TECHNICAL MANUAL

CALIBRATION PROCEDURE

FOR

DIGITAL MULTIMETER

34401A

(HEWLETT-PACKARD)

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1 CALIBRATION DESCRIPTION:

Table 1.

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
DC Voltage	Range: 0 to 1000 V Accuracy: 100 mV rng: ±(0.005% rdg + 0.0035% rng); 1 V rng: ±(0.004% rdg + 0.0007% rng); 10 V rng: ±(0.0035% rdg + 0.0005% rng); 100 V rng: ±(0.0045% rdg + 0.0006% rng); 1000 V rng: ±(0.0045% rdg + 0.001% rng)	Compared to a DC Voltage Standard
AC Voltage	Range: 0 to 750 V Accuracy: 100 mV rng: ±(1% rdg + 0.04% rng) 3 to 5 Hz; ±(0.35% rdg + 0.04% rng) 5 to 10 Hz; ±(0.06% rdg + 0.04% rng) 10 Hz to 20 kHz; ±(0.12% rdg + 0.05% rng) 20 to 50 kHz; ±(0.6% rdg + 0.08% rng) 50 to 100 kHz; ±(4% rdg + 0.5% rng) 100 to 300 kHz 1 thru 750 V rng: ±(1% rdg + 0.03% rng) 3 to 5 Hz; ±(0.35% rdg + 0.03% rng) 5 to 10 Hz; ±(0.06% rdg + 0.03% rng) 10 Hz to 20 kHz; ±(0.12% rdg + 0.05% rng) 20 to 50 kHz; ±(0.6% rdg + 0.08% rng) 50 to 100 kHz; ±(4% rdg + 0.5% rng) 100 to 300 kHz	Compared to an AC Voltage Standard
DC Current	Range: 0 to 3 A Accuracy: 10 mA rng: ±(0.05% rdg + 0.02% rng); 100 mA rng: ±(0.05% rdg + 0.005% rng);	Compared to a DC Current Standard

Table 1. (Cont.)

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
DC Current *(Cont.)*	Range: 0 to 3 A Accuracy: 1 A rng: ±(0.1% rdg + 0.01% rng); 3 A rng: ±(0.12% rdg + 0.02% rng)	Compared to a DC Current Standard
AC Current	Range: 0 to 3 A Accuracy: 1 A rng: ±(1% rdg + 0.04% rng) 3 to 5 Hz; ±(0.3% rdg + 0.04% rng) 5 to 10 Hz; ±(0.1% rdg + 0.04% rng) 10 Hz to 5 kHz 3 A rng: ±(1.1% rdg + 0.06% rng) 3 to 5 Hz; ±(0.35% rdg + 0.06% rng) 5 to 10 Hz; ±(0.15% rdg + 0.06% rng) 10 Hz to 5 kHz	Compared to an AC Current Standard
Resistance	Range: 0 to 100 MΩ Accuracy: * 100 Ω rng: ±(0.01% rdg + 0.004% rng); 1 kΩ thru 1 MΩ rngs: ±(0.01% rdg + 0.001% rng); 10 MΩ rng: ±(0.04% rdg + 0.001% rng); 100 MΩ rng: ±(0.8% rdg + 0.01% rng)	Compared to a Resistance Standard
DC Ratio	Range: 0 to 1000 VDC Accuracy: (Input Accuracy + Reference Accuracy)	Accuracy verified during DC Voltage Calibration
Frequency, Period	Range: 0 to 300 kHz Accuracy: ±0.1% rdg at 3 to 5 Hz; ±0.05% rdg at 5 to 10 Hz; ±0.03% rdg at 10 to 40 Hz; ±0.01% rdg at 40 Hz to 300 kHz Sensitivity: 100 mV rms	Compared to a Signal Generator

* Specifications are for 4-wire Ω function or 2-wire Ω using MATH NULL. Add 0.2 Ω additional error in 2-wire Ω function.

2 EQUIPMENT REQUIREMENTS:

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.1	METER CALIBRATOR	Range: 0 to 1000 VDC; 0 to 740 VAC; 0 to 2.9 AAC; 0 to 2 ADC; 0 to 100 MΩ Accuracy: ±0.002% of setting, 220 mV DC rng; ±0.001% of setting, 2 thru 11 VDC rngs; ±0.0012% of setting, 220 and 1100 VDC rngs ±0.0137% of setting, 22 and 220 mA DC rngs; ±0.037% of setting, 2.2 ADC rng; ±0.052% of setting, 11 ADC rng used for AC/DC transfer for AAC (TAR 3.8:1) N/A for AC Current; ±0.0027% of setting, 100 Ω thru 1 MΩ rng; ±0.01% of setting, 10 MΩ rng; ±0.2% of setting, 100 MΩ rng N/A, 10 to 20 Hz on all VAC rngs and 49 kHz on the 220 mV rng; ±0.022% of setting, 40 Hz to 20 kHz all VAC rngs; ±0.042% of setting, 20 to 50 kHz 220 mV AC thru 220 VAC rngs; ±0.17% of setting, 50 to 100 kHz 220 mV AC thru 220 VAC rngs; ±1% of setting, 100 to 300 kHz 220 mV AC thru 220 VAC rngs; N/A, 30 to 100 kHz on the 1100 VAC rng	Fluke 5700A w/5725A	
2.2	AC MEASUREMENT STANDARD	Range: 0 to 750 VAC Accuracy: ±0.022% of rdg, 220 mV AC thru 220 VAC rngs at 10 Hz; ±0.043% of rdg, 1100 VAC rng at 10 Hz; ±0.042% of rdg, 220 mV and 1100 VAC rng at 49 kHz; ±0.17% of rdg, 1100 VAC rng at 100 kHz; ±0.0027%, transfer accuracy	Fluke 5790A/AF	

Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.3 AC CURRENT SHUNTS	Range: 0 to 3 AAC Accuracy: ±0.02% AC/DC difference	Fluke A45/AF	
2.4 CURRENT SHUNT ADAPTER	Range: N/A Accuracy: N/A	Fluke 5790A-7001	
2.5 SIGNAL GENERATOR	Range: 0 to 100 mV, 4 Hz to 300 kHz Accuracy: Frequency, ±75 ppm; Amplitude, ±0.6 dB	Hewlett-Packard 3325B	
2.6 FEEDTHROUGH TERMINATION	Range: 50 Ω Accuracy: N/A	Tektronix 011-0049-01	

3 PRELIMINARY OPERATIONS:

3.1 Review and become familiar with entire procedure before beginning Calibration Process.

WARNING

Unless otherwise designated, and prior to beginning the Calibration Process, ensure that all test equipment voltage and/or current outputs are set to zero (0) or turned off, where applicable. Ensure that all equipment switches are set to the proper position before making connections or applying power.

3.2 Observe the TI rear panel and assure that the line voltage section switches are set for 120 V operation.

3.3 Connect TI to 115 VAC/50 to 60 Hz power source. Set POWER ON and allow 60 minutes warm-up.

3.4 Connect test equipment to appropriate power source. Set all POWER switches to ON and allow warm-up as required by the manufacturer.

3.5 Set TI POWER OFF. Press and hold the SHIFT key and press POWER ON. Continue to hold the SHIFT key down for at least 5 seconds after POWER ON is pressed. After about 20 seconds, verify TI displays PASS.

3.6 Annotate and attach a Limited Certification Label: AC Voltage and AC Current are not calibrated below 10 Hz.

NOTE

Step 4.1.2 must be performed to return TI to 6 ½ digit operation each time TI function is changed. Repeat step 4.1.2 as required throughout the Calibration Process.

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 DC VOLTAGE CALIBRATION:

4.1.1 Using a high quality, low thermal emf short, connect TI Front terminal SENSE HI and LO together, INPUT HI and LO together and both LOs together. Set TI FRONT/REAR switch to FRONT.

4.1.2 Press TI DC V key. Select the MAN 6 ½ digit range by pressing TI SHIFT key, then the DIGITS 6 key.

4.1.3 Manually select the first TI value listed in Range column of Table 2.

4.1.4 The TI display must indicate within the corresponding values listed in the Limits column of Table 2.

4.1.5 Repeat steps 4.1.3 and 4.1.4 for each remaining range value listed in Table 2.

Table 2.

Range	Limits
100 mV	0 ±3.5 µV
1 V	0 ±7 µV
10 V	0 ±50 µV
100 V	0 ±600 µV
1000 V	0 ±10 mV
10 mA *	0 ±2 µA
100 mA	0 ±5 µA
1 A	0 ±100 µA
3 A	0 ±600 µA
100 Ω **	0 ±4 mΩ
1 kΩ	0 ±10 mΩ
10 kΩ	0 ±100 mΩ
100 kΩ	0 ±1 Ω
1 MΩ	0 ±10 Ω

See footnotes at end of Table.

Table 2. (Cont.)

Range	Limits
10 MΩ	0 ±100 Ω
100 MΩ	0 ±10 kΩ

* Press TI SHIFT, then DC V key.

** Press TI Ω 2W key and press TI MATH NULL key. Also, repeat the Ohms zero check for 4-wire Ohms function without utilizing the MATH NULL function.

4.1.6 Set TI FRONT/REAR switch to REAR. Repeat steps 4.1.1 thru 4.1.5 using the TI REAR INPUT Terminals.

4.1.7 Disconnect the short installed in step 4.1.1. Return TI FRONT/REAR switch to FRONT.

4.1.8 Press TI DC V key.

4.1.9 Connect the Meter Calibrator OUTPUT to TI INPUT HI and LO, observing polarity.

4.1.10 Set Meter Calibrator controls for the first value listed in the Applied column of Table 3 and set OPR/STBY switch to OPR.

4.1.11 The TI display must indicate within the corresponding values listed in the Limits column of Table 3.

4.1.12 Set Meter Calibrator OPR/STBY switch to STBY.

4.1.13 Repeat steps 4.1.10 thru 4.1.12 for each remaining range and applied value listed in Table 3.

Table 3.

Range	Applied (VDC)	Limits (VDC)
100 mV	100 m	99.9915 to 100.0085 m
1 V	1.0	0.999953 to 1.000047
10 V	±10	±9.99960 to 10.00040
	±7	±6.99970 to 7.00030
	±3	±2.99984 to 3.00016
100 V	100	99.9949 to 100.0051
1000 V	950	949.947 to 950.053

4.2 AC VOLTAGE CALIBRATION:

4.2.1 Press TI AC V, SHIFT, MENU ON/OFF to ON and select SLOW filter as follows:

Press CHOICES until A: MEAS MENU appears on display

Press LEVEL until 1: AC FILTER appears on display

Press LEVEL until MED: 20 HZ appears on display

Press CHOICES until SLOW: 3 HZ appears on display, press ENTER

4.2.2 Set Meter Calibrator controls for the first value listed in the Applied column of Table 4 and set OPR/STBY switch to OPR.

4.2.3 The TI display must indicate within the corresponding values listed in the Limits column of Table 4.

4.2.4 Set Meter Calibrator OPR/STBY switch to STBY.

4.2.5 Repeat steps 4.2.2 thru 4.2.4 for each remaining range and applied value listed in Table 4.

Table 4.

Range	Applied (Hz)	Limits (VAC)
100 mV	0.10 V @ 10 *	99.9000 to 100.1000 m
	0.10 V @ 19 k	99.9000 to 100.1000 m
	0.10 V @ 49 k *	99.8300 to 100.1700 m
	0.10 V @ 99 k	99.3200 to 100.6800 m
	0.10 V @ 300 k	95.5000 to 104.5000 m
1 V	1 V @ 10 *	.999100 to 1.000900
	1 V @ 19 k	.999100 to 1.000900
	1 V @ 49 k	.998300 to 1.001700
	1 V @ 99 k	.993200 to 1.006800
	1 V @ 300 k	.955000 to 1.045000
10 V	10 V @ 10 *	9.99100 to 10.00900
	10 V @ 19 k	9.99100 to 10.00900
	10 V @ 49 k	9.98300 to 10.01700
	10 V @ 99 k	9.93200 to 10.06800

See footnote at end of Table.

Table 4. (Cont.)

Range	Applied (Hz)	Limits (VAC)
10 V	10 V @ 300 k	9.55000 to 10.45000
100 V	100 V @ 10 *	99.9100 to 100.0900
	100 V @ 19 k	99.9100 to 100.0900
	100 V @ 49 k	99.8300 to 100.1700
	100 V @ 99 k	99.3200 to 100.6800
	30 V @ 300 k	28.3000 to 31.7000
750 V	200 V @ 10 *	199.655 to 200.345
	740 V @ 40	739.331 to 740.669
	740 V @ 19 k	739.331 to 740.669
	740 V @ 49 k *	738.737 to 741.263
	740 V @ 100 k *	734.960 to 745.040

* Monitor the Meter Calibrator output with the AC Measurement Standard. Edit the Meter Calibrator output as required to obtain the applied value as monitored on the AC Measurement Standard.

4.2.6 Disconnect the test setup.

4.3 DC CURRENT CALIBRATION:

4.3.1 Connect Meter Calibrator OUTPUT to TI 3A and LO jacks.

4.3.2 Press TI SHIFT key, then DC V key.

4.3.3 Set the Meter Calibrator for the first value listed in the Applied column of Table 5 and set OPR/STBY switch to OPR.

4.3.4 The TI display must indicate within the corresponding values listed in the Limits column of Table 5.

4.3.5 Set the Meter Calibrator OPR/STBY switch to STBY.

4.3.6 Repeat steps 4.3.3 thru 4.3.5 for each remaining range and applied value listed in Table 5.

Table 5.

Range	Applied (ADC)	Limits (ADC)
10 mA	10 m	9.99300 to 10.00700 m
100 mA	100 m	99.9450 to 100.0550 m

Table 5. (Cont.)

Range	Applied (ADC)	Limits (ADC)
1 A	1	.998900 to 1.001100
3 A	2	1.99700 to 2.00300

4.3.7 Disconnect the test setup.

4.4 AC CURRENT CALIBRATION:

4.4.1 Press TI SHIFT key, then AC V key.

4.4.2 Connect the Current Shunt Adapter to the AC Measurement Standard SHUNT and INPUT 2 LO terminals, observing polarity.

4.4.3 Lock the AC Measurement Standard on the 700 mV range and press the SHUNT switch.

4.4.4 Connect the 2 A AC Current Shunt to the Current Shunt Adapter.

4.4.5 Connect the Meter Calibrator OUTPUT LO to one input terminal of the AC Current Shunt.

4.4.6 Connect TI LO input to the remaining input terminal of the AC Current Shunt.

4.4.7 Connect the Meter Calibrator OUTPUT HI to TI I INPUT terminal.

4.4.8 Set the Meter Calibrator controls for the first value listed in the Applied (ADC) column of Table 6 and set the OPR/STBY switch to OPR.

4.4.9 Allow for a stable reading and press the AC Measurement Standard Set Ref softkey.

4.4.10 Press the Meter Calibrator –/+ and ENTER pushbuttons to change the output to negative.

4.4.11 Allow for a stable reading and press the AC Measurement Standard Avg Ref softkey.

4.4.12 Set the AC Measurement Standard Control display to show ppm error and note indication.

4.4.13 Set the Meter Calibrator OPR/STBY switch to STBY.

4.4.14 Set the Meter Calibrator controls for the first value listed in the Applied (AAC) column of Table 6 and set the OPR/STBY switch to OPR.

4.4.15 Allow for a stable reading on the AC Measurement Standard.

4.4.16 Edit the Meter Calibrator output until the AC Measurement Standard indicates the noted ppm error in step 4.4.12.

4.4.17 The TI display must indicate within the corresponding values listed in the Limits column of Table 6.

4.4.18 Edit the Meter Calibrator frequency to each remaining value pertaining to the range being calibrated and repeat steps 4.4.16 and 4.4.17 at each frequency.

4.4.19 Set the Meter Calibrator OPR/STBY switch to STBY.

4.4.20 Replace the 2 A AC Current Shunt with the 5 A AC Current Shunt.

4.4.21 Repeat steps 4.4.8 thru 4.4.19 for the remaining range and applied values listed in Table 6.

Table 6.

Range	Applied (ADC)	Applied (AAC)	Limits (AAC)
1 A	1		Reference
		1 A @ 40 Hz	.998600 to 1.001400
		1 A @ 1 kHz	.998600 to 1.001400
		1 A @ 5 kHz	.998600 to 1.001400
3 A	2.9		Reference
		2.9 A @ 40 Hz	2.89385 to 2.90615
		2.9 A @ 1 kHz	2.89385 to 2.90615
		2.9 A @ 5 kHz	2.89385 to 2.90615

4.4.22 Disconnect the test setup.

4.5 RESISTANCE CALIBRATION:

4.5.1 Press TI SHIFT key, then Ω 2W switch.

4.5.2 Connect the Meter Calibrator SENSE HI and LO to TI Ω 4W SENSE HI and LO. Connect the Meter Calibrator OUTPUT HI and LO to TI INPUT HI and LO.

4.5.3 Set the Meter Calibrator for the first value listed in the Applied column of Table 7 and set OPR/STBY switch to OPR.

4.5.4 Set the Meter Calibrator 2 wire Comp softkey to OFF and EX SNS on.

4.5.5 Using the output adjustment controls, adjust the Meter Calibrator until reading on the control display equals the reading on the TI.

4.5.6 The ERROR indication on the Meter Calibrator control display must be within the corresponding values listed in the Limits column of Table 7.

4.5.7 Repeat steps 4.5.3 thru 4.5.6 for each remaining applied value listed in Table 7.

Table 7.

Range	Applied (Ω)	Limits (%/Ω)
100 Ω	100	±0.014% (99.9860 to 100.0140)
1 kΩ	1 k	±0.011% (.999890 to 1.000110 k)
10 kΩ	10 k	±0.011% (9.99890 to 10.00110 k)
100 kΩ	100 k	±0.011% (99.9890 to 100.0110 k)
1 MΩ	1 M	±0.011% (.999890 to 1.000110 M)
10 MΩ *	10 M	±0.041% (9.99590 to 10.00410 M)
100 MΩ	100 M	±0.81% (99.1900 to 100.8100 M)

* Press TI Ω 2W key. Set the Meter Calibrator EX SNS to off.

4.5.8 Disconnect test setup.

4.6 FREQUENCY CALIBRATION:

4.6.1 Connect the Signal Generator 50 Ω OUTPUT thru the Feedthrough Termination to the TI INPUT HI and LO jacks.

4.6.2 Press TI FREQ key.

4.6.3 Set the Signal Generator for the first value listed in the Applied column of Table 8.

4.6.4 The TI display must indicate within the corresponding values listed in the Limits column of Table 8.

4.6.5 Repeat steps 4.6.3 and 4.6.4 for each remaining applied value listed in Table 8.

Table 8.

Applied (rms)	Limits (Hz)
100 mV @ 4 Hz	3.99600 to 4.00400
100 mV @ 9 Hz	8.99550 to 9.00450
100 mV @ 30 Hz	29.9910 to 30.0090
100 mV @ 300 kHz	299.970 to 300.030 k

4.6.6 Set all POWER switches to STANDBY/OFF. Disconnect and secure all equipment.

4.6.7 Annotate and attach a Limited Certification Label as per step 3.6.

CALIBRATION PERFORMANCE TABLE

Not Required