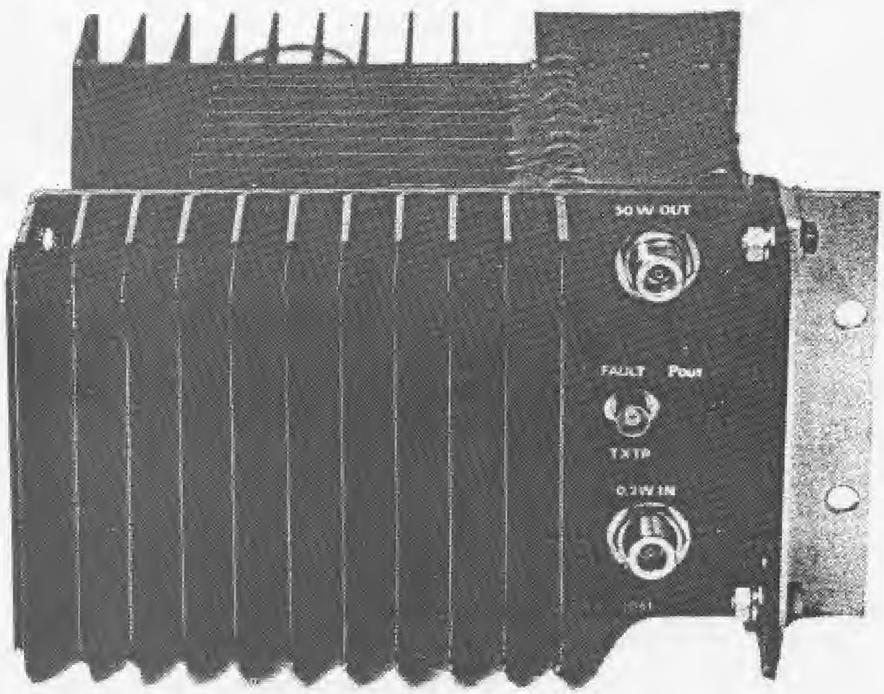
50W POWER AMPLIFIER



ERA 1551-716

SRA
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CONTENTS

INTRODUCTION

GENERAL

The 50 W power amplifier is a modular plug-in amplifier consisting of a power module and two derated rugged –3 dB coupled wideband 50 W transistors with LP-filter and output directional couplers mounted in an RFI-screened aluminium box with good heat transfer. The unit is capable to operate in a continuous mode at max. ambient temperature and high SWR.

The connectors for RF input, RF output, RF test output and LED-indicators for output power and failure respectively are placed on the front of the unit. On the rear side cables for power supply and control signals are situated. Under the cover plate test sockets for current and voltage measurements are placed.

The 50 W power amplifier contains the following four pc boards:

- Driver board
- Final amplifier board
- Relay board
- Test point board

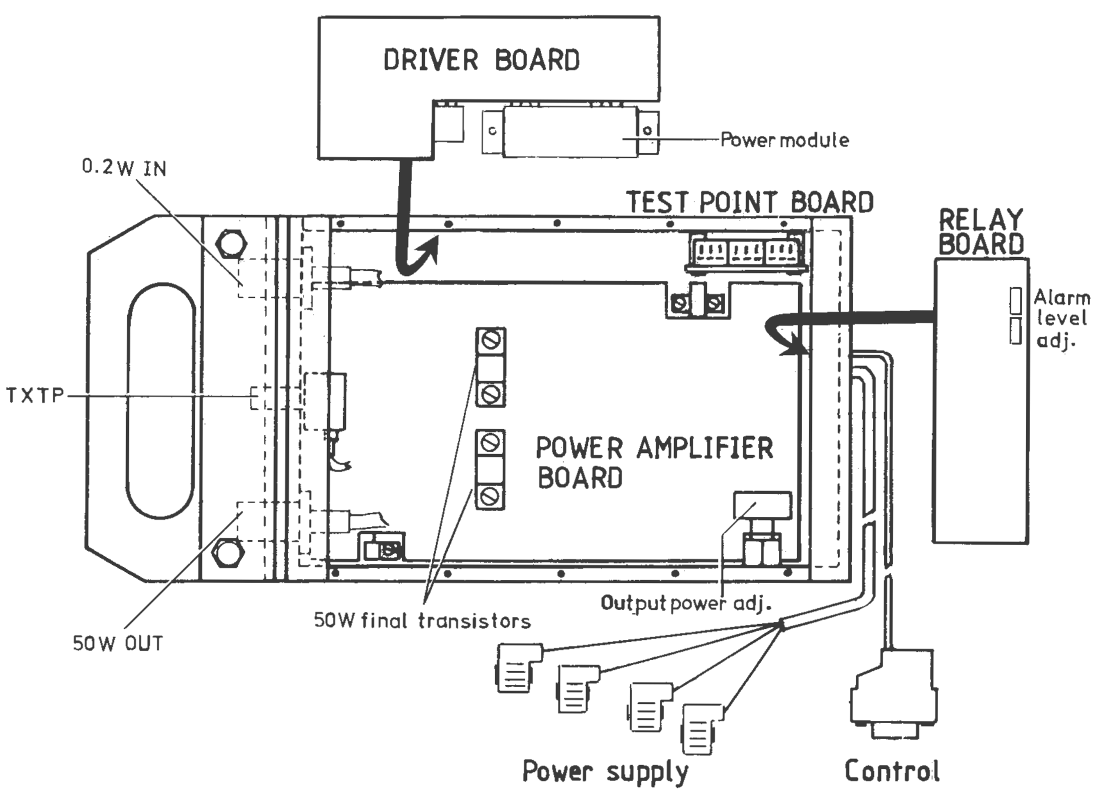


Fig. 1. The 50 W power amplifier and its sub-units.

On the driver board there is an exchangeable power module, the prestanda of which determine the power amplification and frequency range. Here two types are used, providing two variants of the 50 W power amplifier: RS 2051A for 400 – 440 MHz and RS 2061A for 440 – 470 MHz.

The two final transistors, the driver module and the series regulator transistor are all mounted with a thin layer of thermal grease to the solid aluminium chassis, that is provided with several large convecting fins. With a +14 V DC input approximately 10 A is drawn which means that 140 W – 50 W = 90 W is dissipated without the need for forced ventilation.

The cover is screw-sealed to be dust proof and RFI-tight. The +14 V input and alarm outputs are all RFI-screened to reduce radiation into nearby receivers. The amplifier is fitted with reflection protection, chassis temperature protection, output power alarm functions, LEDs, an output power setting resistor, DC test points, and a front panel TXTP (–20 dBm) BNC output.

The two final transistors operate at only 28 W of their maximum 50 W ratings in a redundant 90^{o} hybrid circuit that improves performance and reliability. The power amplifier is fed with 200 mW input power from a transmitter module. If the nominal 200 mW input power drops below 150 mW the power gain of the final transistors, working in class B, is non linear and at a certain level will drop low suddenly. In this transition region some unstability can occur, generating side-bands, and it is not recommended to operate below 30 W or above 55 W output power.

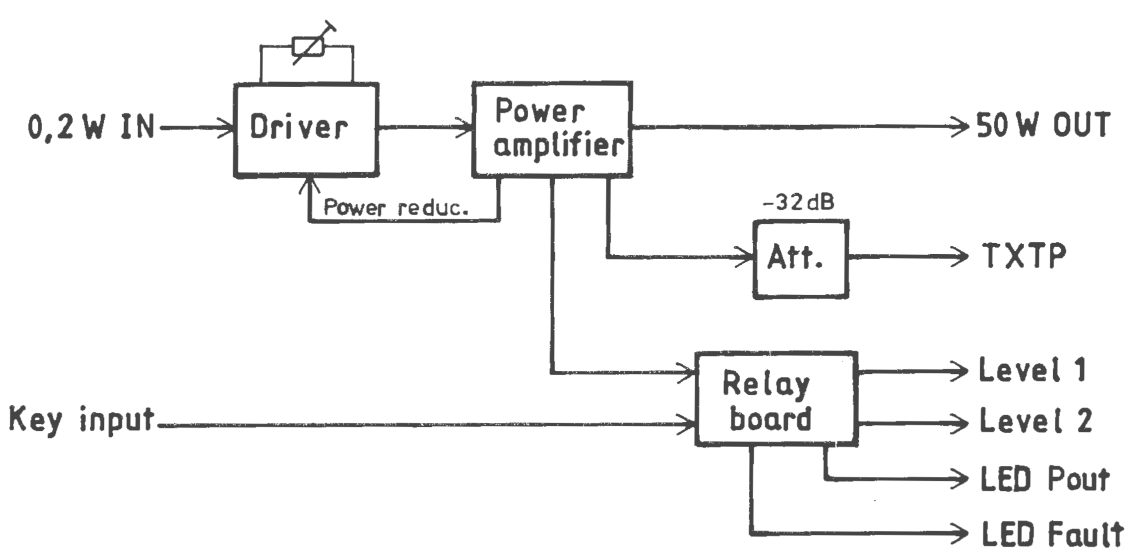


Fig. 2. Simplified block diagram of the 50 W power amplifier.

OPERATION

DRIVER

From 200 mW input to 10 W output

The incoming 200 mW output power from a transmitter module is fed directly into the power module Z2 which contains three cascaded RF transistors mounted in a standardized module package. The nominal output from the power module is 12 W but here only approximately 10 W is taken out by regulating down the collector supply voltage of the first stage at Z2:5 through a variable resistor in addition to the series regulating transistor V6.

The RF input is detected in diode V7. The reading of a 50 µA instrument connected through P1:5 is set by the resistor R26.

The power module Z2 has 50 ohms inputs and outputs and is available at different frequency bands and output powers. A good heat transfer is important to secure a long operational life. Decoupling of the collector leads is provided at low frequencies by L1–C11 and L2–C12.

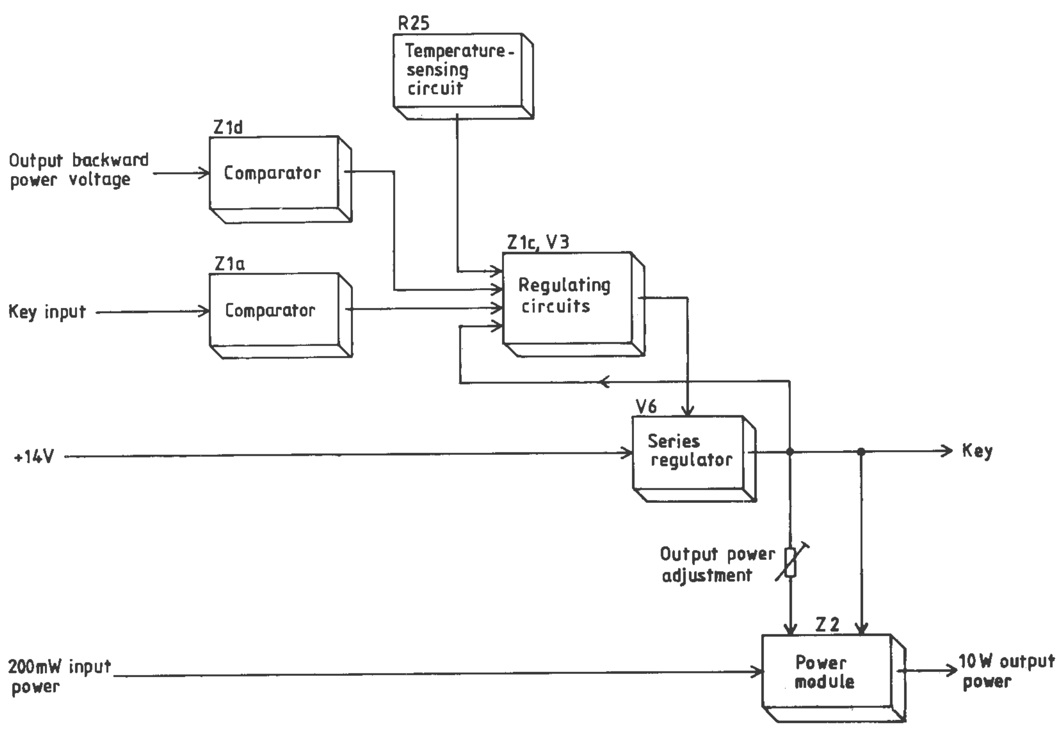


Fig. 3. Block diagram of the driver.

Voltage supply and transmitter keying

Positive +14 V supply is entering the pc board on P1:6/7. The transistor V6 acts as a series regulator for the power module Z2. The total collector current (IC1) into Z2 is measured across the emitter resistor R24 relative to +14 V at P1.8 (0.4 V/2A). A short-circuit protection for V6 at 3 A current is obtained by R24 and V4, V5, whereby the diodes conduct and by-pass base current if $>$ 0.6 V across R24 should occur.

Pin P1:9 can be used for external keying of the 200 mW transmitter feeding the driver, if the key input P1:14 is below 2.5 V (8 mA). In this this case Z1a.1 goes to +14 V and Z1c:8 also goes to +14 V, and V3 conducts base current for V6 to ground, whereby V6 conducts.

The output +13 V is sensed by the voltage divider R19, R18/R25, R17 and R6, and regulated until the voltage on Z1c:9 is +6.2 V, which is the reference voltage into Z1c:10. When key input (P1:14) is above +2.5 V or open Z1a.1 is +0.5 V, Z1c:10 sets to +1.2 V which forces down the +13 V outputs to approximately +2 V, inhibiting RF output. Keying time is set by C1, C5, and loop regulation stability gain is determined by the feedback capacitor C4 and resistor R11.

Power reduction

When the output reflected voltage on pin P1:13 is below −0.6 V, equal to the reference voltage on Z1d:13, the amplifier output Z1d:14 is +0.5 V. A reflection more than +0.6 V DC will be amplified 15 times and reduce the feedback voltage reference and reduce the regulated +13 V. At +1.5 V reflected input the Z1d:14 becomes +14 V and this causes approximately −4 dB output power reduction which is determined by resistor R6.

The NTC-resistor R25 mounted on the heat sink of V6 will also reduce the +13 V voltage and thereby the output power −1 dB above +70°C on the heat sink.

The zener diode V2 provides the +6.2 V reference voltage for the keying voltage, reflection protection and the +13 V output voltage. Pin P1:1 is used for TP U 13 V measurements.

POWER AMPLIFIER

The power is amplified in two identical transistor stages, V2 and V3, that are divided and combined via two identical –3 dB 90^{o} hybrid couplers, T1 and T2 respectively. The two 50 W transistors are only driven to give 28 W output and are thus operating well below maximum ratings of collector current and junction temperature. The transistors operate in class B with base and emitters DC-grounded, mounted to a PTFE dielectric strip line pc board.

The input forward power can be measured with a directional coupler and the diode V1 and capacitor C2. Resistor R3 is a preloading and R2 calibrates the positive current that flows to an external 100 μA instrument via P1:1.

The input base transformation is of the LP-transformation type with six Tchebyscheff sections that transform the 1.2 ohm low base resistance – j 2.0 ohm base inductance up to 50 ohms at the highest frequency of 470 MHz. At lower frequencies there is a gradual –5 dB/octave mismatch to compensate the higher transistor gain at lower frequencies.

Any reflection seen at the load sides of hybrid T1 is dissipated in the 50 ohms load R4. The input SWR will still be good provided the two loads are similar.

The first element of the input transformation to 50 ohms is Rb + Lb. The second element is shunt capacitors C8, C10. The third series element is the series inductance L12. The fourth element is the series capacitor C5. The sixth element is the shunt capacitor C4.

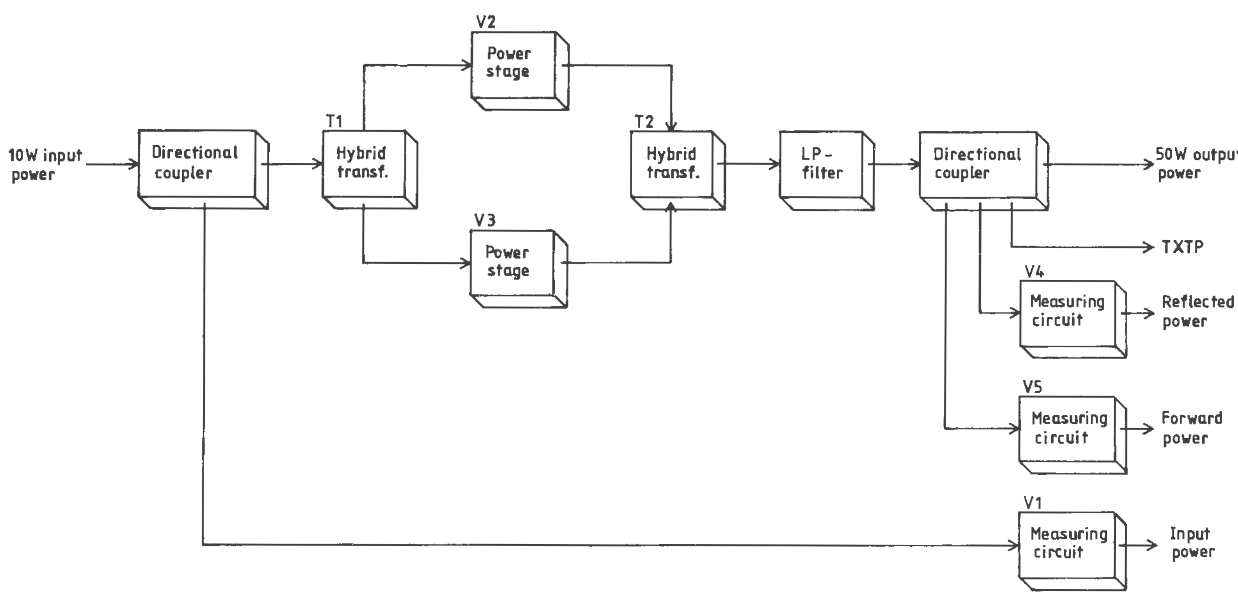


Fig. 4. Block diagram of the power amplifier.

The two wide emitter leads of the strip line flanged transistors are fed to the lower ground plane of the strip line pc board via short copper straps. The locations of the symmetrical base C8, C10 and the collector C9, C11 first transformation porzellan strip line capacitors are very important within a tolerance of ±0.4 mm.

The transistor gain at low frequencies (0.5 – 10 MHz) is quite high and resistive damping is used to reduce the generation of oscillating sidebands at changing load and drive conditions of the transmitter. The base side is damped by R5 and L1, and the collector load is damped by R7 and L5. The +14 V supply is decoupled at low frequencies by the capacitors C24, C32.

The collector RF current is approximately 5.3 A RMS so resistive losses must be short and minimal in C9 and C11. The output coupling capacitor C25 carries 0.75 A RMS and is less critical.

The collector current of each individual transistor as drawn from the +14 V supply can be measured across the 0.050 ohm resistors R8 and R9, on P2:1 (IC3) and P3:1 (IC2) respectively, which reads +0.200 V at 4 A DC.

The output collector transformation is also of the LP-type with six Tchebyscheff sections for flat wideband matching from 1.0 – j 1.0 ohms optimum load resistance up to the 50 ohms input of the hybrid T2.

The first element is RL + Cc + Lc of the transistor collector. The second element is shunt capacitors C9, C11. The third element is the series inductance L15. The fourth element is the shunt capacitors C18, C19. The fifth element is the shunt capacitor C26. Only a fine alignment is possible and neccessary at low RF currents with the capacitors C4, C5, C26.

The two amplified output powers are combined in T2. Only the difference of the output signals will be dissipated in the balance load R11. If, for instance, V3 is faulty approximately 12.5 W (–6 dB will reach the output and 12.5 W will dissipate in R11.

A further advantage of the 90° hybrid coupling is that each transistor sees both the balance 50 ohms load and the antenna SWR. Thus the transistors see less load variations with high antenna reflection, and a better amplifier load stability is obtained. Also IM3 and IM5 attenuation is improved relative to a single final transistor stage.

Imediately after the output combining coupler T2, a soldering link is available at 50 ohms that enables factory fine tuning of the inductors of the LP-filter setting attenuation and SWR.

Output LP-filtering is additionally done in a derivated five sections LP-filter.

After the LP-filter there are two directional coupling loops that each senses −28 dB of the forward and reflected output powers respectively, which are then detected in diodes V5 and V4. Resistor R13 and capacitor C34 terminate the coupled loops and determine the directively (~20dB). Coupling flatness versus frequency is compensated by C40.

Two independent outputs are available with an EMF of +3 V DC at 50 W to P6:1, 2 and P6:5, 4 to drive both 100 µA instrument test points and level alarms. A third output coupler −37 dB forward output power, SMB J2 connector, leads to the front panel TXTP BNC connector.

RELAY BOARD

This pc board is used to obtain power output indications and fault alarms to LEDs and relays.

An input keying 0 V order is sensed at P1:4, that discharges capacitor C1 via R13 to + 4.7 V into Z1c:10. The output Z1c:8 will go high and activate transistor V4 and relay K1 and the red LED (FAULT), if not a detected output voltage from the forward power of the final amplifier is present on pin P1:7. If P1:7 is high the reference voltage on Z1c:9 shifts from +2.4 V to +6.0 V which prevents K1 to activate. Diode V1 provides a charge path for C1.

The potentiometer R9 sets the desired alarm level for level 1 alarms, −3....−6 dB below nominal output power. Resistor R3 provides a hysteresis of the on/off levels. At pin P1:1 a green LED (Pout) indicates full output power.

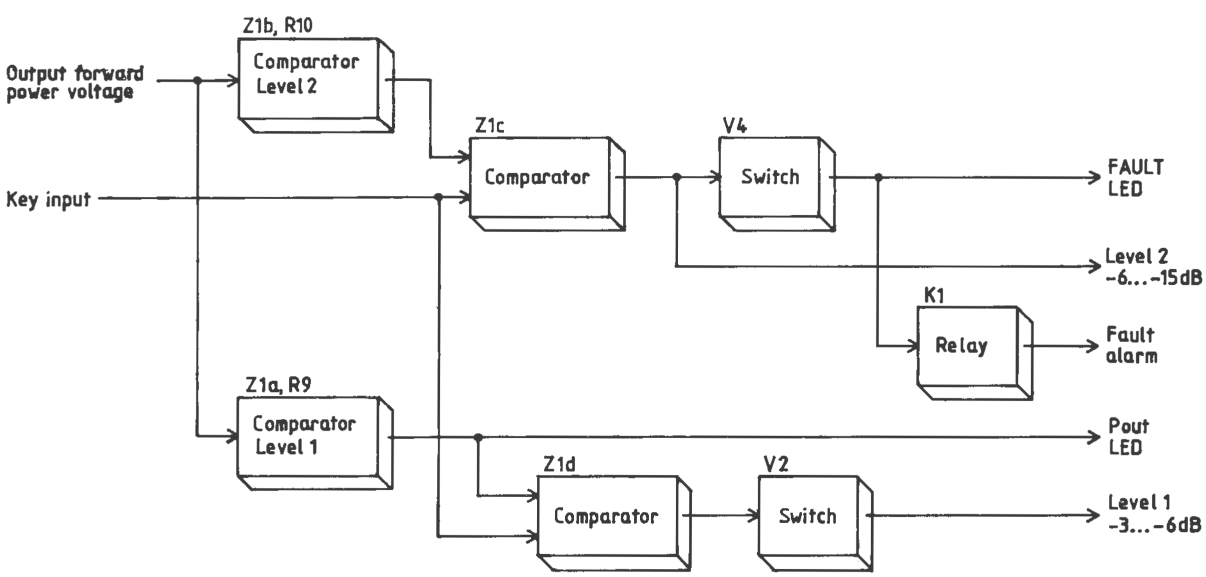


Fig. 5. Block diagram of the relay board.

The potentiometer R10 sets the activating level 2 (–6.... –15 dB) for Z1b:7 and K1. If the input voltage on P1:7 drops below the limit, Z1c:8 goes from +14 V to +0.5 V and relay K1 is activated. Also P1:13 will go high and the red LED (FAULT) will light.

The potentiometers for level 1 and level 2 can be accessed from inside if it is desired to make a change.

A level 2 alarm is transmitted back by the CU, and the MTX normally answers by removing keying for that channel.

A level 1 alarm will normally be indicated but will still be keyed in operation.

TEST POINT BOARD

This pc board contains measuring resistors and sockets for nine test points to an external 100 µA/2000 ohms instrument. The three current test points (IC1....IC3) are referenced to +14 V. The other test points are referenced to ground.

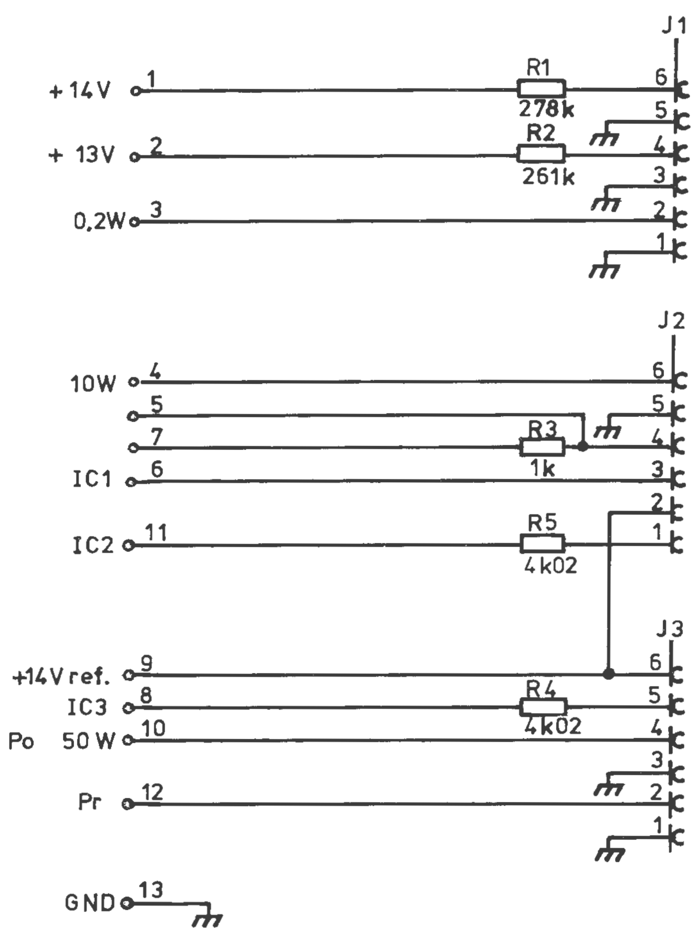


Fig. 6. Circuit diagram of the test point board.

Test socket	Measuring
J1:1	Ground.
J1.2	Input power from TX (200 mW).
J1:3	Ground.
J1.4	+13 V regulated voltage from the driver.
J1.5	Ground.
J1.6	+14 V supply voltage.
J2:1	IC2, collector current from power transistor V3 on final amplifier (0.2 V/4A).
J2.2	+14 V reference voltage for IC2 measurement.
J2.3	IC1, total collector current from Z2 on driver board (0.4 V/2A).
J2.4	+14 V
J2:5	Ground.
J2.6	Input power to the final amplifier (10 W).
J3:1	Ground.
J3.2	Reflected power (−28 dB), 3 V/50 W.
J3.3	Ground.
J3.4	Forward power (−28 dB), 3 V/50 W.
J3:5	IC3, collector current from power transistor V2 on final amplifier board (0.2 V/4A).
J3.6	+14 V reference voltage for IC3 measurement.

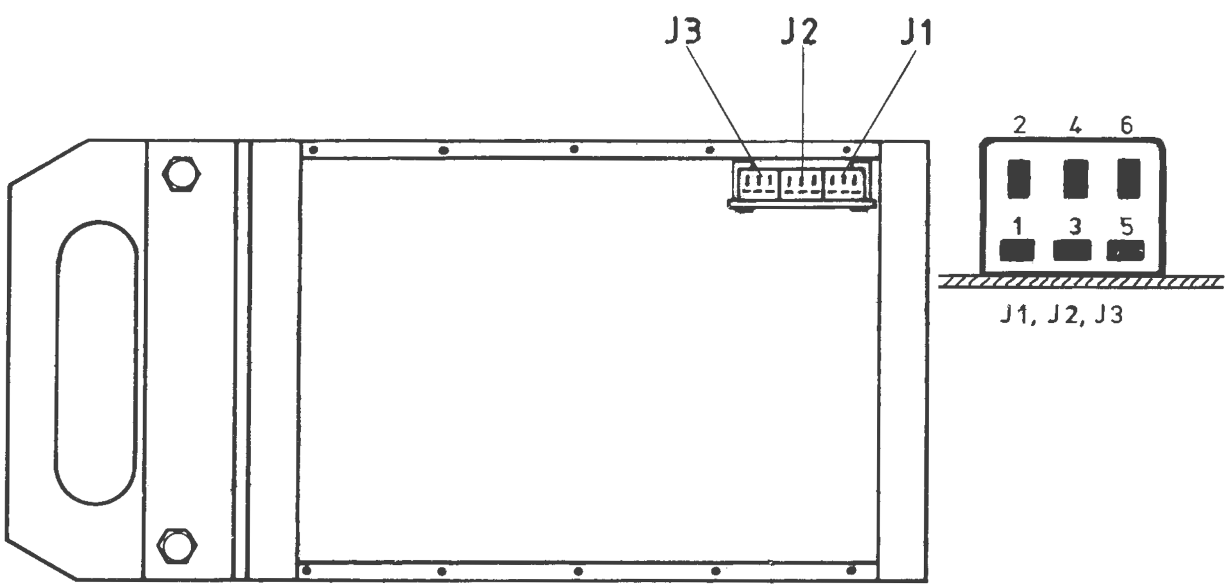


Fig. 7. The test sockets on the test point board.

ALIGNMENT

GENERAL

The following instruments are recommended at centralized complete maintenance:

- Directional power meter for measurement of drive power and input reflection. Type Bird 43 with probes.
- Output power meter and 50 W load. Type Bird 6156.
- Signal generator and power amplifier continuously covering the full bandwidth and 0.2 W output power.
- Spectrum analyzer for stability checking. Type HP 8558B.
- Network analyzer for passively checking or aligning the output LP-filter attenuation and SWR. Type HP 8505A.
- Bi-directional coupler for sweeping input power and reflection. Type Narda 3020A.
- Coaxial cables RG 214, power attenuators and transistors.
- Coaxial load SWR = 1.5 consisting of several meters of RG 213 providing a forward attenuation of 7 dB and a return loss of 14 dB giving giving a 1.5 SWR load with varying phases.
- DC-instruments 100 uA/2000 ohms, two off for measuring collector currents at the current test points.
- Digital multimeter for DC-measurements (insensitive for RF).
- Adjustable power supply 0 – 15 V, 0 – 15 A DC. With current limitation.

Special precautions

Any component exchange or soldering on the strip line final amplifier board should be avoided as special precautions as type of solder, melting temperature, heat permitted and the mechanical stress and training are neccessary for a proper result. A unit or pc board replacement is instead recommended if a fault has been localized with input power on and from conclusion of the instrument readings.

At a replacement of a transistor or coil it shall be soldered with type 96/4 % Pb/Ag (melting temperature of 235°C). At a replacement of a porzellan capacitor it shall be soldered with type 62/36/2 % LMP (melting temperature of 179°C).

At a replacement of transistors a thin layer of silicon grease shall be used. Screw mount the transistor to the chassis before soldering. If the pc board has been removed, check that the flanged resistor and the transistors are tightly screwed to the cooler.

After any repair in the LP-filter the input SWR and harmonic attenuation shall be shecked at the link point on pc board to have a return loss < -20 dB.

Typical test data

The front panel TXTP −20 dB output can be used as a sevice monitoring point when feeding a frequency counter, deviation meter or a spectrum analyzer. Other test points are accessible in the three test sockets J1....J3 on the test point pc board after that the cover plate has been removed.

Typical test data (max. values) are:

P IN	0.2 W + 0.1 W, −0.05 W
P OUT	50 W + 5 W, −10 W
U (14 V)	14.0±0.2 V (10.8....15.6 V)
I	8.5±0.7 A (< 10 A)
U (13 V)	13±0.3 V
P (0.2 W)	E = ±1 V
P (10 W)	E = 2.5±0.2 V
IC 1 (2 A)	1.3±0.3 A (<2 A)
IC 2 (5 A)	3.5±0.7 A (<4.5 A)
IC 3 (5 A)	3.5±0.7 A (<4.5 A)
Po	E = 2.6±0.2 V/50 W
Pr	E = <0.2 V (0.5±0.2 V at SWR = 1.5)

TUNING PROCEDURE

If not enough instruments are available, simplified measurements can be carried out on the normal operating frequency with the actual driver.

1. Check that the transistor screws are firmly secured.

2. Connect the 100 uA instruments to the test sockets IC 1 (J2:3) and IC 2 (J2:1) respectively on the test point board.

3. Connect a 0.2 W driver to the input terminal on the front (0.2 W IN).

4. Check the output power from the driver board (nom. 10 W). If not 10 W it can be adjusted to this value with potentiometer R2, accessible from underside of the chassie body.

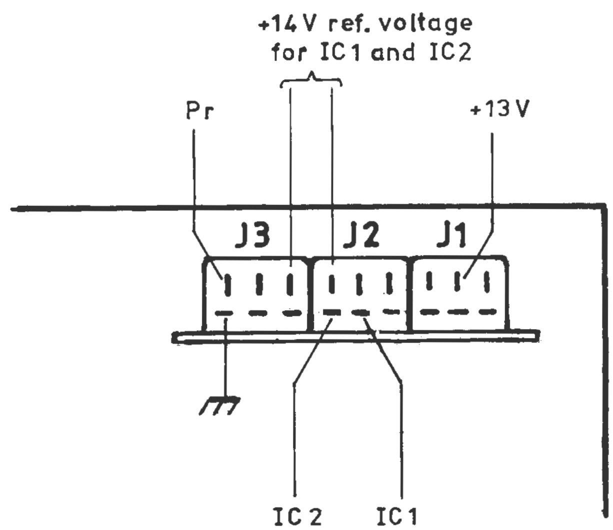


Fig. 8. Test sockets on test point board.

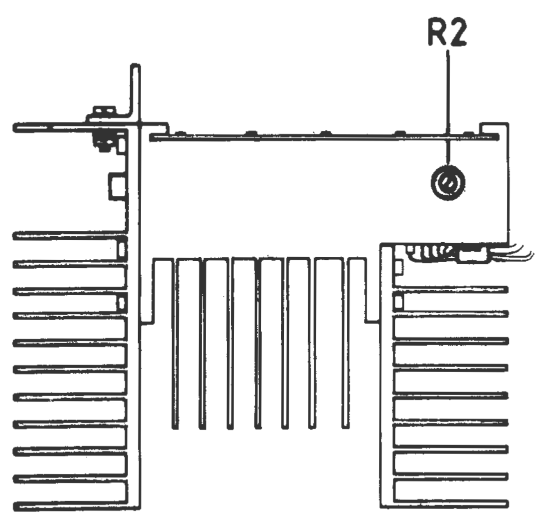


Fig. 9. The 10 W driver output power adjustment potentiometer.

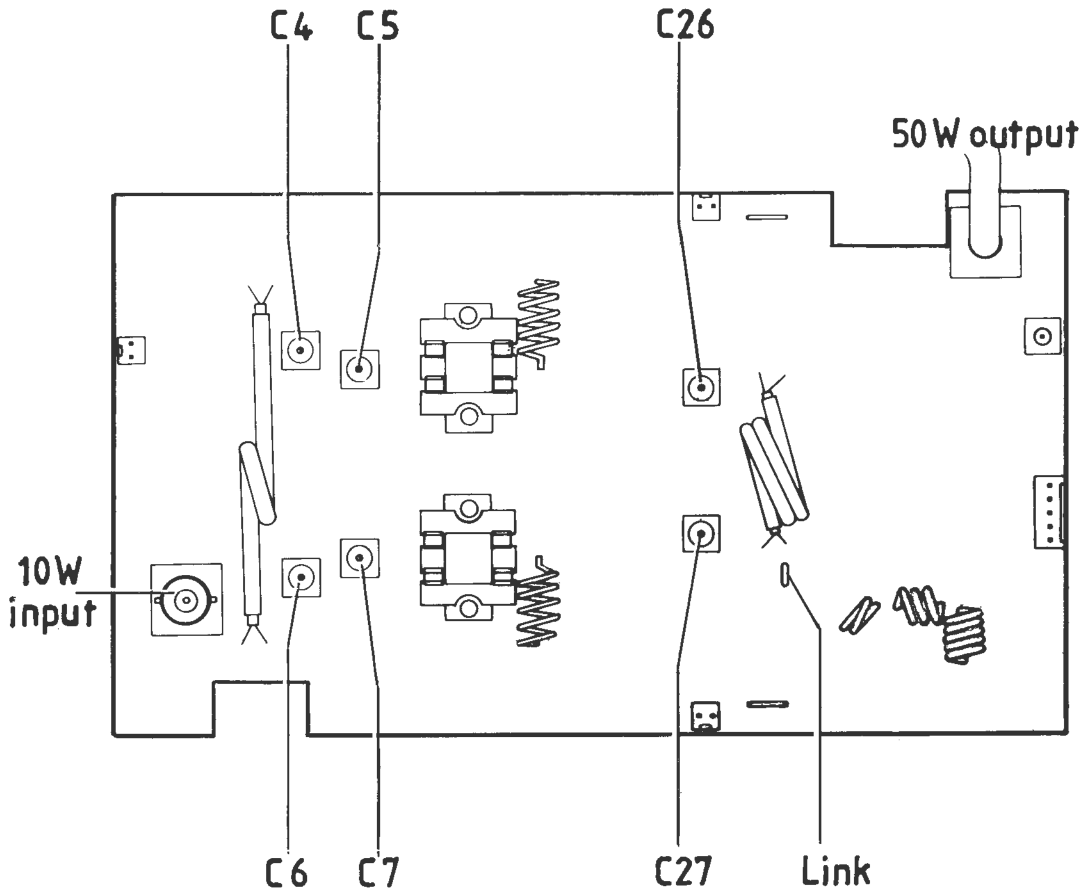


Fig. 10. Trimming points on power amplifier pc board.

5. Connect a 50 W power meter and load close to the 50 W output terminal on the front (50 W OUT).

6. Tune C4, C6 and C5, C7 on the power amplifier board for best input return loss and max. output power across the band.

7. Tune C26 and C27 for max. output power and minimum collector current (the current at test points IC 1 (J2:3) and IC 2 (J2:1) on test point board not exeeding 5 A).

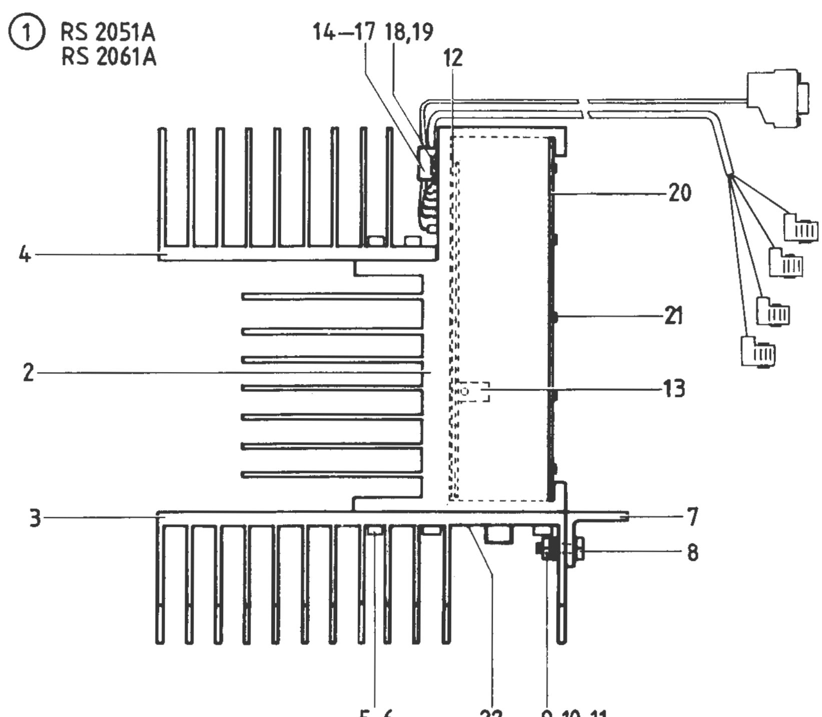
8. Check RF test point J2 on power amplifier board (nom. –10 dBm) and the level at TXTP outlet on the front (–20 dBm).

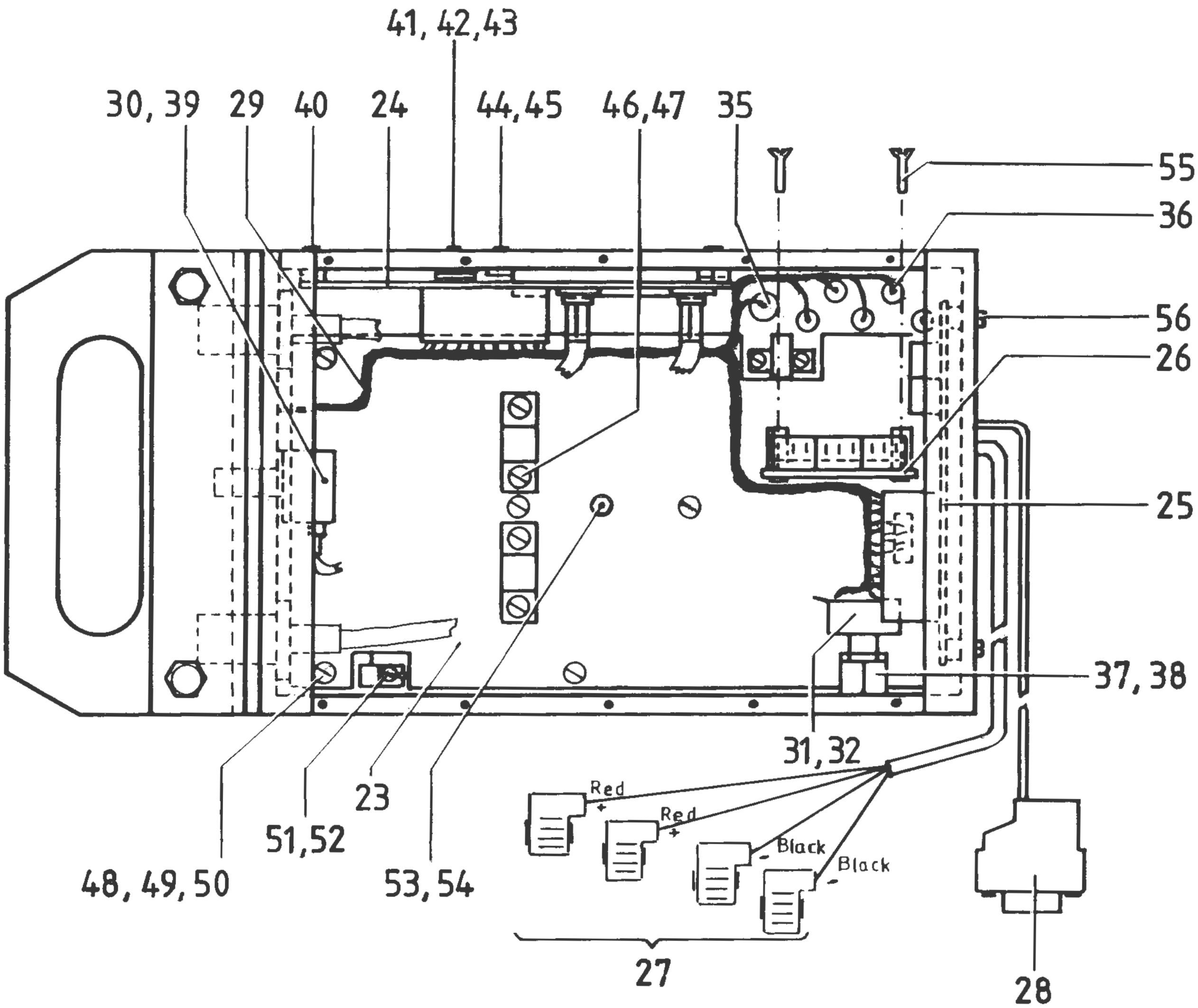
9. Check the output reflection detector with the 1.5 SWR load and the socket J7 removed from pin connector P6 on power amplifier board that the UR voltage is 0.7....1.0 V (test point J3:2 on test point board).

10. Connect the socket J7 to pin connector P6 and check that the +13 V on the driver board (test point J1:4 on test point board) regulates down to approximately 11 V when the RF load in front outlet 50 W OUT is removed.

50 W POWER AMPLIFIER

Item	Description	Qty	Part no
1	50W power amplifier 400–440MHz	1	RS 2051A
	50W power amplifier 440–470MHz	1	RS 2061A
2	Chassie, body	1	RS 20604
3	Cooler, front	1	RS 20626
4	Cooler, rear	1	RS 21107
5	Washer ø 6.4	15	Schnorr
6	Screw MC6S 6x12	15	MC6S 6x12
7	Mounting support	1	RS 21010
8	Screw M6S 6x16	2	M6S 6x16
9	Washer BRB 6.3x10x0.5	2	
10	Spring washer FBB 6.3	2	
11	Nut M6M 6	2	M6M 6
12	Insulating disk (for PC 2062A)	1	RS 20624
13	Insulating disk (for PC 2061A)	1	TO 220
14	Washer ø 4.3	1	Schnorr
15	Screw MCS 4x8	1	MCS 4x8
16	Cable clamp ø 8 Axlund-Zettler	1	118-005
17	Washer BRB 3.2x8x0.5	1	
18	Washer ø 3.2	1	Schnorr
19	Screw MCS 3x8	1	
20	Cover plate	1	RS 21112
21	Screw MCS 2.5x6	10	MCS 2.5x6
22	Signs	1	RS 20652

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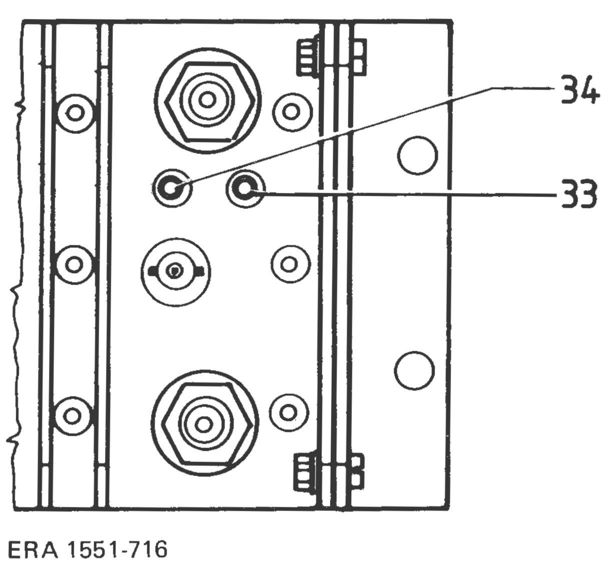
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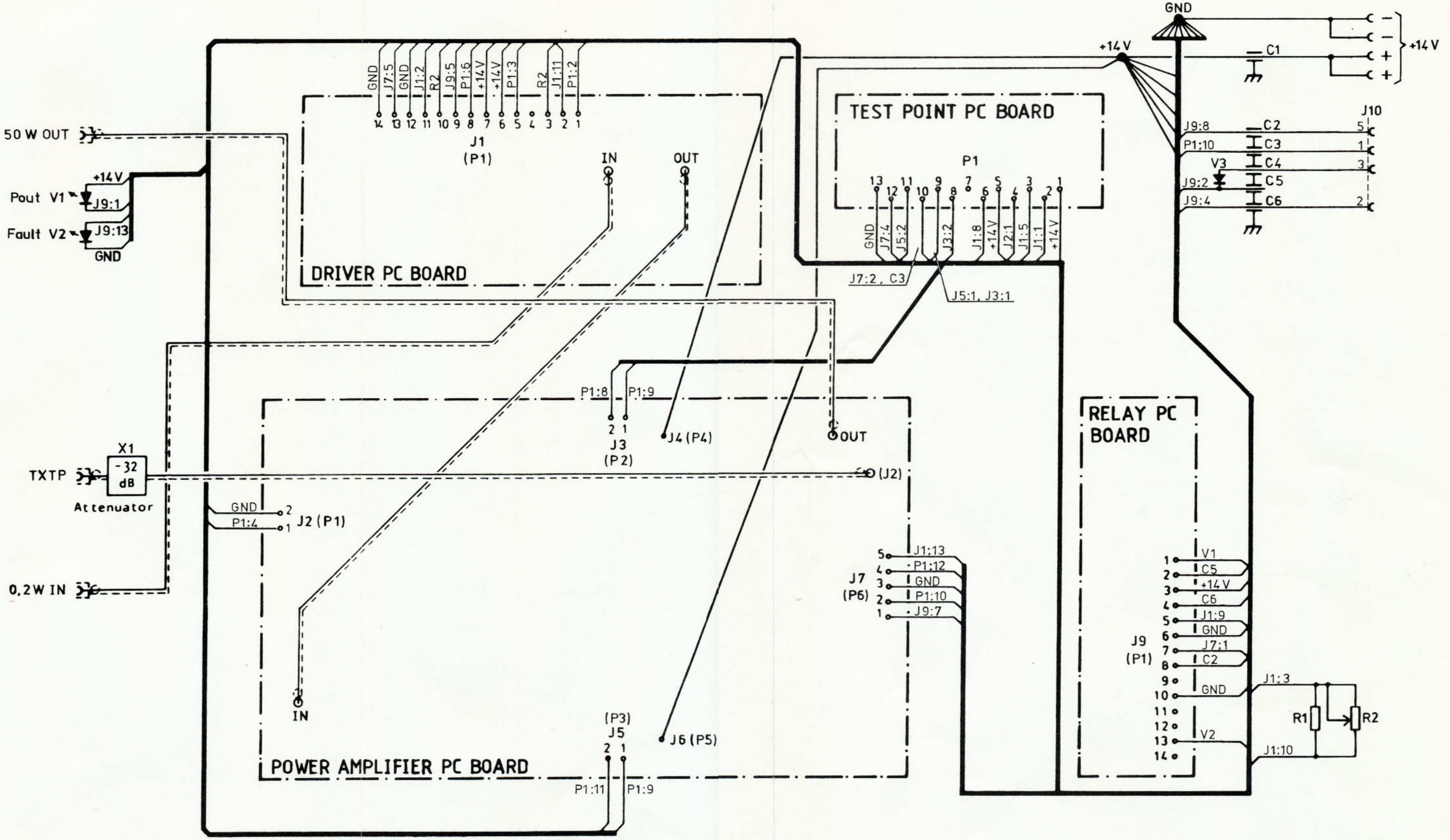
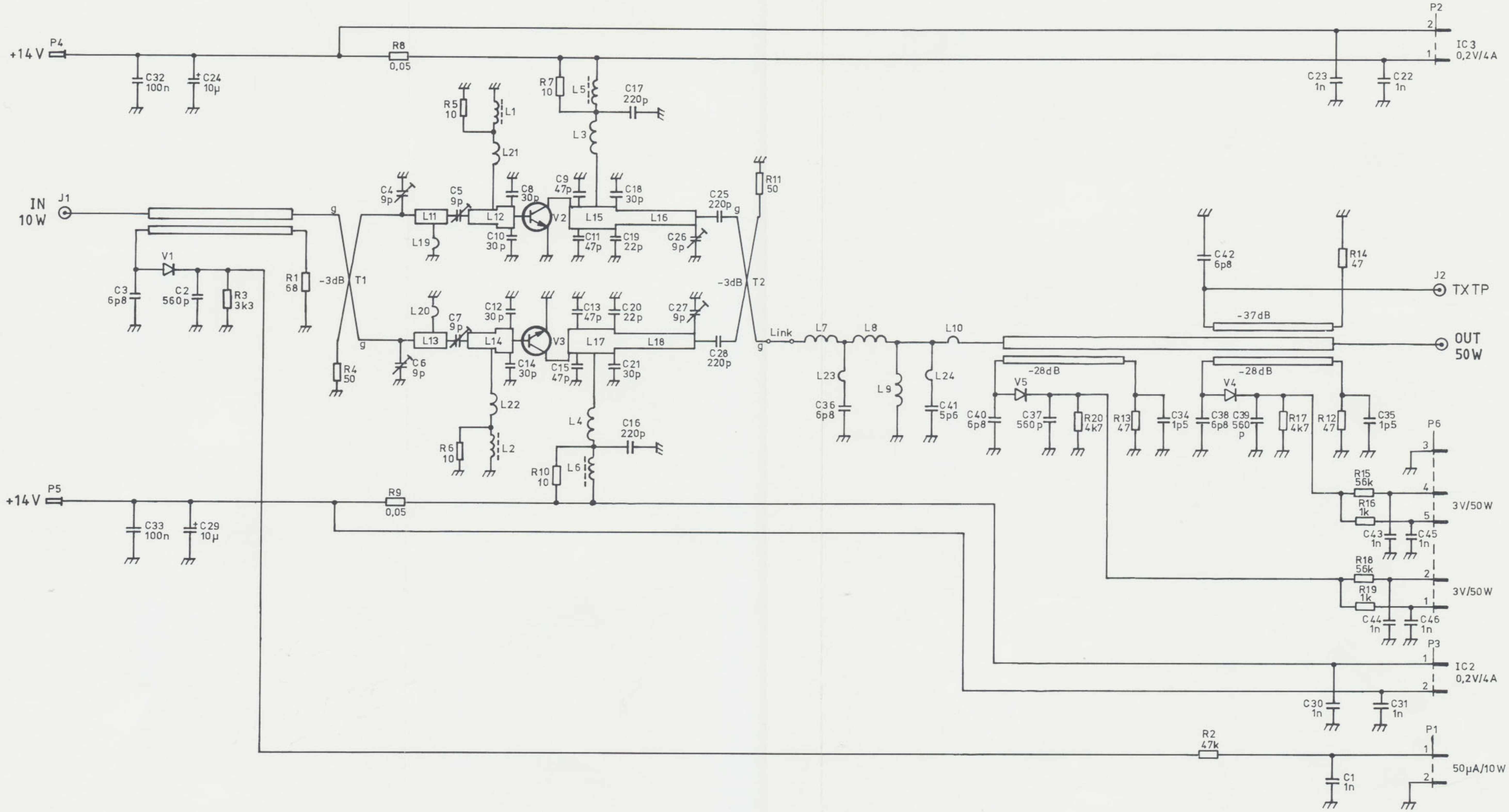
23	Power amplifier pc-board	1	PC 2062A
24	Driver pc-board	1	PC 2051A PC 2061A
25	Relay pc-board	1	PC 2063-5
26	Test point pc-board	1	PC 2064.
27	Power supply cable assy	1	RS 20640-2
28 (J10)	Control cable assy	1	RS 20640-1
29	Cabling, internal	1	RS 206
30 (X1)	Attenuator with cable	1	RS 20651
31 (R2)	Potentiometer 250ohm Danotherm	1	21/23G
32 (R1)	Resistor 220ohm Dale	1	CW-2B-13
33 (V1)	Light-emitting diode, green Ossi C.	1	BS-SG 5531
34 (V2)	Light-emitting diode, red Ossi C.	1	BS-SR 5531
35 (C1)	RFI-filter 25A Eire	1	1202-052
36 (C2–C6)	RFI-filter 5A Ferroperm	5	9/0168.62
37	Bush Stockli	1	58-28-29
38	Bush	1	RS 20672
39	Screw FS 2.5x12	2	FS 2.5x12
40	Screw FS 3x10	4	FS 3x10
41	Screw FS 2.5x10	1	FS 2.5x10
42	Washer ø 2.7	1	Schnorr
43	Nut M6M 2.5	1	M6M 2.5
44	Washer ø 3.2	2	Schnorr
45	Screw FS 3x10	2	FS 3x10
46	Washer ø 3.2	6	Schnorr
47	Screw MCS 3x8	6	MCS 3x8
48	Screw MCS 3x12	9	MCS 3x12
49	Washer ø 3.2	9	Schnorr
50	Nut M4 USM	9	Kalei
51	Washer ø 2.7	1	Schnorr
52	Screw MCS 2.5x6	1	MCS 2.5x6
53	Washer BRB 3.2x8x0.5	1	
54	Screw MCS 3x6	1	MCS 3x6
55	Screw FS 3x10	2	FS 3x10
56	Screw MCS 3x10	4	MCS 3x10



F 705
50 W power amplifier



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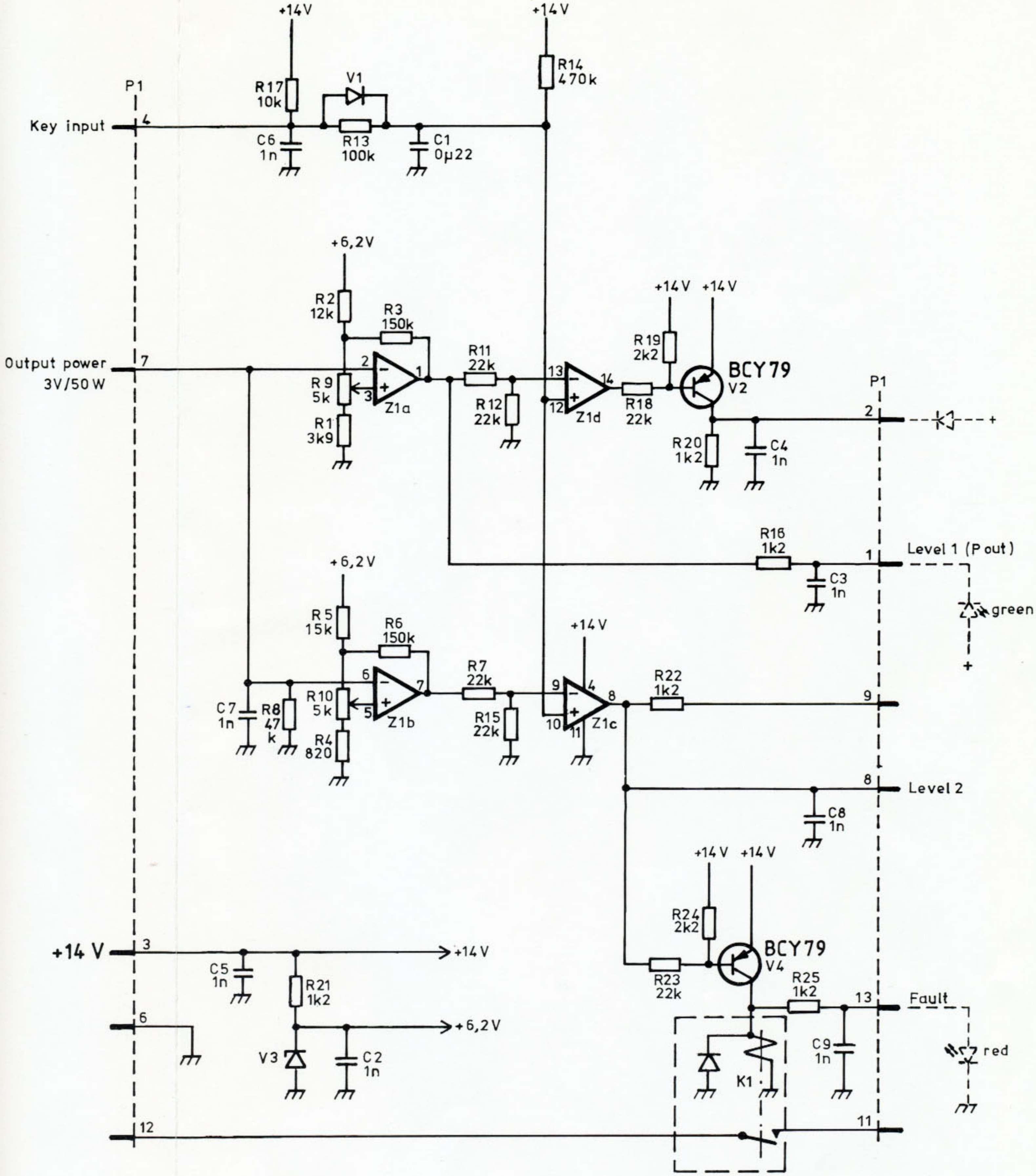
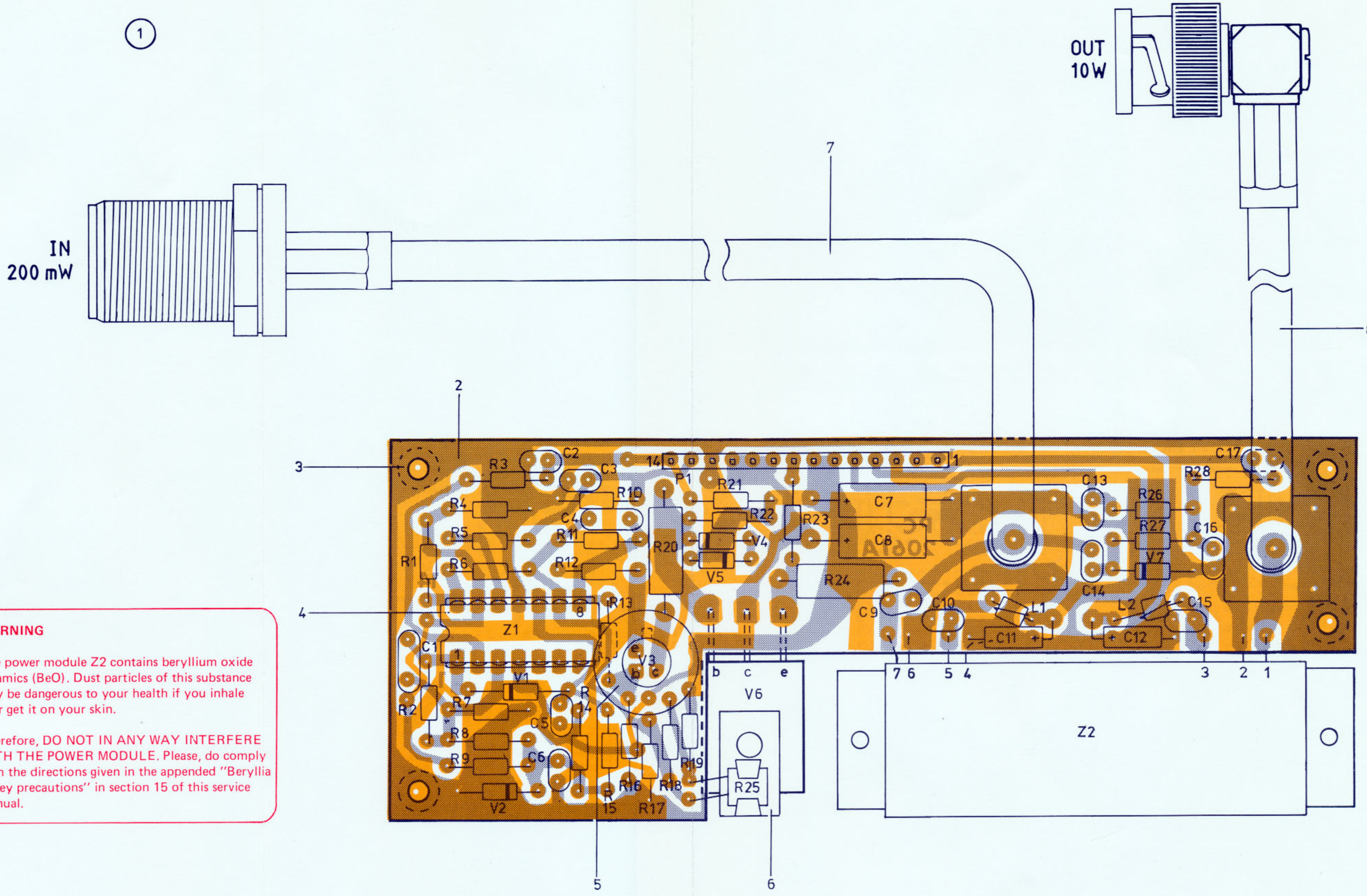
F 705
Power amplifier board



F 705

Relay board



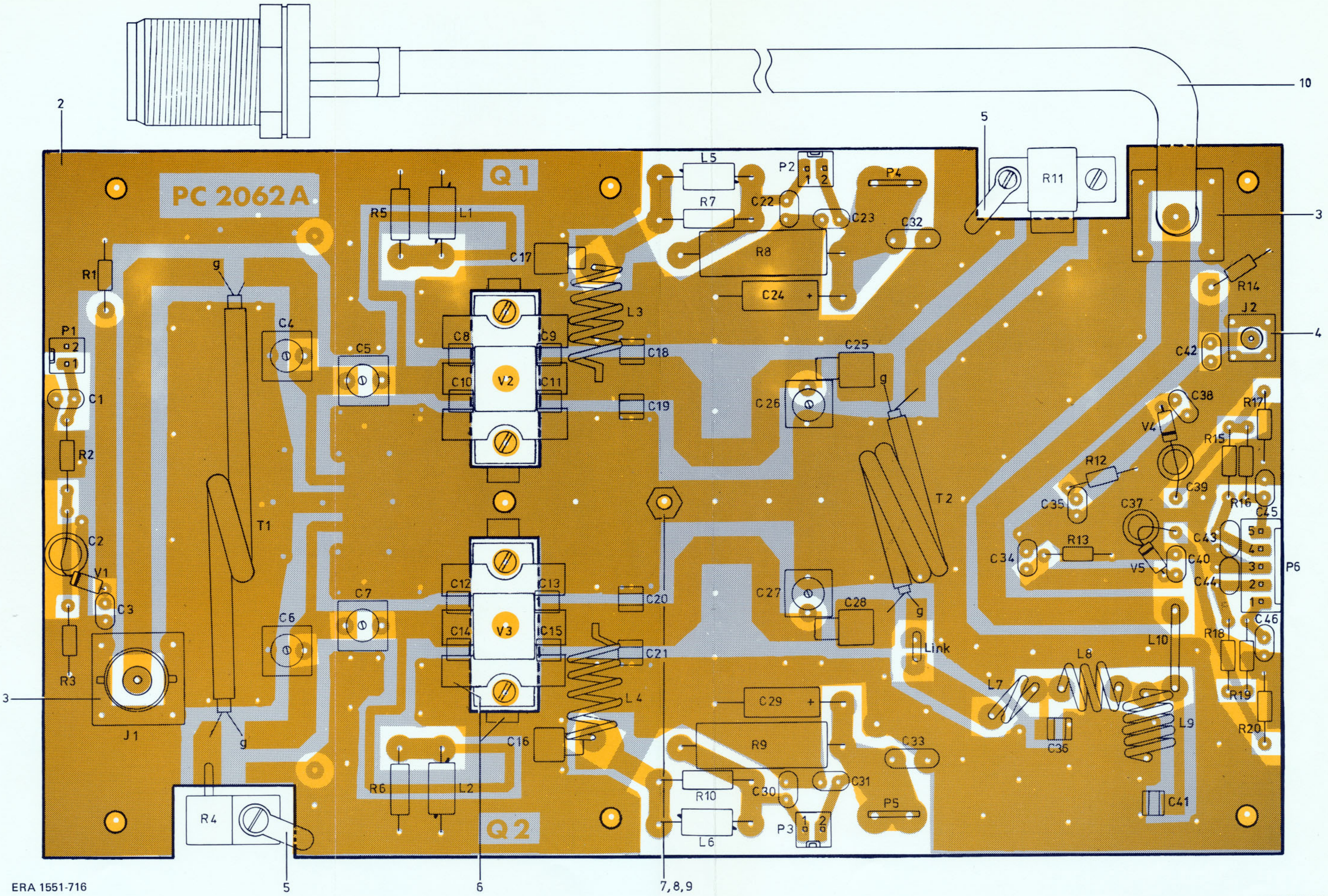
WARNING

The power module Z2 contains beryllium oxide ceramics (BeO). Dust particles of this substance may be dangerous to your health if you inhale it or get it on your skin.

Therefore, DO NOT IN ANY WAY INTERFERE WITH THE POWER MODULE. Please, do comply with the directions given in the appended "Beryllia saftey precautions" in section 15 of this service manual.

F 705
Driver board

1



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F 705
Power amplifier board

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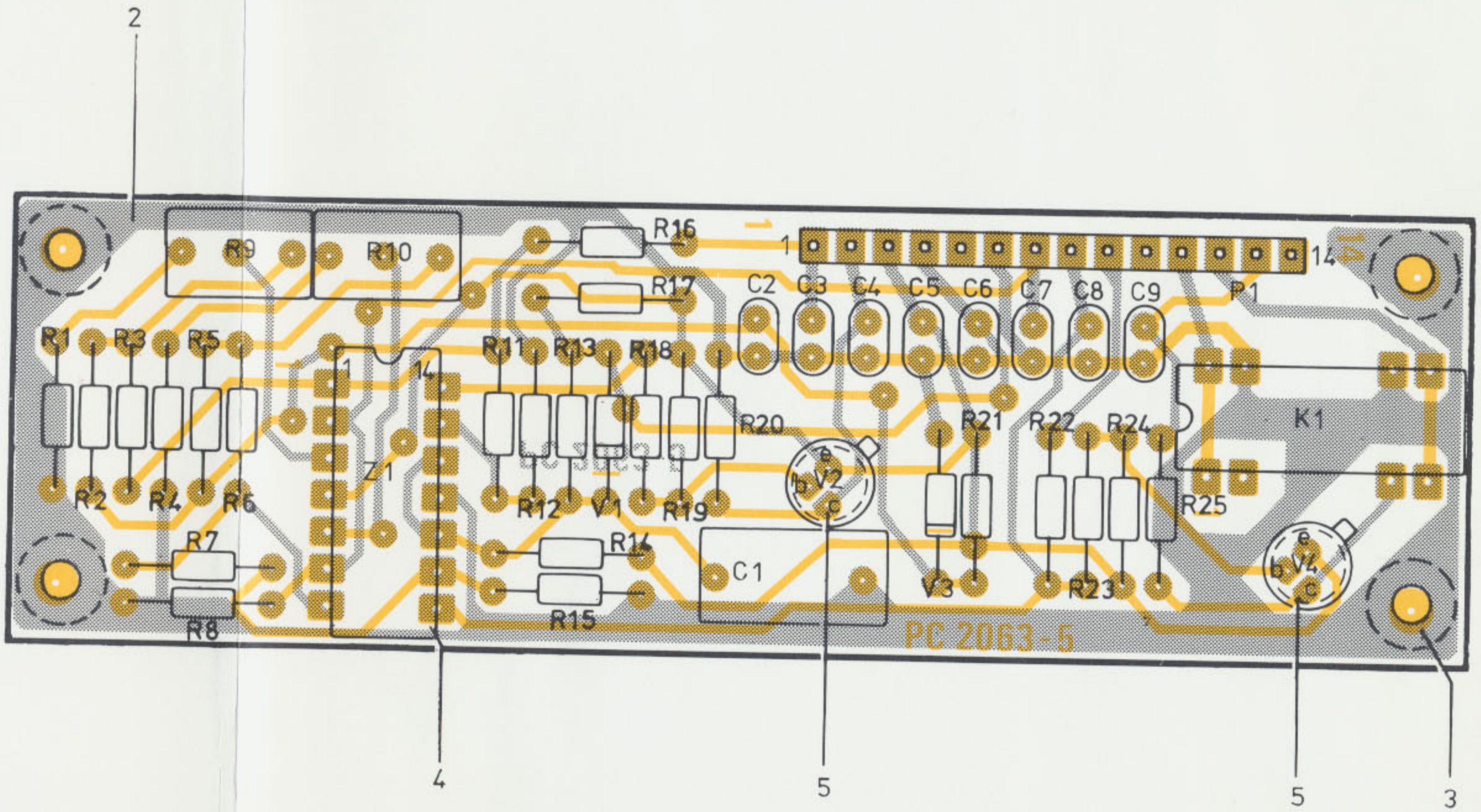
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R11 R12 R13 R14 R15 R16 R17 R18 R19 R20
R21 R22 R23 R24 R25
C1 C2 C3 C4 C5 C6 C7 C8 C9
V1 V2 V3 V4
Z1 K1 P1
PC 2063-5
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4
5
5