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Printed in U.S.A.

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RAHAM™

Models 10, 20, 30, 40 and 50

**Radiation Hazard
Measuring Systems**

OPERATING AND SERVICE MANUAL

WARNING

Harmful effects may result from exposure to electromagnetic (EM) radiation in the frequency range from 300 kHz to 100 GHz. The currently approved continuous wave (CW) radiation protection guide from the American National Standards Institute (ANSI document C95.1-1982) designates different maximum power-density levels at different frequency ranges. Power-density values are averaged over any six-minute period. The time-averaged values should not exceed the levels that are summarized below:

Frequency Range (MHz)	Power Density (mW/cm^2)
0.3-3	100
3-30	900/f^2
30-300	1.0
300-1500	f/300
1500-100,000	5.0

Consult document C95.1-1982 for further guidelines. The above requirements adhere to Occupational Safety and Health Standard 1910.97, Non-ionizing Radiation Recommendations, and pertain to both whole-body irradiation and partial irradiation.

Always approach an unknown field cautiously, starting from as far away as possible and extending the RAHAM System probe at arm's length toward the energy source. Allow 2-3 seconds for the instrument to respond. Observe all safety precautions. Do not walk into a suspected radiation field until the power density is determined to be safe.

General Microwave Corporation's RAHAM* Systems meet requirements specified for test equipment in the IMPI (International Microwave Power Institute) "Performance Standard on Leakage from Industrial Microwave Systems," dated August 1973, and measure power-density levels in accordance with the standards, present and proposed, established by OSHA and the Department of Defense.

*Patent Nos. 3,931,573 and 4,392,108

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Errata and Changes

RAHAM

Page 1-5, SPECIFICATIONS, CHANGE AS FOLLOWS:

Table 1

FEATURE	DESCRIPTIVE DATA Model 40	Model 50
Frequency Range (GHz)	0.0002-40	
Frequency Sensitivity (dB)	±1.25 dB to 26 GHz +2 to -1.25 dB to 40 GHz	

Page 1-16, THEORY OF OPERATION, CHANGE AS FOLLOWS:

Paragraph 4-1, GENERAL

Frequency Range of Model 40 and Model 50 should read 0.0002-40 GHz.

Paragraph 4-2-3, MODELS 94 AND 95
Replace the second sentence with the following:

Accurate wideband, near and far field power density measurements result from a novel circuit design that provides an effective aperature to radiation fields ranging from 0.0002 GHz to 40 GHz, with a frequency sensitivity within ±1.25 dB to 26 GHz and within +2 to -1.25 dB to 40 GHz.

Page 1-37, TO PERFORM RF CALIBRATION OF THE PROBE

Paragraph 6-4-2 (1)
Add the following calibration frequencies to the Model 94 and Model 95:
33.0, 40 GHz

WARNING

Harmful effects may result from exposure to electromagnetic (EM) radiation in the frequency range from 300 kHz to 100 GHz. The currently approved continuous wave (CW) radiation protection guide from the American National Standards Institute (ANSI document C95.1-1982) designates different maximum power-density levels at different frequency ranges. Power-density values are averaged over any six-minute period. The time-averaged values should not exceed the levels that are summarized below:

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0.3-3	100
3-30	$900/f^2$
30-300	1.0
300-1500	f/300
1500-100,000	5.0

Consult document C95.1-1982 for further guidelines. The above requirements adhere to Occupational Safety and Health Standard 1910.97, Non-ionizing Radiation Recommendations, and pertain to both whole-body irradiation and partial irradiation.

Always approach an unknown field cautiously, starting from as far away as possible and extending the RAHAM System probe at arm's length toward the energy source. Allow 2-3 seconds for the instrument to respond. Observe all safety precautions. Do not walk into a suspected radiation field until the power density is determined to be safe.

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*Patent Nos. 3,931,573 and 4,392,108

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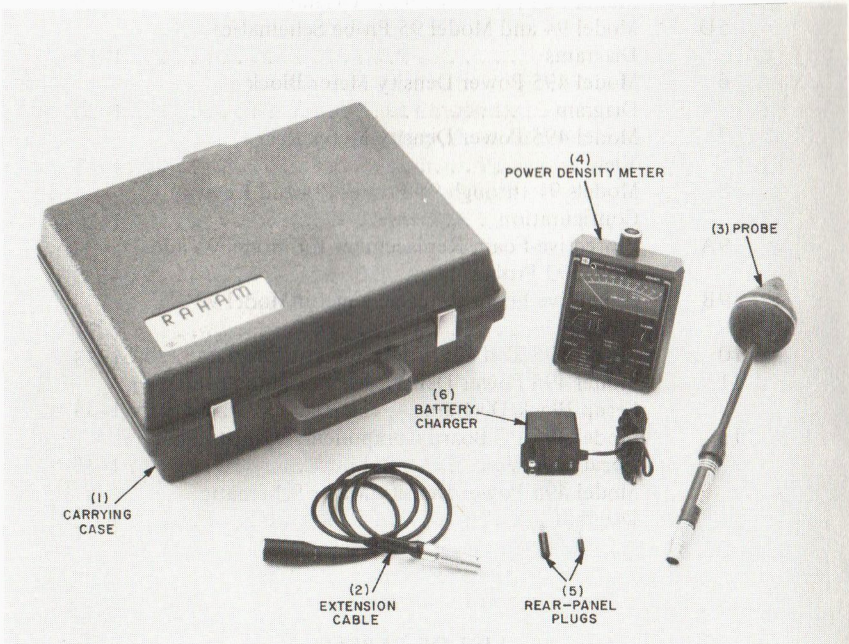


Figure 1. Models 10 through 50 RAHAM Systems

SECTION I

INTRODUCTION

1-1. GENERAL.

The RAHAM™* System Models 10, 20, 30, 40, and 50 are a line of portable, battery-operated meters that detect and measure potentially hazardous EM radiation from RF and microwave sources. The electrical, mechanical, and performance characteristics of those models are described in Table 1. Models 10 through 50 are ideally suited for use with:

- Microwave Ovens
- Medical Equipment
- Radar Installations
- Microwave Heaters and Dryers
- Electronic-Warfare Systems

1-2. DESCRIPTION.

Models 10 through 50 RAHAM Systems consist of the items in the following list. The index numbers correspond to those shown in Figure 1.

INDEX NO.	DESCRIPTION
1	Carrying Case
2	Extension Cable
3	Models 91, 92 (anisotropic) Probes Models 93, 94, or 95 (isotropic) Probes
4	Model 495 Power Density Meter
5	Rear-Panel Plugs
6	Battery Charger

*RAdiation HAzard Meter

1-3. SENSING PATTERN.

The Model 91 Probe uses two orthogonally mounted thin-film thermocouple (tft) arrays; the Model 92 Probe uses two short crossed dipoles each feeding a Schottky barrier diode; the Model 93 Probe uses three orthogonally oriented tft arrays; Models 94 and 95 Probes use three orthogonally oriented thin-film dipole circuits with low barrier Schottky detectors. Models 91 and 92 provide anisotropic response patterns and detect radiation perpendicular to the elements (Figure 2A); Models 93, 94, and 95 give an isotropic response (Figures 2B and 2C). The probes are factory calibrated to permit interchangeability in the field and are designed for use with the Model 495 Power Density Meter.

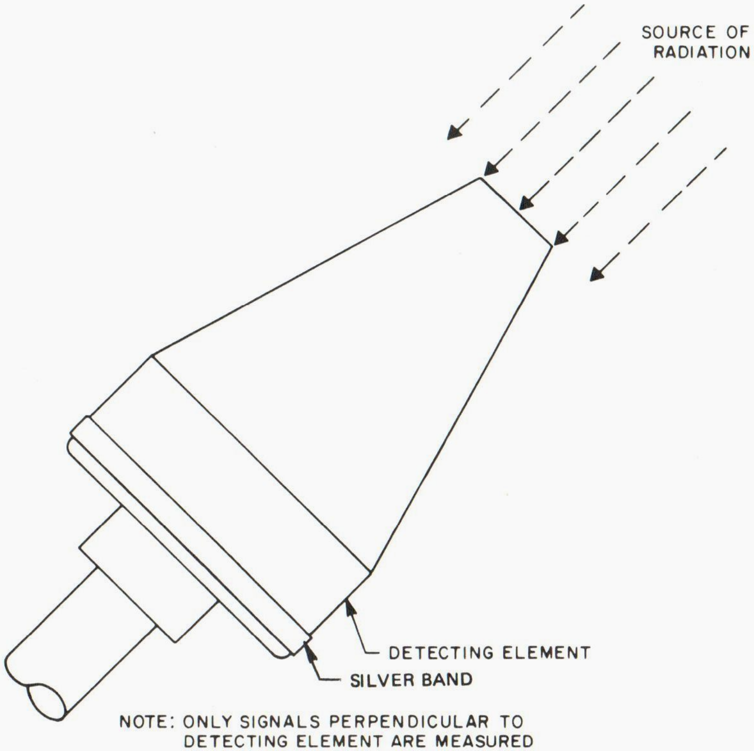


Figure 2A. Anisotropic Radiation-Sensing Pattern for Model 91 and Model 92 Probes

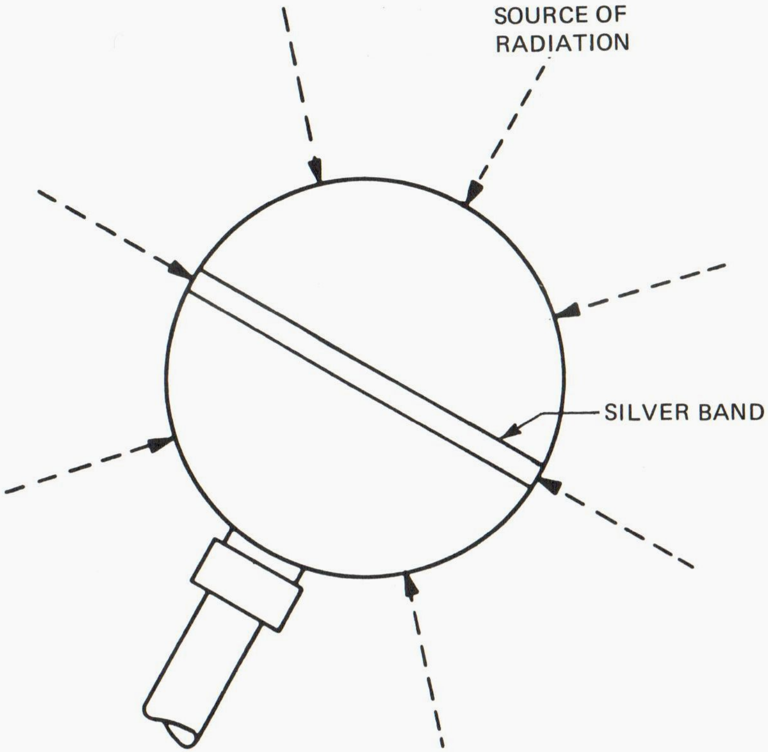


Figure 2B. Isotropic Radiation-Sensing Pattern for the Model 93 Probe

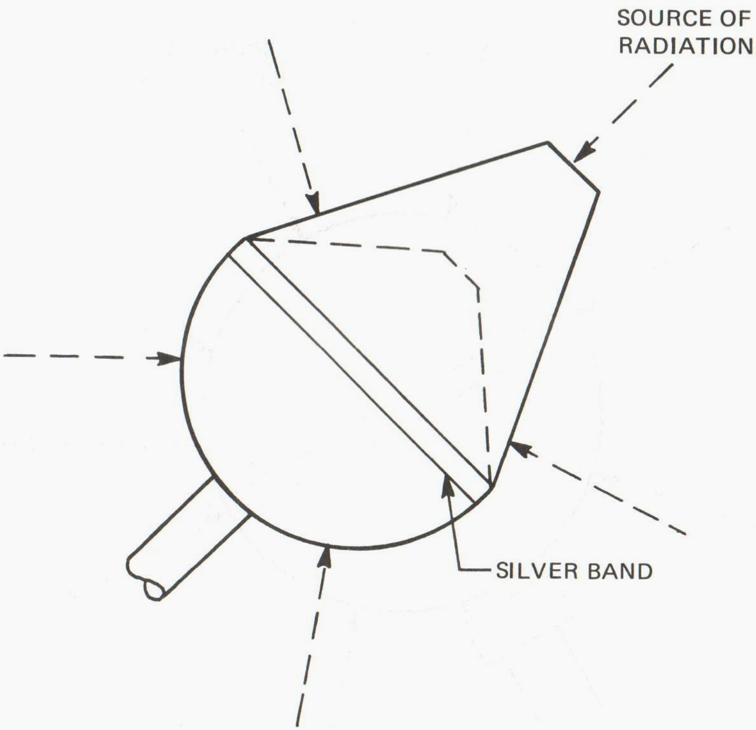


Figure 2C. Isotropic Radiation-Sensing Pattern for Model 94 and Model 95 Probes

SECTION II
SPECIFICATIONS

Table 1. Models 10, 20, 30, 40, and 50 Technical Specifications

FEATURE	DESCRIPTIVE DATA				
	Model 10	Model 20	Model 30	Model 40	Model 50
Frequency Range (GHz)	0.3-18	0.01-3	0.3-18	0.0002-26	0.0002-26
Power-Density Range (dB)	30	30	30	40	40
Full-Scale Readings (mW/cm^2)	2, 20, 200	2, 20, 200	2, 20, 200	0.02, 0.2, 2, 20	0.2, 2, 20, 200
Frequency Sensitivity (dB)	±1.5 for 1-18 GHz; -1 to -6 for 0.3-1 GHz	±1	±1.5 for 1-18 GHz; +0 to -3 for 0.3-1 GHz	±2	±2
Calibration Accuracy(1) (dB)	±0.5				
Average Power Overload at 25°C (W/cm^2)	0.5	1	0.5	0.5	1
Peak Power Overload at 25°C (W/cm^2)	30	30	30	30	60
Pulse Energy Density Overload at 25°C	150 $W\text{-}\mu s/cm^2$				
Polarization	elliptical, measures linearly and circularly polarized signals				
Ellipticity	±0.5 dB maximum change in sensitivity for rotation about an axis through handle		—	—	—
Isotropy	—	—	response varies ±0.5 dB maximum for energy incident from any direction except from or through handle		
Noise (maximum)	1% P-P on most sensitive range			3% P-P on most sensitive range	
Response Time (nominal) normal: slow:	1.5 s 3.0 s				
Calibration Factor Range	0.5-2.0				
Power-Density Average	meter indicates power density as averaged over a 6-min interval; reading updated every 90 s				
Peak	meter indicates peak value until reset manually				
Alarm	audible alarm sounds, and remote alarm operates if meter reading exceeds preset alarm level				
Recorder Output	0.100 VDC full scale into minimum 100 kΩ impedance				
Battery/Line Operation	50 h on built-in, rechargeable batteries; operates from 115/230 VAC with supplied charger/adapter; battery status can be checked on meter scale				
Operating Temperature Range	0°C to 55°C				
Size: Power-Density Meter Each Probe Cable Assembly Carrying Case	 6" x 4.75" x 6.75" (152 mm x 121 mm x 171 mm) 14" long x 2.75" maximum diameter (355 mm x 70 mm) 4' long (1.22 m) 15.5" x 12.25" x 6.25" (394 mm x 311 mm x 159 mm)				
Weight	8 lbs. (3.6 kg)				

(1) Each unit is aligned at 2.45 GHz and calibrated at a number of additional frequencies over its operating frequency range; the resulting data are furnished with the unit.

SECTION III

OPERATION

3-1. GENERAL INFORMATION.

The user has the option of mounting the probe directly on the power-density meter or interconnecting them with the extension cable. Whereas the directly connected probe offers convenient, one-handed operation, the extended probe allows greater flexibility in probing for radiation fields in awkward or cramped areas, as well as permitting the operator to shield himself from potentially hazardous fields.

WARNING

> User may be exposed to potentially hazardous EM radiation levels. Review the "Radiation Protection Guide" on the inside front cover and "Safety Precautions" in Section 3-2. Adhere to all safety procedures before entering a suspected radiation field.

A successful power-density evaluation should include:

(1) Evaluation of radiating sources from the standpoint of personnel-hazard potential; this will include calculation of expected RF density levels.

(2) Planning and conducting a comprehensive survey of potential hazard areas.

(3) Correlation of calculated values with measured data to ensure minimum error.

Pre-evaluation of potentially hazardous areas is important. The direction and distance of sources, frequency and strength of sources, and prominent features of the physical environment are significant influences on the distribution of a radiation field (Section 3-2-1).

When measuring leakage from poorly designed electronic equipment, the user deals with the same field complexities but with the additional problem of locating the radiation source (e.g., a crack in the shielding cabinet or poorly grounded connecting cables). Thus, the technique differs for monitoring radar or communication antennas as compared with a trial-and-error survey for detection of possible leakage or direct radiation from low-power equipment (Section 3-2-1).

Calculation of expected power-density levels before entering the radiation field is desirable. The method of calculation is beyond the scope of this manual. However, to obtain the average radiated power from the antenna and the resultant power density at any point in space requires consideration of the following parameters:

- Rated peak power
- Pulsewidths
- Pulse-repetition frequency
- Operating frequency
- Antenna:

  type and gain
  orientation
  beam width
  height above ground

If the maximum averaged power-density value in the near field is less than the Radiation Protection Guide limit, measurement is only required to locate reflections that might increase the power density.

3-2. SAFETY PRECAUTIONS.

The following precautions are mandatory (see ANSI C95.3-1973 and ANSI C95.5-1982) where calculations indicate the possibility that safe levels may be exceeded.

3-2-1. SURVEYING A RADIATING SYSTEM (such as a high-power radar).

(1) From a knowledge of the system, the survey process should be planned so that RF power-density and duration-of-exposure levels specified in ANSI C95.1-1982 (or current revision) are not exceeded. In some situations, it may be desirable to conduct the survey at a reduced power level and use scaling to compute field levels present at full-power operation.

(2) Before survey begins, antennas should be adjusted far from the most hazardous position and never in the direction of personnel. Surveyors should approach from out of range of radiated beams toward beam areas. Furthermore, if measurements are to be conducted while the antenna is scanning, one should first determine if instrument response time is fast enough to respond to the scanning beam.

(3) Antennas should not be pointed toward metal structures. Metal objects, which not only can create scattering and multipath situations but can also be a source of RF burns, should not inadvertently or unnecessarily be located close to antennas. If, however, the normal transmission area includes such metal objects as towers, guy wires, fences, and reflecting surfaces that can enhance fields or produce hot spots, allowance for such effects should be made. During the survey, the surveyor should be in continual communication with the RF-source operator so that the source may be operated in accordance with survey precautions.

3-2-2. PERFORMING LEAKAGE SURVEYS. Normally, leakage energy drops off as the inverse square of the distance. Therefore, in conducting a survey, one should begin with survey instruments set at sensitivities that can indicate possible overexposure (e.g., 10 mW/cm^2) before approaching the leakage source. The following precautions are also necessary.

(1) The possibility of leakage exists at generating devices, along any transmission line or waveguide – particularly at joints – and at all access doors, panels, or enclosures.

(2) The possibility of RF burns exists at localized leakage ports.

(3) While opening access doors or panels to insert or remove a load (e.g., in an RF-exposure test chamber), the equipment should first be shut down and interlocks left operative.

(4) In checking for possible inoperative interlocks at an RF-enclosure access port, one should ascertain leakage levels with the port closed before slowly opening the port to observe any increase in leakage.

(5) With the source switched off, the surveyor should visually inspect all flexible waveguides for signs of fatigue, aging, damage at joints, lack of adequate support, and so forth.

3-3. MEASUREMENT PROCEDURES FOR EXTERNAL FIELDS.

3-3-1. FAR-FIELD, SINGLE-SOURCE CONDITIONS. Multipath reflections of a linearly polarized plane wave's distribution, particularly at frequencies greater than 300 MHz, can create a highly non-uniform field distribution. To judge the level of exposure at any specific location, a series of measurements should be made. The average field strength within a 2-3 m^2 area should be compared with the pertinent safety guidelines. Placing the probe nearer than 5-10 cm to metallic objects is to be avoided. Field strengths should be measured no closer than about one wavelength from such objects.

3-4. OPERATING CONTROLS. (See Figure 3.)

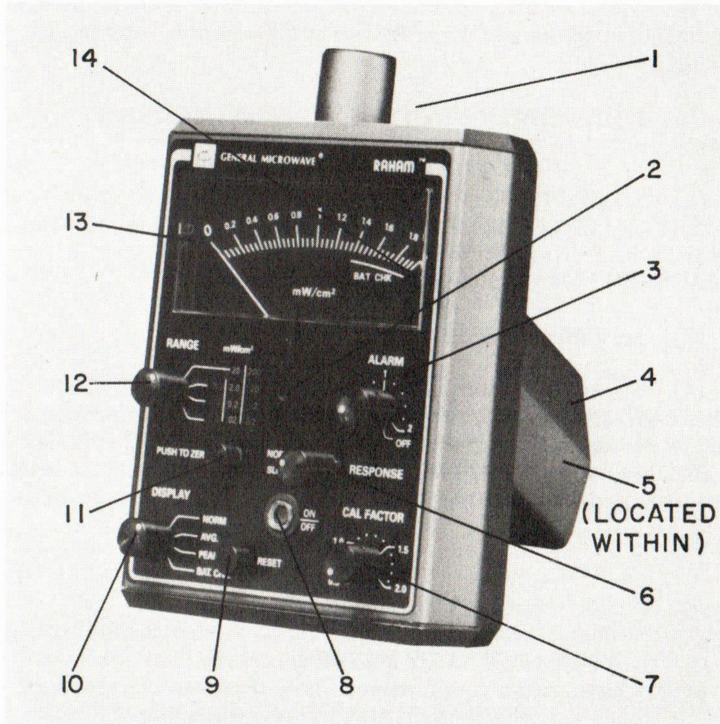
INDEX NO. FIGURE 3	CONTROL/ INDICATOR	FUNCTION
1	PROBE CONNECTOR, J1	Input to power density meter.
2	MECHANICAL ZERO	Screwdriver adjustment, used to mechanically zero the meter.
3	ALARM (ALARM-LEVEL CONTROL), R44	Alarm scale (0-2) corresponds to power-density scale. When set to an operator-defined power level, if that level is exceeded, an audible tone is emitted and a remote logic-state-change signal, that activates the J4 output is generated. Rotation to "OFF" position disables the alarm.
4 (REAR-HANDLE JACKS)	BAT CHGR (BATTERY CHARGER), J2	Used to recharge Nicad battery.
	RCDR (RECORDER OUT), J3	Available for interface with remote monitor; 100 mV full scale, more than 100 kΩ impedance required.
	ALARM (ALARM OUT), J4	Available for interface with remote alarm (see No. 3).
5	BATTERY PACK, B1	Rechargeable Nicad battery pack fits into handle of Model 495 Power-Density Meter.
6	RESPONSE (METER RESPONSE CONTROL), S3	Provides improved readability under changing RF by adjusting instrument bandwidth. Two modes: *normal* (1.5 s); *slow* (3 s) for smoothing incoming-signal variation.
7	CAL FACTOR (CALIBRATION FACTOR CONTROL), R25	Corrects for probe frequency response if frequency of radiating source is known; range: 0.5-2.

3-4. OPERATING CONTROLS (continued). (See Figure 3.)

INDEX NO. FIGURE 3	CONTROL/ INDICATOR	FUNCTION
8	POWER ON-OFF, S6	Self-indicating power switch.
9	DISPLAY (DISPLAY SELECTOR), S2	Selects power-density-reading mode: *normal* for direct power-density readout, *peak-hold* for displaying the maximum power density measured (always push RESET and choose range before selecting this mode) [see Nos. 11 and 14], *average* for automatic calculation and display of the previous 6-min power-density average value (updated every 90 s); and *battery check* mode [see No. 13].
10	PUSH TO ZERO, S4	Resets POWER-DENSITY METER to zero; accurate for all ranges less sensitive than the zeroed range (always zero in the absence of an RF field).
11	RANGE (RANGE SELECTOR), S1	Depending on the frequency range of the probe in use (see color band on wand), selects full-scale sensitivity at 200 mW/cm^2, 20 mW/cm^2, or 2 mW/cm^2 (orange); 20 mW/cm^2, 2 mW/cm^2, 0.2 mW/cm^2, or 0.02 mW/cm^2 (yellow); and 200 mW/cm^2, 20 mW/cm^2, 2 mW/cm^2, or 0.2 mW/cm^2 (green).
12	POWER-DENSITY METER, M1	Displays power-density levels up to 200 mW/cm^2 depending on preselected range setting.
13	BAT. CHK (BATTERY-CHECK SCALE)	If DISPLAY SELECTOR (S2) is in *battery check* mode, a reading below BAT CHK means that batteries must be recharged.

3-4. OPERATING CONTROLS (continued). (See Figure 3.)

INDEX NO. FIGURE 3	CONTROL/ INDICATOR	FUNCTION
14	RESET (PEAK-HOLD RESET), S5	After measurement of peak power density (see No. 9), resets *peak-hold* reading to zero.



1 PROBE CONNECTOR (J1)
2 MECHANICAL ZERO
3 ALARM-LEVEL CONTROL
4 REAR JACKS
RECHARGER (J2)
RECORDER (J3)
ALARM (J4)
5 BATTERY PACK
6 METER RESPONSE (S3)
7 CALIBRATION FACTOR (R25)
8 POWER ON-OFF (S6)
9 RESET (S5)
10 DISPLAY SELECTOR (S2)
11 PUSH TO ZERO
12 RANGE SELECTOR (S1)
13 POWER DENSITY METER (M1)
14 BATTERY CHECK SCALE

Figure 3. Model 495 Power Density Meter Front View

3-5. OPERATING PROCEDURE.

3-5-1. ASSEMBLY. To operate a RAHAM System (Models 10, 20, 30, 40, or 50) connect the probe to the PROBE CONNECTOR of the power-density meter, align the polarizing keyway, and push in the probe for a snug fit. If the extension cable is used, install it between the probe and the power-density meter.

3-5-2. NORMAL OPERATING PROCEDURE. With the RAHAM System assembled for operation and the probe not in the presence of any significant radiation field:

(1) Depress POWER ON-OFF button so that red indicator appears.

(2) Set DISPLAY SELECTOR to BAT. CHK. while observing BATTERY-CHECK SCALE for indication of battery condition. If indicator is below BAT CHK, refer to BATTERY RECHARGING/ REPLACEMENT instructions (Section 5-2).

(3) Set DISPLAY SELECTOR to NORM.

(4) Depending on the probe selected, set RANGE SELECTOR to maximum sensitivity (2 mW/cm^2 for probe Models 91-93, 0.02 mW/cm^2 for Model 94, and 0.2 mW/cm^2 for Model 95) and zero POWER-DENSITY METER by depressing PUSH TO ZERO; once the meter is zeroed, it need not be readjusted when changing the range.

Note

If POWER-DENSITY METER fails to zero, check batteries as discussed above. Failure of meter to zero when battery is fresh may indicate a burned-out or defective probe.

(5) In the case of varying signal strength, as indicated by POWER-DENSITY METER, adjust instrument bandwidth by setting METER RESPONSE CONTROL to SLOW (three-second response); for steady-state RF conditions, set METER RESPONSE to NORM (1.5-second response).

The instrument should be checked periodically during use to ensure that the probe and circuitry remain operational. This may be done quickly by rezeroing the meter with no radiation source present.

(6) Refer to the plastic insert provided with each probe to determine the calibration factor as a function of the frequency being measured, if known. Then set CAL FACTOR CONTROL to the tabulated value; this automatically corrects for the frequency response of the RAHAM probe. If the frequency is unknown, set CAL FACTOR CONTROL to 1.0. The RAHAM system is now ready for use.

WARNING

Always approach a radiation field of unknown intensity cautiously, starting as far away as possible and extending the probe at arm's length toward the energy source. (See Figure 2.) Allow 2-3 seconds for the instrument to respond. Observe all safety precautions. Do not walk into a suspected radiation field until the power density is determined to be safe.

3-5-3. OPTIONAL ADJUSTMENTS TO NORMAL OPERATING PROCEDURE. With the RAHAM system assembled and the controls set as outlined in the previous section, the operator can select one or more RAHAM operation options depending on the RF field being measured and/or the purpose of the power-density measurement.

(1) DISPLAY SELECTOR.

(a) AVERAGE. To monitor the average RF field over an ANSI-specified time interval of six minutes, updated every 1.5 minutes, display *average* mode data by setting DISPLAY SELECTOR to AVG. NOTE: at least six minutes of operation at a fixed range setting must have elapsed to obtain a meaningful average-power-density reading.

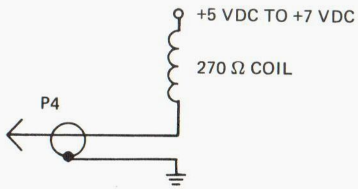
(b) PEAK-HOLD/NORMAL. For certain purposes, particularly measurements of RF or microwave leakage, the operator can use *peak-hold* mode to display the maximum power-density value recorded by the RAHAM system up to that point in the procedure by setting DISPLAY SELECTOR to PEAK; display of *peak-hold* mode data can be alternated with display of *normal* mode data to gradually zero in on a point source of leakage by switching DISPLAY SELECTOR from PEAK to NORM. Depressing PEAK-HOLD RESET clears the stored peak-power-density reading from the instrument's memory. Note: while monitoring peak reading a fixed range must be selected.

(2) ALARM-LEVEL CONTROL:

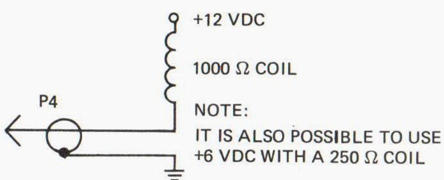
This control can be preset continuously from 0 to 2 (scaled for a given range setting). If the power density subsequently exceeds that level, an audible tone is emitted and a logic signal becomes available at the ALARM-OUT JACK; this signal can be used to activate a remote alarm indicator.

The alarm can be disabled by setting ALARM-LEVEL CONTROL to OFF. Using the plug (P4) supplied with the RAHAM, the following are typical of circuits that can be interfaced with the ALARM-OUT JACK (J4) in the handle.

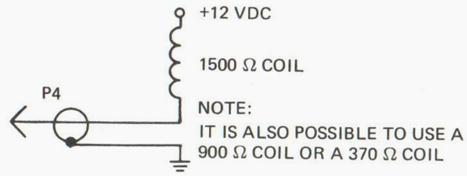
(a) CRYDOM series DP solid-state relays.



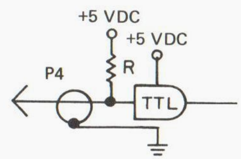
(b) Douglass Randall series MM (Reed) or HgM (mercury-wetted relays).



(c) Coto-Coil CR-2200 series +12 VDC Reed relays.



(d) Open collector output, can Drive 1 TTL load.



The ALARM OUT circuit is shown in Figure 4.

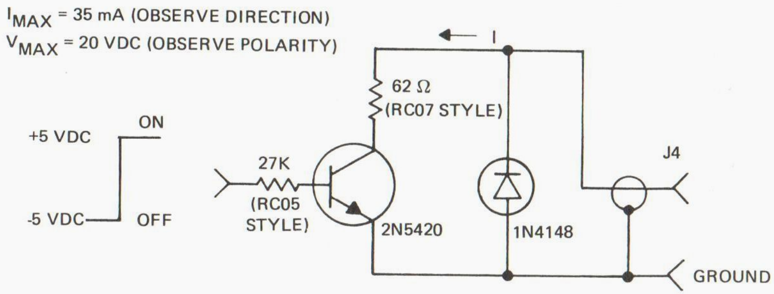


Figure 4. Alarm-Out Circuit, Model 495 Power Density Meter

SECTION IV

THEORY OF OPERATION

4-1. GENERAL.

RAHAM system Models 10, 20, 30, 40, and 50 Power Density Meters are portable, battery-operated instruments that detect and measure potentially hazardous electromagnetic energy radiating from RF and microwave sources. Model 10 is capable of direct measurements from 0.2 mW/cm^2 to 200 mW/cm^2 over a frequency range of 0.3-18 GHz, Model 20 from 0.2 mW/cm^2 to 200 mW/cm^2 over the 0.01-3 GHz range, Model 30 from 0.2 mW/cm^2 to 200 mW/cm^2 over 0.3-18 GHz, Model 40 from 0.002 mW/cm^2 to 20 mW/cm^2 over the 0.0002-26 GHz frequency range, and Model 50 from 0.02 mW/cm^2 to 200 mW/cm^2 over the 0.0002-26 GHz frequency range.

4-2. PROBES.

4-2-1. MODELS 91 AND 93. (See Figures 5A and 5B.) The Models 91 and 93 Probe designs use thin-film thermoelectric (tft) arrays that contain a large number of series-connected thermal junctions mounted between a pair of thermally conductive dielectric wafers that enhance sensitivity and reduce drift. If the probe is irradiated, alternate junctions located within the RF field rise in temperature relative to adjacent, thermally "sinked" junctions. By keeping the temperature differential small, the probe acts as a true square-law (rms) detector, producing a DC output voltage directly proportional to the absorbed radiation. In addition, the Model 93 Probe has an isotropic sensor with response varying ±0.5 dB (maximum) for energy incident from any direction except from or through the handle. The Model 91 Probe has an anisotropic response.

Wideband frequency performance results from the design of the Model 91 thermocouple array, which is equivalent to a thin-film resistive screen of high surface resistivity relative to free-space impedance. This provides an almost constant effective aperture to radiation fields ranging from UHF to K-band wavelengths.

4-2-2. MODEL 92. (See Figure 5C.) The Model 92 Probe design uses two short crossed dipoles, each feeding a Schottky barrier diode (CR1 and CR2). Diode impedance is largely characterized by barrier capacity in the operating frequency range. This capacitance is in series with that of the short dipole whose coupling action to free space is also represented by an equivalent capacitance. As long as the total circuit capacitance is large relative to free-space impedance (a condition that sets the upper frequency limit), the induced voltage at constant power density remains essentially

constant with frequency. As a consequence of the capacitive-divider action, the induced voltage across the diode also is constant. The lower frequency limit (less than about 0.01 GHz) is reached if barrier capacitive reactance becomes comparable to barrier resistance.

4-2-3. MODELS 94 AND 95. (See Figure 5D.) The Models 94 and 95 Probe designs use three orthogonally oriented detecting circuits that provide isotropic response. Accurate wideband, near- and far-field power-density measurements result from a novel circuit design that provides an almost constant effective aperture to radiation fields ranging from 0.0002 GHz to 26 GHz, with frequency sensitivity over the operating band held to within ±2 dB. The Models 94 and 95 Probes have an isotropic response that varies ±0.5 dB (maximum) of energy incident from any direction except from or through the probe handle.

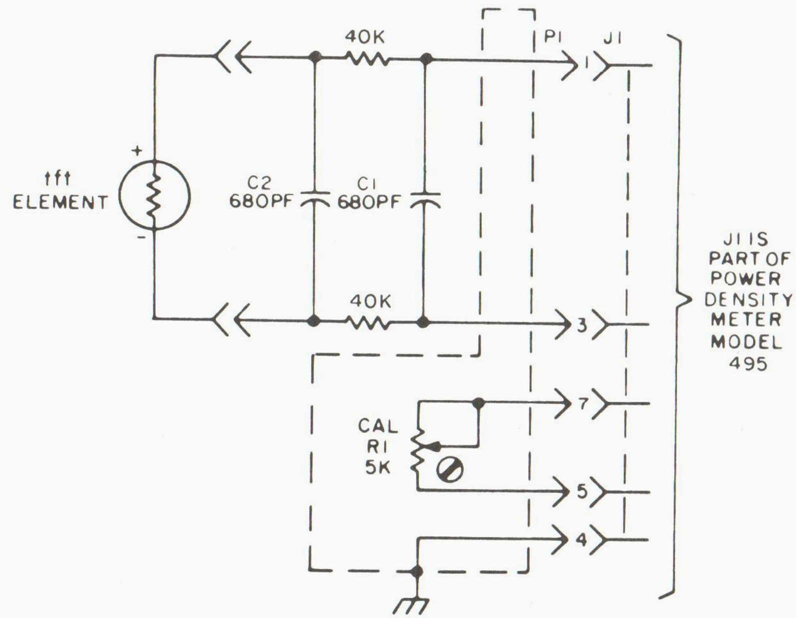


Figure 5A. Model 91 Probe Schematic Diagram

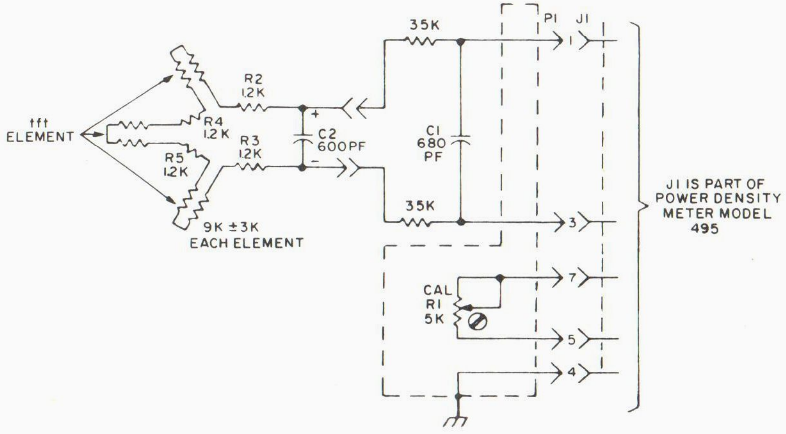


Figure 5B. Model 93 Probe Schematic Diagram

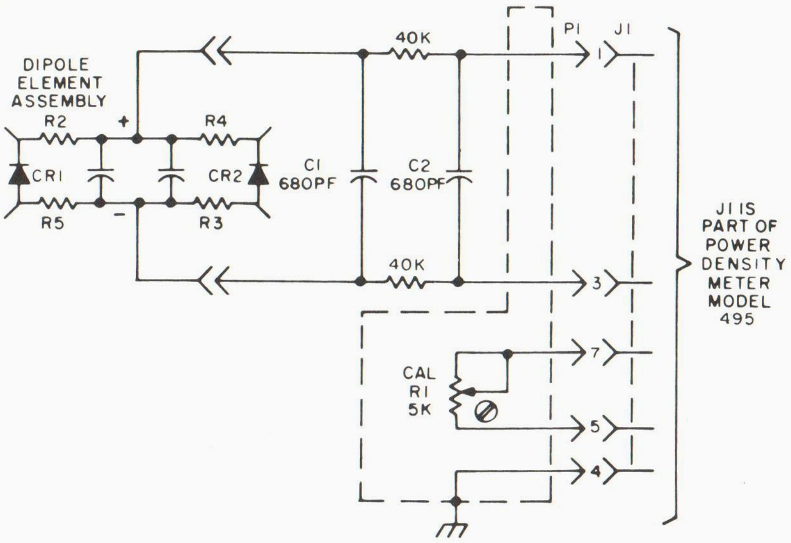


Figure 5C. Model 92 Probe Schematic Diagram

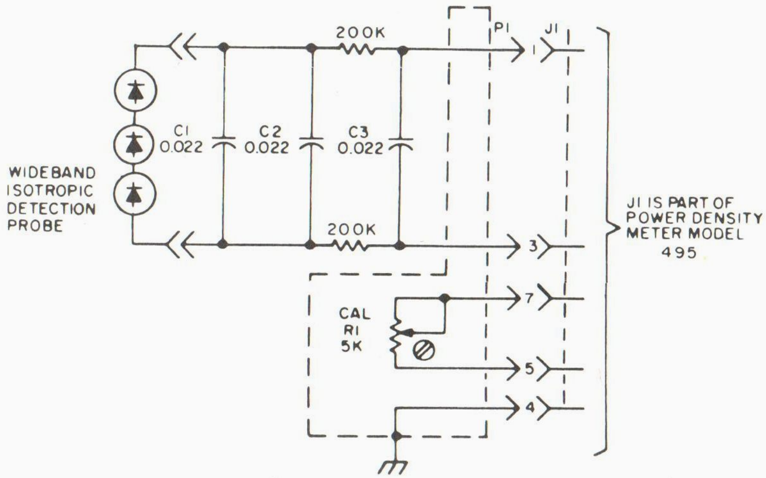


Figure 5D. Model 94 and Model 95 Probe Schematic Diagrams

4-3. POWER-DENSITY METER. (See Figure 6 and schematic diagram on pages 1-22 and 1-23.)

The Model 495 Power Density Meter operates from a 6 VDC nickel-cadmium (Nicad) rechargeable battery (B1). Voltage inverters U14 and U15 generate -6 VDC power supplies. Diode D2 in the power supply is an overvoltage protector.

Amplifiers U1, U2, and ½U3 comprise a differential amplifier that measures and amplifies low-level output voltages from the probe. Amplifiers U1 and U2 are each chopper stabilized to ensure low drift. The range is achieved by selecting R8-R13 to be the gain-setting resistors for the differential amplifier. For RAHAM System Models 10, 20, and 30, R8 sets the (highest) gain on the most sensitive range and R11 sets the (lowest) gain on the least sensitive range. In the RAHAM System Models 40 and 50, R13 and diode D1, in parallel with R12, determine the gain for an additional low-sensitivity range setting (20 mW/cm^2 for the Model 40 and 200 mW/cm^2 for the Model 50), with D1 correcting for square-law deviation of these probes.

Amplifiers U17 and ½U5 form a feedback loop for zeroing the differential amplifier U1, U2, and ½U3. If PUSH TO ZERO (S4) is depressed, the output voltage at pin 1 of U3 is forced to zero by the feedback loop. The voltage necessary to satisfy this condition is stored on capacitor C26 and is held there after PUSH TO ZERO is released. The voltage is then fed back to the amplifier input via voltage follower U5. (The second half of U5 is used as a cable driver to minimize noise arising from flexing of the extension cable.) The output of amplifier U3 pin 1 is fed to voltage

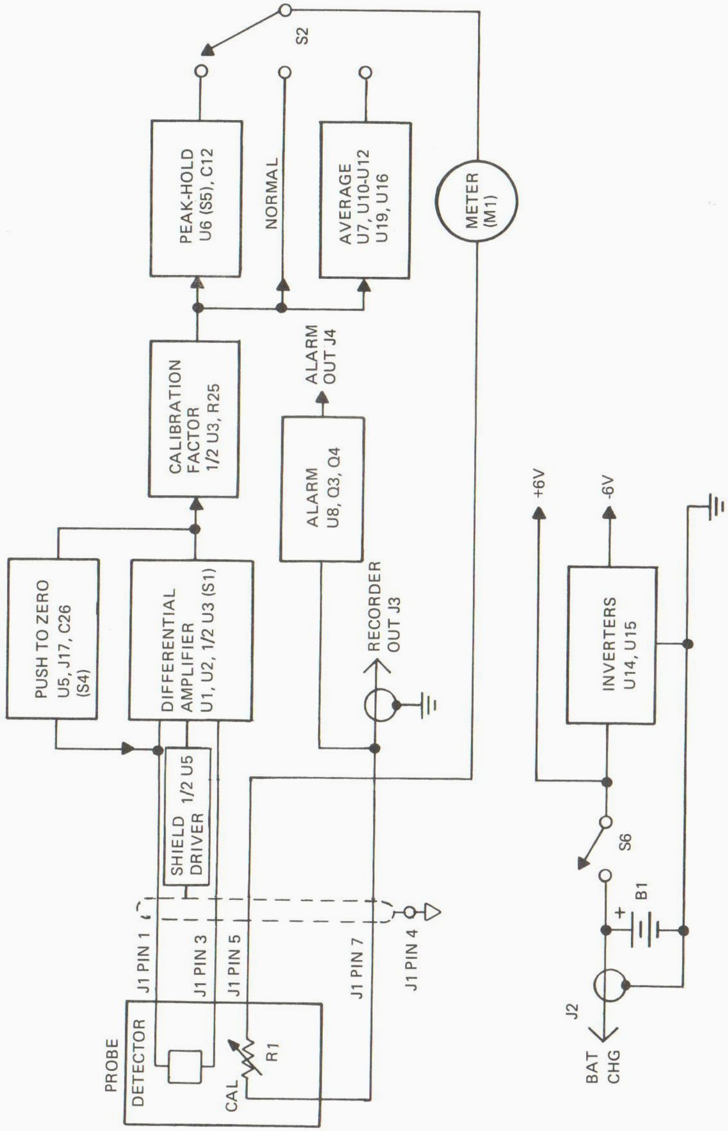


Figure 6. Model 495 Power Density Meter Block Diagram

divider R21 and R22 and then to the METER RESPONSE CONTROL (S3). In *slow* mode, S3 places C10 in parallel with C9 to give a three-second response time. Transistor Q5 is used in this circuit to eliminate instrument-turn-on transients. Amplifier U3, pins 5-7, is a variable-gain stage that adjusts system gain as CALIBRATION FACTOR CONTROL (R25) is set.

The output from U3 pin 7 simultaneously feeds:

- POWER-DENSITY METER (M1) during direct readout of power density (*normal* mode)
- U6 pin 3 during peak detection (*peak-hold* mode)
- R36-R39 during six-minute averaging (*average* mode)

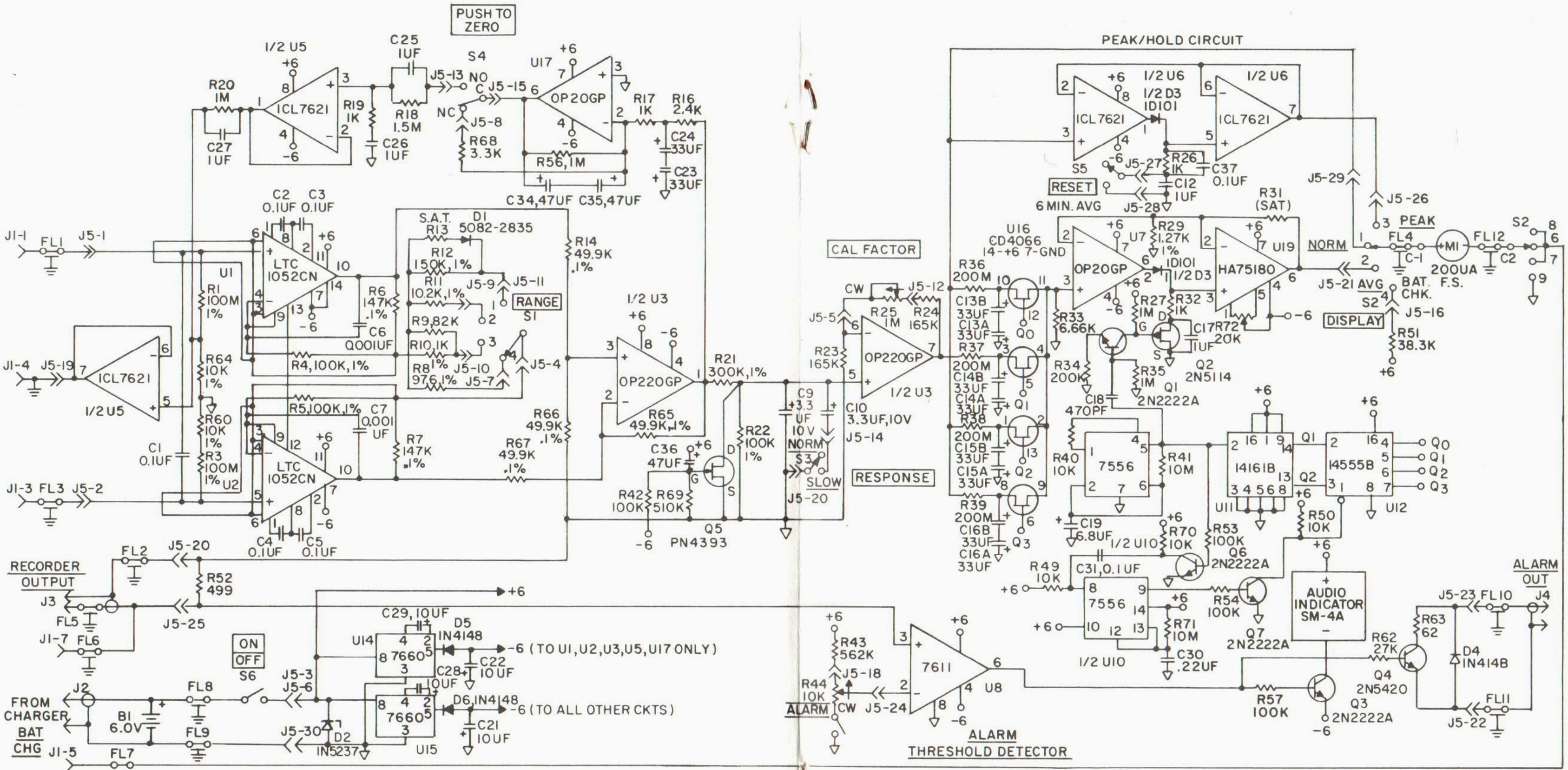
The meter return connects with the calibration potentiometer in the probe via PROBE CONNECTOR (J1) pin 5 and returns from the probe to R52 via J1 pin 7. In this manner, each probe is calibrated automatically for sensitivity when connected to the Model 495 Power Density Meter.

In *normal* mode, the amplifier drives M1 directly. Therefore, with DISPLAY SELECTOR (S2) set to NORM, M1 will follow the detected output signal from the probe.

In *peak-hold* mode, amplifier U6 is configured as a peak detector in which C12 stores and holds the largest impressed signal; if S2 is set to PEAK, M1 indicates the value held on C12. (Depressing PEAK-HOLD RESET (S5) discharges the voltage across C12.)

In *average* mode, the six-minute-averaging circuit comprises U7, U16, and U19 along with their associated components. The circuit consists of four long-term integrators and integrates detected signals from the probe. Every 90 seconds, as determined by timer U10, binary counter U11, and decoder U12, the sampled output is transferred to the peak-detection circuit U7 and U19. The sampled output is stored on C17 and read out on M1. Transistor Q1 discharges holding capacitor C17 so that data from the next integrator can be transferred. The circuit continues to cycle, and the data from the previous six minutes is always available by selecting AVG. on S2.

Comparator U8, along with transistors Q3 and Q4, makes up the alarm circuit. The calibrated (100 mVDC full-scale signal) appears across R52. This signal is available as both recorder output and as input to U8. ALARM-LEVEL CONTROL (R44) sets a reference voltage into the comparator. If the input signal exceeds that voltage level, the comparator output goes high, turning on transistor Q3 and Q4; Q3 activates the audible alarm, and Q4 enables the logic alarm.



NOTES:

1. PANEL COMPONENTS ARE DESIGNATED AS [ ]

BATTERY COMMON GND

CHASSIS GND

Model 495 Power Density Meter Schematic Diagram

SECTION V

MAINTENANCE

5-1. GENERAL.

As with any instrument designed for field use, a RAHAM System should be cared for properly. Connectors should be kept clean, and mechanical abrasion and/or shock should be avoided. RAHAM System probes and meters are interchangeable. If it is suspected that a particular instrument is defective, substitution of another probe or meter can be used for verification. BATTERY CHECK SCALE can operate without connection to a probe; the meter is otherwise inoperative without the probe.

If the Nicad batteries of the RAHAM System become depleted, they can be recharged or, if necessary, replaced.

5-2. BATTERY RECHARGING/REPLACEMENT. (See Figure 7.)

Estimated operating time between recharging is 50 hours. Overall battery lifetime is 300-1000 recharge cycles.

5-2-1. RECHARGING. If a check of battery conditions indicates that recharging is necessary, proceed as follows:

(1) Turn off power.

(2) Connect recharging cable to BATTERY-CHARGER JACK on the bottom of the instrument handle.

(3) Be sure that 115/230 VAC slide switch is in correct position. Plug cable into 115/230 VAC outlet; approximately 15 hours are required to charge batteries fully.

5-2-2. REPLACEMENT. The battery pack cartridge is located in the instrument's handle. Replacement battery-pack assemblies (P/N 17849-G1) can be obtained directly from General Microwave Corporation.

Depleted batteries should be removed from the instrument immediately. If a check of battery conditions indicates that replacement is necessary, proceed as follows:

(1) Loosen the two screws near the bottom of the handle that secure the battery pack cartridge.

(2) Remove battery-pack cartridge from handle.

(3) Replace battery-pack cartridge, observing internal connector (P6) between battery pack and inside of handle.

(4) Secure screws.

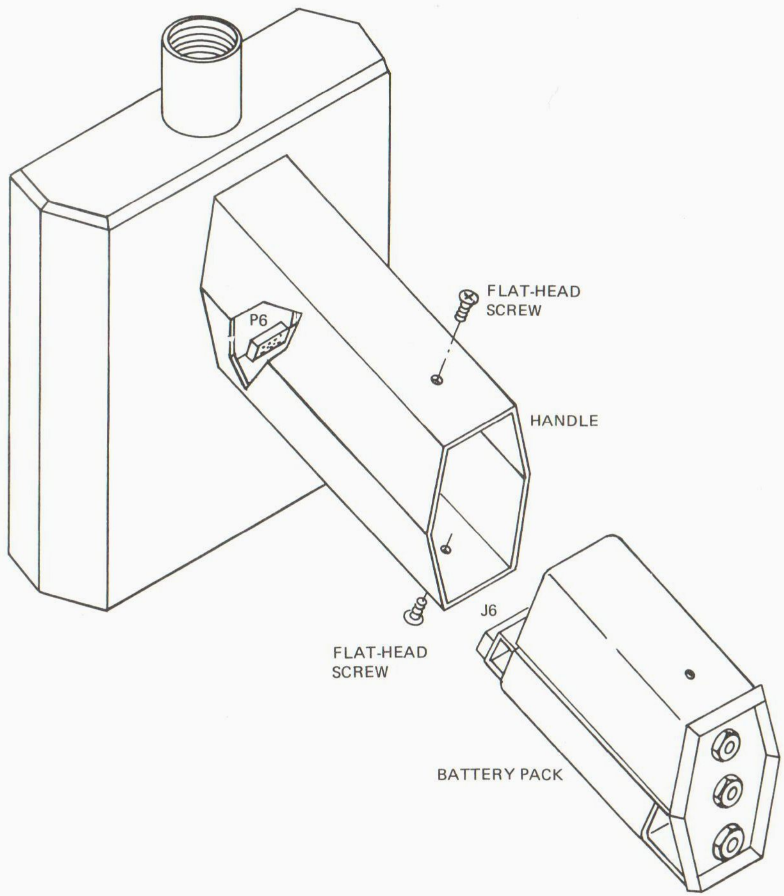


Figure 7. Model 495 Power Density Meter Rear View

5-3. TROUBLESHOOTING.

5-3-1. PROBE. If the unit fails to operate properly after batteries have been checked, isolate the trouble to the probe or meter as follows.

Remove the probe from the PROBE CONNECTOR of the power-density meter and verify that the following resistances are obtained (see Figure 8 for pin-and-keyway configuration):

Table 2. Models 91, 92, 93, 94, and 95 Probe Resistances

CONNECT OHMMETER[1] BETWEEN PINS	Nominal Resistance (Ω)				
	Model 91	Model 92	Model 93	Model 94	Model 95
1 and 3	140K-260K	85K-115K	108K-160K	880K-1055K	700K-875K
4 and case	0	0	0	0	0
5 and 7	0.1K-5K	0.1K-5K	0.1K-5K	0.1K-5K	0.1K-5K

If the measured resistances are not as given in Table 2, return the probe to the factory for repair. Field repair or adjustment of a probe should not be attempted. Because probes and meters are interchangeable in the field, spare assemblies can be stocked to minimize equipment downtime.

5-3-2. POWER-DENSITY METER. As a first step, perform the meter-accuracy check (Section 6-3-2) to help isolate the cause.

[1]Fluke Model 8000A DMM or equivalent with 0.1-mA test current.

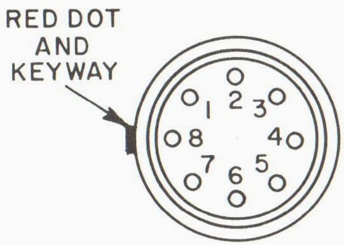


Figure 8. Models 91 through 95 Probe Pin and Keyway Configuration

5-4. REPAIR.

Repair of a defective power-density meter can be performed in the field. To gain access to the unit, remove the back as described under Section 5-4-1. Components failing to meet specifications/tolerances, as given in Section VI and Section VII, should be replaced. In addition to following the special maintenance precautions described in this manual, adhere to the usual precautions and good practices associated with replacing components in precision electronic equipment. For example:

(1) Electrostatically neutralize all tools by placing them in contact with a large mass of metal or known ground.

(2) Avoid damage to the printed circuit board by using a temperature-controlled, eighth-inch soldering iron set to 700°F if component replacement is required. The heat of the soldering iron allows the component to be removed through the conformal coating. After component replacement, thoroughly remove remaining flux with a clean stiff brush dipped in Freon TMC™ solvent. Let dry for one minute and apply Humiseal 1B31™ coating with a second clean stiff brush. Cure for one hour before calibrating the unit.

5-4-1. REMOVAL OF POWER DENSITY METER PRINTED CIRCUIT BOARD.

(1) Remove 6 screws (3 each side) from base plate.

(2) Separate handle/baseplate assembly from front panel by turning handle on an angle so that first one side of meter M1 is removed from the case, and then the other.

(3) Remove 2 screws from meter (M1) face, lift meter. Remove 2 threaded standoffs, lift meter shield and fold away.

(4) Remove 4 screws and lock washers that attach pc board, and remove pc board while observing static precautions.

5-5. PROBE PROTECTIVE-FOAM REPLACEMENT. (See Figures 9A and 9B.)

If the Model 91, Model 92, or Model 93 Probes' sensing-head protective foams are damaged, they can be replaced in the field (Figure 9). No attempt should be made to change a damaged front or rear protective foam on the Model 94 or Model 95 Probe sensing heads. Return all Model 94 and Model 95 Probes to General Microwave Corporation for foam replacement. The procedure that follows, therefore, applies only to Models 91-93.

Note

Both front and rear foams must be replaced if either requires replacement.

5-5-1. REMOVAL. It is first necessary to remove the old foams. Carefully, perform the following steps:

(1) Locate captive nut on tube, behind the rear foam. Unscrew captive nut to remove the sensing head from the tube.

(2) Remove and discard the pressure-sensitive tape.

(3) Using a sharp blade, cut the front foam about one-half inch from the base on the Models 91 and 92 Probes, or along the seam that separates the front and rear foams on the Model 93 Probe; incisions should be approximately one-quarter inch deep.

CAUTION

Components on screw-in element are easily damaged. Exercise great care not to touch them with fingers or tools during foam replacement.

(4) Separate the front foam from the base on the Models 91 and 92 Probes, or from the rear foam on the Model 93 Probe, and discard front foam.

(5) Carefully break the cement bond between screw-in element and rear foam.

(6) Remove screw-in element and discard rear foam.

5-5-2. INSTALLATION. To install the new foam, carefully perform the following steps:

(1) Align screw-in element with front foam on the Models 91 and 92 Probes, or with rear foam on the Model 93 Probe, and press together.

(2) Apply a thin bead of epoxy (Devcon™ or equivalent) to rear surface of the screw-in element on the Models 91 and 92 Probes, or to points on surface of screw-in element half way between each pair of dipole assemblies on the Model 93 Probe (bead should extend about one-eighth inch onto rear foam).

CAUTION

Do not allow epoxy to touch dipole assemblies.

(3) Apply a thin bead of epoxy to the outer-rim surface of new front foam that contacts the outer-rim surface of the new rear foam and rotate to ensure even distribution of epoxy.

(4) Press new front foam against outer rim of new rear foam.

(5) Remove excess epoxy from interface seam.

(6) Place probe sensing head onto tube and retighten captive nut.

(7) Tape new pressure-sensitive band around interface seam.

(8) Connect probe to Model 495 Power Density Meter and check operation.

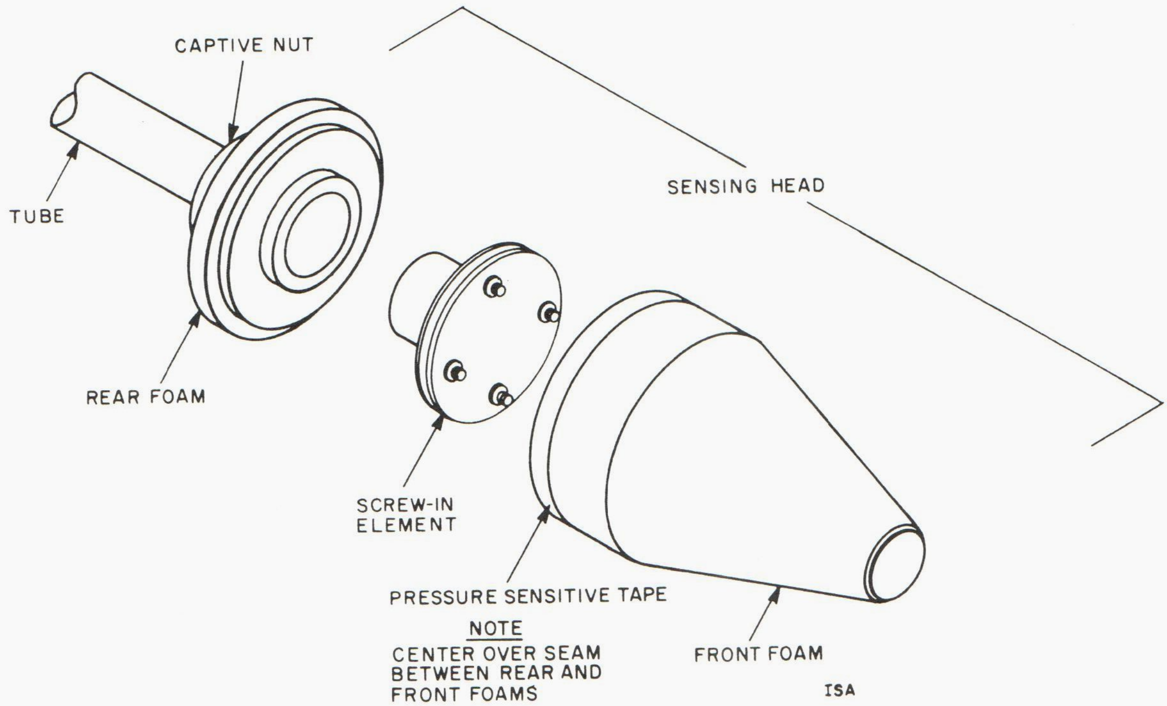


Figure 9A. Protective-Foam Replacement for Model 91 and Model 92 Probes

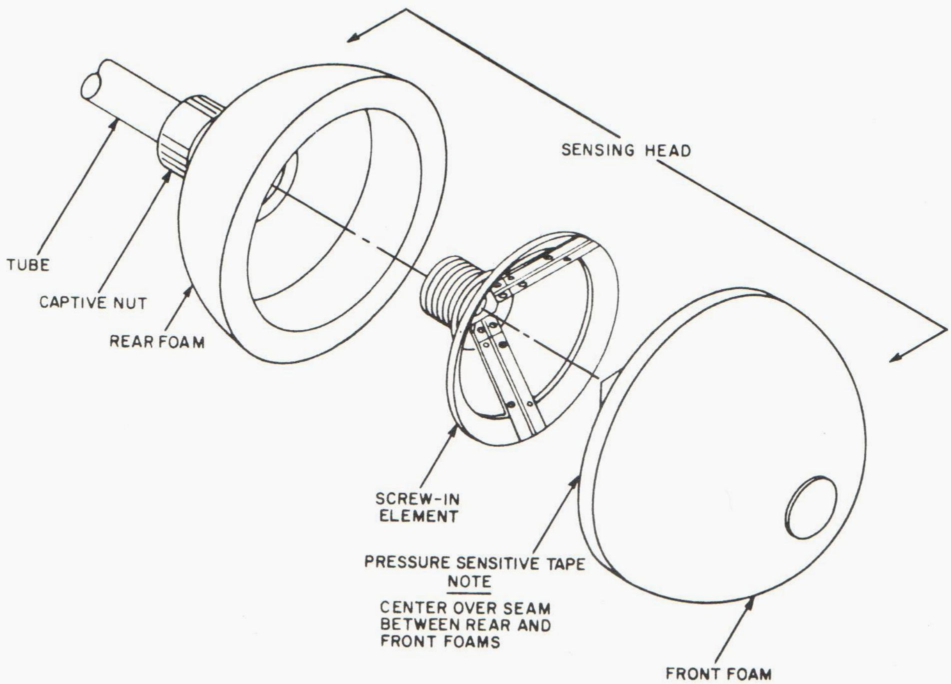


Figure 9B. Protective-Foam Replacement for Model 93 Probe

SECTION VI

CALIBRATION

6-1. GENERAL.

It is recommended that the accuracy of a RAHAM System's power-density meter be checked at 12-month intervals or after a component is replaced. A test fixture that provides voltages at specified impedances is needed to simulate those provided by an operating probe. Figure 10 is a schematic diagram of the Model 495 Power Density Meter test fixture.

6-2. LIST OF TEST EQUIPMENT.

The following equipment (or equivalents) are necessary:

1. Test fixture	See Figure 10	
2. Digital Multimeter (DMM)	Fluke	8000A
3. Oscilloscope	Tektronix	564/3A9

6-3. POWER-DENSITY-METER CALIBRATION. (See Figures 3 and 10.)

6-3-1. PRELIMINARY PROCEDURE.

(1) Set POWER ON-OFF on the Model 495 unit under test (UUT) to OFF.

(2) Remove probe from PROBE CONNECTOR of the UUT.

(3) Zero the power density meter using the MECHANICAL ZERO of the UUT.

(4) Set POWER ON-OFF to ON. Set DISPLAY SELECTOR to BAT. CHK. Meter should read in the green (battery check) scale.

(5) Set POWER ON-OFF to OFF.

6-3-2. ACCURACY CHECK.

(1) Connect Model 495 Power Density Meter test fixture to UUT.

(2) Connect DMM to RECORDER-OUT JACK (J3) of UUT (Figure 11) using P3.

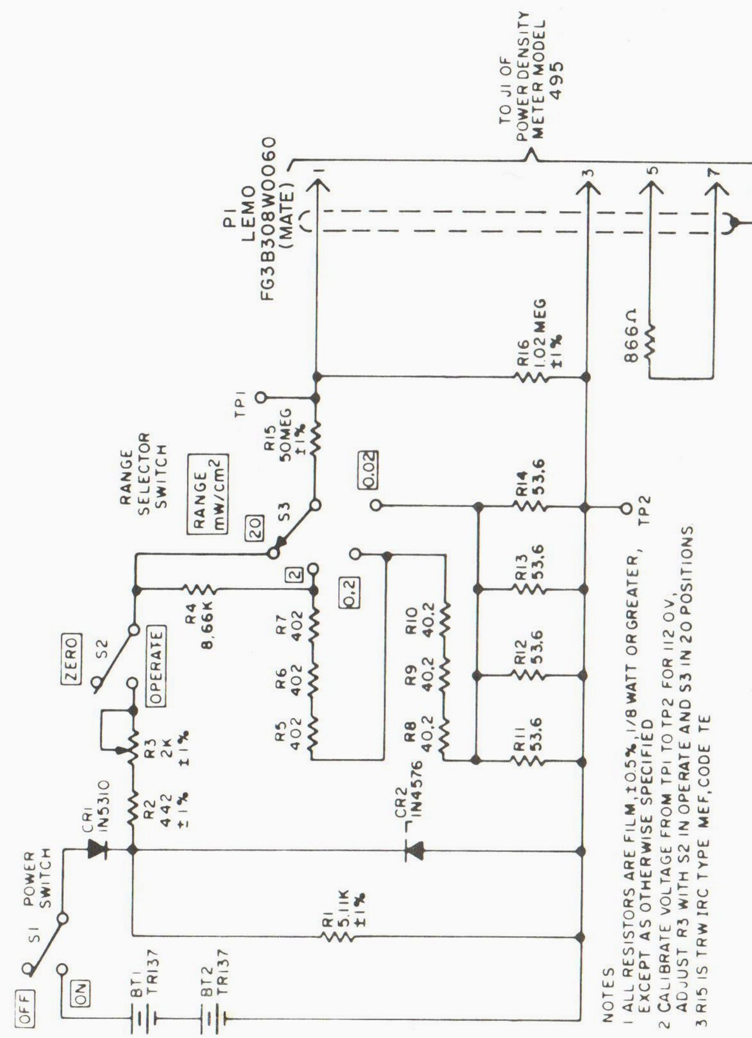


Figure 10. Model 495 Test Fixture Schematic Diagram

(3) Set POWER ON-OFF to ON; allow 10 minutes for stabilization to occur.

(4) Set RANGE SELECTORS of UUT and test fixture to 2 mW/ cm^2 using the yellow scale on the UUT. Depress PUSH TO ZERO on UUT. Set ZERO-OPERATE to OPERATE, on test fixture.

(5) Adjust CAL FACTOR control on UUT so that DMM reads 100 mV.

(6) Set RANGE SELECTOR of UUT and RANGE SELECTOR of test fixture to 0.02 mW/cm^2. Set ZERO-OPERATE to ZERO on test fixture.

(7) Zero UUT using PUSH TO ZERO for zero (±2.5 mV) readout on DMM at RECORDER-OUT jack (J3).

(8) Set test fixture ZERO-OPERATE to OPERATE; DMM should indicate a change of 100.0 mV ± 2.5 mV.

(9) Set RANGE SELECTOR of UUT and RANGE SELECTOR of test fixture to 0.2 mW/cm^2 and repeat steps (7) and (8) setting ZERO-OPERATE switch to zero on test fixture.

(10) Set RANGE SELECTORS of UUT and test fixture to 20 mW/ cm^2 and repeat steps (7) and (8) setting zero-operate switch to zero on test fixture.

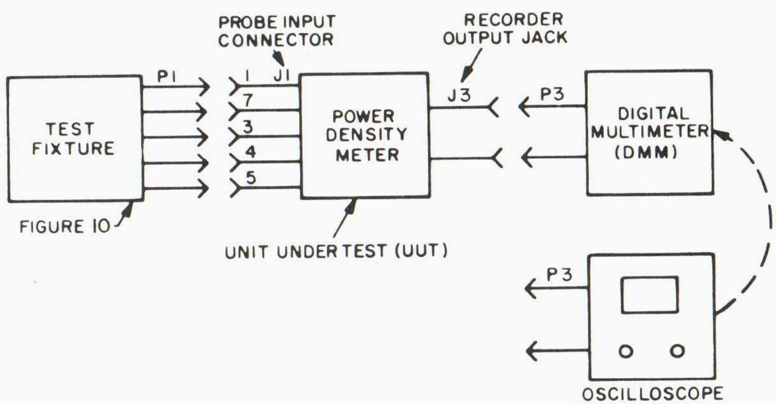


Figure 11. Model 495 Power Density Meter Calibration Setup Block Diagram

(11) Set POWER ON-OFF switches on UUT and test fixture to OFF; disconnect equipment.

6-3-3. ALARM TEST.

(1) Connect Model 495 test fixture to UUT.

(2) Set ALARM-LEVEL CONTROL of UUT to 1.

(3) Set RANGE SELECTORS of UUT and test fixture to 0.02 mW/cm^2.

(4) Set ZERO-OPERATE of test fixture to OPERATE; when power density meter readout is greater than 1, alarm will sound. Reset ZERO-OPERATE to ZERO; alarm should no longer sound.

6-3-4. AVERAGE TEST.

(1) Attach test fixture to UUT.

(2) Repeat section 6-3-2 steps 3, 4 and 5.

(3) Set DISPLAY SELECTOR of UUT to AVG.

(4) Set ZERO-OPERATE of test fixture to ZERO; after six minutes, power density meter should read zero (monitor RECORDER-OUT jack.) If power density is not zero, adjust R72 on PC board to 0 V ± 2.5 mV (Figure 12).

(5) Set ZERO-OPERATE of test fixture to OPERATE. Power density meter will update every 90 seconds and read full scale (100 mV ± 10%) after six minutes.

6-3-5. PEAK-HOLD TEST.

(1) Repeat steps (1) and (2) from Section 6-3-4, and set ZERO-OPERATE of test fixture to zero.

(2) Set DISPLAY SELECTOR of UUT to NORM.

(3) Push PEAK-HOLD RESET on UUT.

(4) Set ZERO-OPERATE of test fixture to OPERATE; power-density meter readout will be nominally full scale, switch ZERO-OPERATE to ZERO on test fixture.

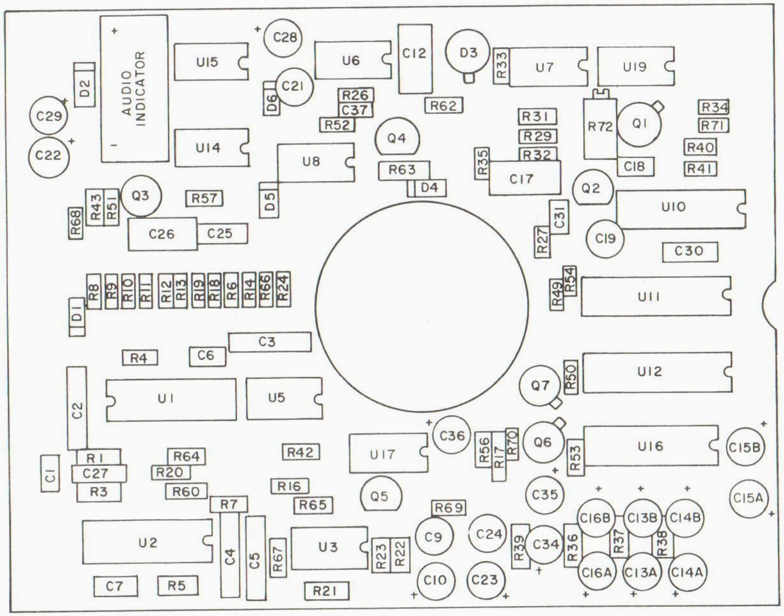


Figure 12. Model 495 PC Board Components/Adjustments Location

(5) Set DISPLAY SELECTOR of UUT to PEAK and observe peak reading as indicated in step (4) above. (To zero the readout, push PEAK-HOLD RESET).

6-4. PROBE CALIBRATION.

6-4-1. GENERAL. The recommended calibration interval for a RAHAM system probe is six months. Because highly specialized test equipment and facilities (such as a radio-frequency anechoic chamber) are required, the probe should be sent to General Microwave Corporation or to another qualified calibration facility for this service.

WITHOUT THESE FACILITIES, NO ATTEMPT TO ADJUST THE CALIBRATION POTENTIOMETER IN THE PROBE SHOULD BE MADE BY THE USER.

Government facilities that can be contacted for Power Density Calibration services are the National Bureau of Standards in Boulder, Colorado, and the Bureau of Radiological Health, Division of Electronic Products, in

Rockville, Maryland. Although inquiries can be made directly to either of those agencies to determine all details of available services, General Microwave Corporation will be pleased to provide assistance if required.

6-4-2. TO PERFORM RF CALIBRATION OF THE PROBE.

(1) Obtain sensitivity values (S_{RF}) for the probe at the following frequencies (GHz):

Model 91: 0.3, 1.1, 2.45, 3.8, 8.0, 12.0, and 18.0

Model 92: 0.010, 0.027, 0.1, 0.3, 1.1, 2.45, 3.0

Model 93: 0.3, 1.1, 2.45, 3.8, 8.0, 12.0, 18.0

Model 94: 0.0002, 0.002, 0.027, 0.1, 0.3, 1.1, 2.45, 3.8, 8.0, 12.0, 18.0, 26.0

Model 95: 0.0002, 0.002, 0.027, 0.1, 0.3, 1.1, 2.45, 3.8, 8.0, 12.0, 18.0, 26.0

(2) Determine the largest (S_{MAX}) and smallest (S_{MIN}) of the sensitivity values.

S_{REF} is the mean value of the probe's frequency sensitivity. Calculate S_{REF} using the following formula:

$$S_{REF} = \sqrt{S_{MAX} S_{MIN}}, \text{ in mV/mW/cm}^2$$

(3) Align the unit to reference value S_{REF} by adjusting probe calibration potentiometer R1 for a resistance R_{CAL} as measured between pins 5 and 7 of the probe connector. (The calibration potentiometer is located under the gray circular tape on the probe handle.)

Models 91-93: $R_{CAL} = [(29820)S_{REF} - 1370]$, in Ω

Model 94: $R_{CAL} = [(298.2)S_{REF} - 1370]$, in Ω

Model 95: $R_{CAL} = [(2982)S_{REF} - 1370]$, in Ω

(4) Determine the Cal Factor of the probe at each calibration frequency using the following equation:

$$\text{Cal Factor} = \frac{S_{REF}}{S_F}$$

SECTION VII

REPLACEMENT PARTS

Tables 3A-3C list parts that can be replaced if defective. Parts are listed in the following sections:

TABLE	DESCRIPTION
3A	Power-Density Meter
3B	Sensing-Head Probe
3C	Extension Cable

Whenever possible, readily available replacement parts are used. These, or equivalents, are obtainable from a large number of local sources.

If necessary, special parts are used. These are obtainable from General Microwave Corporation, manufacturers' code 11332. See Table 4 for other manufacturers' codes.

Table 3A. Model 495 Replacement Parts List

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
C1	CAP,FXD,CER,.1μF,10%, 50VDC,CK05BX104K	3	81349	
C2-C5	CAP,FXD,POLYEST,.1μF, 20%,100VDC,713A1BB-104PM101SK	4	MEPCO	
C6,C7	CAP,FXD,CER,1000pF,10%, 200VDC,CK05BX102K	2	81349	
C9,C10	CAP,FXD,TANT,3.3μF,20%, 6.3VDC,199D335X06R3AE2	2	SPRAG	
C12	CAP,FXD,POLYCARBONATE, 1μF,10%,ECR105BK	3	ELECT	
C17	SAME AS C12			
C18	CAP,FXD,CER,470pF,10%, 200VDC,CK05BX471K	1	81349	

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
C19	CAP,FXD,TANT,6.8μF,10%, 6.3VDC,199D685X96R3BE2	1	SPRAG	
C21,C22	CAP,FXD,TANT,10μF,20%, 10VDC,199D106X0010BE2	4	SPRAG	
C25	CAP,FXD,CER,1μF,10%, 50VDC,CK06BX105K	2	81349	
C26	SAME AS C12			
C27	SAME AS C25			
C28,C29	SAME AS C21			
C30	CAP,FXD,CER,.22μF,10%, 100VDC,CK06BX224K	1	81349	
C31	SAME AS C1			
C34,C35	CAP,FXD,TANT,47μF,20%, 6.3VDC, 199D476X06R3DE2	2	SPRAG	
C36	CAP,FXD,TANT,47μF,20%, 16VDC,199D476X0016EE2	1	SPRAG	
C37	SAME AS C1			
D1	DIODE,SCHOTTKY, 5082-2835	1	HEWLE	
D2	DIODE,ZENER,8.2V, 1N5237B	1	81349	
D3	DIODE,LOW LEAKAGE, DUAL,ID-101	1	INTER	
D4-D6	DIODE,SWITCHING,1N4148	3	81349	
J1	CONN,RCPT-ROUND TYPE, RG3B308CA222	1	LEMO	

Table 3A. Model 495 Replacement Parts List (continued)

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
J2	JACK,POWER,PANEL,712A	1	SWITC	
J3	JACK,SUBMIN PHONE, PANEL,TR-2A	1	SWITC	
J4	JACK,MINTR,PHONE, PANEL,41	1	SWITC	
J6	CONN,RCPT-RECT TYPE, SRE11SNSS	1	WINCH	
M1	METER	1		15560-P1
P5	CONN,PCB,HEADER, 1-102885-5	2	AMP	
P6	CONN,PLUG-RECT TYPE, SRE11PNSS	1	WINCH	
Q1	TRANSISTOR,NPN,2N2222A	4	81349	
Q2	TRANSISTOR,JFET,P CHANNEL,2N5114	1	81349	
Q3	SAME AS Q1			
Q4	TRANSISTOR,NPN,2N5420	1	81349	
Q5	TRANSISTOR,JFET,N CHANNEL,PN4393	1	81349	
Q6,Q7	SAME AS Q1			
R1	RES,FXD,COMP,100 MEGOHM,2%,.25W, M0X200,100 MEGOHM	2	VICTO	
R3	SAME AS R1			

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
R4,R5	RES,FXD,FILM,100K OHM, 1%,.05W,RN50C1003F	3	81349	
R6,R7	RES,FXD,FILM,147K OHM, 0.1%,.05W,RN50C1473B	2	81349	
R8	RES,FXD,FILM,97.6 OHM, 1%,.05W,RN50C97R6F	1	81349	
R9	RES,FXD,COMP,82K OHM, 5%,.12W,RC05GF823J	1	81349	
R10	RES,FXD,FILM,1K OHM, 1%,.05W,RN50C1001F	1	81349	
R11	RES,FXD,FILM,10.2K OHM, 1%,.05W,RN50C1022F	1	81349	
R12	RES,FXD,FILM,150K OHM, 1%,.05W,RN50C1503F	1	81349	
R13	RES,FXD,FILM,(SAT), RN50C(SAT)	1	81349	
R14	RES,FXD,FILM,49.9K OHM, .1%,.05W,RN50C4992B	4	81349	
R16	RES,FXD,COMP,2.4K OHM, 5%,.12W,RC05GF242J	1	81349	
R17	RES,FXD,COMP,1K OHM, 5%,.12W,RC05GF102J	4	81349	
R18	RES,FXD,COMP,1.5 MEG-OHM,5%,.12W,RC05GF155J	1	81349	
R19	SAME AS R17			
R20	RES,FXD,COMP,1 MEGOHM, 5%,.12W,RC05GF105J	4	81349	

Table 3A. Model 495 Replacement Parts List (continued)

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
R21	RES,FXD,FILM,301K OHM, 1%,.05W,RN50C3013F	1	81349	
R22	SAME AS R4			
R23,R24	RES,FXD,FILM,165K OHM, 1%,.05W,RN50C1653F	2	81349	
R26	SAME AS R17			
R27	SAME AS R20			
R29	RES,FXD,FILM,1.27K OHM, 1%,.05W,RN50C1271F	1	81349	
R31	RES,FXD,FILM,(SAT), RN50C(SAT)	1	81349	
R32	SAME AS R17			
R33	RES,FXD,FILM,6.65K OHM, 1%,.05W,RN50C6651F	1	81349	
R34	RES,FXD,COMP,200K OHM, 5%,.12W,RC05GF204J	1	81349	
R35	SAME AS R20			
R36-R39	RES,FXD,COMP,200 MEG-OHM,2%,.25W, M0X200,200 MEGOHM	4	VICTO	
R40	RES,FXD,COMP,10K OHM, 5%,.12W,RC05GF103J	4	81349	
R41	RES,FXD,COMP,10 MEGOHM, 5%,.12W,RC05GF106J	2	81349	
R42	RES,FXD,COMP,100K OHMS, 5%,.12W,RC05GF104J	4	81349	

Table 3A. Model 495 Replacement Parts List (continued)

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
R43	RES,FXD,FILM,562K OHM, 1%,.05W,RN50C5623F	1	81349	
R49,R50	SAME AS R40			
R51	RES,FXD,COMP,38.3K OHM, 1%,.05W,RN50C3832F	1	81349	
R52	RES,FXD,FILM,499 OHM, 1%,.05W,RN50C4990F	1	81349	
R53,R54	SAME AS R42			
R56	SAME AS R20			
R57	SAME AS R42			
R60	RES,FXD,FILM,10K OHM, 1%,.05W,RN50C1002F	2	81349	
R62	RES,FXD,COMP,27K OHM, 5%,.12W,RC05GF273J	1	81349	
R63	RES,FXD,COMP,62 OHM, 1/4W,5%,RC07GF620J	1	81349	
R64	SAME AS R60			
R65-R67	SAME AS R14			
R68	RES,FXD,COMP,3.3K OHM, 5%,.12W,RC05GF332J	1	81349	
R69	RES,FXD,COMP,510K OHM, 5%,.12W,RC05GF514J	1	81349	
R70	SAME AS R40			
R71	SAME AS R41			

Table 3A. Model 495 Replacement Parts List (continued)

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
R72	RES,VAR,NON-WW,25T,20K OHM,.5W,64X203	1	SPECT	
S1	SWITCH,ROTARY,SP-4 POS	1		16663-P1
S2	SWITCH,ROTARY,DP-4 POS	1		16664-P1
S3	SWITCH,ROTARY,SP-12 POS	1		16665-P1
S4	SWITCH,PUSHBUTTON, MOMENTARY,SPDT	1		16666-P1
S5	SWITCH,PUSHBUTTON, MOMENTARY,SPST,8631CG	1	C & K	
S6	SWITCH,PUSHBUTTON,RED, SPST,A3A-7251-2404	1	OMRON	
U1.,U2	IC,LINEAR,OP AMP, LTC1052CN	2	LINEA	
U3	IC,LINEAR,OP AMP,MICRO-POWER,DUAL,OP220GZ	1	PMI	
U5,U6	IC,LINEAR,OP AMP,DUAL, FXD,ICL7621BCPA	2	INTER	
U7	IC,LINEAR,OP AMP,MICRO-POWER,OP20GP	2	PMI	
U8	IC,LINEAR,OP AMP, ICL7611BCPA	1	INTER	
U10	IC,LINEAR,TIMER,DUAL, ICM7556IPD	1	INTER	
U11	IC,DGTL,COUNTER,BIN, 4 BIT,CMOS,MC14161BCB	1	MOTOR	

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
U12	IC,DGTL,DECODER,DUAL, BIN 1 OF 4,CMOS, MC14555BCP	1	MOTOR	
U14,U15	IC,LINEAR,VOLTAGE CONVERTER, ICL7660SCPA	2	INTER	
U16	IC,LINEAR,ANLG SWITCH, 4XSPST,CD4066AE	1	RCA	
U17	SAME AS U7			
U19	IC,OP AMP,HA-7-5180-5	1	HARRI	
	BUZZER, SM-4A	1	JARMS	
	PRINTED WIRING BD	1		15203-P1
	FILTER,FEEDTHRU, 859614-1	8	AMP	
	GASKET,METER	1		15195-P1
	KNOB,RESET	1		15493-P1
	GASKET,BASEPLATE	1		15199-P2
	KNOB,DISPLAY & RANGE	5		16444-P1
	BATTERY CHARGER	1		16412-P1
	KNOB,PUSH TO ZERO	1		16323-P1
	BATTERY PACK ASSY	1		17849-G1

Table 3B. Models 91, 92, and 93 Protective-Foam Replacement Parts List

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
	Model 91, 92 Protective Foam Replacement Parts List			
–	SENSING HEAD,REAR	1		7171-P3
–	SENSING HEAD,FRONT	1		7171-P3
	Model 93 Protective Foam Replacement Parts List			
–	SENSING HEAD,REAR	1		8091-P1
–	SENSING HEAD,FRONT	1		8092-P1

Table 3C. Extension Cable Assemblies–Replacement Parts List

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
	Model 91, 92, 93 Extension Cable Assembly (16416-G1) Replacement Parts List			
–	ADAPTER,CONNECTOR	1		11561-P1
–	CABLE,RETRACTABLE	1		7645-P1
–	BOOT,CONNECTOR	1		8283-P1
–	CONNECTOR,PLUG-ROUND TYPE	1		14156-P1
–	RELIEF,BEND	1		14156-P2
–	CONNECTOR,RECEPTACLE-ROUND TYPE	1		14156-P3
–	TERMINATION,MX1530A/μ	1	81349	

Table 3C. Extension Cable Assemblies–Replacement Parts List (continued)

REF DES	DESCRIPTION	QTY	MFRS CODE	GMC DWG NO.
	Model 94, 95 Extension Cable Assembly (16418-G1) Replacement Parts List			
–	ADAPTER,CONNECTOR	1		11561-P1
–	CABLE,LOW NOISE	51"		12243-P1
–	BOOT,CONNECTOR	1		8283-P1
–	CONNECTOR,PLUG-ROUND TYPE	1		14156-P1
–	RELIEF,BEND	1		14156-P2
–	CONNECTOR,RECEPTACLE-ROUND TYPE	1		14156-P3
–	TERMINATION,MX1530A/μ	1	81349	

Table 4. Manufacturer's Codes

CODE	MANUFACTURER	ADDRESS
81349	GOVERNMENT SPECIFICATIONS	ANY MANUFACTURER
ACCUR	ACCURATE SCREW MACH CO.	NUTLEY,NJ 07110
ALLEN	ALLEN BRADLEY	DISTR
AMP	AMP	HARRISBURG,PA 17105
C & K	C & K COMPONENTS	DISTR
CAMBI	CAMBION	DISTR
ELECT	ELECTRONIC CONCEPTS	EATONTOWN,NJ 07724

Table 4. Manufacturers' Codes (continued)

CODE	MANUFACTURER	ADDRESS
ESNA	ESNA	UNION,NJ 07083
GRAYH	GRAYHILL	DISTR
HARRI	HARRIS SEMICONDUCTOR	DISTR
HEWLE	HEWLETT PACKARD	WOODBURY,NJ 11794
INTER	INTERSIL	DISTR
JARMS	JARMS ELEC. INDS.	DISTR
LEMO	LEMO U.S.A.	SANTA ROSA,CA 95406
LINEA	LINEAR TECHNOLOGY	DISTR
MATSU	MATSUO	DISTR
MEPCO	MEPCO ELECTRA	MORRISTOWN,NJ 07960
MOTOR	MOTOROLA	DISTR
NKKS	NKK SWITCHES (NIKKAI)	DISTR
OMRON	OMRON	DISTR
PMI	PMI	DISTR
RCA	RCA	DISTR
SPECT	SPECTROL	CITY OF INDUSTRY, CA 91745
SPRAG	SPRAGUE	DISTR
SWITC	SWITCHCRAFT	CHICAGO,IL 60630
VICTO	VICTOREEN	CLEVELAND,OH 44104
WINCH	WINCHESTER	DISTR