*TB 9-6625-2185-24

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR RADIO FREQUENCY POWER TEST SET, AN/USM-491 (BOONTON, MODEL 4200 RF MICROWATTMETER AND SERIES 4200-6E SENSOR)

Headquarters, Department of the Army, Washington, DC
23 January 2008

REPORTING OF ERRORS AND RECOMMENDING IMPROVEMENTS

You can improve this manual. If you find any mistakes or if you know of a way to improve these 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, ATTN: AMSAM-MMC-MA-NP, Redstone Arsenal, AL 35898-5000. A reply will be furnished to you. You may also send in your comments electronically to our E-mail address: 2028@redstone.army.mil or by fax 256-842-6546/DSN 788-6546. For the World Wide Web use: https://amcom2028.redstone.army.mil. Instructions for sending an electronic 2028 can be found at the back of this manual.

This bulletin supersedes TB 9-6625-2185-35, dated 21 April 2003.

SECTION I
IDENTIFICATION AND DESCRIPTION

1. Test Instrument Identification. This bulletin provides instructions for the calibration of Radio Frequency Power Test Set, AN/USM-491 (Boonton, Model 4200 RF Microwattmeter and Series 4200-6E Sensor). TM 11-6625-3164-14 was used as the prime data source in compiling these instructions. The equipment being calibrated will be referred to as the TI (test instrument) throughout this bulletin.

a. Model Variations. None.

b. Time and Technique. The time required for this calibration is approximately 4 hours, using the dc and low frequency and microwave technique.

2. Forms, Records, and Reports

a. Forms, records, and reports required for calibration personnel at all levels are prescribed by TB 750-25.

b. Adjustments to be reported are designated (R) at the end of the sentence in which they appear. When adjustments are in tables, the (R) follows the designated adjustment. Report only those adjustments made and designated with (R).

3. Calibration Description. TI parameters and performance specifications which pertain to this calibration are listed in table 1.

Table 1. Calibration Description

Test instrument parameters	Performance specifications
Power reference output[1]	Range: 1.00 mW at 50 MHz Accuracy: ± 1.2%
Dc voltage	Range: 9 μV to 4.5 V dc Accuracy: ± 0.5% + ±1 μV
Power measurement	Frequency range: 100 kHz to 18 GHz Power range: -40 to + 30 dBm Accuracy: The total accuracy is the sum of 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. $RSS = \sqrt{(A^2 + B^2 + C^2 + D^2)}$ A. Basic Uncertainty (includes all instrumentation, noise, zero and shaping errors and includes 0.7% power reference setting error). INPUT LEVEL — POWER UNCERTAINTY > 1 μW — 1.2% of reading ± 0.1% full scale < 1 μW — 1.5% of reading ± 1.5% full scale

See footnotes at end of table.

Table 1. Calibration Description - Continued

<table>
<tr><td>Test instrument parameters</td><td colspan="6">Performance specifications</td></tr>
<tr><td rowspan="6">Power measurement - continued</td><td colspan="6">B. Temperature Uncertainty (at 1 MHz)</td></tr>
<tr><td colspan="2">Temperature</td><td colspan="2">Instrument</td><td colspan="2">All Sensors</td></tr>
<tr><td colspan="2">21° C to 25° C (reference)</td><td colspan="2">0% (0 dB)</td><td colspan="2">0% (0 dB)</td></tr>
<tr><td colspan="2">18° C to 30° C</td><td colspan="2">0% (0 dB)</td><td colspan="2">± 2.32% (0.1 dB)</td></tr>
<tr><td colspan="2">10° C to 40° C</td><td colspan="2">±0.5% (0.2 dB)</td><td colspan="2">± 4.7% (0.2 dB)</td></tr>
<tr><td colspan="2">0° C to 55° C</td><td colspan="2">± 0.6% (0.6 dB)</td><td colspan="2"></td></tr>
<tr><td colspan="6">C. Calibration Factor Uncertainty</td></tr>
<tr><td rowspan="2">Frequency GHz</td><td colspan="2">Uncertainty</td><td rowspan="2">Frequency GHz</td><td colspan="2">Uncertainty</td></tr>
<tr><td>Max (%)</td><td>RSS (%)</td><td>Max</td><td>RSS (%)</td></tr>
<tr><td>0.05 [2]</td><td>0</td><td>0</td><td>9</td><td>4.0</td><td>2.4</td></tr>
<tr><td><2</td><td>1.3</td><td>1.3</td><td>10</td><td>4.0</td><td>2.3</td></tr>
<tr><td>2</td><td>3.0</td><td>1.7</td><td>11</td><td>4.0</td><td>2.2</td></tr>
<tr><td>3</td><td>3.0</td><td>1.7</td><td>12</td><td>4.5</td><td>2.8</td></tr>
<tr><td>4</td><td>3.5</td><td>1.7</td><td>13</td><td>6.0</td><td>3.0</td></tr>
<tr><td>5</td><td>3.5</td><td>1.7</td><td>14</td><td>6.0</td><td>2.8</td></tr>
<tr><td>6</td><td>3.5</td><td>1.8</td><td>15</td><td>6.0</td><td>2.8</td></tr>
<tr><td>7</td><td>3.5</td><td>1.9</td><td>16</td><td>6.0</td><td>2.9</td></tr>
<tr><td>8</td><td>4.0</td><td>2.0</td><td>17</td><td>6.0</td><td>2.8</td></tr>
<tr><td>- - - -</td><td>- - - -</td><td>- - - -</td><td>18</td><td>6.0</td><td>3.1</td></tr>
<tr><td colspan="6">D. Power Reference Uncertainty. Power reference accuracy is ±1.2% worst case for 1 year (0 °C to 55 °C). When calculating the sum of uncertainties, only include 0.5% for the power reference as the remaining 0.7% is included in A above.</td></tr>
</table>

[1]Certified to 0.95%.
[2]Reference frequency.

SECTION II
EQUIPMENT REQUIREMENTS

4. Equipment Required. Table 2 identifies the specific equipment to be used in this calibration procedure. This equipment is issued with Secondary Transfer Calibration Standards Set AN/GSM-286; AN/GSM-287; or AN/GSM-705. Alternate items may be used by the calibrating activity. The items selected must be verified to perform satisfactorily prior to use and must bear evidence of current calibration. The equipment must meet or exceed the minimum use specifications listed in table 2. The accuracies listed in table 2 provide a four-to-one ratio between the standard and TI. Where the four-to-one ratio cannot be met, the actual accuracy of the equipment selected is shown in parenthesis.

5. Accessories Required. The accessories required for this calibration are common usage accessories, issued as indicated in paragraph **4** above, and are not listed in this calibration procedure. The following peculiar accessories are also required for this calibration: Calibration Adapter (7917058); RF Power Amplifier, Antenna Research, Model 757LC (MIS45845).

Table 2. Minimum Specifications of Equipment Required

Common name	Minimum use specifications	Manufacturer and model (part number)
CALIBRATOR	Range: 0.09 to 10 V dc Accuracy: ± 0.125%	Fluke, Model 5720A (5720A) (p/o MIS-35947)
FREQUENCY COUNTER	Range: 100 kHz to 50 MHz Accuracy: ±0.25%	Fluke, Model PM6681/656 (PM6681/656)
MULTIMETER	Range: 0 to 5.2 V dc Accuracy: ±0.002%	Agilent, Model 3458A (3458A)
POWER METER	Range: -10 to +7 dBm Accuracy: ±(0.95% at 50MHz)	Agilent, Model E12-432A (MIS-30525) w/thermistor mount, Agilent, Model 478A-H75 (7915907) or 8478B (8478B)
RESISTANCE STANDARD[1]	Range: 554 kΩ Accuracy:[2]	Biddle-Gray, Model 71-631 (7910328)
SYNTHESIZER/LEVEL GENERATOR	Range: -34 to +10 dBm Accuracy: ±0.05 dBm	Agilent, Model 3335AOPT 001-K06 (MIS-35938)
SYNTHESIZED SIGNAL GENERATOR	Range: 0.05 to 18 GHz Accuracy: ±0.5% Range ±10 dBm	Anritsu, Model 68369NV (68369NV)

[1]Two required.
[2]Combined accuracy of calibrator and resistance standard: 0.125%.

SECTION III
CALIBRATION PROCESS

6. Preliminary Instructions

a. The instructions outlined in paragraphs **6** and **7** are preparatory to the calibration process. Personnel should become familiar with the entire bulletin before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name as listed in table 2.

c. Unless otherwise specified, verify the result of each test and, whenever the test requirement is not met, take corrective action before continuing with the calibration. Adjustments required to calibrate the TI are included in this procedure. Additional maintenance information is contained in the manufacturer's manual and TM 11-6625-3164-14 for this TI.

d. When indications specified in paragraphs **9** through **10** are not within tolerance, perform the power supply check prior to making adjustments. After adjustments are made, repeat paragraphs **9** through **10**. Do not perform power supply check if all other parameters are within tolerance.

e. Unless otherwise specified, all controls and control settings refer to the TI.

7. Equipment Setup

WARNING

HIGH VOLTAGE is used or exposed during the performance of this calibration. DEATH ON CONTACT may result if personnel fail to observe safety precautions. REDUCE OUTPUT(S) to minimum after each step within the performance check where applicable.

a. Remove top and bottom covers as needed to gain access to calibration switches and adjustment locations respectively.

b. Connect sensor to TI with interconnect cable (p/o TI).

c. Connect TI to 115 V ac power source and allow a 30 minute warm-up.

d. Connect thermistor mount H75-478A to power meter. Set power meter **CALIBRATION FACTOR** switch to **100%**. Allow 30 minute warm-up.

NOTE

Ensure multimeter input jacks are isolated from chassis ground throughout this procedure.

NOTE

Calibration factors and serial numbers of power sensors are stored in the nonvolatile memory of TI. Owning organization must submit meter and sensor as a unit for proper calibration. More than one power sensor may be stored in memory. To select a sensor, press sensor number (**1** or **2**) and **SELECT SENS**. To check the sensor serial number selected, press decimal (**.**) and **SELECT SENS**.

NOTE

Actual value of 20 dB attenuator (p/o TI) should be known to be within 0.04 dB at 50 MHz prior to calibration of TI.

e. Press decimal (**.**) and **SELECT SENS** pushbuttons. Confirm that TI display matches serial number of sensor (last four digits).

8. Power Reference Level

a. Performance Check

(1) Connect frequency counter to TI **PWR REF**. Frequency counter will indicate between 49.5 and 50.5 MHz.

(2) Press power to **OFF** on power meter and remove thermistor mount from interconnect cable. Set multimeter to measure resistance.

(3) Connect multimeter to V_{RF} center connector on rear panel of power meter and pin 1 of interconnect cable.

(4) Record bridge resistance value (2 decimal place resolution) as indicated on multimeter as R (approximately 200 Ω).

(5) Disconnect multimeter and set to read dc V.

(6) Reconnect thermistor mount to interconnect cable and press power meter power to **ON**. Allow power meter to stabilize.

(7) Connect multimeter to V_{COMP} (+) and V_{RF} (-) jacks on rear of power meter.

NOTE

Ensure that multimeter input leads are isolated from chassis ground in following steps.

(8) Set power meter **RANGE** switch to **COARSE ZERO** and adjust front panel **COARSE ZERO** control for a zero meter indication.

(9) Fine zero power meter on most sensitive range, then set power meter **RANGE** switch to **1 mW**. If multimeter indicates less than 400 mV, record this value to the nearest microvolt as V_0. If value is greater than 400 mV, rezero power meter.

(10) Connect thermistor mount to **PWR REF** and record multimeter indication as V_1.

(11) Disconnect multimeter (-) input lead from the V_{RF} connector and reconnect to power meter chassis ground. Record multimeter indication as V_{COMP}.

(12) Calculate **PWR REF** output power using the following formula:

$$P_O = \frac{2\,V_{COMP}\,(V_1 - V_0) + V_0^2 - V_1^2}{4\,R\,(\text{CALIBRATION FACTOR})}$$

Where:
P_O = Power output in watts
V_{COMP} = Value recorded in (11) above
V_1 = Value recorded in (10) above
V_0 = Value recorded in (9) above
R = Value recorded in (4) above
CALIBRATION FACTOR = Test report value for thermistor mount at 50 MHz (or other test frequencies being measured).

NOTE

The technique of (7) through (12) for measuring power will be used throughout this procedure and will be referred to as precision power measurement technique.

NOTE

Retain value of R recorded in (4) above for use in precision power measurement technique.

(13) If calculated P_O is not between 0.993 and 1.007 mW, perform **b** below.

b. Adjustments

(1) Remove two screws (A) and remove front panel strip (fig. 1).

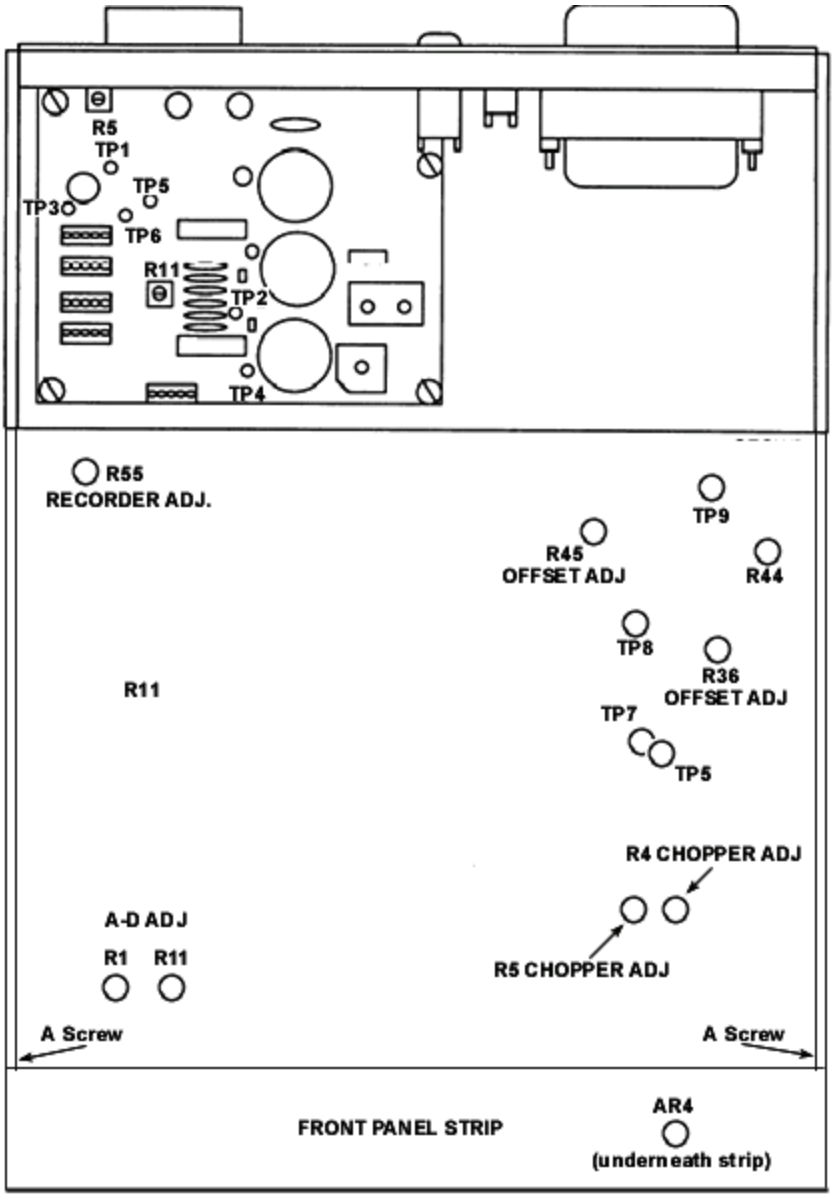


Figure 1. Adjustment locations - bottom view.

(2) Adjust AR4 (fig. 1) so that calculated **PWR REF** output power is 1 mW as calculated in (7) through (12) above. (R)

9. Basic Instrument Accuracy

a. Performance Check

(1) Press pushbuttons as listed in (a) through (h) below:

(a) **1**, **SELECT CHNL**.
(b) **1**, **SELECT SENS**.
(c) **MODE PWR**, **RANGE AUTO**.
(d) **99**, **dB LIMITS HI**.
(e) **99**, **CHS**, **dB LIMITS LO**.
(f) **0**, **CAL FACTOR dB**.
(g) **0**, **REF LEVEL dB**.
(h) **ZERO** (display will indicate **cccc** while zeroing, **cc03** when complete).

(2) Connect TI sensor to **PWR REF** and press **CAL** pushbutton. If display does not indicate from 0.998 to 1.002 mW, perform paragraph **10** below.

(3) Press **MODE dB** pushbutton.

(4) Position synthesizer/level generator controls for 50 MHz, 0 dBm output, and connect power meter sensor to 50 Ω **OUTPUT**.

(5) Set synthesizer/level generator output for exactly 1 mW, using precision power measurement technique in paragraph **8 a** (7) through (12) above. Record error from 0.00 dBm indicated on synthesizer/level generator display as generator correction factor.

NOTE

The correction factor recorded in (5) above must be added to all synthesizer/level generator output settings used in this paragraph.

(6) Disconnect TI sensor from **PWR REF** and connect to synthesizer/level generator 50 Ω **OUTPUT**.

(7) Position synthesizer/level generator controls for 50 MHz and output of +10 dBm. If TI display does not indicate between +9.85 and +10.15, perform **b** (1) through (31) below.

(8) Repeat technique of (7) above, using control settings listed in table 3. If TI display does not indicate within limits specified, perform **b** (1) through (31) below.

NOTE

Actual value of 20 dB attenuator (p/o TI) must be known to within 0.04 dB.

Table 3. Basic Instrument Accuracy

Synthesizer/level generator output (dBm)	Display indications (dBm)	
	Min	Max
+9.0	+08.85	+09.15
+8.0	+07.85	+08.15
+7.0	+06.85	+07.15
+6.0	+05.86	+06.14

Table 3. Basic Instrument Accuracy - Continued

Synthesizer/level generator output (dBm)	Display indications (dBm)	
	Min	Max
+5.0	+04.87	+05.13
+4.0	+03.88	+04.12
+3.0	+02.89	+03.11
+2.0	+01.90	+02.10
+1.0	+0.91	+01.09
0	-0.08	+00.08
-10	-10.15	-09.85
-20	-20.15	-19.85
-30	-30.21	-29.79

(9) Position synthesizer/level generator controls for a 50 MHz, -86 dBm output and connect equipment as shown in figure 2, CONNECTION A.

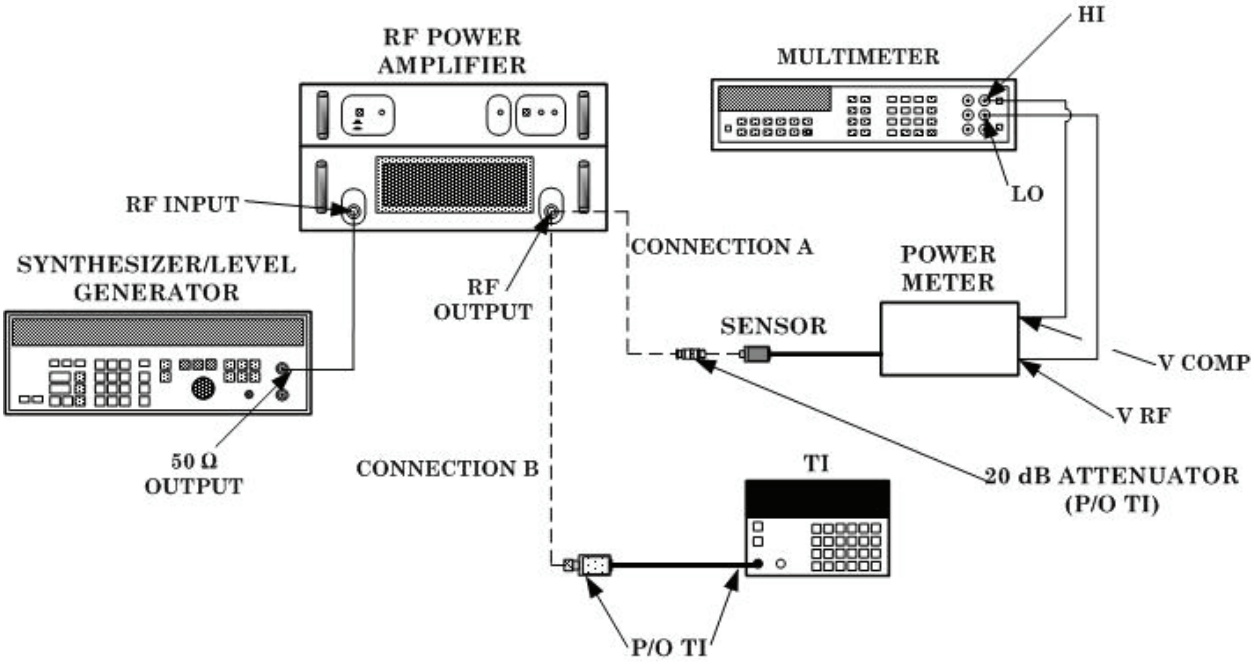


Figure 2. +15 and +25 dBm accuracy – equipment setup.

(10) Adjust synthesizer/level generator output level to within RF power amplifier input operating range. Slowly increase RF power amplifier gain control for a power meter indication of -5 dBm.

(11) Use precision power measurement technique used in paragraph **8 a** (7) through (12) above; calculate power and record as P_2.

(12) Utilizing formula below, convert power recorded in (11) above to dBm.

$$dBm = 10 \log \left(\frac{P_2}{1\ mW} \right)$$

(13) Algebraically add actual value of 20 dB attenuator (p/o TI) and dBm value from (12) above as in example below:

Example:
Attenuator value (+19.75) + (-5.02) dB = +14.73
Record this value.

(14) Disconnect cable from input of amplifier and connect equipment as shown in figure 2, CONNECTION B.

(15) Reconnect cable to input of amplifier. If display does not indicate power recorded in (13) above ±0.18 dBm, perform **b** (32) through (51) below, and (52) through (54) for (16) below.

(16) Repeat technique of (9) through (15) above for a power level of +5 dBm in (10) above.

b. Adjustments

NOTE

Due to inability to distinguish between dc and sensor inaccuracies, perform paragraph **10**, Dc Instrumentation Accuracy, before performing adjustments below.

NOTE

Adjustments below are actually alterations to data stored in nonvolatile memory of TI.

(1) Disconnect sensor from synthesizer/level generator and press **ZERO** pushbutton twice. Wait for the TI to complete the zero cycle.

(2) Press pushbuttons as follows: **1**, **SELECT CHNL**, **1**, **SELECT SENS**, **0**, **CAL FAC dB**, **0**, **REF LVL dB**.

NOTE

If sensor number is not 1 as indicated on sensor label, change accordingly. *Example*: **2**, **SELECT SENS**.

(3) Set control board bit switches to CALIBRATE MODE 1 (DC CAL) (fig. 3).

(4) Press pushbuttons **2**, **CAL FAC GHz**, **1000**, **CAL FAC dB**.

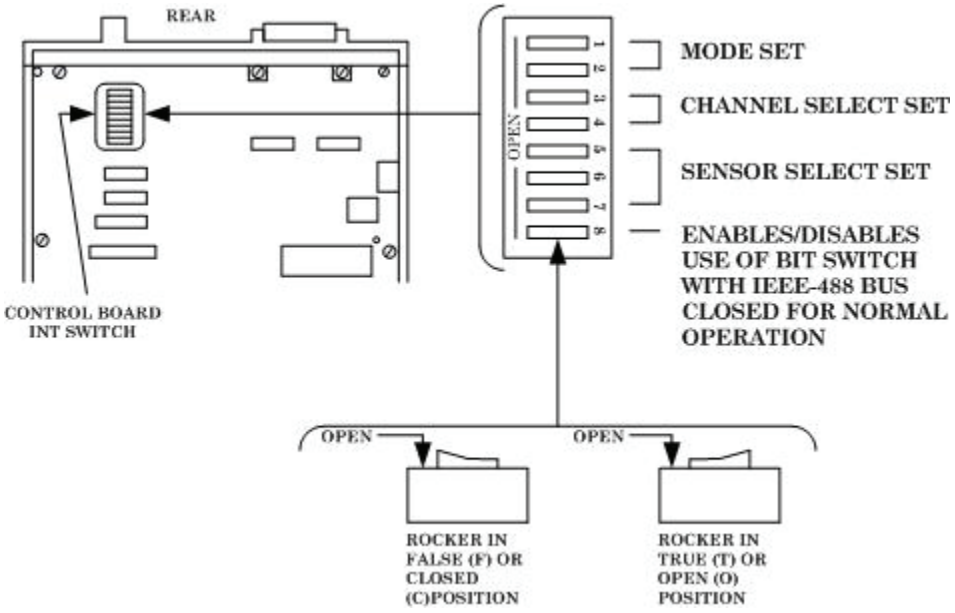
(5) Press pushbuttons for the last four digits of sensor serial number, **dB LIMITS HI**, **1000**, and **RANGE AUTO**.

(6) Set control board bit switch to CALIBRATE MODE 2 (AC CAL) (fig. 3).

(7) Press pushbuttons **0**, **RANGE HOLD**.

(8) Press **ZERO** pushbutton.

(9) Position synthesizer/level generator controls for 50 MHz and -34 dBm output level.



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	C					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

Figure 3. Control board bit switch location and mode positions - top rear view.

(10) Connect sensor to synthesizer/level generator **50Ω** output.

(11) Press pushbuttons **0**, **RANGE HOLD**, **39.80**, **MODE dB**.

(12) Wait 30 seconds for settling and press pushbuttons **0**, **dB LIMITS HI**, **CAL**, **REF LVL dB**. Record display indication (approximately 5000) as range **0** gain.

(13) Repeat technique of (9), (11), and (12) above for synthesizer/level generator output, TI pushbuttons and record display indications as listed in table 4 below.

Table 4. Full Scale Gain Data

Synthesizer/level generator set to 50 MHz (dBm)	Press	Allow settings	Press	Record display
-24	1, RANGE HOLD, 3, 9, ., 8, 0, MODE dB	- - -	0,dB LIMITS HI, CAL, REF LVL dB	Range 1 = approximately 5000
-14	2, RANGE HOLD, 3, 9, ., 8, 0, MODE dB	- - -	0,dB LIMITS HI, CAL, REF LVL dB	Range 2 = approximately 5000
-4	3, RANGE HOLD, 3, 9, ., 8, 0, MODE dB	- - -	0,dB LIMITS HI, CAL, REF LVL dB	Range 3 = approximately 5000
+6	4, RANGE HOLD, 3, 9, ., 8, 0, MODE dB	- - -	0,dB LIMITS HI, CAL, REF LVL dB	Range 4 = approximately 5000

(14) Set synthesizer/level generator to **STANDBY**, allow sensor to settle for 30 seconds.

(15) Set control board bit switch to OPERATE MODE (fig. 3).

(16) Press pushbuttons **RANGE AUTO**, **MODE PWR**, and **ZERO** (cc03 when complete).

(17) Turn synthesizer/level generator to **ON** and position controls for 50 MHz, -30 dBm output. Record display indication as range 1 downscale reading.

(18) Compute downscale sensor correction as follows: Subtract downscale reading recorded in (17) above from 1.000 μW.

NOTE

Disregard decimals; always use whole numbers when computing downscale correction.

Example: 1.000 μW minus downscale reading of 1.008 μW equals a downscale of -8.

(19) Record calculated value as range 1 down scale correction.

(20) Repeat technique of (17) through (19) for synthesizer/level generator settings and record corrections as listed in table 5.

Table 5. Downscale Sensor Correction Levels

Range	Function generator (dBm)	Record display readings	Reading should be:	Downscale correction
2	-20	- - -	10.00 µw	- - -
3	-10	- - -	100.00 µw	- - -
4	-0	- - -	1.00 mw	- - -

(21) Set synthesizer/level generator to **STANDBY**.

(22) Set control bit switch to CALIBRATE MODE 2 (AC CAL) (fig. 3).

(23) Using downscale corrections recorded in (19) and table 5 above, press pushbuttons from left to right as listed in table 6.

Table 6. Downscale Correction Data Entry

Press Pushbuttons [1] [2]
0, RANGE HOLD, 0, 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

[1]X Denotes downscale correction.

[2]See note and example on page 16

NOTE

To enter negative corrections, press **CHS** pushbutton after downscale number.

Example: To enter -8 on range 1, press **1**, **RANGE HOLD**, **8**, **CHS**, and **dB LIMITS HI** pushbuttons.

(24) Set control board bit switch to OPERATE MODE (fig. 3).

(25) Press **RANGE AUTO**, **MODE dB**, and **ZERO** pushbuttons, wait for zeroing to complete.

(26) Turn synthesizer/level generator to **ON** and position controls for a 50 MHz, -34 dBm output. If display does not indicate between -34**.**12 and -33**.**88, record as out-of-tolerance display indication for range 0.

(27) Repeat technique of (26) above for synthesizer/level generator output and display indications listed in table 7. If all ranges are in tolerance, repeat paragraph **9 a** above.

Table 7. Upscale Accuracy Measurements

Synthesizer/level generator output (dBm)	Display indications		Record out-of-tolerance indications and corresponding range
	Min	Max	
-24	-23.92	-24.08	Range 1
-14	-13.92	-14.08	Range 2
-4	-3.95	-4.05	Range 3
+6	+5.92	+6.08	Range 4

(28) Calculate upscale corrections for out-of-tolerance ranges using formula as shown in example below:

Example:
New gain factor = old gain factor + (TI error X 1200)

NOTE

For every 0.01 dB of error, a correction of 12 counts must be added or subtracted to gain factor. Gain factors were recorded in (12) above and table 4.

Example:
Display indicates -24.16 dBm
Actual power level is -24.00 dBm
TI error is .16 dB low (add to gain factor)
Gain factor from table is 5032
New gain factor = 5032 + (0.16 X 1200)
New gain factor = 5224

(29) Set control board bit switch to CALIBRATE MODE 2 (AC CAL) (fig. 3).

(30) Press pushbuttons **N**, **RANGE HOLD**, **XXXX**, **REF LVL dB**.

NOTE

N is out-of-tolerance range, **XXXX** is new gain factor from (28) above.

(31) Set control board bit switch to OPERATE MODE (fig. 3). Repeat paragraph **9 a** above.

(32) Connect equipment as shown in figure 2, CONNECTION A.

(33) Set synthesizer/level generator for a frequency of 50 MHz and adjust synthesizer/level generator output to within RF power amplifier input operating range. Slowly increase RF power amplifier gain control for a power meter indication of 0 dBm.

(34) Use precision power measurement technique, calculate and record calculated power as P_2.

(35) Using calculator and formula below, convert P_2 to dBm. Record dBm value.

$$dBm = 10 \log \left(\frac{P_2}{1\ mW} \right)$$

(36) Algebraically add actual value of 20 dB attenuator (p/o TI) and dBm from (35) above. Record this as actual power.

(37) Disconnect cable from input of amplifier and connect equipment as shown in figure 2, CONNECTION B.

(38) Reconnect cable to input of amplifier. If display does not indicate actual power from (36) above ±0.12 dBm, subtract display indication from actual and record difference as dB error. If display indicates within tolerance, proceed to (45) below.

(39) With power level still set and connected to sensor, set control board bit switch to CALIBRATE MODE 2 (AC CAL) (fig. 3).

(40) Press pushbuttons **5**, **RANGE HOLD**, and **REF LVL dB**. Record display indication as upscale gain factor for range 5.

(41) Using technique, of (28) above and dB error in (38) above and gain factor in (40) above, calculate a new gain factor.

(42) To enter new gain factor press pushbuttons **5**, **RANGE HOLD**, **XXXX**, and **REF LVL dB**.

NOTE

XXXX = New gain factor in (41) above.

(43) Set control board bit switch to OPERATE MODE (fig. 3).

(44) If display does not indicate actual power from (36) above ±0.12 dBm, repeat (33) through (43) above.

(45) Position synthesizer/level generator controls for -86 dBm output and disconnect amplifier from setup. Connect sensor to synthesizer/level generator 50 Ω output.

(46) Position synthesizer/level generator controls for +10 dBm output. If display does not indicate between +9.92 to +10.08 dBm, perform (47) through (51) below. If within tolerance proceed to (52) below.

(47) Set control board bit switch to CALIBRATE MODE 2 (AC CAL) (fig. 3).

(48) Press pushbuttons **5**, **RANGE HOLD**, **dB LIMITS HI**. Note downscale correction on display.

(49) Increase or decrease downscale correction by 5 to 10 counts according to error in (46) above, ((38) above for range 6).

(50) Press pushbuttons **5**, **RANGE HOLD**, (new downscale correction), **dB LIMITS HI**.

NOTE

If correction is changed more than 20 counts perform (32) through (44) above.

(51) Set control board bit switch to OPERATE MODE (fig. 3). If display does not indicate between +9.92 to +10.08 dBm, repeat (47) through (51) until no further adjustment is necessary.

(52) Repeat technique of (32) through (44) above for a power level of +7 dBm in (33) and range 6 in place of range 5 for all steps concerned.

(53) Repeat technique of (32) through (38) above for a power level of +3 dBm in (33) and range 6 for all steps concerned. If (38) above is within tolerance, adjustments are complete, if not perform (54) below.

(54) Repeat technique of (47) through (51) for range 6 until display indicates ±0.12 dBm of values recorded in (36) above.

10. Dc Instrumentation Accuracy

NOTE

Do not perform the following paragraph if paragraph **9**, Basic Instrument Accuracy, was within specifications.

a. Performance Check

(1) With TI **LINE** power **OFF**, remove sensor from interconnect cable and connect calibration adapter to interconnect cable.

(2) Set multimeter to measure resistance and connect to banana plugs on calibration adapter.

(3) Record resistance value indicated on multimeter (resolution two decimal places) as R_a (approximately 998 Ω).

(4) Using following formula, solve for R_d.

$$R_d - \frac{(R_a \times 1000) - R_a}{2}$$

Where:

R_a - Resistance of calibration adapter

R_d - Resistance value for dividers (approximately 498 k)

(5) Set calibrator to **OPR** at 0 V dc output.

(6) Set both resistance standards for R_d value calculated in (4) above and connect equipment as shown in figure 4.

(7) Set TI **LINE** power switch to **ON**.

(8) Ensure control board bit switches are in OPERATE MODE (fig. 3).

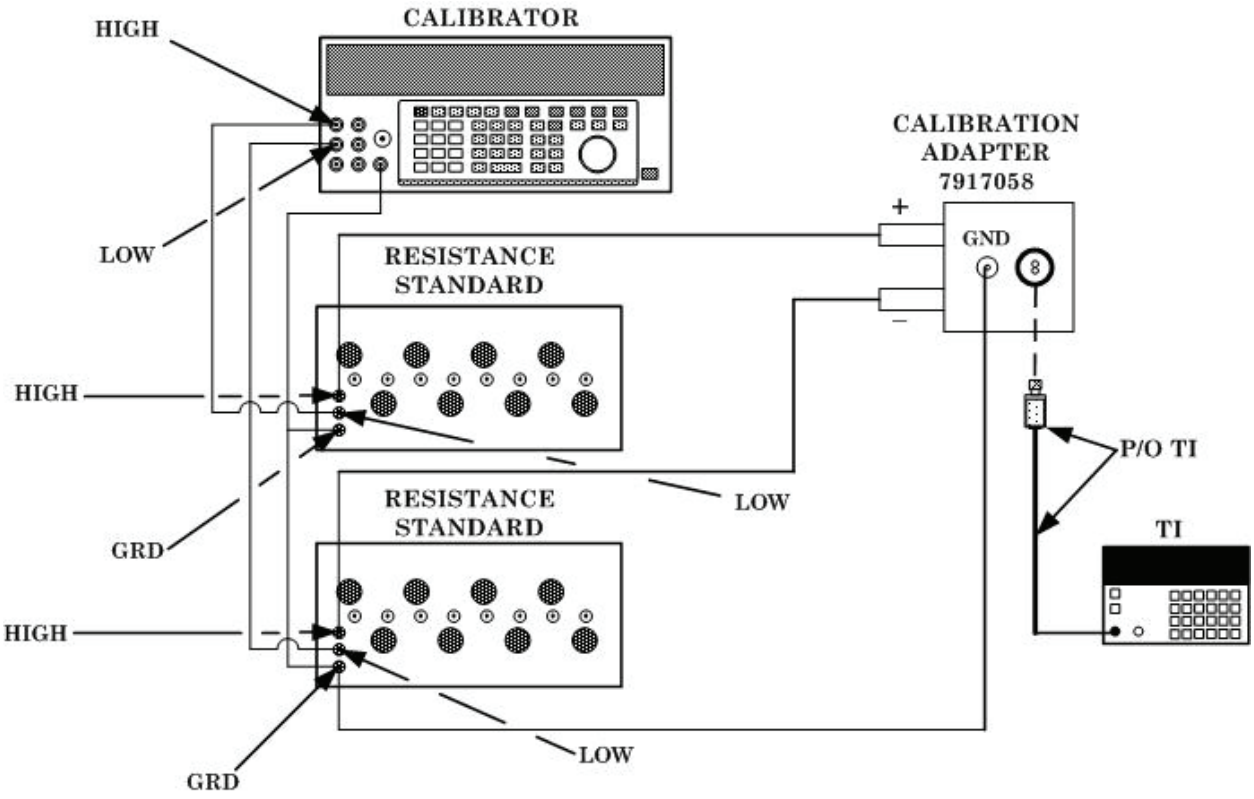


Figure 4. DC accuracy, low ranges - equipment setup.

(9) Press pushbuttons as listed in (a) through (e) below:

(a) **1**, **SELECT CHNL**.
(b) **MODE PWR**.
(c) **0**, **CAL FAC dB**.
(d) **0**, **REF LVL dB**.
(e) **ZERO** (display will indicate **cccc** while zeroing and **cc03** when complete).

NOTE

TI will require zeroing often on most sensitive ranges. To zero TI, set calibrator to 0 mV dc and **OPR**. Press TI **ZERO** pushbutton.

(10) Set control board bit switches to CALIBRATE MODE 1 (DC CAL) (fig. 3).

(11) Press pushbuttons as listed in (a) through (c) below:

(a) **1000**, **RANGE AUTO**.
(b) **0**, **RANGE HOLD**.
(c) **36.85**, **MODE dB**.

(12) Set calibrator to 0.009 V dc and **OPR**, allow 30 seconds settling time before continuing.

(13) Press pushbuttons **CAL** and **REF LVL dB**, if TI does not indicate between 990 and 1010, perform **b** below.

(14) Repeat technique of (11) through (13) above, using calibrator outputs and TI pushbuttons listed in table 8. If TI does not indicate between 996 and 1004, perform **b** below.

Table 8. Dc Accuracy (Ranges 1, 2, and 3)

Press pushbuttons	Calibrator output (V dc)	Allow settling	Wait 30 seconds and press pushbuttons
1, RANGE HOLD	0.09	0	CAL, REF LVL DB
2, RANGE HOLD	0.90	- - -	CAL, REF LVL DB
3, RANGE HOLD	9.00	- - -	CAL, REF LVL DB

(15) Set calibrator to **STBY** and disconnect test equipment. Connect equipment as shown in figure 5.

(16) Repeat (14) above for calibrator outputs and TI pushbuttons listed in table 9.

(17) Disconnect all equipment, press **CLEAR** pushbutton.

(18) Set control board bit switches to OPERATE MODE (fig. 3).

(19) Set TI **LINE** power switch to **OFF**.

(20) Connect sensor to TI interconnect cable.

(21) Set TI **LINE** power switch to **ON** and repeat **9 a** above.

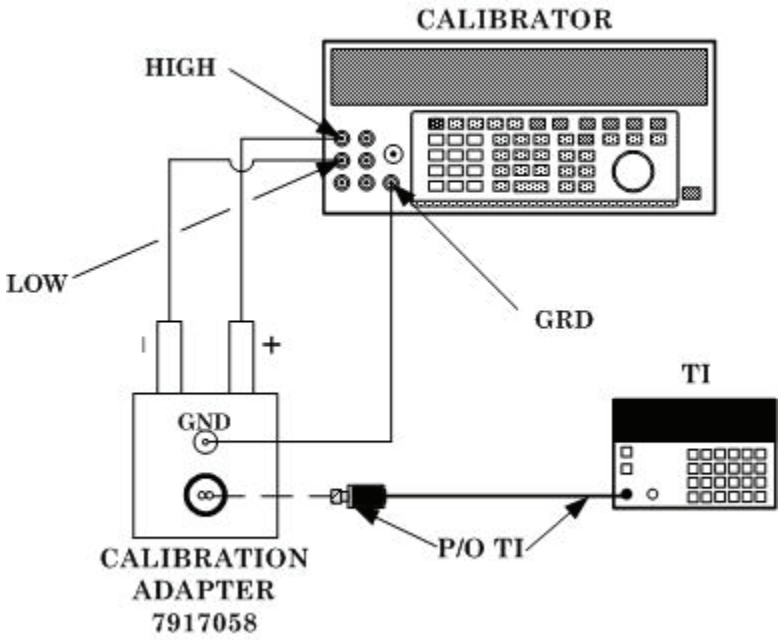


Figure 5. Dc accuracy - high range - equipment setup.

Table 9. Dc Accuracy (Ranges 4, 5, and 6)

Press pushbuttons	Calibrator output (V dc)	Allow settling	Wait 30 seconds and press pushbuttons
4, RANGE HOLD	0.09	- - -	CAL, REF LVL DB
5, RANGE HOLD	0.90	- - -	CAL, REF LVL DB
6, RANGE HOLD	4.5	- - -	CAL, REF LVL DB

b. Adjustments

(1) Set calibrator to 0 mV dc and **OPR**.

(2) Press **1**, **SELECT CHNL**, **0** and **RANGE HOLD** pushbuttons.

(3) Connect TP7 and TP8 (fig. 1) to chassis ground.

(4) Connect multimeter to TP9 and chassis ground (fig. 1). If multimeter does not indicate between +10 and -10 mV, adjust R45 (fig. 1) for a 0 V indication. (R)

(5) Remove connection from TP8 and chassis ground. If multimeter does not indicate between +10 and -10 mV, adjust R36 (fig. 1) for a 0 V indication. (R)

(6) Remove connection from TP7 and chassis ground. If multimeter does not indicate 0 $\pm$100 mV, adjust R4 CHOPPER ADJ and R5 CHOPPER ADJ (fig. 1) equally but in opposite direction to obtain as close to 0 V indication as possible.

NOTE

Due to considerable fluctuation in multimeter indication above, use averaging to determine values.

(7) Disconnect multimeter from TI. Press **ZERO** pushbutton and wait for zeroing to end.

(8) Press **5** and **RANGE HOLD** pushbuttons.

(9) Connect equipment as shown in figure 5.

(10) Set calibrator for 0.9 V dc output. If TI display does not indicate 3685, adjust R1 (fig. 1) for indication of 3685. (R)

(11) Set calibrator for 0.09 V dc output. If display does not indicate 368 or 369, adjust R11 (fig. 1) for indication of 368. (R)

(12) Repeat (10) and (11) above until no further adjustments are needed.

NOTE

Perform (13) through (16) only if (10 or (11) are unsatisfactory after adjustments.

(13) Adjust R1 and R11 (fig. 1) near center.

(14) Set calibrator for 0.9 V dc output.

(15) Adjust R44 (fig. 1) until TI displays 3685. (R)

(16) Repeat (11) above.

(17) Repeat **10 a** above.

11. Sensor Frequency Response

a. Performance Check

(1) Press pushbuttons as listed in paragraph **9 a** (1) above.

(2) Replace thermistor mount H75-478A with thermistor mount 8478B and allow warm-up of power meter.

(3) Connect equipment as shown in figure 6, CONNECTION A.

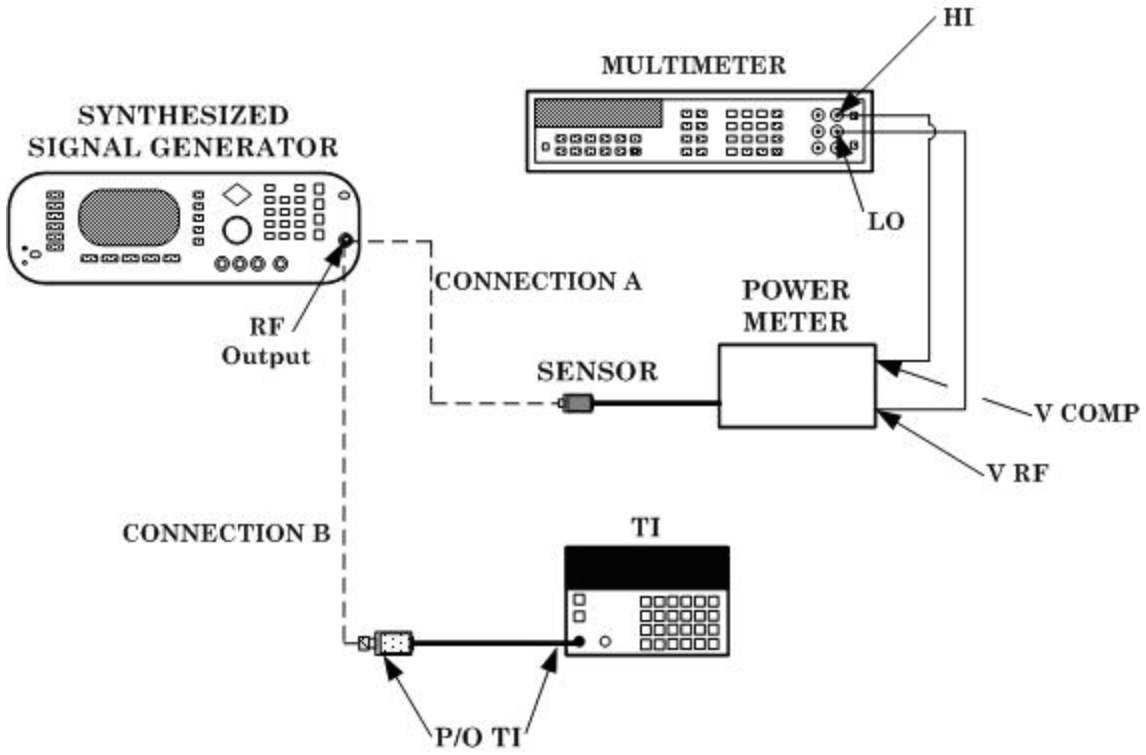


Figure 6. Frequency response - equipment setup.

(4) Adjust synthesized signal generator for a 1 GHz, 1 mW output as indicated on power meter.

(5) Calculate power using precision power measurement technique listed in paragraph **8 a** (7) through (12) above. Record power level.

(6) Press **MODE PWR, X** (where **X** is the frequency being measured) and **CAL FAC GHz** pushbuttons.

(7) Connect equipment as shown in figure 6, CONNECTION B. If display does not indicate within 3 percent of power calculated in (5) above, perform **b** below.

(8) Repeat technique of (3) through (7) above for frequencies and tolerances listed in table 10.

Table 10. Frequency Response

Frequency (GHz)	Tolerance (%)
2	4.7
9	5.7
18	7.7

(9) Disconnect equipment and connect TI sensor to 50 Ω output of synthesizer/level generator.

(10) Press **0**, **CAL FAC GHz**, **0**, and **CAL FAC dB** pushbuttons.

(11) Position synthesizer/level generator controls for a 0.0 dBm output at a frequency of 10 MHz. Display will indicate between 0.97 and 1.03 mW.

(12) Repeat (11) above for frequencies of 1 MHz and 100 kHz.

b. Adjustments

(1) Connect equipment as shown in figure 6, CONNECTION A.

(2) Adjust synthesized signal generator for a 1 GHz, 1 mW output; calculate using precision power measurement technique described in paragraph **8a**(7) through (12) above.

(3) Connect equipment as shown in figure 6, CONNECTION B.

(4) Press **MODE**, **dB, 0**, **CAL FAC GHz**, **0**, **CAL FAC dB** pushbuttons.

(5) Record difference in TI display and 00.00 dBm actual.

Example: **DISPLAY** = -00.60 dB
00.00 - (-00.60) = 0.60 at 5 GHz

DISPLAY = 00.75
00.00 - (-00.75) = 0.75 at 6 GHz

(6) Repeat technique of (1) through (5) for frequencies of 1 through 18 GHz at 1 GHz intervals and record results calculated in (5) above as calibration factors at test frequency on power sensor label.

(7) Set control board bit switch to CALIBRATE MODE 1 (DC CAL) (fig. 3).

(8) Press pushbuttons as listed in (a) through (c) below:

(a) **1**, **SELECT SENS**.

(b) Last four digits of serial number of sensor.

(c) **dB LIMITS HI**, **1000**, **CAL FAC dB**, **2**, **CAL FAC GHz**.

(9) Set control board bit switch to CALIBRATE MODE 2 (AC CAL) (fig. 3).

(10) Press pushbuttons as listed in table 11, from left to right.

Table 11. Sensor High Frequency Calibration Factors

Entry number		Frequency (GHz)		Correction (dB)[1]	
0	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	- - - -	- - - -	- - - -	- - - -

[1]N.NN is calibration factor calculated in (5) above. (CHS) is for negative (-) cal factors only.

(11) Press **0** and **RANGE AUTO** pushbuttons.

(12) Set control board bit switch to OPERATE MODE (fig. 3).

12. Power Supply

a. Performance Check

(1) Connect multimeter to TP3 (fig. 1) and chassis ground. If multimeter does not indicate between 5.198 and 5.202, perform **b** (1) below.

(2) Connect multimeter to TP2 and TP4 (fig. 1). If multimeter does not indicate between 140 and 160 mV dc, perform **b** (2) below.

(3) Connect multimeter to TP1 (fig. 1) and chassis ground. Multimeter will indicate between 14.4 and 15.6 V dc.

(4) Connect multimeter to TP5 (fig. 1) and chassis ground. Multimeter will indicate between -14.4 and -15.6 V dc.

(5) Disconnect multimeter from TP5 and connect to TP6 (fig. 1). Multimeter will indicate between -4.89 and -5.2 V dc.

b. Adjustments

(1) Adjust R5 CHOPPER ADJ (fig. 1) for 5.200 V dc multimeter indication. (R)

(2) Adjust R11 (fig. 1) for a 150 mV dc multimeter indication. (R)

13. Final Procedure

a. Deenergize and disconnect all equipment.

b. Annotate and affix DA label/form in accordance with TB 750-25.

By Order of the Secretary of the Army:

GEORGE W. CASEY, JR.
General, United States Army
Chief of Staff

Official:

JOYCE E. MORROW
Administrative Assistant to the
Secretary of the Army

0733209

Distribution:

To be distributed in accordance with the initial distribution number (IDN) 342270, requirements for calibration procedure TB 9-6625-2185-24.

Instructions for Submitting 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@redstone.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.