

RADIOMETER

Vaccum-Tube Voltmeter
type RV33

Electrical
measuring instruments for
industrial and scientific work



Vaccum-Tube Voltmeter
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Vacuum-Tube Voltmeter type RV 33

20 cycles - 3 Mc

Introduction:

This voltmeter combines good sensitivity, high input impedance, and wide frequency range. The instrument is well fit for use in audio-frequency, supersonics, and carrier frequency work. Due to negative feedback the meter reading will remain virtually unaffected by line voltage variations. The vacuum-tube voltmeter is provided with a pair of

output jacks and may be used as a wide-band amplifier with a maximum gain of 70 db.

Description:

The voltmeter contains a cathode-follower input stage, a 3-stage amplifier, a rectifier meter, and a power supply.

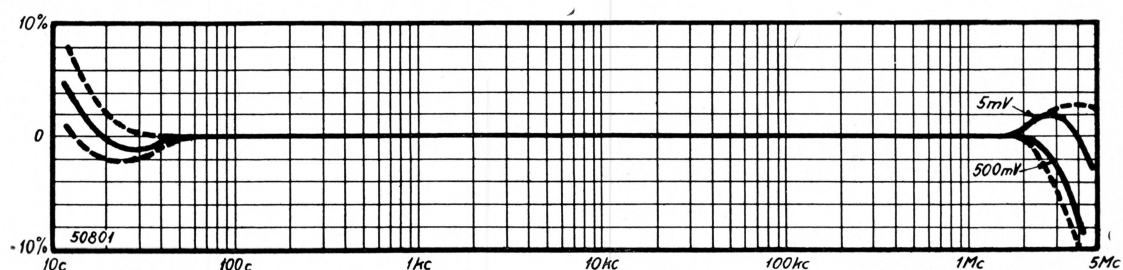


Fig. 1.: typical response curves for the type RV 33. The curves in full line are average response curves, whereas the dotted-line curves show the variation limits of the individual instruments.

The instrument has 11 voltage ranges from 5 mV to 500 volts full scale. On the mV ranges the sensitivity is varied between the cathode-follower and the 1st amplifier tube, while on the volt ranges an extra 40-db attenuator is inserted before the cathode follower. The input impedance, therefore, varies somewhat with the range-switch setting, cf. the specifications.

The amplifier employs heavy negative feedback to ensure good frequency response and stability

against changes in circuit elements arising from ageing or voltage variations.

The meter is a full-wave rectifier meter employing crystal diodes. The reading is proportional to the mean voltage of the applied signal, but it is calibrated in rms volts for a sine wave. The meter face carries two linear voltage scales 0-5 and 0-15, and a common db scale.

The instrument is effectively protected against overload through the limiting effect of the amplifier tubes.

SPECIFICATIONS:

Voltage ranges:

5-15-50-150 and 500 mV; 1.5-5-15-50-150 and 500 volts, full scale. The meter has 2 linear voltage scales and a common db-scale. The latter gives the voltage level in db above 1 mV when the number of db indicated by the range switch is added.

The instrument indicates the mean value but is calibrated in rms volts for a sine wave.

Accuracy and frequency range:

On the straight part of the response curve (60 cycles to 1.5 Mc, cf. fig. 1) the accuracy is 2% of full scale. Beyond these limits the accuracy is 2% plus an amount given by the limit curves of fig. 1.

Input impedance:

On the millivolt ranges the input capacitance is 19 pF. At low frequencies the damping is 8 megohms, decreasing to 1 megohm at 2 Mc. Around 2.5 Mc the damping changes from $+\infty$ to $-\infty$ and remains negative above 2.5 Mc.

On the volt ranges the input capacitance is about 11 pF. At low frequencies the damping is 2 megohms, decreasing to about 0.5 megohm at 3 Mc.

Amplifier:

The instrument can be used as a wide-band amplifier with a maximum gain of 70 db and an output impedance of 10 kilohms in series with 0.1 μ F. Max. open-circuit output voltage 60 volts.

Power supply:

110, 127, 150, 200, 220, and 240 volts, 50-60 cycles. Consumption 30 watts.

Mounting and finish:

Grey enamelled metal case.

Overall dimensions:

H: 270 mm; W: 200 mm; D: 165 mm.

Weight:

5.5 kilos.

Data subject to change without notice.



VACUUM-TUBE VOLTMETER type RV33

1. General Description

This vacuum-tube voltmeter is designed to measure a-c voltages both in the sonic, the super-sonic, and the carrier frequency range or wherever there is a demand for a combination of great sensitivity, wide frequency range, and wide voltage range.

The instrument has 11 ranges with full deflection for 5-15-50-150 and 500 millivolts and 1.5-5-15-50-150 and 500 volts. An additional db scale indicates the voltage in db over 1 millivolt. The frequency range is 20 cps to 3 Mc in all ranges.

The instrument operates with cathode-follower input in the ranges 5 to 500 millivolts, and consequently with high input impedance. In the remaining ranges a 2 Megohm voltage divider is used before the cathode follower.

The instrument can be used as an amplifier with an amplification of approximately 70 db in the 5 millivolt range.

The instrument is designed for operation from an a-c 50-60 cps power-supply. The negative feedback employed renders the instrument substantially independent of variations in line voltage, tubes, circuit components, etc.

2. Operating Principle

The instrument consists of a cathode-follower input stage, a 3-stage amplifier with negative feedback, a full wave crystal diode rectifier and a meter to indicate the rectified current. The different measuring ranges are selected by means of two attenuators one of them mounted between the cathode follower and the amplifier and the other mounted before the cathode follower. The amplifier operates with heavy negative feedback and is therefore almost independent of line voltage variations and tube aging. The rectifiers and the meter are automatically disconnected when the instrument is used as an amplifier.

3. Setting the Line Voltage

When leaving the factory the instrument is set to 220 volts line voltage, but operation at the following voltages 110-127-150-200 and 240 is also possible. The adjustment is made by means of a switch mounted on the line transformer.

NB! After adjustment remember to set the dial at the back of the instrument to the voltage chosen.

4. Operating the Vacuum-Tube Voltmeter

The instrument is ready for use in about one minute after being switched on. It is only possible to measure on sources one terminal of which is connected to chassis. A superimposed d-c voltage of 300 volts can be allowed for.

5. Measuring Ranges

The vacuum-tube voltmeter has 11 ranges with full deflection for: 5-15-50-150 and 500 millivolts and 1.5-5-15-50-150 and 500 volts. On all ranges the frequency range is 20 cps to 3 Mc.

6. Accuracy and Frequency Response

The accuracy at 1 Kc is 2% of full-scale deflection and about the same accuracy can be obtained in the frequency range from 60 cps to 1.5 Mc because the response of the amplifier is straight in this range. In the range 20 cps to 60 cps the response of the amplifier shows a maximum drop of about 1% at 30 cps. At 20 cps the drop is between 0 and 1%. The response at low frequencies is not affected by the range switch. At frequencies higher than 1.5 Mc the response depends somewhat on the position of the range switch and is generally between +2% and -2% to -3% at 3 Mc. At 4 Mc the limits are about -2% and -10%.

7. Input Impedance

The input impedance is dependent on the position of the switch. In the positions 5-15-50-150 and 500 millivolts the input voltage is fed directly to the grid of the cathode-follower, and an input impedance of 8 megohms in parallel with 19 pF is obtained at low frequencies. The ohmic component of the input impedance is dependent on the frequency. At 50 Kc it is about 5 M Ω and it falls proportionally to the logarithm of the frequency to about 1 M Ω at 2 Mc. Then it rises to an infinitely high positive value at about 2.5 Mc to 3 Mc and turns over to an infinitely high negative value, which numerically goes down to some hundred kilohms as the frequency rises.

In the positions 1.5 volt to 500 volts a 40 db attenuator is switched on before the cathode follower. The attenuator consists of 2 M Ω in series with 20.2 K Ω . The input impedance is 11 pF in parallel with 2 M Ω at frequencies up to 300 Kc. At higher frequencies the ohmic component drops proportional to the logarithm of the frequency to about 0.5 M Ω at 3 Mc.

8. Resistance to overload

The circuits are so designed that neither the rectifiers nor the meter can be damaged by overloading. The input voltage should not during a long period exceed about ten times the voltage that gives full-scale deflection so as not to damage the cathode follower, and it should not exceed 500 volts very much, so as not to damage the switch.

9. Influence of waveform

The indication of the meter is proportional to the average value of the a-c voltage, but the calibration is made so that the meter reads the rms value of a sinusoidal voltage. The deflection practically only depends on the fundamental wave, and the influence of harmonics or other (weaker) frequencies is negligible.

10. Influence of Line Voltage

In general $\pm 10\%$ change in line voltage causes only about $\pm 1\%$ change in deflection. At the limits of the frequency range the change is about $\pm 2\%$ because the negative feedback is somewhat lower. If the influence of line voltage variations is much greater this indicates that one or more of the tubes are worn out.

11. Adjusting the Vacuum-Tube Voltmeter

The stability of the voltmeter is so good that in general no calibration has to be made, except when replacing tubes or when compensating for the wear of tubes that have been used for a long time. The calibration is made by measuring an exactly known voltage of e.g. 5 millivolts at 1 Kc. The voltage has to be taken from a generator supplying a pure sinusoidal voltage, e.g. the Radiometer type H031 or type H012 Beat-Frequency Oscillator.

12. Hum Voltages

With short circuited input a little deflection is observed with the switch in the 5 millivolt position. The deflection is due to hum voltages and they do not affect the reading, if only the voltage to be measured is 2 or 3 times higher. At frequencies in the neighbourhood of the line frequency, the hum voltages causes small oscillations of the meter needle. The correct reading is had as the average of the highest and lowest deflection.

When measuring at the line frequency two different deflections are had if the line plug is reversed. Also in this case the correct value will be the average of the two readings. The hum voltage referred to the input is generally less than 100 microvolts. It is set to a minimum by means of a potentiometer across the filament winding of the transformer. The potentiometer shaft has a slot for screw-driver adjustment and is accessible when the plug button at the back of the voltmeter has been removed. (On instruments with a serial number below 9103 this button is located at the bottom and farthest from the front plate).

13. Using the Vacuum-Tube Voltmeter as an amplifier

When using the instrument as an amplifier the amplification is about 70 db in the 5 mV position, 60 db in the 15 mV position, etc. When a banana plug is inserted in the output jack, the rectifiers and the meter are automatically switched off. The output impedance is 10 k Ω in series with 0.1 μ F. The frequency response depends on the load. With a load of 10 pF the amplification has dropped about 3 db at 500 Kc and about 6 db at 1 Mc. The maximum output voltage is about 60 volts. At a 20 volt output, unloaded, the distortion is about 0.5%, and at 40 volts it is about 1%. At higher output voltages the distortion increases rapidly.

14. Servicing the Vacuum-Tube Voltmeter

The frequency response is critically dependent on the wiring and the placing of components in the amplifier and the attenuator. The wire-wound resistors of the attenuator are of a non-inductive type and should not be replaced by resistors of another type.

The attenuator mounted before the cathode-follower consists of a 2 M Ω resistor in series with 20.2 K Ω . A trimmer is placed in parallel with the 2 M Ω resistor. This trimmer is accessible through a hole in the bottom of the instrument. The hole is covered by a plug button. It will probably never be necessary to trim the trimmer (only if the frequency response in the ranges 1.5-500 volts is not straight at frequencies beyond 50 Kc).

The crystal rectifiers used will easily be damaged by electrostatic discharges, and any interference in the circuits concerning the rectifiers should not be made before the line voltage plug has been withdrawn and the rectifiers have been short-circuited.

NB! The rectifiers lie at the anode potential of the tube No. 4.

After replacement of a tube the sensitivity and the hum must be checked.

Tube No. 1 is a type EF40 and only very few specimens will give rise to too much hum. Tubes No. 2, 3, and 4 are of the type EF42 and some specimens used as tube No. 2 will cause too much hum, even after setting the hum compensating potentiometer to its optimal position.

If the instrument does not operate at all, the fault may be due to a defective fuse. Two fuses are mounted at the line transformer, 1 Amp. in the primary and 0.2 Amp. in the secondary, in order to protect the transformer and the rectifying tube against short-circuiting of the electrolytic condenser.

