INSTRUCTION MANUAL

Type SE11

POWER SUPPLY

RADIOMETER

ELECTRONIC MEASURING INSTRUMENTS

FOR SCIENTIFIC AND INDUSTRIAL USE

INSTRUCTION AND OPERATING MANUAL

FOR

Type SE11

POWER SUPPLY

CONTENTS

Printed in Denmark

SECTION 1
SPECIFICATIONS

REGULATED OUTPUT VOLTAGE

0 to 30 volts, d-c. continuously variable

FULL LOAD OUTPUT CURRENT

250 mA over the entire voltage range with full regulation. Up to 300 mA over the entire voltage range with slightly reduced regulation.

LOAD REGULATION

The change in output voltage from no load to 250 mA is less than 0.15% or 15 mV, whichever is greater. The regulation is independent of the METER RANGE setting.

LINE REGULATION

A ±10% change in line voltage will cause a change in output voltage which is less than ±0.15% or ±10 mV, whichever is greater.

RIPPLE AND NOISE

Less than 150 µV rms.

OUTPUT IMPEDANCE

Less than 0.1 ohm in series with 10 µH, independent of the METER RANGE setting.

METER RANGES

Full scale indications of: 10 mA, 30 mA, 100 mA, and 300 mA, 30 volts and 10 volts.

METER ACCURACY

±2%. On the 10 mA range the meter reads approximately 0.15 mA high.

OVERLOAD PROTECTION

The current limit is selected with the switch in 6 steps: 30 mA, 60 mA, 120 mA, 180 mA, 240 mA, and 320 mA, ±5% accuracy.

OUTPUT TERMINALS

Three binding posts. Positive and negative terminals are insulated from the chassis. A maximum of 300 volts d-c can be applied between the ground and either output terminal. The maximum line frequency leakage current from either output terminal to ground is less than 1 μA.

MAXIMUM AMBIENT TEMPERATURE

For sustained short circuit current of 320 mA: +45° C

For current up to 250 mA: +50° C

POWER

110, 115, 127, 200, 220, 240 volts ±10%, 50 to 60 cps, 20 watts.

WEIGHT

3.5 kilos net (7.7 lbs.)

DIMENSIONS

Width: 240 mm	Height: 150 mm	Depth: 185 mm
9-1/2 inches	6 inches	7-1/4 inches

SECTION 2
GENERAL INFORMATION

2.1 GENERAL DESCRIPTION

The model SE11 Power-Supply produces a stabilized d-c voltage, which is continuously variable from 0 to 30 volts. The output voltage is almost independent of line voltage variations and of the current drawn from the supply, when within the specified limits.

A feature of the Power-Supply is an electronic current-limiting device which protects the supplied circuits from accidental destruction. The maximum current can be set with the CURRENT-LIMIT selector to a value which is nearest above the normal operating current. At low values of load resistance, the Supply will automatically limit the current to the set value, thus acting as a constant current supply.

2.11 Built-in metering

A built-in meter monitors either the output voltage or the current, whichever is selected by the METER RANGE switch. The meter circuit is included in the regulating loop, so that the regulation and output impedance are independent of the METER RANGE setting.

2.12 Output

Both of the output terminals are insulated from the chassis. Either terminal may be grounded or a number of supplies may be connected in series to obtain higher voltages. The insulation used allows operating the terminals up to 300 volts off ground potential.

Special shielding in the line transformer permits the floating operation of the supply without the output terminals being grounded.

2.13 Operation in parallel

The electronic current-limiting device allows parallel operation of two Supplies. Each Supply will contribute only the current selected by the CURRENT-LIMIT selector.

2.14 Reliability

The model SE11 Power-Supply is a compact, fully transistorized unit which can operate continuously at ambient temperatures between 0 and +50° C. Only a minimum of maintenance is necessary because the instrument incorporates high-quality components and is fully transistorized.

2.2 INSPECTION AND INITIAL OPERATION

On receipt of the instrument inspect it for damage. Set the LINE VOLTAGE selector, which is combined with the fuse holder at the back of the instrument, to the proper voltage. When operating on voltages between 200 and 240 volts, install a slow-blow 160 mA fuse. In the case of line voltages between 110 and 127 volts, install a 315 mA slow-blow fuse.

Put the instrument in operation to make sure that it functions properly.

SECTION 3
OPERATING INSTRUCTIONS

3.1 OPERATING CONTROLS

The instrument has only a few controls. They are all clearly marked so that their use is self-evident.

Some additional information on the operation of the instrument is given below.

3.2 METER RANGE SWITCH

Leave the METER RANGE switch in one of the voltage range positions, except when actually measuring load current. Otherwise an accidental short circuit can damage the meter.

The meter measures the current flowing in the regulating loop in addition to the current drawn from the terminals. However, the current in the regulating loop is very low (approximately 0.15 mA) and therefore hardly noticeable, except on the most sensitive range.

3.3 CURRENT-LIMIT SELECTOR

This switch controls a circuit which determines the current level at which voltage clipping occurs. The calibration is nominal. The true current values may be had by shorting the output terminals and reading the monitor meter.

The transition from the constant-voltage region to the constant-current region, or vice versa, is gradual and occurs close to the voltage and the current values which are selected with the VOLTAGE CONTROL and the CURRENT-LIMIT selector.

The transition begins at approximately 90% of the actual voltage and the current values selected.

In case pulse-type circuits are supplied, the average current, as indicated by the meter, may be well below the current limit, but the peak currents may cause clipping. In this case the CURRENT-LIMIT selector should be set at a value high enough for the peak current requirements of the circuit.

The output terminals of the instrument are shunted by a 50 μF capacitor, which helps to give high peak currents of short duration.

Still higher peak currents can be supplied by adding a capacitor externally. In this case, however, the CURRENT-LIMIT circuit provides decreased safety. The ensuing surge currents may be so high that the external components are destroyed before the supply limiting circuit starts operating.

3.4 OPERATING SUPPLIES IN SERIES

When several type SE11 Supplies are operated in series, be sure that the CURRENT-LIMIT selectors of all the Supplies are set at the same value.

When operating the instruments at a high voltage off ground, avoid exposing the instrument to high voltage surges due to accidental short-circuiting, because this may damage the electrolytic capacitors and the transistors.

3.5 OPERATING SUPPLIES IN PARALLEL

Two Supplies may be connected in parallel to supply loads exceeding 250 mA.

By setting the CURRENT-LIMIT selector of the first unit to 320 mA, this unit becomes a constant current source. It will supply this current, but the ripple and regulation can no longer be guaranteed.

The second unit is made to share the load and to take over the regulating action by advancing the VOLTAGE CONTROL slightly above the setting of the first unit. The second Supply will furnish regulation up to the limit of its capacity (250 mA). The second Supply may be loaded beyond 250 mA, making a total of 640 mA available. However, the source impedance and voltage regulation specifications do not apply in this case. It is not recommended to operate more than two instruments in parallel since accidental misadjustments may cause instability.

SECTION 4
THEORY OF OPERATION

4.1 GENERAL DESCRIPTION OF CIRCUIT

The regulation is performed by a power transistor acting as a variable resistor in series with the load. The power transistor is controlled by a three-stage amplifier in such a manner that the voltage which is selected with the panel control is not affected by variations in load and line voltage.

The current-limiting device senses the current drawn and clips the output voltage when the current reaches the pre-set value selected with the panel control, thus limiting the current to this value.

4.2 DESCRIPTION OF MAIN AND AUXILIARY RECTIFIER

The power transformer (T1) supplies the main rectifier, which is made up of a bridge rectifier (CR1), a storage capacitor (C2), and an auxiliary rectifier. This rectifier consists of a bridge rectifier (CR2) and a filter unit (CR3, R1, C4, and C5). It supplies the control amplifier and the reference circuits.

4.3 THE REFERENCE VOLTAGE

The reference voltage is derived from the negative auxiliary supply with a zener diode (CR6), which operates in the breakdown condition.

The output voltage and reference voltage are summed up by a resistance adder (R22, R21, R24, R25, and R23) whose output (Q4 base) is kept at a constant potential by the regulating action.

4.4 DESCRIPTION OF REGULATION CYCLE

When the output voltage rises, the base of Q4 becomes more positive, which results in a decrease of the base current. This decrease is amplified in the Q4 emitter and next in the collector of Q3. As a result the current of Q2 increases, and decreases the base current of Q1. This makes the effective resistance of Q1 higher and consequently the output voltage drops. This voltage drop almost completely offsets the initial rise assumed, thus furnishing regulation. The regulation cannot be infinite with the finite amplifier gain, since a finite variation in the output voltage is necessary to initiate the regulating action. Output variations because of the loading are reduced further by the use of positive current feedback (R32, R13, R9). This feedback is adjusted to completely compensate the voltage variations otherwise caused by loading, so that a virtual zero output impedance is obtained. The output impedance encountered in practice is somewhat dependent on the voltage setting and temperature but it will remain within the specified limits for all settings and ambients between 0 and +50° C.

4.5 CURRENT-LIMITING CIRCUIT

The output current is sensed by the voltage drop over a series resistor whose magnitude is determined by the CURRENT-LIMIT selector (R27 to R32). The voltage drop and the positive reference voltages which are developed over a zener diode (CR5) are summed up by a resistive adder (R5, R6, R7). When the voltage drop reaches a certain level, a diode (CR3) becomes conductive. This transfers the amplifier control from the output voltage to the output current. Any further increase in output current causes transistor Q2 to conduct heavily. This increases the resistance of the series transistor and results in a drop of the output voltage. Transistors Q3 and Q4 are bottomed in the current controlled region.

4.6 OUTPUT SURGE PROTECTION CIRCUIT

A diode (CR4) prevents the large surge in the output voltage which normally occurs when the voltage control is set to low output and the power switch is turned off. The surge is a result of the difference in the decay-times of the main rectifier and the auxiliary rectifier. To prevent this surge, which may damage external components, the base of Q1 is connected via the diode (CR4) to a tap on the adder (R24, R25). When the auxiliary voltage collapses, the base of Q1 is pulled positive, resulting in a rapid cut-off of the power transistor. In normal use the diode is reverse-biased and does not affect the circuit performance.

4.7 REVERSE CURRENT PROTECTION CIRCUIT

A silicon rectifier diode (CR7) shunts the output terminals, thus protecting the instrument from reverse current which may occur when Supplies are operated in parallel and during accidental short circuit when Supplies are operated in series.

4.8 FREQUENCY RESPONSE

The a-c output impedance is independent of the voltage setting because of a capacitor (C6) which shunts the voltage control. The output is by-passed by a high capacitance (C7, C8) to get a low internal impedance at high frequencies, which are beyond the handling capability of the amplifier. The transformer secondary is RF by-passed (C1) to eliminate high frequency noise coming from the power line.

SECTION 5
MAINTENANCE

5.1 GENERAL INFORMATION

The instrument is fully transistorized and should therefore operate indefinitely without routine maintenance. If one of the components has to be replaced, readjust the screw-driver controls as explained below.

Remove the cover by unscrewing the two screws on each side of the cabinet. The two side panels, which hold the print-board and the auxiliary rectifier, can be swung out to give better access to the components. To do so remove the upper screws and loosen the lower screws which fasten the side panels to the chassis.

When soldering on the print-board, be careful not to damage it by excessive heat, and do not insert the components by force.

5.2 SETTING THE MAXIMUM OUTPUT VOLTAGE

(1) Switch to ON.
(2) Set the METER RANGE to 30 volts.
(3) Turn the VOLTAGE CONTROL to its extreme right-hand position.
(4) Adjust R23 to obtain 31 volts.
(5) Reseal the control.

5.3 CALIBRATING THE METER

(1) Accurately set the mechanical zero before calibrating the meter.
(2) Connect a 1 kΩ 0.5% precision resistor to the output terminals.
(3) Set the METER RANGE to 30 volts.
(4) Adjust the VOLTAGE CONTROL to an output of 30.0 volts.
(5) Set the METER RANGE to 30 mA.
(6) Adjust R20 to obtain a 30.0 mA reading.
(7) Reseal the control.

The meter calibration should be checked with an external standard on all the ranges. If the calibration accuracy is less than 2%, the meter shunt or the series resistors are defective.

5.4 CALIBRATING THE CURRENT-LIMITING CIRCUIT

(1) Set the METER RANGE to 300 mA.

(2) Turn the VOLTAGE CONTROL to the extreme right-hand position.

(3) Set the CURRENT LIMIT to 320 mA.

(4) Short circuit the output terminals.

(5) Adjust R5 to obtain 320 mA.

(6) Check the current obtained on all other settings of the CURRENT-LIMIT selector. The currents obtained should be within 5% of the nominal values. If a larger deviation occurs, check the resistors R27 to R32.

(7) Reseal R5.

5.5 REGULATION TEST AND OUTPUT IMPEDANCE ADJUSTMENT

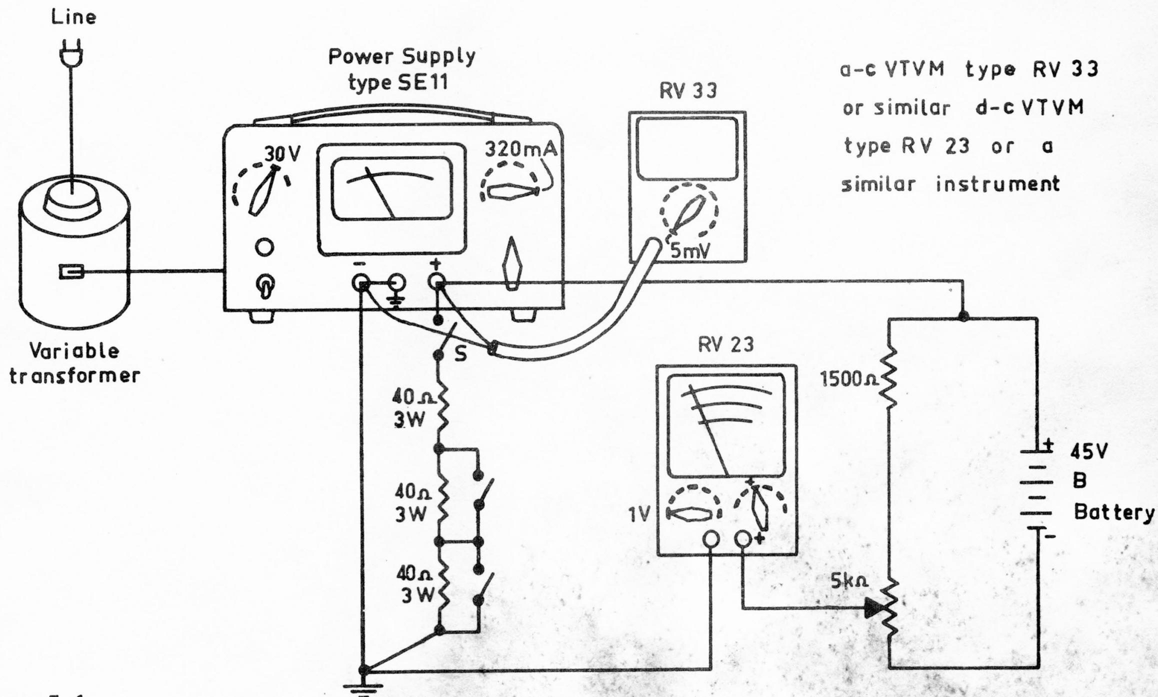


Figure 5-1
Checking voltage regulation and ripple

Use the test set-up shown in figure 5-1. Follow the wiring closely to prevent common loops, which may give wrong measuring results.

(1) Set the METER RANGE to 30 volts.

(2) Set the CURRENT LIMIT to 320 mA.

(3) Adjust the VOLTAGE CONTROL to 30 volts.

(4) Set the d-c vtvm to the 1 volt d-c range.

(5) Adjust the battery bucking voltage to obtain center-scale reading on the d-c vtvm.

(6) Close the toggle switch S, thus loading the Supply with 120 Ω (for the rated current output).

(7) Adjust R9 until there is no change in the reading of the d-c vtvm when S is opened or closed.

(8) Reseal R9.

(9) Repeat the test at an output of 20 and 10 volts, loading the Supply with 80 and 40 ohms. The voltage should not change by more than 0.15% or 15 mV when the load is applied.

(10) Disconnect the load and set the VOLTAGE CONTROL to an output of 30 volts. Vary the line voltage by ±10% on either side of the nominal voltage. The output voltage will remain constant to within ±45 mV. Repeat the test with a full load and at the other voltage settings. The output voltage will remain constant within ±0.15% or ±10 mV, whichever is greater.

(11) Measure the ripple and the noise with an a-c vtvm. They will be less than 0.15 mV for all output voltages, load conditions, and line voltages within the specified limits.

If the regulation is poor, one of the transistors or rectifiers may be defective.

If the noise and the ripple are higher than specified, check the capacitors C2, C6, C7, and C8.

If the output voltage is unstable and drifts, CR6 may be defective.

5.6 MEASURING A-C INTERNAL IMPEDANCE

Use the test set-up given in figure 5-2 below.

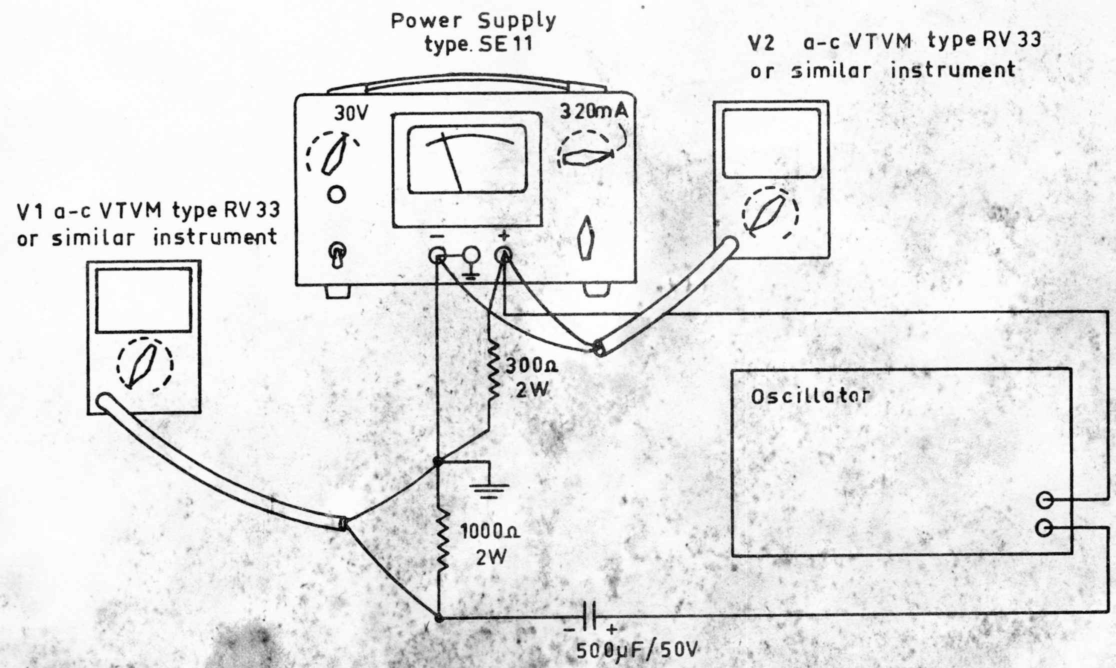


Figure 5-2
Measuring a-c impedance

Since the a-c impedance is very low, be careful not to couple the loops. A proper grounding technique must be employed. A constant a-c current of I = 10 mA (10 volts on V1) is driven through the Supply, and the resulting a-c voltage V2 is measured with V2. The output impedance is calculated by Ohm's law to be

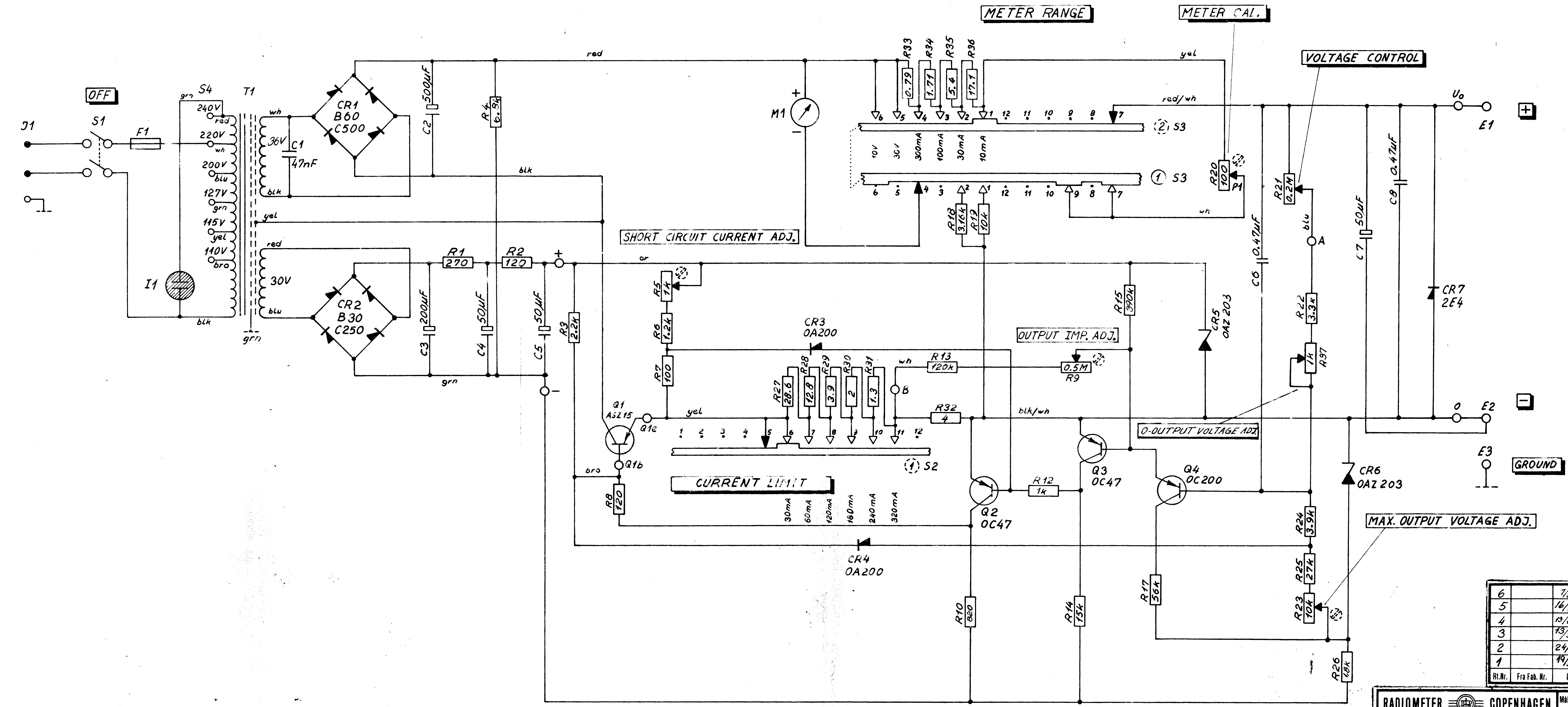
$$Z = \frac{V2}{I}$$

for various frequencies. The a-c output impedance is almost independent of the VOLTAGE CONTROL setting or the load, provided that the d-c current is larger than the peak a-c current driven through the Supply.

The a-c impedance measured will be below 100 milliohms in series with 10 µH (below 1 Ω up to 600 kc/s).

5.7 REPLACING THE POWER TRANSISTOR

When replacing Q1, the bottom cover must be removed. Be careful to notice the position of the nylon bushings and mica sheet which insulates the transistor mounting base from the chassis. A thin layer of silicone grease should be applied evenly over the transistor mounting base to insure a good thermal contact. When soldering the base and the emitter leads, be careful to prevent excessive heating of the transistor.



Rt.Nr.	Fra Fab. Nr.	Dato	Rt. af	Konf.	Norm.
6		7/8-63	LTJ	KR.	
5		16/5-62	[illegible]		
4		13/4-62	[illegible]	[illegible]	
3		13/3-62	ELH	[illegible]	
2		24/1-62	[illegible]		
1		19/5-61	[illegible]		

RADIOMETER COPENHAGEN
72 EMDRUPVEJ NV

Målestok | Tegn. KU. 15/3-61 | Konf. | Norm.

Transistor Power-Supply

TYPE SE 11a

From no. 49652 to no.

Erstatter

1333-A2

Erstattes af