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NBS RF VOLTAGE COMPARATOR

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This manual describes a wideband rf voltage comparator which covers the frequency range of 100 kHz to 1 GHz from 10 mV to 20 volts. This device uses a pair of matched Schottky-barrier diodes in each independent channel of a 2 dual-channel configuration. The coaxial line sections are impedance compensated to assure a VSWR less than 1.03 up to 1 GHz. Applications covered are calibration of signal generators and rf voltmeters. A troubleshooting and maintenance section is also included as well as illustrations and circuit diagrams to facilitate repair.

Key words: Comparator; rf voltage; rf voltmeters.

I. INTRODUCTION

The NBS Voltage Comparator is basically a differential voltmeter. It enables comparison of an unknown rf CW voltage to an accurately known ac voltage (1-100 kHz). Both voltages are detected by diode detectors and algebraically summed giving an output proportional to the difference in the two signals. The advantages of the device are (1) high resolution, (2) high accuracy, (3) wide voltage range (10 mV-20 V), (4) broad frequency range (0.1-1000 MHz), (5) simplicity of operation, (6) insensitivity to ambient conditions, and (7) low construction cost. This device can be used for calibration or qualification of both rf signal generators and rf voltmeters.

II. SPECIFICATIONS

A. Low Level Channel (3 V max)

Frequency range: 100 kHz - 1 GHz
Voltage range: 10 millivolts - 3 volts rms
Characteristic impedance: 50 ohms
Input VSWR (terminated in 50 Ω): <1.03 to 1 GHz
Reference plane: 0.159 cm (1/16") from end of type N female plugged into comparator

Accuracy:	10 mV to 100 mV	100 kHz to 100 MHz	<3%
	10 mV to 100 mV	100 MHz to 1 GHz	<5%
	100 mV to 3 V	100 kHz to 100 MHz	<1%
	100 mV to 3 V	100 MHz to 1 GHz	<3%

RF ref input/output connector: precision type N male
RF input/output connector: precision type N female
AC reference input connector: panel mount BNC female
Null output connector: panel mount BNC female

B. High Level Channel (20 V max)

Frequency range: 100 kHz - 10 MHz
Voltage range: 3 - 20 volts rms
Accuracy: 100 kHz - 10 MHz < 1%
RF reference input/output connector: precision type "N" male
RF input/output connector: precision type "N" female
AC reference input connector: panel mount BNC female
Null output connector: panel mount BNC female

C. General Comparator Package

Housing dimensions: 4 1/8" L x 2 3/4" D x 1 5/8" H

D. Power Supply

Input: 105 to 125 VAC, 60 Hz, 1/4 amp
Output: ±15 V dc, ±25 ma
Housing dimensions: 4 1/8" L x 2 3/4" D x 1 5/8" H
An 8' cord connects the power supply output to the comparator housing.

E. <u>Required Equipment for Operation</u>

AC Reference Generator

Voltage range: 10 mV to 20 V rms
Voltage accuracy: 0.1% for max. accuracies
Frequency range: 1-100 kHz
Distortion and noise: 0.05%
Load capability: 25 mA

DC Null Detector

Display: analog, zero center
Sensitivity: ±100 microvolts full scale minimum to
±10 volts full scale maximum
Input impedance: > = 10 megohms

Coaxial Termination

Impedance	Frequency Range	Connector	Power Rating
50 ohms ± 1 percent	100 kHz to 1 GHz	Type N male	1 watt
75 ohms ± 1 percent	100 kHz to 10 MHz	Type N male	1 watt
90 ohms ± 1 percent	100 kHz to 10 MHz	Type N male	1 watt
135 ohms ± 1 percent	100 kHz to 10 MHz	Type N male	1 watt
600 ohms ± 1 percent	100 kHz to 10 MHz	Type N male	1 watt

III. PRINCIPLES OF OPERATION AND DESCRIPTION

The rf voltage comparator is basically a differential voltmeter. It enables comparison of an unknown rf voltage to an accurately known, adjustable, ac reference voltage (1-100 kHz). Both voltages are detected, their outputs are algebraically summed and a voltage proportional to their difference is displayed on a dc null indicator as illustrated in figure 1.

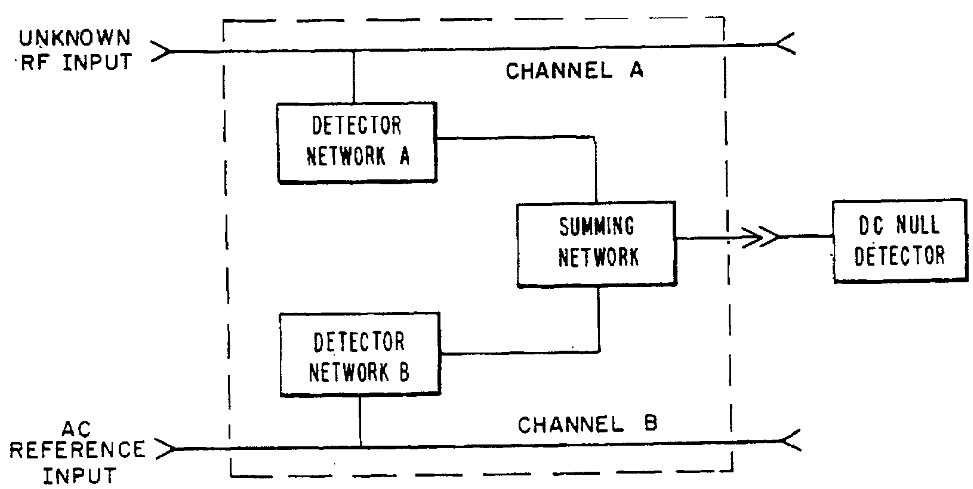

Figure 1. Basic Block Diagram of RF Voltage Comparator

The advantages of this measurement scheme are (1) high resolution, (2) high accuracy, (3) minimal sensitivity to ambient conditions, (4) simplicity of operation and design, (5) wide voltage range (10 mV to 20 V), (6) broad frequency range (.1 to 1000 MHz), and (7) low construction cost. Since the rf channel is a thru channel, one can use the comparator as an in-line instrument as well as a terminating measuring device.

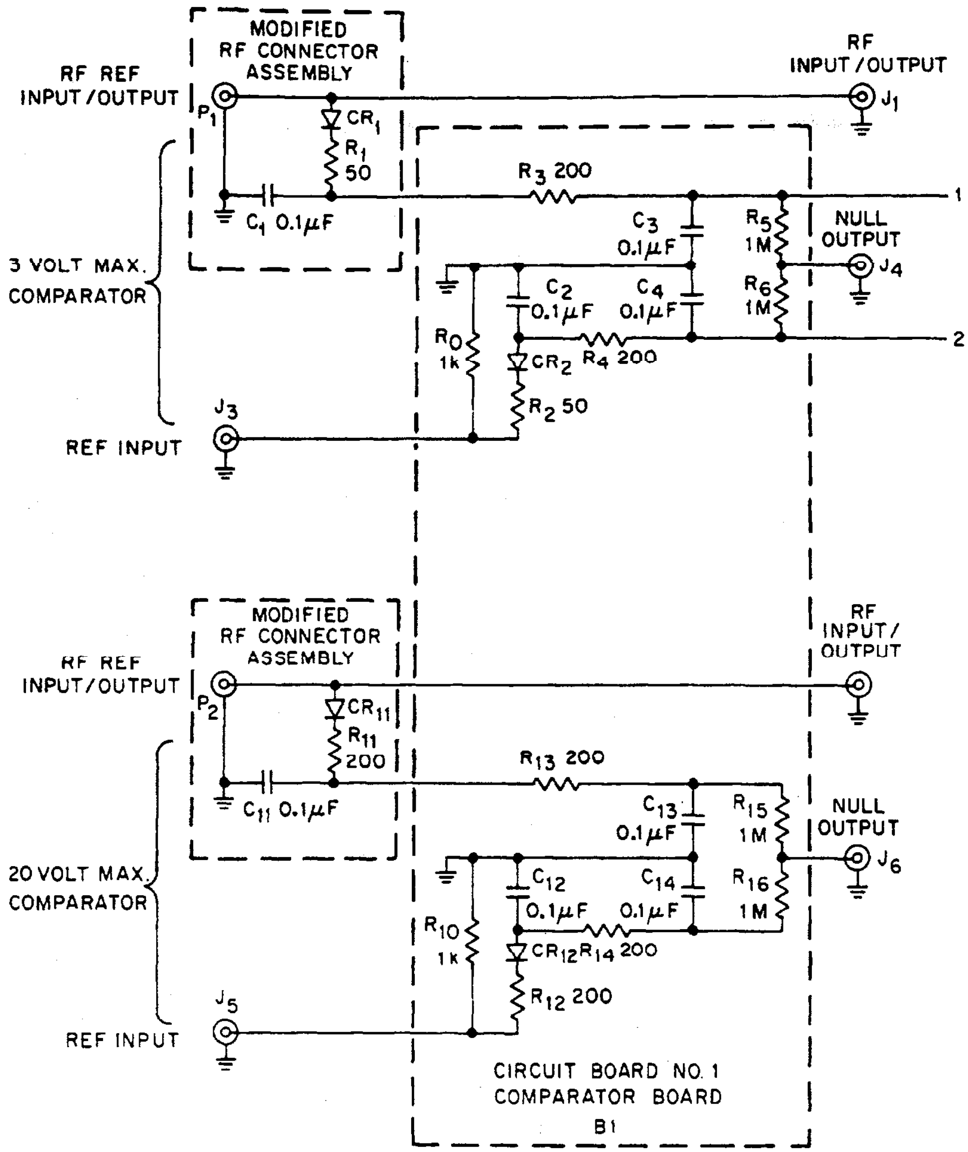

Figure 2. Circuit Diagram of Detector and Summing Networks of RF Voltage Comparator

The heart of the comparator circuit is a pair of closely-matched Schottky Barrier diodes. These diodes detect the rf and reference signals and are oriented in the circuit such that the detected outputs have opposite polarities. This allows the use of a simple resistive circuit to sum the outputs. Also, with this differential arrangement, the temperature coefficients of the diodes tend to compensate one another.

The comparator described in this manual is illustrated in the circuit diagram in figure 2. This device is more complicated than the basic comparator circuit of figure 1, as several unique features were necessary to meet the design goals. The most significant feature is the placement of the rf detector circuit inside a precision type "N" male connector. This is accomplished, as shown in figure 3, through the use of miniature circuit components. The use of a pill packaged diode (CR_1, CR_{11}), a pellet resistor (R_1, R_{11}), and a monolithic chip capacitor (C_1, C_{11}) places the rf detecting diode within 0.16 cm of the end plane of a mated type "N" female connector, while insuring a low comparator VSWR (< 1.03). The result is a very significant reduction in errors when measuring devices having large VSWR's.

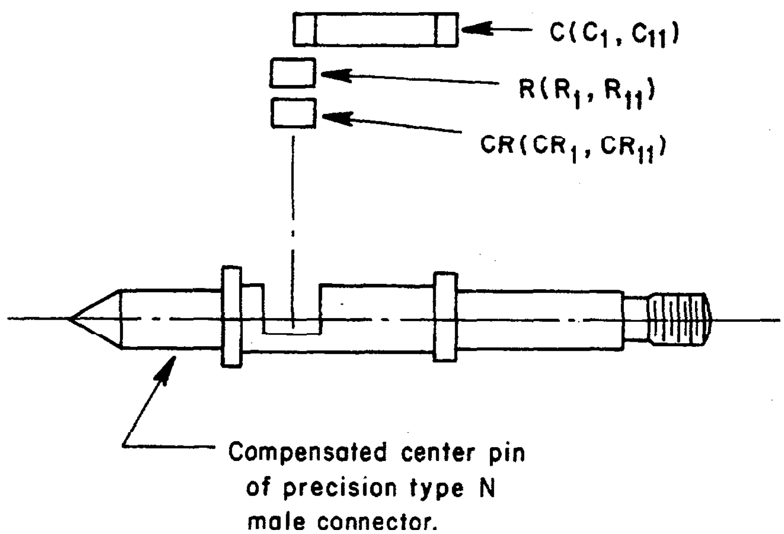

Figure 3. RF Detector Subassembly

The instrument utilizes two complete and separate comparator circuits. They allow the required, wide-range coverage in voltage (10 mV - 20 V) and frequency (.1 - 1000 MHz). One comparator is designed for voltage levels between 10 mV and 3 V in the frequency range of .1 - 1000 MHz. The other comparator operates between 3 and 20 V at frequencies from .1 - 10 MHz.

The 3 V max comparator uses special low capacitance (C_j = .08 pf) Schottky Barrier diodes. The low capacitance of the diode together with a slight undercut of the center conductor of the rf channel results in VSWR's < 1.03 up to 1 GHz (see figure 3). Since the diodes in this section must respond to voltage levels as low as 10 mV, it is necessary to forward bias each diode. This is provided by the constant current section, shown in figure 4, which utilizes a closely matched dual FET device. This device is integrated into conventional constant-current circuits which provide the required (+) and (-) diode biasing currents. Designed in the 3 volt max comparator is a circuit which triggers an audible alarm if either the rf level or the reference level exceeds 3 volts. This is accomplished with a pair of FET input operational amplifiers and a miniature audio alarm. A modular ± 15 V power supply, shown in figure 5, is connected to the comparator housing to supply power to the current source and alarm circuitry.

The 20 volt max comparator also uses Schottky Barrier diodes, but of the high reverse breakdown variety (70 V). These diodes provide useful detection up to levels as high as 20 V. Since the maximum intended operating frequency of this comparator is 10 MHz, their junction capacitance (≈ 2 pf) is insignificant; therefore, rf line compensation is unnecessary. In the 3 - 20 V range, the diodes behave as peak detectors, thus making diode biasing unnecessary. Consequently, the accuracy of this comparator is entirely dependent upon the tracking of the rf and reference diodes.

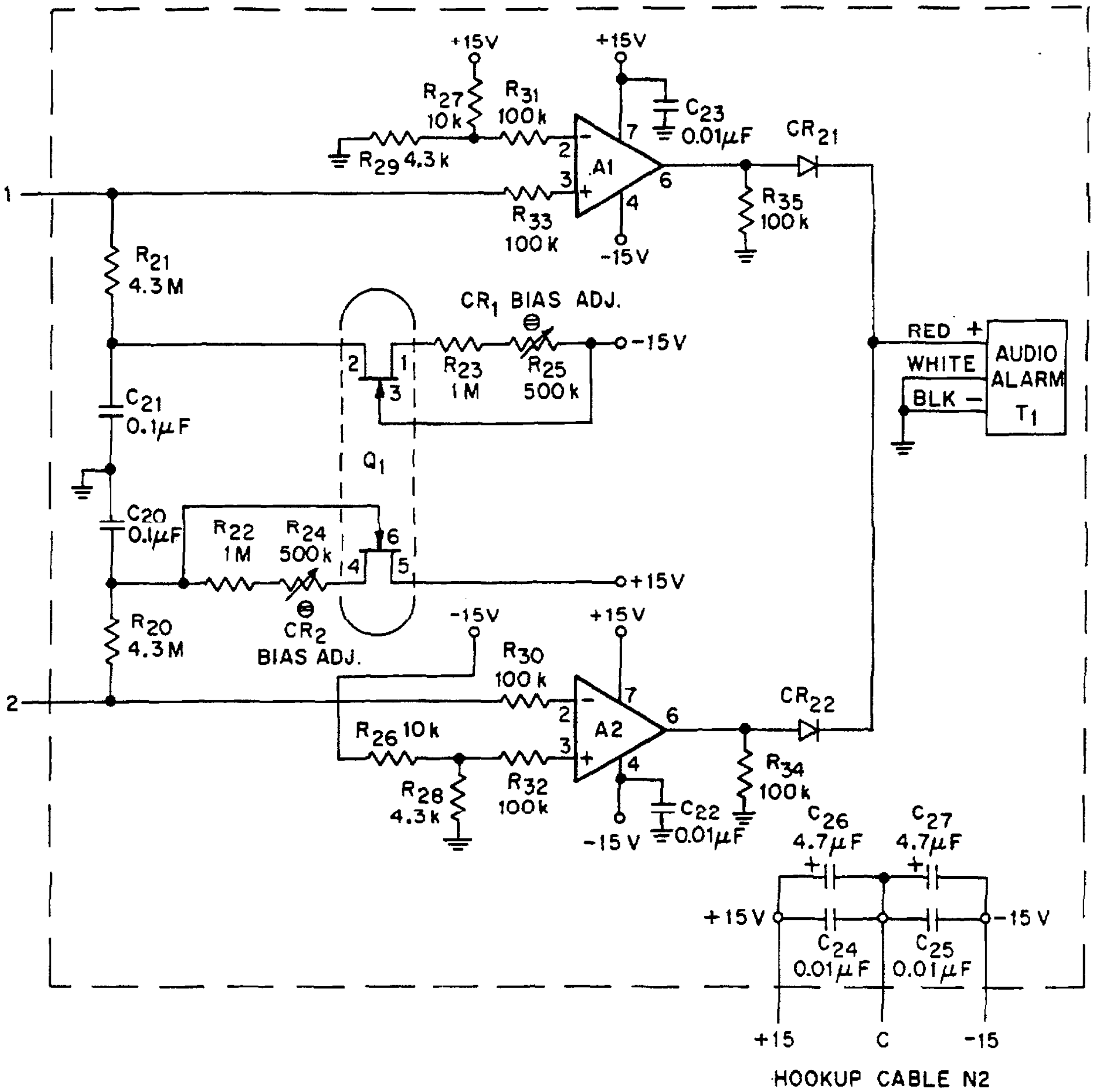

Figure 4. Circuit Diagram of Constant Current Source and Alarm Board

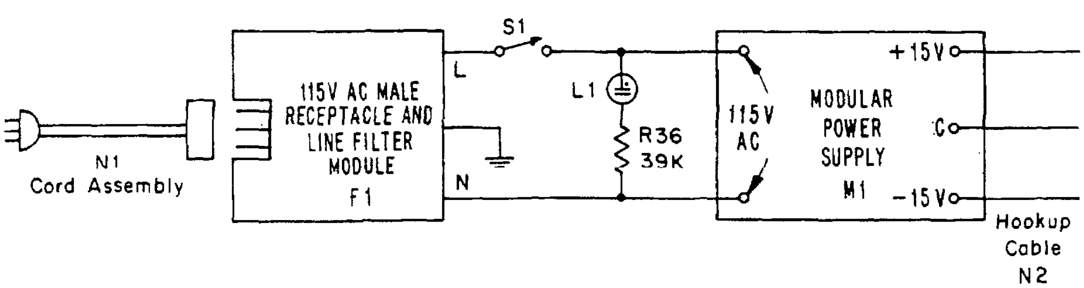

Figure 5. Block Diagram of Modular Power Supply (±15 Volts)

IV. OPERATING INSTRUCTIONS

A. General

The two separate comparators in this instrument (the low level or 3 V max channel and the high level or 20 V max channel) operate essentially the same. One exception is that the 3 V max comparator must undergo an "initial null zero procedure" before being used. This preliminary adjustment is not necessary with the 20 V max comparator.

Both comparators can be used to calibrate rf generators and rf voltmeters. These devices must operate within the limits of the voltage comparator; i.e., at frequencies between 100 kHz and 1 GHz and at voltage levels between 10 mV and 20 V rms. Also, rf voltmeters can be either the terminating type or the feed thru tee type.

Always check section II (Specifications) to determine the appropriate comparator section to use before making a measurement. Also, be certain that the ac reference generator and the dc null detector meet the required specifications described in section II.

The comparator power supply need only be energized if the 3 V max comparator is to be used.

<u>CAUTION</u>: The diodes used in the low level (3 V max) comparator can be damaged by static discharge. Since coaxial connecting cables can store energy, one should momentarily short the inner and outer conductors together before connecting any cables to either the ref input or the rf inputs of the comparator. In general, avoid any situation that could cause a static discharge through either detecting diode. Additional precautions against static discharge are given in the discussion covering diode testing and replacement in section V.

<u>CAUTION</u>: Any severe stress or force that could tend to twist the center conductors in the rigid 50 ohm line sections could cause mechanical failure of the rf detector assemblies. Therefore, whenever connecting to these lines always hold the mating connectors securely while turning only the tightening sleeve of the male connector.

<u>CAUTION</u>: Before turning on the power supply, always be certain that the rf channel of the 3 V max comparator is terminated. Also, when removing a termination or terminating device from this channel, always turn off the power supply first.

B. Measurement of rf Voltages Between 0.01 and 0.1 Volt

The offset voltage between the reference and rf detectors of the comparator must be determined before any voltage measurement can be made at the 0.01 volt level. This is accomplished in the following manner.

1. Set the frequency and output level of the reference generator to minimum.

2. Turn the power supply on and allow sufficient warmup before proceeding.

3. Connect the equipment as shown in figure 6.

   Note: Obtaining a null will be easier if the sensitivity of the null detector is initially decreased; however, the final null detector sensitivity setting should be on the proper range, as indicated in the subsequent sections. This procedure should be followed during any null zero process.

4. Set the null detector to zero, on the 100 μV range, by adjusting the bias pots.

5. Set the reference generator to 0.01 volts at 100 kHz, and record the magnitude and sign of the null detector indication for future use. This indication is the measure of the offset voltage and must be used when making measurements below 0.1 volt. This value should not be more than 20 μV.

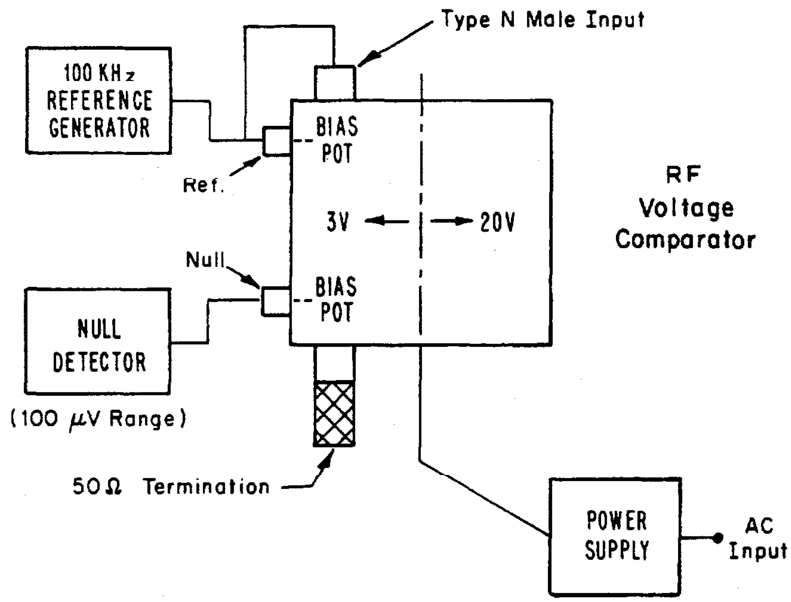

Figure 6. Offset Voltage Measurement Diagram

C. RF Signal Generator Calibration

1. RF input voltages between 0.01 and 0.1 volts rms.

   a. Determine the offset voltage value as outlined in section IV.B.

   b. Set the frequency and output level of the rf and reference generators to minimum.

   c. Connect the equipment as shown in figure 7.

   d. After a sufficient warmup period, set the null detector to zero, on the 100 μV range, by adjusting the bias pots.

   e. Select the desired calibration frequency on the rf and reference generators.

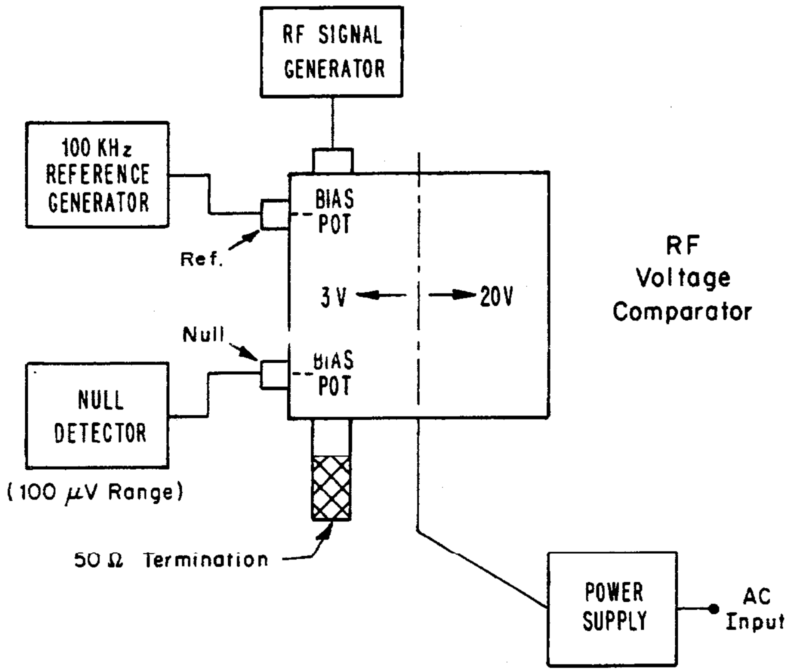

Figure 7. Block Diagram for Calibration of RF Signal Generators (0.01 - 0.1 V)

CAUTION: If the audio alarm sounds while either the rf generator level or the ac reference generator level is increased, the respective level has reached an unsafe level for the detecting diode. Turn down both levels immediately and recheck the equipment and layout.

f. Slowly advance the rf generator level until the desired calibration point is reached on either a calibration dial or an output meter of the rf generator.

   NOTE: Avoid pegging the meter on the null detector. As the rf generator level is increased, reduce the null detector sensitivity to keep a near-full scale indication.

g. Slowly advance the ac reference level until the null indication returns to the offset value noted in step IV.B.5.

h. The calibrated rf voltage level (V_{rf}) is: $V_{rf} = V_{ref}$.

i. Turn the rf and ac reference generators to their minimums and check if the null voltage returns to zero.

j. If the null does not return to zero, record the magnitude of the drift.

k. The percentage drift, D(%), relative to the reference value can be calculated by:

$$D(\%) = \left(\frac{\text{Magnitude of Drift}}{\text{V reference}}\right) \times 100$$

NOTE: The drift should be less than 0.5%. If it is greater, repeat steps d through k. Refer to the Troubleshooting and Maintenance Section if this problem persists.

2. RF input voltages between 0.1 and 3 volts rms.

   Perform the same procedure as outlined for the 0.01 to 0.1 volt range, with the exception that the null zero need not be rechecked once initially set. The final null detector sensitivity settings should be set to the 1 mV position from 0.1 V to 1 V levels and to the 10 mV position from 1 V to 3 V levels.

3. RF input voltages between 3 and 20 volts rms.

   a. Set the frequency and the output level of the rf and reference generators to minimum.

   b. Connect the equipment as shown in figure 8.

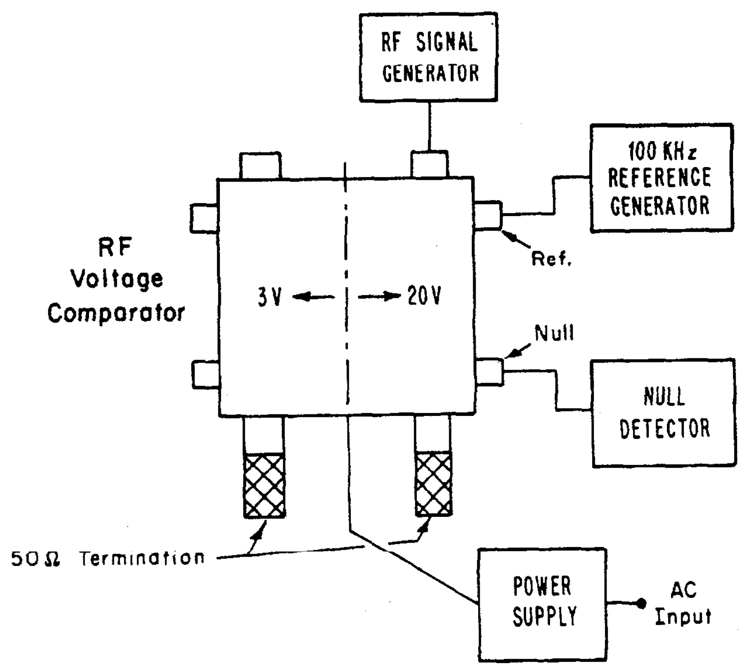

Figure 8. Block Diagram for Calibration of RF Signal Generators (3 - 20 V)

CAUTION: Be certain that the 20 V max comparator section is being used for measurements in this range. Since the audio alarm is incorporated only in the 3 V max comparator circuitry, use caution when increasing the input levels to avoid exceeding the 20 volt rms limit.

CAUTION: Be certain that the termination has the proper wattage rating.

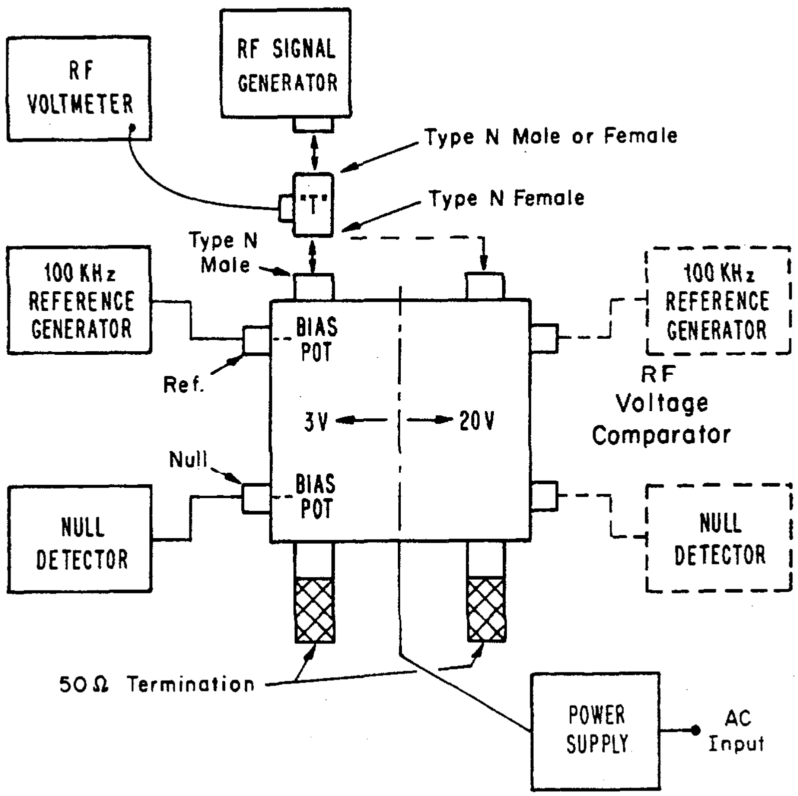

Figure 9. Block Diagram for Calibration of RF Voltmeters (0.01-20V)

c. Select the desired calibration frequency on the rf generator.

d. Slowly advance the rf generator level until the desired calibration point is reached on either a calibration dial or an output meter of the rf generator.

e. Slowly advance the ac reference level until a null is obtained on a sufficiently sensitive scale of the dc null meter. The final null detector sensitivity settings should be set to 3 mV from 3 V to 10 V, and to 100 mV from 10 V to 20 V.

f. The calibrated rf voltage level V_{rf} is: $V_{rf} = V_{ref}$.

g. Turn the rf and ac reference generators to their minimums.

D. RF Voltmeter Calibration (Feed Through Tee Types)

1. RF input voltage between 0.01 and 0.1 volts rms.

a. Determine the offset voltage value as outlined in section IV.B.

b. Set the frequency and output level of the rf and reference generators to minimum.

c. Connect the equipment as shown in figure 9.

d. After a sufficient warmup period, set the null-detector to zero, by adjusting the bias pots.

e. Select the desired calibration frequency on the rf and reference generators.

f. Select the voltage range to be calibrated on the rf voltmeter.

NOTE: Avoid pegging the meter on the null detector. As the rf generator level is increased, reduce the null detector sensitivity to keep a near-full scale indication.

CAUTION: If the audio alarm sounds while either the rf generator level or the ac reference level is being advanced, the respective level has reached an unsafe level for the detecting diode. Turn down both levels immediately and recheck equipment and layout.

g. Slowly advance the rf generator level until the desired calibration point is reached on the rf voltmeter.

h. Slowly advance the ac reference level until the null indication returns to the offset value noted in section IV.D.1.a.

i. The calibrated rf voltage level (V_{rf}) is $V_{rf} = V_{ref}$.

j. Turn the rf and ac reference generators to their minimums and check that the null voltage returns to the zero.

k. If the null does not return to zero, record the magnitude of the drift.

l. The percentage drift, D(%), relative to the reference value can be calculated by:

$$D(\%) = \left(\frac{\text{Magnitude of Drift}}{V_{reference}}\right) \times 100$$

NOTE: The drift should be less than 0.5%. If it is greater, repeat steps d through l. Refer to the Troubleshooting and Maintenance Section if this problem persists.

2. RF input voltages between 0.1 and 3 volts rms.

Perform the same procedure as outlined for the 0.01 to 0.1 volt range, with the exception that the null zero need not be rechecked once initially set. The final null detector sensitivity settings should be set to 1 mV from 0.1 V to 1 V, and to 10 mV from 1 V to 3 V.

3. RF input voltages between 3 and 20 volts rms.

a. Set the frequency and the output level of the rf and reference generators to minimum.

b. Connect the equipment as shown by the dotted lines in figure 9.

CAUTION: Be certain that the 20 V max comparator section is being used for measurements in this range. Since the audio alarm is incorporated only in the 3 V max comparator circuitry, use caution when increasing the input levels to avoid exceeding the 20 volt rms limit.

CAUTION: Be certain that the termination has the proper wattage rating.

c. Select the desired calibration frequency on the rf generator.

d. Select the voltage range to be calibrated on the rf voltmeter.

NOTE: Avoid pegging the meter on the null detector. As the rf generator level is increased, reduce the null detector sensitivity to keep a near full scale indication.

e. Slowly advance the rf generator level until the desired calibration point is reached on the rf voltmeter.

f. Slowly advance the ac reference level until a null is obtained on a sufficiently sensitive scale of the dc null meter. The final null detector sensitivity settings should be set to 3 mV from 3 V to 10 V and to 10 mV from 10 V to 20 V.

g. The calibrated rf voltage level (V_{rf}) is: $V_{rf} = V_{ref}$.

h. Turn the rf and ac reference generators to their minimums.

V. TROUBLESHOOTING AND MAINTENANCE

A. Troubleshooting Chart

SYMPTOM	POSSIBLE CAUSE	REMEDY AND CHECKS
Unable to initially zero the low voltage comparator as outlined in IV.	1. Power supply is OFF.	1. Turn on power supply.
	2. RF channel has no return path for bias current.	2. Check cable connecting rf and reference channels. Check dc resistance of rf termination.
	3. Diode CR1 and/or diode CR2 not receiving current bias.	3. Check bias currents as outlined in this section. Check connecting wires between circuit boards B1 & B2. Check the ± 15 volts at Q1.
	4. Bias currents present, but one or both cannot be varied.	4. Check trimpots R24 & R25. Check Q1 for proper operation.
	5. CR1 and/or CR2 failure.	5. Check diodes and replace as needed in accordance with procedure outlined in this section.
Audio Alarm Sounding	1. Rf channel of 3 volt max comparator not property terminated (no dc return path).	1. Turn OFF power supply and properly terminate rf channel.
	2. Rf input level and/or reference input level too high (3 V max comparator only).	2. Reduce level or levels immediately.
	3. CR1 and/or CR2 failure.	3. Check diodes and replace as needed in accordance with procedure outlined in this section.
	4. FET Op Amp circuitry failure.	4. Check input, output and supply voltages of A1 and A2. Check A1 and A2 for proper operation.
Low Sensitivity	1. Wrong comparator section being used.	1. Check connections and change if needed.
	2. Faulty null indicator.	2. Check null indicator sensitivity.
	3. Rf and/or reference diode failure.	3. Check diodes and replace as needed in accordance with procedure outlined in this section.
Unable to obtain a null with rf and reference voltages applied.	1. Faulty rf or reference generator.	1. Check rf and reference generators.
	2. Faulty null indicator.	2. Check null indicator.
(a) Low voltage comparator	3. Same as listed under initial zero problem.	3. Same as listed under initial zero problem.
(b) High voltage comparator.	4. CR11 and/or CR12 failure.	4. Check diodes and replace as needed in accordance with procedure outlined in this section.

B. Maintenance

1. General

Keep all input and output connectors clean. Clean with a low deposit solvent and blow out with compressed air.

CAUTION: When cleaning the rf and reference connectors, avoid any contact or disturbance to the rf detector assembly. Also, do not allow cleaning solvent to penetrate this region of the connector.

2. Diode bias current supplies

There are two general methods of checking the bias currents; one method can be done externally while the other method requires opening the comparator housing to allow internal measurements.

a. *External current check*

1. With the power supply turned OFF, terminate the rf channel of the low voltage comparator with a 1 kilohm load.

2. Turn on the power supply.

3. Obtain a dc millivoltmeter with a floating input and an input resistance >> 1 kilohm.

4. Connect the voltmeter across the 1 kilohm resistor and note the voltage reading. It should be between .5 and 1.5 millivolts. This value should be variable via the screwdriver adjustment access hole.

5. Connect the voltmeter to the reference input connector. This voltage should be approximately the same magnitude as measured in step 4 but will have the opposite polarity. This value should also be variable via the screwdriver adjustment access hole.

6. If one or both of these voltages are not present, the internal current check must be performed. Such a condition could indicate a diode failure, a connection problem between the current source and the detecting diodes or a failure of the current source or sources.

b. Internal current check

1. With the power supply turned OFF, terminate the rf channel.

2. Unscrew holding nut on audio alarm and remove top cover of voltage comparator.

3. Obtain a dc voltmeter with a floating input having an input resistance >> 1 megohm.

4. Turn on the power supply.

5. Connect the voltmeter across R22 and note reading. The voltage should be somewhere between .5 and 2 volts.

6. Vary R24 while observing the voltage across R22. This voltage should change as R24 is varied. If no change is observed, check both R24 and Q1.

7. Measure voltage across R23. It should be close to that across R22, but of opposite polarity.

8. Use same procedure as specified in step 6--only using R23 and R25.

9. If one or both of the voltages checked in steps 5 and 7 are zero, check Q1 and its associated circuitry. Also check for the presence of the ± 15 V supply voltages to Q1. Change Q1 if indicated.

3. Detector diode replacement

CAUTION: When testing or handling the detector diodes in the low voltage comparator (CR1 and CR2), observe the following precautions to avoid static discharge damage:

a. The operator, tweezers, or any other pick-up tool must be grounded to the test or inspection station.

b. All test fixtures should incorporate a short across the terminals. The short may be removed once the diode is in place. Where shorts are not practical, a series resistor of approximately 10 kΩ can be used.

c. Spurious pulses generated by test equipment must be eliminated.

d. When a diode is passed from one operator to another, the receiving operator should grasp the lead held by the passing operator.

e. All soldering apparatus should be transformer isolated from the power line and should be free of leakage.

CAUTION: The rf and reference detector diodes in each of the comparator sections are matched pairs. CR1 and CR2 are the matched pair for the low voltage comparator and CR11 and CR12 are the matched pair for the high voltage comparator. When a diode failure is discovered, it will be necessary to replace both diodes of the appropriate comparator with a new matched pair. Also, it is important to use the right type for replacement diodes since the detector diodes used in the low voltage comparator are a different type than the pair used in the high voltage comparator.

The rf and reference detector diodes can be replaced using the following procedure:

f. Unscrew lock nut holding the audio alarm T1 and remove the top and bottom covers of the comparator housing.

g. Unsolder the two wires connecting the circuit boards together at their connecting points on R20 and R21.

h. Unsolder ± 15 V and ground connection from modular power supply.

i. Remove the holding screws on circuit board B2 and carefully remove the board from the comparator housing.

j. Unsolder the formex lead which attaches the rf detector (in the precision type "N" male connector) to the comparator circuit board B1. Unsolder this wire at either R3 or R13, depending on the diode pair that is being replaced.

k. Unscrew holding screws and remove the appropriate small aluminum shielding can.

l. Unsolder miniature coax cable coming from the reference input connector. Unsolder inner and outer connectors of this cable at the circuit board end.

m. Unsolder the fine wire from the reference detector assembly where it attaches to the appropriate 1 kΩ resistor (R0 or R10).

n. Remove holding nut for reference detector assembly from the bottom side of B1 and remove detector assembly.

CAUTION: Before replacing a pair of diodes, make certain that they are the proper type for the comparator section being repaired, and make certain that the two diodes constitute a matched pair.

CAUTION: Always observe the static discharge precautions, previously prescribed, when handling or checking the diodes used in the low voltage comparator section (CR1 & CR2).

o. Place a small piece of conductive foam over components of the detector assembly.

p. Replace reference detector assembly and reassemble this section in reverse order to steps 5 thru 8.

q. Remove body of precision type "N" female connector from the appropriate 50 ohm line section.

r. Loosen and remove holding collar on type "N" male end of line.

s. Remove line from voltage comparator housing.

t. Obtain a termination, attenuator, etc., that has a precision type "N" female connector on it. Screw this female connector into the lines type "N" male connector--holding both connectors rigid and turning only the locking sleeve. The female end of the 50 ohm line section of the voltage comparator could be used if necessary. This will serve as a "supporting connector."

u. Using a pin vise to grasp the female center pin of the type "N" female connector, gently pull until the internal center conductor joint disengages.

v. Hold male type "N" connector rigidly while unscrewing outer conductor of 50 ohm line section.

w. Remove rf detector assembly from connector.

x. Unscrew type "N" female connector ("supporting connector") from the precision type "N" male connector.

y. Place a small piece of conductive foam over components of the detector assembly.

z. Feed formex wire of new rf detector assembly into rear of type "N" male connector; loop wire back on itself enough to enable feeding it through the small slanted hole inside the connector. Gently feed assembly into connector while pulling formax wire through hole. Make certain connector bead properly seats into the undercut region inside the connector body.

aa. Hold type "N" male connector and detector assembly firmly while screwing outer conductor of 50 ohm line into the connector. Tighten firmly.

bb. Connect "supporting connector" to type "N" male connector.

cc. Check female center pin--bead--center conductor assembly for tightness and feed it into open end of 50 ohm line section.

dd. When properly aligned, carefully push on this assembly axially until it seats into the mating center conductor section.

ee. Feed the 50 ohm line section back into the voltage comparator housing. Be certain to feed the formex wire into the comparator housing properly while performing this step.

ff. Replace and tighten holding collar after properly positioning line and formex wire.

gg. Replace and tighten type "N" female connector. Do not allow the line section to rotate while performing this step.

hh. Cut formex wire to the proper length, strip end and solder to appropriate resistor (R3 or R13) on comparator board (B1).

ii. Tighten holding screws to B1, if they had to be loosened.

jj. Reposition circuit board B2 in housing while carefully feeding the two connecting wires from B1 through the proper holes in B2. Resolder these wires. Tighten the holding screws that secure B2.

kk. Remove pieces of conductive foam used on replacement detector assemblies.

ll. Replace top and bottom covers to voltage comparator housing. Replace and tighten lock nut for alarm T1.

mm. Test the general operation of the voltage comparator section just repaired. If it was the low voltage comparator, perform the null zeroing procedure described in section IV. If the high voltage diodes were replaced, feed the 100 kHz reference signal into both channels (rf and reference) and check the diode tracking (as indicated by the null output reading) at several levels between 3 and 20 volts rms.

VI. PARTS LIST AND MANUFACTURER LIST

Parts List

Reference Symbol	Total Quantity	Description	Manufacturer type and/or Part Number	Manufacturer Code No.
A1, A2	2	FET Operational Amplifier	LH0042CH	1
B1	1	Comparator circuit board	NBS	
B2	1	Current source & alarm circuit board	NBS	
C1-C4, C11-C14	8	Monolythic chip capacitors, 0.1 µf, required dimensions L = 0.175 ± 0.015", W = 0.125 ± 0.005", and T = 0.045 ± 0.005"	11C1812X7R104M 50A (with specified dimensions)	2
C20,C21	2	Polycarbonate capacitors, 0.1 µfd, 250 VDC	B32-541	3
C22-C25	4	Disk capacitors, 0.01 uf	5GA	2
C26,C27	2	Tantalum capacitors, 4.7 µf, polarized 35 V	150D	2
CR1, CR2	2	Matched Schottky barrier diode pair, matched V_F within ± 1 mV at 10, 100 & 1000 µa I_F, V_R > = 12 V at I_R = 10 µa, mounted in "P" package outline	A2X1126-1	4
CR11, CR12	2	Matched Schottky barrier diode pair, matched V_F within ± 5 mV at 10, 100 & 1000 µa I_F, V_R > = 70 V at I_R = 10 µa, mounted in "P" outline	A2X1127-5	4
CR21, CR22	2	Silicon diode, axial lead	1N4153	5
F1	1	115 VAC receptacle/line filter module, 250 V at 3 a. 50-60 Hz	3EF1	6
H1,H2	2	Comparator and power supply housings, metal enclosure	3301	7
J1,J2	2	Precision type "N" connector, 7 mm jack	131-10004	8
J3-J6	4	Panel receptacle, BNC female	UG-290 A/U	9
L1	1	Neon lamp with cap, flush mount	CM22-1000-00A1A	10

Parts List

Reference Symbol	Total Quantity	Description	Manufacturer type and/or Part Number	Manufacturer Code No.
M1	1	Modular ± 15 V dc power supply, ± 25 ma	279-015-03	11
N1	1	115 VAC power cord assembly	17250	12
N2	1	± 15 V hookup cable between comparat & power supply, 8 foot length	8451	12
P1,P2	2	Precision type "N" connector, 7 mm plug	131-10003	8
Q1	1	Matched dual N-channel silicon junction field effect transistors, T071 CAN	2N5045	13
R0	2	Metal film resistor, 1 KΩ, 1%, 1/8 W	1001F	14
R1,R2	2	Cermet pellet resistor, 50 Ω, 5%, 1/10 W	50A5T	15
R3,R4	4	Carbon resistor, 200 Ω, 5%, 1/8 W	RCR05	16
R5,R6	4	Metal film resistors, 1 MΩ, 1%, 1/8 W, (hand picked to be within 0.05% of each other)	1004F	14
R10		Metal film resistor, 1 KΩ, 1%, 1/8 W. Same as R0.	1001F	14
R11,R12	2	Cermet pellet resistor, 200 Ω, 5%, 1/10 W	200A5T	15
R13,R14		Carbon resistor, 200 Ω, 5%, 1/8 W. Same as R3,R4.	RCR05	16
R15,R16		Metal film resistors, 1 MΩ, 1%, 1/8 W, (hand picked to be within 0.05% of each other). Same as R5,R6.	1004F	14
R20,R21	2	Carbon resistor, 4.3 MΩ, 5%, 1/8 W	RCR05	16

Parts List

Reference Symbol	Total Quantity	Description	Manufacturer type and/or Part Number	Manufacturer Code No.
R22,R23	2	Metal film resistor, 1 MΩ, 1%, 1/8 W	1004F	14
R24,R25	2	Variable resistor, Cermet trimpot, 500 KΩ, 20 turns, 3/4 W, screwdriver adjust	E-Z TRIM 3009P-1-504	17
R26,R27	2	Carbon resistor, 10 KΩ, 5%, 1/8 W	RCR05	16
R28,R29	2	Carbon resistor, 4.3 KΩ, 5%, 1/8 W	RCR05	16
R30,R35	6	Carbon resistor, 100 KΩ, 5%, 1/8 W	RCR05	16
R36	1	Carbon resistor, 39 KΩ, 5%, 1/4 W	RCR07	16
S1	1	Miniature SPDT switch, 125 VAC, 5a	JMT 123	18
T1	1	Subminiature audible signalling device, 1 kHz, 5 to 25 V dc	Mini-bleeptone Model 525	19

Manufacturer List *

Manufacturer Code No.	Manufacturer	Manufacturer's Address
1	National Semiconductor Corporation	Santa Clara, Calif.
2	Sprague Electric Company	North Adams, Mass.
3	Siemens Corporation	Iselin, N.J.
4	Aertech Industries	Sunnyvale, Calif.
5	General Electric Company	Syracuse, N.Y.
6	Corcom	Chicago, Ill.
7	Pomona Electronics Co., Inc.	Pomona, Calif.
8	Bunker-Ramo Corporation	
	Amphenol RF Division	Danbury, Conn.
9	Bunker-Ramo Corporation	
	Amphenol Connector Division	Broadview, Ill.
10	Chicago Minlight Works	Chicago, Ill.
11	Bunker-Ramo Corporation	
	Amphenol Cadre Division	Endicott, N.Y.
12	Belden Corporation	Chicago, Ill.
13	Siliconix Incorporated	Santa Clara, Calif.
14	Corning Glass Works	Corning, N.Y.
15	CTS Microelectronics, Inc.	Lafayette, Ind.
16	Allen Bradley Company	Milwaukee, Wis.
17	Bourne, Inc., Trimpot Prod. Div.	Riverside, Calif.
18	JBT Instruments Incorporated	New Haven, Conn.
19	C.A. Briggs Company, Cybersonic Div.	Glenside, Pa.

*Certain commercial equipment, instruments, or materials are identified in this paper in order to adequately specify the experimental procedure. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the material or equipment identified is necessarily the best available for the purpose.