*TB 9-6625-1932-35

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DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR POWER SENSORS AND THERMISTOR MOUNTS 10 MHZ TO 40 GHZ (GENERAL)

Headquarters, Department of the Army, Washington, DC
16 December 1996

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SECTION I
IDENTIFICATION AND DESCRIPTION

1. Test Instrument Identification. This bulletin provides instructions for the calibration of Power Sensors and Thermistor Mounts 10 MHz to 40 GHz (General). The manufacturers' specifications were used as the prime data sources in compiling these instructions. The equipment being calibrated will be referred to as the TI (test instrument) throughout this bulletin.

a. Model Variations. Variations among models are described in the text and appendix A.

b. Time and Technique. The time required for this calibration is approximately 2 hours, using the microwave technique.

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

3. Calibration Description. TI parameters and performance specifications which pertain to this calibration are listed in appendix A. Any other power sensors or thermistor mounts within the frequency range prescribed in this bulletin may be calibrated following these instructions provided the manufacturers' specifications are available.

SECTION II
EQUIPMENT REQUIREMENTS

4. Equipment Required. Table 1 identifies the specific equipment to be used in this calibration procedure. This equipment is issued with Secondary Transfer Calibration Standards Set AN/GSM-287 and Secondary Reference Calibration Set 4931-00-621-7878. 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 1. The accuracies listed in table 1 provide a four-to-one ratio between the standard and TI.

5. Accessories Required. The accessories listed in table 2 are issued as indicated in paragraph **4** above and are used in this calibration procedure. When necessary, these items may be substituted by equivalent items, unless specifically prohibited.

Table 1. Minimum Specifications of Equipment Required

Common name	Minimum use specifications	Manufacturer and model (part number)
ATTENUATOR (FIXED)	Range: 30 dB Frequency range: 10 MHz to 18 GHz Accuracy: ±1.0 dB Range: 60 dB Frequency range: 10 MHz to 18 GHz Accuracy: ±1.5 dB	Weinschel, Model 9918, 9918-30dB, and 9918-60dB (9918)
DIGITAL MULTIMETER	Dc range: 0.1 V dc Accuracy: 0.013% of indication +0.005% of FS Dc range: 1 to 15 V dc Accuracy: 0.013% of indication +0.002% of FS Resistance range: 200Ω Accuracy: ±3%	John Fluke, Model 8506A/CT (p/o MIS-35947)
DIRECTIONAL COUPLER NO. 1	Frequency range: 8.2 to 12.4 GHz Coupling: 10 dB Directivity: 40 dB Coupling variation: ±0.4 dB of nominal	Hewlett-Packard, Model X752C (7923188)
DIRECTIONAL COUPLER NO. 2	Frequency range: 12.4 to 18 GHz Coupling: 10 dB Directivity: 40 dB Coupling variation: ±0.4 dB of nominal	Hewlett-Packard, Model P752C (7923187)
DIRECTIONAL COUPLER NO. 3[1]	Frequency range: 18.0 to 26.5 GHz Coupling: 10 dB Directivity: 40 dB Coupling variation: ±0.4 dB of nominal	PRD, Model K414-10-FS1 (7923152)
DIRECTIONAL COUPLER NO. 4	Frequency range: 26.5 to 40 GHz Coupling: 10 dB Directivity: 40 dB Coupling variation: ±0.4 dB of nominal	PRD, Model A414-10-FS1 (7923153)
FREQUENCY EXTENSION KIT NO. 1	Frequency range: 18.0 to 26.5 GHz IF frequency: 700 MHz Combined accuracy with receiver system: ±0.03 dB/10dB	Weinschel, Model 1611 (1611)
FREQUENCY EXTENSION KIT NO. 2	Frequency range: 26.5 to 40 GHz IF frequency: 1 GHz Combined accuracy with receiver system: 0 ±.03 dB/10 dB	Weinschel, Model 1612 (1612)
POWER BRIDGE	No substitute	NBS, Model Type II (Type II)
POWER METER NO. 1	Furnished with TI	- - -
POWER METER NO. 2	Power range: -10 to +3 dBm	Hewlett-Packard, Model E12-432A (MIS-30525)

See footnotes at end of table.

Table 1. Minimum Specifications of Equipment Required

Common name	Minimum use specifications	Manufacturer and model (part number)
POWER SPLITTER	Frequency range: 10 MHz to 18 GHz Output tracking between ports: 10 MHz to 2 GHz: ±0.15 dB 2 to 8 GHz: ±0.2 dB 8 to 18 GHz: ±0.25 dB	Weinschel, Model 1870A (7916839)
PROGRAMMABLE SWEEP GENERATOR	Frequency range: 10 MHz to 40 GHz Output power: At least +3 dBm below 20 GHz, 0 dBm above 20 GHz	Wiltron, Model 6669M (6669M)
RECEIVER SYSTEM	Frequency range: 10 MHz to 18 GHz Attenuation range: 0.00 to 40 dB Accuracy: ±0.02 dB/10 dB	Weinschel, Model VM4A (VM4A)
SIGNAL GENERATOR	Frequency range: 2 to 18 GHz Power output: 0 to +8 dBm Accuracy: ±2 dB	(SG-1219/U)
STANDARD THERMISTOR MOUNTS[2]	Frequency range: 10 MHz to 40 GHz Accuracy:[3]	Hewlett-Packard, Models 8478B, 478A, P486A, X486A, K486A, R486A, (8478B, 478A, P486A, X486A, K486A, R486A)
VSWR BRIDGE NO. 1	Frequency range: 10 MHz to 2 GHz Directivity: 39 dB	Wiltron, Model 60NF50 (7916686)
VSWR BRIDGE NO. 2	Frequency range: 2 to 18 GHz Directivity: 39 dB	Wiltron, Model 87A50-1 (7916685)

[1]Two required.
[2]Select standard thermistor mount compatible to frequency range of TI.
[3]Certified at Army Standards Laboratory (Primary) (for secondary reference only)

Table 2. Accessories Required

Common name	Description (part number)
ADAPTER COAXIAL	(13335441) K to N adapters
ADAPTER WAVEGUIDE TO COAXIAL	(10519423) (8 to 12.4 GHz) 2 each (7923163) (12.4 to 18 GHz) 2 each (13335442-1) (18 to 26.5 GHz) 2 each (13335442-2) (18 to 26.5 GHz) 2 each (13335442-3) (26.5 to 40 GHz) (13335442-4) (26.5 to 40 GHz)
CABLE ASSEMBLY FLEXIBLE RF	(18876-1) (12-inch) (18876-2) (24-inch)
CABLE ADAPTER	Hewlett-Packard, Model 11528A (or fabricate according to figure 1)
SHORT, FIXED	Maury, Model K344A (18 to 26.5 GHz) Maury, Model U344A (26.5 to 40 GHz)
WAVEGUIDE BEND	Part of frequency extension kit No. 1
WAVEGUIDE BEND	Part of frequency extension kit No. 2

SECTION III
CALIBRATION PROCESS
(SECONDARY REFERENCE ONLY)

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 procedure before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name as listed in table 1.

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.

7. Equipment Setup

CAUTION

Do not twist the body of power sensor when connecting and disconnecting. Twisting can cause major damage to the power sensor circuit.

a. If Hewlett-Packard, Model 11528A adapter/cable is not available, fabricate adapter/cable according to figure 1.

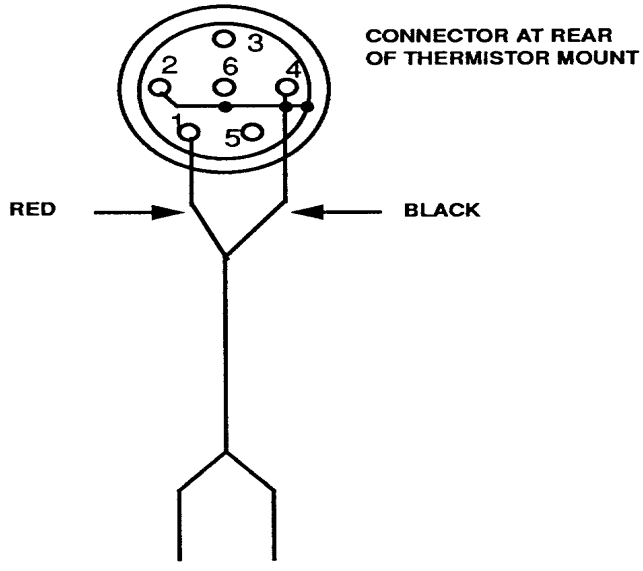


Figure 1. Power measurement system adapter/cable fabrication.

b. Select standard thermistor mount according to TI being calibrated.

c. Evaluate TI for frequency range and determine cardinal test point frequencies from standard thermistor mount chart selected in **b** above.

d. Set power meter No. 1 **CALIBRATION FACTOR** control to **100%** and standardize TI.

e. Connect equipment as shown in figure 2.

f. Energize equipment and allow 1 hour for warmup.

g. Prepare a test report for all thermistor mounts certified for system codes U10, U11, and U12.

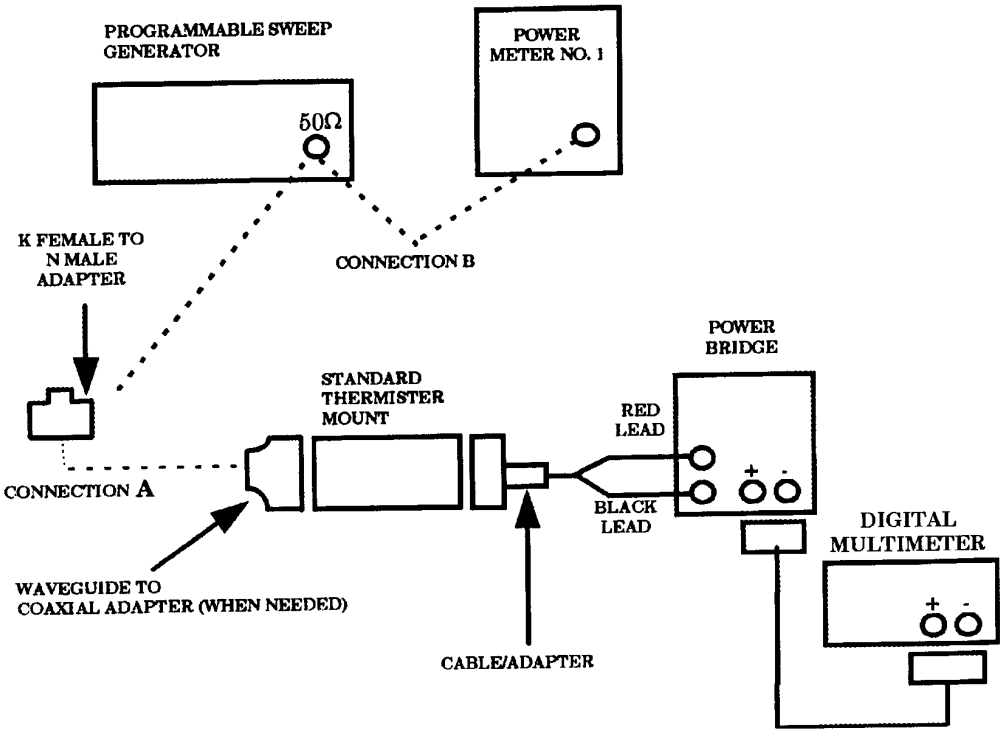


Figure 2. Thermistor mount/power sensor (10 to 40 GHz) - equipment setup.

8. Power Accuracy

a. Performance Check

(1) Adjust programmable sweep generator CW-F1 frequency controls to first TI cardinal test point frequency determined in **7c** above.

NOTE

Perform (2) below for TI power sensors or (3) below for TI thermistor mounts.

(2) Adjust programmable sweep generator **LEVEL** output controls for 0.1 mW or a suitable power level within the range of the TI. Record digital multimeter indication as V2.

(3) Adjust programmable sweep generator **LEVEL** output controls for 1 mW or a suitable power level within the range of the TI. Record digital multimeter indication as V2.

(4) Press programmable sweep generator RF output pushbutton to **OFF** position. Record digital multimeter indication as V1.

(5) Press programmable sweep generator RF output pushbutton to **ON** position. Ensure digital multimeter indicates V2 value recorded in (2) or (3) above.

(6) Disconnect standard thermistor mount from equipment setup.

WARNING

Do not disturb programmable sweep generator **LEVEL** output.

(7) Connect equipment as shown in either figure 2 or 3, CONNECTION B.

(8) Allow enough time for TI to stabilize and record power meter No. 1 indication.

(9) Use formula below and calculate substituted dc power level for standard thermistor mount.

$$\left[P = R \frac{V1w - Vw2}{Kb} \right]$$

Where:

P = Power in mW.

R = Bridge connection factor (2.2222 for 200Ω thermistor mount and 2.500 for 100Ω standard thermistor mount).

V1 = Power bridge output voltage with RF output **OFF**.

V2 = Power bridge output voltage with RF output **ON**.

Kb = **CAL FACTOR** of standard thermistor mount from chart.

(10) To determine TI CAL FACTOR (Kb): Divide power calculated in (9) above into power recorded for TI in (8) above. Difference in computed Kb factor value and Kb value marked on TI will not exceed tolerance listed in appendix A.

NOTE

Perform **b** below for Hewlett-Packard, Models 478A and 8478B that fail (10) above.

(11) Repeat technique of (1) through (10) above for remaining standard thermistor mounts cardinal test point frequencies determined in **7c** above.

NOTE

Perform steps listed below for all TIs which marginally pass (1) through (11) above.

Perform (12) through (25) for coaxial TIs with frequency range between 10 MHz and 18 GHz.

Perform (26) through (35) below for waveguide TIs with frequency range up to 18 GHz

Perform (36) through (46) below for waveguide TIs with frequency range between 18 and 26.5 GHz.

Perform (47) through (58) below for waveguide TIs with frequency range between 26.5 and 40 GHz.

(12) Connect equipment as shown in figure 3.

(13) Adjust programmable sweep generator CW-F1 frequency controls to first cardinal test point frequency determined in **7c** above.

(14) Adjust programmable sweep generator **LEVEL** output controls to +3 dBm.

(15) Allow equipment to warm up for 1 hour before proceeding to (16) below.

NOTE

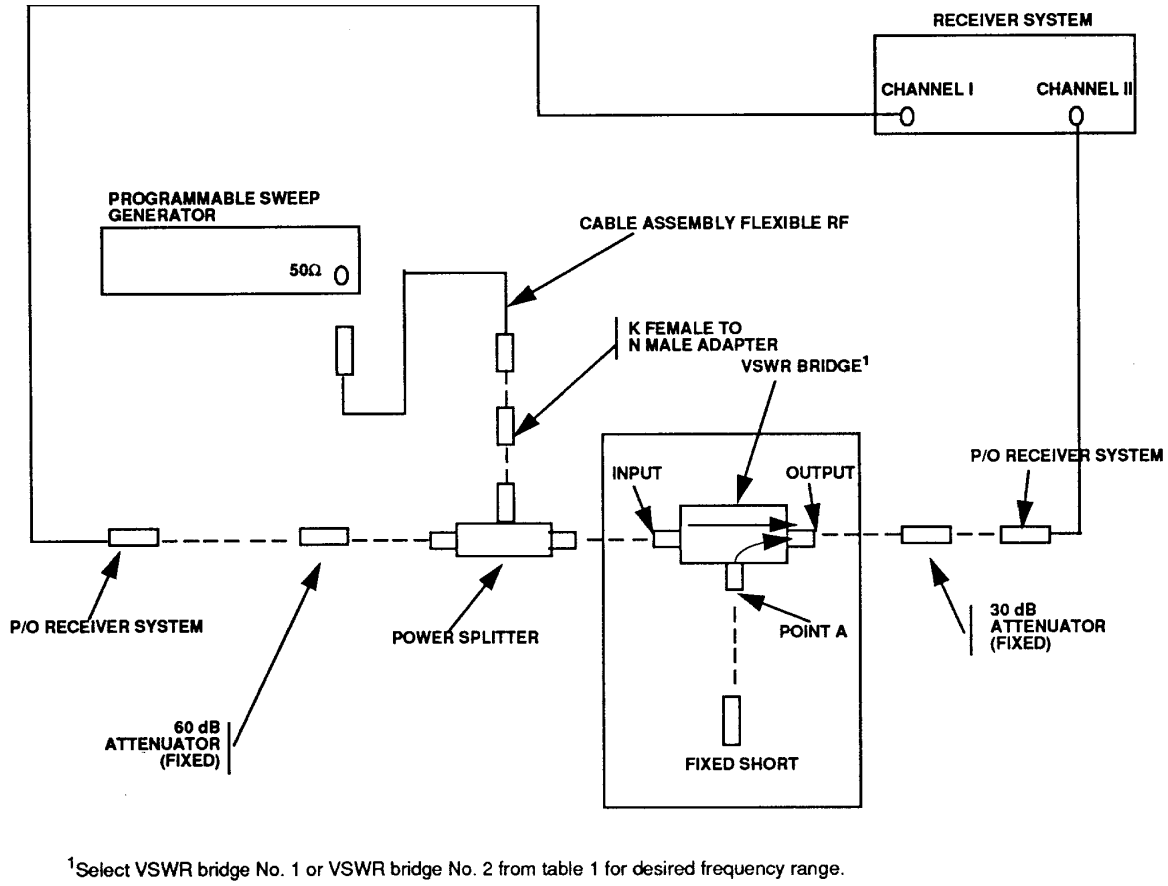
Do not perform (15) above when repeating procedure for remaining cardinal test point frequencies.

(16) Establish a 0.00 dB reference on receiver system at cardinal test point frequency.

NOTE

Ensure receiver system is in measurement mode.

(17) Disconnect fixed short from equipment setup (fig. 3). Record receiver system readout indication (to include the + or - sign).



[1]Select VSWR bridge No. 1 or VSWR bridge No. 2 from table 1 for desired frequency range.

Figure 3. VSWR (coaxial TIs from 10 MHz to 18 GHz) - equipment setup.

(18) Zero power meter No. 1 and connect TI to VSWR bridge No. 1 (No. 2). Record receiver system indication.

(19) Perform (20) below if value recorded in (17) above is -(negative), or (21) below if value recorded in (17) above is +(positive).

(20) Divide value recorded in (17) above by 2. Invert sign and add to value recorded in (18) above. Record sum as return loss.

EXAMPLE A: If value of (17) above is -1.425.

(a) Divide -1.425 by 2 = -0.712.

(b) Invert sign of -0.712 = +0.712.

(c) Add +0.712 to value recorded in (18) above (let value recorded in (18) above be 10.741).

10.741	(18) above
+0.712	
11.453	return loss.

(21) Divide value recorded in (17) above by 2. Invert sign and add to value recorded in (18) above. Record sum as return loss.

EXAMPLE B: If value of (17) above is +1.425

(a) Divide +1.425 by 2 = +0.712.

(b) Invert sign of +0.712 = -0.712.

(c) Add -0.712 to value recorded in (18) above (let value recorded in (18) above be 10.741).

10.741	(18) above
-0.712	
10.029	return loss

(22) Remove TI from VSWR bridge No. 1 (No. 2) and connect fixed short to VSWR bridge No. 1 (No. 2) point A (fig. 3).

(23) Repeat technique of (16) through (22) above 2 more times and average values.

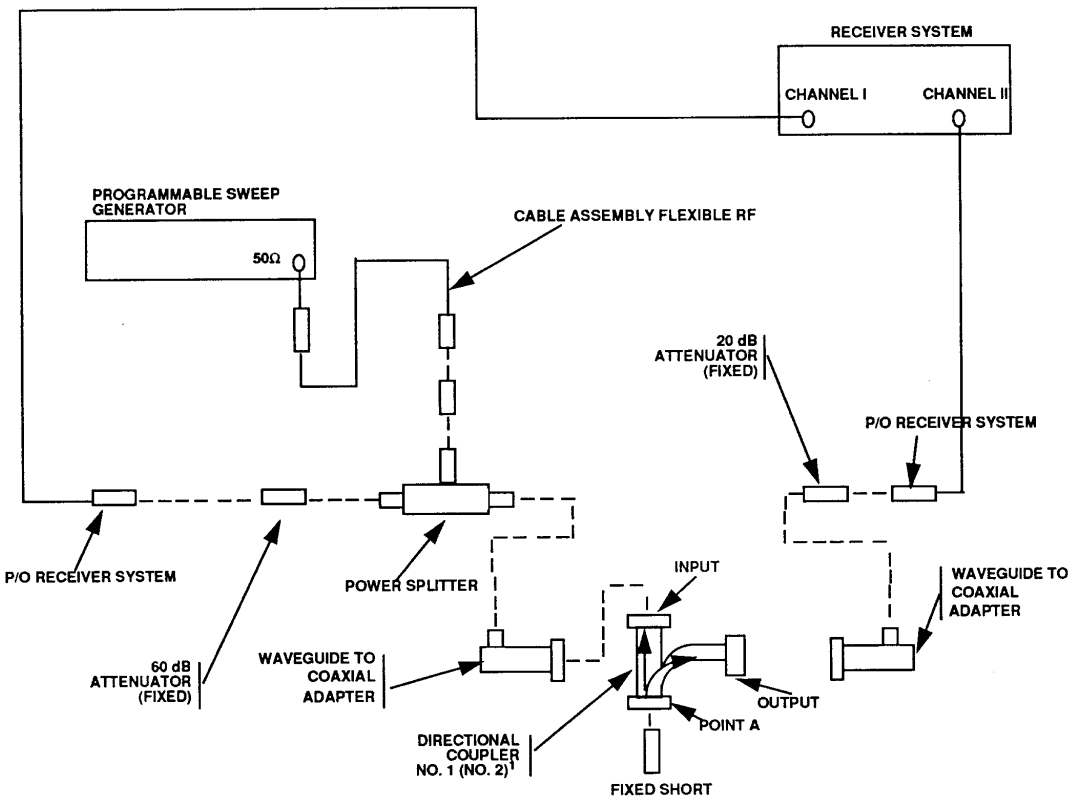
(24) Refer to appendix B and determine VSWR. VSWR will be within the limits listed in appendix A.

(25) Repeat technique of (12) through (24) above for remaining cardinal test point frequencies determined in **7c** above.

(26) Connect equipment as shown in figure 4.

(27) Adjust programmable sweep generator CW-F1 frequency controls to first cardinal test point frequency recorded in **7c** above

(28) Adjust programmable sweep generator **LEVEL** output controls to +3 dBm.



[1]Select directional coupler No. 1 or directional coupler No. 2 for frequency range from table 1.

Figure 4. VSWR (waveguide TIs, up to 18 GHz) - equipment setup.

NOTE

Allow equipment to warm up for one hour for first cardinal test point frequency only.

(29) Establish a 0.00 dB reference on receiver system at test frequency.

NOTE

Ensure receiver system is in measurement mode.

(30) Disconnect fixed short from equipment setup (fig. 4)

(31) Zero power meter No. 1 and connect TI to directional coupler No. 1 (No. 2), point A (fig. 4). Record receiver system indication as return loss.

(32) Disconnect TI from directional coupler No. 1 (No. 2) and connect fixed short to directional coupler No. 1 (No. 2) point A (fig. 4).

(33) Repeat technique of (29) through (32) above 2 more times and average values.

(34) Determine VSWR using appendix B. VSWR will be within the limits listed in appendix A.

(35) Repeat technique of (26) through (34) above for remaining cardinal test point frequencies determined in **7c** above.

(36) Connect equipment as shown in figure 5 and allow equipment to warm up for 3 hours.

(37) Adjust programmable sweep generator CW-F1 frequency controls to first cardinal test point frequency determined in **7c** above.

(38) Adjust programmable sweep generator **LEVEL** output controls for +3 dBm.

(39) Determine signal generator frequency (LO) required for the desired measurement by calculating the following equation:

LO = (RF-IF) / 2
Where:
RF= Frequency of programmable sweep generator (37) above.
IF= Intermediate frequency at which receiver system is to perform measurement (0.700 GHz).

EXAMPLE:
Let IF = 0.700 GHz
Let RF = 18 GHz (37) above
Let LO = signal generator frequency
LO = (RF-IF) / 2
LO = (18 GHz-0.700 GHz) / 2
LO = 17.3 GHz / 2
LO = 8.65 GHz

Signal generator frequency controls for this measurement would be set to 8.65 GHz.

(40) Adjust signal generator frequency controls for value determined in (39) above and RF output controls for +8 dBm.

(41) Establish a 0.00 dB reference on receiver system at 0.700 GHz.

NOTE

Ensure receiver system is in measurement mode.

(42) Disconnect fixed short from equipment setup in figure 5.

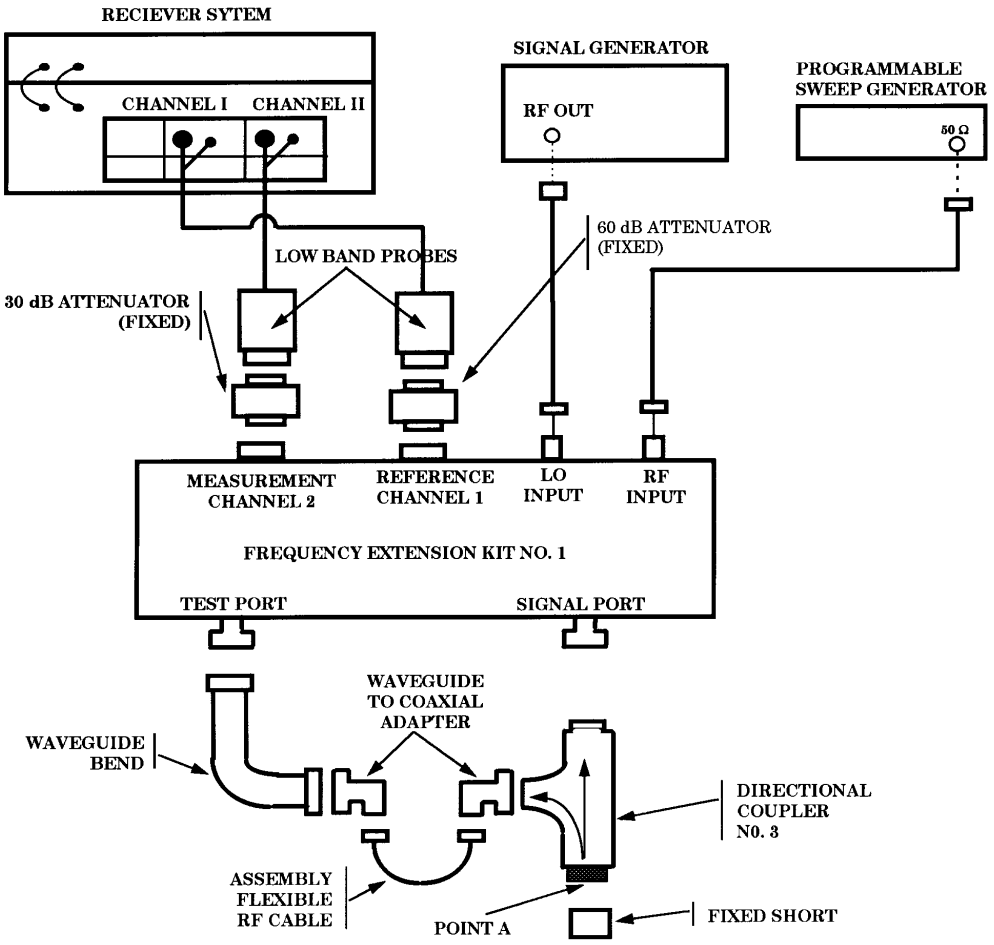


Figure 5. VSWR waveguide (18 to 26 GHz) - equipment setup.

(43) Zero power meter No. 1 and connect TI to directional coupler No. 3, point A (fig. 5). Record receiver system readout indication as return loss.

(44) Remove TI from directional coupler and connect fixed short to directional coupler No. 3, point A (fig. 5).

(45) Repeat (41) through (44) two more times and average values recorded in (43) above. Determine VSWR using appendix B. VSWR will be within the limits listed in appendix A.

(46) Repeat technique of (37) through (45) above for remaining cardinal test point frequencies recorded in **7c** above.

(47) Connect equipment as shown in figure 6 and allow equipment to warm up for 3 hours.

(48) Refer to cardinal test point frequencies determined in **7c** above. Record these values.

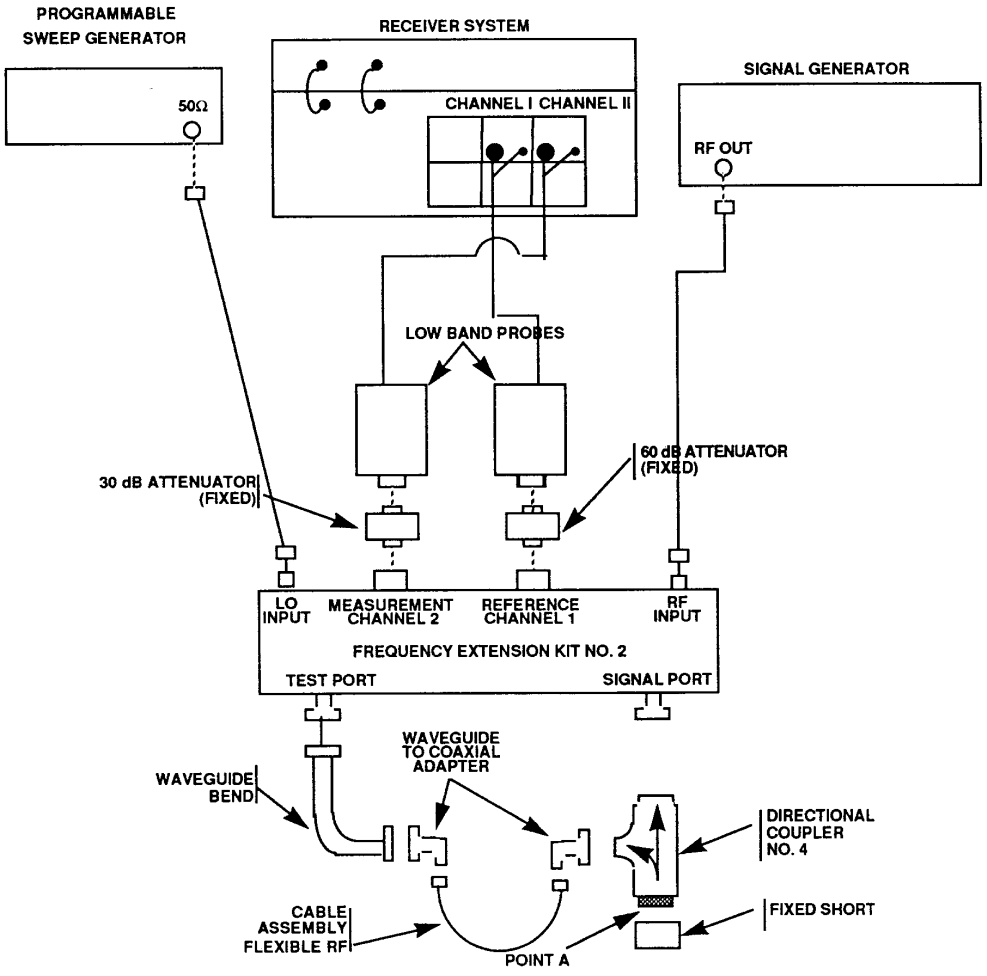


Figure 6. VSWR waveguide (26.5 to 40 GHz)

(49) Determine and record the signal generator frequency (RF) required for the desired measurement by calculating the following equation: RF = Test frequency in GHz (48) above divided by 3.

EXAMPLE A: If first test frequency recorded in (48) above is 27 GHz:
RF = 27 / 3
RF =9 or 9 GHz

(50) Determine and record the programmable sweep generator frequency (LO) required for the desired measurement by calculating the following equation:

LO = ((3 X RF)-IF) / 2
EXAMPLE B:
Where:
RF = Signal generator frequency in GHz recorded in (49) above.
IF = 1 (operating frequency of receiver system in GHz)
LO = Programmable sweep generator frequency
LO = ((3 X 9) -1) / 2
LO = (27 - 1) / 2
LO = 26 / 2
LO = 13 or 13 GHz

(51) Adjust signal generator frequency controls for frequency determined in (49) above and RF output controls for +3 dBm.

(52) Adjust programmable sweep generator frequency controls to value determined in (50) above and **LEVEL** output controls for +3 dBm.

(53) Establish a 0.00 dB reference on receiver system at 1 GHz.

NOTE
Ensure receiver system is in measurement mode.

(54) Disconnect fixed short from directional coupler No. 4 (fig. 6).

(55) Zero power meter No. 1 and connect TI to directional coupler No. 4, point A (fig. 6). Record receiver system indication as return loss.

(56) Remove TI from directional coupler No. 4 and connect fixed short to directional coupler No. 4, point A (fig. 6).

(57) Repeat technique of (53) through (56) above two more times and average values recorded in (55) above. Determine VSWR using appendix B. VSWR will be within the limits listed in appendix A.

(58) Repeat (49) through (58) for remaining cardinal test point frequencies recorded in (48) above.

b. Adjustments (Hewlett-Packard, Models 478A and 8478B only)

CAUTION

Use extreme care when making A adjustments (fig. 7) in the cw direction. Over adjustment will damage TI.

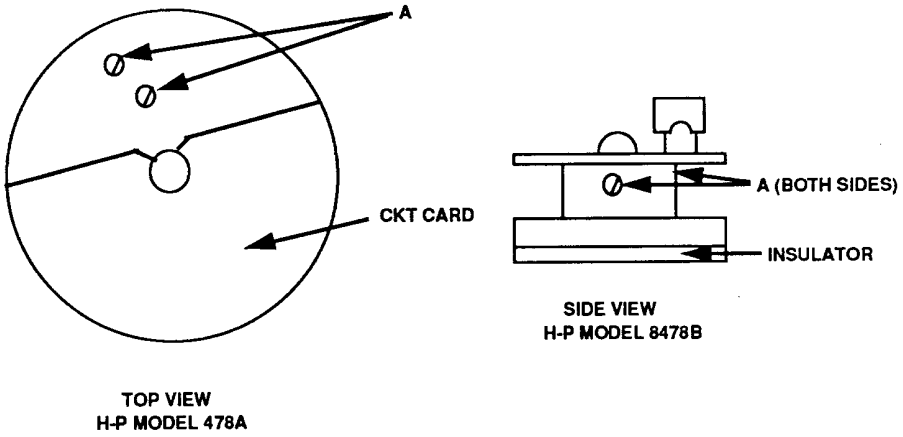


Figure 7. Hewlett-Packard, Models 478A and 8478B only - adjustment locations.

(1) Set power meter No. 1 power switch to **OFF.**

(2) Adjust power meter No. 1 **COARSE ZERO** control to midrange (five turns from fully ccw) and set **RANGE** switch to **COARSE ZERO.**

(3) Remove three screws on thermistor mount.

(4) Slide cover to expose thermistor and circuit card. Set power meter No. 1 power switch to **ON.**

(5) Adjust A adjustments (fig. 7) ccw to adjust down scale and cw to adjust up scale.

NOTE

Both A adjustments (fig. 7) should be made as equal as possible.

9. Final Procedure

a. Deenergize and disconnect all equipment.

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

SECTION IV
CALIBRATION PROCESS
(SECONDARY TRANSFER ONLY)

10. Preliminary Instructions

a. The instructions outlined in paragraphs **10** and **11** are preparatory to the calibration process. Personnel should become familiar with the entire procedure before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name as listed in table 1.

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.

11. Equipment Setup

CAUTION

Do not twist the body of power sensors when connecting and disconnecting. Twisting can cause major damage to the power sensor circuit.

a. Evaluate TI for frequency range and select test frequencies near top, center, and lower end of TI frequency range unless certification at specific frequencies is requested by activity submitting TI for calibration.

NOTE

Select test frequencies which are closest to values listed on test report for standard thermistor mount.

b. Select standard thermistor mount according to TI being calibrated.

c. Connect TI to power meter No. 1 interconnect cable.

WARNING

Do not apply power to power meter No. 2 for steps **d** through **g** below.

d. Set up digital multimeter to measure resistance.

e. Connect digital multimeter leads between power meter No. 2 VRF center conductor (rear panel) and pin 1 of standard thermistor mount end of power meter No. 2 interconnect cable.

f. Round off digital multimeter indication to two decimal places and record value as R.

g. Disconnect digital multimeter leads from power meter No. 2.

h. Press power meter No. 1 and power meter No. 2 **POWER** switches to on position.

i. Set power meter No. 1 **CAL FACTOR %** control to value listed on TI body for lowest test frequency.

j. Set power meter No. 2 **CAL FACTOR %** control to value listed on standard thermistor mount body for lowest test frequency.

k. Connect equipment as shown in figure 8, CONNECTION A, and allow 1 hour for warmup.

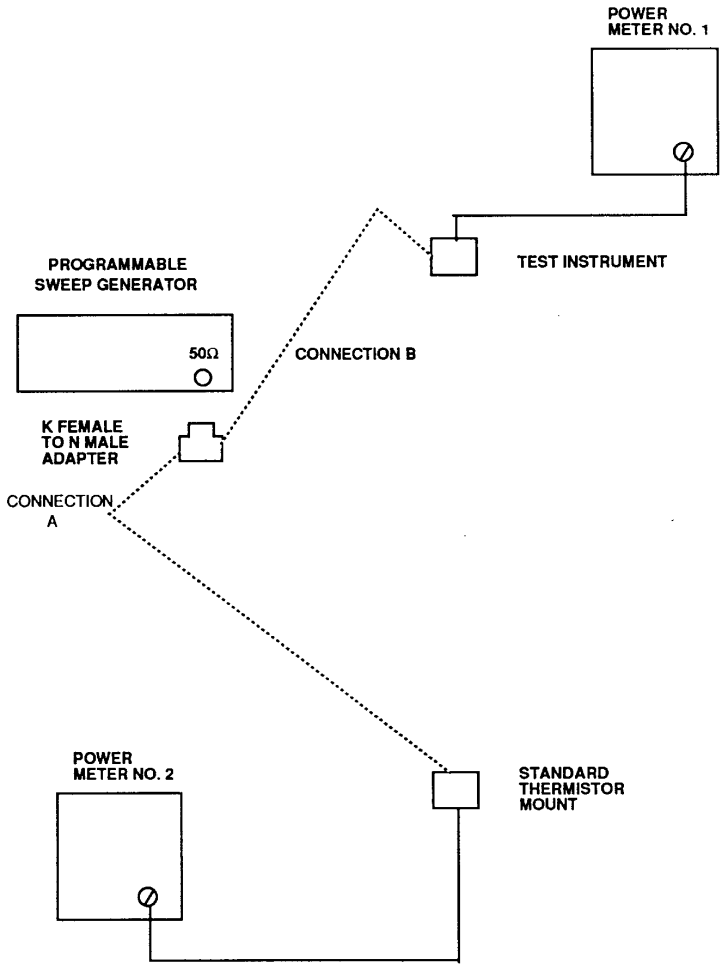


Figure 8. Calibration factor equipment setup.

12. Calibration Factors

a. Performance Check

(1) Press programmable sweep generator **RF** output pushbutton to **OFF** position.

(2) Adjust programmable sweep generator frequency controls for first cardinal point determined in **11a** above.

(3) Set power meter No. 2 **RANGE** switch to **COARSE ZERO** and adjust front panel **COARSE ZERO** control for a zero meter indication.

(4) Ensure digital multimeter input terminals are isolated from chassis ground for (5) below.

(5) Connect digital multimeter positive lead to power meter No. 2 **VCOMP** and connect digital multimeter negative lead to power meter **VRF**.

(6) Set power meter No. 2 **RANGE** switch to **1 mW.**

(7) Adjust digital multimeter (dc mode) controls to measure microvolts.

(8) Press and hold power meter No. 2 **FINE ZERO** control and record digital multimeter indication as V_0.

(9) Release power meter No. 2 **FINE ZERO** control.

(10) Set programmable sweep generator **RF** output pushbutton to **ON** position.

(11) Adjust programmable sweep generator **LEVEL** output controls for a power meter No. 2 indication (reference) of 1 mW full scale or suitable power level full scale indication within range of the TI.

(12) Record digital multimeter indication as V_1.

(13) Disconnect digital multimeter negative lead from power meter No. 2 **VRF** and connect digital multimeter negative lead to power meter No. 2 chassis ground. Record digital multimeter indication as $V_{comp.}$

(14) Calculate and record the power level from the below listed formula as P1:

$$P1 = \frac{2\ V_{COMP}\ (V_1 - V_0) + V_0^2 - V^{12}}{4\ R\ (\text{calibration factor})}$$

P1 = Output power level
V_{COMP} = Value recorded in (13) above.
V_1 =Value recorded in (12) above
V_0 = Value recorded in (8) above
R = Value recorded in **11f** above
Calibration Factor = Value for standard thermistor mount at test frequency

(15) Set power meter No. 1 **RANGE** switch to **COARSE ZERO** and adjust front panel **COARSE ZERO** control for a zero meter indication.

(16) Set power meter No. 1 **RANGE** switch to 1 mW and zero power meter No. 1.

(17) Disconnect power meter No. 2 from programmable sweep generator and connect equipment as shown in figure 8, CONNECTION B.

NOTE

Do not disturb programmable sweep generator **LEVEL** output controls while performing (18) below.

(18) Record power meter No. 1 indication as P2.

(19) Compare power meter No. 2 (P1) value recorded in (14) above with power meter No. 1 (P2) level recorded in (18) above. Differences in power levels will not exceed the tolerance listed in appendix A.

NOTE

Perform **b** below for Hewlett-Packard, Models 478A and 8478B that fail (19) above.

(20) Repeat technique of (1) through (19) above for a test frequency near the center and one at the upper end to TI response range or at specified frequencies requested by activity submitting TI for calibration.

b. Adjustments. Perform **8b** above.

13. Final Procedure

a. Deenergize and disconnect all equipment and reinstall protective cover on TI.

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

APPENDIX A
TEST INSTRUMENT SPECIFICATIONS

Thermistor Mounts

Model	Manufacturer	Frequency range	Power range	Standard limitations from test report indications (Kb factor)	VSWR max
GIL360	Struthers	10 MHz to 10 GHz	1 µW to 10 mW	±3%	10 to 25 MHz: 1.75 25 MHz to 7 GHz: 1.3 7 to 10 GHz: 1.5
GIL360-2	Struthers	10 MHz to 10 GHz	1 µW to 10 mW	±3%	10 to 25 MHz: 1.75 25 MHz to 7 GHz: 1.3 7 to 10 GHz: 1.5
GIL 360A	Struthers	10 MHz to 10 GHz	1 µW to 10 mW	±3%	10 to 25 MHz: 1.75 25 MHz to 7 GHz: 1.3 7 to 10 GHz: 1.5
G486A	Hewlett-Packard	3.95 to 5.85 GHz	1 µW to 10 mW	±3%	3.95 to 5.85 GHz: 1.5
H486A	Hewlett-Packard	7.05 to 10 GHz	1 µW to 10 mW	±3%	7.05 to 10 GHz: 1.5
K486A	Hewlett-Packard	18 to 26.5 GHz	1 µW to 10 mW	±3%	18 to 26.5 GHz: 2.0
MX7772U (478A)	Hewlett-Packard	10 MHz to 10 GHz	1 µW to 10 mW	±3%	Same as GIL360A
P486A	Hewlett-Packard	12.4 to 18.0 GHz	1 µW to 10 mW	±3%	12.4 to 18 GHz: 1.5
P487B	Hewlett-Packard	12.4 to 18 GHz	1 µW to 10 mW	±3%	12.4 to 18 GHz: 1.5
R486A	Hewlett-Packard	26.5 to 40 GHz	1 µW to 10 mW	±3%	26.5 to 40 GHz: 2.0
X486A	Hewlett-Packard	8.2 to 12.4 GHz	1 µW to 10 mW	±3%	8.2 to 12.4 GHz: 1.5
X487B	Hewlett-Packard	8.2 to 12.4 GHz	1 µW to 10 mW	±3%	8.2 to 12.4 GHz: 1.5
478A	Hewlett-Packard	10 MHz to 10 GHz	1 µW to 10 mW	±3%	10 to 25 MHz: 1.75 25 MHz to 7 GHz: 1.3 7 to 10 GHz: 1.5
480	Narda Microline	10 MHz to 10 GHz	1 µW to 10 mW	±3%	10 to 15 MHz: 1.35 15 MHz to 7 GHz: 1.3 7 to 10 GHz: 1.5
8420	Narda	10 MHz to 12.4 GHz	1 µW to 10 mW	±3%	10 MHz to 12.4 GHz: 1.5
8421	Narda	10 MHz to 12.4 GHz	10 µW to 10 mW	±3%	10 MHz to l2.4 GHz: 1.5
8422	Narda	10 MHz to 12.4 GHz	100 µW to 10 mW	±3%	10 MHz to 12.4 GHz: 1.5
8478B	Hewlett-Packard	10 MHz to 18 GHz	1 µW to 10 mW	±3%	10 to 30 MHz: 1.75 30 to 100 MHz: 1.35 0.1 to 1 GHz: 1.1 1 to 12.4 GHz: 1.35 12.4 to 18 GHz: 1.6

See footnotes at end of table

APPENDIX A
TEST INSTRUMENT SPECIFICATIONS

Power Sensors

Model	Manufacturer	Frequency range	Power range	Standard limitations from test report indications (Kb factor)	VSWR max
A420C	General Microwave	26.5 to 40 GHz	0.3 µW to 1 mW	±3%	1.65
ME10314USM (N4240A)	General Microwave	10 MHz to 12.4 GHz	1 µW to 10 mW	±3%	10 to 15 MHz: 1.5 15 MHz, to 10 GHz: 1.35 10 to 18 GHz: 1.6
N420( )	General Microwave	10 MHz to 12.4 GHz	0.3 µW to 10 mW	±3%	10 to 15 MHz: 1.75 15 MHz to 12.4 GHz: 1.5
N421( )	General Microwave	10 MHz to 12.4 GHz	0.3 µW to 100 mW	±3%	Same as N420( )
N422( )	General Microwave	10 MHz to 12.4 GHz	0.3 mW to 1 mW	±3%	Same as N420( )
N423( )	General Microwave	10 MHz to 12.4 GHz	0.3 mW to 3 W	±3%	10 MHz to 12.0 GHz: 1.5 12.0 to 12.4 GHz: 1.75
N4240B	General Microwave	10 MHz to 18 GHz	.1 µW to 1 µW 1 µW to 3.16 mW 3.16 mW to 10 mW	±2.3% +1.16% -1.15% ±2.3%	10 to 15 MHz: 1.5 15 MHz to 10 GHz: 1.35 10 to 18 GHz: 1.6
N4241A	General Microwave	10 MHz to 18 GHz	0.1 µW to 100 mW	(15 to 35 C) -30 to -20 dBm: ±0.1 dB -20 to +15 dBm: ±0.05 dB +15 to +20 dBm: ±0.1 dB	10 MHz to 10 GHz: 1.35 10 to 18 GHz: 1.6
N436A-2A	General Microwave	10 MHz to 18 GHz	- - -	±3%	- - -
8481A 8481A-H001	Hewlett-Packard	10 MHz to 18 GHz	1 µW to 100 mW	10 MHz to 16 GHz: ±3% 16 to 18 GHz: ±3.2%	10 to 30 MHz: 1.40 30 to 50 MHz: 1.18 50 MHz to 2 GHz: 1.10 2 to 12.4 GHz: 1.18 12.4 to 18 GHz: 1.28
8481B	Hewlett-Packard	10 MHz to 18 GHz	0 °C to 35 °C 1 mW to 25 W 35 °C to 55 °C 1 mW to 20 W	0.01 to 0.1 GHz: ±3% 0.1 to 7 GHz: ±3.1% 7 to 9 GHz: ±3.2% 9 to 11 GHz: ±3.3% 11 to 15 GHz: ±4.1% 15 to 17 GHz: ±4.2% 17 to 18 GHz: ±4.3%	10 MHz to 2 GHz: 1.10 2 to 12.4 GHz: 1.18 12.4 to 18 GHz: 1.28

See footnotes at end of table.

APPENDIX A
TEST INSTRUMENT SPECIFICATIONS

Power Sensors - Continued

Model	Manufacturer	Frequency range	Power range	Standard limitations from test report indications (Kb factor)	VSWR max
8481D[1]	Hewlett-Packard	10 MHz to 18 GHz	100 pW to 10 µW	1.0 GHz: ±1.9% 2.0 to 6.0 GHz: ±1.8% 8.0 GHz: ±2.0% 10.0 GHz: ±2.2% 12.0 GHz: ±2.8% 14.0 GHz: ±3.2% 16.0 GHz: ±3.4% 18.0 GHz: ±3.7%	10 to 30 MHz: 1.40 30 MHz to 4 GHz: 1.15 4 to 10 GHz: 1.20 10 to 15 GHz: 1.30 15 to 18 GHz: 1.35
8481H	Hewlett-Packard	10 MHz to 18 GHz	100 µW to 3 W	±3% below 25 dBm ±5%, 25 to 35 dBm	10 MHz to 8 GHz: 1.20 8 to 12.4 GHz: 1.25 12.4 to 18 GHz: 1.30
8482A	Hewlett-Packard	100 kHz to 4.2 GHz[2]	0.3 µW to 100 mW	0.1 MHz to 4 GHz: 3%	100 to 300 kHz: 1.60 300 kHz to 1 MHz: 1.20 1 MHz to 2 GHz: 1.10 2 to 4.2 GHz: 1.3
8482B	Hewlett-Packard	100 kHz to 4.2 GHz	1 mW to 25 W	0.1 to 30 MHz: ±2.8% 50 MHz: ±2.7% 100 to 1000 MHz:: ±3.3% 1000 to 4000 MHz:: ±3.1%	0.1 to 2 GHz: 1.10 2 to 4.2 GHz: 1.18
8482H	Hewlett-Packard	100 kHz to 4.2 GHz[2]	100 µW to 3 W	±3% below 25 dBm ±5%, +25 to +35 dBm	100 kHz to 4.2 GHz: 1.20
8483A	Hewlett-Packard	100 kHz to 2 GHz (75Ω)[2]	0.3 µW to 100 mW	0.1 MHz to 2 GHz: ±3%	100 to 600 kHz: 1.80 600 kHz to 2 GHz: 1.18
8484A[3]	Hewlett-Packard	10 MHz to 18 GHz	0.1 nW to 10 µW	10 MHz to 12.4 GHz: ±3% 12.4 to 14 GHz: ±3.24% 14 to 16 GHz: ±3.4% 16 to 18 GHz: ±3.30%	10 to 30 MHz: 1.4 30 MHz to 4 GHz: 1.15 4 to 10 GHz: 1.2 10 to 18 GHz: 1.30

See footnotes at end of table.

APPENDIX A
TEST INSTRUMENT SPECIFICATIONS

Power Sensors - Continued

Model	Manufacturer	Frequency range	Power range	Standard limitations from test report indications (Kb factor)	VSWR max
8485A[3]	Hewlett-Packard	50 MHz to 26.5 GHz	1 µW to 100 mW (-30 dBm to +20 dBm)	50 MHz to 2 GHz: 3% of calibration factor listed on mount 50 MHz to 10 GHz: ±3% 14 GHz:± 3.2% 18 GHz:± 3.6% 22 GHz:± 3.7% 26.5 GHz:±4.0%	50 to 100 MHz: 1.15 100 MHz to 2 GHz: 1.10 2 to 12.4 GHz: 1.15 12.4 to 18 GHz: 1.20 18 to 26.5 GHz: 1.25

[1]Hewlett-Packard, Model 11708A (30 dB) attenuator must be calibrated with power sensor.

[2]Not checked below 10 MHz.

[3]Weinschel, Model 991830 dB attenuator is needed in the calibration of Hewlett-Packard, Model 8484A (attenuator connection factor will be considered when calculating power level).

APPENDIX B
CONVERSIONS OF VSWR TO RETURN LOSS DB

CONVERSIONS OF VSWR TO RETURN LOSS DB

VSWR	Return loss dB	VSWR	Return loss dB
1.000	- - -	1.330	16.98
1.010	46.06	1.340	16.76
1.020	40.09	1.350	16.54
1.030	36.61	1.360	16.33
1.040	3.415	1.370	16.13
1.050	32.25	1.380	15.94
1.060	30.71	1.390	15.75
1.070	29.42	1.400	15.56
1.080	28.30	1.410	15.39
1.090	27.32	1.420	15.21
1.100	26.44	1.430	15.04
1.110	25.66	1.440	14.88
1.120	24.94	1.450	14.72
1.130	24.29	1.460	14.56
1.140	23.69	1.470	14.41
1.150	23.13	1.480	14.26
1.160	22.61	1.490	14.12
1.170	22.12	1.500	13.98
1.180	21.66	1.510	13.84
1.190	21.23	1.520	13.71
1.200	20.83	1.530	13.58
1.210	20.44	1.540	13.45
1.220	20.08	1.550	13.32
1.230	19.73	1.560	13.20
1.240	19.40	1.570	13.08
1.250	19.03	1.580	12.96
1.260	18.78	1.590	12.85
1.270	18.49	1.600	12.74
1.280	18.22	1.610	12.63
1.290	17.95	1.620	12.52
1.300	17.69	1.630	12.41
1.310	17.45	1.640	12.31
1.320	17.21	1.6750	12.21

APPENDIX B
CONVERSIONS OF VSWR TO RETURN LOSS DB

CONVERSIONS OF VSWR TO RETURN LOSS DB

VSWR	Return loss dB		VSWR	Return loss dB
1.660	12.11		1.920	10.03
1.670	12.01		1.930	9.97
1.680	11.91		1.940	9.91
1.690	11.82		1.950	9.84
1.700	11.73		1.960	9.78
1.710	11.63		1.970	9.72
1.720	11.55		1.980	9.66
1.730	11.46		1.990	9.60
1.740	11.37		2.000	9.54
1.750	11.29		2.010	9.48
1.760	11.20		2.020	9.43
1.770	11.12		2.030	9.37
1.780	11.04		2.040	9.32
1.790	10.96		2.050	9.26
1.800	10.88		2.060	9.21
1.810	10.80		2.070	9.15
1.820	10.73		2.080	9.10
1.830	10.65		2.090	9.05
1.840	10.58		2.100	9.00
1.850	10.51		2.110	8.95
1.860	10.44		2.120	8.90
1.870	10.37		2.130	8.85
1.880	10.30		2.140	8.80
1.890	10.23		2.150	8.75
1.900	10.16		2.160	8.70
1.910	10.10		2.170	8.66

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