*TB 9-4931-534-35

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR MISMATCHES, TERMINATIONS, AND ISOLATORS 10 MHz TO 40 GHz (GENERAL)

Headquarters, Department of the Army, Washington, DC
12 November 2003

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 provide DA Form 2028 information to AMCOM via e-mail, fax, or the World Wide Web. Our fax number is DSN 788-6546 or Commercial 256-842-6546. Our e-mail address is: 2028@redstone.army.mil. Instructions for sending an electronic 2028 may be found at the back of this manual. For the World Wide Web, use: https://amcom2028.redstone.army.mil.

*This technical bulletin supersedes TB 9-4931-534-35, dated 21 May 1991, including all changes.

SECTION I
IDENTIFICATION AND DESCRIPTION

1. Test Instrument Identification. This bulletin provides instructions for the calibration of Mismatches, Terminations, and Isolators 10 MHz to 40 GHz (General). The manufacturer's manuals 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 Appendix A.

b. Time and Technique. The time required for this calibration is approximately 4 hours, using the dc and low frequency and/or 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 Appendix A. Any other mismatch, termination, or isolator within the frequency range prescribed in this procedure may be calibrated with these instructions provided the manufacturer's 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 or AN/GSM-705, Secondary Reference Calibration Standards

Set NSN 4931-00-621-7878, Secondary Reference Calibration Standards Set with limited deployment standards, and Microwave Standards Kit, 18-40 GHz (Secondary Reference). Alternate items may be used by the calibrating activity when the equipment listed in table 1 is not available. 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.

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 accessory is also required for this calibration: Microwave Hardware Kit (7915898), 18-40 GHz (Secondary Reference and AN/GSM-287 or AN/GSM-705).

Table 1. Minimum Specifications of Equipment Required

Common name	Minimum use specifications	Manufacturer and model (part number)
ATTENUATOR (FIXED)	Range: 20 dB Frequency Range: 10 MHz to 18 GHz Accuracy: ±0.5 dB 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, 9918-20dB, and 9918-30dB, and 9918-60dB (9918)
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 18.0 GHz Coupling: 10 dB Directivity: 40 dB Coupling variation: ±0.4 dB of nominal	Hewlett-Packard, Model P752C (7923187)
DIRECTIONAL COUPLER NO. 3[1,2]	Frequency range: 18.0 to 26.5 GHz Coupling: l0 dB Directivity: 40 dB Coupling variation: ±0.4 dB of nominal	PRD, Model K414-10-FSI (7923152)
DIRECTIONAL COUPLER NO. 4[3]	Frequency range: 26.5 to 40 GHz Coupling: 10 dB Directivity: 25 dB Coupling variation: ±1.2 dB of nominal	PRD, Model Al 41-10-FSI (7923153)
FREQUENCY EXTENSION NO. 1[1,4]	Frequency range: 18.0 to 26.5 GHz IF frequency: 700 MHz Combined accuracy with receiver system: ±0.03 dB/10 dB	Weinschel, Model 1611 (1611)
FREQUENCY EXTENSION NO. 2[3,4]	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)

See footnotes at end of table.

Table 1. Minimum Specifications of Equipment Required - Continued

Common name	Minimum use specifications	Manufacturer and model (part number)
POWER SPLITTER	Frequency range: 10 MHz to 18 GHz Insertion loss: -6 dB -0.2 + 1.5 dB Output tracking between ports: 10 MHz to 2 GHz: ±0.l 5 dB 2 to 8 GHz: ±0.2 dB 8 to 18 GHz: ±0.25 dB	Weinschel, Model 1870A (7916839)
RECEIVER SYSTEM	Frequency range: 1 0 MHz to 18 GHz Attenuation range: 0.5 to 40 dB Accuracy: ± 0.02 dB/10 dB	Weinschel, Model VM4A (VM4A)
SIGNAL GENERATOR	Frequency range: 2 to 18 GHz Power output: +3 to +8 dBm Accuracy: ±2 dB	(SG-1219/U)
SYNTHESIZED SIGNAL GENERATOR	Frequency range: 10 MHz to 40 GHz Accuracy: ±0.5% Power output: at least 0 dBm	Wiltron, Model 68369NV (68369NV)
VSWR BRIDGE NO. 1	Frequency range: 10 MHz to 2 GHz Directivity: 40 dB	Wiltron, Model 60NF50 (7916686)
VSWR BRIDGE NO. 2	Frequency range: 2 to 18 GHz Directivity: 32.2 dB	Wiltron, Model 87A50-1 (7916685)

[1]Part of microwave standards kit, 18 to 26.5 GHz, limited deployed item (Secondary Reference).
[2]Two each required.
[3]Part of microwave standards kit, 26.5 to 40 GHz, limited deployed item (Secondary Reference).
[4]Accessories included.

SECTION III
CALIBRATION PROCESS

6. Preliminary Instructions

a. 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 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. Additional maintenance information is contained in the manufacturer's manual for this TI.

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

7. Equipment Setup

a. Refer to TI as listed in Appendix A and evaluate TI for connector type and parameters. Determine and record at least 10 equally spaced frequency test points.

b. Perform paragraph **8** below for coaxial mismatches and terminations with frequency test points from 10 MHz to 18 GHz.

c. Perform paragraph **9** below for waveguide mismatches and terminations with frequency test points up to 18 GHz.

d. Perform paragraph **10** below for waveguide mismatches and terminations with frequency test points from 18 to 26.5 GHz.

e. Perform paragraph **11** below for waveguide mismatches and terminations with frequency test points from 26.5 to 40 GHz.

f. Perform paragraph **12** below for coaxial isolators with frequency test points from 10 MHz to 18 GHz.

g. Perform paragraph **13** below for waveguide isolators with frequency test points up to 18 GHz.

h. Perform paragraph **14** below for waveguide isolators with frequency test points from 18 to 26.5 GHz.

i. Perform paragraph **15** below for waveguide isolators with frequency test points from 26.5 to 40 GHz.

8. VSWR, Coaxial Mismatches, and Terminations (to 18 GHz)

a. Performance Check

(1) Connect equipment as shown in figure 1.

(2) Allow equipment to warm-up for 1 hour before proceeding to (3) below.

(3) Adjust **synthesized signal generator** to test frequency recorded in **7 a** above and RF output level to +5 dBm.

(4) Establish a reference on receiver system at test frequency.

(5) Press receiver system **MEAS-REF** pushbutton.

(6) Disconnect short from equipment setup (fig. 1). Record receiver system readout indication (to include the ± sign).

(7) Connect TI to VSWR bridge and record receiver system indication.

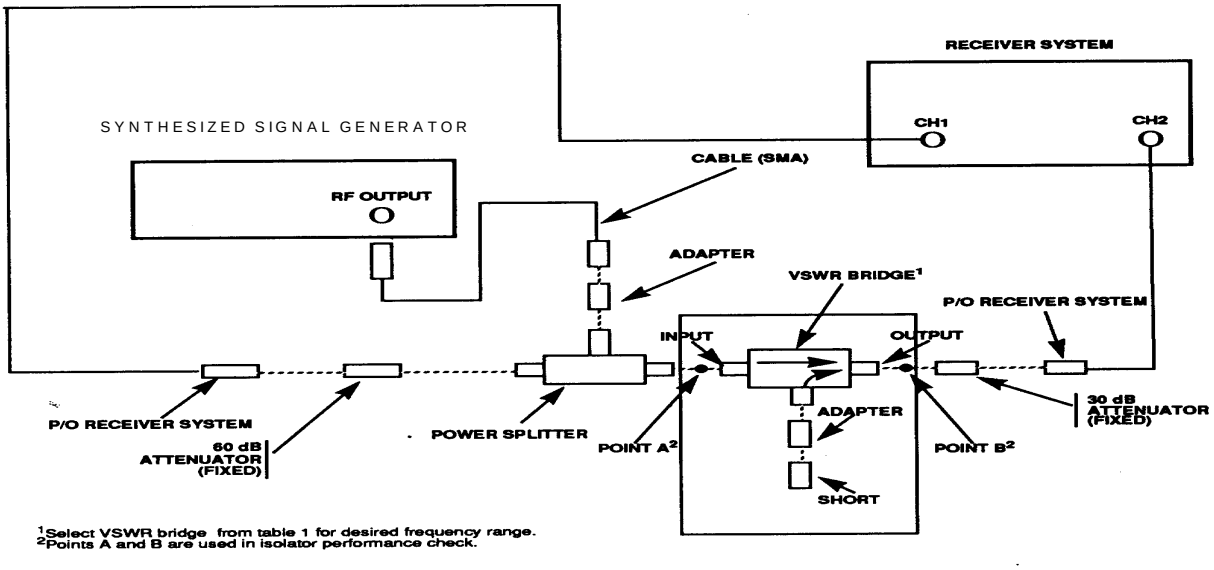


Figure 1. VSWR, insertion loss and isolation equipment setup.

NOTE

Sliding terminations and mismatches only: Adjust sliding load to phase the standard with the TI by establishing a minimum and maximum return loss indication. Average the two indications and record results as TI return loss.

(8) Perform (9) below if value recorded in (6) above is – (negative), or (10) below if value recorded in (6) above is + (positive).

(9) Divide value recorded in (6) above by 2. Invert sign and add to value recorded in (7) above. Record sum as return loss.

EXAMPLE A: If a value of (6) above is –1.425

(a) Divide –1.425 by 2

–1.425 ÷ 2 = –0.712

(b) Invert sign of –0.712 = +0.712

(c) Add +0.712 to value recorded in (7) above. (Let value recorded in (7) above be 10.741.)

10.741 (7 above)

+0.712

11.453 return loss

(10) Divide value record value recorded in (6) above by 2. Invert sign and subtract from value recorded in (7) above. Record difference as return loss:

EXAMPLE B: If value of (6) above is +1.425

(a) Divide +1.425 by 2

+1.425 ÷ 2 = +0.712

(b) Invert sign of +0.712 = –0.712

(c) Subtract –0.712 from value recorded in (7) above. (Let value recorded in (7) above be 10.741.)

10.741 (7) above

<u>–0.712</u>

10.029 return loss

(11) Remove TI from VSWR bridge and connect short to VSWR bridge.

(12) Adjust **synthesized signal generator** RF output level to reference established on receiver system in (4) above.

(13) Repeat technique of (6) through (12) above two times and average values. Averaged value in dB will be within the limits as listed in Appendix A.

(14) Repeat (11) above.

(15) Adjust **synthesized signal generator** frequency to the next frequency test point listed in **7 a** above and RF output level to reference established on receiver system in (4) above.

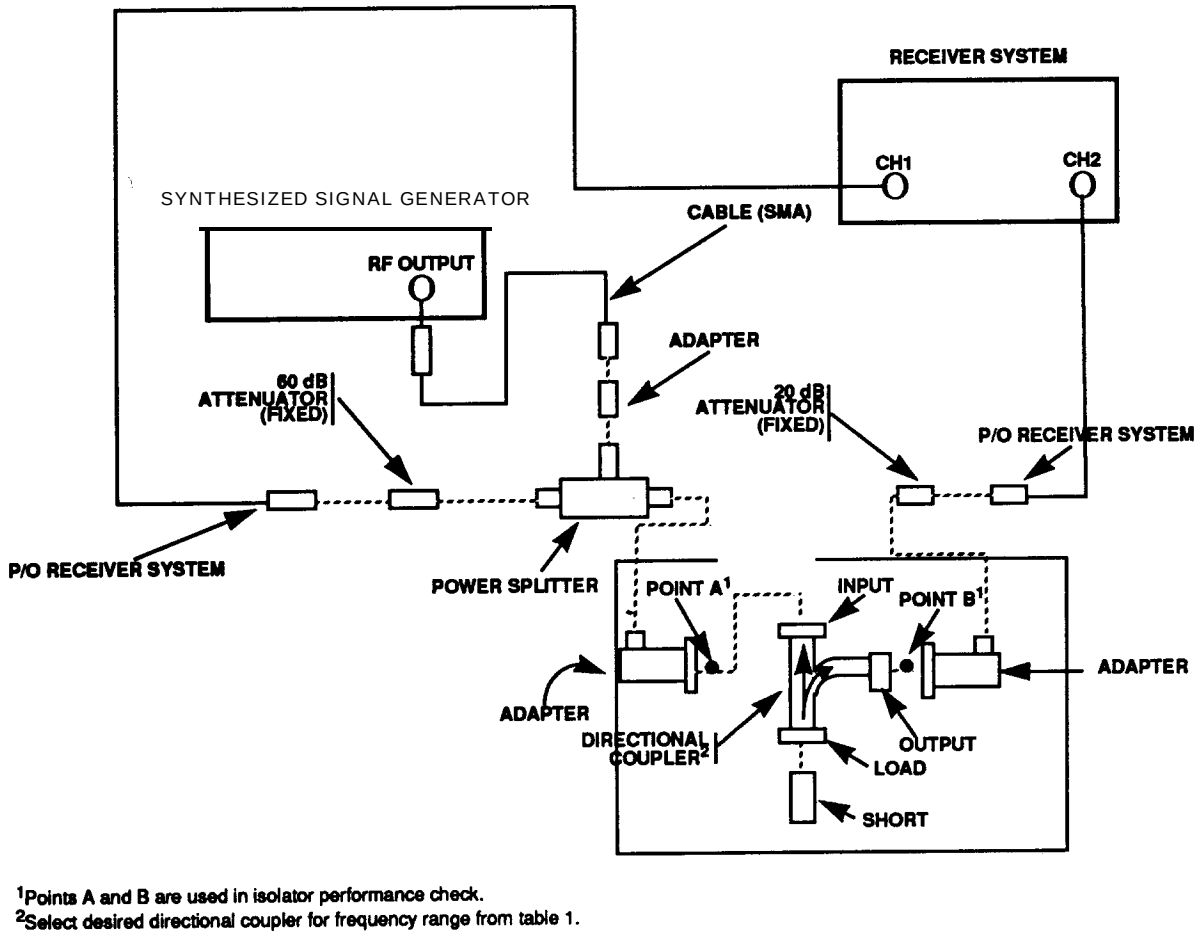
(16) Repeat (6) through (15) above for remaining frequencies recorded in **7 a** above.

b. Adjustments. No adjustments can be made; however, a correction chart may be prepared showing actual VSWR values at test frequencies.

9. VSWR, Waveguide Mismatches, and Terminations (to 18 GHz)

a. Performance Check

(1) Connect equipment as shown in figure 2 and allow equipment to warm-up for 1 hour.



[1]POINTS A AND B ARE USED IN ISOLATOR PERFORMANCE CHECK.
[2]SELECT DESIRED DIRECTIONAL COUPLER FOR FREQUENCY RANGE FROM TABLE 1.

Figure 2. VSWR, insertion loss, and isolation equipment setup - waveguide up to 18 GHz.

(2) Adjust **synthesized signal generator** frequency to first frequency test point recorded in **7 a** above and RF output level to +5 dBm.

(3) Establish a reference on receiver system at test frequency.

(4) Press receiver system **MEAS-REF** pushbutton.

(5) Disconnect short from equipment setup (fig. 2).

(6) Connect TI to directional coupler and record receiver system readout indication as return loss.

NOTE

Sliding terminations and mismatches only: Adjust sliding load to phase the standard with the TI by establishing a minimum and maximum return loss indication. Average the two indications and record results as TI return loss.

(7) Disconnect TI from directional coupler and connect short to directional coupler.

(8) Adjust **synthesized signal generator** RF output level to reference established on receiver system in (3) above.

(9) Repeat technique of (3) through (8) above two times and average values. Return loss averaged value in dB will be within the limits as listed in Appendix A.

NOTE

If out-of-tolerance condition is consistently indicated, replace waveguide adapters and repeat performance check.

(10) Repeat (7) above.

(11) Adjust **synthesized signal generator** frequency to next frequency test point recorded in **7 a** above and RF output level to reference established on receiver system in (3) above.

(12) Repeat technique of (5) through (11) above for remaining frequency test points determined in **7 a** above.

b. Adjustments. No adjustments can be made; however, a correction chart may be prepared showing actual VSWR values at test frequencies.

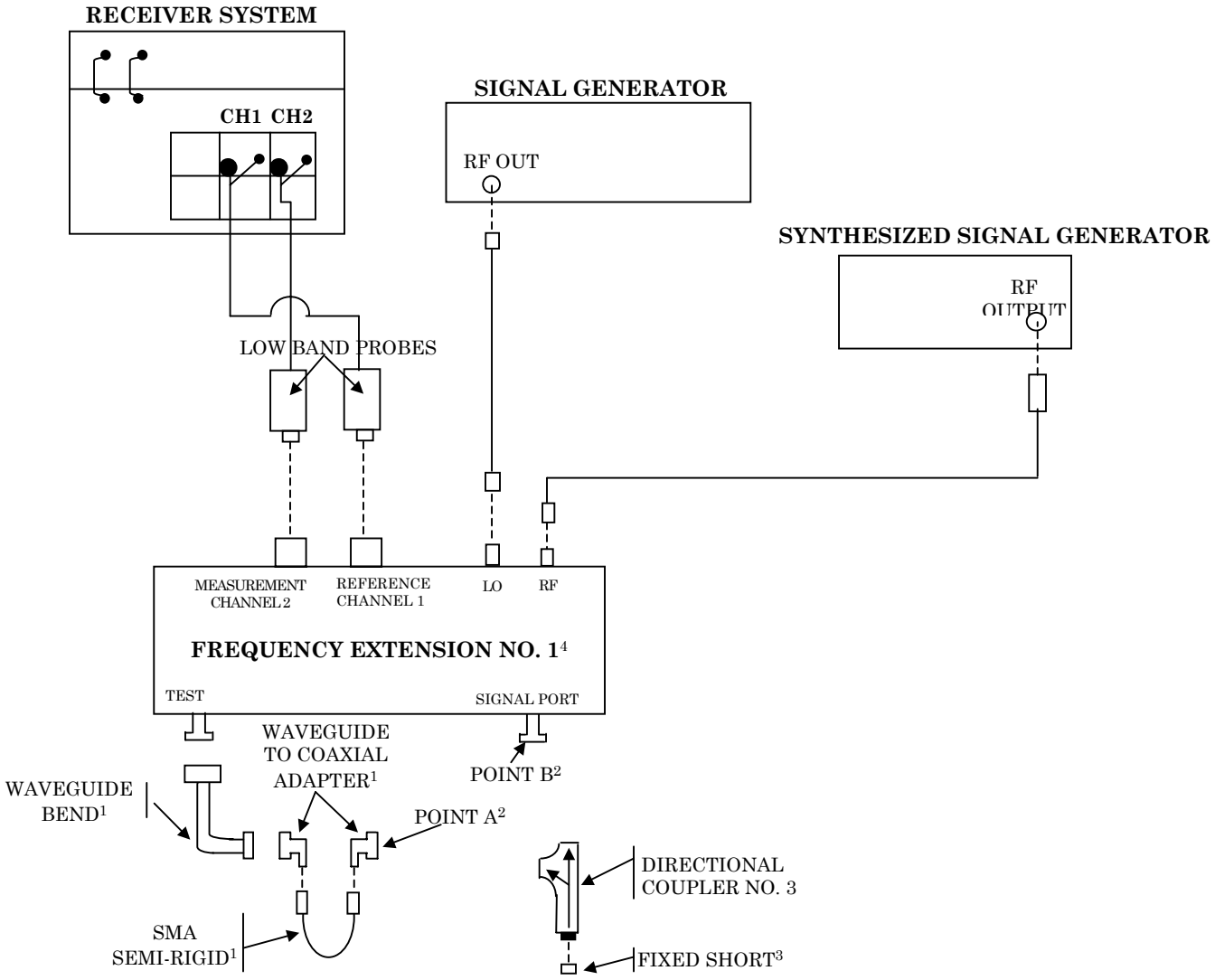
10. VSWR, Waveguide Mismatches, and Terminations (18 to 26.5 GHz)

a. Performance Check

(1) Connect equipment as shown in figure 3 and allow equipment to warm-up for 1 hour.

(2) Adjust **synthesized signal generator** frequency to test frequency (RF value) recorded in **7 a** above and RF output level control for a power meter indication of –7 dBm.

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



[1]Waveguide to coaxial adapters, 90 degree waveguide bends, and SMA semi-rigid cable part of frequency extension kit.

[2]Points A and B are used in isolator equipment setup only. Point A is input to waveguide to coaxial adapter and Point B is output of signal port.

[3]Maury, Model K344A fixed short part of microwave standards kit, 18 to 26.5 GHz.

[4]Part of frequency extension kit.

Figure 3. VSWR waveguide (18 to 26.5 GHZ) – equipment setup.

LO = (RF – IF) ÷ 2

Where: RF = Frequency of **synthesized signal generator** in (2) 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 from (2) 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 for this measurement would be set to 8.65 GHz.

(4) Adjust **signal generator** frequency to value determined in (3) above and RF output to + 8 dBm.

(5) Establish a reference on receiver system at 0.700 GHz and press receiver system **MEAS-REF** pushbutton.

(6) Disconnect fixed short from equipment setup.

(7) Connect TI to directional coupler and record receiver system readout indication as return loss.

NOTE

Sliding terminations and mismatches only: Adjust sliding load to phase the standard with the TI by establishing a minimum and maximum return loss indication. Average the two indications and record results as TI return loss.

(8) Remove TI from directional coupler and connect fixed short to directional coupler.

(9) Repeat technique of (5) through (8) above two times and average values recorded in (7) above. Averaged return loss in dB will be within the limits listed in Appendix A.

(10) Repeat (2) through (9) above for remaining test frequencies recorded in **7 a** above.

b. Adjustments. No adjustments can be made; however, a correction chart may be prepared showing actual VSWR values at test frequency.

11. VSWR, Waveguide Mismatches, and Terminations (26.5 to 40 GHz)

a. Performance Check

(1) Connect equipment as shown in figure 4 and allow equipment to warm up for 1 hour.

(2) Refer to test frequencies determined in **7 a** above. Record these values here.

(3) Determine and record the **signal generator** frequency (RF) required for the desired measurement by calculating the following equation:

RF = test frequency in GHz form (2) above ÷ 3

EXAMPLE A: If first test frequency recorded in (2) above is 27 GHz:

RF = 27 ÷ 3

RF = 9 or 9 GHz

(4) Determine and record the **synthesized signal generator** frequency (LO) required for desired measurement by calculating the following equation:

LO = [(3 x RF) - IF] ÷ 2

EXAMPLE B: Where: RF = **signal generator** frequency in GHz recorded in (3) above.

IF = 1 (operating frequency of receiver system in GHz)

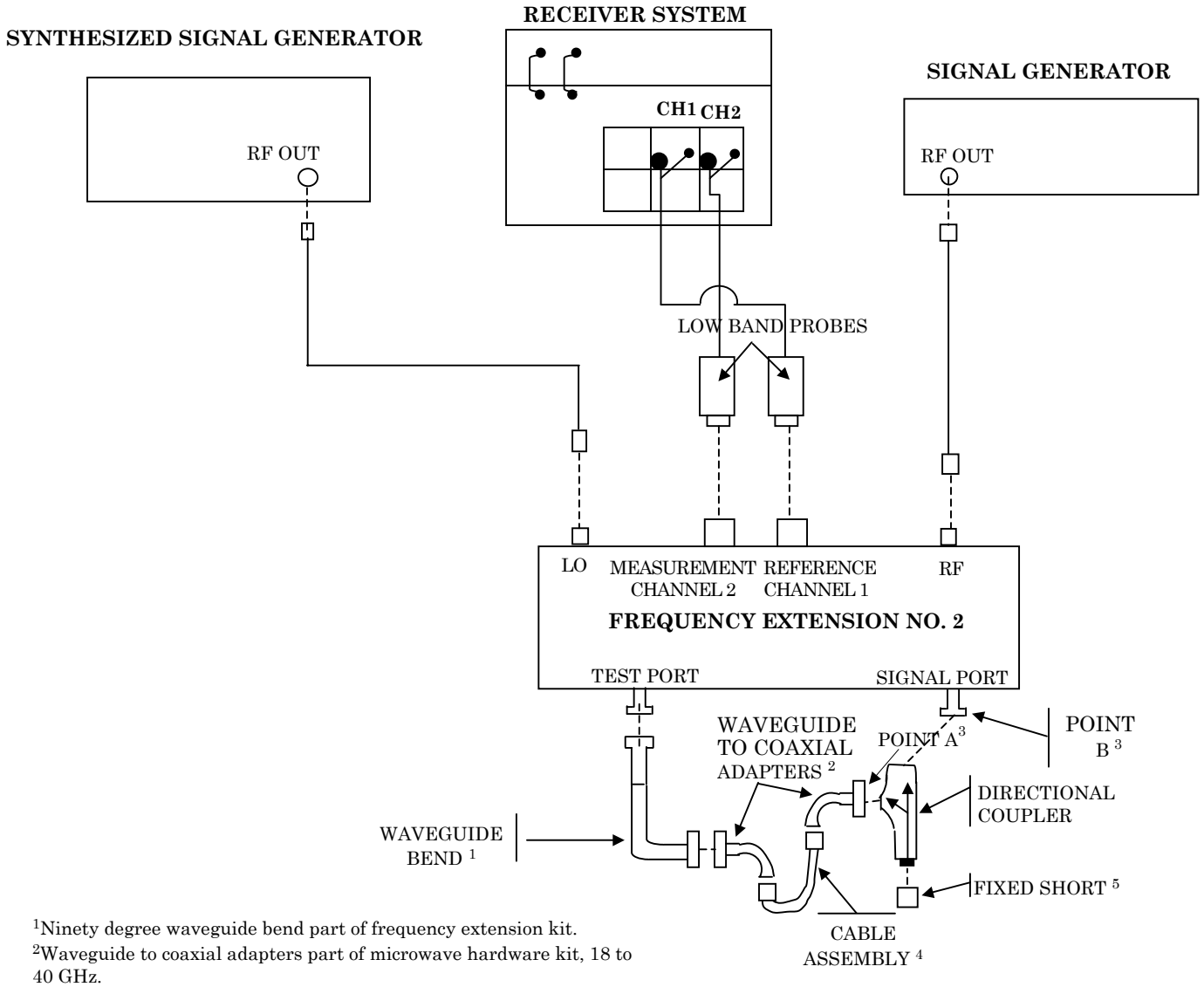
LO = **synthesized signal generator** frequency

LO = [(3 x 9) - 1] ÷ 2

LO = (27-1) ÷ 2

LO = 26 ÷ 2

LO = 13 or 13 GHz



[1]Ninety degree waveguide bend part of frequency extension kit.
[2]Waveguide to coaxial adapters part of microwave hardware kit, 18 to 40 GHz.
[3]Points A and B are used in isolator equipment setup only. Point A is input to waveguide coaxial adapter and Point B, frequency extension No. 2 signal port.
[4]Cable assembly, part of microwave hardware kit, 18 to 40 GHz.
[5]Fixed short part of microwave standards kit, 26.5 to 40 GHz.

Figure 4. VSWR waveguide – 26.5 to 40 GHz.

(5) Adjust **signal generator** to frequency determined in (3) above and RF output to +3 dBm.

(6) Adjust **synthesized signal generator** to frequency determined in (4) above and RF output to 0 dBm.

(7) Establish a reference on receiver system at 1 GHz and press receiver system **MEAS-REF** pushbutton.

(8) Disconnect fixed short from directional coupler.

(9) Connect TI to directional coupler and record receiver system readout indication as return loss.

NOTE

Sliding terminations and mismatches only: Adjust sliding load to phase the standard with the TI by establishing minimum and maximum return loss indications. Average the two indications and record results as TI return loss in dB.

(10) Remove TI from directional coupler and connect fixed short to directional coupler.

(11) Repeat technique of (7) through (10) above two times and average values recorded in (9) above. Averaged value as return loss in dB will be within the limits listed in Appendix A.

(12) Remove TI from directional coupler and connect fixed short to directional coupler.

(13) Repeat (2) through (11) above for remaining test frequencies.

b. Adjustments. No adjustments can be made; however, a correction chart may be prepared showing actual VSWR value at test frequencies.

12. Insertion Loss and Isolation (Coaxial Isolators)

a. Performance Check

(1) Connect equipment as shown in figure 1 except do not connect VSWR bridge into equipment setup. Allow equipment to warm-up 1 hour.

(2) Adjust **synthesized signal generator** frequency to test frequency recorded in **7a** above with optimum RF output.

(3) Connect POINT A to POINT B (fig. 1).

(4) Establish a reference on the receiver system at test frequency recorded in **7 a** above.

(5) Press receiver system **MEAS-REF** pushbutton.

(6) Connect TI between POINT A and POINT B (fig. 1). TI arrow must be pointed in direction of signal flow from **synthesized signal generator** to receiver system.

(7) Insertion loss in dB indications displayed on receiver system will be within limits listed in Appendix A.

(8) Reverse TI connections at POINT A and POINT B (fig. 1). TI arrow must be pointed against the signal flow from **synthesized signal generator** to receiver system.

(9) Isolation in dB (minimum) indication displayed on receiver system will be within limits listed in Appendix A.

(10) Repeat (2) through (9) above for remaining test frequencies recorded in **7 a** above.

b. Adjustments. No adjustments can be made.

13. Insertion Loss and Isolation (Isolator WG to 18 GHz)

a. Performance Check

(1) Connect equipment as shown in figure 2 except do not connect directional coupler into equipment setup. Allow equipment to warm up for 1 hour.

(2) Adjust **synthesized signal generator** to test frequency recorded in **7 a** above with optimum RF output.

(3) Connect POINT A to POINT B (fig. 2).

(4) Establish a reference on the receiver system at test frequency determined in **7 a** above.

(5) Press receiver system **MEAS-REF** pushbutton.

(6) Connect TI between POINT A and POINT B (fig. 2). TI arrow must be pointed in direction of signal flow from **synthesized signal generator** to receiver system.

(7) Insertion loss in dB indication displayed on receiver system will be within limits listed in Appendix A.

NOTE

If out-of-tolerance condition is consistently indicated on receiver system, replace adapters and repeat performance check.

(8) Reverse TI connections at POINT A and POINT B (fig. 2). TI arrow must be pointed against the signal flow from **synthesized signal generator** to receiver system.

(9) Isolation in dB (minimum) indication displayed on receiver system will be within limits listed in Appendix A.

(10) Repeat (2) through (9) above for remaining test frequencies recorded in **7 a** above.

b. Adjustments. No adjustments can be made.

14. Insertion Loss and Isolation (Isolator WG from 18 to 26.5 GHz)

a. Performance Check

(1) Connect equipment as shown in figure 3 with the following exception: Connect POINT A and POINT B together. Allow equipment to warm up for 1 hour.

(2) Adjust **synthesized signal generator** frequency to test frequency (RF value) recorded in **7 a** above and RF output control for a indication of –7 dBm.

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

LO = (RF - IF) ÷ 2

Where: RF = frequency of **synthesized signal generator** from (2) above

IF = intermediate frequency at which receiver system is to perform measurement (0.700 GHz)

EXAMPLE: Let IF = 0.700 GHz

Let RF = 1 8 GHz from (2) above

Let LO = **signal generator** frequency

LO = (RF - IF) ÷ 2

LO = (1 8 GHz - 0.700 GHz) ÷ 2

LO = 17.3 GHz ÷ 2

LO = 8.65 GHz

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

(4) Adjust **signal generator** frequency to value determined in (3) above and RF output to +8 dBm.

(5) Establish a reference on receiver system at 0.700 GHz and press receiver system **MEAS-REF** pushbutton.

(6) Connect TI between POINT A and POINT B (fig. 3) with the TI directional arrow pointed towards the microwave frequency divider TEST PORT (fig. 3). The insertion loss indication displayed on the receiver system will be within the limits listed in Appendix A.

(7) Reverse TI connection at POINT A and POINT B (fig. 3). TI arrow must be pointed towards the microwave frequency divider SIGNAL PORT (fig. 3).

(8) Isolation in dB (minimum) indication displayed on receiver system will be within the limits listed in Appendix A.

(9) Remove TI from POINT A and POINT B (fig. 3).

(10) Connect POINT A and POINT B (fig. 3) together.

(11) Repeat (2) through (10) above for remaining test frequency (RF) recorded in **7 a** above.

b. Adjustments. No adjustments can be made.

15. Insertion Loss and Isolation (Isolator WG from 26.5 to 40 GHz)

a. Performance Check

(1) Connect equipment as shown in figure 4 with the following exceptions on frequency extension kit: Replace directional coupler with 90-degree waveguide bend and connect straight waveguide section between POINT A and POINT B. Allow equipment to warm-up for 1 hour.

(2) Refer to test frequencies determined in **7 a** above. Record these values here.

(3) Determine and record the **signal generator** frequency (RF) required for the desired measurement by calculating the following equation:

RF = test frequency in GHz (2) above ÷ 3

EXAMPLE A: If first test frequency recorded in (2) above is 27 GHz:

RF = 27 ÷ 3
RF = 9 or 9 GHz

(4) Determine and record **synthesized signal generator** frequency (LO) required for the desired measurement by calculating the following equation:

LO=[(3xRF)- IF] ÷ 2

EXAMPLE B:

Where: RF = **signal generator** frequency in GHz recorded in (3) above

IF = 1 (operating frequency at receiver system in GHz)

LO = **synthesized signal generator** frequency

LO = [(3 x 9) -1] ÷ 2

LO = [27-1] ÷ 2

LO = 26 ÷ 2

LO = 13 or 13 GHz

(5) Adjust **signal generator** to frequency determined in (3) above and RF output to +3 dBm.

(6) Adjust **synthesized signal generator** to frequency determined in (4) above and RF output to 0 dBm.

(7) Establish a reference on receiver system at 1 GHz and press receiver system **MEAS-REF** pushbutton.

(8) Disconnect straight waveguide section from POINT A and POINT B (fig. 4).

(9) Connect TI between POINT A and POINT B (fig. 4) with the TI directional arrow pointed towards the frequency extension kit TEST PORT (fig. 4). The insertion loss indication displayed on the receiver system will be within the limits listed in Appendix A.

(10) Reverse TI connection at POINT A and POINT B (fig. 4). TI arrow must be pointed towards the frequency extension kit SIGNAL PORT (fig. 4).

(11) Isolation in dB indication displayed on receiver system will be within the limits listed in Appendix A.

(12) Remove TI from POINT A and POINT B (fig. 4).

(13) Connect straight waveguide section between POINT A and POINT B (fig. 4).

(14) Repeat technique of (2) through (11) above for remaining test frequencies.

b. Adjustments. No adjustments can be made.

16. Final Procedure

a. Deenergize and disconnect all equipment.

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

APPENDIX A

TEST INSTRUMENT SPECIFICATIONS

Test instrument parameters mismatches		Performance specifications accuracy in return loss dB			
Model	Manufacturer	VSWR	Frequency (GHz)	Min	Max
P320E	Maury Microwave	1.5 ±0.02	12.4 to 18	13.71	14.26
TRM 1 - 1. 00F (DA 465/U)	Telonic[2]	1.00 ± 0.05	Dc to 3[3]	32.25	40.00[4]
TRM 1-1.200F (DA 467/U)	Telonic	1.20 ±0.06	Dc to 3[3]	18.78	23.69
TRM 1-1.40F	Telonic	1.40 ±0.07	Dc to 3[3]	14.41	16.98
TRM 1-1.50F (DA 466/U)	Telonic	1.50 ±0.075	Dc to 3[3]	13.02	15.13
TRM 1-1.60F	Telonic	1.60 ±0.08	Dc to 3[3]	11.91	13.71
TRM 1-2.0F	Telonic	2.00 ±0.10	Dc to 3[3]	9.00	10.16
TRM 146498 (1.00)	Telonic	1.00 ±0.05	Dc to 4[3]	32.25	40.00[4]
TRM 146499 (1.1 0)	Telonic	1.10 ±0.055	Dc to 4[3]	22.86	33.15
TRM 146500 (1.15)	Telonic	1.15 ±0.0575	Dc to 4[3]	20.54	27.09
TRM 146500 (1.20)	Telonic	1.20 ±0.06	Dc to 4[3]	18.78	23.69
TRM 147241 (1.05)	Telonic	1.05 ±0.0525	Dc to 4[3]	26.25	40.00[4]
1402B	PRD Electronics	1.105 ±0.0025[5]	8 to 12.4	25.62	26.49
1402E	PRD Electronics	1.50 ±0.007[5]	8 to 12.4	13.68	14.29
1405B	PRD Electronics	1.105 ±0.0025[5]	12.4 to 1 8	25.62	26.49
1405E	PRD Electronics	1.50 ±0.0075[5]	12.4 to 1 8	13.66	14.31
1406BF1[6]	PRD Electronics	1.105 ±0.0035[5]	18 to 26.5	25.45	26.67
1406E [6]	PRD Electronics	1.50 ±0.0009[5]	18 to 26.5	13.60	14.38
1407BF1 [6]	PRD Electronics	1.105 ±0.004[5]	26.4 to 40	25.37	26.77
1407E [6]	PRD Electronics	1.50 ±0.0l0[5]	26.5 to 40	13.55	14.42
1410-1.2 (Ml 4l0-l.2)[7]	Weinschel	1.2 ±0.06 ±0.07	Dc to 8[3] 8 to 12.4	18.78 18.49	23.69 24.29
141 0-1.5 (Ml 410-1.5)[7]	Weinschel	1.5 ± 0.08 ±0.09	Dc to 8[3] 8 to 12.4	12.96 12.85	15.21 15.38

See footnotes at end of table.

APPENDIX A - Continued

TEST INSTRUMENT SPECIFICATIONS (Continued)

Test instrument parameters mismatches	Performance specifications accuracy in return loss dB				
Model	Manufacturer	VSWR	Frequency (GHz)	Min	Max
141 0-2.0 (Ml410-2.0)[7]	Weinschel	2.0 ± 0.12	Dc to 12.4[3]	8.90	10.30
2334-001-1	Premier Microwave	1.05 ±0.05	Dc to 18 GHz[3]	26.44	40.00[4]
2334-001-2	Premier Microwave	1.2 ±0.10	Dc to 18 GHz[3]	17.69	26.45
2334-001-3	Premier Microwave	1.5 ±0.17	Dc to 18 GHz[3]	12.01	16.98
2334-001-4	Premier Microwave	2.00 ±0.22	Dc to 18 GHz[3]	8.43	11.04
510A03	Microlab	1.50 +-0.007[5]	8 to 12.4	13.68	14.29
510A04	Microlab	1.50 ±0.007[5]	12.4 to 18	13.68	14.29
510A05 [6]	Microlab	1.50 ±0.007[5]	1 8 to 26.4	13.68	14.29
510A06 [6]	Microlab	1.50 ±0.007[5]	26.4 to 40	13.68	14.29
7913200-1-5 same as 510A03					
7913200-2-5 same as 510A04					
7913200-3-2 same as 1406BF1[6]					
7913200-3-5 same as 510A05[6]					
7913200-4-2 same as 1407BF					
7913200-4-5 same as 510A06 [6]					
7916901-1-3 same as 2334-001-1					
7916901-3-3 same as 2334-001-2					
7916901-5-3 same as 2334-001-3					
7916901-7-3 same as 2334-001-4					
900WR150	General Radio	1.50 ± (.0075 + .0150 x f (GHz))[8]	Dc to 1 [3]	13.67	14.30
		1.50 ± (.0155 + .0070 x f (GHz))[8]	1 to 8.5	13.02	15.13

See footnotes at end of table.

APPENDIX A - Continued

TERMINATIONS

Test instrument parameters			Performance specifications	
Model	Manufacturer	VSWR	Frequency Range (GHz)	Minimum value in return loss dB[1]
H510E	Microlab/FXR	1.50 + 0.01	3.95 to 5.85	13.84
P910A	Hewlett-Packard	1.02 (max)	12.4 to 18	40.00[4]
W510E	Microlab/FXR	1.50 + 0.01	7.05 to 10	13.84
X910B [2]	Hewlett-Packard	1.015 (max)	8.2 to 12.4	40.00[4]
160-50D	Sierra	1.10 (max) 1.20 (max) 1.40 (max)	Dc to 1 [3] 1 to 4 4 to 5	26.44 20.83 15.56
160B300	Sierra	1. 1 0 (max) 1.20 (max)	Dc to 1[3] 1 to 4	26.44 20.83
161 A50D	Sierra	1. 1 0 (max)	Dc to 3.5	26.44
7913442 same as 160-50D				
7913461 same as 160B300				
8085	Bird Engineering	1. 1 0 (max) 1.25(max)	Dc to 1[3] 1 to 3.5	26.44 19.08
900W50	General Radio	1.005+0.005xf(GHz)[8]	Dc to 8[3]	40.00[4]
ISOLATORS				
Model	Manufacturer	Frequency Range (GHz)	Insertion loss (dB Max)	Isolation (dB min)
1203B	PRD Electronics	8 to 12.4	1.0	30.0
1208B	PRD Electronics	12.4 to 1 8	1.0	24.0
1209BF1[6]	PRD Electronics	18 to 26.5	1.0	24.0
1213BF1[6]	PRD Electronics	26.5 to 40	2.0	20.0
157A27	Microlab/FXR	1 to 2	0.5	20.0

See footnotes at end of table.

APPENDIX A - Continued

ISOLATORS (continued)

Test instrument parameters			Performance specifications	
Model	Manufacturer	Frequency Range (GHz)	Insertion loss (dB Max)	Isolation (dB min)
157A28	Microlab/FXR	2 to 4	0.5	20.0
157A29	Microlab/FXR	4 to 8	0.5	20.0
7913127-1 same as 157A27				
7913127-2 same as 157A28				
7913127-3 same as 157A29				
7923167		8 to 12.4	1.0	20
7923168		12.4 to 18	1.0	20
7923169[6]		18 to 26.5	1.0	20
7923170[6] same as 1213BF1				

[1]Formula, return loss dB -20 log [(VSWR -1 + (VSWR +1)] can be used to calculate values different from those listed in Appendix A or refer to Appendix B.
[2]If out-of-tolerance indication is obtained, provide calibration report of actual values with TI.
[3]Lowest frequency checked is 10 MHz.
[4]Standards limitations.
[5]Reflection coefficient.
[6]These items can only be calibrated by secondary reference levels which were issued the limited deployment standard set.
[7]Item part of Weinschel, Model 1415, Reflection Standard Set.
[8]Accuracy in VSWR value column must be calculated and converted to return loss in dB for frequencies above 1 GHz, using Appendix B. New VSWR values must be rounded to nearest value listed in Appendix B without tightening the tolerance.

APPENDIX B

CONVERSIONS OF VSWR TO REFLECTION COEFFICIENT AND RETURN LOSS dB

VSWR	Reflection coefficient	Return loss dB	VSWR	Reflection coefficient	Return loss DB
1.000	.0000	---	1.250	.1111	19.08
1.010	.0050	46.06	1.260	.1150	18.78
1.020	.0099	40.09	1.270	.1189	18.49
1.030	.0148	36.61	1.280	.1228	18.22
1.040	.0196	34.15	1.290	.1266	17.95
1.050	.0244	32.25	1.300	.1304	17.69
1.060	.0291	30.71	1.310	.1342	17.45
1.070	.0338	29.42	1.320	.1379	17.21
1.080	.0385	28.30	1.330	.1416	16.98
1.090	.0431	27.32	1.340	.1453	16.76
1.100	.0476	26.44	1.350	.1489	16.54
1.110	.0521	25.66	1.360	.1525	16.33
1.120	.0566	24.94	1.370	.1561	16.13
1.130	.0610	24.29	1.380	.1597	15.94
1.140	.0654	23.69	1.390	.1632	15.75
1.150	.0698	23.13	1.400	.1667	15.56
1.160	.0741	22.61	1.410	.1701	15.39
1.170	.0783	22.12	1.420	.1736	15.21
1.180	.0826	21.66	1.430	.1770	15.04
1.190	.0868	21.23	1.440	.1803	14.88
1.200	.0909	20.83	1.450	.1837	14.72
1.210	.0950	20.44	1.460	.1870	14.56
1.220	.0991	20.08	1.470	.1903	14.41
1.230	.1031	19.73	1.480	.1935	14.26
1.240	.1071	19.40	1.490	.1968	14.12

APPENDIX B - Continued

CONVERSIONS OF VSWR TO REFLECTION COEFFICIENT AND RETURN LOSS dB (Continued)

VSWR	Reflection coefficient	Return loss dB	VSWR	Reflection coefficient	Return loss DB
1.500	.2000	13.98	1.750	.2727	11.29
1.510	.2032	13.84	1.760	.2754	11.20
1.520	.2063	13.71	1.770	.2780	11.12
1.530	.2095	13.58	1.780	.2806	11.04
1.540	.2126	13.45	1.790	.2832	10.96
1.550	.2157	13.32	1.800	.2857	10.88
1.560	.2188	13.20	1.810	.2883	10.80
1.570	.2218	13.08	1.820	.2908	10.73
1.580	.2248	12.96	1.830	.2933	10.65
1.590	.2278	12.85	1.840	.2958	10.58
1.600	.2308	12.74	1.850	.2982	10.51
1.610	.2337	12.63	1.860	.3007	10.44
1.620	.2366	12.52	1.870	.3031	10.37
1.630	.2395	12.41	1.880	.3056	10.30
1.640	.2424	12.31	1.890	.3080	10.23
1.650	.2453	12.21	1.900	.3103	10.16
1.660	.2481	12.11	1.910	.3127	10.10
1.670	.2509	12.01	1.920	.3151	10.03
1.680	.2537	11.91	1.930	.3174	9.97
1.690	.2565	11.82	1.940	.3197	9.91
1.700	.2593	11.73	1.950	.3220	9.84
1.710	.2620	11.63	1.960	.3243	9.78
1.720	.2647	11.55	1.970	.3266	9.72
1.730	.2674	11.46	1.980	.3289	9.66
1.740	.2701	11.37	1.990	.3311	9.60

APPENDIX B - Continued

CONVERSIONS OF VSWR TO REFLECTION COEFFICIENT AND RETURN LOSS dB (Continued)

VSWR	Reflection coefficient	Return loss dB	VSWR	Reflection coefficient	Return loss dB
2.000	.3333	9.54	2.090	.3528	9.05
2.010	.3355	9.48	2.100	.3548	9.00
2.020	.3377	9.43	2.110	.3568	8.95
2.030	.3400	9.37	2.120	.3590	8.90
2.040	.3421	9.32	2.130	.3610	8.85
2.050	.3443	9.26	2.140	.3631	8.80
2.060	.3464	9.21	2.150	.3651	8.75
2.070	.3485	9.15	2.160	.3671	8.70
2.080	.3506	9.10	2.170	.3691	8.66

By Order of the Secretary of the Army:

Official:

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

JOEL B. HUDSON
Administrative Assistant to the
Secretary of the Army

0325401

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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.

PIN: 060960-000