Improving Test Ratios Using Reference Multimeters

Boosting the working accuracy of precision sources

Abstract

- Quite often when we want to calibrate 5.5 or 6.5 digit multimeters our multi-product calibrator does not always have a good enough test accuracy ratio for functions like resistance or direct voltage. This presentations discusses how we can improve the test ratios using a Reference Multimeter to ensure confident pass or fail status for the UUT.

Problem Statement

- Accepted levels of test uncertainty ratios (TURs) and test specification ratios (TSRs) have been set to various levels by different quality and calibration standards, such as 10:1 or 4:1 or 3:1.
- These levels are set as acceptable limits for calibration pass or fail decisions.
  - This minimizes the risk of incorrect decisions on marginal units under test (UUTs)
- Even when we are more concerned about measurement uncertainty, TSRs are a good indicator, rule of thumb, to see if our standard is acceptable for calibrating our UUT.
- However, there will always be instrument test requirements whose TURs are less than the required levels.
  - Calibration instruments will always have test requirements where the test requirement is for better uncertainty than the instrument capabilities alone.
  - In these cases, special metrology engineering work is done to design an acceptable test technique with appropriate levels of uncertainty.

A Case Study of Improving a TUR from 2:1

Using a multi-product calibrator to calibrate a high performance 6.5 Digital Multimeter

The calibrator:
Fluke 5520A MPC

The UUT:
Direct Voltage for a Fluke 8846A

Details of the Challenge

- Fluke 8846A has a precision dc voltage measurement capability that must be calibrated.
- The available calibrator is a 5520A Multi-Product Calibrator which for the other 8846A functions is adequate.
- Calibration points of 100 mV, 1V, 10V, 100V and 1000V are are required.
- 8846A has a specification of 24 ppm for the 10V dc range.
- 5520A has specification of 12 ppm at 10 V dc
- A test uncertainty ratio (TUR) of 2:1 (24ppm/12ppm) is not acceptable.

What enhancements can be made to improve the TUR between the calibrating standard of the 5520A and the measurement accuracy of the 8846A?

Accuracy Enhancement

Assist with a DMM because it has better dc voltage specs than the 5520A.

- Measure the 5520A calibrator with the precision DMM.
- Note the reading correction and then quickly make measurement of the same parameter with the 8846A.
- Uncertainty is based on a combination of the meter reading and calibrator stability.

Instrument Uncertainties to Consider

DC Voltage

DC Voltage [1][2][3]

Range	Full Scale	Uncertainty Relative to Cal Stds ± (ppm Reading + ppm Range) [4]			Absolute Uncertainties ± (ppm Reading + ppm Range) [4]	
		24 hour TCal ±1 °C	90 day TCal ±1 °C	365 day TCal ±1 °C	365 day TCal ±1 °C	365 day TCal ±5 °C
95 % Confidence Level						
200 mV	199.999 999	0.7 + 0.5	1.4 + 0.5	2.7 + 0.5	4.5 + 0.5	5.0 + 0.5
2 V	1.999 999 99	0.5 + 0.2	1.4 + 0.2	2.7 + 0.2	3.0 + 0.2	3.5 + 0.2
20 V	19.999 999 9	0.5 + 0.2	1.4 + 0.2	2.7 + 0.2	3.0 + 0.2	3.5 + 0.2
200 V	199.999 999	1.0 + 0.2	2.6 + 0.2	4.0 + 0.2	4.5 + 0.2	5.5 + 0.2
1000 V	1050.000 00	1.0 + 0.5	2.6 + 0.5	4.0 + 0.5	4.5 + 0.5	5.5 + 0.5

- 8508A direct voltage measurement:
  - 1 Year, 95 % confidence, Tcal ±5 ºC absolute spec
  - ± 3.5 ppm of reading + 0.2 ppm of range equals
  - At 10 V equals 3.9 ppm of uncertainty
- Short term stability of 5520A
  - Not normally specified
  - Evaluated for this case

5520A Short Term Stability Evaluation

- 5520A output set at 10 Volts
- Measurements made for three minutes
- Repeated 10 times, including operate-to-standby-to-operate transitions
- Standard deviation (σ) determined
- Measurement uncertainty
  - “Type A”
  - 2 x σ for 95 % confidence
- 2 * 0.94 = 1.9 ppm

Error Analysis

- DMM ohms readout gives 3.9 ppm
- Short term stability of the calibrator was measured to be 1.9 ppm
- Combine the errors using an RSS method results in 4.4 ppm
- This improved TUR is:
  - (24 ppm/4.4 ppm) = 5.5:1
  - a definite improvement over 2:1

Accuracy Enhancement Summary

There are several ways a high performance meter can improve a calibrator's performance.

- Calibrator disciplining through direct measurement of the output improves it up to the limit of the DMM spec plus calibrator stability.
- This example is used for the 100 mV, 1 V, 100 V and 1000 V range points.

The Value of Accuracy Enhancement

- Inadequate measurement accuracy ratios is a common situation in many labs. This can have a costly impact on test quality when incorrect “pass” decisions are made.
- A precision reference multimeter is a versatile cal lab tool that can effectively improve accuracy ratios in metrology applications where an existing precision source’s specifications fall short of the required uncertainties.
- The costs of higher accuracy sources and standards are often significantly large when merely improving existing sourcing uncertainties compared to the versatility that precision measurement offers as an addition to precision sourcing.

Questions?