF (voltage-controlled-frequency) input is provided for externally sweeping or controlling the frequency. Approximately +10V applied at the VCF input will sweep the generator frequency down three decades (1000:1). The generator may also be swept up in frequency by applying a negative voltage at the VCF input. This input can also be used to fine-tune frequency or to frequency modulate.

VARIABLE RAMP/PULSE

Time symmetry of the OUTPUT waveforms, including the TTL PULSE output, is controlled by the VAR RAMP/PULSE potentiometer.

When this control is set to the CAL position, the time symmetry of the output waveforms is 50/50 (approximately 100% symmetrical).

This control allows the time period of one-half the waveform to be changed while the other half remains fixed as determined by RANGE and MULTIPLIER settings. This unique feature provides ramp waveforms, variable pulse width and variable duty cycle pulses, and skewed sinewaves.

RAMP/PULSE INVERT

A pushbutton switch inverts the time symmetry set by the VARIABLE RAMP/PULSE control.

Table 2-1 illustrates the effect of the RAMP/PULSE INVERT switch and VAR RAMP/PULSE control.

PULSE OUTPUT

The PULSE OUTPUT is suitable for driving TTL logic. The rise- and fall-time is typically 15 ns. The pulse width and repetition rate may be set as desired, by using the RANGE, MULTIPLIER, and VARIABLE RAMP/PULSE controls. The symmetry of the PULSE output is controlled the same way as the output waveforms described in Table 2-1.

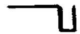
Ramp/Pulse Invert Switch	Variable Ramp Pulse Control	MAIN OUTPUT Square	Triangle	Sine	Pulse Output
Out	Cal				
In	Cal				
In	Max CW				
Out	Max CW				

Table 2-1 Variable Ramp/Pulse Control

NOTE: The time symmetry illustrated above is for reference only. Any desired time-symmetry ratio may be set within the limits described in Section 4 (Var Ramp/Pulse).

AM (Model 119M only)

A pushbutton switches the Modulator in or out. When the AM is on, specifications for distortion, symmetry, and output amplitude are not valid.

CARRIER (Model 119M only)

The CARRIER control allows the carrier level to be adjusted and its phase inverted. This provides full four quadrant and double-sideband suppressed-carrier capabilities. The AM switch must be engaged.

MODULATION (Model 119M only)

The MODULATION control adjusts the AM input sensitivity. The AM switch must be engaged.

AM INPUT (Model 119M only)

The AM INPUT allows remote amplitude control and Amplitude Modulation of the carrier. Approximately 5V of either polarity will provide full output during remote amplitude control; approximately 10V P-P is required for full double-sideband suppressed-carrier modulation; and approximately 5V P-P is required for 100% AM. The input impedance is 100K ohms.

WIDTH (Model 121 only)

The width control sets the sweep width as desired up to a three decade (1000:1) range.

RATE (Model 121 only)

This control adjusts the sweep rate over a two decade (100:1) range.

SWEEP RANGE (Model 121 only)

Two pushbutton-selected ranges allow 1 ms to 10 sec. sweep rates.

RAMP OUTPUT (Model 121 only)

The Ramp Output signal is a negative sweep waveform of approximately −2.5V peak. The Ramp Time is set by the sweep RATE and sweep RANGE controls.

RAMP SYNC OUTPUT (Model 121 only)

The RAMP SYNC output is a positive pulse of approximately +5V coincident with the reset time of the sweep waveform.

NOTE: The VCF input and PULSE output on the MODEL 119 are front-panel binding posts. On the 119M and 121 these are rear-panel banana jacks.

FIRST TIME OPERATION

NOTE: Before applying power be sure the proper line voltage is available. Plug the power cord into the proper source of 115 VAC 50-60 Hz. All instruments are wired for 115 VAC unless otherwise ordered from Exact. The proper procedure for rewiring is described in Section 2 (AC Power Requirements). Set the controls as follows:

RANGE-HZ	10K	
MULTIPLIER	2.0	
FUNCTION	∿	
VAR RAMP/PULSE	CAL	
AMPLITUDE	MAX	
OFFSET	OFF	
WIDTH	OFF	MODEL 121 ONLY
ATTENUATOR (Option A)	0 dB	
AM	OFF	} MODEL 119M ONLY
CARRIER	'0'	} MODEL 119M ONLY
MODULATION	OFF (CCW)	} MODEL 119M ONLY

MAIN OUTPUT

Connect an oscilloscope to the HI OUTPUT.

Observe a 20V P-P 20 kHz triangle waveform.

FUNCTION SWITCH

Select and observe a 20V P-P squarewave and sinewave.

AMPLITUDE CONTROL

Rotate the AMPLITUDE vernier from maximum to minimum and observe at least 30 dB of attenuation.

ATTENUATOR SWITCH (OPTION A)

Reset the AMPLITUDE control to maximum. Change the ATTENUATOR to 20 dB, observe a 10X voltage reduction, change it to 40 dB and observe an additional 10X voltage reduction (100X total). Reset ATTENUATOR to 0 dB.

LO OUTPUT (Except with A or K options)

Connect the oscilloscope to the LO OUTPUT and observe the signal level 30 dB lower than the HI OUTPUT level.

DC OFFSET

Reconnect the oscilloscope to the HI OUTPUT and select the triangle waveform. Rotate the DC OFFSET control and observe the peaks will "clip" when the DC OFFSET plus the peak amplitude exceeds ±10V.

Reduce the output amplitude and observe that the DC OFFSET may be increased by the same amount the peak amplitude has been decreased.

Return the DC OFFSET to OFF and the AMPLITUDE to maximum.

VAR RAMP/PULSE CONTROL

While observing the triangle waveform on the oscilloscope, rotate the VAR RAMP/PULSE control CW from the CAL position.

Observe that one slope of the triangle remains constant while the other slope is variable over a 20:1 range (typical), producing a ramp waveform.

RAMP/PULSE INVERT SWITCH

Depress the RAMP/PULSE INVERT pushbutton. The positive and negative slopes of the ramp waveform reverse (invert).

By selecting the squarewave and repeating the same procedure, the MODEL 119 and 121 FUNCTION GENERATORS become

very versatile pulse generators. The pulse width may be determined by the following formula:

PULSE WIDTH = the reciprocal of 2 x freq. setting.

In other words, the pulse width equals one-half the time period of the frequency set by the RANGE and MULTIPLIER controls.

The time symmetry of the sinewave may be set in the same manner, providing additional versatility.

NOTE: The VAR RAMP/PULSE control and RAMP/PULSE INVERT switch provide the same flexibility for the PULSE output.

PULSE OUTPUT

Connect the oscilloscope to the PULSE output. By adjusting the generator frequency, the VAR RAMP/PULSE control and the RAMP/PULSE INVERT switch, the highspeed TTL pulse may be used as a very versatile pulse generator. With the RAMP/PULSE switch in the NORM position (out), the pulse width "on time" is determined by the RANGE and MULTIPLIER settings and the repetition rate "off time" is set by the VAR RAMP/PULSE control.

NOTE: When the RAMP/PULSE INVERT switch is set to INVERT, the pulse "off time" is determined by the RANGE and MULTIPLIER setting and the pulse "on time" is set with the VAR RAMP/PULSE control.

AM (Model 119M only)

Connect the oscilloscope to the HI OUTPUT and set the generator for a 200 kHz sinewave. Observe a 20V P-P 200 kHz sinewave.

Now engage the modulator by depressing the AM pushbutton. Observe a 200 kHz sinewave at a reduced amplitude. The amount of reduction will depend on the CARRIER setting.

CARRIER (Model 119M only)

Externally trigger the oscilloscope from the 119M PULSE OUTPUT (rear panel). Vary the CARRIER control. Observe that the waveform is at minimum amplitude when CARRIER is centered ('0') and at maximum amplitude when CARRIER is fully CW or fully CCW. Also observe phase reversal as the CARRIER control passes through '0.'

MODULATION (Model 119M only)

Adjust CARRIER for 5V P-P output. Apply a 5V P-P 400 Hz triangle or sinewave to the 119M rear-panel AM input. Rotate MODULATION clockwise and observe a 200 kHz carrier modulated by a 400 Hz tone. Note that the MODULATION control sets the modulation percentage. Rotate CARRIER to '0' and observe a double-sideband suppressed-carrier signal.

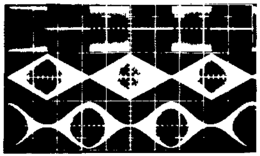
REMOTE CONTROL OF AMPLITUDE (Model 119M only)

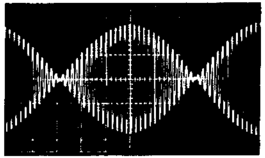
With the AM pushbutton disengaged, set up the generator for the frequency, waveforms, and maximum amplitude desired.

Engage the AM pushbutton. With the MODULATION control off (CCW), adjust the carrier control for minimum output.

Apply your maximum external control voltage to the rear panel AM input, and slowly increase the MODULATION control setting until the desired maximum output signal is obtained. Note: When the MODULATION control is set to MAX (CW), approximately 5V of either polarity will produce the maximum output signal.

By using a Digital-to-Analog Converter (DAC) between a computer port and the 119M AM input, you can program the amplitude with the computer. (A second DAC could be used with the VCF input for frequency control).





SWEEP RANGE (Model 121 only)

Connect the oscilloscope to the auxiliary RAMP OUTPUT on the rear panel.

Select the 1 ms SWEEP RANGE. Set the rate control to the CAL position (MAX CW). Observe a negative sweep waveform with approximately 1 ms ramp time.

RATE (Model 121 only)

Rotate the rate control and observe the ramp duration is variable from 1 ms to 100 ms. Select the 100 ms sweep RANGE and observe the ramp duration is adjustable from 100 ms to 10 sec.

WIDTH (Model 121 only)

Connect the oscilloscope to the MAIN OUTPUT and observe a 20 kHz triangle waveform. Select the 100 ms SWEEP RANGE and set the sweep rate to mid position (approx 1 sec). Set the Multiplier to 0.2 and RANGE to 10 kHz (2 kHz).

Rotate the sweep WIDTH control CW from the off position. By setting the sweep width properly, the main generator will sweep from 2 kHz to 20 kHz at approximately a 1 Hz rate. (As set by the RATE and SWEEP RANGE setting).

By setting the Multiplier to <0.2 and increasing the sweep WIDTH control setting, the generator will sweep a three decade (1000:1) range.

RAMP OUTPUT (Rear Panel Model 121 only)

Connect the oscilloscope to the ramp output on the rear panel and observe a negative ramp (sweep waveform).

RAMP SYNC OUTPUT (Rear Panel Model 121 only)

Connect the oscilloscope to the Ramp Sync output on the rear panel and observe a positive pulse coincident with the ramp fall time.

SECTION 3

SPECIFICATION VERIFICATION

GENERAL

This procedure will ensure that the instrument is operating properly and within its specifications. If any reading is not within tolerance, refer to the Calibration Procedure.

If the instrument fails to operate properly, refer to the Troubleshooting Procedure.

PREPARATION

Allow at least 30 minutes warm-up time before checking specifications or attempting to re-calibrate.

PROCEDURE

Connect the test equipment as shown in the table for each accuracy check. Set all controls as indicated in each table and perform the measurements as called out in each case.

EQUIPMENT

Table 3-1 is a list of test equipment necessary for complete specification verification or calibration.

Table 3-1 Required Test and Calibration Equipment

EQUIP	REQUIRED SPECS
Oscilloscope	Bandwidth >20 MHz Rise Time <10 ns Vert. Accuracy ±3% Horzi. Accuracy ±5%
Frequency Counter	Freq. Accuracy ±.1% Freq. Response >10 MHz
Voltage Source	>10V Output (Variable) Well Regulated
Distortion Analyzer	Freq. Response >100 KHz Residual Distortion <.1%

Set controls as indicated below for all accuracy checks unless indicated otherwise in the table.

POWER	ON	
RANGE	REFER TO TABLES	
MULTIPLIER	REFER TO TABLES	
RAMP/PULSE	NORM (OUT)	
FUNCTION	∿	
VAR RAMP/PULSE	CAL (MAX CCW)	
DC OFFSET	OFF	
AMPLITUDE	MAX (MAX CW)	
ATTENUATOR (Option A)	0 dB	
WIDTH	OFF	MODEL 121 ONLY
RATE	CAL	MODEL 121 ONLY
SWEEP RANGE	1 ms	MODEL 121 ONLY
AM	OFF	MODEL 119M ONLY
CARRIER	'0'	MODEL 119M ONLY
MODULATION	OFF	MODEL 119M ONLY

Table 3-2 Frequency Accuracy

Range	Mult.	Frequency Setting	Measured Frequency Max. Min.	Time Period Should Be	Measured Time Period Max. Min.
1M*		2.0 MHz	2.10 to 1.90 MHz	0.50 μs	0.526 to 0.476 μs
100K		200 kHz	210 to 190 kHz	5.0 μs	5.26 to 4.76 μs
10K		20 kHz	21.0 to 19.0 kHz	50 μs	52.6 to 47.6 μs
1K	2.0	2.0 kHz	2.10 to 1.90 kHz	0.50 ms	0.526 to 0.476 ms
100		200 Hz	210 to 190 Hz	5.0 ms	5.26 to 4.76 ms
10		20 Hz	21.0 to 19.0 Hz	50 ms	52.6 to 47.6 ms
1		2.0 Hz	2.10 to 1.90 Hz	0.50 sec	0.526 to 0.476 sec
1M*		200 kHz	300 to 100 kHz	5.0 μs	3.33 to 10.0 μs
100K		20 kHz	30 to 10 kHz	50 μs	33.3 to 100 μs
10K		2.0 kHz	3.0 to 1.0 kHz	0.5 ms	0.333 to 1.0 ms
1K	0.20	200 Hz	300 to 100 Hz	5.0 ms	3.33 to 10.0 ms
100		20 Hz	30 to 10 Hz	50 ms	33.3 to 100 ms
10		2.0 Hz	3.0 to 1.0 Hz	0.50 s	0.333 to 1.00 s
1		0.20 Hz	0.30 to 0.10 Hz	5.00 s	3.33 to 10.0 s

(Continued on Next Page)

*There is no 1M range with option B.

Table 3-2 Frequency Accuracy (Continued)

Range	Mult.	Frequency Setting	Measured Frequency Max. Min.	Time Period Should Be	Measured Time Period Max. Min.
1M*	1.0	1000 kHz	1100 to 900 kHz	1.00 μs	1.11 to 0.909 μs
100K		100 kHz	110 to 90 kHz	10.0 μs	11.1 to 9.09 μs
10K		10 kHz	11.0 to 9.0 kHz	100 μs	111 to 90.9 μs
1K		1000 Hz	1100 to 900 Hz	1.00 ms	1.11 to 0.909 ms
100		100 Hz	110 to 90 Hz	10.0 ms	11.1 to 9.09 ms
10		10 Hz	11.0 to 9.0 Hz	100 ms	111 to 90.9 ms
1		1.0 Hz	1.10 to 0.90 Hz	1.00 s	1.11 to 0.909 s

*There is no 1M range with option B.

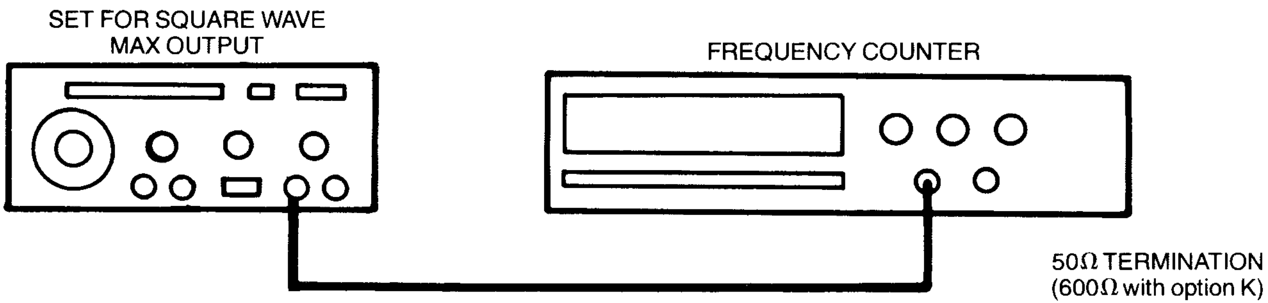


Table 3-3 Frequency Range

Range	Multiplier	Frequency Must Be	Time Period Must Be
1M*	Max CW	>2.00 MHz	<0.500 μs
1	<0.20	<0.2000 Hz	>5.000 s

*Use the 100k range on instruments with option B. (>200 kHz <5.0 μs)

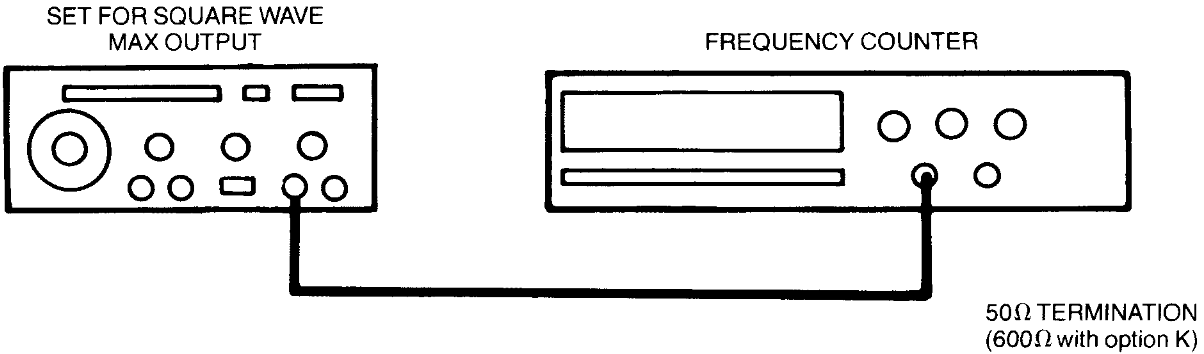


Table 3-4 VCF (Voltage Controlled Frequency)

Range	Mult.	VCF Input Voltage	Voltage Tolerance	Measured Frequency	Measured Time Period
100K	2.0	0V	±250 mV	200 kHz ±5%	5.0 μs ±5%
100K	2.0	See Note: +10 VDC	±1 VDC	200 Hz ±5%	5.0 ms ±5%

Note: Apply a Positive Voltage at the VCF input (Approx +10 VDC) until a Frequency of 200 Hz ±5% is obtained.

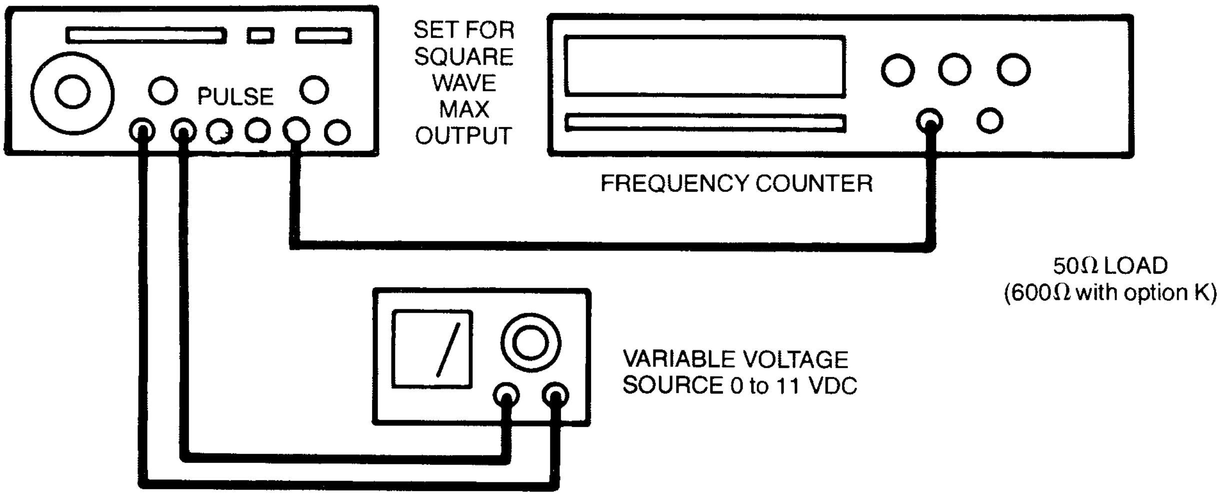


Table 3-5 Main Output Amplitude

Range	Mult	Function	Amplitude	vpp Voltage Tolerance	Output Load
1K	2.0	⎍	Max (CW)	≥20 V P-P	Open Ckt
		∧		≥20 V P-P	
		∿		≥20 V P-P	
		⎍	Min (CW)	≤632 mV P-P	
		∧		≤632 mV P-P	
		∿		≤632 mV P-P	

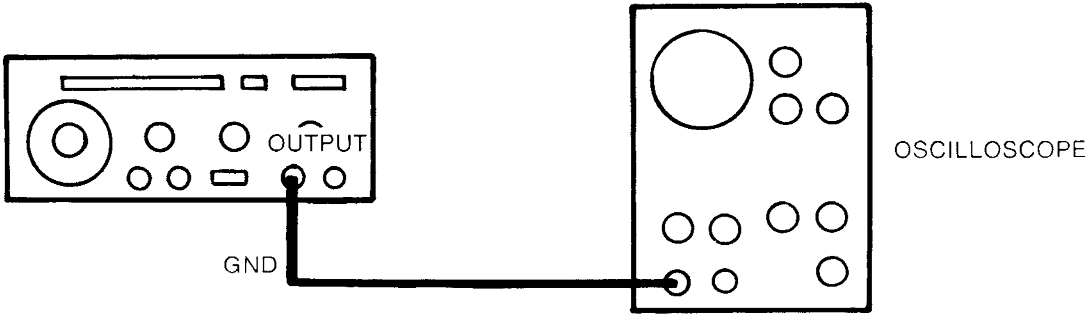


Table 3-6 DC Offset (Main Output)

Range	Mult	Function	Amplitude	DC Offset	Output Voltage Tolerance
1K	2.0	∿	Min (CCW)	Max CW +	≥10 VDC Open Ckt
				Max CCW − but NOT "OFF"	≥−10 VDC Open Ckt
				Max CW +	≥5 VDC into 50Ω Load (600Ω load with option K)
				Max CCW − but NOT "OFF"	≥−5 VDC into 50Ω Load (600Ω load with option K)

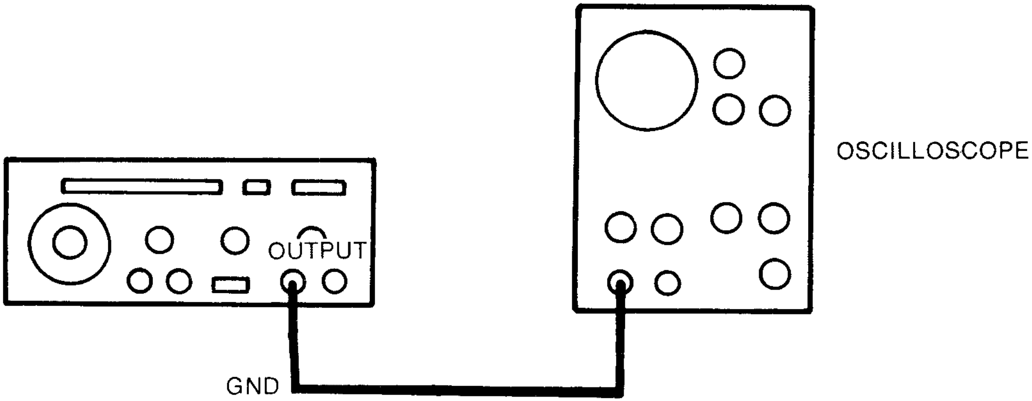


Table 3-7 Sine Distortion

Range	Mult	Function	Measured Sine Distortion	
100K	2.0	∼	<1% Sine Distortion	
	0.20			
10K	2.0			
	0.20			
1K	2.0			
	0.20			
100	2.0			
	0.20			
10	2.0			
	0.20			
1	2.0			
	0.20			
1M*	2.0		All Harmonics >30 dB down	Note: Disconnect Distortion Analyzer
	0.20			Before Connecting Spectrum Analyzer

*There is no 1M range with option B.

(Continued on Next Page)

Table 3-7 Sine Distortion (Continued)

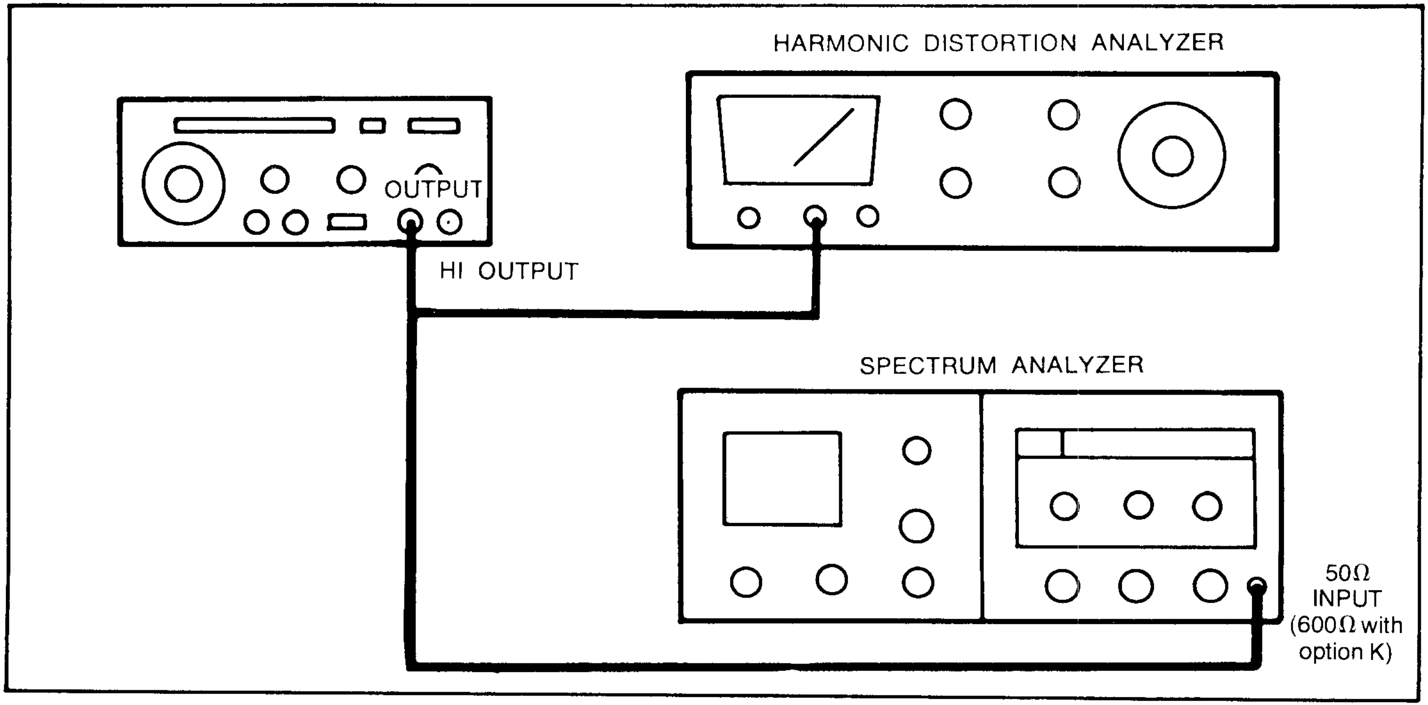
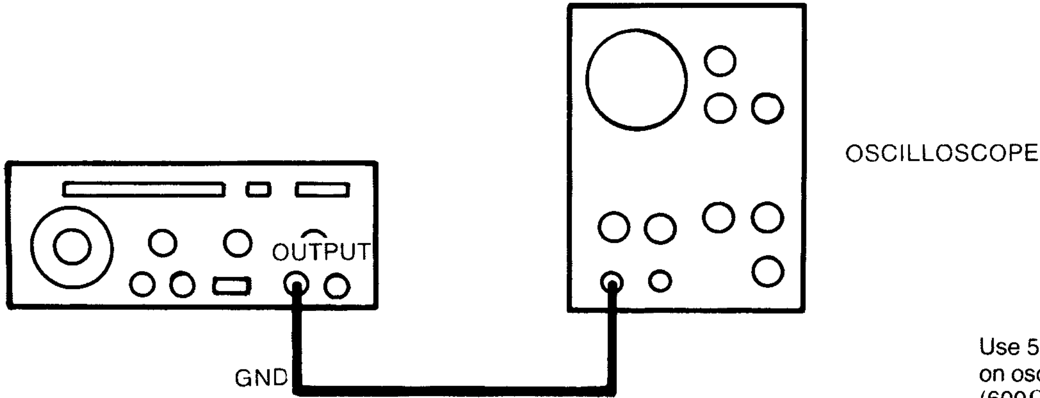


Table 3-8 Sine Frequency Response

Range	Mult	Amplitude	Sine Amplitude	Tolerance
10K	2.0	Max CW	Reference Value	
100K				Reference Value ±0.1 dB (±1.15%)
1M*				Reference Value ±0.5 dB (±5.92%)

*There is no 1M range with option B



Use 50Ω termination on oscilloscope input (600Ω with option K)

Table 3-9 Squarewave Rise and Fall Time

Range	Mult	Amplitude	Function	Rise Time	Fall Time	Square Aberrations
100K	2.0	10V P-P	⎍	<100ns	<100ns	<±5% of P-P Amp or ±0.5V

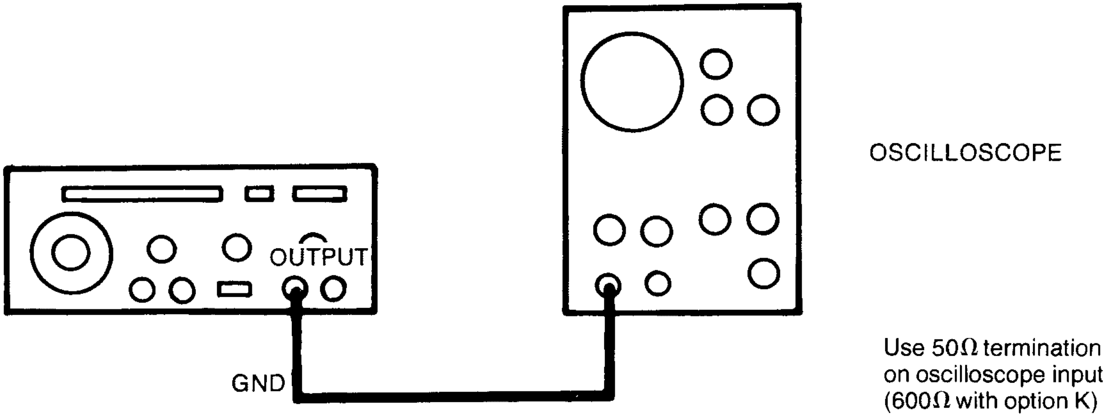


Table 3-10 Pulse Output

Range	Mult	Nominal	Pulse Amplitude Range	Maximum Transition Times	Pulse Output Load	Nominal Transition Times
100K	2.0	+3.5V 0V	>+3V <+0.8V	25 ns	Open Circuit	10 ns
		+5V +0.7V	>2.0V <+0.8V	25 ns	20 TTL Loads 131 Ω Res From Pulse Output to +5.0 VDC	15 ns

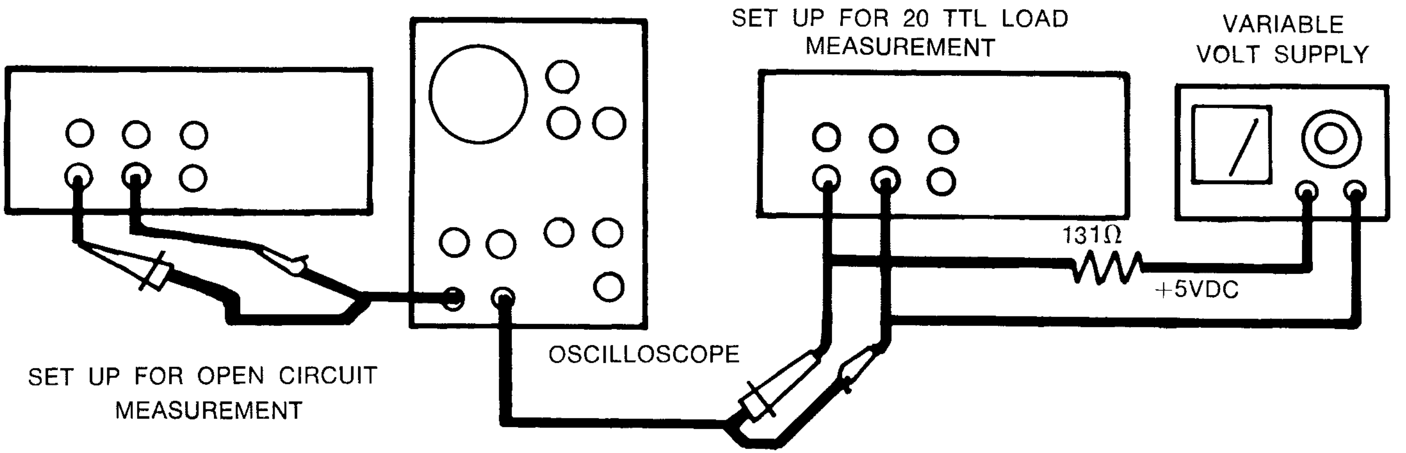


Table 3-11 Ramp Time (Sweep Generator)

Range	Rate	Time Interval Setting	Time Interval Range
1 ms	Cal	1 ms	1.1000 ms to 0.9000 ms
1 ms	Max CCW	>100 ms	>100 ms
100 ms	Cal	100 ms	110.00 ms to 90.000 ms
100 ms	Max CCW	>10 s	>10 s

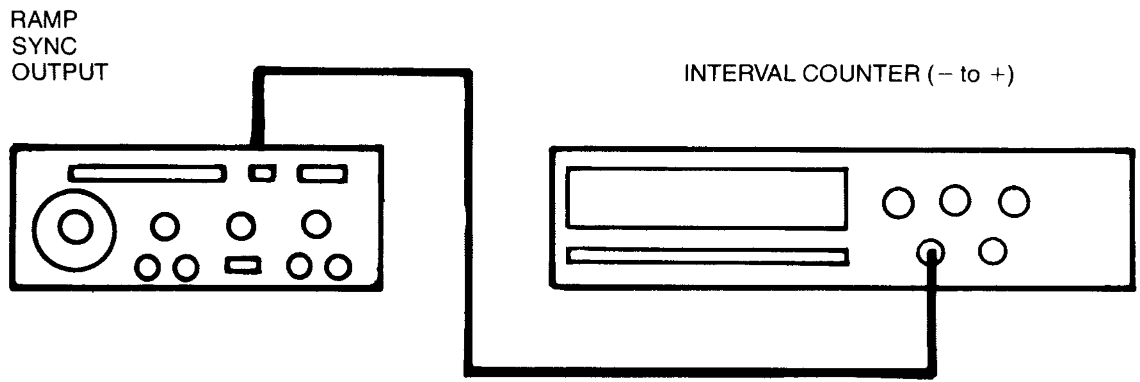


Table 3-12 Sweep Width (Sweep Generator)

Main Generator		Sweep Generator			Sweep Width	Main Generator Frequency
Range	Mult	Range	Rate	Width >1000:1		
100K	Max CCW	100 ms	Max CCW	Max	3 decades	<200 Hz to >200 kHz

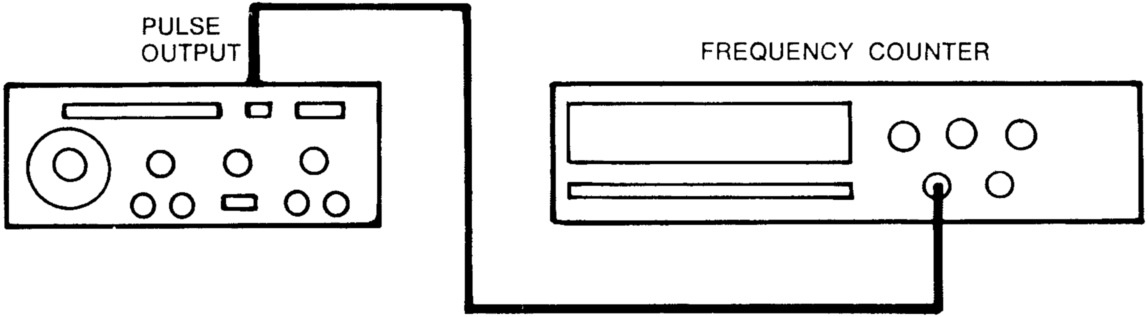
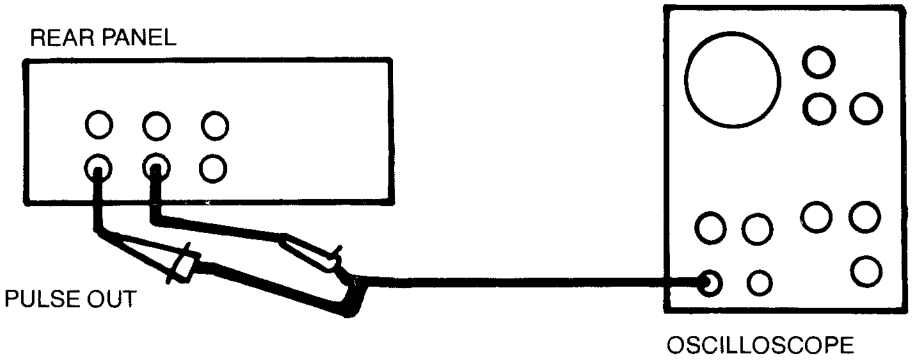


Table 3-13 Ramp Reset Time (Sweep Generator)

Range	Rate	Ramp Time	Reset Time	Reset Time
1 ms	CAL	1 ms ±10%	Approx. 15% of Ramp time	Approx. 150 μs
1 ms	Max CCW	>100 ms	Approx. 0.15% of Ramp Time	Approx. 150 μs



SECTION 4

THEORY OF OPERATION

GENERAL

This section describes the operation in detail as well as a brief description relating to the Block Diagram (See Section 6). The drawings contained in this section also supplement the schematics in Section 6.

MAIN GENERATOR:

A DC voltage from the MULTIPLIER potentiometer is applied to the Summing Amplifier Q200 and Q230. The output of the Summing Amplifier drives the Positive Current Source Q250, Q270 and the Inverter Q220, Q240. The Inverter in turn drives the Negative Current Source Q260 and Q280.

Two constant current sources of opposite polarity charge and discharge a timing capacitor producing the triangle waveform, Figure 4-1.

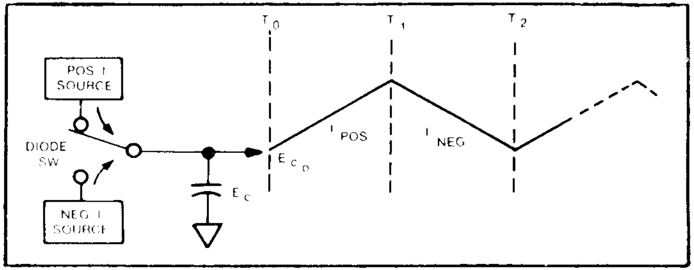


Fig. 4-1 Triangle Waveform

The Positive Current Source charges the timing capacitor during the time period T_0-T_1 causing the voltage on the timing capacitor to increase linearly from T_0 to T_1. At time T_1, the Diode Switch disconnects the Positive Current Source from the timing capacitor and connects the Negative Current Source. The voltage on the timing capacitor will now discharge or decrease linearly until time T_2 when the Diode Switch will disconnect the Negative Current Source and connect the Positive Current Source, etc.

R230A and R230B are equal in value and determine the positive and negative voltage at the Positive and Negative Current Sources. The VAR RAMP/PULSE potentiometer varies the voltage and thus the current of the Positive or Negative Current Source depending upon the position of the RAMP/PULSE switch.

By varying the current from one current source and not the other, the timing capacitor will charge and discharge at different rates and generate an unsymmetrical triangle waveform (Ramp) Figure 4-2.

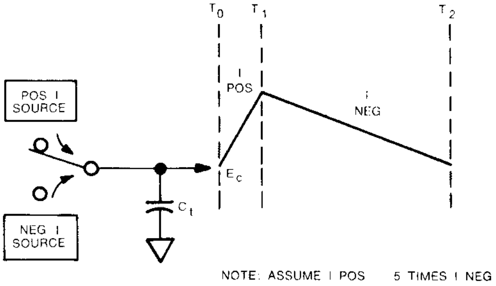


Fig. 4-2 Unsymmetrical Triangle (Ramp) Waveform

The RANGE switch selects different timing resistors and timing capacitors to determine the frequency. A high input impedance BUFFER Q290, Q300A and B prevents loading of the timing capacitor at low timing currents. The triangle waveform is applied to the LEVEL DETECTOR Q300C D, E, Q330, and Q350. The LEVEL DETECTOR switches when the voltage at its input reaches a pre-determined level. The output from the LEVEL DETECTOR causes the Current-Source Diode-Bridge to switch, disconnecting one current source and connecting the other. Connecting and disconnecting the current sources at the proper timing-capacitor voltage produces the triangle waveform. The output from the LEVEL DETECTOR also drives another diode switch to produce a symmetrical squarewave for use at the OUTPUT AMPLIFIER.

A TTL GATE is also driven by the LEVEL DETECTOR squarewave. The output of the TTL GATE provides a TTL pulse at the PULSE OUTPUT connector.

A diode bridge shaping network uses the log curve of silicon diodes to simulate a sinusoidal curve. Figure 4-3.

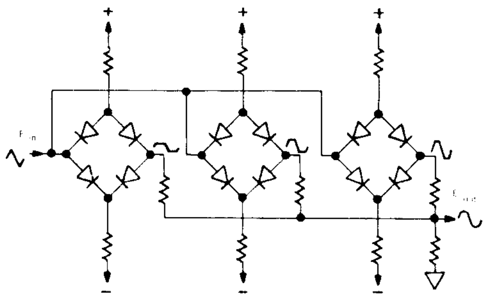


Fig. 4-3 Diode Shaping Bridge

The sine amplifier, Q400, boosts the sinewave amplitude to the proper level for the OUTPUT AMPLIFIER.

A square, triangle, or sine waveform can be selected by the FUNCTION switch. The desired waveform is connected to the AMPLITUDE potentiometer. The OUTPUT AMPLIFIER, Q500 through Q550, is a non-inverting amplifier.

Sweep Generator: (Model 121 only)

The sweep generator uses two operational amplifiers to produce a free-running ramp waveform. One amplifier is an integrator producing the ramp waveform; the second amplifier is a level detector resetting the ramp at the proper time. The ramp waveform is connected to the VCF input of the main generator to provide internal sweep. A transistor provides a Ramp Sync output from the level detector. The ramp waveform from the integrator provides the auxiliary ramp output.

CIRCUIT DESCRIPTION (Main Generator)

The power supply shown in the Bl;ock Diagram, Figure 6-1, consists of a full wave unregulated ±20V supply and a regulated ±15V supply.

Note: Unregulated ±20V supply: Refer to the schematic diagram Figure 6-3.

Line voltage is applied to transformer T100 through power switch S100. The Power On indicator LED (D 100) is connected to the −15V DC supply when S100 is in the On position.

Jumpers B, C, D, and E provide for line voltages of 100, 115, 200, and 230 VAC 50-60 Hz.
NOTE: If it is necessary to change the wiring on the transformer primary to accept Line voltages other than 115 VAC, refer to Section 2 (AC Power Requirements) for the proper procedure. The proper wiring, jumpers, and fuse data for different line voltages are shown on the power supply schematic (Fig. 6-3).

D101, D102, D103, and D104 are a full wave rectifier converting the line voltage to approximately ±20V DC across filter capacitors C100, C101, C106, and C107.

Q100 is a dual regulator supplying ±15V DC.

R101 and R102 are current-sensing resistors providing protection in the event of short circuit on one of the supplies. The short-circuit current-limit is set at approximately 200mA. Sine C Adjust balances the ±15V supplies. This small amount of adjustment (approximately ±300 mV) helps adjust the waveform symmetry for minimum sine distortion.

Summing Amplifier

Refer to Figure 6-4 (Schematic Diagram MODEL 119 and 121 FUNCTION GENERATORS). Q200 is an operational amplifier. Q230 is an emitter follower buffer used in conjunction with the operational amplifier. Q200 and Q230 are a summing amplifier with a closed loop gain of −1 (inverting). The MULTIPLIER, R202, supplies a negative voltage to the summing amplifier input (pin 2) through summing resistor R206. The negative voltage of approximately −2V to 0V is inverted by the summing amplifier and appears as +2V to 0V at Q230's emitter.

Main Timing potentiometer R203 adjusts the voltage on the MULTIPLIER for frequency calibration. The frequency is dependent upon the voltage of the summing amplifier output. (Q230 emitter).

The frequency may be swept (adjusted) over a three decade range (1000:1) by the MULTIPLIER or by applying the proper AC or DC voltage at the VCF input. With the MULTIPLIER set at 2.0, the voltage at the summing resistor R206 is approximately −2V. By applying approximately +10V DC at the VCF input, +2V is applied at summing resistor R205. The −2V from the MULTIPLIER and the +2V from the VCF input add to provide 0V at the summing amplifier output. This causes the frequency to decrease approximately three decades (1000:1). To sweep up in frequency rather than down, set the MULTIPLIER at maximum counterclockwise (approximately 0V at the summing amplifier output). This sets the frequency approximately three decades below the selected frequency RANGE. By applying approximately −10V at the VCF input, the summing amplifier output will be forced to +2V, causing the frequency to increase three decades (or to the maximum frequency indicated on the selected frequency RANGE). By setting the MULTIPLIER at the desired start frequency and applying the proper AC or DC voltage at the VCF input, the frequency may be swept as desired over a three-decade range.

NOTE: The maximum and minimum frequency limits on any selected frequency RANGE are 0.002 and 2.0 (1000:1) on the MULTIPLIER dial.

Q230 provides a voltage-to-current conversion for driving the positive current source. Q230 converts the voltage at Q230's emitter to a constant current through R230A. Assume VAR RAMP/PULSE control is in the CAL position. By varying the MULTIPLIER the voltage on R231A varies, causing the current through R230A to vary. The current through R231A and R230A is equal except for a small base current for Q230 and bias current for Q220.

Inverter

The INVERTER (Q220, Q240) inverts the voltage at the summing amplifier output (Q230 emitter) and applies it across 231B which is equal to R231A. Q220 is an operational amplifier connected for a closed-loop gain of −1 (inverting). The +2V at Q230 emitter is inverted and becomes −2V at Q240 emitter. Q240 is an emitter follower buffer used in conjunction with the operational amplifier Q220. The voltage across R231B is equal to the voltage across R231A, therefore the current through R231B is equal to the current through R231A (assuming R250 is in the Cal position). Q240, like Q230, provides a voltage-to-current conversion.

Positive and Negative Current Source

The positive and negative current sources provide constant currents for charging and discharging the timing capacitors.

Q250 and Q270 form a voltage follower. Q250 is an operational amplifier with very low input bias currents to prevent timing current errors. Q270 is an emitter follower providing the voltage-to-current conversion for the current source.

Q260 and Q280 perform the same function for the negative current source. Equal voltages appear at the current source inputs and outputs depending on the MULTIPLIER setting as previously explained.

Since the currents through R230A and R230B are equal, the voltage at Q250 and Q260 inputs is equal and opposite in polarity. The voltage appearing at Q270 and Q280 emitters is also equal and opposite in polarity.

The timing current is determined by the voltage across the timing resistors (R270 to R273 and R280 to R283).

The RANGE pushbutton switches select the proper timing resistors and capacitors according to the frequency range selected.

Var Ramp/Pulse

S250 RAMP/PULSE switch and R250 VAR RAMP/PULSE control are used to obtain pulse and ramp waveforms. When the VAR RAMP/PULSE control R250 is in the CAL position. R231A and R231B are both connected to ground in either position of the RAMP/PULSE switch S250.

As long as R231A and R231B are grounded, the current through them is equal. When the RAMP/PULSE switch is in the NORM position (out), R231A is grounded directly and R231B is grounded through R250, the VAR RAMP/PULSE control. With R250 in the CAL position, currents through R231A, R231B, R230A, and R230B are equal; therefore the voltages at Q270 and Q280 are equal and opposite. A triangle waveform is produced across the timing capacitor. When R250 is not set to the CAL position, the resistance between Q240's emitter and ground is variable from 1K ohm to approximately 20K ohms. The voltage at Q240's emitter remains constant as determined by the MULTIPLIER setting. This causes the current through R231B to vary over approximately a 20:1 range; approximately 2mA in the CAL position (1K) and approximately 0.1 mA in the CW position (20K). Current through R231A remains constant while current through R231B is variable. The positive current-source voltage remains fixed and the negative current-source voltage is variable by the VAR

RAMP/PULSE control. A variable-slope ramp waveform is produced in this manner. The slope of the ramp is adjusted as desired over approximately a 20:1 range. When the RAMP/PULSE INVERT switch (S250) is set to the INVERT position, the positive current source becomes variable and the negative current source remains fixed, reversing the slopes of the ramp waveform. NOTE: When R250 is in the CAL position, the position of S250 has no effect because R231A and R231B are both grounded in either position of S250.

Current-Source Diode-Switch

A diode switch connects and disconnects the current sources. Output from the level detector sinks the current from either the positive or negative current-source. When the input to the switching bridge is positive, the level indicator sinks the current from the negative current-source through diodes D281 and D280. This positive input signal reverse biases D273 and D272. The positive current-source now charges the timing capacitor positive. When the voltage on the timing capacitor reaches approximately +1V, the level-detector switches and the diode-bridge input switches negative. This negative voltage at the input to the switching bridge sinks the current from the positive current-source through D273 and D272. It also reverse biases D281 and D280. The negative current-source now discharges the timing capacitor. When the voltage on the timing capacitor reaches approximately −1V, the level-detector switches and the timing capacitor charges positive again, etc.

Buffer

Q290, Q300A, and Q300B form the high input impedance buffer. Q290 is an FET with a very high input impedance. Q300B is a current source supplying bias current for Q290. The ZERO BAL adjust R303 sets the bias current through the FET (Q290) to the proper level to obtain a gate-to-source voltage equal to the base emitter drop of Q300A. The gate-to-source voltage of the N-channel FET Q290 is opposite in polarity to that of the emitter follower Q300A. The input-to-output offset thereby is adjusted to 0V. The emitter follower output (pin 10) drives the level detector and associated circuitry.

Level Detector

The level detector senses the voltage on the timing capacitor (the buffer output) and switches the diode switch to produce the triangle waveform. Q300C and D form a differential amplifier. Q330E is a current source. Q330 and Q350 form a second differential amplifier driven from the input differential amplifier Q300C and D. Positive feedback is applied to Q300D's base through the reference switching bridge (D330-D333). This positive feedback and high open-loop gain provide very fast switching for the level detector. Q330's collector drives the reference switching-bridge to provide the positive and negative reference current through R308. When Q330 is on, the collector holds the reference bridge input positive. Q330 sinks the current from the negative supply through R335, R333, and D333. Current through R308, D330, R331, and R330 establishes the positive reference voltage (approximately +0.5V) at Q300D's base. Q330's collector is also connected to the current-source switching-bridge at the junction of D273 and D280. This positive signal allows the timing capacitor to charge in the positive direction as explained in Section 4, (Theory of Operation).

The level detector input is voltage divider R304 and R305. +1V at R304's input equals approximately +0.5V at Q300C's base. When the voltage at Q300C's base rises above the reference voltage at Q300D (+0.5V), the level detector switches. Q330 will turn off, causing the voltage at the reference bridge (D330 to D333) and the current-source switching-bridge (D270 to D273 and D280 to D283) to switch negative. This negative voltage causes the reference voltage at Q300D to switch negative and the timing capacitor to begin charging negative (discharge). When the timing capacitor has charged to approximately −1V, the signal at Q300C is more negative than the reference voltage at Q300D (not approximately −0.5V) and the level detector switches again, etc. Q350's collector supplies the squarewave signal to drive the Square Diode-Switch and the TTL Gate Q360.

TTL Gate

Q360 is a Dual, 4-Input, Positive Nand-gate providing the TTL PULSE OUTPUT. D360, D361, and D362 provide the necessary level shifting of the squarewave from Q350's collector to drive the TTL GATE inputs (pins 1 and 9). D363 is a zener diode providing a +5V power supply for the TTL GATE. The two nand-gate outputs (pins 6 and 8) are paralleled to provide the capability of sinking 20 TTL Gates.

The TTL GATE output levels are approximately +3V and 0V open circuit at 10 ns (typical) rise and fall times. The PULSE out is a squarewave as long as the VAR RAMP/PULSE control is in the CAL position. A variable pulse width and variable-duty-cycle pulse are easily set up using the VAR RAMP/PULSE control and RAMP/PULSE INVERT switch as shown in Section 2, Table 2-1.

Squarewave Diode Switch

The squarewave diode-switch (D356 to D359) provides a clean squarewave of approximately ±1V from the ±2V signal at Q350's collector. The signal from Q350's collector is routed through FUNCTION Switch S500C, activating the diode switch only when the squarewave is selected. The positive signal sinks the current through D358 and R353. The positive portion of the squarewave is developed across the amplitude potentiometer (R508) through R354, D357, and R352. The negative portion of the squarewave is developed across R508 through R354, D359, and R353, when the squarewave at Q350's collector reverses polarity. R354 provides a small adjustment to calibrate the squarewave amplitude.

Sine Shaper

Three diode bridges produce a sinewave from the triangle waveform. D400, D401, and D402 are three matched sets of 4 diodes each. The triangle waveform from the buffer output is connected to these three diode bridges through R400. As the triangle voltage rises above 0V, the current through R404 increases exponentially in the positive direction through D400B and R402 while the current through D400D and R401 is being shunted through D400C. When the triangle has reached its positive peak, the current through R404 to the + 15V supply has reached maximum. The current now decreases exponentially as the triangle rises toward its negative peak. When the triangle has reached approximately 0V, the current through R404 is nearly zero because an equal current is passing through D400D and D400B. As the triangle increases in the negative direction, current increases through D400D and R404 exponentially. Current through R402 is now being shunted through D400A as the triangle rises toward its negative peak. The current through R404, R406, and R409 increase in the positive and negative direction exponentially through each of the three bridges in the same manner. The current through each bridge is determined by their respective resistors, the exponential currents of the three bridges are summed, or added, into R410 to produce a sinewave. The distortion is typically 0.5%.

Sine Amplifier

Q400 is an operational amplifier boosting the small sinewave at R410 to approximately 2V P-P. This amplifier is connected as an inverting amplifier with a closed-loop gain of approximately −6. R416 adjusts feedback to set the sinewave amplitude. The sinewave is then connected to the AMPLITUDE control, R508, when the sinewave is selected by the FUNCTION switch, S500.

Output Amplifier

±20V P-P waveforms are produced by the output amplifier. Squarewave rise and fall times <100 ns are provided with this amplifier's 200V/μsec slew rate. Q500 and Q510 form the input differential amplifier. Feedback for this non-inverting amplifier is through R505. R505 and R504 form a voltage divider at Q510 (the inverting input), establishing a closed-loop gain of approximately 10. Q520 and Q530 are constant-current sources driving bias diodes D520 and D530. R522, R523, and R531 are a voltage divider providing the bias voltage for Q520 and Q530. R530 sets the current for Q530 a few milliamps less than the current for Q520. Q510 supplies a current equal to the current difference between Q520 and Q530. Q540 and Q550 form a complementary-output emitter-follower. A positive-going signal at Q500's base will cause Q500's, collector current to increase and Q510's collector current to decrease. A decrease in current from Q510 causes excess current from the Q520 current source to raise the voltage at Q540's, and Q550's bases. Negative feedback from the output emitter-followers through R505 to the base of Q510 maintains an output signal 10 times the input signal. As the input signal becomes negative, Q500's collector current decreases and Q510's collector current increases. As Q510's collector current increases, the current from Q520's, collector becomes less than the current from Q530 and the output follows the input negative. Negative feedback maintains the output at 10 times the input signal as previously explained. R542 and R543 provide a 50Ω output impedance and short-circuit protection.

LO Output

R544 to R548 make the output attenuator for the LO OUTPUT.

Attenuator (Option A)

The LO OUTPUT is replaced by a switch providing 0-20-40 dB attenuation.

MODULATOR: (Model 119M only)

When in the AM mode, the modulator circuitry is inserted between the FUNCTION switch and the AMPLITUDE control. U1 is a 4-Quadrant multiplier. The signal from the FUNCTION switch is the carrier and is applied to one input of U1. The modulating signal from the AM INPUT is applied to the other input. When the CARRIER control is centered it applies 0V to U1 pin 8. U1 is then a balanced modulator, suppressing the carrier when there is no voltage at the AM INPUT. When the CARRIER control is not centered, it applies a voltage to pin 8 and U1 then is an amplitude modulator.

The differential output of U1 is applied to the inputs of differential op-amp U2. U2 shifts the level to remove DC offset and converts the signal to a single-end output. The output is then applied to the AMPLITUDE control.

When the generator is not in the AM mode, the signal from the FUNCTION switch bypasses the modulator.

SWEEP GENERATOR (Model 121 only)

Integrator

Q700 is an operational amplifier used as an integrator. Timing current is supplied from the rate control (R702) and timing resistor R701. R704 (Ramp Timing) adjusts the ramp duration during calibration. A bottoming resistor R703 limits the Variable Sweep RATE to 100:1.

C701 and C702 provide two sweep rate ranges (1 ms and 100 ms).

The timing current is supplied from the +15V supply. The integrator output charges the timing capacitor negative at a rate determined by the RATE control setting and the selected timing capacitor. When the integrator output reaches approximately −2.5V, the level-detector switches negative. Q710 turns on through R710, discharging the timing capacitor at a much faster rate, providing a reset time of about 15%.

Level Detector (121)

Q720 is an operational amplifier connected as a level detector.

Assume Q720's output is NEGATIVE initially. Q710 will turn on causing the integrator output to charge positive (ramp reset). The negative output of Q720 reverse biased by approximately −12V. Pin 2 of Q720 is grounded. The output of Q720 will remain negative until the input on Pin 3 becomes more positive than Pin 2. When the Ramp has reset to approximately 0V, the output of Q720 will switch positive.

When Q720 switches positive, Q710 is turned off allowing the integrator output to charge negative. The positive output of Q720 also reverse biases D721. With D721 reverse biased, R721 provides a positive input current to Q720 Pin 3. The output of Q700 now charges negative until the negative input current through R720 is greater than the positive input current through R721. Q720 then switches negative, turning on Q710 etc. R720 and R721 establish the ramp amplitude at approximately −2.5V.

Reset (121)

Q710 provides a fixed reset-current to reset the ramp waveform. This current provides approximately a 15% reset time when RATE is set for maximum timing current (CAL position). When RATE is set fully CCW (100:1) the timing current is 100 times smaller than in the CAL position. This then provides a reset time of approximately 0.15%.

Ramp Sync (121)

Q730 provides a +5V (approximately) pulse output coincident with the reset of the ramp. When Q720's output is positive, Q730 will be turned 'on,' pulling the Ramp Sync output signal near ground. When Q720's output is negative, Q730 will be reverse biased. R731 and R732 are voltage divider providing approximately +5V at the Ramp Sync output when Q730 is 'off.'

Ramp Output (121)

The negative ramp from Q700 is connected to the Ramp output through R740.

SECTION 5

MAINTENANCE

FUSE REPLACEMENT

If for some reason the fuse blows, first try to determine the cause of the failure and repair it.

The proper size fuse is listed on Figure 6-3.

NOTE: Replace ONLY with the proper size fuse to prevent damage to the instrument.

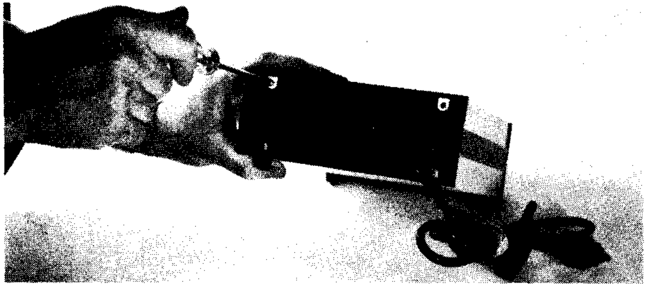


Fig. 5-1 Retaining Screw Removal

DISASSEMBLY FOR CALIBRATION

(a) Remove the retaining screws on the rear bezel which secure the top cover, Figure 5-1.

(b) Push up on the two tabs from which the retaining screws are removed to loosen the cover. Lift the rear of the top cover away from the rear bezel, Figure 5-2.

(c) Push the cover away from the front bezel, Figure 5-3.

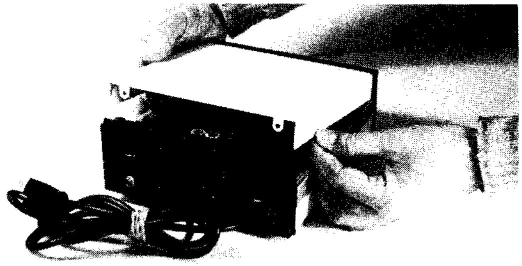


Fig. 5-2 Top Cover – Mounting Tabs Removed from Rear Bezel

This provides access to all Model 119 calibration adjustments. To access the 119M and 121 calibration adjustments, remove the bottom cover in the same manner.

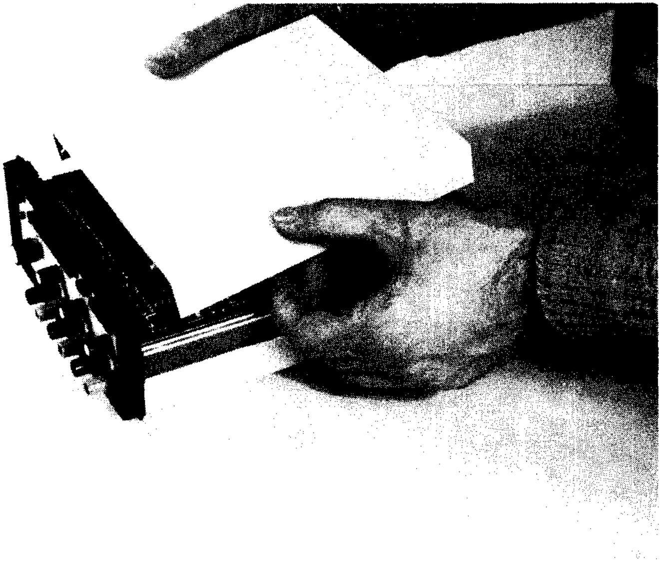


Fig. 5-3 Top Cover Removal

DISASSEMBLY FOR PARTS REPLACEMENT

Remove the top and bottom cover as described under disassembly for calibration. With the top and bottom covers removed, both sides of the printed circuit board are accessible for parts replacement or troubleshooting.

REASSEMBLY

The top and bottom covers are reassembled simply by reversing the disassembly procedure.

CALIBRATION

Required Equipment

The equipment required for calibration is listed in table 3-1.

Preparation For Calibration

Perform Section 5 (Disassembly for Calibration).

Apply power to the generator and allow at least 30 minutes warm-up time.

All adjustments are labeled on the top of the PC boards to help locate them. Refer also to Figure 5-4 (Adjustment Location).

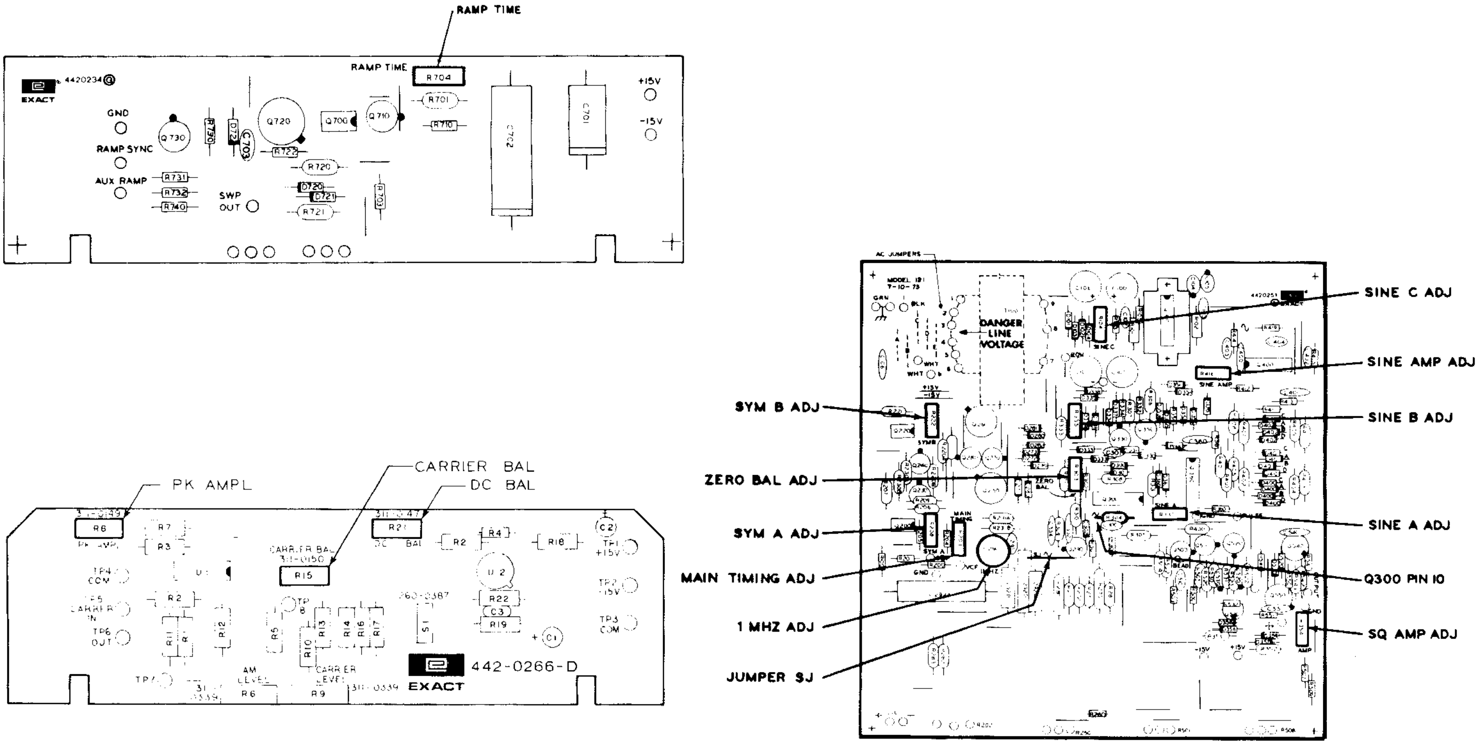


Fig. 5-4 Adjustment Locations

Procedure

Set all controls as follows unless otherwise indicated:

POWER	ON	
RANGE-Hz	1K	
MULTIPLIER	2.0	
RAMP/PULSE	NORM (OUT)	
FUNCTION	∿	
VAR RAMP/PULSE	CAL	
DC OFFSET	OFF	
AMPLITUDE	MAX (CW)	
ATTENUATOR (Option A)	0 dB	
WIDTH	OFF	121 ONLY
RATE	CAL	121 ONLY
SWEEP RANGE	1 MS	121 ONLY
AM	OFF	119M ONLY
CARRIER	'0'	119M ONLY
MODULATION	OFF (CCW)	119M ONLY

Zero Balance

Connect a jumper from the main-output ground to the jumper marked SJ (summing junction) on the PC board, Figure 5-4. Using a voltmeter, DVM, or oscilloscope, adjust ZERO BAL to obtain OV ±25mV at Q300 pin 10, Figure 5-4. Remove the jumper and proceed with the next step.

1000:1 Symmetry Adjust

Set the MULTIPLIER to the MAX CCW end of rotation. Select the 100 kHz RANGE and the triangle waveform. Observe the triangle waveform on an oscilloscope connected to the main OUTPUT. Set the horizontal sweep rate of the oscilloscope to 0.5 ms/Div.

Adjust SYM A and SYM B to obtain one complete symmetrical triangle across the CRT (10 Div).

NOTE: 5 ms = 200 Hz (1000:1)

Sine Distortion

Connect a distortion analyzer to the main OUTPUT and monitor the harmonic distortion.

Adjust Sine A, B, and C adjusts to obtain minimum sine distortion. Typically 0.5%.

Main Timing

(a) Connect a frequency counter to the PULSE output and monitor the frequency.

With the MULTIPLIER set at 2.0 and the 1k RANGE selected, adjust the MAIN TIMING to obtain *2 kHz ±1%.

NOTE: Be sure the VAR RAMP/PULSE CONTROL is in the CAL position.

(b) Set the MULTIPLIIER to 0.2 and observe *200 Hz ±10% on the frequency counter.

NOTE: If the frequency at the 0.2 end of the MULTIPLIER is out of tolerance, or it becomes necessary to re-set the MULTIPLIER knob; refer to Section 5 (multiplier alignment procedure) for the proper procedure to re-align the MULTIPLIER knob.

(c) Select the 1M RANGE and set the MULTIPLIER to 2.0. Adjust the 2 MHz trimmer capacitor to obtain *2 MHz ±1%.

*This is tighter than the 5% of full scale specification.

Output Amplitude

Select the 1K RANGE. Connect an oscilloscope to the main OUTPUT through a 50Ω terminator and observe a triangle waveform 10V P-P.

Select the sine waveform and adjust the SINE AMPLITUDE for 10V P-P.

Select the square waveform and adjust the SQ AMP adjust for 10V P-P.

NOTE: A small amount of DC offset may exist from one waveform to another, however, the DC OFFSET control allows the DC level of all waveforms to be set as desired.

CALIBRATION PROCEDURE M OPTION

Connect an oscillosocpe to HI OUTPUT.

(a) With the AM switch off, set FUNCTION to triangle, AMPLITUDE to full scale, (ATTENUATOR to "0dB," for 119MA), RANGE to 100 Hz, dial to 2.0, VAR RAMP/PULSE to CAL, MODULATION fully CW.

(b) Adjust DC OFFSET control for symmetrical peaks about ground ±100 mV.

(c) Depress AM switch, adjust CARRIER level for minimum signal at output. Locate "DC BAL" adjustment on the AM board, and set if for 0V at OUTPUT, ±50 mV DC.

(d) Rotate CARRIER level from CCW to CW several times as necessary, adjusting "Carrier BAL" on AM board for equal DC levels.

(e) Rotate CARRIER CCW, and record voltage P-P. Rotate CARRIER CW, and do the same. Adjust "Peak Amplitude" for the larger of the two P-P readings. Amplitude should be the same as when the AM switch is off.

Ramp Timing (Model 121 only)

(a) Connect a timer/counter to the Ramp Sync output. Set the counter to measure the interval from −slope to +slope.

(b) Adjust the Ramp Timing adjust to obtain 1 ms ±10% and 100 ms ±10% with the RATE control in the CAL position.

TROUBLESHOOTING

A *troubleshooting* chart of symptoms and probable causes is provided, Table 5-1.

The table indicates the circuit most likely at fault and test points to check for proper operating voltage and waveforms. The pages of the theory section describing the circuit operation are also indicated.

Procedure

(a) Determine the exact nature and extent of the problem by performing the SPECIFICATION VERIFICATION PROCEDURE in Section 3 and noting which instrument operations fail to perform properly.

(b) With power removed, perform the disassembly procedure described in Section 5, (Disassembly for Calibration).

(c) According to the information obtained in step (a), find the symptoms in Table 5-1 most nearly describing the problem observed. Then perform the appropriate troubleshooting operations.

NOTE: The data provided in the troubleshooting chart is with the controls set as follows:

POWER	ON	
RANGE	1K	
MULTIPLIER	2.0	
RAMP/PULSE	NORM (OUT)	
FUNCTION	∿	
VAR RAMP/PULSE	CAL (MAX CCW)	
DC OFFSET	OFF	
AMPLITUDE	MAX	
ATTENUATOR (option A)	0 dB	
WIDTH	OFF	MODEL 121 ONLY
RATE	CAL	MODEL 121 ONLY
SWEEP RANGE	1 ms	MODEL 121 ONLY
AM	OFF	MODEL 119M ONLY
CARRIER	'0'	MODEL 119M ONLY
MODULATION	OFF (CCW)	MODEL 119M ONLY

Table 5-1 Troubleshooting Procedure

Symptom	Probable Cause	Circuit	Test Point	Signal	Reference Page No.
No Power On Indication	No Power	Power Supply	+20V	+20V ±5V	33, 58
			−20V	−20V ±5V	
			+15V	+15V ±1V	
			−15V	−15V ±1V	38, 57
No Output	Faulty Component	Output Amplifier	Q500 Base	∿ 1V P-P	
			Q520 Emitter	+12.8 VDC	
			Q530 Emitter	−13 VDC	
			Q540 Collector	+14.9 VDC	
			Q550 Collector	−14.9 VDC	
	Generator Loop Not Running	Current Sources Buffer and Level Detector	Q270 Emitter	+9 VDC	35, 56
			Q280 Emitter	−9 VDC	
			Q230 Collector	+9 VDC	35, 56
			Q240 Collector	−9 VDC	
			Q230 Emitter	+2.2 VDC	
			Q290 Gate SJ	±1V	36, 56

(Continued on Next Page)

Table 5-1 Troubleshooting Procedure (Continued)

Symptom	Probable Cause	Circuit	Test Point	Signal	Reference Page Number
No Output Cont'd	Generator Loop Not Running	Current Sources Buffer and Level Detector	Q300A Emitter	±1V	36, 56
			Q300C D Collector	+4.35 VDC	36, 57
			Q300 C D Emitter	−0.5 VDC	
			Q300, Q350 Emitter	+4.78 VDC	
No Output 119M only	AM switch engaged With CARRIER control centered and no modulating signal				
	AM Switch defective	Modulator	TP5, TP6 (AM switch)	2V P-P	39, 59
	Modulator Components	Modulator	U2 pin 6	up to 2V P-P	39, 59
			U1 pin 2	up to 350 mV P-P	

(Continued on Next Page)

Table 5-1 Troubleshooting Procedure (Continued)

Symptom	Probable Cause	Circuit	Test Point	Signal	Reference Page No.
Output Waveforms Clipped	Excessive DC Offset	Output Amplifier	R501 Slider	0V ±0.5 VDC	38, 57
			Q510 Base	±0.5V	
			Q500 Base	±1V	
	Low Voltage	Power Supply	See Power Supply		33, 58
No Sinewave, Triangle & Square OK	Faulty Component	Sine Amplifier	R419	2V P-P	37, 38, 57
			R410	150 mV P-P	
			Q400 pin 3 & 4	0V ±250 mV	
			R400	2V P-P	
	Intermittent Function SW	S500	S500A NO	2V P-P	38, 57
			S500A arm	2V P-P	
No Square Wave Triangle & Sine Ok	Faulty Comp	SQ Wave Diode Switch	D356 Cathode	4V P-P	37, 57
			D357 Cathode	2V P-P	
	Intermittent Function SW	S500	S500D Arm	4V P-P	
			S500D N.O.	4V P-P	
			S500C N.O.	2V P-P	
			S500C Arm	2V P-P	

(Continued on Next Page)

Table 5-1 Troubleshooting Procedure (Continued)

Symptom	Probable Cause	Circuit	Test Point	Signal	Ref. Page
No Pulse Output	Faulty Comp	Pulse Output	D360 Cathode	±2V	57
			Q360 Pin 1 & 9	+1.6V 0V	
			Q360 Pin 14	+5V ±0.5V	
			Q360 Pin 6 & 8	+3V 0V	
MODEL 121 No Internal Sweep, External Sweep OK	Multiplier Set at 2.0	Internal Sweep Generator Sweeps Up Only			
	Width Control In Off Position				
	Defective Switch	Sweep Generator	S722 Contacts	Width Control Max. −2.5V 0V	39,60
	Defective Component	Sweep Generator	Aux. Ramp Out.	Width Control Max. −2.5V 0V	

(Continued on Next Page)

Table 5-1 Troubleshooting Procedure (Continued)

Symptom	Probable Cause	Circuit	Test Point	Signal	Reference Page No.
No Modulation	No signal applied to AM INPUT	A modulating signal must be applied from an external source			
119M only	MODULATION control in off position				
	U1 defective		U1 pin 4	Up to 5V P-P	59

MULTIPLIER ALIGNMENT PROCEDURE

If it becomes necessary to re-align the MULTIPLIER knob with the potentiometer shaft for any reason, perform the following:

POWER	ON
RANGE	10K
VAR RAMP/PULSE	CAL
DC OFFSET	OFF

(a) Connect a frequency counter to the PULSE output and monitor the frequency.

(b) Loosen the two allen screws in the MULTIPLIER knob and remove the knob and dial skirt assembly from the MULTIPLIER potentiometer shaft. Figure 5-5.

(c) Rotate the potentiometer shaft CCW until a frequency of 2 kHz ±1% is obtained.

(d) Place the MULTIPLIER knob and dial skirt on the shaft with the index mark on the front panel. Figure 5-6.

(e) Tighten one allen screw while holding the dial skirt in alignment with the index mark. NOTE: Be sure the frequency counter reads 2 kHz ±10% before tightening the allen screw.

(f) Set the MULTIPLIER to 2.0 and adjust the MAIN TIMING to obtain 20 kHz ±1% if necessary.

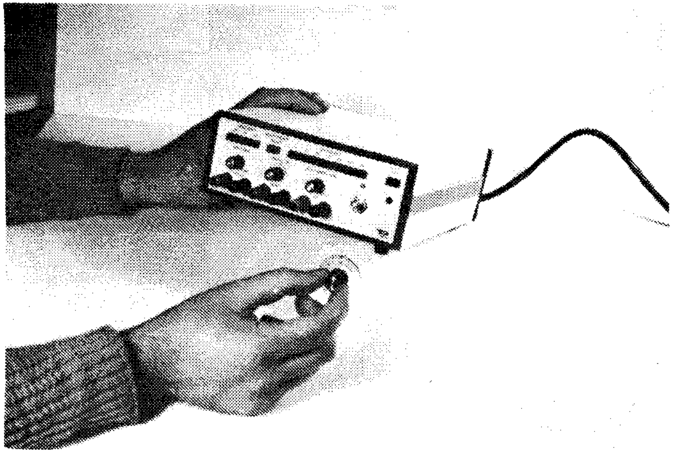


Fig. 5-5

(g) In some cases it may be necessary to repeat steps (b) through (f) until both ends of the MULTIPLIER dial read correctly.

(h) Tighten the remaining set screw.

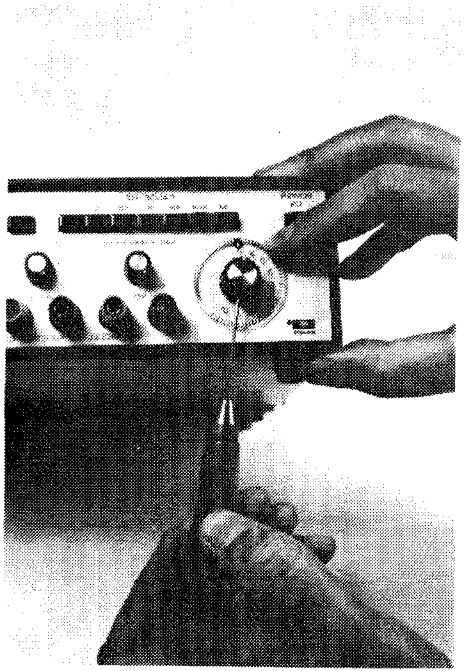


Fig. 5-6

SECTION 6
SCHEMATICS

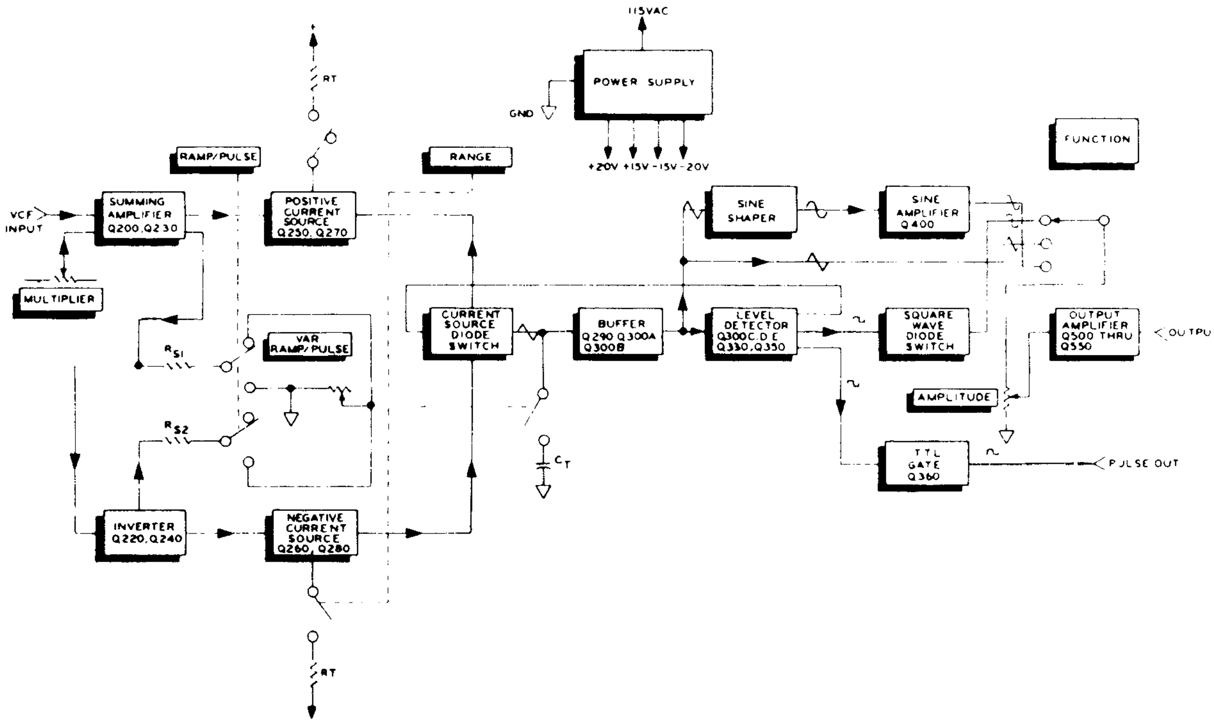
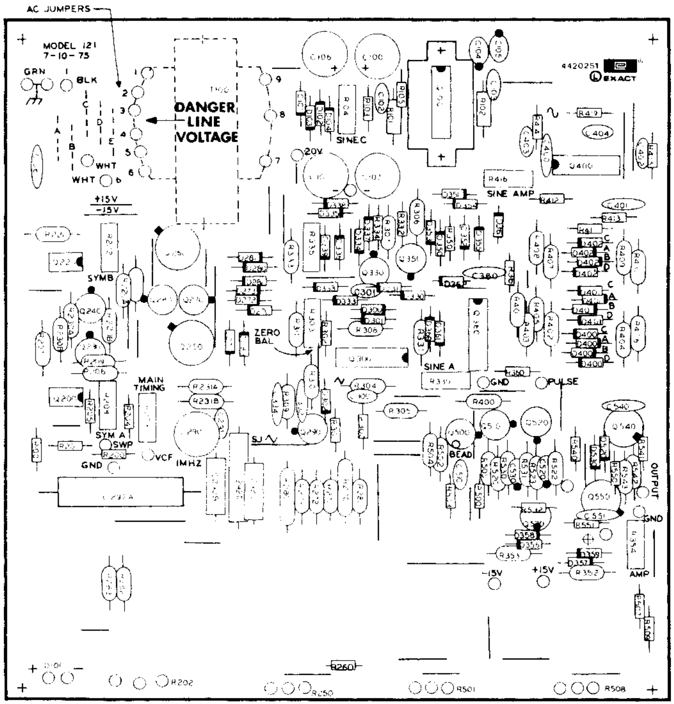
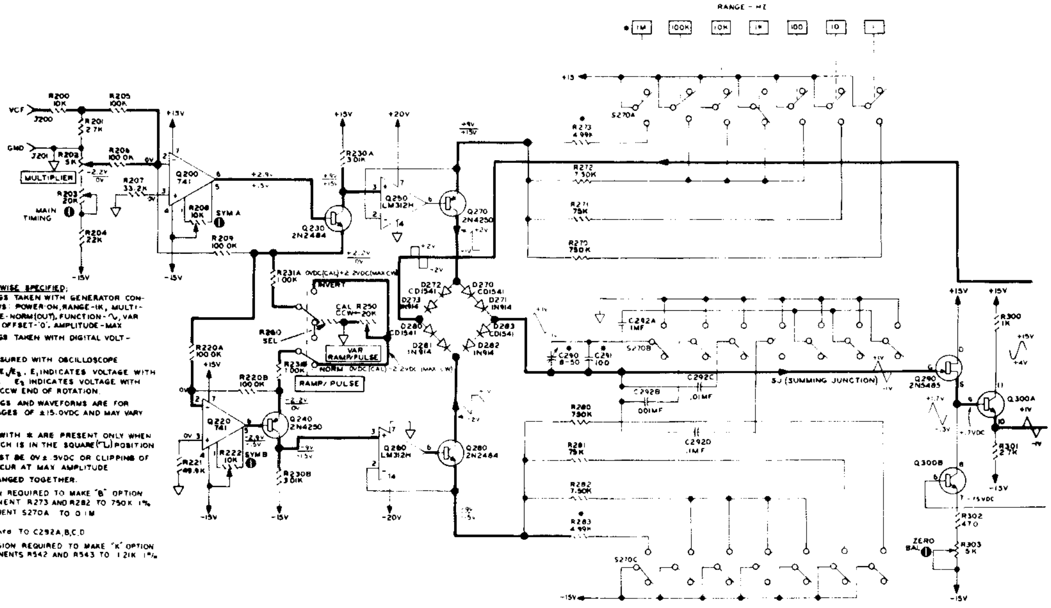


Fig. 6-1 Block Diagram

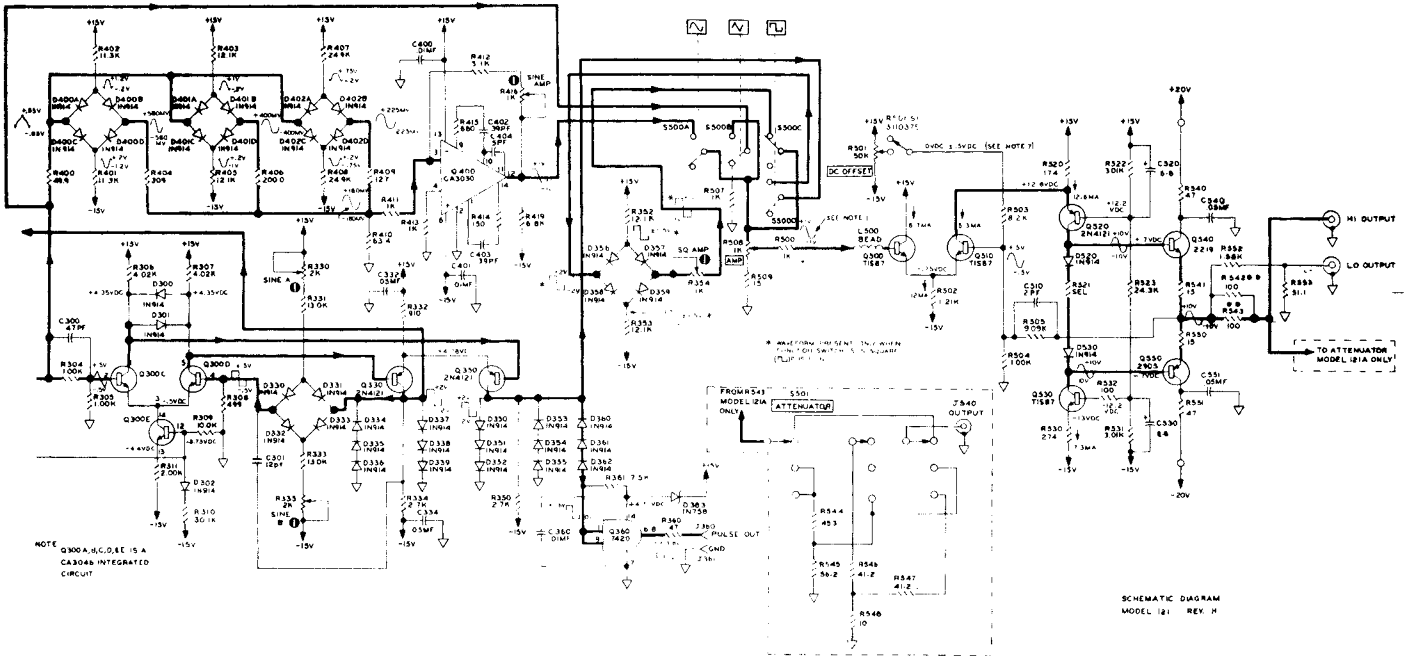

AC JUMPERS
MODEL 121
7-10-75
GRN
BLK
WHT
DANGER
LINE
VOLTAGE
SINE C
20V
SINE AMP
4420251
EXACT
+15V
-15V
SYMB
SYM A
SWP
GND
VCF
MAIN
TIMING
1MHZ
ZERO
BAL
SINE A
GND
PULSE
SJ
BEAD
OUTPUT
GND
AMP
-15V
+15V



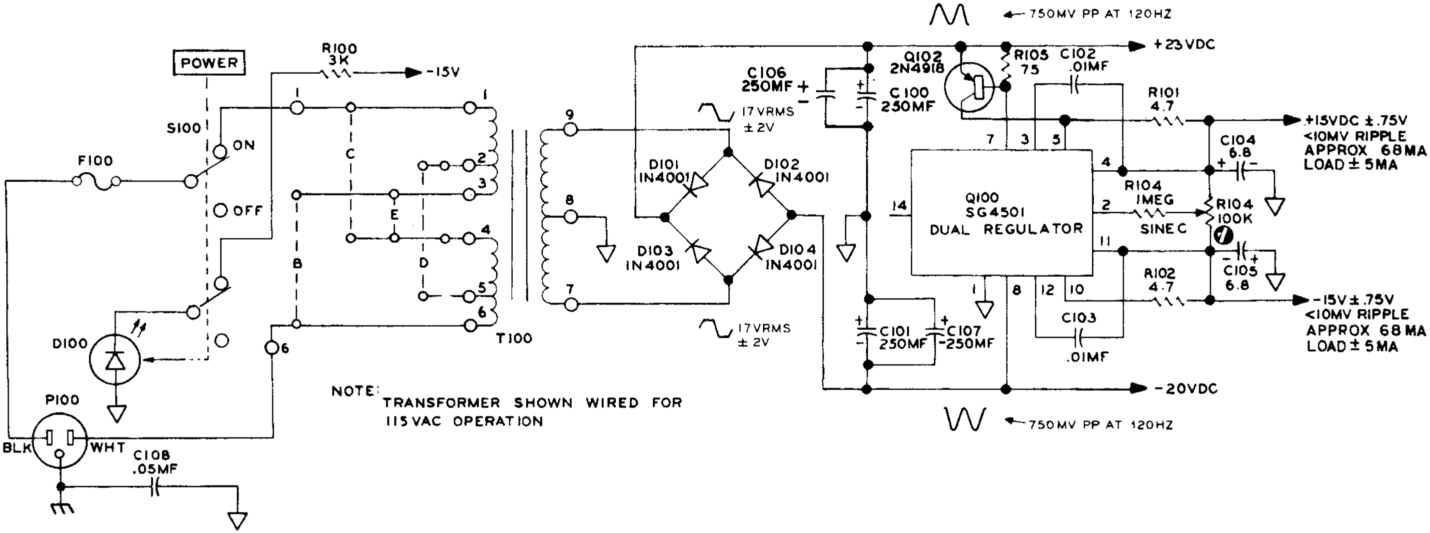
NOTES: UNLESS OTHERWISE SPECIFIED;

1. ALL VOLTAGE READINGS TAKEN WITH GENERATOR CONTROLS SET AS FOLLOWS: POWER-ON, RANGE-1K, MULTIPLIER-1.0, RAMP/PULSE-NORM (OUT), FUNCTION-∿, VAR RAMP/PULSE-CAL, DC OFFSET-'0', AMPLITUDE-MAX
2. ALL VOLTAGE READINGS TAKEN WITH DIGITAL VOLTMETER.
3. ALL WAVEFORMS MEASURED WITH OSCILLOSCOPE
4. VOLTAGES INDICATED E_1/E_2. E_1 INDICATES VOLTAGE WITH MULTIPLIER AT 1.0 &, E_2 INDICATES VOLTAGE WITH MULTIPLIER AT MAX CCW END OF ROTATION.
5. ALL VOLTAGE READINGS AND WAVEFORMS ARE FOR POWER SUPPLY VOLTAGES OF ±15.0VDC AND MAY VARY ±5%.
6. WAVEFORMS SHOWN WITH ✱ ARE PRESENT ONLY WHEN THE FUNCTION SWITCH IS IN THE SQUARE (⊓⊔) POSITION
7. VOLTAGE AT R501 MUST BE 0V ± .5VDC OR CLIPPING OF WAVEFORMS WILL OCCUR AT MAX AMPLITUDE
8. S270A, B, & C ARE GANGED TOGETHER.
9. ● INDICATES REVISION REQUIRED TO MAKE "B" OPTION
   REVISE COMPONENT R273 AND R282 TO 750K 1%
   REVISE COMPONENT S270A TO 0.1M
   DELETE C290
   MATCH C291 10mfd TO C292A,B,C,D
10. ●● INDICATES REVISION REQUIRED TO MAKE "K" OPTION
   REVISE COMPONENTS R542 AND R543 TO 1.21K 1%

7000457 REV G



SCHEMATIC DIAGRAM
MODEL 121 REV. H

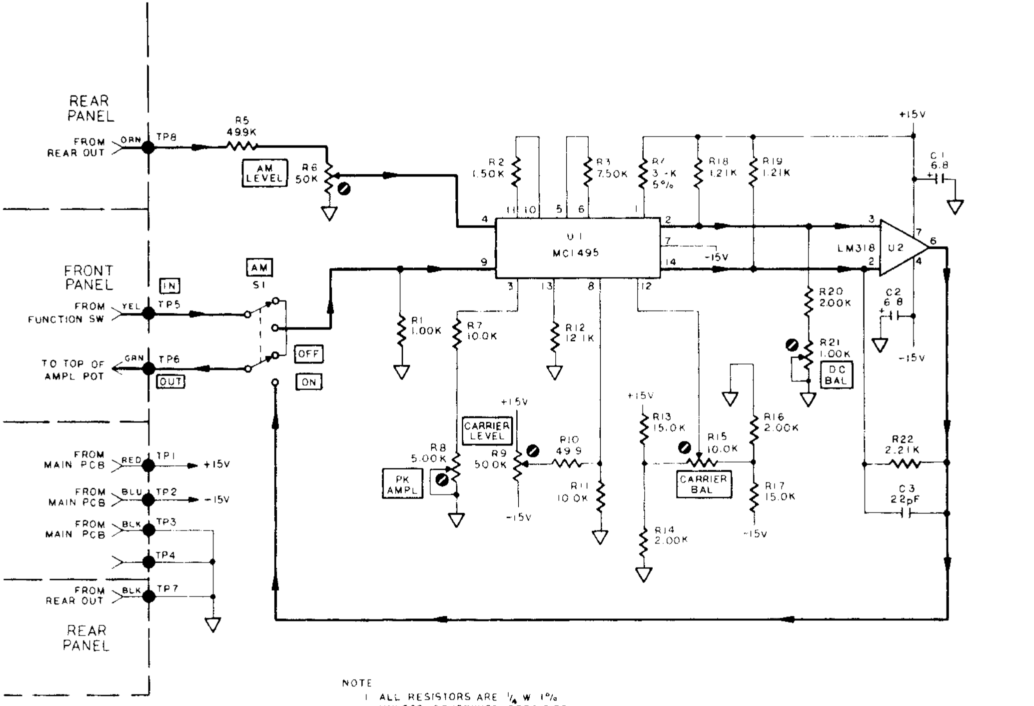


VOLTS	JUMPERS	WHT WIRE	FUSE
100	C AND D	5	1/4 A FAS-BLO
117	B AND C	6	1/8 A SLO-BLO
220 230	E	5	1/8 A SLO-BLO
240	E	6	1/8 A SLO-BLO

NOTES: UNLESS OTHERWISE SPECIFIED;

1. VOLTAGES MEASURED WITH DVM AND LINE VOLTAGE AT 115VAC
2. WAVEFORMS MEASURED WITH OSCILLOSCOPE

FIGURE 6-3 POWER SUPPLY
MODEL 121
FUNCTION GENERATOR



NOTE
1 ALL RESISTORS ARE 1/4 W 1% UNLESS OTHERWISE SPECIFIED

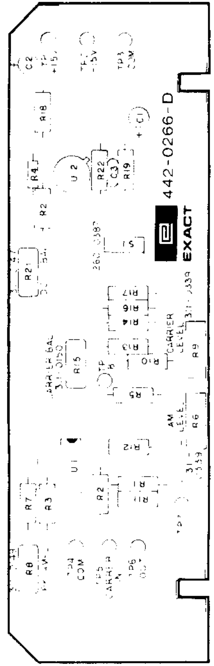
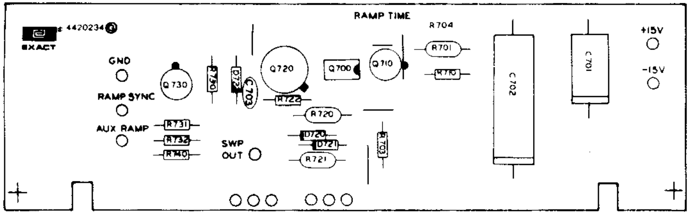


Fig. 6-5

MODEL 119M
AM PCB
7000512 REV B



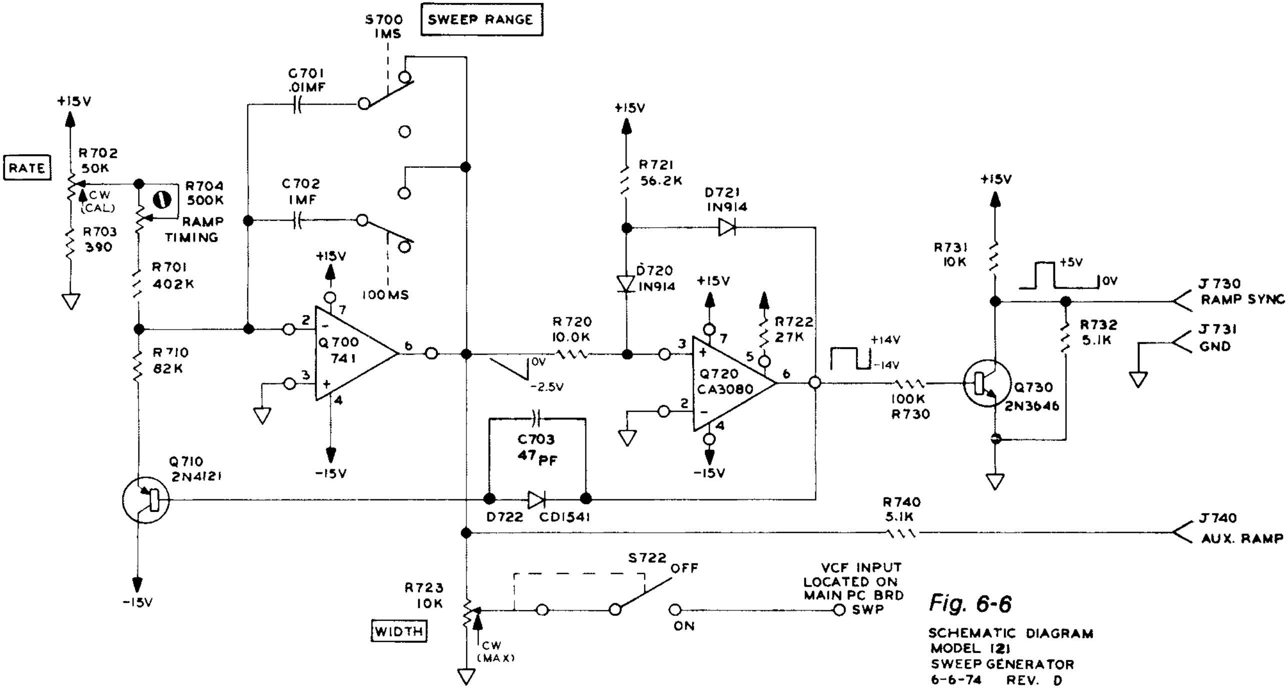


Fig. 6-6

SCHEMATIC DIAGRAM
MODEL 121
SWEEP GENERATOR
6-6-74 REV. D

SECTION 7
PARTS LIST

C001	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C002	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C003	CAPACITOR, 22PF	2810530	853
C100	CAPACITOR, 250 MFD 25 VOLT	2900058	10597
C101	CAPACITOR, 250 MFD 25 VOLT	2900058	10597
C102	CAPACITOR, 1000 PF DISC	2830000	91418
C103	CAPACITOR, 1000 PF DISC	2830000	91418
C104	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C105	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C106	CAPACITOR, 250 MFD 25 VOLT	2900058	10597
C107	CAPACITOR, 250 MFD 25 VOLT	2900058	10597
C290	CAPACITOR, 8-50PF TRIM	2810022	72982
C291	CAPACITOR, 100PF MICA	2810537	853
C292	CAPACITOR, TIMING SET	2950010	10597
C300	CAPACITOR, 47PF MICA	2810532	853
C301	CAPACITOR, 12PF MICA	2810541	853
C332	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C334	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C360	CAPACITOR, 0.01 UF DISCAP	2830005	91418
C400	CAPACITOR, 0.01 UF DISCAP	2830005	91418
C401	CAPACITOR, 0.01 UF DISCAP	2830005	91418
C402	CAPACITOR, 39PF MICA	2810531	853
C403	CAPACITOR, 39PF MICA	2810531	853
C404	CAPACITOR, 5PF MICA	2810501	853
C510	CAPACITOR, 2PF MICA	2810542	10597
C520	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C530	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
C530	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C540	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C551	CAPACITOR, 0.05 UF DISCAP	2830010	91418
C701	CAPACITOR, 0.01 MFD 600V	2900019	37942
C702	CAPACITOR, 1MF 100V	2900065	10597
C703	CAPACITOR, 47PF MICA	2810532	853
D100	LED, MLED650	1520002	4713
D101	DIODE, 1N4001	1524001	1295
D102	DIODE, 1N4001	1524001	1295
D103	DIODE, 1N4001	1524001	1295
D104	DIODE, 1N4001	1524001	1295
D270	DIODE, FDH 333	1520333	1295
D271	DIODE, 1N914	1520914	7910
D272	DIODE, FDH 333	1520333	1295
D273	DIODE, 1N914	1520914	7910
D280	DIODE, FDH333	1520333	1295
D281	DIODE,1N914	1520914	7910
D282	DIODE, 1N914	1520914	7910
D283	DIODE, FDH333	1520333	1295
D300	DIODE, 1N914	1520914	7910
D301	DIODE, 1N914	1520914	7910
D302	DIODE, 1N914	1520914	7910
D330	DIODE, 1N914	1520914	7910
D331	DIODE, 1N914	1520914	7910
D332	DIODE, 1N914	1520914	7910
D333	DIODE, 1N914	1520914	7910
D334	DIODE, 1N914	1520914	7910
D335	DIODE, 1N914	1520914	7910
D336	DIODE, 1N914	1520914	7910
D337	DIODE, 1N914	1520914	7910
D338	DIODE, 1N914	1520914	7910
D339	DIODE, 1N914	1520914	7910
D350	DIODE, 1N914	1520914	7910
D351	DIODE, 1N914	1520914	7910
D352	DIODE, 1N914	1520914	7910
D353	DIODE, 1N914	1520914	7910
D354	DIODE, 1N914	1520914	7910
D355	DIODE, 1N914	1520914	7910
D356	DIODE, 1N914	1520914	7910
D357	DIODE, 1N914	1520914	7910
D358	DIODE, 1N914	1520914	7910
D359	DIODE, 1N914	1520914	7910
D360	DIODE, 1N914	1520914	7910
D361	DIODE, 1N914	1520914	7910
D362	DIODE, 1N914	1520914	7910
D363	DIODE, 1N758	1520758	1295
D400	DIODES, MATCHED SET 1N914	1530914	10597
D401	DIODES, MATCHED SET 1N914	1530914	10597
D402	DIODES, MATCHED SET 1N914	1530914	10597
D520	DIODE, 1N914	1520914	7910
D530	DIODE, 1N914	1520914	7910
D720	DIODE, 1N914	1520914	7910
D721	DIODE, 1N914	1520914	7910
D722	DIODE, FDH 333	1520333	1295
J200	JACK, BANANA BLUE	1310087	04713
J200	BINDING POST, BLUE	3550537	10597
J201	JACK, BANANA BLACK	1310088	0776
J201	BINDING POST, BLACK	3550536	10597
J360	JACK, BANANA BLUE	1310087	04713
J360	BINDING POST, BLUE	3550537	10597
J361	BINDING POST, BLACK	3550536	10597

J361	JACK, BANANA BLACK	1310088	0776
J540	CONNECTOR, BNC	1310047	91836
J540	BINDING POST, WHITE	3550535	10597
J550	CONNECTOR, BNC	1310047	91836
J550	BINDING POST, BLACK	3550536	10597
J730	JACK, BANANA BLUE	1310087	7497C
J731	JACK, BANANA BLACK	1310088	74970
J740	JACK, BANANA BLACK	1310087	74970
L500	BEAD, FERRITE G303	1140034	1121
P100	POWER CORD. 3 WIRE	1750203	10597
Q100	INTEGRATED CIRCUIT, MC1468L	1584502	1295
Q102	TRANSISTOR, 2N4918	1564918	1295
Q200	OPERATIONAL AMPLIFIER, UA741	1580010	7263
Q220	OPERATIONAL AMPLIFIER, UA741	1580010	7263
Q230	TRANSISTOR, 2N2484	1562484	7263
Q240	TRANSISTOR, 2N4250	1564250	7263
Q250	INTEGRATED CIRCUIT, LM312	1580312	10597
Q260	INTEGRATED CIRCUIT, LM312	1580312	10597
Q270	TRANSISTOR, 2N4250	1564250	7263
Q280	TRANSISTOR, 2N2484	1562484	7263
Q290	TRANSISTOR, 2N5485	1565485	4713
Q300	INTEGRATED CIRCUIT, CA3046	1580043	1295
Q330	TRANSISTOR, 2N4121	1564121	7263
Q350	TRANSISTOR, 2N4121	1564121	7263
Q360	INTEGRATED CIRCUIT, SN7420N	1580033	1295
Q400	OPERATIONAL AMPLIFIER, CA3030A	1580008	2735
Q500	TRANSISTOR, TIS87	1560087	1295
Q510	TRANSISTOR, TIS87	1560087	1295
Q520	TRANSISTOR, 2N4121	1564121	7263
Q530	TRANSISTOR, TIS87	1560087	1295
Q540	TRANSISTOR, 2N2219	1562219	1295
Q550	TRANSISTOR, 2N2905	1562905	1295
Q700	OPERATIONAL AMPLIFIER, UA741	1580010	7263
Q710	TRANSISTOR, 2N4121	1564121	7263
Q720	INTEGRATED CIRCUIT, CA3080	1583080	2735
Q730	TRANSISTOR, MPS3646	1563646	4713
R001	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R002	RESISTOR, 1500 OHM 1/4W 1% METAL FILM	3131501	7115
R003	RESISTOR, 7500 OHM 1/4W 1% METAL FILM	3137501	7115
R004	RESISTOR, 3900 OHM 1/4W 5% CARBON	3070392	1121
R005	RESISTOR, 49900 OHM 1/4W 1% METAL FILM	3134992	7115
R006	POTENTIOMETER 50K	3110339	10597
R007	RESISTOR, 10K OHM 1/4W 1% METAL FILM	3131002	7115
R008	POTENTIOMETER, 5K OHM TRIM	3110149	71450
R009	POTENTIOMETER, 50K	3110339	10597
R010	RESISTOR, 49900 OHM 1/4W 1% METAL FILM	3134992	7115
R011	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R012	RESISTOR, 12100 OHM 1/4W 1% METAL FILM	3131212	7115
R013	RESISTOR, 15000 OHM 1/4W 1% METAL FILM	3131502	7115
R014	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R015	POTENTIOMETER, 5K OHM TRIM	3110149	71450
R016	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R017	RESISTOR, 15000 OHM 1/4W 1% METAL FILM	3131502	7115
R018	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R019	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R020	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R021	POTENTIOMETER 1K OHM TRIM	3110147	71450
R022	RESISTOR, 2210 OHM 1/4W 1% METAL FILM	3132211	7115
R100	RESISTOR, 3000 OHM 1/4W 5%CARBON	3070302	1121
R101	RESISTOR, 2.0 OHM 1/2W 5% CARBON	3010020	1121
R102	RESISTOR, 2.0 OHM 1/2W 5% CARBON	3010020	1121
R103	RESISTOR, 1M OHM 1/4W 5% CARBON	3070105	1121
R104	POTENTIOMETER, 100K OHM TRIM	3110143	71450
R105	RESISTOR, 75 OHM 1/4W 5% CARBON	3070750	7115
R200	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103	1121
R201	RESISTOR, 2700 OHM 1/4W 5% CARBON	3070272	1121
R202	POTENTIOMETER, 5K	3110340	10597
R203	POTENTIOMETER, 20K OHM PC TRIM	3110131	78488
R204	RESISTOR, 15K OHM 1/4 5% CARBON	3070153	7115
R205	RESISTOR, 100K OHM 1/4W 5% CARBON	3070104	1121
R206	RESISTOR, 100K OHM 1/4W 1% METAL FILM	3131003	7115
R207	RESISTOR, 33.2K OHM 1/4W 1% METAL FILM	3133322	1121
R208	POTENTIOMETER, 10K OHM TRIM	3110150	71450
R209	RESISTOR, 100K OHM 1/4 W 1% METAL FILM	3131003	7115
R210	RESISTOR, 100K OHM 1/4W 1% METAL FILM	3131003	7115
R220	RESISTOR, 100K OHM 1/4W MATCHED	3121003	10597
R221	RESISTOR, 49.9K OHM 1/4W 1% METAL FILM	3134992	1121
R222	POTENTIMETOR, 10K OHM TRIM	3110150	71450
R230	RESISTOR, 3010 OHM MATCHED	3123011	10597
R231	RESISTOR, 1000 OHM MATCHED	3121001	10597
R250	POTENTIOMETER, 20K	3110341	10597
R260	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150	1121
R270	RESISTOR, 750K OHM 1/4W 1% METAL FILM	3137503	7115
R271	RESISTOR, 75K OHM 1/4W 1% METAL FILM	3137502	7115
R272	RESISTOR, 7500 OHM 1/4W 1% METAL FILM	3137501	7115
R273	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R273	RESISTOR, 75K OHM 1/4W 1% METAL FILM	3137503	7115

R280	RESISTOR, 750K OHM 1/4W 1% METAL FILM	3137503	7115
R281	RESISTOR, 75K OHM 1/4W 1% METAL FILM	3137502	7115
R282	RESISTOR, 7500 OHM 1/4 1% METAL FILM	3137501	7115
R283	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R283	RESISTOR, 750K OHM 1/4W 1% METAL FILM	3137503	7115
R300	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R301	RESISTOR, 2700 OHM 1/4W 5% CARBON	3070272	1121
R302	RESISTOR, 470 OHM 1/4W 5% CARBON	3070471	7115
R303	POTENTIOMETER, 10K OHM TRIM	3110150	71450
R304	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R305	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R306	RESISTOR, 4020 OHM 1/4W 1% METAL FILM	3134021	7115
R307	RESISTOR, 4020 OHM 1/4W 1% METAL FILM	3134021	7115
R308	RESISTOR, 499 OHM 1/4W 1% METAL FILM	3134990	7115
R309	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R310	RESISTOR, 30100 OHM 1/4W 1% METAL FILM	3133012	7115
R311	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R330	POTENTIOMETER, 2K OHM PC TRIM	3110130	78488
R331	RESISTOR, 13000 OHM 1/4 1% METAL FILM	3131302	7115
R332	RESISTOR, 910 OHM 1/4W 5% CARBON	3070911	1121
R333	RESISTOR, 13000 OHM 1/4W 1% METAL FILM	3131302	7115
R334	RESISTOR, 2700 OHM 1/4W 5% CARBON	3070272	1121
R335	POTENTIOMETER, 2K OHM PC TRIM	3110130	78488
R350	RESISTOR, 2700 OHM 1/4W 5% CARBON	3070272	1121
R352	RESISTOR, 12.1K OHM 1/4W 1% METAL FILM	3131212	7115
R353	RESISTOR, 12.1K OHM 1/4W 1% METAL FILM	3131212	7115
R354	POTENTIOMETER, 1K OHM TRIM	3110147	71450
R360	RESISTOR, 10 OHM 1/4W 5% CARBON	3070100	1121
R361	RESISTOR, 7500 OHM 1/4W 5% CARBON	3070752	1121
R400	RESISTOR, 49.9 OHM 1/4W 1% METAL FILM	3130499	7115
R401	RESISTOR, 11300 OHM 1/4W 1% METAL FILM	3131132	7115
R402	RESISTOR, 11300 OHM 1/4W 1% METAL FILM	3131132	7115
R403	RESISTOR, 12100 OHM 1/4W 1% METAL FILM	3131212	7115
R404	RESISTOR, 309 OHM 1/4W 1% METAL FILM	3133090	7115
R405	RESISTOR, 12100 OHM 1/4W 1% METAL FILM	3131212	7115
R406	RESISTOR, 200 OHM 1/4W 1% METAL FILM	3132000	7115
R407	RESISTOR, 24900 OHM 1/4W 1% METAL FILM	3132492	7115
R408	RESISTOR, 24900 OHM 1/4W 1% METAL FILM	3132492	7115
R409	RESISTOR, 127 OHM 1/4W 1% METAL FILM	3131270	7115
R410	RESISTOR, 63.4 OHM 1/4W 1% METAL FILM	3130634	7115
R411	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R412	RESISTOR, 5100 OHM 1/4 5% CARBON	3070512	1121
R413	RESISTOR, 1000 OHM 1/4 5% CARBON	3070102	1121
R414	RESISTOR, 150 OHM 1/4W 5% CARBON	3070151	1121
R415	RESISTOR, 680 OHM 1/4W 5% CARBON	3070681	1121
R416	POTENTIOMETER, 1K OHM PC TRIM	3110147	78488
R419	RESISTOR, 6800 OHM 1/4W 5% CARBON	3070682	1121
R500	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R501	POTENTIOMETER, 50K	3110339	10597
R502	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R503	RESISTOR, 8200 OHM 1/4W 5% CARBON	3070822	1121
R504	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R505	RESISTOR, 9090 OHM 1/4W 1% METAL FILM	3139091	7115
R507	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R508	POTENTIOMETER, 1K	3110342	10597
R509	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150	1121
R520	RESISTOR, 174 OHM 1/4W 1% METAL	3131740	7115
R521	RESISTOR, SELECTED VALUE		
R522	RESISTOR, 3010 OHM 1/4W 1% METAL FILM	3133011	7115
R523	RESISTOR, 24300 OHM 1/4W 1% METAL FILM	3132432	7115
R530	RESISTOR, 274 OHM 1/4W 1% METAL FILM	3132740	7115
R531	RESISTOR, 3010 OHM 1/4W 1% METAL FILM	3133011	7115
R532	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R540	RESISTOR, 47 OHM 1/4W 5% CARBON	3070470	1121
R541	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150	1121
R542	RESISTOR, 100 OHM 1/4W 1% METAL FILM	3131000	7115
R542	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R543	RESISTOR, 100 OHM 1/4W 1% METAL FILM	3131000	7115
R543	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R544	RESISTOR, 453 OHM 1/2W 1% METAL FILM	3104530	7115
R545	RESISTOR, 56.2 OHM 1/4W 1% METAL FILM	3130562	7115
R546	RESISTOR, 41.2 OHM 1/2W 1% METAL FILM	3100412	7115
R547	RESISTOR, 41.2 OHM 1/2W 1% METAL FILM	3100412	7115
R548	RESISTOR, 10.0 OHM 1/4W 1% METAL FILM	3130100	7115
R550	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150	1121
R551	RESISTOR, 47 OHM 1/4W 5% CARBON	3070470	1121
R552	RESISTOR, 1580 OHM 1/4W 1% METAL FILM	3131581	1121
R553	RESISTOR, 510 OHM 1/4W 1% METAL FILM	3130511	1121
R701	RESISTOR, 402K OHM 1/4W 1% METAL FILM	3134023	7115
R702	POTENTIOMETER, 50K	3110339	10597
R703	RESISTOR, 560 OHM 1/4W 5% CARBON	3070561	1121
R704	POTENTIOMETER, 500K OHM PC TRIM	3110132	78488
R710	RESISTOR, 82K OHM 1/4W 5% CARBON	3070823	1121
R720	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R721	RESISTOR, 56200 OHM 1/4W 1% METAL FILM	3135622	7115
R722	RESISTOR, 27K OHM 1/4W 5% CARBON	3070273	1121

R723	POTENTIOMETER, 10K OHM WITH SWITCH	3110343	10597
R730	RESISTOR, 100K OHM 1/4W 5% CARBON	3070104	1121
R731	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103	1121
R732	RESISTOR, 5100 OHM 1/4W 5% CARBON	3070512	1121
R740	RESISTOR, 5100 OHM 1/4W 5% CARBON	3070512	1121
S001	SWITCH, CTS 206-122 DIP	2600431	10597
S100	SWITCH, PUSHBUTTON DPDT	2600375	10597
S270	SWITCH, PUSHBUTTON 13 STATION	2600376	10597
S501	SWITCH, MIN. ROTARY 3P3T	2600090	76854
S700	SWITCH, 2 STATION INTERLOCK	2600378	71450
T100	TRANSFORMER, POWER	1200058	10597
U001	INTEGRATED CIRCUIT, MC1495L	1581495	4713
U002	INTEGRATED CIRCUIT, LM318	1580318	4713

Code List of Manufacturers

Code No.	Manufacturer	Address
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping and Tool	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite, Inc.	Neptune, N.J.
74455	J. H. Winns and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Illinois
74868	R.F. Prod. Div. of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Div. of Cinch Mfg. Corp.	Chicago, Illinois
75378	James Knights Co.	Sandwich, Illinois
75382	Kulka Electric Corp.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Illinois
75915	Littlefuse, Inc.	Des Plaines, Illinois
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamoid Electronic Mfg. Corp	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Illinois
77068	Bendix Pacific Div. of Bendix Corp.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostron Instrument and Electronic Co.	S. Pasadena, Calif.
77250	Phaell Manufacturing Co.	Chicago, Illinois
77252	Philadelphia Steel and Wire Corporation	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine/Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof, Div. of Illinois Tool Works	Elgin, Illinois
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn, Inc.	Pitman, N.J.
78452	Thompson-Bremer and Co.	Chicago, Illinois
78471	Tilley Manufacturing Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Illinois
79727	Continental-Wirt Elect. Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco, Div. of Sessions Clock Company	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Assoc. Any brand tube meeting EIA standards.	Washington D.C.
80207	Unimax Switch, Div. of W L Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Illinois
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro, Div. Robershaw Fulton Controls Co.	Columbus, Ohio Columbus, Ohio
80486	All Star Products, Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Illinois
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co, Inc.	Norwalk, Conn.
81349	Military Specifications	....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div, Industrial Tube Oper.	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82047	Carter Parts Co.	Skokie, Illinois
82142	Jeffers Electronics, Div. of Speer Carbon Co.	DuBois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod., Electronic Tube Div.	Emporium, Pa.
82376	Astron Company	E. Newark, N.J.
82389	Switchcraft, Inc.	Orange, Illinois
82647	Metals and Controls, Inc., Div. Texas Instruments, Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wisc.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, California
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp/Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Illinois
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Illinois
83501	Gavitt Wire and Cable Co., Div. Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Co.	Boonton, N.J.
85474	R.M. Bracamonte and Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Illinois
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansing Div.)	Lansing, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco
87664	Van Waters and Rogers, Inc.	Seattle, Wash.
87930	Tower Mfg. Co.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Illinois
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baker Co.	Chicago, Illinois
89665	United Transformer Co.	Chicago, Illinois
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Illinois
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia
91737	Gremar Mfg Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div	Freeport, Illinois
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92507	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod, Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith, Inc.	Port Monmouth, N.J.
93929	G.V. Controls	Livingston, N.J.
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Comp. Div, Rec. Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div, Calif. St. Plt	Newton, Mass.
94148	Scientific Radio Products	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	E. Paterson, N.J.
94222	Southco, Div. S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod., Div. Model Engineering and Mfg. Co.	Chicago, Illinois
94330	Wire Cloth Products, Inc.	Chicago, Illinois
94682	Worcester Pressed Alum. Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Illinois
95712	Dage Electric Co., Inc.	Franklin, Ind
95987	Weckesser Co.	Chicago, Illinois
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Div. of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner, Div. Maguire Industries, Inc.	Mt. Carmel, Ill
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Illinois
96341	Microwave Associates, Inc.	Burlington, Mass
96501	Excel Transformer Co.	Oakland, Calif
97464	Industrial Retaining Ring Co.	Irvington, N J
97539	Automatic and Precision Mfg.	Yonkers, N.Y.
97966	CBS Electronics Div. C.B.S., Inc.	Danvers, Mass
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif
98278	Microdot, Inc.	S. Pasadena, Calif
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif
99515	Marshall Industries, Electron Products Division	Pasadena, Calif
99707	Control Switch Div, Controls Co. of America	El Segundo, Calif
99800	Delevan Electronics Corp.	E. Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind
99934	Renbrandt, Inc.	Boston, Mass
99942	Hoffman Semiconductor Div of Hoffman Electronics Corp	Evanston, Illinois
99957	Technology Instrument Corp of California	Newbury Park, Calif

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