FF 6046

OLTRONIX

OLTRONIX-ELECTRONICS: Regulated Power Supplies and Digital Voltmeters

OPERATING AND SERVICE MANUAL

RACPAC

150 - 1000

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SECTION 1
GENERAL DESCRIPTION

A. GENERAL

Oltronix RACPAC 150, 300, 600 and 1000 is a line of low voltage, high power, regulated DC power supplies. There is no derating in any part of their voltage or current ranges. They are fully protected against overload and overvoltage.

The model number, e.g. B32-20R is a code for the performance of the power supply. The first letter indicates the approximate stability for $\pm$ 10 % line voltage fluctuation.

A < 0,01 %
B = 0,01 - 0,03 %
C = 0,03 - 0,1 %
D > 0,1 %

The first group of figures in the model number states the maximum output voltage. The figure after the dash shows the maximum output current of the power supply. "R" after the model numer indicates a rack model.

B. FEATURES

All RACPAC power supplies are equipped with dual range volt-and ammeter for simultaneous reading of output voltage and current.

A calibrated current limit control is incorporated. It serves the triple duty: to protect the load and the power supply from excessive current and to make it possible to use the power supply as a constant current generator.

The power supplies include facilities for resistance programming, voltage programming, remote sensing and modulation.
Programming operation gives the possibility to control the output voltage by an external resistor or voltage.

The remote sensing circuit allows the power supply to regulate the voltage across the load instead of the voltage at the output terminals. This compensates voltage drops in long cables to the load.

The modulation mode allows the output voltage to be controlled by an external low power signal.

The terminals for operating the power supply are available both from binding posts on the front panel and the 14-prong plug at the rear. Modulation and voltage programming are possible through the rear plug only.

If higher voltage or current is desired, two or more units can be connected in series, or in parallel. Then programming and remote sensing are still possible.

C. PRESENTATION

Figure 1 shows the front panel of the Oltronix power supply, type RACPAC.

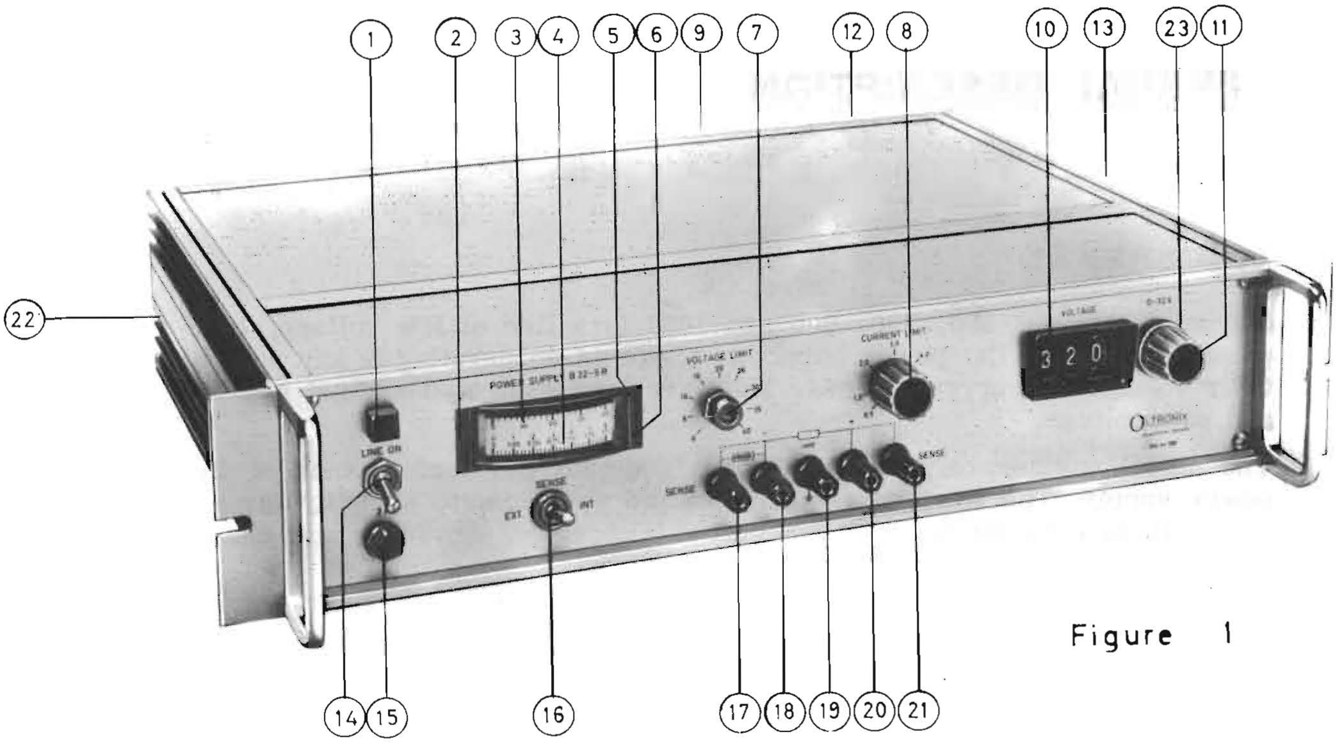


Figure 1

1. Pilot lamp, monitoring AC input
2. Constant voltage - constant current indicator
3. Output DC voltmeter
4. Output DC ammeter
5. Voltmeter range indicator
6. Ammeter range indicator
7. Overvoltage protection (OVP) control
8. Current limit control
9. OVP fuse RACPAC 600 & 1000 only
10. Output voltage reading
11. Output voltage control
12. Fourteen-prong rear connector
13. OVP fuse RACPAC 150 & 300 only
14. Line switch, AC only
15. AC fuse
16. Sense switch, EXT or INT
17. Remote sensing "-" and programming terminal
18. DC power "-" terminal
19. Power supply ground terminal
20. DC power "+" terminal
21. Remote sensing "+" terminal
22. Line voltage indicator
23. Voltage control lock

D. INCOMING INSPECTION

a. MECHANICAL CHECK

When the power supply is received, verify that the package contents are complete and as ordered. Inspect the instrument for any physical damage such as a scratched panel surface, broken knobs or connectors etc. incurred in shipping. Visually check inside the instrument for loose or damaged components.

To facilitate possible reshipment, keep the original packing.

If damage is found, file a claim with the responsible carrier or insurance company and refer to the warranty, last page in this manual.

b. PERFORMANCE CHECK

The power supply may be checked for electrical operation within the specifications of section 2 by following the procedures of section 5. If the instrument does not operate as specified, refer to the warranty page of this manual.

SECTION 2
SPECIFICATIONS

Data	Power	Model	DC output Volt	DC output Amp.	Line regulation (10 % mains swing)	Load regulation (100 % Load change)	Ripple and Noise mV RMS	Dimensions height x width x depth mm	Weight Kg
Constant voltage (CV)	150 W	B32-5R	32	5	1 mV or 0.01 %	5 mV or 0.03 %	0.2	88x19"x320	11
		B60-2.5R	60	2.5	1 mV or 0.01 %	5 mV or 0.03 %	0.2	88x19"x320	11
	300 W	B32-10R	32	10	1 mV or 0.01 %	5 mV or 0.03 %	0.2	88x19"x320	13.5
		B60-5R	60	5	1 mV or 0.01 %	5 mV or 0.03 %	0.2	88x19"x320	13.5
	600 W	B32-20R	32	20	1 mV or 0.01 %	7 mV or 0.05 %	0.5	132x19"x410	22
		B60-10R	60	10	1 mV or 0.01 %	7 mV or 0.05 %	0.5	132x19"x410	22
	1000 W	B32-30R	32	30	1 mV or 0.01 %	10 mV or 0.05 %	0.5	132x19"x410	30
		B60-15R	60	15	1 mV or 0.01 %	20 mV or 0.05 %	0.5	132x19"x410	30

			Current regulation using internal precision resistor				Current regulation using 4 volt over external shunt				
Data	Power	Model	Current range 2–110 % A	Line regulation (10 % mains swing) mA	Regulation (100 % voltage change) mA	Ripple and Noise mA pp	Current range mA–A	Line regulation (10 % mains swing) mA	Regulation (100 % voltage change) mA	Ripple and Noise mA pp	8 hours stability %
Constant current (CC)	150 W	B32-5R	0.1 – 5.5	2.5	20	2	5– 5	1.5	0.5	1	0.05
		B60-2.5R	0.05– 2.75	1.5	30	2	5– 2.5	0.75	0.25	0.5	0.05
	300 W	B32-10R	0.2 –11	5	20	2	5–10	3	1	2	0.05
		B60-5R	0.1 – 5.5	2.5	30	2	5– 5	1.5	0.5	1	0.05
	600 W	332-20R	0.4 –22	10	30	4	5–20	6	2	4	0.05
		B60-10R	0.2 –11	6	40	4	5–10	3	1	2	0.05
	1000 W	B32-30R	0.6 –33	15	30	5	5–30	10	3	6	0.05
		B60-15R	0.3 –16.5	8	40	5	5–15	5	1.5	3	0.05

All specifications as listed above for constant current are typical.

Input: 110, 117, 220 and 235 V ± 10 %, 50 Hz. (60 Hz available).

	Model	Input power
Input power with nominal voltage and 100 % load, typical values:	150 W	225 W– 300 VA
	300 W	450 W– 650 VA
	600 W	875 W–1250 VA
	1000 W	1350 W–1950 VA

Output: Floating. Either positive or negative terminal may be grounded. The voltage is continuously adjustable from zero to rated output voltage.

Recovery time: 50 μs.

Output impedance: The output impedance is almost constant from DC to approximately 5 kHz. Above 5 kHz it increases up to about 100 kHz after which it decreases.

Temperature drift: 100 ppm/°C.

Long term stability: 0.02 % per 8 hours.

Max operating ambient temperature:

Model	Bench top version with perforated coverplates	Rackversion with fan and solid coverplates
150 W	60°C	60°C
300 W	50°C	50°C
600 W	40°C	50°C
1000 W	40°C	50°C

Storage temperature: –40°C – +70°C.

Chassis insulation voltage: 500 V.

A. STANDARD ACCESSORIES (=BENCH MODEL)

NUMBER	ITEM	PART NO
2	Handles 150 & 300W	2923
2	Handles 600 & 1000W	3374
2	Decoration strips 88mm	3131
2	Decoration strips 132mm	3132
4	Plastic feet	3077
1	Receptacle MS 3106B20-27P	1786
2	Perforated cover plates 150 & 300W	2915
2	Perforated cover plates 600 & 1000W	3368

B. EXTRA ACCESSORIES

a. REMOTE INDICATION

1	Relay 24V Haller, type 532	2128

b. FAN-KIT FOR RACK MODELS 150 & 300W

1	Rack mounting ear, right	2924
1	Rack mounting, ear, left	2925
1	Coolrac 88, blower set complete	0379
2	Skin plates, unperforated	

c. FAN-KIT FOR RACK MODELS 600 & 100W

2	Rack mounting ears	3437
1	Coolrac 132, blower set complete	0377
2	Skin plates, unperforated	

For further information about accessories please also refer to section 3P.

SECTION 3
OPERATION

A. GENERAL

a. LINE VOLTAGE

Unless otherwise specified RACPAC is wired and calibrated for 220 V, 50 Hz when delivered from the factory. For other line voltages, connect the transformer as indicated on it, and adjust the line voltage indicator accordingly.

For 110 V or 117 V lines replace the AC fuse for the higher value, indicated over the fuseholder on the front panel.

Use slow blow fuses. For 60 Hz operation, see section 3R: "60 Hz operation".

b. LINE ON

The power supply is switched on with the toggle switch, marked "LINE ON".

c. OUTPUT VOLTAGE

The desired voltage is set with the calibrated output voltage control, figure 1 pos. 10, 11. The voltage control can be locked by turning the ring behind the voltage control knob clockwise (figure 1 pos. 23). Read the output voltage from the voltmeter on the front panel. Note that the voltmeter has two ranges with automatic switch over. The range in use is shown on the voltmeter range indicator (figure 1 pos.5).

d. OVP

Set the "Overvoltage protection" control (figure 1 pos. 7) well above the desired output voltage, but below the voltage that could damage the load.

Usually the calibrated scale on the panel will give sufficient accuracy.
For higher accuracy, set the OVP to maximum and the voltage control to the desired trip over voltage for the OVP. Turn the OVP slowly CCW until the output voltage suddenly disappears. Lock the OVP control.

WARNING: If RACPAC is connected to an external power source, e.g. used for charging a battery, the OVP MUST NOT BE USED.

Such an external power source can damage both the OVP thyristor and the cable harness.

The OVP switched off by turning the control fully CW where it switches to an OFF position.

e. CURRENT LIMIT

Set "Current limit" control at a value well above the expected peak current, but below the value which could damage the load.
Read output current from the ammeter on the front panel. Also the ammeter has two ranges with automatic switch over (figure 1, pos.6).

B. ENVIRONMENTAL CONDITIONS

RACPAC is designed for operation under conditions where the vertical ventilation through the perforated cover plates is free.
Of course, it is also essentia that the rear extrusion with the power transistors has free access to cooling air.

Sufficient vertical ventilation is achieved when RACPAC stands on a bench and is provided with plastic feet.

When rack-mounted, a corresponding distance (20 mm) to the nearest obstrucle top and bottom is sufficient, provided it is not a heat generator. If so, the temperature of the air below RACPAC, under worst heat generating conditions, has to be regarded as the cooling air for RACPAC. For maximum operating ambient temperatures see section 2: "Specifications".

IF THE ENVIRONMENTAL CONDITIONS MENTIONED DO NOT APPLY, RACPAC HAS TO BE EQUIPPED WITH AN EXTERNAL FAN.
See section 3P: "Accessories".

C. NORMAL OPERATION

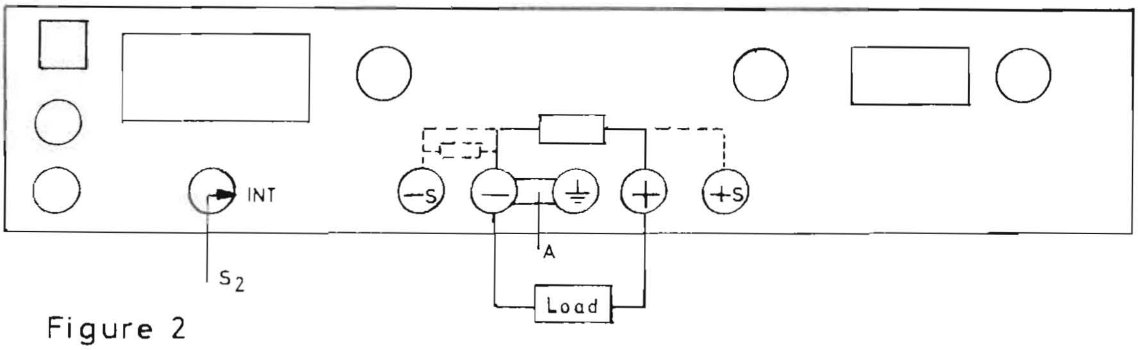


Figure 2

The "Normal-Parallel" switch S4 on the main PC-board is in "Normal" position (as delivered from the factory).

The "sense" switch S2 is in position "INT". The output may be positive, negative or floating, depending on how jumper A in figure 2 is connected.

<u>It is important that the load is connected to the terminals marked "+" and "-". Using the "sense" terminals for current output may damage RACPAC. This applies for all RACPAC applications.</u>

D. REMOTE SENSING

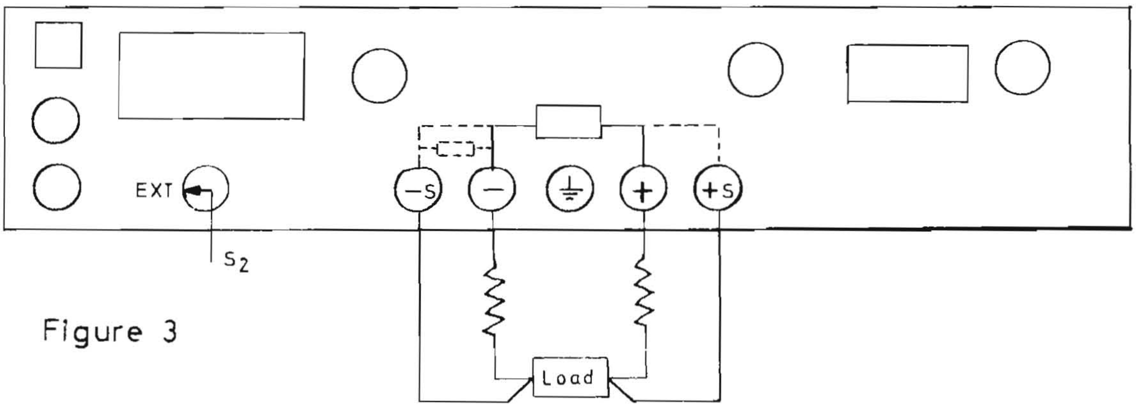


Figure 3

This circuit permits sensing the voltage at the load terminals instead of at the power supply terminals. Thus regulation loss caused by IR drops in the load leads is compensated for. The influence from the resistance in the "sense" leads is negligible as a low (a few mA) and almost constant current flows through these.

Set "EXT-INT" switch S2 in position "EXT". If possible, connect cable with lowest expected voltage drop to "+".
When using the remote sensing circuit, the following limitations should be taken into account:

1. The voltage drop in the "+" cable should not exceed 0, 5 V.
2. The maximum voltage at the instrument terminals should not exceed the maximum rating for the actual power supply. This means that the maximum available voltage at the load is the maximum power supply voltage minus the voltage drop in the power cables.
3. The power supply voltmeter indicates the voltage at the instrument terminals (not the voltage at the load).

E. RESISTANCE PROGRAMMING

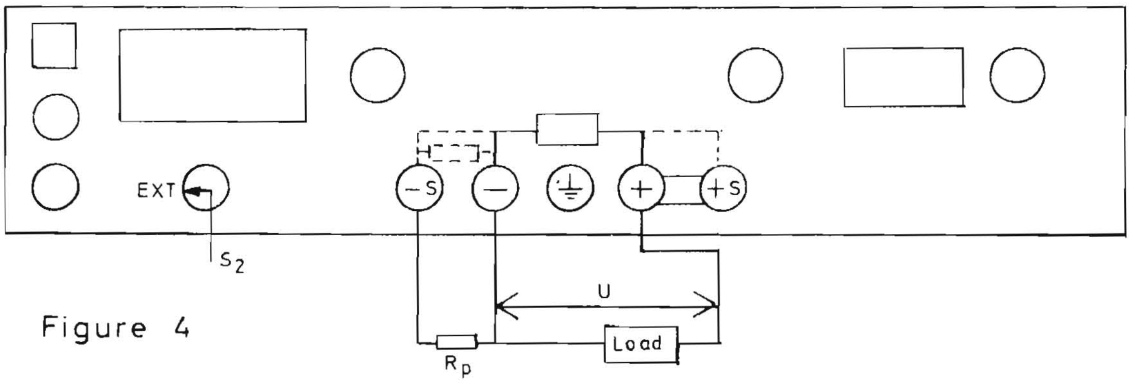


Figure 4

When the resistance programming mode is used, the output voltage is controlled by an external resistor. The connection procedure is as follows:

1. Switch off the power
2. Set "sense" switch S2 to "EXT" and connect jumper between "+" and "+sense".
3. Set voltage control at zero.
4. Now the output voltage is controlled by the programming resistor R_p. The relation between R_p and output voltage U is:

$$U = K_p \cdot R_p \ (R_p \text{ in kohms})$$

where: $K_p = 3,75$ for 32 V models (270 ohms/V)

$K_p = 3,35$ for 60 V models (300 ohms/V)

Exception:

Early 60 V RACPAC'S have $K_p = 3,75$
This applies for RACPAC'S with the following serial numbers:

MODEL	SWEDISH SER.NO	DUTCH SER.NO
B60-2,5R	001-004 and 100-125	N100-121
B60-5R	001-004 and 100-140	N100-121
B60-10R	001-003 and 100-125	N100-106
B60-15R	001-110 and 100-110	N100-106

Note: Do not increase R_p over the value that gives maximum specified output voltage.
32 V models: 8,5 kohms
60 V models with K_p = 3,35: 17,8 kohms
60 V models with K_p = 3,75: 16,3 kohms
Programming may be performed by the receptacle at the rear side as well.
Remote sensing is achieved by connecting "+ sense" and R_p directly tot "+" and "-" of the load.

F. VOLTAGE PROGRAMMING

The output may be controlled by an external signal.

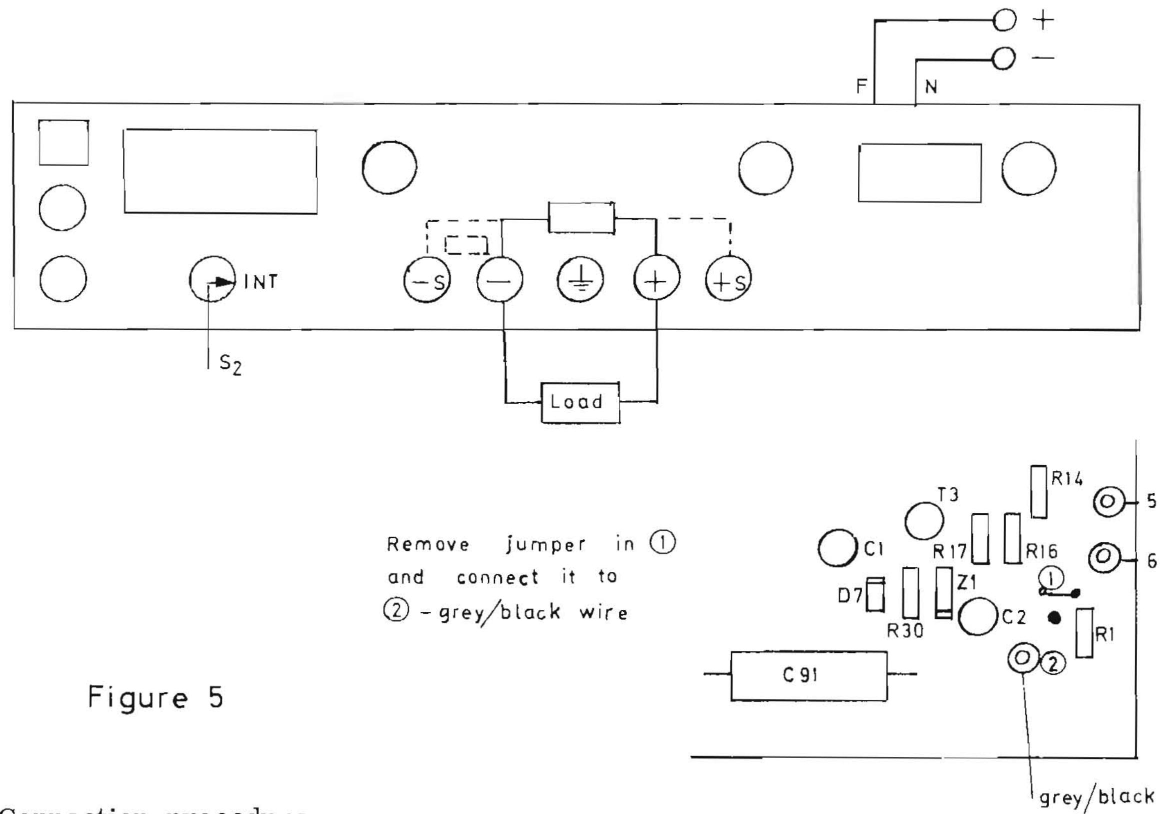


Figure 5

Connection procedure:

1. Set "INT-EXT" switch at "INT".
2. Connect jumper on main PC-board as shown in figure 5.
3. Connect modulating voltage to prongs B and N of the rear connector.
   B is to be regarded as the signal input and N the common (="+sense").
   B to be positive with respect to N.
4. Set output voltage control to maximum desired voltage.
5. Now the output voltage is controlled by the programming voltage.

$$V_{out} = V_{max} \cdot \frac{Vp}{6,2}$$

where: V_{out} = output voltage
V_{max} = reading on digital voltage reading
V_p = programming voltage

The tolerance in V_{out} is $\pm$ 5 % but may be adjusted with P1.
For programming speed refer to 3G.

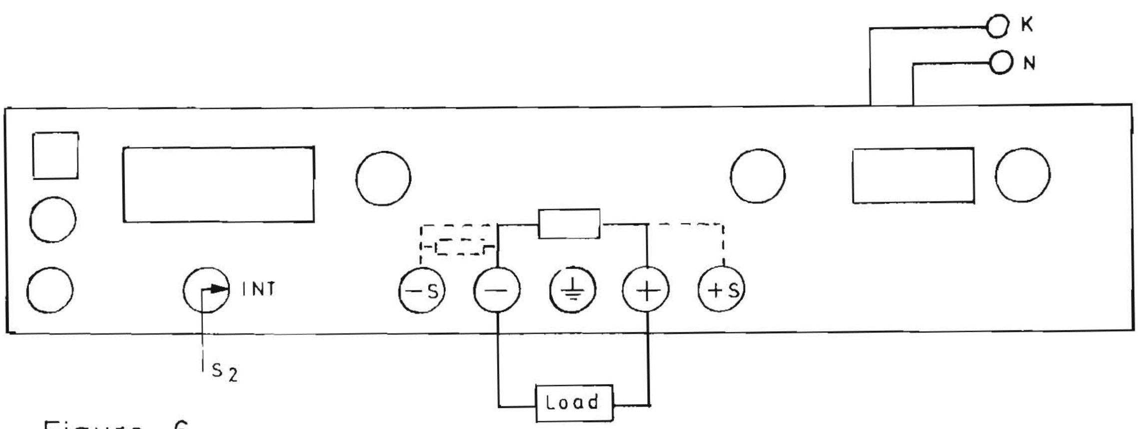


Figure 6

The power supply output voltage can be modulated by an external low power signal. This mode of operation is initially intended to give a possibility to add a variable amount of ripple to the output voltage. This is useful for example, when a circuit has been developed using a practically ripple free regulated power supply as power source, and is intended to be operated from a simple rectifier. The amount of ripple which the actual circuit can stand, is easily examined by varying the ripple modulation amplitude from the laboratory regulated power supply. When this low amplitude modulation (less than 2 V p-p) is used, the upper frequency limit (-3 dB) is approximately 25 Hz with 20-100 % load.
Above this frequency limit the amplitude-frequency curve falls 6 dB per octave. At frequencies over 50 Hz the amplitude is limited by the slew-rate capability.

MODEL	SLEW-RATE at 1 A
150-600 W 32 V	200 V/sec
1000 W 32 V	100 V/sec
150-600 W 60 V	300 V/sec
1000 W 60 V	150 V/sec

The slew-rates as specified above apply for a minimum current of 1 A and 1 A below the value the current limit is set to.
The slew-rate is proportional to the smallest of:

1) DC output current
2) Difference between current limit and DC output current

Example: Model B32-5R with a 3A DC load and current set at 5A.
How much is the slew-rate?
1) DC output current is 3 A.
2) Difference between the current limit and DC output current is:
   5 A - 3 A = 2 A.

2 A is the lowest of the two. Slew-rate at 1 A is 200 V/sec.
So the slew-rate in this example amounts to 2 x 200 = 400 V/sec.

Figure 7 illustrates the slew-rate limitation as a function of output DC current for the eight models of RACPAC, each having its current limit control set at maximum.

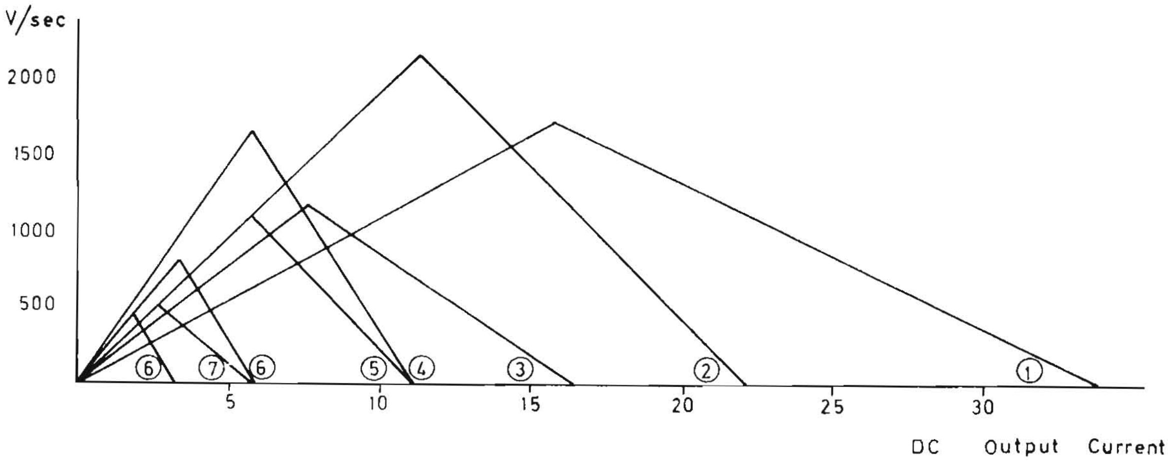


Figure 7

① B32-30R	⑤ B32-10R
② B32-20R	⑥ B60- 5R
③ B60-15R	⑦ B32- 5R
④ B60-10R	⑧ B60-2,5R

If the output current is higher than 1 A and more than 1 A below the current limit, the amplitude increases correspondingly (see figure 7).
When applying a sine-wave, the slew-rate limitation implies, that the maximum output peak to peak amplitude with minimum 1 A load and minimum 1 A below the current limit will be:

with	50 Hz	1 V
	500 Hz	0,1 V
	5000 Hz	10 mV

These figures apply for all RACPAC'S with a 200 V/sec slew-rate at 1 A. For other RACPAC'S the peak to peak amplitude is proportional to the slew-rate.

The modulation technique of controlling the power supply also makes it possible to vary the output voltage over the whole output voltage range with a low power signal. Then the power supply acts as a DC power amplifier.

Maximum frequency range with high modulation amplitude (typically)

Model	I peak=max. spec. V peak=max. spec. V min.= O V	I peak-max. spec. V peak-max. spec. V min.= 5 V
B32-5R	2 Hz.	4 Hz
B32-10R	2 Hz	4 Hz
B32-30R	3 Hz	4 Hz
B60-2, 5 R	0, 5 Hz	1 Hz
B60-5R	1 Hz	2 Hz
B60-15R	2 Hz	4 Hz

The modulation input has an impedance of 1 kohm.
When the power supply is used as DC power amplifier, it is convenient to regard the output "+" terminal as ground potentional, as it is common to both input and output. (Prong N is internally connected to "+" side sense terminal). With this definition the phase angle of the power supply is 180^0.
The modulating signal can be applied through prong K in the rear input socket only.

The relation between the modulating voltage E, the output DC voltage U_{DC} and the output voltage deflection ΔU is:

$\Delta U = U_{DC} \cdot K_m \cdot E$

$K_m = 0{,}27$ for 32 V models

$K_m = 0{,}30$ for 60 V models with $K_p = 3{,}35$

$K_m = 0{,}27$ for 60 V models with $K_p = 3{,}75$

(See section 3E for K_p values).

E.g. B32-10R,, set for 24 V and modulated 2 V p-p sine-wave.

What is the modulating voltage E?

$\Delta U = 1$ V

$U_{DC} = 24$ V

$K_m = 0{,}27$ for 32 V models

$$E = \frac{\Delta U}{U_{DC}\ K_m} = \frac{1}{24.0{,}27} = 0{,}154$$

E is a sine-wave with 0, 154 V p-p which equals to 55 mV RMS.

Note:

1. The percentage of modulation is independent of the voltage control setting.
2. U_{DC} is the output DC voltage corresponding to the actual voltage control setting (not to the modulated output DC voltage).
3. The output voltage cannot be modulated above 100 %, or in other words, the output voltage cannot be reversed, no matter how high a modulation voltage is applied. Neither should the peak output voltage exceed the maximum nominal value.
4. Avoid modulating voltages giving more than 100 % modulation.

When operating the power supply in the modulation mode, connect the modulating voltage and the load according to figure 6.
Adjust the voltage controls for the desired output DC level.
Increase the modulating voltage for the desired modulation amplitude.

H. SERIAL OPERATION

If higher output voltage is desired, two or more units can be connected in series, provided the maximum voltage to ground does not exceed 500 V. The output may be positive, negative or floating (as shown in figure 8), depending on how jumpers A and B are connected. Jumper A to ground gives positive output; jumper B to ground gives negative output.

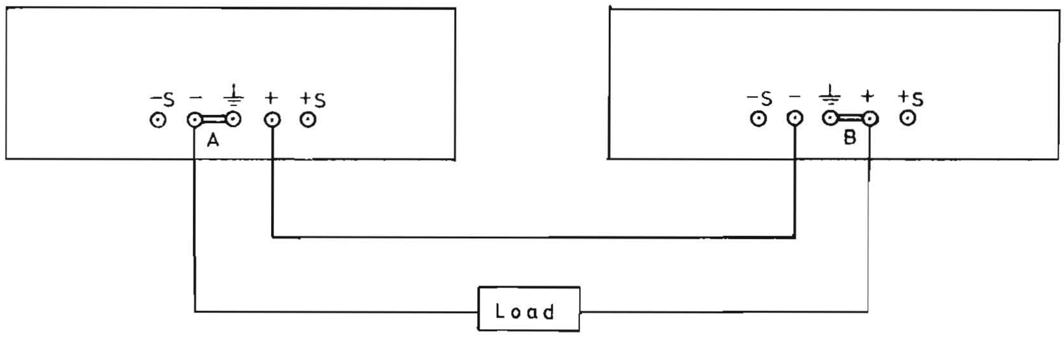


Figure 8

Set "sense" switch at "INT". Set current limit on both units well above the expected peak output current, but below the value that can damage the load.

I. SERIAL OPERATION, REMOTE SENSING

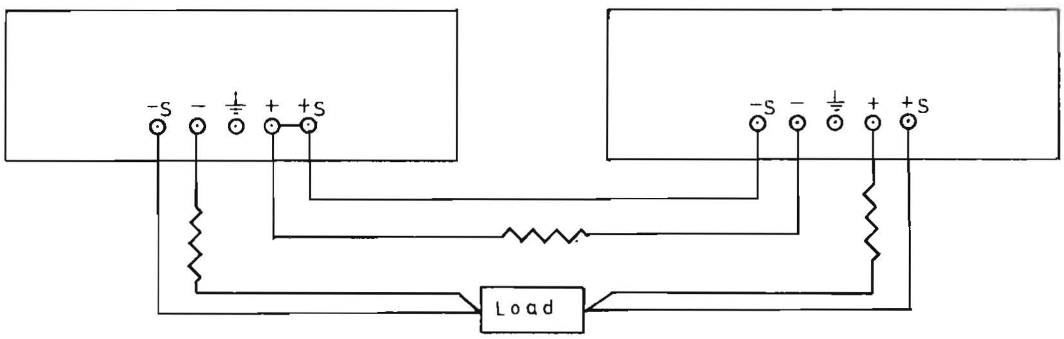


Figure 9

Set "sense" switch at "EXT". If one power cable is short, so that only a small voltage drop is expected in it, the sensing circuit for this cable can be omitted. Also refer to section 3D.

J. SERIAL OPERATION, PROGRAMMING

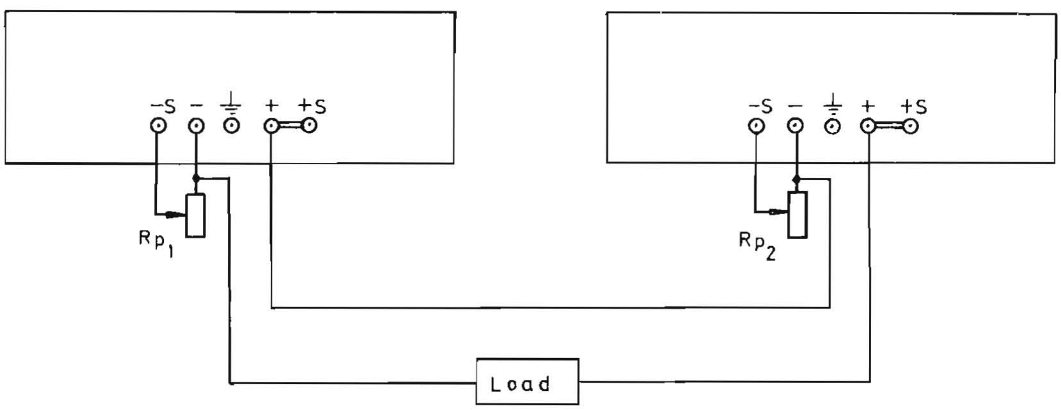


Figure 10

Set "sense" switch at "EXT". The output voltage is controlled by the resistors R_{p1} and R_{p2}. The relation between R_{p1}, R_{p2} and output voltage U is:

$$U = K_p (R_{p1} + R_{p2})$$

K_p is given in section 3E.

If the voltage variation range wanted is less than the control range of one of the power supplies, one R_p can be omitted and the corresponding power supply is arranged for serial operation in the usual way. Also refer to "Resistance programming", section 3E, "Voltage programming", section 3F and "Serial operation", section 3H.

K. PARALLEL OPERATION

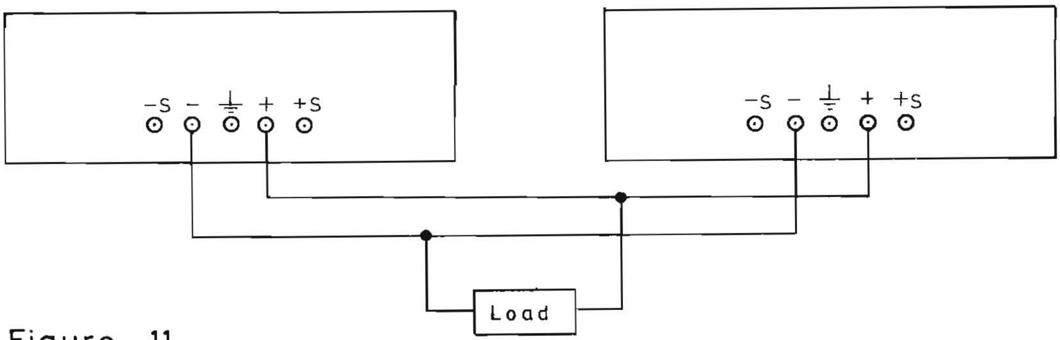


Figure 11

If higher output current is required, several units can be connected in parallel.

Adjustment:

1. Set "sense" switch at position "INT".
2. Set all voltage controls at desired voltage.
3. Set all current limit controls to approximately the same percentage of maximum and so, that the sum of them is the desired current limit.
4. Switch off the OVP. (See section 3Ad).

In practice, there will aways be a difference between the voltages, the parallel connected RACPAC'S are stabilizing at. This will result in the following output characteristic. It is assumed that 30 V is desired, one RACPAC is set at 30,2 V ant the other one is set 30,0 V.

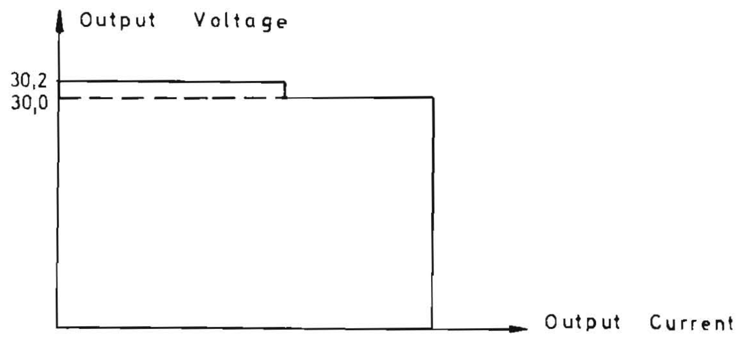


Figure 12

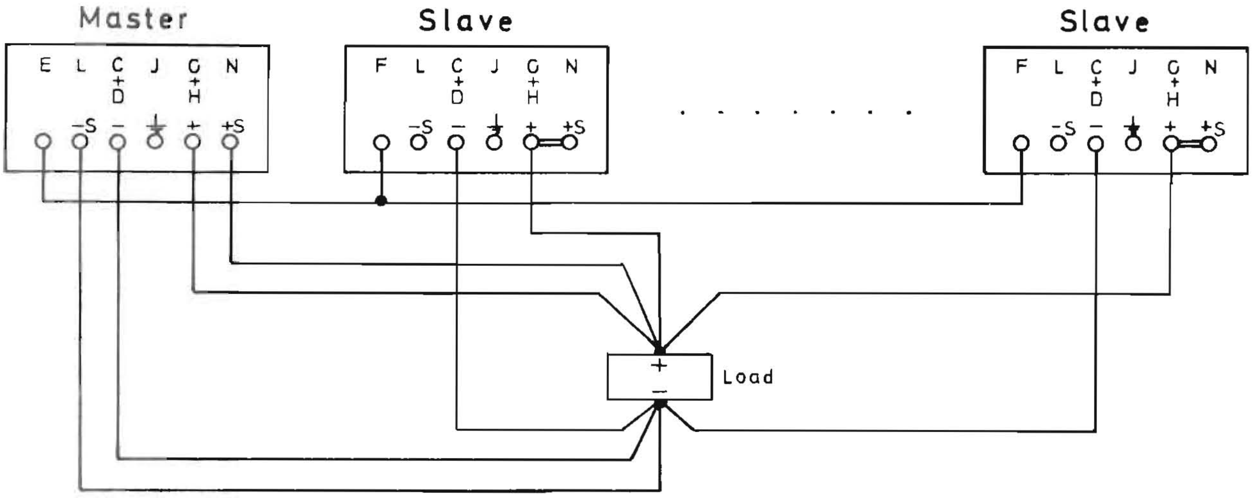


Figure 13

As long as the output current is less than the RACPAC set to 30,2 V can supply, the output voltage will be 30,2 V.
When this unit reaches its current limit, the other RACPAC will take over the remaining current and stabilize at 30,0 V.
If this output characteristic cannot be accepted, use the "Master-Slave parallel operation", as described in section 3L.

L. MASTER-SLAVE PARALLEL OPERATION, REMOTE SENSING

If the voltage step in the output characteristic, caused by different voltages from the parallel connected power supplies, described above, cannot be accepted, a "Master-Slave" configuration can be used. In such a case the data from the parallel connected power supplies are identical to these from the RACPAC that is operating as "Master".

1. Connect all RACPAC'S according to figure 13.
2. Set "Normal-Parallel" switch on main PC-board in postition "Parallel" on all "Slaves". ("Normal" on "Master").
3. "Sense" switch on all RACPAC'S in position "EXT", including "Master".
4. The cable from "Master" + output to load + should have same resistance (same area and same length) as cables from "Slave" + output to load +.
5. With this method, RACPAC'S of various models can successfully be connected in parallel. The current will automatically be shared, so that all RACPAC'S give the same current in percentage of their maximum rating.
6. Set desired voltage with voltage control on the "Master" and to maximum on the "Slaves".
7. Switch off the OVP (See section 3Ad).

M. CONSTANT CURRENT WITH CURRENT LIMIT CONTROL

The simplest method to obtain constant current in the load is achieved by using the current limit function.

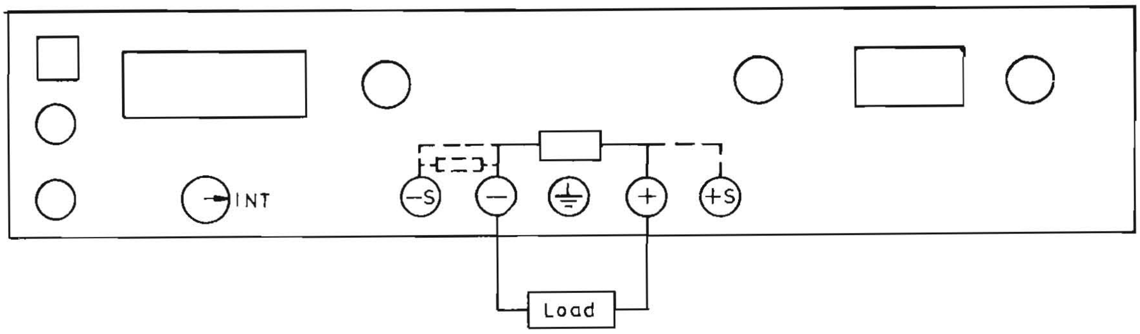


Figure 14

1. Connect as shown in figure 14.
2. "Sense" switch in "INT" position.
3. Set the voltage control to some higher value than is necessary to operate the load, but not so high that the load could be damaged.
4. Note that the voltage control acts as a "voltage limit" in this application.
5. Set the current limit to the desired constant current.
6. The CV-CC lamps should indicate CC.
7. The specification achieved with this method is given in section 2 "Constant current, current regulation using internal precision resistor". If this specification is not sufficient, see section 3N for better stability.

N. CONSTANT CURRENT WITH EXTERNAL SHUNT

If the specification achieved with "Constant current with current limit control" is not satisfactory, a better specification can be achieved by using this method.

For specifications, see section 2 "Constant current, current regulation using 4 V over external shunt".

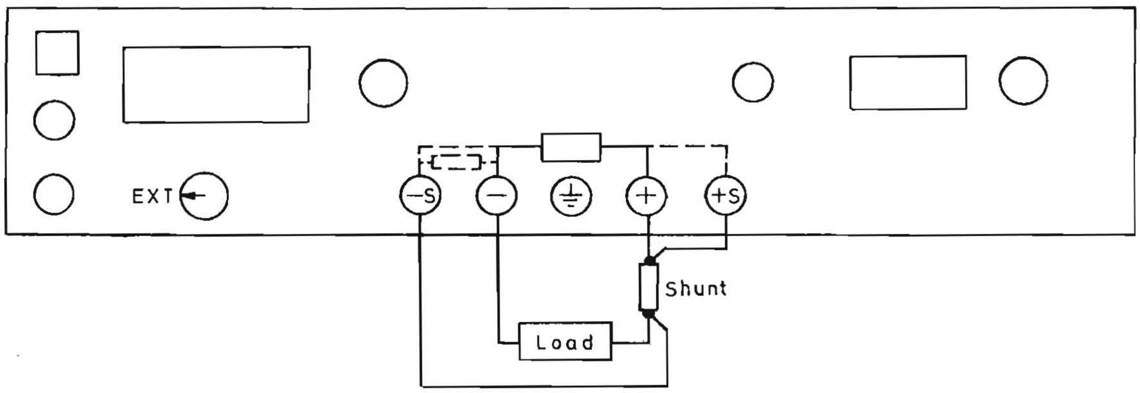


Figure 15

Recommended and specified voltage across the shunt is 4 V. For lower voltages the specification will decrease proportionally. For higher voltages the specification will not improve very much.
The shunt resistor <u>must</u> be in the "+" cable. It should be a high stability low temperature coefficient type, as the stability of the constant current is directly affected by the stability of the shunt resistance. The influence of resistance variations of the shunt is not included in the specification referred to above.

1. "Sense" switch in "EXT" position.
2. Set the voltage control to zero and the "Current limit" control to a value, well above the current desired, but below the value that could damage the load. The output current cannot exceed the CL value in this application.
3. Increase the voltage control, until the current reaches its desired value. This will happen when the voltage control shows 4,0 V, provided that the shunt is designed for that value.
   The CV lamp should be lit in this application (note <u>not</u> the CC one).

O. CONSTANT CURRENT PROGRAMMING

When constant current with external shunt is used, the resolution of the voltage control (controlling the current) might not be satisfactory. In such a case constant current programming is recommended.

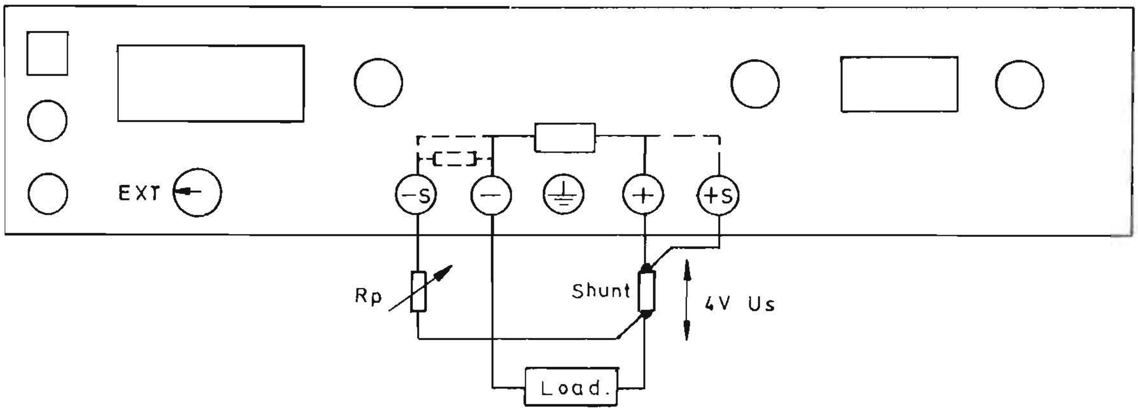


Figure 16

Also refer to section 3 N.

1. Set "sense" switch at "EXT".
2. Set voltage control at zero and control output current with R_p.
   With 4 V maximum across the shunt:

   R_p = 1070 ohms for models with K_p = 3,75
   R_p = 1210 ohms for models with K_p = 3,35

For more information about K_p, see section 3E. For other voltages across the shunt: $R_p = \frac{U_s}{K_p}$

where: U_s = voltage across the shunt and K_p = see section 3E.

P. ACCESSORIES

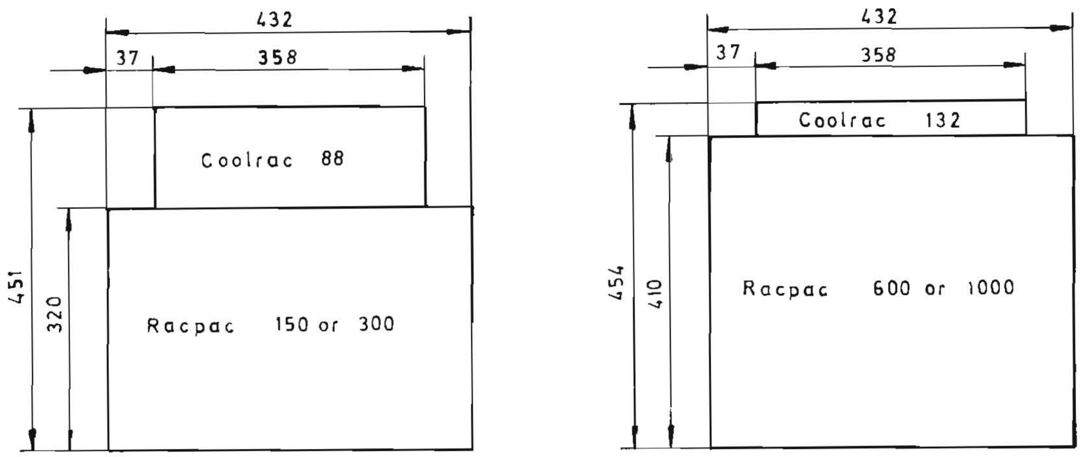
a. COOLRAC

When good vertical ventilation can be assured, RACPAC does not need a fan. Typical such applications are, when standing free on a work bench with the plastic feet mounted or when rackmounted with generous distance between RACPAC and other instruments (see also section 3B).

If such conditions cannot be assured, RACPAC should be equipped with a Coolrac. This is a box which is mounted on the rear side of RACPAC and it contains a fan. To make sure the ventilation through RACPAC is correct, the perforated cover plates will have to be removed and replaced by non-perforated cover plates.

Then the ventilating air will enter RACPAC through the perforated holes in the left and right hand extrusions and leave it through the perforated holes in the rear extrusion.

Coolrac is automatically supplied with power for the fan when mounted on RACPAC. The fan is controlled by the line switch of RACPAC.



Dimensions Racpac with Coolrac

Figure 17

ORDERING INFORMATION

A kit consisting of boxed fan, non-perforated cover plates and rack mounting ears can be ordered as per:

RACPAC 150 & 300	....	Coolrac 88
RACPAC 600 & 1000	....	Coolrac 132

ENVIRONMENTAL CONDITIONS

Maximum ambient temperature for RACPAC with Coolrac is specified in section 2: "Rack version with fan and solid cover plates".

MOUNTING INSTRUCTIONS

1. Remove the two decoration strips marked: "Pull to open". Pull the perforated cover plate forward and remove it. Install the unperforated cover plates and the decoration strips.
2. Check that the AC connector on the fan box is mounted in the two middle mounting holes seen from the open side of the fan box.
3. Install the fan by pressing the plastic parts in between the two outmost cooling fins. Make sure that the plugs and jacks for the fan power mate properly.
   Note that the fan box should be mounted so that the rear connector is completely accessible.
4. Rack mounting ears, see below.

b. RACK MOUNTING EARS

For mounting RACPAC in a standard 19" rack, special rack mounting ears can be delivered. Sizes are indicated below.

RACPAC 150 and 300	88 mm
RACPAC 600 and 1000	132 mm

Note that these rack mounting ears are part of the fan-kit mentioned above.

ORDERING INFORMATION

Rack mounting ears as per

RACPAC 150 and 300 .... Racflanges 88
RACPAC 600 and 1000 .... Racflanges 132

MOUNTING INSTRUCTIONS

Remove the silver-blue strips from the outside of the handles.
Screw the rack mounting ears into the 3 or 5 holes of the handle.
On RACPAC 150 and 300 the rack mounting hole in the ear should be below the centre line.

Remove the plastic feet by removing the two rear screws and pulling the feet backwards out of the slot.

c. REMOTE INDICATION

If it is desirable to indicate when RACPAC switches from constant voltage to constant current mode at remote, the Remote Indication option should be installed.
It consists of a relay: Haller 532 (24 V 13 mA).

ORDERING INFORMATION

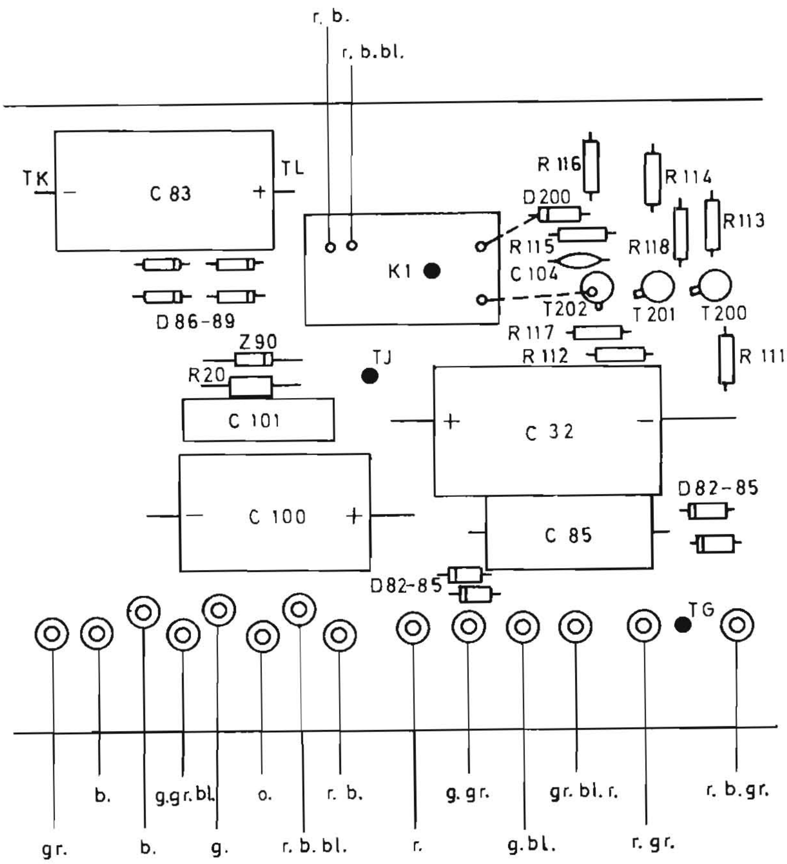
The Remote Indication option is ordered as per:

Remote Indication

This option is identical for all RACPAC models.

MOUNTING INSTRUCTIONS

Mount and solder the relay onto the main PC-board of RACPAC (figure 18). Constant current condition is then indicated by contact closure between pins A and I of the rear output connector.



Mounting of the relay K1 onto the main PC-board

Figure 18

R. 60 HZ OPERATION

When operating at 60 Hz the saw-tooth generator changes its amplitude compared with 50 Hz. This has to be adjusted for.

1. Connect RACPAC to a 60 Hz line
2. Connect an oscilloscope between TA and TC (=ground).
   See circuit diagram (section 9) and "Component identification" (section 7).
3. Adjust P53 for an 8 V p-p saw-tooth (see section 5Da).

SECTION 4
CIRCUIT DESCRIPTION

A. GENERAL

This section describes the electrical operation of the circuit.
First the principal operation is described by means of a block diagram.
A detailed description of the blocks follows. Also refer to the complete diagram, section 9 in this manual.

B. BLOCK DIAGRAM

The complete block diagram of the power supply is shown in figure 19.
The line delivers power to the transformer, where it is transformed to a suitable voltage. In the block "Controlled rectifying bridge" the voltage from the transformer is rectified.

The SCR's of the "Controlled rectifying bridge" are fired at such a phase angle by the firing system, that the DC pulses fed into the filter come out as a DC voltage after the filter, which is just a few volts above the desired output voltage.

The sampling element is designed so, that the input voltage to the "CV error amplifier" is zero if the output voltage is correct. If for example the output voltage is lower, the error is amplified in the "CV error amplifier", the "OR-gate" and the "Driver amplifier". The phase angle of this chain is such that the series element is controlled to decrease the voltage across itself. As this happens, the output voltage comes back to its correct value.

To make sure that the output current will never be excessive, RACPAC is equipped with a current limit system. The output current is monitored through the resistor R70.

When the voltage across R70 is higher than the voltage at the wiper arm of P93, the "CL amplifier" comes in through the "OR gate" and the "Driver amplifier" and controls the "Series element" in such a way that the voltage across R70 does not exceed a predetermined value.

The "Reference bridge" together with the "Reference bridge amplifier" supplies an extremely constant reference voltage across Z1. This circuit also supplies voltages for the other amplifiers in RACPAC.

The "VM range selector circuit" monitors the output voltage.
When the output voltage is low (below 6,5 V for 60 V models and below 8 V for 32 V models) the "VM range selector circuit" closes the switch T325, giving the voltmeter full scale deflection of 6,5 V for 60 V models and 8 V for 32 V models. For higher output voltages T325 is opened and the voltmeter has full scale deflection of 65 V for 60 V models and 40 V for 32 V models. The range in use is indicated by the lamps I321 and I322.

The "AM range selector circuit" measures the output current by monitoring the voltage across R70. In a similar way to the "VM range selector circuit" it determines in which range the output current is and selects proper full scale deflection for the ammeter by opening and closing the switch T307. The ammeter range in use is indicated by the lamps I301 and I302.

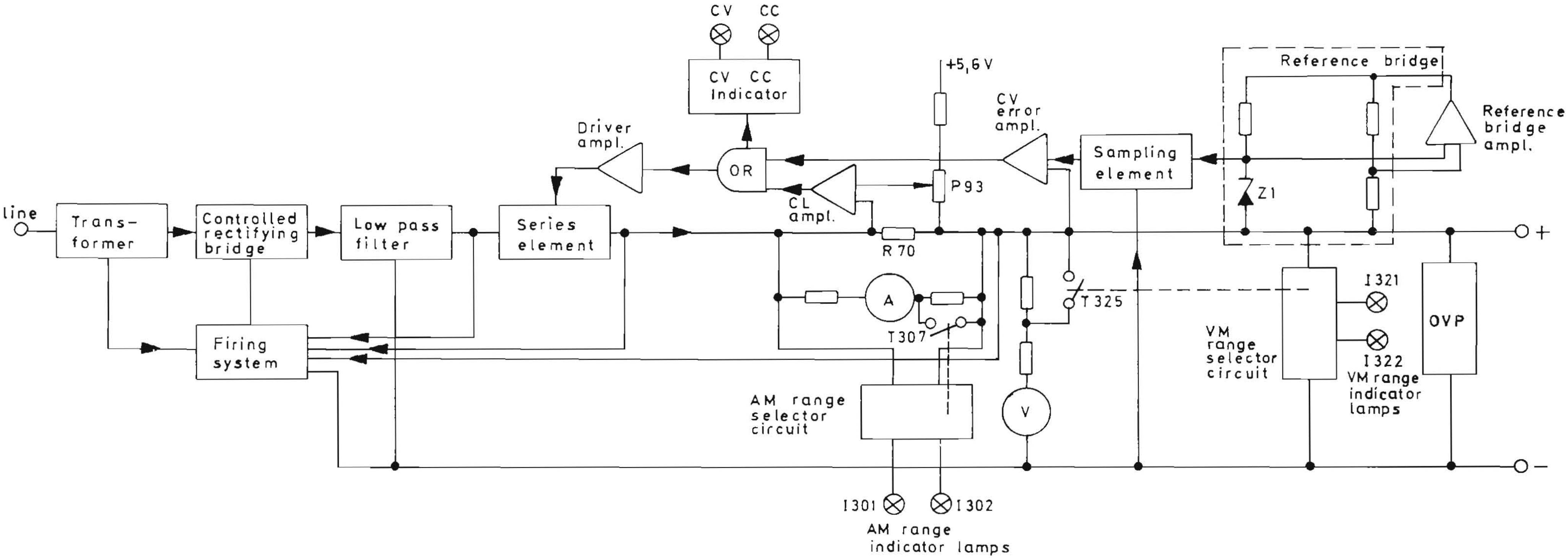


Figure 19 Block diagram

The CV-CC indicator" monitors in the "OR-gate " if the "CV error amplifier" is controlling output voltage or current.
If the "CV error amplifier" controls the output it implies that RACPAC is under constant voltage operating condition and the "CV-CC indicator" lights the CV lamp. Under the other condition the CC lamp is lit.

The OVP circuit senses the output voltage with respect to an internal reference. If the output is above the value, the OVP is set for; it is switched on and the output is shortcircuited. This is made to protect the load in case the normal regulation system of RACPAC is unoperational or if the panel voltage control is accidently set to a too high value.

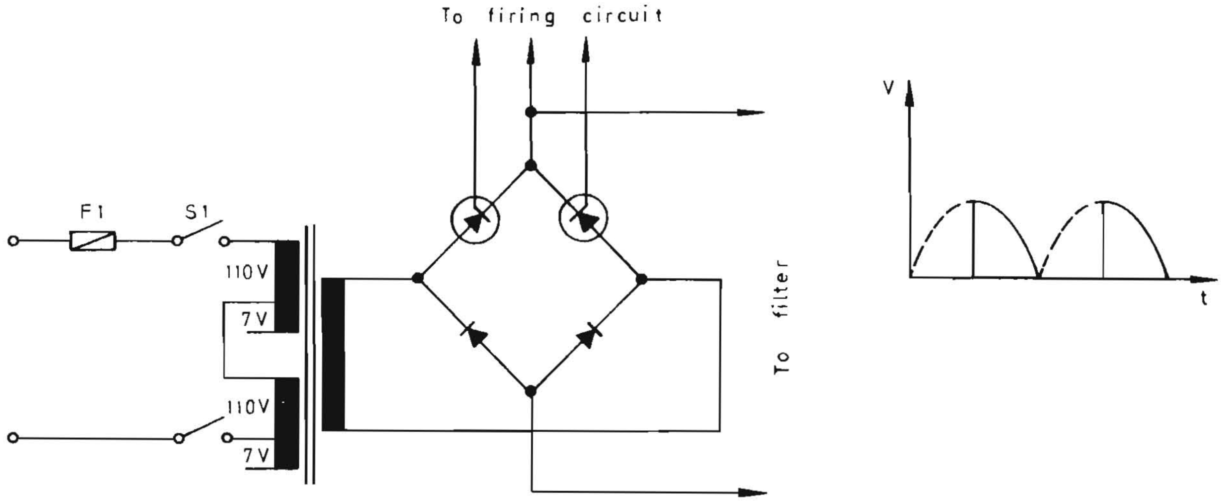


Figure 20

Figure 20 illustrates the rectifying circuit. It consists of the diodes D80 and D81 and the controlled rectifiers SCR1 and SCR2.

The transformer may be wired for 110, 117, 220 or 240 V, 50 Hz lines, as is indicated on the transformer. For 60 Hz operation see section 3R.

The AC fuse F1 and the line switch S1 are located in series with the primary of the power transformer.

The "Rectifying bridge" consists of two rectifiers and two thyristors, obtaining firing pulses from the "Firing circuit".

The rectified voltage is filtered by the filter, consisting of choke Dr2 and capacitor C80.

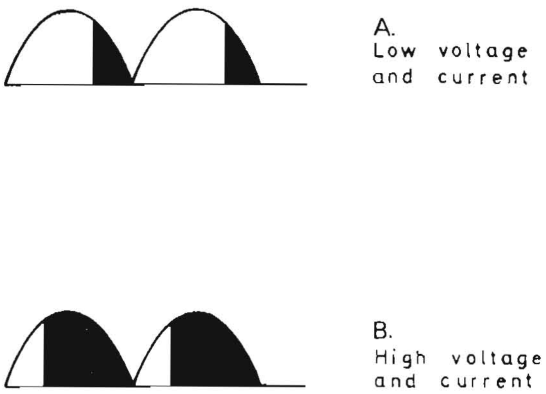


Figure 21

Figure 21 illustrates the waveform of the rectified voltage with low respectively high voltage and current.

The "Rectifying circuit" and filter operate as a coarse regulator. Its task is to supply a rectified voltage to the series regulator which is a few volts higher than the output voltage. In this way excessive power dissipation in the series transistors is avoided.

When low output voltage is desired only a low voltage has to be supplied to the "Series element". Then the SCR's are fired late every half period. Thus only the shadowed areas in figure 21A are fed to the filter input.

For high output voltage and current, more voltage has to be supplied to the "Series element". The the SCR's are fired earlier every half period, as shown by the shadowed area in figure 21B.

By varying the firing point at each half period, the mean value of the voltage to the filter and consequently the DC voltage after the filter is varied. This regulation is achieved with "negligible power dissipation. After filtering a voltage is obtained, being the mean value of the voltage supplied to the filter.

D87 called freewheel diode, gives a path for the inductive current in Dr2 during the period when the thyristors are not fired.

D. FILTER

The "Controlled rectifying bridge" supplies a voltage, typically as in the figure below.

Figure 22

To convert these sine-wave pulses to a DC voltage, an LC low pass filter. with cut off frequency far below the pulse frequency is used.

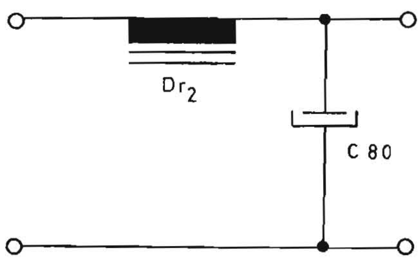
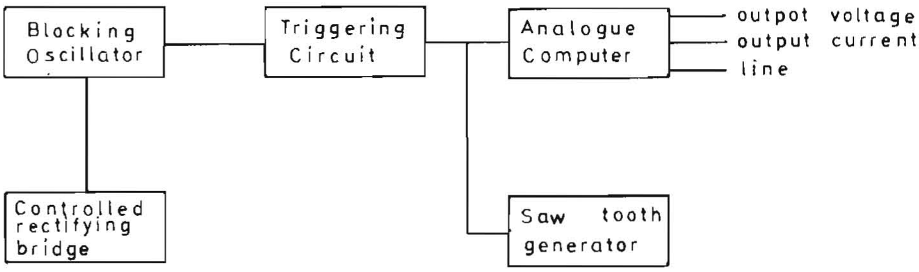


Figure 23

The ripple after the filter is in the order of a few volts.

E. FIRING CIRCUIT

The "Firing circuit" is to supply pulses to the thyristors at the correct moment each half period. The actual moment of firing the thyristors is determined by the actual output voltage, output current and input line voltage. For this, signals representing these values are supplied to the "Firing circuit". These signals are recalculated by an "analogue computer" to a signal which represents the moment each half period when firing is to take place. This signal is superimposed by a saw-tooth voltage, being synchronized with the line frequency.



Block diagram of the firing circuit

Figure 24

This mixed signal is fed into a triggering circuit, supplying a 100 Hz square wave, which determines the firing moments for the thyristors. The square wave controls a blocking oscillator in such a way that it oscillates as long as the thyristors should be conducting.

The advantage of giving continuously firing pulses as long as the thyristors should conduct is, that greater reliability for firing is assured, especially when the thyristors are fired in the beginning of the period or with low currents.

The output current is sensed across R70. It is amplified approximately 15 times in the inverting DC amplifier T50 and T51 (see figure 25).

The output voltage is sensed via the voltage divider R69, R80.
The line voltage is sensed at test point T8.

As an additional correction factor for the firing angle, the voltage across the pass element is sensed through R65 + R81.
P52 through R67 forms a static fine adjustment for the firing angle.
(Factory adjustment for voltage across T70).

The relative importance of output current, output voltage, line voltage and the voltage across T70 is determined by the resistors R66, R68+P51, R61a+P50, R65+R81.

From this information the proper firing angle is computed by T54. This transistor stops conducting, when firing should take place.

All the voltages representing output voltage, output current, line voltage and voltage across T71 together with their resistors R67, R66, R61a+P50 and R65 +R81 are designed so, that they give the same current but opposite polarity as the current via R41 from the saw-tooth at the firing moment. At this moment the base current to T54 reaches zero and T54 thus stops conducting.

By applying a constant voltage across R40+P53, the Miller capacitor C51 will be discharged by a constant current as the base current of T55 is small. A linear sweep will thus appear at the collector of T55.

R43 and R44 (circuit diagram) are protection resistors which have no influence on the basic function. Discharging C51 continues for a full half period.

The discharge is discontinued at the end of the half period when T56 opens for a short moment and charges C51 to the full supply voltage. Between test points T9 and T10 a full-wave rectified sine-wave is applied of which the zero points opens T56.

The triggering circuit T53 supplies square wave pulses to the base of the blocking oscillator T52 with its transformer Tr50.
The firing pulses are rectified by D52 and D58 and the positive firing pulses are fed to gates SCR1 and SCR2 via R57 and R58.

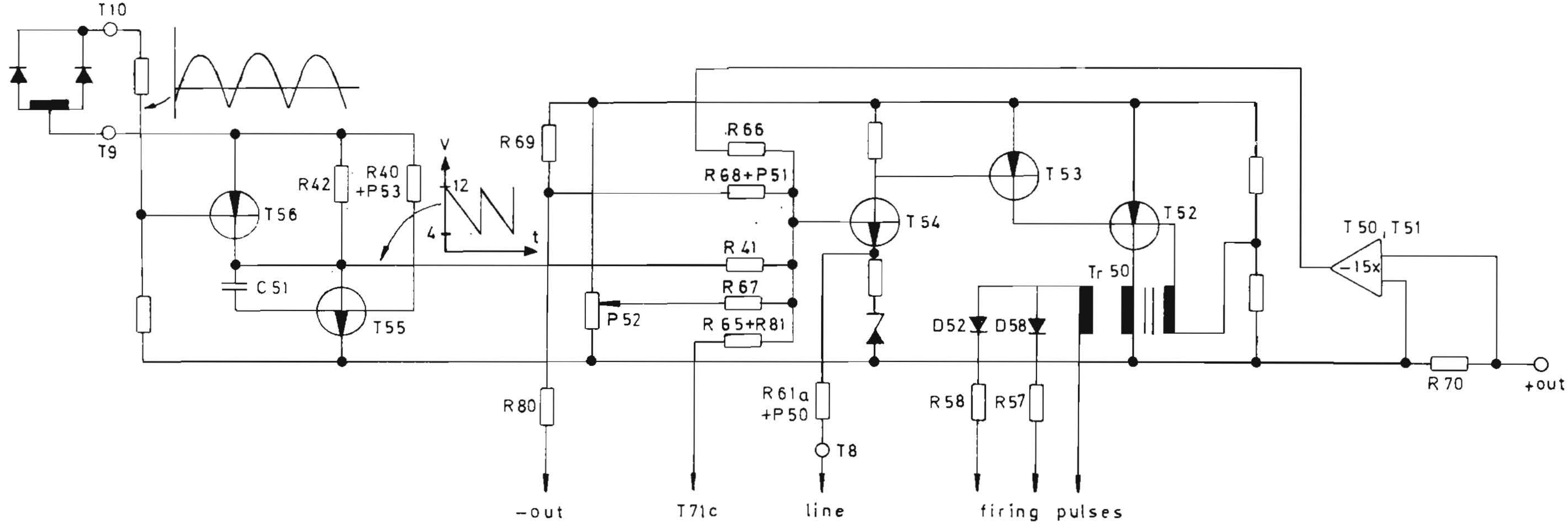
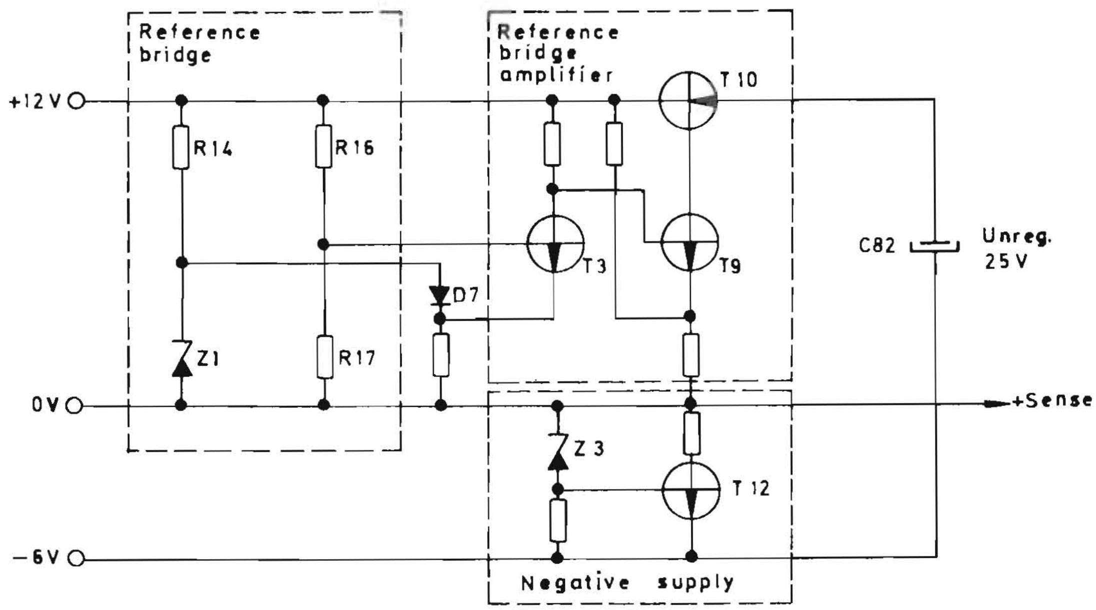

T10
T9
R42
R40
+P53
T56
C51
T55
V
12
4
t
R69
R80
P52
R66
R68+P51
R41
R67
R65+R81
R61a
+P50
T8
T54
T53
T52
Tr 50
D52
D58
R58
R57
T50, T51
−15x
R70
+out
−out
T71c
line
firing pulses

Figure 25

F. REFERENCE CIRCUIT



Stabilizer for reference and internal supply voltages

Figure 26

Z1 is a temperature compensated zener diode, which supplies a highly stable reference voltage for RACPAC.

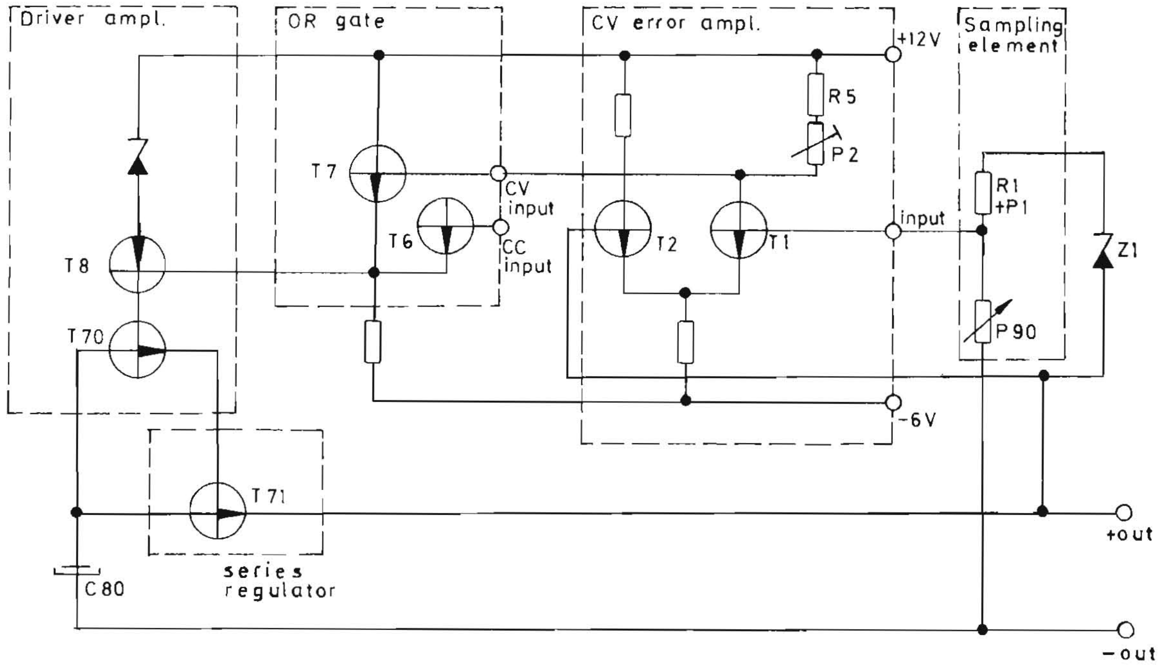
The "Reference bridge" is stabilized by the "Reference bridge amplifier". This serves two purposes:

1. To supply a stable current to the reference zener diode Z1.
2. To supply a stable voltage (+12V) to other amplifiers.

The "Reference bridge amplifier" consists of a temperature compensated input stage T3+D7, a driver stage T9 and an output stage T10.

The zener diode Z3 + transistor T12 are inserted in the reference supply in order to achieve a negative (-6V) power supply to other amplifiers. T12 increases the current handling capability of Z3.

G. VOLTAGE STABILIZING WITH SAMPLING ELEMENT



Principle drawing of voltage stabilizing

Figure 27

The "Sampling element" consisting of the voltage divider R1+P1 and P90 is designed so, that the voltage over R1+P1 becomes exactly indentical to the reference voltage if the output voltage has the correct value. This implies that the voltage between the inputs of the"CV error amplifier" T1+T2 is zero.

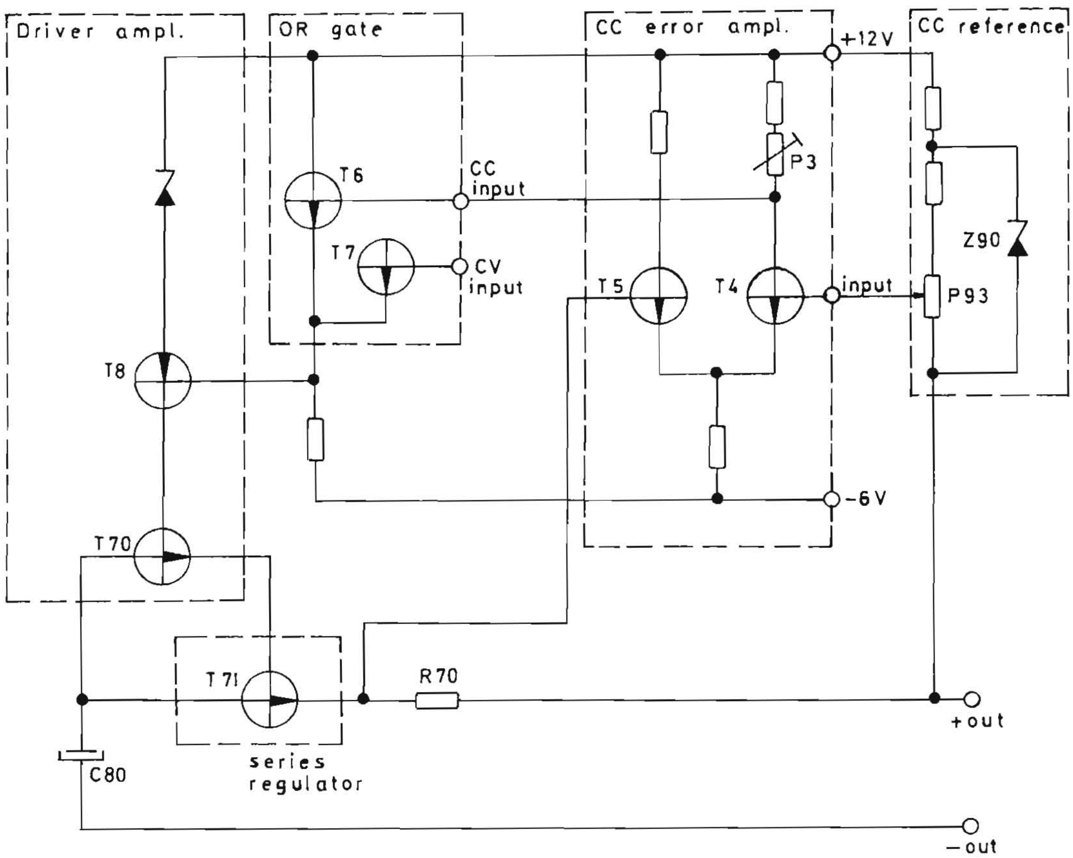
Should the output voltage e.g., decrease, a positive voltage is applied at the input of the "CV error amplifier". This increases the base current of the series regulator through the "OR-gate" and "Driver amplifier", resulting in a lower voltage drop over "Series regulator" and the output voltage returns to the correct value.

The "Driver amplifier" increases the voltage and current gains to a sufficient level to control the Series regulator.

T1+T2 is a temperature compensated pair and hence should be matched.

P1 is the programming constant (K_p) adjustment.
P90 is the output voltage control.
Referring to the circuit diagram:
D1, D2 and R2 form a protection circuit for the CV error amplifier.
C91 is an AC feed-back, reducing ripple and noise.
P2 is the offset adjustment for T1+T2.
T6 together with T7 form the "OR-gate" where T7 is the CV input.
Under CV conditions the CC input of the "OR-gate" is not active as the base of T6 is reversed biased.

H. CURRENT STABILIZING



Principle drawing current stabilizing

Figure 28

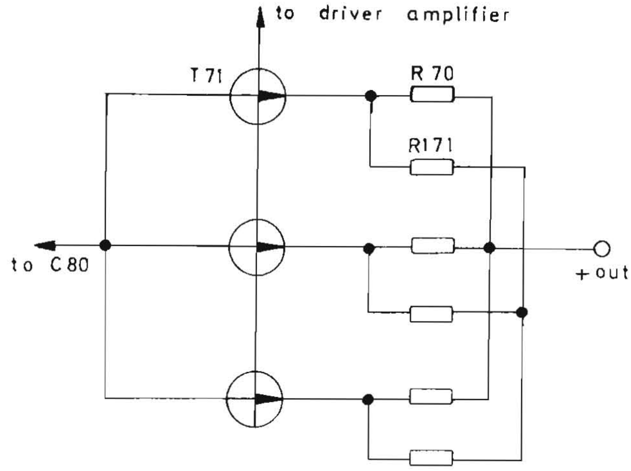
The output current flows through R70. The voltage across R70 is proportional to the output current. Via P93 a reference voltage is added to the voltage at the "+ out" side of R70. At low output currents the potentional at the wiper arm of P93 is more positive than the voltage at the T71e side of R70. In this situation the "OR-gate" acts so, that the current limit does not effect the "Series element" and the voltage stabilizer controls the output voltage.

If the output current through R70 increases, the voltage over R70 will increase. If this voltage = reference voltage (wiper arm P93), the output current will not increase any more. This is because T5 starts conducting which decreases the current through T4. The voltage at T4c then becomes more positive. T6 acts as an emitter follower causing the voltage at T8b to go positive. T8 being an PNP transistor conducts less, in turn reducing the output current through the emitter follower T70. The maximum value of this current is determined by P93 which is the "Current limit" control on the front panel of the instrument.

One resistor R70 is located in the emitter of each T71.
They act as current sharing resistors. The average voltage across the R70's is proportional to the output current. This average is taken by the R171's, one to each resistor R70.

The input of the "CC error amplifier" is protected by R21, R26, D3 and D4 (see circuit diagram).
Under CC conditions the CV input of the "OR-gate" is not active, as the base of T7 is reversed biased.

I. SERIES REGULATOR



Series regulator

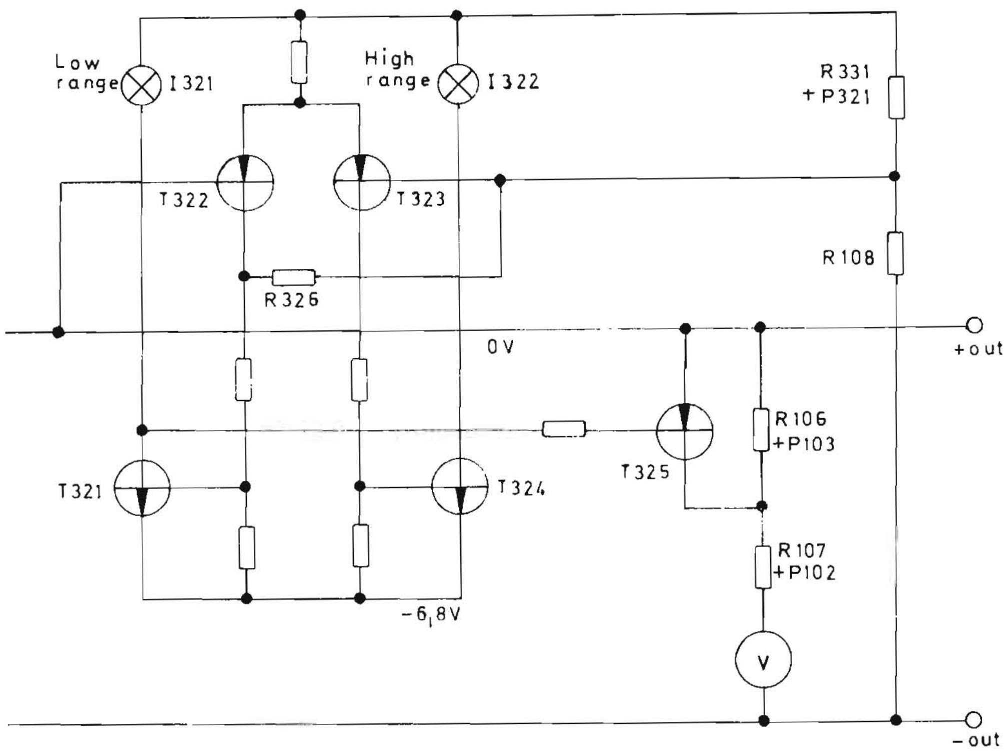
Figure 29

The series regulator consists of a number of parallel connected power transistors T71. Each one has an emitter resistor R70.
The number of power transistors is:

RACPAC 150		2 pcs
RACPAC 300		3 pcs
RACPAC 600		5 pcs
RACPAC 1000		
RACPAC 1000	B32-30R	8 pcs
	B32-15R	7 pcs

In order to compensate for the differences in the characteristics of the T71's, the resistors R70 are inserted. Without these current sharing resistors risk exists for overloading one of the transistors, as its collector current might become too high. The R71's take the average of the voltage across the R70's. This voltage is proportional to the output current and is used for current limit, firing, output ammeter etc.

J. VOLTMETER RANGE SELECTOR CIRCUIT



Voltmeter range selector circuit

Figure 30

The two transistors T322, T323 form a Schmitt-trigger circuit where the positive feed-back is achieved with R326. Only one of the two transistors conduct at a time. The one that is conducting gives base current and is thus opening T321 or T324, which in turn switch on I321 or I322 respectively.

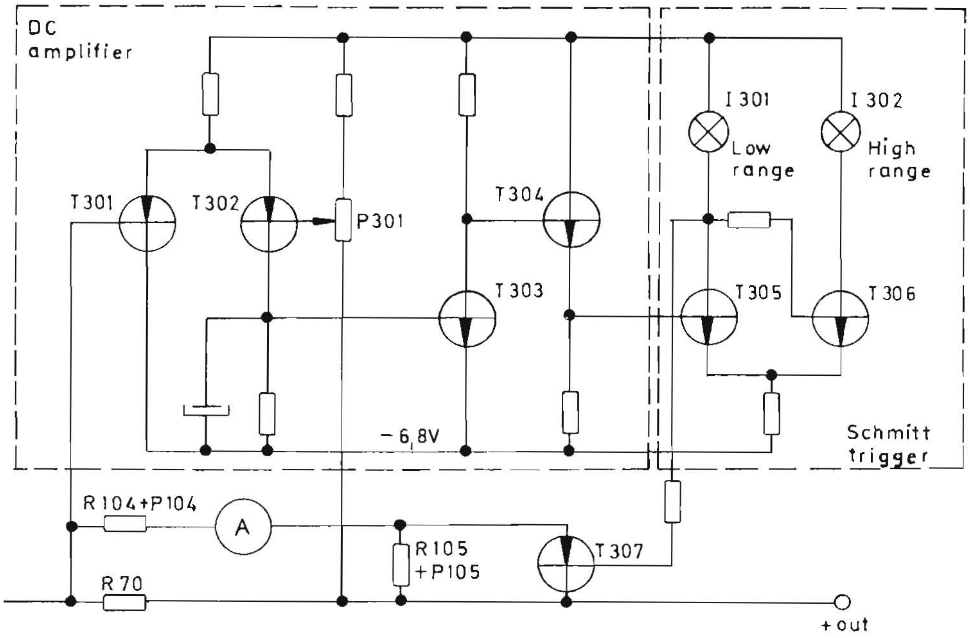
The voltage divider R331 + P321, R108 is designed so, that the base voltage of T323 is positive with respect to "+out" for output voltages smaller than 6,5 V on 60 V models and 8 V on 32 V models. This switches off T323 and on T322, in turn lighting I321 via T321.

For output voltages higher than mentioned above T323 opens and lights I322 (high voltage range) via T324 instead.

When T321 conducts, T325 is conducting, shorting R106+P103.
Then the only series resistor to the voltmeter is P102+R107 which gives the voltmeter an FSD of 6,5 V (60 V models) or 8 V (32 V models).

When T321 is switched off, T325 stops conducting and the series resistance to the voltmeter is R106+P103+P102+R107, giving FSD of 65 V (60 V models) or 40 V (32 V models).

K. AMMETER RANGE SELECTOR CIRCUIT



Ammeter range selector circuit

Figure 31

The wiper arm of potentiometer P301 is adjusted to a voltage, equal to the voltage across R70 caused by the output current when the ammeter is switched between its ranges.

The "DC amplifier" acts as a zero for the difference in voltage between P301 wiper arm and R70. When this voltage changes polarity, the output from the amplifier changes, driving the "Schmitt-trigger" from one state to the other. For low output currents T305 is conducting, lighting I301 and for high output currents T306 is conducting, lighting I302.

When T305 is conducting, T307 is switched on, shorting R105+P105.

The ammeter acts as a voltmeter across R70, so for low output currents it has only R104+P104 as series resistance, giving FSD for low currents.

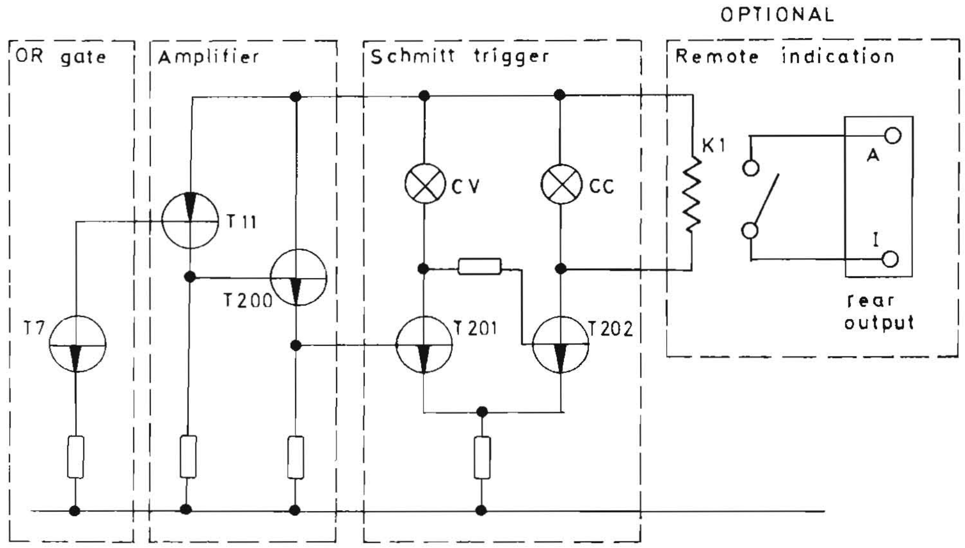
With high output current T307 is switched off and the ammeter series resistance is R104+P104+R105+P105. This gives a high current for FSD.

The "DC amplifier" consists of a differential input stage T301+T302. Further gain is achieved by T303. The output stage is an emitter follower T304.

The "Schmitt-trigger" is of conventional design and needs no explication.

T307 is connected as an "inverted switch" for extremely low on resistance.

L. CV-CC INDICATOR



CV−CC indicator

Figure 32

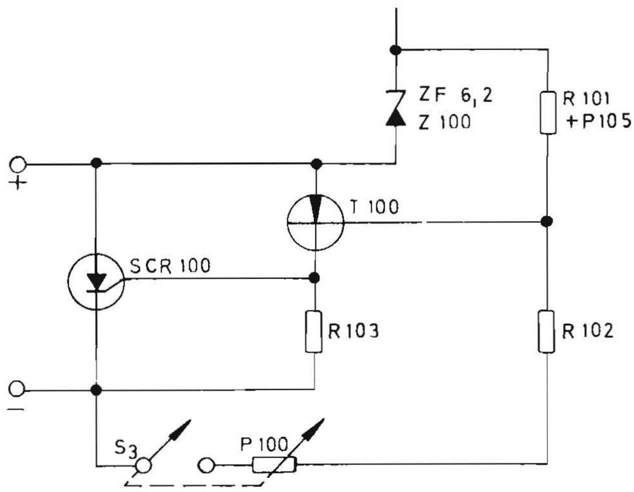
Under CV conditions the transistor T7 in the "OR-gate" is conducting. The collector current of T7 is amplified in the amplifier T11 + T200, giving a positive voltage to the base of T 201.

Then the Schmitt-trigger switches to the state where the CV lamp is lit.

Under CC conditions T7 is not conducting, T201 is switched off and T202 on through the amplifier. The CC lamp is then lit.

As a remote indication option the relay K1 can be inserted. It is connected in parallel with the CC lamp and thus pulls under CC conditions. This closes the circuit via the rear output prongs A and I.
This can be used for a remote bell or lamp etc.

M. OVERVOLTAGE PROTECTION



Over voltage protection

Figure 33

The "Overvoltage protection" OVP serves to protect the connected load for overvoltage, which may be caused by either a faulty regulation system or by abusive adjustment of the controls on the front panel.

The protection obtains own reference voltage fron Z100.
The voltage divider R101+P105, R102+P100 is designed so that, as long as the output voltage is lower than the OVP is set to (P100), the voltage at the base of T100 is positive. If the output voltage exceeds the OVP limit, T100 is actuated and thyristor SCR100 is fired. The output is consequently short-circuited. If the OVP is actuated e.g. by abusive setting of the controls and RACPAC operates normally, the power supply switches over to current limit with output voltage near zero.

The power supply is reset by setting the controls on the front panel in correct position and switching off the line.

If the current limit does not function e.g. in case of a short-circuit in the series regulator, the fuse F2 (OVP fuse) is blown.
Then the fault has to be located and F2 is to be replaced.

When P95 is in full CW position, switch S3 is opened and the OVP is not working.

SECTION 5
MAINTENANCE

A. GENERAL

This section contains information on maintenance of the Oltronix power supplies, type RACPAC 150, 300, 600 and 1000.

These power supplies are fully equipped with semiconductors and under normal operating conditions require little or no maintenance throughout their lives.

Do not troubleshoot these instruments without carefully studying the troubleshooting information given in this manual.

Changing and adjustment setting accidently might involve considerable alignment time. Switch off the instrument when replacing any component.

B. FRONT PANEL CHECK

The table below describes a function check which can be performed with the instrument in its cabinet without additional equipment. These tests will establish that the instrument is probably operating normally.
A performance test is described in section 5Db.

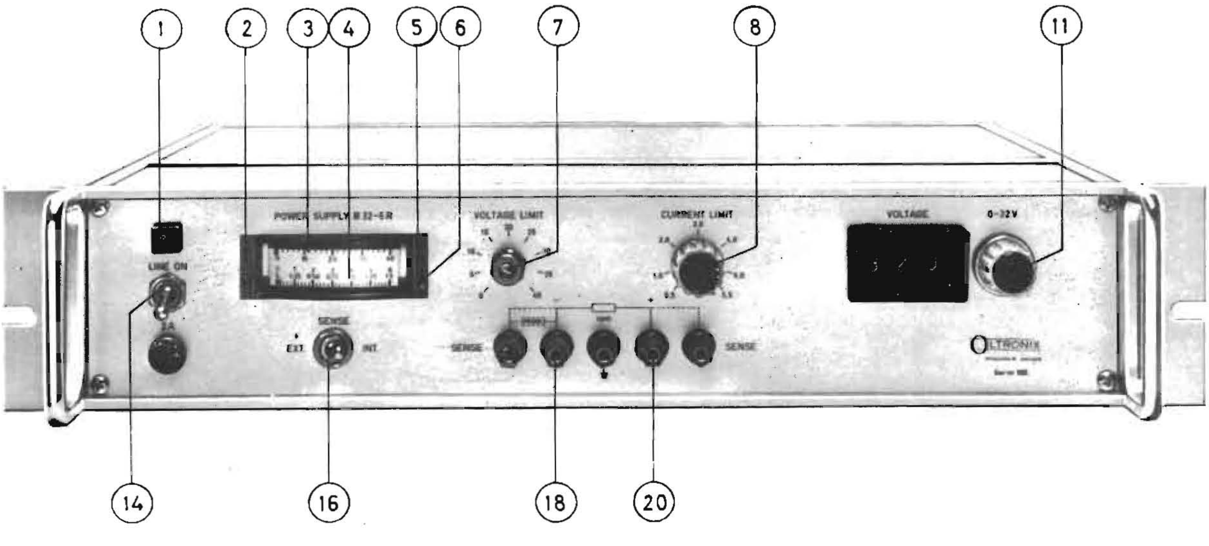


Figure 34

1. Turn "Voltage control" (11) fully CCW and "Current limit" (8) fully CW. Switch "Sense" (16) in position "INT". OVP (7) is off.

2. Switch on the power supply (14). Pilot lamp (1) is lit.

3. Increase the output voltage slowly, checking that the voltmeter (3) tracks the voltage approximately. Also check that the voltmeter changes range (5) near FS of lower voltmeter range.

4. Decrease the voltage control to zero.

5. Connect an external resistor, giving 100% output current to "+" and "-" terminals (18, 20). Increase the voltage, watching both the voltmeter and the ammeter (4). Also check that the ammeter changes range (6) near FS of lower range.

6. Disconnect the load at full output voltage and check that the voltmeter does not change.

7. Turn the "Current limit" slowly CCW, watching that the ammeter tracks the scale of the "Current limit" control approximately and that the "CV-CC indicator" (2) switches to CC.

8. Set the voltage control to 25 V on 32 V models and to 55 V on 60 V models. Set the OVP control to 30 respectively 60 V.
Increase the "Voltage control" and check that the output voltage disappears when the OVP value is reached.

C. COVER REMOVAL

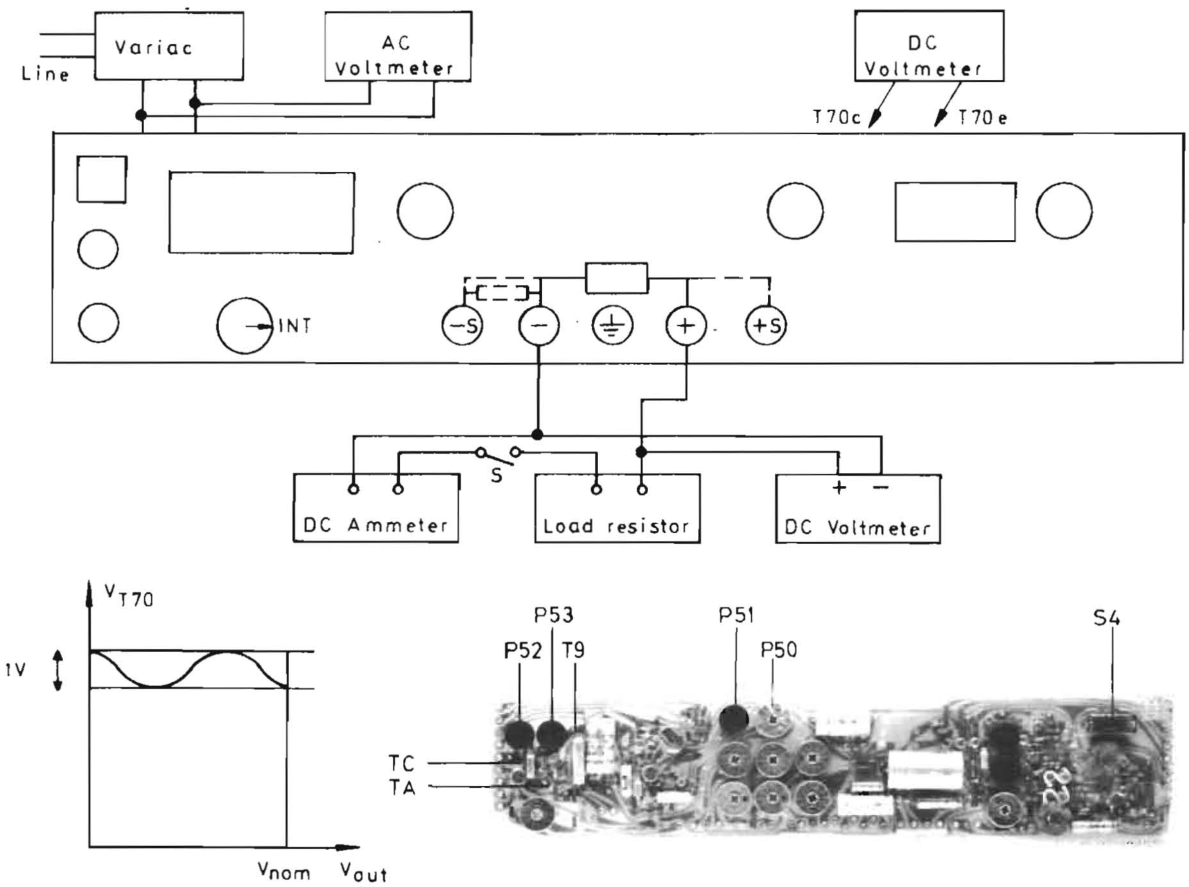
Switch off the line voltage.
Upper cover: Remove the blue strip marked "Pull to open".
Cover plates are removed.
Bottom cover: Identically removed as upper cover.
Now the main PC board is accessible by folding it out from the chassis by twisting three fasteners 1/4 turn.
Exchanging OVP fuse: With RACPAC 150 and 300 this fuse is located at the right side. With RACPAC 600 and 1000 it is found at the rear side.

D. ALIGNMENT PROCEDURE

In the following paragraphs a to e the main part of the alignment procedure is described. This alignment is completed when the power supply is delivered from the factory. Though it is unlikely that the power supply will fall out of trim when used under normal operating conditions, it is advisable to check alignment once a year, to be sure it fullfills the specifications.

After replacing components it is necessary to check the circuits concerned, especially after transistor replacement.
Further information on necessary tests is given in section 6, table 8.

a. FIRING CIRCUIT ADJUSTMENT



Firing circuit adjustment

Figure 35

MODEL	LOAD RESISTOR (MIN)
B32-5 R	0-10 ohms 5 A
B32-10R	0-5 ohms 10 A
B32-20R	0-2,5 ohms 20 A
B32-30R	0-2 ohms 30 A
B60-2,5R	0-30 ohms 2,5 A
B60-5R	0-15 ohms 5 A
B60-10R	0-7 ohms 10 A
B60-15R	0-5 ohms 15 A

1. Connect RACPAC as shown. "Sense" switch at "INT". S4 at "NORMAL". OVP is off.
2. Set the variac for 220 V line.
3. Check TC: T9. Correct value 12 $\pm$ 0,7 V.
4. Connect an oscilloscope between TC and TA. (TC=ground). Adjust P53 for an 8 V p-p saw-tooth. DC level: + 12 V to + 4 V.
5. Check that the saw-tooth does not change for 200-240 V line.

6. Set the output voltage for 32 V resp. 60 V. Close switch S; adjust load for max. output current. Adjust P52 for a voltage T70e: T70c of
4 V on 32 V models
5 V on 60 V models (at 220 V line)

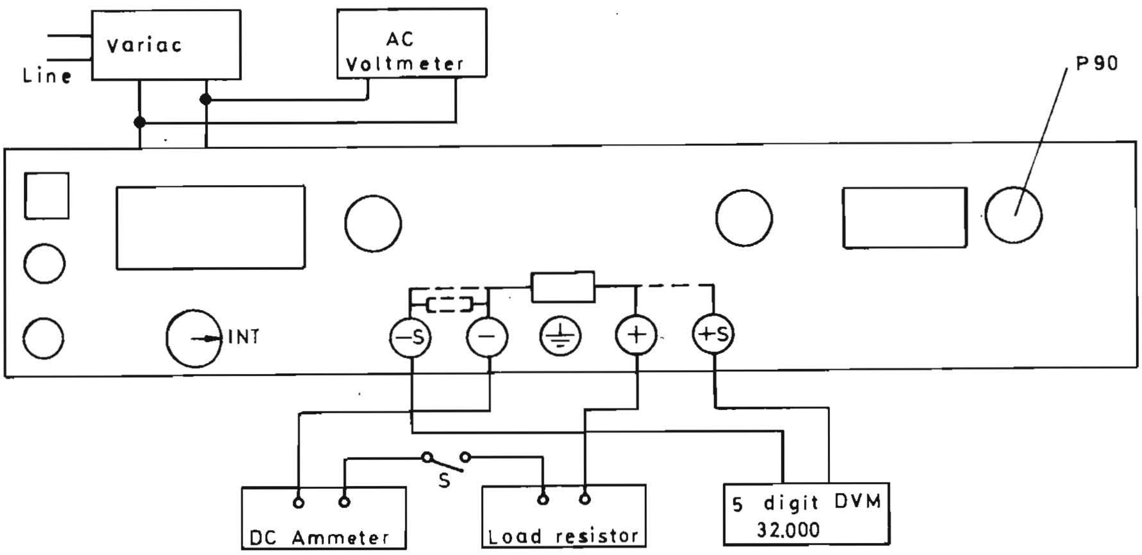
7. Set the current limit to max. nominal output voltage as in 6. Decrease the output voltage to zero by decreasing load to zero ohms. Note the voltage across T70. Adjust P51 for a behaviour as shown above.
8. Set the output voltage at 20 resp. 30 V on 32 resp. 60 V models. Vary the load from max. monimal to 0,6 times max. nominal. The voltage across T70 should not vary more than 0,5V.

9. Set the output voltage to 22 resp. 35 V on 32 resp. 60 V models. Set the output current to max. nominal. Adjust P50 for min. (0,5 V) influence on the voltage across T70 by line voltage variation 200-240 V. Reset the voltage across T70 to 4 V resp. 5 V, every time P50 is changed.

10. Adjust P52 for a voltage across T70 at max. nominal current:

MODEL	OUTPUT VOLTS	V_{T70}
32 V	20 V	4 V
60 V	40 V	5 V

b. VOLTAGE STABILIZING, CALIBRATION AND SPECIFICATION



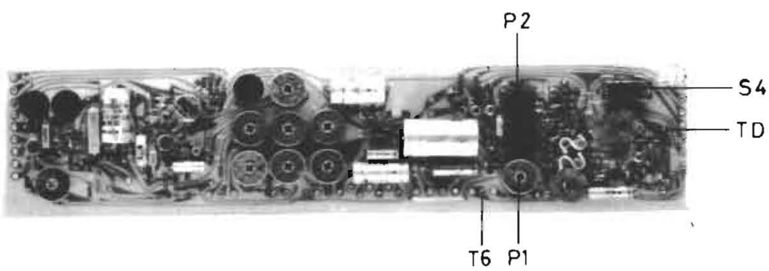
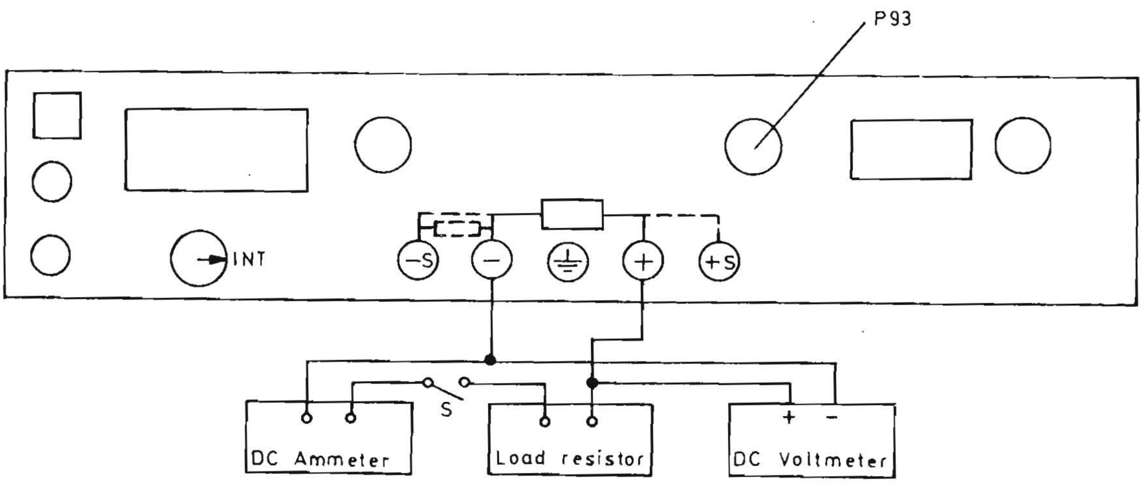


Figure 36. DC Voltage stabilizing calibration and specification

Load resistor: see "Firing circuit adjustment".

1. Connect RACPAC as shown. "Sense" switch at "INT". S4 at "NORMAL". Voltage control at 32 V or 60 V respectively. No load. OVP is off.
2. Connect a voltmeter between TD and TG. Increase line voltage and check that voltage TD:TG stabilizes at 9,7 - 11,3 V for 180 V line at the lowest.
3. Connect a TVM or VTVM voltmeter 10 mV FSD between TG and the wiper arm (red-blue-grey) of P90. Adjust P2 for zero reading.
4. Set voltage control to 32.00 or 60.00 volts respectively. Adjust P1 for correct reading on DVM.
5. Specification check:
   a. Close switch S and adjust the load resistor for max. nominal output current. Read the output voltage variation for 0-100% load (see specification "Load regulation").
   b. Open S. Read output voltage variation for 200-222 V and 218-240 V line variation. Repeat with S closed 100% load. (see specification "Line regulation").
   c. Connect an AC RMS voltmeter across the output, "+" or "-" side grounded. Read AC voltmeter for O and 100% load. (see specification "Ripple and noise").
   d. Lower line voltage to min. specified (e.g. 200 for 220 V operation) and check that ripple does not increase.

c. CURRENT LIMIT ADJUSTMENT



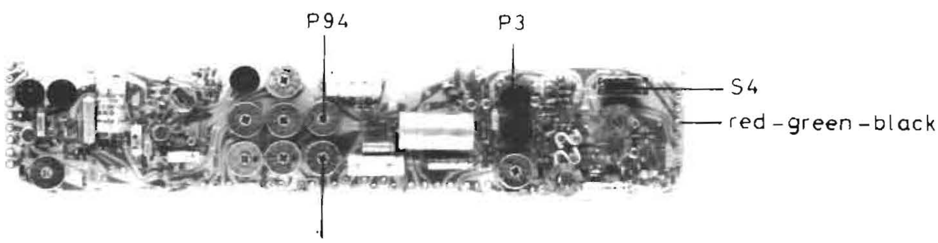
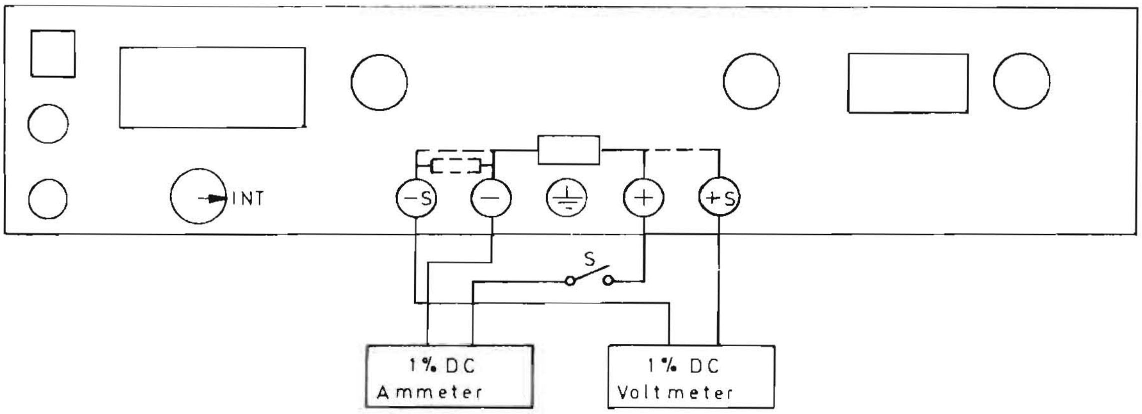


Figure 37. DC current limit adjustment

Load resistor: see "Firing circuit adjustment".

1. Connect RACPAC as shown. "Sense" switch at "INT". S4 at "NORMAL". Voltage control at 32 resp. 60 V. OVP is off.
2. Set current limit (CL) control to 50% nominal current. Connect a 10 mA FSD VTVM or TVM between red-green-black wire (ground) and wiper arm of P93 (red-black-grey).
3. Close S and adjust the load resistor so that output falls to approximately 1/3 nominal output voltage.
4. Adjust P3 for zero reading on VTVM.
5. Set the CL control to min. and adjust P94 for an output current equal to min. current, given in the specification "Current range".
6. Set CL control to max. nominal. Adjust P92 for correct output current.

d. METER CALIBRATION



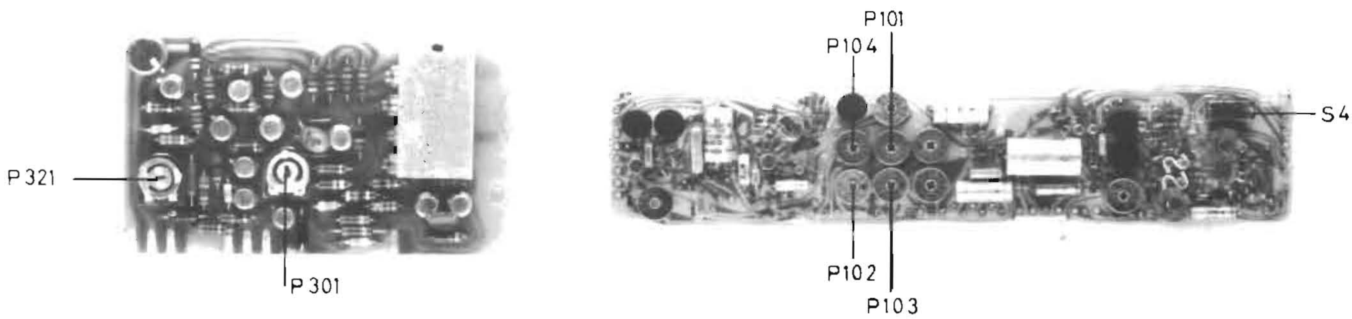


Figure 38. Meter calibration

Voltmeter (Figures within brackets refer to 60 V models)

1. Connect RACPAC as shown. "Sense" switch at "INT". S4 at "NORMAL". S open. OVP is off.
2. Set the output voltage at 7,8 V (6,3 V). Adjust P321 to obtain range switching.
3. Set the voltage at 7,0 V (6,0 V). Calibrate lower range of the voltmeter with P102.

4. Set the voltage at 30 V (60 V). Calibrate the voltmeter with P103.

Note I: Replace any defective indicator lamp before adjustment or faultfinding.

Note II: The indicator lamps are intentionally operated considerably below normal working voltage to insure long life.

Ammeter

5. Set the voltage control at 5 V. Current limit at min. Close S.

6. Set output current with the current limit as shown below

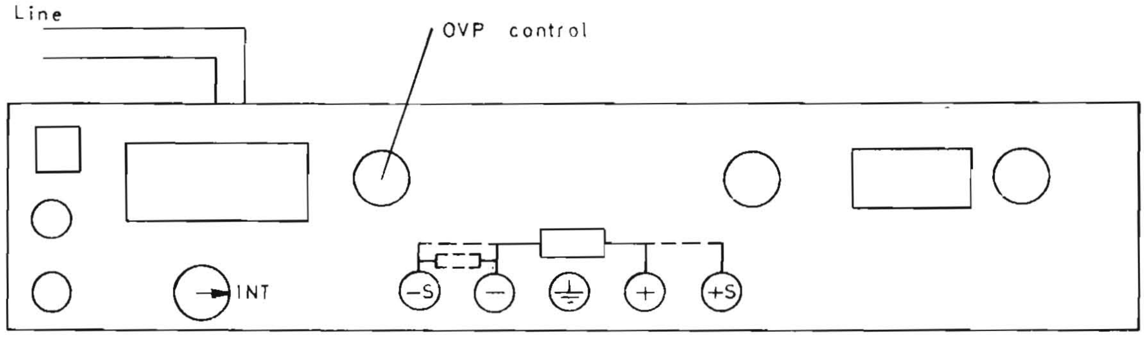
B60-2,5R	0,7 A	B60-10R	2,75 A
B32-5R	1,4 A	B60-15R	4,0 A
B60-5R	1,4 A	B32-20R	5,0 A
B32-10R	2,75 A	B32-30R	8,0 A

Adjust P301 to obtain range switching.

7. Decrease the current limit and calibrate the lower range of the ammeter with P104.

8. Increase the current limit to max. nominal and calibrate the ammeter with P101.

e. OVP CALIBRATION



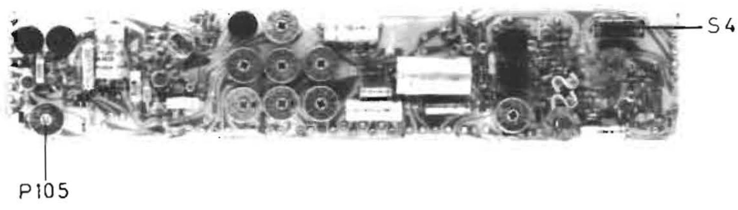


Figure 39. OVP calibration

1. Connect RACPAC as shown. "Sense" switch at "INT". S4 at "NORMAL". OVP is off.

2. Switch on. Set output voltage at 30 V (32 V models) resp. 60 V (60 V models).

3. Turn P105 fully CW.

4. Set the OVP control at 30 V resp. 60 V.
5. Turn P105 slowly CCW until the output voltage suddenly disappears.
6. Set the voltage control at 25 resp. 55 V. Switch line off.
7. Line on. Increase output voltage slowly and check that it disappears at 30 resp. 60 V. If necessary, readjust P105.

SECTION 6
TROUBLESHOOTING

A. GENERAL

This section provides information about Oltronix regulated power supplies, type RACPAC 150, 300, 600 and 1000 that will enable an efficient troubleshooting in case of equipment failure.
Before troubleshooting the power supply, study the rest of this instruction manual, especially section 4 "Circuit Description" in order to become familiar with the principles of operation.

We have not attempted to give a complete detailed step-by-step instruction for finding the cause of all possible troubles.
This guide rather gives a check schedule that leads the fastest way to detect the most probable area of the actual trouble.

If a burned component is found, special care has to be taken. This kind of fault often indicates that there is another fault in the circuit as well. Be sure to find out wat has caused the component to burn before it is replaced.
Before starting a detailed troubleshooting, make sure that an apparent trouble is due to malfunction within the power supply and not due to improper control setting. Initial check instructions are give in this section, paragraph C.

B. PROCEDURE TO GUIDE TROUBLESHOOTING

Equipment needed: DC voltmeter, AC voltmeter, oscilloscope.
The troubleshooting pattern is divided into three parts.
Always start with "Initial checks". If the fault still remains locate the faulty area with the "Fault area location table". Then proceed the troubleshooting according to the given table.
The values indicated in the tables are typical values which vary slightly from instrument to instrument. Some of the readings are also depending on the line voltage. If the line voltage is more than a few percent off its nominal value, use a variac and adjust it for correct voltage.

If a transistor has been replaced, consult table 8 for necessary calibrations.

C. INITIAL CHECKS

a. "Sense switch in "INT" position.
b. S4 on main PC-board in "NORMAL" position.
c. OVP off (=fully CW).
d. Check line and OVP fuses. The former on the front panel, the latter on right hand side with RACPAC 150 & 300 and on the rear with RACPAC 600 & 1000.

Note: If the OVP fuse F2 is blown, this usually indicates a fault in the voltage stabilizing circuits.

e. Check that the transformer is wired for proper line voltage (see instructions on the transformer).

D. FAULT AREA LOCATION

If the fault is still present after performing the initial checks, proceed with the table below:

SYMPTOM	PROCEDURE
Output voltage above correct value	Table 1
Output voltage below correct value	Table 2
Load regulation not according to the specification	Table 2
OVP fuse blown	Tables 1 and 6
Line fuse blown	Check, SCR1, 2 and D80, 81
Current limit unoperative	Table 3
Volt- and ammeter with indicator lamps work incorrectly	Replace defective lamps Table 5
CV-CC indicator	Replace defective lamps Table 5
OVP continuously on.	Table 6
Does not switch on	Table 7

TABLE 1

Output voltage considerably above the indicated value of the output voltage control.
DO NOT SET THE VOLTAGE CONTROL TO ZERO. (Voltages within brackets refer to 60 V models).

Ref. no	Important control settings	Test equipm. connection	Correct reading	Remedy
I	Volt. 32 V (60 V) No load	Voltm.TG:TD Voltm.TG:TF	9, 7-11, 3 V -6, 2 V $\pm$ 5%	Correct: cont. II. Faulty: check Z1, T3, T9, T10, (-6, 2 V: Z3, T12)
II	As above	DC voltm. + out to T8c	1, 1 V	Lower: cont. III Higher: cont. IV
III	As above	DC voltm. + out to T71e	0, 4-0, 5 V	Lower: check all T71's. Also perform table 4. Correct: check T70. Also perform table 4.
IV	As above	Voltm. TG:TD	9, 7-11, 3V	Correct: cont. V. Wrong: check T3, T9, T10, Z1.
V	As above	Voltm.TG:wip. arm P90 (red-blue-grey)	-	Pos: check P90 and connection -out to -sense. Neg: cont. VI. Zero: switch off and check mechanical alignment of digital read-out.
VI	As above	Voltm.TG:T1c	8-10 V	Correct: cont. VII. Lower: check T1, 2
VII	As above	Voltm.TG:TM	4-5, 8 V	Correct: cont. VIII. Faulty: check Z2.
VIII	As above	Voltm.TG:T7e	0, 7 V below reading in VI	Correct: check T7, 11. Faulty: check T8.

TABLE 2

Output voltage considerably below the indicated value of the voltage control. (Voltages within brackets refer to 60 V models).

Ref. no	Important control settings	Test equipm. connection	Correct reading	Remedy
Ia	Voltage control 32 V (60V). OVP off. Current limit 50%	Voltm.TG:TD	9,7-11,3V	Correct: cont. Ib. Faulty: check Z1, T3, T9, T10. Ammeter reading 50%: check OVP, table 6.
Ib	As above	Voltm.TG:TF	-6,2 V ± 5%	Faulty: check Z3, T12. Correct: cont. II
II	As above	Voltm. + out to C80+. 1 kohm 10W across C80	7-20 V	Correct: cont. III. Lower: cont. IX
III	As above	Voltm.TG:T8c	1,1 V	Correct or higher: check T10 and all T71's. Lower: cont. IV.
IV	As above	Voltm.TG:wip. arm P90 (red-blue-grey)		Zero: check P1, P90 and R1. Pos: cont. V
V	As above	Voltm.TG:TM	4-5,8V	Correct: cont. VI. Faulty: check Z2.
VI	As above	Voltm.TM:D8 Cathode	0,6 V	Faulty: check current limit. Correct: cont. VII
VII	As above	Voltm.TG:T1c	0,7V bel. value in V	Higher: check T1, T2. Correct: cont. VIII
VIII	As above	Voltm.TG:T7e	0,7V bel. Value in V	Higher: check T7. Correct or lower: check T8.
IX	As above	Oscilloscope across D59 and deflection 1-3 V D60. Anode gr.		Correct: check X. No pulses: perform "Firing circuit check"
X	As above	Tr80 secund.	55V (97V)	Faulty: check Tr 80 and primary voltage. Correct: check SCR1, 2 and D80, 81.

TABLE 3

Current limit inoperative. (Voltages within brackets refer to 60 V models).

Ref. no	Important control settings	Test equipm. connection	Correct reading	Remedy
Ia	Output volt. 32 V (60V). Current limit 50%. Load current 50%, OVP off.	Voltm.TG:TD	9,7-11,3V	Faulty: check T3, T9, T10, Z1. Correct: cont. Ib.
Ib	As above	Voltm.TG:TF	-6,2 V ± 5%	Faulty: check Z3, T12 Correct: cont. II
II	As above	DC voltm.junction R26-R171 (red-green-black) to wiper arm P93 (red-black-grey).	Should change polarity when current passes CL value	Faulty: check P92, P93, P94, R15, Z90, R171. Correct: cont. III
III	As above	Voltm.TG:T4c	changes 0,6 V when CL value is passed.	Faulty: check T4, T5 correct: check T6.

TABLE 4

Firing circuit check. For all tests in this paragraph connect a 1 kohm 10 W resistor across C80.
(Voltages within brackets refer to 60 V models).

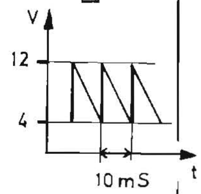
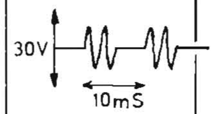
Ref. no	Important control settings	Test equipm. connection	Correct reading	Remedy
I	Output volt. 32V (60V). OVP off No load.	Check F50		If blown check T52, R48. If not, cont. II
II	As above	DC voltm. TC:T9	12V ± 5%	Faulty: check Z50, D54-57 Correct: check III
III	As above	Oscil. TC:TA		Faulty: check T55, T56 Correct: check IV
IV	As above	DC voltm. TC:Z51+	6,2 V ± 5%	Faulty: check Z51 Correct: check V
V	As above	DC voltm. TC:T54e	5-7,5 V 	Higher: check T54 Correct: check VI
VI	As above	Oscil. TB:TC		No pulses: cont. VII
VII	As above	As above. Short T53b to T53e	Contin. pulses	Correct: check T53 No pulses: check T52, Tr50 and F50.

TABLE 5

Meter range selector circuit check

Note I: Replace any defective indicator lamp before adjustment or faultfinding.

Note II: The indicator lamps are intentionally operated considerably below normal working voltage to insure long life.

The meter range circuits are straight forward, so after reading the circuit description any faultfinding is simple and need no further instructions but:

Test	Voltage
TK-TL	22 V
TK-Z380+	6,8 V
TK-Z381+	13,6 V

CV-CC indicator

Note I and II see "Meter range selector circuit".
Also this circuit is simple and needs no detailed faultfinding instruction.

Test	Voltage	Note
TF-TJ	23 V	
T11e-T11b	0 V	CC condition
T11e-T11b	0,6 V	CV condition

TABLE 6

OVP continuously on. This state is recognized by that the ammeter indicates current when no load is connected. (Voltages within brackets refer to 60 V models).

Ref. no	Important control settings	Test equipm. connection	Correct reading	Remedy
I	Volt. 32V (60 V) Current limit 50% OVP off	Voltm.+out to Z100+	6,2 V $\pm$ 5 %	Faulty: check Z100 Correct: cont. II
II	As above	Voltm. +out to T100b	base approx. +6V	Faulty: check P105, P100, S3 Correct: cont. III
III	As above	Voltm. -out to T100c	0 V	Faulty: check T100 Correct: check SCR 100

TABLE 7

OVP does not switch on.

I	Voltage 32V (60V) Current limit 50%	Voltm.+out to Z100+	6,2 V $\pm$ 5%	Faulty: check Z100 Correct: cont. II
II	As above but OVP 15 V (30V)	Voltm.+out to T100b	base 0,5-0,8V neg.	Pos: check P100, S3 More neg: check T100; SCR100. Note: if SCR100 is open circuited, this in turn results in destruction of T100. Thus check both T100 and SCR100 before switching on.

TABLE 8

Calibration and checks to be made after component replacement

Component replaced	Check	Refer to par.
T1, T2, T7, Z1	Load regulation	5Db
	Voltage calibration	
T4, T5, T6, Z90	Current limit	5Dc
T8, T70, T71	Voltage stabilizing	5Db
	Current limit	5Dc
	T70, T71 also check isolation transistor to chassis	-
T3, T9, T10	Aux. supply voltage	5Db par.2
T50-T56, SCR1, SCR2	Firing circuit	5Da
T301-T307	Ammeter	5Dd par.5-8
T321-T325	Voltmeter	5Db par.1-4
Z380, Z381	Meters	5Dd
T11, T200, T202	CV-CC indicator lamps	-

SECTION 7
IDENTIFICATION OF COMPONENTS

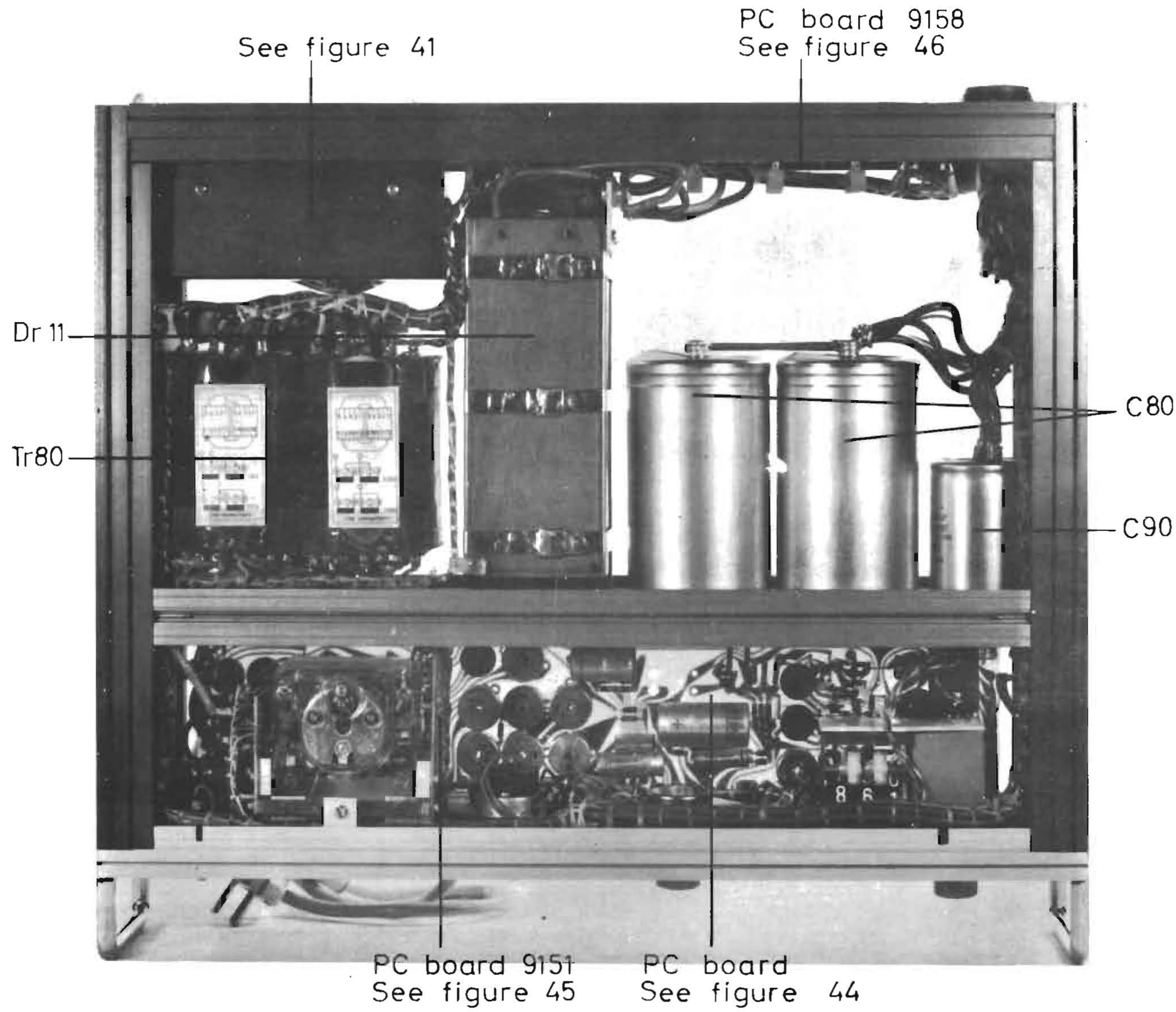


Figure 40. Top view RACPAC 300

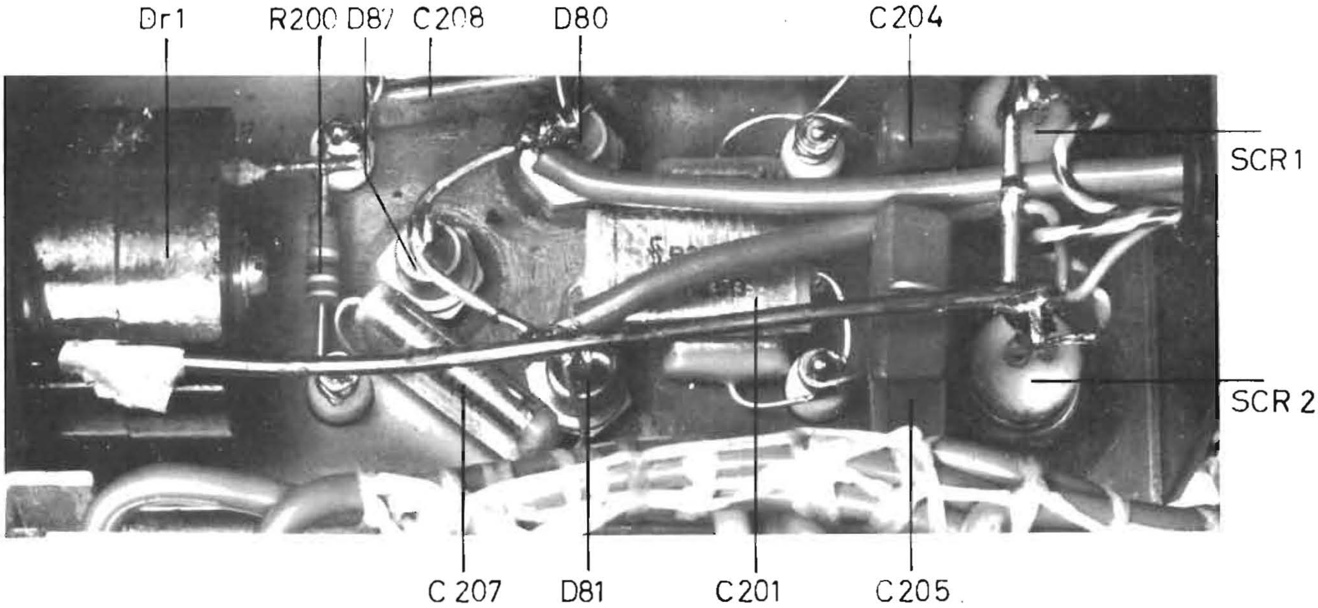


Figure 41. Rectifying circuit RACPAC 300

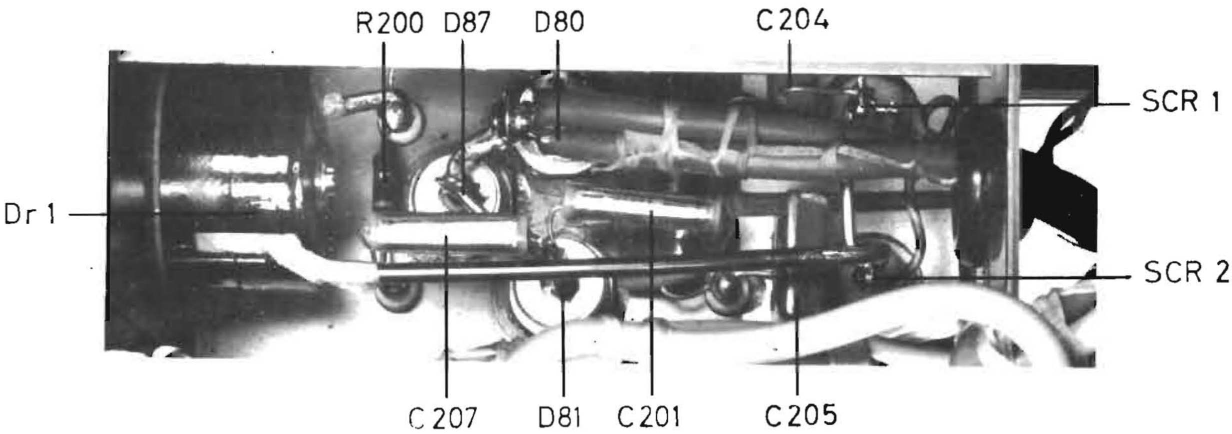


Figure 42. Rectifying circuit RACPAC 1000

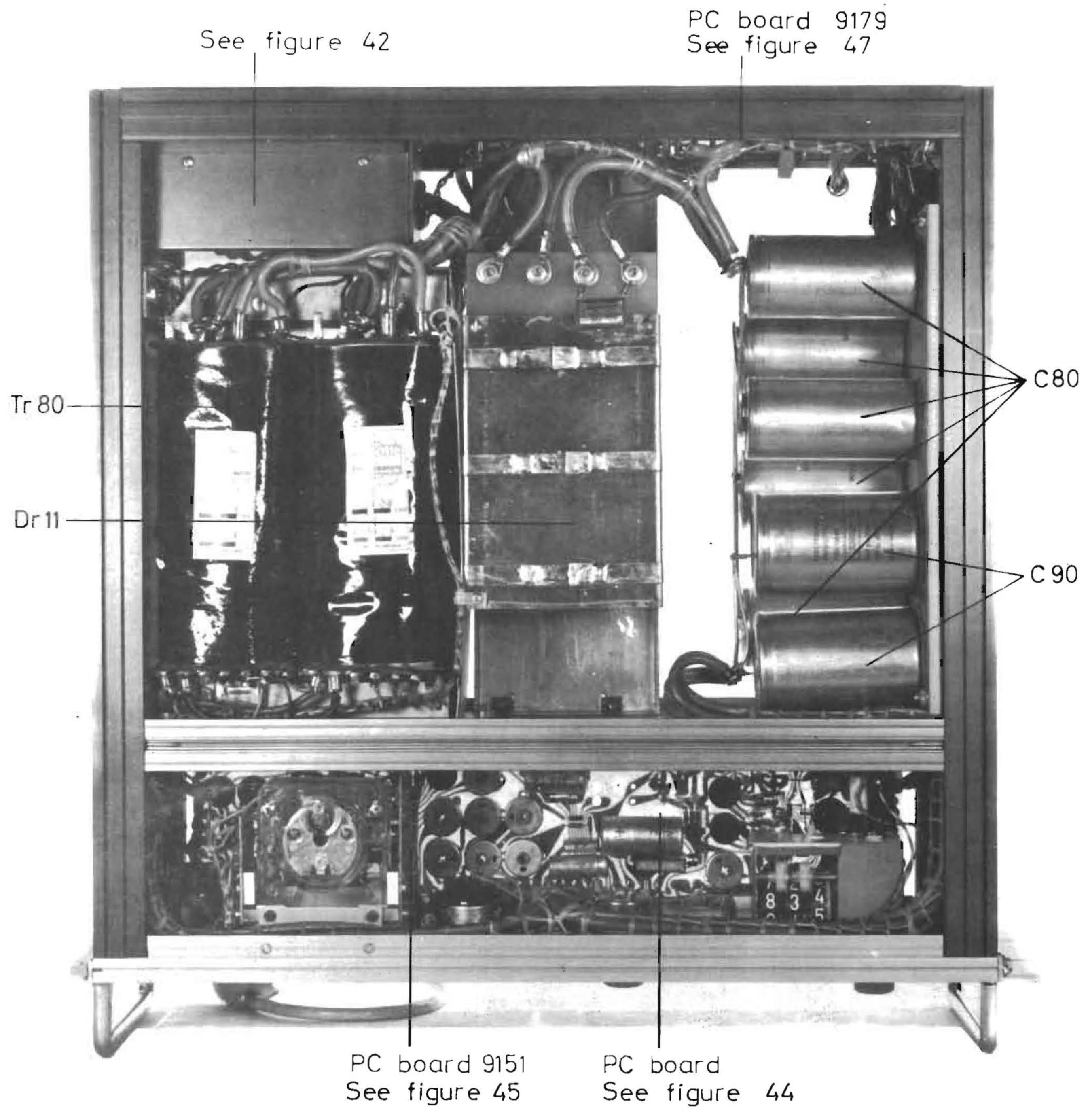


Figure 43. Top view RACPAC 1000

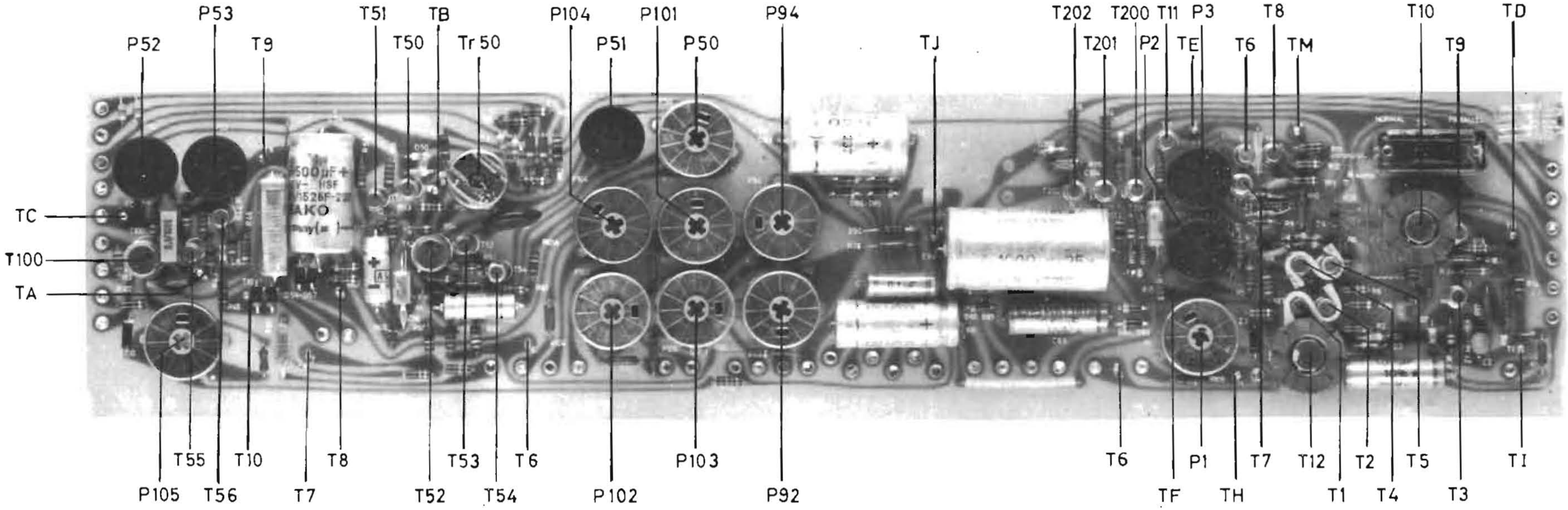


Figure 44. Main PC board { 9154 – 32V models / 9155 – 60V models } RACPAC

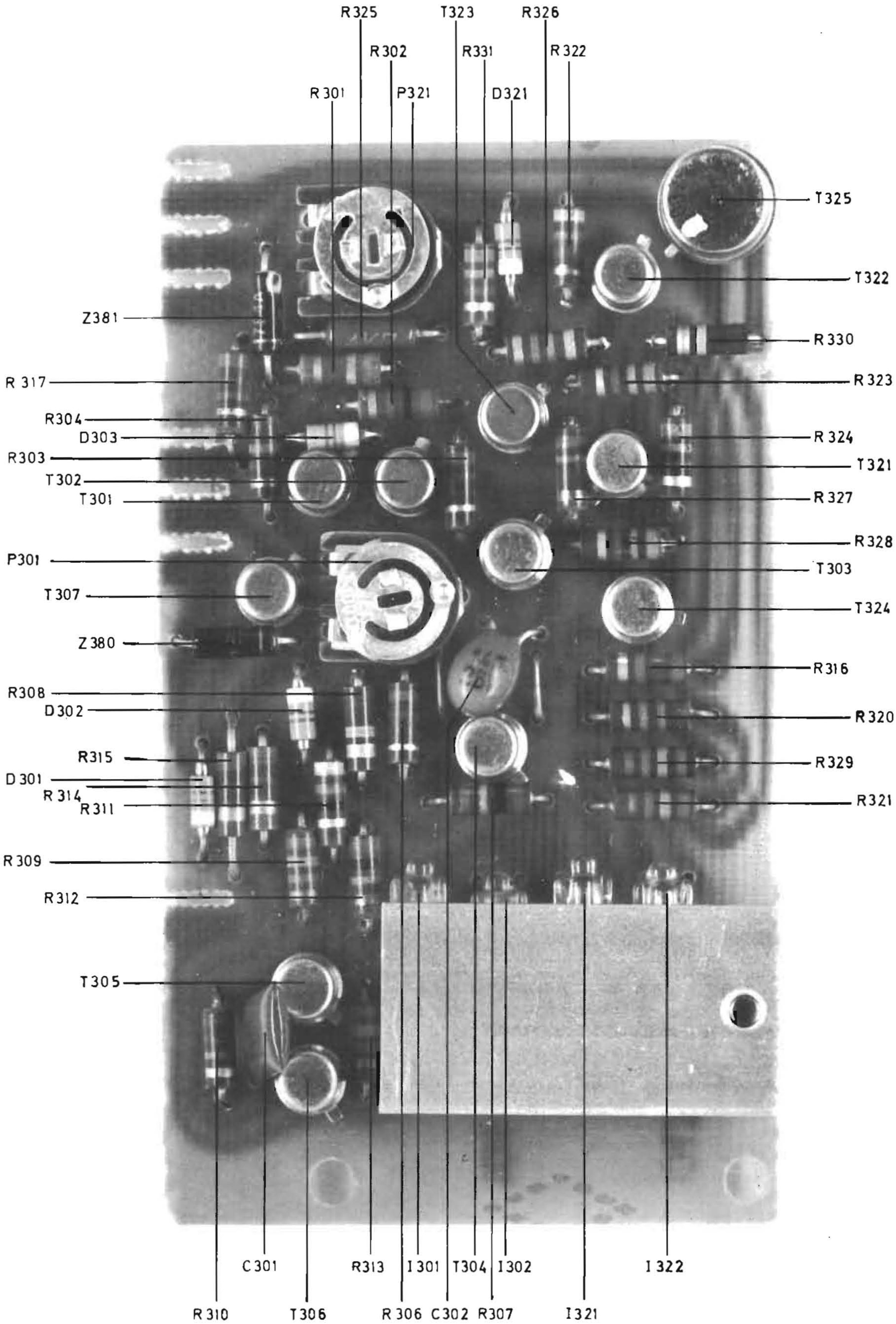


Figure 45. Lamp indicator PC board 9151 all models RACPAC

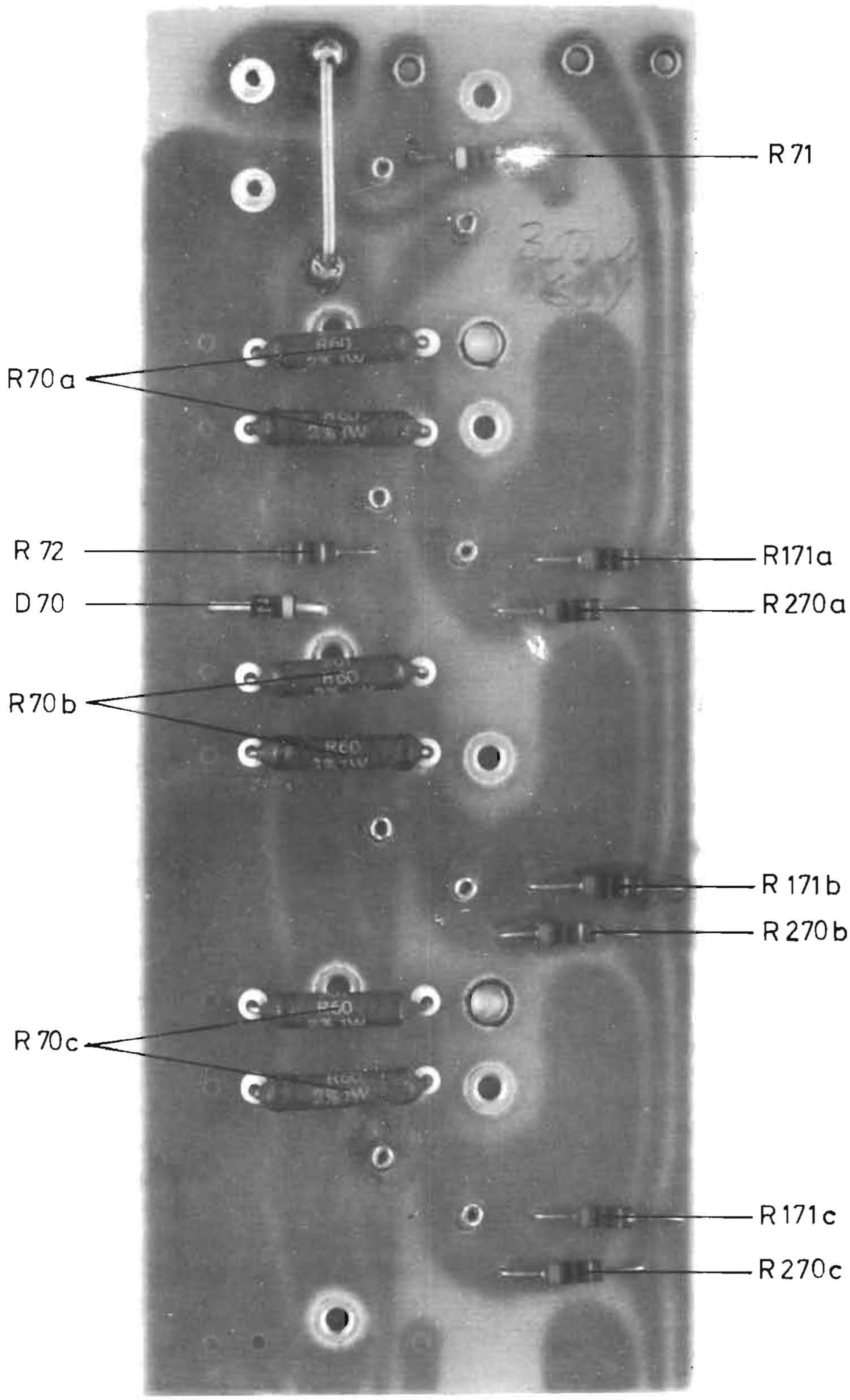


Figure 46. Series transistor PC board 9158 RACPAC 300

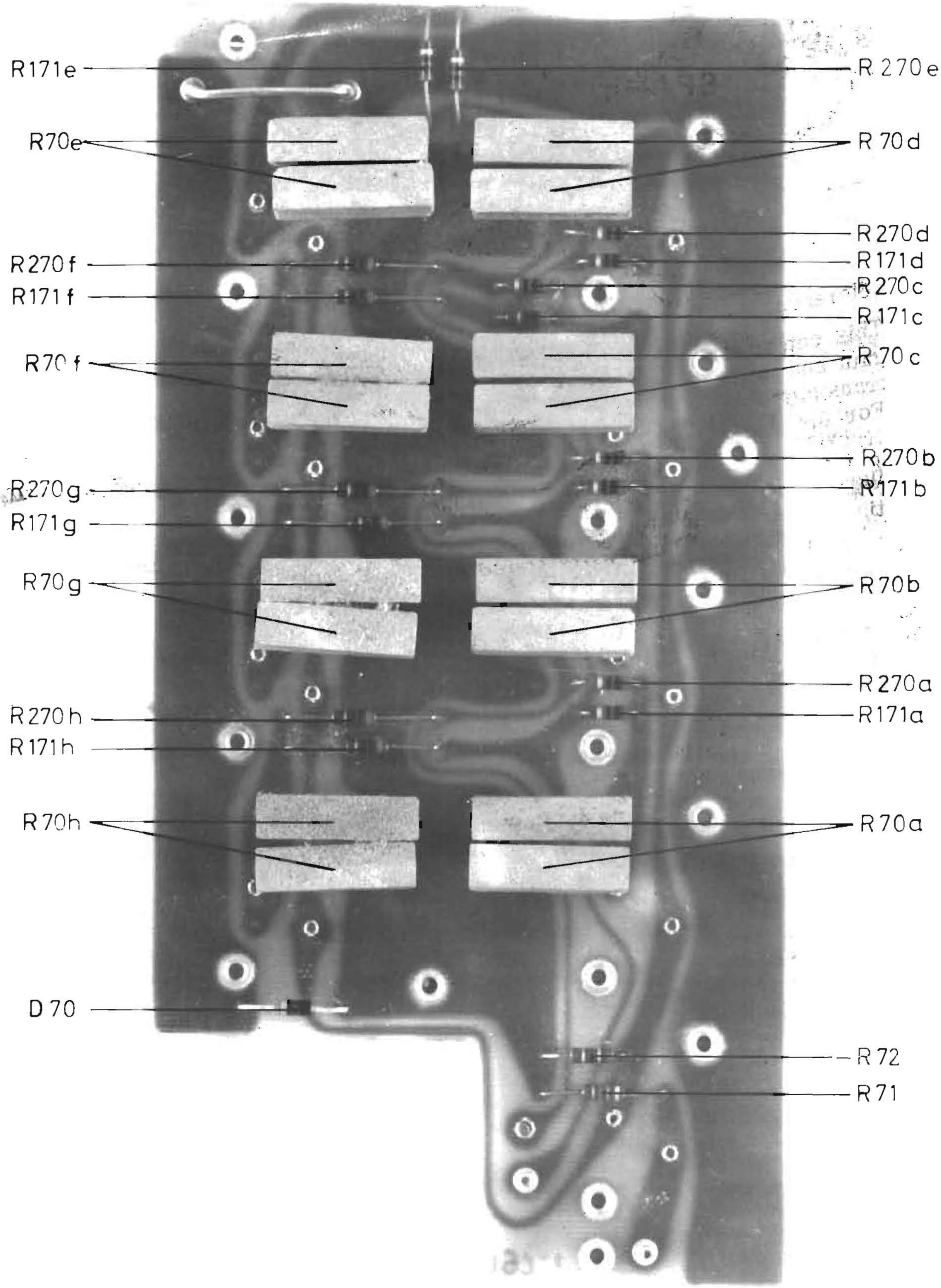


Figure 47. Series transistor PC board 9179 RACPAC 1000.

SECTION 8
LIST OF SPARE PARTS

Order spare parts from your local representative or from
OLTRONIX AB
Box 180, S-685 00 Torsby
Sweden
Mark order "Spare parts".

A. GENERAL

Replacement parts are available from the Oltronix factory.
All standard parts can also be ordered through most wellequipped component distributors.

Note that some transistors have a letter-number combination e.g. H75 in the spare parts list in addition to the manufacturers number and the circuit reference.

This combination indicates the quality of the transistor expressed in current gain and maximum voltage. This description should always accompany the transistor when a replacement is ordered.
For further information on the classification refer to the "Oltronix transistor identification code" which is found after the spare parts list.

When a pair of matched transistors is needed, add "Matched" to the description. When ordering parts listed below, state the following information for each part:

a. Model and serial number of the instrument
b. Circuit reference
c. Type and value

For parts not listed below state:

a. Model and serial number of the instrument
b. Complete description of the part
c. Function and location of the part

B. ABBREVIATIONS

Car	=	carbon
Cer	=	ceramic
EMC	=	electrolytic metal case
F	=	farad
k	=	kilo or 10^3
M	=	mega or 10^6
mA	=	milli Amperes
MF	=	metal film
p	=	pico or 10^{-12}
SCR	=	sil. controlled rectifier
Si	=	silicon
Tan	=	tantal
U	=	micro or 10^{-6}
V	=	volts
Var	=	varistor
W	=	watts
WW	=	wire round

C. SUB UNITS

All RACPAC's consist of the following sub units:

1.	Main PC-board	Part no 9154 or 9155
2.	Series transistor PC-board	Part no 9156-9159 & 9177-9180
3.	Lamp indicator PC-board	Part no 9151
4.	CV-CC lamp PC-board	Part no 9152
5.	Voltage control unit	Part 3015, 3665 (3013)
6.	Remaining parts	

Sub unit, see above	1	2	5
B32-5R	9154	9156	3015
B60-2,5R	9155	9157	3665*
B32-10R	9154	9158	3015
B60-5R	9155	9159	3665*
B32-20R	9154	9177	3015
B60-10R	9155	9178	3665*
B32-30R	9154	9179	3015
B60-15R	9155	9180	3665*

* 3013 in 60 V models with K_p 3,75 (see section 3E).

1. PRINTED CIRCUIT BOARD 9154 - 32 V MODELS

Unless otherwise specified all resistors are 0.25W 10% carbon.

Pos	Value	Part no	Type
R 1	1,5k 0,13W 1%	1285	MF
R 2	1k	1016	
R 5	82k	1039	
R 6	100k	1040	
R 7	82k	1039	
R 8	100k	1040	
R 9	1,5k	1018	
R10	5,6k 0,13W 1%	2865	MF
R11	100	1004	
R12	1k	1016	
R13	10k	1028	
R14	330	1010	when Z1= white
	390	1011	when Z1= violet
	470	1012	when Z1= green
R15	820	1015	
R16	4,7k 0,13W 1%	1292	MF
R17	6,8k 0,13W 1%	2866	MF
R18	4,7k 0,13W 1%	1292	MF
R19	39k	1035	
R20	8,2k 0,13W 1%	2867	MF
R21	1k	1016	
R23	330k	1046	
R24	6,8k 0,13W 1%	2866	MF
R26	1k	1016	
R27	47k	1036	
R28	47k	1036	
R29	2,7k	1021	
R30	22k	1032	
R31	100	1004	
R32	150	1006	
R34	2,2k	1020	
R40	100k	1040	
R41	68k	1038	
R42	33k	1034	
R43	1k	1016	
R44	100	1004	
R45	2,7k	1021	
R46	8,2k	1027	
R47 (2pcs)	820	1015	
R48	GA24	1314	Var
R50	1k	1016	
R51	33k	1034	
R52	33k	1034	
R53	1,8k	1019	
R54	4,7k	1024	
R55	470	1012	
R56	330	1010	
R57	100	1004	
R58	100	1004	
R59	2,2k	1020	
R60	2,2k	1020	
R61	3,3k	1022	
R61A	3,3k	1022	

Pos	Value	Part no	Type
R62	10k	1028	
R63	1k	1016	
R64	680	1014	
R65	100k	1040	
R66	560k	1049	
R67	100k	1040	
R68	180k	1043	
R69	27k	1033	
R80	33k	1034	
R81	220k	1044	
R82	47	1002	
R83	220k	1044	
R100	680	1014	
R101	1,5k 0,13W 1%	1285	MF
R102	100	1004	
R103	3,3k	1022	
R104	18 0,13W 1%	1280	MF
R105	180 0,13W 1%	1281	MF
R106	27k 0,13W 1%	3079	MF
R107	6,8k 0,13W 1%	2866	MF
R109	1k	1016	
R110	8,2k	1027	
R111	5,6k	1025	
R112	22k	1032	
R113	10k	1028	
R114	180	1007	
R115	15k	1030	
R116	180	1007	
R117	47	1002	
R118	10k	1028	

CAPACITORS

C 1	4,7	uF	25V	1415	Tan
C 2	4,7	uF	25V	1415	Tan
C 3	2,2	nF	100V	2875	MP
C 4	1,5	nF	100V	2874	MP
C 5	47	pF	500V	2873	Cer
C 6	47	pF	500V	2873	Cer
C 7	0,02	uF	100V	1398	MP
C 8	47	pF	500V	2873	Cer
C 50	0,01	uF	100V	1397	MP
C 51	0,1	uF	100V	1394	MP
C 52	22	uF	25V	2871	EMC
C 53	10	uF	64V	1478	EMC
C 54	500	uF	35V	1517	EMC
C 81	0,033	uF	400V	1387	MP
C 82	1000	uF	35V	1519	EMC
C 83	500	uF	35V	1517	EMC
C 85	0,68	uF	250V	1405	MP
C 91	0,68	uF	250V	1405	MP
C100	100	uF	100V	1492	EMC
C101	0,1	uF	400V	1389	MP
C103	15	uF	12V	2870	EMC
C104	0,01	uF	100V	1397	MP
C206	1	uF	250V	2938	MP

Pos	Value	Part no	Type
TRANSISTORS			
T1-T2	BC109C	2363	Matched
T3	BC108B	2861	Si
T4-T5	BC109C	2363	Matched
T6	BC108B	2861	Si
T7	BC109C	2930	Si
T8	BC178B	2862	Si
T9	BC108B	2861	Si
T10	2N4037	1606	H50
T11	BC178B	2862	Si
T12	2N3053	1569	H50
T50	BC178B	2862	Si
T51	BC108B	2861	Si
T52	2N4037	1604	L100
T53	BC178B	2862	Si
T54	BC108B	2861	Si
T55	BC108B	2861	Si
T56	BC178B	2862	Si
T100	2N4307	1604	L100
T200	BC108B	2861	Si
T201	BC108B	2861	Si
T202	BC108B	2861	Si
DIODES			
D1-D8	1S921	1667	Si
D50-D53	1S921	1667	Si
D54-D57	1N4003	1668	Si
D58-D60	1S921	1667	Si
D82-D85	1N4003	1668	Si
D86-D89	1N4003	1668	Si
D200	1S921	1667	Si
MISCELLANEOUS			
S4	2p 2W	2882	
Tr50	PT2	2883	
I (spare)		3001	Lamp

Pos	Value		Part no	Type
ZENER DIODES				
Z1	1N823		1677	Si
Z2-Z3	ZF5,6	1N752A	1686	Si
Z50	ZD12	1Z12T5	1698	Si
Z51	ZF6,2	1N753A	2758	Si
Z90	ZF5,6	1N752A	1686	Si
Z100	ZF6,2	1N753A	2758	Si

POTENTIOMETERS

P1	250	1,5W	2877	WW
P2	25k	0,25W	2880	Car
P3	25k	0,25W	2880	Car
P50	10k	1,5W	2879	WW
P51	100k	0,25W	2881	Car
P52	25k	0,25W	2880	Car
P53	100k	0,25W	2881	Car
P92	10k	1,5W	2879	WW
P94	100	1,5W	2876	WW
P101	1k	1,5W	2878	WW
P102	2,5k	1,5W	2937	WW
P103	10k	1,5W	2879	WW
P104	100	1,5W	2876	WW
P105	1k	1,5W	2878	WW

2. PRINTED CIRCUIT BOARD 9155 - 60 V models

Unless otherwise specified all resistors are 0.25W carbon and 10%.

R 1	1,8k	0,13W 1%	1286	MF
R 2	1k		1016	
R 5	82k		1039	
R 6	100k		1040	
R 7	82k		1039	
R 8	100k		1040	
R 9	1,5k		1018	
R10	5,6k	0,13W 1%	2865	MF
R11	100		1004	
R12	1k		1016	
R13	10k		1028	
R14	330		1010	when Z1 = white
	390		1011	when Z1 = viol
	470		1012	when Z1 = green
R15	820		1015	
R16	4,7k	0,13W 1%	1292	MF
R17	6,8k	0,13W 1%	2866	MF
R18	4,7k	0,13W 1%	1292	MF
R19	39k		1035	
R20	8,2k	0,13W 1%	2867	MF
R21	1k		1016	
R23	330k		1046	
R24	6,8k	0,13W 1%	2866	MF

Pos	Value		Part no	Type
R26	1k		1016	
R27	47k		1036	
R28	47k		1036	
R29	2, 7k		1021	
R30	22k		1032	
R31	100		1004	
R32	150		1006	
R34	2, 2k		1020	
R40	100k		1040	
R41	68k		1038	
R42	33k		1034	
R43	1k		1016	
R44	100		1004	
R45	2, 7k		1021	
R46	8, 2k		1027	
R47	820		1015	
R48	GA24		1314	Var
R50	1k		1016	
R51	33k		1034	
R52	33k		1034	
R53	1, 8k		1019	
R54	4, 7k		1024	
R55	470		1012	
R56	330		1010	
R57	100		1004	
R58	100		1004	
R59	2, 2k		1020	
R60	2, 2k		1020	
R61	3, 3k		1022	
R61A	3, 3k		1022	
R62	10k		1028	
R63	1k		1016	
R64	680		1014	
R65	100k		1040	
R66	560k		1049	
R67	100k		1040	
R68	180k		1043	
R69	27k		1033	
R80	68k		1038	
R81	220k		1044	
R82	47		1002	
R83	220k		1044	
R100	680		1014	
R101	680	0, 13W 1%	2375	MF
R102	100		1004	
R103	3, 3k		1022	
R104	18	0, 13W 1%	1280	MF
R105	180	0, 13W 1%	1281	MF
R106	56k	0, 13W 1%	2869	MF
R107	5, 6k	0, 13W 1%	2865	MF
R109	1k		1016	
R110	8, 2k		1027	
R111	5, 6k		1025	
R112	22k		1032	
R113	10k		1028	
R114	180		1007	
R115	15k		1030	

Pos	Value	Part no	Type
R116	180	1007	
R117	47	1002	
R118	10k	1028	

CAPACITORS

Pos	Value	Part no	Type
C 1	4,7 uF 25V	1415	Tan
C 2	4,7 uF 25V	1415	Tan
C 3	2,2 nF 100V	2875	MP
C 4	470 pF 500V	1422	Cer
C 5	47 pF 500V	2873	Cer
C 6	47 pF 500V	2873	Cer
C 7	0,02 uF 100V	1398	MP
C 50	0,01 uF 100V	1397	MP
C 51	0,1 uF 100V	1394	MP
C 52	22 uF 225V	2871	EMC
C 53	10 uF 64V	1478	EMC
C 54	500 uF 35V	1517	EMC
C 81	0,033 uF 400V	1387	MP
C 82	1000 uF 35V	1519	EMC
C 83	500 uF 35V	1517	EMC
C 85	0,68 uF 250V	1405	MP
C 91	0,68 uF 250V	1405	MP
C100	100 uF 100V	1492	EMC
C101	0,1 uF 400V	1389	MP
C103	15 uF 12V	2870	EMC
C104	0,01 uF 100V	1397	MP
C206	1 uF 250V	2938	MP

MISCELLANEOUS

Pos	Value	Part no	Type
S4	2p 2W	2882	
Tr50	PT2	2883	
I (spare)		3001	Lamp

TRANSISTORS

Pos	Value	Part no	Type
T1-T2	BC109C	2363	Matched
T3	BC108B	2861	Si
T4-T5	BC109C	2363	Matched
T6	BC108B	2861	Si
T7	BC109C	2930	Si
T8	BC178B	2862	Si
T9	BC108B	2861	Si
T10	2N4037	1606	H50

Pos	Value		Part no	Type
T11	BC178B		2862	Si
T12	2N3053		1569	H50
T50	BC178B		2862	Si
T51	BC108B		2861	Si
T52	2N4037		1604	L100
T53	BC178B		2862	Si
T54	BC108B		2861	Si
T55	BC108B		2861	Si
T56	BC178B		2862	Si
T100	2N4037		1604	L100
T200	BC108B		2861	Si
T201	BC108B		2861	Si
T202	BC108B		2861	Si

DIODES

D1-D8	1S921	1667	Si
D50-D53	1S921	1667	Si
D54-D57	1N4003	1668	Si
D58-D60	1S921	1667	Si
D82-D85	1N4003	1668	Si
D86-D89	1N4003	1668	Si
D200	1S921	1667	Si

ZENER DIODES

Z1	1N823		1677	Si
Z2-Z3	ZF5,6	1N752A	1686	Si
Z50	ZD12	IZ12T5	1698	Si
Z51	ZF6,2	IN753A	2758	Si
Z90	ZF5,6	IN752A	1686	Si
Z100	ZF6,2	IN753A	2758	Si

POTENTIOMETERS

P1	250	1,5W	2877	WW
P2	25k	0,25W	2880	Car
P3	25k	0,25W	2880	Car
P50	10k	1,5W	2879	WW
P51	100k	0,25W	2881	Car
P52	25k	0,25W	2880	Car
P53	100k	0,25W	2881	Car
P92	10k	1,5W	2879	WW
P94	100	1,5W	2876	WW
P101	1k	1,5W	2878	WW
P102	2,5k	1,5W	2937	WW
P103	10k	1,5W	2879	WW
P104	100	1,5W	2876	WW
P105	1k	1,5W	2878	WW

Pos	Value			Part no	Type

3, PRINTED CIRCUIT BOARD 9156

DIODE

D70	1N4003	1668	Si

RESISTORS

R70A-B	0,2	5W	5%	2969	WW
R71	470	0,25W	10%	1012	Car
R72	27	0,25W	10%	2949	Car
R171A-B	10	0,25W	10%	1001	Car
R270A-B	10	0,25W	10%	1001	Car

4. PRINTED CIRCUIT BOARD 9157

DIODE

D70	1N4003	1668	Si

RESISTORS

R70A-B	0,4	1W	2%	2979	WW
R71	470	0,25W	10%	1012	Car
R72	27	0,25W	10%	2949	Car
R171A-B	10	0,25W	10%	1001	Car
R270A-B	10	0,25W	10%	1001	Car

5. PRINTED CIRCUIT BOARD 9158

DIODES

D70	1N4003	1668	Si

RESISTORS

R70A-C	0,15	1W	5%	2967	WW
R71	470	0,25W	10%	1012	Car
R72	27	0,25W	10%	2949	Car
R171A-C	10	0,25W	10%	1001	Car
R270A-C	10	0,25W	10%	1001	Car

Pos	Value			Part no	Type

6. PRINTED CIRCUIT BOARD 9159

DIODE

D70	1N4003			1668	Si

RESISTORS

R70A-F	0,6	1W	2%	2980	WW
R71	470	0,25W	10%	1012	Car
R72	27	0,25W	10%	2949	Car
R171A-C	10	0,25W	10%	1001	Car
R270A-C	10	0,25W	10%	1001	Car

7. PRINTED CIRCUIT BOARD 9177

DIODE

D70	1N4003			1668	Si

RESISTORS

R70A-J	0,25	5W	5%	2970	WW
R71	470	0,25W	10%	1012	Car
R72	27	0,25W	10%	2949	Car
R171A-E	10	0,25W	10%	1001	Car
R270A-E	10	0,25W	10%	1001	Car

8. PRINTED CIRCUIT BOARD 9178

DIODE

D70	1N4003			1668	Si

RESISTORS

R70A-E	0,25	5W	5%	2970	WW
R71	470	0,25W	10%	1012	Car
R72	27	0,25W	10%	2949	Car
R171A-E	10	0,25W	10%	1001	Car
R270A-E	10	0,25W	10%	1001	Car

Pos	Value			Part no	Type

9. PRINTED CIRCUIT BOARD 9179

DIODE

D70	1N4003			1668	Si

RESISTORS

R70A-H	0, 20	5W	5%	2969	WW
R70A-H	0, 40	1W	2%	2979	WW
R71	470	0, 25W	10%	1012	Car
R72	27	0, 25W	10%	2949	Car
R170A-H	10	0, 25W	10%	1001	Car
R270A-H	10	0, 25W	10%	1001	Car

10. PRINTED CIRCUIT BOARD 9180

DIODE

D70	1N4003			1668	Si

RESISTORS

R70A-G	0, 25	5W	5%	2970	WW
R70A-G	33	1W	2%	3093	WW
R71	470	0, 25W	10%	1012	Car
R72	27	0, 25W	10%	2949	Car
R73	100	0, 25W	10%	1004	Car
R171A-G	10	0, 25W	10%	1001	Car
R270A-G	10	0, 25W	10%	1001	Car

CAPACITORS

C70	0, 02uF	100V		1398	MP

11. PRINTED CIRCUIT BOARD 9151 - ALL MODELS RACPAC

CAPACITORS

C301	0, 01 uF	100V		1397	MP
C302	4, 7 uF	25V		1415	Tan

Pos	Value	Part no	Type

DIODES

D301-D303	1S921	1667	Si
D321	1S921	1667	Si

POTENTIOMETERS

P301	100 0,05W	1347	Car
P321	10k 0,05W	1350	Car

RESISTORS

Unless otherwise specified all resistors are 0.25W 10% and carbon.

R301	6,8k	1026	
R302	1k	1016	
R303	1,2k	1017	
R304	2,7k	1021	
R306	5,6k	1025	
R307	10k	1028	
R308	15k	1032	
R309	180	1007	
R310	15k	1030	
R311	47	1002	
R312	10k	1028	
R313	180	1007	
R314	1,5k	1018	
R315	1,5k	1018	
R316	820	1015	
R317	560	1013	
R320	27k	1033	
R321	180	1007	
R322	470	1012	
R323	3,3k	1022	
R324	3,3k	1022	
R325	4,7k 0,13W 1%	1292	MF T2
R326	47k	1036	
R327	3,3k	1022	
R328	3,3k	1022	
R329	180	1007	
R330	22k	1032	
R331	3,3k	1022	

TRANSISTORS

T301-T302	BC178B	2862	Si
T303-T306	BC108B	2861	Si
T307	BC178B	2862	Si
T321	BC108B	2861	Si
T322	BC178B	2862	Si

Pos	Value	Part no	Type
T324	BC108B	2861	Si
T325	BC178B (32V mod)	2862	Si
T325	2N4037 (60V mod)	1608	H75

ZENER DIODES

Z380-Z381	ZF6,8 IN754A	1689	Si

MISCELLANEOUS

I301-I302	24V 30mA	3001	Lamp
I321-I322	24V 30mA	3001	Lamp

12. PRINTED CIRCUIT BOARD 9152 - ALL MODELS RACPAC

R108	5,6k 8W	1246	WW
I100-101	24V 30mA	3001	Lamp

13. VOLTAGE CONTROL UNITS

32 V units	3015
60 V units	3665
60 V units (with $K_p = 3,75$, see section 3E)	3013

14. MODEL B32-5R. REMAINING PARTS

CONNECTORS

Rear	MS3102A-20-27S	1781
Cable	MS3106B-20-27P	1786

DIODES

D80	409D	2954	Si
D81	409D	2954	Si
D87	409D	2954	Si
D90	409D	2954	Si

Pos	Value	Part no	Type
CAPACITORS			
C30	0,1 uF 250V	2946	MP
C80	10000 uF 64-70V	2934	EMC
C90	5000 uF 64V	1459	EMC
C102	100 uF 100V	1492	EMC
C200-201	1 uF 250V	2938	MP
C203	1 uF 250V	2938	MP
C204-205	4700 pF 500V	2935	Mica
C207	1 uF 250V	2938	MP
C208-209	0,1 uF 250V	2946	MP
TRANSISTORS			
T70	2N3055	1532	H75
T71A-B	2N3055	1532	H75
CHOKE COIL			
Dr2	D106	3002	
TRANSFORMER			
Tr80	T161	3003	
PULSE TRANSFORMER			
Dr1	PT10	3659	
FUSES			
F1	FEP/FEK	2019	holder
F1(220V)	2A	1983	slow
F1(110V)	4A	1987	slow
F2	FEP/FEK	2019	holder
F2	5A	1990	fast
LAMP			
Line	SGF9G red	2001	110V
POTENTIOMETERS			
P90	10k 2W 5%	3023	10-turn
P93	1k 2W 10%	1325	WW
P100	10k 2W 10%	2955	WW+Sw

Pos	Value		Part no	Type

THYRISTORS

SCR1	BTY87-200R		2940	
SCR2	BTY87-200R		2940	
SCR100	BTY87-200R		2940	

RESISTOR

R200A-B	33	0,33W 5%	1072	Car

SWITCHES

S1	2 pos 1 W		2963	toggle
S2	2 pos 1 W		2964	toggle

15. MODEL B60-2,5R. REMAINING PARTS

CONNECTORS

Rear	MS3102A-20-27S	1781	
Cable	MS3106B-20-27P	1786	

DIODES

D80	409D	2954	Si
D81	409D	2954	Si
D87	409D	2954	Si
D90	409D	2954	Si

CAPACITORS

C30	0,1 uF	250V	2946	MP
C80	5000 uF	100V	2936	EMC
C90	3200 uF	100V	1521	EMC
C102	100 uF	100V	1492	EMC
C200-201	1 uF	250V	2938	MP
C203	1 uF	250V	2938	MP
C204-205	4700 pF	500V	2935	Mica
C207	1 uF	250V	2938	MP
C208-209	0,1 uF	250V	2946	MP

Pos	Value	Part no	Type
TRANSISTORS			
T70	2N3442	1653	H75
T71A-B	2N3442	1653	H75
CHOKE COIL			
Dr2	D106	3002	
TRANSFORMER			
Tr80		3003	
PULSE TRANSFORMER			
Dr1	PT11	3660	
FUSES			
F1	FEP/FEK	2019	holder
F1(220V)	1,5A	1981	slow
F1(110V)	3A	1985	slow
F2	FEP/FEK	2019	holder
F2	3A	1986	fast
LAMP			
Line	SGF9G red	2001	110V
POTENTIOMETERS			
P90	20k 2W 5%	3024	10-turn
P93	1k 2W 10%	1325	WW
P100	10k 2W 10%	2955	WW+Sw
THYRISTORS			
SCR1	BTY87-200R	2940	
SCR2	BTY87-200R	2940	
SCR100	BTX81-100R	3035	
RESISTORS			
R200A-B	33 0,33W 5%	1072	Car

Pos	Value	Part no	Type
SWITCHES			
S1	2 pos 1W	2963	toggle
S2	2 pos 1W	2964	toggle

16. MODEL B32-10R. REMAINING PARTS

CONNECTORS

Rear	MS3102A-20-27S	1781
Cable	MS3106B-20-27P	1786

DIODES

D80	409D	2954	Si
D81	409D	2954	Si
D87	409D	2954	Si
D90	409D	2954	Si

CAPACITORS

C30	0,1	uF	250V	2946	MP
C80 A-B	10000	uF	64-70V	2934	EMC
C90	5000	uF	64V	1459	EMC
C102	100	uF	100V	1492	EMC
C200-C201	1	uF	250V	2938	MP
C203	1	uF	250V	2938	MP
C204-C205	4700	pF	500V	2935	Mica
C207	1	uF	250V	2938	MP
C208-C209	0,1	uF	250V	2946	MP

TRANSISTORS

T70	2N3055	1532	H75
T71A-C	2N3055	1532	H75

CHOKE COIL

Dr2	D107	3029

TRANSFORMER

Tr80	T149	3026

Pos	Value	Part no	Type
PULSE TRANSFORMER			
Dr1	PT10	3659	
FUSES			
F1	FEP/FEK	2019	holder
F1(220V)	4A	1987	slow
F1(110V)	8A	1992	slow
F2	FEP/FEK	2019	holder
F2	10A	1995	fast
LAMP			
Line	SGF9G	2001	110V
POTENTIOMETERS			
P90	10k 2W 5%	3023	10-turn
P93	1k 2W 10%	1325	WW
P100	10k 2W 10%	2955	WW+Sw
THYRISTORS			
SCR1	BTY91-100R	2941	
SCR2	BTY91-100R	2941	
SCR100	BTY91-100R	2941	
RESISTORS			
R200A-B	33 0,33W 5%	1072	Car
SWITCHES			
S1	2 pos 1W	2963	toggle
S2	2 pos 1W	2964	toggle

17. MODEL B60-5R. REMAINING PARTS

CONNECTORS

Rear	MS3102A-20-27S	1781
Cable	MS3106B-20-27P	1786

Pos	Value	Part no	Type
DIODES			
D80	409D	2954	Si
D81	409D	2954	Si
D87	409D	2954	Si
D90	409D	2954	Si
CAPACITORS			
C30	0,1 uF 250V	2946	MP
C80 A-B	10000 uF 64-70V	2934	EMC
C90	5000 uF 64V	1459	EMC
C102	100 uF 100V	1492	EMC
C200-C201	1 uF 250V	2938	MP
C203	1 uF 250V	2938	MP
C204-C205	4700 pF 500V	2935	Mica
C207	1 uF 250V	2938	MP
C208-C209	0,1 uF 250V	2946	MP
TRANSISTORS			
T70	2N3442	1653	H75
T71A-C	2N3442	1653	H75
CHOKE COIL			
Dr2	D107	3029	
TRANSFORMER			
Tr80	T149	3026	
PULSE TRANSFORMER			
Dr1	PT11	3660	
FUSES			
F1	FEP/FEK	2019	holder
F1(220V)	4A	1987	slow
F1(110V)	8A	1992	slow
F2	FEP/FEK	2019	holder
F2	5A	1990	fast
LAMP			
Line	SGF9G red	2001	110V

Pos	Value	Part no	Type

POTENTIOMETERS

P90	20K 2W 5%	3024	10-turn
P93	1K 2W 10%	1325	WW
P100	1oK 2W 10%	2955	WW+Sw

THYRISTORS

SCR1	BTY87-200R	2940	
SCR2	BTY87-200R	2940	
SCR100	BTX81-100R	3035	

RESISTOR

R200A-B	33 0,33W 5%	1072	Car

SWITCHES

S1	2 pos 1W	2963	toggle
S2	2 pos 1W	2964	toggle

18. MODEL B32-20R. REMAINING PARTS

CONNECTORS

Rear	MS3102A-20-27S	1781	
Cable	MS3106B-20-27P	1786	

DIODES

D80	419B	3063	Si
D81	419B	3063	Si
D87	419B	3063	Si
D90	419B	3063	Si

CAPACITORS

C30	0,1 uF 250V	2946	MP
C80 A-D	10000 uF 64-70V	2934	EMC
C90	5000 uF 64V	1459	EMC
C102	100 uF 100V	1492	EMC
C200-C201	1 uF 250V	2938	MP
C203	1 uF 250V	2938	MP
C204-C205	4700 pF 500V	2935	Mica
C207	1 uF 250V	2938	MP
C208-C209	0,1 uF 250V	2946	MP

Pos	Value	Part no	Type
TRANSISTORS			
T70	2N3055	1532	H75
T71A-E	2N3055	1532	H75
CHOKE COIL			
Dr2	D105	3369	
TRANSFORMER			
Tr80	T160	3371	
PULSE TRANSFORMER			
Dr1	PT12	3661	
FUSES			
F1	FEP/FEK	2019	holder
F1(220V)	7, 5A	3068	slow
F1(110V)	10A	3069	slow
F2	FEP/FEK	2019	holder
F2	20A	3661	fast
LAMP			
Line	SGF9G red	2001	110V
POTENTIOMETERS			
P90	10K 2W 5%	3023	10-turn
P93	1K 2W 10%	1325	WW
P100	10K 2W 10%	2955	WW+Sw
THYRISTORS			
SCR1	BTX81-100R	3035	
SCR2	BTX81-100R	3035	
SCR100	BTX81-100R	3035	
RESISTORS			
R200A-B	33 0,33W 5%	1072	Car

Pos	Value	Part no	Type
SWITCHES			
S1	2 pos 1W	2963	toggle
S2	2 pos 1W	2964	toggle

19. MODEL B60-10R. REMAINING PARTS

CONNECTORS			
Rear	MS3102A-20-27S	1781	
Cable	MS3106B-20-27P	1786	
DIODES			
D80	419D	3425	Si
D81	419D	3425	Si
D87	419D	3425	Si
D90	419D	3425	Si
CAPACITORS			
C30	0,1 uF 250V	2946	MP
C80 A-D	5000 uF 100V	2936	EMC
C90	3200 uF 100V	1521	EMC
C102	100 uuF 100V	1492	EMC
C200-C201	1 uF 250V	2938	MP
C203	1 uF 250V	2938	MP
C204-C205	4700 pF 500V	2935	MP
C207	1 uF 250V	2938	MP
C208-C209	0,1 uF 250V	2946	MP
TRANSISTORS			
T70	2N3442	1548	H100
T71A-E	2N3442	1548	H100
CHOKE COIL			
Dr2	D105	3369	
TRANSFORMER			
Tr80	T160	3371	

Pos	Value	Part no	Type
PULSE TRANSFORMER			
Dr1	PT10	.3659	
FUSES			
F1	L1744	3067	holder
F1(220V)	7,5A	3068	slow
F1(110V)	10A	3069	slow
F2	L1744	3067	holder
F2	10A	3067	fast
LAMP			
Line	SGF9G red	2001	110V
POTENTIOMETERS			
P90	20K 2W 5%	3024	10-turn
P93	1K 2W 10%	1325	WW
P100	10K 2W 10%	2955	WW+Sw
THYRISTORS			
SCR1	BTY91-200R	2945	
SCR2	BTY91-200R	2945	
SCR100	BTX81-100R	3035	
RESISTORS			
R200A-B	33 0,33W 5%	1072	Car
SWITCHES			
S1	2 pos 1W	2963	toggle
S2	2 pos 1W	2964	toggle

20. MODEL B32-30R. REMAINING PARTS

CONNECTORS

Rear	MS3102A-20-27S	1781
Cable	MS3106B-20-27P	1786

Pos	Value	Part no	Type
DIODES			
D80	419B	3063	Si
D81	419B	3063	Si
D87	419B	3063	Si
D90	419B	3063	Si
CAPACITORS			
C30	0,1 uF 250V	2946	MP
C80 A-E	10000 uF 64-70V	2934	EMC
C90 A-B	5000 uF 64V	1459	EMC
C102	100 uF 100V	1492	EMC
C200-C201	1 uF 250V	2938	MP
C203	1 uF 250V	2938	MP
C204-C205	4700 pF 500V	2935	Mica
C207	1 uF 250V	2938	MP
C208-C209	0,1 uF 250V	2946	MP
TRANSISTORS			
T70	2N3055	1532	H75
T71A-H	2N3055	1532	H75
CHOKE COIL			
Dr2	D108	3590	
TRANSFORMER			
Tr80	T165	3589	
PULSE TRANSFORMER			
Dr1	PT12	3661	
FUSES			
F1 (220V)	10A	3069	slow
F1 (110V)	20A	3072	slow
F1	30A	3074	fast
F1-F2	L1744	3067	holder
LAMP			
Line	SGF9G red	2001	110V

Pos	Value	Part no	Type

POTENTIOMETERS

P90	10K 2W 5%	3023	10-turn
P93	1K 2W 10%	1325	WW
P100	10K 2W 10%	2955	WW+Sw

THYRISTORS

SCR1	BTX86-100R	3579	
SCR2	BTX86-100R	3579	
SCR100	BTY95-100R	1703	

RESISTORS

R200A-B	33 0,33W 5%	1072	Car

SWITCHES

S1	2 pos 1W	2963	toggle
S2	2 pos 1W	2964	toggle

21. MODEL B60-15R. REMAINING PARTS

CONNECTORS

Rear	MS3102A-20-27S	1781	
Cable	MS3106B-20-27P	1786	

DIODES

D80	419D	3425	Si
D81	419D	3425	Si
D87	419D	3425	Si
D90	419D	3425	Si

CAPACITORS

C30	0,1 uF 250V	2946	MP
C80 A-E	5000 uF 100V	2936	EMC
C90 A-B	3200 uF 100V	1521	EMC
C102	100 uF 100V	1492	EMC
C200-C201	1 uF 250V	2938	MP
C203	1 uF 250V	2938	MP
C204-C205	4700 pF 500V	2935	Mica
C207	0,1 uF 250V	2938	MP
C208-C209	0,1 uF 250V	2946	MP

Pos	Value	Part no	Type
TRANSISTORS			
T70	2N3773	3581	Power
T71A-G	2N3773	3581	Power
CHOKE COIL			
Dr2	D108	3590	
TRANSFORMER			
Tr80	T165	3589	
PULSE TRANSFORMER			
Dr1	PT12	3661	
FUSES			
F1 (220V)	10A	3069	slow
F1 (110V)	20A	3072	slow
F2	15A	3071	fast
F1-F2	L1744	3067	holder
LAMP			
Line	SGF9G red	2001	110V
POTENTIOMETERS			
P90	20K 2W 5%	3024	10-turn
P93	1K 2W 10%	1325	WW
P100	10K 2W 10%	2955	WW+Sw
THYRISTORS			
SCR1	BTX81-200R	3580	
SCR2	BTX81-200R	3580	
SCR100	BTX81-100R	3035	
RESISTORS			
R200A-B	33 0,33W 5%	1072	Car
SWITCHES			
S1	2 pos 1W	2963	toggle
S2	2 pos 1W	2964	toggle

D. OLTRONIX TRANSISTOR IDENTIFICATION CODE

To assure that the transistors in the Oltronix power supplies have good enough data for their actual application, all transistors are tested with a Tektronix Curve Tracer before they are mounted in any instrument. Certain transistors e.g. power transistors and transistors for high voltage use pass a more complete test after which a classification mark is applied. This mark is a letter-number combination on the power transistors and a colour dot on the smaller transistors.
The letter indicates high "H" or low "L" current gain. The number shows the maximum working voltage.
The test conditions are:

Test	Power transistors TO-3 and TO-36	Other transistors To-5 and similar
Current gain	I_c = 2A	I_c = 1mA
	V_{CE} = 10V	V_{CE} = 10V
	High if $h_{FE} \geq 50$	High if $h_{FE} \geq 50$
	Low if $h_{FE} < 50$	Low if $h_{FE} < 50$
	Transistors with extremely high or extremely low h_{FE} are rejected	
Voltage	I_c = 400mA	I_c = 1mA
	R_{BE} = 100 ohms	R_{BE} = 1, 5k ohms

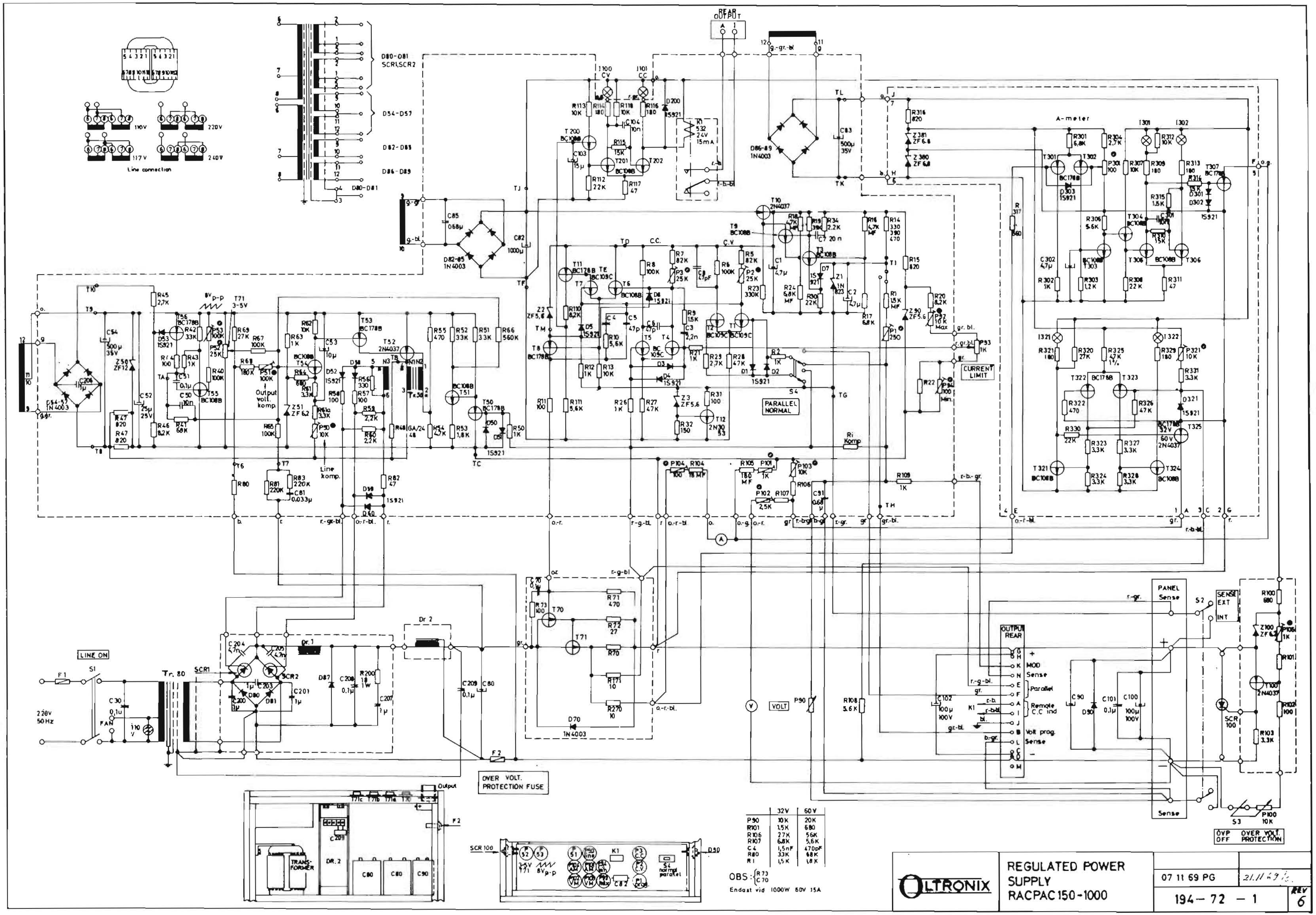
The colour code is:

Class	Colour	Class	Colour
L25	Brown	L100	Silver
H25	Red	H100	Black
L50	Yellow	L125	Silver and brown
H50	Green	H125	Black and red
H65	Blue	L150	Silver and yellow
L75	White	H150	Black and green
H75	Violet	L175	Silver and white
		H175	Black and violet

Colour code for wiring is:

b	=	blue	l	=	violet
bl	=	black	o	=	orange
br	=	brown	r	=	red
g	=	green	w	=	white
gr	=	grey	y	=	yellow

E.g. an orange-black wire is indicated as o-bl.



	32V	60V
P90	10K	20K
R101	1,5K	680
R106	27K	56K
R107	6,8K	5,6K
C4	1,5nF	470pF
R80	33K	68K
R1	1,5K	1,8K

OBS: {R73, C70} Endast vid 1000W 60V 15A

OLTRONIX

REGULATED POWER SUPPLY
RACPAC 150-1000

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REV 6

WARRANTY

All our products are warranted against defects in materials and workmanship for two years from the date of receipt.

Our obligation is limited to repairing or replacing products which prove to be defective during the warranty period.

We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact nearest Oltronix factory or representative for instructions.

Give full details of the diffeculty and include the instrument model and serial number.

There will be no charge for repair of instruments under warranty, **except transportation charges.**