

*TB 9-6625-1947-24

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

CALIBRATION PROCEDURE FOR TEST OSCILLATOR HEWLETT-PACKARD, MODEL 654A

Headquarters, Department of the Army, Washington, DC

11 March 2008

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REPORTING OF ERRORS AND RECOMMENDING IMPROVEMENTS

You can improve this manual. If you find any mistakes or if you know of a way to improve these procedures, please let us know. Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to: Commander, U.S. Army Aviation and Missile Command, ATTN: AMSAM-MMC-MA-NP, Redstone Arsenal, AL 35898-5000. A reply will be furnished to you. You may also send in your comments electronically to our E-mail address: 2028@redstone.army.mil or by fax 256-842-6546/DSN 788-6546. For the World Wide Web use: <https://amcom2028.redstone.army.mil>. Instructions for sending an electronic 2028 can be found at the back of this manual.

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*This bulletin supersedes TB 9-6625-1947-35, dated 15 July 2004, including all changes.

SECTION I IDENTIFICATION AND DESCRIPTION

1. Test Instrument Identification. This bulletin provides instructions for the calibration of Test Oscillator, Hewlett-Packard, Model 654A. The manufacturer's manual was used as the prime data source in compiling these instructions. The equipment being calibrated will be referred to as the TI (test instrument) throughout this bulletin.

a. Model Variations. None.

b. Time and Technique. The time required for this calibration is approximately 4 hours, using the dc and low frequency 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
Frequency	Range: 10 Hz to 10 MHz in 6 bands Accuracy: ±2%, 100 Hz (on X100 range) to 5 MHz ±3%, 10 Hz to 5 MHz ±4%, 10 Hz to 10 MHz
Attenuation ¹	Range: -90 to +11 dB in 10 and 1 dB steps Accuracy: ±1.5% from +10 to -60 dB ±10% below 60 dBm at frequencies greater than 300 kHz
Flatness ²	±0.5% referenced to level at 1 kHz from 10 Hz to 10 MHz for 50 Ω output only
Distortion ³	>40 dB below fundamental from 10 Hz to 1 MHz >34 dB below fundamental from 1 MHz to 10 MHz
Meter tracking	±0.05 dB
Amplitude	± 1% at 1 kHz, 10 dBm level with meter centered
Output impedance	50 Ω and 75 Ω unbalanced outputs 135 Ω, 150 Ω, and 600 Ω balanced outputs

¹Procedure limitation: Certified from +10 to -60 dB only.

²Only the **50 Ω UNBAL** output is checked in this procedure.

³Certified from: 10 Hz to 100 kHz, audio analyzer.
100 kHz to 10 MHz, spectrum analyzer.

SECTION II EQUIPMENT REQUIREMENTS

4. Equipment Required. Table 2 identifies the specific equipment to be used in this calibration procedure. This equipment is issued with Secondary Transfer Calibration Standards Set AN/GSM-286, AN/GSM-287 and 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 ration cannot be met, the actual accuracy of the equipment selected is shown in parenthesis.

5. Accessories Required. The accessories required for this calibration are common usage accessories, issued as indicated in paragraph 4 above, and are not listed in this calibration procedure.

Table 2. Minimum Specifications of Equipment Required

Common name	Minimum use specifications	Manufacturer and model (part number)
AUDIO ANALYZER ¹	Range: 10 Hz to 500 kHz Accuracy: <0.25% distortion	Boonton, Model 1121 (1121)
CALIBRATOR	Range: 2.40 to 2.60 V dc	Fluke, Model 5720A (5720A) (p/o MIS-35947)
FREQUENCY COUNTER	Range: 9.7 Hz to 10.3 MHz Accuracy: $\pm 0.5\%$	Fluke, Model PM6681/656 (PM6681/656)
MULTIMETER	Range: 7 mV to 30.9 V dc 100 mV to 3.2232 V ac Accuracy: $\pm 0.15\%$ dc $\pm 0.125\%$ ac	Fluke, Model 8840A/AF05 (AN/GSM-64D)
RESISTANCE STANDARD ²	Range: 1 and 4.7 k Ω Accuracy: $\pm 1\%$	Biddle-Gray, Model 71-631 (7910328)
SPECTRUM ANALYZER	Range: 10 Hz to 10 MHz Accuracy: <0.25% distortion	(AN/USM-677)
THERMAL CONVERTER	Range: 10 Hz to 10 MHz Accuracy: $\pm 0.0625\%$ $\pm 0.1\%$ to 100 kHz $\pm 0.2\%$ to 1 MHz $\pm 0.4\%$ to 10 MHz	Ballantine, Model 1395A-1 (7913198-2)
TRUE RMS VOLTMETER	Range: 1 mV Resolution: At least 2 μ V	Fluke, Model 8922A/AA (8922A/AA)

¹Spectrum analyzer can be used.

²Two required.

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. When indications specified in paragraphs 8 through 13 are not within tolerance, perform the power supply check prior to making adjustments. After adjustments are made, repeat paragraphs 8 through 13. Do not perform power supply check if all other parameters are within tolerance.

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

7. Equipment Setup

WARNING

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

a. Rotate **AMPLITUDE** control fully ccw.

b. Set 115/230 slide switch (rear panel) to 115.

c. Connect to a 115 V ac power source.

d. Set **LINE** switch to **ON** and allow 30 minutes for TI to warm-up and stabilize.

e. Set **LINE** switch to off (down) and wait 30 seconds.

f. Insert pointed object into TI meter recess on adjustment wheel and rotate wheel until meter pointer is exactly over -1 dBm mark.

g. Set **LINE** switch to **ON**.

8. Frequency Accuracy, Stability, and Range

a. Performance Check

- (1) Connect frequency counter to **TI COUNTER OUTPUT** connector (rear panel), using 50 Ω feed-through termination.
- (2) Set **FREQUENCY RANGE** switch to **X10** and rotate **FREQUENCY** dial fully cw. Frequency counter will indicate 10 Hz or less.
- (3) Set **FREQUENCY RANGE** switch to **X1M** and rotate **FREQUENCY** dial fully ccw. If frequency counter does not indicate 10 MHz or more, perform **b** below.
- (4) Set **FREQUENCY RANGE** switch to **X10** and **FREQUENCY** dial to **1**. If frequency counter does not indicate between 9.70 Hz and 10.30 Hz, perform **b** below.
- (5) Set **FREQUENCY RANGE** switch and **FREQUENCY** dial as listed in table 3. If frequency counter does not indicate within limits specified, perform **b** below.

Table 3. Frequency Accuracy Check

Test Instrument		Frequency counter indications			
FREQUENCY RANGE switch settings	REQUENCY dial settings	Min		Max	
X10	5	48.5	Hz	51.5	Hz
X10	10	97	Hz	103	Hz
X100	1	98	Hz	102	Hz
X100	5	490	Hz	510	Hz
X100	10	980	Hz	1020	Hz
X1K	5	4.9	kHz	5.1	kHz
X1K	10	9.8	kHz	10.2	kHz
X10K	1	9.8	kHz	10.2	kHz
X10K	5	49.0	kHz	51.0	kHz
X10K	10	98.0	kHz	102.0	kHz
X100K	1	98.0	kHz	102.0	kHz
X100K	5	490.0	kHz	510.0	kHz
X100K	10	0.98	MHz	1.02	MHz
X1M	1	0.98	MHz	1.02	MHz
X1M	5	4.90	MHz	5.10	MHz
X1M	10	9.6	MHz	10.4	MHz

- (6) Position controls as listed in (a) through (d) below:
 - (a) **FREQUENCY RANGE** switch to **X1K**.
 - (b) **FREQUENCY** dial to **1**.
 - (c) **OUTPUT LEVEL** dBm switch to **+10**.
 - (d) Press **IMPEDANCE 50 UNBAL** pushbutton.
- (7) Adjust **AMPLITUDE** control for a +10 dBm indication on TI meter. If frequency counter does not indicate between 980 Hz and 1020 Hz, perform **b** below.

b. Adjustments

(1) Connect multimeter between A2TP2 (fig. 1) and chassis ground termination.

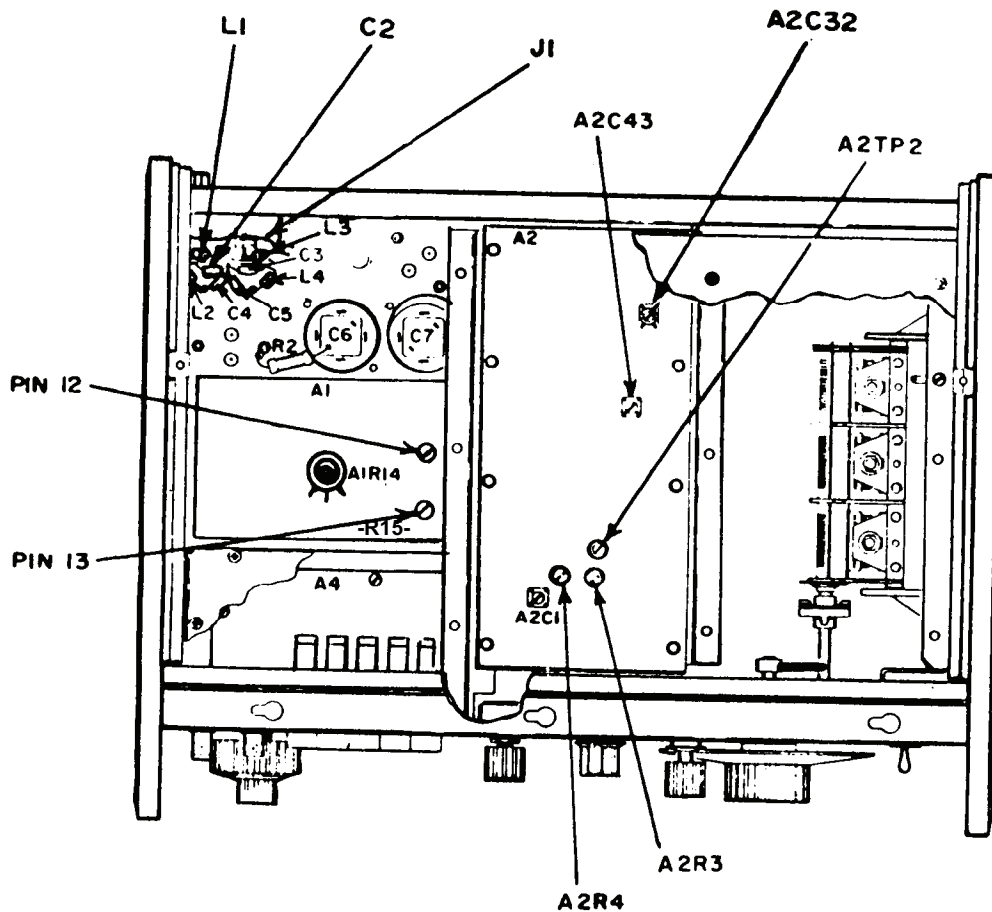


Figure 1. Adjustment locations - bottom view.

(2) Connect audio analyzer or spectrum analyzer to TI UNBAL output, using 50 Ω feed-through termination.

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

- (a) **FREQUENCY RANGE** switch to **X1K**.
- (b) **FREQUENCY** dial fully cw.
- (c) **OUTPUT LEVEL dBm** switch to **+10**.
- (d) **AMPLITUDE** control fully ccw.

(4) Adjust A2R3 (fig. 1) for a -350 mV indication on multimeter (R).

(5) Adjust A2R4 (fig. 1) for minimum distortion on audio analyzer, or at least -46 dB on the spectrum analyzer (R).

(6) Rotate **FREQUENCY** dial fully ccw.

(7) Alternately adjust S2C2 (fig. 2) and S2C8 (fig. 2) until frequency counter indicates 10.2 kHz and multimeter indicates between -340 mV and -360 mV (R).

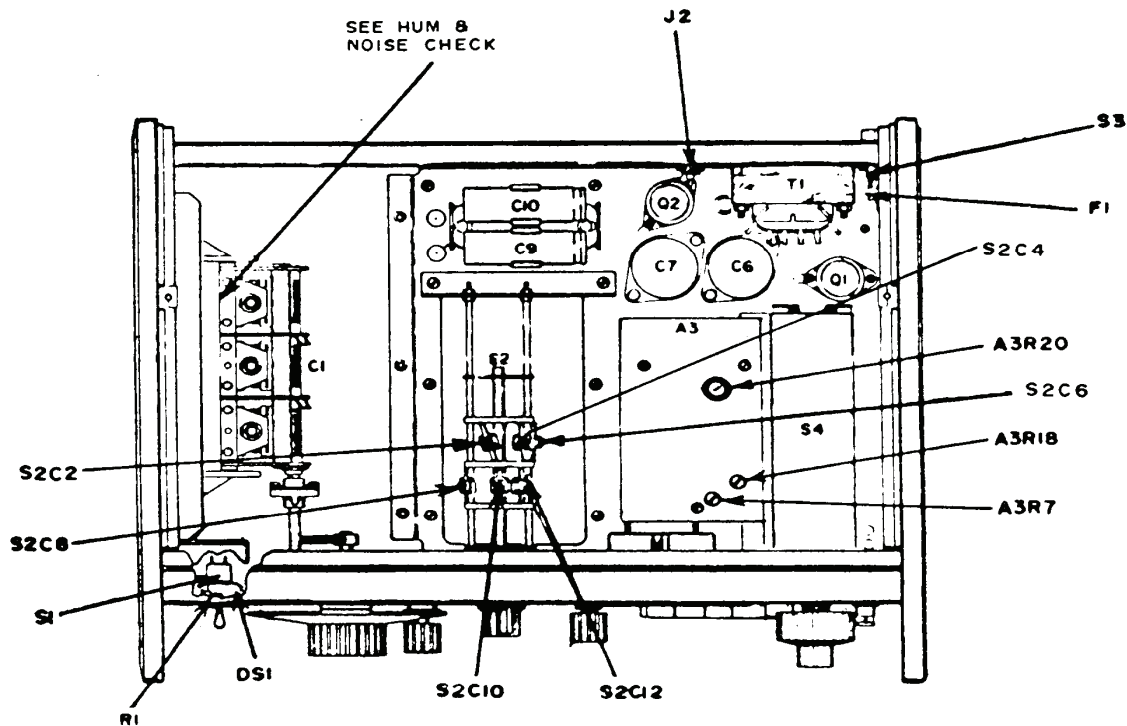


Figure 2. Adjustment locations - top view.

(8) Rotate **FREQUENCY** dial fully cw. Frequency counter will indicate between 965 Hz and 970 Hz.

(9) Set **FREQUENCY** dial for a 1 kHz indication on frequency counter. If dial does not indicate 1, perform (a) through (c) as listed below:

- (a) Remove **FREQUENCY** dial knob and loosen the four retaining screws.
- (b) Slip **FREQUENCY** dial until 1 is aligned with reference marker.
- (c) Tighten retaining screws and install **FREQUENCY** dial knob (R).

(10) Set **FREQUENCY** dial to 10.

(11) Readjust S2C2 (fig. 2) and S2C8 (fig. 2) alternately until frequency counter indicates 10 kHz and multimeter indicates -350 mV (R).

(12) Set **FREQUENCY RANGE** switch to **X1M** and **FREQUENCY** dial to 10.

(13) Adjust S2C6 (fig. 2) and S2C12 (fig. 2) for a frequency counter reading between 10.1 MHz and 10.2 MHz, and A2TP2 (fig. 1) for multimeter reading between -0.38 V and -0.40 V (R).

(14) Set **FREQUENCY** dial to **5**. If frequency counter does not indicate between 4.935 MHz and 5.065 MHz, go to (15) below. If (15) below is not performed, proceed to (16) below.

(15) Set **FREQUENCY DIAL** to **10**. If frequency counter indication was high, adjust A2C1 (fig. 1). If frequency counter reading was low, adjust A2C1 (fig. 1) to lower frequency counter reading and repeat (12) through (14) above (R).

(16) Set **FREQUENCY RANGE** switch to **X100K** and **FREQUENCY** dial to **10**. Adjust S2C4 (fig. 2) and S2C10 (fig. 2) for a frequency counter reading between 987 kHz and 1013 kHz and multimeter reading at A2TP2 (fig. 1) between -0.3 V and -0.4 V (R).

(17) Repeat (1) through (16) above until frequencies are within specified limits.

9. Meter Tracking and Output Voltage Flatness

a. Performance Check

(1) Connect multimeter to **TI UNBAL** output using 50 Ω feed-through termination.

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

(a) **FREQUENCY RANGE** switch to **X1K**.

(b) **FREQUENCY** dial to **1**.

(c) **OUTPUT LEVEL dBm** switch to **+10**.

(3) Adjust **AMPLITUDE** control for a 0 dBm indication on TI meter. If multimeter does not indicate between 0.7000 V rms and 0.7142 V rms, perform **b** below. Record indication as R1.

(4) Adjust **AMPLITUDE** control for a 1.0 dBm indication on TI meter. Divide multimeter indications by R1 value recorded in (3) above. If quotient is not between 1.111 and 1.133, perform **b** (1) through (10) below.

(5) Repeat technique of (4) above, using TI meter indications listed in table 4. If quotients are not within limits specified, perform **b** (1) through (10) below.

Table 4. Meter Tracking

Test instrument meter indications (dBm)	Multimeter indications (V Ac)
+0.8	$V_{ac} \div R1 = 1.085$ to 1.107
+0.4	$V_{ac} \div R1 = 1.037$ to 1.058
-0.4	$V_{ac} \div R1 = .945$ to .965
-0.8	$V_{ac} \div R1 = .800$ to .921

(6) Adjust **AMPLITUDE** control to minimum and disconnect multimeter and termination from TI.

(7) Connect thermal converter to **UNBAL** output.

(8) Connect multimeter to thermal converter.

(9) Adjust **AMPLITUDE** control for a 0 dBm indication on TI meter and record dc voltage indication on multimeter as R2.

- (10) Disconnect thermal converter from TI and connect to calibrator.
- (11) Adjust calibrator output until value of R2 is indicated on multimeter. Record calibrator indication.
- (12) Adjust calibrator to +0.5 percent of value recorded in (11) above. Record multimeter indication as R3.
- (13) Adjust calibrator to -0.5 percent of value recorded in (11) above. Record multimeter indication as R4.
- (14) Disconnect calibrator from thermal converter and connect thermal converter to TI **UNBAL** output. Set **FREQUENCY RANGE** switch to **X1M** and **FREQUENCY** dial to **10**.
- (15) Adjust **AMPLITUDE** control for a 0 dBm indication on TI meter. If multimeter does not indicate within limits of R3 and R4, perform **b** (11) through (13) below.
- (16) Repeat technique of (14) and (15) above for **FREQUENCY RANGE** switch and **FREQUENCY** dial settings listed in table 5. If multimeter does not indicate within limits of R3 and R4, perform **b** (11) through (13) below.

Table 5. Normal Frequency Response

Test instrument	
FREQUENCY RANGE switch settings	FREQUENCY dial settings
X1M	4
X1M	1
X100K	5
X10K	5
X1K	5
X100	1
X10	2
X10	1

b. Adjustments

- (1) Rotate A3R18 (fig. 2) fully cw.
- (2) Adjust A3R7 (fig. 2) until **AMPLITUDE** control has sufficient range to exceed maximum meter deflection at both ends of meter scale.
- (3) Adjust **AMPLITUDE** control for a -1 dBm indication on TI meter. Record multimeter indication as R2.
- (4) Multiply R2 by 1.259 and record as R4.
- (5) Adjust **AMPLITUDE** control for value of R4 on multimeter.
- (6) Adjust A3R18 (fig. 2) for a +1.0 dBm indication on TI meter
- (7) Adjust **AMPLITUDE** control for a 0.7071 V rms indication on multimeter.
- (8) Adjust A3R7 (fig. 2) for a 0 dBm indication on TI meter (R).
- (9) Rotate **AMPLITUDE** control fully cw.

- (10) Adjust A3R20 (fig. 2) for a 0.80 V indication on multimeter (R).
- (11) Adjust **AMPLITUDE** control for a 0 dBm indication on TI meter.
- (12) Adjust A2C43 (fig. 1) for R2 value recorded in 9 a (9) above (R).
- (13) Repeat 9 a (14) above.

10. Output Impedance

a. Performance Check

- (1) Connect equipment as shown in figure 3.

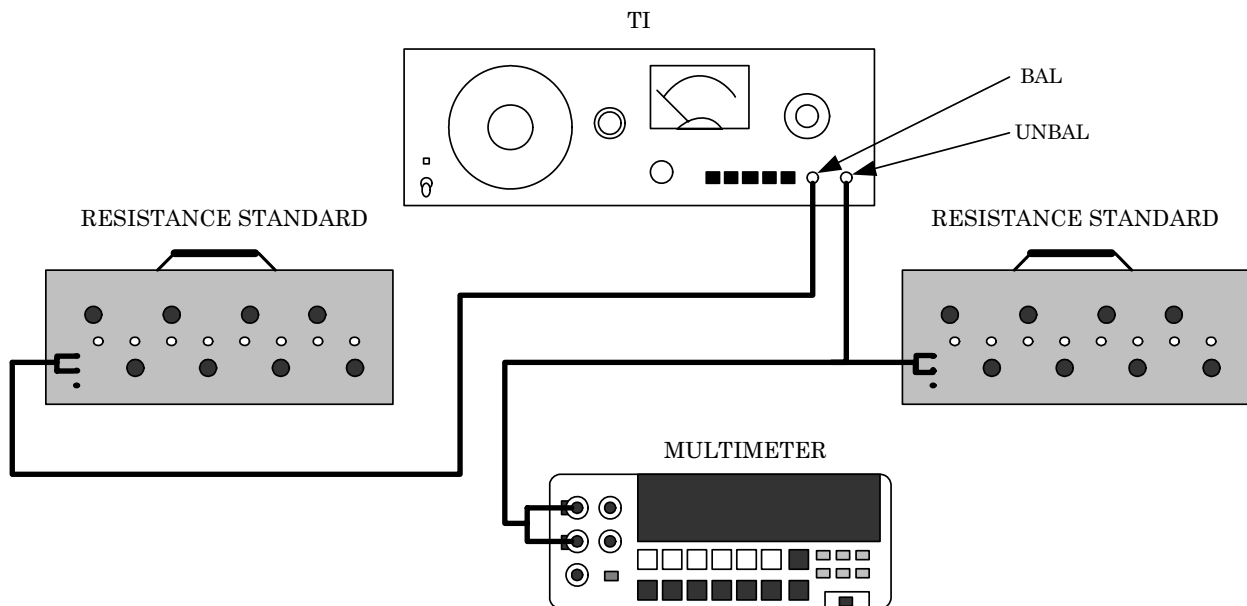


Figure 3. Output impedance - equipment setup.

- (2) Position controls as listed in (a) through (d) below:
 - (a) **FREQUENCY RANGE** switch to **X1K**.
 - (b) **FREQUENCY** dial to 1.
 - (c) **OUTPUT LEVEL dBm** switch to **+10**.
 - (d) Press **IMPEDANCE 75 UNBAL** pushbutton.
- (3) Set both resistance standards to 75 Ω .
- (4) Adjust **AMPLITUDE** control for a 0 dBm indication on TI meter. Multimeter will indicate between .8573 V rms and .8747 V rms.
- (5) Set both resistance standards to 67.5 Ω .
- (6) Press **IMPEDANCE 135 BAL** pushbutton.
- (7) Adjust **AMPLITUDE** control for a 0 dBm indication on TI meter.

(8) Connect multimeter, in turn, to each resistance standard and record readings. Sum of multimeter readings will be between 1.150 V rms and 1.174 V rms.

(9) Repeat technique of (5) through (8) above with resistance standard set to 75 Ω and press **IMPEDANCE 150 BAL** pushbutton. Sum of multimeter readings will be between 1.213 and 1.237 V rms.

(10) Repeat technique of (5) through (8) above with resistance standard set to 300 Ω and press **IMPEDANCE 600 BAL** pushbutton. Sum of multimeter readings will be between 2.424 V rms and 2.474 V rms.

b. Adjustments. No further adjustments can be made.

11. Distortion

a. Performance Check

(1) Connect audio analyzer or spectrum analyzer to TI **UNBAL** output connector, using a 50 Ω feed-through termination.

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

(a) **FREQUENCY RANGE** switch to **X10**.

(b) **FREQUENCY** dial to **1**.

(c) **OUTPUT LEVEL dBm** switch to **+10**.

(d) Press **IMPEDANCE 50 Ω UNBAL** pushbutton.

(3) Adjust **AMPLITUDE** control for a +1 dBm indication on TI meter. If measured distortion is not greater than 40 dB below the fundamental frequency, perform **b** below.

(4) Repeat technique of (2) and (3) above at **FREQUENCY RANGE** switch and **FREQUENCY** dial settings listed in table 6. Measured distortion will be greater than 40 dB below fundamental frequency.

Table 6. Distortion Check

Test instrument	
FREQUENCY RANGE switch settings	FREQUENCY dial settings
X10	5
X10	10
X100	1
X100	10
X1K	10
X10K	1
X10K	2
X100K	1
X100K	5
X100K ¹	10
X1M	10
X1M	5
X1M	1

¹Replace audio analyzer with spectrum analyzer and measured distortion will be greater than 34 dB below fundamental frequency.

b. Adjustments. Adjust A2R4 (fig. 1) for minimum distortion of at least 46 dB (10 Hz to 500 kHz) and at least 34 dB (1 to 10 MHz) below fundamental frequency (R).

12. Output Attenuator Accuracy

a. Performance Check

(1) Connect true rms voltmeter to **UNBAL** output connector, using a 50 Ω feed-through termination.

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

(a) **FREQUENCY** dial to **3**.

(b) **FREQUENCY RANGE** switch to **X100K**.

(c) **OUTPUT LEVEL** switch to **+10 dBm**.

(d) Press **IMPEDANCE 50 Ω UNBAL** pushbutton.

(e) **AMPLITUDE** control to **+0 dBm**.

(3) True rms voltmeter will indicate between +9.85 dBm to +10.15 dBm.

(4) Repeat technique of (2) and (3) above for settings and indications listed in table 7. True rms voltmeter will indicate within specified limits.

Table 7. Attenuator Accuracy

Test instrument OUTPUT LEVEL switch settings (dBm)	True rms voltmeter indications (dBm)	
	Min	Max
0	-0.15	+0.15
-10	-9.85	-10.15
-20	-19.85	-20.15
-30	-29.85	-30.15
-40	-39.85	-40.15
-50	-49.85	-50.15
-60	-59.85	-60.15
-1	-0.85	-1.15
-2	-1.85	-2.15
-3	-2.85	-3.15
-4	-3.85	-4.15
-5	-4.85	-5.15
-6	-5.85	-6.15
-7	-6.85	-7.15
-8	-7.85	-8.15
-9	-8.85	-9.15

b. Adjustments. No adjustments can be made.

13. Power Supply

a. Performance Check

NOTE

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

(1) Connect multimeter positive lead to TI PIN 12 (fig. 1) and negative lead to chassis ground. If multimeter does not indicate between 30.8 and 31.2 V, perform **b** (1) below

(2) Move positive lead to PIN 13 (fig. 1). If multimeter does not indicate between -25.5 and -26.5 V, perform **b** (2) below.

b. Adjustments

(1) Adjust A1R14 (fig. 1) for a +31 V indication on multimeter (R).

(2) Change the value of R15 (fig. 1) to obtain the required voltage (increasing the value of A1R15 makes the power supply less negative, and vice versa.

14. Final Procedure

a. Deenergize and disconnect all equipment.

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

By Order of the Secretary of the Army:

Official:



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

0802807

GEORGE W. CASEY, JR.
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Distribution:

To be distributed in accordance with the initial distribution number (IDN) 342153, requirements for calibration procedure TB 9-6625-1947-24.

Instructions for Submitting an Electronic 2028

The following format must be used if submitting an electronic 2028. The subject line must be exactly the same and all fields must be included; however, only the following fields are mandatory: 1, 3, 4, 5, 6, 7, 8, 9, 10, 13, 15, 16, 17, and 27.

From: "Whomever" whomever@redstone.army.mil
To: <2028@redstone.army.mil

Subject: DA Form 2028

1. **From:** Joe Smith
2. **Unit:** home
3. **Address:** 4300 Park
4. **City:** Hometown
5. **St:** MO
6. **Zip:** 77777
7. **Date Sent:** 19-OCT-93
8. **Pub no:** 55-2840-229-23
9. **Pub Title:** TM
10. **Publication Date:** 04-JUL-85
11. **Change Number:** 7
12. **Submitter Rank:** MSG
13. **Submitter FName:** Joe
14. **Submitter MName:** T
15. **Submitter LName:** Smith
16. **Submitter Phone:** 123-123-1234
17. **Problem:** 1
18. **Page:** 2
19. **Paragraph:** 3
20. **Line:** 4
21. **NSN:** 5
22. **Reference:** 6
23. **Figure:** 7
24. **Table:** 8
25. **Item:** 9
26. **Total:** 123
27. **Text**

This is the text for the problem below line 27.

