SIEMENS

Transmitter Tubes
Data Book

This data book presents our current range of grid-controlled triodes and tetrodes.

The tubes are intended for use in RF amplifiers in the field of research and development, in amplifier stages of broadcast transmitters for the SW, MW and LW range, in single-sideband communications transmitters, as well as in FM and TV transmitters.

RS 1036 L is especially worth mentioning. With this tube it is now possible to implement aircooled TV transmitters in band IV/V vor up to 20 kW in vision transmission or up to 10 kW / 1 kW in common vision and sound transmission.

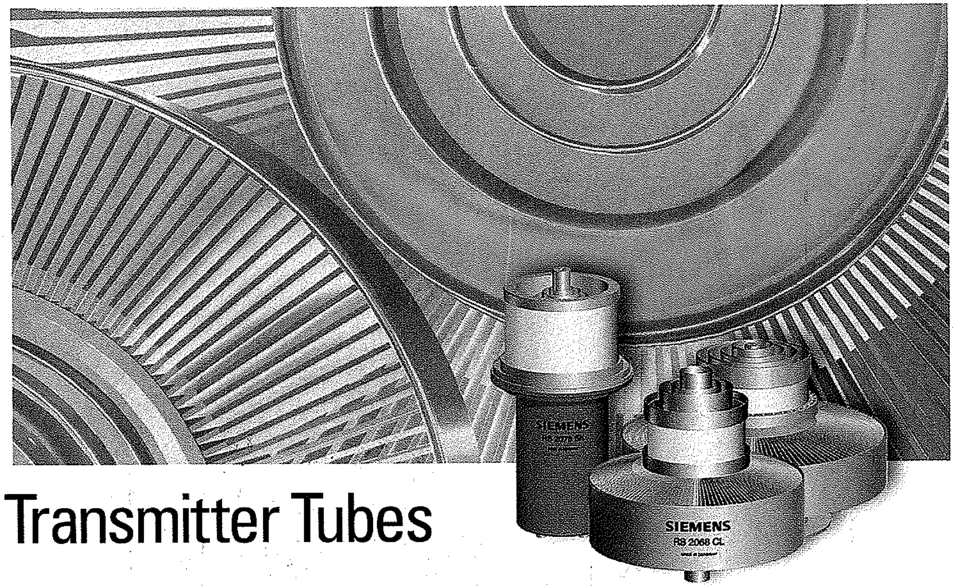
We are always available for detailed consulting on technical questions, special applications and reconfiguration of existing amplifiers/transmitters to our series products.

Newly included in this data book:

Type	Application
RS 1036 L	TV transmitters
RS 1092 L	
RS 1092 SK	
RS 1094 L	
RS 2016 CL	FM transmitters
RS 2018 CL	
RS 2068 CL	
RS 2015 CL	Broadcast transmitters
RS 2078 SK	
RS 2048 CJ	RF amplifiers

Eric Montesinos

SIEMENS



Transmitter Tubes

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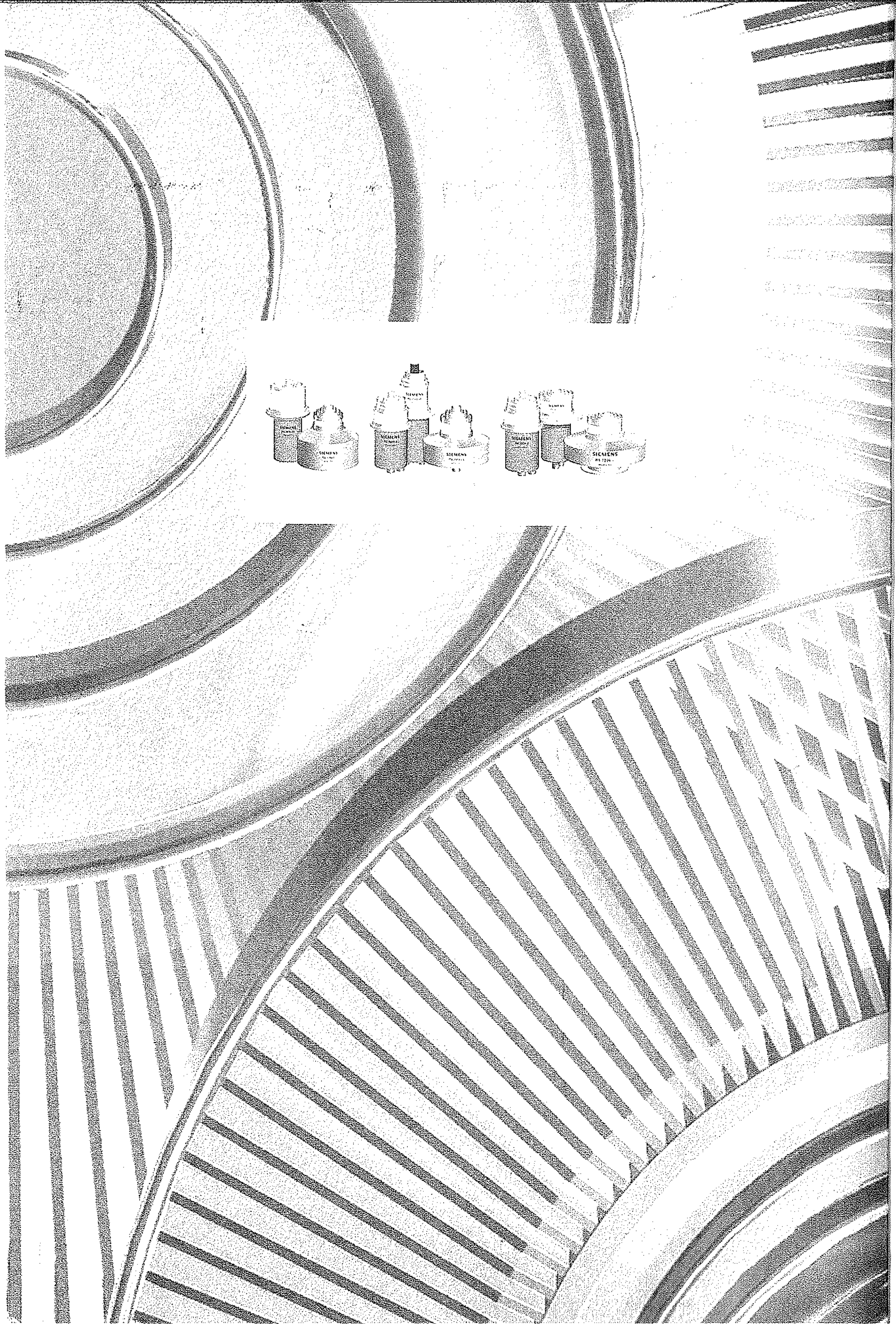

Transmitter Tubes

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The following tables are intended to facilitate selection of the appropriate tubes for the modes of operation listed below.

The tubes are, of course, also suitable for other applications than those given below. In this case we recommend to use the data sheets or to contact the manufacturer for further information.

Modes of operation:

1. RF amplifiers, telegraphy, pulse operation
2. Anode voltage modulation
3. AF amplifiers and modulators
4. RF linear amplifiers, single-sideband modulation
5. FM and TV transmitters
6. Pulse-duration modulation (PDM) / pulse-step modulation (PSM)

This data books contains all tubes which are recommended for the modes of operation 1 through 6.

Tubes which are particularly suitable for industrial applications are separately dealt with in the data book "Generator Tubes".

1 Transmitter tubes for RF amplifiers, telegraphy, pulse operation

P_2 1) kW	f MHz	f_{max} 2) MHz	Siemens type	Type	$P_{A\,max}$ kW	$U_{A\,max}$ kV	Page
1,7	230	1215	YL 1056	Tetrode	2	3,5	375
9	150	160	RS 2034 CL	Tetrode	12	8	256
11	110		RS 2012 CL	Tetrode	12	9	173
11	110		RS 2064 CL	Tetrode	10	12	323
12	110		RS 2024 CL	Tetrode	12	9	229
12	110		RS 2032 CL	Tetrode	12	9	250
15	50	110	RS 2012 CJ	Tetrode	18	9	173
15	230	300	RS 2026 CL	Tetrode	16	7	236
16	30	110	RS 2014 CL	Tetrode	6	7,5	186
22	30	70	RS 2011 V	Triode	12	11	164
22	110		RS 2068 CL	Tetrode	16	12	328
40	110		RS 2048 CJ	Tetrode	30	13	283
45	30		RS 1081 V	Triode	45	15	82
64	200	220	RS 2058 CJ	Tetrode	90	12	313
75	10	250	RS 1084 CJ	Tetrode	70	16	101
120	10	70	RS 2021 V	Triode	60	16	211
125	110	130	RS 2052 CV	Tetrode	120	12	294
125	200	220	RS 2004 J	Tetrode	120	9	157
165	30		RS 2031 V	Triode	110	12,5	243
190	50	150	RS 2054 SK	Tetrode	120	24	299
220	10	30	RS 2001 K	Triode	110	16	137
330	10	30	RS 2002 V	Tetrode	150	15	147
330	50	170	RS 2042 HF	Tetrode	300	23	270
350	30	60	YL 1490	Tetrode	200	15	395
600	50	110	RS 2074 HF	Tetrode	500	24	333
650	50	110	RS 2078 SK	Tetrode	500	28	348
660	10	30	RS 2041 V	Triode	220	19	262

1) Continuous wave output power; pulse output power upon request.
2) With derated data.

2 Transmitter tubes for anode voltage modulation

P_{trg} kW	f MHz	Siemens type	Type	$P_{A\,max}$ kW	$U_{A\,max}$ kV	Page
5,8	30	RS 2014 CL	Tetrode	5	5	186
6	30	RS 2011 V	Triode	12	6,5	164
10	160	RS 2015 CL	Triode	10	8	194
12	30	RS 2012 CL	Tetrode	12	6	173
12	30	RS 2012 CJ	Tetrode	18	6	173
22	30	YL 1500	Tetrode	15	8	402
22	30	RS 1081 V	Triode	45	10,5	82
55	30	RS 1082 CL	Tetrode	30	10,5	90
55	30	RS 1082 CV	Tetrode	45	10,5	90
66	30	RS 2021 V	Triode	60	11,5	211
66	30	RS 1084 CJ	Tetrode	70	10,5	101
100	30	RS 2001 K	Triode	110	11,5	137
105	30	RS 2054 SK	Tetrode	120	15	299
110	30	RS 2052 CV	Tetrode	120	12	294
212	30	RS 1043 CV	Triode	180	13	64
220	30	RS 2002 V	Tetrode	150	11,5	147
270	30	YL 1490	Tetrode	200	13	395
325	30	RS 2042 SK	Tetrode	300	15	270
330	10	RS 2041 V	Triode	220	11,5	262
400	30	RS 1828	Triode	250	12	126
525	30	RS 2074 SK	Tetrode	500	15	333
540	30	RS 2078 SK	Tetrode	500	13,5	348

3 Transmitter tubes for AF amplifiers and modulators, output power for 2 tubes in push-pull circuit

P_2 kW	Siemens type	Type	$P_{A\,max}$ kW	$U_{A\,max}$ kV	Page
16	RS 2012 CL	Tetrode	12	7	173
16	RS 2012 CJ	Tetrode	18	7	173
17,5	RS 2014 CL	Tetrode	6	7,5	186
20	RS 870	Triode	10	10	37
39	RS 2011 V	Triode	12	11	164
78	RS 2021 V	Triode	60	12	211
80	RS 1081 V	Triode	45	12	82
186	RS 2054 SK	Tetrode	120	15	299
200	RS 876	Triode	75	14	42
230	RS 2001 K	Triode	110	12	137
240	RS 2031 V	Triode	110	12	243
280	RS 2002 V	Tetrode	150	12	147
350	YL 1490	Tetrode	200	15	395
373	RS 2042 SK	Tetrode	300	15	270
410	RS 2041 V	Triode	220	15	262
420	RS 2051 V	Triode	180	12	289
450	RS 1043 CV	Triode	180	13	64
600	RS 2074 SK	Tetrode	500	15	333

4 Transmitter tubes for RF linear amplifiers, single-sideband modulation, carrier suppressed

P_2 kW	f MHz	f_{max} 1) MHz	Siemens type	Type	$P_{A\,max}$ kW	$U_{A\,max}$ kV	Page
9	30	110	RS 2014 CL	Tetrode	6	7,5	186
11	30	110	RS 2012 CL	Tetrode	12	9	173
11	30	110	RS 2012 CJ	Tetrode	18	9	173
12,5	30	110	RS 2794	Tetrode	12	8	354
33	30	110	RS 2795	Tetrode	25	11	360
33	30	250	RS 1082 CL	Tetrode	30	12	90
33	30	250	RS 1082 CV	Tetrode	45	12	90
44	30	250	RS 1084 CJ	Tetrode	70	12	101
110	30		RS 1896	Tetrode	100	15	132
110	30		RS 2002 V	Tetrode	150	15	147

1) With derated data.

5 Transmitter tubes for FM and TV transmitters

P_2 kW	f MHz	Siemens type	$P_{A\,max}$ kW	$U_{A\,max}$ kV	Band, application, circuit	Page
0,22	860	YL 1055	1,8	3,0	TV band IV/V, combined vision-sound amplification	368
0,55	860	YL 1056	2,0	3,5	TV band IV/V, combined vision-sound amplification	375
0,80	230	YL 1055	1,8	3,0	TV band III, sound amplification	368
1,00	230	YL 1056	2,0	3,5	TV band III, vision amplification	375
1,10	860	YL 1057	2,0	3,6	TV band IV/V, combined vision-sound amplification	382
1,10	860	RS 1094 L	4,5	5,0	TV band IV/V, combined vision-sound amplification	119
1,44	230	YL 1058	2,2	3,6	TV band III, sound amplification (two tone)	389
1,70	230	YL 1056	2,0	3,5	TV band III, sound amplification	375
2,20	230	YL 1057	2,0	3,6	TV band III, sound amplification	382
2,20	860	RS 1094 L	4,5	5,0	TV band IV/V, vision amplification	119
2,60	860	RS 1054	5,0	5,0	TV band IV/V, combined vision-sound amplification	70
3,10	860	RS 1054	5,0	5,0	TV band IV/V, sound amplification	70
4,60	860	RS 1054	5,0	5,0	TV band IV/V, vision amplification	70
5,25	860	RS 1092 L	12,5	6,5	TV band IV/V, combined vision-sound amplification	111
5,50	230	RS 2022 CL	12,0	5,5	TV band III, combined vision-sound amplification	222
6,30	860	RS 1034 L	13,0	5,5	TV band IV/V, combined vision-sound amplification	47
10,50	860	RS 1092 SK	25,0	7,5	TV band IV/V, combined vision-sound amplification	111
11,00	860	RS 1092 L	12,5	6,5	TV band IV/V, vision amplification	111
11,00	110	RS 2064 CL	10,0	12,0	FM, grounded grid circuit	323
11,50	860	RS 1036 L	20,0	7,0	TV band IV/V, combined vision-sound amplification	57
12,00	110	RS 2016 CL	12,0	9,0	FM, grounded cathode circuit	198
12,00	110	RS 2018 CL	12,0	9,0	FM, grounded cathode circuit	205
12,00	110	RS 2024 CL	12,0	9,0	FM, grounded cathode circuit	229
12,00	110	RS 2032 CL	12,0	9,0	FM, grounded cathode circuit	250

Transmitter tubes for FM and TV transmitters (continued)

P_2 kW	f MHz	Siemens type	$P_{A\,max}$ kW	$U_{A\,max}$ kV	Band, application, circuit	Page
12,40	860	RS 1034 L	13,0	5,5	TV band IV/V, vision amplification	47
12,60	860	RS 1034 SK	25,0	7,5	TV band IV/V, combined vision-sound amplification	47
16,00	230	RS 2022 CL	12,0	5,5	TV band III, vision amplification	222
22,00	230	RS 2026 CL	16,0	7,0	TV band III, vision amplification	236
22,00	860	RS 1092 SK	25,0	7,5	TV band IV/V, vision amplification	111
22,00	860	RS 1036 L	20,0	7,0	TV band IV/V, vision amplification	57
22,00	110	RS 2068 CL	16,0	12,0	FM, grounded grid circuit	328
25,80	860	RS 1034 SK	25,0	7,5	TV band IV/V, vision amplification	47
26,00	230	RS 1082 CL	30,0	6,0	TV band III, vision amplification	90

6 Transmitter tubes for pulse-duration modulation (PDM) / pulse-step modulation (PSM)

P_2 kW	Siemens type	Type	$P_{A\,max}$ kW	$U_{A\,max}$ kV	Page
125	RS 2054 SK	Tetrode	120	24	299
420	RS 2042 SK	Tetrode	300	28	270
700	RS 2074 SK	Tetrode	500	28	333
700	RS 2078 SK	Tetrode	500	28	348

Equivalent Transmitter Tubes

The tubes listed below can normally be replaced by the equivalent Siemens types. As minor electrical and mechanical variations are possible, it is, however, in any case necessary to compare data, characteristic curves, and surface dimensions of the tubes concerned prior to the exchange. The types in parentheses are nearly equivalent and in most cases may be exchanged unhesitatingly. For some types, minor modifications of the circuit are required. If the Siemens type is not contained in this data book, please contact your nearest Siemens office or representative.

Type	Siemens type	Type	Siemens type
BY 1161	RS 826	SRL 353	(RS 1001 L)
C 1108	(RS 1007)	SRS 456	RS 1002 A
C 1112	(RS 1002 A)	SRS 551	RS 1003
C 1136	RS 1002 A	TBL 12/50	(RS 1031 L)
CQS 50-1	(RS 2054 SK)	TH 290	(RS 1032 C)
CQS 200-3	(RS 2042 SK)	TH 345	RS 2068 CL
CQS 200-3	(YL 1490)	TH 347	RS 1094 L
CQS 400-1	(RS 2074 SK)	TH 361	(RS 2022 CL)
CQS 600-1	(RS 2074 SK)	TH 373	RS 2024 CL
CV 2130	RS 1007	TH 375	RS 2022 CL
CV 2131	(RS 1002 A)	TH 382	RS 1092 L
CV 3879	RS 1002 A	TH 393	(RS 1054 L)
CV 1172	RS 2002 V	TH 399	(RS 2024 CL)
E 125 A	RS 1007	TH 399	(RS 2032 CL)
E 250 A	(RS 1002 A)	TH 477	(RS 1031 V)
Q 160-1	(RS 1007)	TH 479	(RS 1081 V)
Q 400-1	(RS 1002 A)	TH 485	(RS 2021 V)
QB 3/300	RS 1007	TH 547	(RS 1054 SK)
QB 3,5/750	(RS 1002 A)	TH 558	RS 2078 SK
QB 4/1100	(RS 1002 A)	TH 573	(RS 2042 SK)
QY 3-125	RS 1007	TH 581	(RS 2054 SK)
QY 4-250	(RS 1002 A)	TH 582	RS 1092 SK
QY 4-400	RS 1002 A	TT 16	RS 1007
RD 250 VM	(RS 2041 V)	X-2170	(RS 2074 SK)
RE 125 C	RS 1007	X-2203	(RS 2074 SK)
RE 400 C	RS 1002 A	YD 1001	RS 2021 L
RS 683	(RS 1007)	YD 1002	RS 2021 V
RS 685	RS 1007	YD 1032	RS 2001 K
RS 686	(RS 1002 A)	YD 1092	RS 2031 V
RS 865	RS 2001 K	YD 1252	RS 2051 V
RS 875	RS 2031 V	YD 1262	RS 2041 V

Equivalent Transmitter Tubes

Type	Siemens type	Type	Siemens type
YL 1011	RS 1082 CL	3 CX 10000 A7	RS 2015 CL
YL 1012	RS 1082 CV	4-125 A	RS 1007
YL 1091	RS 2002 V	4-250 A	(RS 1002 A)
YL 1100	(YL 1042)	4-400 A	RS 1002 A
YL 1101	YL 1042	4 CW 100000 G	(RS 2058 CJ)
YL 1102	(YL 1042)	4 CX 5000 A	RS 2014 CL
YL 1103	(YL 1042)	4 CX 10000 A	(RS 2024 CL)
YL 1110	RS 1062 C	4 D 21	RS 1007
YL 1181	RS 1012 L	4 F 16 R	YL 1042
YL 1182	RS 1012 V	5 D 22	(RS 1002 A)
YL 1230	(RS 1072 C)	5 F 22	(RS 1002 A)
YL 1280	(YL 1050)	5 F 23	(RS 1002 A)
YL 1380	RS 1032 C	6155	RS 1007
YL 1470	(RS 2024 CL)	6156	(RS 1002 A)
YL 1470	(RS 2032 CL)	6816	(YL 1042)
YL 1520	(RS 2026 CL)	6884	(YL 1042)
YL 1560	(RS 1054 L)	7213	(RS 1072 C)
YL 1570	RS 1084 CJ	7213	(YL 1050)
YL 1580	(RS 1034 L)	7527	RS 1002 A
YL 1610	(RS 2024 CL)	7650	RS 1062 C
YL 1610	(RS 2032 CL)	8438	RS 1002 A
YL 1680	(RS 2058 CJ)	8973	(RS 2074 SK)
YL 1690	(RS 2064 CL)	8985	RS 2064 CL
		8990	RS 2064 CL

Symbols and Terms

Symbols for electrodes

A, a	Anode
F	Heater/filament terminal
F, K	Heater/filament terminal, cathode terminal
F_M	Filament center
G, g	Grid
G1, g1	Control grid
G2, g2	Screen grid
K, k	Cathode

Capacitances

C_{ga}	Capacitance grid/anode
C_{g1a}	Capacitance control grid/anode
C_{g2a}	Capacitance screen grid/anode
C_{g1g2}	Capacitance control grid/screen grid
C_{ka}	Capacitance cathode/anode
C_{kg}	Capacitance cathode/grid
C_{kg1}	Capacitance cathode/control grid
C_{kg2}	Capacitance cathode/screen grid
C_{xy}	Capacitance between the electrodes x and y
$C_{xy/z}$	Capacitance of the electrodes x and y with respect to the electrode z
C_1	Input capacitance
C_2	Output capacitance

Currents

I_A	Anode current (dc)
$I_{A\,0}$	Zero signal anode current (dc)
$I_{A\,M}$	Peak anode current
$I_{A\,p}$	Pulse anode current (dc)
$I_{A\,RMS}$	RMS value of ac anode current
$I_{A\,SW}$	Anode current (dc), black level
$I_{A\,SY}$	Anode current (dc), sync. level
I_{em}	Emission current
I_F	Heater/filament current
$I_{F\,M}$	Max. permissible starting current (peak value)
I_G	Grid current (dc)
$I_{G\,M}$	Peak grid current
$I_{G\,p}$	Pulse grid current (dc)
$I_{G\,RMS}$	RMS value of ac grid current
$I_{G1\,M}$	Peak control grid current
$I_{G1\,p}$	Pulse control grid current (dc)
$I_{G1\,RMS}$	RMS value of ac control grid current
$I_{G1\,SW}$	Control grid current (dc), black level
$I_{G1\,SY}$	Control grid current (dc), sync. level

Currents (continued)

I_{G2}	Screen grid current (dc)
$I_{G2\ p}$	Pulse screen grid current (dc)
$I_{G2\ SW}$	Screen grid current (dc), black level
$I_{G2\ SY}$	Screen grid current (dc), sync. level
I_K	Cathode current (dc)
$I_{K\ M}$	Peak cathode current
$I_{K\ p}$	Pulse cathode current (dc)
I_0	Direct current, average value

Powers

P_A	Anode dissipation
$P_{A\ 0}$	Zero signal anode dissipation
$P_{A\ mod}$	Anode dissipation at modulation
$P_{A\ p}$	Pulse anode dissipation
$P_{A\ SW}$	Anode dissipation, black level
$P_{A\ SY}$	Anode dissipation, sync. level
$P_{B\ A}$	Anode input power
$P_{B\ A\ mod}$	Anode input power at modulation with m = 1
$P_{B\ A\ p}$	Pulse anode input power
$P_{B\ A\ SW}$	Anode input power, black level
$P_{B\ A\ SY}$	Anode input power, sync. level
P_F	Heater/filament power
P_G	Grid dissipation
$P_{G\ mod}$	Grid dissipation at modulation
$P_{G\ p}$	Pulse grid dissipation
P_{G1}	Control grid dissipation
$P_{G1\ p}$	Pulse control grid dissipation
$P_{G1\ SW}$	Control grid dissipation, black level
$P_{G1\ SY}$	Control grid dissipation, sync. level
P_{G2}	Screen grid dissipation
$P_{G2\ p}$	Pulse screen grid dissipation
$P_{G2\ SW}$	Screen grid dissipation, black level
P_{mod}	for m = 1 required modulation power
P_{trg}	Carrier power
P_1	Drive power
$P_{1\ p}$	Pulse drive power
$P_{1\ SW}$	Drive power, black level
$P_{1\ SY}$	Drive power, sync. level
$P_{1\ Ton}$	Drive power, sound
P_2	Output power
$P_{2\ p}$	Pulse output power
$P_{2\ SW}$	Output power, black level
$P_{2\ SY}$	Output power, sync. level

Resistances

R_A	Anode load resistance
R_{AA}	Effective load resistance (anode to anode)
R_{ant}	Antenna resistance
$R_{A\ prot}$	Resistance for anode protection
R_G	Grid resistance
$R_{G\ sperr}$	Grid resistance (tube not conducting)
R_{G1}	Control grid resistance
R_K	Cathode resistance

Voltages

U_A	Anode voltage (dc)
$U_{A\ M}$	Peak anode voltage
$U_{A\ p}$	Pulse anode voltage (dc)
$U_{A\ 0}$	Cold anode voltage (dc), tube not conducting
U_{AG}	Anode-grid voltage (dc)
$U_{a\ m}$	Peak anode voltage (ac)
$U_{B\ A}$	Anode input voltage (dc)
U_F	Heater/filament voltage
$U_{F'}$	Preheating voltage
U_G	Grid voltage (dc)
$U_{G\ M}$	Peak grid voltage
$U_{G\ p}$	Pulse grid voltage (dc)
$U_{g\ m}$	Peak control grid voltage (ac)
$U_{g\ m\ p}$	Peak pulse control grid voltage (ac)
$U_{g1\ m\ SY}$	Peak control grid voltage (ac), sync. level
$U_{gg\ m}$	Peak control grid voltage (ac) between grids in push-pull circuitry
$U_{G\ RMS}$	RMS value of ac grid voltage
U_{G1}	Control grid voltage (dc)
$U_{G1\ cut\ off}$	Control grid cut-off voltage
$U_{G1\ fix}$	Control grid bias (dc), fixed
U_{G2}	Screen grid voltage (dc)
U_{KG}	Cathode-grid voltage (dc)
$U_{kk\ m}$	Peak voltage (ac) between cathodes in push-pull circuitry
U_{mod}	Modulation voltage
U_{TR}	Transformer voltage

Index of Symbols

Miscellaneous

a_{IM2}	2-tone intermodulation ratio
a_{IM3}	3-tone intermodulation ratio
B	Bandwidth
D	Duty cycle
d_3	Third order intermodulation products
$d_{3\,2}$	Third order intermodulation products, 2 carriers
d_5	Fifth order intermodulation products
f	Frequency
f_B	Vision carrier frequency
f_{max}	Max. operating frequency
f_p	Pulse repetition frequency
f_{SB}	Sideband frequency
f_{ST}	Interference frequency
f_T	Sound carrier frequency
h	Altitude above sea level
IP_3	Third order intercept point
k	Total distortion
k_p	AM/PM conversion
m	Modulation factor
p_{syst}	Static system pressure, absolute
Q	Coolant flow rate
s	Transconductance
t_A	Anode temperature
t_{amb}	Ambient temperature
t_h	Preheating time
t_K	Cathode temperature
t_p	Pulse period
t_{surf}	Surface temperature
t_0	Pulse break
t_1	Inlet temperature
t_2	Outlet temperature
V_p	Power gain
α	Cold loss
Δp	Pressure drop
η	Anode efficiency
η_p	Pulse efficiency
η_{total}	Total efficiency
μ	Amplification factor
μ_{g2g1}	Amplification factor of screen grid

Commas used in numerical values denote decimal points.

Explanations on Technical Data

1 General information

In order to facilitate quick orientation, each data sheet is preceded by a brief description of construction, cooling and application as well as maximum power and frequency ratings.

Characteristics, capacitances and characteristic curves apply to the average tube. Spread data are supplied upon request.

We recommend the use of the accessories specified for the individual tubes to ensure smooth operation. Detailed information on accessories upon request.

2 Heating

The type of cathode used determines the requirements on stability which have to be met to obtain maximum service life. For this reason the type of heating and the cathode material are always specified in addition to heater voltage and heater current.

2.1 Thoriated tungsten cathodes

The stated heater voltage is the maximum value required by a new tube in order to deliver its rated output power. The maximum permissible deviation from the specified value, caused by temporary fluctuations in the line voltage, must not exceed ± 5 %, unless other tolerances are given in the data sheets. Radiation-cooled tubes (and tubes for industrial generators) in contrast, permit a temporary deviation of + 5/– 10 %.

The heater voltage generally requires stabilization to compensate for possible line voltage fluctuations. If a phase control circuit is used, this should be taken into account when dimensioning the heater transformer (increased rms value of primary current).

To measure the heater voltage for control and adjustment purposes a true rms voltmeter, class 0,5, should be directly applied to the cathode terminals.

A constant deviation of the heater voltage mean value from the specified value, e. g. due to a wrong transformation ratio or a long-term alternation of the mean line voltage (e.g. change from 380 V to 400 V line voltage), must be kept within the limits of + 1/– 3 %. Therefore the primary voltage should be tapped at ± 2,5 % and ± 5 % to ensure appropriate adjustment of the transformation ratio.

The heater current of new tubes may deviate from the rated value within certain tolerances. In addition, the evaporation of the emissive material in the course of the service life leads to a slow increase of the heater current to 15 % of its initial value. This has to be considered when dimensioning the heater transformer.

There must be no RF voltage between the cathode and heater terminals of a directly heated tube. If necessary, a capacitive short circuit has to be provided.

2.2 Oxide cathodes

Overheating of this cathode type results in a rapid emission decrease, whereas underheating causes localized emission on few preferred coating spots, thus damaging the cathode. Furthermore there is the danger of cathode contamination. For oxide cathodes the maximum permissible temporary deviation from the specified value due to line voltage fluctuations must therefore not exceed ± 10 % and the permanent deviation must be within + 1/– 3 %.

Heating up between heater and cathode by RF currents has to be avoided by means of a suitable circuit.

3 Startup

3.1 Switching on the heating and the grid bias voltage

In general, the heating can be switched on at full heater voltage, provided that a heater transformer with standard magnetic stray field is used. The maximum permissible starting current should not exceed 6 times the normal heater current. For some types, however, the permissible starting currents are substantially lower. In some cases the data sheet specifications prescribe a slow increase of the heater voltage until the specified value is reached. These requirements can be met by applying the heater voltage step by step or by providing a motor-driven control transformer or a thyristor transformer on the primary side of the heater voltage transformer. The maximum current to be expected can be calculated from the cathode's cold resistance and the current/voltage dependence of the heater current source. It is easier, however, to determine the peak starting current by use of an oscillograph.

Grid bias voltage and heater voltage may be simultaneously applied, unless no other instructions are given in the data sheets.

3.2 Switching on the anode dc voltage

The anode voltage may only be applied to tubes with external anode and thoriated tungsten cathode after the cathode has reached its operating temperature. This can be checked by means of the heater current. The preheating time, differing from tube to tube but also depending on the internal impedance of the heater current source, is between 2 and 3 seconds. The switching sequence described here must also be maintained in case of power supply failures or operational breakdowns. It is advisable to preheat new tubes or tubes which have been stored for a long time. Generally 15 minutes are sufficient.

For transmitter tubes with external anode, measures should be taken to assure that the anode dc voltage for hardening the tube and tuning the resonant circuits can be applied with at least one intermediate stage. On the other hand, when turning on the tuned transmitter under normal conditions no intermediate stage is required for applying the anode voltage, provided that during the turn-on process the peak voltage (overshoot) does not exceed the maximum permissible anode voltage stated in the data sheets. We therefore recommend to check the turn-on process by means of an oscillosgraph.

Tubes using an oxide cathode must always be preheated for at least 3 minutes before the positive electrode voltages are applied.

For instruction on necessary protection measures in the grid and anode circuits see "Safety precautions".

3.3 Switching on the screen grid voltage of tetrodes

It is essential to apply the screen grid voltage always after the anode voltage. With the help of a voltage-operated relay in the anode circuit it must be assured that the screen grid voltage is switched off at exactly the same moment as the anode voltage. The use of a surge arrester or spark gap between screen grid and cathode is recommended to protect control grid and cathode in case of tube spark-overs.

3.4 Transmitter off-periods

3.4.1 Influencing parameters

Maximum customer benefit is achieved if the costs produced by transmitter off-periods can be minimized. The total costs result from three influencing parameters, which have to be evaluated and optimized.

- Frequent switching of the heating of tubes with thoriated tungsten filament reduces tube lifetime because of the thermal cycling that accompanies this.
- Heating operation of a tube with rated voltage reduces cathode lifetime because of decarburizing of the filaments, since these remain at operating temperature.
- Heating operation causes power costs; these result from the tube heat output and the motor power for blowers and water pumps that is needed for cooling (not with vapor-condensation-cooled tubes).

3.4.2 Constant heating

For optimum tube utilization it is necessary that the full heater voltage (and cooling) is left switched on for up to two hours during transmitter off-periods.

In the case of several short transmitting blocks a day (e.g. four blocks of three hours each) we recommend constant heating (and cooling) throughout the day, as has already been practiced for some time, with success, by a number of large broadcasting stations.

3.4.3 Black heating

Here tubes are heated at such low power during transmitter off-periods that no forced cooling is necessary. This is better in every case than switching off the tube heating entirely, because thermal cycling stays low and there is no drop in emission through decarburization. The tube time meter, which is important for the warranty period, is off during this period.

Black heating should be provided for station breaks of more than two hours in the case of our modern UHF tetrodes. We recommend partial heating for tubes with high UHF heater power.

3.4.4 Partial heating

In cases where there are many long station breaks daily, because of short times on the air, high-power transmitters should be equipped for partial heating, i.e. heating with approx. 60% of normal heating power.

In this procedure the cathode temperature is stepped down far enough so that there is no drop in emission through decarburizatuion. Thermal cycling is reduced substantially by the relatively small temperature jump, compared both to black heating and especially to entire shutdown of the heating. The tube time meter is off during partial heating.

Power costs drop – compared to constant heating – because of the reduced heating power accompanied by the possiblity of cutting back the motors for the coolants.

Please contact us for detailed consultation.

4 Characteristics

The stated emission current I_{em} is the current provided by the cathode when voltage is applied to all other interconnected electrodes. This voltage value is specified in addition to the emission current. Measuring the I_{em} requires special methods to avoid overloading the tube and is therefore reserved to the tube manufacturer. In general, the stated value also represents the maximum current that can be drawn from the cathode during oscillator operation. Values for pulse operation are available upon request.

The amplification factor μ indicates the ratio of an anode voltage change (for tetrodes of a screen grid voltage change) to the control grid voltage change at constant anode current (inverse amplification factor: $D = \mu^{-1}$).

The transconductance s indicates the ratio of an anode current change to the control grid voltage change with all other electrodes at constant voltages. As the characteristic curves of the individual tubes are non-linear and therefore μ and s are no constants, the voltages and anode currents chosen for measuring these two values are quoted.

The values of μ and s are average values, hence deviations may be expected from tube to tube as a result of production variations. The permissible tolerance has been selected such that tubes of the same type can be interchanged. The same applies to the capacitance values. They have been measured at the cold tube and are determined such that the capacitance values of electrodes not used in the measurement have no effect on the result.

5 Modes of operation, maximum ratings and operating characteristics

5.1 General

The various modes of operation under which the tube can be operated demand different characteristics, e. g. with respect to its emission and its electric strength. Maximum ratings are therefore stated for each specific mode of operation. For reasons of service life and reliable tube operation these maximum ratings must not be exceed under any circumstances, for example in case of unbalanced resonant circuits, variable load, or voltage fluctuations. Each maximum rating is an absolute value that must be kept even if all other maximum ratings are not reached.

Of course, the tubes can also be used for operating modes which are not included in this book, provided that the maximum ratings are not exceeded. Operating data are supplied upon request.

5.2 Maximum ratings

The maximum operating frequency has been determined under consideration of the design of the tube. Exceeding these values may damage the electrodes and the glass or ceramic insulators. When determining the maximum operating frequency for a specific tube type, factors such as lead inductances, interelectrode capacitances, electron transit times, capacitive heating of the glass or ceramic parts, and RF voltages are taken into consideration. The data sheets therefore contain different values of the maximum operating frequency in conjunction with corresponding maximum anode voltage values for continuous operation, e. g.

RS 1084 CJ: f_{max} = 10 MHz at U_A = 16 kV;
f_{max} = 40 MHz at U_A = 12 kV.

For pulse operation with high powers (also at high frequencies) the stated power dissipation and ac voltages may be exceeded during the short pulse period. Recommeded operating data upon request.

The maximum ratings of anode dc voltage and grid dc voltage U_A and U_G may depend on operating frequency, electrode spacing for the relevant mode of operation, and dielectric strength of the insulator materials. These ratings must not be exceeded even with an unheated cathode. Particular attention has to be paid to this requirement if the screen grid is connected via a series resistor.

The maximum permissible anode voltage U_A at operation with alternating or unsmoothed voltages is the peak AF value.

The absolute maximum value of dc cathode current I_K is the maximum current that may be drawn during the actual mode of operation. It consists of the dc anode current and all dc grid currents.

The same applies analogously to the peak cathode current $I_{K\,M}$.

The maximum permissible anode dissipation P_A is determined by the permissible thermal loading of the anode. Exceeding this maximum value may lead to an impairment of the vacuum due to outgassing, depositions on insulation paths, melting of the anode body in tubes with external anode, impermissible heating of the glass bulb in radiation-cooled tubes, and thus to damage or total destruction of the tube.

For tubes with external anode the maximum rating stated must not be exceeded, even if the coolant flow rate is increased above the value specified for the permissible power dissipation.

If the maximum coolant flow rate is not available, the reduced maximum rating given in the diagram has to be strictly observed.

For suitable protection measures against thermal overloading of the anode see “Safety precautions”.

The maximum admissible control grid and screen grid dissipation P_{G1} or P_{G2} respectively, are likewise determined by the thermal load handling capability. Depending on the mode of operation and operating frequency the maximum grid dissipation will have different values to allow for additional grid heating due to RF current. Therefore, particular attention should be given to this rating.

The dc electrode voltages stated under maximum ratings and operating characteristics are referred to the cathode unless otherwise denoted by additional indices. The quoted ac voltages are always peak values (e. g. $U_{g\,m}$).

5.3 Operating characteristics

The specified operating characteristics for the individual modes of operation represent recommended settings for optimum utilization of the tube; the maximum ratings are observed with due regard to a practical safety margin. The operating characteristics are based on precise calculations according to the measured characteristic curves of average tubes, which have been confirmed by measurements during operation in testing laboratories and by the user.

The output power P_2 gives the power available at the tube output for amplifier operation. It can be calculated by subtracting the anode dissipation from the anode input power (dc power):

$P_2 = P_{B\,A} - P_A = U_A \; I_A - P_A$.

The actual RF output power is then reduced by the losses of the output circuit; it can be determined calorimetrically by means of an effective resistor which converts the power into heat. The formula is the same as for the determination of P_A, see below.

The values specified for P_2 usually do not include circuit losses. If circuit losses are taken into account, this is stated in the footnote.

The drive power P_1 required by the grid to control the tube can be approximately calculated by the grid ac voltage and the grid dc current:

$$P_1 \approx (0{,}92 \text{ to } 0{,}95)\ U_{G1m}\ I_{G1}.$$

For class B operation the smaller multiplying factor should be chosen and for class C operation the greater one.

The anode dissipation P_A can be determined calorimetrically from the temperature rise and the flow rate of the cooling agent:

$P_A = 0{,}070\,(t_2 - t_1)\,Q_W$ (water cooling, vapor condensation cooling),

$P_A \approx 0{,}018\,(t_2 - t_1)\,Q_L$ [1] (air cooling).

P_A in kW results from the temperature rise in °C and the water flow rate in l/min or the air flow rate in m³/min.

The anode dissipation of radiation-cooled tubes can be measured pyrometrically. The anode temperature for the intended operation is compared with that in static operation. This measurement is especially recommended when new equipment is designed.

The screen grid dissipation P_{G2} is the product of the screen grid dc voltage and the mean value of the screen grid current. If the screen grid also carries ac voltage, then the momentary values of voltage and current are required.

The control grid dissipation P_{G1} is the difference between the drive power and the power supplied by the grid voltage source and can be approximated by the formula:

$P_{G1} = P_1 - |U_{G1}|\ I_{G1}$ (P_1 determined by approximation, see above).

The direct calculation of P_{G1} from the characteristic curves is based on the mean value of the momentary products of control grid voltage and current. The result can then be used for a reliable calculation of the drive power:

$$P_1 = P_{G1} + |U_{G1}|\ I_{G1}$$

The efficiency η is the percentage ratio of the tube output power P_2 to the anode input power $P_{B\,A}$.

When operating the tube in grounded grid circuit, considerably more power is required from the driver stage than with grounded cathode circuit; however, this extra power is transferred completely to the output circuit and adds to the tube output power. This RF power supplied by the driver stage is called transition power and is specified in the relevant data sheets for both P_1 and P_2 as separate term of the sum.

1) Valid with a max. error of ± 5 %, if at 1 bar air pressure the average cooling air temperature $(t_1 + t_2)/2$ lies between 39 °C and 72 °C.

For an amplifier in grounded grid circuit the total output power is consequently greater by the factor $1 + U_{g1\,m} / U_{a\,m}$. When calculating the tube efficiency in this case, the transition power must not be added to the tube's output power.

The anode load resistance R_A is the ac resistance required for safe loading under the given operating mode. The load resistance must satisfy the equation $R_A = U_{a\,m}^2 / 2\,P_2$ in order to obtain the correct anode ac voltage $U_{a\,m}$ at the desired power P_2.

Deviations from the quoted value usually lead to a deterioration of the operating conditions with regard to power or efficiency or may also lead to exceeding the maximum ratings. An RF output transformer or a transforming network of reactance resistors can provide low-loss matching of the given load resistance to the target value R_A.

With grounded cathode circuit R_A is located between anode and cathode and with grounded grid circuit between the tube's anode and grid.

In case of sinusoidal modulation the modulation factor m is the ratio of the amplitude of the modulating AF voltage to the voltage amplitude of the carrier. It is most conveniently measured by means of an oscilloscope. In case of anode voltage modulation via a modulating transformer the value P_{mod} indicates the power to be supplied by the modulator for $m = 1$, i. e.

$$P_{mod} = \frac{m^2}{2} P_{B\,A} = \frac{1}{2} P_{B\,A}.$$

$P_{B\,A}$ is the anode input power of the RF stage with unmodulated carrier.

6 Mounting and connection

6.1 Mounting position

Transmitter tubes are usually mounted vertically with the anode up or down, according to the instructions given for the individual types. Exceptions are some types with oxide cathodes, which can be mounted in any position.

6.2 Mounting and removal

Mounting and removal of transmitter tubes have to be carried out with particular care to avoid any damage to the cathode or the fragile parts of the vacuum envelope. By all means, any shock or impact has to be avoided. This also applies to defective tubes, if they are subject to claims under warranty.

For the same reasons the connectors and particularly the large header sockets must be mounted on the tube with utmost care and under smooth and uniform pressure.

7 Cooling

7.1 Maximum tube surface temperature

During operation the tube is heated by the heater or filament and the power dissipated by grid and anode. Cooling keeps the heating effect within bounds and avoids damage due to overheating.

In order to determine whether the temperature is maintained within the limits stated for each type of tube, temperature measurements have to be carried out under worst-case operating conditions with respect to temperature rise. This is particularly important when new equipment is put into operation. Calibrated thermocouples or temperature indicators (thermocolor paints and similar), for example, can be used for measuring the tube surface temperature.

7.2 Forced-air cooling

Forced-air-cooled tubes have a metallic external anode, the outer surface of which is enlarged by cooling fins. The cooling air, which is filtered to prevent contamination, is either blown or sucked through this radiator.

The minimum air flow rate Q required for a certain anode dissipation P_A, the pressure drop in the radiator Δp and the air outlet temperature t_2 are given in the cooling air diagrams contained in the data sheets. The curves apply to an air inlet temperature t_1 of 25 °C, a normal air pressure of 1 bar, and air supply from the side of the terminals.

Operation at air inlet temperatures above 25 °C is possible if the same outlet temperature can be maintained by increasing the air flow rate which results in a correspondingly lower temperature rise. With inlet temperatures below 25 °C the air flow rate should however not be reduced.

For operation at high altitudes above sea level the cooling air flow rate should be increased inversely proportional to the decrease in air pressure; for example 13 % at 1000 m altitude or 45 % at 3000 m.

With reverse cooling air direction, i. e. from the anode base, cooling of the tube terminals is less effective so that at the most only 85 % of the normally permitted anode dissipation is allowed.

For high-power tubes or for RF operation it may be necessary to provide suitable air ducts in the region of the tube terminals or a separate flow of cooling air on the terminal side of the tube, in order to keep within the temperature limits.

When using cavity circuits it should be ensured that sufficient space is provided between the individual springs of the contact ring for the passage of cooling air.

The air flow and the outlet temperature should be monitored by means of a trip circuit which disconnects the voltages applied to the tube, including the heater voltage, in case of operational malfunction.

The deciding factor for the setting of these trip circuits and for the dimensioning of the radiator is always the maintenance of the maximum permissible temperature.

7.3 Water cooling

Water-cooled tubes (J types) are fitted with a cooling jacket, which forms a unit with the anode. This design has replaced the older type with separate cooling jacket because of its advantages of lower cooling water requirement and more simple construction.

The water inlet and outlet pipes must be insulated. In order to avoid electrolytic corrosion, it is recommended that our "LL electrolytic target" is used for the water connections on the anode side.

The water stream is directed to flow upwards along the hot anode wall. If the tube is mounted anode-down, the arrows next to the water connections show the direction of water flow. If the tube is mounted anode-up, then the cooling water must flow in the opposite direction to the arrows.

In order to prevent damage to the tube as a result of mineral deposits on the anode, it is recommended to use a closed cooling cycle filled with distilled or deionized water. This cooling cycle is to be connected via a heat exchanger to a series-connected cooling system. The cooling water diagrams given for the individual types of tube apply to distilled or deionized water, especially those diagrams which are provided for water inlet temperatures of 35 °C with regard to operational considerations and cost-saving dimensioning of the heat exchanger.

The minimum water flow rate Q for a given anode dissipation P_A as well as the water outlet temperature t_2 and the pressure drop Δp can be read from the cooling water diagrams.

The maximum water outlet temperature is 65 °C when distilled water is used. The maximum permissible pressure of the cooling water is 5 bar, if not otherwise specified (overpressure).

For cleaning of the cooling system from mineral deposits 10 % citric acid solution should be used, which is left for a few hours in the system to take effect. The cleaning work has to be carried out with great care since the cathode of the tube is very sensitive to shock.

If the primary anode cooling circuit contains corrodable foreign materials such as iron or zinc alloys (this should be avoided in new systems), the oxygen content of the water that causes corrosion or dezincing can be bound by adding 15 % diamine hydrate. The products of the reaction are only pure water and nitrogen. Approximately 1 ml of solutions is required to 1 l of water.

It is recommended to check the quality of the circulating cooling water after starting operation and at regular intervals by measuring the electrical conductivity (≤ 50 µS/cm) and the hydrogen ion concentration (pH value 7 to 9).

The water pumps must be switched on latest with the tube heating. The flow rate and the water temperature must be automatically monitored during operation. When the flow rate drops below a certain value the tube electrode voltages, including the heater voltage, must be disconnected automatically. The same applies if the maximum admissible water outlet temperature is exceeded. After-cooling is normally not necessary after the equipment has been switched off.

Additional air cooling of the tube's terminal side is necessary to keep the temperature within the specified limits. The given air flow rates are recommended values; the decisive factor is always the maintenance of the maximum permissible temperature.

7.4 Vapor cooling

Vapor cooling makes use of the fact that a thermal energy of 2260 kJ is necessary to convert 1 l of water with a temperature of 100 °C into steam of the same temperature. The required heat is taken from the anode, which is cooled by this effect.

The data sheets include detailed information on the total dissipated power, on the amount of water vaporized per unit time and on the volume of vapor produced at various coolant inlet temperatures in the boiler (returning water temperature). Distilled or deionized water should be used as coolant. In the time period immediately after starting operation the total water contents are to be exchanged repeatedly until the equipment and the pipe network are purged from unavoidable contamination. The cooling water should be exchanged as part of servicing, if the specific resistance falls during the operation of the equipment to below 20 kΩcm or if the conductivity increases to over 50 µS/cm.

The maximum permissible anode dissipation given in the data sheets for vapor-cooled tubes can only be regarded as ensured if even traces of contaminants in the cooling water are avoided, e. g. organic matter such as oil and grease.

Siemens supplies accessories that were especially developed for vapor cooling. The use of these accessories is imperative for trouble-free equipment operation.

Additional cooling of the grid and cathode terminals by means of an adequate air flow is required for keeping the temperature within in the specified limits. The given air flow rates are recommended values; the deciding factor is always the maintenance of the maximum permissible temperature.

The header sockets supplied as accessories should be provided with a connection for cooling air.

7.5 Vapor condensation cooling

The vapor condensation method is a combined steam/water cooling method. The coolant cycle, which is normally hermetically closed, and the special structure of the anode surface enable a more efficient removal of the dissipation heat than the previously used cooling methods. For each kilowatt of dissipation power approx. 0,5 l/min of distilled or deionized circulating water is required (conductivity ≤ 50 µS/cm).

If the cooling water has a permanent overpressure of 1,5 bar, the temperature of the water outlet may be up to 100 °C. The prescribed safety fuse must respond to an overpressure of 2 bar. For the vapor condensation system the relation between the anode dissipation P_A, the minimum water flow rate Q, the pressure drop Δp between the water connections and the water outlet temperatures t_1 = 60 °C, 65 °C or 70 °C are given in the cooling water diagram for the tube.

Operation with open cooling cycle, i. e. without overpressure, is also possible if it is ensured that with normal external air pressure of ≈ 1 bar the water outlet temperature cannot exceed 70 °C. This can be achieved using an appropriately lower water intake temperature and, if necessary, an increased cooling water flow rate.

The cooling system comprises a cooling water pump, the tube to be cooled in the SK version, a heat exchanger and a reservoir vessel and, additionally for operation under pressure, a pressure equalizing vessel, which can be combined with the reservoir vessel, as well as devices for operational and monitoring tasks. Impermissible increases in pressure due to fault conditions are avoided by the 2 bar overpressure safety valve.

The water inlet and outlet pipes must be insulated. In order to avoid electrolytic corrosion, it is recommended that our “LL electrolytic target” is used for the water connections on the anode side (accessory).

The prescribed direction of water flow is indicated by arrows; it is not dependent on the mounting position of the tube.

The water pumps must be switched on at the same time as the tube heating. Additional cooling of the tube terminals is necessary for keeping the temperatures within the specified limits. The air flow rates given in the data sheets are recommended values; the deciding factor is always the maintenance of the maximum permissible temperature.

The water flow rate and the water outlet temperature should be monitored by automatic trip circuits so that all voltages applied to the tube, including the heater voltage, are switched off under fault conditions.

To facilitate tube exchange without loss of cooling water the larger tubes of the SK series have a threaded joint for connection of a drain pump.

8 Safety precautions

Transmitter tubes must be equipped with certain protective devices, which comprise automatic safety and trip circuits to prevent the tube from being damaged in case of malfunction. Claims under warranty can only be asserted if these safety devices have been provided.

For tetrodes in amplifier operation it has to be ensured by means of an interlocking circuit that (after switching on the cooling system of tubes with separate cooling) the operating voltages are applied in the following sequence: heater voltage and grid bias – anode voltage – screen grid voltage – control grid ac voltage.

In addition to the relatively slow anode overcurrent trip circuit a high-speed trip circuit for the anode voltage is required to protect the tube in case of sparkovers.

The effectiveness of the high-speed trip circuit can be checked by means of a copper test wire of a given diameter (see table 1, next page). For this purpose the applied anode voltage is short-circuited by the copper wire directly at the tube terminals. If the wire does not fuse, the trip circuit meets the requirements. The remaining electrodes should be tested in the same way (each electrode to each other).

With the aid of the value I^2t, which is additionally included in table 1, it is possible to check by calculation whether the trip circuit works properly, provided that the time characteristic of the short-circuit current is known or can be estimated.

The integral $\int I^2 dt$ over the time in which short-circuit current flows through the tube must not be greater than the value I^2t in the table.

In general, the above requirements will only be met if a short-circuiting device such as an ignitron is connected in parallel with the tube. This device assures a rapid removal of the voltage and, if necessary, a fast discharge of the smoothing capacitor via this parallel path.

In case of power supplies with smoothed anode voltage, apart from this measure the anode circuit must include an appropriately dimensioned series protection resistor that, in case of sparkover, absorbs the larger part of the energy stored in the smoothing capacitor and assures compliance with the test wire requirements.

For modulator operation the protection of the tube is already given by the fact that with the use of a common power supply for RF stage and modulator the current rise in the modulator tubes is also monitored. When the set threshold is reached, the short-circuit devices, e. g. ignitrons, are triggered and the power supply is switched off.

The anode voltage may only be applied again after a stabilization time of at least 100 ms.

Table 1 Copper wire diameters for checking the high-speed trip circuit

Type	I^2t A^2s	Test wire dia. (mm)	Type	I^2t A^2s	Test wire dia. (mm)
RS 870	95	0,20	RS 2015 CL	95	0,20
RS 876	230	0,25	RS 2016 CL	95	0,20
RS 1034	12	0,12	RS 2018 CL	95	0,20
RS 1036 L	12	0,12	RS 2021 V	270	0,26
RS 1043 CV	270	0,26	RS 2022 CL	95	0,20
RS 1054	12	0,12	RS 2024 CL	95	0,20
RS 1081 V	270	0,26	RS 2026 CL	95	0,20
RS 1082 C	95	0,20	RS 2031 V	200	0,24
RS 1084 CJ	95	0,20	RS 2032 CL	95	0,20
RS 1092 L, SK	60	0,18	RS 2034 CL	95	0,20
RS 1094 L	12	0,12	RS 2041 V	500	0,30
RS 1828	230	0,25	RS 2042	1500	0,40
RS 1896	140	0,22	RS 2048 CJ	230	0,25
RS 2001 K	270	0,26	RS 2051 V	270	0,26
RS 2002 V	500	0,30	RS 2052 CV	500	0,30
RS 2004 J	95	0,20	RS 2054 SK	500	0,30
RS 2011 V	95	0,20	RS 2058 CJ	230	0,25
RS 2012 C	95	0,20	RS 2064 CL	95	0,20
RS 2074	900	0,35	RS 2068 CL	95	0,20
RS 2078 SK	900	0,35	YL1056	6	0,10
RS 2794	95	0,20	YL1057	12	0,12
RS 2795	95	0,20	YL1058	12	0,12
YL1055	6	0,10	YL1490	500	0,30
RS 2014 CL	95	0,20	YL1500	95	0,20

Length of test wires: approx. 20 mm per 1000 V of applied anode voltage.

For tetrodes the use of a spark gap or surge arrester between screen grid and cathode is recommended, to protect the control grid and cathode from damage by sparkovers from the anode. To prevent overloading of the screen grid due to wrong transmitter setting or faults at the transmitter output, an overcurrent relay should be provided in the screen grid supply, which automatically switches off the screen grid voltage.

In order to prevent a stationary arc discharge between control grid and cathode, which is fed by the grid current supply, the control grid circuit must be designed such that the grid dc current circuit becomes high-ohmic ($R \geq 5$ kΩ) in the event of tube sparkover, e. g. by the opening of a contact in the anode current circuit high-speed relay. Additional protection can be achieved if this series resistor can also be connected via an overcurrent relay in the grid circuit. The protective resistor may be switched off only after a stabilization time of 100 ms.

To protect the anodes of air-cooled and water-cooled tubes against thermal overloead, tube fuses have been developed which, in conjunction with a pull switch, automatically switch off anode and heater voltage. Note that the tube fuse (RöSich4) in vapor-cooled tubes serves primarily as a protection against excessive water level drop in the boiler. It is no general protection against thermal overloading of the anode, since local overheating may occur on the side opposite to where the fuse is screwed into the anode.

Information on the appropriate tube fuses is given in the data sheets on the individual tubes.

Irrespective of the use of these fuses, the instructions on automatic monitoring of coolant flow rate and temperature given in the previous sections on cooling have to be observed for all tubes with separate cooling.

An automatic monitoring device is also required for additional cooling of the tube terminals by a separate radiator.

9 Notes on possible dangers

Irregularities in the operation of transmitter tubes and equipment or improper handling of them can produce the following risks. All persons involved should be instructed on the possible risks and act accordingly.

9.1 High voltage

Transmitter tubes are usually operated on high voltages, meaning that the following points should be carefully observed:

a) Follow all safety regulations applying to work with high-voltage apparatus.

b) Make sure that cavity resonators are properly grounded.

c) A tube should only be replaced when its voltages are switched off. It is advisable to provide automatic voltage cutout with forced grounding of all conductive parts.

9.2 RF radiation

Exposure of the human body to RF radiation should be kept as low as possible, and the vicinity of antennas and open RF connectors in particular should be avoided. Never look into open RF connectors, there is the risk of damage to the eyes. All RF leads should be closed and tight. A check for tightness of leads should be made after first-time startup and service work. Make sure that national regulations are adhered to.

9.3 X-rays

High-vacuum tubes that are operated on voltages of more than 5 kV are to be considered as sources of spurious radiation.

The dose rate of X-rays will depend on the construction of a tube and the maximum operating voltage, measurable dose rates generally not occurring until voltages exceed 20 kV.

Measured data on the different types of tube will be sent to you on request. The operation of our tubes is governed by the X-ray regulations of 8 January 1987 and the relevant national regulations.

9.4 Implosion

Electron tubes are evacuated and can implode if they are subjected to excessive mechanical stress. In such cases tubes with a large vacuum vessel represent a danger to the operating personnel because of the splinters and parts that can fly around. There is no danger of this kind with television tubes.

9.5 High temperatures

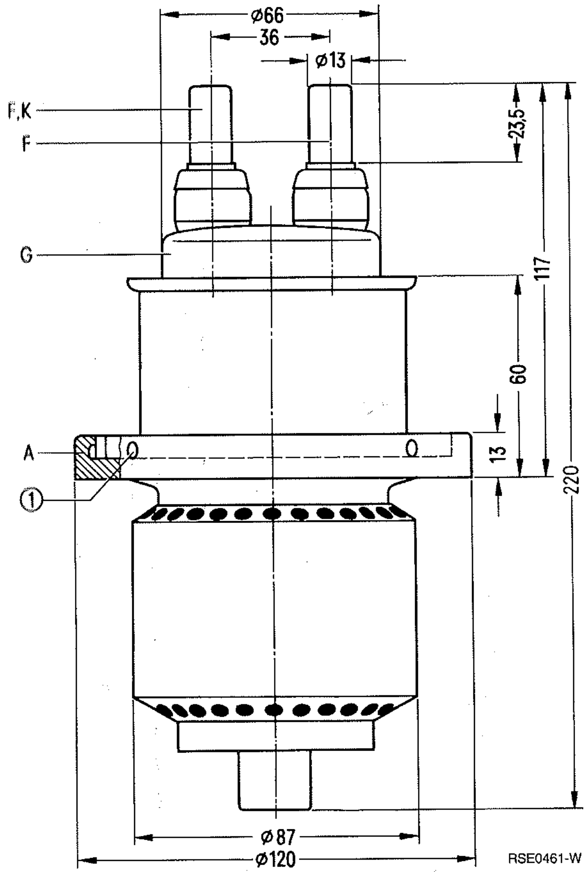
The tubes and their cooling devices can reach very high surface temperatures, which can persist long after a tube is switched off. Contact with these hot surfaces or with coolants if there is a break in the cooling system can lead to burns; make sure that appropriate preventive measures are taken.

10 Conversion of pressure values

1 bar	approx. 1 at = 1 kp/cm^2
1 mbar	= 100 Pa approx. 1 cm water column
1 Torr	= 1 mm Hg = 1,3332 mbar
1 psi	approx. 69,00 mbar
1 ft H_2O	approx. 29,90 mbar
1 in H_2O	approx. 2,49 mbar
1 in Hg	approx. 33,90 mbar

Ordering code Q53-X870

Vapor-cooled triode with coaxial grid lead-through, particularly suitable for modulators of 10 kW to 25 kW transmitters.



Dimensions in mm

① Tapholes for handle RöZub833

Approx. weight 3,5 kg

Heating

Heater voltage	U_F	5,0	V
Heater current	I_F	≈ 80	A
Permissible starting current	I_{FM}	≤ 180	A
Heating: direct			
Cathode: thoriated tungsten			

Characteristics

Emission current at $U_A = U_G = 300$ V	I_{em}	15	A
Amplification factor at U_A = 3 to 6 kV, I_A = 1 A	μ	16	
Transconductance at U_A = 5 kV, I_A = 1 A	s	22	mA/V

Capacitances

Cathode/grid	c_{kg}	≈ 55	pF
Cathode/anode	c_{ka}	≈ 2,0	pF [1])
Grid/anode	c_{ga}	≈ 27	pF

Accessories		Ordering code
Cathode terminal (2 for each tube)	RöKat534	Q1001-X7
Grid terminal	RöGit533	Q1001-X15
Handle	RöZub833	Q1001-X100
Boiler	RöKüV833	Q1001-X35
Water level stabilizer with control electrodes	RöZubV4	Q81-X2105
LL electrolytic target	RöEl40	C65055-A667-A40
Gasket ring for boiler		C65055-A620-C591
Gasket ring for water supply line		C65055-A620-C592
Gasket ring for vapor outlet		C65055-A620-C593

1) Measured by means of a 50 cm diameter screening plate in the grid terminal plane.

AF amplifier and modulator, class B operation, 2 tubes in push-pull circuit

Maximum ratings

Anode voltage (dc)	U_A	10	kV
Grid voltage (dc)	U_G	– 900	V
Cathode current (dc)	I_K	4,0	A
Peak cathode current	I_{KM}	15	A
Anode dissipation	P_A	10	kW
Grid dissipation	P_G	100	W

Operating characteristics

at modulator operation for

		25 kW carrier power		20 kW carrier power		
Output power	P_2	0	20	0	16	kW
Anode voltage (dc)	U_A	7,5	7,5	6,0	6,0	kV
Grid voltage (dc)	U_G	– 460	– 460	– 370	– 370	V
Peak control grid voltage (ac) between the 2 tubes	$U_{gg\,m}$	0	1160	0	1000	V
Anode current (dc)	I_A	2 × 0,2	2 × 2,2	2 × 0,2	2 × 2,2	A
Grid current (dc)	I_G	0	2 × 0,1	0	2 × 0,12	A
Peak grid current	I_{GM}	0	2 × 0,7	0	2 × 0,8	A
Anode input power	P_{BA}	2 × 1,5	2 × 16,5	2 × 1,2	2 × 13,2	kW
Drive power	P_1	0	2 × 55	0	2 × 60	W
Anode dissipation	P_A	2 × 1,5	2 × 6,5	2 × 1,2	2 × 5,2	kW
Grid dissipation	P_G	0	2 × 12	0	2 × 15	W
Efficiency	η	–	60	–	60	%
Effective load resistance (anode to anode)	R_{AA}	–	3360	–	2640	Ω

Tube mounting

Axis vertical, anode down.

For connection of the tube use the terminals listed under "Accessories".

Maximum tube surface temperature

The temperature of the glass-to-metal seals must not exceed 200 °C at any point. The maximum permissible temperature between grid and anode is 220 °C. If necessary, the glass bulb must be additionally cooled by a slight air flow. At the metal-to-ceramic seals of heater and cathode lead-throughs the temperature should not exceed 200 °C.

Vapor cooling

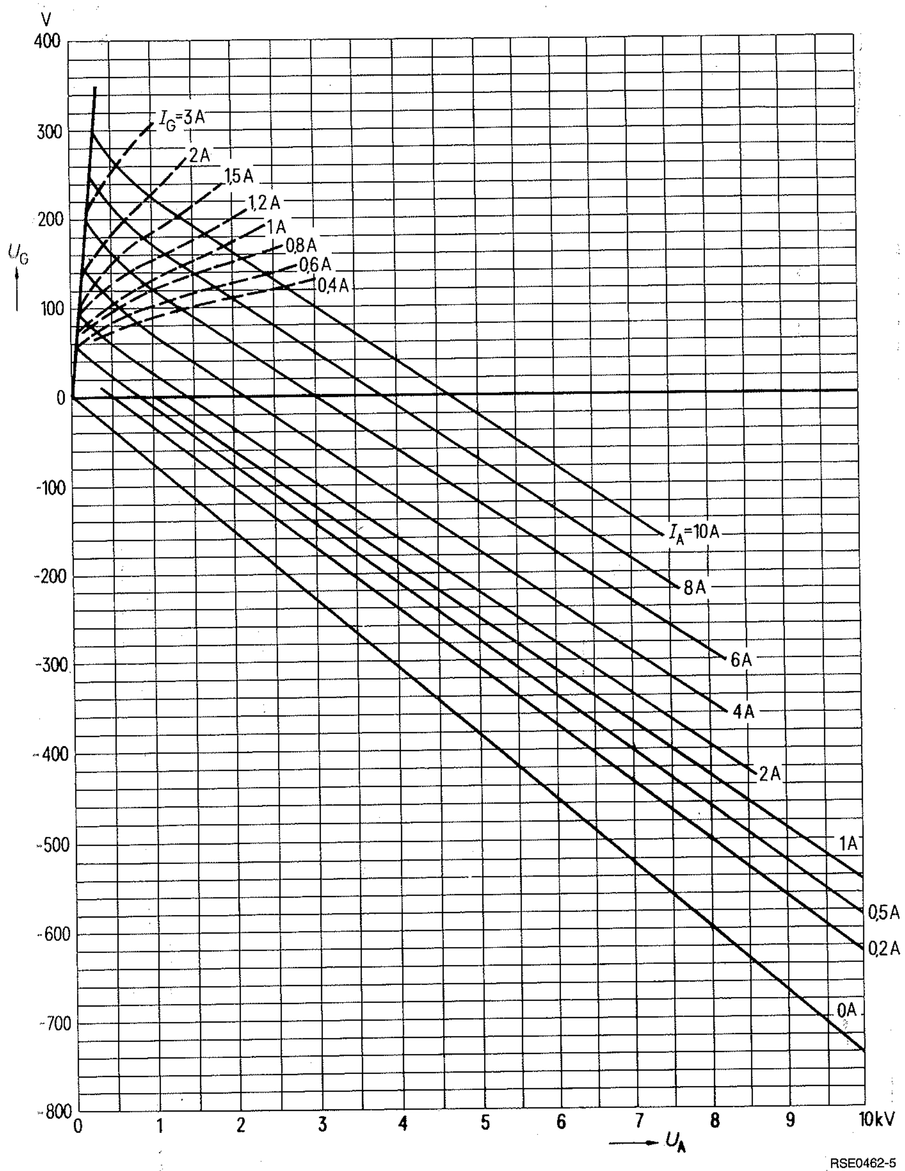
Cooling data for maximum anode dissipation	$P_{A\,max}$ = 10 kW
Total power to be dissipated by the cooling system ($P_A + P_G + 0{,}8\ P_F$)	10,4 kW
Equivalent thermal output	625 kJ/min (149 kcal/min)
Flow rate of returning water at returning water temperature of 20 °C at returning water temperature of 90 °C	 approx. 0,24 l/min approx. 0,27 l/min
Volume of generated vapor at returning water temperature of 20 °C at returning water temperature of 90 °C	 approx. 0,40 m³/min approx. 0,45 m³/min

Detailed information on vapor cooling upon request. Please observe instructions on vapor cooling given under "Explanations on Technical Data".

Safety precautions

The section "Safety precautions" under "Explanations on Technical Data" describes how the tube is to be protected against damage due to electric overload or insufficient cooling. A copper wire with 0,20 mm diameter should be used to test the anode overcurrent trip circuit.

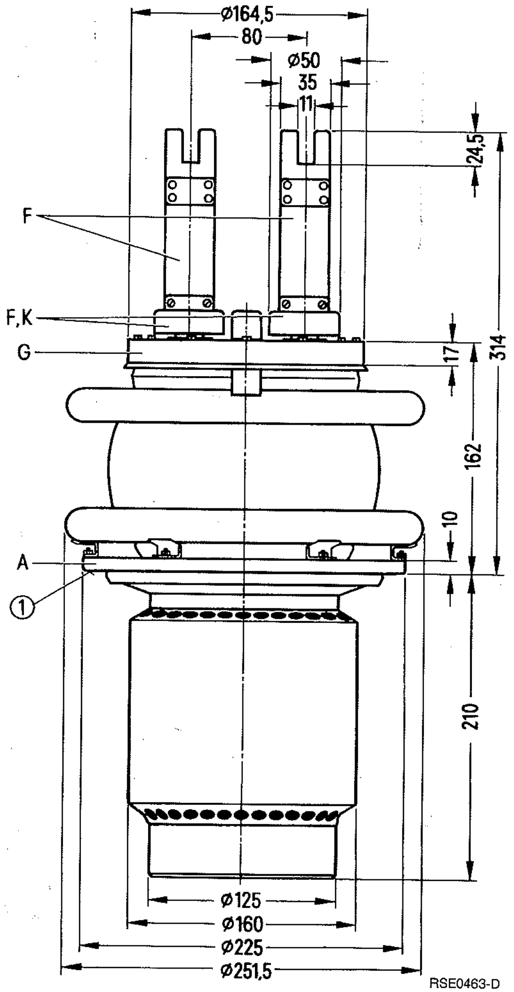
$U_G = f(U_A)$ Parameter = I_A ———— Parameter = I_G — — — —



RSE0462-5

Ordering code Q53-X876

Vapor-cooled triode with coaxial grid lead-through, particularly suitable for modulators of 200 kW to 250 kW transmitters.



Dimensions in mm

① Sealing surface

Approx. weight 24 kg

Heating			
Heater voltage	U_F	11	V
Heater current	I_F	≈ 155	A
Permissible starting current	I_{FM}	≤ 300	A
Heating: direct			
Cathode: thoriated tungsten			

Characteristics			
Emission current at $U_A = U_G = 500$ V	I_{em}	42	A
Amplification factor at $U_A = 8$ to 10 kV, $I_A = 3$ A	μ	15	
Transconductance at $U_A = 8$ kV, $I_A = 3$ A	s	40	mA/V

Capacitances			
Cathode/grid	c_{kg}	≈ 130	pF
Cathode/anode	c_{ka}	≈ 3,8	pF [1]
Grid/anode	c_{ga}	≈ 75	pF

Accessories		Ordering code
Mounting instruction	RöMo876	
RF terminal (2 for each tube)	RöKat876	Q1001-X24
Grid terminal for SW	RöGit876	Q1001-X13
Grid terminal for MW	RöGit877	Q1001-X11
Handle	RöZub876	Q1001-X101
Boiler	RöKüV876	Q1001-X42
Insulating pipe at water inlet	RöKüV31Zub4	Q81-X1634
Union at water inlet	RöKüV31Zub7	Q81-X1637
Gasket at vapor outlet	RöKüV201Zub8	Q81-X1678
Insulating pipe at vapor outlet	RöKüV876Zub3	Q81-X1610
Insulator	RöKüV876Zub5K	Q81-X1659
Water level stabilizer with control electrodes	RöZubV4	Q81-X2105
LL electrolytic target	RöEl41	C65055-A667-A41
Gasket ring for boiler		C65051-A411-C552
Gasket ring for water supply line		C65055-A620-C523
Gasket ring for vapor outlet		C65055-A620-C526

1) Measured by means of a 50 cm diameter screening plate in the grid terminal plane.

AF amplifier and modulator, class B operation, 2 tubes in push-pull circuit

Maximum ratings

Anode voltage (dc)	U_A	14	kV
Grid voltage (dc)	U_G	− 2	kV
Cathode current (dc)	I_K	16	A
Peak cathode current	$I_{K\,M}$	50	A
Anode dissipation	P_A	75	kW
Grid dissipation	P_G	700	W

Operating characteristics at modulator operation for

		250 kW carrier power		
Output power	P_2	0	200	kW
Anode voltage (dc)	U_A	11,5	11,5	kV
Grid voltage (dc)	U_G	− 720	− 720	V
Peak control grid voltage (ac) between the 2 tubes	$U_{gg\,m}$	0	2340	V
Anode current (dc)	I_A	2 × 1	2 × 14,5	A
Grid current (dc)	I_G	0	2 × 0,7	A
Anode input power	$P_{B\,A}$	2 × 11,5	2 × 167	kW
Drive power	P_1	0	2 × 820	W
Anode dissipation	P_A	2 × 11,5	2 × 67	kW
Grid dissipation	P_G	0	2 × 310	W
Efficiency	η	–	60	%
Effective load resistance (anode to anode)	R_{AA}	–	820	Ω

Tube mounting

Axis vertical, anode down.

For connection of the tube use the terminals listed under "Accessories". The heater current is applied via flexible strips which are attached to the tube and must not be removed. A possibly necessary RF connection must be established via helix contacts at the caps below the flexible heater strips.

Maximum tube surface temperature

The temperature of the glass-to-metal seals must not exceed 170 °C at any point. The maximum permissible temperature in the center of the glass bulb between grid and anode is 220 °C. At the ceramic cathode lead-throughs the temperature should not exceed 220 °C.

The maximum temperature difference at the bulb circumference is 50 °C, and in axial direction 120 °C. The temperature gradient must not exceed 25 °C/cm. The temperature can be kept within these limits by providing additional air cooling of the tube terminals by an adequately directed air flow of at least 2 m^3/min.

Vapor cooling

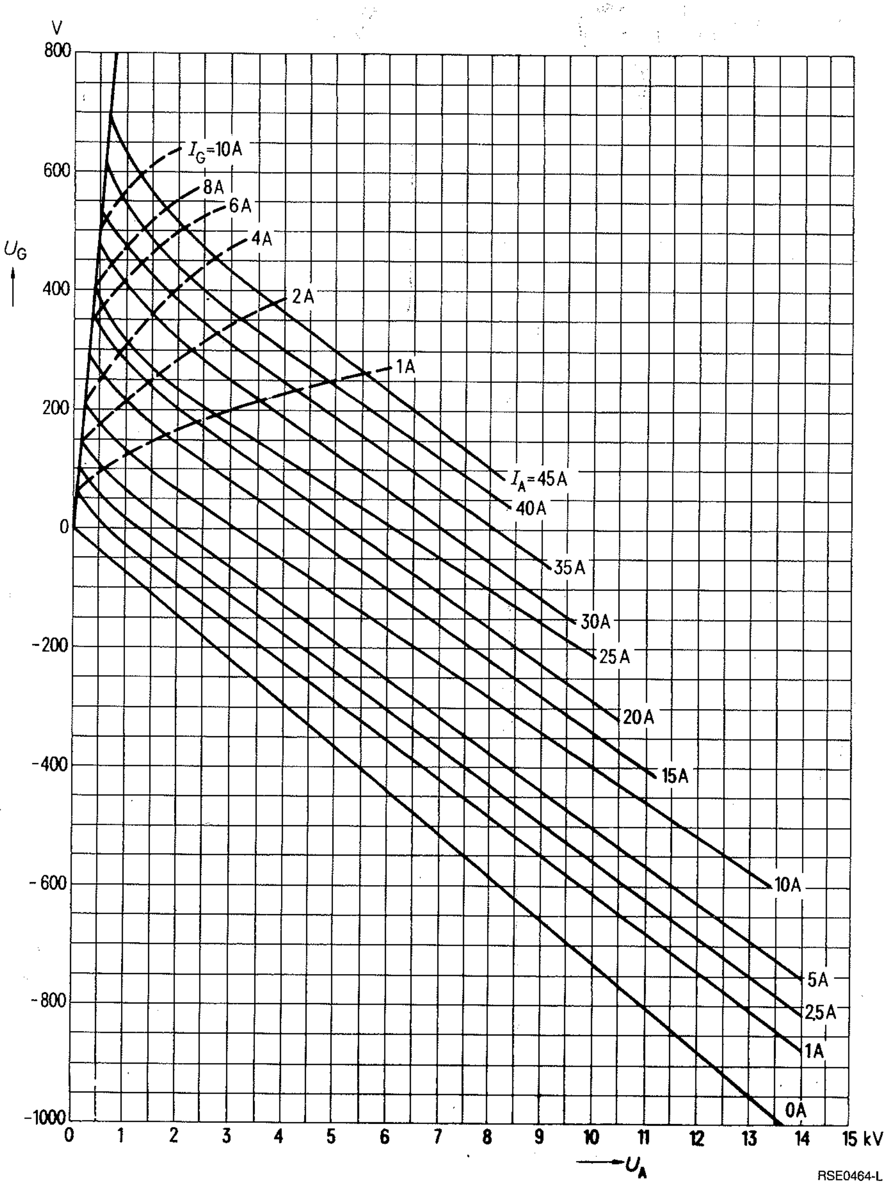
Cooling data for maximum anode dissipation	$P_{A\,max}$ = 75 kW
Total power to be dissipated by the cooling system ($P_A + P_G + 0{,}8\ P_F$)	76,1 kW
Equivalent thermal output	4570 kJ/min (1090 kcal/min)
Flow rate of returning water	
at returning water temperature of 20 °C	approx. 1,8 l/min
at returning water temperature of 90 °C	approx. 2,0 l/min
Volume of generated vapor	
at returning water temperature of 20 °C	approx. 3,0 m^3/min
at returning water temperature of 90 °C	approx. 3,3 m^3/min

Detailed information on vapor cooling upon request. Please observe instructions on vapor cooling given under "Explanations on Technical Data".

Safety precautions

The section "Safety precautions" under "Explanations on Technical Data" describes how the tube is to be protected against damage due to electric overload or insufficient cooling. A copper wire with 0,25 mm diameter should be used to test the anode overcurrent trip circuit.

$U_G = f(U_A)$ Parameter = I_A ———— Parameter = I_G – – – –



For frequencies up to 960 MHz

Coaxial metal-ceramic tetrode with integrated resonance suppression, forced-air-cooled or vapor-condensation-cooled, particularly suitable for TV transmitters, band IV/V.

Forced-air-cooled version

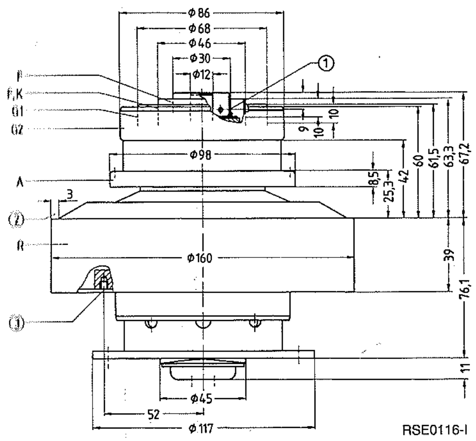
RS 1034 L

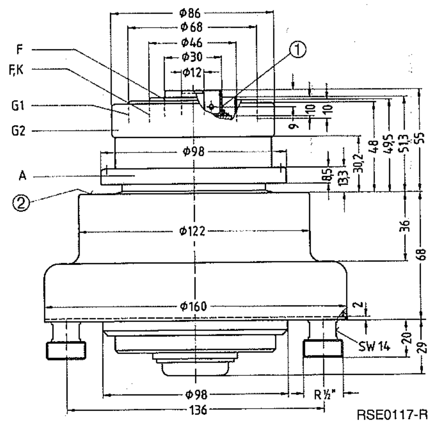
Ordering code Q51-X1034

Vapor-condensation-cooled version

RS 1034 SK

Ordering code Q53-X1034





Dimensions in mm

① 8 tapholes Ø 3 (8 × 45°)
② Tube support in the cavity
③ Taphole M4 for tube fuse RöSich2

Approx. weight 5,3 kg

Approx. 7 kg

The radiator or boiler and the terminals are of concentric design with the following diameters:

Radiator (R)	Ø 161,5	G1 terminal	Ø 69,0
Boiler	Ø 123,5	Heater/cathode terminal	Ø 47,0
Anode terminal	Ø 99,0	Heater terminal	Ø 30,6
G2 terminal	Ø 87,0		

Heating

Heater voltage	U_F	4,5	V
Heater current	I_F	≈ 200	A
Heating: direct			
Cathode: thoriated tungsten			

Characteristics

Emission current at $U_A = U_{G2} = U_{G1} = 300$ V	I_{em}	45	A
Amplification factor of screen grid at $U_A = 2$ kV, $U_{G2} = 500$ to 800 V, $I_A = 3$ A	μ_{g2g1}	7,5	
Transconductance at $U_A = 2$ kV, $U_{G2} = 800$ V, $I_A = 2$ to 4 A	S	120	mA/V

Capacitances

Cathode/control grid	c_{kg1}	≈ 100	pF
Cathode/screen grid	c_{kg2}	≈ 7,80	pF
Cathode/anode	c_{ka}	≈ 0,05	pF [1]
Control grid/screen grid	c_{g1g2}	≈ 184	pF
Control grid/anode	c_{g1a}	≈ 0,55	pF [1]
Screen grid/anode	c_{g2a}	≈ 23,5	pF [2]

Accessories RS 1034 L

			Ordering code
Socket wrench for tube fuse		RöZub10	Q81-X2110
Tube extractor		RöZub134	Q81-X2115
Tube fuse		RöSich2	Q81-X1402
Pull switch for tube fuse		RöKt11	Q81-X1311
Cavity band IV/V,	10 kW vision	TK8305 or	Q94-X8305
		TK8311	Q94-X8311
	5 kW vision/sound	TK8305 or	Q94-X8305
		TK8311	Q94-X8311

RS 1034 SK

Tube extractor		RöZub134SK	Q81-X2116
LL electrolytic target for 1/2″-hose		RöEl5	Q81-X365
Cavity band IV/V,	20 kW vision	TK8306 or	Q94-X8306
		TK8312	Q94-X8312
	10 kW vision/sound	TK8306 or	Q94-X8306
		TK8312	Q94-X8312

1) Measured by a Ø 50 cm screening plate in the screen-grid terminal plane.
2) Measured by a Ø 50 cm screening plate in the anode ceramic plane.

TV vision transmitter,
grounded control-grid screen-grid circuit, negative modulation standard G

Maximum ratings

Frequency		f	960	MHz
Anode voltage (dc)	(RS 1034 L)	U_A	5,5	kV
Anode voltage (dc)	(RS 1034 SK)	U_A	7,5	kV
Screen grid voltage (dc)		U_{G2}	1000	V
Control grid voltage (dc)		U_{G1}	– 200	V
Cathode current (dc)		I_K	6,0	A
Peak cathode current		I_{KM}	40	A
Anode dissipation	(RS 1034 L)	P_A	13	kW
Anode dissipation	(RS 1034 SK)	P_A	25	kW
Screen grid dissipation		P_{G2}	180	W
Control grid dissipation		P_{G1}	80	W

Operating characteristics

		1)		
Frequency	f	470 … 800	470 … 800	MHz
Bandwidth (1 dB)	B	12	12	MHz
Output power, sync level	$P_{2\,SY}$	24	12,4	kW [2]
Output power, black level	$P_{2\,SW}$	13,6	7,0	kW [2] [3]
Gain	V_p	15,5	16	dB
Anode voltage (dc)	U_A	6,6	5,1	kV
Screen grid voltage (dc)	U_{G2}	800	800	V
Control grid voltage (dc)	U_{G1}	– 110	– 110	V
Peak control grid voltage (ac), sync level	$U_{g1\,m\,SY}$	104	100	V
Zero-signal anode current (dc)	$I_{A\,0}$	2,2 [4]	1,6 [4]	A
Anode current (dc), black level	$I_{A\,SW}$	5,3 [4]	3,6 [4]	A
Screen grid current (dc), black level	$I_{G2\,SW}$	140	60	mA
Anode input power, black level	$P_{B\,A\,SW}$	35	18,4	kW
Drive power, sync level	$P_{1\,SY}$	675	310	W
Anode dissipation, black level	$P_{A\,SW}$	21,4	11,4	kW
Screen grid dissipation, black level	$P_{G2\,SW}$	110	48	W
Anode load resistance	R_A	460	450	Ω

1) Only for RS 1034 SK.
2) Without taking circuit losses into account.
3) Black level with gated sync. pulses.
4) Average value ± 0,2 A.

Amplifier for TV transmitters with common vision and sound carrier transmission, grounded control-grid screen-grid circuit, vision-to-sound ratio 10:1, standard G

Maximum ratings

Frequency		f	960	MHz
Anode voltage (dc)	(RS 1034 L)	U_A	5,5	kV
Anode voltage (dc)	(RS 1034 SK)	U_A	7,5	kV
Screen grid voltage (dc)		U_{G2}	1000	V
Control grid voltage (dc)		U_{G1}	– 200	V
Cathode current (dc)		I_K	6,0	A
Peak cathode current		$I_{K\,M}$	40	A
Anode dissipation	(RS 1034 L)	P_A	13	kW
Anode dissipation	(RS 1034 SK)	P_A	25	kW
Screen grid dissipation		P_{G2}	180	W
Control grid dissipation		P_{G1}	80	W

Operating characteristics

		1)		
Frequency	f	470 ... 800	470 ... 800	MHz
Output power, sync level	$P_{2\,SY}$	12,6/1,26	6,3/0,63	kW 2)
Gain	V_p	15,5	16	dB
3-tone intermodulation ratio	a_{IM3}	≥ 50	≥ 52	dB
Anode voltage (dc)	U_A	6,3	5,1	kV
Screen grid voltage (dc)	U_{G2}	800	800	V
Control grid voltage (dc)	U_{G1}	– 112	– 108	V
Peak control grid voltage (ac), sync level	$U_{g1\,m\,SY}$	100	70	V
Zero-signal anode current (dc)	$I_{A\,0}$	1,8	1,8	A 3)
Anode current (dc), black level	$I_{A\,SW}$	3,9	2,8	A
Screen grid current (dc), black level	$I_{G2\,SW}$	90	50	mA
Anode input power, black level	$P_{B\,A\,SW}$	24,6	14,3	kW
Drive power, sync level	$P_{1\,SY}$	360	160	W
Drive power, sound	$P_{1\,Ton}$	36	16	W
Anode dissipation, black level	$P_{A\,SW}$	16,2	10,1	kW
Anode load resistance	R_A	440	520	Ω

1) Only for RS 1034 SK.
2) Without taking circuit losses into account.
3) Average value ± 0,2 A.

Tube mounting

Axis vertical, anode up or down.

Spring contact rings are suitable connectors for cathode, control grid, screen grid and anode. The spring tension must be dimensioned such that the required power for inserting and withdrawing the tube remains below 150 N. Recommended pull-off power per spring contact ring is approx. 20 N. For further details see “Explanations on Technical Data”.

Maximum tube surface temperature

The temperature of the electrode terminals and ceramic insulators must not exceed 220 °C. For keeping below this maximum temperature an air flow is required to cool the terminal rings. For this purpose the terminal contacts must be designed for providing a uniform cooling effect.

Forced-air cooling (RS 1034 L)

The minimum air flow rate required for maximum anode dissipation is given in the cooling air diagram, valid for 25 °C inlet temperature at 1 bar air pressure (sea level). The cooling air must be supplied from the electrode terminal side. For detailed information on forced-air cooling refer to “Explanations on Technical Data”.

Vapor condensation cooling (RS 1034 SK)

The cooling water diagram gives the minimum water flow rate (distilled or deionized water) for maximum anode dissipation, as well as pressure drop and water outlet temperature at 70 °C water inlet temperature. The diagram applies to a hermetically sealed cooling system with 1,5 bar overpressure at the tube's cooling water outlet and with a maximum permissible water outlet temperature of 100 °C.

Operation with open cooling cycle (without overpressure) is also possible if the maximum outlet temperature remains below 70 °C (sea level, air pressure ≈ 1 bar) with lower inlet temperature and, if required, increased water flow rate.

For more information on vapor condensation cooling refer to “Explanations on Technical Data”.

Automatic heating power regulation

Recommendations for automatic heating power stabilization are contained in the instruction “UHF TV Tetrodes, Heating Power Adjustment”, which is supplied upon request.

Safety precautions

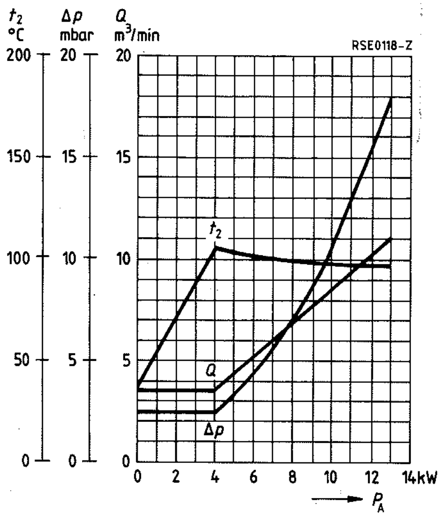
The section “Safety precautions” under “Explanations on Technical Data” describes how the tube is to be protected against damage due to electric overload or insufficient cooling. A copper wire with Ø 0,12 mm should be used to test the anode overcurrent trip circuit.

For protecting RS 1034 L against thermal anode overload the tube fuse RöSich2 is recommended. In conjunction with pull switch RöKt11 it disconnects the voltages at the tube in case of overload (accessories).

Transmitter off-periods

Frequent switching of the heating reduces lifetime. So the heating (and cooling) should be left on during transmitter off-periods of up to two hours. Continuous heating with reduced power (black heating) should be provided for longer off-periods. Refer to "Explanations on Technical Data".

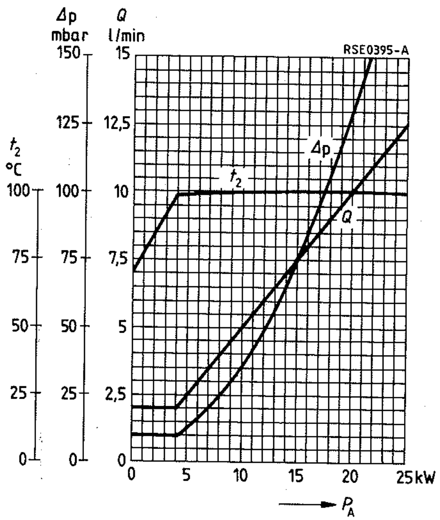
Cooling air diagram (RS 1034 L)



The cooling air is supplied from the electrode terminal side.

Air pressure = 1 bar
t_1 = 25 °C

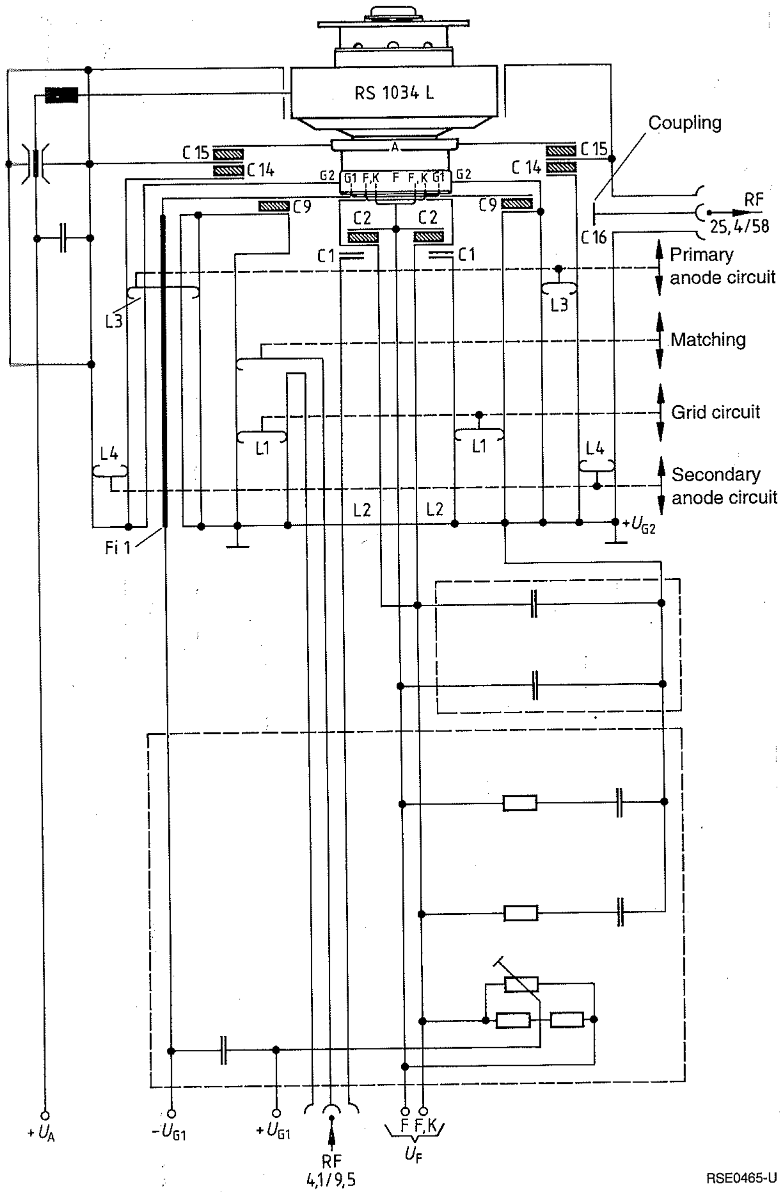
Cooling water diagram (RS 1034 SK)



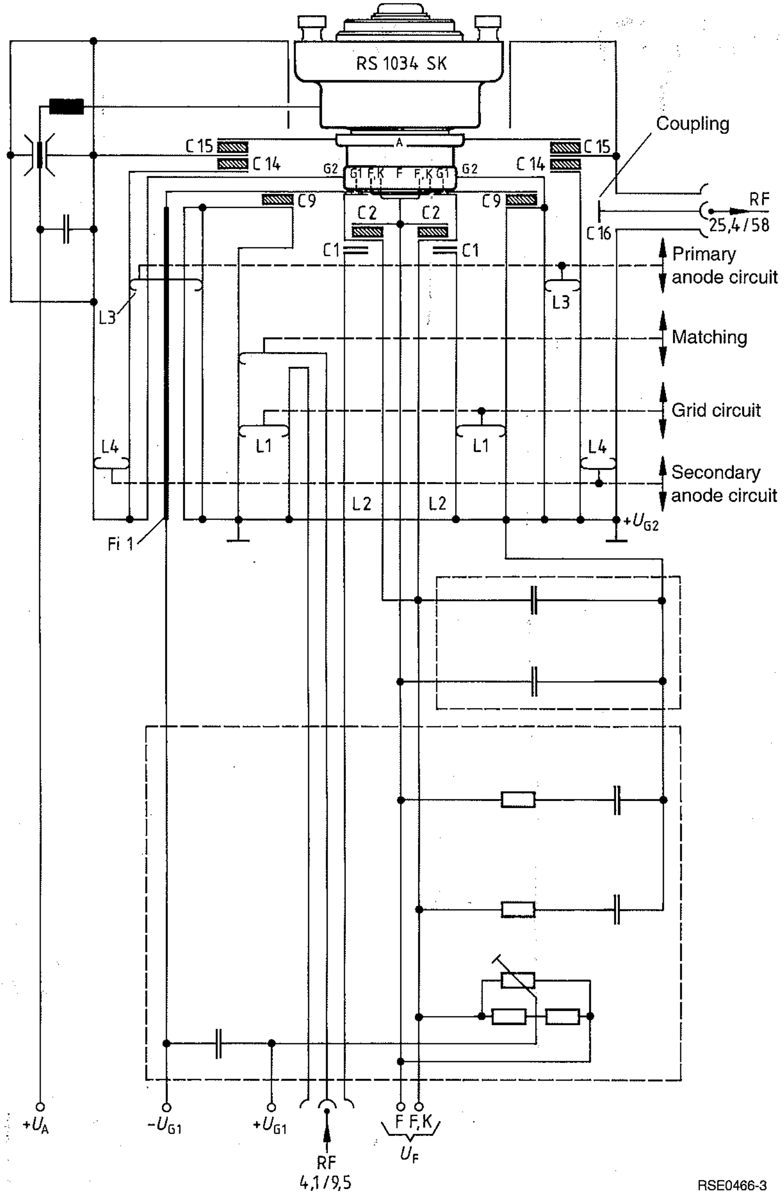
Closed cooling cycle with distilled water.

Overpressure = 1,5 bar
t_1 = 70 °C

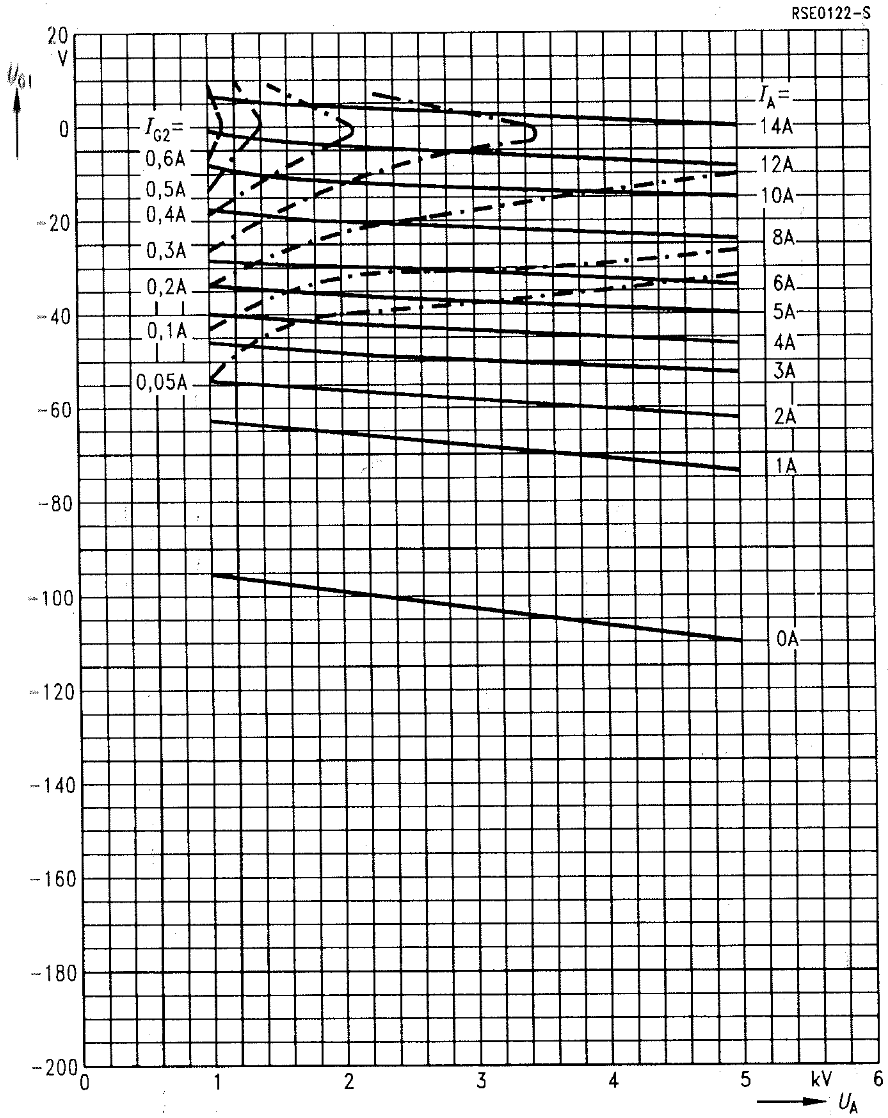
Basic circuit diagram of final-stage cavity



Basic circuit diagram of final-stage cavity

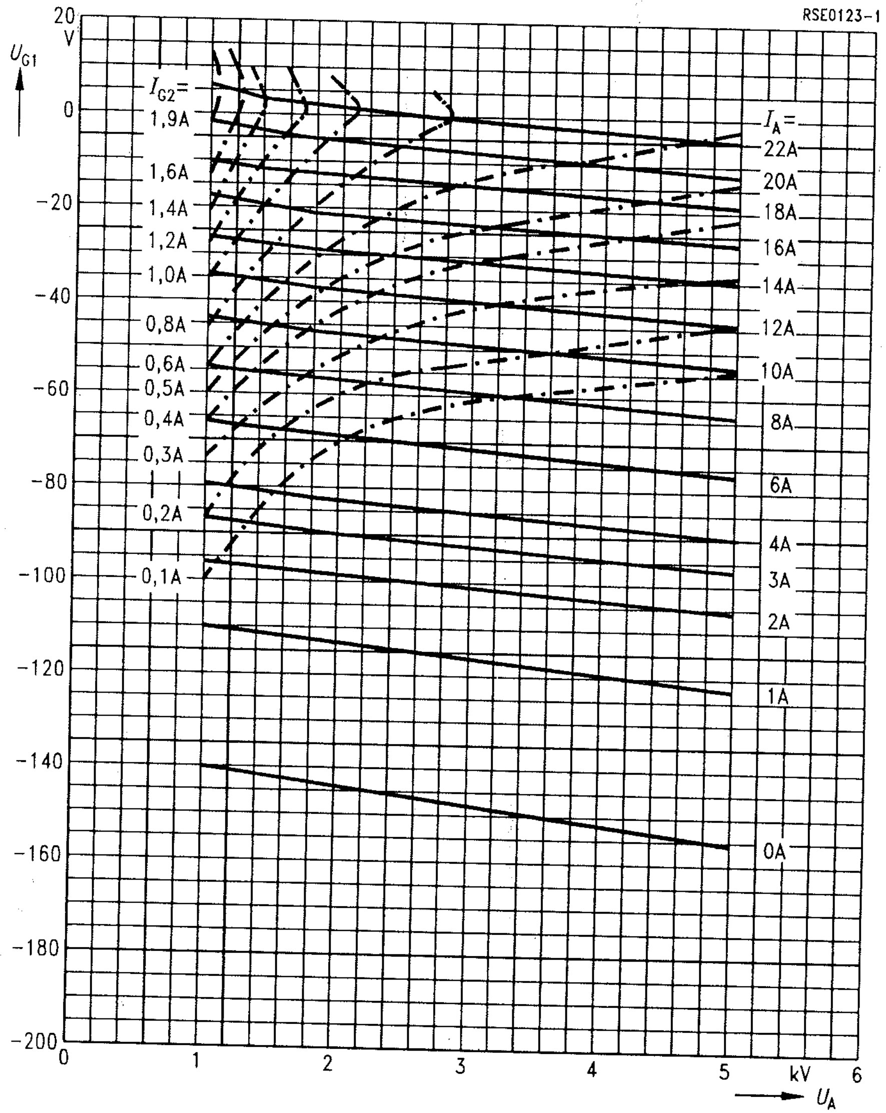


$U_{G1} = f(U_A)$ Parameter = I_A ————————
$U_{G2} = 500$ V Parameter = I_{G2} —·—·—·—·—



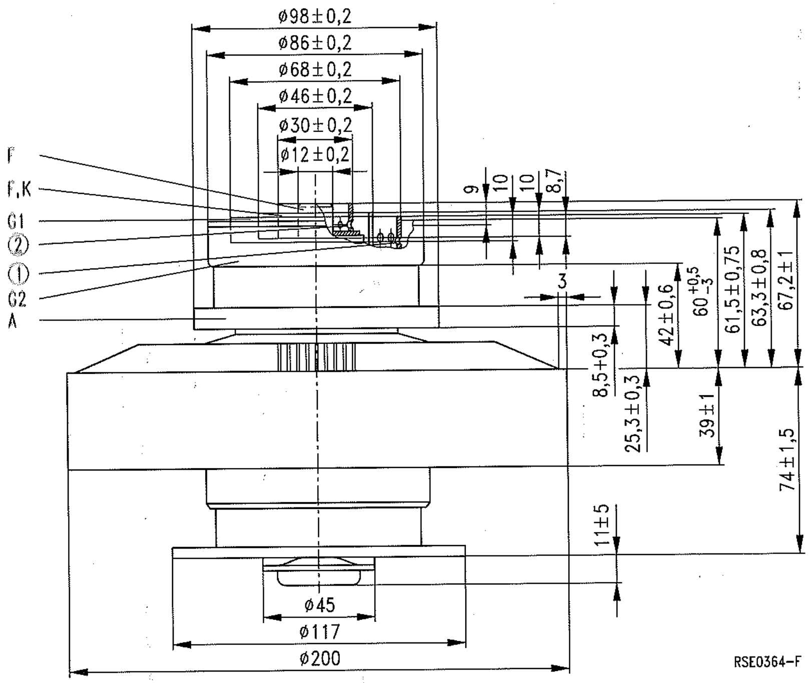
$U_{G1} = f(U_A)$ Parameter = I_A ———————

U_{G2} = 800 V Parameter = I_{G2} —·—·—·—·—



Ordering code Q51-X1036

Coaxial metal-ceramic tetrode with integrated resonance suppression for TV transmitters, band IV/V.



Dimensions in mm

① 18 tapholes Ø 3
② 8 tapholes Ø 3

Approx. weight 7,8 kg

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