MODEL 163
VACUUM TUBE VOLTMETER

OPERATION MANUAL

印刷表紙使用のこと

KIKUSUI ELECTRONICS CORP.

M O D E L 163

V A C U U M T U B E V O L T M E T E R

The Model 163 Vacuum Tube Voltmeter is a compact, high-sensitivity, AC voltmeter to indicate mean value of AC voltage. Employing stable feed-back amplifier and germanium-diode full-wave rectifier circuit, this equipment measures over a wide range, from 1 millivolt (-60 dbm) to 500 volts (+56 dbm) divided in 10 steps (10 db per step), and its frequency response expands from 5 cps to 1 megacycle. The direct-reading meter indicator is calibrated in RMS values.

SPECIFICATION

Type	Mean value indication type
Power requirement	volts, 50 to 60 cps, approx. 23 VA
Size-Cabinet	150 W x 205 H x 140 D mm
Maximum	160 W x 218 H x 186 D mm
Weight	Approx. 3.8 kgs.
Meter	Length of Scale 105 mm. Sensitivity 200 μA
Tubes Used	1 - 6AU6 (T) 1 - 6DK6 1 - 6AW8 1 - 6X4 2 - SD-34
Item Supplied with Equipment	1 - Type 941B Terminal Adaptor 1 - Operation Manual 1 - Test Data
Scale	Calibrated in RMS with since-wave voltage. Calibration in both volt and decibel (0 db equals to 1 milliwat into 600 ohms).
Input Terminal	UHF-type receptacle and GND terminal spaced at 19 mm (3/4 inc). UHF-type receptacle accepts both UHF-type and M-type plugs.
Input Impedance	1 megohm shunted by 25 $\pm$ 2 pF in all ranges.

Maximum Input	AC component	500 volts RMS maximum ± 710 volts peak maximum
	DC component	± 400 volts maximum
Ranges	10 ranges 0 - 15/50/150/500 mV and 1.5/5/15/50/150/500 volts RMS, or -40/-30/-20/-10/0/10/20/30/40/50 dbm.	
Accuracy	At 1 kc. ±% of full scale	
Stability	For ±10% change in power line voltage, change in meter indication at 1 kc. Within ±2% of full scale.	
Frequency Response (in reference to 1 kc)	Between 7 cps and 2MC	Within ±10% of full scale
	Between 10 cps and 600KC	Within ±5% of full scale
	Between 20 cps and 300KC	Within ±3% of full scale
Noise	With input terminal open circuited. Less than 1% of full scale.	
Output	Terminals spaced at 19 mm (3/4 inch). When meter indication is full scale, output approx. 2.5 volts RMS. Distortion approx. 3%, S/N approx. 35 db.	

At 1000 cps 1.5 volt range

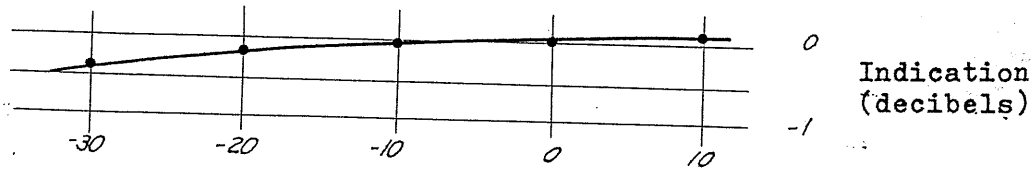


Figure 1 -- Change in meter indication for change in power line voltage.

OPERATION AND APPLICATION

The standard model works on _____ volts 50 to 60 cps power line. As shown in Figure 1, the meter indication is little affected by variation in power line voltage. However, it is preferred that the line voltage is maintained within ____ volts for longer life expectancy.

Functions of Controls and Terminals

POWER — A toggle switch to turn the power on or off. Turning this switch upward, the power is applied, and the dial of the range switch is illuminated. For about 20 seconds after this switch is turned on, the meter pointer may swing irregularly. Also, for about a few seconds after this switch is turned off, the same may happen.

RANGE — This is a black-colored dial on the center of the panel. The figures on the dial have following meanings:

Figures on external circumference: -- These figures indicate full scale voltages. Orange colored figures indicate voltages in millivolts and transparent figures indicate voltage in volts.

Figures on internal circumference: -- These figures indicate center scale voltages in dbm. (Explanation on dbm will appear in later section.)

As this dial is turned clockwise, it steps for higher voltage range. In measurement, it is preferred that the dial is first set in high voltage range, then, gradually switched for lower voltage range until an appropriate indication is obtained so that excessive input to the equipment can be avoided.

INPUT — This is a UHF-type receptacle to apply the voltage to be measured. This receptacle accepts either UHF-type plug or M-type plug. Also, a banana plug can be used for connection to center conductor of the receptacle. In addition, a standard 2-pole banana plug with 3/4 inch spacing can be used for simultanous connections to both input and ground terminals.

Furthermore, UHF-type receptacle accepts Type 941B Terminal Adaptor. This terminal adaptor, similarly to GND terminal, can hold any of banana plug, spade lug, alligator clip, 2-mm (0.08 inch) prod, and wires less than 2-mm diameter.

External conductor of UHF-type receptacle and GND terminal are connected to the panel and chassis of the equipment.

In series to input circuit, a DC blocking capacitor of 400-WV oil capacitor is connected. Input impedance has been adjusted to 1 megohm with a shunt capacitance of 25 ± 2 pF and is constant in all ranges.

OUTPUT

These terminals are used when this equipment is used as an amplifier. Similarly to Type-941B Terminal Adaptor, these terminals can hold any of banana plug, spade lug, alligator clip, 2-mm(0.08-inch) prod, and wires less than 2-mm diameter. A standard 2-pole banana plug is also convenient.

This equipment can perform both as a voltmeter and as an amplifier simultanously. However, if load impedance is too low, several deficiencies are caused as follows.

When resistive component of the load impedance is too low, the lower end of frequency response is sacrificed in the output circuit. However, the frequency response up to output circuit is not affected.

When capacitive component of the load impedance is dominant, the higher end of frequency response is significatly affected. Figure 2 shows an example of the effect of capacitance connected to the output terminals on the frequency response of the amplifier. However, this effect may vary among each voltmeter and as to power line voltage.

Output terminals deliver 2.5 volts output when meter indication is full scale. Since this equipment employs a negative feed-back circuit utilizing the current flowing in the meter, when certain load is connected, distortion and S/N characteristic may also be deteriorated.

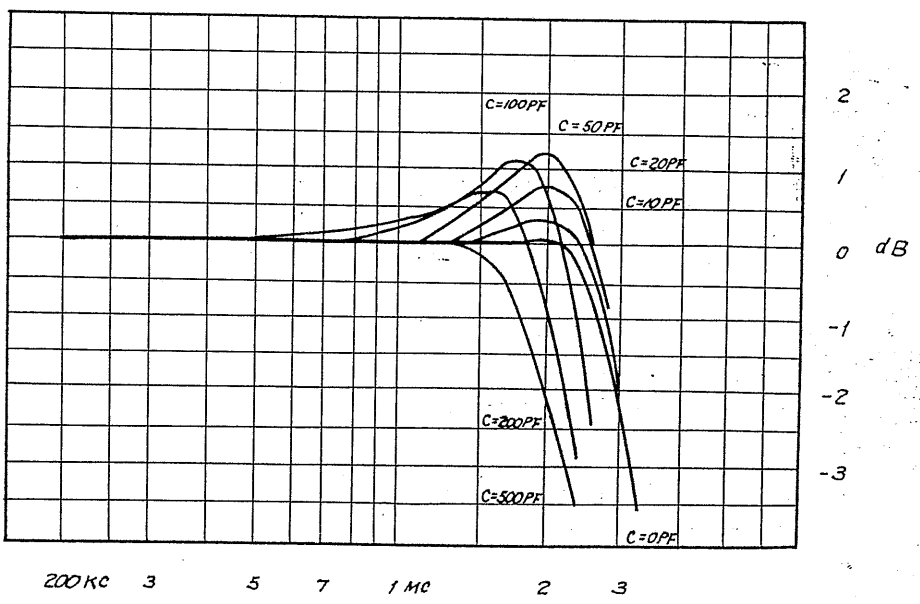


Figure 2 -- Effect of capacitive load on frequency response

Meter Scale

The meter indicator of this equipment has three scales as follows:

1. Upper scale is calibrated from 0 to 50. This scale is read when range switch is set in any one of 50, 500 mV and 5, 50, 500 volt ranges. The figure 50 means 50 mV when range switch is placed in 50 mV position, and 500 mV when range switch is placed in 500 mV position, and so on.

   Example : -- If meter indication is 37 with range switch placed in 500 mV position, the measured voltage is 370 mV or 0.37 volt.

2. Middle scale is calibrated from 0 to 15. This scale is read when range switch is set in any one of 15, 150 mV and 1.5, 15, 150 volt ranges. The meaning of the figures is same as explained above.

3. Lower scale is calibrated in dbm. This scale is read when it is required to measure dbm value (explanation on dbm will appear in later section . The same scale is used for all ranges.

   The dbm value of the measured voltage can be obtained simply by adding the dbm value indicated on the dial to the meter indication.

   Example: -- With range switch placed in 30 dbm (50 volt) range, if meter indication is 5.5 on dbm scale, the dbm value of the measured voltage is:

   $$5.5 + 30 = 35.5 \text{ dbm}$$

   Example: -- In this condiction, if range switch is turned to 40 dbm (150 volt) range, meter pointer now indicates -4.5 on dbm scale. The dbm value is then:

   $$-4.5 + 40 = 35.5 \text{ dbm}$$

   Example: -- With range switch placed in -20 dbm (150 mV) range, if meter indication is 3 on dbm scale, the measured voltage is:

   $$3 + (-20) = 3 - 20 = -17 \text{ dbm}$$

   Example: -- In this conddtion, if range switch is turned to -10 dbm (500 mV) range, meter pointer now indicates -7 on dbm scale. The dbm value is therefore:

   $$-7 + (-10) = -7 - 10 = -17 \text{ dbm}$$

Errors Caused by Distorted Waveforms

This equipment is a voltmeter to indicate "mean value" of the measured AC voltage, however, the scale is calibrated in RMS value. For this reason, if the measured voltage is not sinusoidal, the meter indication may deviate from accurate RMS value. Table 1 shows several examples.

Table 1 -- Comparison of actual RMS values with indication of Model 161.

Waveform of Measured Voltage	Calculated RMS Value	Indication of Model 161
Purely sinusoidal (100% fundamental)	100 %	100 %
100% fundamental + 10% 2nd harmonic	100.5	100
100% fundamental + 20% 2nd harmonic	102	100 - 102
100% fundamental + 50% 2nd harmonic	112	100 - 110
100% fundamental + 10% 3rd harmonic	100.5	96 - 104
100% fundamental + 20% 3rd harmonic	102	94 - 108
100% fundamental + 50% 3rd harmonic	112	90 - 116

Measurement of AC Current

This equipment can also be used to measure AC current. In measurement, a known resistor is connected in series to the AC current circuit, and a voltage drop across such resistory is measured. The, current is calculated by formula:

$$I = E/R$$

In this measurement, it should be noted that GND terminal of this equipment is connected to the panel and chassis.

Type-921 Shunt Resistors are available upon your separate order for your convenience in measurement of currents. These are precision resistors and their banana plugs fit to the input terminals of this equipment. Resistance values of 0.1 -ohm, 1-ohm, 10-ohm, 100-ohm, 1000-ohm, and in addition, 4-ohm, 8-ohm, and 600-ohm, are available.

Example: -- How about to measure heater current of a tube with rating of 6.5 volts 0.3 amps. Using Type-921-0.1 Shunt Resistor, a precision 0.1-ohm resistor, meter indication of 29 millivolts is read off in the connections as shown in Figure 3. Then, heater current is:

$$I = 29 \times 10^{-3}/0.1 = 290 \times 10^{-3} \text{ (amp)} = 290 \text{ (mA)}$$

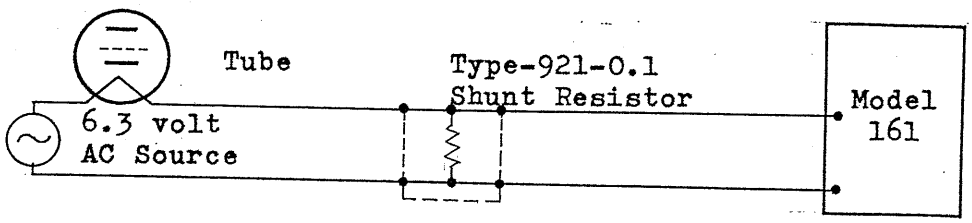


Figure 3 -- Measurement of Heater Current

Measurement of Output Power

This equipment can also be used to measure the audio power. If a voltage across a pure resistance is obtained, the power is calculated using a formula:

$$P = E^2/R$$

In case of 600-ohm load, the power is directly read in decibels on the dbm scale of the meter. When load impedance is different from 600 ohms, the power is also obtained is decibels by adding a figure read in Figure 5 for load impedance values between 1 ohm and 10 kiloohms.

Type-921 Shunt Resistors are also available in resistance values of 4-ohm, 8-ohm and 15-ohm, which are equal to nominal voice-coil impedances of common loud speakers, and these shunt resistors are used in place of loud speakers in measurement of output power up to 0.3 watt.

USING DECIBEL CONVERSION CHARTS

Bell (b) is a unit given to a common logarithm of a ratio of two values of power with base of 10, and decibel (db) is one tenth of bell. Decibel is therefore defined by following formula:

$$db = 10 \log_{10} \frac{P2}{P1}$$

Herein, if impedances at which P1 and P_2 are measured are equal, ratio or power simultanously gives ratio of voltage or current, and formulas:

$$db = 20 \log_{10} E1/E2$$

$$db = 20 \log_{10} I1/I2$$

are obtained.

For example, if input voltage of an amplifier is 10 millivolts and output is 10 volts, its amplification is 10/0.01 or 1000. In decibels,

$$\text{Amplification} = 20 \log_{10} 10/0.01 = 60 \text{ decibels}$$

In RF signal generators, output voltage is expressed in decibels in reference to 1 microvolt. For example, 10 millivolts is

$$10 \text{ mV} = 20 \log_{10} 10 \text{ mV}/1 \ \mu\text{V} = 80 \text{ decibels}$$

dbm is a unit given to a value of power as compared to 1 milliwatt assuming an impedance of 600 ohms. Therefore, 0 dbm equals:

0 dbm = 1 milliwatt into 600 ohms
= 0.775 volts across 600 ohms
= 1.291 mA through 600 ohms

The meter indicator of this equipment is calibrated in dbm, therefore,

in order to obtain decibel value with other reference than 1 milliwatt into 600 ohms, a constant figure should be added or subtracted from the meter indication. Such figure can be obtained using Figures 4 and 5. Figure 4 is convert ratio of voltages, currents, or powers into decibels.

Example 1: -- How many decibels is 5 milliwatts as referred to 1 milliwatt? Ratio 5 mW/1 mW = 5 is obtained, and 7 db is obtained as shown by dotted lines in Figure 4.

Example 2: -- How many decibels are 50 milliwatts and 500 milliwatts as referred to 1 milliwatts? When ratio is more than 10 or less than 0.1, the relation shown in Table 2 is used, and decibel values are obtained as follows:

$$50 \text{ mW} = 5 \text{ mW} \times 10 = 7 \text{ db} - 10 \text{ db} = 17 \text{ db}$$
$$500 \text{ mW} = 5 \text{ mW} \times 100 = 7 \text{ db} - 20 \text{ db} = 27 \text{ db}$$

Example 3: -- How many decibels is 15 mV as compared to 1 volt.

$$15 \text{ mV}/1 \text{ V} = 1.5 \times 0.01 = 3.5 \text{ db} + (-40) \text{ db} = -36.5 \text{ db}$$

Table 2

Ratio	Decibel Power Ratio	Voltage or Current Ratio
$10000 = 1 \times 10^4$	40 db	80 db
$1000 = 1 \times 10^3$	30 db	60 db
$100 = 1 \times 10^2$	20 db	40 db
$10 = 1 \times 10_0$	10 db	20 db
$1 = 1 \times 10^{-1}$	0 db	0 db
$0.1 = 1 \times 10^{-2}$	-10 db	-20 db
$0.01 = 1 \times 10^{-3}$	-20 db	-40 db
$0.001 = 1 \times 10^{-4}$	-30 db	-60 db
$0.0001 = 1 \times 10$	-40 db	-80 db

Figure 5 is used in obtaining power value converting dbm reading on the meter indicator.

Example 1: -- Measuring a voltage across voice coil of 8-ohm speaker, an indication of -4.8 dbm is obtained on the meter. Then, what is the power delivered to the speaker in milliwatt?

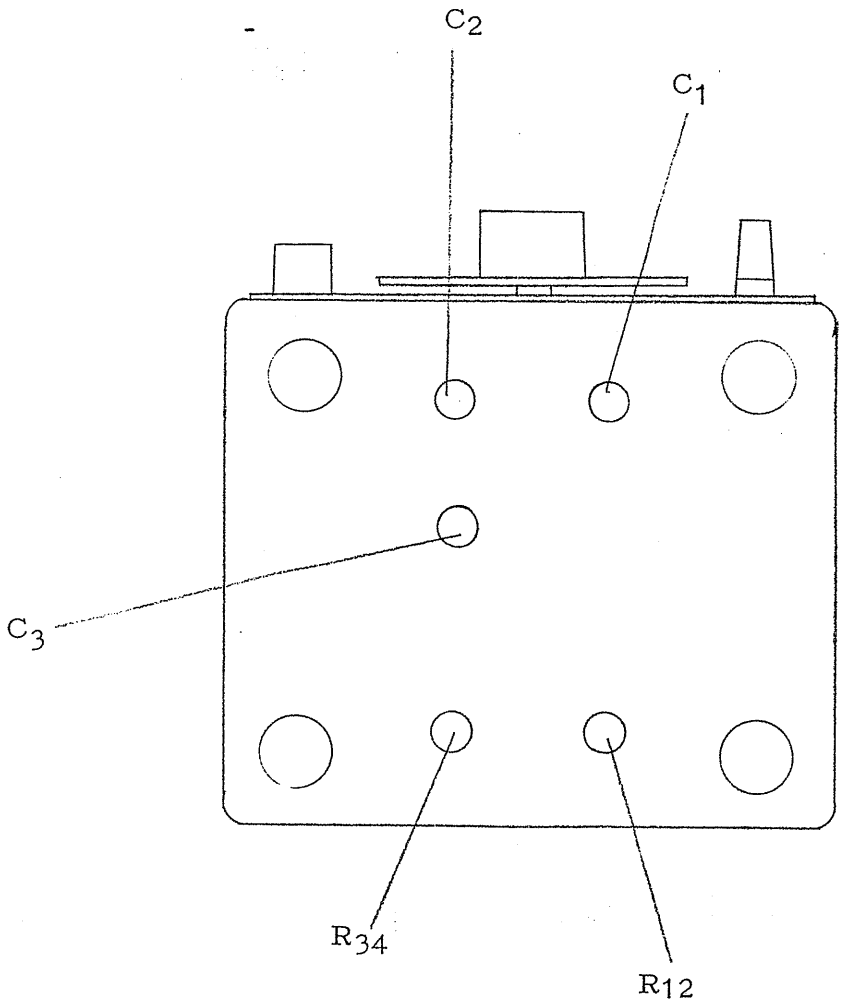
In Figure 5, a figure +18.8 is obtained as shown by dootted line. This figure is added to meter indication,

$$-4.8 + 18.8 = 14 \text{ db}$$

Then, using Figure 4, -14 db can be converted into 25 milliwatts.

Example 2: -- How many volts of voltage is required to deliver a power of 1 watt into a 10-kiloohm load?

1 watt is equal to 1000 milliwatts and is 30 db as referred to 1 milliwatt. In Figure 5, a figure -12.2 is obtained. Then, meter indication should be 30 - (-12.2) = 42.2 dbm to deliver 1 watt into 10 kiloohm load. The indication 42.2 dbm is 2.2 dbm in range of 40 dbm (150 volt), and tequal to 100 volts.



BOTTOM VIEW

TRIMMING PARTS LOCATION