TB 9-6625-003-35

CHANGE 3

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR STANDING WAVE RATIO METERS, HEWLETT-PACKARD, MODELS 415A (AN/USM-37 AND IM-97/U), 415B, 415BR, AND 415D (IM-157B/U), GENERAL MICROWAVE MODEL 351 (IM-175/U, IM-175A/U, AND IM-175B/U)

Headquarters, Department of the Army, Washington, DC
23 November 1985

TB 9-6625-003-35, 31 March 1981, is changed as follows:

1. Remove old pages and insert new pages as indicated below. New or changed material is indicated by a vertical bar in the margin of the page.

Remove pages	***Insert pages***
15 through 18	15 through 18

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

By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

ROBERT M. JOYCE
Major General, United States Army
The Adjutant General

Distribution:
To be distributed in accordance with DA Form 12-34C, Block No. 319, requirements for calibration procedures publications.

PIN: 033009-003

TB 9-6625-003-35

CHANGE 2

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR STANDING WAVE RATIO METERS, HEWLETT-PACKARD, MODELS 415A (AN/USM-37 AND IM-97/U), 415B, 415BR, AND 415D (IM-157B/U), GENERAL MICROWAVE MODEL 351 (IM-175/U, IM-175A/U, AND IM-175B/U)

Headquarters, Department of the Army, Washington, DC
10 December 1982

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9 through 16	9 through 16

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

By Order of the Secretary of the Army:

E. C. MEYER
General, United States Army
Chief of Staff

Official:

ROBERT M. JOYCE
Major General, United States Army
The Adjutant General

Distribution:
To be distributed in accordance with DA Form 12-34C, Block No. 319, requirements for calibration procedures publications.

*This change supersedes C1, 3 May 1982.

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THIS REPRINT INCLUDES CHANGES 2 AND 3. (CHANGE 1 IS SUPERSEDED)

*TB 9-6625-003-35

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR STANDING WAVE RATIO METERS, HEWLETT-PACKARD MODELS 415A (AN/USM-37 AND IM-97/U), 415B, 415BR, AND 415D (IM-157B/U). GENERAL MICROWAVE MODEL 351 (IM-175/U, IM-175A/U, AND IM-175B/U)

Headquarters, Department of the Army, Washington, DC
31 March 1981

♦REPORTING OF ERRORS♦

You can help improve this publication by calling attention to errors and by recommending improvements and stating your reasons for the recommendations. Your letter or DA Form 2028, Recommended Changes to Publications, should be mailed directly to Commander, U.S. Army Aviation and Missile Command, ATTN: AMSAM-TMD-EP, Redstone Arsenal, AL 35898-5000. FAX to DSN 788-2313 (commercial 256-842-2313). A reply will be furnished directly to you.

*This bulletin supersedes TB 9-6625-003-35, 19 August 1977 and TB 11-6625-545-35, 17 March 1976, including all changes.

SECTION I
IDENTIFICATION AND DESCRIPTION

1. Test Instrument Identification. This bulletin provides instructions for the calibration of Standing Wave Ratio Meters, Hewlett-Packard Models 415A (AN/USM-37 and IM-97/U), 415B, 415BR, and 415D (IM-157B/U; and General Microwave Model 351 (IM-175/U, IM-175A/U, and IM-175B/U). The manufacturers' instruction manuals were 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. Cabinet and rack-mounted models may differ in component locations but are electrically the same. Front panel nomenclatures will be slightly different on models 415B and GM (General Microwave) 351. Other differences will be annotated within the text.

b. Time and Technique. The time required for calibration of each instrument will be approximately 2 hours, using the dc and low frequency technique.

2. DA Form 2416 (Calibration Data Card)

a. Forms, records, and reports required for calibration personnel at all levels are prescribed by TB 750-25-1. DA Form 2416 must be annotated in accordance with TB 750-25-1 for each calibration performed.

b. Adjustments to be reported on DA Form 2416 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 input requirements	
Model 415A	115 V ac, 50 to 60 Hz, 60 W
Model 415B, 415BR, and GM 351	115/230 V ac ±10%, 60 Hz, 55 W
Model 415D	115/230 V ac, ±10%, 50 to 1000 Hz, 2 W
Operating frequency	
Model 415A	1000 Hz (center frequency)
Model 415B, 415BR, and GM 351	1000 Hz ±2%
Model 415D	1000 Hz (adjustable, 5%)
Amplifier bandwidth	
Model 415A	50 Hz for 1 kHz unit
Model 415B and 415BR	Approximately 40 Hz at half-power points
Model GM 351	48 ± 8 Hz at 1.5 dB points
Model 415D	Variable, nominally 15 to 100 Hz
Sensitivity	0.3 μV FS
Model 415A	0.1 μV at 200-ohm level for FS
Model 415B, 415BR, and GM 351	30 Hz bandwidth: 0.1 μV
Model 415D	Minimum bandwidth: 0.4 μV
Noise level	
Model 415A	0.04 μV referred to input
Model 415B, 415BR, and GM 351	0.03 μV
Model 415D	30 Hz bandwidth: 5 dB below FS with 0.1 μV sensitivity
	Minimum bandwidth: 7.5 dB below FS with 0.1 μV sensitivity
Bolometer current	
Model 415A	4.3 and 8.75 mA
Model 415B and 415BR	4.3 and 8.4 mA
Model GM 351	4.5 and 8.75 mA
Model 415D	4.3 and 8.7 mA adjustable ±10%

Table 1. Calibration Description - Continued.

Test Instrument Parameters	Performance Specification
Attenuation	
Model 415A	Range: 70 dB, input attenuator provides 60 dB in 10 dB steps Accuracy: ±0.1 dB per step
Model 415B and 415BR	Range: 70 dB, input attenuator provides 60 dB in 10 dB steps Accuracy: ±0.1 dB per step; maximum cumulative error ±0.2 dB
Model GM 351	Range: 60 dB ±0.1 dB per 10 dB step Accuracy: ±0.2 dB maximum cumulative error
Model 415D	Range: 70 dB, input attenuator provides 60 dB in 10 and 2.5 dB steps Accuracy: ±0.1 dB per 10-dB steps, ±0.2 dB maximum cumulative error; ±0.1 dB when switching from any 10-dB step (NORM) to any 2.5 dB step (EXPAND), except ±0.05 dB when switching to 0.0 (EXPAND); ±0.02 dB linearity on EXPAND scale.

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 Sets AN/GSM256, AN/GSM-259, and AN/GSM-287. Alternate items may be used by the calibrating activity when the equipment listed in table 2 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 2. The accuracies listed in table 2 provide a four-to-one ratio between the standard and TI.

5. Accessories Required. The accessories listed in table 3 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 2. Minimum Specifications of Equipment Required

Item	Common name and/or (official nomenclature)	Minimum use specifications	Manufacturer, model and (part number)	
			AN/GSM-287	AN/GSM-256 and AN/GSM-259
A1	ATTENUATOR	Range: 0 to 10 dB Accuracy: ±0.1%	N/A	Hewlett-Packard, Model 355C (355C)
A2	ATTENUATOR	Range: 0 to 100 dB Accuracy: ±0.1%	N/A	Hewlett-Packard, Model 355D (355D)
A3	AUTOTRANSFORMER	Range: 105 to 125 V ac Accuracy: ±1%	General Radio, Model W10MT-3AS3 (7910809)	Same as AN/GSM-287
A4	DC VOLTMETER	Range: -17.82 to 252.35 V dc Accuracy: ±0.75%	Hewlett-Packard, Model 3490A-OPTION060) (3490AOPTION060)	Same as AN/GSM-287
A5	FREQUENCY COUNTER (MEASUREMENT SYSTEM)	Range: 935 to 1070 Hz Accuracy: ±0.75%	Hewlett Packard, Model 5345A (MIS-28754 Type 1)	Hewlett-Packard, Model 5245L (5245L)

Table 2. Minimum Specifications of Equipment Required

Item	Common name and/or (official nomenclature)	Minimum use specifications	Manufacturer, model and (part number)	
			AN/GSM-287	AN/GSM-256 and AN/GSM-259
A6	RATIO TRANSFORMER	Range: .000955 to 1.00000 Accuracy: ±0.75%	ESI, Model DT72A (7915908)	North Atlantic[1] Research, Model RB 503/10 (MIS-10232)
A7	RESISTANCE [2] STANDARD	Range: 200Ω and 200 kΩ Accuracy: ±0.75%	Biddle-Gray, Model 71-631 (7910328)	Same as AN/GSM-287
A8	SWR METER	Range: 0 to 60 dB Accuracy: ±0.75%	N/A	Hewlett-Packard, Model 415E (7910160-2)
A9	TEST OSCILLATOR	Range: 980 to 1020 Hz Accuracy: Amplitude ±2%	Hewlett-Packard, Model 652A (MIS-10224)	Same as AN/GSM-287

[1]For AN/GSM-259 only.
[2]Two required.

Table 3. Accessories Required

Item	Common name (official nomenclature)	Description (part number)
B1	ADAPTER	BNC T type, 2 jacks, 1 plug (MS35173-274C)
B2	ADAPTER (ISOLATION PLUG)	2-wire to 2-wire (7912356)
B3	CABLE[1] (CABLE ASSEMBLY)	30-in., RG-58/U; BNC plug terminations (7907467)
B4	CABLE (TEST LEAD)	36-in., RG-58/U; BNC plug to double banana plug (7907471)
B5	CABLE (CABLE ASSEMBLY)	30-in., RG-58/U; double banana plug terminations (7907470)
B6	PROBE (TEST LEAD)	30-in., RG-58/U; double banana plug to probe and alligator clip (7911305)
B7	TERMINATION (DUMMY LOAD)	200-Ω load on BNC plug termination (7907461)
B8	TERMINATION (DUMMY LOAD)	50-Ω feed-through BNC plug to BNC jack terminations (11048B)

[1]Four required.

SECTION III
CALIBRATION PROCESS FOR HEWLETT-PACKARD MODEL 415A (AN/USM-37 AND IM-97/U)

6. Preliminary Instructions

a. The instructions- outlined in paragraphs **6** and **7** are preparatory to the calibration process. Personnel should become familiar with sections I, II, and III before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name and item identification number as listed in tables 2 and 3. For the identification of equipment referenced by item numbers prefixed with A, see table 2**,** and for prefix B, see table 3.

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.

NOTE

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 manufacturers manual for this TI.

NOTE

When indications specified in paragraphs **8** through **11** are not within tolerance, perform the power supply check prior to making adjustments. After adjustments are made, repeat paragraphs **8** through **11**. Do not perform power supply check if all other parameters are within tolerance.

NOTE

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

7. Equipment Setup

a. Remove protective cover from TI only to make adjustments or to gain access to test points. Replace immediately upon completion.

b. Connect TI to autotransformer (A3), using adapter (B2).

c. Connect autotransformer to a 115-V ac source and adjust controls for a 115-V output. If TI meter does not indicate on infinity mark on the 1 to 4 scale, turn mechanical zero-adjustment screw (located below meter face) clockwise until pointer indicates on infinity mark.

d. Position TI controls as listed in (1) through (3) below:

(1) SWR-DB switch to 0 (zero).

(2) Input selector switch to CRYSTAL.

(3) GAIN control fully clockwise.

e. Set TI power switch to ON and allow 10 minutes for warm up.

8. Sensitivity, Stability, and Noise

a. Performance Check

(1) Connect test oscillator (A9) 50-ohm output to TI INPUT, using cable (B3) with termination (B8) connected to test oscillator.

(2) Adjust test oscillator frequency for 1000 Hz and output for an on-scale indication.

(3) Adjust test oscillator frequency for peak indication on TI meter, reducing amplitude as required.

(4) Adjust test oscillator amplitude for a 0-dB indication on TI meter 0 to 10 dB scale. Test oscillator output meter will indicate 0.3 V or less.

(5) Vary output of autotransformer (A3) from 105 to 125 V while maintaining 0 dB indication on TI meter. Test oscillator output meter will indicate 0.3 V or less.

(6) Adjust autotransformer for a 115-V ac output.

(7) Adjust test oscillator amplitude for 0.04 V and record TI meter indication.

(8) Remove equipment-setup and connect termination (B7) to TI INPUT.

(9) Set SWR-DB switch to 60. If TI meter does not indicate less than (down-scale) indication recorded in (7) above, perform **b** below.

b. Adjustments. Adjust R39 (fig. 1) for minimum down-scale indication on TI (R).

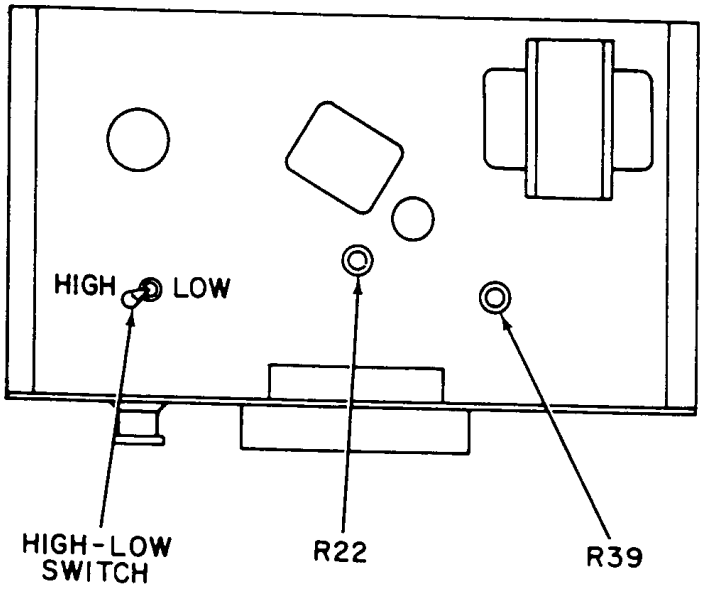

Figure 1. Model-adjustment-top view.

9. Bolometer Bias

a. Performance Check

(1) Set SWR-DB switch to 0 (zero).

(2) Adjust resistance standard (A7) to 200 ohms and connect to TI INPUT, using cable (B4).

(3) Connect dc voltmeter (A4) to resistance standard, using cable (B5).

(4) Set input selector switch to BOLOMETER and HIGH-LOW SWITCH (fig. 1) to LOW. Dc voltmeter will indicate between 0.80 and 0.92 V dc.

(5) Set HIGH-LOW SWITCH to HIGH. Dc voltmeter will indicate between 1.64 and 1.86 V dc.

b. Adjustments. No adjustments can be made.

10. Center Frequency and Bandwidth

a. Performance Check

(1) Connect equipment as shown in figure 2.

(2) Set input selector switch to CRYSTAL and GAIN control one-quarter turn from fully counterclockwise position.

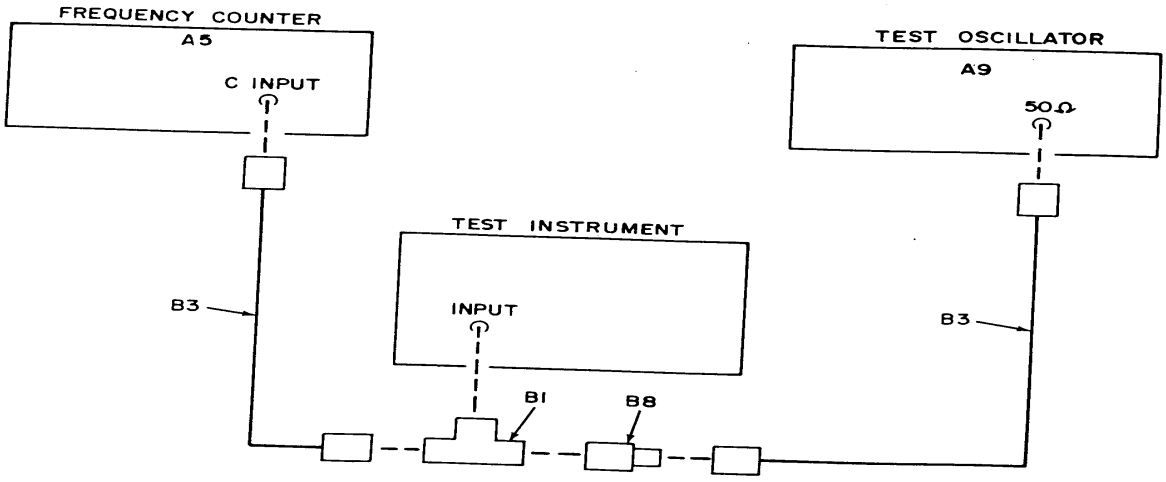

Figure 2. Bandwidth-equipment setup.

(3) Adjust test oscillator (A9) frequency for 1 kHz and amplitude for an on-scale indication on TI meter.

(4) Adjust test oscillator frequency for peak indication on TI meter while maintaining an on-scale indication with GAIN control. Frequency counter (A5) will indicate between 980 and 1020 Hz.

(5) Adjust GAIN control for 0-dB indication on TI meter 0 to 10 DB scale.

(6) Decrease test oscillator frequency until TI meter indicates 1.5 dB on 0 to 10 DB scale. Record frequency counter indication.

(7) Increase test oscillator frequency until TI meter indicates 0 (zero) dB and then drops to 1.5 dB. Record frequency counter indication. If the difference between the two recorded values is not at least 50 Hz, perform **b** below.

b. Adjustments

(1) Adjust test oscillator for peak indication on TI meter.

(2) Adjust R22 (fig. 1) fully clockwise and adjust GAIN control with test oscillator amplitude for a 0-dB indication on TI meter 0 to 10 DB scale.

(3) Adjust R22 until TI meter indicates 4 dB on 0 to 10 DB scale (R).

11. Range Accuracy (exempt AN/GSM-256)

a. Performance Check

(1) Adjust GAIN control fully clockwise.

(2) Connect equipment as shown in figure 3.

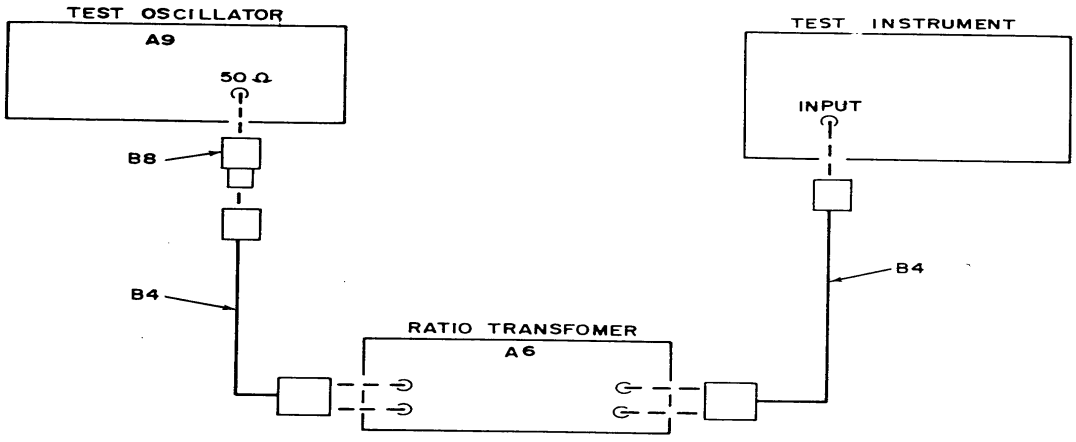

Figure 3. Range accuracy-equipment setup.

(3) Set ratio transformer (A6) controls to .100000.

(4) Adjust test oscillator (A9) frequency for peak indication on TI meter and amplitude for a 0-dB indication on TI meter.

(5) Set ratio transformer controls to .010000 and set SWR-DB switch to 10.

(6) Adjust ratio transformer controls until TI meter indicates 0 dB. Ratio transformer will indicate between .009772 and .010233.

(7) Repeat technique of (5) and (6) above for TI switch settings and indications listed in table 4. Ratio transformer will indicate within limits specified.

Table 4. Range Accuracy

Initial ratio transformer settings	Test instrument SWR DB switch settings	Ratio transformer indications	
		Min	Max
.001000	20	.000955	.001047[1]
.010000	30	.009550	.010471
.001000	40	.000955	.001047[1]
.010000	50	.009550	.010471
.001000	60	.000955	.001047

[1]Before proceeding to next step, perform (a) through (d) below:
(a) Turn TI GAIN control one quarter turn from full counterclockwise position.
(b) Record ratio transformer indication and reduce signal generator amplitude to minimum.
(b) Multiply ratio transformer indication recorded in (b) above by 100 and adjust ratio transformer controls to indicate the product.
(d) Increase signal generator amplitude and adjust frequency for peak indication on TI meter. Adjust amplitude for 0 decibel an TI.

b. Adjustments. No adjustments can be made.

12. Power Supply

NOTE

Do not perform power supply check if all other parameters are within tolerance.

a. Performance Check. Connect dc voltmeter (A4) between pin 8 of V5 (fig. 4) and chassis ground, using probe (B6). If dc voltmeter does not indicate between 232.8 and 247.8 V dc, perform **b** below.

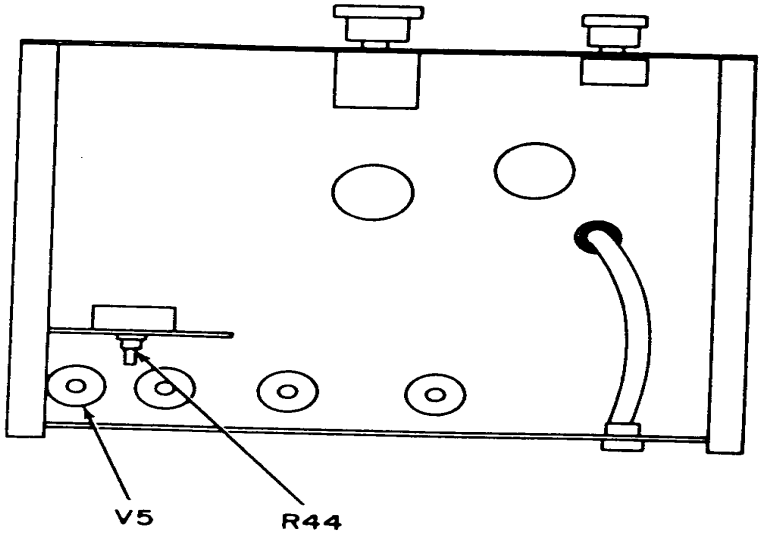

Figure 4. Model 415A-bottom view.

b. Adjustments. Adjust R44 (fig. 4) until dc voltmeter indicates 240 V dc (R).

13. Final Procedure

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

b. When all parameters are within tolerance, annotate and affix DA Label 80 (US Army Calibrated Instrument). When the TI receives limited or special calibration, annotate and affix DA Label 163 (US Army Limited or Special Calibration). When the TI cannot be adjusted within tolerance repair the TI in accordance with the maintenance manual. When repair is delayed for any reason or the TI cannot be repaired -with local resources annotate and affix DA Form 2417 (US Army Calibration System Rejected Instrument) and inform the owner/user accordingly in accordance with TB 750-25-1.

SECTION IV
CALIBRATION PROCESS FOR HEWLETT-PACKARD-MODELS 415B, 415BR, AND GENERAL MICROWAVE MODEL 351 (IM-175/U, IM-175A/U, AND IM-175B/U)

14. Preliminary Instructions

a. The instructions outlined in paragraphs **14** and **15** are preparatory to the calibration process. Personnel should become familiar with sections I, II, and IV before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name and item identification number as listed in tables 2 and 3. For the identification of equipment referenced by item numbers prefixed with A, see table 2, and for prefix B, see table 3.

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.

NOTE

Unless otherwise specified, verify the results 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 listed in this procedure. Additional maintenance information is contained in the manufacturer's manuals for these TI's.

NOTE

When indications specified in paragraphs **16** through **21** are not within tolerance, perform the power supply check prior to making adjustment. After adjustments are made, repeat paragraphs **16** through **21**. Do not perform power supply check if all other parameters are within tolerance.

NOTE

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

15. Equipment Setup

a. Remove protective cover from TI only to make adjustments or to gain access to test points, and replace immediately upon completion.

b. Connect TI to autotransformer (A3), using adapter (B2).

c. Connect autotransformer to a 115-V ac source and adjust a 115-V output.

d. Energize TI and allow 15 minutes for warm up.

e. Set power switch to off (down) position and wait 30 seconds. If TI meter pointer does not indicate 1.3 (radial line model 351) on EXPAND SWR scale, turn mechanical zero adjustment screw clockwise until meter pointer travels to left toward 1.3 or radial line and stops when meter pointer indicates 1.3 or radial line.

f. Position TI controls as listed in (1) through (5) below:

(1) GAIN control fully clockwise.

(2) RANGE switch to 0 (zero).

(3) INPUT SELECTOR switch to XTAL 200Ω.

(4) METER SCALE switch to NORMAL.

(5) Power (LINE) switch to ON.

16. Sensitivity, Stability, and Noise (Exempt AN/GSM-256)

a. Performance Check

(1) Connect equipment as shown in figure 3.

(2) Set ratio transformer (A6) controls to .100000.

(3) Adjust test oscillator (A9) frequency for 1 kHz and amplitude for an on-scale indication.

(4) Adjust test oscillator frequency for a peak indication on TI meter and reduce amplitude as necessary to maintain an on-scale indication.

(5) Adjust test oscillator amplitude for a 0-dB indication on TI meter. Test oscillator output meter will not exceed 1 V rms.

(6) Vary autotransformer output from 105 to 125 V ac and back to 115 V while maintaining 0 dB indication on TI meter with test oscillator amplitude control. Test oscillator output will not exceed 1 V rms.

(7) Adjust test oscillator amplitude to 0.03 V and record TI meter indication.

(8) Disconnect test oscillator and connect termination (B7) to TI INPUT.

(9) Set RANGE switch to 60. TI meter indication will be less than (down scale) indication recorded in (7) above.

b. Adjustments. No adjustments can be made.

17. Bolometer Bias

a. Performance Check

(1) Set RANGE switch to 0 (zero).

(2) Adjust resistance standard (A7) to 200 ohms and connect to TI INPUT, using cable (B4).

(3) Connect dc voltmeter (A4) to resistance standard, using cable (B5).

NOTE

Steps (4) and (5) below pertain to models 415B and 415BR only. Steps (6) and (7) pertains to model 351 only.

(4) Set BOLO BIAS CURRENT switch to HIGH and INPUT SELECTOR switch to BOLO 200Ω. Dc voltmeter will indicate between 1.60 and 1.76 V dc.

(5) Set BOLO BIAS CURRENT switch to LOW. Dc voltmeter will indicate between 0.80 and 0.92 V dc.

(6) Set INPUT SELECTOR switch to BOLO MA 4.5 and METER SCALE switch to BOLO CURR. If TI meter does not indicate on 4.5 MA on bottom scale, and if dc voltmeter does not indicate between 0.83 and 0.97 V dc, perform **b** below.

(7) Set INPUT SELECTOR switch to BOLO MA 8.75. TI will indicate 8.5 MA on bottom scale and dc voltmeter will indicate between 1.62 and 1.88 V dc.

b. Adjustments (Model 351 only). Adjust R54 (fig. 5) until TI indicates 4.5 MA on bottom scale (R).

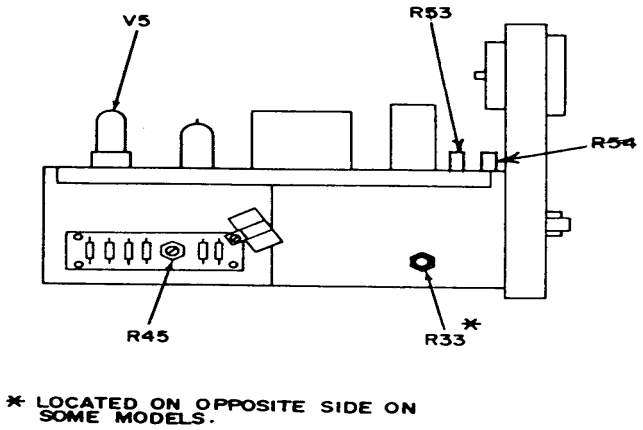

Figure 5. Test instrument-left side view.

18. Frequency and Bandwidth

a. Performance Check

(1) Set INPUT SELECTOR switch to XTAL 200 KΩ and VERNIER and GAIN controls to mid-range.

(2) Connect equipment as shown in figure 2.

(3) Adjust test oscillator (A9) frequency for 1 kHz and amplitude for a mid-scale indication on TI meter.

(4) Adjust test oscillator frequency for peak indication on TI meter while adjusting GAIN control as necessary to maintain mid-scale indication. Frequency counter (A5) will indicate between 980 and 1020 Hz.

(5) Adjust GAIN control until TI meter indicates 0 (zero) on 0 to 10 DB scale.

(6) Decrease test oscillator frequency until TI meter indicates 1.5 dB on 0 to 10 DB scale. Record frequency counter indication.

(7) Increase test oscillator frequency until TI meter reaches peak and dips back to 1.5 dB. Record frequency counter indication. Difference between recorded indications will be 40 Hz or less.

b. Adjustments. No adjustments can be made.

19. Range Accuracy

NOTE

AN/GSM-256 users, disregard paragraphs 19 and 20 and begin with paragraph 21.

a. Performance Check

(1) Adjust test oscillator (A9) amplitude to minimum and set TI VERNIER and GAIN controls fully clockwise.

(2) Set INPUT SELECTOR switch to XTAL 200Ω.

(3) Connect equipment as shown in figure 3.

(4) Set ratio transformer (A6) controls to .100000.

(5) Adjust test oscillator frequency for 1 kHz and amplitude for an on-scale indication on TI meter.

(6) Adjust test oscillator frequency control for peak indication on TI meter and adjust amplitude for a 0-dB indication on TI meter 0 to 10 DB scale.

(7) Set ratio transformer controls to .010000 and set TI RANGE switch to 10.

(8) Adjust ratio transformer controls for a 0-dB indication on TI meter. Ratio transformer will-indicate between .009772 and .010233.

(9) Repeat technique of (7) and (8) above for settings and indications listed in table 5. Ratio transformer will indicate within limits specified.

Table 5 . Range Linearity

Initial ratio transformer settings	Test instrument RANGE SWR DB switch settings	Ratio transformer indications	
		Min	Max
.001000	20	.000955	.001047[1]
.010000	30	.009550	.010471
.001000	40	.000955	.001047[1]
.010000	50	.009550	.010471
.001000	60	.000955	.001047

[1]Before proceeding to next step, perform (a) through (d) below:
(a) Turn TI GAIN control one quarter turn from full counterclockwise position.
(b) Record ratio transformer indication and reduce signal generator amplitude to minimum.
(c) Multiply ratio transformer indication recorded in (b) above by 100 and adjust ratio transformer controls to indicate the product
(d) Increase signal generator amplitude and adjust frequency for peak indication on TI meter. Adjust amplitude for 0 decibel an TI meter.

b. Adjustments. No adjustments can be made**.**

20. Meter Linearity and Expanded Range

a. Performance Check

(1) Set RANGE switch to 10 and ratio transformer (A6) controls to .100000.

(2) Adjust test oscillator (A9) amplitude for an on-scale indication on TI meter and fine-tune for peak indication.

(3) Adjust test oscillator amplitude and TI GAIN controls for a 0-dB indication on TI meter 0 to 10 DB scale.

(4) Adjust ratio transformer controls until TI meter indicates 1 on 0 to 10 DB scale. Ratio transformer will indicate between .077625 and .081283.

(5) Repeat technique of (4) above for settings and indications listed in table 6. Ratio transformer will indicate within limits specified.

Table 6. Range Linearity

Test instrument (0 to 10 dB scale)	Ratio transformer indications	
	Min	Max
2	.061666	.064565
3	.048978	.051286
4	.038905	.040738
5	.030903	.032359

(6) Reduce test oscillator amplitude to minimum and set ratio transformer to .100000.

(7) Set METER SCALE switch to EXPAND and adjust test oscillator amplitude for a 0-dB indication on TI meter 0 to 10 DB scale.

(8) Adjust ratio transformer controls until TI meter indicates 2 on 0 to 2 (2.3) DB scale. If ratio transformer does not indicate between .061660 and .064565, perform **b** below.

NOTE

Steps (9) through (13) pertain to models 415B and 415BR only.

(9) Repeat (6) above.

(10) Set METER SCALE switch to NORMAL and GAIN control fully clockwise.

(11) Adjust test oscillator amplitude, and TI GAIN control if necessary, for a 0-dB indication on TI meter 0 to 10 DB scale.

(12) Set METER SCALE switch to -5 DB.

(13) Adjust ratio transformer for a 0-dB indication on TI meter 0 to 10 DB scale. Ratio -transformer will indicate between .309030 and .323594.

b. Adjustments

(1) Set ratio transformer controls to .063096.

(2) Record TI meter error from 2-dB mark on 0 to 2 (2.3) DB scale.

(3) Adjust R33 (R53 for model 351) (fig. 5) until an equal error is indicated on opposite side of 2-dB mark (R).

21. Attenuator Accuracy (AN/GSM-256 only)

a. Performance Check

(1) Connect equipment as shown in figure 6.

(2) Set attenuators (A1 and A2) to 0 (zero) dB.

(3) Adjust test oscillator (A9) frequency for 1 kHz and amplitude for an up-scale indication on SWR meter (A8).

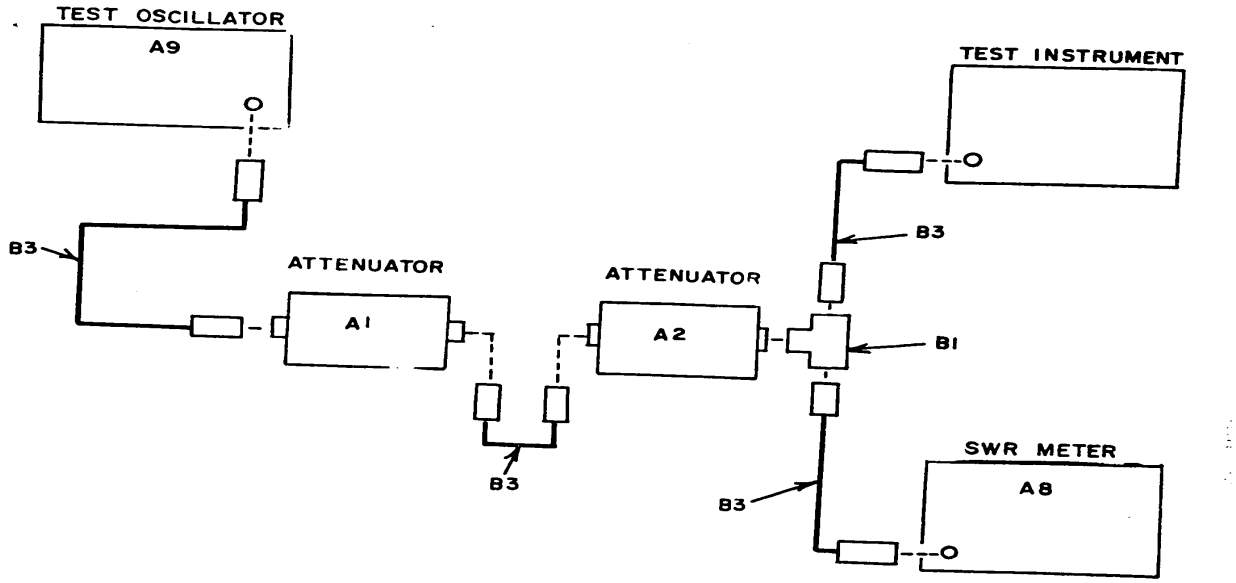

Figure 6. Attenuator accuracy - equipment setup.

(4) Adjust test oscillator frequency and bandwidth controls for a peak indication on SWR meter.

(5) Position TI controls as listed in (a) through (d) below:

(a) VERNIER and GAIN controls fully clockwise.

(b) RANGE switch to 0 DB.

(c) INPUT SELECTOR- switch to XTAL 200Ω.

(d) METER SCALE switch to NORMAL.

(6) Position SWR meter controls as listed in (a) through (d) below:

(a) GAIN control fully clockwise.

(b) RANGE-DB switch to 0 (zero)

(c) INPUT switch to LOW (Models-415B and 415BR only).

(d) EXPAND switch to NORMAL.

(7) Set test oscillator attenuator output to +20 dBm (decibels referred to 1 milliwatt) and adjust amplitude for convenient indication on SWR meter. Record SWR meter indication.

(8) Adjust TI GAIN control for some indication on TI meter as recorded in (7) above.

(9) Set test oscillator attenuator output to 0 DBM and RANGE DB switches on TI and SWR meter to 10 DB.

(10) Adjust test oscillator amplitude for same SWR meter indication recorded in (7) above. TI will indicate within +0.1 dB of SWR meter indication.

(11) Set test oscillator attenuator output to 10 DBM and RANGE DB switches on TI and SWR meter to 20 DB.

(12) Adjust test oscillator amplitude for same SWR meter indication as recorded in (7) above. TI will indicate within ±0.1 dB of SWR meter indication.

(13) Repeat technique above, using test oscillator attenuator and attenuator (A2) to compare each 10 dB step of TI RANGE switch with corresponding step of SWR meter.

(14) Set SWR meter, TI RANGE switch, and attenuator (A2) 0 dB.

(15) Set SWR meter EXPAND switch to 0 (zero) and TI METER SCALE switch to EXPAND.

(16) Adjust SWR meter GAIN control fully counterclockwise.

(17) Adjust test oscillator amplitude for a 0-dB indication on TI meter.

(18) Adjust SWR meter for a 0-dB indication on SWR meter, using GAIN control.

(19) Set attenuator (A1) to 4 dB. If TI meter does not indicate within ±0.1 dB of SWR meter indication, perform **b** below.

b. Adjustments. Adjust R33 (R53 for model 351) (fig. 5) for same TI indication as SWR meter (R).

22. Power Supply

NOTE

Do not perform power supply check if all other parameters are within tolerance.

a. Performance Check. Connect dc voltmeter (A4) between pin 3 of V5 (+245 V) (fig. 5) and chassis ground, using probe (B6). If dc voltmeter does not indicate between +242.55 and +247.45 V, perform **b** below.

b. Adjustments. Adjust R45 (fig. 5) until dc voltmeter indicates 245 V dc (R).

23. Final Procedure

a. Deenergize and disconnect all equipment and replace TI protective cover**.**

b. When all parameters are within tolerance**,** annotate and affix DA Label 80 (US Army Calibrated Instrument). When the TI receives limited or special calibration, annotate and affix DA Label 163 (US Army Limited or Special Calibration). When the TI cannot be adjusted within tolerance, repair the TI in accordance with the maintenance manual. When repair is delayed for any reason, or the TI cannot be repaired with local resources, annotate and affix DA Form 2417 (US Army Calibrated System Rejected Instrument) and inform the owner/user accordingly in accordance with TB 750-25-1.

SECTION V
CALIBRATION PROCESS FOR HEWLETT-PACKARD MODEL 415D (IM-157B/U)

24. Preliminary Instructions

a. The instructions outlined in paragraphs **24** and **25** are preparatory to the calibration process. Personnel should become familiar with sections I, II, and V before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name and item identification number as listed in tables 2 and 3. For the identification of equipment referenced by item numbers prefixed with A, see table 2, and for prefix B, see table 3.

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

NOTE

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 in contained in the manufacturer's manual for this TI.

NOTE

When indications specified in paragraphs **26** through **30** are not within tolerance, perform the power supply check prior to making adjustment After adjustments are made, repeat

paragraphs **26** through **30**. Do not perform power. supply check if all other parameters are within tolerance.

NOTE

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

25. Equipment Setup

a. Remove protective cover from TI only if required to make adjustments or gain access to test points. Replace immediately upon completion.

b. Connect TI to autotransformer (A3), using adapter (B2).

c. Connect autotransformer to a 115-V ac source and adjust for a 115-V output.

d. Set POWER switch to AC and allow 15 minutes for warmup.

e. Set POWER switch to OFF and wait approximately 30 seconds. If meter pointer does not indicate 2.5 on EXPAND scale, adjust mechanical zero adjustment screw clockwise until meter pointer is to the left of 2.5 and moving upscale. Stop meter pointer on 2.5 mark and turn adjustment screw approximately 15 degrees counterclockwise to free screw from meter suspension. Repeat the adjustment if meter pointer moves.

f. Position TI controls as listed in (1) through (8) below:

(1) EXPAND switch to NORM.

(2) RANGE switch to 0 (zero).

(3) INPUT SELECTOR switch to XTAL 200Ω.

(4) GAIN control one-quarter turn from fully clockwise position.

(5) VERNIER control fully clockwise.

(6) BANDWIDTH control fully counterclockwise.

(7) POWER switch to AC.

(8) MTR DAMP switch to IN (rear panel).

NOTE

Some models do not have damping switch.

26. Sensitivity, Stability, and Noise

a. Performance Check

(1) Connect equipment as shown in figure 2.

(2) Adjust test oscillator (A9) frequency until frequency counter (A5) indicates 1000 Hz.

(3) Adjust TI GAIN control for on-scale indication on TI meter and adjust FREQ control for peak indication.

(4) Adjust GAIN control for a 0-dB indication on TI meter.

(5) Adjust BANDWIDTH control clockwise until TI meter indicates 4.25 dB on 0 to 10 DB scale.

(6) Remove frequency counter from equipment setup.

(7) Adjust GAIN control fully clockwise

(8) Adjust test oscillator amplitude for 0-dB indication on TI meter. Test oscillator output meter will indicate 0.1 V or less.

(9) Vary output of autotransformer from 105 to 115 V and back to 115 V while maintaining 0-dB on TI meter with test oscillator amplitude control. Test oscillator output will indicate 0.1 V or less.

(10) Adjust test oscillator amplitude for 0.1 V output while adjusting TI GAIN control for 0-dB indication on TI meter.

(11) Disconnect test oscillator from TI and connect termination (B7) to TI INPUT.

(12) Set RANGE switch to 60. Average noise level as indicated on TI meter will be at least 5 dB down from 0 on 0 to 10 DB scale.

(13) Set INPUT SELECTOR switch to XTAL 200KΩ.

(14) Disconnect termination from TI and connect TI INPUT to resistance standard (A7), using cable (B4).

(15) Adjust resistance standard for 200 kilohms. TI meter will indicate same as in (12) above.

b. Adjustments. No adjustments can be made.

27. Bolometer Bias

a. Performance Check

(1) Adjust resistance standard (A7) for 200 ohms.

(2) Connect dc voltmeter (A4) to resistance standard, using cable (B5).

(3) Set RANGE switch to 0 (zero), INPUT SELECTOR switch to BOLO HIGH, and turn and hold BIAS CHECK control fully cw. If TI does not indicate 8.7 mA on BOLO BIAS scale, and dc voltmeter does not indicate between 1.69 and 1.79 V, perform **b**(1) and (2) below.

(4) Set INPUT SELECTOR switch to BOLO LOW and turn and hold BIAS CHECK control fully cw. If TI does not indicate 4.3 mA on BOLO BIAS scale and dc voltmeter does not indicate between 0.83 and 0.88 V, perform **b**(3) below.

b. Adjustments

(1) Turn and hold BIAS CHECK control in fully cw position while adjusting BOLO BIAS ADJ HIGH (rear panel) for an 8.7-mA indication on BOLO BIAS scale.

(2) Adjust R101 (fig. 7) until dc voltmeter indicates 1.74 V (R).

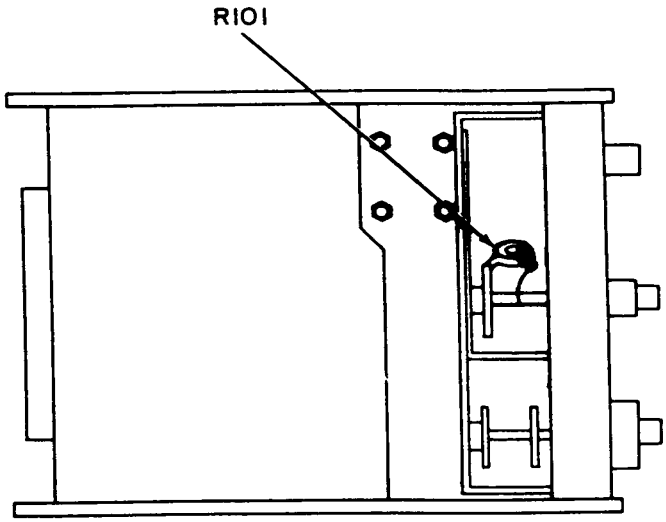

Figure 7. Model 415D- bottom view.

(3) Turn and hold BIAS CHECK control in fully cw position while adjusting BOLO BIAS ADJ LOW (rear panel) until TI indicates 4.3 mA on BOLO BIAS scale.

NOTE

Interaction exists between high and low adjustments. Repeat (1) through (3) above as necessary for best compromise.

28. Frequency and Bandwidth

a. Performance Check

(1) Connect equipment as shown in figure 2.

(2) Position controls as listed in (a) through (e) below:

(a) INPUT SELECTOR switch to XTAL 200Ω.

(b) GAIN control fully clockwise.

(c) VERNIER control fully clockwise.

(d) FREQ control fully counterclockwise.

(e) BANDWIDTH control fully clockwise.

(3) Adjust test oscillator (A9) amplitude for an on-scale indication on TI meter and fine-tune frequency control for peak indication on TI meter. Frequency counter (A5) indication will be greater than 1000 Hz. Record frequency counter indication.

(4) Set FREQ control fully clockwise and adjust test oscillator frequency for peak indication on TI meter. Frequency counter will indicate less than 1000 Hz. Difference between frequency counter indication and indication recorded in (3) above will be at least 50 Hz.

(5) Adjust test oscillator frequency control until frequency counter indicates 1000 Hz.

(6) Adjust FREQ control for peak indication on TI meter.

(7) Adjust test oscillator amplitude for 0-dB indication on TI meter.

(8) Reduce test oscillator frequency until TI meter indication drops to 1.5 dB on 0 to 10 DB scale. Record frequency counter indication.

(9) Increase test oscillator frequency until TI meter reaches peak indication and again drops to 1.5 dB.

(10) Record frequency counter indication. Difference between two recorded frequencies will be 100 Hz or more.

(11) Adjust GAIN control one-quarter turn from fully counterclockwise position.

(12) Adjust BANDWIDTH control fully counterclockwise and adjust test oscillator frequency for peak indication on TI meter, while maintaining an on-scale indication on TI meter.

(13) Repeat (7) and (8) above.

(14) Repeat (9) above and record frequency counter indication. Difference between two recorded frequencies will be 15 Hz or less.

(15) Deleted.

(16) Deleted.

(17) Deleted.

(18) Deleted.

(19) Deleted.

(20) Deleted.

b. Adjustments No adjustments can be made.

29. Range Accuracy (Exempt AN/GSM-256)

a. Performance Check

(1) Position TI controls as listed in (a) through (c) below:

(a) GAIN control fully clockwise.

(b) VERNIER control fully clockwise

(c) INPUT SELECTOR switch to XTAL 200Ω.

(2) Connect equipment as shown in figure 3.

(3) Set ratio transformer (A6) controls to .100000.

(4) Adjust test oscillator (A9) frequency for peak indication on TI meter and adjust amplitude for a 0-dB indication on TI meter.

(5) Set ratio transformer controls to .010000 and set RANGE switch to 10.

(6) Adjust ratio transformer controls for a 0-dB indication on TI meter. Ratio transformer will indicate between .009772 and .010233.

(7) Repeat technique of (5) and (6) above for control settings and indications listed in table 7. Ratio transformer will indicate within limits specified.

Table 7. Range Accuracy

Initial ratio transformer settings	Test instrument (SWR-DB) switch settings	Ratio transformer indications	
		Min	Max
.001000	20	.000955	.001047[1]
.010000	30	.009550	.010471
.001000	40	.000955	.001047[1]
.010000	50	.009550	.010471
.001000	60	.000955	.001047

[1]Before proceeding to next step, perform (a) through (d) below:

(a) Turn TI GAIN control one quarter turn from full counterclockwise position.
(b) Record ratio transformer indication and reduce signal generator amplitude to minimum.
(c) Multiply ratio transformer indication recorded in (b) above by 100 and adjust ratio transformer controls to indicate the product.
(d) Increase signal generator amplitude and adjust frequency for peak indication on TI meter. Adjust amplitude for 0 decibel an TI meter.

(8) Set RANGE switch to 10 and adjust oscillator amplitude to minimum.

(9) Set ratio transformer controls to .100000 and adjust test oscillator amplitude for an on-scale indication on TI meter.

(10) Fine-tune test oscillator frequency for peak indication on TI meter.

(11) Adjust test oscillator amplitude and TI GAIN control for a 0-dB indication on TI 0 to 10 DB scale.

(12) Set ratio transformer controls to .010000 and set TI RANGE switch to 20.

(13) Adjust ratio transformer controls until TI meter indicates 0 dB. Ratio transformer will indicate between .009772 and .010233.

(14) Reduce test oscillator output to minimum and set TI GAIN control one-quarter turn from fully counterclockwise position.

(15) Repeat (9) through (15) above for remaining positions of RANGE switch.

b. Adjustments. No adjustments can be made.

30. Expanded Range Linearity and Accuracy (exempt AN/GSM-256)

a. Performance Check

(1) Position TI controls as listed in (a) through (c) below:

(a) RANGE switch to 20.

(b) EXPAND switch to 0.0

(c) GAIN and VERNIER controls one-quarter turn from fully counterclockwise position.

(2) Set ratio transformer (A6) controls to .100000.

(3) Adjust test oscillator (A9) amplitude for an on-scale indication on TI meter and fine-tune frequency control for peak indication.

(4) Readjust test oscillator amplitude and TI GAIN control for a 0-dB indication on TI meter 0 to 2.5 DB scale. Adjust ratio transformer for TI indication of 2.5 dB on 0 to 2.5 DB scale. If ratio transformer does not indicate between .055975 and .056494, perform **b** below.

(5) Adjust ratio transformer control for TI indications listed in table 8. Ratio transformer will indicate within limits specified.

Table 8. Expanded Range Linearity

Test instrument indications (0 to 2.5 DB scale)	Ratio transformer indications	
	Min	Max
2	.062806	.063388
1.5	.070470	.071122
1	.079068	.079800
.5	.088716	.089537

(6) Repeat (2) through (4) above.

(7) Set ratio transformer controls to .056234 and set TI EXPAND switch to 2.50.

(8) Adjust ratio transformer controls for a 0-dB indication TI meter on 0 to 2.5 DB scale. Ratio transformer will indicate between .054954 and .057544.

(9) Repeat technique of (7) and (8) above for settings and indications listed in table 9. Ratio transformer will indicate within limits specified.

Table 9. Expanded Range Accuracy

Initial ratio transformer settings	Test instrument EXPAND switch positions	Ratio transformer indications	
		Min	Max
.031623	5.0	.030903	.032359
.017783	7.5	.017378	.018197

b. Adjustments

(1) Set ratio transformer controls to .063096 and record TI meter deviation from 2-dB mark on 0 to 2.5 DB scale.

(2) Adjust R189 (fig. 8) until TI meter indicates same deviation on opposite side of 2-dB mark (R).

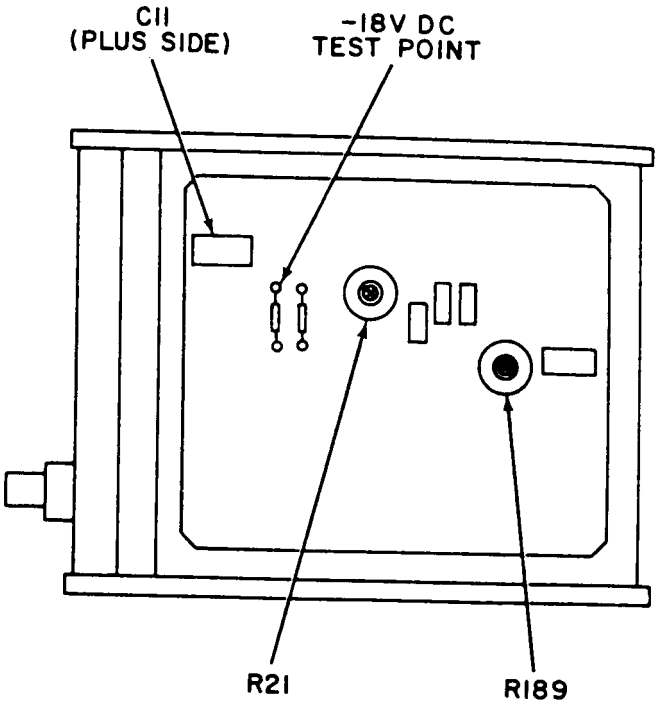

Figure 8. Model 415D-top view.

(3) Set ratio transformer controls to .100000 and adjust TI VERNIER control for 0-dB indication on TI 0 to 2.5 DB scale.

(4) Repeat (1) through (3) above as necessary to obtain optimum indication of 0 (zero) and 2-dB on TI 0 to 2.5 DB scale.

(5) Set ratio transformer controls to .056234 and repeat (1) through (3) above for optimum indications for 0 and 2.5 dB on TI 0 to 2.5 DB scale.

31. Power Supply

NOTE

Do not perform power supply check if all other parameters are within tolerance.

a. Performance Check. Connect dc voltmeter (A4) between -18 VDC test point and positive lead of C11 (fig. 8), using probe (B6). If dc voltmeter does not indicate between -17.82 and -18.18 V dc, perform **b** below.

b. Adjustments. Adjust R21 (fig. 8) until dc voltmeter indicates -18.0 V (R).

32. Final Procedure

a. Deenergize and disconnect all equipment and replace TI protective cover.

b. When all parameters are within tolerance, annotate and affix DA Label 80 (US Army Calibrated Instrument). When the TI receives limited or special calibration, annotate and affix DA Label 163 (US Army Limited or Special Calibration). When the TI cannot be adjusted within tolerance, repair the TI in accordance with the maintenance manual. When repair is delayed for any reason, or the TI cannot be repaired with local resources, annotate and affix DA Form 2417 (US Army Calibrated System Rejected Instrument) and inform the owner/user accordingly in accordance with TB 750-25-1.

TB 9-6625-003-35

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