INSTRUCTION MANUAL

RF VOLTAGE STANDARD

TYPE 245—B

BOONTON RADIO CORPORATION

BOONTON, NEW JERSEY

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CONTENTS

ILLUSTRATIONS

TABLES

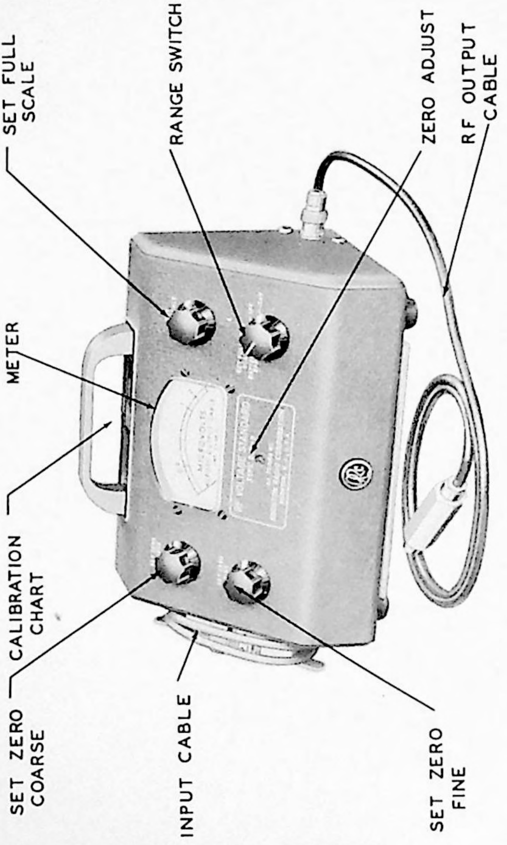

Figure 1. RF Voltage Standard Type 245—B.
Front Panel Control Layout.

SECTION I
DESCRIPTION

INTRODUCTION

The prevailing techniques of establishing the value of rf voltages at the microvolt level entail either the use of a number of signal generators as standards to cover the desired frequency range or the use of a calibrated standard receiver.

These methods are inconvenient, expensive, sometimes inaccurate, and cumbersome for portable operations.

The RF Voltage Standard Type 245-B is designed to supplant these existing methods; it is an accurate, portable and relatively inexpensive means of measuring the output voltage level of signal generators over a wide range of frequencies, thereby establishing the signals for testing radio receivers at the microvolt level.

The RF Voltage Standard shown in Figure 1 (and the system block diagram of Figure 2) takes the output of a signal generator over the frequency range of 0.1 - 1000 mc, monitors the high level input voltage to an attenuator system, attenuates the voltage to the microvolt region and delivers at the open circuit BNC output jack at the end of the output cable accurately calibrated, open circuit rf voltages of 0.5, 1, and 2 μv in series with a source impedance of 50 ohms over the above mentioned frequency range.

The input to the instrument is through a BNC connector on a 36 inch length of double-shielded coaxial cable having a 50 ohm characteristic impedance. The input cable enters through the left side and is an integral part of the instrument..

The output BNC jack on the right hand side of the instrument is equivalent to the front panel output connection of a signal generator having an internal 50 ohm matching resistor and used with a 50 ohm terminated output cable. At the instrument end of the output cable is a BNC plug which mates with the output jack; at the other end is a 50 ohm source impedance output termination with a BNC output jack that feeds the receiver input. Brackets are provided on the left side and rear of the instrument for coiling the input and output cables respectively.

SPECIFICATIONS

FREQUENCY RANGE: 0.1 mc to 1000 mc.

OUTPUT VOLTAGES: 0.5, 1.0, 2.0 microvolts.

OUTPUT VOLTAGE ACCURACY: ±10% to 100 mc.

Above 100 mc, output voltage obtained from standard frequency correction curve to the following accuracies:

±15% to 500 mc.
±20% to 1000 mc.

OUTPUT IMPEDANCE AT OUTPUT END OF OUTPUT CABLE: 50 ohms

VSWR AT OUTPUT END OF OUTPUT CABLE:

Less than 1.04 to 100 mc
Less than 1.06 at 500 mc
Less than 1.10 at 1000 mc

OUTPUT IMPEDANCE AT OUTPUT JACK ON INSTRUMENT: 50 ohms.

INPUT VOLTAGE ACCURACY FOR A READING OF 1 MICROVOLT ON THE METER FROM A VOLTAGE SOURCE OF 50 OHMS:

±10% to 300 mc.

INPUT IMPEDANCE: 50 ohm nominal. Calibrated at approximately 100 mc.

FRONT PANEL CONTROLS AND INDICATORS (See Figure 1)

RANGE SWITCH: The five position range switch (S1) is used to select the various functions of the circuit. The positions are:

Battery Off—The internal battery is disconnected. It is in this position that the mechanical zero of the meter should be checked and corrected if necessary.

Set Full Scale—In this position the instrument should be adjusted for full scale meter reading. Tap meter vigorously while setting using the *set full scale control:*

2μv—In this position the metering circuit is calibrated for the 2 position on the meter.

1μv—In this position the metering circuit is calibrated for the 1 position on the meter.

0.5μv—In this position the metering circuit is calibrated for the 0.5 position on the meter.

SET FULL SCALE: This control (R2) is used to adjust the instrument for full scale meter reading when the range switch is set at *set full scale position.* Clockwise motion of the control causes the pointer to move to the right.

SET ZERO: *course and fine.*

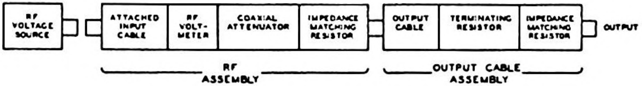

Figure 2. RF Voltage Standard System Block Diagram.

These controls (R3-A, R3-B, R-5) are used to adjust the meter to read zero with no signal being applied to the input cable. The controls function only when the *range switch* is set to 2μv, 1μv or 0.5μv. Clockwise motion of the controls causes the pointer to move to the right. The course potentiometer will cause approximately 10 times the displacement of the fine potentiometer.

PANEL METER: The panel meter (M1) has five calibrated points on it which are used in conjunction with the corresponding five positions on the range switch. They are:

Zero—the extreme left hand line.

Full Scale—the extreme right hand line.

0.5—located at ¼ of full scale.

1—located at ¾ of full scale.

2—located at ⅞ of full scale.

DATA PLATE: The input voltmeter data plate is located on top of the instrument under the handle. It contains the following information:

The serial number of the instrument.

The input voltage at 1 mc and 100 mc necessary to produce a meter reading of 1 with the switch in the $1\mu v$ position.

The frequency at which the input impedance is a pure resistance (approximately 100 mc).

The value of the input resistance at 1 mc and approximately 100 mc.

SECTION II
OPERATING INSTRUCTIONS

PRELIMINARY PROCEDURE

If necessary, the mechanical zero of the voltmeter should be adjusted before turning the power on.

Plug the input cable on the RF Voltage Standard into the output of the signal generator to be used. Turn the selector switch to *set full scale* and use the *set full scale control* to set the pointer at full scale. Clockwise rotation will move the needle to the right.

With the signal generator output at zero, turn the selector switch to the output voltage range which is to be used. By means of the *set zero controls,* set the meter on zero.

Increase the signal generator output until the meter pointer reaches the point on the scale which corresponds to the switch range in use. For example, if the selector switch is set for $1\mu v$ adjust the signal generator output to produce a meter indication of 1. The meter shows the open circuit voltage at the end of the output cable. If the output cable is not attached, the open circuit voltage at the jack on the side of the instrument will be twice the indicated voltage.

Above 100 mc the output frequency correction curve given in Figure 3 must be used. It shows the actual output voltage at the end of the Output Cable as a function of frequency for meter settings of 0.5, 1.0, and 2 μv.

MEASUREMENT PROCEDURE: RECEIVER SENSITIVITY

The sensitivity of a radio receiver has been defined by the Institute of Radio Engineers[1] as the number of microvolts re-

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[1] *"Standards on Radio Receivers"—I.R.E. 1947 (p. 2)*

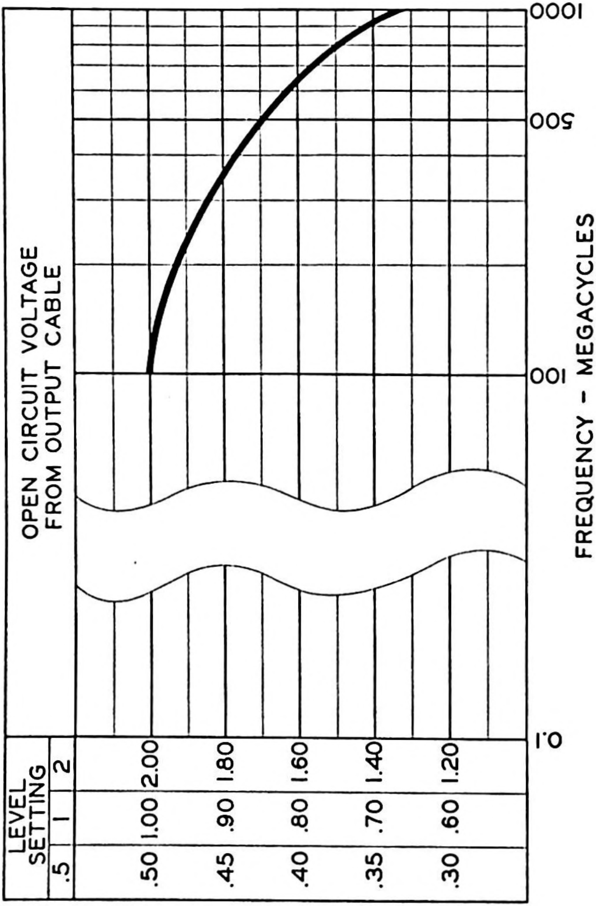


Figure 3: Frequency Correction Curve

quired to produce standard test output when applied to the input impedance of the receiver through the dummy antenna impedance. For a system consisting of a 50 ohm input transmission line and a receiver with a 50 ohm input impedance this means that a "one microvolt receiver" will produce standard output when 1μv is applied across the series combination of the 50 ohms antenna impedance and the 50 ohm input

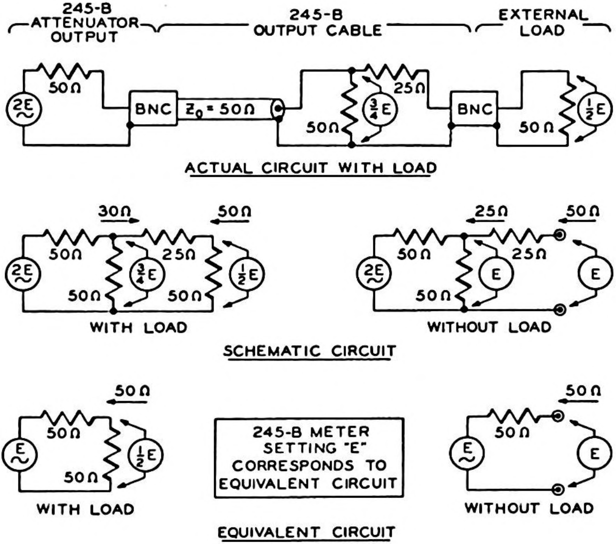


Figure 4. Derivation Of Equivalent Circuit Of RF Voltage Standard Output System Assuming A Matched Load.

impedance of the receiver. This yields 0.5 μv across the receiver input terminals.

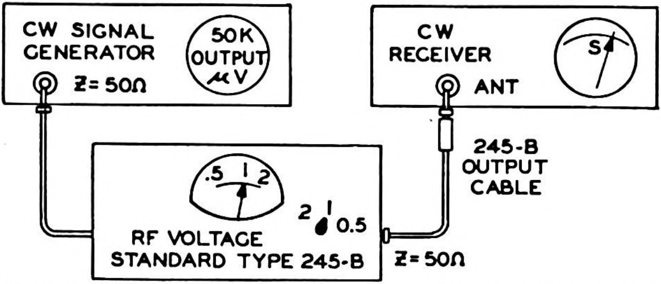
Figure 4 shows how this condition is met by the voltage calibration and output impedance characteristics of the RF Voltage Standard Type 245-B when the input voltage is adjusted to produce an indication of 1μv. The actual circuit can be reduced to the schematic circuit shown because the characteristic impedance of the cable is matched at the voltage source. Under this condition, the length of cable becomes indeterminant and can be considered zero. The diagrams show the distribution of voltages and impedances along the schematic circuits for the loaded and open circuit conditions when the RF Voltage Standard indicates E μv output. The lower set of diagrams shows how the voltage and impedance conditions described above are met by the equivalent circuit.

MEASURING SIGNAL GENERATOR OUTPUT

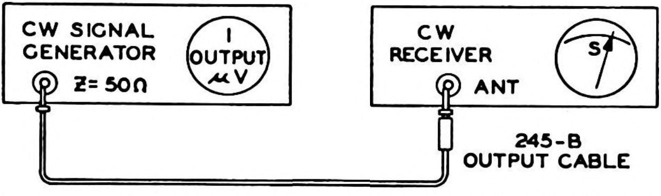
The use of the RF Voltage Standard to measure the output from a signal generator is based on using a receiver as an uncalibrated transfer indicator to compare the outputs from the two sources at a fixed signal level. The receiver used must have good sensitivity, some type of carrier level meter which can be used as an uncalibrated reference, and must remain stable in frequency and sensitivity on a short term basis.

In Figure 5-a the high level input from a 50 ohm signal generator is precisely monitored and accurately attenuated to produce a known open circuit voltage at the output cable of the RF Voltage Standard. In Figure 5-b the output cable is then connected to the 50 ohm output jack of the signal generator. When the signal generator output is adjusted to produce the same receiver indication as was obtained with the RF Voltage Standard, the signal generator will be delivering the same open circuit voltage at the end of the 50 ohm terminated cable as was delivered by the RF Voltage Standard. This value of output voltage is obtained from the calibration curve given in Figure 3.

The method here shown, in which the same output cable is switched from the RF Voltage Standard to the signal gen-



RF voltage at high level is obtained from the signal generator and adjusted to give the desired output. The attenuated output is picked up on a receiver and a reference reading noted. Calibration is in terms of open circuit voltage at the end of the output cable.



The low level output of the signal generator is adjusted to produce the same reference level reading on the receiver as was produced by the known low level output from the RF voltage standard.

Figure 5. Measurement Of 50 ohm Signal Generator Output At The 1 μV Level.

erator output jack is valid only for signal generators having a 50 ohm source impedance at the panel output jack. Some signal generators, however, present 50 ohms only at the output end of their own special 50 ohm terminated output cable. In this case the receiver input itself must be transferred from the output cable on the RF Voltage Standard to the terminals of the output cable on the signal generator. Only in this way will the comparison include standing waves on the signal generator output system as well as cable losses.

In case the signal generator has a source impedance of 50 ohms, it is not necessary that the receiver input impedance be matched to the signal generator output impedance to obtain a valid comparative reading. Since the two sources of voltage present the same impedance, it is necessary only that the receiver input impedance remain constant, at whatever value it may have, throughout the comparison process. If the signal generator source impedance is not 50 ohms, corrections must be made to the comparative readings as outlined under the section Interpretation of Results.

USE WITH AM GENERATOR

In some cases it may not be possible to obtain a receiver with a meter which indicates relative signal strength. In this case an ac meter may be used to indicate the audio output of an a-m receiver with amplitude modulation of the carrier. Provided the modulation is held constant, the receiver is reliably stable, and the avc system is not holding the output level constant, this indication of audio output can be used to indicate relative signal strength.

There is one precaution in the use of modulation with the RF Voltage Standard Type 245-B: the rf voltmeter is a square law detector and responds to total power. When the carrier is modulated the total effective power is increased and the meter on the 245-B will read higher than it should. For low percentages this is negligible as shown in the table below:

Percent Modulation	Percent Error
10	0.2
20	0.9
30	2.0
40	3.8
50	6.0
60	8.5

Table 1.

Percent By Which The Average Carrier Is Below The Level Indicated By The RF Voltage Standard For An Amplitude Modulated Signal.

DIRECT HIGH LEVEL MEASUREMENTS

The voltmeter and attenuator system of the RF Voltage Standard is shown in Figure 6. It contains a length of coaxial cable which connects the source of rf power to the coaxial "head" which consists of a diode voltmeter in parallel with the input to the precision coaxial attenuator.

The diode voltmeter reads the input voltage directly at the input to the attenuator, and the output calibration of the RF Voltage Standard is not affected by standing waves on the cable or losses ahead of this point. The output calibration includes corrections for losses in the output cable beyond the voltmeter.

However, when using the 245-B as an input voltmeter, there must be added to the above corrections the losses in the input cable ahead of the voltmeter. The ratio for each coaxial attenuator is individually determined, and the correct input voltage including the cable loss for the 1 μv level meter setting is given on the input data calibration plate on top of the instrument. This information can be used for checking the calibration of the RF Voltage Standard at 1 mc and for measuring RF input voltages up to 300 mc.

With the *range switch* in the 1 μv position, the input voltage is increased until the meter indicates 1 μv. The input voltage

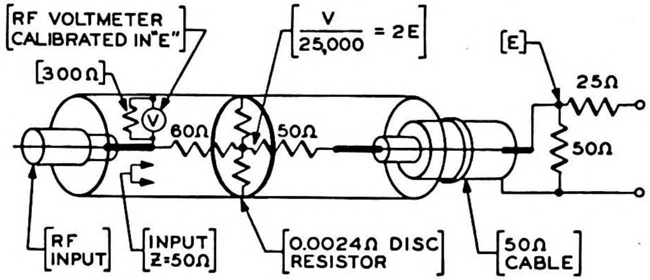


Figure 6. RF Attenuator and Voltmeter

is then equal to the value stamped on the data plate within the tolerances given in the specifications. Input voltages of ½ and 2 times this value can be determined by adjusting the input for meter indications of 0.5 and 2 with the *range switch* in the corresponding positions.

PRECAUTIONS

Several points of technique in handling low level radio frequencies become of particular importance when checking the output of a signal generator. RF leakage out of the signal generator, sometimes along the power cord, will cause trouble if the receiver is not well shielded. Likewise, interfering signals from adjacent equipment or broadcast transmitters will affect poorly shielded receivers and prevent accurate measurements.

The conditions of impedance match and corrections for standing waves on output cables must be accounted for before the performance of a signal generator can be evaluated. The connection between the output cables from the RF Voltage Standard and the signal generator to the receiver input should be as short as possible. The insertion loss of any matching pads must be included in the comparison.

Since the diode voltmeter in the RF Voltage Standard rectifies all power coming out of the signal generator, including harmonics, excessive distortion will introduce errors if the receiver does not also accept all of the energy put out by the signal generator.

Sharp receiver response will cause critical tuning and stability problems, and will pass only the low frequency components of the noise which make the meter bounce. A wider pass band will produce a higher but much steadier noise level to which the desired signal is added.

Always check the signal generator tuning when going from the condition of high level into the RF Voltage Standard to low level into the receiver. It is sometimes advisable to retune the signal generator frequency each time the low level output is readjusted in order to get significant results.

Line voltage fluctuations during a comparison test will sometimes cause different receiver sensitivities and thereby invalidate the measurements.

When first placing the RF Voltage Standard in operation, it is advisable to recheck the *set full scale* and *set zero* positions occasionally. Initial drift can be caused by changes in battery voltage when the instrument is first turned on and by changes in the resistance of the transistor due to a sudden change in temperature, such as bringing the instrument from storage into a warm laboratory. There is no significant heat developed inside the instrument. Readjusting the *set full scale* and *set zero controls* restores the calibration accuracy of the instrument even though the transistor and diode dc resistances may have changed.

SECTION III
INTERPRETATION OF RESULTS

SIGNIFICANCE OF OUTPUT READINGS

The equivalent circuit diagrams in Figure 3 show that the same loaded and open circuit characteristics of voltage and impedance will be presented to the load if a simple series circuit is assumed consisting of an rf generator in series with 50 ohms. The result could have been obtained directly by application of Thevenin's Theorem to the original circuit.

The sensitivity of a receiver designed to work with a 50 ohm antenna line impedance can therefore be read directly from the calibration curve at 0.5, 1, and 2 μv because the equivalent source impedance of the RF Voltage Standard provides the 50 ohms dummy antenna impedance through which 0.5, 1 or 2 μv are applied.

If higher values of antenna resistance are involved, direct readings of receiver sensitivity can be obtained by merely adding in series with the output cable a suitably mounted, non-reactive resistor whose resistance is equal to the desired antenna resistance minus the 50 ohms already presented by the RF Voltage Standard. For example: to read directly the sensitivity of a receiver designed to work from a 75 ohm line, such as RG-11/U, a 25 ohm resistor must be added in series with the inner conductor at the BNC output jack on the output cable to obtain the correct impedance match. If values of antenna resistance less than 50 ohms are involved, it is necessary to use an impedance matching pad and allow for insertion loss.

Interpreting the meaning of signal generator output readings becomes more difficult for a signal generator whose output impedance cannot be made the same as the reference standard by suitable resistive pads, as shown in Figure 7 or whose output cable system sets up standing waves at critical frequencies. The same problem is routinely present in the use of such a signal generator for receiver sensitivity measurements. The necessary information to make these corrections is given in some detail in catalogues and instruction manuals by the major manufacturers of signal generators.

Figure 8 shows a case in which the impedance of the RF Voltage Standard, the signal generator and the receiver are

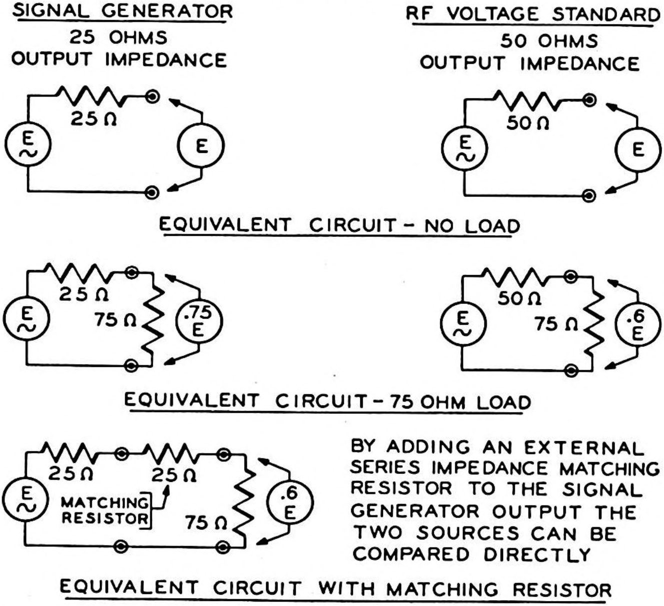


Figure 7. Comparison Of Voltage Output From Unequal Source Impedances By Addition Of An External Impedance Matching Resistor.

50 ohms, 300 ohms and 150 ohms respectively. The general equation shown in the figure gives the number of open circuit microvolts out of the signal generator for any combination of impedances in terms of the indicated output level of the RF Voltage Standard output cable as read from the calibration curve.

The presence of standing waves in the output system of a signal generator that is not matched internally will produce errors in calibration which must be accounted for by using data supplied in the signal generator instruction manual. These errors are a function of frequency and must be taken into account at each frequency setting.

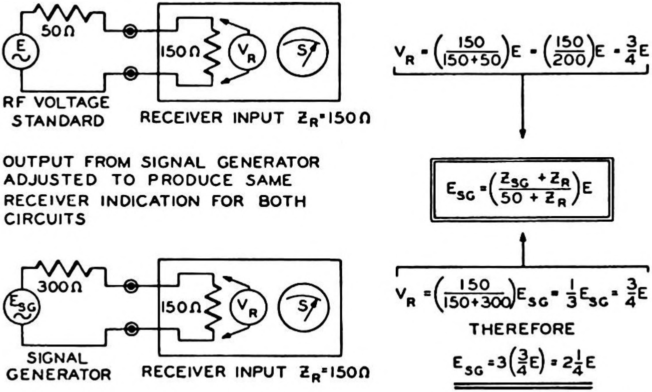


Figure 8. Signal Generator Output Determination When All Three Impedances Are Different.

The following steps should be used in checking the signal generator output:

1. Determine the output impedance characteristics of the signal generator being measured.

2. Attempt to modify the output impedance to 50 ohms by the use of pads or dummy antenna systems, taking into account their effect on the calibration due to attenuation characteristics.

3. If the output impedance cannot be made 50 ohms, determine the complex impedance of *both* the receiver and the signal generator and calculate the resulting voltage divider.

4. Since the voltage into the receiver is the same when the signal generator output is adjusted to give the same receiver reading as the RF Voltage Standard, we can equate the two expressions as follows:

$$\left(\frac{Z_r}{Z_r + Z_{sg}}\right) E_{sg} = \left(\frac{Z_r}{Z_r + 50}\right) E$$

where Z_r = receiver input impedance
Z_{sg} = signal generator output impedance
50 = RF Voltage Standard output impedance
E_{sg} = signal generator open circuit voltage
E = RF Voltage Standard open circuit voltage.

Now the open circuit signal generator output, E_{sg}, which will produce the same receiver response as the output of the RF Voltage Standard, E, can be determined from the equation

$$E_{sg} = \left(\frac{Z_r + Z_{sg}}{Z_r + 50}\right) E$$

SOURCES OF MEASUREMENT ERROR

In addition to a source of error resulting from an unavoidable impedance mismatch, listed below are other sources of error in this type of transfer measurement.

Cable Length: Solid dielectric coaxial cables present surprisingly large percentage losses above several hundred megacycles. Errors in output voltage will result if other than the specified output cable is used.

Temperature: The 0.0024 ohm silver resistor has a temperature coefficient of resistance which will cause a 1% increase in output voltage for each 6°F above 73°F.

Noise Bandwidth: A secondary source of error is also caused by the output impedance of the generator. If a broad band system is used as a detector, the effective thermal noise output of the source impedance can be of a significant magnitude. For example, if the detector system has a 1 mc bandwidth, a 50 ohm output impedance would generate 0.897 μv. If the output impedance were changed to 52.3 ohms, the thermal noise would be 0.918 μv, or 2.3% error. Different source impedances therefore actually generate different open circuit voltages as measured by a broad band detector. The difference in noise level is proportional to the bandwidth, and would be negligible in most receivers.

Generator DC Resistance: The dc resistance of the signal generator used to drive the RF Voltage Standard is part of the dc current return path for the diode voltmeter. The instrument is calibrated for operation with a generator having 50 ohms dc resistance. This value may vary from 20 to several hundred ohms but radical departures from 50 ohms, such as 0 or infinity, can cause as much as 5% error in the voltmeter calibration.

Generator Leakage: Leakage from the signal generator can cause a serious error in the results. Any signal entering the receiver input from the signal generator which did not come through the RF Voltage Standard attenuator system would make the receiver read high and give an improper reference. If this leakage is independent of the signal generator attenuator setting, a simple test can be made—

With the signal generator feeding the RF Voltage Standard which in turn feeds the receiver, reduce the generator output to a minimum. Then shift the generator frequency. If shifting the frequency does not affect the "S" meter, leakage is probably not present. Some generators, however, may leak only when the attenuator is turned near maximum output and this would not be revealed by such a simple check.

The input cable of the RF Voltage Standard uses double-shielded coaxial cable because it has been found that single-shielded cable allows excessive leakage. If it is necessary to use a longer extension to connect to the input cable, a double-shielded cable should be used.

Distortion: An error can be expected if the signal generator in use has a high percentage of distortion or other spurious signals. The rf voltmeter of the RF Voltage Standard measures the total power and not just the power in the desired carrier. Since it would be meaningless to accurately calibrate a highly distorted voltage, this effect is not likely to enter into most measurements.

SECTION IV
THEORY OF OPERATION

VOLTAGE MEASUREMENT AND ATTENUATION

Figure 6 shows the circuit diagram of the rf portion of the attenuator and output cable system of the RF Voltage Standard. Figure 4 shows the distribution of voltages along this cable system under various load conditions and the resulting equivalent circuit from the rf attenuator output to the end of the output cable. At the 1 μv level setting an input level of 0.05 v. is established across the input to the coaxial attenuator by adjusting the voltage output of the external rf voltage source until the indicating meter on the RF Voltage Standard reads at the *1* calibration point on the meter scale with the range switch set to 1 μv. The 25,000: 1 coaxial attenuator divides the 0.05v down to 2 μv which appears across the 0.0024 ohm resistor in series with the 50 ohm impedance matching resistor. At frequencies above 100 megacycles the voltage at the output from the cable is less than the voltage out of the attenuator by the amount of the losses in the output cable.

Since the 50 ohm characteristic impedance of the output cable is matched by the 50 ohm source impedance, its length is electrically indeterminant as mentioned before and the 50 ohm cable terminating resistor is effectively connected to ground directly from the 50 ohm impedance matching resistor in the rf assembly. This divides down the 2 μv delivered by the coaxial attenuator to 1 μv across the 50 ohm cable terminating resistor.

RF VOLTMETER

The input voltage to the attenuator is monitored by a 1N173 semi-conductor diode. The simplified circuit of Figure

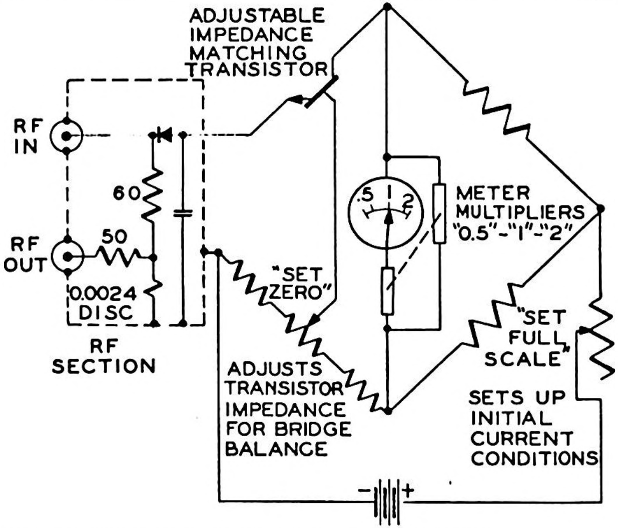


Figure 9. RF Voltage Standard—Basic Circuit.

9 shows the basic dc metering system associated with the rf voltmeter.

The frequency correction curve, Figure 3, makes possible accurate measurements at frequencies between 100 mc and 1000 mc where the series resonance begins to increase the voltmeter response to the applied voltage.

Tests have shown that the rectification efficiency or ratio of dc current to applied ac voltages of a semi-conductor diode at a controlled value of bias current is a very stable characteristic. The justified reputation for instability of semi-conductor components is due to changes in resistance which change the average current, or operating point on the rectification curve for a given applied voltage. As long as the average current remains constant and large compared to the rectified component, a given value of rf voltage will produce a constant amount of direct current even though the resistance of the diode may have changed due to temperature or other effects. In the RF Voltage Standard, the bias current is always set at the same value during initial adjustment procedure by means of the *set full scale control,* and therefore the rectification efficiency is a very stable characteristic of the system.

A common base transistor is used in conjunction with the diode to raise the impedance level presented to the meter to obtain proper damping. The diode current passes through the

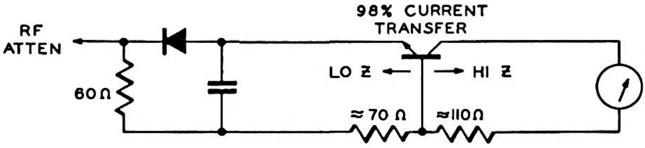


Figure 10. Transistor As Impedance Transformer.

junction transistor with a constant efficiency of about 98% regardless of resistance changes. This current transfer factor, known as "alpha," is very stable and therefore does not contribute any significant variation in accuracy. The transistor's function is analagous to that of a grounded grid amplifier in which the current is kept constant while the impedance transformation occurs.[2] The result is that the crystal works into a suitably low resistance and the meter sees only a high impedance.

DC METERING CIRCUITS

In order to realize the greatest calibration accuracy, each range has only one calibration point. This allows the use of separately adjustable trimming resistors to bring the meter multiplier on each range to the exact value regardless of the individual meter nonlinearity and attenuator variations.

MICROPOTENTIOMETER TYPE ATTENUATOR

The basic attenuator system consists of a 60 ohm resistor in series with a .0024 ohm resistor. This gives a voltage division of 25,000: to 1. There is a 50 ohm resistor in series with the output to give a 50 ohm output impedance.

The .0024 ohm resistor is in the form of a concentric disc consisting of a very thin film of silver on a ceramic disc. The disc resistor element is approximately 40×10^{-6} inches thick and is therefore less than half the thickness of the skin depth at 1000 mc. As a result of this characteristic, the current always flows uniformly through the film from dc up to 1000 mc, and the series resistance of the disc will be the same as the dc value at all frequencies in the range of the instrument. The concentric construction of the disc assures a minimum value of series inductance and for all practical purposes the impedance at dc

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[2] *"Principles of Transistor Circuits"—Richard F. Shea (John Wiley & Sons, 1953) p. 51.*

and 1000 mc are the same. A thorough discussion of this type of element is given in a paper by M. C. Selby of the National Bureau of Standards.[3]

RF RESISTORS IN A UNIFORM TRANSMISSION LINE

The 60 ohm series resistor is a very thin evaporated metal film on a glass rod. This is enclosed in a metal tube of a suitable diameter. It can be considered a coaxial transmission line whose center conductor is resistive. By using the proper design constants this line will be 60 ohms, and have a very low vswr up to 1000 mc.[4] The .0024 ohm disc resistor is placed as a short circuit at the end of the line.

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[3] *"Accurate Radio Frequency Microvoltages," M. C. Selby—Transactions AIEE, May, 1953.*

[4] *"Radio Frequency Resistors As Uniform Transmission Lines," D. R. Crosby and C. H. Pennypacker—Proc. IRE, Feb. 1946, p. 62P.*

SECTION V
CALIBRATION

FACTORY METHODS

The 60 ohm film resistor together with the 0.0024 ohm disc resistor form an accurate attenuator whose actual ratio is carefully determined and taken into account in setting up the voltage into the attenuator at a low frequency. The meter is adjusted to read the desired output voltage. The uniformity of the attenuation ratio among production units is determined by comparing each unit against a carefully measured standard unit at several points over a wide frequency range.

The instruments are adjusted to indicate directly the voltage at the end of the output cable with no load attached, over the frequency range of 0.1 mc to 100 mc. Outside of this range the frequency correction curve should be used.

The long term accuracy, which is of considerably more importance and upon which the specifications are based, includes the stability of several components not involved in the initial calibration. A circuit has been chosen in which these variations are minimized by the procedure used to place the instrument in operation.

FIELD CALIBRATION

Should it be desired to check the input voltmeter, the input voltage and resistance into the cable is given for the 1 μv setting at 1 mc and approximately 100 mc. This information appears on the Data Plate of the instrument. It is best that the check be made at 1 mc. The voltage given is the voltage required at the input to the cable to bring the meter from zero to 1.0 μv. All corrections have been included in the values on the Data Plate. If one desires to check 2 μv or ½ μv, the voltages required are respectively 2 times or ½ the 1.0 μv value.

SECTION VI
FACTORY RECALIBRATION SERVICE

REQUIREMENT FOR FACTORY RECALIBRATION.

The RF Voltage Standard Type 245-B is frequently used as a standard of calibration and inspection. The instruments are carefully calibrated before leaving our factory and our tests indicate that the calibration is dependable for a considerable period of time. If indications of calibration errors occur or if policy dictates periodic recalibration the instrument may be returned to the factory for recalibration service.

AVAILABILITY OF RECALIBRATED INSTRUMENTS FOR EXCHANGE.

Under some conditions periodic recalibration of an inspection standard is required even though no visible evidence of calibration error appears. To fulfill our responsibility in this matter we have established an inventory of recalibrated instruments at the factory. These instruments, properly calibrated and in first class condition, are available as replacements for any customer's instrument under conditions discussed below. This service is made available in the case of the RF Voltage Standard in addition to our normal repair and recalibration service because of the special nature of the instrument's application.

PROCEDURE FOR OBTAINING REPLACEMENT RECALIBRATED INSTRUMENTS.

To obtain replacement recalibrated instrument order "Type 245-B Recalibrated" for delivery on the date when you require a recalibration of your instrument. The factory will establish a price for this service from time to time. Delivery will be made in accordance with your requirements. Within five days of receipt of the factory recalibrated instrument your instrument must be returned to the factory and becomes the property of the factory.

SECTION VII
BATTERY REPLACEMENT

When the point is reached where it is no longer possible to adjust the meter to full scale in *set full scale position,* it will be necessary to replace the batteries.

Remove the rear cover by removing the four screws which are in the corners of the rear cover. They can be removed with the fingers once the keeper plate has been taken off. The keeper plate is held down by two elastic stop nuts.

The two new mercury batteries (General-696 or Eveready E-233) can be pushed into the clips with the fingers. Tighten these only firmly enough to prevent looseness. Do not crush the batteries.

Replace the rear cover, being sure that it is right side up and that the battery wires are not crushed.

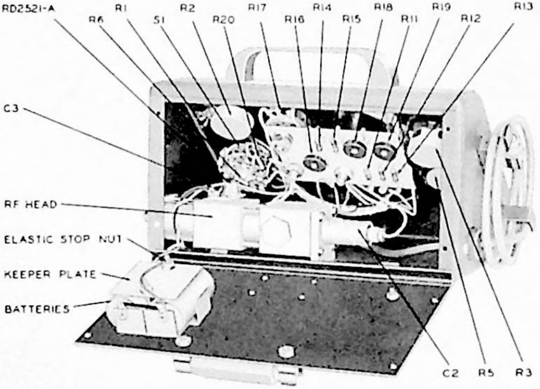
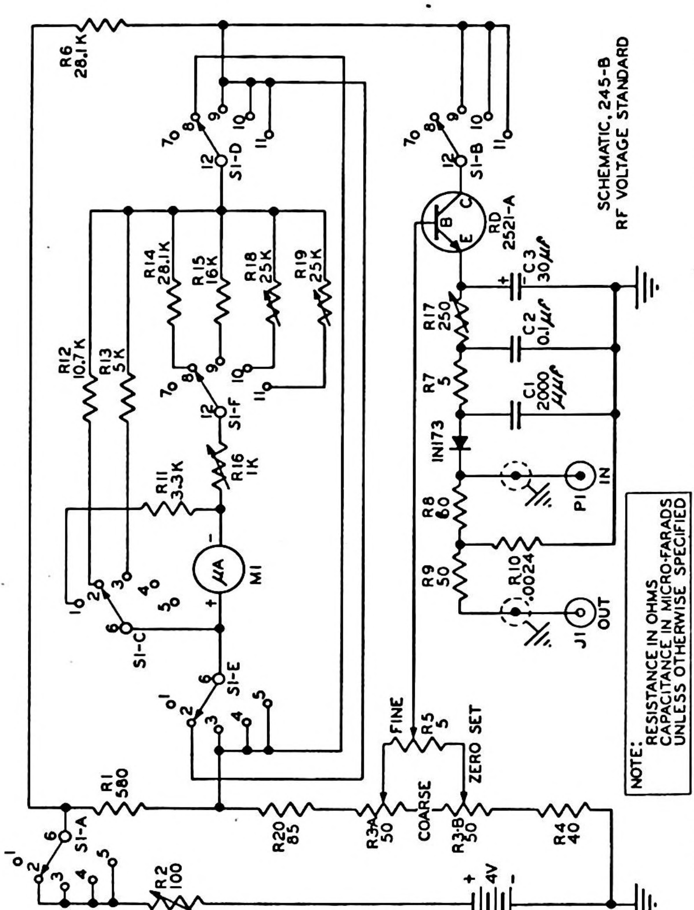


Figure 11. Interior View—Component Layout, Including Mounting Of Batteries.

ELECTRICAL PARTS

RF VOLTAGE STANDARD TYPE 245-B

Circuit Symbol	Value	Description	BRC Part No.
R1	580 Ω	Res. Fixed 1/2W ±1%	80169
R2	100 Ω	Res. Var. ±10%	A81031
R3	50 Ω	Res. Var. Dual	A81029
R4	40.0 Ω	Res. Fixed 1/2W ±1%	80132
R5	5 Ω	Res. Var.	A81030
R6	28.1 KΩ	Res. Fixed 1/2W ±1%	80400
R7	5 Ω	Res. Fixed 1/4W ±5%	80047
R8	60 Ω	Res. Fixed 1/2W ±1% no spiral, EC coat	A80728
R9	50 Ω	Res. Fixed 1/2W ±1%	A80050
R10	.0024 Ω	Res. Fixed Ceramic Disc	A303433
R11	3300 Ω	Res. Fixed 1/2W ±10%	80280
R12	10.7 KΩ	Res. Fixed 1/2W ±1%	80319
R13	5 KΩ	Res. Fixed 1/2W ±1%	80302
R14	28.1 KΩ	Res. Fixed 1/2W ±1%	80400
R15	16 KΩ	Res. Fixed 1/2W ±1%	80323
R16	1 KΩ	Res. Var.	A81121
R17	250 Ω	Res. Var.	A81127
R18	25 KΩ	Res. Var.	A81420
R19	25 KΩ	Res. Var.	A81420
R20	85.0 Ω	Res. Fixed 1/2W ±1%	80134
C1	2000 μμf	Cap. Fixed Silver Button Mica	82319
C2	.1 uf	Cap. Fixed 250 VAC	83096
C3	30 μf	Cap. Fixed 6 WV	83098
S1		Switch, Rotary	A303355
M1	0-20 MA	Meter	B303325
		Transistor RD2521A	303425
		1N173 Mixer Diode	303454
		Mercury Battery, 3.9 Volt (Eveready E-233 or General 696) 1 Dia. x 1.960 Long (2) Reqd.	303440



SCHEMATIC DIAGRAM — VOLTAGE STANDARD TYPE 245-B