uCal + Insight: Bringing Confidence to Every Calibration

Application Note / 2026-05-04

Abstract

The Maury Microwave uCal universal VNA calibration module is a complete solution for calibrating any network analyzer with consistency and confidence. Paired with Maury Insight VNA calibration and measurement software, uCal streamlines the calibration process while maintaining the highest levels of accuracy. Integrated validation and uncertainty analysis provide clear visibility into calibration quality, ensuring users not only know that their calibration is correct, but also understand how accurate and reliable it is.

Getting to Know uCal

The uCal system is an electronically controlled calibration solution designed to simplify and improve the accuracy of vector network analyzer (VNA) measurements. It employs a Short-Open-Load-Thru (SOLT) calibration methodology, with all calibration standards fully integrated within the uCal module. These standards are internally switched using high-performance electronic switching, eliminating the need for manual reconnections and significantly reducing the potential for user-induced variability.

uCal is used with Insight, which is a calibration software suite designed to enable VNA calibration, validation, and uncertainty analysis within a single platform. It provides a consistent, user-friendly interface across VNAs from different manufacturers and generations, simplifying instrument control and workflow. By consolidating calibration, measurement, uncertainty quantification, and data analysis, Insight helps users improve both the accuracy and efficiency of the measurement processes.

Available uCal Configurations

uCal modules are available with multiple connector configurations and frequency ranges to support a wide range of VNA calibration requirements. Available uCal models include:

- **UC26-35** supports measurements from 50 MHz to 26.5 GHz with 3.5mm connectors
- **UC18-7** supports measurements from 50 MHz to 18 GHz with 7mm connectors
- **UC18-N** supports measurements from 50 MHz to 18 GHz with Type N connectors

Tables 1 through 3 summarize directivity, source match, and tracking performance across the uCal modules.

UC26-35: 26.5 GHz uCal with 3.5mm Connectors

	50 MHz to 500 MHz	**0.5 GHz to 2 GHz**	**2 GHz to 20 GHz**	**20 GHz to 26.5 GHz**
Directivity	40 dB	41 dB	38 dB	38 dB
Source Match	38 dB	38 dB	38 dB	35 dB
Tracking	0.08 dB	0.08 dB	0.1 dB	0.1 dB

Table 1. Key performance metrics for the UC26-35.

UC18-7: 18 GHz uCal with 7mm Connectors

	50 MHz to 500 MHz	0.5 GHz to 2 GHz	2 GHz to 18 GHz
Directivity	40 dB	41 dB	35 dB
Source Match	38 dB	38 dB	38 dB
Tracking	0.08 dB	0.08 dB	0.1 dB

Table 2. Key performance metrics for the UC18-7.

UC18-N: 18 GHz uCal with Type N Connectors

	50 MHz to 500 MHz	0.5 GHz to 2 GHz	2 GHz to 18 GHz
Directivity	40 dB	41 dB	38 dB
Source Match	38 dB	38 dB	38 dB
Tracking	0.08 dB	0.08 dB	0.1 dB

Table 3. Key performance metrics for the UC18-N.

Calibration with uCal

Calibration Standards

Each calibration standard within the uCal—Short, Open, Load, and Thru—has been individually characterized during manufacturing.

Key specifications

Max Power: 18 dBm

Time to heat up: Prior to use, the uCal requires an initial warm-up period of approximately 10 minutes to ensure thermal stability. Once this condition is reached, the unit is ready to perform highly repeatable and accurate calibrations.

Comparison with other kits

VNA calibration is affected by sources of uncertainty such as non-linearity, VNA drift and noise, cable stability, and connection repeatability in real-world measurement environments. As a result, calibration quality is often evaluated by measuring residual errors, or the amount of error remaining in the measurement system after calibration.

Figures 1 and 2 compare residual calibration errors for polynomial SOLT, characterized SOLT, and TRL calibration techniques. The characterized SOLT results demonstrate significantly lower residual errors than polynomial SOLT while achieving performance comparable to TRL calibration. This enables fast, broadband calibrations while maintaining highly accurate measurement performance..

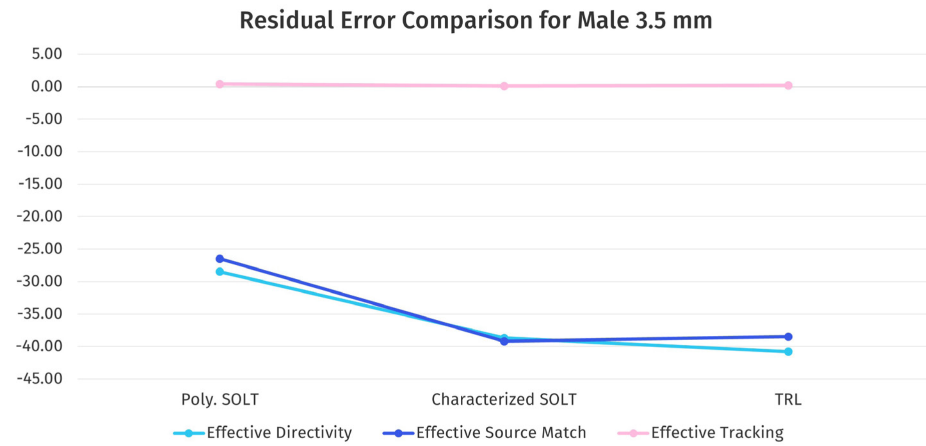


Figure 1. Comparative residual errors for Male 3.5 mm connector.

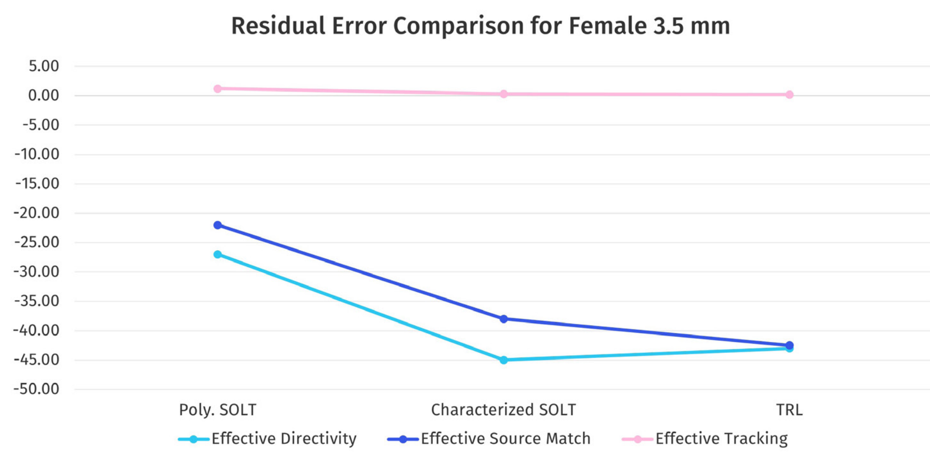


Figure 2. Comparative residual errors for Female 3.5 mm connector.

Operation

Control and operation of the uCal are managed through the Insight software platform. This software provides a unified interface for initiating calibration, communicating with both the uCal hardware and the VNA, and applying the necessary error correction algorithms. Unlike many automatic calibration modules on the market that are restricted to a specific VNA vendor or model family, the uCal system is instrument-agnostic. Through built-in drivers within the Insight software, it can interface with a wide range of VNAs from multiple manufacturers, including Copper Mountain, Agilent/Keysight, and Rohde & Schwarz. This flexibility allows the uCal to be deployed across diverse test environments without being tied to a single instrument ecosystem.

As shown in Figure 3, the uCal module connects to a host computer via a USB interface. The computer, running the Insight software, serves as the central control point for the system. Through Insight, the computer communicates with both the uCal and the VNA, coordinating the calibration process and managing data exchange between the two instruments.

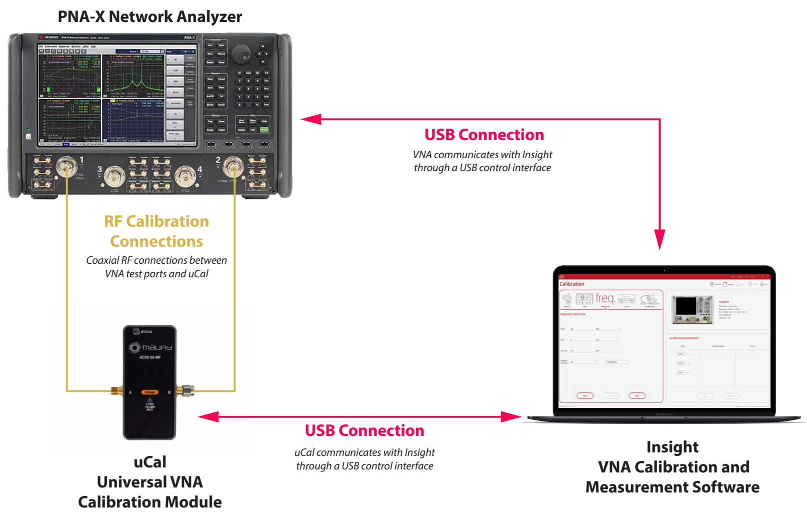


Figure 3. VNA calibration setup using uCal and Insight software for automated calibration control and measurement management.

Gaining Confidence in Calibration

In addition to the SOLT standards, the uCal includes a dedicated two-port line standard used specifically for calibration validation. This validation step is integrated into the Insight software workflow and follows the calibration process. By measuring this independent verification standard—whose S-parameters are also provided to the user—the software can assess the quality of the calibration. The validation process measures the verification standard and plots the measured response against the known reference values, allowing users to directly visualize any deviation between the measured and expected results. The software also calculates a normalized error metric to quantitatively assess calibration accuracy and provide users with confidence in the measurement setup before proceeding with device characterization, as shown in Figures 4, 5, and 6.

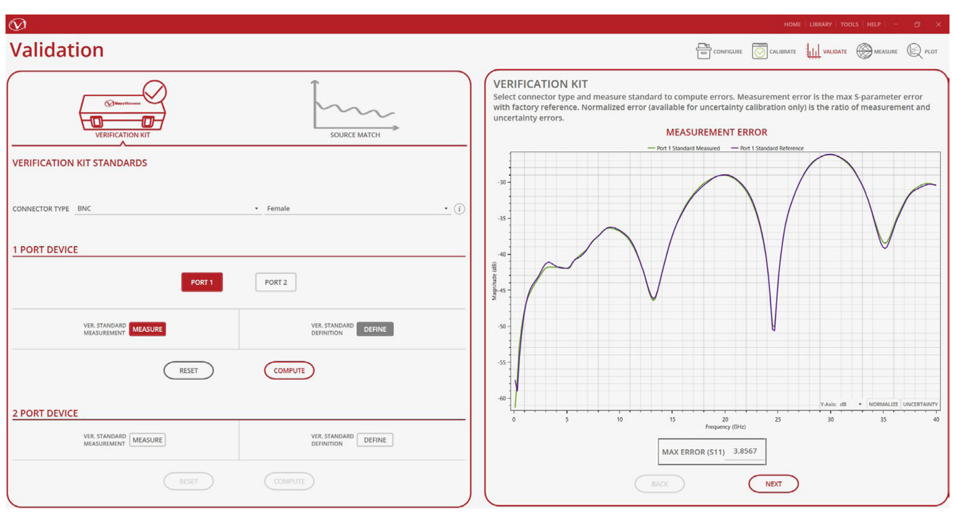


Figure 4. Insight calibration validation wizard that guides users through the validation process.

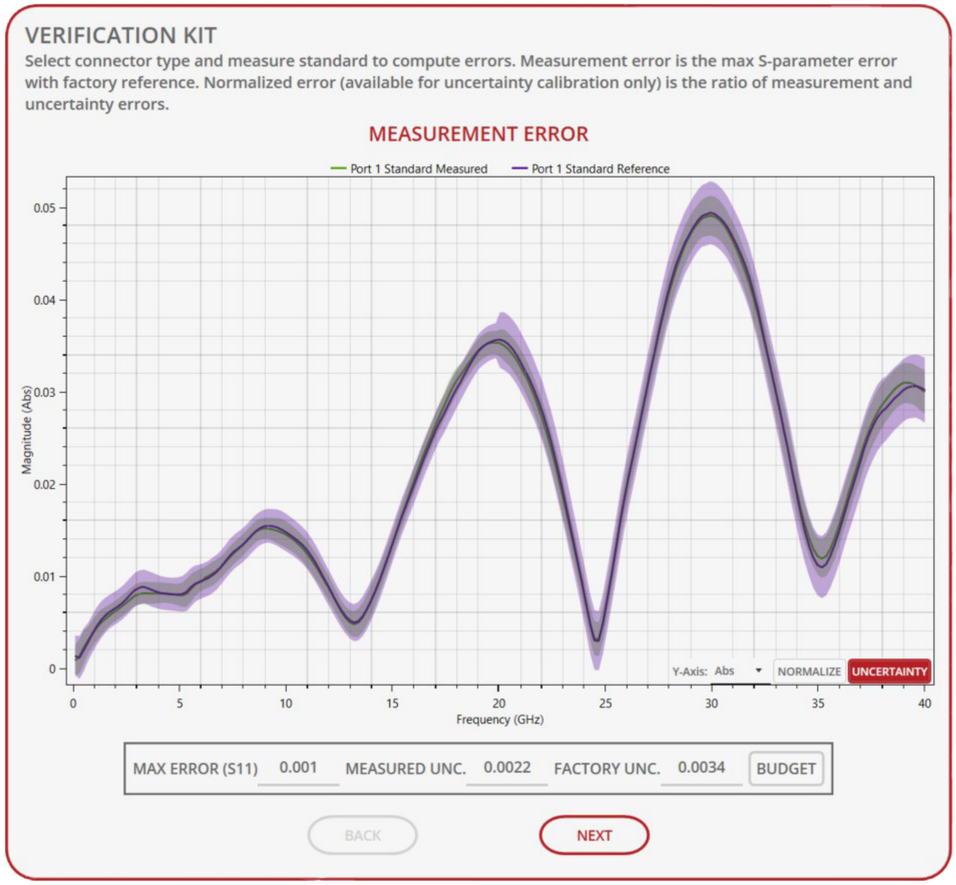


Figure 5. Uncertainty calibration validation comparing user-measured and factory-measured uncertainty boundaries.

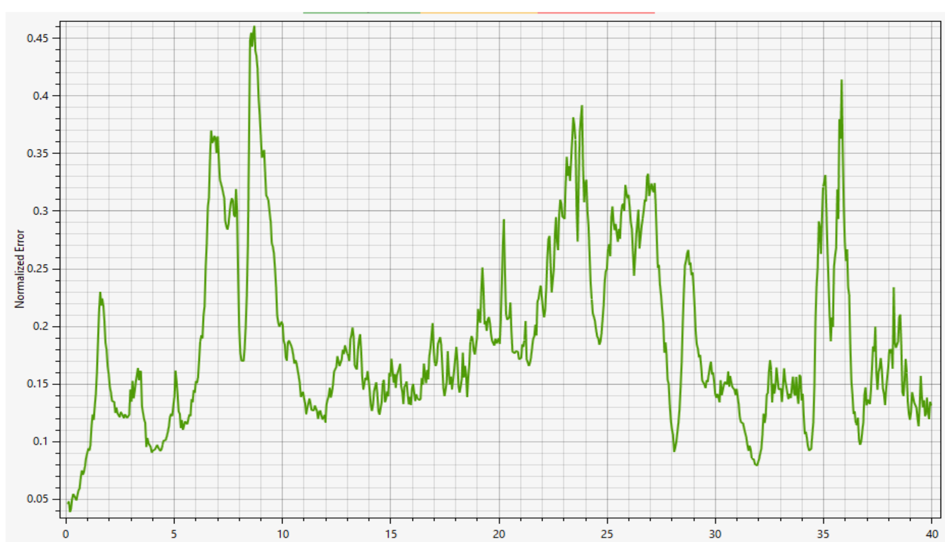


Figure 6. Final step of verification showing normalized error vs. frequency.

The normalized error (Figure 6) shows how closely our measured S_{21} values match the manufacturer's reference data when measurement uncertainty is taken into account. Instead of only looking at the raw difference between the two measurements, the normalized error compares that difference to the combined uncertainty of both measurements. A value close to 0 means very strong agreement, while a value of 1 would indicate the measurements differ by about as much as the expected uncertainty allows. Since all values in this plot remain well below 1, the results show that the measured airline data agrees well with the factory characterization across the full frequency range.

Calibrate with Uncertainties using uCal

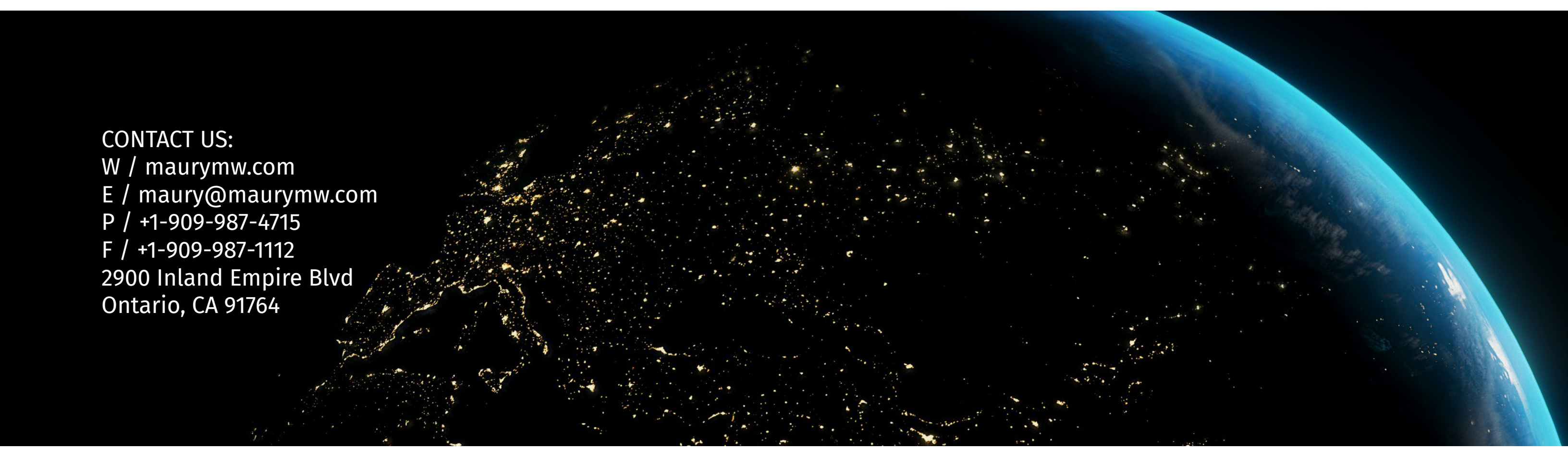
Beyond standard error correction, the uCal system enables calibration with quantified measurement uncertainty. In addition to storing the S-parameter characterization of each calibration standard, the uCal also includes associated uncertainty data for those measurements, with traceability to METAS (the Swiss Federal Institute of Metrology). This allows the calibration process to move beyond deterministic correction and incorporate a metrologically rigorous uncertainty framework.

Through the Insight software, these uncertainty contributions are combined with system-level factors to provide a more complete picture of measurement quality. Key sources of uncertainty—such as VNA drift and noise, cable transmission and reflection characteristics, and connector repeatability—are characterized for the specific measurement setup in use. Insight then propagates these contributions through the calibration and into the final measured results.

As a result, users not only achieve a calibrated measurement, but also gain quantitative insight into the confidence bounds of that measurement. This enables identification of dominant uncertainty contributors and supports informed decisions to optimize the measurement setup, ultimately improving overall accuracy and reliability (Figure 7).

Figure 7. Example measurement uncertainty plot using Insight.

Application Note / 2026-05-04



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