Agilent Technologies 3458A Multimeter

User's Guide

Agilent Technologies

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Appendix A Specifications

Introduction

The 3458A accuracy is specified as a part per million (ppm) of the reading plus a ppm of range for dcV, Ohms, and dcl. In acV and acl, the specification is percent of reading plus percent of range. Range means the name of the scale, e.g. 1 V, 10 V, etc.; range does not mean the full scale reading, e.g. 1.2 V, 12 V, etc. These accuracies are valid for a specific time from the last calibration.

Absolute versus Relative Accuracy

All 3458A accuracy specifications are relative to the calibration standards. Absolute accuracy of the 3458A is determined by adding these relative accuracies to the traceability of your calibration standard. For dcV, 2 ppm is the traceability error from the Agilent factory. That means that the absolute error relative to the U.S. National Institute of Standards and Technology (NIST) is 2 ppm in addition to the dcV accuracy specifications. When you recalibrate the 3458A, your actual traceability error will depend upon the errors from your calibration standards. These errors will likely be different from the Agilent error of 2 ppm.

Example 1: Relative Accuracy; 24 Hour Operating temperature is Tcal ± 1°C

Assume that the ambient temperature for the measurement is within ± 1°C of the temperature of calibration (Tcal). The 24 hour accuracy specification for a 10 V dc measurement on the 10 V range is 0.5 ppm ± 0.05 ppm. That accuracy specification means:

0.5 ppm of Reading + 0.05 ppm of Range

For relative accuracy, the error associated with the measurement is:

(0.5/1,000,000 x 10 V) + (0.05/1,000,000 x 10 V) = ± 5.5 µV or 0.55 ppm of 10 V

Errors from temperature changes

The optimum technical specifications of the 3458A are based on auto-calibration (ACAL) of the instrument within the previous 24 hours and following ambient temperature changes of less than ±1°C. The 3458A's ACAL capability corrects for measurement errors resulting from the drift of critical components from time and temperature.

The following examples illustrate the error correction of auto-calibration by computing the relative measurement error of the 3458A for various temperature conditions. Constant conditions for each example are:

10 V DC input
10 V DC range
Tcal = 23°C
90 day accuracy specifications

Example 2: Operating temperature is 28°C;

With ACAL

This example shows basic accuracy of the 3458A using auto-calibration with an operating temperature of 28°C. Results are rounded to 2 digits.

(4.1 ppm x 10 V) + (0.05 ppm x 10 V) = 42 µV

Total relative error = 42 µV

Example 3: Operating temperature is 38°C;

Without ACAL

The operating temperature of the 3458A is 38°C, 14°C beyond the range of Tcal ±1°C. Additional measurement errors result because of the added temperature coefficient without using ACAL.

(4.1 ppm x 10 V) + (0.05 ppm x 10 V) = 42 µV

Temperature Coefficient (specification is per °C):

(0.5ppm x 10V + 0.01 ppm x 10V) x 14°C = 71 µV

Total error = 113 µV

Example 4: Operating temperature is 38°C;

With ACAL

Assuming the same conditions as Example 3, but using ACAL significantly reduces the error due to temperature difference from calibration temperature. Operating temperature is 10°C beyond the standard range of Tcal ±5°C.

(4.1 ppm x 10 V) + (0.05 ppm x 10 V) = 42 µV

Temperature Coefficient (specification is per °C):

(0.15ppm x 10V + 0.01ppm x 10V) x 10°C = 16µV

Total error = 58 µV

Example 5: Absolute Accuracy; 90 Day

Assuming the same conditions as Example 4, but now add the traceability error to establish absolute accuracy.

(4.1 ppm x 10 V) + (0.05 ppm x 10 V) = 42 µV

Temperature Coefficient (specification is per °C):

(0.15ppm x 10V + 0.01ppm x 10V) x 10°C = 16µV

Agilent factory traceability error of 2 ppm:

(2 ppm x 10 V) = 20 µV

Total absolute error = 78 µV

Additional errors

When the 3458A is operated at power line cycles below 100, additional errors due to noise and gain become significant. Example 6 illustrates the error correction at 0.1 PLC.

Example 6: operating temperature is 28×C; 0.1 PLC

Assuming the same conditions as Example 2, but now add additional error.

(4.1 ppm x 10 V) t (0.05 ppm x 10 V) = 42 µV

Referring to the Additional Errors chart and RMS Noise Multiplier table, additional error at 0.1 PLC is:

(2 ppm x 10 V) + (0.4 ppm x 1 x 3 x 10 V) = 32 µV

Total relative error = 74 µV

1 / DC Voltage

DC Voltage

Range	Full Scale	Maximum Resolution	Input Impedance	Temperature Coefficient (ppm of Reading + ppm of Range) /º C	
				Without ACAL[1]	With ACAL[2]
100 mV	120.00000	10 nV	>10 GΩ	1.2 + 1	0.15 + 1
1 V	1.20000000	10 nV	>10 GΩ	1.2 + 0.1	0.15 + 0.1
10 V	12.0000000	100 nV	>10 GΩ	0.5 + 0.01	0.15 + 0.01
100 V	120.000000	1 µV	10 MΩ ± 1%	2 + 0.4	0.15 + 0.1
1000 V	1050.00000	10 µV	10 MΩ ± 1%	2 + 0.04	0.15 + 0.01

Accuracy[3] (ppm of Reading (ppm of Reading for Option 002) + ppm of Range)

Range	24 Hour [4]	90 Day [5]	1 Year [5]	2 Year [5]
100 mV	2.5 + 3	5.0 (3.5)+ 3	9 (5)+ 3	14 (10)+ 3
1 V	1.5 + 0.3	4.6 (3.1)+0.3	8 (4)+ 0.3	14 (10)+0.3
10 V	0.5 + 0.05	4.1 (2.6) + 0.05	8 (4) + 0.05	14 (10)+0.05
100 V	2.5 + 0.3	6.0 (4.5) + 0.3	10 (6)+0.3	14 (10)+ 0.3
1000 V[6]	2.5 + 0.1	6.0 (4.5)+ 0.1	10 (6)+ 0.1	14 (10)+ 0.1

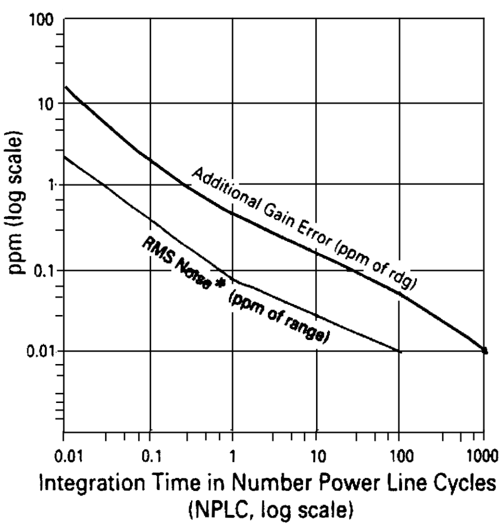
Transfer Accuracy/Linearity

Range	10 Min, Tref ± 0.5ºC (ppm of Reading + ppm of Range)	Conditions
100 mV	0.5 + 0.5	• Following 4 hour warm-up. Full scale to 10% of full scale • Measurements on the 1000 V range are within 5% of the initial meausurement value and following measurement setting. • Tref is the starting ambient temperature. • Measurements are made on a fixed range (>4 min.) using accepted metrology practices
1 V	0.3 + 0.1	
10 V	0.05 + 0.05	
100 V	0.5 + 0.1	
1000 V	1.5+0.05	

Settling Characteristics

For first reading or range change error, add 0.0001% of input voltage step additional error.
Reading settling times are affected by source impedance and cable dielectric absorption characteristics.

Additional Errors



Noise Rejection (dB) [7]

	AC NMR [8]	AC ECMR	DC ECMR
NPLC<1	0	90	140
NPLC>1	60	150	140
NPLC > 10	60	150	140
NPLC > 100	60	160	140
NPLC = 1000	75	170	140

*RMS Noise

Range	Multiplier
0.1V	x20
1 V	x2
10 V	x1
100 V	x2
1000 V	x1

For RMS noise error, multiply RMS noise result from graph by multiplier in chart. For peak noise error. multiply RMS noise error by 3.

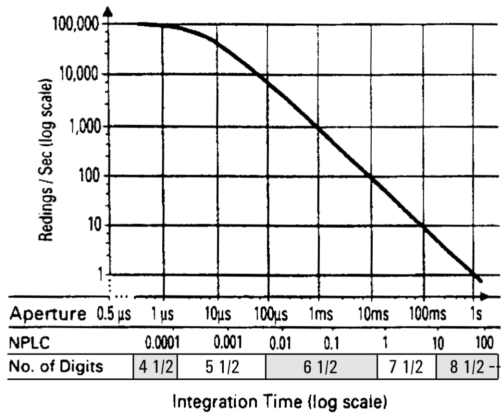
1. Additional error from Tcal or last ACAL ± 1 º C.
2. Additional error from Tcal ±5º C
3. Specifications are for PRESET, NPLC 100.
4. For fixed range (> 4 min.), MATH NULL and Tcal ±1ºC.
5. Specifications for 90 day, 1 year and 2 year are within 24 hours and ±1º C of last ACAL; Tcal ±5ºC, MATH NULL and fixed range.

   ppm of Reading specifications for High Stability (Option 002) are in parentheses.

   Without MATH NULL, add 0.15 ppm of Range to 10 V, 0.7 ppm of Range to 1 V, and 7 ppm of Range to 0.1 V. Without math null and for fixed range less than 4 minutes, add 0.25 ppm of Range to 10 V, 1.7 ppm of Range to 1 V and 17 ppm of Range to 0.1 V.

   Add 2 ppm of reading additional error for Agilent factory traceability to US NIST. Traceability error is the absolute error relative to National Standards associated with the source of last external calibration.
6. Add 12 ppm X $(Vin/1000)^2$ additional error for inputs > 100 V.
7. Applies for 1 kΩ unbalance in the LO lead and ± 0.1% of the line frequency currently set for LFREQ.
8. For line frequency ± 1%, ACNMR is 40 dB for NPLC ≥ 1, or 55 dB for NPLC ≥ 100. For line frequency ± 5%, ACNMR is 30 dB for NPLC ≥ 100.

Reading Rate (Auto-Zero Off)



Temperature Coefficient (Auto-Zero off)

For a stable environment ±1°C add the following additional error for AZERO OFF

Range	Error
100 mV–10 V	5 µV/°C
100 V–1000 V	500 µV/°C

Selected Reading Rates [1]

NPLC	Aperture	Digits	Bits	Readings / Sec A-Zero Off	Readings / Sec A-Zero On
0.0001	1.4 µs	4.5	16	100,000 [3]	4,130
0.0006	10 µs	5.5	18	50,000	3,150
0.01	167 µs[2]	6.5	21	5,300	930
0.1	1.67 ms[2]	6.5	21	592	245
1	16.6 ms[2]	7.5	25	60	29.4
10	0.166 s[2]	8.5	28	6	3
100		8.5	28	36/min	18/min
1000		8.5	28	3.6/min	1.8/min

1. For PRESET; DELAY 0; DISP OFF; OFORMAT DINT; ARANGE OFF.
2. Aperture is selected independent of line frequency (LFREQ). These apertures are for 60 Hz NPLC values where 1 NPLC = 1/LFREQ. For 50 Hz and NPLC indicated, aperture will increase by 1.2 and reading rates will decrease by 0.833
3. For OFORMAT SINT

Maximum Input

	Rated Input	Non-Destructive
HI to LO	±1000 V pk	±1200 V pk
LO to Guard[4]	±200 V pk	±350 V pk
Guard to Earth[5]	±500 V pk	±1000 V pk

4. > 10^{10} Ω LO to Guard with guard open.
5. > 10^{12} Ω Guard to Earth.

Input Terminals

Terminal Material: Gold-plated Tellurium Copper
Input Leakage Current:<20pA at 25°C

2 / Resistance

Two-wire and Four-wire Ohms (OHM and OHMF Functions)

Range	Full Scale	Maximum Resolution	Current Source[6]	Test Voltage	Open Circuit	Maximum Lead Resistance (OHMF)	Maximum Series Offset (OCOMP ON)	Temperature Coefficient (ppm of Reading + ppm of Range) / °C Without ACAL[7]	Temperature Coefficient (ppm of Reading + ppm of Range) / °C With ACAL[8]
10 Ω	12.00000	10 µΩ	10 mA	0.1 V	12 V	20 Ω	0.01 V	3+1	1+1
100 Ω	120.00000	10 µΩ	1 mA	0.1 V	12 V	200 Ω	0.01 V	3+1	1+1
1 kΩ	1.2000000	100 µΩ	1 mA	1.0 V	12 V	150 Ω	0.1 V	3+0.1	1+0.1
10 kΩ	12.000000	1 mΩ	100 µA	1.0 V	12 V	1.5 kΩ	0.1 V	3+0.1	1+0.1
100 kΩ	120.00000	10 mΩ	50 µA	5.0 V	12 V	1.5 kΩ	0.5 V	3+0.1	1+0.1
1 MΩ	1.2000000	100 mΩ	5 µA	5.0 V	12 V	1.5 kΩ		3+1	1+1
10 MΩ	12.000000	1 Ω	500 nA	5.0 V	12 V	1.5 kΩ		20+20	5+2
100 MΩ[9]	120.00000	10 Ω	500 nA	5.0 V	5 V	1.5 kΩ		100+20	25+2
1 GΩ[7]	1.2000000	100 Ω	500 nA	5.0 V	5 V	1.5 kΩ		1000+20	250+2

6. Current source is ± 3% absolute accuracy.
7. Additional error from Tcal or last ACAL ± 1° C.
8. Additional error from Tcal ± 5° C.
9. Measurement is computed from 10 M Ω in parallel with input

2 Accuracy[1] (ppm of Reading + ppm of Range)

Range	24 Hour [2]	90 Day[3]	1 Year[3]	2 Year[3]
10 Ω	5+3	15+5	15+5	20+10
100 Ω	3+3	10+5	12+5	20+10
1 kΩ	2+0.2	8+0.5	10+0.5	15+1
10 kΩ	2+0.2	8+0.5	10+0.5	15+1
100 kΩ	2+0.2	8+0.5	10+0.5	15+1
1 MΩ	10+1	12+2	15+2	20+4
10 MΩ	50+5	50+10	50+10	75+10
100 MΩ	500+10	500+10	500+10	0.1%+10
1 GΩ	0.5%+10	0.5%+10	0.5%+10	1%+10

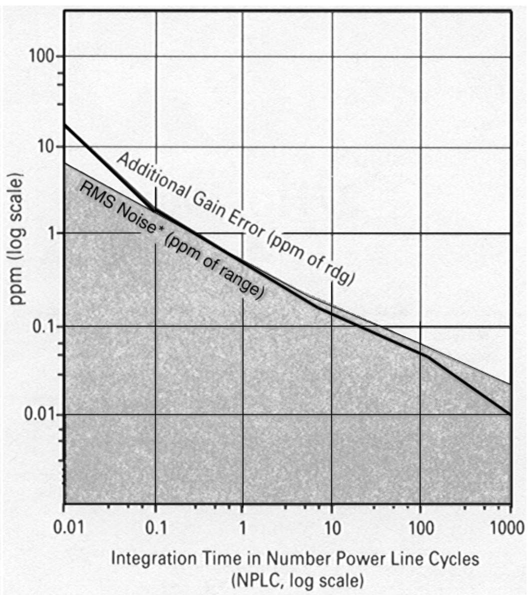
1. Specifications are for PRESET; NPLC 100; OCOMP ON; OHMF.
2. Tcal ± 1°C.
3. Specifications for 90 day, 1 year, and 2 year are within 24 hours and ± 1°C of last ACAL; Tcal ±5°C.

   Add 3 ppm of reading additional error for Agilent factory traceability of 10 KΩ to US NIST. Traceability is the absolute error relative to National Standards associated wifh the source of last external calibration.

Two-Wire Ohms Accuracy

For Two-Wire Ohms (OHM) accuracy, add the following offset errors to the Four-Wire Ohms (OHMF) accuracy. 24 Hour: 50 mΩ. 90 Day: 150 mΩ. 1 Year: 250 mΩ. 2 Year: 500 mΩ

Additional Errors



*RMS Noise	
Range	**Multiplier**
10 Ω & 100 Ω	×10
1k Ω to 100 kΩ	×1
1 MΩ	×1.5
10 MΩ	×2
100 MΩ	×120
1 GΩ	×1200

For RMS noise error, multiply RMS noise result from graph by multiplier in chart. For peak noise error, multiply RMS noise error by 3.

Settling Characteristics

For first reading error following range change, add the total 90 day measurement error for the current range. Preprogrammed settling delay times are for < 200 pF external circuit capacitance.

Selected Reading Rates [4]

			Readings/Sec	
NPLC [5]	Aperture	Digits	Auto-Zero Off	Auto-Zero On
0.0001	1.4 µs	4.5	100,000 [7]	4,130
0.0006	10 µs	5.5	50,000	3,150
0.01	167 µs[6]	6.5	5,300	930
0.1	1.66 ms[6]	6.5	592	245
1	16.6 ms[6]	7.5	60	29.4
10	0.166 s[6]	7.5	6	3
100		7.5	36 /min	18/min

4. For PRESET; DELAY 0; DISP OFF; OFORMAT DINT; ARANGE OFF.

   For OHMF or OCOMP ON, the maximum reading rates will be slower.
5. Ohms measurements at rates < NPLC 1 are subject to potential noise pickup. Care must be taken to provide adequate shielding and guarding to maintain measurement accuracies.
6. Aperture is selected independent of line frequency (LFREQ). These apertures are for 60 Hz NPLC values where 1 NPLC=1/ LFREQ. For 50 Hz and NPLC indicated, aperture will increase by 1.2 and reading rates will decrease by 0.833.
7. For OFORMAT SINT

Measurement Consideration

Agilent recommends the use of PTFE cable or other high impedance, low dielectric absorption cable for these measurements.

Maximum Input

	Rated Input	Non-Destructive
HI to LO	± 1000 V pk	± 1000 V pk
HI & LO Sense to LO	± 200 V pk	± 350 V pk
LO to Guard	± 200 V pk	± 350 V pk
Guard to Earth	± 500 V pk	± 1000 V pk

Temperature Coefficient (Auto-Zero off)

For a stable environment ± 1°C add the following error for AZERO OFF. (ppm of Range) /°C

Range	Error
10 Ω	50
100 Ω	50
1 kΩ	5
10 kΩ	5
100 kΩ	1

Range	Error
1 MΩ	1
10 MΩ	1
100 MΩ	10
1 GΩ	100