

*TB 9-4931-321-35

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR STANDING WAVE RATIO METER HEWLETT-PACKARD MODEL 415E AND PRD MODEL 277D

Headquarters, Department of the Army, Washington, DC
8 December 2004

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REPORTING OF ERRORS AND RECOMMENDING IMPROVEMENTS

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SECTION		Paragraph	Page
I.	IDENTIFICATION AND DESCRIPTION		
	Test instrument identification	1	2
	Forms, records, and reports	2	2
	Calibration description	3	2
II.	EQUIPMENT REQUIREMENTS		
	Equipment required	4	2
	Accessories required	5	3
III.	CALIBRATION PROCESS		
	Preliminary instructions	6	3
	Equipment setup	7	4
	Bolometer bias	8	4
	Sensitivity, stability, and noise	9	5
	Input frequency	10	6
	Bandwidth	11	7
	Range accuracy	12	8
	Expanded range linearity and accuracy	13	9
	Final procedure	14	10

*This bulletin supersedes TB 9-4931-321-35, dated 29 May 1979, including all changes.

**SECTION I
IDENTIFICATION AND DESCRIPTION**

1. Test Instrument Identification. This bulletin provides instructions for the calibration of Standing Wave Ratio Meter Hewlett-Packard Model 415E and PRD Model 277D. The manufacturers' manuals were used as 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. PRD Model 277D differs from the HP Model 415E in this bulletin by front panel nomenclature and component designation. Where these differences occur, the PRD Model 277D information is shown in parenthesis.

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

2. Forms, Records, and Reports

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

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

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

Table 1. Calibration Description

Test instrument parameters	Performance specifications
Power input	Satisfactory performance w/line voltage between 105 and 125 V ac
Noise level	7.5 dB below FS at rated sensitivity with input terminated in optimum source impedance
Bolometer Current: Range Accuracy	8.7 or 4.5 mA ±3% into 200 Ω
Attenuator: Range Accuracy	0 to 70 dB in 10 dB steps 0 to 8 dB in 2 dB steps ±0.05 dB per 10 dB step ±0.02 dB per 2 dB step ±0.02 dB on expanded 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/GSM-287 or AN/GSM-705. Alternate items may be used by the calibrating activity. The items selected must be verified to perform satisfactorily prior to use and must bear evidence of current calibration. The equipment must meet or exceed the

minimum use specifications listed in table 2. The accuracies listed in table 2 provide a four-to-one ratio between the standard and TI. Where the four-to-one ratio cannot be met, the actual accuracy of the equipment selected is shown in parenthesis.

5. Accessories Required. The accessories required for this calibration are common usage accessories, issued as indicated in paragraph 4 above, and are not listed in the calibration procedure. The following peculiar accessories are also required for this calibration: Termination (Dummy Load), 50 Ω feedthrough; BNC plug to BNC jack, Hewlett-Packard, Model 11048C (11048C) and Isolation Plug (Three wire to two wire adapter) (7912356).

Table 2. Minimum Specifications of Equipment Required

Common name	Minimum use specifications	Manufacturer and model (part number)
AUTOTRANSFORMER	Range: 105 to 125 V ac Accuracy: ± 1%	Ridge, Model 9020A (9020A)
FUNCTION/ARBITRARY GENERATOR	Output Range: 0.015 to 1 V rms at 1 kHz Accuracy: Amplitude ±2% Output Frequency: 890 to 1,020 Hz Accuracy: ±1%	Agilent, Model 33250A (33250A)
MULTIMETER	Range: 0.87 to 1.8 V dc Accuracy: ±1%	Fluke, Model 8840A/AF05 (AN/GSM-64D)
RATIO TRANSFORMER	Range: 0.098850 to 1.000000 Accuracy: ±0.06%	ESI, Model DT72A (7915908)
RESISTANCE STANDARD	Range: 100 to 5,000 Ω Accuracy: +0.75%	Biddle-Gray, Model 71-650 (71-650)

**SECTION III
CALIBRATION PROCESS**

6. Preliminary Instructions

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

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

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

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

7. Equipment Setup

WARNING

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

- a. Connect TI to autotransformer.
- b. Connect autotransformer to a 115 V ac source and adjust for a 115 V output.
- c. Position controls as listed in (1) through (7) below:
 - (1) **RANGE-DB** switch to **0**.
 - (2) **EXPAND** switch to **NORM**.
 - (3) **INPUT (INPUT SELECTOR)** switch to **8.7 MA**.
 - (4) **GAIN (COARSE GAIN)** control fully clockwise.
 - (5) **VERNIER (FINE GAIN)** control fully clockwise.
 - (6) **BANDWIDTH** control fully clockwise.
 - (7) **POWER** switch to **LINE ON**.
- d. Allow at least 30 minutes for equipment to warm-up and stabilize.
- e. Set **POWER** switch to **OFF** and verify that meter pointer aligns with 2 on 0 (zero) to 2 dB (decibel) scale. If necessary, rotate mechanical zero-adjustment screw clockwise until pointer is to the left of 2, moving upscale. Stop clockwise adjustment when pointer is aligned with 2.
- f. Set **POWER** switch to **LINE ON**.

8. Bolometer Bias

a. Performance Check

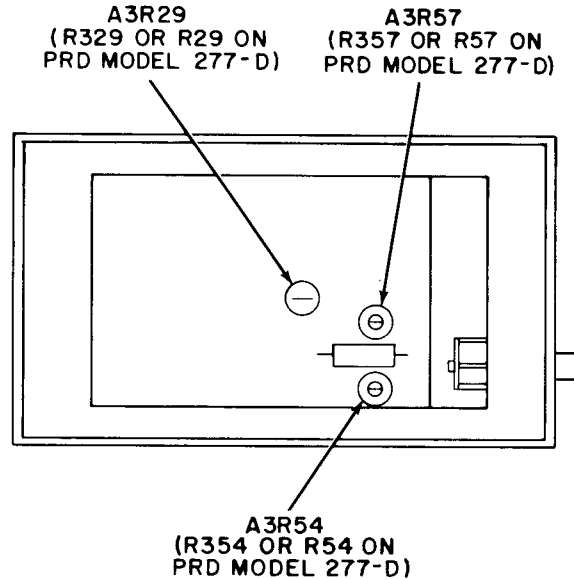
- (1) Connect resistance standard to TI **INPUT** and connect multimeter across resistance standard.
- (2) Set resistance standard and TI **INPUT (INPUT SELECTOR)** switch to settings listed in table 3. If multimeter does not indicate within specified limits, perform **b** below.

Table 3. Bolometer Bias

Resistance standard setting (Ω)	Test instrument INPUT (INPUT) SELECTOR switch setting	Multimeter indication (V dc)	
		Min	Max
200	8.7 MA	1.688	1.792
200	4.5 MA	0.873	0.927
1000	BIASED	0.97	1.03

(3) Set **TI INPUT (INPUT SELECTOR)** switch to **LOW**.

b. Adjustments. Adjust A3R54 (R354 or R54) (fig. 1) until all multimeter indications listed in table 4 are within specified limits.



NOTE: COMPONENTS WITH A3 PREFIX ARE FOR HEWLETT-PACKARD MODELS. COMPONENTS FOR PRD ARE IDENTIFIED WITH EITHER 2 OR 3 DIGIT NUMBERS.

Figure 1. Standing wave ratio meter - left view.

9. Sensitivity, Stability and Noise

a. Performance Check

- (1) Connect function/arbitrary generator to **TI INPUT** using 50 Ω termination.
- (2) Set function/arbitrary generator frequency to 1000 Hz and adjust amplitude for up-scale indication on TI meter.
- (3) Adjust **FREQ** control for maximum meter indication. If necessary, reduce amplitude of function/arbitrary generator output.
- (4) Adjust amplitude of function/arbitrary generator output for a 0 (zero) dB indication on TI meter 0 (zero) to 10 dB scale.
- (5) Function/arbitrary generator output will not exceed 0.15 V rms.
- (6) Adjust autotransformer from 105 to 125 V, while maintaining 0 (zero) dB indication on TI meter with amplitude control of function/arbitrary generator.
- (7) Function/arbitrary generator output amplitude will not exceed 0.15 V rms.
- (8) Adjust autotransformer for a 115 V output.
- (9) Set **INPUT (INPUT SELECTOR)** switch to **HIGH**.

TB 9-4931-321-35

(10) Adjust amplitude of function/arbitrary generator for a 0 (zero) dB indication on TI meter.

(11) Function/arbitrary generator output amplitude will not exceed 1 V rms.

(12) Adjust **FREQ** control fully clockwise and function/arbitrary generator frequency for peak indication on TI meter. Adjust function/arbitrary generator amplitude as necessary.

(13) Adjust function/arbitrary generator output amplitude to 1.0 V and adjust **GAIN** controls for a 0 (zero) dB indication on TI meter.

NOTE

Strap **LOW** and **GRD** terminals on resistance standard.

(14) Disconnect function/arbitrary generator. Set resistance standard to 5000 ohms and connect to **TI INPUT**.

(15) Set **RANGE-DB** switch to **60**.

(16) Average noise level will be at least 7.5 dB down from 0 (zero) on TI meter 0 (zero) to 10 dB scale.

(17) Set **RANGE-DB** switch to 0 (zero) and **INPUT (INPUT SELECTOR)** switch to **LOW**.

(18) Adjust function/arbitrary generator output amplitude for 0.15 V rms.

(19) Disconnect resistance standard and reconnect function/arbitrary generator to **INPUT**. Adjust **GAIN** control as required.

(20) Adjust function/arbitrary generator frequency for peak TI meter indication and **GAIN** control for a 0 (zero) dB indication on TI meter.

(21) Disconnect function/arbitrary generator. Set resistance standard to 100 ohms and connect to **INPUT**.

(22) Set **RANGE-DB** switch to **60** and repeat (16) above.

(23) Set **RANGE-DB** switch to **0** (zero).

b. Adjustments. No adjustments can be made.

10. Input Frequency

a. Performance Check

(1) Connect function/arbitrary generator to **TI INPUT** using 50 Ω termination.

(2) Set **EXPAND** switch to 0 (zero) and turn **GAIN** and **FREQ** controls fully clockwise.

(3) Adjust function/arbitrary generator output amplitude for on-scale indication on TI meter. Adjust function/arbitrary generator frequency to obtain peak indication on TI meter. Readjust function/arbitrary generator output amplitude to obtain a 0 (zero) dB indication on TI meter 0 (zero) to 2 dB scale. Function/arbitrary generator frequency display will indicate 1020 Hz or more. Record function/arbitrary generator frequency indication.

(4) Turn **FREQ** control fully counterclockwise.

(5) Adjust function/arbitrary generator frequency to obtain peak indication on TI meter. If necessary, adjust function/arbitrary generator output amplitude to maintain on-scale indication on TI meter. Function/arbitrary generator frequency display will indicate 980 Hz or less. Difference between this indication and indication recorded in (3) above will be 70 Hz or more.

b. Adjustments. No adjustments can be made.

11. Bandwidth

a. Performance Check

- (1) Adjust function/arbitrary generator frequency for 1000 Hz.
- (2) Adjust **FREQ** control to obtain peak indication on TI meter.
- (3) Adjust function/arbitrary generator output amplitude to obtain a 0 (zero) dB indication on TI meter 0 (zero) to 2 dB scale.
- (4) While maintaining function/arbitrary generator output amplitude constant, reduce function/arbitrary generator frequency until TI meter indicates 1.5 dB on 0 (zero) to 2 dB scale. Record function/arbitrary generator frequency indication.
- (5) While continuing to maintain function/arbitrary generator output amplitude constant, increase function/arbitrary generator frequency until TI meter indication returns to 0 (zero) dB and again drops to 1.5 dB. The difference in this function/arbitrary generator frequency indication and indication recorded in (4) above will be 130 Hz or more.
- (6) Turn **BANDWIDTH** control fully counterclockwise and repeat (1) through (4) above.
- (7) Repeat technique of (5) above. The difference in frequencies will be 15 Hz or less.
- (8) Set **INPUT (INPUT SELECTOR)** switch to **HIGH**. Adjust function/arbitrary generator output amplitude to obtain on-scale indication on TI meter.
- (9) Adjust function/arbitrary generator frequency and **FREQ** control to obtain peak indication on TI meter.
- (10) Adjust function/arbitrary generator output amplitude to obtain a 1 dB indication on TI meter 0 (zero) to 2 dB scale.
- (11) Turn **BANDWIDTH** control fully clockwise. Adjust **FREQ** control to obtain peak TI meter indication.
- (12) If TI meter does not indicate between 0.5 and 1.5 dB on 0 (zero) to 2 dB scale (between 0.9 and 1.1 dB), perform **b** below.

b. Adjustments

- (1) Set function/arbitrary generator frequency to 1000 Hz.
- (2) Adjust **FREQ** control to obtain peak indication on TI meter.
- (3) Adjust function/arbitrary generator output amplitude to obtain 1 dB indication on TI meter 0 (zero) to 2 dB scale.
- (4) Turn **BANDWIDTH** control fully counterclockwise.

TB 9-4931-321-35

(5) Adjust **FREQ** control to obtain peak indication on TI meter.

(6) Adjust A3R29 (R329 or R29) (fig. 1) to obtain indication of 1 dB on TI meter 0 (zero) to 2 dB scale (R).

(7) Turn **BANDWIDTH** control fully clockwise and repeat (2) through (6) above until TI meter indication remains between 0.5 and 1.5 dB throughout range of **BANDWIDTH** control.

12. Range Accuracy

a. Performance Check

(1) Set **EXPAND** switch to **NORM** and **BANDWIDTH** control fully clockwise.

(2) Connect function/arbitrary generator output to ratio transformer input using 50 Ω termination and connect ratio transformer output to **TI INPUT**.

NOTE

Isolate TI from power line ground for remainder of procedure utilizing isolation plug.

(3) Adjust ratio transformer to 1.000000 and adjust function/arbitrary generator output amplitude to obtain on-scale indication on TI meter.

(4) Adjust function/arbitrary generator frequency to obtain peak indication on TI meter. Adjust function/arbitrary generator output to 1 V rms.

(5) Adjust **GAIN** controls to obtain a 0 (zero) dB indication on TI meter. Readjust function/arbitrary generator output amplitude if necessary.

(6) Adjust ratio transformer to .100000 and set **RANGE-DB** switch to 10.

(7) Adjust ratio transformer to obtain a 0 (zero) dB indication on TI meter. Ratio transformer will indicate between .098850 and .101160.

(8) Reduce function/arbitrary generator output amplitude and adjust ratio transformer to 1.000000.

(9) Adjust function/arbitrary generator output amplitude to obtain a 0 (zero) dB indication on TI meter.

(10) Adjust ratio transformer to .100000 and set **RANGE-DB** switch to 20.

(11) Adjust ratio transformer to obtain a 0 (zero) dB indication on TI meter. Ratio transformer will indicate between .098850 and .101160.

(12) Repeat technique of (8) through (11) above for remaining **RANGE-DB** switch positions.

NOTE

Before performing (8) above for 50 dB switch position, rotate **GAIN** control counterclockwise. Return **GAIN** control to clockwise position when checks are complete.

b. Adjustments. No adjustments can be made.

13. Expanded Range Linearity and Accuracy

a. Performance Check

- (1) Reduce function/arbitrary generator output amplitude and adjust ratio transformer to 1.000000.
- (2) Set **RANGE-DB** switch to **0** and **EXPAND** to **0**.
- (3) Adjust function/arbitrary generator output amplitude to obtain an on-scale indication on TI meter. Adjust function/arbitrary generator frequency to obtain peak indication on TI meter
- (4) Adjust function/arbitrary generator output amplitude and **GAIN** controls to obtain a 0 (zero) dB indication on TI meter 0 (zero) to 2 dB scale.
- (5) Adjust ratio transformer to obtain 0.5 dB indication on TI meter 0 (zero) to 2 dB scale.
- (6) If ratio transformer does not indicate between .887160 and .895360, perform **b** (1) through (3) below.
- (7) Adjust ratio transformer to obtain TI meter indications listed in table 4. If ratio transformer does not indicate within specified limits, perform **b** (4) and (5) below.

Table 4. Expanded Range Linearity

Test instrument indication (0 to 2 dB scale)	Ratio transformer indication		
	Min	Optimum	Max
1	.790684	.794328	.798001
1.5	.704700	.707946	.711212
2	.628063	.630957	.633870

- (8) Repeat (1), (3), and (4) above.
- (9) Adjust ratio transformer to .630957 and set **EXPAND** switch to 2.
- (10) Adjust ratio transformer to obtain a 0 (zero) dB indication on TI meter 0 (zero) to 2 dB scale. Ratio transformer will indicate between .623735 and .638266.
- (11) Repeat technique of (9) and (10) above, using settings listed in table 5. Ratio transformer indications will be within specified limits.

Table 5. Expanded Range Accuracy

Initial ratio transformer setting	Test instrument EXPAND switch position	Ratio transformer indication	
		Min	Max
.398107	4	.393551	.402712
.251189	6	.248313	.254097
.158489	8	.156675	.160325

b. Adjustments

- (1) Adjust ratio transformer to .891251.
- (2) Adjust A3R57 (R357 or R57) (fig. 1) to obtain 0.5 dB indication on TI meter 0 (zero) to 2 dB scale (R).

TB 9-4931-321-35

(3) Repeat a (2) through (6) above.

(4) Adjust ratio transformer for optimum values listed in table 5. Adjust A3R57 (R357 or R57) (fig. 1) for corresponding TI meter indication or best in-tolerance compromise of error across 0 (zero) to 2 dB scale (R).


(5) Repeat a (2) through (7) above.

14. 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.

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SANDRA R. RILEY
*Administrative Assistant to the
Secretary of the Army*
0428601

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

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From: "Whomever" whomever@redstone.army.milT
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.

