rf millivolter

Model RF 801

HELPER INSTRUMENTS COMPANY
P.O. BOX 3628 / INDIALANTIC, FLORIDA 32903
(305) 777-1440

INSTRUCTION MANUAL

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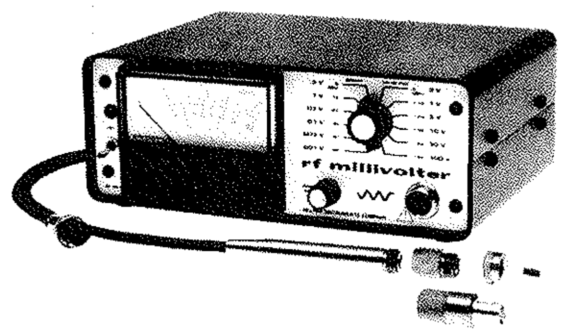
Model RF 801



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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual, violates safety standards of design, manufacture, and intended use of the instrument. Manufacturer/Vendor assumes no liability for the user's failure to comply with these requirements.

EARTH THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical earth. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into a three-pole mains socket with earth or used with a three-pole to a two-pole adaptor with the earth wire (green/yellow) firmly connected to an electrical earth at the power outlet. The power inlet and mating connector of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation is present.

OBEY STRICTLY ALL WARNINGS IN THE FOLLOWING PAGES

Dangerous voltages, capable of causing death, are present in this instrument.

Use extreme caution when handling, testing, and adjusting.

IMPORTANT

Before even applying power to your R.F. MILLIVOLTER™, please take the time to study this manual thoroughly. R.F. Voltage measurements require special techniques to obtain meaningful measurements. Further, R.F. probes are quite costly and easily damaged by misuse. **NO WARRANTY CLAIMS WILL BE HONORED ON R.F. PROBES SUBJECTED TO MISUSE.**

THE BASIC PROBE ON THIS INSTRUMENT HAS A MAXIMUM RATING OF 5 VOLTS PEAK A.C. AND 150 VOLTS D.C. EXCEEDING THESE RATINGS MAY RESULT IN SERIOUS DAMAGE TO THE PROBE. THE 50 dB ADAPTOR HAS A MAXIMUM RATING OF 150 VOLTS PEAK A.C. AND 150 VOLTS D.C.

Do not attempt to solder to the probe tip. The heat involved may ruin the tip diodes, and may loosen the tip. R & D labs which have a need to fasten the probe in place for repeated readings should use a tip jack. These jacks, available in packets of 10, may be soldered to the circuit to be measured, and the tip plugged into the jack after soldering.

OPERATOR'S INSTRUCTIONS

OPERATING CONTROLS AND INDICATORS:

a. POWER SWITCH: Controls both AC power mains and DC (battery)input.

b. RANGE SWITCH: 6 direct ranges from .001 Volts (1000 microvolts) to .3 Volts full scale, and 6 ranges from .3 Volts to 100 Volts with 50 dB pad (voltage divider). DB markings on the range switch indicate the dBm level required to obtain a meter deflection to the 0 dBm scale marking. The dBm calibrations refer to the power that would be developed by the measured voltage if applied to a 50 ohm load, with 0 dBm referenced to 1 milliwatt at 50 ohms.

c. ZERO SET: The zero set control is used to set the reading of the MILLIVOLTER™ to zero meter deflection when no input voltage is being supplied to the probe. It is not necessary to set the zero control on the three highest voltage scales.

OPERATING PROCEDURES:

POWER SUPPLY:

The instrument operates from either a 117 Volt 50/60 Hz supply, a 240 Volt 50/60 Hz supply, or a 13.5 Volt D.C., negative ground automotive power supply.

For A.C. operation, the choice between 117 and 240 Volts operation is made by internal jumper wires. Unless otherwise specifically ordered, instruments delivered in North America are wired at the factory for 117 Volts A.C. and instruments delivered in UK/Europe for 220/240 Volts A.C. Before attempting to operate the unit on 240 Volts A.C., check to be certain that the proper jumpers are in place.

For D.C. operation, a 13.5 Volt D.C. automotive, negative ground supply may be connected to the instrument using the connector supplied. When operated on D.C., the instrument case and the probe case are at the negative ground potential. For this reason, do not attempt to use the instrument on a positive grounded system, and be certain that the chassis (or common) of the equipment being tested is (or can be) connected to the negative ground of the vehicle.

WARNING: **THE METAL HOUSING OF THE PROBE IS ELECTRICALLY GROUNDED TO THE METAL INSTRUMENT HOUSING, AND BOTH ARE ELECTRICALLY GROUNDED TO THE GROUNDING CONDUCTOR ON THE THREE CONDUCTOR POWER CORD. BE SURE THAT EQUIPMENT UNDER TEST HAS ITS CHASSIS (COMMON) AT GROUND POTENTIAL. AN ISOLATING LINE TRANSFORMER MAY BE NEEDED TO SUPPLY POWER TO EQUIPMENT UNDER TEST.**

WARNING: **TO AVOID THE POSSIBILITY OF EXCEEDING THE VOLTAGE RATINGS OF THE PROBE, ALWAYS CONNECT THE PROBE GROUNDING LEAD TO THE CHASSIS (COMMON) OF THE EQUIPMENT UNDER TEST BEFORE TOUCHING THE PROBE TIP TO ANY PORTION OF THE EQUIPMENT UNDER TEST.**

The grounding lead is important because power line filtering capacitors on some equipment may cause the equipment chassis to have an A.C. voltage approaching the power line voltage. In some cases, where the equipment chassis is not connected to any ground, static charges of very high voltage can accumulate.

WARNING: **THE BASIC PROBE ON THIS INSTRUMENT HAS A MAXIMUM RATING OF 5 VOLTS PEAK A.C. AND 50 VOLTS D.C., EXCEEDING THESE RATINGS MAY RESULT IN SERIOUS DAMAGE TO THE PROBE. THE 50 dB ADAPTER HAS A MAXIMUM RATING OF 150 VOLTS PEAK A.C. and 150 VOLTS D.C.**

USE OF THE PROBE ACCESSORIES:

Probe accessories supplied with the instrument are:

1. A 50 ohm terminated, BNC probe adaptor.
2. A 50 dB capacitive voltage divider.
3. A probe cap.

The probe and its accessories are shown in Figure 1.

When using the probe directly, the probe cap must be screwed onto the end of the probe. The probe cap must be tightened firmly onto the probe. Tighten the cap by hand only. . .do not use pliers.

To use the 50 dB voltage divider, remove the probe cap from the probe, and screw the 50 dB adaptor onto the probe. Then screw the probe cap onto the end of the adaptor. The voltage divider, and the probe cap must both be firmly tightened in place. Again tighten by hand only. . .do not use pliers.

To use the 50 ohm terminated BNC adaptor, remove the probe cap from the probe, and screw the 50 ohm adaptor onto the probe. The adapter must be firmly tightened in place. Tighten by hand only. . .do not use pliers. When using to 50 dB adaptor, full scale ranges for both volts and dB are given by the range switch markings to the right.

The terminated BNC adaptor is limited to a power dissipation of .25 watts, which corresponds to 3.5 Volts RMS at 50 ohms. Do not exceed the power rating of the adapter.

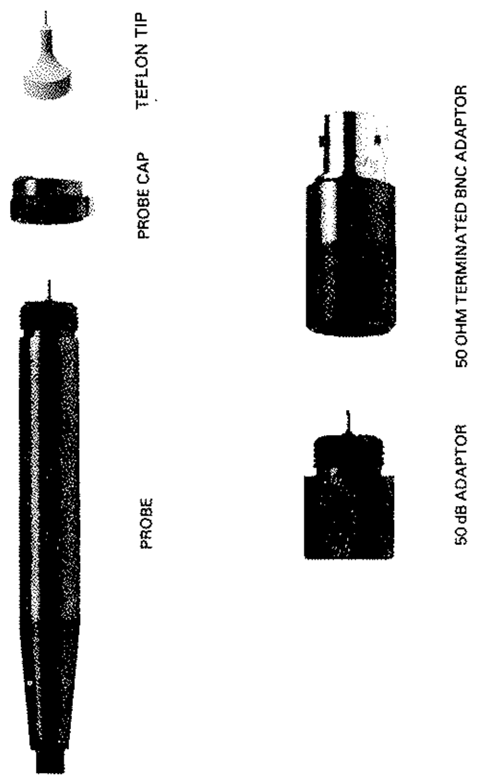


FIGURE 1

OPERATOR'S INSTRUCTIONS (Cont'd)

START UP AND ZERO SET PROCEDURE:

Plug the probe cable connector into the probe receptacle on the front of the R. F. MILLIVOLTER™. Then, plug the power cable into a suitable power source. (It is best to attach the probe connector before any power is supplied to the instrument. This protects the probe from possible transients.)

Turn the range switch to the .001 Volt position. If the instrument has been turned on, the meter indicator may swing rapidly from one side to the other, or may go off scale in one direction or the other.

After about 30 seconds, turn the "zero set" control as necessary to bring the meter indicator to the left hand mark of the meter scale. The "zero set" is a multi-turn control.

It may take one or two minutes for the setting to stabilize. As soon as the setting remains stable, you are ready to make measurements. It is not necessary to adjust the zero set on the three highest voltage scales. Fluctuations of the meter needle on the .001 Volt scale are normal as a result of noise. These variations are more noticeable with no voltage input to the instrument than they are when voltages above the 300 microvolts minimum reading level are being measured.

If you are making measurements on the .001 Volt Scale, be sure to check the meter zero setting from time to time. On the higher scales, the zero setting is not likely to change over reasonable periods of time.

MEASUREMENT PROCEDURE:

IMPORTANT

BEFORE MAKING ANY CONNECTIONS TO THE EQUIPMENT BEING TESTED, READ THE THREE WARNING PARAGRAPHS BEGINNING ON PAGE 2. R.F. PROBES ARE NECESSARILY DELICATE IN NATURE, AND WARRANTY DOES NOT COVER DAMAGE DUE TO EXCESSIVE VOLTAGES.

1. To make a measurement with MILLIVOLTER™, first connect the probe grounding wire to the ground of the equipment being tested.

2. Estimate the amount of R.F. voltage at the point to be measured and switch the MILLIVOLTER™ to the appropriate scale. If the expected voltage is above .3 Volts (the top scale of the MILLIVOLTER™) use the 50 dB adaptor.

NOTE

As long as the voltage rating of the probe is not exceeded, no damage will be caused to the MILLIVOLTER™ by having it switched to a scale too low for the voltage measured.

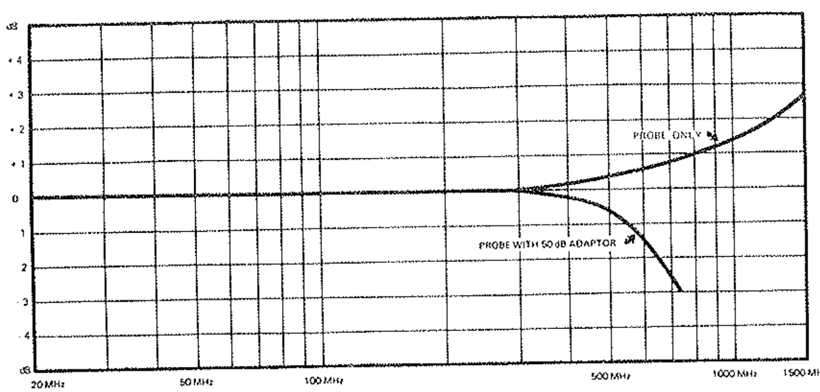
3. When measuring high frequency R.F. voltages, it is important to obtain a very short ground from the circuit being measured to the probe. This is accomplished by touching the ground end of the probe to the equipment ground as closely as possible to the point being measured. Obtaining a short and direct ground to the probe is very important to accurate readings, and the importance increases as the frequencies become higher.

   Even when measuring lower frequency circuits, failure to obtain a short and direct ground may be very important to accurate readings. A long ground circuit (such as the long ground circuit obtained when using only the flexible probe grounding lead) may cause pick-up of strong R.F. signals, such as those from nearby TV and Broadcast stations. In testing of radio receivers, the receiver local oscillator may create enough radiation to impair the accuracy of the readings obtained.

4. The correct sequence for making a voltage measurement is ground first, then touch the probe tip to the point to be measured.

FREQUENCY CORRECTIONS:

When making measurements of signals with frequencies above 300 MHz, added accuracy can be obtained by correcting your readings according to the following correction charts. The charts show the number of decibels by which the voltmeter readings will be above, or below, the correct value as a result of frequency errors in the probe and in the 50 dB adaptor. Subtract (algebraically) the amount shown on the chart from the voltmeter reading to obtain the more accurate result.



FREQUENCY ERROR, R.F. MULTIVOLTER, MODEL RF 801

In general, the probe capacitance won't make much difference in higher powered transmitters, R.F. amplifiers, and in measurements across a 50 ohm transmission line. Nor will it usually change things very much in typical 455 kHz I.F. systems. However, it will badly detune many circuits of the lower powered receiver amplifier stages — particularly the higher impedance tuned circuits usually associated with the collector circuits of transistor R.F. amplifiers.

This doesn't defeat getting a good measurement. If you have need for an accurate measurement, just peak up the circuit tuning adjustment for a peak reading on the R.F. Voltmeter. That compensates for the probe's capacitance while you are taking the measurement. (Naturally you want to return the tuning to its previous setting when you take the probe away.)

The R.F. probe also produces a resistive loading effect on a tuned circuit, this loading effect being about the same as a 100,000 ohm resistor. In most circuits, this resistive loading will not produce much error in reading. If you are comparing your R.F. Voltage readings on a repair job with those given in the maintenance manual, remember that the engineer that prepared the manual had to make his measurements with a probe having similar resistive loading effect!

Summarizing the loading effect of probe: The capacitance loading is the most serious of the two loading effects. Where it matters most — in sharply tuned, higher frequency, tuned circuits, it can be compensated for by tuning the circuit being measured.

USING THE MOST SENSITIVE (.001 Volt) SCALE

When using the most sensitive scale, you will notice that the meter indicator fluctuates somewhat, particularly in the zero set condition, and on the lower voltages. This condition is natural, and is caused by the statistical nature of noise. On the higher ranges, noise contribution to the reading is negligible, and the indicator is quite stable.

When using the lowest range, be sure to check the meter zero frequently, and take the meter reading as the average of the up and down fluctuations of the needle.

In addition to the noise fluctuations, measurements made on the .001 scale are more likely to be rendered inaccurate by the presence of radiated R.F. fields. Follow the probe grounding methods described earlier to minimize this type of error. In some cases, it is wise to disable the stage being measured while the probe is in place to see if the reading is caused by external sources.

STAGE GAIN MEASUREMENTS

Since stage gain measurements are often made in receiver stages with sharply tuned circuits, you can get the best measurements by using the proper procedure to compensate for the detuning effect on the probe.

OPERATOR'S INSTRUCTIONS (Cont'd)

Consider the R.F. amplifier stage shown in Figure 2. First put the probe on point "A", and retune L1 for maximum meter reading. Note that reading, then move the probe to "B". Now, retune L1 back to its former location (or simply retune it for maximum reading from point "B".) While the probe is still on point "B" slightly retune L2 for maximum reading, and take that reading. In the manner, you move on up the amplifier, from one stage to the next.

If the stage gain is given as something like "16 times", you should take your readings from the voltage calibrations on meter, divide the reading at "B" by the reading at "A", and compare with the manufacturer's figure. If the stage gain is stated in dB, you should use the dBm calibrations on the meter, and subtract the reading at "A" from the reading at "B", to compare with the manufacturer's figure.

In amplifier stage gain measurements, it is best to arrange the input signal so that the input voltage is above .001 volt (i.e., 1000 microvolts). This avoids taking measurements, on the lower part of the lowest scale, thereby avoiding the reading uncertainty caused by noise fluctuations. If the circuit is part of an AGC loop, you must take the measurements at the level specified by the manufacturer, because higher levels will actuate the AGC controlled bias, thereby reducing the gain of the amplifier. (In which case the manufacturer will probably specify adequately large signal levels for making the measurement — after all, he had to make the same measurements to print the data!)

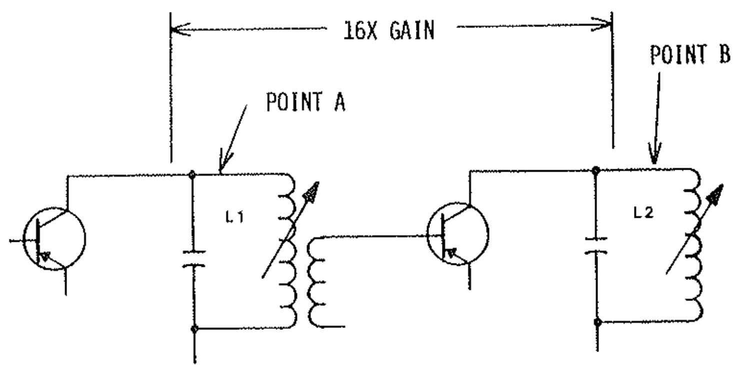
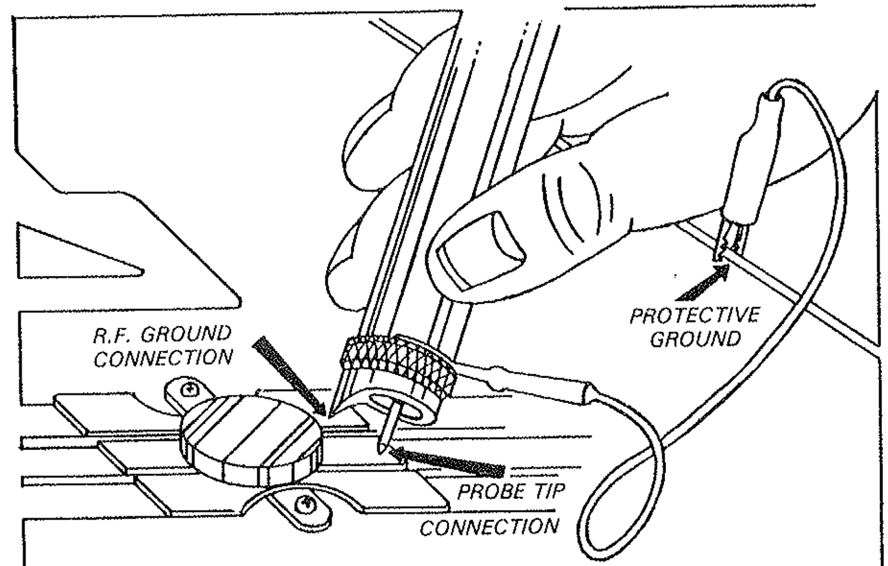
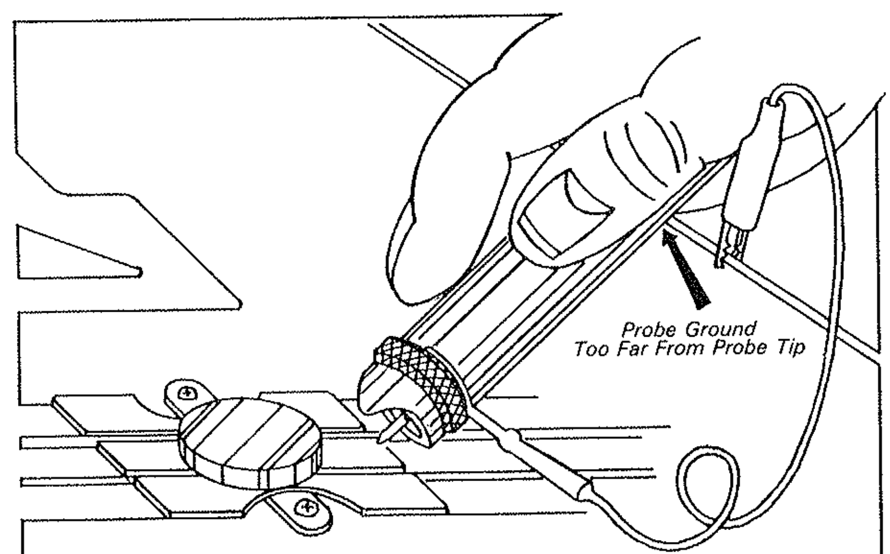


FIGURE 2, STAGE GAIN MEASUREMENTS



PROPER GROUNDING TECHNIQUE

FIGURE 3



POOR GROUNDING TECHNIQUE

FIGURE 4

GETTING THE MOST FROM YOUR R.F. MILLIVOLTER™

Don't expect to use an R.F. Voltmeter as casually as you use an ordinary D.C. or audio voltmeter. Since you are measuring R.F., your connections to the circuit being tested must take into account the characteristics of R.F. The engineer that designed the equipment you are testing went to a lot of trouble to keep all of the R.F. signal leads direct and short. You must do the same when making connection to the R.F. probe.

It isn't enough to get a direct connection to the probe tip — you also need a short, direct, connection to the probe ground. The higher the frequency, the more important these precautions become. Above about 300 MHz, it is important to keep the connection very short. The tip of the probe should contact the point being tested, and the ground end of the probe should contact the equipment ground (i.e., the chassis, or common, circuit) in the immediate vicinity.

Figure 3 shows one way to get a short connection to both the probe tip and the probe ground.

Figure 4 shows a common mistake in obtaining the probe ground. The edge of a chassis may seem to be an easy way to make the ground connection, but the long path from the circuit ground to the tip can create large errors. Further, the loop created by the chassis and the probe handle can pick up local radiated fields and cause further errors.

While we're talking about short connections, don't be mislead by the flexible grounding lead supplied with the probe. This lead is **not** intended to be used as the **measurement** ground. it is far too long for use at VHF or UHF. The flexible ground lead is primarily intended as a safety ground to avoid damage to the probe diodes. This ground lead should always be connected to the equipment under test before any connection is made to the probe tip. Here's why: Some equipment use R.F. filtering condensers, connected between the equipment chassis and the input power line. These condensers can place quite high voltages on the equipment chassis. Open circuit, the voltage can be well above the rating of the probe diodes. In other cases, particularly in dry climates, a high static potential may accumulate on the equipment chassis - touch the probe tip first, and some of the charge is drained off — through the sensitive probe diodes.

Back to the importance of a short ground connection again: Even if you are measuring fairly low frequency voltages, the short ground may be necessary to avoid interference from R.F. fields in the area. This gets important in the vicinity of transmitters. In testing VHF or UHF receivers the local oscillator chain may radiate enough energy to disturb your readings — more about this in the section in making stage gain measurements.

PROBE CAPACITANCE:

When making measurements with an R.F. Voltmeter, one needs to take into account the detuning effect that the probe capacitance may have on the circuit being measured.

The probe input capacitance is about two picofarads. Depending upon what type of circuit you are measuring, this small capacitance can make a lot of difference in the reading, or it may not affect accuracy at all.

THEORY OF OPERATION

The radio frequency voltage being measured is rectified by diodes CR1 and CR2, located in the probe, creating a positive voltage at pin 4 of the probe connector, and a negative voltage at pin 2 of the probe connector. U5, a CMOS analog switch alternately connects these two voltages to one terminal of C27. The voltage presented to C27 thus is a square wave, having a frequency of the switching drive of the analog switch, and an amplitude dependent upon the magnitude of the radio frequency voltage being measured.

This square wave voltage is amplified by integrated circuit operational amplifiers U1, U2, and U3. The gain of each of these amplifiers is dependent upon the position of the range switch section SW2C. More gain is required for the more sensitive scales. SW2C causes FET switches Q1, Q2, Q3, to be in a conductive, or non-conductive condition, as required for the particular range. The condition of Q1, Q2, and Q3, determines the gain of operational amplifiers U1, U2, and U3, respectively.

The output of U3, therefore, is a square wave, with amplitude dependent upon magnitude of the radio frequency voltage being measured, and dependent upon the position of the range switch.

The square wave at the output of U3 is converted to a D.C. voltage by the action of Q4. Q4 is switched on and off by the same switching drive voltage that operates the input analog switch U5, and thus acts essentially as a synchronous rectifier. The D.C. voltage thus obtained is supplied to the input of U4. U4 serves as a D.C. amplifier, supplying adequate current to operate the panel meter. The gain of U4 is determined by the position of the range change switch section SW2B. As SW2B is changed from one range to another, it switches in trimming resistors R53 to R58 to obtain the correct gain from U4. R53 to R58 are set to the proper value during the calibration procedure.

Before the output voltage from U4 is fed to the meter, it is fed through a non-linear circuit, consisting of R30, R31, CR7, CR8, and the various fixed resistors and trimming resistors associated with range switch section SW2A. The voltage developed by the probe essentially follows a square law characteristic. The non-linear circuit modifies this characteristic to the more linear calibrations given on the meter scale. Since different degrees of correction are needed on the various scales, appropriate fixed resistors and trimming resistors are switched into the circuit by range switch section SW2A.

During the calibration procedure, the trimming resistors associated with SW2B are set to adjust the meter reading at the lower part of each scale, and the trimming resistors associated with SW2A are set to adjust the meter reading at the top of each scale.

The switching drive for the input analog switch U5, and the synchronous rectifier Q4 are derived from a circuit consisting of U8, U9, U10, and U11. The switching drive frequency is 300 Hz (assuming operation from a 60 Hz power source). When the R.F. voltmeter is in operation in a typical laboratory, it is almost impossible to avoid having power line voltages induced into the probe circuit. If the switching frequency of U5 is set to an exact odd harmonic of the power source frequency, induced power line voltages will balance out and cause no errors in readings.

MAINTENANCE INSTRUCTIONS

To maintain the switching frequency at an exact odd multiple of the power line frequency, a phase locked loop system is used. U9 samples some of the A.C. supply voltages from the power supply, amplifies it and provides a square wave output for one input of the phase detector section of U10. The oscillator section of U10, with its output at pin four operates at a nominal 600 Hz. This 600 Hz output is divided by a factor of ten by U11, and fed to the other phase detector input of U10. The phase lock action of U10 then locks the oscillator section to exactly 600 Hz (in case of a 60 Hz supply frequency). This 600 Hz square wave is fed to U8, which acts as a frequency divider, and provides two 300 Hz square waves with a precise 50% duty cycle at pins 12 and 13.

The output at pins 12 and 13 is used to operate the switching action of U5 and the rectifying action of Q4. When the instrument is operated on a 50 Hz power system, the system operates in the same manner, but the resulting switching frequency is 250 Hz. When the instrument is operated from a D.C. power source, the oscillator is free running, and provides a switching frequency slightly below 250 Hz.

CALIBRATION INSTRUCTIONS:

In normal use, recalibration of the instrument should not be necessary. With the exception of the probe parts, most of the semiconductors and other components of the instrument may be replaced with items of the same type and value without seriously changing calibration.

If the probe is replaced, or the diodes in the probe are replaced, however, recalibration is advisable. To accomplish recalibration, a source of radio frequency of accurately known amplitude is required. The following is the procedure:

1. Locate the instrument in a level position. With the instrument power off, set the mechanical meter zero adjustment so the needle reads exactly on the left meter index (0).

2. With power off, remove integrated circuit U3 from its socket. Turn the range switch to the .001 volt (-50 dBm) scale, and turn the insturment power on. Wait about two minutes for the circuits to stabilize; then adjust the output amplifier offset potentiometer, R76, so the meter needle reads exactly at the left meter index.

3. Turn the instrument off, and replace U3 in its socket. Leave the range switch in the .001 Volt (-50 dBm) position, and turn the instrument power back on.

4. Install the 50 ohm terminated BNC adaptor on the probe, connect the BNC connector end of the adaptor to the radio frequency generator.

5. Be sure that the R.F. Generator is not delivering any signal. After the instrument power has been on for above five minutes to permit all circuits to stablize, adjust the "zero set" control (front panel) so the meter needle reads at the left meter index.
   (**Note:** On this most sensitive scale, the meter needle will fluctuate somewhat. Adjust the "zero set" so the needle fluctuates equally above and below the left index mark.)

6. a. With the range switch still set to the .001 (-50 dBm) scale set the R.F. Generator to provide a -57 dBm power level to the terminated probe adaptor, and adjust R58 so the meter indicates at the -7 dB marking.

   b. Set the R.F. Generator to provide a level of -47 dBm, and adjust R49 so the meter indicates at the +3 dBm mark, (i.e., the right hand index). On this sensitive scale it is advisable to recheck the zero setting, to be sure that the zero has not changed during the adjustment.

7. a. Set the range switch to the .003 volt (-40 dBm) scale. Set the R.F. Generatoı to zero output, and check the meter zero. Reset, if necessary, using the "zero set" control. Set the R.F. Generator to -47 dBm, and adjust R57 so the meter indicates at the -7 dBm mark.

   b. Set the R.F. Generator to -37 dBm, and adjust R46 so the meter indicates at the+3 dBm mark.

8. a. Set the range switch to the .01 volt (-30 dBm) scale. Set the R.F. Generator to zero output and check the meter zero. Reset, if necessary, using the "zero set" control. Set the R.F. Generator to -37 dBm, and adjust R56 so the meter indicates at the -7 dBm mark.

   b. Set the R.F. Generator to -27 dBm, and adjust R43 so the +3 dBm mark.

9. a. Set the range switch to the .03 volt (-20 dBm) scale. Set the R.F. Generator to zero output and check the meter zero. Reset, if necessary, using the "zero set" control. Set the R.F. Generator to -27 dBm, and adjust R55 so the meter indicates at -7 dBm mark.

   b. Set the R.F. Generator to -17 dBm, and adjust R40 so the meter indicates at the +3 dBm mark.

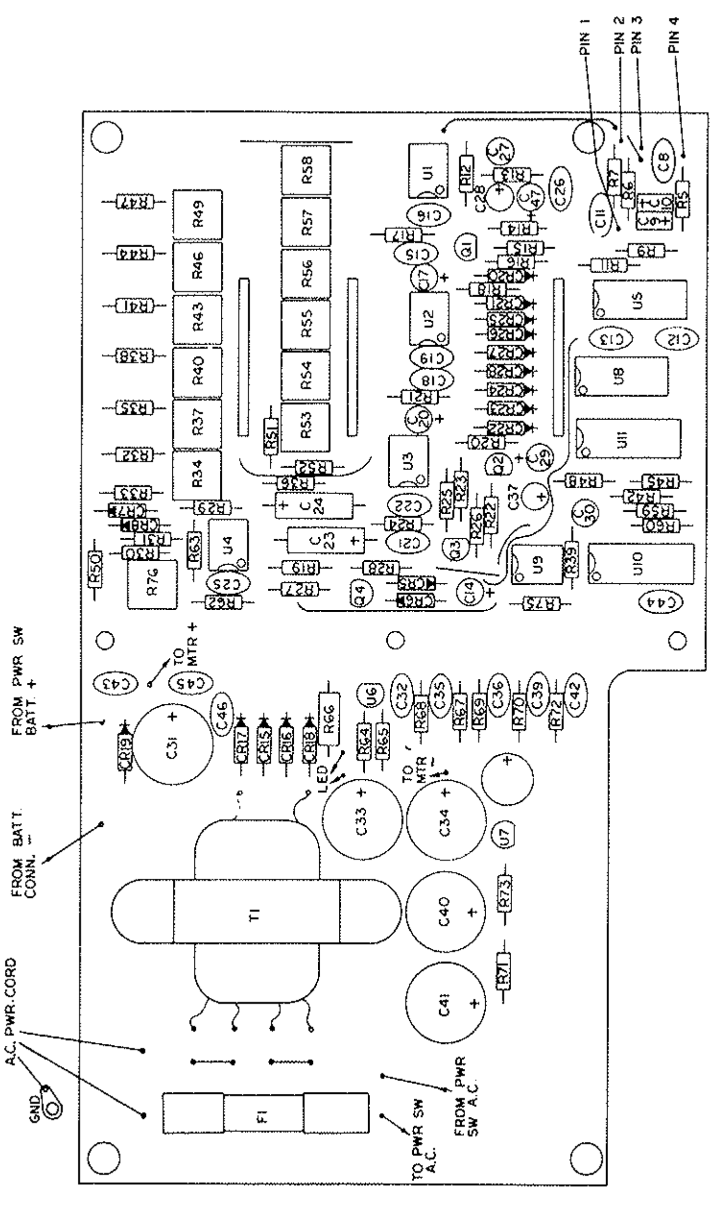
10. a. Set the range switch to the .1 volt (-10 dBm) scale. Set the R.F. Generator to zero output and check the meter zero. Reset, if necessary, using the "zero set" control. Set the R.F. Generator to -17 dBm, and adjust R54 so the meter indicates at the -7 dBm mark.

    b. Set the R.F. Generator to -7 dBm, and adjust R37 so the meter indicates at the +3 dBm mark.

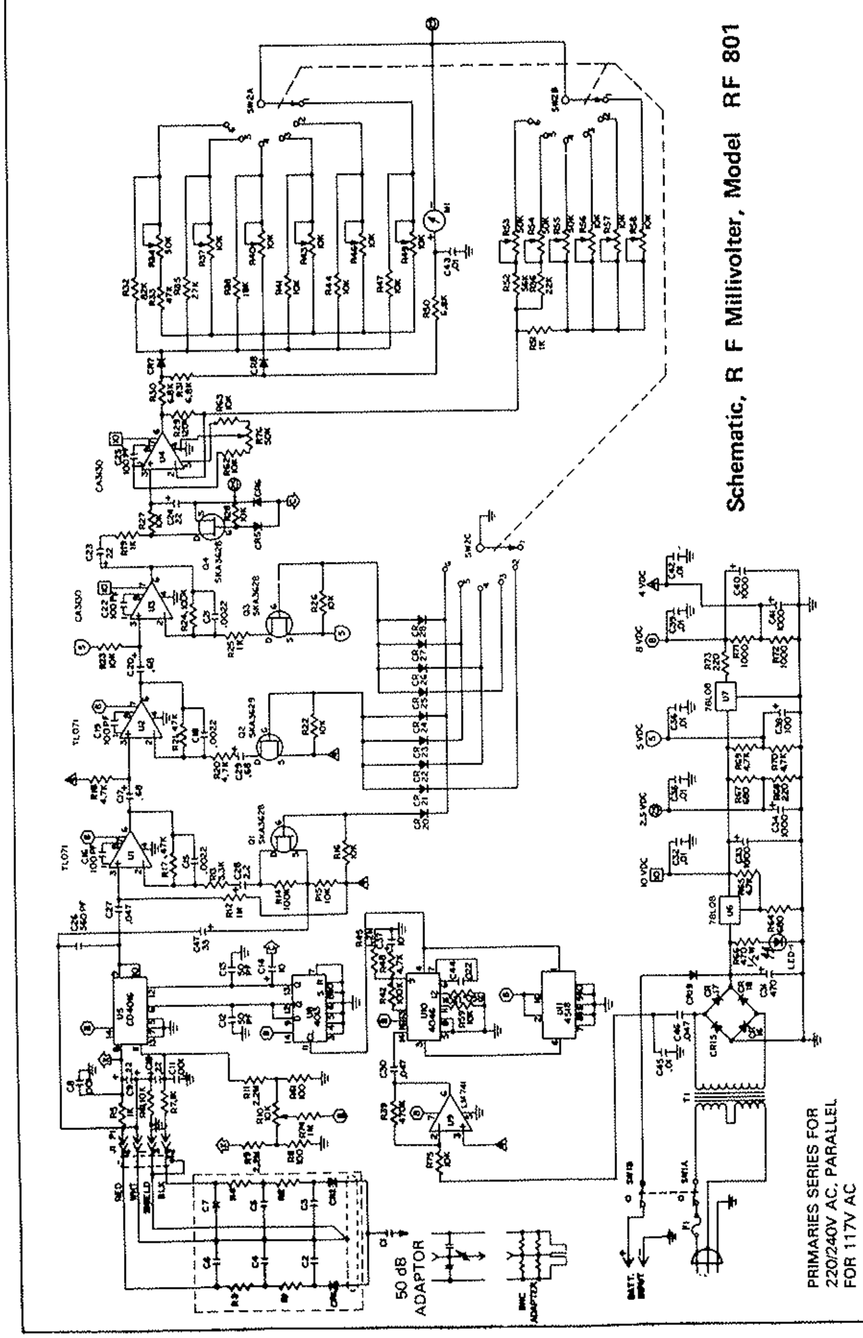
11. a. Set the range switch to the .3 volt (0 dBm) scale. Set the R.F. Generator to zero output and check the meter zero. Reset, if necessary, using the "zero set" control. Set the R.F. Generator to -7 dBm, and adjust R53 so the meter indicates at the -7 dBm mark.

    b. Set the R.F. Generator to -3 dBm, and adjust R34 so the meter indicates at the +3 dBm mark.

That completes the calibration. Aren't you glad?



Board Assembly, R F Millivolter, Model RF 801



Schematic, R F Millivolter, Model RF 801

Specifications:

Voltage Ranges:	1 millivolt to 100 volts (full scale). Lowest useful reading 300 miocrovolts. Six direct ranges — 1 mV, 3 mV, 10 mV, 30 mV, 100mV, 300mV full scale. Six ranges with 50 dB Adaptor (supplied) — 300 mV, 1V, 3V, 10V, 30V, 100V full scale
Accuracy:	(As measured with 50 ohm terminating BNC Adaptor.) 20 kHz to 520 MHz: 1 dB 520 MHz to 1000 MHz: 1.5 dB 1000 MHz to 1600 MHz: 3.0 dB Usable as indicator to 3 GHz
Probe Input Impedance:	100,000 ohms, in parallel with 2 pf
50 dB Adaptor Input Impedance:	1.2 pf
Indication:	Calibrated in RMS volts and dBm. True RMS reading on bottom 4 scales (to 30 mV direct, 10V with adaptor)
Power Requirements:	220/240V or 110/120V, 50/60 Hz, as chosen by transformer taps Also operable from 12V D.C., negative ground automotive supply
Dimensions:	88 mm H x 225 mm W x 178 mm OD (3½" H x 8¾" W x 6 7/8" OD)
Weight:	1.9 kg. (4.2 lbs)
Accessories Supplied:	Probe with 5' cable Low inductance grounding probe cap 50 dB Adaptor Protective grounding lead 50 ohm Terminating BNC Adaptor Teflon Tip 12 Volt Plug
Optional Accessories:	Unterminated BNC Adaptor, tip jack (packet of 10)

Prices and specifications subject to change.
Specifications unless otherwise stated are those of a typical instrument.