TECHNICAL MANUAL

OPERATOR'S, UNIT, INTERMEDIATE DIRECT SUPPORT, AND INTERMEDIATE GENERAL SUPPORT MAINTENANCE MANUAL

FOR

TEST SET, RADIO FREQUENCY POWER

AN/USM-491

(NSN 6625-01-191-7679) (EIC: KD7)

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HEADQUARTERS, DEPARTMENT OF THE ARMY
15 SEPTEMBER 1987

5 SAFETY STEPS TO FOLLOW IF SOMEONE IS THE VICTIM OF ELECTRICAL SHOCK

1 DO NOT TRY TO PULL OR GRAB THE INDIVIDUAL

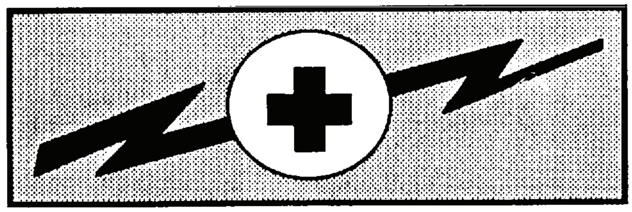
2 IF POSSIBLE, TURN OFF THE ELECTRICAL POWER

3 IF YOU CANNOT TURN OFF THE ELECTRICAL POWER, PULL, PUSH, OR LIFT THE PERSON TO SAFETY USING A DRY WOODEN POLE OR A DRY ROPE OR SOME OTHER INSULATING MATERIAL

4 SEND FOR HELP AS SOON AS POSSIBLE

5 AFTER THE INJURED PERSON IS FREE OF CONTACT WITH THE SOURCE OF ELECTRICAL SHOCK, MOVE THE PERSON A SHORT DISTANCE AWAY AND IMMEDIATELY START ARTIFICIAL RESUSCITATION

WARNING



HIGH VOLTAGE

is used in the operation of this equipment

DEATH ON CONTACT

may result if personnel fail to observe safety precautions

Never work on electronic equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment and who is competent in administering first aid. When technicians are aided by operators, they must be warned about dangerous areas.

Whenever possible, the power supply to the equipment must be shut off before beginning work on the equipment. Take particular care to ground every capacitor likely to hold a dangerous potential. When working inside the equipment, after the power has been turned off, always ground every part before touching it.

Be careful not to contact high-voltage connections or 115 volt ac input connections when installing or operating this equipment.

Whenever the nature of the operation permits, keep one hand away from the equipment to reduce the hazard of current flowing through the body.

Warning: Do not be misled by the term "low voltage.." Potentials as low as 50 volts may cause death under adverse conditions.

For Artificial Respiration, refer to FM 4-25.11.

WARNING

HFE 71 DE is toxic to eyes, skin, and respiratory tract, and decomposes into other hazardous products when exposed to extreme heat. Wear chemical protective gloves and goggles/face shield. Avoid repeated or prolonged contact. Use only in well ventilated areas. If ventilation is not adequate, use approved respirator as determined by local safety/industrial hygiene personnel. Keep away from open flames, welding, or other sources of extreme heat.

CAUTION

THIS EQUIPMENT CONTAINS PARTS AND ASSEMBLIES SENSITIVE TO DAMAGE BY ELECTROSTATIC DISCHARGE (ESD). USE ESD PRECAUTIONARY PROCEDURES WHEN TOUCHING, REMOVING OR INSERTING PRINTED CIRCUIT BOARDS.

ESD
CLASS 1

GENERAL HANDLING PROCEDURES FOR ESDS ITEMS

- USE WRIST GROUND STRAPS OR MANUAL GROUNDING PROCEDURES
- KEEP ESDS ITEMS IN PROTECTIVE COVERING WHEN NOT IN USE
- GROUND ALL ELECTRICAL TOOLS AND TEST EQUIPMENT
- PERIODICALLY CHECK CONTINUITY AND RESISTANCE OF GROUNDING SYSTEM
- USE ONLY METALIZED SOLDER SUCKERS
- HANDLE ASDS ITEMS ONLY IN PROTECTED AREAS

MANUAL GROUNDING PROCEDURES

- MAKE CERTAIN EQUIPMENT IS POWERED DOWN
- TOUCH GROUND PRIOR TO REMOVING ESDS ITEMS
- TOUCH PACKAGE OF REPLACEMENT ESDS ITEM TO GROUND BEFORE OPENING
- TOUCH GROUND PRIOR TO INSERTING REPLACEMENT ESDS ITEMS

ESD PROTECTIVE PACKAGING AND LABELING

- INTIMATE COVERING OF ANTISTATIC MATERIAL WITH AN OUTER WRAP OF EITHER TYPE 1 ALUMINIZED MATERIAL OR CONDUCTIVE PLASTIC FILM OR HYBRID LAMINATED BAGS HAVING AN INTERIOR OF ANTISTATIC MATERIAL WITH AN OUTER METALIZED LAYER
- LABEL WITH SENSITIVE ELECTRONIC SYMBOL AND CAUTION NOTE

CAUTION

Devices such as CMOS, NMOS, MNOS, VMOS, HMOS, thin-film resistors PMOS, and MOSFET used in many equipments can be damaged by static voltages present in most repair facilities. Most of the components contain internal gate protection circuits that are partially effective, but sound maintenance practice and the cost of equipment failure in time and money dictate careful handling of all electrostatic sensitive components.

The following precautions should be observed when handling all electrostatic sensitive components and units containing such components.

CAUTION

Failure to observe all of these precautions can cause permanent damage to the electrostatic sensitive device. This damage can cause the device to fail immediately or at a later date when exposed to an adverse environment.

STEP 1 Turn off and/or disconnect all power and signal sources and loads used with the unit.

STEP 2 Place the unit on grounded conductive work surfaces.

STEP 3 Ground the repair operator using a conductive wrist strap or other device using a 1-M series resistor to protect the operator.

STEP 4 Ground any tools (including soldering equipment) that will contact the unit. Contact with the operator's hand provides a sufficient ground for tools that are otherwise electrically isolated.

STEP 5 All electrostatic sensitive replacement components are shipped in conductive foam or tubes and must be stored in the original shipping container until installed.

STEP 6 When these devices and assemblies are removed from the unit, they should be placed on the conductive work surface or in conductive containers.

STEP 7 When not being worked on wrap disconnected circuit boards in aluminum foil or in plastic bags that have been coated or impregnated with a conductive material.

STEP 8 Do not handle these devices unnecessarily or remove from their packages until actually used or tested.

CAUTION

Thorough drying of solvent is necessary to prevent the production of corrosive byproducts.

CHANGE No. 1

**Headquarters
Department of the Army
Washington, D.C., 24 February 2006**

OPERATOR'S, UNIT, INTERMEDIATE DIRECT SUPPORT, AND INTERMEDIATE GENERAL SUPPORT MAINTENANCE MANUAL FOR TEST SET, RADIO FREQUENCY POWER AN/USM-491 (NSN 6625-01-191-7679) (EIC: KD7)

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1. Remove old pages and insert new pages as indicated below. New or changed material is indicated by a vertical bar in the outer margin of the page. Illustration changes are indicated by a pointing hand. New or changed part numbers are indicated by an asterisk (*). Completely revised sections or chapters are indicated by a vertical bar adjacent to the title only.
2. This change implements Army Maintenance Transformation and changes the Maintenance Allocation Chart (MAC) to support Field and Sustainment Maintenance.

Remove Pages	**Insert Pages**
A, B	A, B
-----	E/(F blank)
i, ii	i ii
0-1, 1-0	0-1, 1-0
5-1, 5-2	5-1, 5-2
A-1/(A-2 blank)	A-1/(A-2 blank)
C-1 thru C-6	C-1 thru C-6/(C-7 blank)
D-1, D-2	D-1, D-2
Cover Page	Cover Page

3. File this change sheet in front of the publication for reference purposes.

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PETER J. SCHOOMAKER
General, United States Army
Chief of Staff

Official:

SANDRA R. RILEY
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Date of issue for original and changed pages are:

Original 0 15 September 1987
Change 1 24 February 2006

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Page No.	*Change No.
Cover	1
A	1
B	0
C, D	0
E / (F blank)	1
i	1
ii thru vi	0
0-1	2
1-0 thru 1-6	0
1-7 / (1-8 blank)	0
2-1, 2-2	0
3-1 thru 3-12	0
4-1 thru 4-29	0
5-0	0
5-1	1
5-2 thru 5-66	0
5-67 / (5-68 blank)	0
6-1 / (6-2 blank)	0
7-1 / (7-2 blank)	0
A-1 / (A-2 blank)	1
B-1, B-2	0
B-3 / (B-4 blank)	0
C-1 thru C-6 / (C-7 blank)	1
D-1	0
D-2	1
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Technical Manual No. 11-6625-3164-14	Headquarters Department of the Army Washington, D.C., 15 September 1987

OPERATOR'S, UNIT, INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT MAINTENANCE MANUAL FOR TEST SET, RADIO FREQUENCY POWER AN/USM-491 (NSN 6625-01-191-7679) (EIC: KD7)

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to: Commander, U. S. Army Aviation and Missile Command, AMSAM-MMC-MA-NP, Redstone Arsenal, AL 35898-5000. A reply will be furnished to you. You may also provide DA Form 2028 information to AMCOM via email, fax or the World Wide Web. Our fax number is: DSN 788-6546 or Commercial 256-842-6546. Our email address is: 2028@redstone.army.mil. Instructions for sending an electronic 2028 may be found at the back of this manual immediately preceding the hardcopy 2028. For the World Wide Web use: https://amcom2028.redstone.army.mil.

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This manual is an authentication of the manufacturer's commercial literature which, through usage, has been found to cover the data required to operate and maintain this equipment. Since the manual was not prepared in accordance with military specifications, the format has not been structured to consider levels of maintenance.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION 0

INSTRUCTIONS

0-1. SCOPE.

This manual contains instructions for the Test Set, Radio Frequency Power, AN/USM-491. The Test Set consists of the Boonton Electronics Corporation Model 4200 RF Microwattmeter and Series 4200-6E sensor. Throughout this manual the nomenclature item is referred to as either the Test Set, Instrument or AN/USM-491. The 4200-6E sensor is referred to as the sensor.

0-2. CONSOLIDATED INDEX OF ARMY PUBLICATIONS AND BLANK FORMS.

Refer to the latest issue of DA PAM 25-30 to determine whether there are new additions, changes, or additional publications pertaining to this equipment.

0-3. MAINTENANCE FORMS, RECORDS, AND REPORTS.

a. Report of Maintenance and Unsatisfactory Equipment. Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA PAM 750-8 as contained in Maintenance Management Update.

b. Report of Packaging and Handling Deficiencies. Fill out and forward SF 364 Report of Discrepancy (ROD) as prescribed in AR 735-11-2/DLAR 4140.55/NAVMATINST 4355.73B/AFR 400-54/MCO 4430.3H.

c. Discrepancy in Shipment Report (DISREP) (SF 361. Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38/NAVSUPINST 4610.33C/AFR 75-18/MCO P4610.19D/DLAR 4500.15.

0-4. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR).

If your Test Set needs improvement, let us know. Send us an EIR. You the user are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design or performance. Put it on an SF 368 (Product Quality Deficiency Report). Mail it to us at: Commander, U.S. Army Aviation and Missile Command, AMSAM-MMC-MA-NM, Redstone Arsenal, AL. 35898-5000. We'll send you a reply.

0-5. ADMINISTRATIVE STORAGE.

Administrative storage of equipment issued to and used by Army activities will have preventive maintenance performed in accordance with PMCS charts before storing. When removing the equipment from administrative storage the PMCS should be performed to assure operational readiness.

0-6. DESTRUCTION OF ARMY ELECTRONICS MATERIEL.

Destruction of Army electronics materiel to prevent enemy use shall be in accordance with TM 750-244-2.

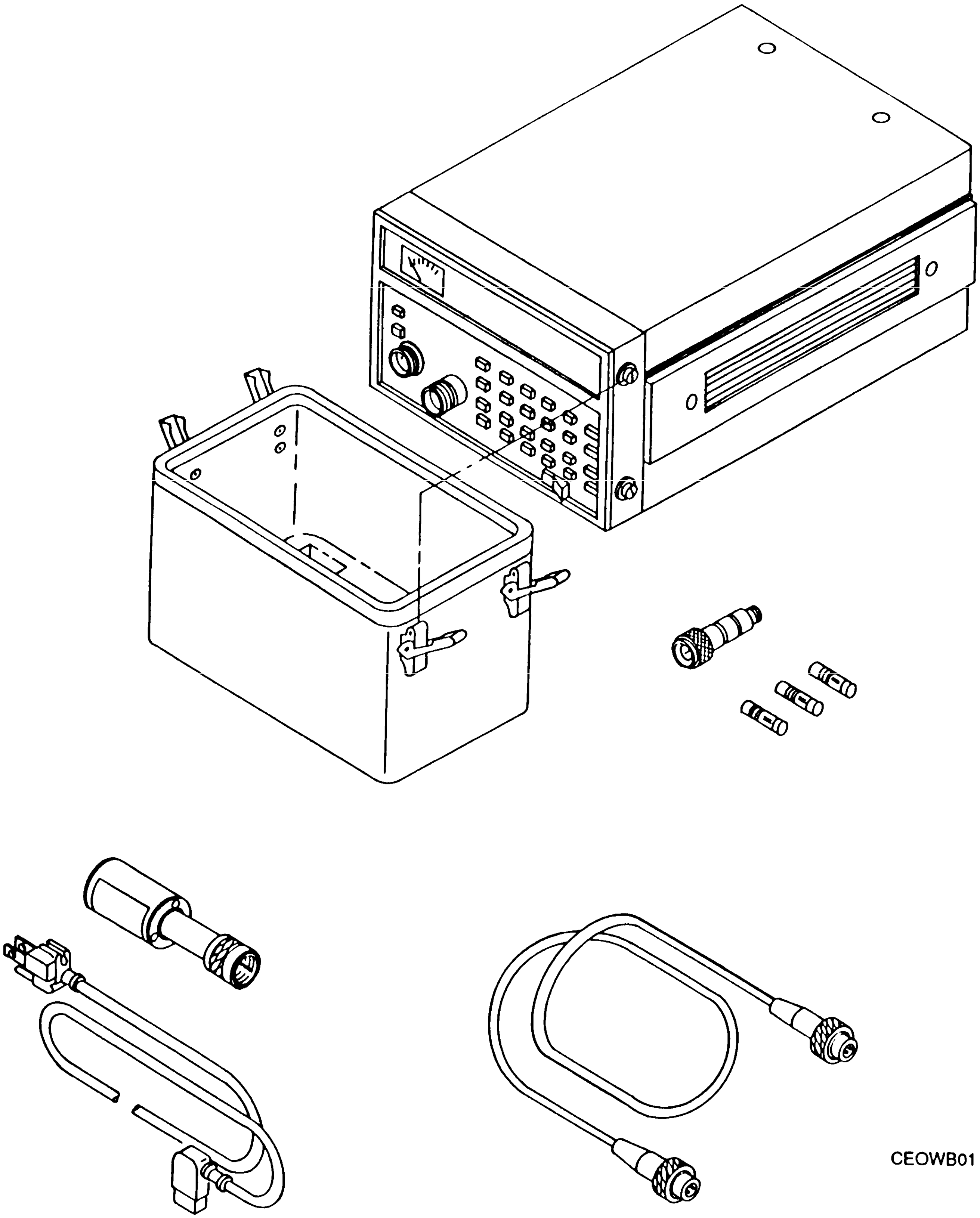


Figure 1-1. Test Set, RF Power AN/USM-491

SECTION I

INTRODUCTION

1-1. DESCRIPTION.

The AN/USM-491 is a microprocessor-based solid state RF microwattmeter. The Test Sets calibrated power level and frequency range is determined by the sensor. Refer to Table 1-1 for performance specifications. The frequency range of the Test Set may be extended by use of the MX-18291/USM-491 sensor, refer to Appendix E.

1-2. CAPABILITIES.

This test set is designed to perform the following operations:

a. Low-power transmitter, signal generator, and oscillator power measurements.

b. SWR and return-loss measurements with directional couplers and slotted lines.

c. Gain and insertion loss measurements.

d. RF attenuation measurements.

e. Antenna measurements.

1-3. DESIGN FEATURES.

a. Low Noise. The test set has been designed and constructed to minimize noise from all sources. The sensor cable is of a special low-noise design; vigorous flexing causes only momentary minor deflections on the most sensitive range of the instrument. The sensor is insensitive to shock and vibration; even sharp tapping on the sensor barrel causes no visible deflection on any range. Internal signal amplification occurs at approximately 94 Hz, thereby reducing susceptibility to 50 or 60 Hz fields. A low-noise solid-state chopper is used.

b. LED Display. Measured power levels are displayed by a LED type readout with decimal points and minus sign. Annunciators associated with the LED display indicate the units of measurement. The result is a clear, unambiguous readout that minimizes the possibility of misinterpretation. This display is also used to show data being entered into non-volatile memory and to display data recalled from non-volatile memory; the display and annunciators blink on and off during data entry and recall to indicate that displayed values are not measured values.

c. Analog Indications. A front-panel analog meter provides relative power indications for peaking or nulling applications. A dc voltage proportional to the measured power level is available at a rear-panel connector for application to a recorder or other external device.

d. Pushbutton Measurement Mode Selection. A choice of measurement modes is available to the operator. Indications in terms of power or dBm can be selected by pressing the appropriate front-panel key switch. A dB reference level can be entered through the keyboard and a display mode selected to indicate power levels in dB, relative to a dB reference level.

e. Automatic Ranging. Auto-ranging under control of the microprocessor eliminates the need for manual ranging. Alternately, a measurement range can be retained for all measurements, if desired, by selecting the range hold mode. Applications of power levels that are outside of the maximum or minimum measurement capability of the instrument (or range in the hold mode) result in an error indication on the LED display.

f. Automatic Zeroing. An automatic zeroing circuit eliminates the need for tedious, often inaccurate, manual zeroing. With zero input to the sensor, pressing a front-panel key switch directs the microprocessor to compute and store zero corrections for each range, and the instrument is thereafter corrected on each range in accordance with the stored data.

NOTE

Sensor calibration data is programmed into the instrument at the factory. If additional sensor(s) are required after the instrument is in the field, the new sensor data can be installed at the Intermediate Maintenance Level.

g. Automatic Sensor Compensation. Calibration factors are stored in the microprocessor. Calibration data is written into non-volatile storage at the factory, and it may also be written into storage in the field. When the sensor and the measurement frequency are specified through front-panel keyboard entry, measurement values are corrected automatically with calibration factors. Alternately, the calibration factor in dB for the sensor being used may be entered through the keyboard, and the measurement values are then corrected automatically in accordance with the calibration factor. Both power and dB values are corrected.

h. Built-in Power Reference. An accurate, 1.000 milliwatt, 50 MHz signal for instrument adjustment is provided by a built-in power reference. Adjustment is simply a matter of connecting the sensor to the power reference and pressing a key; the correction is computed automatically by the microprocessor. The correction circuit has built-in protection against inadvertent key actuation when the sensor is not connected to the power reference. Correction is limited to approximately 7.5% from the original factory set value. Computer corrections that exceed this range are rejected automatically, and the instrument returns to its previous sensitivity.

i. Pushbutton High/Low dB Limit Selection. High/low dB limits may be entered through the front-panel keyboard. A front-panel annunciator indicates when measured dB levels are outside the preset limits. Signals are also activated at a rear–panel connector to provide remote indications of out-of-limit measurements.

j. Solid-state Chopper. Signal amplification in the instrument occurs at approximately 94 Hz. Input signals from the sensor are converted into a 94 Hz signal by a solid-state, low-level input modulator (chopper), which represents a distinct improvement over electromechanical choppers. Extended service life is assured through the elimination of contact wear, contamination, and other problems associated with electromechanical choppers.

k. IEEE-488 Bus Interface. The IEEE-488 General Purpose Interface Bus (GPIB) permits external control of the instrument and data capture by a wide variety of compatible controllers. The instrument may be operated with other GPIB-compatible devices to achieve specific test automation goals, with no specialized control interface requirements for proper electrical operation. Although no standard GPIB interface data formats have yet been established, certain common practices are achieving de facto standard status. These practices have been adhered to in the design of the interface formats and delineators, thereby assuring the user of format compatibility with almost all controllers.

1-4. EVIRONMENTAL REQUIREMENTS.

The AN/USM-491 is designed for normal use in an electronics laboratory or maintenance facility used for the troubleshooting and repair of electronics. This includes those electronic components which emit RF radiation. However, high concentrations of RF radiation, extreme ambient temperatures, and high humidity are not considered normal environmental conditions and the AN/USM-491 should not be operated in that environment.

NOTE

- Operation of the test set in close proximity to a source of high power RF radiation could cause inaccuracies in measurements and possible damage to the instrument and/or sensor.
- Operation of the test set at temperatures below 18°C (64°F) and above 30°C (86°F) may affect the uncertainty of measurement accuracy (see Table l-l).
- Humidity affects the dielectric properties of RF components and therefore will result in incorrect measurements. The test set should not be operated in an environment of high humidity.

1-5. STORAGE DATA.

The AN/USM-491 should be stored in a cool, dry place and packed in accordance with the instructions of Section 2 of this manual.

1-6. TOOLS AND TEST EQUIPMENT.

Tools and test equipment required for operation and maintenance of the AN/-USM-491 are listed in Appendix C (Maintenance Allocation Chart).

1-7. WARRANTY INFORMATION.

The AN/USM-491 is warranted by the manufacturer to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of two years from date of shipment.

Table 1-1. Performance Specifications

Parameter	Specifications
FREQUENCY RANGE	100 KHz to 18 GHz
POWER RANGE (Display calibrated in mW, µW, nW, dBm, and dB relative to selected reference)	-40 dBm to +30 dBm (100 nW to 1W) (May be extended to +50 dBm by placing a 20 dB attenuator of known exact value in-line with the sensor. Calculate: True Power = Display + Attenuation)
INPUT TYPE	Coaxial Type N male
IMPEDANCE	50 ohm
MAXIMUM SWR	10 MHZ - 14 GHz 1.4 14 GHz - 18 GHz 1.5
OVERLOAD RATING	2W (+33 dBm)
BASIC ACCURACY Calibration Zero and Noise	 0.25% or reading 0.1% full scale 0.25%
RANGING	Autoranging plus hold on range
BASIC MEASUREMENT ACCURACY The total accuracy is the sum of the uncertainties noted in sections A, B, C and D. These uncertainties may also be added in an RSS fashion which represents the most probable total uncertainty. $RSS = (A^2 + B^2 + C^2 + D^2)^{1/2}$	A. Basic Uncertainty (includes all instrumentation, noise, zero, and shaping errors and includes 0.7% power reference setting error). INPUT LEVEL — POWER UNCERTAINTY >1µW — 1.2% of reading — 0.1% full scale <1µW — 1.5% of reading — 1.5% full scale B. Temperature Uncertainty (at 1 MHz) Temperature — Instrument — All Sensors 21°C to 25°C (reference) — 0% (0 dB) — 0% (0 dB) 18°C to 30°C — 0%(0 dB) — ±2.32%(0.1 dB) 10°C to 40°C — ±0.5%(0.2 dB) — ±4.7%(0.2 dB) 0°C to 55°C — ± 0.6%(0.6 dB) C. Calibration Factor Uncertainty

Table 1-1. Performance Specifications (Cont'd)

Parameter	Specifications

FREQUENCY GHz	UNCERTAINTY MAX %	RSS %	FREQUENCY GHz	UNCERTAINTY MAX %	RSS %
.05*	0	0	9	4.0	2.4
<2	1.3	1.3	10	4.0	2.3
2	3.0	1.7	11	4.0	2.2
3	3.0	1.7	12	4.5	2.8
4	3.5	1.7	13	6.0	3.0
5	3.5	1.7	14	6.0	2.8
6	3.5	1.8	15	6.0	2.8
7	3.5	1.9	16	6.0	2.9
8	4.0	2.0	17	6.0	2.8
			18	6.0	3.1

Parameter	Specifications
	D. Power Reference Uncertainty. Power reference accuracy is ±l.2% worst case for one year (0° to 55°C). When calculating the sum of the uncertainties, only include 0.5% for the power reference as the remaining 0.7% is included in A above.
POWER REFERENCE	
Source	Internal 50 MHz oscillator with Type N female connector on front panel.
Power output	1.00 mW, factory set to ±O.7%, traceable to National Bureau of Standards, ±1.2% worst case for one year (0° to 55°C).
CALIBRATION	Front panel key automatically calibrates instrument to power reference. This should not be construed with calibration IAW TB 43-180.
ZERO	Automatic, operated by front-panel switch.
CALIBRATION FACTOR	+3.0 dB to -3.0 dB ranges in 0.01 dB steps, entered through front panel keys; alternately, stored calibration factors are interpolated linearly and applied automatically to readings when the frequency is entered through front panel keys. High frequency calibration factors are individually adjusted at every 1 GHz over the range of the sensor.

*Reference frequency

Table 1-1. Performance Specifications (Cont'd)

Parameter	Specifications
MEASUREMENT TIME	Diode sensors, typically 0.2 to 0.5 s except 2-6 s below -20 dBm. Refer to Table 1-2.
RECORDER OUTPUT.	
Watt Mode	10 volts full-scale, proportional to indicated power over each range.
dB Mode	8 volts equivalent to O dBm with a sensitivity of 1 volt per 10 dB change over the entire range (O to 11 V).
DISPLAY	4-digit LED, 3-1/2 digit display of power, 4-digit of dB with 0.01 dB resolution. Auxiliary analog display, uncalibrated, proportional to recorder output.
dB LIMITS	Entered through front panel in dB only, operable in both dB and power modes.
ANNUNCIATORS	LED display of mW, µW, dBm, or relative dB (dBr); LED indication of use of channel 1 (CH1), out of dB limits; and condition of GPIB activity (LSN, ATN, REM, AND TALK).
POWER CONSUMPTION	24 VA; 100, 120, 220, and 240 volts, 50 to 400 Hz.
WEIGHT	4.54 kg (10 lbs.) approximately.
DIMENSIONS	17.39 in. long x 9.25 in. wide x 5.83 in. high (34.9 cm deep x 21.1 cm wide x 14.9 cm high).
ACCESSORIES FURNISHED	a. AC power cord b. Sensor cable c. Spare fuses located inside front cover, one 250 VAC 0.3 ampere, MDL Slo-Blo; two 250 VAC 0.2 ampere, MDL Slo-Blo. d. 20 dB 5 watt type N attenuator
REMOTE OPERATION TO IEEE BUS STANDARD	All front panel controls except line switch and power reference switch. In addition individual power and dB ranges may be selected and selectively zeroed. Listen/talk address set by rear-panel bit switch.

Table 1-1. Performance Specifications (Cont'd)

Parameter	Specifications
	The AN/USM-491 implements these subsets of the GPIB function. MLA = My Listen Address MTA = My Talk Address SH1 SOURCE HANDSHAKE, complete capability AH1 ACCEPTOR HANDSHAKE, complete capability T6 BASIC TALKER, SERIAL POLL, UNADDRESS IF MLA, NO TALKER ONLY capability TE0 NO EXTENDED TALKER capability L4 BASIC LISTENER, UNADDRESS IF MTA, NO LISTENER ONLY capability LEO NO EXTENDED LISTENER capability SR1 SERVICE REQUEST capability RL1 REMOTE-LOCAL capability, LOCAL LOCKOUT PPO NO PARALLEL POLL capability DC1 DEVICE CLEAR capability DT1 DEVICE TRIGGER capability CO NO CONTROLLER capability.

Table 1-2. AN/USM--49l Response Time

Starting Level dBm	10-dB Power Step		20-dB Power Step		30-dB Power Step		50-dB Power Step	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
-40	0.60 s	N.A	0.65 s	N.A.	0.45 s	N.A.	0.50 s	N.A.
-30	0.60 s	5.4 s	0.40 s	N.A.	0.35 s	N.A.	0.50 s	N.A.
-20	0.40 s	1.0s	0.35 s	5.4 s	0.40 s	N.A.	0.35 s	N.A.
-lo	0.35 s	0.50 s	0.35 s	1.0s	0.40 s	5.4 s	N.A.	N.A.
0	0.35 s	0.30 s	0.35 s	0.55 s	0.30 s	1.0s	N.A.	N.A.
+10	0.20 s	0.25 s	0.15s	0.25 s	N.A.	0.70 s	N.A.	6.0 s
+20	0.15s	0.35 s	N.A.	0.35 s	N.A.	0.50 s	N.A.	1.7s
+30	N.A.	0.35 s	N.A.	0.35 s	N.A.	0.60 s	N.A.	1.0s

SECTION II

PREPARATION FOR USE AND INSTALLATION INSTRUCTIONS

2-1. INSTALLATION.

For bench use, choose a clean, sturdy, uncluttered surface.

2-2. POWER REQUIREMENTS.

The instrument has a tapped power transformer which permits operation from 100, 120, 220, or 240 volt ±lO%, 50 to 400 Hz, single phase ac power sources. Power consumption is approximately 24 volt-amperes at 60 Hz.

2-3. CABLE CONNECTIONS.

Interconnecting cable connections required depend upon the system applications of the AN/USM-491. A line cord and sensor cable are supplied with the test set. Cable connections that may be required are detailed in the following paragraphs.

2-4. SENSORS.

The sensor cable supplied with the basic instrument connects directly to the front-panel SENSOR connector, and the sensor connects directly to the other end of the sensor cable. Although the sensor is insulated against extreme temperature variations, it is advisable to locate the sensor away from heat sources when using the most sensitive ranges of the instrument. If the test set is to be used to measure the output of equipment that generates heat significantly above the ambient temperature, a short length of coaxial cable or solid line having the same characteristic impedance (50 ohms) as the sensor may be used between the sensor and the equipment undergoing test to allow heat to dissipate before reaching the sensor. If such a cable is used, the length must be kept as short as possible for operation at the high end of the frequency range; cable losses and an increase in SWR will tend to degrade measurement accuracy.

2-5. RECORDER OUTPUT.

Recorder connector J20 (type BNC) on the rear panel provides an analog dc voltage for application to a remote recorder. The output resistance is 9090 ohms, delivering 1.00 milliampere into a 1000 ohm load for full scale input in the power mode. When open circuited, the analog dc voltage is proportional to the following:

In the power mode, it is proportional to displayed power, with 10 volts for full scale for each 10 dB range.

b. In the dB mode, it is proportional to displayed dBm with the relationship shown below:

Recorder Output (dBm)	(volts)
+30	11
+20	10
+10	9
0	8
-10	7
-20	6
-30	5
-40	4

2-6. STATUS OUTPUT.

Rear-panel connector P3 provides signal outputs for source disabling during zeroing operations, and provides high and low dB limit signals during dB measurements. The dB limits always test against the displayed value for operation. With the calibration factor and dB reference level equal to zero, the dB limits as entered prevail. With a dB reference level other than zero, the displayed value is checked against the limits chosen. Pin connections are as follows:

Connector Pin	Signal
1	Common
2	Not used
3	Logic high indicates zeroing operation
4	Logic low within dB limits; logic high above high dB limit
5	Logic low within dB limits; logic high below low dB limit.

SECTION III

THEORY OF OPERATION

3-1. GENERAL THEORY.

The AN/USM-491 is a completely solid-state unit that employs a microprocessor for versatility in use. The microprocessor is controlled by a permanently stored, internal program; pertinent operating parameters can be entered by means of a front-panel keyboard. Use of a microprocessor enables automation of numerous functions, such as zeroing, calibration, sensor compensation, range selection, unit conversion, dB limit testing, and relative dB measurements. Measured values are displayed directly on a 4 digit LED display in terms of nW, μW, mW, dBm, or dBr (relative dB). Annunciators associated with the display indicate the unit of measurement. An analog meter provides relative power measurements; this feature simplifies such operations as nulling and peaking.

3-2. MAJOR MODULES DESCRIPTION.

The overall block diagram for the major modules of the AN/USM-491 is illustrated by Figure 3-1. The main frame schematic is illustrated by Figure FO-1. The following paragraphs describe the operation of these modules.

3-3. SENSOR.

Power levels to be measured are applied to the sensor, which is connected to a front-panel connector through a five-foot sensor cable. Input power appears across a precision resistor (50 ohms). Because the resistance value is constant, the voltage developed across the resistor is a function of input power ($E^2 = PR$). The RF voltage developed across the resistor is converted to a DC voltage, and the resulting DC voltage is applied to the input module of the instrument.

3-4. INPUT MODULE A6.

The input module receives the DC voltage developed by the sensor. Operation under control of the control module, the input module converts the DC signal to an AC signal at 94 Hz, amplifies the AC signal to eliminate offsets in the amplifiers, converts the amplified AC signal to an analog DC signal, and converts the analog DC signal to a digital signal. If the autoranging function of the instrument is being used, the gain of the amplifiers in the input module is adjusted automatically by the control module to accommodate any power level within the range of the instrument. The digital output signal of the input module is supplied to the control module for linearity correction and further processing. The control module sends the processed data back to the input module for conversion back to analog. This signal is applied to the analog meter on the display module for relative power measurements, and to a rear-panel connector for application to a peripheral recorder.

3-5. CONTROL MODULE A5.

The control module consists primarily of a pre-programmed microprocessor. The microprocessor accepts and stores measurement parameter commands entered through

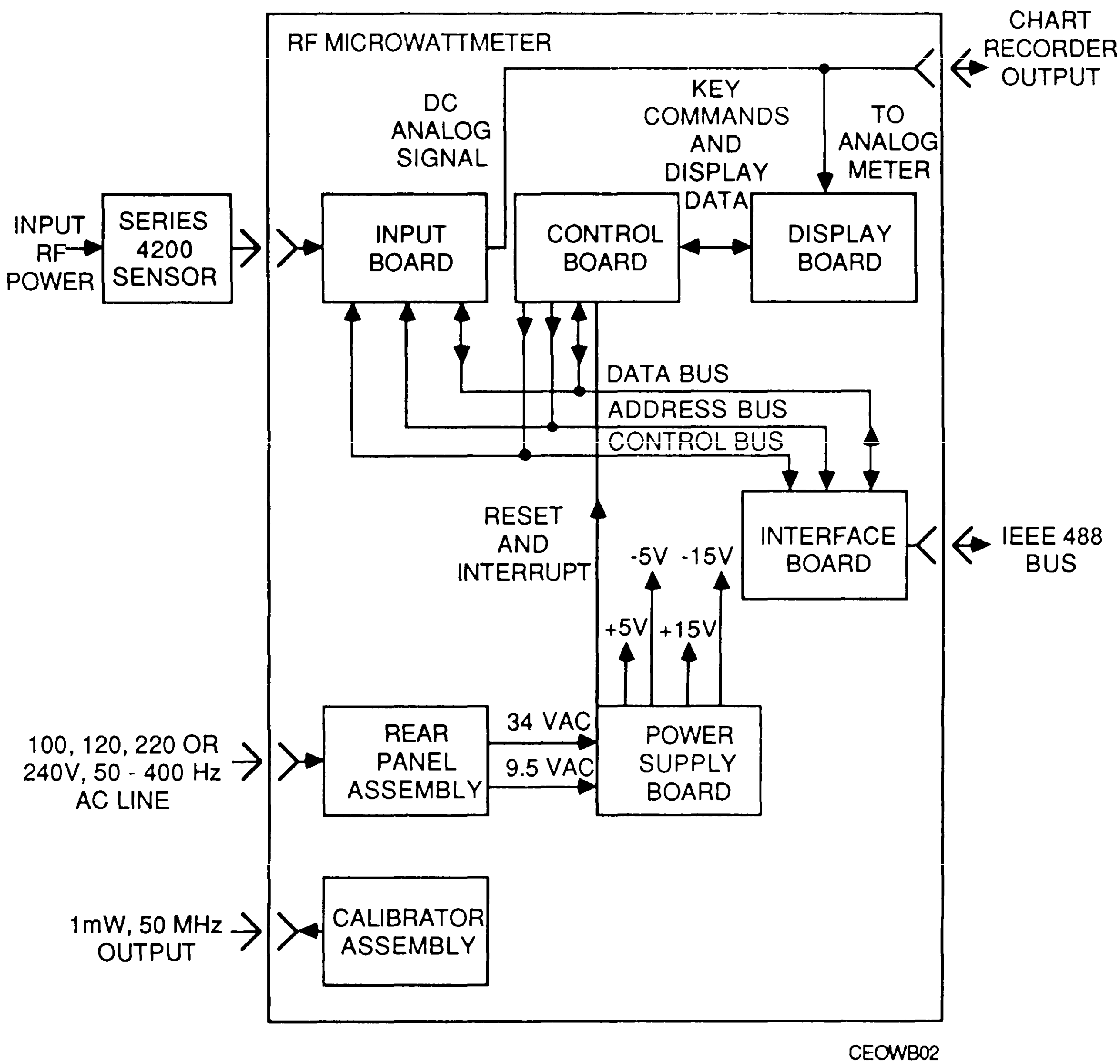


Figure 3-1. Overall Block Diagram

the front-panel keyboard, and controls operation of the internal circuits of the instrument in accordance with its program and keyed-in commands. The microprocessor performs measurement value corrections based on stored zero corrections and stored or keyed-in sensor calibration factors, unit conversions based on selected measurement modes, and dB limit determinatiorn. The microprocessor also performs automatic instrument zeroing and calibration. The processed digital signal, which defines the final measurement value, is applied to a data bus and to the display module.

3-6. DISPLAY MODULE A2.

The display module contains the keyboard and LED display circuits. Parameters to be used for power measurements can be entered at any time through the keyboard. Keyed-in values are read and stored by the microprocessor, and selected numerical values are shown on the LED display during parameter selection. Computed power levels are processed by the microprocessor in accordance with the keyed-in parameters; the digital values representing the final computed measurement values are decoded by the display module circuits to produce a direct LED readout of measured values and to activate the appropriate annunciators.

3-7. CALIBRATOR ASSEMBLY.

The calibrator assembly generates a precision, 1.00 mW, 50 MHz signal that is used for calibration of the instrument. When this signal is applied to the sensor and the front-panel CAL key is pressed, fine sensitivity adjustments of the instrument are performed automatically under microprocessor control.

3-8. REAR PANEL ASSEMBLY.

The rear panel assembly controls the input line voltage of 100, 120, 220, or 240 volts, 50 to 400 Hz, AC and steps it down to 34 and 9.5 volts AC for use by the power supply module.

3-9. POWER SUPPLY MODULE A7.

The power supply module provides all DC voltages required for operation of the internal circuits. It also provides a reset signal to the control module when it is powered up, and an interrupt signal if an undervoltage condition is detected.

3-10. INTERFACE MODULE A23.

The interface module is a microprocessor driven data interface which converts IEEE 488 bus compatible signals into control codes that operate the internal control bus of the instrument. It also converts instrument data into IEEE 488 compatible signals for use on the bus. All data transfers are handled by source and acceptor handshake protocols as defined by IEEE-488-1978.

3-11. DETAILED THEORY OF OPERATION.

3-12. SENSOR CIRCUIT.

The sensor contains two paralleled precision resistors across which the input power is applied. With a constant load resistance, the RF voltage developed across the load resistance is a function of the RF power (E^2=PR). The RF voltage is rectified by a rectifier that permits measurement of highly asymmetrical waveforms without substantial error. When the applied power level is within the square-law region of the diodes the sensor has a true RMS response. Above this power level, the sensor response approaches peak-to-peak, calibrated in the instrument in terms of true average power.

NOTE

The sensor has an input attenuator which permits measurements to 1000 mW (+30 dB).

a. The body of the sensor has been designed and fabricated very carefully to eliminate any cavity resonance effects within the calibrated frequency range and to minimize noise. The sensor diodes are specially selected for this application. The DC output voltage of the sensor is applied to the input connector of the instrument through a low-noise sensor cable. Figure 3-2 depicts the sensor's circuitry.

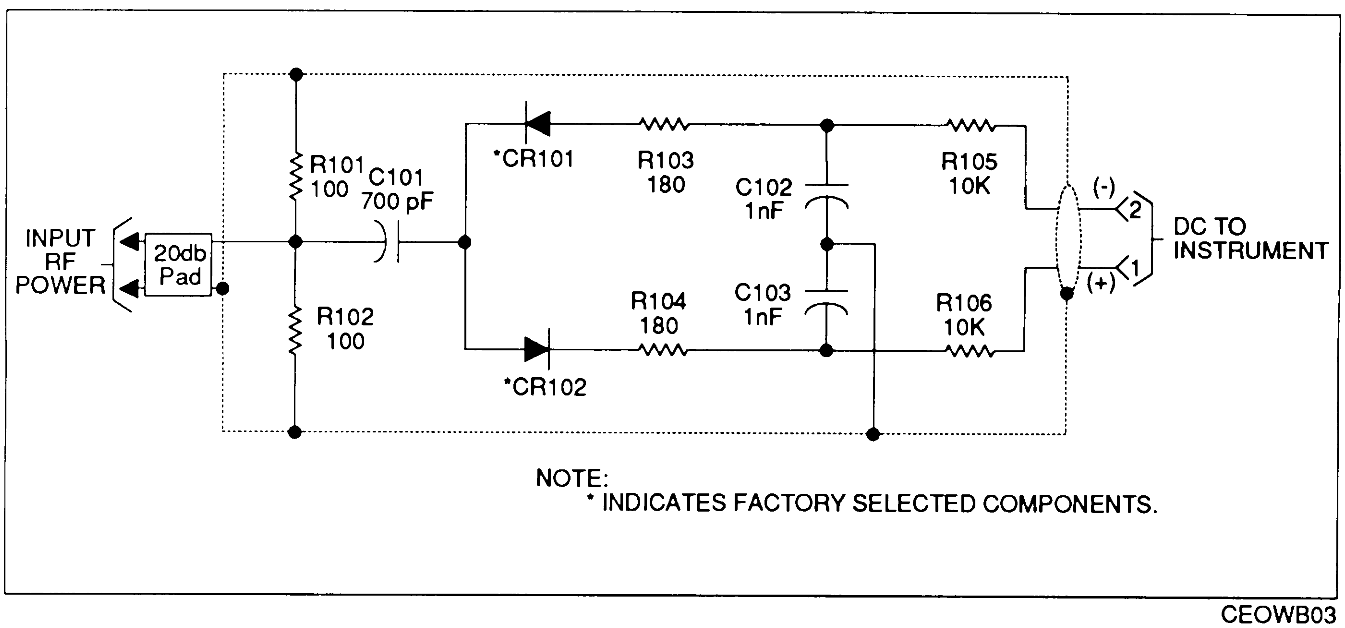


Figure 3-2. Sensor Circuit

3-13. INPUT MODULE A6.

The input printed circuit board receives from the sensor a DC voltage that is a function of the power level being measured. Under control of the control board circuits, it provides amplification and signal processing required to develop an analog DC voltage and a digital signal that are proportional to the input RF power level. The input DC signal from the sensor is balanced in form and may vary from microvolt to volts, depending upon the input power level. The input printed circuit board must provide amplification with a wide range of gain, low offset voltage, and low noise; therefore, the input DC signal is converted to an AC signal which is amplified, and the amplified AC signal is converted to a DC analog signal and to a digital signal.

a. The input DC signal is converted to an AC signal by a chopper module, which plugs into the input printed circuit board. The chopper is composed of solid-state switches ICla, IClb, ICIc, and ICld in a balanced arrangement, operating at a frequency of approximately 94 Hz to minimize AC line and line-related component interaction. The chopper drive signal is derived from the output of an astable multivibrator, which is completely independent of line frequency. The use of a solid–state chopper eliminates many of the problems, such as contact wear and contamination, associated with electromechanical choppers. The chopper supplies a balanced AC version of the input signal of approximately 94 Hz to the input amplifier.

b. The 94 Hz drive signal for the chopper is derived from the output signal of astable multivibrator IC5. Multivibrator IC5 drives flip-flops IC7a and IC7b, and these flip-flops supply the drive signal to the chopper circuits. Flip-flop IC7a also drives flip–flops IC8a and IC8b, which provide a 94 Hz, synchronized drive signal to the demodulator circuits that convert the amplified AC signal back to a DC signal.

c. Amplification of the balanced AC signal from the chopper is accomplished in an input amplifier composed of low-noise, operational amplifiers A5, A6, and A7. A balanced arrangement with degenerative feedback for stabilization and gain control is employed. The input AC signal is amplified by 500, 50, 5, or 0.5, depending upon the instrument range. Demultiplexer IC6, under control of the control printed circuit board, adjusts the degenerative feedback in accordance with the range selected by the microprocessor to provide the required gain switching. An attenuator at the output of the input amplifier provides attenuation of two (2) for the highest range only; on all other ranges its attenuator is zero. This attenuator is switched into the circuit on the highest range through solid-state switches IC1Oa, IC9b, and IC9C. Demultiplexer IC13 decodes digital signals that define the range from the microprocessor and activates the solid-state switches on the highest instrument range.

d. The amplified 94 Hz signal is converted to a DC analog signal by means of a demodulator circuit that operates in synchronism with the chopper. The demodulator consists essentially of a sample and hold switch, composed of solid-state switches IC1Ob and IC1Oc and associated circuitry. Switches ICIOb and IC1Oc are controlled by the 94 Hz drive signals from flip-flops IC8a and IC8b. The sampling point and period of the sample and hold circuit has been chosen to minimize switching products and noise, and to vary signal averaging in accordance with the signal level. Switch IC9a adjusts operating parameters automatically in accordance with instrument range; the switch is activated through gates IC11b and IC11C and demultiplexer IC13 on the four highest ranges.

e. The DC output voltage of the sample and hold circuit is amplified by an amplifier circuit composed of integrated circuits A8, A9, and IC14, and associated circuitry. Integrated circuit IC14 is a demultiplexer which decodes micro-processor-supplied digital signals that define the selected range and adjusts an attenuator circuit accordingly; the gain of the amplifier is 125, 12.5, or 1.25, depending upon the selected range. The full-scale output voltage of the amplifier is 2.25 volts nominal on each range.

f. The DC output voltage of integrated circuit A9 is usually unipolar and positive; however, during the automatic zeroing process of the instrument, the DC output voltage may be positive or negative, depending upon small DC offsets. Because some of the following circuits operate only with unipolar signals, a polarity switch is required. This polarity switch, which consists of solid-state switches IC3b and IC3c, operates under control of the microprocessor on the control printed circuit board, which tests for polarity. The DC voltage is routed through the polarity switch to the appropriate input of operational amplifier A3 so that the output DC from this amplifier is always negative. This output voltage is applied to a comparator circuit.

g. Comparator A2 operates in conjunction with the microprocessor on the control printed circuit board and D/A converter IC2 to convert the DC output signal of amplifier A3, which is proportional to the input power, to a digital signal that can be processed by the microprocessor circuits. D/A converter IC2 is supplied with successive half-level digital signals (full scale/2, full scale/4, etc.) by the microprocessor. D/A converter IC2 converts these digital signals to a DC analog voltage, and this analog DC voltage is applied through amplifier Al to comparator A2, where it is compared with the DC signal from amplifier A3. The difference signal from comparator A2 is supplied to the microprocessor through interface IC1 so that the microprocessor can monitor the results of the comparison and adjust the microprocessor until the two input signals to comparator A2 are equal . The resulting digital signal then defines the input DC level being measured. This digital signal is then processed (zero correction, calibration correction, unit conversion, etc.) by the microprocessor before application to the LED display circuits of the instrument.

h. After the digital signal has been fully processed by the microprocessor, the processed digital signal is again supplied by the microprocessor to D/A converter IC2, which converts the processed digital signal to a corresponding DC analog voltage that is used to drive the front-panel meter and the recorder output of the instrument. This DC analog voltage from D/A converter IC2 is supplied through amplifier Al to sample and hold switch IC3a, which is closed at this time by a control signal from the microprocessor. The DC analog voltage at the output of the sample and hold circuit is applied through amplifier A4 and the control printed circuit board to the display printed circuit board.

i. All interfacing between the input printed circuit board and the microprocessor is accomplished through interface IC1. Interface IC1 is an input/output device that operates under control of the microprocessor. When signal RD is activated by the microprocessor, data are transferred from the input printed circuit board to the microprocessor, provided that signal CS to interface IC1 is also active; when signals WR and CS are both activated by the microprocessor, data are transferred from the microprocessor to the input printed circuit board. Data flow between the input printed circuit board and the microprocessor over the eight-line hi-directional data bus. Routing of data through the interface is controlled by the address signals supplied to the interface by the microprocessor.

3-14. CONTROL MODULE A5.

The operation of the instrument is controlled by a microprocessor contained on the control printed circuit board. The control printed circuit board is organized around a central processing unit (CPU), associated memories, input/output ports, and a 40-line bus.

a. A stored program, in conjunction with key-entered commands, enables the microprocessor to perform a variety of functions, including the following:

(1) Analog to digital conversion

(2) Zero determination
(3) Zero correction
(4) Ranging
(5) Calibration
(6) Signal processing
(7) Binary to BCD conversion
(8) dB conversion
(9) dB reference conversion
(10) dB limit testing
(11) Diagnostics

b. Integrated circuit IC3 is the microprocessor CPU. It is an 8-bit unit that operates at a clock frequency of 2 MHz, generated by integrated circuits IC1a through IC1c and associated circuitry. The operating program for the microprocessor is stored in integrated circuits IC6 and IC7, which are programmable read-only memories (PROMS). RAM IC8 provides temporary storage of data during operation of the instrument. It also stores certain measurement parameters such as sensor data, calibration factors, some key–entered parameters, etc. Lithium-type battery BT1, which has an anticipated life of 10 years, supplies power to RAM IC8 during power-down of the instrument to enable retention of data in memory. During normal operation, RAM IC8 is powered by transistor Q1. Integrated circuit IC16 is an I/O port which interfaces with the following:

(1) An 8-bit switch used to set the mode of operation, number of channels, and number of sensors.

(2) A test socket (J3) that is not used for the AN/USM-491.

(3) A plug (P3) for output of status information.

c. The CPU receives and transmits data over an eight-line data bus. A 15-line address bus is used for addressing, and a control bus is used for various control functions. When the instrument is turned off, signal RESET is activated by the power supply circuits and the microprocessor is reset to the start of the operating program; when the instrument is next turned, on and DC voltages have reached the correct operating levels, the RESET signal is deactivated by the power supply circuits and the microprocessor begins to execute the stored program. Instructions are retrieved from storage by the CPU in accordance with the address code developed at its output. Decoder IC4 enables the appropriate PROM (IC6 or IC7), and the instruction contained in the memory location defined by the address on address lines AO through All is read and transmitted by the CPU over the data bus. The CPU then executes this instruction.

d. During the measurement process, the CPU must retrieve data from storage and from the input and display printed circuit boards, it must store temporary calculation values, and it must output data to the input and display printed circuit boards. To retrieve data from memory, the storage device and data location are defined by the address supplied by the CPU, and signals MREQ and RD are activated. Integrated circuit IC4 decodes three of the address bits to activate signal CS at RAM IC8 through gates IC9a and IC9c. Signal OE at RAM IC8 is activated through gate IC15d, and data stored at the location specified by the remaining address bits are transmitted over the data bus to the CPU or to other circuits connected to the data bus. To access data developed by circuits outside the control printed circuit board, the CPU activates signals IORQ and RD along with the appropriate address lines. Decoder IC14 decodes three address bits to develop enabling signal CS for interface IC16, Integrated circuit IC18, or interface IC1 on the input printed circuit board, as specified by the three address bits, and gate IC15b activates signal RD for the read function. If integrated circuit IC18 is enabled, keyed-in commands from the display printed circuit board, which had been stored in integrated circuit IC18, are transmitted over the data bus. If integrated circuit IC16 is enabled, input data from bit switch S1 or power supply connector P4, as determined by address bits AO and Al, are supplied through interface IC16 to the data bus. If interface IC1 on the input printed circuit board is enabled, data generated on the input printed circuit board are transmitted over the data bus through interface IC1.

e. To store data, the CPU activates signal WR and the address lines that define the storage device and storage location. Decoder IC4 decodes three address bits to enable signal CS at RAM IC8, signal WR enables the write function of RAM IC8 through inverter IC1d and gate IC9b, and data on the data bus are written into memory at the location defined by the remaining address lines. To output data to circuits outside the control printed circuit board, signal IORQ is activated by the CPU in addition to the previously mentioned signals. Signals IORQ and WR activate the write enable signal to the device defined by the address bits. Decoder IC14 decodes three address bits to select the appropriate device (interface IC16, interface IC18, or interface IC1 on the input printed circuit board). Data on the data bus are then transferred to the selected device. If interface IC16 is selected, these data are transferred through interface IC16 to connector P3 or J3, as determined by address bits AO and A1. The output to connector P3 consists of dB out-of-limit signals and an input disconnect signal which is active when the automatic zeroing function is selected. The output data at connector J3 are used *in* signature analysis checks. If interface IC18 is selected, the data on the data bus are written into storage in interface IC18 for application to the display printed circuit board. These data are then clocked out of storage to activate the LED display and annunciators on the display printed circuit board. If interface IC1 on the input printed circuit board is selected, data on the data bus are transferred through the interface to control various functions on the input printed circuit board.

f. Connector J1 is included in the data bus on the control printed circuit board to facilitate signature analysis maintenance of the microprocessor circuits. When connector J1 is pulled out, the data bus is disconnected from the CPU, and the CPU executes successive NOPS for free-running signature analysis checks.

g. The CPU receives two control signals directly from the power supply printed circuit board. If the power supply voltage should drop during operation, or on equipment turn-off, signal NMI is activated by the power supply circuits; the CPU, upon receipt of this signal, activates signal HALT, and halts further execution of the program. Signal HALT is applied to the power supply printed circuit board, where it latches signal RESET to the active state. Signal RESET, in turn, causes the microprocessor to return to the starting point of the program. When the power supply rises to a level approximately 150 millivolts below its nominal value, either as a result of correction of the undervoltage condition or of power turn-on, signal RESET is deactivated to permit execution of the stored program by the microprocessor.

3-15. DISPLAY MODULE A2.

The display printed circuit board contains the instrument LED display, meter, annunciators, keyboard, and control circuits for these items. It interfaces directly with the control printed circuit board. When any keyboard key is pressed, the microprocessor on the control printed circuit board interrupts the normal measurement process and accepts and stores the key–entered commands; the microprocessor also supplies digital data to the display printed circuit board to cause keyed–in numerical values to appear on the LED display. The microprocessor resumes the normal measurement process when any of the terminator keys (LIMITS dB, CAL FACTOR, SELECT, REF LEVEL dB) is pressed. Upon completion of the measurement by the microprocessor, measurement values are supplied to the display printed circuit board.

a. Operation of the display printed circuit board is controlled by the microprocessor through integrated circuit IC18 on the control printed circuit board, which provides the following functions:

(1) It provides a RAM for storage of microprocessor output data to the display printed circuit board.

(2) It provides a first-in, first-out RAM which accepts and stores input information (up to 8 key commands) from the display printed circuit board.

(3) It provides scan signals for both the LED display and the keyboard.

b. The LED display consists of four 7-segment displays, which provide a display capacity of four digits with decimal points, and a fifth display which is capable of displaying a minus sign. Each display consists of individual anodes for each segment that makes up the display and the decimal point, and a common cathode. The character that appears on the display is determined by the activated anodes at the time that the common cathode is scanned. The individual displays and the associated annunciators are scanned in sequence. The display duty cycle is 12.5%; that is, each digit or annunciator of the instrument is on 12.5% of the time.

c. Digital information for the LED display and annunciators is developed by the microprocessor, and is stored in the output RAM contained in integrated circuit IC18 on the control printed circuit board. Digital information that defines display and annunciator row selection is supplied to 8-channel demultiplexer IC2. The output lines of demultiplexer IC2 are activated in sequence, based on the input digital codes. The signal on the active output line of demultiplexer IC2 is applied through resistive network IC5 to display driver IC7, and the display driver supplies driving power for the corresponding display and the corresponding row of annunciators. At the same time, digital data that define the display segments and the annunciators that are to be activated are supplied to decoder IC1. The binary-coded input is decoded by decoder IC1, and the output lines of the decoder are activated in accordance with this decode. The outputs of the decoder activate the individual anodes of the selected display and the individual annunciators in the active annunciator row, thereby providing the appropriate instrument display. A decimal point signal is applied through transistor Q1, when appropriate, to cause a decimal point to be displayed to the right of the character on the active display.

d. Demultiplexer IC2 also provides scanning signals to the keyboard. As each of its first five output lines is activated in sequence, a scan signal is applied to an individual row of the keyboard through an inverter. If any key in the row being scanned is pressed, a signal is supplied to one of the column output lines to the RAM in integrated circuit IC19 on the control printed circuit board, and the key command is stored by the RAM. Key selection is defined by a combination of the row scan signal and the column output line. The RAM can store up to a maximum of eight key commands, and it delivers this stored information to the microprocessor when it is read. Actuation of more than eight key commands without a read causes the RAM to be cleared.

e. Analog DC voltage, which is proportional to the measured power level, is supplied from the control printed circuit board to drive the front panel meter to provide a relative indication of measured power for peaking and nulling applications. This also supplies a DC analog voltage to rear-panel connector P1. This signal can be used to drive an external recorder.

3-16. CALIBRATOR ASSEMBLY.

The circuits on the calibrator printed circuit board are used to develop a 1.00 mW reference power level with a 50–ohm source resistance. This reference level can be used for automatic calibration of the instrument.

a. The reference signal is generated by transistor oscillator Q1, which operates at a frequency of approximately 50 MHz. An automatic leveling circuit is used to maintain a constant reference power level. Leveling is achieved by rectifying the oscillator output signal in the signal level detector circuit, and comparing the resulting DC voltage with a stable DC voltage developed by voltage reference IC1. The difference voltage is amplified by operational amplifier Al, and the output level from the operational amplifier controls a varactor in a capacitive divider that determines the drive to the oscillator. The output of the operational amplifier adjusts the varactor effective capacitance as required to adjust the drive to the oscillator in the direction and amount required to maintain a constant output level. A second capacitive divider at the output of the oscillator divides the oscillator output signal and tends to provide some isolation from the load. Because the source impedance of this divider is low, a 50-ohm series resistor is used to establish the desired 50–ohm source resistance. The output reference power level signal is available at the front-panel POWER REF connector.

3-17. REAR PANEL ASSEMBLY.

Input ac line power is supplied to the primary of power transformer T1 through fuse F1, line switch S1, and a line voltage selector switch. Power transformer T1 steps down the ac line voltage to two secondary windings. The secondary windings supply 34 VAC and 9.5 VAC to the power supply printed circuit board. Refer to Figure FO-1.

3-18. POWER SUPPLY MODULE A7.

The power supply printed circuit board performs the following functions:

a. Converts 34 VAC and 9.5 VAC from the power transformer T1 to -5, +5, +5.2, +15, and -15 volts dc for system operation.

b. Generates a power-up signal for the microprocessor when supply voltages reach the proper values for system operation.

c. Activates an interrupt signal to the microprocessor when supply voltages drop to levels too low for reliable operation.

d. The T1 secondary windings voltages are rectified by bridge rectifiers CR1 and CR2. The dc voltage supplied by CR1 is filtered by C1 and C2 and drives regulators IC2 and IC3 which develop +15 and -15 volts, respectively. The regulated -15 volt supply also drives regulator IC5 to develop the -5 volt supply.

e. The dc voltage developed from CR2 is filtered by C3 and drives regulator IC4 to produce +5.2 volts. R5 provides adjustment for the +5.2 volt supply.

f. The unregulated +15 volt supply also drives regulator IC1 to produce +5 volts to power A1, IC6, and generate a voltage reference at the junction of R7 and R8.

g. The output voltage of the +5.2-volt regulated DC supply is monitored by comparator A1a to develop a power-up signal on turn-on and an interrupt signal at undervoltage or power-down conditions. When the instrument is turned on, comparator A1a develops a positive output pulse when the output of the +5.2-volt regulated supply rises to a value approximately 150 mV below the nominal output voltage; the exact power–up signal point is adjustable by means of potentiometer R11. The positive output pulse of comparator Ala clocks flip-flop IC6 to deactivate signal RESET to the microprocessor on the control printed circuit board. If the output voltage of the +5.2-volt regulated supply should drop below the reliable usable level during operation of the instrument and during instrument shut–down, comparator A1a switches its output level to a logic low, thereby activating signal NMI to the microprocessor. The microprocessor activates signal HALT, which resets flip-flop IC6, thereby latching signal RESET low to ensure resetting of the microprocessor to the start of the program.

3-19. INTERFACE MODULE A23.

All data manipulation and IEEE-488 bus management are controlled by CPU A51C3 on the control board in conjunction with a microprogram stored in PROM A23U1 on the interface board. All data transfer is handled in parallel-to-parallel mode by adapter A23U4. Latch A23U5 handles transfer of bit switch data that defines the instrument address and message termination characters to the instrument data bus. Bi-directional buffers A23U6 and A23U7 handle data and control signal transfers, respectively, between adapter A23U4 and the interface buses.

When the instrument is turned on, the RESET line to adapter A23U4 is set low while capacitor A23C1 charges through pull-up network A23U1, thereby clearing the adapter. To initiate an interface transaction, signal ROM-IF is set low by CPU A51C3, thereby enabling the output of PROM A23U1. Interface microprogram instructions from the PROM memory location specified by the address bits from the CPU are written onto the instrument data bus. The CPU executes these instructions and activates the control signals required to perform the commanded interface transaction.

b. Instrument address and message termination character data manually preset into bit switch A23S1 is supplied to latch A23U5. To read the switch data, control signals RD and CSIF and address bit A6 are activated, thereby enabling the latch output through gates A23U2C and A23U2b and inverter A23U3C. The switch data is then transferred through the latch to the instrument data bus.

c. To read incoming interface control signals, the CPU activates signals RD and CSIF and sets address bit A6 low. The interface control signal port of adapter A23U4 is selected through address bits A0, A1, and A5. Adapter A23U4 is enabled through gate A23U2a. Because signal RD is active, signal TE supplied by the adapter to buffer A23U7 is inactive, and this buffer is set up for data transfer from the interface control signal bus to the control signal port of adapter A23U4. Incoming interface control signals are transferred through buffer A23U7 and adapter A23U4 to the instrument data bus. Clocking of adapter operations is controlled by the clock signal from the instrument control board. Interface control signal transfer in the opposite direction is achieved by reversing the states of signals RD and WR. An active WR causes signal TE to buffer A23U7 to become active, thereby reversing the direction of data flow through the buffer. Interface control signals from the instrument data bus are then written onto the interface control bus through adapter A23U4 and buffer A23U7. Interface control signals are defined as follows:

DAV	DATA VALID
NRFD	NOT READY FOR DATA
NDAC	NOT DATA ACCEPTED
ATN	ATTENTION
IFC	INTERFACE CLEAR
REN	REMOTE ENABLE
SRQ	SERVICE REQUEST
EOI	END OR IDENTIFY.

d. To handle data transfers between the instrument data bus and the interface data bus, adapter A23U4 is similarly enabled through gate A23U2a by control signal CSIF and a low address bit A6. Address bits AO, A1, and A5 are set to select the data port of adapter A23U4, and signals WR and RD specify the write and read functions. If data is to be written onto the interface data bus, signal WR is activated, thereby activating signal TE to buffer A23U6. Data on the instrument data bus is then transferred through adapter A23U4 and buffer A23U6 to the interface data bus. For data transfers from the interface data bus to the instrument data bus, signal WR is inactive and signal RD is active. Signal TE to buffer A23U6 is deactivated by adapter A23U4 to reverse the direction of data transfer through the buffer.

SECTION IV

OPERATING INSTRUCTIONS

4-1. OPERATING CONTROLS, INDICATORS, AND CONNECTORS.

The controls, indicators, and connectors used during the operation of the test set are shown in Figure 4-1 and listed in Table 4-1. The keyboard section of the front panel (Figure 4-2) is arranged in functional groupings, or FUNCTIONS. Within the functional groupings are the individual keys which establish the operating parameters of the instrument:

FUNCTION	KEY(S)
MODE	PWR; dB
RANGE	AUTO; HOLD
dB LIMITS	LO; HI
CAL FAC	dB; GHz
SELECT	SENS/S/N ;CHNL
REF LVL	dB/SET
NUMERICAL	O-9: (.); CHS

4-2. SENSOR CALIBRATION DATA.

Calibration correction information for the sensor is written into microprocessor storage at the factory before shipment of the test set. A copy of this information is stored under the top cover. When the CAL FAC GHz function of the Instrument is used during measurement, the microprocessor reads and interpolates the stored data on the basis of the specified measurement frequency, and corrects all measurement values accordingly. Also, gain and linearity data for each range is stored for each sensor.

4-3. POWER APPLICATION.

The instrument is designed for operation from a 100, 120, 220, or 240 volt, 50 to 400 Hz, single phase, ac power source. To apply ac power, proceed as follows:

(continued on page 4-5)

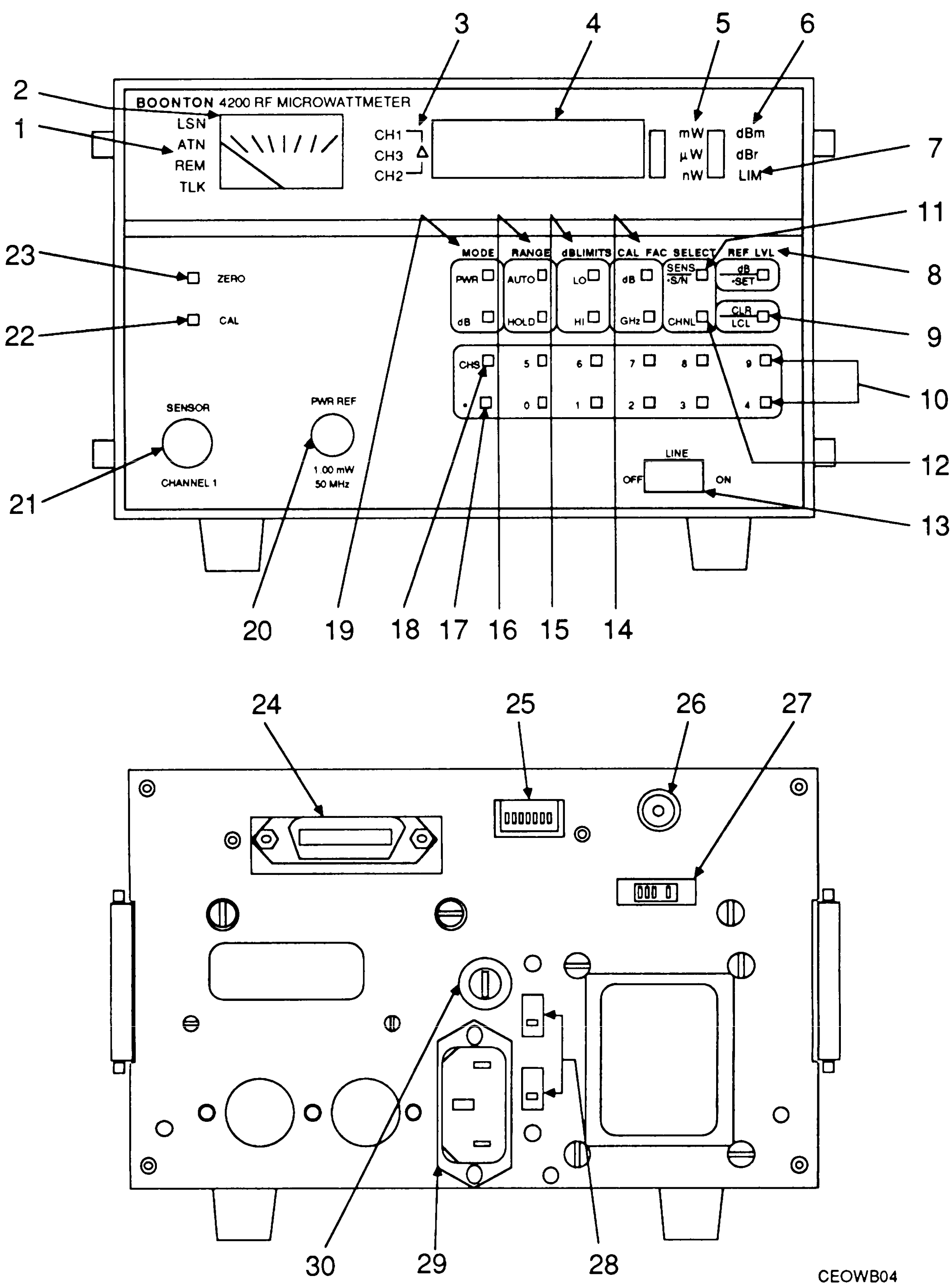


Figure 4-1. Operating Controls, Indicators, and Connectors

Table 4-1. Operating Controls, Indicators and Connectors

Figure 4-1 and Index Number	Control, Indicator or Connectors	Function
1	LSN, ATN, REM, and TLK indicators	Indicates which remote function(s) is in use when the meter is operated by remote control: LSN = Listen ATN = Attention REM = Remote TLK = Talk.
2	Meter	Indicates power and dB levels for peaking and nulling operations.
3	Channel 1, 2 and 3 (CH1, 2, and 3)	Displays channel 1 in use. (Channels 2 and 3 not applicable.)
4	LED display	Four digit LED display with minus sign and decimal point. Displays the following: a. measured power or dBm, b. data entered or recalled, c. error message.
5	mW, µW, and nW indicators	Shows units of power when meter is in power mode.
6	dBm and dBr indicators	Shows dB mode in use when meter is in dB mode.
7	LIM indicator	Illuminates when power level in dB is outside selected dB limits.
8	REF LVL, dB/.SET key	Provides means to set and recall the dB reference level, and to set the reference level to the current dBm reading. (Press . first to do the latter.)
9	CLR/LCL key	Used for the following: a. To clear incorrect entry shown by LED display, b. To reduce dB calibration factor or dB reference level to zero, c. To return to keyboard control.
10	NUMERICAL 0 - 9 keys	Used to enter data.

Table 4-1. Operating Controls, Indicators and Connectors (Continued)

Figure 4-1 and Index Number	Control, Indicator or Connectors	Function
11	SELECT SENS key .S/N	Used to enter and recall sensor number, (1, 2) and the sensor serial number. (Press . first to recall serial number.)
12	CHNL key	Used to enter and recall channel number. Only Channel 1 is used.
13	LINE switch	Used to turn AC line power ON and OFF.
14	CAL FAC dB key GHz key	 Used to enter and recall adjustment factors in dB. Used to enter and recall adjustment factors in frequency (GHz).
15	dB LIMITS LO key HI key	 Used to enter or recall low dB limits. Used to enter or recall high dB limits.
16	RANGE AUTO key HOLD key	 Used to select automatic range mode. Used to select hold range mode.*
17	Decimal (.) key	Used to enter decimal point, and as a pre-cursor to some other keys.
18	CHS key	Used to enter negative sign.
19	MODE PWR key dB key	 Selects power mode on LED display. Selects dB mode on LED display.
20	PWR REF (power reference) connector	Supplies 1 mW level at 50 MHz to 50 ohm load.
21	SENSOR connector	Used to connect sensor.
22	CAL key	Used to adjust meter when sensor is connected to 1 mW source.
23	ZERO key	Used to generate and store zero corrections for all ranges with zero input to sensor.

*The range referred to here is the "internal" or hardware range.

Table 4-1. Operating Controls, Indicators and Connectors (Continued)

Figure 4-1 and Index Number	Control, Indicator or Connectors	Function
24	Connector	Connector to IEEE-488 bus operation.
25	S1 switch	Used to select instrument address.
26	RECORDER Connector	Used to provide an analog DC voltage to a remote recorder.
27	P3 Connector	Provides logic level signals for input disconnect during zeroing operations and high and low dB limit signals during dB measurements.
28	LINE VOLTAGE selector switch	Used to select line voltage.
29	Power connector	Connection for power cord.
30	Fuse holder	Contains fuse.

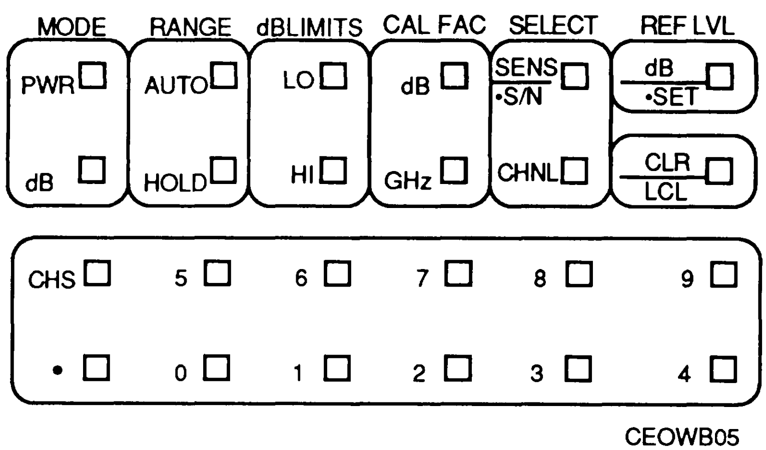


Figure 4-2. Front Panel Keyboard Section

(Continued from page 4-1)

a. Determine the line voltage at the ac power output receptacle.

b. Set the two slide switches on the rear of the meter to conform to the available ac line voltage (see Figure 4–1, Item 28).

Check the rating of the fuse in the rear-panel fuse holder (see Figure 4-1, Item 30). For 100/120 volt operations, the fuse should be a 0.3 ampere, MDL Slo-Blo type. For 220/240 volt operations, the fuse should be a 0.2 ampere, MDL Slo-Blo type. If the rating of the installed fuse is incorrect, remove it, and install a fuse of the required rating in the fuse holder.

WARNING

The instrument is designed to operate from a 3-terminal (one ground) ac power receptacle.

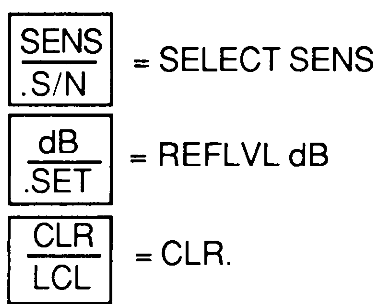
d. Connect the power cord between the ac power connector on the rear panel of the instrument and the ac power receptacle.

4-4. OPERATOR CHECKOUT.

NOTE

- When the instrument is in the store or recall mode, the LED display and indicator lights blink on and off. This warns the operator that the value displayed is not a measured value. It is a value that has been recalled from memory or is to be entered into memory.

- References in the text to the following keys will be as shown:



a. In some of the following procedures the instructions will require the operator to be familiar with the functional arrangement of the keyboard. The following examples will be helpful:

(1) Example: "Key in 0.2, CAL FAC dB."

The operator will be required to take the following steps:

(1) Select "0" in the numerical function.
(2) Select "." in the numerical function.
(3) Select "2" in the numerical function.
(4) Select "dB" in the CAL FAC function.

(2) Example: "Key in 1, CHS, REF LVL dB.1"

(1) Select "1" in the numerical function.
(2) Select "CHS" in the numerical function.
(3) Select "dB" in the REF LVL function.

b. To perform the operator checkout, proceed as follows:

(1) Set the LINE switch to the ON position.

(2) Check operation of the LED display and the numerical keys by pressing the following keys in the sequence listed and noting the LED display:

Press	Display
CLR	0000
.	0000.
0	000.0
1	00.01
2	0.012
3	0123
CLR	0000
4	0004
5	0045
6	0456
7	4567
CLR	0000
8	0008
9	0089
CHS	-0089
CLR	0000

(3) Enter measurement parameters by pressing the following keys:
1, SELECT CHNL
MODE dB
RANGE AUTO
O, CAL FAC dB
O, REF LVL dB
90, CHS, dB LIMITS LO

(4) Connect the sensor cable to the front-panel SENSOR connector, and connect the sensor to the free end of the sensor cable. Note the sensor number indicated on the barrel of the sensor, and enter this number through the numerical keyboard by pressing the numerical key corresponding to the sensor number, and then pressing the SELECT SENS key.

(5) Check to see that dBm and CH1 indicators are lighted. If not, repeat paragraph 4-5b.(3) above.

(6) With zero input to the sensor (disconnected), press the ZERO key. The meter will begin the zeroing process. The instrument display will show "cccc" or "-cccc" during the zeroing period. Upon completion of zeroing, the display will show "cc03" or "-cc03."

(7) Connect the sensor to the PWR REF connector. The LED display should indicate approximately 00.00 dBm. If it does not, press the CAL key.

(8) Key in 0.2, CAL FAC dB. Press the CAL FAC dB key a second time. The LED display should change to approximately 00.20 dBm, and blink.

(9) Key in O, CAL FAC dB. Press the CAL FAC dB key a second time. The LED display should change to approximately 00.00 dBm and blink.

(10) Key in 1, CHS, REF LVL dB. Press the REF LVL db key a second time. The LED display should indicate approximately -01.00 dBr, and blink.

(11) Key in 1, REF LVL dB. Press the REF LVL dB key a second time. The LED display should indicate approximately 01.00 dBr, and blink.

(12) Key in 5, dB LIMITS HI. The LIM indicator should be off.

(13) Key in 5, CHS, dB LIMITS LO. The LIM indicator should be off.

(14) Key in .5, dB LIMITS HI. The LIM indicator should stay off.

(15) Key in .5, CHS, dB LIMITS LO. The LIM indicator should light.

(16) Key in O, REF LVL dB. Press REF LVL dB a second time. The LED display should indicate 00.00, the LIM indicator should be off, and the dBm indicator should light.

(17) Press the MODE PWR key. The LED display should indicate approximately 1.000 mW.

(18) Disconnect the sensor from the PWR REF connector.

4-5. OPERATING INSTRUCTIONS.

4-6. MEASUREMENT PARAMETERS.

Measurement parameters are entered into the microprocessor through the front-panel keyboard. In order to eliminate the need for repeated programming, parameters entered through the keyboard are stored in non-volatile memory, and the stored parameters are unaffected by instrument turn-off and turn-on. The last parameters entered will affect the next measurement taken.

4-7. USE OF NUMERICAL KEYS.

The numerical keys are used to enter numerical values for dB LIMITS, CAL FAC, SELECT, and REF LVL dB functions. Whenever any numerical key is pressed, the microprocessor interrupts the measurement operation to accept new data. Numerical values are keyed in normal sequence, and keyed-in values enter the LED display from right to left. Up to four digits, plus decimal point and minus sign, can be entered; entries exceeding four digits are ignored. Pressing the decimal point key places a decimal point after the right-most digit in the LED display. Pressing the CHS key changes the sign of the entry in the LED display; that is, plus becomes minus, or minus becomes plus (the plus sign is not displayed). If an error is made during entry of numerical values, press the CLR key and repeat the data entry process. When the LED display shows the desired numerical value, pressing the applicable dB LIMITS, CAL FAC, SELECT, or REF LVL dB key will cause the microprocessor to store the keyed-in parameter and return automatically to the measurement cycle. Recall of the last entered values is accomplished by depressing the dB LIMITS HI, dB LIMITS LO, CAL FAC dB, CAL FAC GHz, SELECT CHNL, SELECT SENS, or REF LVL dB keys, as applicable. Recalling of the sensor serial number is done by pressing ., SELECT .S/N. The value stored for the selected parameter is displayed on the LED display. When a recall is performde, the instrument remains in the recall state until either a MODE key or a RANGE keyis depressed; the instrument then returns to the operating state

4-8. SELECT FUNCTION.

The SELECT keys are used by the operator to specify the number of the sensor to be used for measurements, and the measurement channel.

NOTE

For normal operation, the channel and sensor must be selected before any operation is performed; however, the channel must be selected before the sensor is selected.

The AN/USM-491 contains only one measurement channel. This measurement channel is designated channel 1, and the front-panel SENSOR connector provides the input to this channel. To select the sensor, press the 1 and SELECT CHNL keys, then press 1 and SELECT SENS.

4-9. MODE SELECTION.

The MODE keys enable the operator to select the desired measurement mode. When the MODE PWR key is pressed, measured power levels are displayed in mW, μW, or nW; the annunciators associated with the LED display light accordingly to distinguish the appropriate unit. When the MODE dB key is pressed, measurement values are displayed in terms of dB with respect to an operator-entered dB reference level. If O dB had been chosen as the reference level, the displayed numerical values represent dBm, and the dBm annunciator is lighted; selection of any other dB reference level causes lighting of the dBr annunciator, and displayed measurement values represent dB with respect to the selected reference level. Resolution of the instrument in the dB mode is 0.01 dB.

4-10. RANGE SELECTION.

The RANGE keys enable the operator to select either automatic ranging or a range hold function. The automatic ranging function, which is most effective when measuring unknown or wide varying power levels, is activated by pressing the RANGE AUTO key, and the microprocessor then selects the appropriate measurement range automatically. If input power levels exceed the upper measurement limit of the instrument, an error indication (cc04) appears on the LED display; if input power levels are below the low measurement limit of the instrument, the instrument displays cc03. Ranging time is a function of a number of factors such as absolute level, change in level, analog response time, and direction of change. The range hold function is useful when a series of measurements of approximately the same power level are to be made; selecting this mode eliminates delays due to ranging time. The range hold function is useful only in the PWR mode. When the RANGE HOLD key is pressed, the instrument remains on the measurement range that was active at the time the key was pressed. Input power levels that exceed the upper limit of this range cause an error indication (cc04) on the LED display; input power levels below the low limit of this range result in fewer significant digits in the LED display. If the minimum capability of the instrument is reached, the instrument displays cc03.

4-11. dB LIMITS SELECTION.

The dB LIMITS keys enable the operator to program high and low dB limits into the instrument. Input power levels outside these limits will cause lighting of the LIM annunciator and activation of out-of-limit signals at rear-panel connector P3 for remote operation.

a. Limits are entered by keying in the numerical value in dB, using the numerical keys, and then pressing the dB LIMITS LO or dB LIMITS HI key, as applicable.

(1) Example: To enter a low limit of -31.34 db, press the following keys:

31.34
CHS (negative sign on LED)
dB LIMITS LO.

b. The dB limits always test against the value displayed. If the measurement is in dBm (O, REF LVL dB), the limit is in dBm. If any value other than O dB is chosen for the reference level, the limits operate in dBr (relative dB), which is the displayed value. If it is desired to have the limits operate on dBm when the reference level is other than O dBm, the value entered as the reference level should be subtracted algebraically from the desired dBm limits (reverse the sign of the reference level dB and add algebraically to the desired limit in dBm).

(1) Example: If a desired low dBm limit is -31.34 and the reference level is –15.3 dB, subtracting the reference level from the low limit will result in a new low limit of -16.04 dB.

c. The dB limit function is always operative in the instrument. For all practical purposes, it can be cancelled, if desired, by entering a high limit of 90 dB and a low limit of -90 dB.

4-12. CALIBRATION FACTOR SELECTION.

NOTE

This calibration procedure should not be misconstrued with calibration in accordance with TB 43-180.

The sensor is frequency sensitive; that is, with a constant input power level applied, its output signal level does not remain constant as the measurement frequency is changed. The CAL FAC keys provide means for introducing a calibration factor in terms of one or two parameters, either the actual dB calibration factor, or the measurement frequency.

a. A calibration chart is attached to the barrel of the sensor, and the calibration factor in dB for the measurement frequency being used can be obtained from this chart. This dB calibration factor can then be entered into the instrument, using the numerical keys and the CAL FAC dB key, and the microprocessor will correct all subsequent measurements, both dB and power, automatically in accordance with the dB calibration factor entered.

(1) Example: To enter a dB calibration factor of -0.3 dB; press the following keys:

0.3
CHS (negative sign on LED)
CAL FAC dB.

b. When the sensor number and the measurement frequency are entered through the keyboard, the microprocessor computes the required correction from the stored data and corrects subsequent dB and power measurements accordingly. The sensor number is entered using the SELECT function described in paragraph 4-7, and the measurement frequency is entered using the numerical keys and the CAL FAC GHz key. To recall the last entered frequency for display, press the CAL FAC GHz key; to determine the calibration factor value for this frequency, press the CAL FAC dB key. Press a MODE key or a RANGE key to return the instrument to the operating mode.

(1) Example: To specify a measurement frequency of 3.3 GHz, press the following keys:

3.3
CAL FAC GHz

4-13. REFERENCE LEVEL dB SELECTION.

The instrument normally uses 1 mW, 50 ohms as a reference for computing dBm measurement values; the dBm annunciator is lighted during such operation. The REF LVL dB key, used in conjunction with the numerical keys, enables the operator to select any other desired dB reference level; subsequent level indications are with respect to the selected reference, and this display mode is indicated by lighting of the dBr annunciator.

a. A dB reference level is entered by keying in the desired numerical value in dB, using the numerical keys, and then pressing the REF LVL dB key.

(1) Example: To enter a dB reference level of -15.3 dB; press the following keys:

15.3
CHS (negative sign on LED)
REF LVL dB.

NOTE

At this point, dBm annunciator should be "OFF" and dBr annunciator lighted.

b. To return to the dBm measurement display mode, enter a O dB reference level, or press the CLR and REF LVL dB keys. At this point, dBm annunciator should be lighted, and dBr annunciator "OFF."

NOTE

The maximum display capability of the LED display is ±99.99 dB. When operating in the dBr mode, keep this fact in mind. Avoid choice of dB reference levels that will result in display values that exceed the LED display capacity. Keyboard entries beyond the capability of the instrument produce error indications (ccO1 or cc02 for entries too small or too large, respectively.)

The displayed dBm may also be used as the reference level. This is accomplished by first depressing the decimal point key and then the REF LVL dB key. The display will indicate 00.00 showing that the previously displayed dBm level has now become the reference level. This reference may be recalled by pressing the REF LVL dB key; it can be cleared by depressing the CLR and the REF LVL dB keys.

NOTE

- This entry method utilizes the current dBm level, and would replace any previously entered dB reference level.
- This procedure of entering the existing dBm level as the dB reference level is not operative in IEEE–488 bus interface operation.

4-14. ENTRY LIMIT VALUES.

NOTE

If entry limits are exceeded, an error may occur, or in some cases the unit defaults to a max/min.

Parameter	Key	Limits
Calibration Factor (dB)	CAL FAC dB	3.00 to -3.00
Calibration Factor (GHz)	CAL FAC GHz	0.1 GHz to 999 GHz (0.1 GHz increments)
Reference Level (dB)	REF LVL dB	+99.99 to -99.99 (.01 dB increments)

Parameter	Key	Limits
dB Limits (lower)	dB LIMITS LO	+99.99 to -99.99 (.01 dB increments)
db Limits (higher)	dB LIMITS HI	+99.99 to –99.99 (.01 dB increments)

4-15. RECALL OF ENTERED VALUES.

The last entered value for each of the corresponding functions may be recalled for display on the LED display by pressing the following keys:

dB LIMITS LO	SELECT SENS	CAL FAC dB	REF LVL dB
dB LIMITS HI	SELECT CHNL	CAL FAC GHz	

NOTE

When the instrument is in the recall mode, the LED display and the annunciators will blink on and off.

After any of the above keys are pressed, the instrument remains in the recall mode. To return to the operating mode, press any of the MODE keys or RANGE keys.

4-16. ZEROING THE INSTRUMENT.

For greatest accuracy, especially on the most–sensitive ranges, the instrument must be zeroed. Zeroing is accomplished by depressing the ZERO key with zero power applied to the sensor.

a. The zeroing period is composed of two parts. When the ZERO key is depressed, a range-dependent "waiting period" occurs first; it is followed by the actual zero acquisition for each range. The purpose of the waiting period is to permit the sensor, and the instrument’s analog and digital circuits, to reach a clear (zero) state. The higher the level of the signal prior to zeroing, the longer the waiting period required.

NOTE

When the instrument is first turned on, two successive zeroing operations should be performed.

b. A TTL-compatible signal (true high), marking the beginning of the zeroing operation, is available at Pin 3 of P3 on the rear panel. If this signal is utilized to remove incoming power to the sensor, the waiting period will automatically become range–dependent. If this TTL signal is not utilized, the same results can be achieved by depressing the ZERO key immediately before removing the incoming signal from the power sensor. If the incoming signal is removed prior to depressing the ZERO key, the instrument will immediately begin down-ranging -- which would result in a shorter waiting period than is desirable. In such an event, a second zeroing operation should be used.

NOTE

If the rear-panel (Pin 3, P3) power-removal signal is not utilized, signal power must be removed immediately following depression of the ZERO key. If signal power remains connected to the sensor during the zeroing operation, an erroneous set of zeroes will be generated.

c. During the warm-up period, and whenever ambient conditions are changing, the instrument should be zeroed frequently if the lowest ranges (i.e., highest-sensitivity ranges) are being used.

d. The display during the zeroing period will indicate cccc. On completion of zeroing, and if no signal is being applied to the sensor, the display will indicate cc03. If a signal is being applied, and if the rear-panel (Pin 3, P3) power-disconnect signal is being utilized, the display will indicate the power being supplied to the sensor.

e. The approximate zeroing times, including the “waiting periods, ” are listed below:

dBm	Zeroing Time (Seconds)
+30	22
+20	20
+10	18
0	16
-10	14
-20	12
-30	10

4-17. COMPENSATING THE INSTRUMENT.

The instrument incorporates a power reference and automatic adjustment facilities for fine sensitivity corrections. Sensitivity corrections are limited to a maximum of approximately ±l dB from the original, factory-set values as a precautionary measure. This feature protects against gross miscalibration which might occur if compensation were attempted with a power level other than that supplied by the power reference applied to the sensor. If computed corrections, from the factory-set value, exceed approximately ±l dB, the instrument rejects the sensitivity correction and reverts to its previous sensitivity. To use the compensation function, proceed as follows:

a. Press the PWR MODE and RANGE AUTO keys.

b. Press numerical key that represents the measurement channel, and the SELECT CHNL key.

c. Press numerical key that represents the number of the sensor, and the SELECT SENS key.

d. Press "O" and CAL FAC dB keys.

e. Connect sensor to the PWR REF connector.

f. Press the CAL key. The LED display should indicate 1.000 ±W ±0.1%.

4-18. ERROR MESSAGES.

Under certain conditions, the LED display returns error messages as follows:

Display	Condition
cc01	Illegal entry, too low
cc02	Illegal entry, too high
cc03	Signal level out of range (low)
cc04	Signal level out of range (high)
cc05	Zero acquisition out of range-excessive negative offset (hardware malfunction)
cc06	Zero acquisition out of range-excessive positive offset (input too large).

4-19. MEASUREMENTS.

4-20. MAKING POWER MEASUREMENTS.

Set measurement parameters described in paragraphs 4-5 through 4-17 as required before making power level measurements. Connect the sensor to the source whose power level is to be measured. The power level will be displayed directly on the LED display. Use the CAL FAC dB or CAL FAC GHz keys as required.

Example: To measure an unknown power level at 4.5 GHz, press the following keys:

1, SELECT CHNL
1, SELECT SENS
ZERO
MODE PWR (or dB)
RANGE AUTO
4.5, CAL FAC GHz

4-21. WAVEFORM SENSITIVITY.

The detection for diode sensors is square-law (true RMS) over the bottom two thirds (roughly) of their range and peak detecting at the top, however, the instrument is calibrated for sinewaves over the entire region. Therefore, measurements at the top are valid only for non-modulated (CW) signals. In the RMS region, the linearity error is extremely good and any signal type can be measured, including AM, FM and PM modulated signals. (FM and PM signals wave a constant envelope and the RMS restriction doesn’t apply.) The RMS region for the sensor is up to O dBm.

a. Pulsed RF can also be measured for either rectangular or complex envelopes, as long as the peak instantaneous RF power averaged over 1 cycle of RF does not exceed the RMS window limits specified above. The meter responds to average power, so for rectangular envelopes, the peak power can be calculated by dividing the meter reading by the duty cycle, where duty cycle is expressed as a fraction from O tel.

4-22. HIGH-LEVEL MEASUREMENTS.

Zeroing of the instrument is not critical when making high-level measurements (1OO µW to 1W). CW and FM power measurements can be obtained within the specified accuracy up to 1W.

4-23. HIGH-FREQUENCY MEASUREMENTS.

At frequencies above 1 GHz, the appropriate sensor calibration factor must be entered through the keyboard if the specified accuracy of the instrument is to be realized. (Refer to paragraph 4-11.)

NOTE

The sensor is adjusted for use with a 50-ohm source. Impedance mismatches will increase SWR and affect measurement accuracy. This effect can be reduced by inserting a low SWR attenuator (SWR less than 1.10) or a low loss tuner between the source and the sensor.

4-24. TEMPERATURE EFFECTS.

Specified instrument accuracies apply over an ambient temperature range of 21°C to 25°C. Operation outside this temperature range causes some additional error. Refer to Table 1-1 for accuracy versus temperature. Figure 4-3 shows typical temperature characteristics of the sensor, and Figure 4–4 shows typical temperature characteristics of the instrument and sensor combined. Handling the sensor may cause its temperature to rise a few degrees.

NOTE

For best zero stability of the instrument, allow the instrument and sensor to reach a stable temperature.

4-25. STANDING WAVE RATIO MEASUREMENTS.

The Standing Wave Ratio (SWR) is found by measuring the dB difference between a maximum and a minimum power point on a slotted line, and calculating SWR. An adapter is required to couple the sensor to the slotted line. To make slotted line SWR measurements, proceed as follows:

Connect the sensor to the sliding carriage, using a suitable adapter (usually available from the slotted line manufacturer).

b. Zero the meter with the signal source turned off.

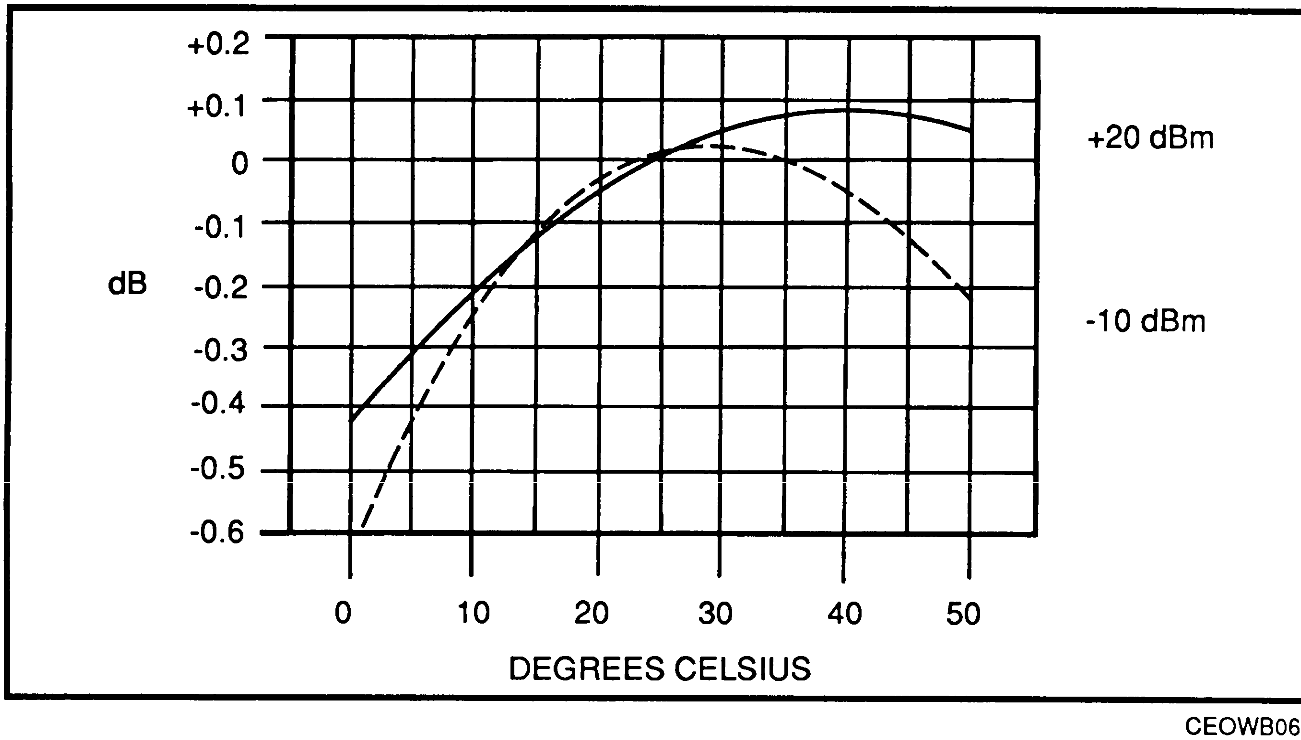


Figure 4-3. Typical Temperature Characteristics of the Sensor

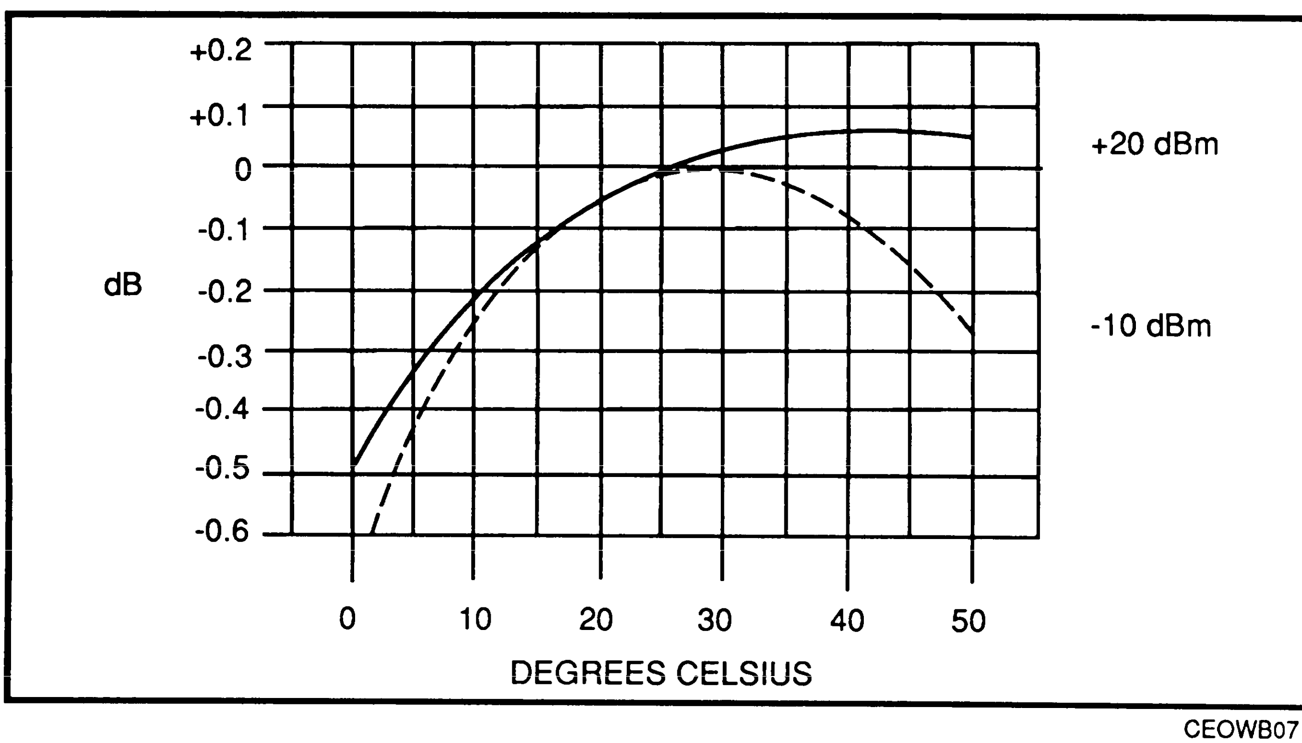


Figure 4-4. Typical Combined Temperature Characteristics of Instrument and the Sensor

c. Turn on the signal source and slide the carriage along the slotted line until a maximum power is indicated. Adjust the source signal level and the probe setting for the least coupling that yields a -41 dBm reading at the maximum point (the incident power should be at least 0 dBm).

d. Slide the carriage along the slotted line until minimum power is indicated. Read the level at this point. Subtract the measured level at the minimum point for the level at the maximum point. Ignore the signs. Use the SWR Conversion Chart to convert the result into SWR (See Figure 4-5). The change in dB may be converted into SWR by computation. SWR is the antilog, base 10, of change dB/20.

$$SWR = Log_{10}^{-1} \frac{dB}{20}$$

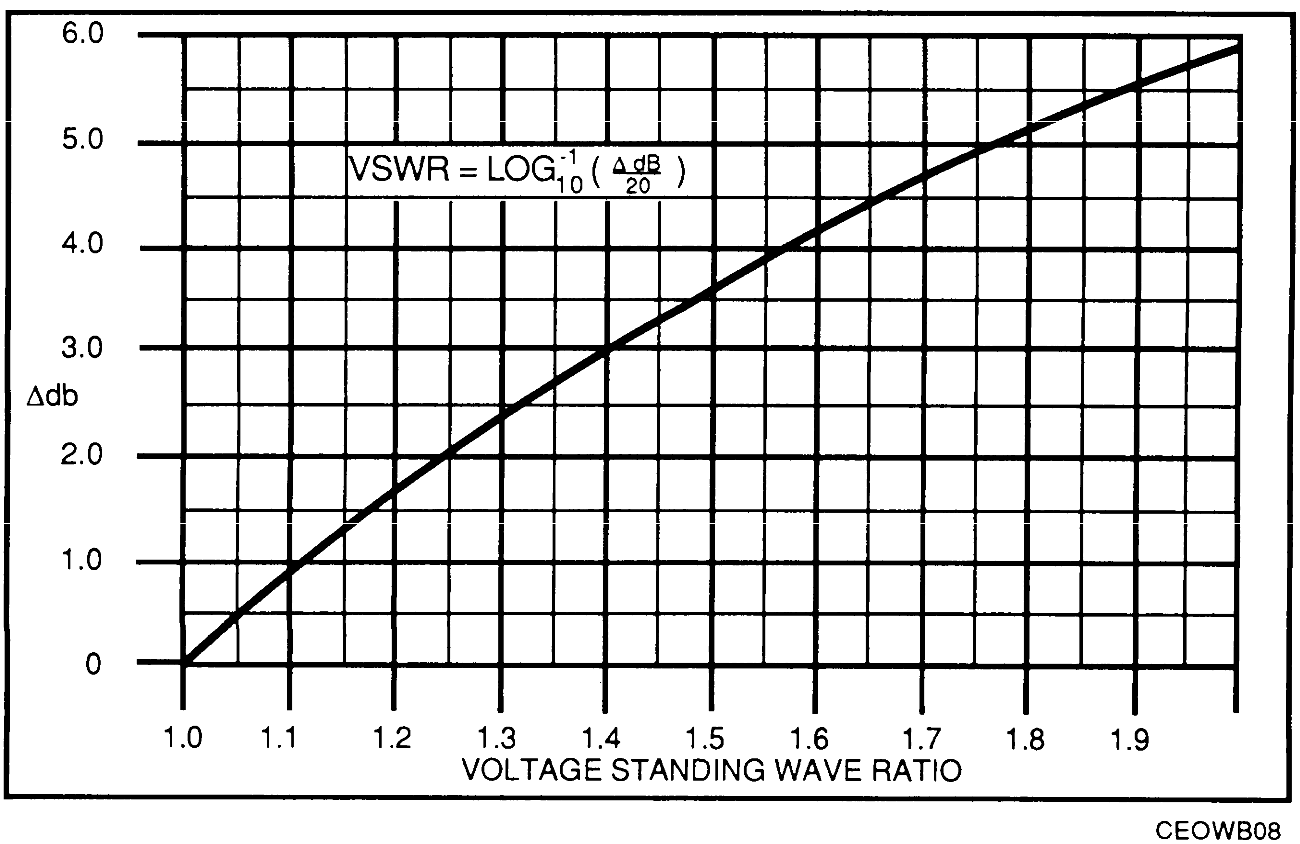


Figure 4-5. dB-SWR Conversion Chart

4-26. SHIELDING RECOMMENDATIONS.

If the test set is subjected to strong noise fields, accurate zeroing may be difficult unless the sensor is shielded during the zeroing operation. The simplest method of shielding is to connect the sensor to the device whose power level is to be measured, first making sure that the device is turned off; however, in some instances, the device may act as an antenna and introduce additional noise voltage into the sensor. If this happens, disconnect the sensor from the device, stand the sensor, end down, on a copper plate, and hold it down firmly so that the rim of the sensor connector makes good contact with the copper plate at all points. Alternatively, wrap a piece of thin copper foil around the threaded portion of the connector body, and crimp the foil around the open end of a female bulkhead type N connector, making certain that the center pin of the connector is not shorted. If frequent zeroing in strong noise fields is necessary, construct an adapter, using a Type N connector permanently fitted with a copper foil shield.

4-27. ANALOG OUTPUT.

A dc voltage proportional to either power or dBm is available at rear panel recorder connector J20 for recorder or other applications. This output voltage will be affected in both power and dB modes by calibration factor entries. The source resistance of the recorder output is 9.09K ohms, permitting a current of 1.00 mA into a load of 1000 ohms at full scale power. The open circuit output levels for various measurement modes are as follows:

a. In the power mode, the dc output level is proportional to the displayed power, with 10 volts at full scale for each range. The range referred to here is the displayed, or "external" range.

b. In the dB mode, the dc output level is proportional to dBm according to the formula

$$V\ OUT = \left(8 + \frac{dBm}{10}\right) \text{volts}$$

(1) Example: The voltage output at -20 dBm would be:

$$\left(8 + \frac{-20}{10}\right) \text{volts} = 6 \text{ volts.}$$

This output is a function of dBm only, but is affected by CAL FAC entries. (The recorder output mimics the displayed power, without including dBr).

4-28. IEEE-488 BUS INTERFACE.

a. The test set contains an IEEE-488 (GPIB) bus interface to permit external control of the test set, as well as data capture by a wide variety of compatible controllers.

b. It is assumed that the user is acquainted with GPIB principles and terminology. Refer to the controller instruction manual for the syntax needed to create specific bus commands and addressing sequences.

c. The remote programming syntax mirrors the front-panel keystroke sequence closely. Each key has been assigned an alphanumeric character, and sending that character is equivalent to pressing that front-panel key. The resulting operation is indistinguishable from local control. Numerical values are translated by the GPIB interface so that commonly observed formats may be used.

4-29. REMOTE ADDRESS ASSIGNMENT.

Before using a remote control device with the AN/USM-491, the device must be assigned a unique address. Refer to Table 4-2 and set the five right-most sections of switch S1 (see Figure 4-1, Item 25) to assign the address.

Table 4-2. Address Assignment

*Decimal Address	Talk Code	Listen Code	Switch Setting 5	4	3	2	1
0		SP	0	0	0	0	0
1	A	!	0	0	0	0	1
2	B	"	0	0	0	1	0
3	C	#	0	0	0	1	1
4	D	$	0	0	1	0	0
5	E	%	0	0	1	0	1
6	F	&	0	0	1	1	0
7	G	'	0	0	1	1	1
8	H	(	0	1	0	0	0
9	I	)	0	1	0	0	1
10	J	*	0	1	0	1	0
11	K	+	0	1	0	1	1
12	L	,	0	1	1	0	0
13	M	-	0	1	1	0	1
14	N	.	0	1	1	1	0
15	O	/	0	1	1	1	1
16	P	0	1	0	0	0	0
17	Q	1	1	0	0	0	1
18	R	2	1	0	0	1	0
19	S	3	1	0	0	1	1
20	T	4	1	0	1	0	0
21	U	5	1	0	1	0	1
22	V	6	1	0	1	1	0
23	W	7	1	0	1	1	1
24	X	8	1	1	0	0	0
25	Y	9	1	1	0	0	1
26	Z	:	1	1	0	1	0
27	[	;	1	1	0	1	1
28	\	<	1	1	1	0	0
29	]	=	1	1	1	0	1
30	∧	>	1	1	1	1	0

*Address 31 (11111) will not be recognized and should not be used.

4-30. REMOTE MESSAGE TERMINATOR.

After setting the address assignment, refer to Table 4–3 and set the two left-most sections of switch S1 (see Figure 4-1, Item 25) to select message terminators.

Table 4-3. Message-Terminator Selection

SWITCH		MESSAGE TERMINATOR
7	6	
0	0	EOI
0	1	CR*
1	0	LF*
1	1	CR LF*

*With or without EOI

4-31. REMOTE COMMAND RESPONSE.

In addition to Talk and Listen Address commands, the instrument responds to the following commands:

a. Addressed Commands (Responses if Listen Addressed).

Mnemonic	Name	Function
GTL	Go to Local	Enables panel control
GET	Group Execute Trigger	Trigger a measurement
SDC	Selective Device Clear	Clears, J, U,Q, and V commands

b. Listen Address Group

UNL	Unlisten	De-address as listener

c. Talk Address Group

UNT	Untalk	De-address as talker

d. Unencoded Commands

IFC	Interface Clear	Initialize interface
REN	Remote Enable	Permits remote operation

4-32. REMOTE OPERATING STATES.

The instrument operates in two separate states, whether in local or remote control. One state is the measurement state, during which the instrument performs and displays measurements; the other state is the data entry/recall state, which is operative during number entry or after recall of stored information. When remotely operated, the instrument can send only the Information which appears on the LED display. When the instrument is in the store or recall mode, the LED display and indicators will blink, indicating the displayed value is not a measured value.

4-33. REMOTE MEASUREMENT MODE FUNCTIONS.

Table 4-4 lists and describes the functions that change the measurement mode when operating the instrument by remote control.

Table 4-4. Measurement Mode Functions

Keyname/Function	Remote Command	Description
PWR MODE	P	Display measured power.
dB MODE	B	Display measured dBm or dBr.
AUTO	A	Set autorange mode.
HOLD	O	Set range hold mode.
Trigger	T	Used with controllers that do not have a GET (Group Execute Trigger) capability; the GET command is asynchronous and therefore may be faster responding than the T comnand.
Unsoothed Data	1J (enabled) 0J (disabled)	Exponential averaging is used in the measurement process to reduce the effects of noise and other spurious factors. Averaging time is a function of level, being highest on the lowest ranges where noise is a more prominent factor. It therefore increases the measurement time accordingly. The averaging function may be eliminated by enabling the J1lJ) command, thereby reducing the response time. A consequence of this however, is an Increase in indication jitter or uncertainty on the lower ranges.

NOTE

The J. Q. U. and V. commands are always disabled with Interface Clear, Device Clear, and Selected Device Clear commands, with the front panel CLR key when used for Go To Local, and with the power off/on sequence.

Table 4-4. Measurement Mode Functions (Continued)

Keyname/Function	Remote Command	Description
Hold Indication	1Q (enabled) 0Q (disabled)	This command, when enabled, automatically invokes an initial T command (i.e., following its receipt, one measurement is made and the indication is held). The instrument continues the measurement process, but does not update the display until receipt of a T, 1Q or 0Q command. This provides a faster measurement cycle because display-update time is eliminated until an update is commanded with the T, 1Q, or 0Q commands.
Service Request (SRQ)	1V (enabled) 0V (disabled)	This command, when enabled, provides for the issuance of an SRQ (Service Request) at the completion of a measurement. The command must be reenabled, if desired, following each issuance of the SRQ.
Limit Service Request	1U (enabled) 0U (disabled)	This command, when enabled results in the issuance of a Service Request (SRQ) whenever a limit is exceeded. The limit exceeded can be determined from the service request byte.
CLR		When operating with the remote indicator on, pressing this key returns the instrument to local operation.

4-34. REMOTE DATA ENTRY/RECALL FUNCTIONS.

Table 4-5 lists and describes those functions that enable entry or retrieval of data in the instrument. Operation reverts to the measuring state after data storage.

4-35. REMOTE SPECIAL FUNCTIONS.

Special functions include the automatic zeroing, automatic calibration, and clear functions, as listed below:

Key Name	Remote Command	Function
ZERO	Z	Initiates an automatic zeroing cycle that takes 8 to 20 seconds.

Key Name	Remote Command	Function
CAL	K	Performs 1 mW automatic calibration.
CLEAR	C	Clears numeric entry to zero.

Table 4-5. Remote Data/Entry Recall Functions

Keyname/ Function	Remote Command	Description
LO LIMIT	L	Low limit value, in dB.
HI LIMIT	H	High limit value, in dB.
dB CAL FAC	D	Calibration factor constant, in dB.
GHz	F	Interpolate frequency/calibration factor table.
SENS	S	Select sensor data tables.
CHNL	N	Select channel number.
dB REF	R	dB reference level for dB mode.
Unsoothed Data	J	Sending this command recalls its state on the front panel display (1 = enabled; O = disabled).
Limit Service Request	U	Sending this command with no argument recalls its state on the front panel display (1 = enabled; O = disabled.)
Service Request	V	Sending this command with no argument recalls its state on the front panel display (1 = enabled; O = disabled).

4-36. REMOTE COMMAND EXTENSIONS.

The following functions are added to bus operation:

Name	Remote Command	Function
ADR. ZERO	Y	Zero selected ranges (0-6).
SET RANGE	G	Set to selected range (0-6).

These commands must be preceded by an appropriate argument. The argument for y is the span of ranges to be zeroed; for example, 26 specifies zeroing ranges 2 through 6. If only one range is to be zeroed, the argument must begin and end with the same code (e.g., 11Y to zero only range 1). The argument for G is the range number to be set. From execution of the Y command to measurement mode, the maximum time is as follows:

Command	Time	Command	Time
00Y	2.3 seconds	04Y	3.8 seconds
01Y	2.9 seconds	05Y	4.0 seconds
02Y	3.3 seconds	06Y	4.3 seconds.
03Y	3.5 seconds		

The "Y" command allows no wait time for a sensor to reach a stable zero before actual offset storage occurs.

NOTE

The G command sets the instrument to an internal range which may not correspond to the range code output in the data string in paragraph 4-40.

The internal range is the range that the amplifiers are set to and is shown in the Table 4-6. The external, or displayed range, reflects the position of the decimal point and the instrument annunciators.

Table 4-6. Internal Range for Various Sensor Levels

SENSOR LEVEL	INTERNAL HARDWARE AN/USM-491 RANGE
+30 to +24 dBm	6
+24 to + 8 dBm	5
+ 8 to - 3 dBm	4
- 3 to -13 dBm	3
-13 to -23 dBm	2
-23 to -33 dBm	1
-33 to - ¥	0

4-37. REMOTE AVAILABILITY.

When the instrument is sent a string, it does not normally tie up the bus while responding to the string; other bus communications are possible during the interval. The instrument can inform the controller when it is finished by use of the Service Request (see Table 4-4), if this is desired.

a. The instrument can, however, be made to lock up the bus while it is responding to a string - if such action is desired – by sending it two strings in succession (even if the second string is only a Null command).

(1) Example: A "zero" command: WRT 716,"Z"
Followed by a "talk" command: RED 716,A,B,C.

4-38. PROGRAMMING EXAMPLES.

4-39. REMOTE PROGRAMMING SYNTAX.

Fixed formats and floating point formats may both be used. These representations are converted to their equivalent fixed point values, and the sign information is post-fixed automatically, thereby ensuring that natural notations for numbers will be accepted by the instrument. Suppose that it is desired to set the instrument to the PWR mode. The examples given apply to the HP 9825 calculator(or equivalent). The calculator could be programmed:

```
wrt 716, "P"
```

The "wrt" instructs the calculator to send data on the bus to one or more listeners. The number following is the address information; 7 is the calculator address, and 16 is the instrument address. (All examples herein will use 16 as the instrument address, although any valid address can be assigned to the instrument.) When the calculator interprets the first part of the line, it will assert the ATN line to signify that commands or addresses will be sent on the bus. Following that, it will send three bytes or characters: Unlisten, the calculator Talk Address, and the instrument Listen Address. This information will configure both the calculator and the instrument for the data transfer. After the last command byte has been accepted, ATN will be released to the false state by the calculator. All information on the bus is interpreted as data in this mode. While in the data mode, the calculator will send the character "P" to the instrument. At the instrument, this will be interpreted as equivalent to pressing the MODE PWR key, and that function will be executed. Because there is no more data to be sent, the calculator will send a delimiter (the preselected ASCII code for the termination character). The instrument recognizes the termination character as an end-of-message signal, and returns to the bus idle condition.

a. The preceding discussion of the sending of a single programming byte serves to illustrate two important points: every data transfer is preceded by a command/address preamble, and each transfer is terminated by a termination character. In the preceding example, six characters were sent on the bus; only one was a programming byte.

b. The measurement mode functions (P,B,A,O) and the special functions (Z,K) do not expect any numeric value. These functions all execute as received. For example: the following will program dB and autorange mode:

```
wrt 716, "BA"
     or
wrt 716, "AB"
```

Note that the sequence is unimportant, except that each function executes in the order it is received on the bus.

c. Suppose that the instrument is to be zeroed automatically, and then asked to send the reading in the PWR and RANGE AUTO mode. The HP 9825 calculator could be instructed as follows:

```
wrt 716, "APZ"
red 716, V,S
```

The automatic zeroing cycle time is approximately 8 to 20 seconds, depending on range. Until zeroing is completed, the instrument will be unable to respond with new data. The first line of the preceding instructions sets the operating mode and initiates the zeroing cycle. The last line reads the response from the instrument. The instrument response consists of two numeric values: the first value is the front panel reading, and the second is a status value (normally zero). These two numbers will be stored in the calculator variables (storage locations) V and S. Note that each data transmission from the instrument consists of two values. When the status value is non-zero, indicating an error condition, the data value will be set to zero. The program will normally test the status value to assure valid operating conditions.

4-40. STORE/RECALL FUNCTIONS SYNTAX.

The general syntax for store/recall functions is the same as the front panel sequence; if a numeric value immediately precedes the function, that value will be stored; otherwise, the existing stored value will be recalled to the front panel. These functions (L,H,D,F,S,N,R,J,U,V) thus operate in a dual mode. When the instrument is in the store or recall mode the display will blink to indicate that the instrument is not in the measurement mode. The instrument is returned to the measurement mode by sending any of the following: P,B,A,O,T,1J,0J,1Q,0Q,1V,0V,1U, or 0U.

a. Suppose that it is desired to store the current power level in dBm into the dBm reference so that all future readings will be referenced to the current value. Allowance must be made for the possibility that the current value is a dB relative value. To do this, the current dB value must be read, the existing dB reference must be recalled, the true dBm value must be computed, and this value must be stored into dB reference. The calculator could be instructed as follows:

```
red 716, V,S
wrt 716, "R"
red 716, X,S
V+X   Y
wrt 716, Y, "R"
```

Note that R is used twice in the program, the first time to obtain the existing value for the dB reference, and the second time to store the computed value. Also, note that the two read statements (red) each fetch a different value, the first value is the power value in dB, and the second is the dB reference.

4-41. OUTPUT DATA FORMAT.

The data output of the instrument consists of two numeric values. The first is the numeric data in the display, and the second is the status information. The normal data output will have the following format:

```
abcsddddEsd,S,R(tc)
```

Where:

ab = mode (power in milliwatts = PW; dB = DM; dBr = DR)
c = channel (A=1)
= sign (+ or -)
dddd = data (four digits, each digit O-9)
Esd = exponent, sign, digit
, = data delimiter
S = status digit:
- 0 = no error
- 1 = entry too small
- 2 = entry too large
- 3 = measurement under range
- 4 = measurement over range
- 5 = zero acquisition out of range - excessive negative offset
- 6 = zero acquisition out of range – excessive positive offset

R = Range Code (See Table 4-6)
tc = termination character

4-42. HOLD INDICATION FUNCTION SYNTAX.

The Hold Indication function, when enabled (1Q), automatically does a measurement cycle following its receipt and then holds the indication until receipt of a T, OQ, or another 1Q command. It is intended primarily for use with the Trigger or Group Execute Trigger commands. Following its receipt, the instrument continues to measure but does not update the display. This can be useful where response time is important since display-update time is eliminated until called for with a Trigger (T) command; another 1Q command will also update the display and maintain the old indication function; a OQ command will update the display and negate the old indication function.

4-43. SRQ FUNCTION SYNTAX.

The controller can command the instrument to pull the SRQ line true after each measurement. The syntax for this command is 1V; to command the instrument not to pull the SRQ line true after each measurement, the syntax is 0V.

4-44. MEASUREMENT TRIGGER SYNTAX.

The Trigger (T) commands an addressed command (wrt 716, "T"), used to trigger a measurement, and is generally used in conjunction with the Hold Indication function (Q). (Refer to paragraph 4-41.) The instrument is also responsive to the unaddressed Group Execute Trigger (GET) command. This command is asynchronous and may result in a slightly faster response time than the T command, which is executed only once each measurement cycle.

4-45. LIMIT SERVICE REQUEST.

This command, when enabled, will result in a service request by the instrument when either dB limit (high or low) of the channel is exceeded. The limit exceeded can be determined from the service request byte as shown below:

NOTE

Bit 6 when set, is the service request.

Bit	Limit Exceeded
7 6 5 4 3 2 1 0	
X l X X X X 0 1	Channel 1 low limit
X 1 X X X X 1 0	Channel 1 high limit.

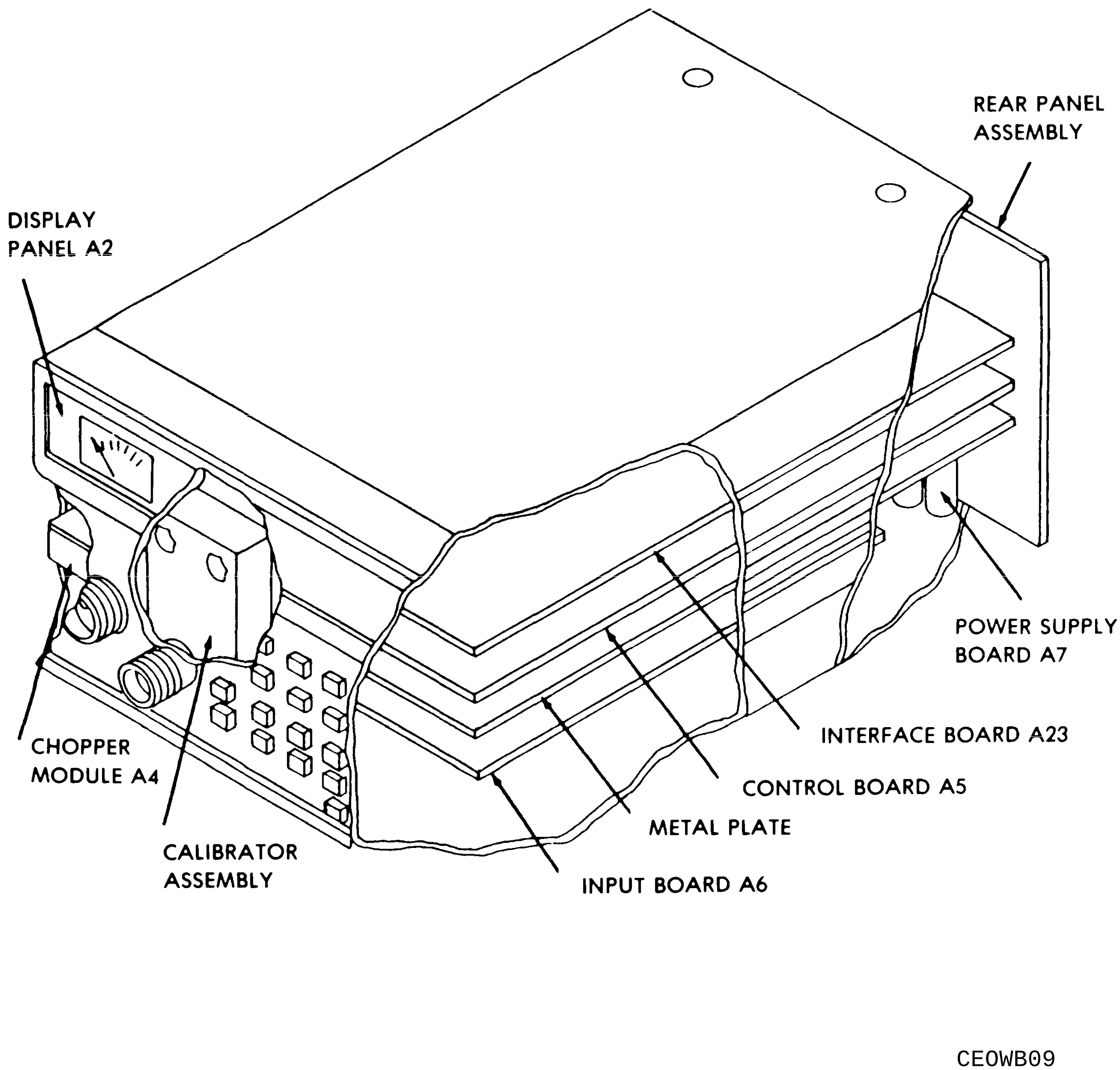


Figure 5-1. Board and Assembly Locations

SECTION V
MAINTENANCE INSTRUCTIONS

5-1. SAFETY REQUIREMENTS.

Failure to comply with the precautions listed in the Safety Summary at the front of this manual or with specific warnings given throughout this manual could result in serious injury or death. Maintenance and repair should be performed only by qualified personnel.

5-2. TEST EQUIPMENT REQUIRED.

Tools and test equipment required for maintenance of the AN/USM-491 are listed in Appendix C (Maintenance Allocation Chart). Illustrations are provided in this section for test equipment hook–up together with step–by–step procedures to perform the performance tests, instrument adjustments and troubleshooting requirements.

5-3. PREVENTIVE MAINTENANCE AND CLEANING.

a. Before and after use ensure that the external components of the instrument, sensor, cabling, and associated hardware are clean and free of contaminants.

b. Before, during, and after use ensure that the instrument, sensor, cabling, and associated hardware are not exposed to mishandling which could result in damage to the equipment.

c. Clean with a mild liquid or detergent (Appendix D, Item 1) and water. With a clean, damp (not soaked) cloth (Appendix D, Item 2), wipe the front panel, switches, meter glass, top and bottom covers, and rear panel.

CAUTION

Do not attempt cleaning of any plugs and connectors in this manner as soap residue could effect equipment performance.

d. Oil and grease stains may be removed from plugs and connectors by:

WARNING

HFE-71DE is toxic to eyes, skin, and respiratory tract, and decomposes into other hazardous products when exposed to extreme heat. Wear chemical protective gloves and goggles/face shield. Avoid repeated or prolonged contact. Use only in well-ventilated areas. If ventilation is not adequate, use approved respirator as determined by local safety/industrial hygiene personnel. Keep away from open flames, welding, or other sources of extreme heat.

(1) Applying cleaning compound, solvent HFE-71DE, (Appendix D, Item 3), with a soft brush (Appendix D, Item 4).

CAUTION

Thorough drying of solvent is necessary to prevent the production of corrosive byproducts.

(2) Wipe with a lint free cloth, (Appendix D, Item 2). Plugs and connectors may be allowed to air dry.

(3) Apply a light film of water displacing preservative compound (Appendix D, Item 5). Avoid excessive application of preservative; wipe off excess with a lint free cloth (Appendix D, Item 2).

e. To ensure proper operation of all circuits the instrument adjustments in paragraphs 5-13 through 5-19 and the performance tests in paragraphs 5-4 through 5-12 should be performed every 12 months.

5-4. PERFORMANCE TESTS.

5-5. PRELIMINARY SETUP.

Connect the test equipment to the AN/USM-491 as shown in Figure 5-2.

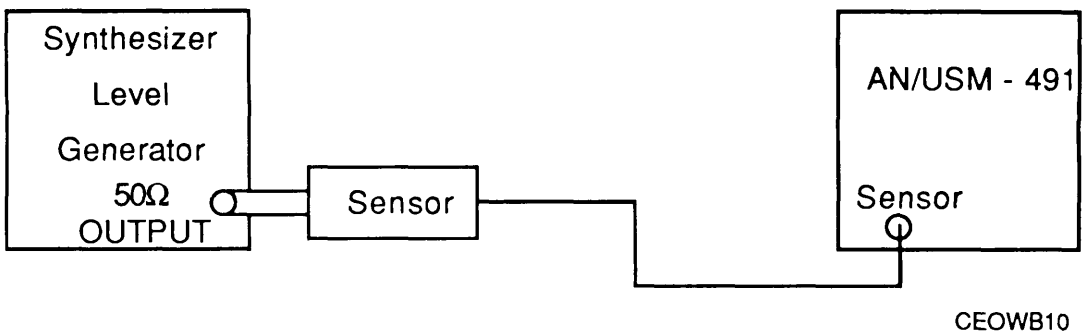


Figure 5-2. Preliminary Setup

a. Turn on the instrument and the synthesizer level generator and allow sufficient warmup time.

b. Set the generator to 30 MHz with the output to zero power and zero modulation.

c. Key in the following measurement parameter data through the keyboard:

1, SELECT CHNL
1, SELECT SENS
MODE dB
RANGE AUTO
99, dB LIMITS HI
99, CHS, dB LIMITS LO
O, CAL FAC dB
O, REF LVL dB.

NOTE

Maintain the same measurement parameters for each of the following tests unless specifically directed otherwise.

5-6. AUTOMATIC ZERO FUNCTION TEST.

a. Ascertain that the signal input to the sensor is zero.

NOTE

Do not confuse O dB with zero input. For zero input to the sensor, turn off the generator.

b. Press the ZERO key. During zeroing (approximately 20 seconds), the front-panel LED display should show the following:

Display	Comment
cccc	Zeroing
cc03	Zeroing complete.

5-7. RANGE HOLD FUNCTION TEST.

a. Set the output level of the generator to O dBm.

b. Press the RANGE HOLD key and the MODE PWR key.

c. Ascertain that the LED display readout is 1.000 mW ±1.2%.

d. Set the generator output to each of the following levels in succession, and ascertain that the corresponding listed LED indications are obtained on the instrument:

Power Source Level	Instrument Indication
10 dBm	cc04 (power level too high)
O dBm	1.000 mW
-10 dBm	0.100 mW
-20 dBm	0.010 mW or cc03 (if less than 10 counts; power level is too low).

e. Press the RANGE AUTO key.

5-8. BASIC INSTRUMENT ACCURACY TEST.

a. Turn the generator off, wait approximately 30 seconds, then zero the instrument by pressing the ZERO key.

b. Disconnect the sensor from the generator and connect it to the instrument PWR REF connector. Press the CAL key.

c. Note the indication of the LED display. If the indication is not 1.000 mW, press the CAL key, and ascertain that the indication is now 1.000 mW ±2 counts.

d. Disconnect the sensor from the PWR REF connector and connect the frequency counter to the PWR REF output.

e. The frequency should be 50 MHz (±O.5 MHz).

f. Disconnect the frequency counter.

g. Connect the sensor to the generator and press the MODE dB key.

h. Turn on the generator and set to 30 MHz.

i. Set the output level of the generator to each of the following dBm values in succession, and ascertain that the LED display readout agrees with the output level of the generator within the specified dB limits:

Power Source Level	LED Display Tolerance
+10 dBm	±O.15 dB
+ 9 dBm	±0.15 dB
+ 8 dBm	±0.15 dB
+ 7 dBm	±O.15 dB
+ 6 dBm	±O.14 dB
+ 5 dBm	±O.13 dB
+ 4 dBm	±O.12 dB
+ 3 dBm	±O.11 dB
+ 2 dBm	±O.10 dB
+ 1 dBm	±O.09 dB
O dBm	±0.08 dB
-10 dBm	±O.15 dB
-20 dBm	±0.15 dB
-30 dBm	±O.21 dB

NOTE

If the dBm indications are within limits, it may be assumed that power mode indications are also within limits; dBm indications are computed from power measurements within the instrument.

5-9. HIGH POWER LEVEL (15 dBm AND 25 dBm) ACCURACY TEST.

NOTE

- High power level verification requires a special technique since the power levels generated by the source cannot go to +30 dBm. An uncalibrated amplifier is used as shown below.

- Ensure the test equipment has been operating for at least one hour. The RF amplifier in particular must be fully stable for the following steps.
- Cables should not be used between the generator, attenuator, or sensor.

a. Connect the equipment as shown in Figure 5-3.

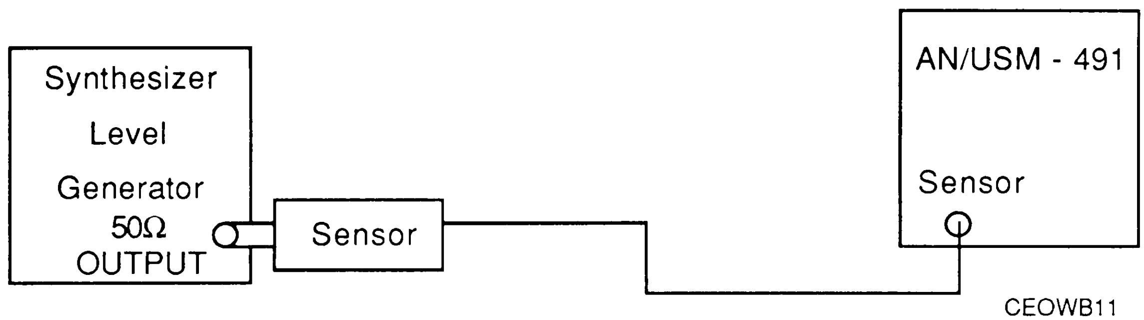


Figure 5-3. Test Setup for Attenuator Measurement Reference

b. Measure the exact value of the 20 dB attenuator with the following steps:

NOTE

Steps 1 through 4 may be skipped if the attenuation value is known to within .02 dB. If the attenuator has been calibrated at DC, this figure may be used at 30 MHz.

(1) Set the level generator for O dBm at 30 MHz.

(2) Press the CAL key.

(3) Connect the equipment as shown in Figure 5-4.

(4) Record the attenuator value on the LED display, ignoring the minus sign, and call it "A".

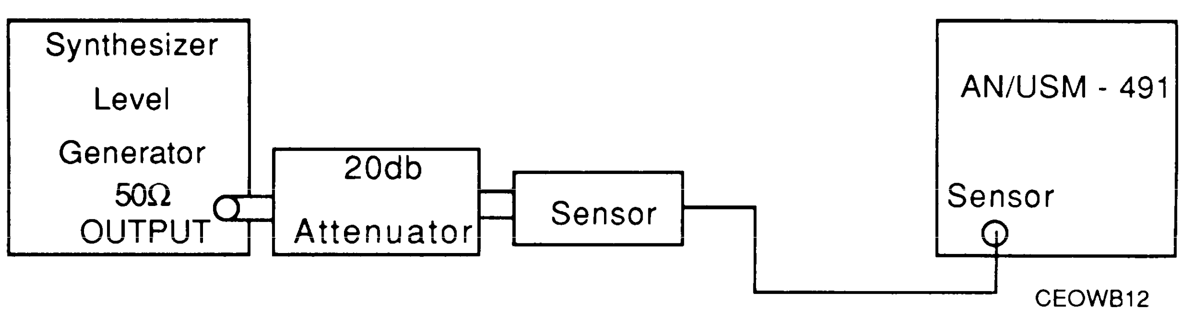


Figure 5-4. Test Setup for Attenuator Measurement "A"

CAUTION

The RF amplifier has enough power to burn out the sensor if driven hard enough. The equipment should always be connected with the level generator in standby or with the level set very low (below -40 dBm). Never apply power to the amplifier when there is no load connected to it.

c. Connect the equipment as shown in Figure 5-5.

d. Set the generator for -40 dBm at 30 MHz. Tune the amplifier to 30 MHz.

e. Bring the generator power level up slowly until the LED display reads as close to -5 dBm as possible (-4.5 to -5.5 dBm is acceptable). Record the LED display and call it "B".

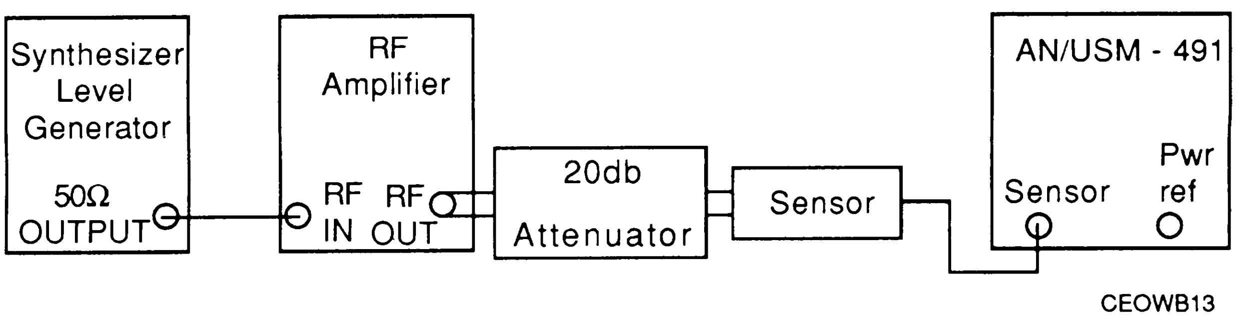


Figure 5-5. Test Setup for 15 dBm Measurement "B" and 25 dBm Measurement "C"

f. Turn off the level generator output and connect the equipment as shown in Figure 5-6.

g. Turn on the generator to the same level it was before. The LED display should be equal to: LED display = B + Attenuation (A) ±0.13 dB.

(1) Example, if B is -5.21 dBm, Attenuation is 20.32, the LED display should be equal to 15.11 dBm, within 0.13 dB.

h. Connect the equipment as shown in Figure 5-5.

i. Set the generator for -40 dBm at 30 MHz. Tune the amplifier to 30 MHz.

j. Bring the generator power level up slowly until the LED display reads as close to +5 dBm as possible (+4.5 to +5.5 dBm is acceptable). Record the LED display and call it "C".

k. Turn off the generator output and connect the equipment as shown in Figure 5-6.

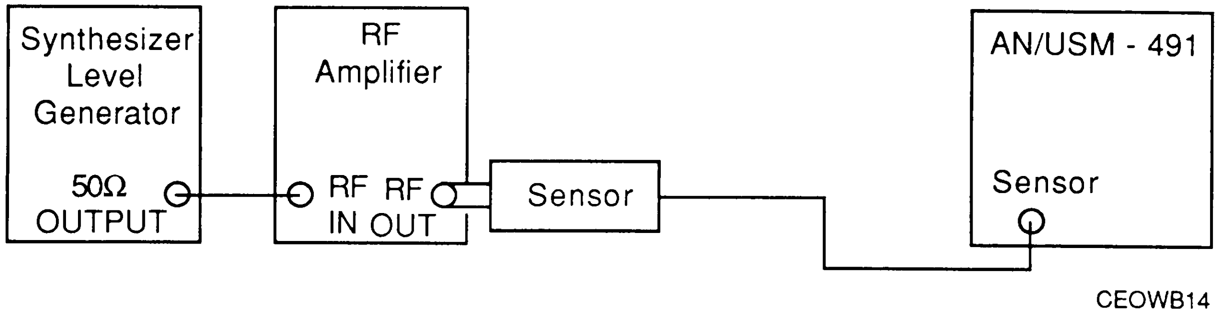


Figure 5-6. 15 dBm and 25 dBm Accuracy Check

1. Turn on the level generator to the same power level it was before. The LED display should be equal to: Display = C + Attenuation (A) ±0.13 dB.

(1) Example, if c is 4.60 dBm, Atten is 20.32, the reading should be equal to 24.92 dBm, within 0.13 dB.

5-10. dB REFERENCE LEVEL FUNCTION TEST.

a. Connect the equipment as shown in Figure 5-3.

b. Set the output power level of the generator to O dBm.

c. Press the MODE dB key and ascertain that the LED display indicates O dBm ±0.05 dB.

d. Enter a -10 dB reference level by pressing the following keys:

1
0
CHS (negative sign on LED)
REF LVL dB.

e. See if the LED display now indicates +10 dBr ±0.05 dB. The dBm annunciator should be off, and the dBr annunciator should be lighted.

f. Reset the instrument to indicate dBm by pressing the following keys:

0
REF LVL dB.

g. See if the LED display again indicates O dBm ±0.05 dB. The dBm annunciator should be lighted, and the dBr annunciator should be off.

h. Set the input level to -7 dBm.

i. Press the CLR and the REF LVL dB keys; the indication should be approximately -7.00 dB.

j. Press the decimal-point and the REF LVL dB keys; the display should now indicate 00.00 dBr.

k. Recall the dB reference level by pressing the REF LVL dB key; the indication should be -7.00, showing that the original dBm level is now stored as the dB reference level.

l. Press the CLR and the REF LVL dB keys; the indication now should be -7.00 dBm, showing that the dB reference level is now O dBm.

NOTE

This method of entering the current dBm level as the dB reference level is operative only in the local mode--not in IEEE-488 interface mode, as discussed in paragraph 4-13.

5-11. dB LIMIT TEST.

a. Connect the equipment as shown in Figure 5-7.

b. Set the output level of the generator to O dBm.

NOTE

Limits can be entered only in terms of dB, not power; however, the limit function operates in both the dB mode and the PWR mode.

c. Enter a +1 dB high limit by pressing the following keys:

1
dB LIMITS HI.

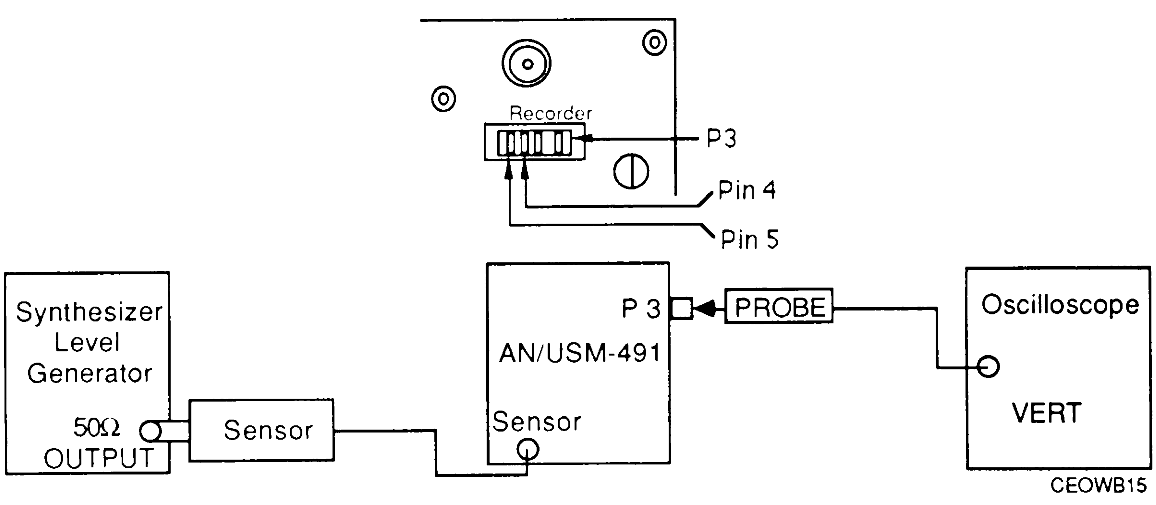


Figure 5-7. Test Setup for dB Limit Test

d. LIM annunciator should be off.

e. Enter a -1 dB low limit by pressing the following keys:

1
CHS (negative sign on LED)
dB LIMITS LO.

f. LIM annunciator should be off.

g. Set the output level of the synthesizer level generator to -2.0 dBm. The LIM annunciator should be lighted. The logic level at pin 5 of rear-panel connector P3 should be high; the logic level at pin 4 of connector P3 should be low.

h. Set the output level of the synthesizer level generator to +2.0 dBm. The LIM annunciator should be lighted. The logic level at pin 4 of rear-panel connector P3 should be high; the logic level at pin 5 of the connector P3 should be low.

5-12. CALIBRATION FACTOR TEST.

NOTE

This calibration procedure should not be misconstrued with calibration in accordance with TB 43-180.

a. Connect the test equipment as shown in Figure 5-3.

b. Set the output level of the level generator to O dBm.

c. Press the MODE dB key and note the indication on the LED display.

d. Enter a 0.2 dB calibration factor by pressing the following keys:

0
.
2
CAL FAC dB.

e. See if the indication on the LED display is equal to the value noted in step c plus 0.2 dB.

f. Enter a 2 GHz calibration factor by pressing the following keys:

2
CAL FAC GHz.

g. Determine the calibration correction for 2 GHz from the chart on the barrel of the sensor. See if the LED display indicates the value noted on the chart on the sensor barrel.

NOTE

For proper calibration factor correction and instrument accuracy, it is essential that the sensor number entered into the instrument prior to measurement agrees with the number indicated on the barrel of the sensor used for the measurement. (Refer to paragraph 4-8.) Calibration factors that are invoked are operative in both the dB mode and the PWR mode.

5-13. INSTRUMENT ADJUSTMENTS.

5-14. GENERAL.

Adjustment procedures are provided for the power supply, input board, chopper assembly, calibrator assembly, and sensor. When multiple adjustments are required, they should be made in sequence.

a. Remove power by disconnecting the AN/USM-491 from the power source.

CAUTION

This instrument contains electrostatic discharge sensitive (ESDS) devices. Special handling methods and materials must be used to prevent equipment damage. Refer to electrostatic discharge sensitive device procedures, pages C and D of this manual, before performing maintenance on the equipment.

b. Remove Covers

(1) Remove the two screws at the rear of the bottom cover.

(2) Slide the bottom cover off.

(3) Remove the two screws at the rear of the top cover.

(4) Slide the top cover off.

5-15. POWER SUPPLY ADJUSTMENTS.

WARNING

High voltage is used in the operation of this equipment. Death on contact may result if personnel fail to observe safety precautions.

a. Apply ac power to the AN/USM-491.

b. Connect a digital multimeter between TP3 and ground (see Figure 5-8). The reading should be 5.20 Vdc ±0.002 Vdc. If necessary, adjust R5 until voltage is correct.

c. Connect the multimeter HI lead to TP2 and LO lead to TP4. The reading should be 150 mV ± 10 mV. If necessary, adjust R11 until voltage is correct.

NOTE

The polarity of the reading will depend on the test probe connections.

d. Connect the multimeter between TP1 and ground. The voltage should be +15 Vdc ±0.6 Vdc.

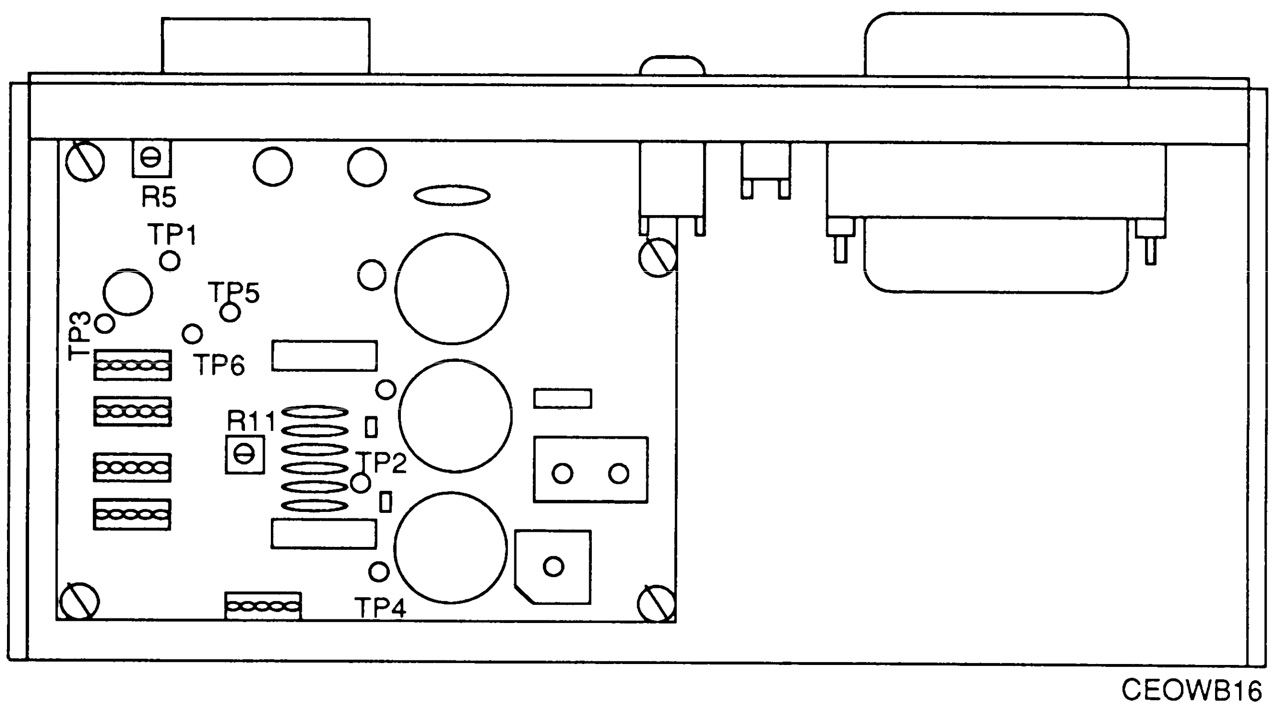


Figure 5-8. Power Supply Test Points and Adjustments

e. Connect the multimeter between TP5 and ground. The reading should be -15 Vdc ±0.6 Vdc.

f. Connect the multimeter between TP6 and ground. The reading should be -5 Vdc ±0.2 Vdc.

5-16. INPUT BOARD AND CHOPPER ASSEMBLY ADJUSTMENTS.

a. Connect the equipment as indicated in Figure 5-9.

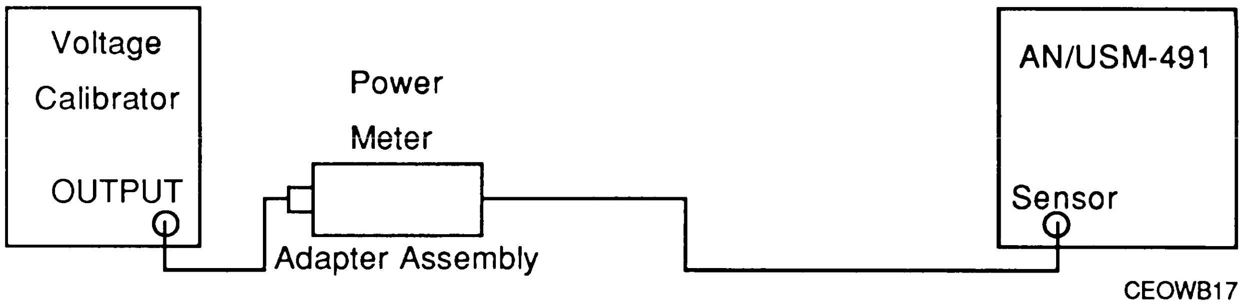


Figure 5-9. Test Setup for Input Board

NOTE

- The adapter assembly provides a differential signal to the AN/USM–491 at a controlled impedance.
- Observe polarity when connecting the power meter adapter assembly to the voltage calibrator.

b. Apply ac power to the AN/USM-491 and test equipment. Let the equipment warm up for at least 30 minutes.

c. Set the control board bit switch for Calibrate Mode 1 (see Figure 5-10).

d. Press 1, SELECT CHNL, O, and RANGE HOLD.

e. Set the voltage calibrator to O volts.

NOTE

Refer to Figure 5-11 for the input board and chopper assembly test points and adjustments.

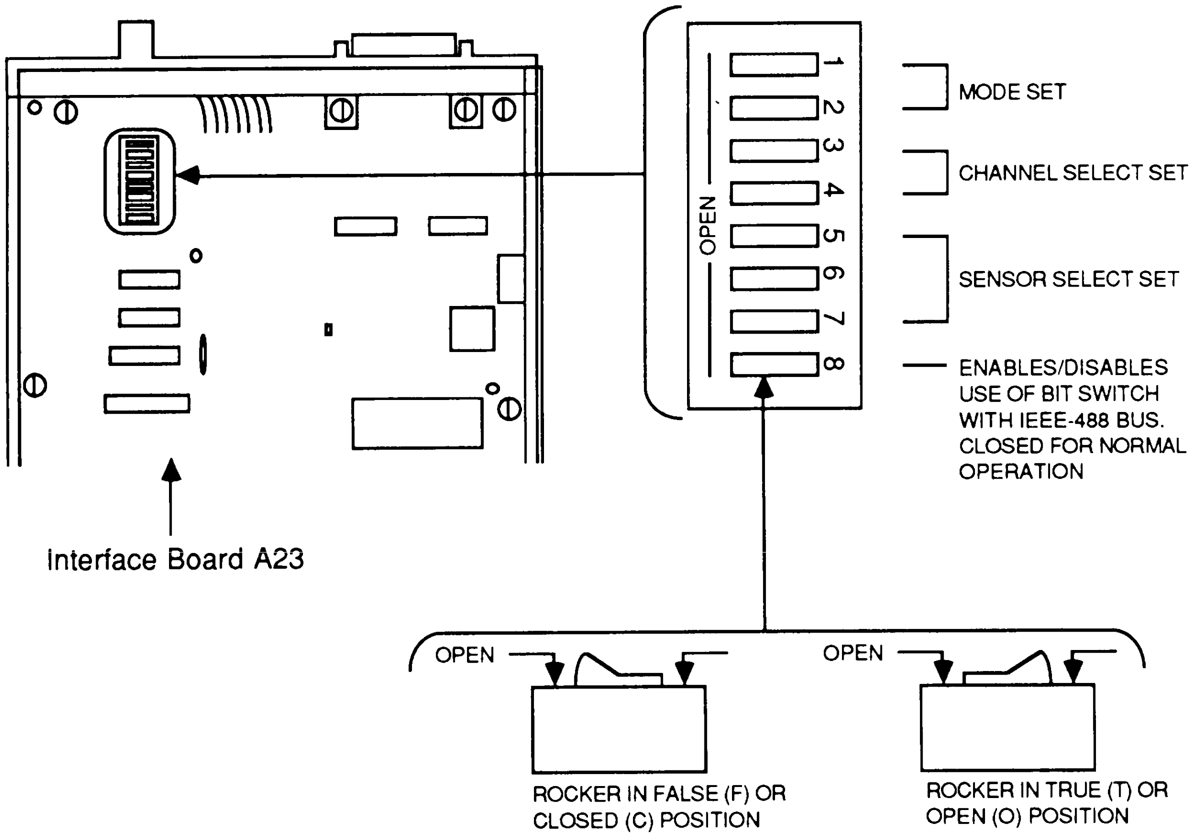
f. Connect a clip lead from TP8 to chassis or ground.

g. Connect a clip lead from TP7 to chassis or ground.

h. Connect a digital multimeter between TP9 and ground. The reading should be between +10 millivolts and -10 millivolts. If necessary, adjust R45 until the voltage is between +10 millivolts and -10 millivolts.

i. Remove the clip lead from TP8. The reading at TP9 should be between +10 millivolts and -10 millivolts. If necessary, adjust R36 until the reading is between +10 millivolts and -10 millivolts.

j. Remove the clip lead from TP7.



Switch Setting								Comment
8	7	6	5	4	3	2	1	
ALWAYS CLOSED	NOT USED							
						C	C	Operate Mode
						C	O	Calibrate Mode 1 (DC Cal.)
						O	C	Calibrate Mode 2 (AC Cal.)
				C	O			One Channel Operation
				O	O			Two Channel Operation
	C	C	C					One Sensor Capability
	C	C	O					Two Sensor Capability
	C	O	C					Three Sensor Capability
	C	O	O					Four Sensor Capability
	O	C	C					Five Sensor Capability
	O	C	O					Six Sensor Capability
	O	O	C					Seven Sensor Capability
	O	O	O					Eight Sensor Capability

CEOWB18

Figure 5-10. Control Board BIT Switch

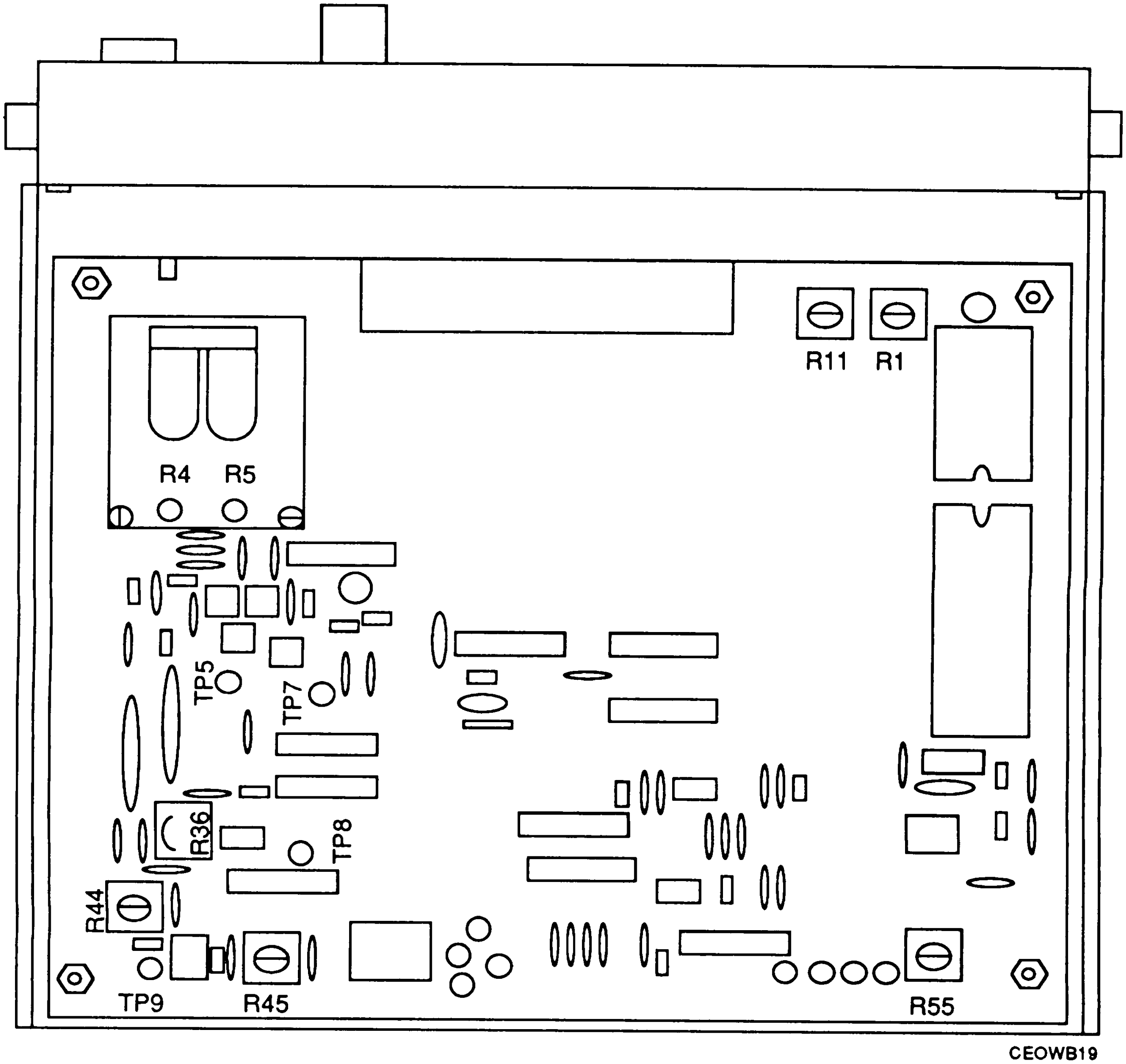


Figure 5-11. Input Board and Chopper Assembly Test Points and Adjustments

k. Using the digital multimeter, measure the voltage at TP5. The voltage should be between +100 millivolts and -100 millivolts.

NOTE

The multimeter reading will fluctuate during the following step. Average the readings.

l. Using a digital multimeter, measure the voltage at TP9 on the input board. The DVM reading should be between +100 millivolts and -100 millivolts. If necessary, adjust R4 and R5 on the chopper module equally and opposite until the reading is between +100 millivolts and -100 millivolts. The reading should be as close to O as possible.

m. Press the ZERO key on the AN/USM-491. Wait for zeroing to end.

n. Press 5 and RANGE HOLD.

o. Set the voltage calibrator to 900 mV.

p. The LED display should show 3685. If necessary, adjust R1 until the AN/USM-491 shows 3685. If 3685 cannot be set perform step s.

q. Set the voltage calibrator to 90 mV.

r. Adjust R11 until the LED displays 368 or 369. If 368/369 cannot be set perform step s.

NOTE

Steps s through w are only required if step (p) or (r) is unsatisfactory.

s. If either step p or r display the incorrect reading center R1 and R11.

t. Set the voltage calibrator to 900 mV.

u. Adjust R44 until the LED displays 3685.

v. Set the voltage calibrator to 90 mV.

w. Adjust R11 until the LED displays 368 or 369.

5-17. ANALOG TO DIGITAL CONVERTER ADJUSTMENT.

NOTE

Steps a through k are not normally required over the life of the input module, but may be done at the user's discretion, for example if the operation of the AN/USM-491 is suspect.

a. Connect the equipment as shown in Figure 5-9.

b. Ensure the control board bit switch to the Operate Mode (see Figure 5-10).

c. Set the voltage calibrator to O volts.

d. Press 1, SELECT CHNL, Press MODE PWR, O, CAL FAC dB, O, and REF LVL.

e. Press ZERO. Wait for zeroing to end.

f. Set the control board bit switch to calibrate mode 1 (see Figure 5-10).

g. Enter 1000 and press RANGE AUTO.

h. Set the voltage calibrator to 9 microvolt.

i. Line-by-line, set the voltage calibrator and AN/USM-491 as listed in Table 5-1. The DC calibration numbers may be recorded if desired to allow entry at a later date without recalibration.

NOTE

To enter DC calibration data that has previously been generated and recorded, replace the cal operation in the table with the number to be entered for a given range, for example: O, Range Hold, 3, 6, ., 8, 5, mode dB, 1, 0, 2, 6, REF LVL dB.

Table 5-1. DC Calibration Test

NOTE

This calibration procedure should not be misconstrued with calibration in accordance with TB 43-180.

DC Calibrator	Press	Allow Settling	Press	Record Display
9 μv	O, RANGE HOLD 3, 6, ., 8, 5, MODE dB	---	CAL, REF LVL dB	Approx. 1000
90 μV	1, RANGE HOLD	---	CAL, REF LVL dB	Approx. 1000
900 μv	2, RANGE HOLD	---	CAL, REF LVL dB	Approx. 1000
9 mv	3, RANGE HOLD	---	CAL, REF LVL dB	Approx. 1000
90 mv	4, RANGE HOLD	---	CAL, REF LVL dB	Approx. 1000
900 mv	5, RANGE HOLD	---	CAL, REF LVL dB	Approx. 1000
4.5V	6, RANGE HOLD	---	CAL, REF LVL dB	Approx. 1000

j. Disconnect the voltage calibrator.

k. Set the control board bit switch to Operate Mode (see Figure 5-10).

5-18. RECORDER OUTPUT ADJUSTMENT.

a. Connect the equipment as shown in Figure 5-12.

b. Press MODE PWR, RANGE AUTO, O, CAL FAC dB, O, and REF LVL dB.

c. Set the level generator output until the LED displays 1.000 mW (not 1.00 mW).

d. With 1.000 mW showing on the AN/USM-491, note the digital multimeter reading. The reading should be 9.98 to 10.02 volts. If the reading is incorrect, complete steps 1. through 7.

(1) Set the control board bit switch to Calibrate Mode 1 (see Figure 5-10).

(2) Press dB LIMITS LO. The AN/USM-491 should show a gain modifier of about 3600.

NOTE

Digital Multimeter connects to the AN/USM-491 recorder output connector on the rear panel

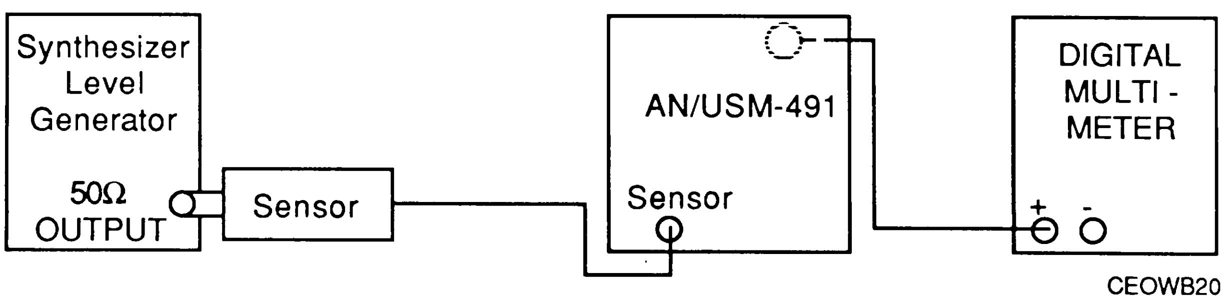


Figure 5-12. Test Setup for Recorder Output Adjustment

(3) For every 3 millivolt error adjust the gain modifier 1 number in the opposite direction.

Example: If the digital multimeter indication were 9.80 volts and the dB LIMITS LO key recalled a gain modifier of 3500, the revised gain modifier value would be 3500 + (200/3) = 3566.

(4) Enter the revised gain modifier and press dB LIMITS LO.

(5) Press dB LIMITS LO again. The AN/USM-491 should show the new gain modifier.

(6) Set the control board bit switch to Operate Mode (see Figure 5-10).

(7) Press Range AUTO.

(8) Note the reading on the digital multimeter. The reading should be 9.80 to 10.2 volts. If necessary, repeat steps 1 through 7 until the correct reading is obtained.

e. Set the level generator output to -9.0 dBm.

f. Note the reading of the AN/USM-491 and the digital multimeter. The millivolt reading of the multimeter should be ten times greater than the AN/USM-491 reading 2 counts. If necessary, adjust R55 (see Figure 5-11) until the multimeter shows the correct reading.

g. Repeat steps d. through f. until further adjustment is not required.

h. Set the control board bit switch to Operate Mode (See Figure 5-10).

5-19. CALIBRATOR ASSEMBLY ADJUSTMENT.

NOTE

This calibration procedure should not be misconstrued with calibration in accordance with TB 43-180.

a. Connect the test equipment as shown in Figure 5-13.

b. Disconnect the power head from the thermistor mount cable.

c. Set up the digital multimeter to measure resistance.

NOTE

Power should not be applied to the power meter when measuring the internal bridge resistance.

(1) Round off the digital multimeter indication to two decimal places and record this value as the internal bridge resistance (R) of the test power meter (approximately 200 ohms).

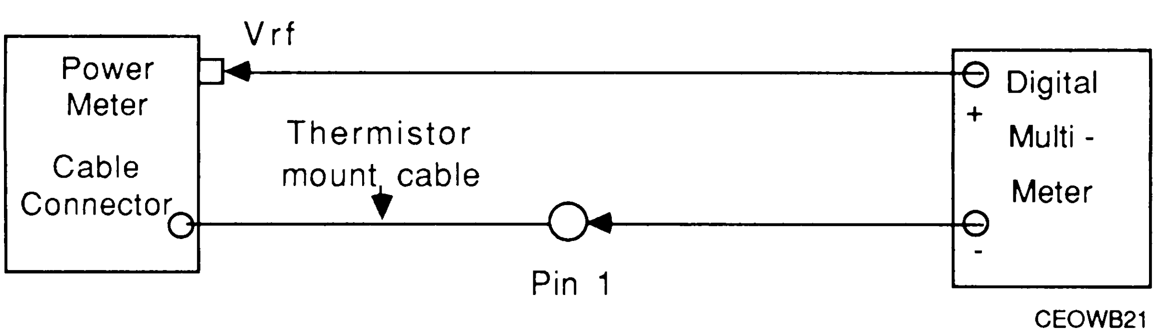


Figure 5-13. Test Setup to Measure the Internal Bridge Resistance of the Power Meter

d. Connect the equipment as shown in Figure 5-14.

e. Set the power meter mount resistance switch to 200 ohms.

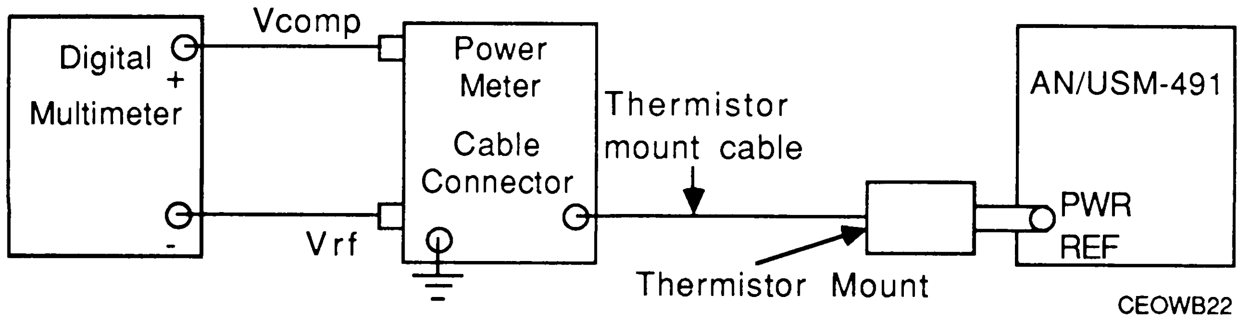


Figure 5-14. Test Setup for Power Reference Measurement "A"

(1) Apply AC power to the AN/USM-491 and the power meter and let the equipment stabilize for at least 30 minutes.

(2) Set the multimeter to read DC volts.

NOTE

The negative lead of the digital multimeter is <u>not</u> connected to ground.

(3) With no RF power applied to the thermistor mount, adjust the coarse zero control on the power meter so that the digital multimeter reading is as close to zero as possible. Ignore the analog meter reading and do not press the fine zero control.

(4) Connect the thermistor mount to the power reference output of the AN/USM-491, taking care to handle only the plastic portions, to reduce the heat effects.

(5) Take a digital multimeter reading and call it "A".

f. Connect the test equipment as shown in Figure 5-15.

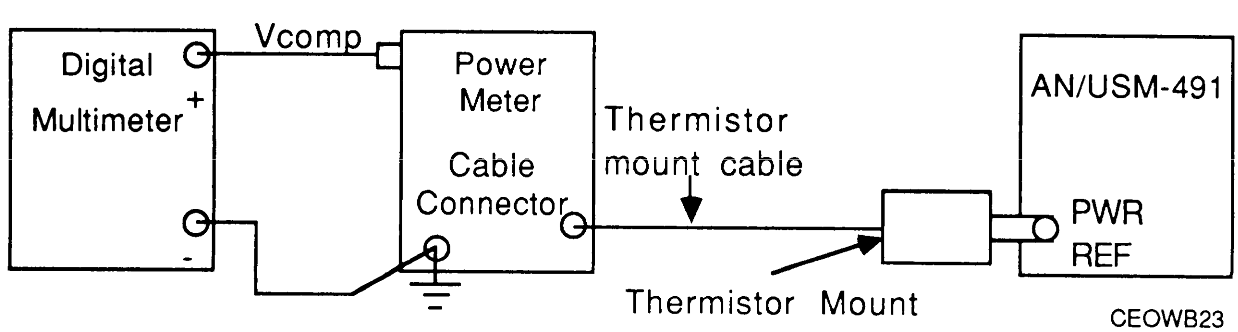


Figure 5-15. Test Setup for Power Reference Measurement "B"

(1) Take a digital multimeter reading and call it "B".

(2) Calculate the power from:

$P = A(2B-A)/4R \times$ Efficiency where A, B, and R are previously recorded values, and the efficiency is supplied with the thermistor mount, at 50 MHz.

g. The power should be between 0.993 and 1.007 mW. If not, complete steps 1 through 4.

(1) Remove the two screws at the rear of the bottom cover.

(2) Slide the bottom cover off.

(3) Remove the 2 bottom trim strip screws.

(4) Lift off bottom trip strip.

(5) Adjust R4 on the calibrator assembly module up or down as required (see Figure 5-16). The analog meter on the power meter may be used as a direction indicator.

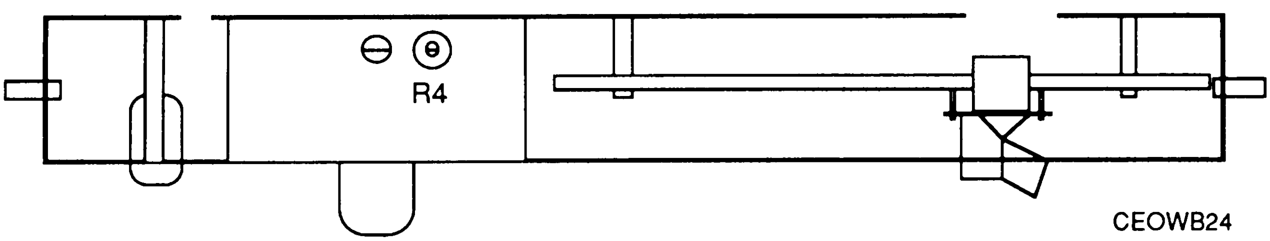


Figure 5-16. Calibrator Assembly Adjustment

h. Repeat steps d(2) through f, and adjust the AN/USM-491 until the reading is acceptable.

i. Connect the

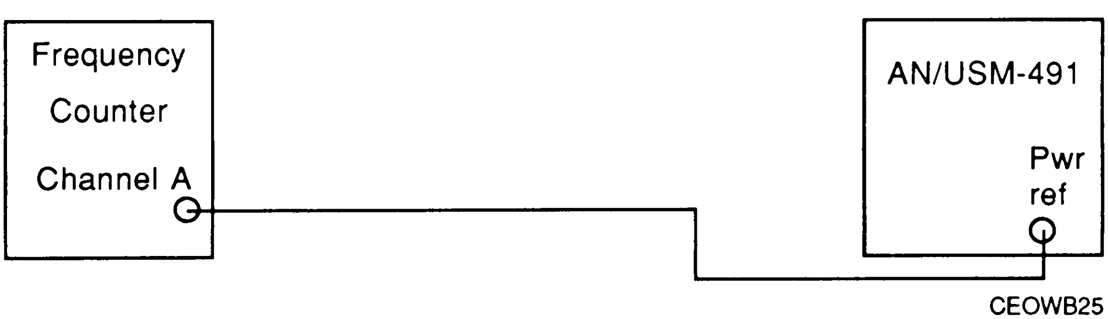


Figure 5-17.

j. The frequency should be 50 MHz (0.5 MHz).

k. Disconnect the test equipment.

l. If removed, reinstall the trim strip and bottom cover. Ensure that the sides and front of the cover are engaged in the slots.

5-20. SENSOR ADJUSTMENTS.

These adjustments are for when the sensor appears to be malfunctioning or sensor data is not available or is suspect. The procedures detailed in paragraphs 5-21 and 5-22 will verify or develop the sensor adjustment and correction data required to match the sensor to the Instrument.

5-21. ADJUSTMENT OF RANGES O THROUGH 4.

NOTE

The numbers that appear on the display in steps 1 and q may be recorded and recentered at a later date for a particular sensor rather than re-doing this procedure. See paragraph 5-23 for the entry procedures (Sensor Replacement).

a. Apply ac power to the AN/USM-491 and test equipment. Set test equipment to no output.

b. Connect the AN/USM-491 to the test equipment as shown in Figure 5-18.

c. Ensure the control board bit switch is set to Operate Mode (see Figure 5-10).

d. Press the ZERO key twice.

e. Press 1, SELECT CHNL, SENSOR NUMBER (1, 2, ETC), SELECT SENS, O, CAL FAC dB, O, REF LVL dB.

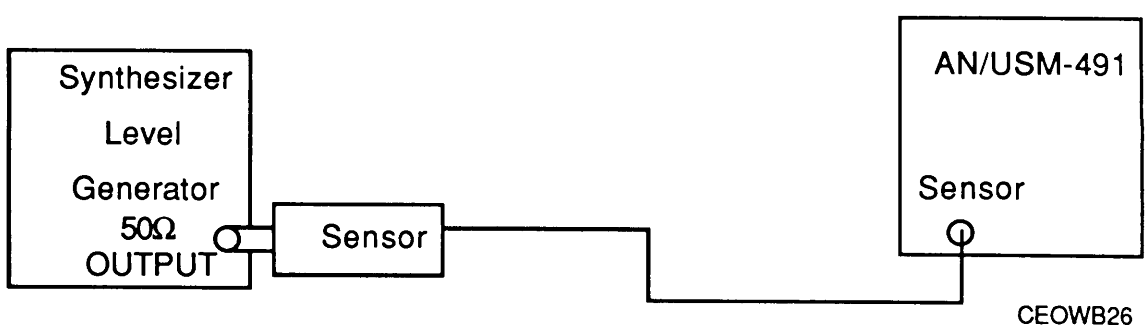


Figure 5-18. Test Setup for Adjustment of Ranges 1 through 4

f. Set the control board bit switch to Calibrate Mode 1 (see Figure 5-10).

g. Press 2, CAL FAC GHz, 1000, CAL FAC dB.

h. Enter the last four digits of the sensor serial number and press dB LIMITS HI, 1000, RANGE AUTO.

i. Set the control board bit switch to Calibrate Mode 2 (see Figure 5-10).

j. Press O and RANGE HOLD.

k. Press the ZERO key. Wait for zeroing to end.

l. Line-by-line, set the level generator and AN/USM-491 as shown in Table 5-2.

Table 5-2. Full Scale Sensor Adjustment Data

synthesizer Level Generator Set to 30 MHz	Press	Allow Settling	Press	Record Display
-34 dBm	O, HOLD, 3, 9, ., 8 0, MODE dB	---	0, dB LIMITS HI, CAL, REF LVL dB	Approx. 5000
-24 dBm	1, HOLD, 3,9, .,8 0, MODE dB	---	0, dB LIMITS HI, CAL, REF LVL dB	Approx. 5000
-14 dBm	2, HOLD, 3, 9, ., 8 0, MODE dB	---	0, dB LIMITS HI, CAL, REF LVL dB	Approx. 5000
-4 dBm	3, HOLD, 3, 9, ., 8 0, MODE dB	---	0, dB LIMITS HI, CAL, REF LVL dB	Approx. 5000
+6 dBm	4, HOLD, 3, 9, ., 8 0, MODE dB	---	0, dB LIMITS HI, CAL, REF LVL dB	Approx. 5000
	5, HOLD, 5, 0, 0 O, REF LVL dB, O, HI	---	THIS LOADS UNUSED STORAGE REGISTERS	
	6, HOLD, 5, 0, 0 O, REF LVL dB, O HI	---	THIS LOADS UNUSED STORAGE REGISTERS	

NOTE

The numbers that appear on the display when the REF dB level is pressed are the upscale adjustment numbers. They may be recorded for later use.

m. Set the level generator to No Output, and allow the sensor to settle for 30 seconds.

n. Set the control board bit switch to Operate Mode (see Figure 5-10).

o. Press RANGE AUTO and MODE PWR.

p. Press ZERO. Wait for zeroing to end.

q. Set the level generator according to Table 5-3. This is the downscale adjustment. Record the LED display readings and compute a correction factor for each range. Note the following examples:

Table 5-3. Downscale Sensor Adjustment Levels

Range	Synthesizer Level Generator	Record Display Reading	Reading should be:	Downscale Correction
1	-30 dBm		1.000μW	
2	-20 dBm		10.00 μw	
3	-10 dBm		100.0 μw	
4	O dBm		1.00 mW	

(1) Example: True reading = 100.O μW, LED display reading = 100.6 μW, Downscale correction = -6

(2) Example: True reading = 10.OO μW, LED display reading = 9.95 μW, Downscale correction = 5

Always use whole numbers when calculating the downscale correction.

NOTE

There is a one-to-one relationship between the counts entered for downscale correction and the resulting correction.

r. Set the control board bit switch to Calibrate Mode 2 (see Figure 5-10).

s. Refer to Table 5-4 and line-by-line enter the downscale correction.

t. Set the control board bit switch to Operate Mode (see Figure 5-10), and press mode dB.

u. Check the AN/USM-491 accuracy for out-of-tolerance conditions at the full scale power levels shown in Table 5-2. Note the following example:

(1) Example: Present upscale gain factor = 5020, Operate Mode input = -24.00 dBm, LED display reading = -24.03 dBm, Difference = 0.03

In the above example the difference is .03 dB low. In dBm Mode, a change of *every* 12 counts in the upscale gain factor causes a .01 dB change. Thus the gain factor for this example would be 5020 + (.03/.01 x 12) = 5056.

Table 5-4. Downscale CorrectIon Data Entry

PRESS
O, RANGE HOLD, O, dB LIMITS HI
1, RANGE HOLD, X, dB LIMITS HI
2, RANGE HOLD, X, dB LIMITS HI
3, RANGE HOLD, X, dB LIMITS HI
4, RANGE HOLD, X, dB LIMITS HI

X Denotes downscale correction

v. If necessary, complete steps (1) through (4) to enter the new gain factors for each range:

(1) Set the control board bit switch to Calibrate Mode 2 (see Figure 5-10).

(2) Press RANGE HOLD.

(3) Press REF LVL dB. The LED display should show a gain factor of 4000 to 6000.

(4) Enter the correction determined in step u. and press REF LVL dB.

5-22. ADJUSTMENT OF RANGES 5 AND 6.

a. Set the control board bit switch to Calibrate Mode 2 (see Figure 5-10).

b. Enter 5000 as the upscale gain factors for range 6 as follows: Press 6, RANGE HOLD, 5, 0, 0,0, REF LVL dB.

c. Enter 5000 as the upscale gain factor on range 5 as follows: Press 5, RANGE HOLD, 5, 0, 0, 0, REF LVL dB.

d. Enter zero as the downscale adjustment factor in range 6 as follows: Press 6, Range Hold, O, dB Limits HI.

e. Enter zero as the downscale adjustment factor on range 5 as follows: Press 5, RANGE HOLD, O, dB Limits HI.

f. Set the control board bit switch to Operate Mode (See Figure 5-10).

NOTE

- Ensure the test equipment has been operating for at least one hour. The RF amplifier in particular must be fully stable for the following steps.
- Cables should not be used between the generator, attenuator, or sensor.

g. Measure the exact value of the 20 dB attenuator.

NOTE

Steps (1) through (5) may be skipped if the attenuation value is known to within .02 dB. If the attenuator has been measured at DC, this figure may be used at 30 MHz.

(1) Connect the test equipment as shown in Figure 5-19. Set the level generator for 0 dBm at 30 MHz.

(2) Press the CAL key.

(3) Connect the equipment as shown in Figure 5-20.

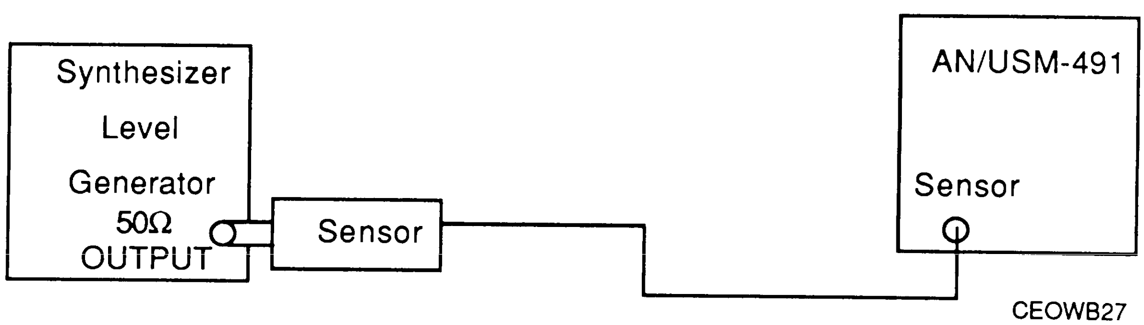


Figure 5-19. Test Setup for Attenuator Measurement Reference

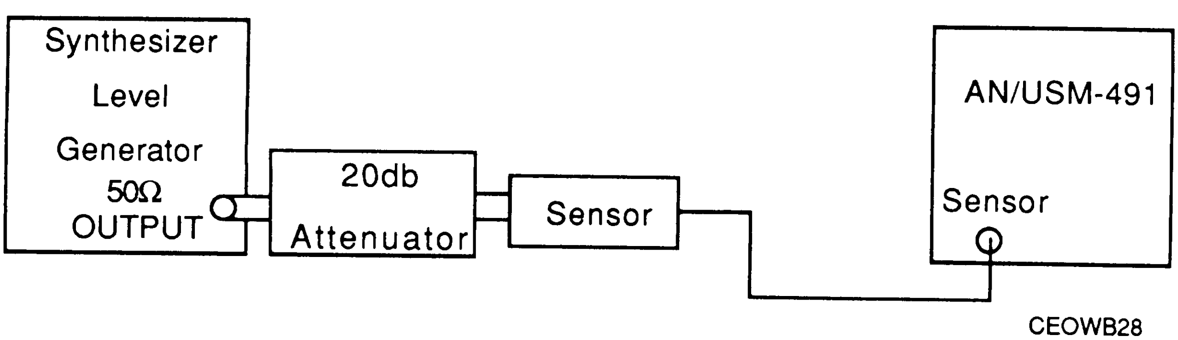


Figure 5-20. Test Setup for Attenuator Measurement "A"

(4) Record the attenuator value on the LED display and call it "A".

h. Upscale range 5 adjustment.

CAUTION

The RF amplifier has enough power to burn out the sensor if driven hard enough. The equipment should always be connected with the level generator in standby or with the level set very low (below -40 dBm). Never apply power to the RF amplifier when there is no load connected to it.

(1) Set the control board bit switch to operate mode (see Figure 5-10).

(2) Connect the equipment as shown in Figure S-21. Set the level generator for -40 dBm at 30 MHz. Tune the RF amplifier to 30 MHz.

NOTE

The RF amplifier must be fully stable. Allow at least one hour warm up time.

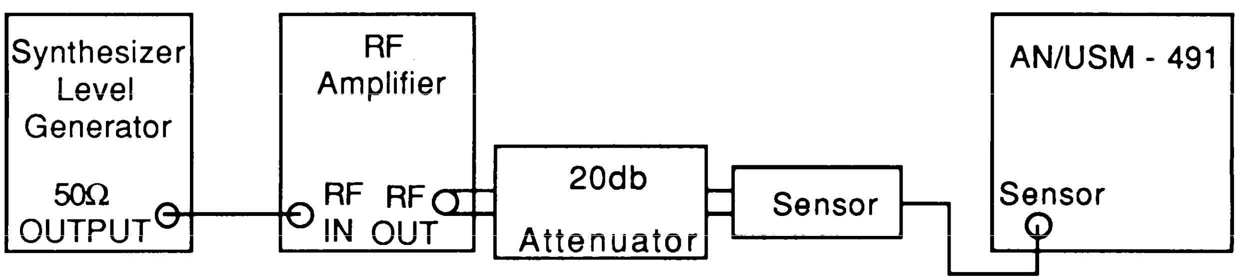


Figure 5-21. Test Setup for Upscale Range 5 Measurement "B" and Upscale Range 6 Measurement "C"

(3) Bring the generator power level up slowly until the LED display reads as close to O dBm as possible (-0.5 to +0.5 dBm is acceptable). Record the LED display and call it "B".

(4) Turn off the level generator output and remove the attenuator so the equipment is connected as shown in Figure 5-22. Turn on the level generator to the same power level it was before. The LED display should be equal to: Display = B + Attenuation (A) ±O.18 dB.

Example: if B is -0.21 dBm, Attenuation (A) is 20.32, the display should be equal to 20.11 dBm, within fO.18 dB.

NOTE

If the LED display is not correct perform steps 5 through 12. If it is correct go to paragraph i.

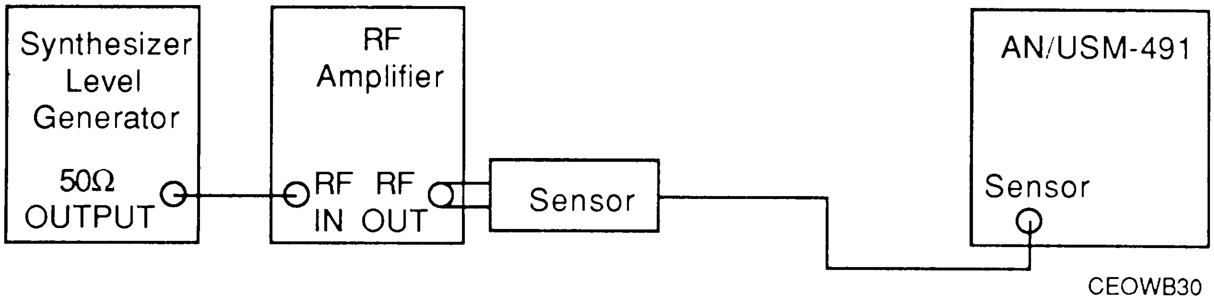


Figure 5-22. Upscale Range 5 and 6 Adjustment

(5) Leaving the level generator on, set the control board bit switch to calibrate mode 2 (See Figure 5-10).

(6) Press 5, Range Hold, REF LVL dB.

(7) The number on the display is the upscale gain factor for this range.

(8) To correct the power reading obtained in step 4, the gain factor should be adjusted up or down approximately 12 counts for every .01 dB that the power reading was off.

(9) Press 5, Range Hold, New # (upscale gain factor +(1200 x error in dB), REF LVL dB.

(10) Set the control board bit switch to the operate mode. (See Figure 5-10.)

(11) Repeat step (4) above.

(12) Repeat steps (5) through (11) until the upscale power reading is within .02 dB of the correct reading.

i. Downscale range 5 adjustment.

(1) Set the control board bit switch to operate mode (See Figure 5-10).

(2) Connect the equipment as shown in Figure 5-22 and set the level generator to +10 dBm. Take a power reading in dBm mode. The LED display should be +10 dBm ±0.08 dBm.

NOTE

If the LED display is not correct perform steps (3) through (8) below. If it is correct go to paragraph j.

(3) Set the control board bit switch to calibrate Mode 2 (See Figure 5-10).

(4) Press 5, Range Hold, dB limits HI.

(5) Note the LED display. Increase or decrease this value in increments of 5 or 10 counts, in a direction to increase or decrease the downscale reading obtained in step H-2. Enter the number.

(6) Press 5, dB Limits HI.

(7) Return the bit switch to the operate mode (See Figure 5-10) to see the effect on the power reading.

(8) Repeat the adjustment as necessary.

NOTE

If the downscale adjustment was changed by more than 20 counts repeat step g.

j. Upscale range 6 adjustment.

(1) Set the control board bit switch to the operate mode (see Figure 5-10).

(2) Connect the equipment as shown in Figure 5-21 using the 20 dB attenuator and set the level generator for -40 dBm at 30 MHz. Tune the RF amplifier to 30 MHz for a maximum indication on the AN/USM-491 analog meter.

(3) Bring the generator power level up slowly until the LED display reads +9.00 dBm. Record the LED display and call it "C".

(4) Turn off the generator output and remove the attenuator so the equipment is connected as shown in Figure 5-22. Turn on the level generator to the same power level it was before. The LED display should be equal to: Display = C + Attenuation (A) ±0.18 dB.

Example: If C is 8.60 dBm, Attenuation (A) is 20.32, the reading should be equal to 28.92 dBm, within ± 0.18 dB.

NOTE

If the LED display is not correct perform steps 5 through 12. If it is correct go to paragraph j.

(5) Set the control board bit switch to Calibrate Mode 2 (See Figure 5-10).

(6) Press 6, Range Hold, REF LVL dB.

(7) The number on the display is the upscale gain factor for this range.

(8) To adjust the power reading obtained in step 4, the gain factor should be adjusted up or down approximately 12 counts for every .01 dB that the Power reading was off. New # = old # ± (1200 x dB off).

(9) Press 6, Range Hold, New #, REF LVL dB.

(10) Set the control board bit switch to the operate mode. (See Figure 5-10.)

(11) Repeat step (4) above.

(12) Repeat steps (5) through (11) until the power reading is within .08 dB.

k. Downscale range 6 adjustment.

(1) Set the control board bit switch to the operate mode (See Figure 5-10).

(2) Connect the equipment as shown in Figure 5-21.

(3) Bring the generator level up slowly until the LED display reads +3 dBm. Retune the RF amplifier as necessary for a maximum indication on the AN/USM-491 analog meter. Record the LED display and call it "D".

(4) Turn off the generator output and remove the attenuator so the equipment is connected as shown in Figure 5-22. Turn on the generator to the same level it was before. The LED display should be equal to D + Attenuation (A). The steps below will correct this if it is not.

(5) Set the control board bit switch to Calibrate Mode 2 (See Figure 5-10).

(6) Press 6, Range Hold, dB Limits HI.

(7) Note the reading on the LED display. Increase or decrease this value in increments of 5 or 10 counts, in a direction to increase or decrease the downscale reading obtained in step j (4). Enter the number.

(8) Press 6, dB Limits Hi.

(9) Return to operate mode (See Figure 5-10) to see the effect on the power reading.

(10) Repeat the adjustment as necessary.

NOTE

If the downscale adjustment was changed by more than 20 counts repeat step j.

(11) Return the bit switch to operate mode. (See Figure 5-10.)

5-23. SENSOR REPLACEMENT ADJUSTMENTS.

NOTE

This calibration procedure should not be misconstrued with calibration in accordance with TB 43-180.

a. When a sensor is replaced, the calibration data for the new sensor must be loaded into the instrument. The data is in two forms:

(1) Sensor low frequency gain data (upscale and downscale data for each range, total of 14 points).

(2) Sensor high frequency CAL FAC, for up to 20 frequency points.

b. Enter the calibration data with the following procedure.

NOTE

No test equipment is required to load this data in.

(1) Remove the two screws at the rear of the top cover.

(2) Slide the top cover off.

(3) Apply AC power to the AN/USM-491.

(4) Set the control board bit switch to calibrate mode 1 (see Figure 5-10).

(5) Press 1, SELECT SENS, last four digits of the serial number of the sensor, dB limits HI, 1000, CAL FAC dB, 2, CAL FAC GHz.

(6) Set the control board bit switch to Calibrate Mode 2 (see Figure 5-10).

NOTE

The upscale and downscale data points are on the sensor data sheet as supplied by the vendor, or have been stored as a result of a previous calibration. There are 7 upscale and 7 downscale points (one each for each range).

(7) Enter the low frequency gain data by setting the AN/USM-491 as listed in Table 5-5. The data may be entered by doing the left column first (upscale data) and then the right column, or by doing each range as a set (left to right).

NOTE

NNNN is the upscale number
NN is the downscale number

(8) Enter the high frequency calibration factors by setting the AN/USM-491 as listed in Table 5-6 working left to right.

NOTE

The Sensor High Frequency calibration factors are on the sensor decal.

(9) When all high frequency calibration factors have been entered press O and RANGE AUTO.

Table 5-5. Sensor Low Frequency Gain Data

Range	Upscale	Downscale
0	O, Range HOLD, NNNN, Ref LVL dB	NN, CHS (if a negative number), dB limits HI
1	1, Range HOLD, NNNN, Ref LVL dB	NN, CHS (if a negative number), dB limits HI
2	2, Range HOLD, NNNN, Ref LVL dB	NN, CHS (if a negative number), dB limits HI
3	3, Range HOLD, NNNN, Ref LVL dB	NN, CHS (if a negative number), dB limits HI
4	4, Range HOLD, NNNN, Ref LVL dB	NN, CHS (if a negative number), dB limits HI
5	5, Range HOLD, NNNN, Ref LVL dB	NN, CHS (if a negative number), dB limits HI
6	6, Range HOLD, NNNN, Ref LVL dB	NN, CHS (if a negative number), dB limits HI

Table 5-6. Sensor High Frequency Calibration Factors

Entry Number		GHz Frequency			
o	RANGE AUTO	0	CAL FAC GHz	0	CAL FAC dB
1	RANGE AUTO	1	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
2	RANGE AUTO	2	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
3	RANGE AUTO	3	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
4	RANGE AUTO	4	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
5	RANGE AUTO	5	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
6	RANGE AUTO	6	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
7	RANGE AUTO	7	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
8	RANGE AUTO	8	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
9	RANGE AUTO	9	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
10	RANGE AUTO	10	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
11	RANGE AUTO	11	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
12	RANGE AUTO	12	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
13	RANGE AUTO	13	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
14	RANGE AUTO	14	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
15	RANGE AUTO	15	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
16	RANGE AUTO	16	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
17	RANGE AUTO	17	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
18	RANGE AUTO	18	CAL FAC GHz	N.NN (CHS)	CAL FAC dB
0	RANGE AUTO				

(10) Set the control board bit switch to Operate Mode (see Figure 5-10).

(11) Slide the top cover into its slots. Ensure the sides and front of the cover are engaged in its slots.

(12) Install two screws at the rear of the top cover.

5-24. TROUBLESHOOTING PROCEDURES.

a. The following troubleshooting procedure chart, Table 5-7, identifies malfunctions that may occur to the AN/USM-491. The troubleshooting chart states:

(1) The indication or symptom of the trouble.

(2) The instructions necessary, including test hookups with illustrations, to determine the cause.

(3) The action necessary to restore the AN/USM-491 to operating condition.

b. Indications for tests number 1, and 3 through 8 are normally found while performing the operator checkout and do not require external test equipment.

c. Tests 9 through 25 require external test equipment to perform.

(1) Corrective/repair actions are limited to the replacement of boards, modules, and the rear panel assembly.

5-25. DISASSEMBLY/ASSEMBLY.

The following paragraphs provide step-by-step procedural instructions for removal and installation of the AN/USM–491 major assemblies.

5-26. REMOVAL OF IEEE-488 INTERFACE BOARD A23. (Figure 5-29 on page 5-51))

WARNING

Ensure electrical power is disconnected to prevent electrical shock to personnel or damage to equipment.

a. Disconnect the ac power line from the ac power source.

CAUTION

This instrument contains electrostatic discharge sensitive (ESDS) devices. Special handling methods and materials must be used to prevent equipment damage. Refer to electrostatic discharge sensitive device procedures, pages C and D of this manual, before performing maintenance on the equipment.

NOTE

Go to page 5-50 for paragraph 5-26b.

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
		WARNING High voltage is present in this instrument if electrical power is connected. Death on contact may result if personnel fail to observe safety precautions. **CAUTION** This instrument contains electrostatic discharge sensitive (ESDS) devices. Special handling methods and materials must be used to prevent equipment damage. Refer to electrostatic discharge sensitive device procedures, pages C and D of this manual, before performing maintenance on the equipment.		
1	No LED display, no analog meter movement when the line switch is placed to the ON position.	(a) Verify AC power source.	Test 1b	Connect to a valid AC power source.
		(b) Verify the LINE VOLTAGE selector switch is selected to the correct setting.	Tests 2 and 11	Select correct setting.
2	All malfunctions	Remove the top and bottom covers and inspect all assemblies for the following: (a) foreign material (b) unseated integrated circuits (c) unseated transistors (d) unseated connectors (e) broken leads (f) scorched components (g) loose hardware	Test 9	Remove, reseat, repair or replace as necessary.

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, of Test Fails
3	LED display incorrect.	Perform Test 9.	N/A	
4	dBm and/or CH1 indicators do not light.	Perform Test 9.	N/A	
5	Instrument does not zero	Perform Test 9.	N/A	
6	With the sensor connected to the PWR REF connector the LED display is incorrect	Press the CAL key and perform operator checkout paragraph 4-4b(8) and 4-4b(16).	Perform paragraph 4-4b(17)	Perform Test 7.
7	MODE PWR check incorrect	Connect a known good sensor.	N/A	Replace sensor, perform paragraph 5-23.
8	Sensor replacement does not correct MODE PWR check	Perform Test 9.	N/A	Perform Test 8.

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
9		Verify test set adjustments. Perform the adjustment procedures. Refer to paragraph 5-13 through 5-23. Some of the software correction data that is stored in non-volatile RAM can affect the readings to a degree where the instrument will not work.	Proceed to step 20.	Remove and replace defective component as identified in steps 10 through 19.
		NOTE Test #10 through Test #19 are a troubleshooting guide to correct malfunctions encountered while performing the adjustment procedures.		
10	The power supply test points are of the improper value and cannot be adjusted to the correct value	(a) Disconnect power supply plugs P-4, P-5, P-6, P-7 and P-10. Recheck voltage test points. Refer to paragraph 5-15.	Test 10b	Perform Test 11.
		(b) Connect P-4. Recheck voltage test points.	Test 10c	Replace control board A5. Refer to paragraph 5-28 and 5-29.
		(c) Connect P-5. Recheck voltage test points.	Test 10d	Replace display board A2. Refer to paragraph 5-38 and 5-39.
		(d) Connect P-6. Recheck voltage test points.	Test 10e	Repair short in wire or clean recorder connection.
		(e) Connect P-7. Recheck voltage test points.	Test 10f	Replace input board A6. Refer to paragraph 5-34 and 5-35.

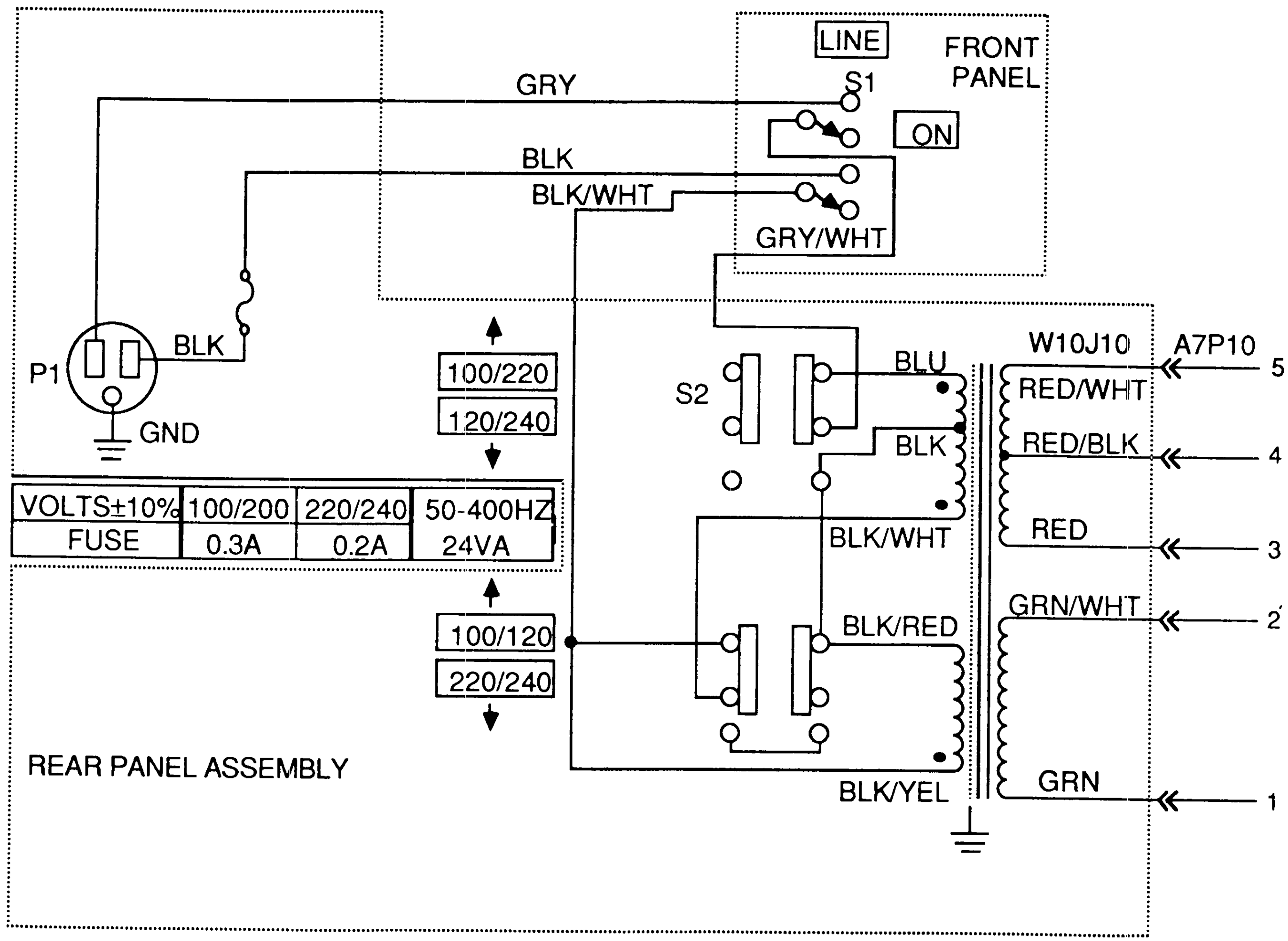
Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
		(f) Connect P-10. Recheck voltage test points.	Test 11a and 11d	Replace IEEE board A-23. Refer to paragraph 5-26 and 5-27.

WARNING

High voltage is present in this instrument if electrical power is connected. **Death on contact** may result if personnel fail to observe safety precautions.

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
11	No voltage indication at the power supply test points	(a) Turn the line switch to OFF and unplug the AN/USM-491 from the power source.		
		(b) Measure the rear panel fuse for continuity with the digital multimeter.	Test 11c	Replace fuse.
		(c) Measure the power cord for continuity with the digital multimeter.	Test 11d	Replace power cord.
		(d) Measure continuity of line switch S1, voltage selector switch S2, and interconnecting wiring by connecting the ohmmeter to the input pins of P1.	Test 11e	Replace rear panel assembly. Refer to paragraph 5-40 and 5-41.
		(e) Disconnect the transformer plug P1 from the power supply board.		
		(1) Set the digital multimeter to read AC volts and connect it to pins 1 and 2 of the plug.		
		(2) Connect the power cord to the AC voltage source and turn the AN/USM-491 line switch on. The AC voltage reading should be 9.5 VAC (1.4V).	Test 11e (3)	Replace the rear panel assembly. Refer to paragraph 5-40 and 5-41.



NOTES:
1. ☐ DENOTES EXTERNAL MARKINGS

CEOWB31

Figure 5-23. Rear Panel Assembly, Schematic Diagram

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
11 cont'd		(3) Connect the digital multimeter to pins 3 and 5 of the transformer plug. The AC voltage reading should be 34 VAC (±5.0V).	Replace power supply board A7. Refer to paragraph 5-30 and 5-31.	Replace the rear panel assembly. Refer to paragraph 5-40 and 5-41.
12	Cannot adjust the input board test point TP9 to the correct value with TP7 and/or TP8 connected to ground	None	None	Replace the input board A6. Refer to paragraph 5-34 and 5-35.
13	The voltage reading at input board TP5 is incorrect	None	None	Replace the input board A6. Refer to paragraph 5-34 and 5-35.

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
14	The voltage reading at input board TP9 (with the grounding clips removed from TP7 and TP8) cannot be adjusted to the correct level with R4 and R5 on the chopper assembly	(a) Remove the input shield. (b) Connect the test equipment as shown in Figure 5-24. (c) Set the voltage calibrator to 1 VDC. (d) Set the oscilloscope to 0.2V per division and 5 msec per division. (e) Connect the oscilloscope probe to the end of R18 and then R19 away from the chopper assembly. See Figure 5-25. (f) On both R18 and R19 the oscilloscope should display a square wave of +/-0.45V (0.9V peak to peak).	Replace input board A6. Refer to paragraph 5-34 and 5-35.	Perform Test 14f.

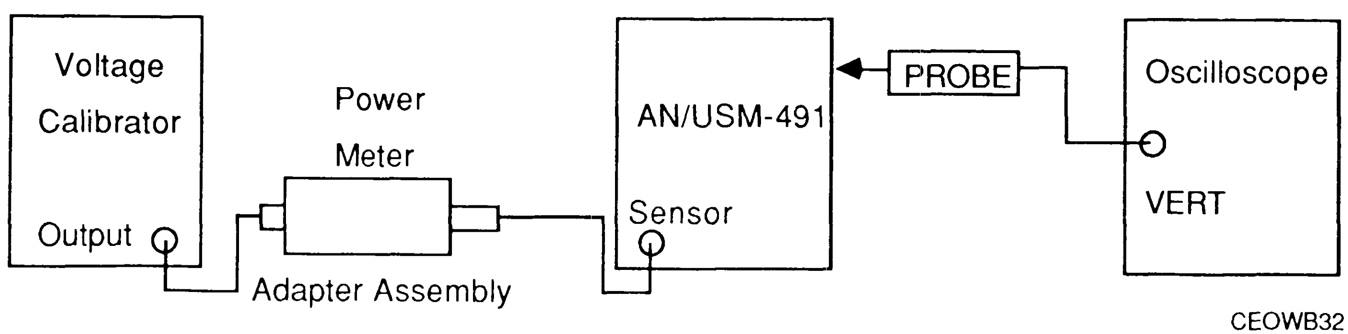


Figure 5-24. Test Setup for Chopper Assembly and Input Board Troubleshooting

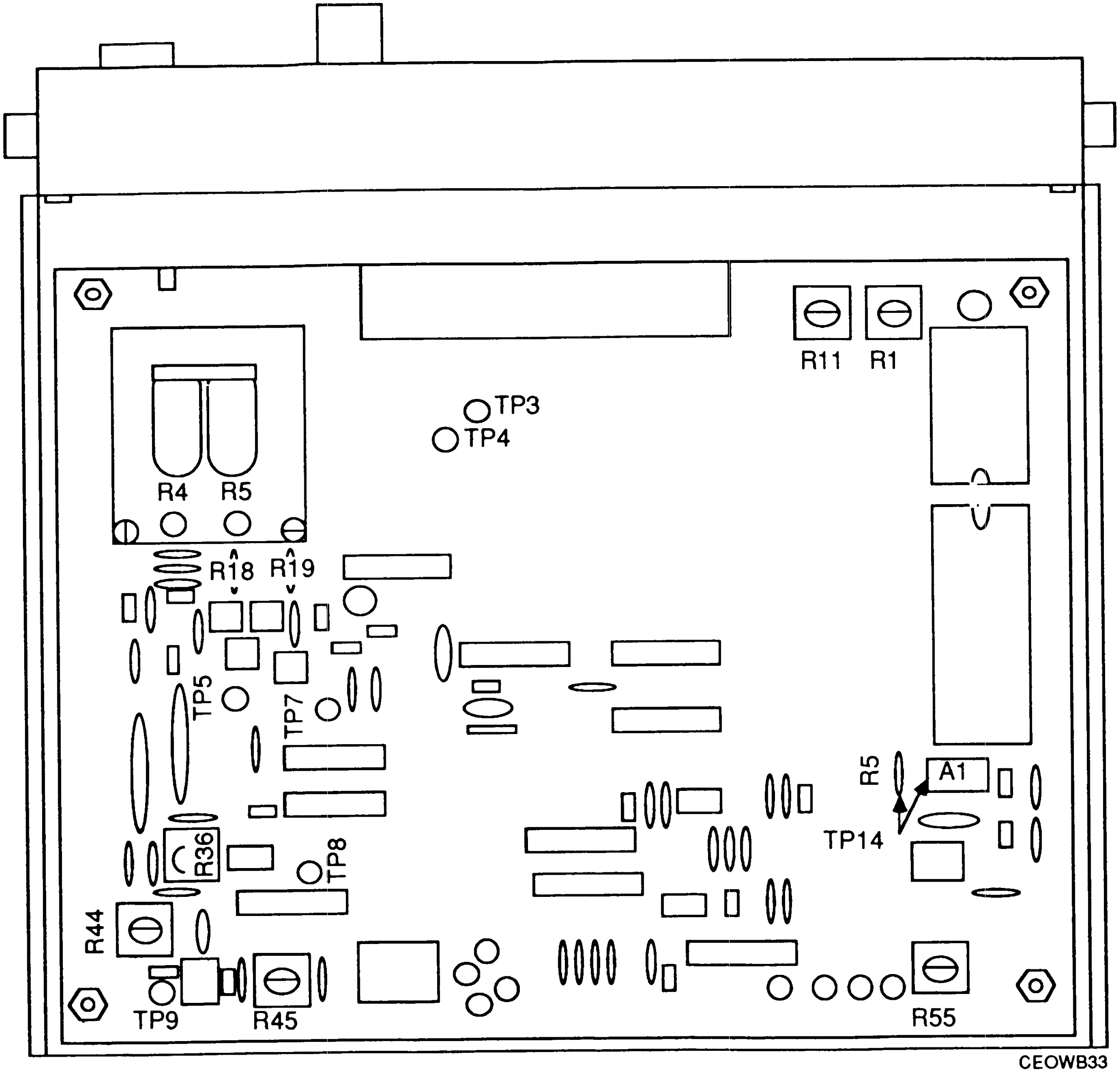


Figure 5-25. Chopper Assembly and Input Boards Test Points

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
14 cont'd		(g) Set the oscilloscope to 2.0V per division and 5 msec per division. (h) Connect the oscilloscope probe to TP3 and then TP4 of the input board (See Figure 5-25). Both test points should display a +/-5V square wave (10V peak to peak).	Replace the chopper module A4. Refer to paragraph 5-32 and 5-33.	Replace the input board A6. Refer to paragraph 5-34 and 5-35.
15	LED displays invalid characters or is locked up	(a) Connect the test equipment as shown in Figure 5-26. (b) Set the level generator to 30 MHz with an output of between 0 to 10 dBm.		

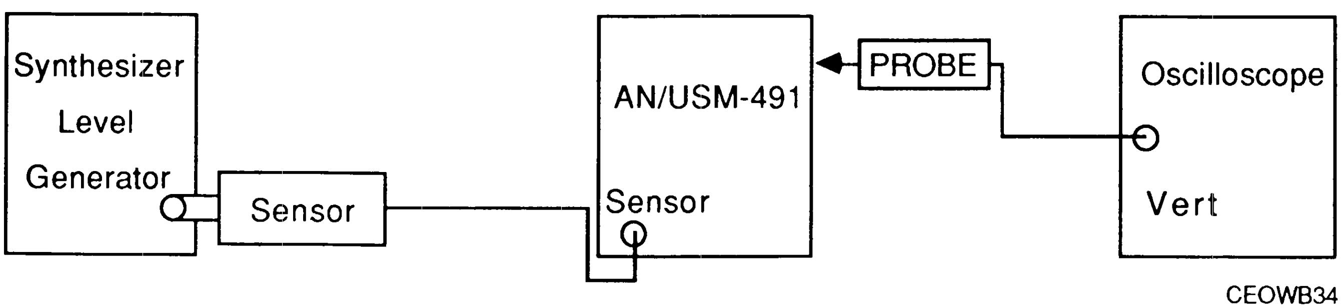


Figure 5-26. Test Setup for when the LED Displays Invalid Character or is Locked Up

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
		(c) Set the oscilloscope to 2 volts per division and 0.2 msec per division. (d) Remove the input shield (if installed).		

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
		(e) With the oscilloscope, look at the signal on the input board at pin 6 of A1 (TP14) or at the rear side of R5 (see Figure 5-25). (f) There should be repetitive staircase waveforms with each staircase alternating up and down every few steps.	Perform test 24.	Replace control board A5. Refer to paragraph 5-28 and 5-29.
16	When performing Table 5-1, DC calibration test, some (not all) ranges fail. Display is okay.	None	N/A	Replace input board A6. Refer to paragraph 5-34 and 5-35.
17	Recorder output voltage incorrect after adjustment.	None	N/A	Replace input board A6. Refer to paragraph 5-34 and 5-35.
18	Cannot obtain a power reference output of between 0.993 and 1.007 mW by adjusting R-4 on the calibrator assembly.	None	N/A	Replace the calibrator assembly. Refer to paragraph 5-36 and 5-37.

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
19	The power reference frequency is not between 49.5 MHz and 50.5 MHz when checked with the frequency meter.	None	N/A	Replace the calibrator assembly. Refer to paragraph 5-36 and 5-37.

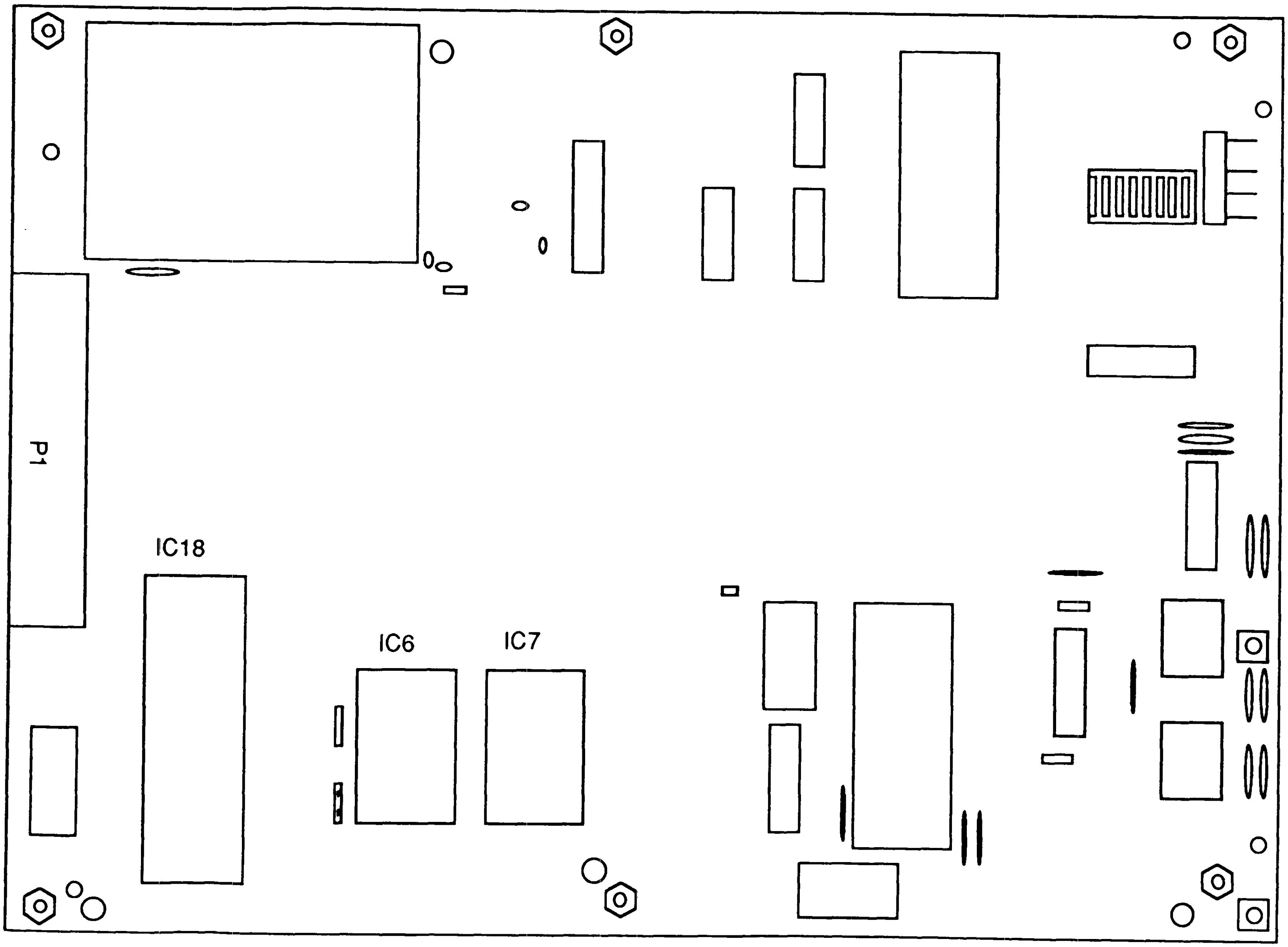
NOTE

If the malfunction was not identified while performing the adjustment procedures, the trouble may be isolated with the following procedures. The control board affects the operation of both the input board and the display board. The tests are designed to isolate faulty input and display boards by elimination of the control board as a problem. Testing should begin with Test 20.

20	When performing Table 5-1, DC calibration test, some (not all) ranges fail. Display is okay.	HOLD Range test. This is a quick test of the basic control board operation and the display board. (a) Set the control board bit switch to CAL mode 2 (See Figure 5-10). (b) Press 5, Range Hold, Range Hold. (c) The LED displays should indicate 0005, blinking.	Perform Test 21.	Perform Test 24.

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
21		Display Test (a) Turn the AN/USM-491 line switch to "OFF". (b) Remove the IEEE board to gain access to the control board. (c) Remove IC6 and IC7 from the control board. (See Figure 5-27.) (d) Install the diagnostic ROM Part No. 53433200A from kit 96101001A into the IC6 socket, observing pin 1 orientation. (e) Set the control board BIT switch as follows: 1 2 3 4 5 6 7 8 O O C O O C C O (f) Turn the AN/USM-491 line switch to "ON". (g) The LED should display in succession: All zeros All ones through all nines All decimal points All left LEDs All middle LEDs All right LEDs and minus sign Repeat of above.	Perform Test 22.	Perform Test 24.
22		Keyboard test (a) The diagnostic ROM is still installed as in test 21. (b) Set the control board BIT switch to the following: 1 2 3 4 5 6 7 8 C C O C C C C O		



CEOWB35

Figure 5-27. Location of IC6, IC7, IC18, and P1 on the Control Board

Table 5-7. Troubleshooting Procedures

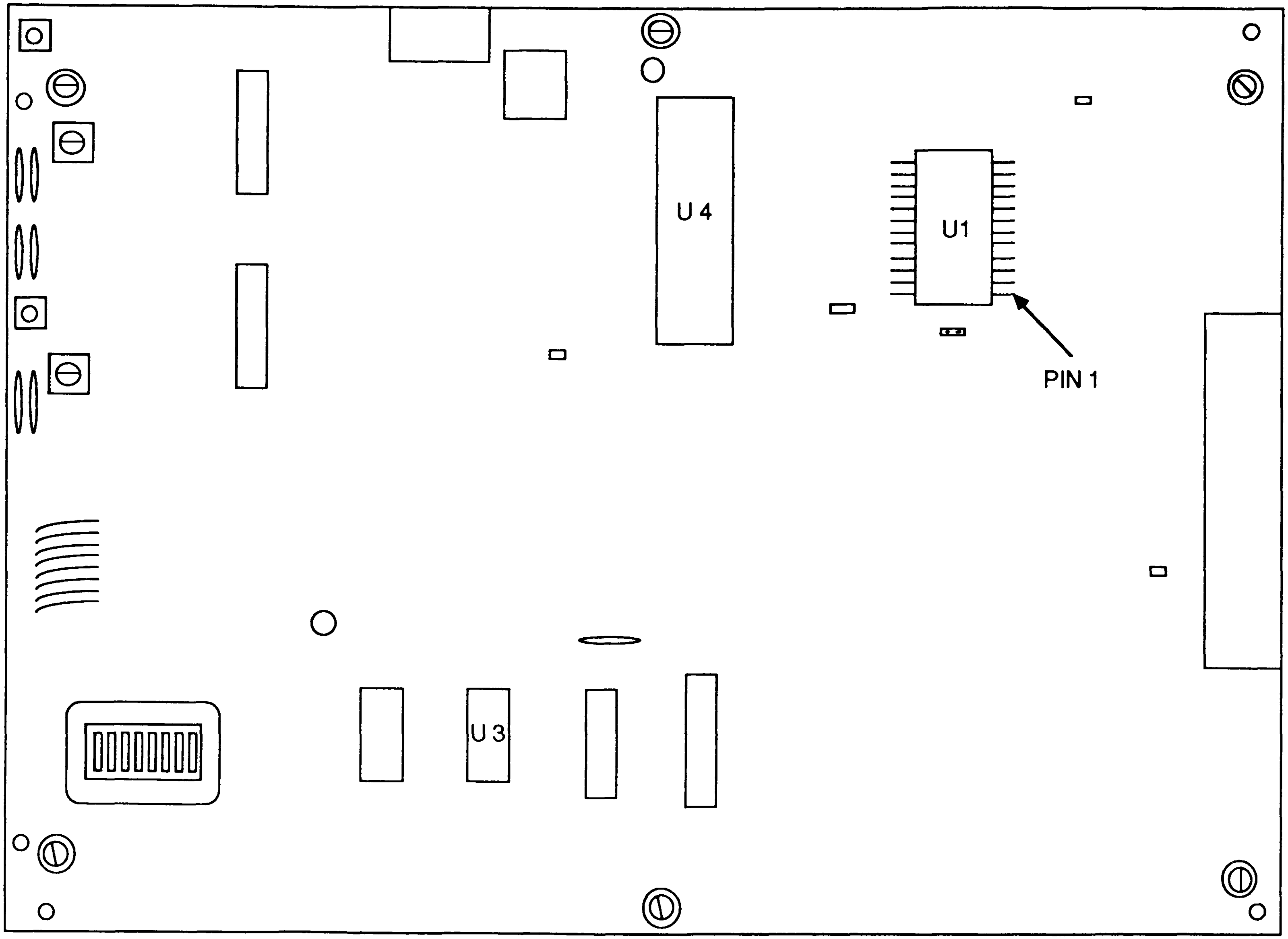
Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
22 cont'd		(c) Press any key and note the LED display. (d) A different number should appear for each key pressed.	Perform Test 23.	Perform Test 24.
23		Data writes into input board test. (This test checks the data and address lines going from the control board to the input board.) (a) The diagnostic ROM is still installed as in tests 21 and 22. (b) The oscilloscope is required for this test. (c) The best access to these signals is on P1 of the control board. (See Figure 5-27.) (d) Look for pulse width of any duration, 0 (0 to .45 VDC max) or +5 VDC (2.5 min to 5.2 VDC max) on pins 1 through 19 and on pin 32. A line with no pulse activity indicates something is wrong with the control board.		Replace the control board A5. Refer to paragraph 5-28 and 5-29.
		(e) If this test 23 is correct and tests 20,21, and 22 were correct there is a problem in the input board.	Replace the input board A6. Refer to paragraph 5-34 and 5-35.	

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
24		Control Board Test (a) This test may be performed with either the diagnostic or the normal operating ROMs in place on the control board. (b) The oscilloscope is required for this test. (c) Remove the IEEE interface board if installed. (d) Check the signals at IC18 on the control board (see Figure 5-27) for the signals described below (frequencies shown should match to ±15%). PIN SIGNAL 23 3.3 KHz Rectangular Waveform 28 Pulses 29 Pulses 30 Pulses 31 Pulses 32 1.6 KHz Square Wave 33 830 Hz Square Wave 34 420 Hz Square Wave 1 Pulses at 2 msec interval (hold the dB Low Limits key for this test).		
		(e) If any of the signals are incorrect the control board is bad.		Replace the control board A5. Refer to paragraph 5-28 and 5-29.
		(f) If all signals are correct the display board is bad.		Replace the display board A2. Refer to paragraph 5-38 and 5-39.

Table 5-7. Troubleshooting Procedures

Test No.	Indication	Test Procedure	If correct, Perform	Repair Action, if Test Fails
25	Remote (IEEE) operation fails, local operation okay.	(a) The oscilloscope is required for this test. (b) Check for input signals to U3 pin 1 and U4 pin 4 (see Figure 5-28). There should be activity on these pins at all times. (c) Check for random input signals to U1 pins 1 through 8, 19, 22 and 23. There may not be activity on all pins at all times but there should be some.	Replace the IEEE interface board A23. Refer to paragraph 5-26 and 5-27.	Perform Test 20.



CEOWB36

Figure 5-28. IEEE Interface Board Test Points

b. Remove the two screws at the rear of the top cover.

c. Slide the top cover off to expose the IEEE interface board.

d. Disconnect the edge card connector P1 (1) from the interface board.

e. Disconnect the four pin connector P2 (2).

f. Remove the six screws (3) from the board.

g. Remove the interface board.

5-27. INSTALLATION OF IEEE-488 INTERFACE BOARD A23. (Figure 5-29)

a. Connect the edge card connector to the board at P1 (1).

b. Install the interface board with six screws (3).

c. Connect the four pin connector to the board at P2 (2).

d. Slide the top cover into its slots. Ensure the sides and front of the cover are in the slots.

e. Install two screws at the rear of the top cover.

NOTE

There are no adjustments required for the interface board.

f. Perform the performance tests as directed by the remote controller equipment.

5-28. REMOVAL OF CONTROL BOARD A5. (Figure 5-30)

WARNING

Ensure electrical power is disconnected to prevent electrical shock to personnel or damage to equipment.

a. Disconnect the ac power line from the ac power source.

CAUTION

This instrument contains electrostatic discharge sensitive (ESDS) devices. Special handling methods and materials must be used to prevent equipment damage. Refer to electrostatic discharge sensitive device procedures, pages C and D of this manual, before performing maintenance on the equipment.

b. Remove the two screws from the rear of the top cover.

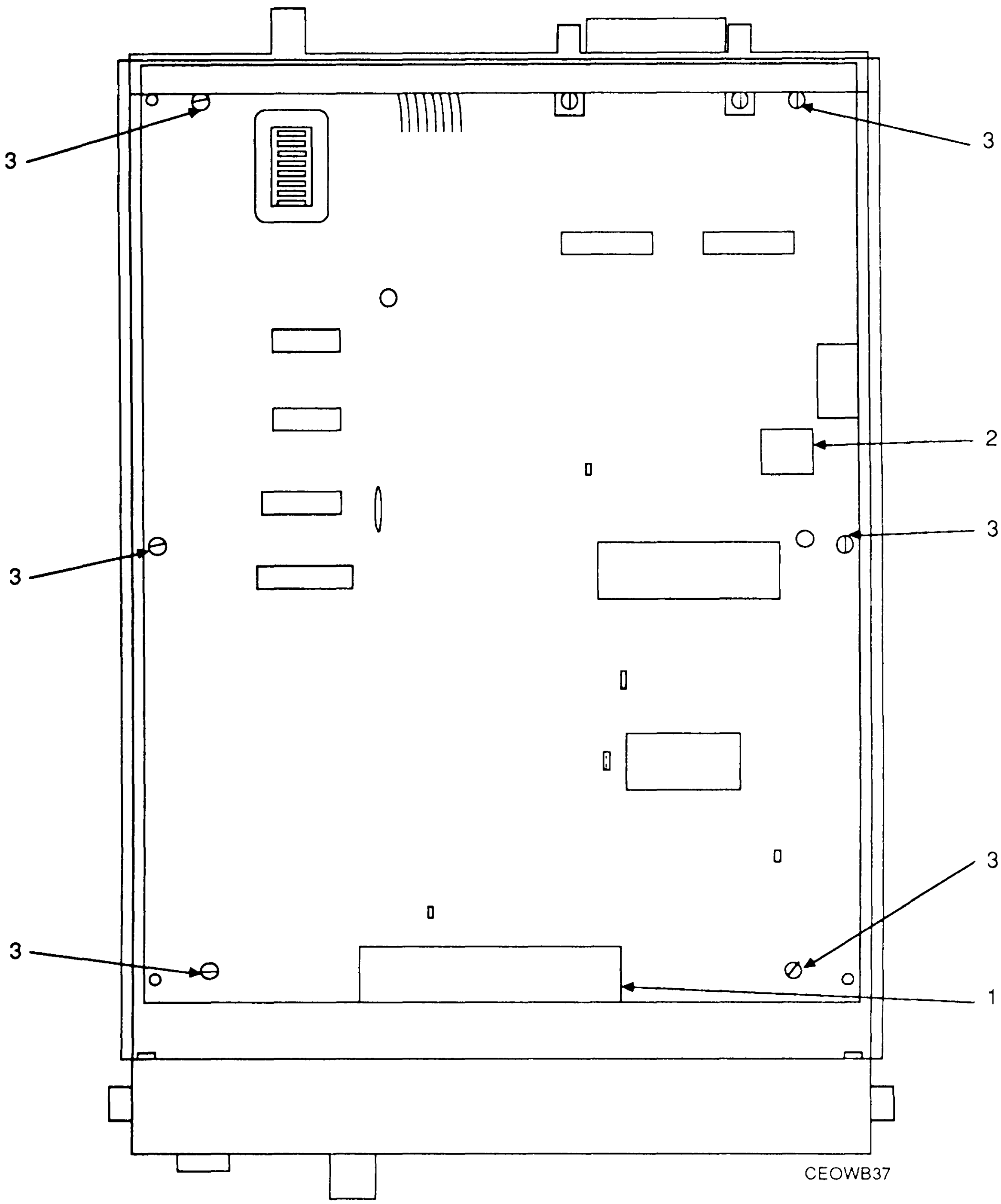


Figure 5-29. IEEE-488 Interface Board

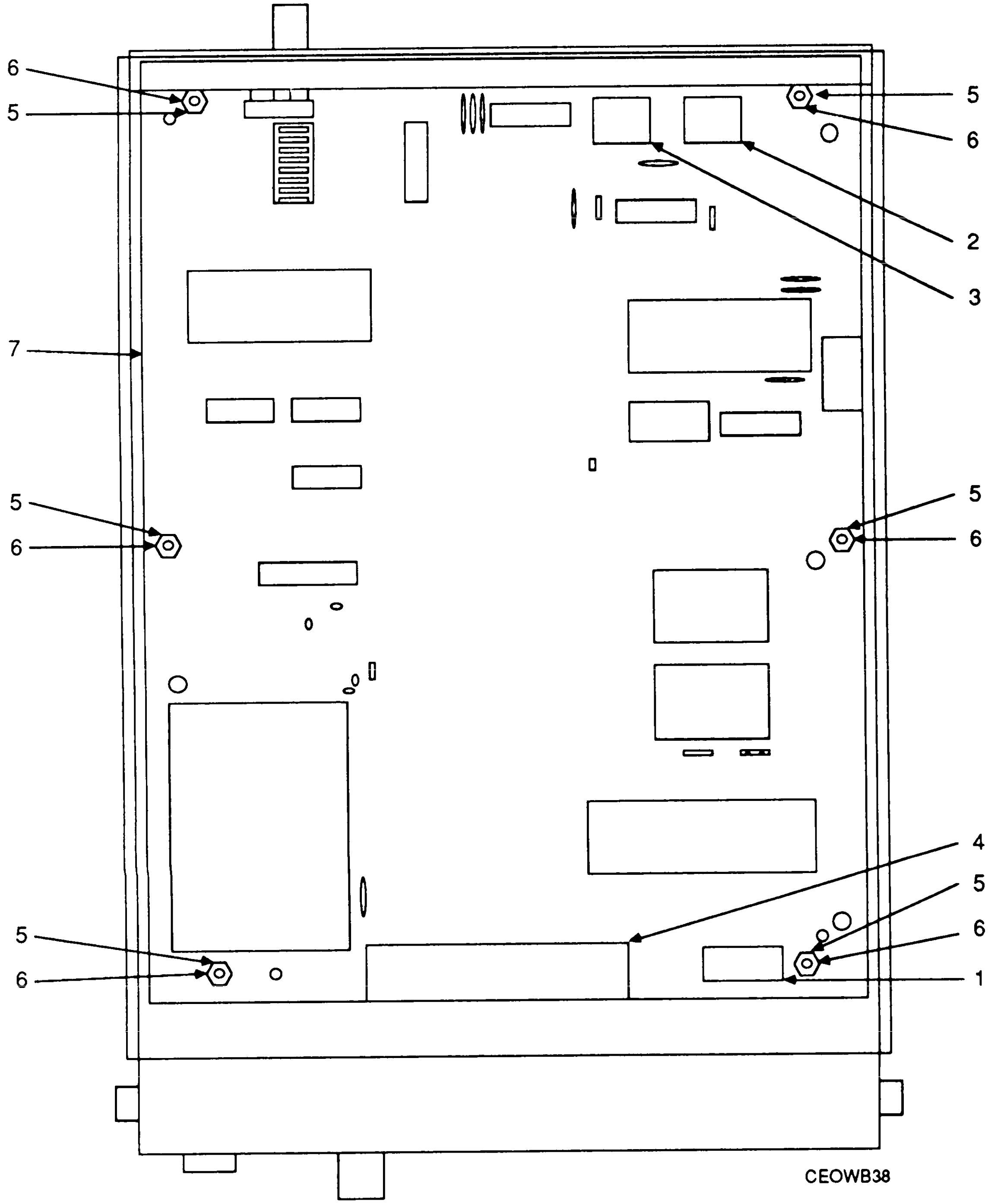


Figure 5-30. Control Board

c. Slide the top cover off.

d. Following the procedures of paragraph 5-26 remove the IEEE-488 interface board.

e. Disconnect the ribbon cable connector at J2 (1) from the control board.

f. Disconnect the four pin connector P2 (2).

g. Disconnect the five pin connector P4 (3).

h. Disconnect the edge card connector P1 (4).

i. Remove the six standoffs (5) and lock washers (6),

j. Remove the control board (7).

5-29. INSTALLATION OF CONTROL BOARD A5. (Figure 5-30)

a. Connect the edge card connector to the board at P1 (4).

b. Install the board with six standoffs (5) and lock washers (6).

c. Connect the five pin connector to the board at P4 (3).

d. Connect the four pin connector to the board at P2 (2).

e. Connect the ribbon cable connector to the board at J2 (l).

f. Perform adjustments following the procedures of paragraphs 5-17, 5-18 and 5-23.

g. Install the IEEE-488 interface board (see paragraph 5-27).

h. Slide the top cover into its slots., Ensure the sides and front of the cover are in the slots.

i. Install two screws at the rear of the top cover.

j. Perform the performance tests following the procedures of paragraphs 5-4 through 5-12.

5-30. REMOVAL OF POWER SUPPLY BOARD A7. (Figure 5-31)

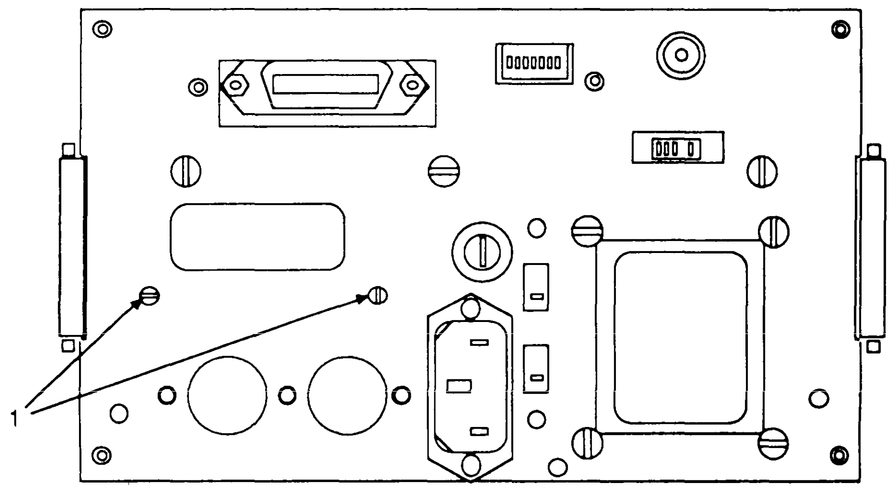
WARNING

Ensure electrical power is disconnected to prevent electrical shock to personnel or damage to equipment.

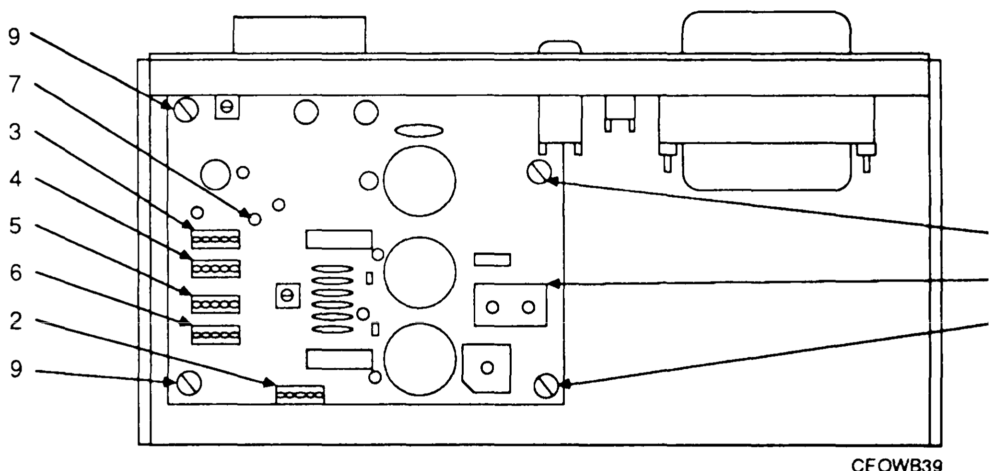
a. Disconnect the ac power line from the ac power source.

CAUTION

This instrument contains electrostatic discharge sensitive (ESDS) devices. Special handling methods and materials must be used to prevent equipment damage. Refer to electrostatic discharge sensitive device procedures, pages C and D of this manual, before performing maintenance on the equipment.



View A



View B

Figure 5-31. Power Supply Board

b. Remove the two screws at the rear of the bottom cover.

c. Slide the bottom cover off.

d. Remove the two screws (1) from the rear panel.

e. Disconnect connectors P4 (2), P5 (3), P7 (4), P9 (5) and P1O (6).

f. Disconnect the single wire push-pin connector (7).

g. Disconnect the transformer connector P1 (8).

h. Remove the four screws (9) from the power supply board.

i. Remove the power supply board.

5-31. INSTALLATION OF POWER SUPPLY BOARD A7. (Figure 5-31)

a. Install two screws (1) at the rear panel.

b. Install the power supply board with four screws (9).

c. Connect the transformer connector to the board at P1 (8).

d. Connect the single wire push-pin connector to the board at pin P6 (7).

e. Connect P4 (2), P5 (3), P7 (4), P9 (5), and P1O (6) to the board. A label on the chassis frame indicates the correct positioning of the connectors.

f. Perform adjustments following the procedures of paragraphs 5-13 through 5-19.

g. Slide the bottom cover into its slots. Ensure the sides and front of the cover are engaged in the slots.

h. Install two screws at the rear of the bottom cover.

i. Perform the performance tests following the procedures of paragraphs 5-4 through 5-12.

5-32. REMOVAL OF CHOPPER MODULE A4. (Figure 5-32, Item 3)

WARNING

Ensure electrical power is disconnected to prevent electrical shock to personnel or damage to equipment.

a. Remove the two screws from the rear of the bottom cover.

CAUTION

This instrument contains electrostatic discharge sensitive (ESDS) devices. Special handling methods and materials must be used to prevent equipment damage. Refer to electrostatic discharge sensitive device procedures, pages C and D of this manual, before performing maintenance on the equipment.

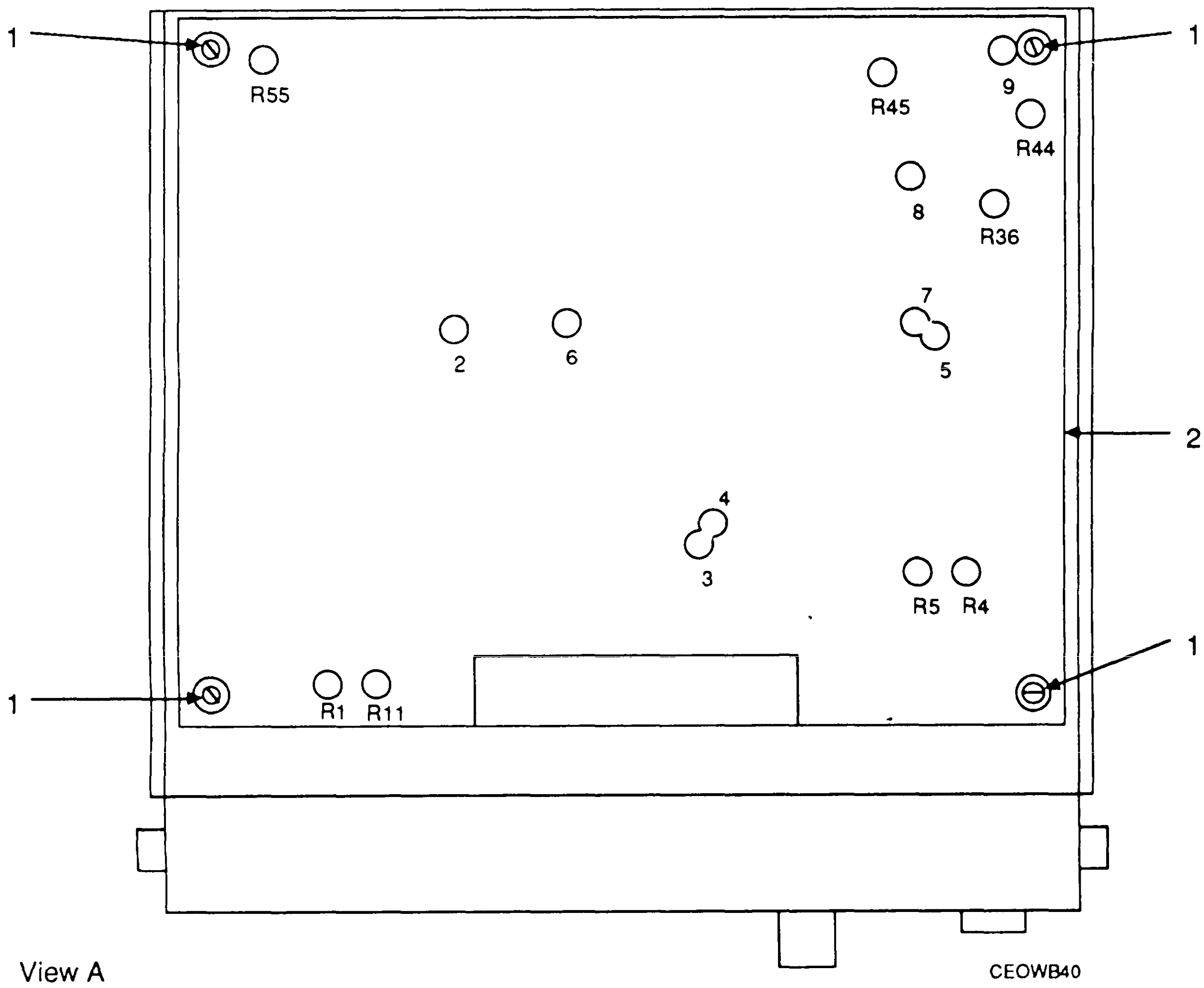


Figure 5-32. Chopper Module and Input Board (View A)

b. Slide the bottom cover off.

c. Remove the four screws (1) from the input shield (2).

d. Remove the input shield (2).

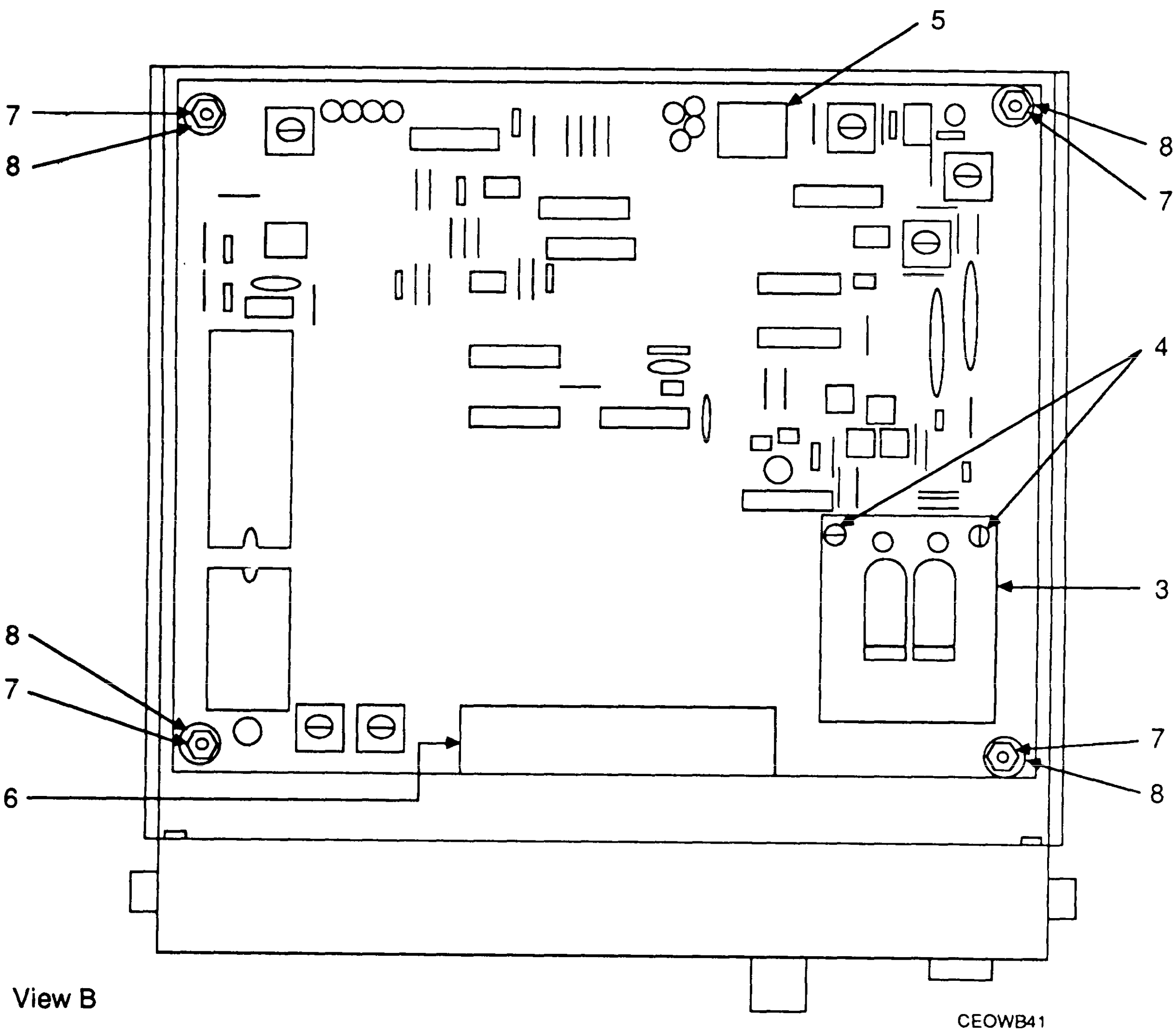


Figure 5-32. Chopper Module and Input Board (View B)

e. Remove two screws (4) from the chopper module cover.

f. Lift the cover from the chopper module.

g. Slide the clear insulation back on the red wire and the black wire. Unsolder the red wire from P2-1 and the black wire from P2-2.

h. Lift out the chopper module from the input module board.

5-33. INSTALLATION OF CHOPPER MODULE A4. (Figure 5-32, Item 3)

a. Install chopper module on the input board. Ensure the pins mate properly with connectors.

b. Solder red wire to P2-1 and the black wire to P2-2.

c. Slide insulation over solder connections.

d. Install the chopper module cover with two screws (4).

Perform the adjustments following the procedures of paragraphs 5-13 through 5-19.

f. Install the input shield (2) with four screws (l).

g. Slide the bottom cover into its slots.

h. Install two screws at the rear of the bottom cover.

i. Perform the performance tests following the procedures of paragraphs 5-4 through 5-12.

5-34. REMOVAL OF INPUT BOARD A6. (Figure 5-32)

WARNING

Ensure electrical power is disconnected to prevent electrical shock to personnel or damage to equipment.

a. Disconnect the ac power line from the ac power source.

CAUTION

This instrument contains electrostatic discharge sensitive (ESDS) devices. Special handling methods and materials must be used to prevent equipment damage. Refer to electrostatic discharge sensitive device procedures, pages C and D of this manual, before performing maintenance on the equipment.

b. Remove the two screws at the rear of the bottom cover.

c. Slide the bottom cover off.

d. Remove the four screws (1) from the input shield (2).

e. Remove the input shield (2).

f. Disconnect the five pin connector P2 (5).

g. Disconnect the edge card connector P1 (6).

h. Remove the two screws (4) from the chopper module (3).

i. Lift the cover from the chopper module.

j. Lift chopper module (3) to the side being careful not to damage connections.

k. Remove the four standoffs (7) and lock washers (8).

l. Remove the input board.

5-35. INSTALLATION OF INPUT BOARD A6. (Figure 5-32)

a. Install the input module board with four standoffs (7) and lock washers (8).

b. Install the chopper assembly (3) on the input board. Ensure the pins mate properly with connectors.

c. Install the chopper module cover with two screws (4).

d. Connect the edge card connector to the board at P1 (6).

e. Connect the five pin connector to the board at P2 (5).

f. Perform adjustments following the procedures of paragraphs 5-13 through 5-19.

g. Install the input shield with four screws (l). Ensure the holes in the shield are correctly aligned with the adjusting screws and pins on the input module board.

h. Slide the bottom cover into its slots. Ensure the sides and front of the cover are in the slots.

i. Install the two screws at the rear of the bottom cover.

j. Perform the performance tests following the procedures of paragraphs 5-4 through 5-12.

5-36. REMOVAL OF CALIBRATOR ASSEMBLY. (Figure 5-33)

WARNING

Ensure electrical power is disconnected to prevent electrical shock to personnel or damage to equipment.

CAUTION

This instrument contains electrostatic discharge sensitive (ESDS) devices. Special handling methods and materials must be used to prevent equipment damage. Refer to electrostatic discharge sensitive device procedures, pages C and D of this manual, before performing maintenance on the equipment.

a. Remove two screws from bottom cover.

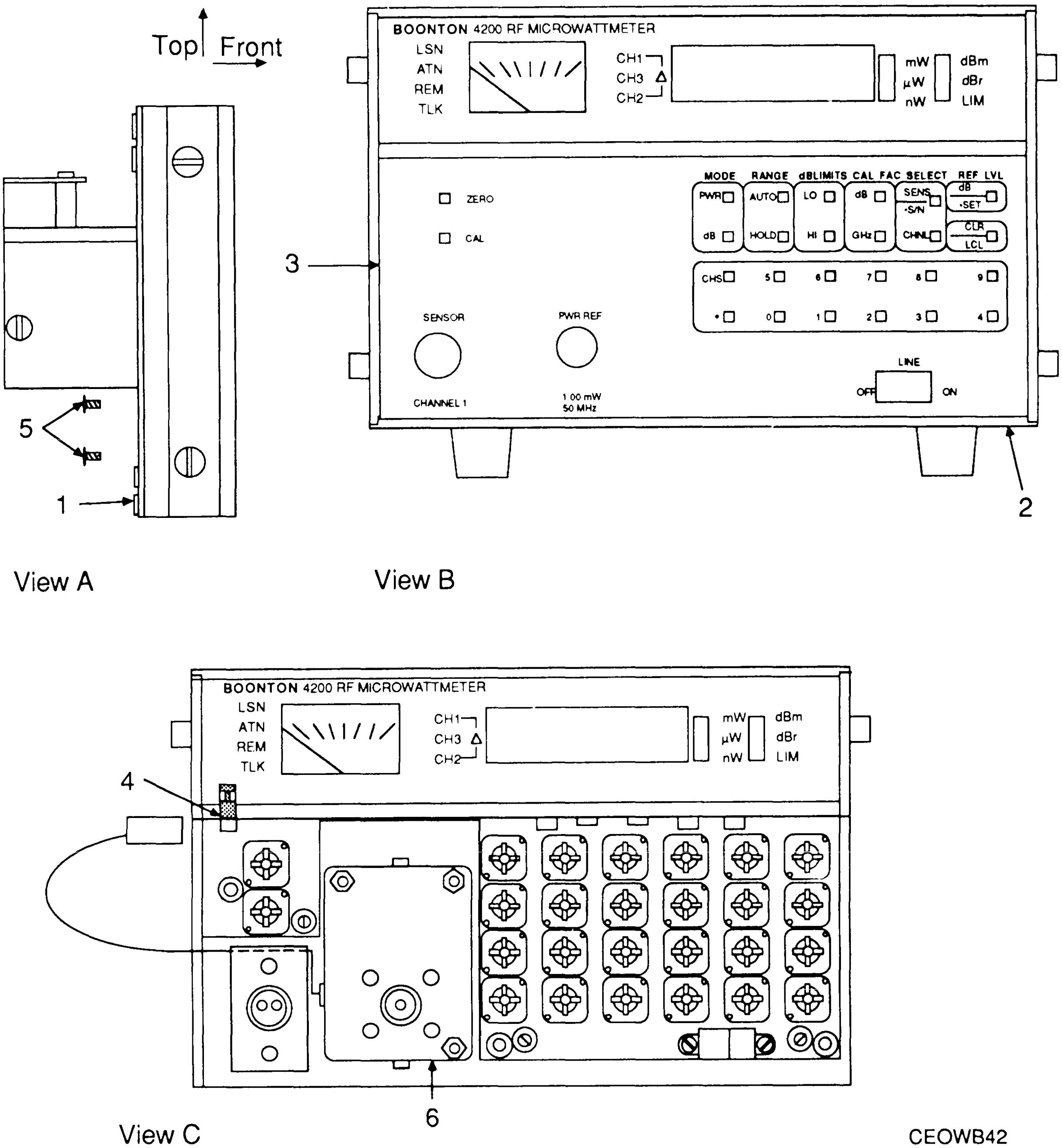


Figure 5-33. Calibrator Assembly

b. Slide bottom cover off.

c. Remove two screws (1) from the bottom trim strip.

d. Remove bottom trim strip (2).

e. Remove the front panel (3).

f. Disconnect connector P2 (4) from the display board.

g. Remove the four screws (Figure 5-32 Item (1)) from the input shield.

h. Remove the input shield (Figure 5-32 Item (2)).

i. Remove two screws (5) that secure the calibrator assembly.

j. Remove the calibrator assembly (6).

5-37. INSTALLATION OF CALIBRATOR ASSEMBLY. (Figure 5-33)

a. Install the calibrator assembly (6) with two screws (5).

b. Install the input shield (Figure 5-32 Item (2)) with four screws (Figure 5-32 Item (l)).

c. Connect connector P2 (4) to the display board.

d. Install the front panel (3).

e. Perform adjustment following the procedures of paragraph 5-19.

f. Install the bottom trim strip (2) with two screws (l).

g. Slide the bottom cover into its slots on the bottom of the meter. Ensure the sides and front of the cover are in the slots.

h. Install two screws at the rear of the bottom cover.

i. Perform the performance test following the procedures of paragraph 5-8.

5-38. REMOVAL OF DISPLAY BOARD A2. (Figure 5-34)

WARNING

Ensure electrical power is disconnected to prevent electrical shock to personnel or damage to equipment.

a. Disconnect the ac power line from the ac power source.

CAUTION

This instrument contains electrostatic discharge sensitive (ESDS) devices. Special handling methods and materials must be used to prevent equipment damage. Refer to electrostatic discharge sensitive device procedures, pages C and D of this manual, before performing maintenance on the equipment.

b. Remove the two screws at the rear of the top cover.

c. Slide the top cover off.

d. Remove the two screws from the rear of the bottom cover.

e. Slide the bottom cover off.

f. Remove the two screws (1) from the top trim strip (2).

g. Remove the top trim strip (2).

h. Remove the display panel (3).

i. Turn the meter on its side.

j. Remove two screws (4) from the side trim.

k. Remove side trim (5).

l. Remove panel support (6).

m. Remove the two screws (Figure 5-33 Item (l)) from the bottom trim strip.

n. Remove the bottom trim strip (Figure 5-33 Item (2)).

o. Remove front panel (7).

p. Remove the 26 push buttons (8).

q. Disconnect two pin connector P2 (9).

r. Remove two screws (10) from rocker (ON/OFF) switch (11).

s. Remove five screws (12) from display board (15).

t. Disconnect five pin connector P1 (13) on rear side of display board (15).

u. Disconnect the ribbon cable connector from J1 (14) on the rear of the display board (15).

v. Remove display board (15) from chassis.

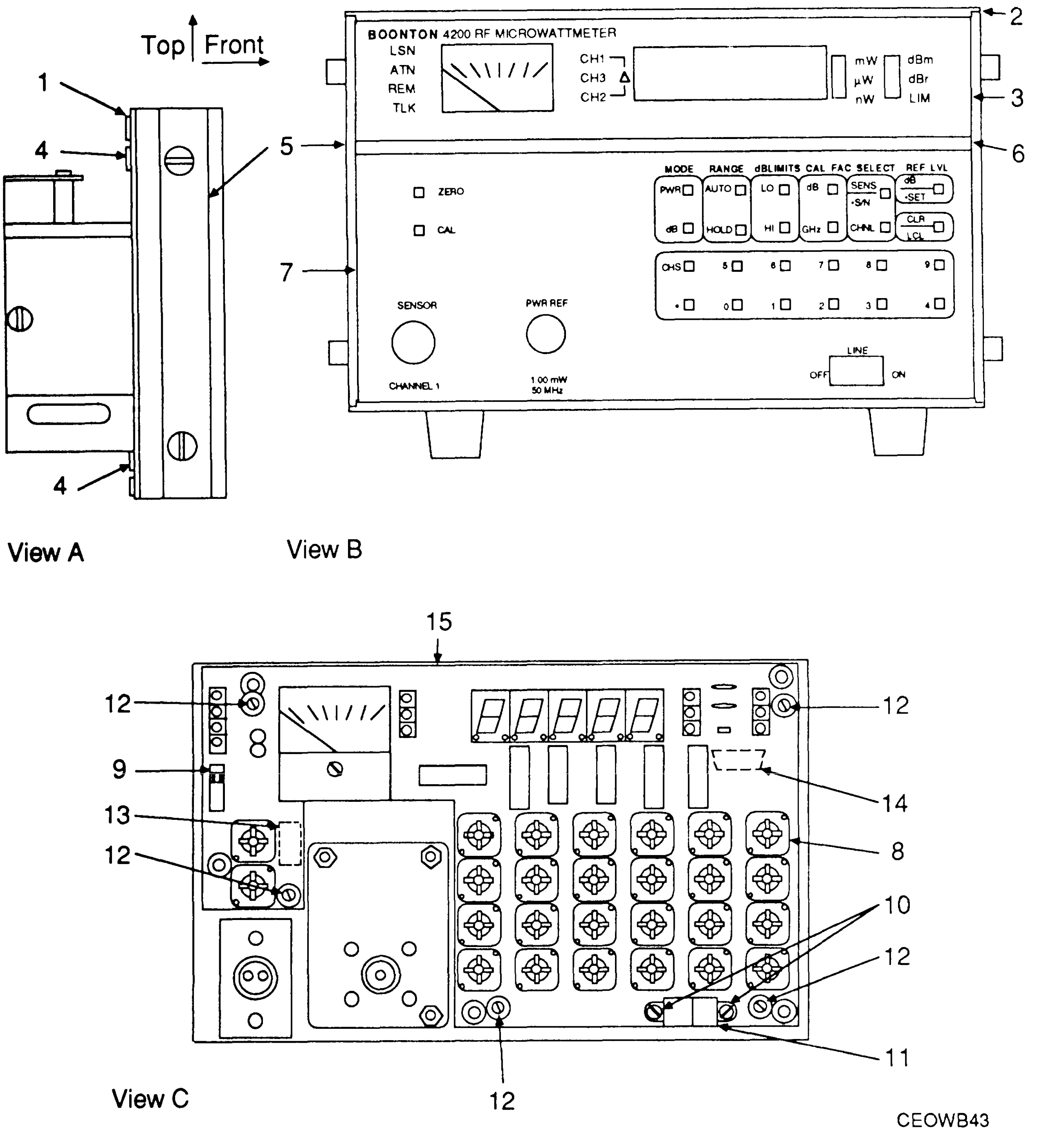


Figure 5-34. Display Board

5-39. INSTALLATION OF DISPLAY BOARD A2. (Figure 5-34)

a. Connect the ribbon cable connector to J1 (14) on the rear of the display boar (15).

b. Connect the five pin connector P1 (13) to the rear of the display board (15).

c. Install the display board (15) with five screws (12).

d. Install the Rocker (ON/ OFF) switch (11) with two screws (10).

e. Install two pin connector P2 (9).

f. Replace 26 push-buttons (8) on the switches.

g. Install the front panel (7).

h. Install the bottom trim strip (Figure 5-33 Item (2)) with two screws (Figure 5-33 Item (1)).

i. Install the panel support (6). Ensure the bracket on the side trim stip (5) engages the panel support.

j. Install the display panel (3).

k. Install the side trim strip (5) with two screws (4). Ensure the bracket on the side trim engages the support bracket.

l. Install the top trim strip (2) with two screws (1).

m. Perform adjustments following the procedures of paragraphs 5-13 through 5-19.

n. Slide the top cover into its slots on the top of the meter. Ensure the sides and front of the cover are in the slots.

o. Install two screws at the rear of the top cover.

p. Slide the bottom cover into its slots on the bottom of the meter. Ensure the sides and front of the cover are in the slots.

q. Install two screws at the rear of the bottom cover.

r. Perform the performance tests following the procedures of paragraphs 5-4 through 5-12.

5-40. REMOVAL OF REAR PANEL ASSEMBLY. (Figure 5-35)

WARNING

Ensure electrical power is disconnected to prevent electrical shock to personnel or damage to equipment.

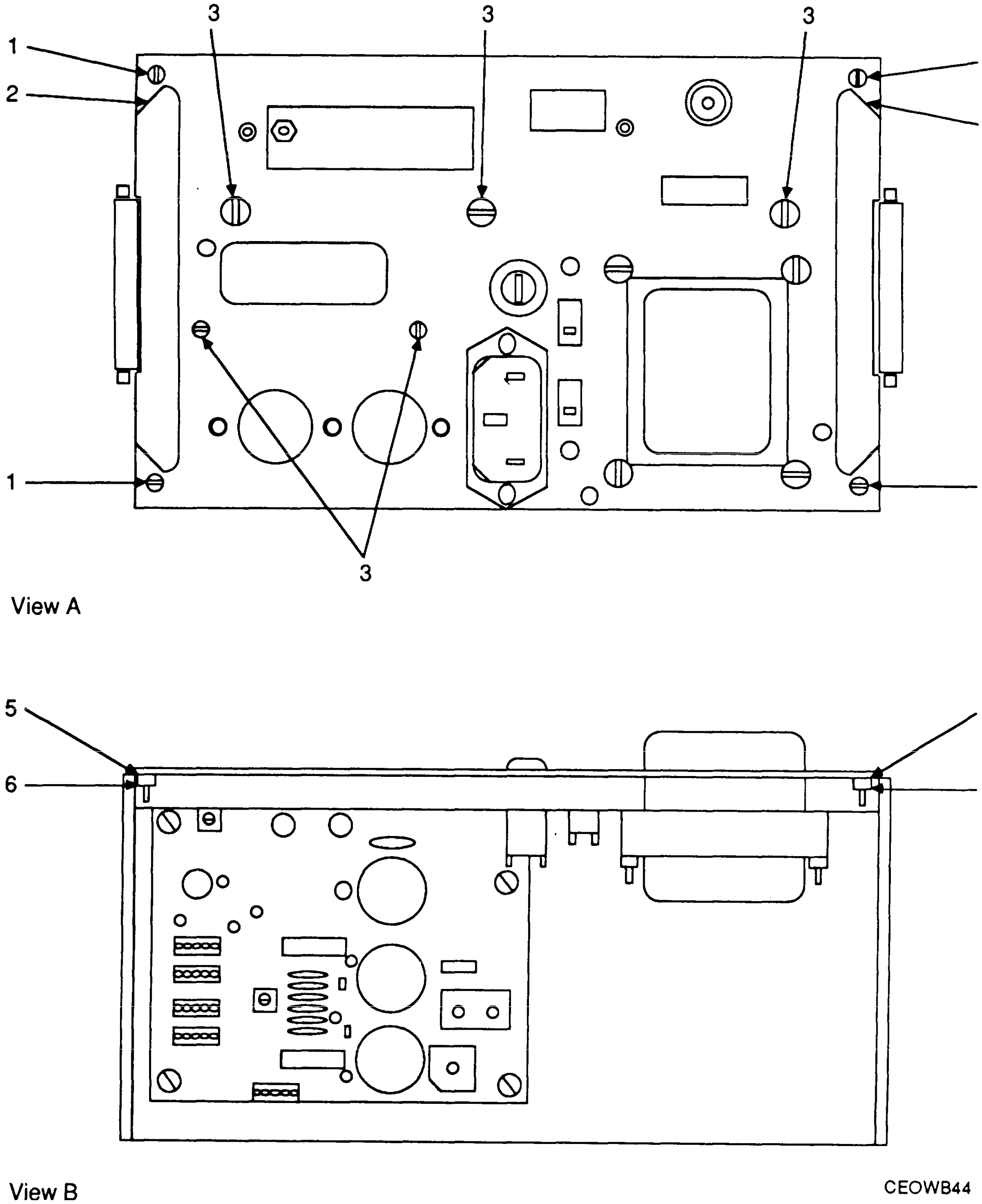


Figure 5-35. Removal/Installation of the Rear Panel Assembly

a. Remove the two screws at the rear of the bottom cover.

b. Slide the bottom cover off.

c. Disconnect connector P1 (Figure 5-31 Item (8)) from the power supply board.

d. Disconnect the single wire push-pin connector (Figure 5-31 Item (7)) from the power supply board.

e. Remove the IEEE-488 interface board A23. Refer to paragraph 5-26.

f. Remove the control board A5. Refer to paragraph 5-28.

g. Remove the two screws (Figure 5-33 Item (4)) from the bottom trim strip (Figure 5-33 Item (5)).

h. Remove the front panel (Figure 5-33 Item (6)).

i. Remove the two screws (Figure 5-34 Item (10)) from the rocker (on/off) switch (Figure 5-34 Item (11)).

j. Remove the switch cable from under the clip on the back side of the panel and work it through the chassis opening.

k. Remove the cable from under the two clips on the panel and lift it away from the chassis.

l. Cut the two tie wraps and work the wire disconnected in step d through the opening in the chassis.

m. Remove the four screws (1) from the two line cord brackets (2).

n. Remove five screws (3) from the rear panel assembly (4).

o. Remove two nuts (5) and lockwashers (6) from the studs on the inside that secure the rear panel to the chassis.

p. Remove the rear panel assembly (4).

5-41. INSTALLATION OF REAR PANEL ASSEMBLY. (Figure 5-35)

a. Align the two studs on the rear panel assembly (4) through the holes in the chassis. Ensure the switch cable passes through the opening to the top side. Install two lockwashers (6) and nuts (5).

b. Install five screws (3) in the rear panel assembly.

c. Install the two line cord brackets (2) with four screws (l).

d. Run the single wire push-pin connector through the opening in the chassis and connect it to the power supply board. (Figure 5-31 Item (7)).

e. Install connector P1 (Figure 5-31 Item (8)) to the power supply board.

f. Lay the switch cable down the side of the chassis and install it under the two clips on the back side of the front.

g. Run the switch cable through the opening in the chassis and under the clip.

h. Install the rocker (on/off) switch (Figure 5-34 Item (11)) with the two screws (Figure 5-34 Item (10)).

i. Slide the front panel (Figure 5-33 Item (6)) in place.

j. Install the bottom trip strip (Figure 5-33 Item (5)) with two screws (Figure 5-33 Item (4)).

k. Install the control board A5. Refer to paragraph 5-29.

l. Install the IEEE-488 interface board A23. Refer to paragraph 5-27.

m. Perform adjustments following the procedures of paragraphs 5-13 through 5-19.

n. Slide the top and bottom covers into their slots. Ensure the sides and front of the cover are engaged in the slots.

o. Install the screws at the rear of the top and bottom covers.

p. Perform the minimum performance standards following the procedures of paragraphs 5-4 through 5-12.

SECTION VI

PREPARATION FOR RESHIPMENT

6-1. PACKAGING

The AN/USM-491 should be repackaged using the materials and methodology shown in Figure 6-1.

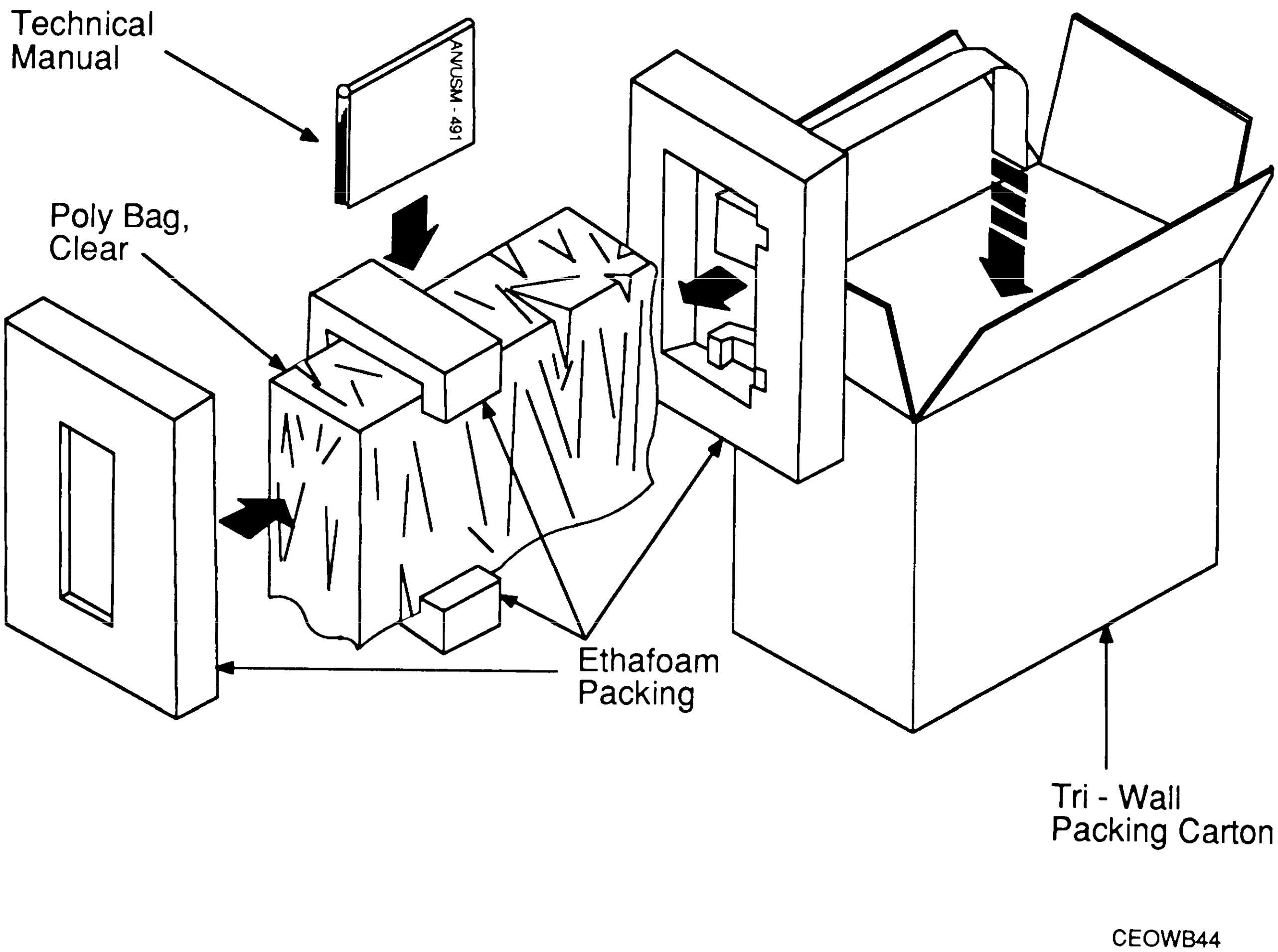


Figure 6-1. Packaging Diagram

SECTION VII

STORAGE

7-1. PREPARATION FOR STORAGE

Before storing the AN/USM-491, perform routine cleaning, dusting and check for loose nuts, bolts, handles, connectors, etc.

7-2. PACKING FOR STORAGE

Packing the AN/USM-491 for administrative storage should be accomplished in accordance with Figure 6-1.

7-3. STORAGE

There are no special storage requirements for the AN/USM-491 Test Set, however, as with all electronics, the instrument should not be stored in extreme ambient temperatures or in areas of high humidity.

APPENDIX A
REFERENCES

A-1. SCOPE.

This appendix lists all forms, technical bulletins, technical manuals, and miscellaneous publications referenced in this manual.

A-2. FORMS .

Recommended Changes to Publications and Blank Form ....DA Form 2028
Report of Discrepancy ....Form SF 364
Quality Deficiency Report ....Form SF 368

A-3. TECHNICAL MANUALS.

The Army Maintenance Management System (TAMMS) ....DA Pam 750-8
Procedures for Destruction of Electronics Materiel to
Prevent Enemy Use (Electronics Command)..................................TM 750-244-2
Unit, Intermediate Direct Support, and General Support
Maintenance Repair Parts and Special Tools List for Test
Set, Radio Frequency Power, AN/ USM-491 ....TM 11-6625-3164-24P

A-4. MISCELLANEOUS.

Common Table of Allowances ....CTA 50-970
Consolidated Index of Army Publications and Blank Forms ......DA Pam 25-30
First Aid...FM 4-25.11
Abbreviations and Acronyms...ASME-Y14/38M
Preservation, Packaging, Packing and Marking Materials,
Supplies and Equipment Used By the Army ....SBA 38-100

APPENDIX B

COMPONENTS OF END ITEM AND BASIC ISSUE ITEMS LIST

B-1. SCOPE.

This appendix lists components of end item and basic issue items for the Test Set, Radio Frequency Power AN/USM-491 to help you inventory items required for safe and efficient operation.

B-2. GENERAL.

The Components of End Item and Basic Issue Items Lists are divided into the following sections:

a. Section II. Components of End Item. This listing is for informational purposes only, and is not authority to requisition replacements. These items are part of the end item, but are removed and separately packaged for transpiration or shipment. As part of the end item, these items must be with the end item whenever it is issued or transferred between property accounts. Illustrations are furnished to assist you in identifying the items.

b. Section III. Basic Issue Items (BII). These are the minimum essential items required to place the AN/USM-491 Radio Frequency Power Test Set in operation, to operate it, and to perform emergency repairs. The BII are shipped separately packaged. Since all essential items required for operation of the AN/USM-491 are included in Section II, no BII are identified for the AN/USM-491.

B-3. EXPLANATION OF COLUMNS.

The following is an explanation of columns found in the tabular listings:

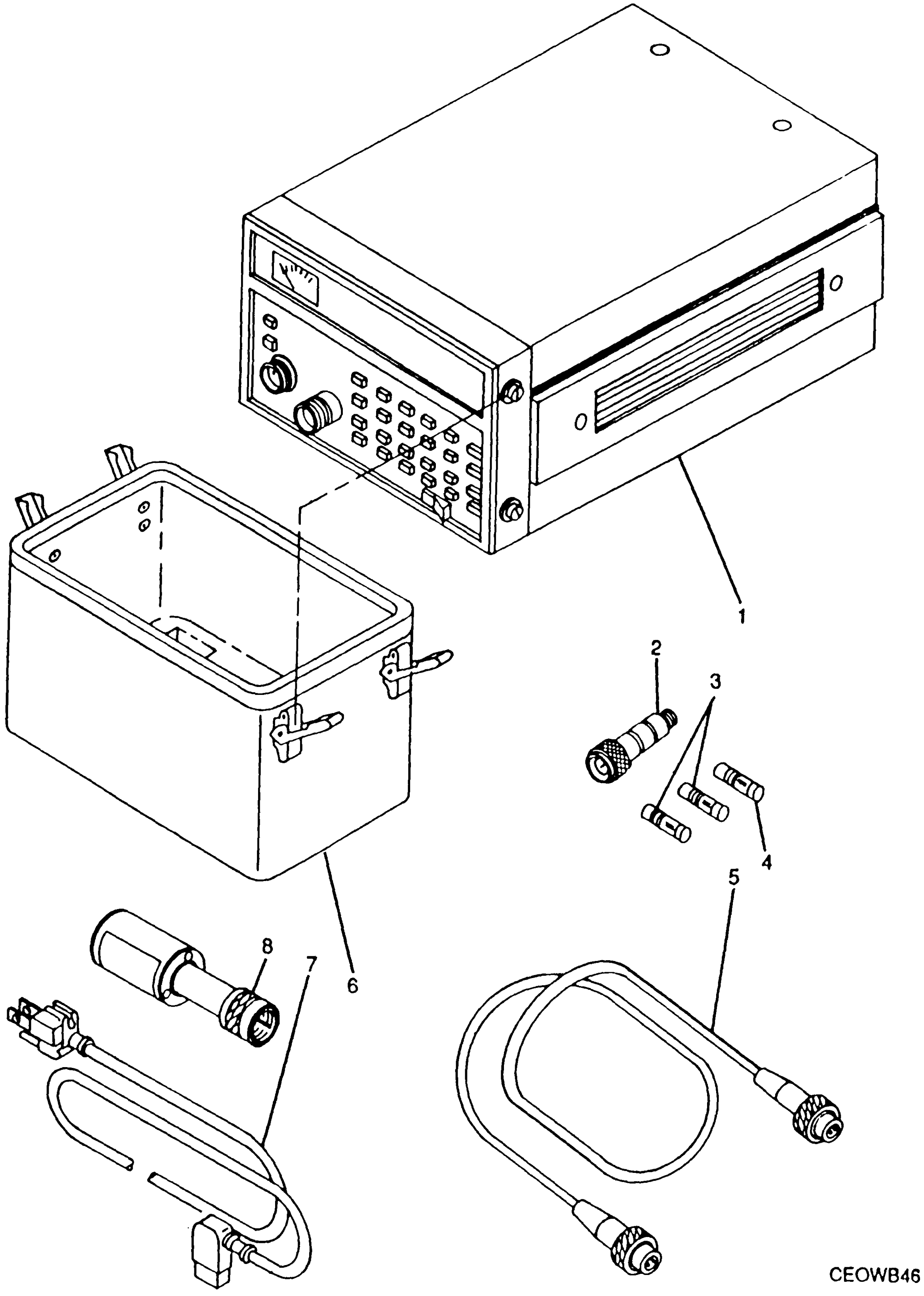
a. Column (1) - Illustration Number (Illus. No.). This column indicates the number of the illustration in which the item is shown.

b. Column (2) - National Stock Number. Indicates the National Stock Number assigned to the item and will be used for requisitioning purposes.

c. Column (3) - Description. Indicates the Federal item name and, if required, a minimum description to identify and locate the item. The last line for each item indicates the Federal Supply Code for Manufacturer (FSCM) (in parentheses) followed by the part number. If item needed differs for different models of this equipment, the model is shown under the Usable On heading in this column.

d. Column (4) - Unit of Measure (U/M). Indicates the measure used in performing the actual operational/maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e.g., ea, in, pr).

SECTION II.
COMPONENTS OF END ITEM



e. Column (5) - Quantity Required (Qty Rqr). Indicates the quantity of the item authorized to be used with the Test Set.

(1) Illus. No.	(2) National Stock Number	(3) Description FSCM and Part Number	Usable On Code	(4) U/M	(5) Qty Rqr
1		4200 RF Microwattmeter (04901) 04233400A		ea	1
2		20 dB Attenuator (04901) 95105401A		ea	1
3		Fuse, 0.2 AMp, 230 VAC, MIL SLO-BLO (04901) 545508000		ea	2
4		Fuse, 0.3 Amp. 115 VAC, MIL SLO-8L0 (04901) 54550700		ea	1
5		Power Sensor Cable Assembly (04901) 09170501A		ea	1
6		Cover Assy Accessory (04901) 04240000A		ea	1
7		Line Cord (70903) CH9461		ea	1
8		6E Power Sensor (04901) O41O5658A		ea	1

APPENDIX C
MAINTENANCE ALLOCATION CHART

Section I. INTRODUCTION

C-1. General.

a. This appendix provides a general explanation of all maintenance and repair function authorized at the two maintenance levels under the Two-Level Maintenance System concept for the Test Set, Radio Frequency Power AN/USM-491.

b. The Maintenance Allocation Chart (MAC) designates overall authority and responsibility for the performance of maintenance functions on the identified end item or component. The application of the maintenance functions to the end item or component levels, which are shown on the MAC in column (4) as:

1. Field – includes two columns, Unit maintenance and Direct Support maintenance. The Unit maintenance column is divided again into two more subcolumns, C for Operator or Crew and O for Unit maintenance.
2. Sustainment – includes two subcolumns, general support (H) and depot (D).

c. Section III lists the tools and test equipment requirements (both special tools and common tool sets) required for each maintenance function as referenced from the Section II.

d. Section IV contains supplemental instructions and explanatory notes for a particular maintenance function.

C-2. Maintenance Functions

Maintenance functions are limited to and defined as follows:

a. Inspect. To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination (e.g. by sight, sound, or feel). This includes scheduled inspection and gagings and evaluation of cannon tubes.

b. Test. To verify serviceability by measuring the mechanical, pneumatic, hydraulic, or electrical characteristics of an item and comparing those characteristics with prescribed standards on a scheduled basis, i.e., load testing of lift devices and hydrostatic testing of pressure hoses.

c. Service. Operations required periodically to keep an item in proper operating condition; e.g., to clean (includes decontaminate, when required), to preserve, to drain, to paint, or to replenish fuel, lubricants, chemical fluids, or gases. This includes scheduled exercising and purging of recoil mechanisms.

The following are examples of service functions:

1. Unpack. To remove from packing box for service or when required for the performance of maintenance operations.
2. Repack. To return item to packing box after service and other maintenance operations.
3. Clean. To rid the item of contamination.
4. Touch up. To spot paint scratched or blistered surfaces.
5. Mark. To restore obliterated identification.

d. Adjust. To maintain or regulate, within prescribed limits, by bringing into proper position, or by setting the operating characteristics to specified parameters.

e. Align. To adjust specified variable elements of an item to bring about optimum or desired performance.

f. Calibrate. To determine and cause corrections to be made or to be adjusted on instruments of test, measuring, and diagnostic equipment used in precision measurement. Consists of comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

g. Remove/install. To remove and install the same item when required to perform service or other maintenance functions. Install may be the act of emplacing, seating, or fixing into position a spare, repair part, or module (component or assembly) in a manner to allow the proper functioning of an equipment or system.

h. Paint. To prepare and spray color coats of paint so that the ammunition can be identified and protected. The color indicating primary use is applied, preferably, to the entire exterior surface as the background color of the item. Other markings are to be repainted as original so as to retain proper ammunition identification.

i. Replace. To remove an unserviceable item and install a serviceable counterpart in its place "Repair" is authorized by the MAC and assigned maintenance level is shown as the third position code of the Source, Maintenance and Recoverability (SMR) code.

j. Repair. The application of maintenance services, including fault location/troubleshooting, removal/installation, disassembly/assembly procedures and maintenance actions to identify troubles and restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module (component or assembly), end item or system.

NOTE

The following definitions are applicable to the "repair" maintenance function:

1. Services. Inspect, test, service adjust, align, calibrate, and/or replace.
2. Fault location/troubleshooting. The process of investigating and detecting the case of equipment malfunctioning; the act of isolating a fault within a system or Unit Under Test (UUT).
3. Disassembly/assembly. The step-by-step breakdown (taking apart) of a spare/functional group coded item to the level of its least component, that is assigned an SMR code for the level of maintenance under consideration (i.e., identified as maintenance significant).
4. Actions. Welding, grinding, riveting, straightening, facing, machining, and/or resurfacing.

k. Overhaul. That maintenance effort (service/action) prescribed to restore an item to a completely serviceable/operational condition as required by maintenance standards in appropriate technical publications. Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

l. Rebuild. Consists of those services/actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards. Rebuild is the highest degree of material maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (e.g., hours/miles) considered in classifying army equipment/components.

C-3. Explanation of Columns in the MAC, SECTION II.

a. Column (1) Group Number. Column (1) lists FGC numbers, the purpose of which is to identify maintenance significant components, assemblies, subassemblies, and modules with the Next Higher Assembly (NHA).

b. Column (2) Component/Assembly. Column (2) contains the item names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. Column (3) Maintenance Function. Column (3) lists the functions to be performed on the item listed in column (2). (For a detailed explanation of these functions, refer to "Maintenance Functions" outlined above.)

d. Column (4) Maintenance Level. Column (4) specifies each level of maintenance authorized to perform each function listed in column (3), by indicating work time required (expressed as man hours in whole hours or decimals) in the appropriate subcolumn. The work time figure represents the active time required to perform that maintenance function at the indicated level of maintenance. If the number or complexity of the tasks within the listed maintenance function varies at different maintenance levels, appropriate work time figures are to be shown for each level. The work time figure represents the average time required to restore an item (assembly, subassembly, component, module, end item or system) to a serviceable condition under typical field operating conditions. This time includes preparation time (including any necessary disassembly/assembly time), troubleshooting/fault location time, and quality assurance time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the MAC. The symbol designations for the various maintenance levels are as follows:

1. <u>Field</u>:
   C Operator or Crew maintenance
   O Unit maintenance
   F Direct Support maintenance

2. <u>Sustainment</u>:
   L Specialized Repair Activity
   H General Support maintenance
   D Depot maintenance

<u>NOTE</u>

The "L" maintenance level is not included in column (4) of the MAC. Functions to this level of maintenance are identified by work time figure in the "H" column of column (4), and an associated reference code is used in the REMARKS column (6). This code is keyed to the remarks and the SRA complete repair application is explained there.

e. Column (5) Tools and Equipment Reference Code. Column (5) specifies, by code, those common tool sets (not individual tools), common Test, Measurement and Diagnostic Equipment (TMDE), and special tools, special TMDE and special support equipment required to perform the designated function. Codes are keyed to the entries in the tools and test equipment table.

f. Column (6) Remarks Code. When applicable, this column contains a letter code, in alphabetical order, which is keyed to the remarks table entries.

C-4. Explanation of Columns in the Tools and Test Equipment Requirements, SECTION III.

a. Column (1) Tool or Test Equipment Reference Code. The tool or test equipment reference code correlates with a code used in column (5) of the MAC.

b. Column (2) Maintenance Level. The lowest level of maintenance authorized to use the tool or test equipment.

c. Column (3) Nomenclature. Name or identification of the tool or test equipment.

d. Column (4) National Stock Number (NSN). The NSN of the tool or test equipment.

e. Column (5) Tool Number. The manufacturer's part number, model number, or type number.

B-5. Explanation of Columns in the Remarks, SECTION IV.

a. Column (1) Remarks Code. The code recorded in column (6) of the MAC.

b. Column (2) Remarks. This column lists information pertinent to the maintenance function being performed as indicated in the MAC."

Section II. MAINTENANCE ALLOCATION CHART FOR TEST SET, RADIO FREQUENCY POWER AN/USM-491

(1) GROUP NUMBER	(2) COMPONENT/ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL: FIELD: UNIT C	FIELD: UNIT O	FIELD: DS F	SUSTAINMENT: GS H	SUSTAINMENT: DEPOT D	(5) TOOLS AND EQUIPMENT REFENENCE CODE	(6) REMARKS
8	Test Set, Radio Frequency Power	INSPECT		0.1					A
		INSPECT			0.1			1	A
		SERVICE		0.1					
		TEST		0.1					B
		TEST			0.1			4, 8. 9	C
		CALIBRATE			1.0			2-5,8, 9,11,13	D
		REPAIR		0.1					E
		REPAIR			1.0				K
01	RF Micro-Wattmeter	INSPECT		0.1					A
		INSPECT			0.1				A
		TEST			1.0			1-3,5-7,10-13	
		CALIBRATE			1.5			2-5,8,9,11,13	D
		REPAIR			1.75			1-13	F
02	Power Sensor	INSPECT		0.1	0.1				A
		CALIBRATE			1.0			4, 6-9	D,J
		REPAIR			0.1				G
		REPLACE			0.1				H

Section III. TOOL AND TEST EQUIPMENT REQUIREMENTS FOR TEST SET, RADIO FREQUENCY POWER AN/USM-491

(1) TOOLS OR TEST EQUIPMENT REF CODE	(2) MAINTENANCE LEVEL	(3) NOMENCLATURE	(4) NATIONAL STOCK NUMBER	(5) TOOL NUMBER
1	O	Tool Kit, Electrical	5180-01-195-0855	JTK-17
2	F	Multimeter, Digital	6625-01-298-9045	DM511 Opt 02
3	F	Oscilloscope	6695-01-074-7954	MIS-30526/2
4	F	Synthesizer Level Generator	6625-01-089-6304	3335A
5	F	Voltage Calibrator	6625-00-150-6994	332B
6	F	Power Meter	6625-00-436-4883	432A
7	F	Thermistor Mount or Thermistor Mount	5985-01-094-7840 5985-01-2579470	478A-H55 478A-H75
8	F	Amplifier, RF	4931-00-128-1444	RF815
9	F	Attenuator, 20db, 50 ohm Weinschel	5985-00-454-6924	2-20
10	F	Counter, Frequency	6625-00-531-4752	5345A
11	F	Power Module Tektronix	6625-01-048-8920	RTM506
12	F	Diagnostic ROM Kit		96101001A
13	F	Power Meter Adapter Assembly (AN/USM-491)	6625-01-2663-8766	7917058

Section IV. REMARKS
FOR
TEST SET, RADIO FREQUENCY POWER AN/USM-491

REMARKS CODE	REMARKS
A	VISUAL INSPECTION, INSURE THAT THE TEST SET AND POWER SENSOR ARE A MATCHED PAIR.
B	OPERATIONAL TEST.
C	PERFORMANCE TEST.
D	IN ACCORDANCE WITH TECHNICAL BULLETIN LISTED IN TB 43-180.
E	REPAIR BY REPLACEMENT OF FUSE, LINE CORD, AND COVER ASSEMBLY.
F	REPAIR BY REPLACING CIRCUIT CARD ASSEMBLIES (A2, A4, A5, A6, A7, A23), REAR PANEL ASSEMBLY AND POWER CALIBRATOR ASSEMBLY.
G	REPAIR IS LIMITED TO CALIBRATION ONLY.
H	CODE ‘NON-REPAIRABLE’ AND RETURN TO OWNER/USER.
J	POWER SENSOR MUST BE CALIBRATED WITH THE END ITEM AND USED AS A MATCHED SET.
K	REPAIR BY REPLACING LINE REPLACEABLE UNIT (LRU).

APPENDIX D

EXPENDABLE SUPPLIES AND MATERIALS

Section I. INTRODUCTION

D-1. SCOPE

This appendix lists expendable supplies and materials you will need to operate and maintain the AN/USM-491. These items are authorized to you by CTA 50-70, Expendable Items (Except Medical, Class V, Repair parts, and Heraldic Items).

D-2. EXPLANATION OF COLUMNS

a. Column (1) - Item Number. This number is assigned to the entry in the listing and is referenced to the entry in the listing and is referenced in the narrative instructions to identify the material (e.g., "Use cleaning compound, item 1, App. E").

b. Column (2) - Level. This column identifies the lowest level of maintenance that requires the listed item.

C - Operator/Crew
O - Organizational Maintenance
F - Direct Support Maintenance
H - General Support Maintenance

c. Column (3) - National Stock Number. This is the National stock number assigned the item; use it to request or requisition the item.

d. Column (4) - Description. Indicates the Federal item name and, if required, a description to identify the item. The last line for each item indicates the Federal Supply Code for Manufacturer (FSCM) in parentheses followed by the part number.

e. Column (5) - Unit of Measure (U/M). Indicates the measure used in performing the actual maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e.g., ea, in, pr). If the unit of measure differs from the unit of issue, requisition the lowest unit of issue that will satisfy your requirements.

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION	(5) U/M
1	0		DETERGENT, MILD LIQUID	OZ
2	0	8305-00-267-3015	CLOTH, CHEESECLOTH, COTTON, LINTLESS, CCC-C-440, TYPE II, CLASS 2 (81348)	YD
3	H	6850-01-459-0069	CLEANING COMPOUND, SOLVENT, HFE-71DE, (28112)	GL
4	H	3530-00-290-2920	BRUSH, (TOOTHBRUSH) H-T - 560	EA
5	H	8030-00-546-8637	CORROSION PREVENTIVE COMPOUND, WATER DISPLACING, ULTRA-THIN FILM. MIL-C-81309E(3) TYPE III CLASS 2	OZ

APPENDIX E

ADDITIONAL AUTHORIZATION LIST

Section 1. INTRODUCTION

E-1. SCOPE.

This appendix lists additional items you are authorized for the support of the AN/USM-491.

E-2. GENERAL.

This list identifies items that do not have to accompany the AN/USM-491 and that do not have to be turned in with it. These items are all authorized to you by CTA, MTOE, TDA, or JTA.

E-3. EXPLANATION OF LISTING.

National stock number, description, and quanties are provided to help you identify and request the additional item you require to support this equipment. The items are listed in alphabetical sequence by item name under the type document (i.e., CTA, MTOE, TDA, or JTA) which authorizes the item(s) to you.

(1) NATIONAL STOCK NUMBER	(2) DESCRIPTION FSCM & PART NUMBER	USABLE ON CODE	(3) U/M	(4) QTY AUTH
	MTOE AUTHORIZED ITEMS			
6625-01-247-5786	(0490) 95105201A	Sensor, Power MX-18291/USM-491	1	1

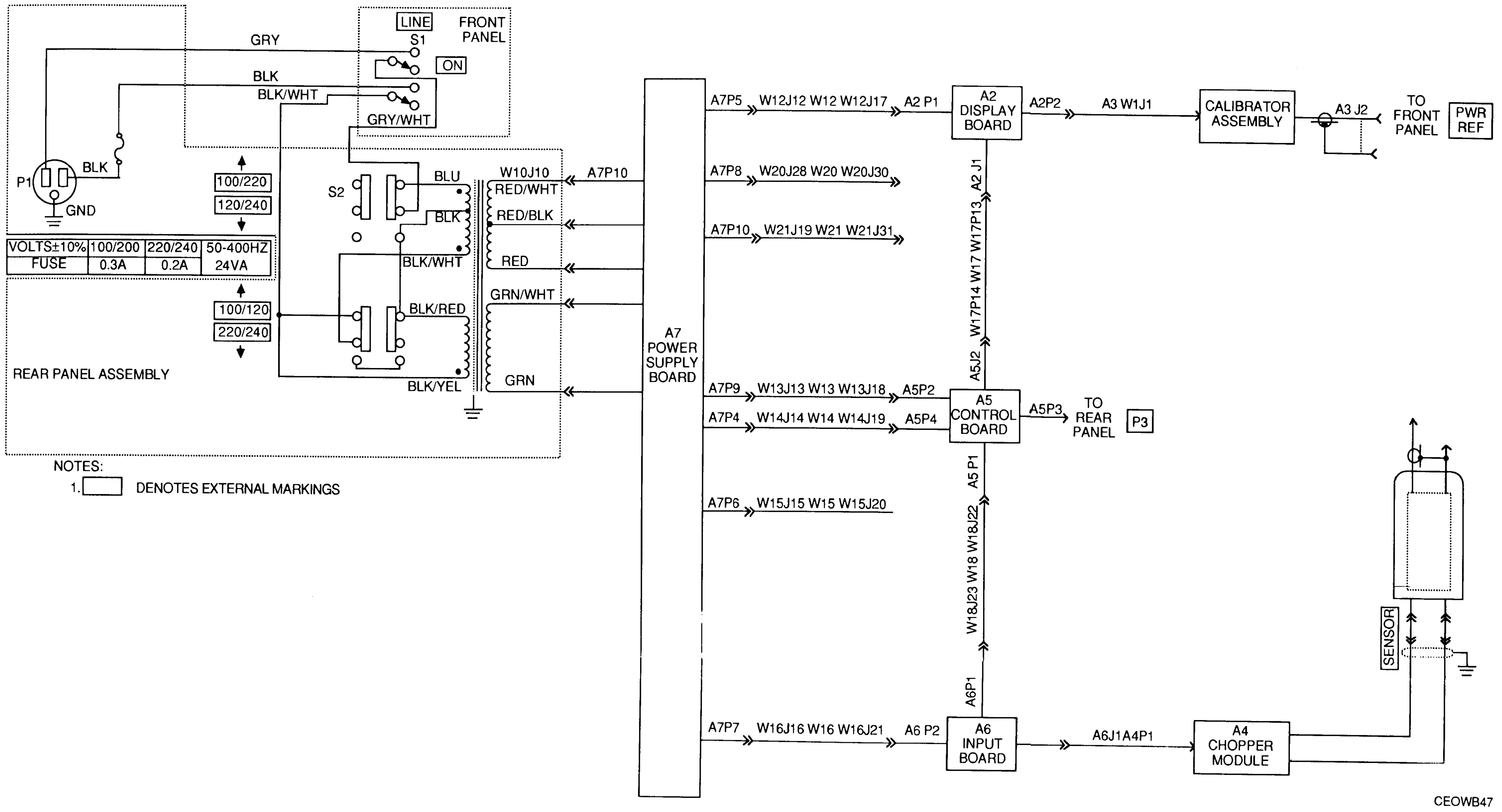


Figure FO-1. Main Frame, Schematic Diagram

By Order of the Secretary of the Army:

CARL E. VUONO
General, United States Army
Chief of Staff

Official:

R.L. DILWORTH
Brigadier General, United States Army
The Adjutant General

DISTRIBUTION:
To be distributed in accordance with DA Form 12-36 literature requirements for AN/USM-491.

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These are the instructions for sending an electronic 2028

The following format must be used if submitting an electronic 2028. The subject line must be exactly the same and all fields must be included; however only the following fields are mandatory: 1, 3, 4, 5, 6, 7, 8, 9, 10, 13, 15, 16, 17, and 27.

From: “Whomever” <whomever@wherever.army.mil>
To: 2028@redstone.army.mil

Subject: DA Form 2028

1. ***From:*** Joe Smith
2. *Unit:* home
3. ***Address:*** 4300 Park
4. ***City:*** Hometown
5. ***St:*** MO
6. ***Zip:*** 77777
7. ***Date Sent:*** 19–OCT–93
8. ***Pub no:*** 55–2840–229–23
9. ***Pub Title:*** TM
10. ***Publication Date:*** 04–JUL–85
11. *Change Number:* 7
12. *Submitter Rank:* MSG
13. ***Submitter FName:*** Joe
14. *Submitter MName:* T
15. ***Submitter LName:*** Smith
16. ***Submitter Phone:*** 123–123–1234
17. ***Problem:*** **1**
18. *Page:* 2
19. *Paragraph:* 3
20. *Line:* 4
21. *NSN:* 5
22. *Reference:* 6
23. *Figure:* 7
24. *Table:* 8
25. *Item:* 9
26. *Total:* 123
27. ***Text:***

This is the text for the problem below line 27.

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 25–30; the proponent agency is ODISC4.	Use Part II (*reverse*) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/ Supply Manuals (SC/SM)	DATE 8/30/02
TO: (*Forward to proponent of publication or form)(Include ZIP Code)* Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM–MMC–MA–NP Redstone Arsenal, 35898	FROM: (*Activity and location)(Include ZIP Code)* MSG, Jane Q. Doe 1234 Any Street Nowhere Town, AL 34565	

PART 1 – ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
TM 9–1005–433–24	16 Sep 2002	Organizational, Direct Support, And General Support Maintenance Manual for Machine Gun, .50 Caliber M3P and M3P Machine Gun Electrical Test Set Used On Avenger Air Defense Weapon System

ITEM NO.	PAGE NO.	PARA–GRAPH	LINE NO. *	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON
1	WP0005 PG 3		2			Test or Corrective Action column should identify a different WP number.

EXAMPLE

** Reference to line numbers within the paragraph or subparagraph.*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/ AUTOVON, PLUS EXTENSION	SIGNATURE
MSG, Jane Q. Doe, SFC	788–1234	

DA FORM 2028, FEB 74 REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED. USAPA V3.01

TO: (*Forward direct to addressee listed in publication*) Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM–MMC–MA–NP Redstone Arsenal, 35898	**FROM:** (*Activity and location) (Include ZIP Code)* MSG, Jane Q. Doe 1234 Any Street Nowhere Town, AL 34565	**DATE** 8/30/02

PART II – REPAIR PARTS AND SPECIAL TOOL LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

PUBLICATION NUMBER	DATE	TITLE

PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

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TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE
MSG, Jane Q. Doe, SFC	788–1234	

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 25–30; the proponent agency is ODISC4.	Use Part II *(reverse)* for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/ Supply Manuals (SC/SM)	DATE
TO: *(Forward to proponent of publication or form)(Include ZIP Code)* Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM-MMC-MA-NP Redstone Arsenal, AL 35898	FROM: *(Activity and location)(Include ZIP Code)*	

PART 1 – ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE

ITEM NO.	PAGE NO.	PARA–GRAPH	LINE NO. *	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON

** Reference to line numbers within the paragraph or subparagraph.*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/ AUTOVON, PLUS EXTENSION	SIGNATURE

TO: (*Forward direct to addressee listed in publication*) Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM-MMC-MA-NP Redstone Arsenal, AL 35898	**FROM:** (*Activity and location) (Include ZIP Code)*	**DATE**

PART II – REPAIR PARTS AND SPECIAL TOOL LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

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