TECHNICAL MANUAL

INSTRUMENT CALIBRATION PROCEDURE

PORTABLE CALIBRATOR

FLUKE 515A

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SECTION 1

INTRODUCTION AND DESCRIPTION

1.1 This procedure describes the calibration of the Fluke 515A Portable Calibrator. The instrument being calibrated is referred to herein as the TI (Test Instrument).

1.2 All comments concerning this procedure should be directed to Navy Measurement Science Directorate, Naval Warfare Assessment Division, P.O. Box 5000, Corona, CA 91718–5000.

1.3 This procedure includes tests of essential performance parameters only. Any malfunction noticed during calibration, whether specifically tested for or not, should be corrected.

Table 1. Calibration Description

TI Characteristics	Performance Specifications	Test Method
Line regulation	Voltage output for a ±10% line voltage change: µV range: ±1 µV or less 1V or 10V Range: ±1 ppm of range or less 100V Range: ±10 ppm of range or less	The TI output voltage is monitored as the line voltage is changed.
DC voltage output	Range: µV: 0 to 999 µV continuous with 1 µV resolution Tolerance: ±2 µV 1V: 0.0 to 1.0V in 0.1V steps 10V: 0 to 10V in 1V steps 100V: cardinal point Tolerance: ±0.003% of setting or ±30 µV whichever is greater	1, 10 and 100V TI output: Verified by a standard–cellreferenced direct voltage measurement system. DC microvolt output: Verified by using the voltage divider to step down the voltage output of the standard–cell–referenced direct voltage measurement system. 10 Volt DC decade output: Compared TI output with the DC voltage calibrator output by using ratio measurement.
Frequency response	Range: 10V Output frequencies: 10V, 400 Hz, 4 kHz, or 50 kHz 1 or 100V: 400 Hz Voltage tolerance: 1V: ±0.05% 10V: ±0.04%; 400 Hz or 4 kHz, ±0.1%; 50 kHz 100V: ±0.06%	10V output tolerance is verified at all frequency output by using the thermal transfer method.

TI Characteristics	Performance Specifications	Test Method
AC voltage output	Same as above	The AV source output is set to obtain a reference null; then the TI output is substituted and the deviation from the reference–null is measured.
Frequency output	Tolerance: 400 Hz or 4 kHz; ±1%; 50 kHz; ±5%	Verified with an electronic counter
Resistance	Range: 10Ω through 10 MΩ in decade steps Tolerance: 0Ω; 150 milliohms or less (residual Ω) 10Ω to 100Ω; ±0.06% + residual Ω 1 kΩ to 1 MΩ; ±0.015% + residual Ω 10 MΩ; 0.075% + residual Ω Power rating: 0.2 watt	Measured with the resistance measuring system

SECTION 2

EQUIPMENT REQUIREMENTS

NOTE

Minimum use specifications are the principal parameters required for performance of the calibration, and are included to assist in the selection of alternate equipment, which may be used at the discretion of the using laboratory. Satisfactory performance of alternate items shall be verified prior to use. All applicable equipment must bear evidence of current calibration.

The instruments utilized in this procedure were selected from those known to be available at Navy calibration facilities, and the listing by make or model number carries no implication of preference, recommendation, or approval for use by other agencies. It is recognized that equivalent equipment produced by other manufacturers may be capable of equally satisfactory performance in this procedure.

Item	Minimum Use Specifications	Calibration Equipment
2.1 Autotransformer	Range: Input 115V, output adjustable between 105 and 125V Current: 200 mA Uncertainty: N/A	General Radio W5MT3A or W10MT3A
2.2 Multimeter	Range: 105 to 125 volts av Input impedance: 5 kΩ/V Uncertainty: ±5%	Simpson 260 series
2.3 Differential voltmeter	Range: 0 to 125V Null range: must be able to discriminate ±10 μV deviations Uncertainty: N/A	John Fluke 895A
2.4 Direct voltage measurement system consisting of:	Ranges: 1, 10, or 100V Uncertainty: 1V range; ±7.5 ppm of output 10V range; ±12.8 ppm of output 100V range; ±13.2 ppm of output	Fluke 7105A:
2.4.1 Null detectors		John Fluke 845AB (2 required)
2.4.2 Reference divider		John Fluke 750A
2.4.3 DC voltage calibrator		John Fluke 332A or 332B
2.4.4 DC transfer standard		John Fluke 731B or 731A
2.4.5 Accessory kit leads	Shielded low–thermal cable with low–thermal spade lugs	Fluke P/N 6016–278887 ” P/N 6016–278895 ” P/N 6016–279893 ” P/N 6016–278403 ” P/N 6016–278911 ” P/N 6016–278929 ” P/N 6016–278945 ” P/N 6016–278937
2.5 Voltage divider	Ratio range: 0 to 1.1 with a 1.1 input tap Resolution: 0.1 ppm of input with 7 decades Uncertainty: 1 ppm of input	John Fluke 720A
2.6 Thermal transfer standard	Measurement uncertainty when corrected for AC–DC difference, 1V to 100V, 400 Hz to 50 kHz; 120 ppm of input	John Fluke 540B
2.7 Differential voltmeter	Range: 1 to 100V; av to 50 kHz Uncertainty: N/A (Prime interest is repeatability)	John Fluke 931B01 or 931AB

Item	Minimum Use Specifications	Calibration Equipment
2.8 Alternating voltage (AV) source	Range: 0 to 100V av Uncertainty: 0.01 to 100V, to 20 kHz; ±0.023%	Hewlett–Packard 745A or John Fluke 5200A
2.9 Electronic counter	Frequency range: 400 to 50 kHz Uncertainty: ±0.25% of input	Hewlett–Packard 5245L
2.10 Resistance measuring system	Range: 0.01 ohm to 10.01 megohms Uncertainty: ±0.005%	Electro Scientific Industries 242B, C, or D

SECTION 3

PRELIMINARY OPERATIONS

3.1 Set all equipment controls as necessary to avoid damage to the equipment and so that dangerous voltages will not be present on the terminals when the power switches are turned on, or when circuit test configurations are being changed for further calibration tests.

3.2 Connect all auxiliary equipment to the appropriate power source, set all power switches on, and allow one hour for the equipment to stabilize.

3.3 Set the autotransformer for 115V av output and connect equipment as shown in Figure 1.

3.4 Set the TI POWER switch to on.

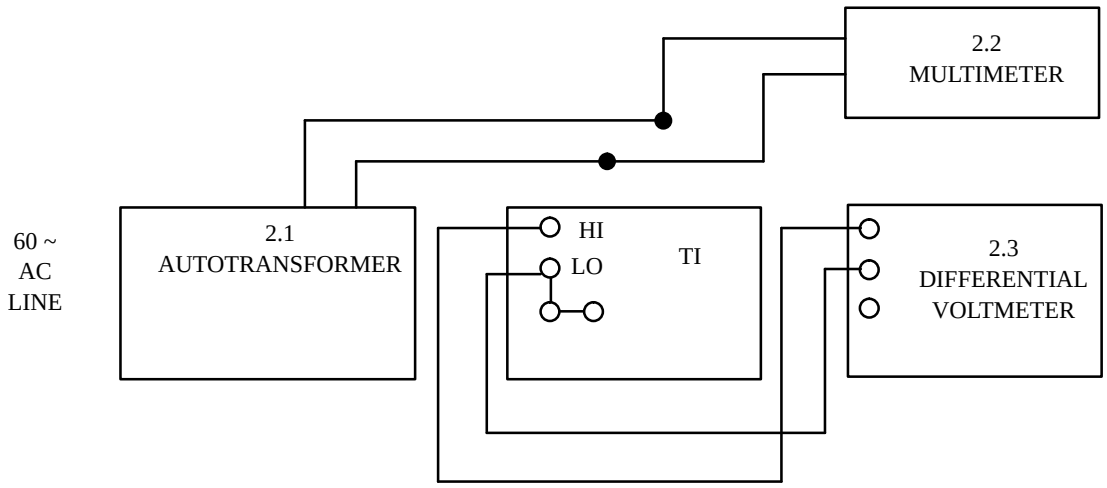

Figure 1. Line Regulation Test Configuration

SECTION 4

CALIBRATION PROCESS

NOTE

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met, before proceeding.

4.1 LINE REGULATION TEST

4.1.1 Set the TI control(s) for a 10V dc output, and adjust the differential voltmeter control(s) as required for a reference null indication.

4.1.2 Adjust the autotransformer output voltage to 105V, and verify that the differential voltmeter indication is $\pm$10 μV or less.

4.1.3 Adjust the autotransformer output voltage to 115V and reestablish a reference null on the differential voltmeter.

4.1.4 Adjust the autotransformer output voltage to 125V, and verify that the differential voltmeter indication is $\pm$10 μV or less.

4.1.5 Adjust the autotransformer output voltage to 115V, set the TI for a minimum output, and disconnect the test configuration.

4.2 DC VOLTAGE RANGE TEST

4.2.1 Set the dc voltage standard controls as follows:

Power switch to	STDBY/RESET
Voltage Range switch to	100
Voltage dials set for	100V output
Voltage Trip switch to	100 (332B)
Voltage Trip vernier	fully cw
Meter switch to	voltage
Current Limit control	as required

4.2.2 Set the reference divider controls as follows:

Std Cell Circuit switch to	Open
Input Voltage switch to	100
Output Voltage switch to	100
Standard Cell Voltage Dials to	Calibrated Value of DC Transfer Standard

4.2.3 Set the controls on both null detectors as follows:

Operate–zero switch to	Zero
Range switch to	10 mV

4.2.4 Connect the equipment as shown in figure 2.

4.2.5 Set operate–zero switch of both null detectors I and II to OPR, then adjust the zero control of each null detector to obtain a null indication on the 10 μV range as follows:

NOTE

To isolate, offset, and/or minimize unwanted voltage pick up, mainly thermoelectric voltages, which may contribute to false indications, the null detectors shall be zeroed in the operate–condition.

4.2.5.1 Lift and connect each positive (+) or Hi terminal of each voltage source (TI, Fluke 731A, and 332A or 332B) to each of its output negative (–) or Lo terminal.

4.2.5.2 Set the reference divider standard cell circuit switch to locked.

4.2.5.3 Adjust the zero control of each null detector for a zero (null) indication; then, set the null detectors operate–zero switch to zero.

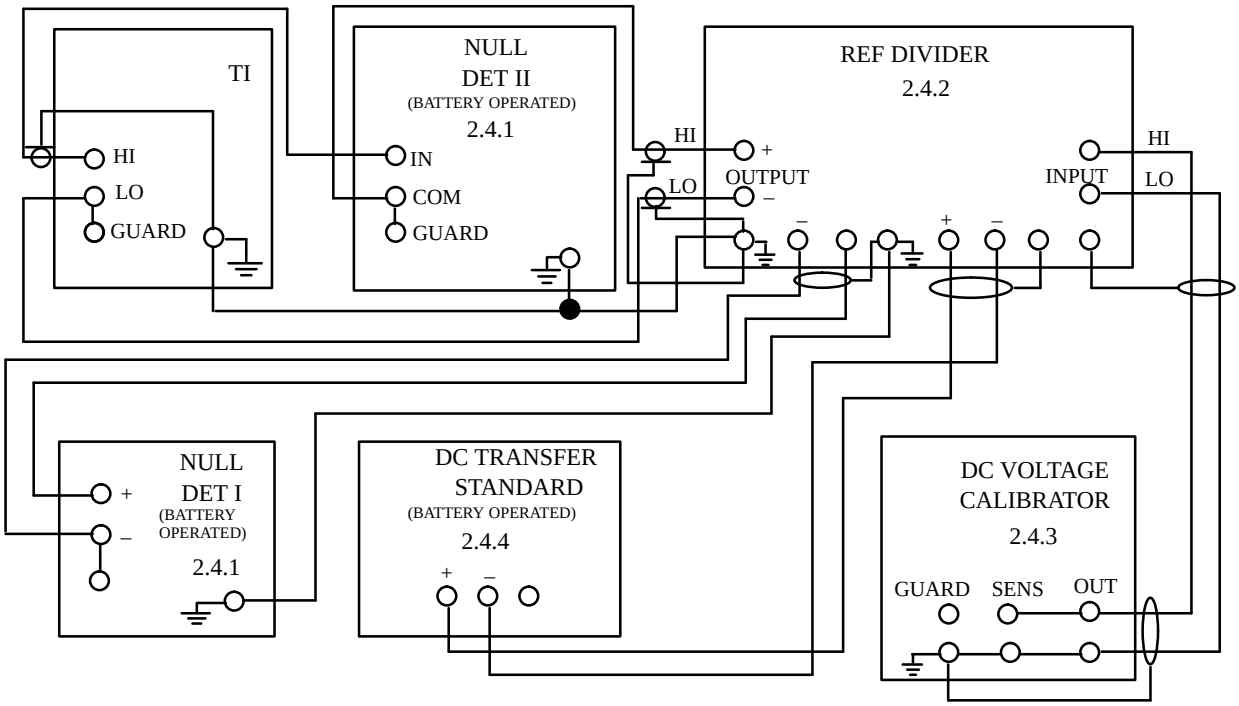

Figure 2. DC Output Voltage Range Test Configuration

4.2.5.4 Reconnect the applicable test configuration (Figure 2 or 3).

4.2.6 Set the dc voltage standard power switch to operate.

4.2.7 Perform calibration in accordance with the following table as follows:

4.2.7.1 For each operation “zero”, set the null detectors operate–zero switch (sw) to zero; make the required equipment settings and switch the null detectors operate–zero switch to operate.

4.2.7.2 During each operation “Null I”, set the DC voltage standard output voltage control(s) and/or adjust the reference divider coarse and fine controls to obtain a null on the null detector I 10 μV range; then, verify that the null detector II indication is within the applicable tolerance limit listed.

Null Detectors Operation	TI Range Settings	Reference Divider		DC Voltage Standard	Null Det. I Operation	Tolerance Limits
		Input SW	Output SW			
”Zero”	100V	100V	100V	100V	”Null I”	±3 mV or less
”	10V	100V	10V	100V	”	±300 μV or less
”	1V	100V	1V	100V	”	±30 μV or less

4.3 DC MICROVOLTS OUTPUT AND LINEARITY TEST

4.3.1 Set equipment control(s) to allow circuit changes without causing damage to the equipment whenever applicable.

4.3.2 Connect equipment as shown in Figure 3.

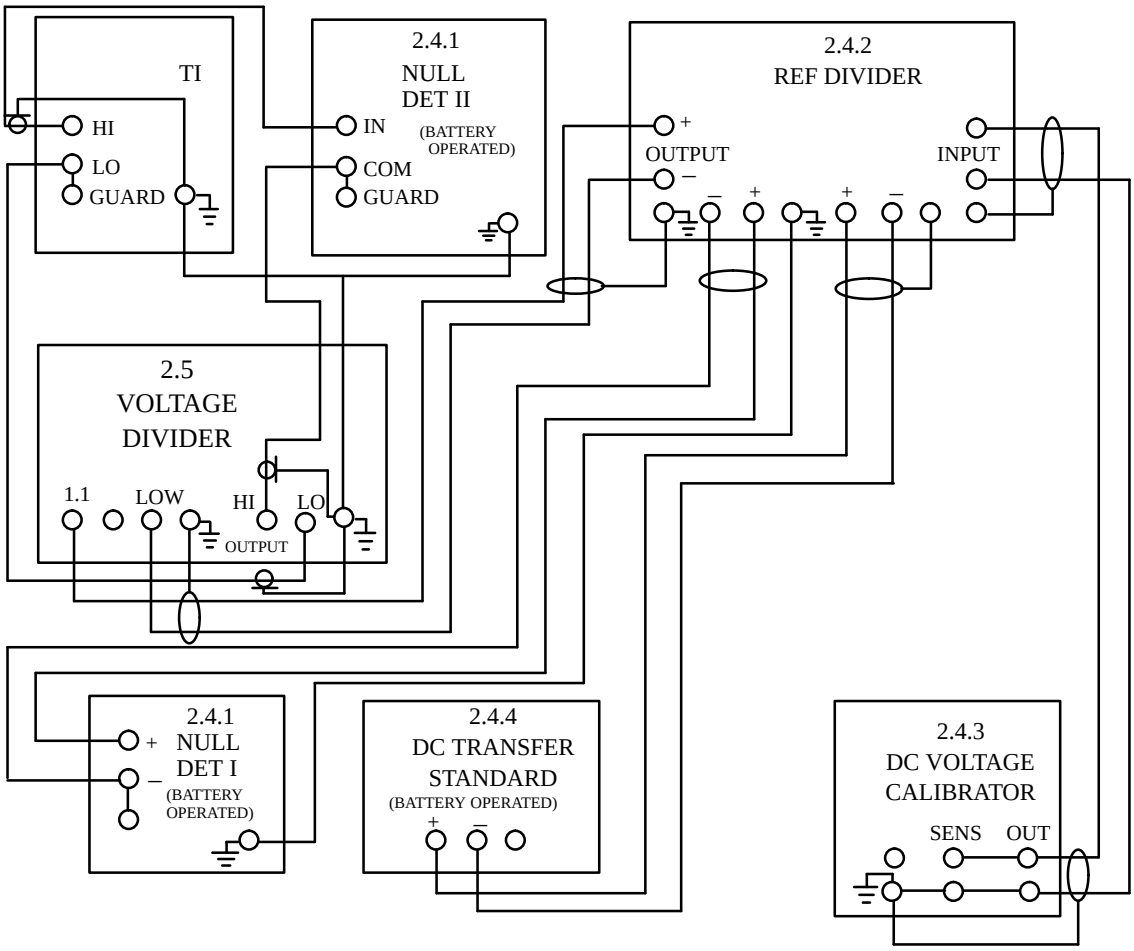

Figure 3. DC Microvolts Output and Linearity Test Configuration

4.3.3 Set the dc voltage standard output control(s) for a 1.100000V output indication, the reference divider input and output switches to 1.1, the voltage divider control(s) to 0.000999X, and the TI μV dial for an indication of 1000 μV.

4.3.4 Zero the null detectors in the operate mode by repeating steps 4.2.5 through 4.2.5.4.

4.3.5 Set the dc voltage standard and the null detectors control(s) to operate.

4.3.6 For each of the following settings, adjust the reference divider coarse and fine input controls and/or the dc voltage standard output control(s) to obtain a reference null indication on the null detector I, then verify that the null detector II indication is within the tolerance limits listed.

TI mV Dial Setting	Voltage Divider Setting	Tolerance Limits
1000	0.000999X	±2 μV or less
700	0.000699X	”
500	0.000499X	”
200	0.000199X	”
100	0.000099X	”
0	0*	±3 μV or less

*Connect the null detector II common lead to the low terminal of the TI, and wait until the thermal emf caused by the heat from the operator’s hands has subsided.

4.3.7 Set the null detectors operate–zero switch–to zero.

4.3.8 Set the voltage sources for minimum output, and disconnect the test configuration.

4.4 10 VOLT DC DECADE TEST

4.4.1 Connect equipment as shown in Figure 4.

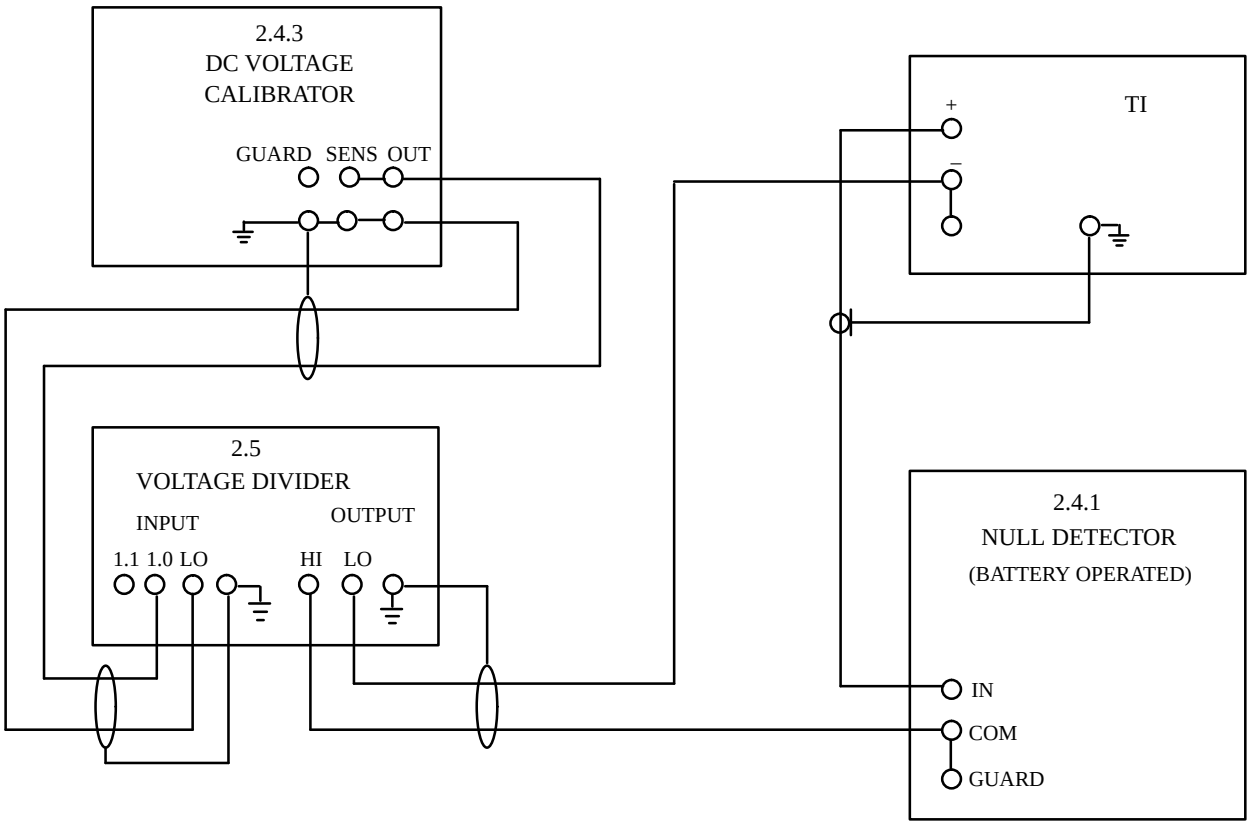

Figure 4. DC Volts Decade Test Configuration

4.4.2 Set the TI voltage output control(s) to obtain a 10V dc output and the voltage divider control(s) to 0.999999X.

4.4.3 Set the dc voltage standard for a 10V output and adjust it as required to establish a reference null indication on the 10 μV range of the null detector.

4.4.4 For each of the following TI output and voltage divider setting verify that the null detector indication is within the tolerance limits listed.

TI Output Setting	Ratio Setting	Tolerance Limits
10V x 0.9	0.899999 (X)	±270 μV or less
” 0.8	0.799999 (X)	±240 ”
” 0.7	0.699999 (X)	±210 ”
” 0.6	0.599999 (X)	±180 ”
” 0.5	0.499999 (X)	±150 ”
” 0.4	0.399999 (X)	±120 ”
” 0.3	0.299999 (X)	± 90 ”
” 0.2	0.199999 (X)	± 60 ”
” 0.1	0.099999 (X)	± 30 ”

4.4.5 Set the equipment control(s) for minimum voltage output, and disconnect the test configuration.

4.5 AC FREQUENCY RESPONSE TEST UP TO 50 KHZ

4.5.1 Connect equipment as shown in Figure 5.

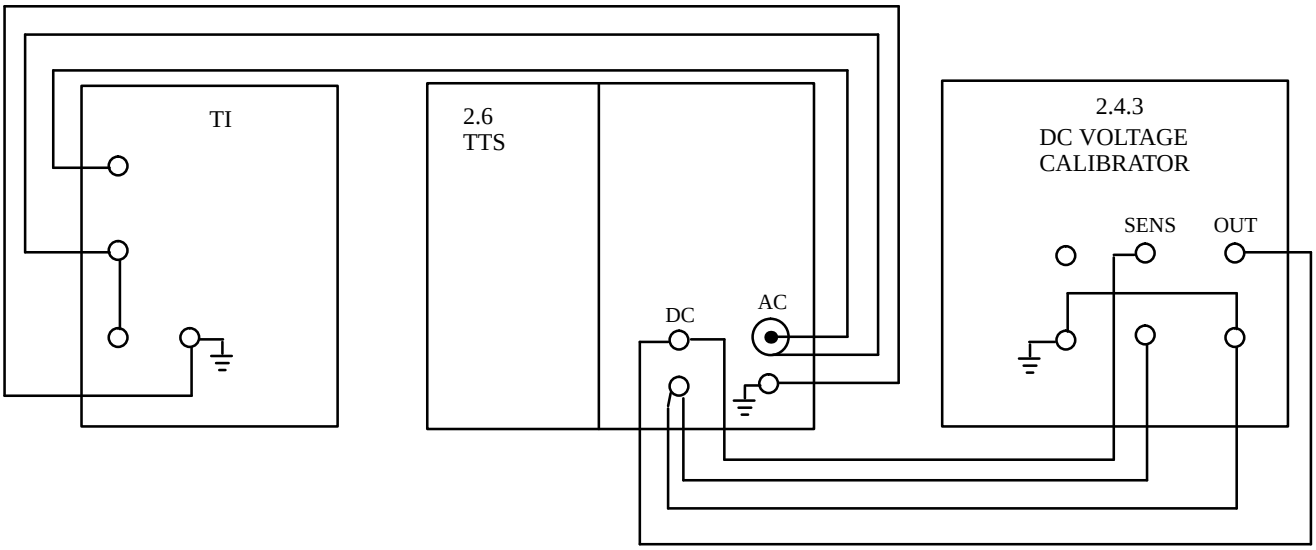

Figure 5. Frequency Response Test Configuration

NOTE

(Perform AC–DC difference corrections as given in the Thermal Transfer Standard’s Current Calibration Report.)

4.5.2 Set the TI AC output control(s) to obtain an output of 10V at 400 Hz and set the thermal transfer standard (TTS) range switch to 10V.

4.5.3 Set the TTS mode switch to the ac transfer position. Establish a galvanometer null at its most sensitive range while maintaining an on–scale meter indication by adjusting the applicable reference–adjust control(s) when switching to a more sensitive range. Adjust galv zero control for electrical zero as required.

4.5.4 Set the TTS galv switch to open and the sensitivity switch to low.

NOTE

Allow for stabilization time. The Fluke 540B may initially take as long as 10 minutes; however, it is considered stabilized when the galvanometer indication drifts less than 2 small divisions per minute in its most sensitive position. Readjust the reference–adjust controls to reestablish the galvanometer null.

4.5.5 Set the TTS mode switch to dc transfer.

4.5.6 Vary the dc voltage standard output control(s) as required to reestablish the galvanometer null indication. (Do not adjust the TTS reference control(s) while in dc mode.)

4.5.7 Obtain a null indication successively in the “medium” and “high” positions of the TTS sensitivity switch by adjusting the dc voltage standard output control(s).

4.5.8 Allow 15 to 30 seconds for the galvanometer to stabilize. Verify that the dc voltage standard output indication is within 9.996 to 10.004 volts.

4.5.9 Repeat steps 4.5.3 through 4.5.8 at each of the following TI output settings. At each setting, verify that the dc voltage standard output indication is within the tolerance limits shown.

TI Output Setting		Tolerance Limits
Range	Freq	(DC Volts)
10V	4 kHz	9.996 to 10.004
10V	50 kHz	9.990 to 10.010

4.5.10 Set the equipment control(s) for minimum voltage output, and disconnect the test configuration.

4.6 AC VOLTAGE TEST

4.6.1 Connect the AV source to the differential voltmeter as shown by the solid line in Figure 6.

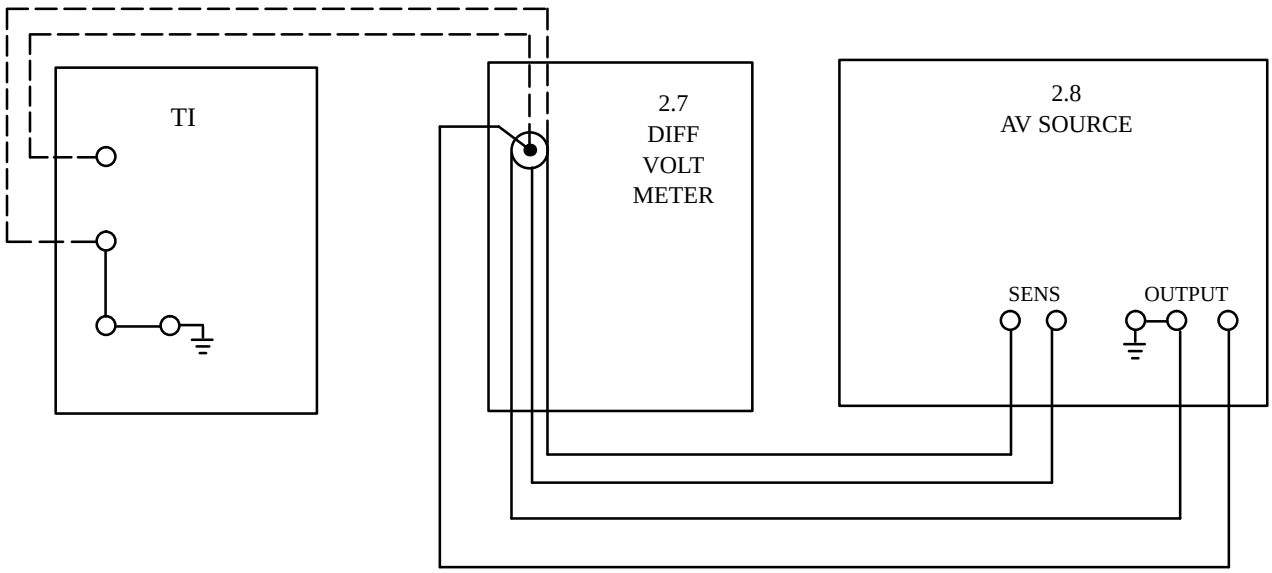

Figure 6. AC Voltage Test Configuration

4.6.2 Using each of the following equipment settings tabulated below, perform calibration as follows:

4.6.2.1 Establish a reference null on the differential voltmeter 0.1% null range by adjusting the differential voltmeter dial(s).

4.6.2.2 Disconnect and replace the AV Source with the TI and without readjusting the differential voltmeter dial(s), verify that the differential voltmeter indication is within the applicable tolerance limits listed.

Step	AV Source		TI Output		Tolerance Limits
	(Volts)	(Freq)	(Volts)	(Freq)	%
4.6.2.1	1.000000	400 Hz	disconnected		Reference null
4.6.2.2	disconnected		1V	400 Hz	±0.058 or less
4.6.2.1	100.0000	400 Hz	disconnected		Reference null
4.6.2.2	disconnected		100V	400 Hz	±0.068 or less

4.6.3 Set the equipment control(s) for minimum output, and disconnect the test configuration.

4.7 FREQUENCY TEST

4.7.1 Connect the TI output connector to the electronic counter (item 2.9) input connector.

4.7.2 Verify that each electronic frequency counter indication is within the tolerance limits listed for each of the following TI output control(s) settings.

TI Output Settings		Tolerance Limits
(Volts)	(Freq)	(Hz)
10	400 Hz	396 to 404
10	4 kHz	3960 tp 4040
10	50 kHz	47500 to 52500

4.8 RESISTANCE TEST

4.8.1 Using the leads specified in item 2.4.5, connect the TI to the resistance measuring system as shown in figure 7.

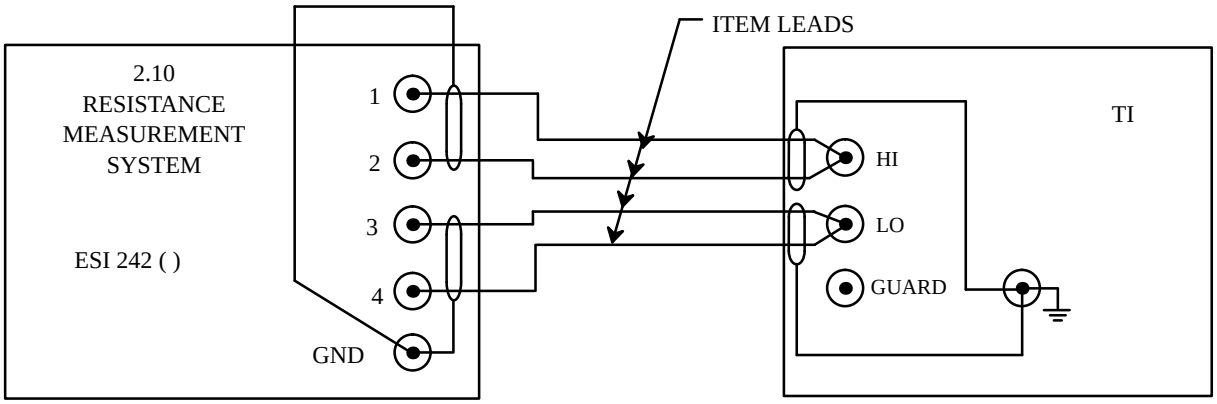

Figure 7. Resistance Test Configuration

4.8.2 Set the TI decade dial control(s) to zero OHMS and maintain POWER switch to ON.

4.8.3 Set resistance measuring system deviation control(s) to zero, and adjust the system detector zero control(s) for a null indication on the detector meter. Change the detector range setting as required for detector sensitivity.

4.8.4 Set the resistance measuring system output switch to + (plus), refer to table 2, and set the measuring system multiplier dial as required.

4.8.5 Adjust the measuring system decade resistance dials to obtain a null indication on the detector meter.

4.8.6 Set the measuring system function switch to lead adj, and adjust the lead adjust controls as required to compensate for lead and terminal resistance, increasing the detector sensitivity as required.

4.8.7 Set the measuring system function switch to yoke adj, and adjust the yoke adj control(s) for a detector null, increasing the detector sensitivity as required.

4.8.8 Set the measuring system function switch–to NORMAL.

4.8.9 Adjust the decade resistance dials for a null indication on the detector meter, and note indication of decade dials.

4.8.10 Set the measuring system output switch to – (negative), and obtain a resistance measurement by repeating steps 4.8.5 through 4.8.9.

4.8.11 Average the resistance measurement obtained in steps 4.8.9 and 4.8.10. Verify that the average value (residual resistance) is $\pm$150 mΩ or less.

4.8.12 Repeat the resistance measurements for each of the remaining steps of the TI decade dial as described in steps 4.8.3 through 4.8.9 and the checklist. Verify at each measurement of the TI decade dial resistance setting that the measuring system decade resistance dial indication is within the tolerance limits listed.

Table 2. Applicable Multiplier Dial Settings

TI Decade Dial Settings	Multiplier Dial Settings
0Ω	X.01
10Ω	X.01
100Ω	X.01
1 kΩ	X.01
10 kΩ	X.01
100 kΩ	X.1
1 MΩ	X1
10 MΩ	X10

4.8.13 Unless other measurements are to be performed, turn all power switches off, and disconnect the TI.

CALIBRATION CHECKLIST

TEST INST (S) Fluke 515A Portable Calibrator

PROC. NO. NA 17–20AQ–70			MFG.	MODEL			SER. NO.
PROCEDURE STEP NO. (1)	FUNCTION TESTED (2)		NOMINAL (3)	MEASURED VALUES FIRST RUN (4)	MEASURED VALUES SECOND RUN (5)	OUT OF TOL (6)	CALIBRATION TOLERANCES (7)
4.1	Line Regulation Test						
4.1.2	Line voltage 105		—	ck ( )			±10 μV or less
4.1.4	”	125	—	ck ( )			”
4.2	DC Voltage Range Test						
	TI Range		(mV)	(mV)			
4.2.7.2	100V		0				±3 mV or less
”			(μV)	(μV)			
4.2.7.2	10V		0				±300 μV or less
	1V		0				±30 ”
4.3	DC Microvolts Output and Linearity Test						
	TI μV	Divider	(μV)	(μV)			
4.3.6	1000	0.000999X	0				±2 μV or less
”	700	0.000699X	0				”
”	500	0.000499X	0				”
”	200	0.000199X	0				”
”	100	0.000099X	0				”
”	0	0.0000000	0				±3 μV ”
4.4	10 Volts DC Decade Test						
4.4.3	10 (1)	0.999999X	—	ck ( )			Ref Null
	TI Output	Ratio	(μV)	(μV)			
4.4.4	10 (0.9)	0.899999(X)	0				±270 μV or less
”	10 (0.8)	0.799999(X)	0				±240 ”
”	10 (0.7)	0.699999(X)	0				±210 ”
”	10 (0.6)	0.599999(X)	0				±180 ”
”	10 (0.5)	0.499999(X)	0				±150 ”
”	10 (0.4)	0.399999(X)	0				±120 ”
”	10 (0.3)	0.299999(X)	0				± 90 ”
”	10 (0.2)	0.199999(X)	0				± 60 ”
”	10 (0.1)	0.099999(X)	0				± 30 ”

CALIBRATION CHECKLIST

TEST INST (S) Fluke 515A Portable Calibrator

PROC. NO. NA 17–20AQ–70		MFG.	MODEL			SER. NO.
PROCEDURE STEP NO. (1)	FUNCTION TESTED (2)	NOMINAL (3)	MEASURED VALUES FIRST RUN (4)	MEASURED VALUES SECOND RUN (5)	OUT OF TOL (6)	CALIBRATION TOLERANCES (7)
4.5	AC Frequency Response Test up to 50 KHz					
	TI Range Freq	(DC Volts)	(DC Volts)			(DC Volts)
4.5.8	10V 400 Hz	10.000				9.996 to 10.004
4.5.9	10V 4 kHz	10.000				”
”	10V 50 kHz	10.000				9.990 to 10.010
4.6	AC Voltage Test					
	TI Output					
	Range Freq	(%)	(%)			
4.6.2.2	1V 400 Hz	0				±0.058% or less
”	100V ”	0				±0.068% or less
4.7	Frequency Test					
	TI Output					
	Volts Freq	(Hz)	(Hz)			(Hz)
4.7.2	10 400 Hz	400				396 to 404
”	10 4 kHz	4000				3960 to 4040
”	10 50 kHz	50000				47500 to 52500
4.8	Resistance Test					
	TI Output					
	(Ω)		(Ω)			(mΩ)
4.8.11	0 (Residual)	—				±150 or less
4.8.12	10	—				±(6 + residual) or less
”	100	—				±(60 + residual) or less
	(kΩ)		(Ω)			(mΩ)
4.8.12	1	—				±(150 + residual) or less
”	(kΩ)		(Ω)			(Ω)
4.8.12	10k	—				±(1.5 + residual) or less
”	100k	—				±(15 + residual) or less
	(MΩ)		(Ω)			(Ω)
4.8.12	1	—				±(150 + residual) or less
”	10	—				±(7500 + residual) or less