TECHNICAL MANUAL

CALIBRATION PROCEDURE

FOR

MULTIFUNCTION CALIBRATOR

4808, OPT 10, OPT 20, OPT 30, OPT 40, OPT 50, OPT 70

(DATRON/WAVETEK)

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MULTIFUNCTION CALIBRATOR

4808, OPT 10, OPT 20, OPT 30, OPT 40, OPT 50, OPT 60, OPT 70

(DATRON/WAVETEK)

1 CALIBRATION DESCRIPTION:

Table 1.

Test Instrument (TI) Characteristics	Performance Specifications	Test Method

NOTE

The Performance Specifications listed below for the TI show **Relative** specifications as found in the commercial data and **Absolute** specifications. The absolute specifications were calculated by combining the uncertainty of the relative specifications found in the commercial data with the uncertainty of the calibration standards listed in Section 2, Equipment Requirements.

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
Distortion (OPT 20 and 30)	Range: OPT 20: 0 to 100 V, 10 Hz to 1 MHz; OPT 30: 0 to 1000 V, 10 Hz to 1 MHz Accuracy: Pure THD, which is predominately second harmonic, excluding noise, which is included in the main specifications:	Measured with a Distortion Analyzer

Frequency	Voltage Range	≤%
10 to 31 Hz	1 mV thru 100 V rngs	0.1
32 Hz to 33 kHz	1 mV thru 100 V rngs	0.04
30 to 100 kHz	1 mV thru 10 V rngs	0.1
30 to 100 kHz	100 V rng	0.2
100 to 330 kHz	1 mV thru 100 V rngs	0.3
300 kHz to 1 MHz	1 mV thru 100 V rngs	1
10 to 330 Hz	1000 V rng	0.2
300 Hz to 33 kHz	1000 V rng	0.1
30 to 100 kHz	750 V rng	0.5

Table 1. (Cont.)

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
Distortion Wideband (OPT 70)	Range: 0 to 3 V, 10 Hz to 30 MHz Accuracy: THD: ≤-40 dB, volt-hertz product ≤9 X 10^7; ≤-36 dB, volt-hertz product >9 X 10^7 Spurious Frequency Output: ≤-46 dB	Measured with a Distortion Analyzer and a Spectrum Analyzer
Distortion Transconductance Amplifier (OPT 60)	Range: 0 to 10 A, 10 Hz to 20 kHz Accuracy: Pure THD, which is predominately second harmonic, excluding noise, which is included in the main specifications: ≤0.2%, 10 Hz to 10 kHz; ≤1%, 10 to 20 kHz	Measured with a Distortion Analyzer
Frequency (OPT 20, 30 and 70)	Range: OPT 20 and 30: 10 Hz to 1 MHz; OPT 70: 10 Hz to 30 MHz Accuracy: OPT 20 and 30: <±0.01% of setting OPT 70: *[1] ±0.01% of setting	Measured with an Electronic Counter
DC Voltage (OPT 10 and 30)	Range: OPT 10: 0 to 100 V; OPT 30: 0 to 1000 V Accuracy: ±(ppm of output + µV)	Compared to a Standard DC Voltage

OPT 10:	Relative		Absolute	
Range:	ppm	µV	ppm	µV
100 µV	7	0.5	7.44	0.5
1 mV	7	0.5	7.44	0.5
10 mV	7	0.5	7.44	0.5
100 mV	7	0.5	7.45	0.5
1 V	5	1	5.59	1
10 V	3	3	3.91	3
100 V	5	50	5.59	50
OPT 30:				
1000 V	7	500	7.45	500

See footnotes at end of Table.

Table 1. (Cont.)

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
DC Current (OPT 40)	Range: 0 to 1 A Accuracy: ±(ppm of output + µA)	Measure voltage across a Standard Resistor with a Digital Multimeter

Range:	Relative ppm	Relative n/µA	Absolute ppm	Absolute n/µA
100 µA	100	2 n	100.62	2.24 n
1 mA	40	10 n	41.53	10.05 n
10 mA	40	100 n	41.53	100.50 n
100 mA	40	1 µ	41.53	1 µ
1 A	100	20 µ	100.68	20.02 µ

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
DC and AC Current Transconductance Amplifier (OPT 60)	Range: 0 to 10 A, DC; Accuracy: ±(ppm of output + n/µA)	Measure voltage across a DC Current Shunt with a Digital Multimeter

Range:	Relative ppm	Relative n/µA	Absolute ppm	Absolute n/µA
10 ADC	150	500 µA	155.56	509.9 µA

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
	Range: 0 to 10 A at 10 Hz to 20 kHz Accuracy: ±(ppm of output + mA)	Measured with an AC Current Shunt and AC Measurement Standard and compared to a DC Current Shunt and a Digital Multimeter

Frequency	Relative ppm	Relative mA	Absolute ppm	Absolute mA
10 Hz to 1 kHz	400	1.3	408.05	1.3
1 to 5 kHz	850	1.6	855.04	1.6
5 to 10 kHz	2200	6.0	2202.40	6.0
10 to 20 kHz	7200	32	7200.75	32.0

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
AC Current (OPT 40)	Range: 0 to 1 A, 10 Hz to 5 kHz Accuracy: ±(ppm of output + A)	Measure voltage across an AC Current Shunt or known resistance with an AC Measurement Standard and calculate Current

Range	Hz	Relative ppm	Relative A	Absolute ppm	Absolute A
100 µA	10 Hz to 1 kHz	150	10 n	152.41	10.00 n
	1 to 5 kHz	300	14 n	301.21	14.00 n
1 mA	10 Hz to 1 kHz	100	100 n	103.58	100.0 n
	1 to 5 kHz	200	100 n	201.81	100.0 n
10 mA	10 Hz to 1 kHz	100	1 µ	209.07	1 µ
	1 to 5 kHz	200	1 µ	209.07	1 µ

See footnotes at end of Table.

Table 1. (Cont.)

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
AC Current *(Cont.)* (OPT 40)	Range: 0 to 1 A, 10 Hz to 5 kHz Accuracy: ±(ppm of output + A)	Measure voltage across an AC Current Shunt or known resistance with an AC Measurement Standard and calculate Current

Range	Hz	Relative ppm	Relative A	Absolute ppm	Absolute A
100 mA	10 Hz to 1 kHz	100	10 µ *[2]	211.36	10 µ
	1 to 5 kHz	200	10 µ	211.36	10 µ
1 A	10 Hz to 1 kHz	300	100 µ	308.33	100 µ
	1 to 5 kHz	450	140 µ	455.67	140 µ

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
AC Voltage (OPT 20 and 30)	Range: OPT 20: 0 to 100 V, 10 Hz to 1 MHz OPT 30: 0 to 1000 V, 10 Hz to 100 kHz Accuracy: ±(ppm of output + V)	Measured with an AC Measurement Standard

OPT 20 Range	Frequency	Relative ppm	Relative V	Absolute ppm	Absolute V
1 mV	10 to 31 Hz	120	5.4 µ	749.67	5.55 µ
	32 to 330 Hz	70	5.4 µ	425.79	5.55 µ
	300 Hz to 10 kHz	60	5.4 µ	424.26	5.55 µ
	10 to 33 kHz	70	5.4 µ	425.79	5.55 µ
	30 to 100 kHz	300	5.4 µ *[3]	1300.00	5.95 µ
	100 to 330 kHz	1000	12 µ	2507.99	12.65 µ
	300 kHz to 1 MHz	2000	72 µ	4031.13	72.44 µ
10 mV	10 to 31 Hz	120	5.4 µ	224.72	5.55 µ
	32 to 330 Hz	70	5.4 µ	130.38	5.55 µ
	300 Hz to 10 kHz	60	5.4 µ	125.30	5.55 µ
	10 to 33 kHz	70	5.4 µ	130.38	5.55 µ
	30 to 100 kHz	300	5.4 µ *[3]	506.06	5.95 µ
	100 to 330 kHz	1000	12 µ	1286.90	12.65 µ
	300 kHz to 1 MHz	2000	72 µ	2624.88	72.44 µ
100 mV	10 to 31 Hz	120	9 µ	147.05	9.12 µ
	32 to 330 Hz	70	9 µ	79.65	9.12 µ
	300 Hz to 10 kHz	60	9 µ	71.02	9.12 µ
	10 to 33 kHz	70	9 µ	79.65	9.12 µ
	30 to 100 kHz	300	9 µ	340.00	9.34 µ
	100 to 330 kHz	1000	20 µ	1030.78	20.4 µ
	300 kHz to 1 MHz	2000	120 µ	2088.06	120 µ

See footnotes at end of Table.

Table 1. (Cont.)

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
AC Voltage *(Cont.)* (OPT 20 and 30)	Range: OPT 20: 0 to 100 V, 10 Hz to 1 MHz OPT 30: 0 to 1000 V, 10 Hz to 100 kHz Accuracy: ±(ppm of output + V)	Measured with an AC Measurement Standard

OPT 20 Range	Frequency	Relative ppm	V	Absolute ppm	V
1 V	10 to 31 Hz	90	30 µ	111.61	30 µ
	32 to 330 Hz	50	20 µ	55.46	20 µ
	300 Hz to 33 kHz	40	10 µ	46.65	10 µ
	30 to 100 kHz	80	20 µ *3	122.64	20 µ
	100 to 330 kHz	405	100 µ	435.46	100 µ
	300 kHz to 1 MHz	2400	400 µ	2473.86	400 µ
10 V	10 to 31 Hz	90	300 µ	112.20	300 µ
	32 to 330 Hz	50	200 µ	56.82	200 µ
	300 Hz to 33 kHz	40	100 µ	48.26	100 µ
	30 to 100 kHz	80	200 µ *3	144.78	200 µ
	100 to 330 kHz	250	1 m	314.01	1 m
	300 kHz to 1 MHz	1500	5 m	1615.55	5 m
100 V	10 to 31 Hz	100	3 m	120.93	3 m
	32 to 330 Hz	60	2 m	67.54	2 m
	300 Hz to 10 kHz	50	1 m	58.83	1 m
	10 to 33 kHz	60	1 m	67.54	1 m
	30 to 100 kHz	120	3 m *3	170.89	3 m
	100 to 330 kHz	700	50 m	730.82	50 m
	300 kHz to 1 MHz	10000	130 m	10012.49	130 m

OPT 30 Range	Frequency	Relative ppm	V	Absolute ppm	mV
1000 V	10 to 330 Hz	150	20 m	154.74	20 m
	300 Hz to 3.3 kHz	100	20 m	106.98	20 m
	3 to 33 kHz	140	20 m	145.07	20 m
	30 to 100 kHz	1100	40 m	1208.30	40 m

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
AC Voltage Wideband Amplifier (OPT 70) Amplitude	Range: 0 to 3 V, 10 Hz to 30 MHz Accuracy: *1 ±(% of output + µV)	Measured with an AC Measurement Standard

Range	Frequency	Relative %	µV	Absolute %	µV
300 µV to 1 mV	10 to 30 Hz	0.55	0.4	0.5550	1.36
	30 Hz to 20 kHz	0.5	0.4	0.5018	1.36
	20 to 100 kHz	0.5	0.4	0.5142	2.53
	100 to 330 kHz	0.5	0.4 *4	0.8613	4.02

See footnotes at end of Table.

Table 1. (Cont.)

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
AC Voltage *(Cont.)* Wideband Amplifier (OPT 70) Amplitude	Range: 0 to 3 V, 10 Hz to 30 MHz Accuracy: *[1] ±(% of output + µV)	Measured with an AC Measurement Standard

Range	Frequency	Relative %	Relative µV	Absolute %	Absolute µV
1 to 10 mV	10 to 30 Hz	0.34	1	0.3405	1.64
	30 Hz to 20 kHz	0.29	1	0.2902	1.64
	20 to 100 kHz	0.29	1	0.2917	2.69
	100 to 330 kHz	0.29	1	0.3011	4.12

Range	Frequency	Relative %	Relative µV	Absolute %	Absolute µV
10 to 100 mV	10 to 30 Hz	0.33	10	0.3301	10.11
	30 Hz to 20 kHz	0.28	10	0.2800	10.11
	20 to 100 kHz	0.28	10	0.2805	10.31
	100 to 330 kHz	0.28	10	0.2811	10.77

Range	Frequency	Relative %	Relative µV	Absolute %	Absolute µV
100 mV to 1 V	10 to 30 Hz	0.33	100	0.3301	100.0
	30 Hz to 20 kHz	0.28	100	0.2800	100.0
	20 to 100 kHz	0.28	100	0.2801	100.0
	100 to 330 kHz	0.28	100	0.2805	100.0

Range	Frequency	Relative %	Relative µV	Absolute %	Absolute µV
1 to 3 V	10 to 30 Hz	0.27	300	0.2701	300.0
	30 Hz to 20 kHz	0.22	300	0.2200	300.0
	20 to 100 kHz	0.22	300	0.2201	300.0
	100 to 330 kHz	0.22	300	0.2208	300.0

300 kHz to 2 MHz Range	Relative %	Relative µV	Test Method
300 µV to 10 mV	0.34	3	The following 300 kHz to 30 MHz limits are verified during Flatness Calibration
10 to 100 mV	0.34	10	
100 mV to 1 V	0.34	100	
1 to 3 V	0.26	300	

2 to 10 MHz Range	Relative %	Relative µV
300 µV to 10 mV	0.48	3
10 to 100 mV	0.48	10
100 mV to 1 V	0.48	100
1 to 3 V	0.35	300

See footnotes at end of Table.

Table 1. (Cont.)

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
AC Voltage *(Cont.)* Wideband Amplifier (OPT 70) Amplitude	Range: 0 to 3 V, 10 Hz to 30 MHz Accuracy: *[1] ±(% of output + µV)	The following 300 kHz to 30 MHz limits are verified during Flatness Calibration

10 to 20 MHz Range	Relative %	µV
300 µV to 10 mV	0.61	3
10 to 100 mV	0.61	10
100 mV to 1 V	0.61	100
1 to 3 V	0.48 + 300	

20 to 30 MHz Range	Relative %	µV
300 µV to 10 mV	0.76	3
10 to 100 mV	0.76	10
100 mV to 1 V	0.76	100
1 to 3 V	0.60	300

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
AC Voltage Wideband Amplifier (OPT 70) Flatness	Range: 300 kHz to 30 MHz Accuracy: *[1], *[5] ±(% of output + µV) referenced at 1 kHz	Compared with an AC Measurement Standard

Range	Frequency	Relative %	Relative µV	Absolute %	Absolute µV
300 µV to 1 mV	300 kHz to 2 MHz	0.13	3	0.1750	3.35
	2 to 10 MHz	0.18	3	0.4744	3.35
	10 to 20 MHz	0.34	3	0.8661	3.35
	20 to 30 MHz	0.45	3	2.2766	4.24

Range	Frequency	Relative %	Relative µV	Absolute %	Absolute µV
1 to 10 mV	300 kHz to 2 MHz	0.12	3	0.1831	3.0
	2 to 10 MHz	0.18	3	0.2915	3.0
	10 to 20 MHz	0.34	3	0.4828	3.0
	20 to 30 MHz	0.45	3	1.0830	3.0

Range	Frequency	Relative %	Relative µV	Absolute %	Absolute µV
10 to 100 mV	300 kHz to 2 MHz	0.12	3	0.1501	3.0
	2 to 10 MHz	0.18	3	0.3002	3.0
	10 to 20 MHz	0.34	3	0.4502	3.0
	20 to 30 MHz	0.45	3	1.0506	3.0

See footnotes at end of Table.

Table 1. (Cont.)

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
AC Voltage *(Cont.)* Wideband Amplifier (OPT 70) Flatness	Range: 300 kHz to 30 MHz Accuracy: *1, *5 ±(% of output + µV) referenced at 1 kHz	Compared with an AC Measurement Standard

Range	Frequency	Relative %	Relative µV	Absolute %	Absolute µV
100 mV to 1 V	300 kHz to 2 MHz	0.12	3	0.1501	3.0
	2 to 10 MHz	0.18	3	0.3002	3.0
	10 to 20 MHz	0.34	3	0.4502	3.0
	20 to 30 MHz	0.45	3	1.0506	3.0

Range	Frequency	Relative %	Relative µV	Absolute %	Absolute µV
1 to 3 V	300 kHz to 2 MHz	0.08	3	0.1501	3.0
	2 to 10 MHz	0.15	3	0.3002	3.0
	10 to 20 MHz	0.24	3	0.4502	3.0
	20 to 30 MHz	0.35	3	1.0506	3.0

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
Resistance (OPT 50)	Range: 0 to 100 MΩ Accuracy: ± ppm of output	Measured with a Resistance Measurement Standard

Range	Relative	Para 4.11 Absolute	Para 4.11A Absolute
10 Ω	25	25.09	25.50
100 Ω and 1 kΩ	9	9.25	10.31
10 kΩ	9	9.24	10.31
100 kΩ	10	11.03	11.20
1 MΩ	25	26.93	25.50
10 MΩ	50	50.99	52.20
100 MΩ	70	70.71	71.59

add 20 mΩ for 2 wire on 10 and 100 Ω rngs;
add 200 mΩ for 2 wire on 1 kΩ thru 100 MΩ rngs

*1 Specifications apply to the end of the cable and 50 Ω load used for calibration.

*2 The 100 mAAC rng is down graded to ±(200 ppm of output + 10 µA) at 10 Hz to 1 kHz.

*3 The AC Voltage is downgraded as follows:

1 mV rng at 30 to 100 kHz	±(500 ppm of output + 5.4 µV);
10 mV rng at 30 to 100 kHz	±(400 ppm of output + 5.4 µV);
1 V rng at 30 to 100 kHz	±(100 ppm of output + 20 µV);
10 V rng at 30 to 100 kHz	±(120 ppm of output + 200 µV);
100 V rng at 30 to 100 kHz	±(140 ppm of output + 3 mV)

*4 The Wideband Amplifier Amplitude on 300 µV to 1 mV rng is downgraded to ±(0.83% of output + 0.4 µV) at 100 to 330 kHz.

*[5] The Wideband Amplifier Flatness is downgraded as follows:

Accuracy: ±(% of output + μV) referenced at 1 kHz

Output	Frequency	±(% + μV)
300 μV to 1 mV	300 kHz to 2 MHz	0.14 + 3
	2 to 10 MHz	0.4 + 3
	10 to 20 MHz	0.74 + 3
	20 to 30 MHz	2.02 + 3
1 to 10 mV	300 kHz to 2 MHz	0.15 + 3
	2 to 10 MHz	0.25 + 3
	10 to 20 MHz	0.41 + 3
	20 to 30 MHz	0.93 + 3
10 mV to 3 V	300 kHz to 2 MHz	0.13 + 3
	2 to 10 MHz	0.26 + 3
	10 to 20 MHz	0.39 + 3
	20 to 30 MHz	0.91 + 3

2 EQUIPMENT REQUIREMENTS:

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.1	DISTORTION ANALYZER	Range: 0 to 100% at 20 Hz to 600 kHz Accuracy: ±3% FS	Hewlett-Packard 334A	H-P 8903B
2.2	SPECTRUM ANALYZER	Range: 0 to -60 dB at 100 kHz to 100 MHz Accuracy: ±1 dB	Hewlett-Packard 8563E	
2.3	ELECTRONIC COUNTER	Range: 10 Hz to 28 MHz Accuracy: ±25 ppm	Hewlett-Packard 5345A	H-P 53131A
2.4	NULL DETECTOR	Range: 0 to 1000 V Accuracy: ±(2% FS + 0.1 μV)	Fluke 845AB	
2.5	DC REFERENCE STANDARD	Range: 10 V Accuracy: *[1] AFPSL Certified ±2.5 ppm	Fluke 734A/AF	

See footnote at end of Equipment Requirements.

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.6	DC REFERENCE DIVIDER	Range: 0.1 to 1000 V Accuracy: *[1] 10:1 ratio, ±0.2 ppm; 100:1 ratio, ±0.5 ppm, 1 V (TAR 2.63:1); 10 V (TAR 1.68:1); 100 V (TAR 1.61:1); 1000 V (TAR 3.12:1)	Fluke 752A	
2.7	DC VOLTAGE DIVIDER	Range: 0 to 1 ratio Accuracy: *[1] ±0.2 ppm	Fluke 720A	
2.8	STANDARD RESISTOR	Range: 10 Ω to 100 kΩ Accuracy: At time of calibration, charted value: ±6 ppm, 10 Ω/step; ±5 ppm, 100 Ω and 1 kΩ/step, (TAR 2.0:1); ±5 ppm, 100 kΩ/step, (TAR 2.2:1)	ESI SR1060-10, -100, -1k, -100k	
2.9	DC CURRENT SHUNT	Range: 10 ADC Accuracy: ±40 ppm of certified value	Guildline 9211A	Fluke A40B/AF
2.10	DIGITAL MULTIMETER	Range: 0 to 100 VDC Accuracy: ±8.14 ppm of rdg + 1 ppm of rng on the 1 V rng Transfer Accuracy: ±0.5 ppm of rdg + 0.5 ppm of rng on the 100 mV rng; ±0.3 ppm of rdg + 0.1 ppm of rng on the 1 V rng; ±0.05 ppm of rdg + 0.05 ppm of rng on the 10 V rng; ±0.5 ppm of rdg + 0.1 ppm of rng on the 1 V rng	Hewlett-Packard 3458A	Fluke 8508A/01AF

See footnote at end of Equipment Requirements.

Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.11 PARALLEL NETWORK	Range: N/A Accuracy: N/A	ESI PC101	
2.12 SHORTING BARS	Range: N/A Accuracy: N/A	ESI SB103	
2.13 AC CURRENT SHUNT SET	Range: 10 mA to 10 AAC Accuracy: AFPSL Certified: 10 mA AC Shunt: DC to <1 kHz, ±30 ppm of output; 1 to 5 kHz, ±56 ppm of output 100 mA AC Shunt: DC to <1 kHz, ±40 ppm of output; 1 to 5 kHz, ±64 ppm of output 1 AAC Shunt: DC to <1 kHz, ±40 ppm of output; 1 kHz, ±67.0 ppm of output; 5 kHz, ±67.4 ppm of output 2 AAC Shunt: DC to <1 kHz, ±40 ppm of output; 1 kHz, ±67 ppm of output; 5 kHz, ±68.3 ppm of output; 10 and 20 kHz, ±70 ppm of output 10 AAC Shunt: DC to <1 kHz, ±40 ppm of output; 1 kHz, ±77 ppm of output; 5 kHz, ±87.2 ppm of output; 10 kHz, ±100 ppm of output; 20 kHz, ±100.5 ppm of output	Fluke A40B/AF	

Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.14 RESISTOR (Metal Film)	Range: 200 Ω Accuracy: ±1% of value; AC/DC difference negligible due to metal film construction	As Available	
2.15 RESISTOR (Metal Film)	Range: 2 kΩ Accuracy: ±1% of value; AC/DC difference negligible due to metal film construction	As Available	
2.16 AC MEASUREMENT STANDARD	Range: 0 to 1000 V, 10 Hz to 30 MHz Accuracy: ±ppm of rdg + µV	Fluke 5790A	

Range	Frequency Range	±ppm	µV	TAR
2.2 mV	20 to 40 Hz	740	1.3	3.1:1
	40 Hz to 20 kHz	420	1.3	2.6:1
	50 to 100 kHz	1200	2.5	2.0:1
	100 to 300 kHz	2300	4.0	2.4:1
	500 kHz to 1 MHz	3500	8.0	
22 mV	20 to 40 Hz	190	1.3	2.4:1
	40 Hz to 20 kHz	110	1.3	2.8:1
	50 to 100 kHz	310	2.5	2.0:1
	100 to 300 kHz	810	4.0	2.1:1
	500 kHz to 1 MHz	1700	8.0	3.9:1
220 mV	20 to 40 Hz	85	1.5	2.4:1
	40 Hz to 20 kHz	38	1.5	3.1:1
	50 to 100 kHz	160	2.5	2.3:1
	100 to 300 kHz	250	4.0	
	500 kHz to 1 MHz	600		
700 mV AC/DC Transfer				
	40 Hz to 20 kHz	27		
2.2 V	20 to 40 Hz	66		2.2:1
	40 Hz to 20 kHz	24		2.4:1
	50 to 100 kHz	71		2.0:1
	100 to 300 kHz	160		3.4:1
	500 kHz to 1 MHz	600		
7 V	20 to 40 Hz	67		
	40 Hz to 20 kHz	24		
	50 to 100 kHz	81		
	100 to 300 kHz	190		

Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.16 AC MEASUREMENT STANDARD *(Cont.)*	Range: 0 to 1000 V, 10 Hz to 30 MHz	Fluke 5790A	
	Accuracy: ±ppm of rdg + µV		

	Range	Frequency Range	±ppm	µV	TAR
	22 V	20 to 40 Hz	67		2.1:1
		40 Hz to 20 kHz	27		2.9:1
		50 to 100 kHz	81		2.0:1
		100 to 300 kHz	190		2.2:1
		500 kHz to 1 MHz	600		3.5:1
	220 V	20 to 40 Hz	68		2.2:1
		40 Hz to 20 kHz	31		2.2:1
		50 to 100 kHz	98		2.1:1
		100 to 300 kHz	210		
	70 V	300 to 500 kHz	410		
	1000 V	40 Hz to 20 kHz	38		3.3:1
	700 V	50 to 100 kHz	500		2.5:1
Wideband Flatness	2.2 mV	1.2 to 2 MHz	2550		2.0:1
		2 to 10 MHz	4050		2.0:1
		10 to 20 MHz	6000		2.0:1
		20 to 30 MHz	13500		2.0:1
	22 mV	1.2 to 2 MHz	1050		2.0:1
		2 to 10 MHz	1500		2.1:1
		10 to 20 MHz	2550		2.0:1
		20 to 30 MHz	5550		2.0:1
	220 mV	1.2 to 2 MHz	750		2.0:1
		2 to 10 MHz	1500		2.0:1
		10 to 20 MHz	2250		2.0:1
		20 to 30 MHz	5250		2.0:1
	2.2 V	1.2 to 2 MHz	750		2.0:1
		2 to 10 MHz	1500		2.0:1
		10 to 20 MHz	2250		2.0:1
		20 to 30 MHz	5250		2.0:1
	7 V	1.2 to 2 MHz	750		2.0:1
		2 to 10 MHz	1500		2.0:1
		10 to 20 MHz	2250		2.0:1
		20 to 30 MHz	5250		2.0:1

Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.17 RESISTANCE MEASUREMENT SYSTEM	Range: 10 Ω to 100 MΩ Relative Uncertainty: *2 100 Ω, 1 k Ω, 10 kΩ, <0.1 ppm of rdg; 100 kΩ, <4 ppm of rdg; 1 MΩ, <8 ppm of rdg	Guildline 6625AF	
2.17.1 SOFTWARE PACKAGE	Range: N/A Accuracy: N/A	T.O. 33K8-4-9003-10	
2.17.2 STANDARD RESISTORS	Range: 10 Ω thru 1 MΩ Temperature Controlled ±20 m°C Accuracy: AFPSL Certified Values 10 Ω thru 1 kΩ, ±2.15 ppm of value; 10 kΩ, ±2.10 ppm of value; 100 kΩ, ±2.4 ppm of value (TAR 2.1:1); *2 1 MΩ, ±6 ppm of value (TAR 2.5:1) *2	Measurement International 4310AF	
2.18 NANO VOLT/ MICRO OHM METER	Range: 0 VDC Accuracy: N/A	Agilent 34420A	
2.19 TRANSFER STANDARD *3	Range: 1 to 100 MΩ Accuracy: charted value: ±5 ppm, 1 MΩ/ STEP; ±15 ppm, 10 MΩ/ STEP	ESI SR1050-1M, -10M At time of calibration	

*1 The RSS values of (2.5), (2.6) and (2.7) are used to calculate (2.6) TARs.

*2 The RSS values of (2.17) and (2.17.3) are used to calculate (2.17.3) TARS.

*3 Used in Resistance Calibration Alternate Method only.

3 <u>PRELIMINARY OPERATIONS:</u>

3.1 Review and become familiar with the entire procedure before beginning the 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. If not strictly observed, could result in injury to, or death of, personnel or long term health hazards.

3.2 Connect TI to a 115 V/60 Hz power, set POWER switch to On and allow 2 hours warm-up.

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

3.4 Ensure that AC power is applied to the temperature stabilized Standard Resistors. Manufacturers suggested minimum warm-up time 24 hours.

NOTE

If at any time power is removed from the Standard Resistors for over 1 minute, there is a minimum 1 hour warm-up time for the oven to stabilize.

3.5 Connect the Nano Volt/Micro Ohm Meter to the temperature stabilized Standard Resistors temperature monitor terminals and turn TEMP DEV switch to ON. Using TEMP DEV dial to obtain a DCV null reading on the Nano Volt/Micro Ohm Meter, record temperature offset of the TEMP DEV dial before and after calibration. TEMP DEV dial before and after values should be between -20 to +20 m°C (i.e., on scale).

3.6 Verify the Resistance Measurement System is using the current Software Package T.O. 33K8-4-9003-10 with the most recent version per the AF TO Catalog or equivalent.

3.7 Because the Resistance Measurement System is configured locally, the directories, filenames and Channel locations may vary. Execute tests per individual Resistance Measurement System configuration.

3.8 The TI Resistor (Rx) files may be initially set up using para 4.11.

3.9 Calibrate Resistance Standard(s), required to perform the calibration, (2.8) IAW T.O. 33K8-4-1-1 and (2.19) IAW T.O. 33K8-4-467-1 before use. Accuracies are for 24 hours starting at time of calibration. Standard Resistor Oil Bath stability must remain within ±1.8 °F (±1 °C) or laboratory temperature stability must remain within ±3.6 °F (±2 °C).

3.10 Perform ACAL on the Digital Multimeter as required.

3.11 Check the CMOS battery replacement date located on the rear of the TI. If the expiration date will occur before the end of the calibration interval, replace the battery IAW the Commercial Data. Update the replacement date when battery is replaced.

3.12 To attain the amplitude accuracy in this procedure, the following is recommended: 24 inch shielded cables for voltage and a 24 inch unshielded cable for current.

NOTE

The cables in step 3.12 are not requirements, merely a qualification of how the specifications in Table 1 may be met. Cables that produce good results are: for AC Voltage is RG 58 C/U, with 29.5 pF/ft capacitance. For AC Current, a single conductor non-shielded type works well. Any cables that allow TI to meet Table 1 specifications are acceptable.

3.13 Due to local conditions, some PMELs may not be able to calibrate TI 100 µV and 1 mV ranges due to TI display rattle caused by noise. Should this occur, annotate and attach a Limited Certification Label with the range(s) not calibrated.

3.14 Due to lack of Standards, portions of the AC Voltage and all of the WideBand Amplifier has been degraded. Attach a Limited Certification Label and annotate SPECIAL block, see copy of attached performance specifications. Make a copy of the Calibration Procedure Appendix A and submit to the USER with TI.

3.15 If the TI is equipped with OPT 70, a 50 Ω load and cable will be supplied by the owner, attach it to the TI after calibration.

3.16 The TI ⇑⇓ controls will be referred to as keys. The remaining TI controls will be referred to as switches.

3.17 Use only that portion of the calibration procedure that pertains to TI being calibrated.

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 DISTORTION CALIBRATION: (AC Voltage, OPT 20)

4.1.1 Press TI AC Function switch to On and verify REM SENSE is Off.

4.1.2 Connect TI HI and LO terminals to the Distortion Analyzer INPUT terminals, observing polarity.

4.1.3 Press the first TI Output and Frequency Range switches listed in the TI Range Volts and Frequency columns of Table 2.

4.1.4 Adjust TI Output and Frequency keys for the first value listed in the Applied column of Table 2.

4.1.5 Press TI OUTPUT ON + switch to On.

4.1.6 Standardize the Distortion Analyzer for Distortion measurement.

4.1.7 The Distortion Analyzer must indicate within the corresponding value listed in the Limits column of Table 2.

4.1.8 Set TI Frequency Range switch and adjust Frequency keys for each remaining applied value listed in Table 2 which is applicable to the TI Volts setting and repeat steps 4.1.6 and 4.1.7 at each listed frequency.

4.1.9 Press TI OUTPUT OFF switch to Off.

4.1.10 Repeat steps 4.1.3 thru 4.1.9 for each remaining range and applied value listed in Table 2.

Table 2.

TI Range Volts	TI Range Frequency	Applied (VAC)	Limits (%) *
10	100Hz	10 @ 20 Hz	≤0.1 (≤-60 dB)
		10 @ 100 Hz	≤0.04 (≤-68 dB)
	1k	10 @ 1 kHz	≤0.04 (≤-68 dB)
	10k	10 @ 10 kHz	≤0.04 (≤-68 dB)
	100k	10 @ 90 kHz	≤0.1 (≤-60 dB)
	1MHz	10 @ 300 kHz	≤0.3 (≤-50.5 dB)
		10 @ 600 kHz	≤1 (≤-40 dB)
100	100Hz	100 @ 20 Hz	≤0.1 (≤-60 dB)
		100 @ 100 Hz	≤0.04 (≤-68 dB)
	100k	100 @ 40 kHz	≤0.2 (≤-54 dB)
		100 @ 90 kHz	≤0.2 (≤-54 dB)
		100 @ 200 kHz	≤0.3 (≤-50.5 dB)

* If any limits are out of specified value, repeat the test using (2.1) Sub Item. The second harmonic must be within the corresponding value listed in the Limits column of Table 2.

4.1.11 Disconnect the Distortion Analyzer from TI.

4.2 <u>DISTORTION CALIBRATION:</u> (Wideband Amplifier, OPT 70)

4.2.1 Verify TI AC Function is On and REM SENSE is Off.

4.2.2 Connect TI Wideband Amplifier OUTPUT connector thru the 50 Ω load and cable supplied with the TI to the Distortion Analyzer INPUT terminals, observing polarity.

4.2.3 Press the first TI Output and Frequency Range switches listed in the TI Range Volts and Frequency columns of Table 3.

4.2.4 Adjust TI Output and Frequency keys for the first value listed in the Applied column of Table 3.

4.2.5 Press TI OUTPUT ON + switch to On.

4.2.6 Standardize the Distortion Analyzer for Distortion measurement.

4.2.7 The Distortion Analyzer must indicate within the corresponding value listed in the Limits column of Table 3.

4.2.8 Set TI Frequency Range switch and adjust Frequency keys for the 30 and 300 kHz applied values listed in Table 3 and repeat steps 4.2.6 and 4.2.7 at each listed frequency.

4.2.9 Press TI OUTPUT OFF switch to Off.

4.2.10 Disconnect the TI Wideband Amplifier OUTPUT from the Distortion Analyzer and connect to the Spectrum Analyzer INPUT (omit the 50 Ω load).

4.2.11 Set TI Frequency Range switch and adjust Frequency keys for the last value listed in the Applied column of Table 3.

4.2.12 Press TI OUTPUT ON + switch to On.

4.2.13 Establish a 0 dB reference on the Spectrum Analyzer and measure the 2nd, 3rd and 4th harmonic.

4.2.14 Determine the difference between the peak of the fundamental signal and the peak of each of the harmonics (this will be a negative number). Calculate THD as follows:

$$THD\ \% = 100\sqrt{\left(LOG^{-1}\frac{2nd}{20}\right)^2 + \left(LOG^{-1}\frac{3rd}{20}\right)^2 + \left(LOG^{-1}\frac{4th}{20}\right)^2 - - - N}$$

Where: THD = Total Harmonic Distortion
LOG^{-1} = Antilog
2nd, 3rd and 4th = Harmonics in dBc (first three harmonics following the fundamental frequency).

4.2.15 The results of step 4.2.14 must be within the corresponding value listed in the Limits column of Table 3 and the Spurious Frequency Output must be within ≤-46 dB.

Table 3.

TI Range Volts	TI Range Frequency	Applied (VAC)	Limits
10	100Hz	2 @ 20 Hz	≤-40 dB (1%)
	100kHz	2 @ 30 kHz	≤-40 dB (1%)
	1M	2 @ 300 kHz	≤-40 dB (1%)
	30M	2 @ 25 MHz	≤-36 dB (1.58%)

4.2.16 Disconnect the Spectrum Analyzer from TI.

4.3 DISTORTION CALIBRATION: (Transconductance Amplifier, OPT 60)

4.3.1 Press TI AC and I Function switches to On and verify REM SENSE is Off.

4.3.2 Connect TI Transconductance Amplifier I+ and I- terminals to the 20 A AC Current Shunt INPUT connector, observing polarity.

4.3.3 Connect the AC Current Shunt OUTPUT connector to the Distortion Analyzer INPUT terminals, observing polarity.

4.3.4 Press the first TI Output and Frequency Range switches listed in the TI Range Amps and Frequency columns of Table 4.

4.3.5 Adjust TI Output and Frequency keys for the first value listed in the Applied column of Table 4.

4.3.6 Press TI OUTPUT ON + switch to On.

4.3.7 Standardize the Distortion Analyzer for Distortion measurement.

4.3.8 The Distortion Analyzer must indicate within the corresponding value listed in the Limits column of Table 4.

4.3.9 Set TI Frequency Range switch and adjust Frequency keys for each remaining value listed in Applied column of Table 4 and repeat steps 4.3.7 and 4.3.8 at each listed frequency.

4.3.10 Press TI OUTPUT OFF switch to Off.

Table 4.

TI Range			
Amps	**Frequency**	**Applied (AAC)**	**Limits (%) ***
10A	1k	10 @ 1 kHz	≤0.2 (≤-54 dB)
	10k	10 @ 5 kHz	≤0.2 (≤-54 dB)
	10k	10 @ 10 kHz	≤0.2 (≤-54 dB)
	100k	10 @ 20 kHz	≤1 (≤-40 dB)

* If any limits are out of specified value, repeat the test using (2.1) Sub Item. The second harmonic must be within the corresponding value listed in the Limits column of Table 4.

4.3.11 Disconnect the test setup.

4.4 <u>FREQUENCY CALIBRATION:</u> (AC Voltage, OPT 20; Wideband Amplifier, OPT 70)

4.4.1 Connect TI HI and LO terminals to the Electronic Counter Input connector, observing polarity.

4.4.2 Press TI AC Function to On and verify I Function is Off.

4.4.3 Press TI Output Range switch 1 and adjust the Output keys for a TI Output display indication of 1 V.

4.4.4 Press the first TI Frequency Range switch listed in the TI Range column of Table 5.

4.4.5 Adjust TI Frequency keys for the first value listed in the Applied column of Table 5.

4.4.6 Press TI OUTPUT ON + switch to On.

4.4.7 Adjust the Electronic Counter controls as necessary for a stable indication.

4.4.8 The Electronic Counter must indicate within the corresponding values listed in the Limits column of Table 5.

4.4.9 Repeat steps 4.4.4 thru 4.4.8 for each remaining range and applied value listed in Table 5.

4.4.10 Press TI OUTPUT OFF switch to Off.

Table 5.

TI Range	Applied (VAC)	Limits (Hz)
100Hz	1 @ 10 Hz	>9.999 to <10.001
	1 @ 330 Hz	>329.967 to <330.033
1k	1 @ 0.30 kHz	>299.97 to <300.03
	1 @ 3.3 kHz	>3.29967 to <3.30033 k
10k	1 @ 3 kHz	>2.9997 to <3.0003 k
	1 @ 33 kHz	>32.9967 to <33.0033 k
100k	1 @ 30 kHz	>29.997 to <30.003 k
	1 @ 200 kHz	>199.98 to <200.02 k
1M	1 @ 0.3 MHz	>299.97 to <300.03 k
	1 @ 1 MHz	>0.9999 to <1.0001 M
Wideband *[1]	1 @ 10 MHz	9.999 to 10.001 M
	1 @ 28 MHz	27.9972 to 28.0028 M

*[1] Disconnect the Electronic Counter Input from the TI HI and LO terminals and connect through the 50 Ω load and cable supplied with the TI to the TI Wideband Amplifier OUTPUT.

4.4.11 Disconnect the Electronic Counter from TI.

4.5 DC VOLTAGE CALIBRATION: (OPT 10 and 30)

4.5.1 Connect TI HI and LO terminals to the Null Detector INPUT terminals, observing polarity.

4.5.2 Press TI DC Function switch to On.

NOTE

Steps 4.5.4 thru 4.5.10 are performed to minimize offset error and ensure an accurate linearity calibration. The values listed in step 4.5.6 for the 100 µV and 1 mV ranges are desired but may not be attainable. See step 3.13.

4.5.3 Press TI TEST switch.

4.5.4 Press TI Output Range switch 100µ, FULL RANGE/ZERO switch to ZERO and OUTPUT ON + switch to On.

4.5.5 Increase the Null Detector sensitivity as required and verify the TI Output is about zero as monitored on the Null Detector.

4.5.6 The TI zero output shall be within the following listed values (see step 3.13):

100 µV thru 100 mV rngs ≤0.5 µV

1 V rng ≤1 µV

10 V rng ≤3 µV

100 V rng ≤50 µV

1000 V rng ≤500 µV

4.5.7 Decrease the Null Detector sensitivity.

4.5.8 Press TI OUTPUT OFF switch to Off.

4.5.9 Repeat steps 4.5.4 thru 4.5.8 for the remaining TI Ranges.

4.5.10 Press TI Output Range switch 10 and ensure TI Output display indication is zero.

4.5.11 Press TI OUTPUT ON + switch to On.

4.5.12 Increase the Null Detector sensitivity as required and verify the TI Output is 0 ±3 µV.

4.5.13 Decrease the Null Detector sensitivity.

4.5.14 Press TI OUTPUT OFF switch to Off, OUTPUT ON - switch to On and repeat steps 4.5.12 and 4.5.13.

4.5.15 Press TI OUTPUT OFF switch to Off.

4.5.16 Disconnect the Null Detector from TI and connect equipment as shown in Figure 1.

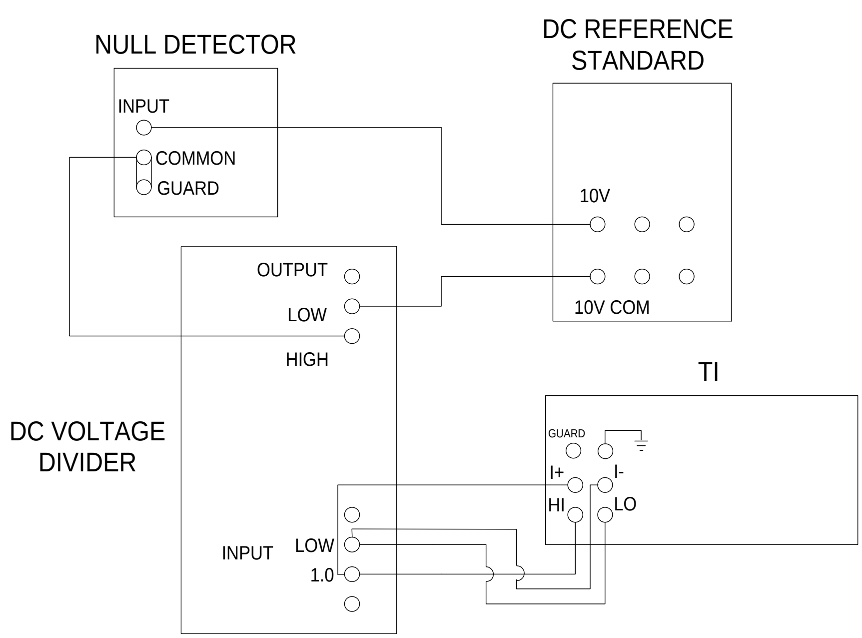

Figure 1.

4.5.17 Divide the certified value of the DC Reference Standard by 19 and set the DC Voltage Divider dials to this value (.5263158, nominal).

4.5.18 Press TI Output Range switch 10 and adjust the Output keys for a TI Output display indication of 19 V.

4.5.19 Press TI OUTPUT ON + switch to On and set TI for REM SENSE to On.

4.5.20 Increase the Null Detector sensitivity as required while adjusting TI Output keys for a null indication on the Null Detector.

4.5.21 Decrease the Null Detector sensitivity.

4.5.22 The TI Output display must indicate within 18.999923 and 19.000077 V

4.5.23 Press TI OUTPUT OFF switch to Off.

4.5.24 Reverse the output connections at the DC Reference Standard to change reference to negative.

4.5.25 Press TI OUTPUT ON - switch to On and repeat steps 4.5.20 thru 4.5.23, observe negative limits.

4.5.26 Change the test setup as shown in Figure 2.

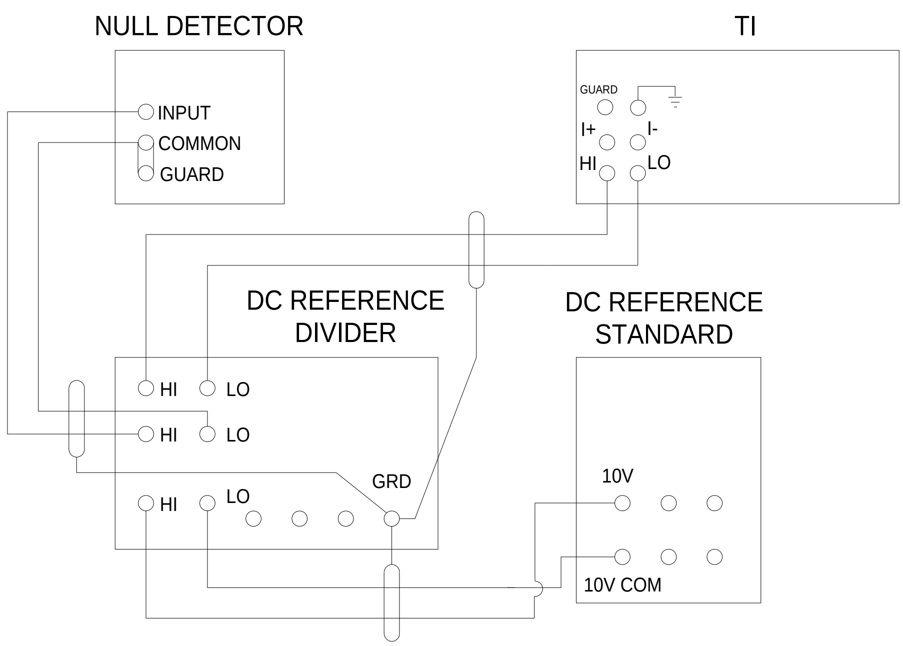

Figure 2.

4.5.27 Set the DC Reference Divider to the first value listed in the Applied Divider column of Table 6.

4.5.28 Divide the certified value of the DC Reference Standard by the first value listed in the Divide/Multiply By column of Table 6 and record this value.

4.5.29 Press the first TI Output Range switch listed in the TI Range column of Table 6.

4.5.30 Adjust TI Output keys until the TI Output display indicates the value recorded in step 4.5.28.

4.5.31 Press TI OUTPUT ON + switch to On.

4.5.32 Increase the Null Detector sensitivity as required while adjusting TI Output keys for a null indication on the Null Detector.

4.5.33 Decrease the Null Detector sensitivity.

4.5.34 The TI Output display must indicate within the corresponding values listed in the Limits column of Table 6 relative to the value recorded in step 4.5.28.

4.5.35 Press TI OUTPUT OFF switch to Off.

4.5.36 Reverse the output connections at the DC Reference Standard to change reference to negative.

4.5.37 Press TI OUTPUT ON - switch to On and repeat steps 4.5.32 thru 4.5.35, observe negative limits.

4.5.38 Press TI OUTPUT OFF switch to Off.

4.5.39 Reverse the output connections at the DC Reference Standard to change reference to positive.

4.5.40 Repeat steps 4.5.27 thru 4.5.39 (in step 4.5.28, multiply or divide as indicated in Table 6) for each remaining range and applied value listed in Table 6.

Table 6.

Applied Divider	**Divide/ Multiply By**	**TI Range**	**Limits *[1] Relative**	**Nominal (VDC)**
0.1 V	÷100	100m	±1.25 µV	(99.99875 to 100.00125 m)
1 V	÷10	1	±6.6 µV	(0.9999934 to 1.0000066)
1 V	÷10	10	±7 µV	(0.999993 to 1.000007)
10 V	1:1	10	±42 µV	(9.999958 to 10.000042)
100 V	X10	100	±0.61 mV	(99.99939 to 100.00061)
1000 V	X100	1000	±7.9 mV	(999.9921 to 1000.0079)

*[1] The values in this columns apply to both positive and negative limits.

4.5.41 Change the test setup as shown in Figure 3.

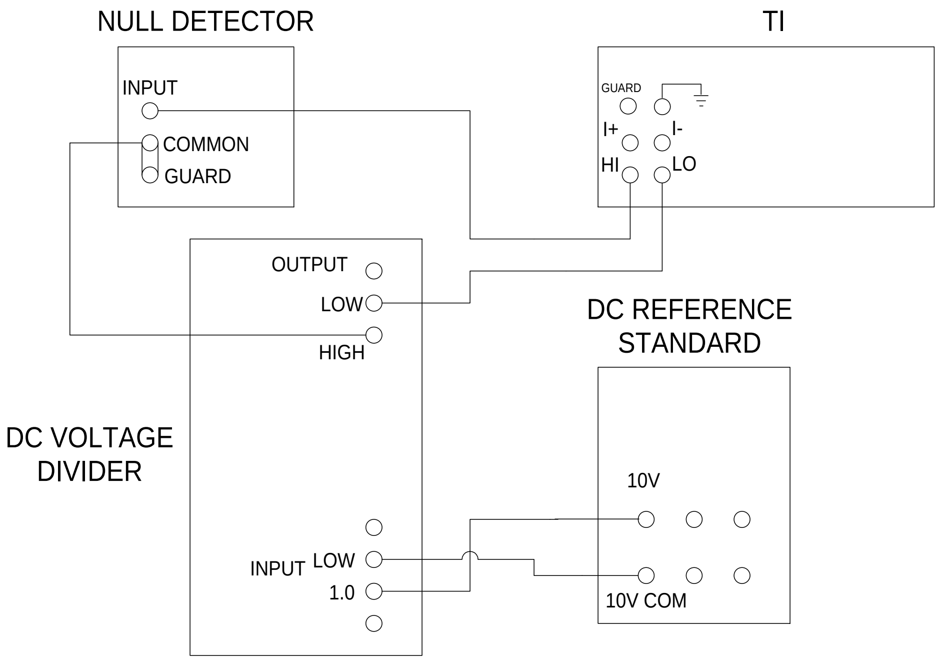

Figure 3.

4.5.42 Set the DC Voltage Divider dials to the first value listed in the Applied Divider column of Table 7.

4.5.43 Repeat steps 4.5.28 thru 4.5.39 substituting Table 7 in place of Table 6.

4.5.44 Repeat steps 4.5.42 and 4.5.43 for each remaining range and applied value listed in Table 7.

Table 7.

Applied Divider	Divide By	TI Range	Limits *[1] Relative	Nominal (VDC)
.0000100	100,000	100µ	±0.50 µV	(99.50 to 100.50 µ)
.0001000	10,000	1m	±0.51 µV	(0.99949 to 1.00051 m)
.0010000	1,000	10m	±0.57 µV	(9.99943 to 10.00057 m)

*[1] The values in this columns apply to both positive and negative limits.

4.5.45 Disconnect the test setup.

4.6 DC CURRENT CALIBRATION: (OPT 40)

4.6.1 Connect equipment as shown in Figure 4.

NOTE

Low Thermal leads or 12 gauge wire is recommended for TI Output terminal connections.

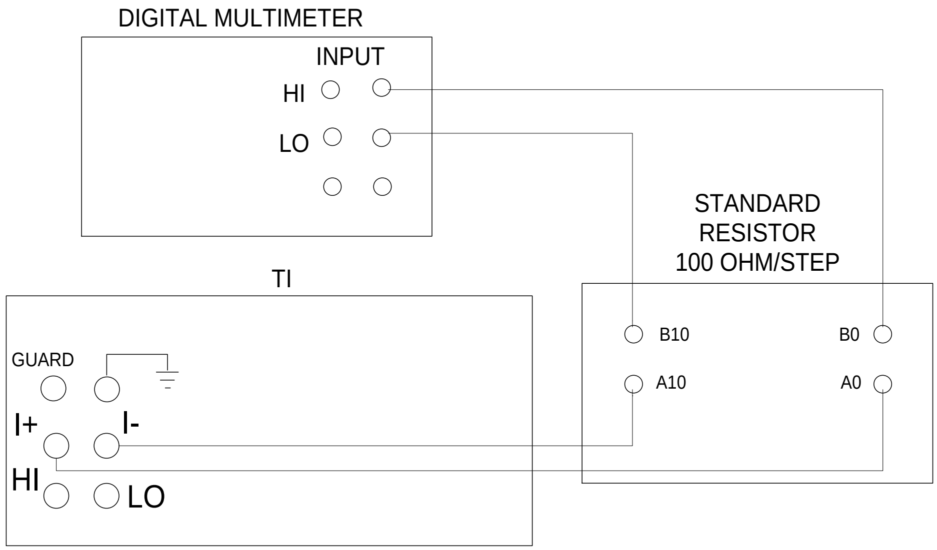

Figure 4.

4.6.2 Set Digital Multimeter to measure VDC on the 1 V range.

NOTE

If required, zero the Digital Multimeter before making measurements.

4.6.3 Press TI DC and I Function switches to On.

4.6.4 Press the first TI Output Range switch listed in the TI Range column of Table 8.

4.6.5 Adjust TI Output keys for the first value listed in the Applied column of Table 8.

4.6.6 Press TI OUTPUT ON + switch to On.

4.6.7 Calculate TI limits as follows: Divide the Digital Multimeter indication by the Standard Resistor certified resistance value.

4.6.8 The results of step 4.6.7 must be within the corresponding values listed in the Limits column of Table 8.

4.6.9 Multiply the Standard Resistor(s) certified resistance value by the corresponding current value listed in the Applied column of Table 8 and note the results.

4.6.10 Adjust TI Output keys until the Digital Multimeter displays the value calculated in step 4.6.9 and record TI Output display indication as TI DCI.

4.6.11 Press TI OUTPUT OFF switch to Off.

4.6.12 Press TI OUTPUT ON - switch to On and repeat steps 4.6.5 and 4.6.7 thru 4.6.11, observe negative limits.

4.6.13 Average the values recorded in step 4.6.10 (ignore polarity) and record the results as TI DCI (±avg) for use during AC Current Calibration (a copy of Table 12 may be used as a worksheet if desired).

4.6.14 Repeat steps 4.6.4 thru 4.6.13 for the TI 1m Range and applied value listed in Table 8.

4.6.15 Change Figure 4 Standard Resistor connections for the TI 10m Range listed in Table 8 as follows: TI I+ and I- terminals to the Standard Resistor A0 and C1 terminals, respectively; Standard Resistor B0 and B1 terminals to the Digital Multimeter HI and LO terminals, respectively.

4.6.16 Repeat steps 4.6.4 thru 4.6.13 for the TI 10m Range and applied value listed in Table 8.

Table 8.

TI Range	Applied (ADC)	Standard Resistor	Limits (ADC) *[1]
100µ	100 µ	A0, A10, B0, B10	99.9877 to 100.0123 µ
1m	1 m	A0, A10, B0, B10	0.999948 to 1.000052 m
10m	10 m	A0, C1, B0, B1	9.99948 to 10.00052 m

*[1] The values in this column apply to both positive and negative limits.

4.6.17 Change the test setup as shown in Figure 5.

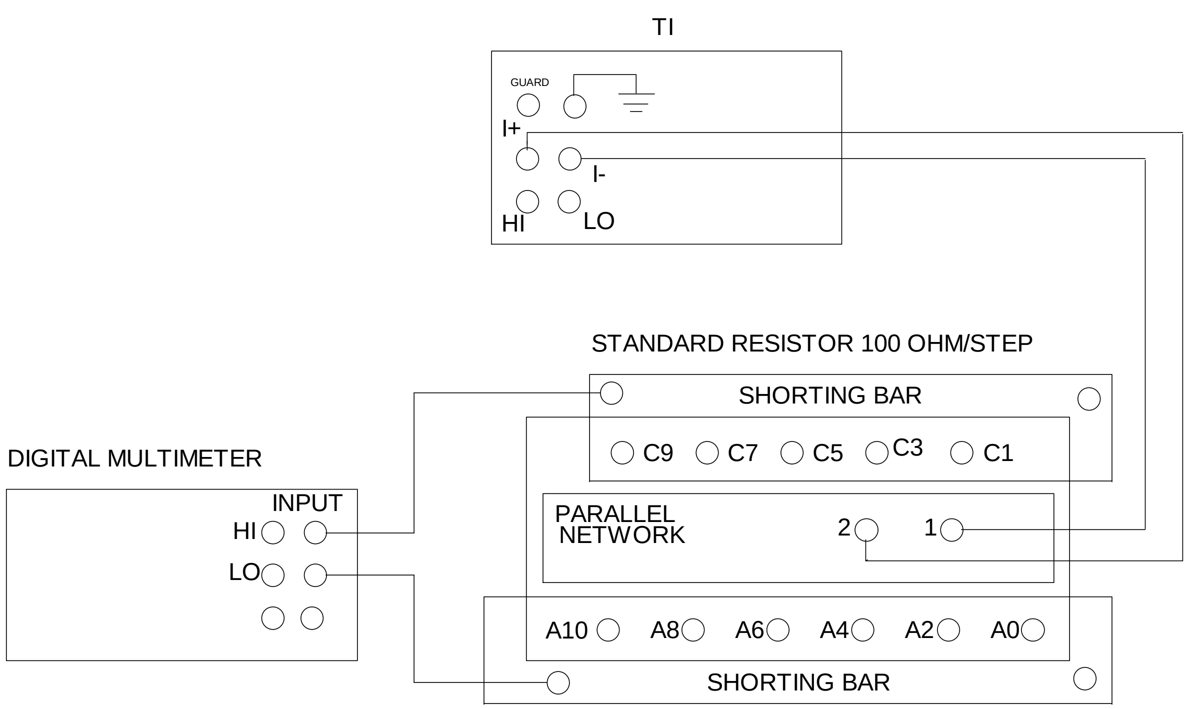

Figure 5.

4.6.18 Repeat steps 4.6.4 thru 4.6.13, substituting Table 9 in place of Table 8, for the TI 100m Range and applied value listed in Table 9.

4.6.19 Replace Standard Resistor 100 Ω/STEP with Standard Resistor 10 Ω/STEP in Figure 5.

4.6.20 Repeat step 4.6.18 for the TI 1 Range and applied value listed in Table 9.

NOTE

Heat build-up in 1 Ω shunt (Standard Resistor) will affect its accuracy. If test exceeds one minute, press TI OUTPUT OFF switch to Off and wait five minutes before repeating test.

Table 9.

TI Range	Applied (ADC)	Limits (ADC) *[1]
100m	100 m	99.9948 to 100.0052 m
1	1	0.999879 to 1.000121

*[1] The values in this column apply to both positive and negative limits.

4.6.21 Disconnect the test setup.

4.7 DC/AC CURRENT CALIBRATION: (Transconductance Amplifier, OPT 60)

4.7.1 Connect the Digital Multimeter INPUT HI and LO terminals to the DC Current Shunt POTENTIAL and COMMON terminals, observing polarity.

4.7.2 Set Digital Multimeter to measure VDC on the 1 V range.

4.7.3 Connect the DC Current Shunt 10 AMP and INPUT COMMON terminals to the TI Transconductance Amplifier OUTPUT I+ and I- terminals, observing polarity.

4.7.4 Insert the DC Current Shunt Shorting Plugs into the 10 AMPERES holes.

4.7.5 Verify TI DC and I Functions are On.

4.7.6 Press TI Output Range switch 10.

4.7.7 Adjust TI Output keys for the first value listed in the Applied column of Table 10.

4.7.8 Press TI OUTPUT ON + switch to On.

NOTE

Allow sufficient time for Digital Multimeter indication to stabilize before taking reading.

4.7.9 Calculate TI limits as follows: Divide the Digital Multimeter indication by the DC Current Shunt certified resistance value.

4.7.10 The results of step 4.7.9 must be within the corresponding values listed in the Limits column of Table 10.

4.7.11 Press TI OUTPUT OFF switch to Off.

4.7.12 Press TI OUTPUT ON - switch to On to change TI Output to negative and repeat steps 4.7.7 and 4.7.9 thru 4.7.11, observe negative limits.

4.7.13 Repeat steps 4.7.7 thru 4.7.12 for the TI 10 ADC applied value listed in Table 10.

Table 10.

TI Range	Applied (ADC)	Limits *[1] Relative (ppm)	Nominal (ADC)
10	2	±410.5	(1.99918 to 2.00082)
	10	±206.6	(9.99793 to 10.00207)

*[1] The values in these columns apply to both positive and negative limits

4.7.14 Disconnect the test setup.

4.7.15 Using the first shunt value listed in the AC Current Shunt column of Table 11, connect the AC Measurement Standard INPUT 2 HI and LO terminals to the AC Current Shunt OUTPUT, observing polarity.

4.7.16 Press AC Measurement Standard INPUT 2 key.

4.7.17 Using the first shunt value listed in the AC Current Shunt column of Table 11, connect the TI Transconductance Amplifier OUTPUT I+ and I- terminals to the AC Current Shunt INPUT, observing polarity.

4.7.18 Press TI AC and I Function switches to On.

4.7.19 Press TI Output Range switch 10.

4.7.20 Adjust TI Output keys, Frequency Range switch and Frequency keys for the first 1 kHz value listed in the Applied column of Table 11.

4.7.21 Press TI OUTPUT ON + switch to On.

NOTE

Allow sufficient time for AC Measurement Standard indication to stabilize before taking a reading.

4.7.22 Calculate the TI Current as follows: divide the AC Measurement Standard indication by the applicable AC Current Shunt AFPSL Certificate of Calibration Measured Resistance value.
Example: with the TI set for 2 AAC at 1 kHz using the 2 AAC Current Shunt (first values in Table 11):
AC Measurement Standard indication = 799.93 mV AC,
AC Current Shunt value from the Certificate of Calibration = 0.39997352 Ω,
the Calculated Value for the TI Current is 1.9999574 AAC

4.7.23 The results of step 4.7.22 must be within the corresponding values listed in the Limits column of Table 11.

4.7.24 Repeat steps 4.7.20, 4.7.22 and 4.7.23 for the 5 kHz, 10 kHz and 20 kHz values listed in the Applied column of Table 11 for the 2 A AC Current Shunt.

4.7.25 Press TI OUTPUT OFF switch to Off.

Table 11.

TI Range	AC Current Shunt	Applied (AAC)	Limits (AAC)
10	2 A	2 @ 1 kHz	1.99789 to 2.00211
		2 @ 5 kHz	1.99669 to 2.00331
		2 @ 10 kHz	1.98960 to 2.01040
		2 @ 20 kHz	1.95360 to 2.04640
	10 A	10 @ 1 kHz	9.99462 to 10.00538
		10 @ 5 kHz	9.98985 to 10.01015
		10 @ 10 kHz	9.97198 to 10.02802
		10 @ 20 kHz	9.89599 to 10.10401

4.7.26 Disconnect the test setup.

4.7.27 Repeat steps 4.7.15 through 4.7.26 using the 10 A AC Current Shunt and remaining applied values listed in Table 11.

4.8 AC CURRENT CALIBRATION: (OPT 40)

4.8.1 Connect Resistor (2.14) across the TI I+ and I- terminals.

4.8.2 Connect the AC Measurement Standard INPUT 2 HI and LO terminals to the TI I+ and I- terminals, observing polarity.

4.8.3 Press AC Measurement Standard INPUT 2 key.

4.8.4 Press TI DC and I Function switches to On.

4.8.5 Press the first TI Output Range switch listed in the TI Range column of Table 12.

4.8.6 Adjust TI Output keys until the TI Output display indicates the first TI DCI (±avg) (recorded in step 4.6.13) as indicated in Table 12.

4.8.7 Press TI OUTPUT ON + switch to On.

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

4.8.9 Press TI OUTPUT OFF switch to Off.

4.8.10 Press TI OUTPUT - switch to On to change TI Output to negative.

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

4.8.12 Set the AC Measurement Standard Control display to show ppm error display.

4.8.13 Press TI OUTPUT OFF switch to Off.

4.8.14 Press TI AC and I Function switches to On.

4.8.15 Adjust TI Output keys, Frequency Range switch and Frequency keys for the first value listed in the Applied column of Table 12.

4.8.16 Press TI OUTPUT ON + switch to On.

4.8.17 The AC Measurement Standard Error display (ppm difference from average reference) must indicate within the corresponding values listed in the Limits column of Table 12.

4.8.18 Repeat steps 4.8.15 and 4.8.17 for the 5 kHz value listed in the TI Applied column of Table 12 for the TI DCI (±avg) value in which the reference was set.

4.8.19 Press TI OUTPUT OFF switch to Off.

4.8.20 Press the AC Measurement Standard CLEAR REF softkey.

4.8.21 Disconnect Resistor (2.14) from the test setup and repeat step 4.8.1 using Resistor (2.15).

4.8.22 Repeat steps 4.8.4 thru 4.8.20 for each remaining range and applied value listed in Table 12.

Table 12.

Resistor Shunt	TI Range	TI DCI (±avg)	TI Applied (AAC)	Limits Relative (ppm)	Nominal (AAC)
200 Ω	1m	1 mADC		Reference	
			1 m @ 1 kHz	±204	(0.999796 to 1.000204 m)
			1 m @ 5 kHz	±303	(0.999697 to 1.000303 m)
2 kΩ	100µ	100 µADC		Reference	
			100 µ @ 1 kHz	±253	(99.9747 to 100.0253 µ)
			100 µ @ 5 kHz	±442	(99.9559 to 100.0441 µ)

4.8.23 Disconnect test setup.

4.8.24 Using the first shunt value listed in the AC Shunt column of Table 13, connect the AC Measurement Standard INPUT 2 HI and LO terminals to the AC Current Shunt OUTPUT, observing polarity.

4.8.25 Using the first shunt value listed in the AC Shunt Column of Table 13, connect the TI Transconductance Amplifier OUTPUT I+ and I- terminals to the AC Current Shunt INPUT, observing polarity.

4.8.26 Press TI AC and I Function switches to On.

4.8.27 Press the first TI Output Range switch listed in the TI Range column of Table 13.

4.8.28 Adjust TI Output keys, Frequency Range switch and Frequency keys for the first value listed in the TI Applied column of Table 13.

4.8.29 Press TI OUTPUT ON + switch to On.

NOTE

Allow sufficient time for AC Measurement Standard indication to stabilize before taking a reading.

4.8.30 Calculate the TI Current as follows: divide the AC Measurement Standard indication by the applicable AC Current Shunt AFPSL Certificate of Calibration Measured Resistance value.
Example: with the TI set for 10 mA AC at 1 kHz using the 10 mA AC Current Shunt (first values in Table 13):
AC Measurement Standard indication = 799.94 mV AC,
AC Current Shunt value from the Certificate of Calibration = 79.9955490 Ω,
the Calculated Value for the TI Current is 9.99980 mA AC

4.8.31 The results of step 4.8.30 must be within the corresponding values listed in the Limits column of Table 13.

4.8.32 Repeat steps 4.8.28, 4.8.30 and 4.8.31 for the 5 kHz value listed in the TI Applied column of Table 13 for the range being calibrated.

4.8.33 Press TI OUTPUT OFF switch to Off.

4.8.34 Disconnect the test setup.

4.8.35 Repeat steps 4.8.24 thru 4.8.34 for each remaining AC Shunt, range and applied value listed in Table 13.

Table 13.

AC Shunt	TI Range	TI Applied (AAC)	Limits (AAC)
10 mA	10m	10 m @ 1 kHz	9.99691 to 10.00309 m
		10 m @ 5 kHz	9.99691 to 10.00309 m
100 mA	100m	100 m @ 1 kHz	99.9689 to 100.0311 m
		100 m @ 5 kHz	99.9689 to 100.0311 m
1 A	1	1 @ 1 kHz	0.999592 to 1.000408
		1 @ 5 kHz	0.999404 to 1.000596

4.8.36 Disconnect the test setup.

4.9 <u>AC VOLTAGE CALIBRATION:</u> (OPT 20 and 30)

4.9.1 Connect TI HI and LO terminals to the AC Measurement Standard INPUT 2 HI and LO terminals, observing polarity.

4.9.2 Press TI AC Function switch to On and verify I Function switch is Off.

4.9.3 Press the first TI Output Range switch listed in the TI Range column of Table 14.

4.9.4 Adjust TI Output keys for the first value listed in the Applied (VAC) column of Table 14.

4.9.5 Set TI Frequency Range switch and adjust Frequency keys for the first value listed in the Applied (Hz) column of Table 14.

4.9.6 Press TI OUTPUT ON + switch to On.

NOTE

Due to local conditions, some PMELs may experience high RFI levels causing TI limits to appear out of specification on the mV ranges. Should this occur, press TI ZERO key and monitor the TI output with the Digital Multimeter, note indication. Subtract the Digital Multimeter noted indication from TI limits on the applicable ranges. Do not make any changes to TI calibration factors if the corrected limits are within specification.

4.9.7 The AC Measurement Standard must indicate within the corresponding values listed in the Limits column of Table 14.

4.9.8 Set TI Frequency Range switch and adjust Frequency keys for each remaining value listed in the Applied (Hz) column of Table 14 which is applicable to the TI VAC setting and repeat step 4.9.7 at each listed frequency.

4.9.9 Press TI OUTPUT OFF switch to Off.

4.9.10 Repeat steps 4.9.3 thru 4.9.9 for each remaining range and applied value listed in Table 14.

Table 14.

TI Range	Applied (VAC)	Applied (Hz)	Limits (VAC)
1m	1 m	20	0.9937 to 1.0063 m
		100	0.9940 to 1.0060 m
		9 k	0.9940 to 1.0060 m
		19 k	0.9938 to 1.0062 m
		90 k	0.9927 to 1.0073 m
		200 k	0.9848 to 1.0152 m
		1 M	0.9235 to 1.0765 m
10m	10 m	20	9.9922 to 10.0078 m
		100	9.9931 to 10.0069 m
		9 k	9.9932 to 10.0068 m
		19 k	9.9931 to 10.0069 m
		90 k	9.9890 to 10.0110 m
		200 k	9.9745 to 10.0255 m
		1 M	9.9013 to 10.0987 m

Table 14. (Cont.)

TI Range	Applied (VAC)	Applied (Hz)	Limits (VAC)
100m	100 m	20	99.9762 to 100.0238 m
		100	99.9829 to 100.0171 m
		9 k	99.9838 to 100.0162 m
		19 k	99.9829 to 100.0171 m
		90 k	99.9567 to 100.0433 m
		200 k	99.8765 to 100.1235 m
		1 M	99.6712 to 100.3288 m
1 *[1]	1	20	0.999858 to 1.000142
		100	0.999925 to 1.000075
		19 k	0.999943 to 1.000057
		90 k	0.999857 to 1.000143
		200 k	0.999465 to 1.000535
		1 M	0.997126 to 1.002874
10	10	20	9.99858 to 10.00142
		100	9.99923 to 10.00077
		19 k	9.99942 to 10.00058
		90 k	9.99835 to 10.00165
		200 k	9.99586 to 10.00414
		1 M	9.97884 to 10.02116
100	100	20	99.9849 to 100.0151
		100	99.9912 to 100.0088
		9 k	99.9931 to 100.0069
		19 k	99.9922 to 100.0078
		90 k	99.9799 to 100.0201
		200 k	99.8769 to 100.1231
	40	500 k	39.4695 to 40.5305

See footnote at end of Table.

Table 14. (Cont.)

TI Range	Applied (VAC)	Applied (Hz)	Limits (VAC)
1000	1000	40	999.825 to 1000.175
		100	999.825 to 1000.175
		2 k	999.873 to 1000.127
		9 k	999.835 to 1000.165
		19 k	999.835 to 1000.165
	700	100 k	699.114 to 700.886

*[1] The TI requires calibration on the 1 and 10 V ranges with both 2 and 4 wire configuration. After completing calibration of the 10 V range in 2 wire configuration, set REM SENSE On and connect TI I+ and I- terminals to the AC Measurement Standard INPUT 2 in a 4-wire configuration, observing polarity. Calibrate the 1 V and above ranges.

4.9.11 Disconnect the test setup.

4.10 <u>WIDEBAND AMPLITUDE AND FLATNESS CALIBRATION:</u> (OPT 70)

4.10.1 Connect the TI Wideband Amplifier OUTPUT thru the 50 Ω load and cable supplied with the TI to the AC Measurement Standard INPUT 2 HI and LO terminals, observing polarity.

4.10.2 Verify TI WBV Function switch is On.

4.10.3 Press the first TI Output Range switch listed in the TI Range column of Table 15.

4.10.4 Adjust TI Output keys, Frequency Range switch and Frequency keys for the first value listed in the Applied column of Table 15.

4.10.5 Press TI OUTPUT ON + switch to On.

4.10.6 The AC Measurement Standard must indicate within the corresponding values listed in the Limits column of Table 15.

4.10.7 Press TI OUTPUT OFF switch to Off.

4.10.8 Repeat steps 4.10.3 thru 4.10.7 for each remaining range and applied value listed in Table 15.

Table 15.

TI Range	Applied (VAC)	Limits (VAC)
1m	1 m @ 20 Hz	0.9931 to 1.0069 m
	1 m @ 1 kHz	0.9936 to 1.0064 m *[1]

See footnote at end of Table.

Table 15. (Cont.)

TI Range	Applied (VAC)	Limits (VAC)
1m	1 m @ 10 kHz	0.9936 to 1.0064 m
	1 m @ 90 kHz	0.9923 to 1.0077 m
	1 m @ 290 kHz	0.9874 to 1.0126 m
10m	10 m @ 20 Hz	9.9643 to 10.0357 m
	10 m @ 1 kHz	9.9693 to 10.0307 m *[1]
	10 m @ 10 kHz	9.9693 to 10.0307 m
	10 m @ 90 kHz	9.9681 to 10.0319 m
	10 m @ 290 kHz	9.9668 to 10.0342 m
100m	100 m @ 20 Hz	99.6598 to 100.3402 m
	100 m @ 1 kHz	99.7099 to 100.2901 m *[1]
	100 m @ 10 kHz	99.7099 to 100.2901 m
	100 m @ 90 kHz	99.7092 to 100.2908 m
	100 m @ 290 kHz	99.7081 to 100.2919 m
1	1 @ 20 Hz	0.996599 to 1.003401
	1 @ 1 kHz	0.997100 to 1.002900 *[1]
	1 @ 10 kHz	0.997100 to 1.002900
	1 @ 90 kHz	0.997099 to 1.002901
	1 @ 290 kHz	0.997095 to 1.002905
10	3 @ 20 Hz	2.99160 to 3.00840
	3 @ 1 kHz	2.99310 to 3.00690 *[1]
	3 @ 10 kHz	2.99310 to 3.00690
	3 @ 90 kHz	2.99310 to 3.00690
	3 @ 290 kHz	2.99308 to 3.00692

*[1] Record AC Measurement Standard indication for future use.

4.10.9 Disconnect the test setup.

4.10.10 Connect the TI Wideband Amplifier OUTPUT using the cable supplied with the TI to the AC Measurement Standard WIDEBAND Input connector (omit the 50 Ω load). Set the AC Measurement Standard to WBND input.

4.10.11 Press the first TI Output Range switch listed in the TI Range column of Table 16.

4.10.12 Adjust TI Output keys for the first value listed in the Applied (VAC) column of Table 16. Continue to adjust TI output to the value recorded in Table 15 for the corresponding range being calibrated.

4.10.13 Set TI Frequency Range switch and adjust Frequency keys for the first value listed in the Applied (Hz) column of Table 16.

4.10.14 Press TI OUTPUT ON + switch to On.

4.10.15 Allow for a stable reading and press the AC Measurement Standard Set Ref softkey and Control display to show % (PCT) error.

4.10.16 Set TI Frequency Range switch and adjust Frequency keys for the next value listed in the Applied (Hz) column of Table 16.

4.10.17 The AC Measurement Standard Error display must indicate within the corresponding values listed in the Limits column of Table 16.

4.10.18 Set TI Frequency Range switch and adjust Frequency keys for each remaining value listed in the Applied (Hz) column of Table 16 which is applicable to the TI VAC setting and repeat step 4.10.17 at each listed frequency.

4.10.19 Press TI OUTPUT OFF switch to Off.

4.10.20 Repeat steps 4.10.11 thru 4.10.19 for each remaining range and applied value listed in Table 16.

Table 16.

			Limits	
TI Range	**Applied (VAC)**	**Applied (Hz)**	**(%)**	**Nominal (VAC)**
1m	1 m	1 k	Reference	
		1.9 M	±0.510	(0.99490 to 1.00510 m)
		9 M	±0.810	(0.99190 to 1.00810 m)
		19 M	±1.201	(0.98798 to 1.01202 m)
		30 M	±2.701	(0.97299 to 1.02701 m)
10m	10 m	1 k	Reference	
		1.9 M	±0.213	(9.9787 to 10.0213 m)
		9 M	±0.322	(9.9678 to 10.0322 m)
		19 M	±0.513	(9.9487 to 10.0513 m)
		30 M	±1.113	(9.8887 to 10.1113 m)

Table 16. (Cont.)

TI Range	Applied (VAC)	Applied (Hz)	Limits (%)	Nominal (VAC)
100m	100 m	1 k	Reference	
		1.9 M	±0.153	(99.847 to 100.153 m)
		9 M	±0.303	(99.697 to 100.303 m)
		19 M	±0.453	(99.547 to 100.453 m)
		30 M	±1.054	(98.946 to 101.054 m)
1	1	1 k	Reference	
		1.9 M	±0.150	(0.99850 to 1.00150)
		9 M	±0.301	(0.99700 to 1.00300)
		19 M	±0.451	(0.99549 to 1.00451)
		30 M	±1.051	(0.98949 to 1.01051)
10	3	1 k	Reference	
		1.9 M	±0.150	(2.99549 to 3.00451)
		9 M	±0.300	(2.99099 to 3.00901)
		19 M	±0.450	(2.98649 to 3.01351)
		30 M	±1.051	(2.96848 to 3.03152)

4.10.21 Disconnect the test setup.

4.11 RESISTANCE CALIBRATION: (OPT 50)

CAUTION

If C1 is connected directly to C2 during the test, the Resistance Measurement System will be damaged! If not strictly observed, could result in damage to, or destruction of, equipment or loss of mission effectiveness.

4.11.1 Connect TI to a Resistance Measurement System unused channel as follows:

TI	Resistance Measurement System
I+	C_1
HI	P_1

I-	C_2
LO	P_2
Guard	GUARD (rear panel)

4.11.2 Press TI Ω switch to On and the REM SENSE switch to ON.

4.11.3 Press the first TI Output Range switch listed in the Rx column of Table 17.

4.11.4 Press the TI Output keys to obtain the first value listed in the Rx column of Table 17.

4.11.5 Press TI OUTPUT ON + switch to On.

4.11.6 Using the Resistance Measurement System Software Package, Select Test Configuration.

4.11.7 Assign a Test No. for the following Test Setups.

CAUTION

Do not click on the Start button until finished configuring the Test Configuration window, as the test will execute the test configuration parameters as displayed. If not strictly observed, could result in damage to, or destruction of, equipment or loss of mission effectiveness.

4.11.8 If a TI Resistance file (Rx) file has been previously configured and is available, select Scanner channel No., press Load, select the existing Rx file, press OK (will load the current/voltage stored with the TI Rx file) then proceed to step 4.11.11. Otherwise, continue with step 4.11.9.

4.11.9 Configure a TI Resistance (Rx) file using Resistance Measurement System Bridge Works software and Table 17 as required (Uncertainty not required).

4.11.10 Under Scanner Setup, load the appropriate Rs and Rx files.

NOTE

Review the AFPSL Resistor Profiles to ensure the values are current before using the Standard Resistors.

4.11.11 Configure the following Test Setup parameters:

Rs Channel	Channel for Standard Resistor (Rs) use Ch 18 for 10 Ω, Ch 19 for 100 Ω, Ch 20 for 1 kΩ, Ch 21 for 10 kΩ, Ch 22 for 100 kΩ and Ch 23 for 1 MΩ Rs files
Rx Channel	See step 4.11.1 for Channel Number and use the Rx file.
Mode	See Table 17
Ohms Reference	Rs
Reversal Rate	60 for 10 Ω to 10 kΩ, 90 for 100 kΩ and 120 for 1 to 100 MΩ - Fixed, with Auto Reversal Rate set to Disabled
Mode Control	See Table 17 Mode
Threshold	0.000

Target Deviation	0.1 for 10 Ω to 10 kΩ, 0.2 for 100 kΩ and 0.6 for 1 to 100 MΩ
Sample Window	10
Sample Limit	50

4.11.12 Press Start, select a directory and file name to save test results and press OK/SAVE.

NOTE

Test is over when Stop light goes out.

4.11.13 When test is complete, open the test results file by View, Test Overview, then File Open, select the file name from step 4.11.12, select the File, Data Manager, set Start and Go for the last 10 samples then press OK.

4.11.14 The TI measured Test Mean value must be within the corresponding values listed in the Limits column of Table 17 relative to the TI displayed value.

4.11.15 Repeat steps 4.11.3 through 4.11.14 as required for the remaining test configurations and values listed in Table 17.

Table 17.

Rs (Ω)	**Rx (Ω)**	**I/V test**	**I/V max**	**Mode**	**Absolute (ppm)**	**Limits (Ω)**
10	10	10 mA	100 mA	mA in Normal	±25.09	9.999749 to 10.000251
100	100	10 mA	25 mA	mA in Normal	±9.25	99.99907 to 100.00093
1 k	1 k	1 mA	10 mA	mA in Normal	±9.25	0.9999907 to 1.0000093 k
10 k	10 k	0.1 mA	2.5 mA	mA in Normal	±9.24	9.999908 to 10.000092 k
100 k	100 k	0.1 mA	1 mA	mA in Normal	±11.03	99.99890 to 100.00110 k
1 M	1 M	10 V	100 V	V in High	±26.93	0.9999731 to 1.0000269 M
1 M *[1]	10 M	10 V	100 V	V in High	±50.99	9.999490 to 10.000510 M
1 M *[2]	100 M	100 V	100 V	V in High	±70.71	99.99293 to 100.00707 M

*[1] Rs to Rx Ratio x10.

*[2] Rs to Rx Ratio x100.

4.11.16 Move test leads from TI I+ and I- connectors to the HI and LO connectors and press TI REMOTE SENSE switch to Off.

4.11.17 Repeat steps 4.11.3 through 4.11.14 as required for the test configurations and values listed in Table 18.

Table 18.

Rs (Ω)	Rx (Ω)	I/V test	I/V max	Mode	Absolute (ppm)	Limits (Ω) *
10	10	10 mA	100 mA	mA in Normal	±25.09	9.979749 to 10.020251
100	100	10 mA	25 mA	mA in Normal	±9.25	99.97908 to 100.02093
1 k	1 k	1 mA	10 mA	mA in Normal	±9.25	0.9997908 to 1.0002093 k
10 k	10 k	0.1 mA	2.5 mA	mA in Normal	±9.24	9.999708 to 10.000292 k
100 k	100 k	0.1 mA	1 mA	mA in Normal	±11.03	99.99870 to 100.00130 k

* TI limits are calculated using the Absolute accuracy and the 2 wire Ω adder.

4.11.18 Disconnect the test setup.

4.11.19 Update the TI 4W and 2W resistance displayed values with the TI 4W and 2W resistance measured Test Mean values per OEM 4808 Users Handbook, section 8.

4.11.20 Set all Power switches to STBY/OFF, disconnect and secure all equipment.

4.11.21 Perform steps 3.13 and 3.14, as required, instructions for use of a Limited Certification Label.

4.11A <u>RESISTANCE CALIBRATION:</u> (OPT 50) (Alternate Method)

4.11A.1 Connect equipment as shown in Figure 1A, solid lines first.

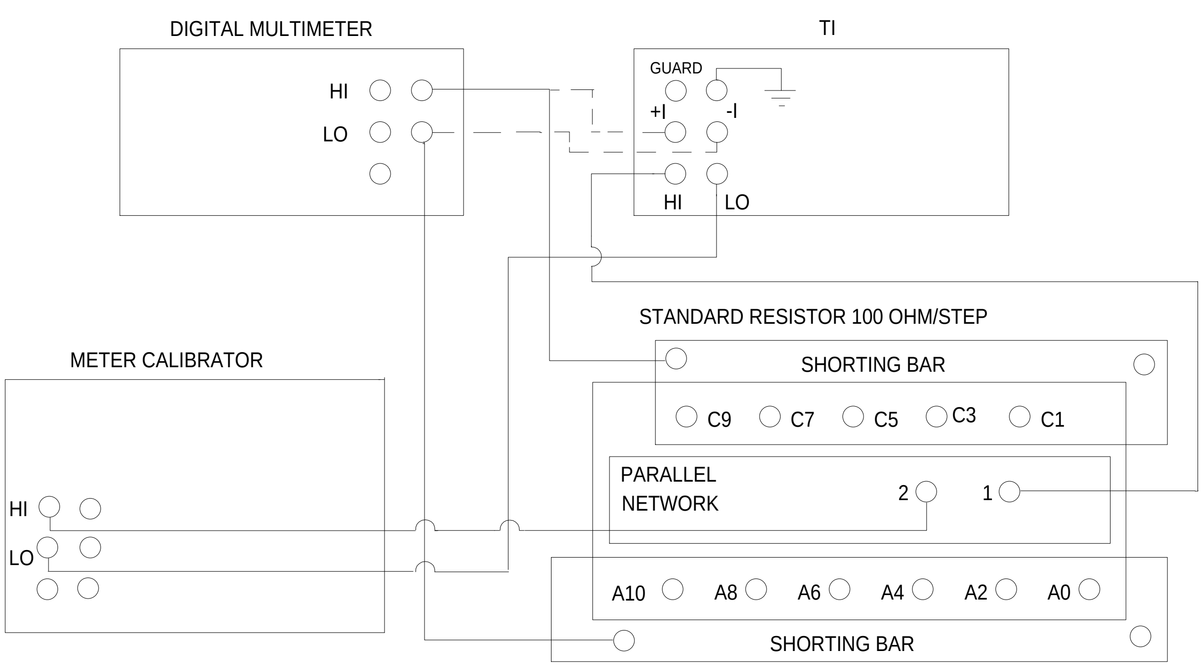

Figure 1A.

4.11A.2 Set the Digital Multimeter to measure VDC and select autorange.

4.11A.3 Press the TI Ω switch to On and the REM SENSE switch to ON.

4.11A.4 Press the first TI Output Range switch listed in the TI Range column of Table 2A.

4.11A.5 Press the TI Output keys to obtain the first value listed in the TI Applied column of Table 2A.

4.11A.6 Press the OUTPUT ON + switch to On.

4.11A.7 Set the Meter Calibrator controls for the first value listed in the MC Applied column of Table 2A and press the OPR/STBY switch to OPR.

NOTE

Allow sufficient settling time before recording the Digital Multimeter Vs and V1 values.

4.11A.8 Record the Digital Multimeter indication as Vs (100 mV, 1, 10 or 100 V depending on the applied value).

WARNING

Voltages hazardous to personnel may be encountered when transferring test leads from the Standard Resistor terminals to TI I+ and I- terminals. All necessary precautions during the conduct of this calibration must be observed. If not strictly observed, could result in injury to, or death of, personnel or long term health hazards.

4.11A.9 Transfer the Digital Multimeter leads to the TI I+ and I- terminals (dashed lines in Figure 1A).

4.11A.10 Record the Digital Multimeter indication as V1.

4.11A.11 Press the TI OUTPUT OFF switch to Off.

4.11A.12 Calculate TI actual resistance (R) as follows:

$$R = \frac{V1\ x\ Rs}{Vs}$$

Vs	= 4.11A.8
Rs	= Standard Resistor charted value
V1	= step 4.11A.10
R	= TI actual resistance

4.11A.13 The TI must indicate within the corresponding values listed in the Limits column of Table 2A relative to the result obtained in step 4.11A.12.

4.11A.14 Refer to Table 2A and Figure 1A, select and connect Standard Resistor for the next range and applied value listed in Table 2A.

4.11A.15 Repeat steps 4.11A.4 thru 4.11A.14 for each remaining range and applied value listed in Table 2A.

Table 2A.

TI Range	TI Applied	MC Applied	Standard Resistor	Limits Absolute (ppm)	Nominal (Ω)
10Ω	10 Ω	10 mA DC	10 Ω, 100 Ω/STEP in parallel	±25.5	(9.999745 10.000255)
100Ω *[1]	100 Ω	2 VDC	100 Ω/STEP	±10.3	(99.99897 to 100.00103)
1kΩ	1 kΩ	2 VDC	1 kΩ/ STEP	±10.3	(0.9999897 to 1.0000103 k)
10kΩ	10 kΩ	2 VDC	10 kΩ, 1 kΩ/STEP in series	±10.3	(9.999897 to 10.000103 k)
100kΩ	100 kΩ	20 VDC	100 kΩ/STEP	±11.2	(99.99888 to 100.00112 k)
1MΩ	1 MΩ	20 VDC	1 MΩ/STEP *[2]	±25.5	(0.9999745 to 1.0000255 M)
10MΩ	10 MΩ	20 VDC	10 MΩ/STEP *[2]	±52.2	(9.999478 to 10.000522 M)
100MΩ	100 MΩ	200 VDC	100 MΩ, 10 MΩ *[2] /STEP in series	±71.6	(99.99284 to 100.00716 M)

*[1] Record the computed resistance. In Figure 1A setup, move test leads from TI I+ and I- connectors to the HI and LO connectors and press TI REMOTE SENSE switch to Off. Compute resistance with this 100 Ω value. The computed resistance must be within ±210.3 ppm of the TI indication. Press TI REMOTE SENSE switch to On and continue with step 4.11A.13.

*[2] Use Transfer Standard (2.19) and Figure 2A for these values.

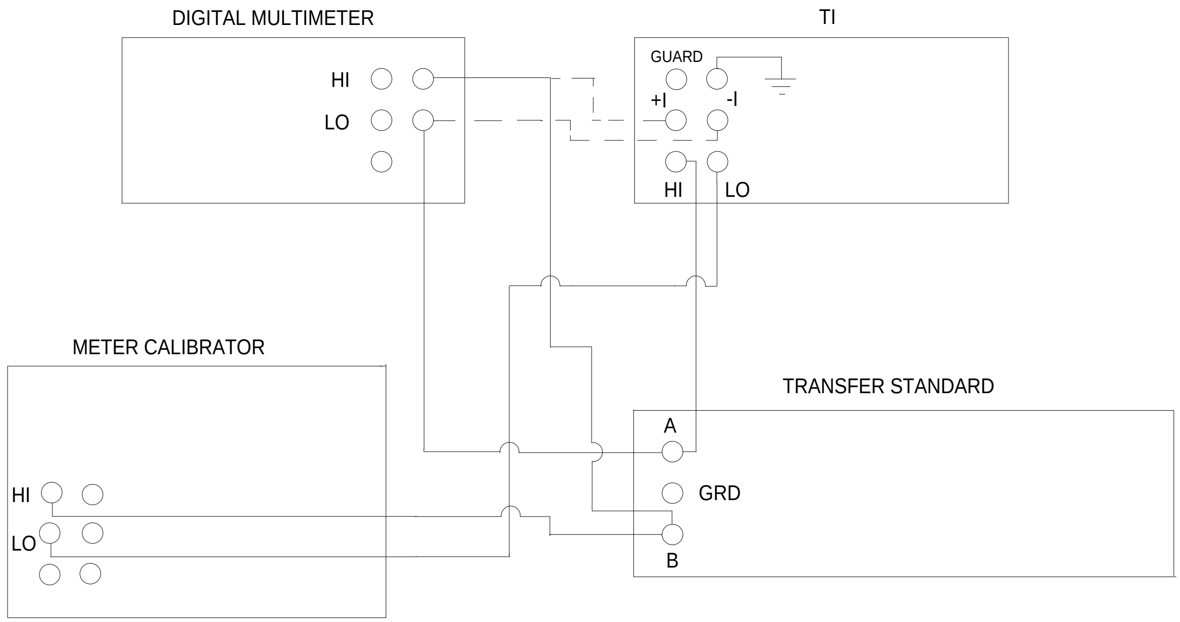

Figure 2A.

4.11A.16 Disconnect the test setup.

4.11A.17 Set all Power switches to STBY/OFF, disconnect and secure all equipment.

4.11A.18 Perform steps 3.13 and 3.14, as required, instructions for use of a Limited Certification Label.

CALIBRATION PERFORMANCE TABLE

Not Required

APPENDIX A

NOTE

The Performance Specifications listed below for the TI are absolute specifications which are calculated by combining the uncertainty of the relative specifications found in the commercial data (operators/instruction manual) with the uncertainty of the Calibration Standards listed in Section 2, Equipment Requirements of 33K series calibration technical order (TO). As opposed to **Relative** specifications which do not include calibration standards uncertainties and other possible uncertainties, **Absolute** specifications are the traceable measurement capabilities (or **calibrated to** specifications) of the TI.

Distortion
(OPT 20 and 30)

Range:
OPT 20: 0 to 100 V, 10 Hz to 1 MHz;
OPT 30: 0 to 1000 V, 10 Hz to 1 MHz

Accuracy: Pure THD, excluding noise, which is included in the main specifications:

Frequency	Voltage Range	≤%
10 to 31 Hz	1 mV thru 100 V rngs	0.1
32 Hz to 33 kHz	1 mV thru 100 V rngs	0.04
30 to 100 kHz	1 mV thru 10 V rngs	0.1
30 to 100 kHz	100 V rng	0.2
100 to 330 kHz	1 mV thru 100 V rngs	0.3
300 kHz to 1 MHz	1 mV thru 100 V rngs	1
10 to 330 Hz	1000 V rng	0.2
300 Hz to 33 kHz	1000 V rng	0.1
30 to 100 kHz	750 V rng	0.5

Distortion
Wideband
(OPT 70)

Range: 0 to 3 V, 10 Hz to 30 MHz

Accuracy:
THD:
≤-40 dB, volt-hertz product ≤9 X 10^7;
≤-36 dB, volt-hertz product >9 X 10^7

Spurious Frequency Output:
≤-46 dB

Distortion
Transconductance Amplifier
(OPT 60)

Range: 0 to 10 A, 10 Hz to 20 kHz

Accuracy: Pure THD, excluding noise, which is included in the main specifications:
≤0.2%, 10 Hz to 10 kHz;
≤1%, 10 to 20 kHz

APPENDIX A (*Cont.)*

Frequency (OPT 20, 30 and 70)	Range: OPT 20 and 30: 10 Hz to 1 MHz; OPT 70: 10 Hz to 30 MHz Accuracy: OPT 20 and 30: <±0.01% of setting OPT 70: ±0.01% of setting
DC Voltage	Range: OPT 10: 0 to 100 V; OPT 30: 0 to 1000 V Accuracy: ±(ppm of output + µV)

OPT 10:	Absolute	
Range:	ppm	µV
100 µV	7.44	0.5
1 mV	7.44	0.5
10 mV	7.44	0.5
100 mV	7.45	0.5
1 V	5.59	1
10 V	3.91	3
100 V	5.59	50
OPT 30:		
1000 V	7.45	500

DC Current

Range: 0 to 1 A

Accuracy: ±(ppm of output + n/µA)

	Absolute	
Range:	ppm	n/µA
100 µA	100.62	2.24 n
1 mA	41.53	10.05 n
10 mA	41.53	100.05 n
100 mA	41.53	1.005 µ
1 A	100.68	20.02 µ

DC and AC Current Transconductance Amplifier (OPT 60)

Range:
0 to 10 A, DC;

Accuracy: ±(ppm of output + n/µA)

	Absolute	
Range:	ppm	n/µA
10 ADC	155.56	509.9 µA

APPENDIX A (*Cont.)*

DC and AC Current (*Cont.)*
Transconductance Amplifier
(OPT 60)

Range:
0 to 10 A, DC;

Accuracy: ±(ppm of output + n/µA)

Range: 0 to 10 A at 10 Hz to 20 kHz

Accuracy: ±(ppm of output + mA)

	Absolute	
Frequency	ppm	mA
10 Hz to 1 kHz	408.05	1.3
1 to 5 kHz	855.04	1.6
5 to 10 kHz	2202.40	6.0
10 to 20 kHz	7200.75	32.0

AC Current
(OPT 40)

Range: 0 to 1 A, 10 Hz to 5 kHz

Accuracy: ±(ppm of output + A)

The 100 mAAC rng Relative Accuracy is down graded to ±(200 ppm of output + 10 µA) at 10 Hz to 1 kHz.

		Absolute	
Range	Hz	ppm	A
100 µA	10 Hz to 1 kHz	152.41	10.00 n
	1 to 5 kHz	301.21	14.00 n
1 mA	10 Hz to 1 kHz	103.58	100.0 n
	1 to 5 kHz	201.81	100.0 n
10 mA	10 Hz to 1 kHz	209.07	1 µ
	1 to 5 kHz	209.07	1 µ
100 mA	10 Hz to 1 kHz	211.36	10 µ
	1 to 5 kHz	211.36	10 µ
1 A	10 Hz to 1 kHz	308.33	100 µ
	1 to 5 kHz	455.67	140 µ

AC Voltage
(OPT 20 and 30)

Range:
OPT 20: 0 to 100 V, 10 Hz to 1 MHz
OPT 30: 0 to 1000 V, 10 Hz to 1 MHz

Accuracy: ±(ppm of output + V)

The AC Voltage Relative Accuracy is downgraded as follows:

1 mV rng at 30 to 100 kHz	±(500 ppm of output + 5.4 µV);
10 mV rng at 30 to 100 kHz	±(400 ppm of output + 5.4 µV);
1 V rng at 30 to 100 kHz	±(100 ppm of output + 20 µV);
10 V rng at 30 to 100 kHz	±(120 ppm of output + 200 µV);
100 V rng at 30 to 100 kHz	±(140 ppm of output + 3 mV)

APPENDIX A (*Cont.)*

AC Voltage (*Cont.)*
(OPT 20 and 30)

Range:
OPT 20: 0 to 100 V, 10 Hz to 1 MHz
OPT 30: 0 to 1000 V, 10 Hz to 1 MHz

Accuracy: ±(ppm of output + V)

OPT 20 Range	Frequency	Absolute ppm	V
1 mV	10 to 31 Hz	749.67	5.55 µ
	32 to 330 Hz	425.79	5.55 µ
	300 Hz to 10 kHz	424.26	5.55 µ
	10 to 33 kHz	425.79	5.55 µ
	30 to 100 kHz	1300.00	5.95 µ
	100 to 330 kHz	2507.99	12.65 µ
	300 kHz to 1 MHz	4031.13	72.44 µ
10 mV	10 to 31 Hz	224.72	5.55 µ
	32 to 330 Hz	130.38	5.55 µ
	300 Hz to 10 kHz	125.30	5.55 µ
	10 to 33 kHz	130.38	5.55 µ
	30 to 100 kHz	506.06	5.95 µ
	100 to 330 kHz	1286.90	12.65 µ
	300 kHz to 1 MHz	2624.88	72.44 µ
100 mV	10 to 31 Hz	147.05	9.12 µ
	32 to 330 Hz	79.65	9.12 µ
	300 Hz to 10 kHz	71.02	9.12 µ
	10 to 33 kHz	79.65	9.12 µ
	30 to 100 kHz	340.00	9.34 µ
	100 to 330 kHz	1030.78	20.4 µ
	300 kHz to 1 MHz	2088.06	120 µ
1 V	10 to 31 Hz	111.61	30 µ
	32 to 330 Hz	55.46	20 µ
	300 Hz to 33 kHz	46.65	10 µ
	30 to 100 kHz	122.64	20 µ
	100 to 330 kHz	435.46	100 µ
	300 kHz to 1 MHz	2473.86	400 µ
10 V	10 to 31 Hz	112.20	300 µ
	32 to 330 Hz	56.82	200 µ
	300 Hz to 33 kHz	48.26	100 µ
	30 to 100 kHz	144.78	200 µ
	100 to 330 kHz	314.01	1 m
	300 kHz to 1 MHz	1615.55	5 m
100 V	10 to 31 Hz	120.93	3 m
	32 to 330 Hz	67.54	2 m
	300 Hz to 10 kHz	58.83	1 m
	10 to 33 kHz	67.54	1 m
	30 to 100 kHz	170.89	3 m
	100 to 330 kHz	730.82	50 m
	300 kHz to 1 MHz	10012.49	130 m

APPENDIX A (*Cont.)*

AC Voltage (*Cont.)*
(OPT 20 and 30)

Range:
OPT 20: 0 to 100 V, 10 Hz to 1 MHz
OPT 30: 0 to 1000 V, 10 Hz to 100 kHz

Accuracy: ±(ppm of output + V)

OPT 30 Range	Frequency	Absolute ppm	V
1000 V	10 to 330 Hz	154.74	20 m
	300 Hz to 3.3 kHz	106.98	20 m
	3 to 33 kHz	145.07	20 m
	30 to 100 kHz	1208.30	40 m

AC Voltage
Wideband Amplifier
(OPT 70) Amplitude

Range: 0 to 3 V, 10 Hz to 30 MHz

Accuracy: ±(% of output + μV)

Range	Frequency	Absolute %	μV
300 μV to 1 mV	10 to 30 Hz	0.5550	1.36
	30 Hz to 20 kHz	0.5018	1.36
	20 to 100 kHz	0.5142	2.53
	100 to 330 kHz	0.8613	4.02
1 to 10 mV	10 to 30 Hz	0.3405	1.64
	30 Hz to 20 kHz	0.2902	1.64
	20 to 100 kHz	0.2917	2.69
	100 to 330 kHz	0.3011	4.12
10 to 100 mV	10 to 30 Hz	0.3301	10.11
	30 Hz to 20 kHz	0.2800	10.11
	20 to 100 kHz	0.2805	10.31
	100 to 330 kHz	0.2811	10.77
100 mV to 1 V	10 to 30 Hz	0.3301	100.0
	30 Hz to 20 kHz	0.2800	100.0
	20 to 100 kHz	0.2801	100.0
	100 to 330 kHz	0.2805	100.0
1 to 3 V	10 to 30 Hz	0.2701	300.0
	30 Hz to 20 kHz	0.2200	300.0
	20 to 100 kHz	0.2201	300.0
	100 to 330 kHz	0.2208	300.0

APPENDIX A (*Cont.)*

The following 300 kHz to 30 MHz Relative limits are verified during Flatness Calibration

AC Voltage (*Cont.)*
Wideband Amplifier
(OPT 70) Amplitude

Range: 0 to 3 V, 10 Hz to 30 MHz

Accuracy: ±(% of output + µV)
The Wideband Amplifier Amplitude on 300 µV to 1 mV rng Relative Accuracy is downgraded to ±(0.83% of output + 0.4 µV) at 100 to 330 kHz.

Range		Relative	
	300 kHz to 2 MHz	%	µV
	300 µV to 10 mV	0.34	3
	10 to 100 mV	0.34	10
	100 mV to 1 V	0.34	100
	1 to 3 V	0.26	300

2 to 10 MHz		
Range	%	µV
300 µV to 10 mV	0.48	3
10 to 100 mV	0.48	10
100 mV to 1 V	0.48	100
1 to 3 V	0.35	300

10 to 20 MHz		
Range	%	µV
300 µV to 10 mV	0.61	3
10 to 100 mV	0.61	10
100 mV to 1 V	0.61	100
1 to 3 V	0.48	300

20 to 30 MHz		
300 µV to 10 mV	0.76	3
10 to 100 mV	0.76	10
100 mV to 1 V	0.76	100
1 to 3 V	0.60	300

AC Voltage
Wideband Amplifier
(OPT 70) Flatness

Range: 300 kHz to 30 MHz

Accuracy: Specifications apply to the end of the cable and 50 Ω load used for calibration.
±(% of output + µV) referenced at 1 kHz

The Wideband Amplifier Flatness is downgraded as follows:

Output	Frequency	±(% + µV)
300 µV to 1 mV	300 kHz to 2 MHz	0.14 + 3
	2 to 10 MHz	0.40 + 3
	10 to 20 MHz	0.74 + 3
	20 to 30 MHz	2.02 + 3

APPENDIX A (*Cont.)*

AC Voltage (*Cont.)*
Wideband Amplifier
(OPT 70) Flatness

Range: 300 kHz to 30 MHz

Accuracy: Specifications apply to the end of the cable and 50 Ω load used for calibration. ±(% of output + µV) referenced at 1 kHz

The Wideband Amplifier Flatness is downgraded as follows:

Output	Frequency	±(% + µV)
1 to 10 mV	300 kHz to 2 MHz	0.15 + 3
	2 to 10 MHz	0.25 + 3
	10 to 20 MHz	0.41 + 3
	20 to 30 MHz	0.93 + 3
10 mV to 3 V	300 kHz to 2 MHz	0.13 + 3
	2 to 10 MHz	0.26 + 3
	10 to 20 MHz	0.39 + 3
	20 to 30 MHz	0.91 + 3

		Absolute	
Range	Frequency	%	µV
300 µV to 1 mV	300 kHz to 2 MHz	0.1750	3.35
	2 to 10 MHz	0.4744	3.35
	10 to 20 MHz	0.8661	3.35
	20 to 30 MHz	2.2766	4.24
1 to 10 mV	300 kHz to 2 MHz	0.1831	3.0
	2 to 10 MHz	0.2915	3.0
	10 to 20 MHz	0.4828	3.0
	20 to 30 MHz	1.0830	3.0
10 to 100 mV	300 kHz to 2 MHz	0.1501	3.0
	2 to 10 MHz	0.3002	3.0
	10 to 20 MHz	0.4502	3.0
	20 to 30 MHz	1.0506	3.0
100 mV to 1 V	300 kHz to 2 MHz	0.1501	3.0
	2 to 10 MHz	0.3002	3.0
	10 to 20 MHz	0.4502	3.0
	20 to 30 MHz	1.0506	3.0
1 to 3 V	300 kHz to 2 MHz	0.1501	3.0
	2 to 10 MHz	0.3002	3.0
	10 to 20 MHz	0.4502	3.0
	20 to 30 MHz	1.0506	3.0

Resistance

Range: 0 to 100 MΩ

Accuracy: ±ppm of output

	Para 4.11	Para 4.11A
Range	Absolute	Absolute
10 Ω	25.09	25.50
100 Ω	9.25	10.32
1 kΩ	9.25	10.31
10 kΩ	9.24	10.31

APPENDIX A (*Cont.)*

Resistance (*Cont.)*

Range: 0 to 100 MΩ

Accuracy: ±ppm of output

	Para 4.11	Para 4.11A
Range	Absolute	Absolute
100 kΩ	11.03	11.20
1 MΩ	26.93	25.50
10 MΩ	50.99	52.20
100 MΩ	70.71	71.59

add 20 mΩ for 2 wire on 10 and 100 Ω rngs;
add 200 mΩ for 2 wire on 1 kΩ thru 100 MΩ rngs