BOONTON

Instruction Manual

QC. 15529 May 81

Model 92C

RF Millivoltmeter

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92C
879

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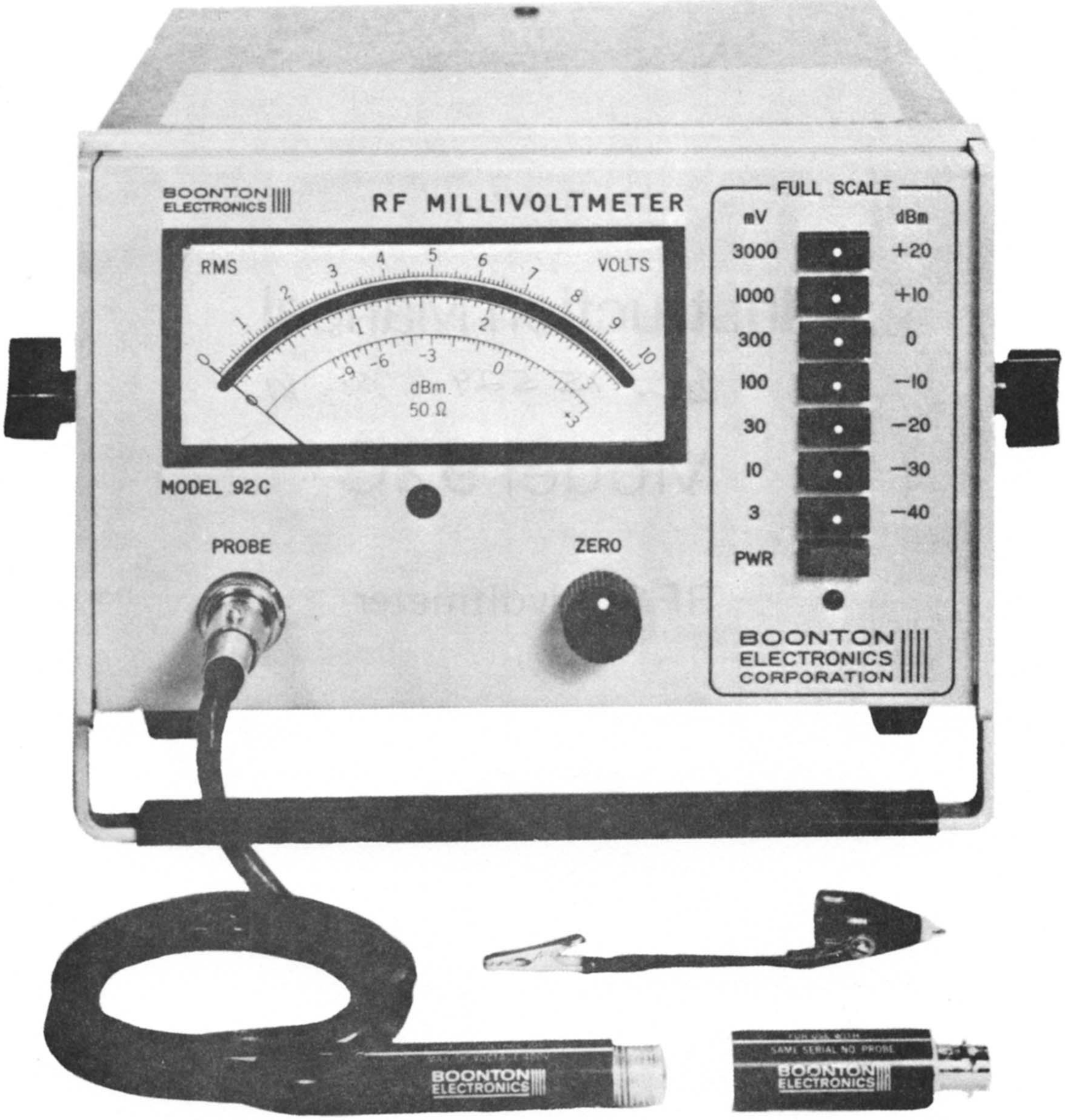
BOONTON ELECTRONICS
RF MILLIVOLTMETER
RMS
VOLTS
dBm
50 Ω
MODEL 92C
FULL SCALE
mV
dBm
3000
+20
1000
+10
300
0
100
−10
30
−20
10
−30
3
−40
PWR
PROBE
ZERO
BOONTON
ELECTRONICS
CORPORATION
SAME SERIAL NO. PROBE
BOONTON ELECTRONICS
BOONTON ELECTRONICS

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CHAPTER I

SPECIFICATIONS

Voltage Range: 500 µV to 3V (300V up to 700 MHz with accessory 100:1 Voltage Divider) (see Table 1)

Full Scale Voltage Ranges: 3, 10, 30, 100, 300, 1000, and 3000 mV.

dBm Range: -50 to +23 dBm (+63 dBm up to 700 MHz with optional accessory, Model 91-7C 100:1 Voltage Divider)

Frequency Range: 10 kHz to 1.2 GHz (uncalibrated response to approximately 8 GHz).

Accuracy:

<table>
<tr><th></th><th colspan="4">2% fs plus</th></tr>
<tr><td>300 mV to 3 V</td><td>1% rdg</td><td rowspan="2">1% rdg</td><td rowspan="2">3% rdg</td><td>10% rdg</td></tr>
<tr><td>500 µV to 300 mV</td><td>2% rdg</td><td>7% rdg</td></tr>
<tr><td></td><td>10 kHz – 50 kHz</td><td>50 kHz – 150 MHz</td><td>150 MHz – 700 MHz</td><td>700 MHz – 1.2 GHz</td></tr>
</table>

Meter: 4-1/2-inch taut-band
Two linear voltage scales
0 to 3; 0.05 per division
0 to 10; 0.1 per division
One logarithmic dBm scale
-10 to +3; 0.2 per division max.

Meter Unrest: Typically, less than 1% on the 3 mV range.

Power: 115 to 230 V ±10%, 50 to 400 Hz, 4 W.

RFI: There is no detectable radiated or conducted leakage from instrument or probe.

Temperature: In accordance with ANSI (ASA) Spec. 39.7

Temperature Range	Temperature Influence	
	Instrument	RF Probe
Ref. 21° C to 25° C	0	0
Normal, 18° C to 30° C	0	± 1% rdg
Severe, 10° C to 40° C	± 1% rdg	± 4% rdg

Waveform Response:	True rms response for input levels up to 30 mV (3V to 700 MHz with 100·1 Voltage Divider), with transition to peak-to-peak (calibrated in rms) at higher levels.
Crest Factor:	84 to 1.4 depending upon input level (see Table 2).
Input Impedance:	See Figures 1 and 2.
VSWR:	Less than 1.15 to 1.2 GHz (Return Loss greater than 23 dB). See Figures 3 and 4.
Power Sensitivity:	5 nW, minimum detectable power in 50 ohms.
Dimensions:	5.2" H (without rubber feet), 8.3" W (1/2 of standard 19 inch rack module) 11.5" D (132 x 211 x 292 mm).
Weight:	Net 7.5 lbs. (3.4 kg) (with standard accessories) Shipping - 10 lbs. (4.6 kg)
Accessories Furnished:	Model 91-12F, RF Probe. RF Probe with low-noise cable and connector assembly for measurements from 10 kHz to 1.2 GHz; see Figures 1 and 2 for input resistance and capacitance. Model 91-13B, Probe Tip. Removable Probe Tip with grounding clip lead; for use up to approximately 100 MHz. Model 91-8B, 50Ω BNC Adapter. Use for measurements up to 600 MHz in a 50-ohm system, for VSWR see curve of Figure 3.
Warm-Up:	Warm-up period, 1 min. Adjust zero on 3 mV range when measuring below 30 mV.
Accessory Kit (Optional) Model 91-24A:	Model 91-6C, Unterminated BNC Adapter. Used for coaxial connection up to approximately 100 MHz, or to 400 MHz when fed from a 50-ohm source in an electrically short system. Model 91-7C, 100:1 Voltage Divider. Attenuates input signal by a factor of 100 (± 1%), permitting measurements up to 300 volts and extending the rms measuring range to 3 volts; increases input resistance by a factor of 1000; operates from 50 kHz to 700 MHz. Maximum input potential, 1000 volts, dc plus peak ac. Model 91-14A, 50Ω Tee Adapter. Type N Tee Connector; with Model 91-15A termination (see below) permits connecting into 50-ohm line; required for measurements above approximately 100 MHz: for VSWR see curve of Figure 4. Model 91-15A, 50Ω Termination. Type N 50-ohm termination for use with Model 91-14A Tee Connector.

Other Accessories (Optional) Available:

Model 91-4C, Special 1 kHz to 250 MHz RF Probe. Low-frequency probe for measurements ranging from 1 kHz to 250 MHz; input resistance essentially the same as that of Model 91-12F, RF Probe.

Model 91-16A, Unterminated Type N Adapter. May be used with all probes, except Model 91-23A. Used for coaxial connection up to approximately 100 MHz, or to 400 MHz when fed from a 50-ohm source in an electrically short system.

Model 92-1A, Rack Mounting Kit. Kit for mounting Model 92C as one-half of a module in a standard 19 inch rack.

IMPORTANT NOTE:

To exploit fully the capabilities of this instrument, the accessories listed below are required for the indicated ranges of operation.

Table 1. Required accessories

MEASURING RANGE	REQUIRED ACCESSORY	REMARKS
100 MHz to 600 MHz	Model 91-8B 50Ω Adapter for shielded connection to 50-ohm line; other impedances available on request.	Supplied as standard equipment with the Model 92C.
Above 600 MHz	Model 91-14A Tee Connector and 91-15A 50 Ω Termination for connection into 50-ohm line.	Available separately.
1 kHz to 250 kHz	Model 91-4C RF Probe.	Available separately.
Input levels up to 300V; rms response with levels to 3V.	Model 91-7C 100:1 Voltage Divider; operates over frequency range from 50 kHz to 700 MHz.	Available separately.

For details on the availability of these and other Boonton Electronics Accessories for RF Voltmeters, call on your local Boonton Electronics Sales Engineering Representative, or write directly to the factory at the address on the title page of this instruction book.

Table 2. Crest Factor

VOLTAGE RANGES (mV) AND CREST FACTORS						
VOLTAGE RANGE (mV)	3	10	30	300*	1000*	3000*
CREST FACTOR**	84 to 14	21 to 4.2	8.4 to 1.4	84 to 14	21 to 4.2	8.4 to 1.4

* With accessory 100:1 Voltage Divider (see Table 1).
**Maximum permissible ratio of peak to rms value of voltage.

STANDARD EQUIPMENT OPTIONS

92C-03	dBV option: dB scale is referred to 1 V.
92C-04	dBV option: dB scale, referred to 1 V, is uppermost.
92C-05	75 Ω dBm option: dBm scale is referred to 75 Ω: 75 Ω 91-8B/1 BNC adapter supplied.
92C-06	75 Ω dBm option: dBm scale, referred to 75 Ω, is uppermost: 75 Ω 91-8B/1 BNC adapter supplied.
92C-07	50 Ω dBm option: dBm scale, referred to 50 Ω, is uppermost.
92C-08	Rear signal input option.
92C-12	dBmV option: dBmV scale is uppermost.

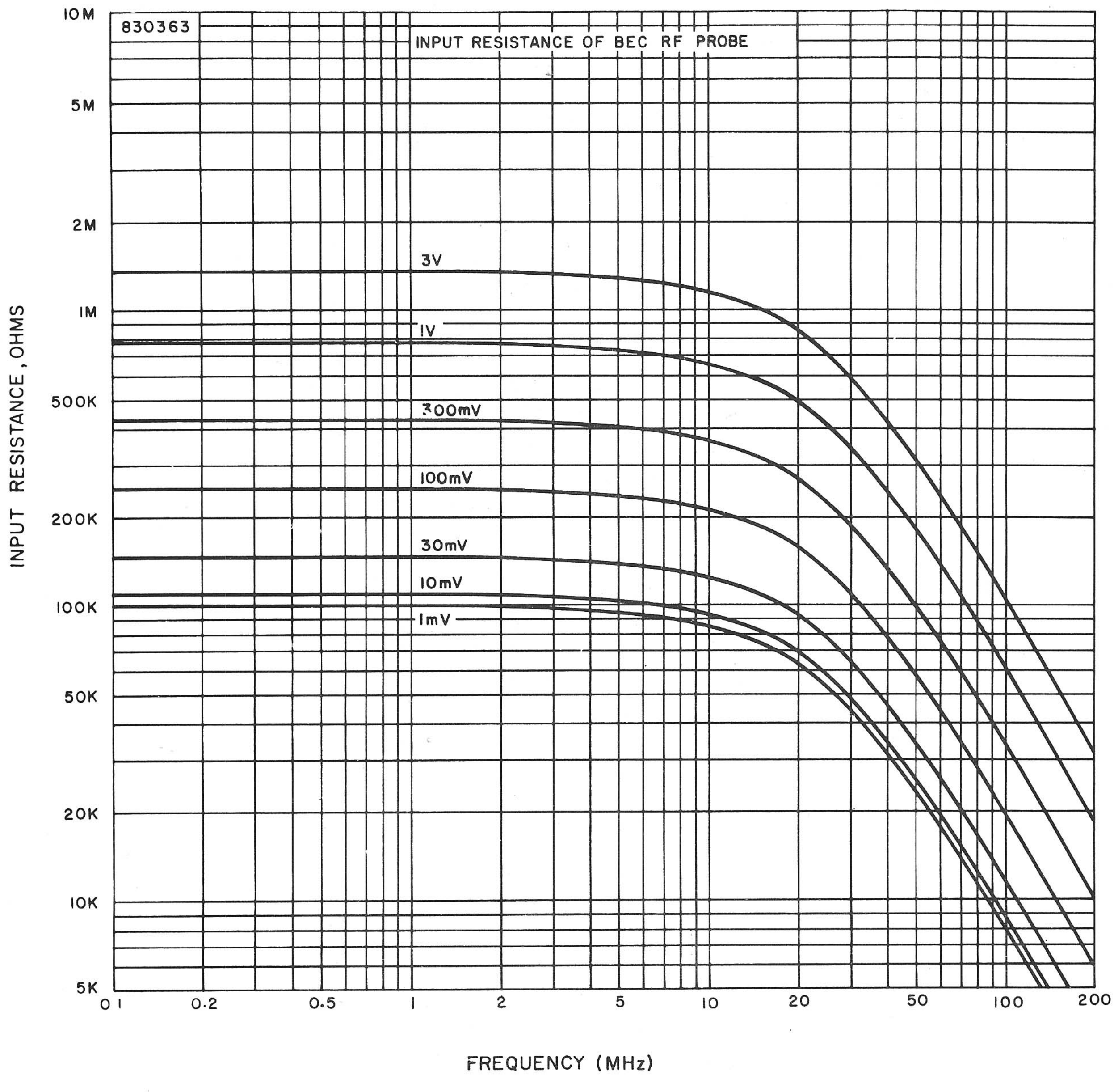


Figure 1. Input Resistance of RF Probe as a Function of Input Level and Frequency

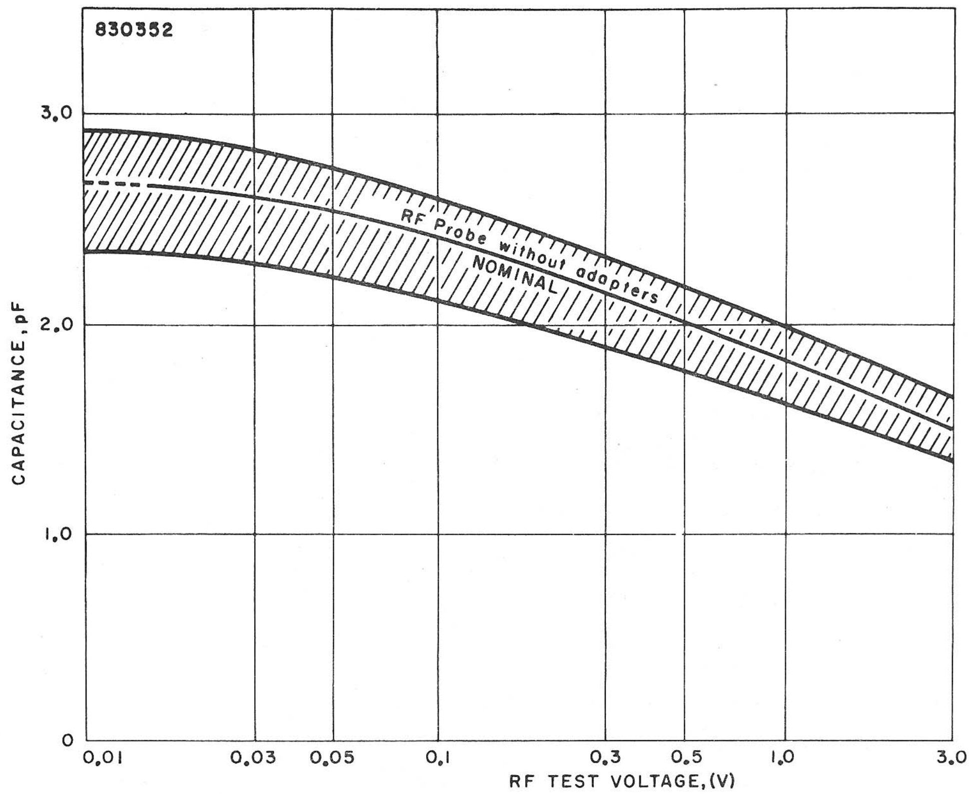


Figure 2. Input Capacitance vs. Input Level of Model 91-12F Probe (Measured at 10 MHz)

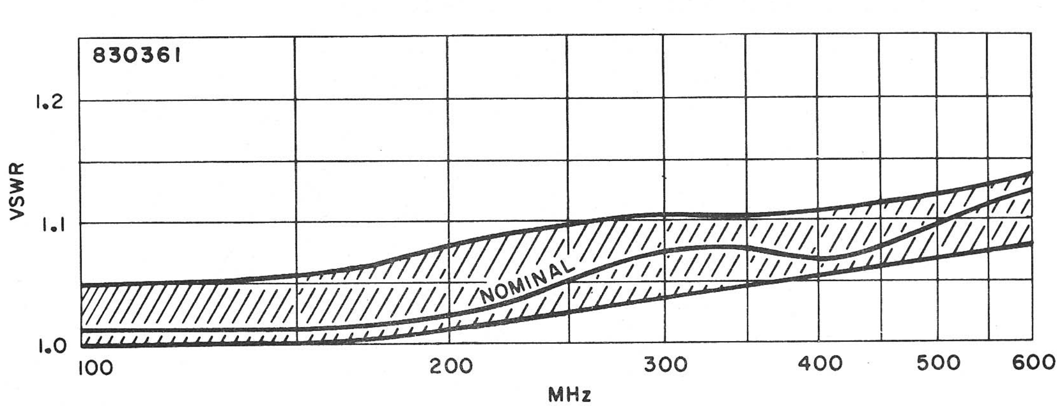


Figure 3. Typical VSWR of Model 91-12F RF Probe with Model 91-8B 50Ω BNC Adapter

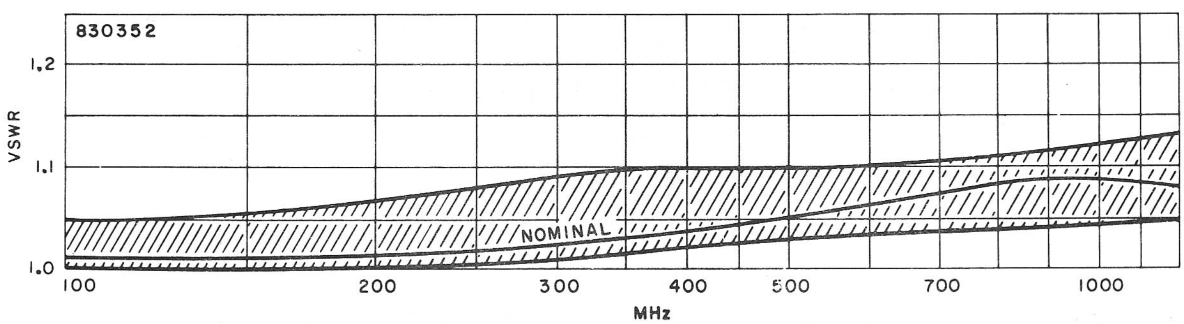


Figure 4. Typical VSWR of Model 91-12F RF Probe with Model 91-14A Type N Tee Adapter and Model 91-15A 50Ω Termination

CHAPTER II

GENERAL DESCRIPTION

2.1 GENERAL. The Model 92C RF Millivoltmeter is a solid state, sensitive, rf millivoltmeter used for measurements from the low radio frequencies to the gigahertz region, and over a voltage range from 500 microvolts to 3 volts.

The Model 92C provides true rms response for input signals up to 30 millivolts, gradually approaching peak-to-peak response calibrated on the meter scale in rms above this level. It is characterized by high input impedance (see Figures 1 and 2), excellent stability, and low noise.

The Model 92C is particularly suitable for production and laboratory applications. It offers a convenient and accurate means for making a wide variety of measurements. Among the typical uses of the Model 92C are the following:

In transistor testing the instrument may be used to measure β, f_t, and other transistor parameters.

VSWR and return loss measurement using the Model 92C with bridge methods, directional couplers, and adjustable or slotted lines.

Gain and loss measurements in wide-band amplifiers, including such design characteristics as stage gain, flatness of the pass band, upper cut-off or corner frequency, negative feedback factors, and other parameters.

Proper adjustment of tuned circuits in narrow-band amplifiers.

The adjustment, measurement of performance, and evaluation of parameters of rf filters.

Measurement of vswr or return loss and attenuation of rf attenuators.

Measurement of output levels of signal generators, adjustment of baluns, harmonic distortion of rf signals, and adjustment of circuits for minimum voltage (null) or maximum voltage (peak).

The Model 92C has a basic accuracy of 1% rdg. + 2% fs. The standard features of the instrument are as follows:

Measures 500 μV to 3V* from 10 kHz to 1.2 GHz.
True rms response to 30 mV**
Convenient push-button ranging and half-rack packaging.
High input resistance, low input capacitance.
Overload protection to 400 Vdc, 10 Vac.
VSWR less than 1.15 up to 1.2 GHz.
* To 300 V, up to 700 MHz with accessory 100:1 divider.
** To 3V, up to 700 MHz with accessory 100:1 divider.

The characteristics of the instrument include: solid state chopper, high reliability, fast warm-up, lengthy intervals between calibrations, light weight, and all other advantages of solid state design.

2.2 EQUIPMENT DESCRIPTION. The instrument is sensitive, accurate, sturdily constructed, and protected against overloads. It will perform over extended periods of time without failure or need for recalibration. It is packaged as a compact (half-rack) bench instrument that can be easily mounted in a standard 19-inch rack using an inexpensive hardware kit.

Important input and accuracy specifications are stipulated on a reference plate fastened to the exterior top cover of the instrument. Clips for holding out-of-use accessories are provided at the rear of the instrument. Calibration instructions are reproduced on the underside of the top cover of the instrument.

The standard accessories furnished with the Model 92C include the following: A Model 19-12F RF Probe with a low-noise cable and connector assembly; a Model 91-8B 50-ohm BNC Adapter, and a Model 91-13B Probe Tip (removable) with a grounding clip lead.

A complete kit of probe accessories is available as optional equipment, including a storage case with space for the Model 91-12F RF Probe and the other standard accessories.

2.2.1 <u>Wide Frequency Range</u>. The calibrated range of the Model 92C extends from 10 kHz to 1.2 GHz, with uncalibrated response to beyond 8 GHz. Relative accuracy above 1.2 GHz is typically ±0.5 dB.

A Model 91-8B 50-ohm BNC Adapter is supplied as a standard accessory with the instrument for 50-ohm voltage measurements up to 600 MHz. A correction curve (Figure 8A) is included for frequencies above 50 MHz. For higher-frequency measurements and for through-line voltage measurements the optional accessory, Model 91-14A Tee Adapter, is recommended. It is designed to compensate for the rf probe capacitance and to present a good vswr (better than 1.15) up to 1.2 GHz. It may be used in conjunction with the Model 91-15A 50-ohm load for terminated voltage measurements. In a coaxial line its insertion loss is low; however, a chart (Figure 8B) is supplied showing loss vs. frequency.

An optional accessory, the Model 91-4C RF Probe, has a frequency range of 1 kHz to 250 MHz for lower-frequency applications.

2.2.2 <u>Wide Voltage Range</u>. The Model 92C has seven ranges, from 3 millivolts full scale to 3 volts full scale, arranged in a 3-10-30 sequence. No attenuator attachments are required for measurements up to 3 volts. While this range is ample for most rf voltage measurements, the capability of the instrument can be increased to 300 volts (up to 700 MHz) by using the optional accessory, Model 91-7C 100:1 Voltage Divider. Use of the Divider also increases the input resistance of the Model 91-4C RF Probe by a factor of greater than 100.

2.2.3 True RMS Response. The Model 92C provides true rms response for signal inputs below approximately 30 millivolts (below 3 volts, up to 700 MHz, with the Model 91-7C 100:1 Voltage Divider). As the input level increases, the waveform response gradually approaches peak-to-peak, calibrated on the meter scale in rms. Thus, in addition to making precise sinusoidal voltage measurements at all levels, the instrument measures non-sinusoidal or asymmetrical signals within the rms region without loss of accuracy.

2.2.4 Low Noise. The Model 92C has been designed and constructed to hold noise from all sources to a minimum.

The probe cable is of special low-noise design; a vigorous flexing causes only momentary, minor deflections on the most sensitive range. The Model 91-12F Probe is not sensitive to shock or vibration; even tapping on the probe barrel causes no visible deflection on any range.

Amplification takes place at 94 Hz, reducing susceptibility to any 50 or 60 Hz line-frequency fields.

2.2.5 Minimal Zero Adjustment. Zero adjustment is not required on the upper five sensitivity ranges of the Model 92C. For measurements on the lower two ranges, the ZERO control is set on the most sensitive range before operation. This control balances out small thermal voltages in the probe elements and, once adjusted, requires only infrequent checking during the course of subsequent measurements.

CHAPTER III

OPERATING PROCEDURE

3.1 INSTALLATION PROCEDURE. The Model 92C has been inspected and tested at the factory before packing, and is shipped ready for operation. If there is any indication of shipping damage, immediately notify the carrier before attempting to put the instrument into operation.

3.1.1 Operating Controls and Indicators. The controls and indicators installed on the Model 92C are shown in Table 3.

Table 3. Model 92C Controls and Indicators

COMPONENT	FUNCTION
 (Symbol on Rear Panel)	This safety requirement symbol has been adopted by the International Electrotechnical Commission, Document 66 (Central Office) 3, paragraph 5.3 which directs that an instrument be so labeled, if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source. Verify that the right fuse is installed for the power available and that the switch on the rear panel, 0.03A and 0.06A, 50-400 Hz, is set to the applicable operating voltage of 115 V or 230 V. Within a brief time, the use of this symbol will be acted upon by ANSI (ASA).
Fuse Holder and Fuse (Rear Panel)	A fuse holder is located on the rear panel for installing either a 1/16 ampere, 117 V, or a 1/32 ampere, 220 V, Bussman MDL SLO-BLO fuse.
Slide Switch (Rear Panel)	Switch which is set to 115 V or 230 V, according to the available power source. Be sure that the proper fuse is located in the fuse holder.

Table 3. Model 92C Controls and Indicators (Cont'd)

COMPONENT	FUNCTION
PWR ON	This switch turns on the instrument.
RANGE, FULL SCALE (mV and dBm) (Push-buttons)	These range push buttons, (3, 10, 30, 100, 300, 1000 and 3000 mV) and (-40, -30, -20, -10, 0, +10 and +20 dBm) select the voltage range.
PROBE (Jack)	The probe cable connects to the instrument through this PROBE jack. Always check that the knurled ferrule nut of the probe cable connection is tightened when in use.
ZERO (Control)	This control is used to zero the instrument.
Component Holders (Clips) (Rear Panel)	Three component holders or component clips are located on the rear panel for securing accessories which are not in use.
METER	A 4 1/2-inch taut-band meter with two linear voltage scales reading out 0 to 3 with 0.05 per division; 0 to 10 with 0.1 per division; and one logarithmic dBm scale reading out -10 to +3 with 0.2 per division maximum.

3.2 OPERATING PROCEDURES. The following paragraphs describe the initial operating procedure for the Model 92C, the various operating notes, and the recommended connection procedures.

3.2.1 Initial Operating Procedure. The Model 92C is put into service by the following procedure:

a. Check the panel meter zero position and, if necessary, adjust the mechanical zero control to align the pointer with the zero reference.

NOTE:

Check to see that the serial number of the probe to be used matches that of the particular model of the Model 92C. Each instrument is calibrated for its particular rf probe. Use of a probe other than that for which the instrument was calibrated may result in errors in measurement.

b. Connect the probe cable to the PROBE jack on the front panel.

c. Next, verify that the proper power source is available. The instrument should be plugged only into a power source having the voltage and frequency indicated on the instrument rear panel.

d. With the power cord plugged into the proper ac power source, turn the instrument on. The Model 92C is operational within 30 seconds.

3.3 OPERATING NOTES. While measuring with the Model 92C is a direct and straightforward process, there are certain precautions and procedures which MUST be observed to obtain satisfactory results.

3.3.1 Overload Limits. The Model 91-12F RF Probe supplied with the Model 92C is overload-protected to 10 volts, ac, and to 400 volts, dc. EXCEEDING THESE LIMITS MAY RESULT IN PERMANENT DAMAGE TO THE PROBE.

The Model 91-8B 50-ohm Adapter should not be subjected to continuous overload of more than 10 volts (dc + rms ac) to avoid excessive heating of the terminating resistor.

When voltages above these limits are likely to be encountered, the Model 91-7C 100:1 Voltage Divider is required. Maximum rating of the Voltage Divider is 1000 volts, dc + peak ac.

3.3.2 Connection for Measurements Below 100 MHz. The RF Probe supplied with the Model 92C is equipped with a detachable tip and ground lead. For measurements of signals below approximately 100 MHz, this tip provides a convenient means for both signal and ground connection.

3.3.3 Connection for Measurement above 100 MHz. For frequencies above 100 MHz, the probe tip should NOT be used with the Model 92C. Connection should be made directly to the center contact of the probe with the ground connection kept as short as possible (see Figure 5).

The connection recommendations outlined in Table 4 below should be followed to maintain specified accuracy.

Table 4. Connection Recommendations

FREQUENCY	SIGNAL CONNECTION
Up to 100 MHz	Probe Tip and grounding lead (supplied)
100 MHz to 250 MHz	Probe without tip (see Figure 5) (supplied)
250 MHz to 600 MHz	Probe with Model 91-8B 50Ω BNC Adapter (supplied)
Beyond 600 MHz	Probe with Model 91-14A Type N Tee Adapter and Model 91-15A Type N 50Ω Termination (see Figure 6) (optional accessories)

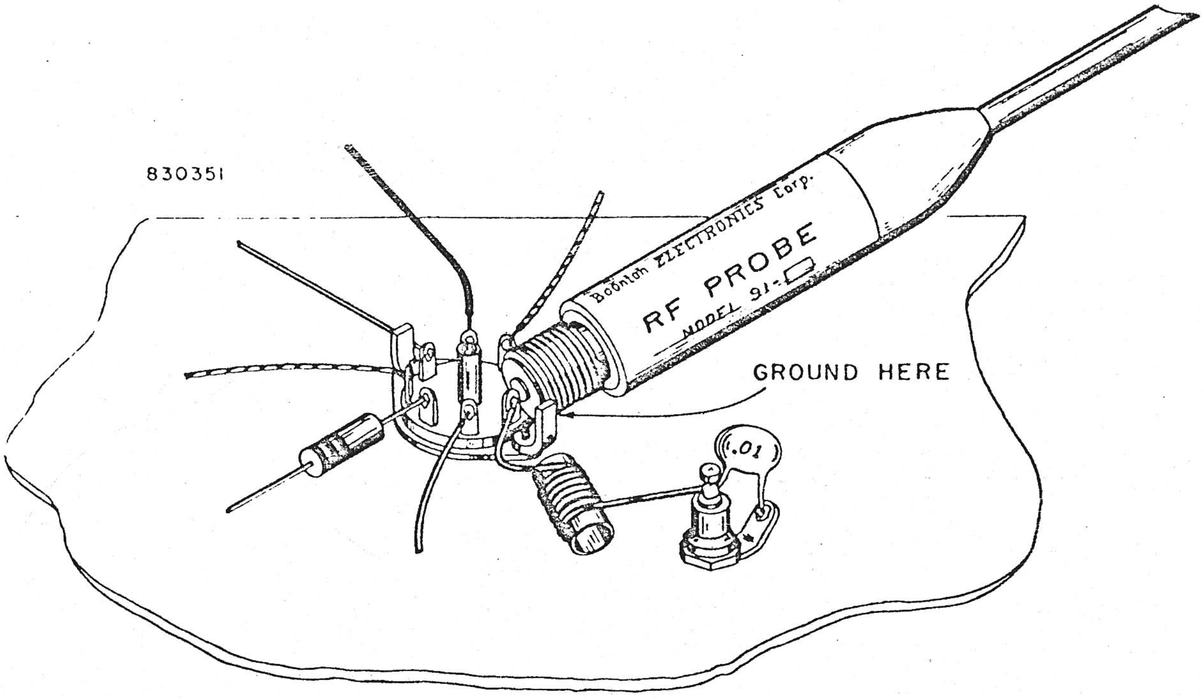


Figure 5. Method for making low-inductance connections to test signal point directly using the RF probe.

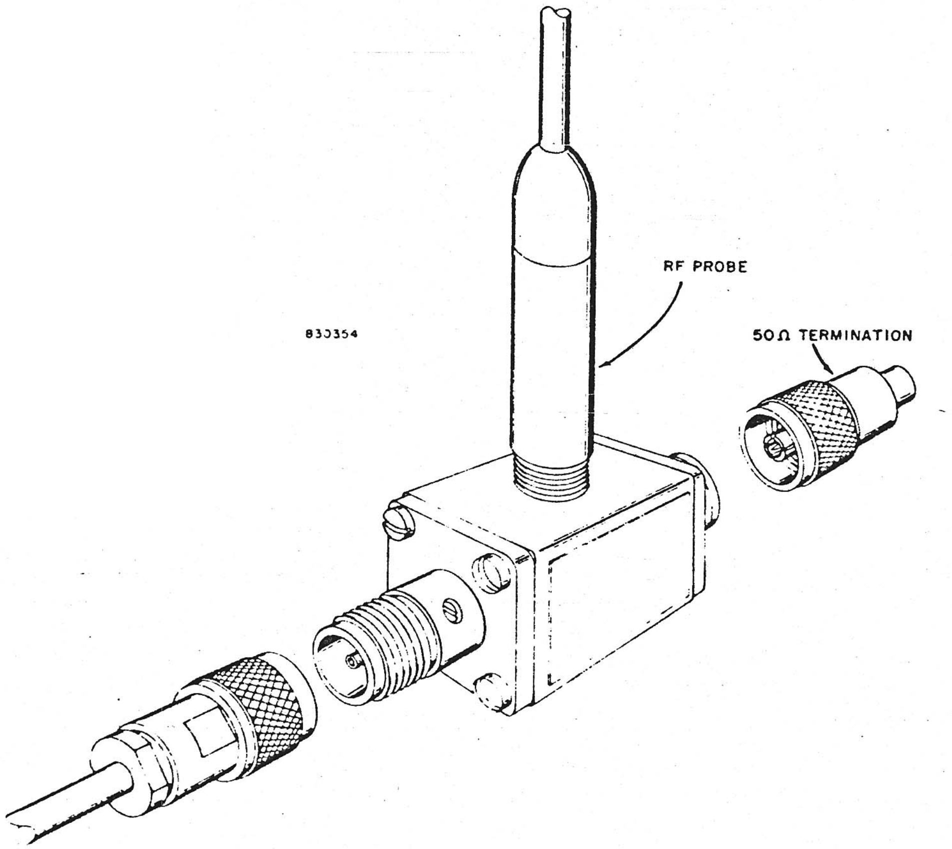


Figure 6. Assembly of Model 91-14A Type N Tee Adapter

Figure 6. Assembly of Model 91-14A Type N Tee Adapter

3.3.4 Low-Level Measurement. The Model 92C has a sensitivity of 300 microvolts, and will provide reliable, reproducible measurements of signal levels as low as 500 microvolts.

When using the most sensitive range, a preliminary zero adjustment is required. On the 10 mV range, particularly for measurements above mid-scale, proper zero adjustment is less critical, although still recommended.

3.3.5 Making the Zero Adjustment. When the instrument is to be used on the 3 mV range, the following zero procedure applies:

a. Set the RANGE FULL SCALE selector to the 3 mV position.

b. See that no voltage is applied to the probe, and that the probe is adequately shielded from local fields (for test procedure, see paragraph 3.3.8).

c. Adjust the ZERO control to bring the reading toward a zero reference condition. Noise may cause the reading to fluctuate up to ±2% of full scale. Adjust the ZERO control so that the reading averages zero.

3.3.6 Signal Overload on 3 mV Range. On the most sensitive (3 mV) range, application of a large ac signal overloads the amplifier and a short time is required for the high-impedance input circuit to discharge. This effect is significant for signals above approximately 100 millivolts. Typically, application of a 1 volt signal will require a recovery time of about fifteen seconds before subsequent measurements may be made. It should be noted, however, that such overloads cause no damage to the equipment as long as they are within the limits outlined in paragraph 3.3.1.

3.3.7 Temperature Effects. The accuracy specifications for the Model 92C apply over temperatures from 50°F to 104°F. Outside of these limits, operation of the equipment is possible but appreciable inaccuracies can be expected. However, no permanent change in probe characteristics will result from any reasonable high or low temperature exposure.

It should be noted that inaccuracies of measurement resulting from temperature effects may occur shortly after soldering to the probe tip, or measuring with the probe in close proximity to sources of intense heat, such as vacuum tubes.

When making low-level measurements (below approximately 2 millivolts) it is important to make sure that the probe has attained a uniform temperature throughout its body. A temperature gradient between the inside and outside of the probe can generate a small thermal voltage that may add to the dc output of the detector diodes. This can be compensated for by turning off the signal source and re-adjusting the ZERO control.

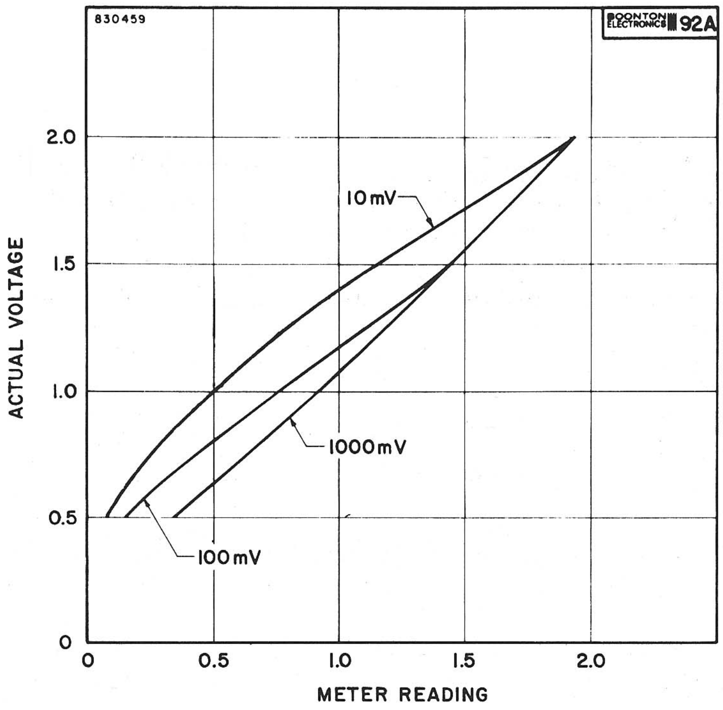
3.3.8 Hum, Noise and Spurious Pick-up. When measuring low-level signals precautions should be taken to avoid the possibility of measurement errors from hum, noise, or stray rf pick-up. Although hum and low-frequency noise are attenuated at the input, it is still possible for unwanted high-level signals to cause errors. In some cases it may be necessary to provide extra shielding around the probe connections to reduce stray pick-up. Typical sources of spurious radiation are: induction or dielectric heating units, diathermy machines, local radio transmitters and grid dip meters.

3.4 LOW-FREQUENCY MEASUREMENTS. The Model 91-12F RF Probe supplied with the Model 92C provides measurements within the specified accuracy from 10 kHz to 1.2 GHz. For measurements at lower frequencies the Model 91-4C RF Probe is available. It operates over a frequency range from 1 kHz to 250 MHz. Important Note: After installing the Model 91-4C RF Probe, the Model 92C must be checked for accuracy of calibration, and recalibrated if required (see paragraphs 5.3 and 5.4).

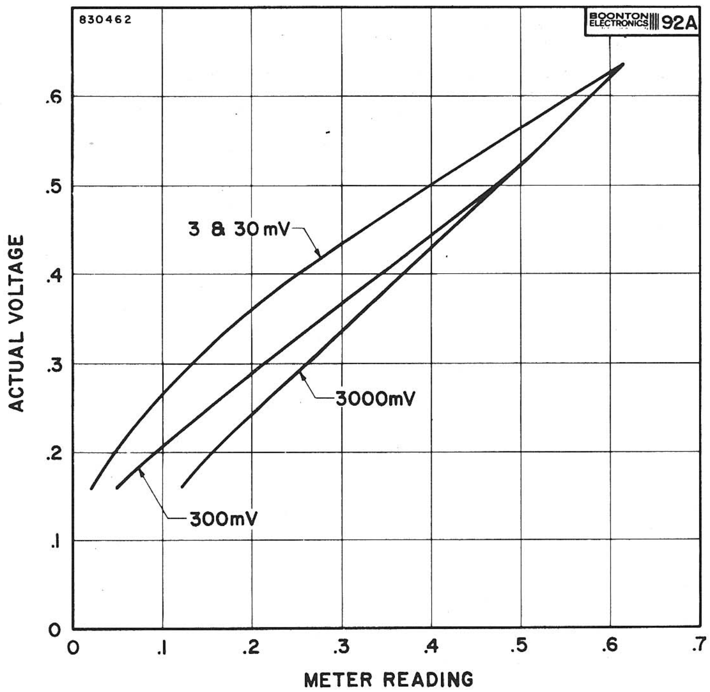
3.5 CORRECTION CURVES FOR ACTUAL VOLTAGE vs. METER READINGS. Use the correction curves of Figure 7 to correct meter readings on the Model 92C and Model 92C Option Instruments.

3.6 CORRECTION CURVE FOR MODEL 91-8B. Use the correction curve of Figure 8A to make corrections when using the Model 91-8B, 50Ω BNC Adapter with the Model 92C and Model 92C Option Instruments.

3.7 CORRECTION CURVE FOR MODEL 91-14A. Use the correction curve of Figure 8B when using the Model 91-14A Type N Tee Adapter.



Down-Scale Correction (0 to 10 scale)



Down-Scale Correction (0 to 3 scale)

Figure 7. Correction Curves, Actual Voltage vs. Meter Reading

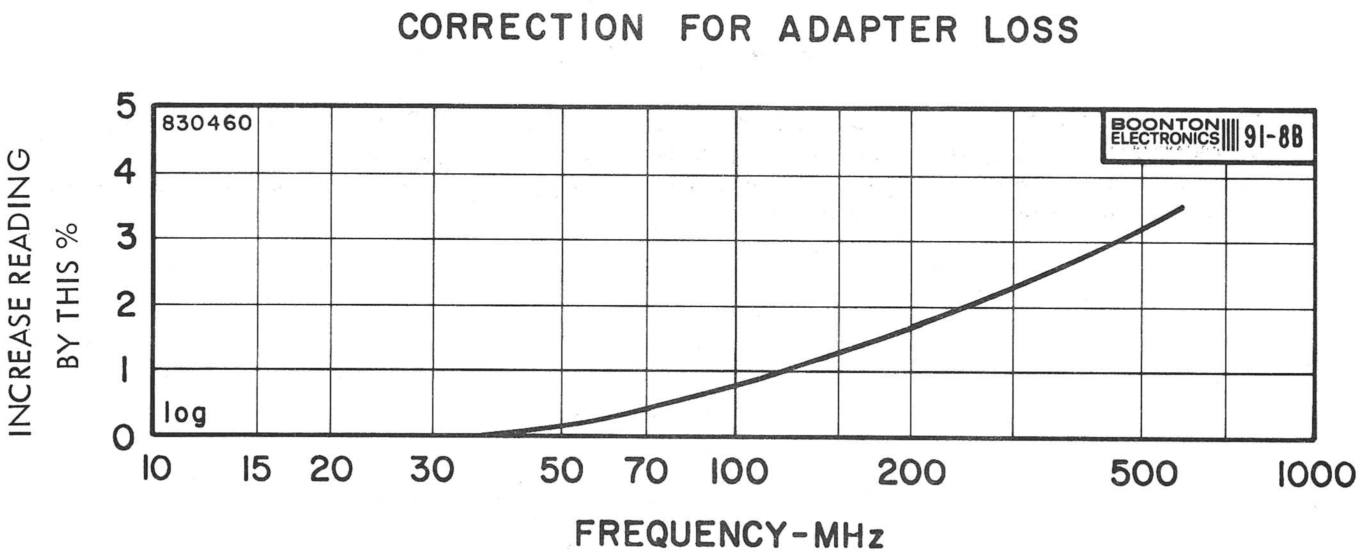


Figure 8A. Model 91-8B 50Ω BNC Adapter Correction Curve.

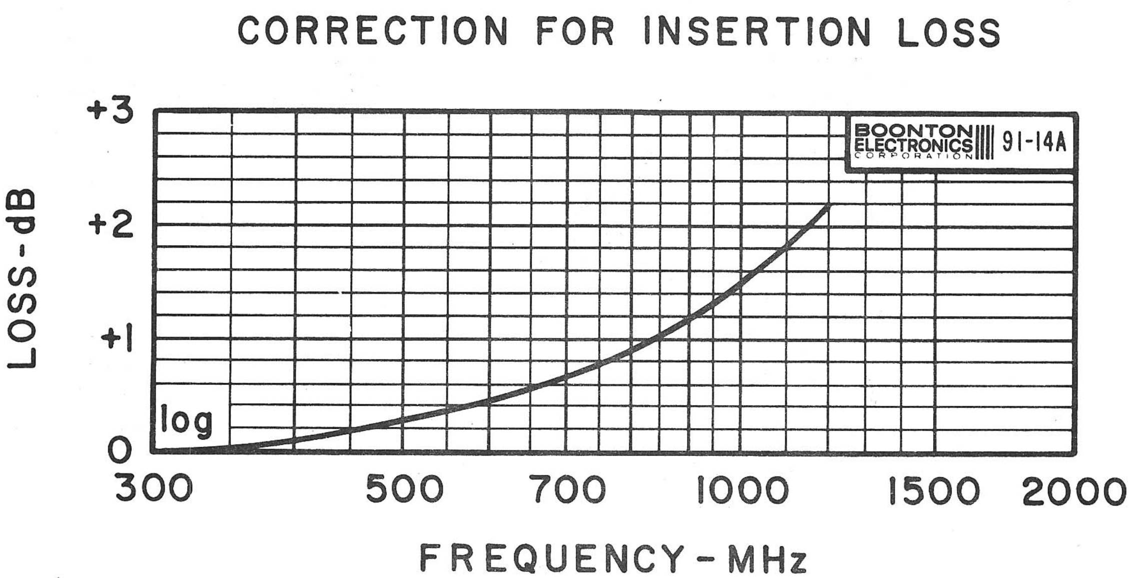


Figure 8B. Model 91-14A Type N Tee Adapter Correction Curve. Input voltage to tee adapter is indicated by voltmeter. Subtract the correction from the indicated value, in dB, to obtain output voltage of tee.

CHAPTER IV

THEORY OF OPERATION

4.1 GENERAL. The operating principles of the Model 92C are shown in the following block diagram. The essential elements of the instruments are the probe, chopper driver, chopper, attenuator, preamplifier, amplifier, pulse generator, synchronous detector, shaping amplifier, power supply, and a meter.

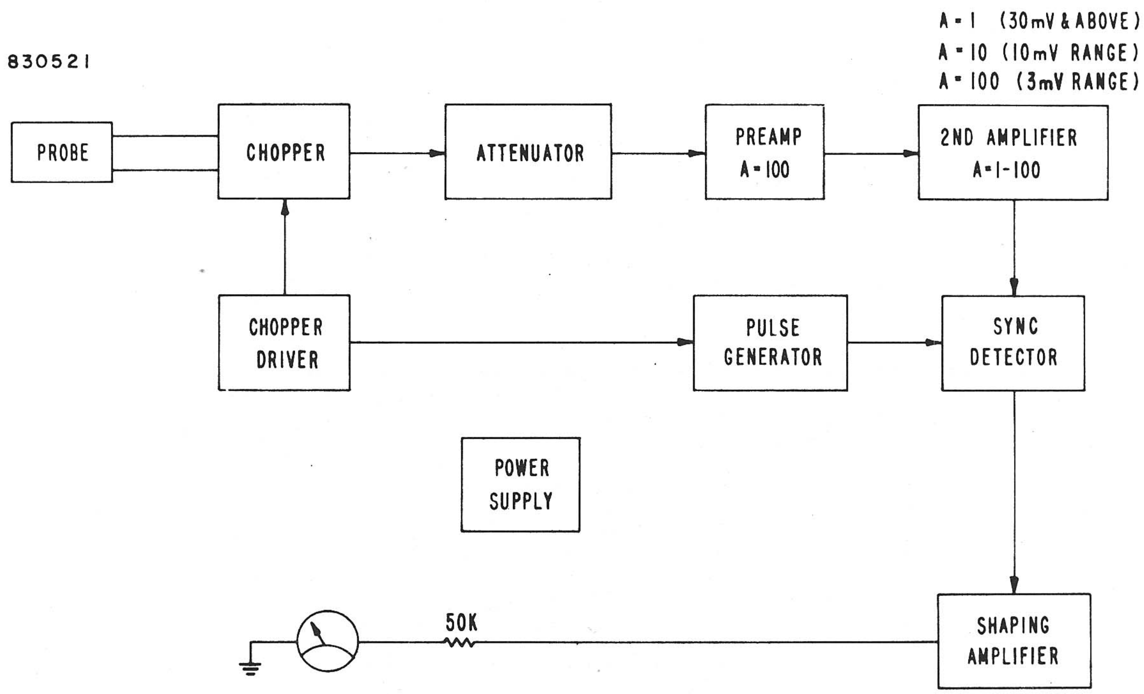


Figure 9. Block Diagram

4.1.1 RF Probe. The RF Probe embodies a full-wave diode detector which rectifies the signal under study to a dc voltage whose level is a function of the input level. While operating in the square-law region (below approximately 30 millivolts) the detector provides true rms response. As the input level increases beyond 30 millivolts, waveform response gradually approaches peak-to-peak, calibrated on the scale in rms.

In addition to increasing efficiency, use of full-wave rectification in the detector probe permits measurement of signals having highly asymmetrical waveforms without errors stemming from turn-over effect.

The diodes used in the RF Probe have been carefully selected for specific characteristics. The user is urged NOT to attempt their replacement with any off-the-shelf types. In case of damage to probe components, call on your local Boonton Electronics Sales Engineering Representative or the factory for instructions.

4.1.2 Attenuator and Amplifiers. The dc output of the probe is converted to ac by the chopper, and the resultant ac signal applied to the attenuator and amplifier sections. For each range the output voltage from the 2nd amplifier is approximately 3V peak-to-peak. This is accomplished by ranging both the attenuation and the gain of the second amplifier in the following manner:

RANGE	$\frac{1}{\text{ATTN}}$	GAIN 2nd AMP.
3 mV	1	100
10	1	10
30	1	1
100	0.15	1
300	0.04	1
1000	0.01	1
3000	0.004	1

The preamplifier has a constant gain of X100, and is designed for very low input noise. Both amplifiers have wide bandwidths and are stabilized by large amounts of negative feedback.

4.1.3 Synchronous Detector. The amplified ac signal from the second detector is converted to dc by the synchronous detector. The peak-to-peak amplitude is derived from a shunt-series capacitor storage circuit using JFET switches. The synchronous detector is driven by pulses generated in the chopper-driver circuit, thus assuring exact synchronization. The characteristics of the detector determine the effective bandwidth of the amplifier-detector combination and allow modification of the bandwidth for different range conditions. The detector also provides conversion without offset.

4.1.4 Shaping Amplifier. The conversion of rf to dc in the probe is non-linear, the response being virtually square-law for the lowest ranges and gradually becoming quasi-linear for the 3V range. The shaping amplifier converts the non-linear output of the synchronous detector to a linear output by using a segmental approximation to the exact correction. The shaping amplifier is actually an operational amplifier so connected that, as the signal increases at its output, its gain is reduced by successively paralleling resistors across the feedback resistors. The number of segments required adequately to linearize the response varies from 6 for the "square-law" ranges down to 2 for the 3V range. The output of the shaping amplifier is +10V which drives the panel meter.

4.1.5 Chopper-Driver Circuits. The chopper-driver block provides all of the drive signals required by the instrument. The chopper frequency is obtained by dividing the output of a unijunction oscillator by two. The oscillator also generates the switching pulse for the synchronous detector. Diode gating feeds the pulse to the proper JFET depending upon chopper phase.

4.1.6 Power Supply. The power supply converts the ac input power to regulated +15V and -15V outputs. Each supply is protected by current limiting against accidental short circuits. The +15V supply is a zener-biased follower, and no adjustment is provided. The -15V supply is referred to a 6.2V zener, and the voltage is adjustable to -15V, ±0.1V.

CHAPTER V

MAINTENANCE

5.1 PERIODIC CALIBRATION. The Model 92C is designed to provide trouble-free operation over extended periods of time. However, as with any precision instrument, the instrument should be checked periodically to verify proper calibration. To make such calibration checks, the following equipment is required:

a. A reliable signal source of 200 kHz to 500 kHz with less than 1% distortion at levels up to 3 volts.

b. A precision ac voltmeter.

c. A precision dc voltmeter capable of measuring -15.0V, ±0.1%.

5.2 PRECAUTIONS WHEN CHECKING CALIBRATION. When checking the calibration of an instrument having the sensitivity and bandwidth of the Model 92C, it is essential to take precautions against errors resulting from stray pick-up voltages. (See paragraph 3.3.8.) A well-shielded signal source must be used in conjunction with coaxial connections to both the Model 92C and the standard reference meter. Even with a well-shielded generator and connections, it is sometimes possible for the reference meter to pick up stray rf signals and feed them into the probe. It is advisable to test for this condition by disconnecting the standard meter and noting any change in level.

5.3 CALIBRATION CHECK. Using the equipment listed in paragraph 5.1, check the calibration of the Model 92C on each range, using a test voltage equal to the full scale value. If the check reveals that recalibration is required, the procedure outlined in paragraph 5.4 should be followed.

5.4 CALIBRATION PROCEDURE. The Model 92C should be calibrated at room temperature (21° to 25°C) after a minimum warmup of one minute.

A calibration outline is provided inside the top cover of the instrument (see Figure 10). The adjustment references listed below are the same as those recorded on the top cover.

NOTE

Check the mechanical zero on the Model 92C with the power off before proceeding with the following adjustments.

Adjustment No. 1. Measure the -15.0V dc supply voltage at Test Point No. 5 located on the main amplifier board to the left of R145. Adjust R145 to -15V ±0.1V.

Adjustment No. 2. Set the RANGE FULL SCALE SELECTOR to the 3 mV Range and zero the instrument as described in paragraph 3.3.5.

Adjustment No. 3. Set the RANGE FULL SCALE SELECTOR to the 30 mV Range and adjust R296 for a zero meter reading.

Adjustment No. 4. Set the RANGE FULL SCALE SELECTOR to the 3 mV Range (zero as in Adjustment No. 2 above), apply 3.00 mV, ±0.2% to the probe, and adjust R208 for a 3.00 mV reading.

Adjustment No. 5. Set the RANGE FULL SCALE SELECTOR to the 10 mV Range (zero as in Adjustment No. 2 above), apply 10.0 mV, ±0.2% to the probe, and adjust R220 for a 10.0 mV reading.

Adjustment No. 6. Set the RANGE FULL SCALE SELECTOR to the 30 mV Range, apply 30.0 mV, ±0.2% to the probe, and adjust R228 for a 30.0 reading.

Adjustment No. 7. Set the RANGE FULL SCALE SELECTOR to the 100 mV Range, apply 100 mV, ±0.2% to the probe, and adjust R236 for a 100 mV reading.

Adjustment No. 8. Set the RANGE FULL SCALE SELECTOR to the 300 mV Range, apply 300 mV, ±0.2% to the probe, and adjust R255 for a 300 mV reading.

Adjustment No. 9. Set the RANGE FULL SCALE SELECTOR to the 1000 mV Range, apply 1000 mV, ±0.2% to the probe, and adjust R268 for a 1000 mV reading.

Adjustment No. 10. Set the RANGE FULL SCALE SELECTOR to the 3000 mV Range, apply 3000 mV, ±0.2% to the probe, and adjust R281 for a 3000 mV reading.

5.5 TROUBLE SHOOTING. The conservative design of the Model 92C results in an instrument requiring a minimum of repair and maintenance. Should trouble develop, however, the procedures outlined in the paragraphs following will help in locating the defective component or circuit. They are listed in order of probability commencing with the RF Probe, which may be subjected to an accidental voltage overload severe enough to damage its diodes. Unless a fault is obvious enough to be immediately apparent, it is suggested that the trouble-shooting procedure be followed in the order given.

5.5.1 <u>No meter indications, ZERO control has no effect:</u> This symptom may indicate an open diode in the RF Probe. If another probe is available, substitution for the suspected probe will quickly determine whether or not this has happened. If no other probe is available, follow the procedure below.

a. Remove the probe connector from the front panel jack.

b. Jump the two terminals of the jack with a short piece of wire, and test the operation of the ZERO control on the 3 mV Range. If this control will now zero the meter, the trouble is probably in the probe. This can be confirmed by making a resistance measurement with an ohmmeter between the two pins on the probe connector. Using a high range on the ohmmeter, a good probe will show approximately 20 kΩ in one direction and virtually infinite resistance in the other. If a diode is open, resistance in either direction will be extremely high.

5.5.2 <u>All readings are abnormally low:</u> This is an indication that a probe diode has short-circuited under a severe overload. This condition cannot easily be verified with a VOM: if another probe is available, substitution for the suspected probe will quickly check this.

NOTE

> The diodes used in the RF Probes are highly specialized components. Their replacement with other diodes should not be attempted. If the tests above verify that a diode has failed, the probe should be returned to the factory for repair.

5.5.3 <u>Readings are erratic on one range:</u>

a. Check the tightness of the miniature connectors on the cable wiring between the two PC boards. If one of them appears loose on the pin, crimp with a pair of long-nosed pliers.

b. Locate the miniature calibration potentiometer associated with the defective range in the row along the top edge of the vertical PC board (see Calibration Chart). Test it with an ohmmeter for correct resistance, and for good rotor contact. Refer to the Schematic or the Table of Replaceable Parts for the resistance value.

c. Test the contacts on the appropriate section of the panel range switch for firm contact and low resistance.

d. Using the Schematic, methodically trace the operating circuits of the instrument with an oscilloscope and a multitester. Waveforms, dc and ac voltages, and other values are included on the schematic.

5.5.4 <u>Pilot lamp lighted, instrument inoperative:</u>

a. Remove the top and bottom covers of the instrument to allow easy access to all points of the circuitry. The vertical PC board may also be removed from the case and allowed to rest across the side frames; the cable is long enough to permit this, except for the two leads to the LED pilot lamp (brown and white/brown). These may be left unconnected.

b. With the instrument turned on, check the dc output of the power supply. The +15 volts is available at the front terminal of C114, and the -15 volts at C115. Both voltages are measured to the chassis.

c. If there is no dc output, check the terminations of the three wires from the power transformer on the back panel to the printed circuit board (red, red/yellow, and red/white) to see that they grip the pins firmly. Measure the ac voltages between these pins, and then the dc voltages through the power supply section to the output points.

d. If the normal dc output voltages are measured in Step b, the trouble should be sought in the other sections of the instrument. It is suggested that the Block Diagram, Figure 9, be consulted in conjunction with the Schematics at the back of the Instruction Book. Using an oscilloscope and voltmeter, a thorough analysis of the circuits should be made, working back from the output to the input. Dc and ac voltages, as well as waveforms, are indicated in the Schematics for critical points in the circuits.

5.5.5 Pilot lamp dark, instrument inoperative: This normally indicates primary power failure.

a. Check the position of the line voltage switch on the rear panel to be sure that it is in the correct position for the line voltage used.

b. Remove the line fuse from its socket on the rear panel and test it. See that it is the right size for the available line voltage.

c. Remove the instrument's top cover by taking out the screw on the top rear of the cover. Examine the terminations of the two leads (grey and white/grey) running to the rear terminals of the panel power switch. See that the miniature connectors grip the pins firmly.

WARNING: These leads carry the ac line voltage. Unplug the instrument's power cable before touching them.

d. With the instrument still unplugged, test the panel power switch for continuity.

e. With the power applied, methodically trace the operating circuits with oscilloscope and VOM, with particular attention to the range in question.

NOTE: Removal of the bottom cover allows access to all parts of the circuitry. The vertical PC board may be removed by taking out the mounting screws from the four metal mounting pillars. The interconnecting wires are long enough to allow the board to function outside the case. The two short wires to the bottom of the panel range switch (brown and white/brown) are the supply leads to the LED pilot lamp; these must be unplugged before removing the PC board, and may be left unconnected during testing.

5.5.6 Replacement of Probe: The Model 92C has been calibrated at the factory with the probe supplied with the instrument. Both instrument and probe should have the same serial number. Should another probe be used, or the original probe be repaired, the instrument's calibration MUST be checked. In some cases full recalibration will be required (see procedure in Par. 5.4). Similarly, if the RF Probe supplied with the instrument is exchanged for a Model 91-4C Low Frequency Probe, recalibration may be required.

5.5.7 Probe Tests: The probe assemblies furnished with the Model 92C can be checked for VSWR and frequency response by following the procedures detailed in the paragraphs below.

Should a probe exhibit out-of-tolerance performance in these tests, the user is urged not to attempt repair himself but to send it back to the factory for repair or adjustment.

A. VSWR Measurement

1. Test Equipment

a. Generator for the desired frequency range. Suggested signal sources are:

125 kHz - 175 MHz, Boonton Model 103A, or 103B
450 kHz - 520 MHz, Boonton Model 102C, or 102D
10 MHz - 1400 MHz, Wavetek Model 2001

b. Slotted line: GR Type 900 LB

c. Detector: GR Type 1241, or Boonton RF Millivoltmeter, 92B or 92C

2. Test Procedure

a. Connect the slotted line to a proper signal source, and terminate the line with the device to be tested, i.e., Boonton Model 91-14A Tee Adapter and Boonton Model 91-15A 50 Ω Termination, or Boonton Model 91-3B 50 Ω Adapter.

It is necessary that the probe and RF Millivoltmeter be connected to whichever accessory is being tested. The probe supplies a perturbation for which the accessory was designed, and which it needs, to meet its specification, and the millivoltmeter permits the test level to be set to the desired value.

b. Move the carriage of the slotted line to a point of minimum voltage, then to a point of maximum voltage, and record the values.

c. The VSWR is the ratio of the maximum and minimum voltages. The measurement can be repeated at other frequencies and levels, as required.

B. Frequency Response: The most accurate method of measuring the frequency response of the RF Probe for the RF Millivoltmeter is through the use of micropotentiometers, electrothermic ac-dc transfer instruments, and A-T (attenuator-thermoelement) voltmeters. Users who have these instruments available will be familiar with their application.

A method of suitable accuracy, compatible with the accuracy of the Model 92C, uses a point by point frequency scan in conjunction with a power divider and calibrated power meter. The method is detailed in the following paragraphs.

1. Test Equipment

   a. Signal source for the frequency range of 10 to 1200 MHz. Suggested instrument is Wavetek Model 2001, 10 - 1400 MHz. In this application the generator is manually swept.

   b. Power Divider, Weinschel Model 1870A

   c. Calibrated RF Power Meter, Boonton Model 42B/BD, or H-P Model 435A

2. Test Procedure

   a. Connect the equipment as shown in the figure below.

   b. Set the frequency of the generator to 10 MHz, and adjust the output control for the desired test level. If the response is to be measured at one level, only, a test voltage of 100 or 200 mV is recommended.

   c. Disable the output of the generator momentarily and zero the power meter. Record the frequency of the generator and the reading of the 92C RF Millivoltmeter. Change the frequency, in whatever increments are desired, through the range of 10 to 1200 MHz, holding the reference reading on the power meter constant.

   d. Reverse the output ports of the power divider and repeat Step c.

   e. The correct voltmeter reading is obtained at each frequency by averaging the two readings. This virtually eliminates the influence of frequency differences of the two ports of the power divider.

   f. Further refinements can be made by filtering the output of the generator, and measuring the complex reflection coefficients of the power meter, rf millivoltmeter accessory under test, and all ports of the power divider. The usual corrections can then be made. These procedures are not usually necessary, and should be done only if the additional accuracy is warranted.

C. Frequency Response and VSWR: An alternate method of measuring both the frequency response and the VSWR (in terms of the reflection coefficient), but with somewhat reduced accuracy, employs a sweep generator, VSWR bridge, external levelling of the generator, power divider, and sensitive oscilloscope.

1. Test Equipment

   a. Sweep Generator, Wavetek Model 2001, 10 - 1400 MHz

   b. SWR Autotester, Wiltron Model 63N50

   c. Oscilloscope, Tektronix Model 5100, with two 5A20 Vertical Amplifiers

   d. Power Divider, Weinschel Model 1870A

e. Standard 1.2 : 1 Mismatch Termination, Weinschel Model M1410-1.2

2. Test Procedure

a. Connect the equipment as shown in the Swept Frequency Response Test Setup figure, and temporarily connect the probe under test to the RF Millivoltmeter. Adjust the output control of the sweep generator for a reading on the 92C of 100 mV at a fixed frequency of 100 MHz.

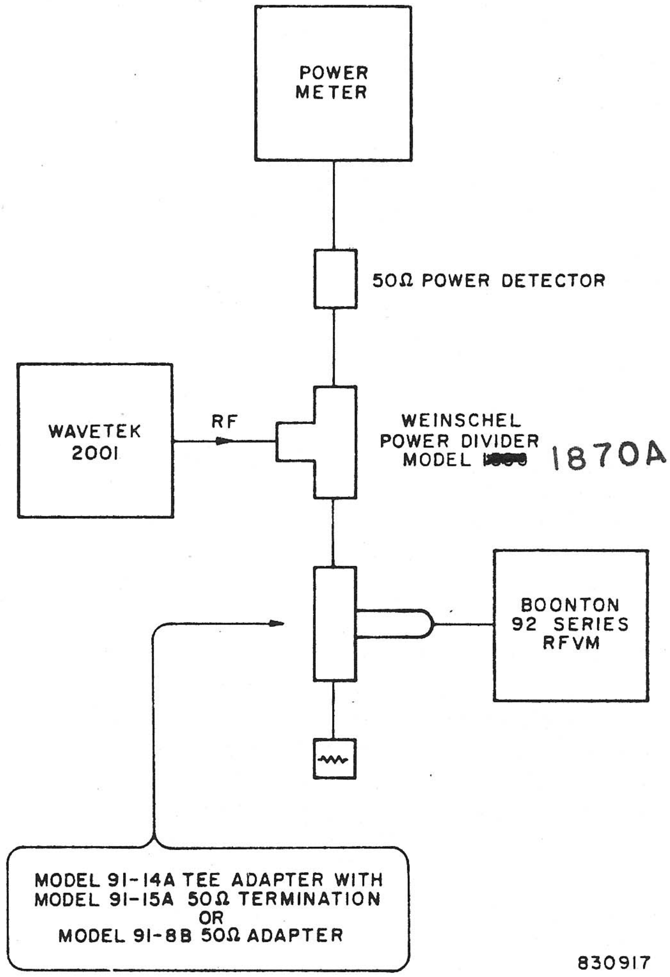
b. Calibrate one of the vertical input amplifiers of the oscilloscope for a sensitivity of 100 μV/div. The other vertical amplifier should be calibrated so that a change from 100 mV to 90 mV applied to the input of the probe under test will produce a vertical deflection of one division. This can be done easily if a Boonton Model 26A RF Millivoltmeter Calibrator is available. The probe should be temporarily connected to the output of the calibrator while output levels of 100 mV and 90 mV are alternately selected, and the sensitivity of the second input amplifier is adjusted for a deflection of one division.

c. Substitute the Standard 1.2 : 1 Mismatch Termination for the accessory under test, and calibrate the graticule of the oscilloscope for a VSWR of 1.2. Replace the accessory and probe.

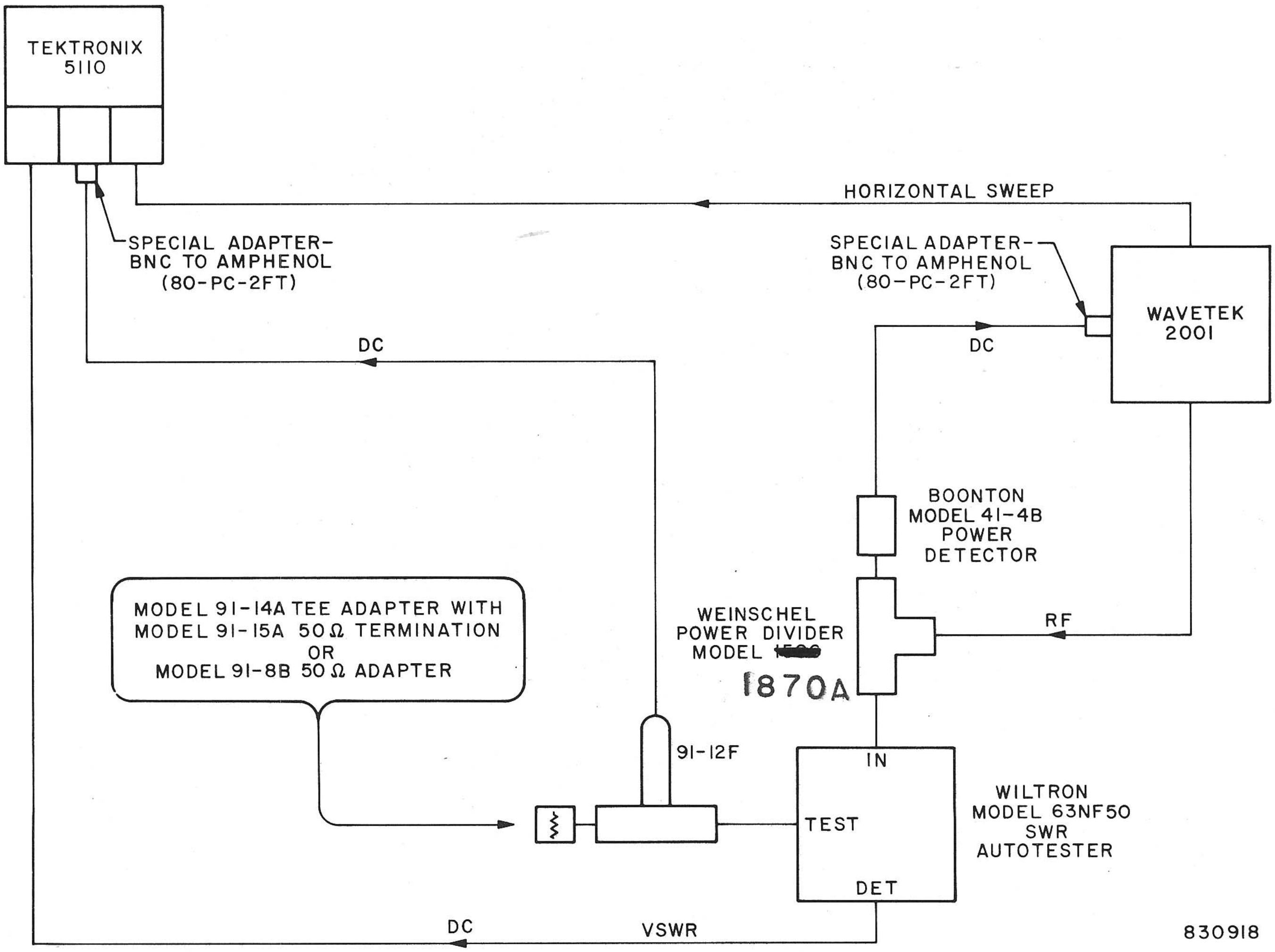
d. Adjust the limits on the three bands of the sweep generator for coverage from 10 to 1200 MHz. Study the traces for both frequency response and VSWR (return loss).

e. Reverse the output ports of the power divider and repeat Steps c and d.

f. It should be noted that the permissible error for the frequency response trace expands with frequency. For the most meaningful results, the graticule should be marked with a grease pencil, showing the maximum permissible errors for the various frequency bands, as determined with a calibrated signal of, say, 1 MHz, and at levels above and below the selected level. It is important to note that the recovered dc from the rf probe, which is applied to the second vertical amplifier, will vary as the square of the rf input level for test levels of 30 mV, or less. Above 30 mV the rf to dc conversion gradually changes from square law to linear, and approaches a peak-to-peak rectifier at an input of 3 volts.



Frequency Response Test Setup



Swept Frequency Response Test Setup

CALIBRATION INSTRUCTIONS

ADJ NO	R	FUNCTION	RANGE mV	INPUT ±0.2%	ADJUST TO
1	145	-15V ADJ	-	-	-15V ± 0.1V
2	401	FRONT PANEL ZERO	3	0	0
3	296	DC ZERO	30	0	0
4	208	RANGE ADJ	3	3mV	3mV
5	220	RANGE ADJ	10	10mV	10mV
6	228	RANGE ADJ	30	30mV	30mV
7	236	RANGE ADJ	100	100mV	100mV
8	255	RANGE ADJ	300	300mV	300mV
9	268	RANGE ADJ	1000	1000mV	1000mV
10	281	RANGE ADJ	3000	3000mV	3000mV

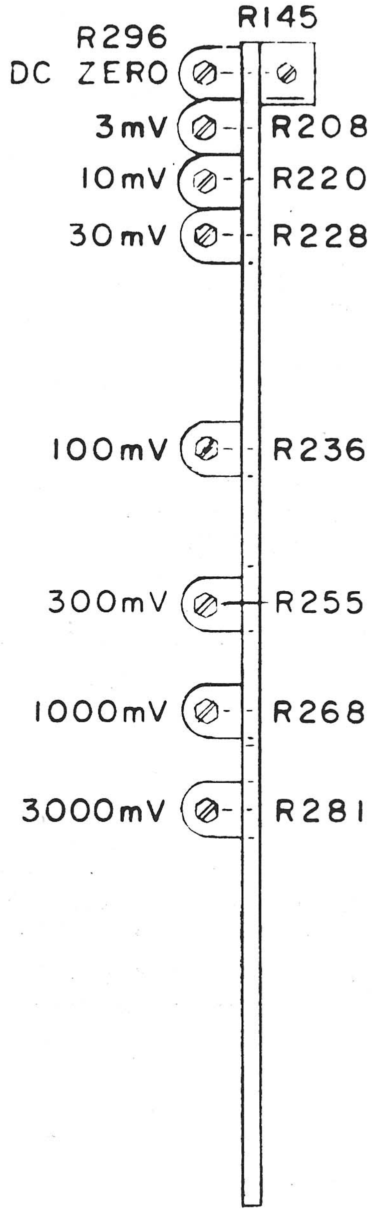


Figure 10. Calibration Instructions

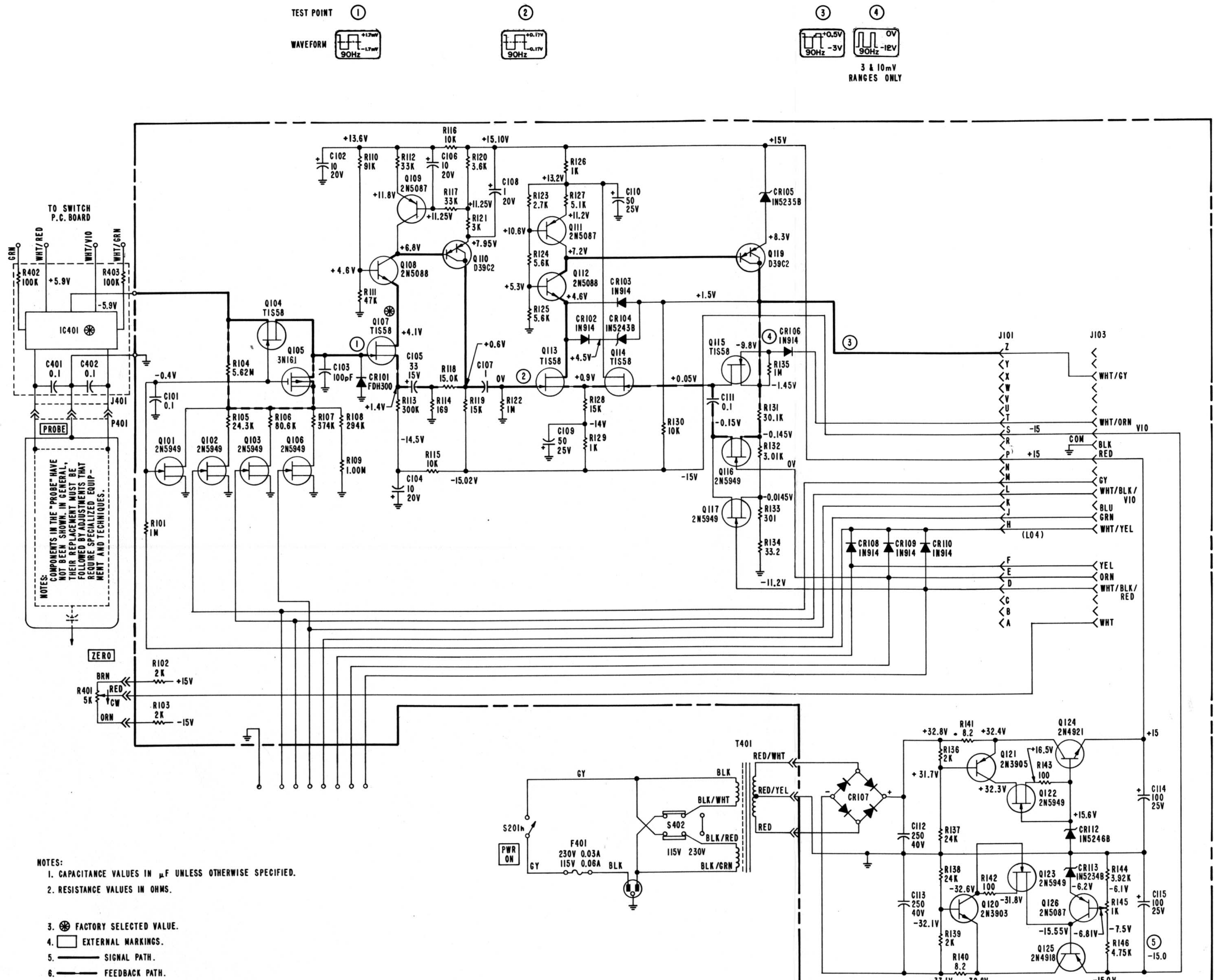
Reference		Description	BEC Part No.
		AMPLIFIER PC BOARD (CONTINUED)	
Q122	Transistor, FET	2N5949	528019
Q123	Transistor, FET	2N5949	528019
Q124	Transistor, NPN	2N4921	528034
Q125	Transistor, PNP	2N4918	528033
Q126	Transistor, PNP	2N5087	528042
R101	Resistor, Comp.	1 MΩ 5%	344600
R102	Resistor, Comp.	2 kΩ 5%	344329
R103	Resistor, Comp.	2 kΩ 5%	344329
R104	Resistor, MF	5.62 MΩ 1% 1/4 W	325397
R105	Resistor, MF	24.3 kΩ 1%	341437
R106	Resistor, MF	80.6 kΩ 1%	341487
R107	Resistor, MF	374 kΩ 1%	341555
R108	Resistor, MF	294 kΩ 1%	341545
R109	Resistor, MF	1.00 MΩ 1%	342600
R110	Resistor, Comp.	91 kΩ 5%	344492
R111	Resistor, Comp.	47 kΩ 5%	344465
R112	Resistor, Comp.	33 kΩ 5%	344450
R113	Resistor, Comp.	300 kΩ 5%	344546
R114	Resistor, MF	169 Ω 1%	341222
R115	Resistor, Comp.	10 kΩ 5%	344400
R116	Resistor, Comp.	10 kΩ 5%	344400
R117	Resistor, Comp.	33 kΩ 5%	344450
R118	Resistor, MF	15.0 kΩ 1%	341417
R119	Resistor, Comp.	15 kΩ 5%	344417
R120	Resistor, Comp.	3.6 kΩ 5%	344353
R121	Resistor, Comp.	3 kΩ 5%	344346
R122	Resistor, Comp.	1 MΩ 5%	344600
R123	Resistor, Comp.	2.7 kΩ 5%	344341
R124	Resistor, Comp.	5.6 kΩ 5%	344372
R125	Resistor, Comp.	5.6 kΩ 5%	344372
R126	Resistor, Comp.	1 kΩ 5%	344300
R127	Resistor, Comp.	5.1 kΩ 5%	344368
R128	Resistor, Comp.	15 kΩ 5%	344417
R129	Resistor, Comp.	1 kΩ 5%	344300
R130	Resistor, Comp.	10 kΩ 5%	344400
R131	Resistor, MF	30.1 kΩ 1%	341446
R132	Resistor, MF	3.01 kΩ 1%	341346
R133	Resistor, MF	301 Ω 1%	341246
R134	Resistor, MF	33.2 Ω 1%	341150
R135	Resistor, Comp.	1 MΩ 5%	344600
R136	Resistor, Comp.	2 kΩ 5%	344329
R137	Resistor, Comp.	24 kΩ 5%	344437
R138	Resistor, Comp.	24 kΩ 5%	344437
R139	Resistor, Comp.	2 kΩ 5%	344329
R140	Resistor, Comp.	8.2 Ω 5%	344088
R141	Resistor, Comp.	8.2 Ω 5%	344088
R142	Resistor, Comp.	100 Ω 5%	343200
R143	Resistor, Comp.	100 Ω 5%	343200
R144	Resistor, MF	3.92 kΩ 1%	341357
R145	Resistor, Var.	1 kΩ 20% 1 W	311257
R146	Resistor, MF	4.75 kΩ 1%	341365

Reference		Description	BEC Part No.
		SWITCH PC BOARD	
A201	Op. Amp.	LM301AN	535012
A202	Op. Amp.	LM302	535003
C201	Capacitor, PE	100 nF 10% 200 V	234005
C202	Capacitor, PE	6.8 nF 10% 200 V	234044
C203	Capacitor, Mica	100 pF 5% 500 V	200001
C204	Capacitor, Mica	100 pF 5% 500 V	200001
C205	Capacitor, Mica	100 pF 5% 500 V	200001
C206	Capacitor, PE	22 nF 10% 200 V	230101
C207	Capacitor, Mica	100 pF 5% 500 V	200001
C208	Capacitor, Elec.	50 µF +75/-10% 25 V	283159
C209	Capacitor, Elec.	50 µF +75/-10% 25 V	283159
C210	Capacitor, Cer.	10 nF 100 V	224119
C211	Capacitor, Mica	33 pF 5% 500 V	200049
C212	Capacitor, Cer.	10 nF 100 V	224119
C213	Capacitor, PE	22 nF 10% 200 V	230101
C214	Capacitor, PE	100 nF 10% 200 V	234005
C215	Capacitor, PE	100 nF 10% 200 V	234005
C216	Capacitor, Cer.	10 nF 100 V	224119
C217	Capacitor, Cer.	10 nF 100 V	224119
C218	Capacitor, Var.	4.5 - 50 pF 250 V	281006
C219	Capacitor, Mica	33 pF 5% 500 V	200049
CR201 through CR208	Diode, Sil.	1N914	530058
CR209	See Rear Panel Assembly		
CR210 through CR214	Diode, Sil.	1N914	530058
CR215	Diode, Sil.	FDH300	530052
CR216	Diode, Sil.	1N914	530058
CR217	Diode, Sil.	1N914	530058
Q201	Transistor, PNP	2N5087	528042
Q202	Transistor, Unij.	2N4871	528051
Q203	Transistor, PNP	2N5087	528042
Q204	Transistor, PNP	2N5087	528042
Q205	Transistor, NPN	MPSA20	528043
Q206	Transistor, PNP	2N5087	528042
Q207	Transistor, PNP	2N5087	528042
Q208	Transistor, NPN	2N5088	528047
Q209	Transistor, NPN	2N5088	528047
Q210	Transistor, NPN	2N5088	528047
Q211	Transistor, PNP	2N5087	528042
Q212	Transistor, PNP	2N5087	528042
Q213	Transistor, PNP	2N5087	528042
Q214	Transistor, NPN	MPSA20	528043
Q215	Transistor, PNP	2N5087	528042
Q216	Transistor, NPN	MPSA20	528043
Q217	Transistor, PNP	2N5087	528042
Q218	Transistor, PNP	2N5087	528042
Q219	Transistor, NPN	MPSA20	528043
Q220	Transistor, PNP	2N5087	528042
Q221	Transistor, PNP	2N5087	528042

Reference		Description	BEC Part No.
		SWITCH PC BOARD (CONTINUED)	
Q222	Transistor, NPN	MPSA20	528043
Q223	Transistor, PNP	2N5087	528042
Q224	Transistor, PNP	2N5087	528042
Q225	Transistor, FET	MPS-A12	528052
Q226	Transistor, FET	TIS58 (Selected)	528093
Q227	Transistor, FET	TIS58 (Selected)	528093
R201	Resistor, Comp.	150 kΩ 5%	344517
R202	Resistor, Comp.	10 kΩ 5%	344400
R203	Resistor, MF	100 kΩ 1%	341500
R204	Resistor, Comp.	10 kΩ 5%	344400
R205	Resistor, MF	53.6 kΩ 1%	341470
R206	Resistor, MF	2.74 kΩ 1%	341342
R207	Resistor, Comp.	33 kΩ 5%	344450
R208	Resistor, Var.	1 kΩ ±20% 1/2 W	311284
R209	Resistor, Comp.	10 kΩ 5%	344400
R210	Resistor, MF	28.7 kΩ 1%	341444
R211	Resistor, MF	200 kΩ 1%	341529
R212	Resistor, MF	1.00 MΩ 1%	342600
R213	Resistor, Comp.	100 Ω 5%	344200
R214	Resistor, Comp.	33 kΩ 5%	344450
R215	Resistor, MF	40.2 kΩ 1%	341458
R216	Resistor, MF	191 kΩ 1%	341527
R217	Resistor, Comp.	100 kΩ 5%	344500
R218	Resistor, Comp.	3.3 kΩ 5%	344350
R219	Not Used		
R220	Resistor, Var.	1 kΩ 20% 1/2 W	311284
R221	Resistor, MF	29.4 kΩ 1%	341445
R222	Resistor, MF	95.3 kΩ 1%	341494
R223	Resistor, Comp.	4.7 kΩ 5%	344365
R224	Resistor, Comp.	10 kΩ 5%	344400
R225	Resistor, MF	28.0 kΩ 1%	341443
R226	Resistor, MF	64.9 kΩ 1%	341478
R227	Resistor, Comp.	10 kΩ 5%	344400
R228	Resistor, Var.	1 kΩ 20% 1/2 W	311284
R229	Resistor, Comp.	270 kΩ 5%	344541
R230	Resistor, MF	26.1 kΩ 1%	341440
R231	Resistor, MF	46.4 kΩ 1%	341464
R232	Resistor, Comp.	10 kΩ 5%	344400
R233	Resistor, Comp.	390 kΩ 5%	344557
R234	Resistor, MF	45.3 kΩ 1%	341463
R235	Resistor, MF	2.74 kΩ 1%	341342
R236	Resistor, Var.	1 kΩ 20% 1/2 W	311284
R237	Resistor, Comp.	18 kΩ 5%	344425
R238	Resistor, Comp.	15 kΩ 5%	344417
R239	Resistor, Comp.	10 kΩ 5%	344400
R240	Resistor, Comp.	47 kΩ 5%	344465
R241	Resistor, MF	21.5 kΩ 1%	341432
R242	Resistor, MF	237 kΩ 1%	341536
R243	Resistor, MF	26.1 kΩ 1%	341440
R244	Resistor, MF	154 kΩ 1%	341518
R245	Resistor, Comp.	10 kΩ 5%	344400
R246	Resistor, MF	54.9 kΩ 1%	341471
R247	Resistor, MF	191 kΩ 1%	341527
R248	Resistor, MF	31.6 kΩ 1%	341448

Reference		Description	BEC Part No.
		SWITCH PC BOARD (CONTINUED)	
R249	Resistor, MF	82.5 kΩ 1%	341488
R250	Resistor, MF	178 kΩ 1%	341524
R251	Resistor, MF	31.6 kΩ 1%	341448
R252	Resistor, Comp.	12 kΩ 5%	344408
R253	Resistor, MF	17.8 kΩ 1%	341424
R254	Resistor, MF	2.74 kΩ 1%	341342
R255	Resistor, Var.	1 kΩ ±20% 1/2 W	311284
R256	Resistor, Comp.	100 kΩ 5%	344500
R257	Resistor, MF	24.3 kΩ 1%	341437
R258	Resistor, MF	232 kΩ 1%	341535
R259	Resistor, MF	95.3 kΩ 1%	341494
R260	Resistor, MF	453 kΩ 1%	341563
R261	Resistor, Comp.	100 kΩ 5%	344500
R262	Resistor, Comp.	12 kΩ 5%	344408
R263	Resistor, MF	200 kΩ 1%	341529
R264	Resistor, MF	634 kΩ 1%	342577
R265	Resistor, MF	31.6 kΩ 1%	341448
R266	Resistor, MF	14.3 kΩ 1%	341415
R267	Resistor, MF	2.74 kΩ 1%	341342
R268	Resistor, Var.	1 kΩ ±20% 1/2 W	311284
R269	Resistor, Comp.	100 kΩ 5%	344500
R270	Resistor, MF	31.6 kΩ 1%	341448
R271	Resistor, Comp.	100 kΩ 5%	344500
R272	Resistor, MF	34.8 kΩ 1%	341452
R273	Resistor, MF	523 kΩ 1%	342569
R274	Resistor, Comp.	2 kΩ 5%	344329
R275	Resistor, Comp.	27 kΩ 5%	344441
R276	Resistor, MF	162 kΩ 1%	341520
R277	Resistor, MF	806 kΩ 1%	342587
R278	Resistor, Comp.	3 kΩ 5%	344346
R279	Resistor, MF	10 kΩ 1%	341400
R280	Resistor, MF	2.74 kΩ 1%	341342
R281	Resistor, Var.	1 kΩ 20% 1/2 W	311284
R282	Resistor, Comp.	1.6 kΩ 5%	344320
R283	Resistor, Comp.	12 kΩ 5%	344408
R284	Resistor, Comp.	4.7 kΩ 5%	344365
R285	Resistor, Comp.	470 Ω 5%	344265
R286	Resistor, Comp.	750 Ω 5%	344284
R287	Resistor, Comp.	100 kΩ 5%	344500
R288	Resistor, MF	127 kΩ 1%	341510
R289	Resistor, MF	604 kΩ 1%	342575
R290	Resistor, Comp.	150 kΩ 5%	344517
R291	Resistor, Comp.	510 kΩ 5%	344568
R292	Resistor, Comp.	15 kΩ 5%	344417
R293	Resistor, Comp.	10 kΩ 5%	344400
R294	Resistor, Comp.	4.7 kΩ 5%	344365
R295	Resistor, MF	49.9 kΩ 1%	341467
R296	Resistor, Var.	2 kΩ 20% 1/2 W	311285
R297	Resistor, Comp.	100 kΩ 5%	344500
R298	Resistor, Comp.	2 kΩ 5%	344329
R299	Resistor, Comp.	3 kΩ 5%	344346
S201	Switch	PB10 M/F 465168	465169

Reference		Description	BEC Part No.
		CHOPPER PC BOARD	
C401	Capacitor, PC	100 nF 10% 50 V	234046
C402	Capacitor, PC	100 nF 10% 50 V	234046
IC401	Integrated Circuit	CD4016AE (Selected)	534020
R402	Resistor, MF	100 kΩ 1%	341500
R403	Resistor, MF	100 kΩ 1%	341500
		REAR PANEL, SUB PANEL	
CR209	Diode, LED	MV5025 (RED)	536000
F401	Fuse, Super Time Lag	1/16 Amp 250 V	545538
F401	Fuse, Slo-Blo	0.1 Amp 117 V	545519
J401	Receptacle	Amphenol No. 80-PC-2FT	479119
M401	Meter & Scale	API	554216
R401	Resistor, Var.	5 kΩ 20% 2 W	311255
R404*	Resistor, Comp.	7.5 kΩ 5%	344384
R404*	Resistor, Comp.	8.2 kΩ 5%	344388
R404*	Resistor, Comp.	9.1 kΩ 5%	344392
R404*	Resistor, Comp.	10 kΩ 5%	344400
R404*	Resistor, Comp.	11 kΩ 5%	344404
R404*	Resistor, Comp.	12 kΩ 5%	344408
R404*	Resistor, Comp.	13 kΩ 5%	344411
R404*	Resistor, Comp.	15 kΩ 5%	344417
R404*	Resistor, Comp.	17 kΩ 5%	344420
R404*	Resistor, Comp.	18 kΩ 5%	344425
R404*	Resistor, Comp.	20 kΩ 5%	344429
R404*	Resistor, Comp.	22 kΩ 5%	344433
R404*	Resistor, Comp.	24 kΩ 5%	344437
R404*	Resistor, Comp.	27 kΩ 5%	344441
R404*	Resistor, Comp.	30 kΩ 5%	344446
R404*	Resistor, Comp.	33 kΩ 5%	344450
R404*	Resistor, Comp.	39 kΩ 5%	344457
R404*	Resistor, Comp.	47 kΩ 5%	344465
R404*	Resistor, Comp.	56 kΩ 5%	344472
	*One of the above to be selected during calibration.		
S402	Switch, Slide	Switchcraft	465134
T401	Transformer, Power	Magnetic, Winding	446052



NOTES:
1. CAPACITANCE VALUES IN μF UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.

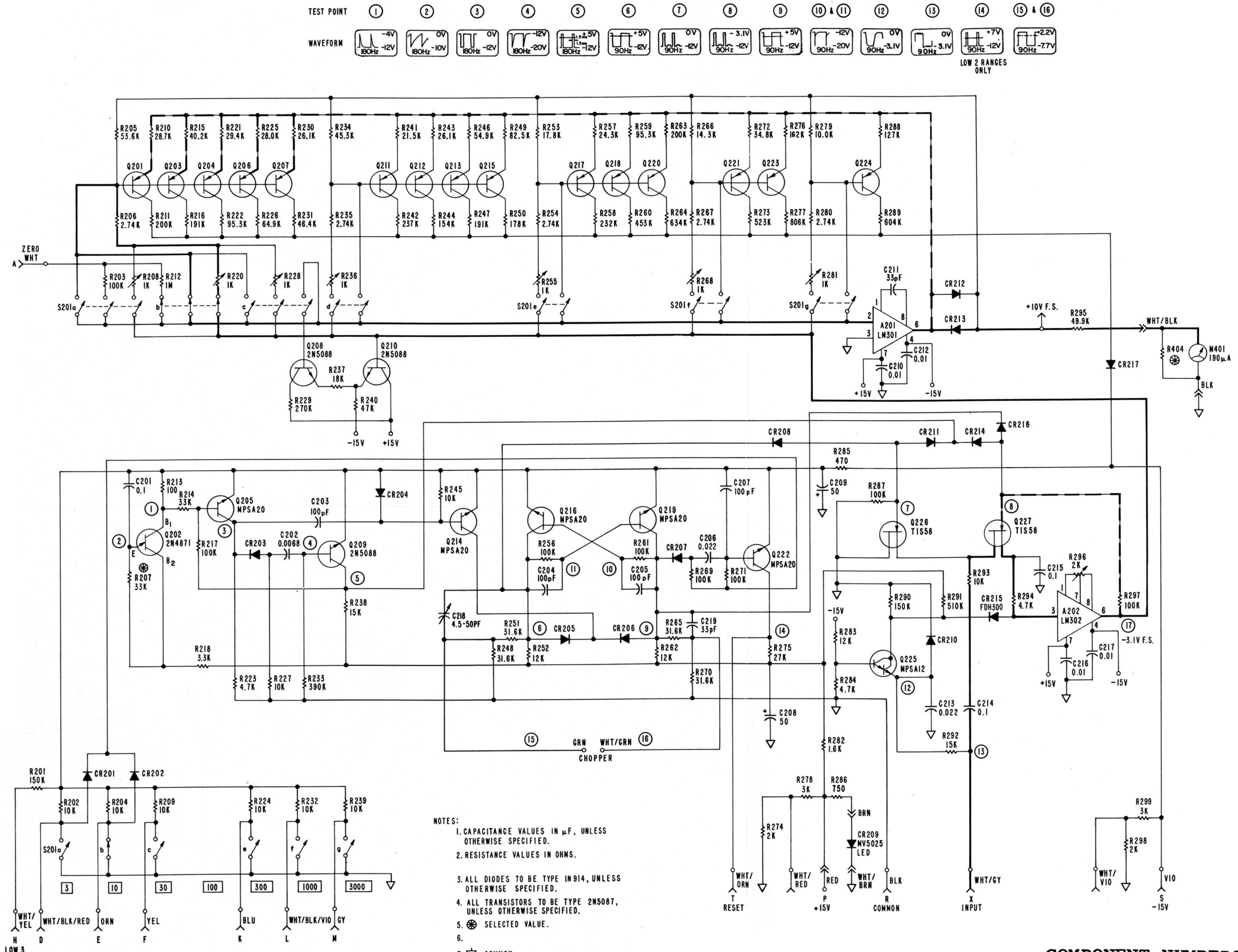
3. ❋ FACTORY SELECTED VALUE.
4. ▭ EXTERNAL MARKINGS.
5. ——— SIGNAL PATH.
6. ——— FEEDBACK PATH.
7. ——— SIGNAL PATH FOR 100, 300, 1000 & 3000mV RANGES ONLY.
8. TEST CONDITIONS: DC VOLTAGES INDICATED ARE NOMINAL VALUES ONLY. 10mV RANGE 10mV SIGNAL
9. LAST NUMBERS USED: R146 C115 R403 C402
10. NUMBERS NOT USED: CR111 Q118
11. ◯ TEST POINTS.

COMPONENT NUMBERS

100 SERIES

BOONTON ELECTRONICS CORPORATION

MODEL 92C
Schematic, Amplifier
E830513G



NOTES:

1. CAPACITANCE VALUES IN µF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. ALL DIODES TO BE TYPE IN914, UNLESS OTHERWISE SPECIFIED.
4. ALL TRANSISTORS TO BE TYPE 2N5087, UNLESS OTHERWISE SPECIFIED.
5. ⊛ SELECTED VALUE.
6.
7. ▽ COMMON.
8. ▭ EXTERNAL MARKINGS.
9. ——— SIGNAL PATH.
10. — — — FEEDBACK PATH.
11. ○ TEST POINT.
12. LAST NUMBER USED: R299 C219 R404
13. NUMBERS NOT USED: R219

COMPONENT NUMBERS
200 SERIES

BOONTON ELECTRONICS CORPORATION

MODEL 92C
Schematic, Switch
E830529J

WARRANTY

Boonton Electronics Corporation warrants its products to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to active devices that have given normal service, to sealed assemblies which have been opened or to any item which has been repaired or altered without our authorization.

We will repair, or at our option, replace any of our products which are found to be defective under the terms of this warranty.

There will be no charge for parts, labor, or forward and return shipment during the first three months of this warranty.

There will be no charge for parts, labor, or return shipment during the fourth through twelfth month of this warranty.

Except for such repair or replacement, we will not be liable for any incidental damages or for any consequential damages, as those terms are defined in Section 2-715 of the Uniform Commercial Code, in connection with products covered by this warranty.

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