Calibrating the Hewlett-Packard 3458A DMM with the Fluke 5720A Multifunction Calibrator

Application Note

Meeting the challenge

The calibration support of your most accurate workload has always been a formidable task. As technical advances make it easier for manufacturers to offer products with state-of-the-art performance, the metrologist must find practical ways to support workload that often pushes the capabilities of the standards available. The test uncertainty ratios (TURs) between the unit under test (UUT) and the standards used can be lower than those recommended by industry standards and practices. Yet, no one can afford to compromise the adequacy and traceability requirements of today's quality standards.

Today's high-performance digital multimeters, like the popular $8^1/_2$ digit Hewlett-Packard 3458A, are excellent examples of such a challenging workload. This application note describes a process and procedure for fast, practical calibration using the Fluke 5720A Calibrator. Guardbanding, as proposed in draft five of ISO Guide 25, and in other technical literature, offers a technique for addressing low TURs by providing a statistical means to assure, with sufficient confidence, that a calibration is adequate and complies with the manufacturer's requirements as well as good metrology guidelines. The fact that both the 3458A and the 5720A are conservatively specified, with small deviations from specification center points, and offer quiet and repeatable performance, makes the approach outlined here possible.

Hewlett-Packard's recommended calibration procedures

Hewlett-Packard publishes two calibration procedures for the 3458A. The first is the routine calibration published in the instrument's calibration manual. It is designed to verify the meter based on its hardware design. The second procedure is used in Hewlett-Packard's service facilities, and is more rigorous from a metrology point of view. The fundamental difference between the two is that the procedure performed at HP service centers adds verification of the most accurate *synchronous sub-sample* ac voltage mode and ac current. The procedures outlined here satisfy both approaches.

The simplest way to begin the discussion is to look at the procedure form included in the HP calibration manual. An example for direct voltage tests is shown in Figure 1.

The approach is quite straightforward. A signal is applied to the 3458A inputs. To pass, its reading must not exceed the limit in called out in the "limit" columns. For most ranges and functions, the 5720A's output uncertainty is low enough to calibrate the 3458A directly. For those points that have low TURs, the guardbanding principles can help you to calculate "new" limits so that the 5720A can be used to determine with sufficient confidence if any measurement point is in- or out-of-tolerance.

Guardbanding

Discrimination

The result of any calibration step falls into one of three classes: *in tolerance*, *out of tolerance* or *indeterminate*. The first step in guardbanding is to calculate test limits that assure that most, if not all, test results accurately fall within the in-tolerance or out-of-tolerance classes.

PERFORMANCE TEST CARD - 1 YEAR LIMITS

Hewlett-Packard Model 3458A Digital Multimeter   Test Performed By ______________

Serial Number ______________   Date ________

DC VOLTAGE TESTS

CAL? 59 ________
TEMP? ________
Difference ________ - (must be less than 5 degrees C)
Perform an ACAL DCV

Test #	3458A Input	3458A Range	Transfer Standard Reading	Unit Under Test Reading	Difference	Limit (Std)	Limit (Opt 002)	Pass	Fail
OFFSET TESTS (NOTE: Math Null is Disabled)									
1	Short	100 mV	N/A	________	N/A	000.00106 mV	000.00106 mV	__	__
2	Short	1 V	N/A	________	N/A	0.00000106 V	0.00000106 V	__	__
3	Short	10 V	N/A	________	N/A	00.0000023 V	00.0000023 V	__	__
4	Short	100 V	N/A	________	N/A	000.000036 V	000.000036 V	__	__
5	Short	1000 V	N/A	________	N/A	0000.00010 V	0000.00010 V	__	__
GAIN TESTS									
1	100 mV	100 mV	________	________	________	000.00212 mV	000.00188 mV	__	__
2	1 V	1 V	________	________	________	0.00000998 V	0.00000740 V	__	__
3	1 V	10 V	________	________	________	00.0000111 V	00.0000085 V	__	__
4	-1 V	10 V	________	________	________	00.0000111 V	00.0000085 V	__	__
5	-10 V	10 V	________	________	________	00.0000892 V	00.0000624 V	__	__
6	10 V	10 V	________	________	________	00.0000892 V	00.0000624 V	__	__
7	100 V	100 V	________	________	________	000.001114 V	000.000853 V	__	__
8	1000 V	1000 V	________	________	________	0000.02396 V	0000.01934 V	__	__

Figure 1. HP 3458A Performance Test Card.

Measurement statistics

Every calibration involves a measurement. All measurements are *estimates* of the true value of the measured parameter. And all measurements are subject to error, described as *uncertainty*.

For most measurements, the errors are normally distributed, described by the familiar "bell curve." Now, let's assume that a measured value, or offset, falls exactly at the upper specification limit for this calibration point, as shown in Figure 2. Given the uncertainty of the calibration standard used, which is described by the area under the bell curve, there is a 50% probability that the *actual* value is really outside the specification for that calibration point. This is the case no matter how low the measurement uncertainty.

A 50% probability that a measurement is in tolerance offers little in the way of a definitive statement about the UUT. Figure 3 shows what happens if the measured value falls between the specification center and the specification limit. Again, the area under the bell curve represents measurement uncertainty, but in this example, only 5% of it falls to the right of the upper specification limit for the UUT. In this example, there is a 95% probability that the measurement is in tolerance.

Calculating the guardband

Guardbanding is a statistical method for setting in-tolerance and out-of-tolerance limits so that you can discriminate between them with adequate confidence when test uncertainty ratios are small. In Table 1, we've calculated in-tolerance limits by comparing the uncertainty of the calibration standard with the specifications of the UUT, then set test limits that give us a 95% probability of being within the UUT's specification limits.

You can use Equation 1 to calculate each test limit:

$$\text{TestLimit}_{\text{In Tol}} = \text{UUT}_{\text{Spec}} - \left(\frac{\text{Standard}_{\text{Spec}}}{2}\right)*1.6448$$

Equation 1. Calculating the in-tolerance test limit.

$\text{Standard}_{\text{Spec}}$ is the 5720A's specification expressed with a 95% confidence level, or two standard deviations (2σ).

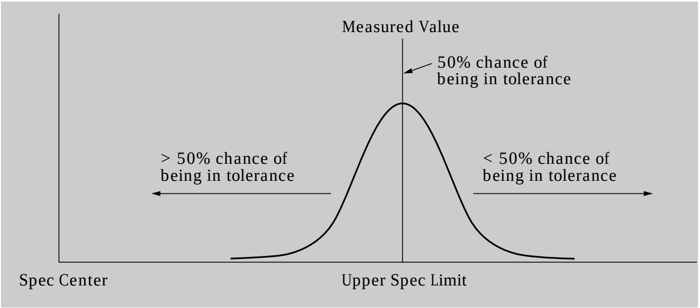

Figure 2. It is difficult to discriminate between in-tolerance and out-of-tolerance conditions when the measurement is made at the specification limit for the UUT.

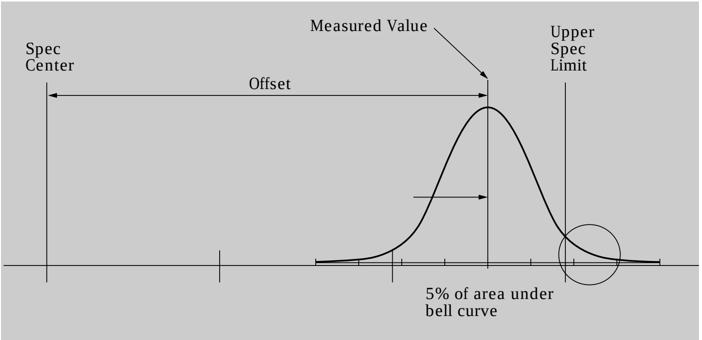

Figure 3. How guardbanding establishes a 95% confidence in-tolerance test limit.

No assumptions are made about the UUT's confidence level or measuring bias. For example, at 1V dc, the specified uncertainty for the 3458A is ±10.4 ppm, and ±4.2 ppm for the 5720A. The test uncertainty ratio is 2.4:1. Using Equation 1, we can increase the confidence of the measurement to a sufficiently high level, by testing the 3458A to a limit of ±7.0 ppm.

For test uncertainty ratios greater than 1.2:1, the error contribution is one-sided, as expressed in Equation 1. As ratios become smaller, the probability can become two sided and additional care must be taken. However, for this application, the lowest test uncertainty ratio is 1.2:1 and Equation 1 will yield sufficient confidence that a measurement is truly in or out of tolerance, without relying on an arbitrary ratio that may be both unnecessary and difficult to achieve efficiently.

Out of tolerance is defined as the test limit that provides at least a 95% probability that the UUT is outside of its specification. Calculating the out-of-tolerance limit is conceptually the same as calculating the in-tolerance limit; simply use Equation 2.

$$\text{TestLimit}_{\text{Out Tol}} = \text{UUT}_{\text{Spec}} + \left(\frac{\text{Standard}_{\text{Spec}}}{2}\right)*1.6448$$

Equation 2. Calculating the out-of-tolerance test limit.

Range	Amplitude	Specification 3458A, 1 year	Specification 5720A, 90 days	Adjustment to Test Limits	New Test Limits
220 mV	100 mV	14.65 ppm	10.00 ppm	8.22 ppm	6.43 ppm
220 mV	-100 mV	14.65 ppm	10.00 ppm	8.22 ppm	6.43 ppm
2.2 V	1 V	10.41 ppm	4.20 ppm	3.45 ppm	6.96 ppm
2.2 V	-1 V	10.41 ppm	4.20 ppm	3.45 ppm	6.96 ppm
11 V	10 V	10.13 ppm	2.75 ppm	2.26 ppm	7.87 ppm
11 V	-10 V	10.13 ppm	2.75 ppm	2.26 ppm	7.87 ppm
220 V	100 V	12.41 ppm	3.90 ppm	3.21 ppm	9.20 ppm
220 V	-100 V	12.41 ppm	3.90 ppm	3.21 ppm	9.20 ppm
1100 V	1000 V	24.18 ppm	4.90 ppm	4.03 ppm	20.15 ppm
1100 V	-1000 V	24.18 ppm	4.90 ppm	4.03 ppm	20.15 ppm

Table 1. Calculating the in-tolerance test points for direct voltage.

Calibrating the 3458A

For the most part, the 5720A provides uncertainties sufficiently low to support the 3458A to its one year specifications with reasonable test limits.

There are exceptions, however, where additional equipment is required. The specifics are determined by whether you use the calibration procedure in the calibration manual, or the procedure used in HP's service centers. Both approaches are covered here.

In this application, we use the 5720A's 90 day, 95% confidence level specifications, in accordance with internationally recognized industry practices, though higher or lower confidence levels could be used by adjusting the test limits.

Calibration according to the 3458A calibration manual

The following tables provide the in-tolerance and out-of-tolerance limits for each calibration point, calculated as described above. The Fluke 5720A can address all points directly except for ±100 µA dc, ±10 mA, and ±100 mA dc. For those points, use a 10 kΩ resistor like the Fluke 742A-10k to characterize the ±100 µA dc point. In the same way, a 10Ω 742A-10 can be used to characterize the ±10 mA dc point and a 1Ω 742A-1 can be used to characterize the ±100 mA dc point.

Perform the characterization by sourcing the current value from the 5720A into the Current terminals of the 742A. Then measure the voltage across the 742A's Sense terminals with the 3458A. Using Ohm's Law, you can calculate the actual output value:

$$\text{Current}_{\text{Actual}} = \frac{\text{VDC}_{\text{measured}}}{742\text{A}_{\Omega\text{Value}}}$$

Equation 3. Characterizing a dc current output with a standard resistor.

To perform the characterization, you can use an in-calibration 3458A or the unit under test after the dc voltage ranges have been verified. The characterization should be performed once a week.

Basic equipment requirement

The equipment required to perform the 3458A procedure called out in the HP calibration manual includes:

- Fluke 5720A Calibrator with 5700A-03 wideband ac voltage option
  - Verification of voltage, current and resistance ranges.
- Fluke 742A-1, 742A-10, and 742A-10k Resistance Standards
  - Characterization of ±100 µA dc, ±10 mA, and ±100 mA dc current outputs of the 5720A.
- Hewlett-Packard 3325A Function Generator
  - Frequency calibration. (Optional, for verifying frequency accuracy, not described in this application note.)
- Fluke 5440A-7002 Low Thermal Test Lead set
  - Connecting the calibrator, standards and unit under test.
- Copper wire
  - Offset tests.

Additional equipment to perform the HP service center procedures

To verify the functions called out in the Hewlett-Packard service center procedure, the following additional equipment is required:

- Fluke 5790A AC Measurement Standard. A 792A AC/DC Transfer Standard can be substituted.
  - Characterization of 12 aV calibration output points.

Each aV point is measured weekly with the 5790A and a correction is applied to the 5720A's output as described below.

Guardbanded test limits

Direct voltage verification

The 5720A can directly support the verification of the 3458A's direct voltage specifications. Table 2 lists each verification point and the required test limits.

Resistance verification

Likewise, the 5720A is capable of directly supporting the 3458A's resistance specifications, as shown in Table 3.

Alternating voltage verification—analog mode

When using the procedure called out in the HP 3458A calibration manual, the 5720A can directly support the analog mode alternating voltage specifications (see Table 4).

Direct Voltage (Input)	Specifications					
	3458A (1 year)	5720A (90 days, 95%)	Test Limit			
			In-tolerance		Out-of-tolerance	
				% of spec		% of spec
100 mV	14.7 ppm	10.0 ppm	6.4 ppm	44%	22.9 ppm	156%
-100 mV	14.7 ppm	10.0 ppm	6.4 ppm	44%	22.9 ppm	156%
1 V	10.4 ppm	4.2 ppm	7.0 ppm	67%	13.9 ppm	133%
-1 V	10.4 ppm	4.2 ppm	7.0 ppm	67%	13.9 ppm	133%
10 V	10.1 ppm	2.8 ppm	7.9 ppm	78%	12.4 ppm	122%
-10 V	10.1 ppm	2.8 ppm	7.9 ppm	78%	12.4 ppm	122%
100 V	12.4 ppm	3.9 ppm	9.2 ppm	74%	15.6 ppm	126%
-100 V	12.4 ppm	3.9 ppm	9.2 ppm	74%	15.6 ppm	126%
1000 V	24.2 ppm	4.9 ppm	20.2 ppm	83%	28.2 ppm	117%
-1000 V	24.2 ppm	4.9 ppm	20.2 ppm	83%	28.2 ppm	117%

Table 2. DC voltage verification points and required test limits.

Resistance (Input)	Specifications					
	3458A (1 year)	5720A (90 days, 95%)	Test Limit			
			In-tolerance		Out-of-tolerance	
				% of spec		% of spec
10 Ω	41.1 ppm	21 ppm	23.8 ppm	58%	58.3 ppm	142%
100 Ω	38.1 ppm	9 ppm	30.6 ppm	81%	45.5 ppm	119%
1 kΩ	15.4 ppm	7.5 ppm	9.2 ppm	60%	21.5 ppm	140%
10 kΩ	15.4 ppm	7.5 ppm	9.2 ppm	60%	21.5 ppm	140%
100 kΩ	15.4 ppm	9 ppm	7.9 ppm	52%	22.8 ppm	148%
1 MΩ	22.8 ppm	15 ppm	10.4 ppm	46%	35.1 ppm	154%
10 MΩ	66.7 ppm	32 ppm	40.3 ppm	61%	93.0 ppm	139%
100 MΩ	729.1 ppm	95 ppm	650.9 ppm	89%	807.2 ppm	111%

Table 3. Resistance verification points and required test limits.

Alternating Voltage (Input)	Frequency	Specifications					
		3458A (1 year)	5720A (90 days, 95%)	Test Limit			
				In-tolerance		Out-of-tolerance	
					% of spec		% of spec
100 mV	1 kHz	0.030%	0.015%	0.018%	61%	0.042%	139%
1 V	1 kHz	0.030%	0.005%	0.026%	87%	0.034%	113%
1 V	50 kHz	0.550%	0.008%	0.544%	99%	0.557%	101%
1 V	1 MHz	25.000%	0.180%	24.852%	99%	25.148%	101%
10 V	10 Hz	0.420%	0.026%	0.399%	95%	0.442%	105%
10 V	20 Hz	0.170%	0.010%	0.162%	95%	0.178%	105%
10 V	200 Hz	0.030%	0.005%	0.026%	88%	0.034%	112%
10 V	500 Hz	0.030%	0.005%	0.026%	88%	0.034%	112%
10 V	1 kHz	0.030%	0.005%	0.026%	88%	0.034%	112%
10 V	20 kHz	0.030%	0.005%	0.026%	88%	0.034%	112%
10 V	50 kHz	0.190%	0.008%	0.184%	97%	0.197%	103%
10 V	100 kHz	0.680%	0.012%	0.671%	99%	0.690%	101%
10 V	1 MHz	7.000%	0.162%	6.867%	98%	7.133%	102%
100 V	1 kHz	0.040%	0.005%	0.036%	89%	0.045%	111%
700 V	1 kHz	0.089%	0.007%	0.083%	94%	0.094%	106%

Table 4. AC voltage (analog mode) verification points and required test limits.

Alternating Voltage (Input)	Specifications						
	Frequency	3458A (1 year)	5720A (90 days, 95%)	Test Limit			
				In-tolerance		Out-of-tolerance	
					% of spec		% of spec
10 mV	1 kHz	0.032%	0.0237% *	0.0125%	39%	0.0517%	161%
10 mV	20 kHz	0.042%	0.0237% *	0.0225%	54%	0.0617%	146%
10 mV	100 kHz	0.512%	0.096%	0.433%	85%	0.591%	115%
10 mV	300 kHz	4.021%	0.190%	3.865%	96%	4.177%	104%
10 mV	1 MHz	1.25%	0.450%	0.881%	70%	1.621%	129%
100 mV	1 kHz	0.010%	0.0047% *	0.0063%	62%	0.0141%	138%
100 mV	20 kHz	0.017%	0.0047% *	0.0133%	78%	0.0211%	123%
100 mV	100 kHz	0.083%	0.0142% *	0.0715%	86%	0.0949%	114%
100 mV	300 kHz	0.311%	0.0225% *	0.2927%	94%	0.3297%	106%
100 mV	1 MHz	1.020%	0.295%	0.768%	76%	1.253%	123%
1 V	1 kHz	0.010%	0.0022% *	0.0084%	82%	0.012%	118%
1 V	20 kHz	0.017%	0.005%	0.013%	77%	0.021%	123%
1 V	50 kHz	0.033%	0.008%	0.027%	80%	0.040%	120%
1 V	100 kHz	0.083%	0.014%	0.072%	87%	0.094%	113%
1 V	300 kHz	0.311%	0.042%	0.277%	89%	0.346%	111%
1 V	500 kHz	1.011%	0.110%	0.921%	91%	1.102%	109%
1 V	1 MHz	1.011%	0.007% *	0.9536%	94%	1.0688%	106%
3 V	100 kHz	0.088%	0.016%	0.075%	85%	0.101%	115%
10 V	10 Hz	0.012%	0.008% *	0.0056%	46%	0.0188%	154%
10 V	20 Hz	0.012%	0.008% *	0.0056%	46%	0.0188%	154%
10 V	40 Hz	0.010%	0.005%	0.006%	64%	0.014%	136%
10 V	1 kHz	0.010%	0.0023% *	0.0083%	82%	0.0121%	118%
10 V	10 Hz	0.017%	0.005%	0.013%	78%	0.021%	122%
10 V	20 kHz	0.017%	0.005%	0.013%	78%	0.021%	122%
10 V	50 kHz	0.033%	0.008%	0.027%	80%	0.040%	120%
10 V	100 kHz	0.083%	0.012%	0.074%	89%	0.093%	111%
10 V	300 kHz	0.311%	0.032%	0.285%	92%	0.338%	108%
10 V	500 kHz	1.011%	0.110%	0.921%	91%	1.102%	109%
10 V	1 MHz	1.011%	0.0920% *	0.9356%	93%	1.0868%	108%
100 V	1 kHz	0.023%	0.005%	0.019%	81%	0.028%	119%
100 V	20 kHz	0.023%	0.005%	0.019%	81%	0.028%	119%
100 V	50 kHz	0.038%	0.009%	0.031%	82%	0.045%	118%
100 V	100 kHz	0.123%	0.016%	0.110%	90%	0.136%	110%
700 V	1 kHz	0.044%	0.007%	0.039%	88%	0.049%	112%

Table 5. AC voltage (synchronous sub-sample mode) verification points and required test limits.

Alternating Current (Input)	Specifications						
	Frequency	3458A (1 year)	5720A (90 days, 95%)	Test Limit			
				In-tolerance		Out-of-tolerance	
					% of spec		% of spec
10 µA	1 kHz	0.360%	0.091%	0.285%	79%	0.435%	121%
100 µA	1 kHz	0.091%	0.019%	0.075%	83%	0.106%	117%
1 mA	1 kHz	0.051%	0.015%	0.039%	76%	0.062%	124%
10 mA	1 kHz	0.051%	0.015%	0.039%	76%	0.062%	124%
100 mA	1 kHz	0.051%	0.014%	0.039%	78%	0.062%	122%
1 A	1 kHz	0.121%	0.0275%	0.098%	81%	0.144%	119%

Table 6. AC current verification points and required test limits.

Alternating voltage verification—synchronous sub-sample mode

The output uncertainties of the 5720A must be characterized at 12 points to meet the verification requirements of the 3458A's synchronous sub-sample mode. Those points are indicated with an asterisk (*) in Table 5 and are derived from a combination of the 5720A's short term stability and the 90-day uncertainty of the 5790A.

Alternating current verification

The 3458A calibration manual does not call for independent verification of the alternating current measurement ranges. They are verified in HP's service centers, and the test limits shown in Table 6 reflect those values. The 5720A is capable of supporting the 3458A's alternating current specifications directly.

Direct current verification

The direct current output uncertainties of the 5720A must be characterized at ±100 μA, ±10 mA and ±100 mA. These characterized uncertainties are listed in Table 7 and are derived from a combination of the 5720A's short term stability and the 1 year specifications of the 742A-1, 742A-10, and 742A-10k resistors and the 3458A.

The specifications were combined using the "root sum square" or "RSS" technique. Characterization is performed by sourcing the desired current value into the current inputs of the 742A, and measuring the voltage at the sense terminals of the 742A with the 3458A. The characterized value can then be calculated using Ohm's Law. (*See "Calibration according to the 3458A calibration manual" on page 4.*)

The characterization should be performed once per week. Table 8 lists the test limits based on the characterized values.

Direct Current (Output)	Calculations				
	3458A (@ 1V) (1 year)	5720A (Stability) (24 hours)	742A		Total Specification
			Value	Specification (1 year)	
100 μA	14.7 ppm	15 ppm	10 kΩ	4.4 ppm	21.4 ppm
-100 μA	14.7 ppm	15 ppm	10 kΩ	4.4 ppm	21.4 ppm
10 mA	10.4 ppm	10 ppm	10 Ω	6.8 ppm	15.9 ppm
-10 mA	10.4 ppm	10 ppm	10 Ω	6.8 ppm	15.9 ppm
100 mA	14.7 ppm	11 ppm	1 Ω	8.6 ppm	20.2 ppm
-100 mA	14.7 ppm	11 ppm	1 Ω	8.6 ppm	20.2 ppm

Table 7. Characterized dc current uncertainties.

Direct Current (Input)	Specifications					
	3458A (1 year)	Composite 742A, 3458A 5720A (Stability)	Test Limit			
			In-tolerance		Out-of-tolerance	
				% of spec		% of spec
100 μA	50.0 ppm	21.4 ppm	32.4 ppm	65%	67.6 ppm	135%
-100 μA	50.0 ppm	21.4 ppm	32.4 ppm	65%	67.6 ppm	135%
1 mA	47.0 ppm	37.0 ppm	16.6 ppm	35%	77.5 ppm	165%
-1 mA	47.0 ppm	37.0 ppm	16.6 ppm	35%	77.5 ppm	165%
10 mA	36.2 ppm	15.9 ppm	23.1 ppm	64%	49.4 ppm	136%
-10 mA	36.2 ppm	15.9 ppm	23.1 ppm	64%	49.4 ppm	136%
100 mA	51.2 ppm	20.2 ppm	34.6 ppm	68%	68 ppm	132%
-100 mA	51.2 ppm	20.2 ppm	34.6 ppm	68%	68 ppm	132%
1 A	131.2 ppm	72.0 ppm	72.0 ppm	55%	190.5 ppm	145%
-1 A	131.2 ppm	72.0 ppm	72.0 ppm	55%	190.5 ppm	145%

Table 8. DC current verification points and required test limits.

FLUKE ®

Alternating Voltage (Input)	Specifications						
				Test Limit			
	Frequency	3458A (1 year)	5720A (90 days, 95%)	In-tolerance		Out-of-tolerance	
					% of spec		% of spec
10 mV	4 MHz	7.0772%	0.6200%	6.6819%	94.4%	7.4725%	105.6%
100 mV	4 MHz	4.0772%	0.5430%	3.7310%	91.5%	4.4234%	108.5%
100 mV	8 MHz	4.0882%	0.5430%	3.7420%	91.5%	4.4344%	108.5%
100 mV	10 MHz	15.1102%	0.5430%	14.7640%	97.7%	15.4564%	102.3%
1 V	4 MHz	4.0772%	0.4903%	3.7646%	92.3%	4.3898%	107.7%
1 V	8 MHz	4.0772%	0.4903%	3.7646%	92.3%	4.3898%	107.7%
1 V	10 MHz	15.1102%	0.4903%	14.7976%	97.9%	15.4228%	102.1%
3 V	2 MHz	4.0819%	0.4168%	3.8799%	95.1%	4.2838%	104.9%
3 V	4 MHz	4.0819%	0.4168%	3.8162%	93.5%	4.3476%	106.5%
3 V	8 MHz	4.0935%	0.4168%	3.8278%	93.5%	4.3592%	106.5%
3 V	10 MHz	15.1169%	0.4168%	14.8512%	98.2%	15.3826%	101.8%

Table 9. AC voltage high frequency verification points and required test limits.

Alternating voltage—high frequency

The 5700A-03 wideband option can be used without characterization to verify the 3458A's high frequency voltage performance. See Table 9.

Automating the process

Fluke has created an automated procedure for verifying the 3458A using MET/CAL® Calibration Software. Using a personal computer with two IEEE-488 interface cards, the MET/CAL procedure tests all the functions of the 3458A (including the optional frequency tests not discussed here) using the guardbanded test limits described above. In addition, it performs the necessary characterizations using the 742A Resistors and 5790A AC Measurement Standard.

Operators have the choice of running the HP calibration manual's procedure or the full HP service center procedure.

MET/CAL dramatically reduces the time to fully verify the 3458A. After completing the ACal procedure recommended by Hewlett-Packard, MET/CAL completes the verification in approximately 30 minutes, as little as a tenth of the time compared with more conventional approaches.

This procedure has been fully approved by Hewlett-Packard and is available to all users of Fluke 5720A Calibrators at no charge.

For more information on Hewlett-Packard test and measurement products, applications or services, please call your local Hewlett-Packard sales offices. A current listing is available via Web through AccessHP at http://www.hp.com. If you do not have access to the Internet, please contact:

Hewlett-Packard Company
Test and Measurement Organization
23 Inverness Way East
Englewood, CO 80112
1-800-425-4844

Fluke. *Keeping your world up and running.*

Fluke Corporation
PO Box 9090, Everett, WA USA 98206

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
U.S.A. (800) 443-5853 or
Fax (425) 356-5116
Europe (31 40) 2 678 200 or
Fax (31 40) 2 678 222
Canada (905) 890-7600 or
Fax (905) 890-6866
Other countries (425) 356-5500 or
Fax (425) 356-5116
Web access: http://www.fluke.com

Printed in U.S.A. 1/98 A0582UEN Rev B

Printed on recycled paper.