# Easy and accurate: analyzing measurement uncertainty using verification kits

How accurate are measurement results after a network analyzer has been calibrated? This question is not easy to answer because many factors contribute to measurement uncertainty. Rohde&Schwarz software and verification kits provide fast and reliable answers.

## How good is the calibration?

Measurement uncertainty after calibration essentially depends on the measurement accuracy of the network analyzer itself. However, the calibration kit and test cables used also have considerable influence. Users might be tempted to reconnect the same calibration standards that were just used to get information about the quality of the calibration and, consequently, the measurement accuracy. But that is not a viable approach. Not even the standards from another calibration kit can provide information about the actual measurement uncertainty. At most, they indicate if the calibration is useful. The only way to get precise information about the absolute measurement uncertainty after calibration is to analyze the measurement results obtained with verification standards, which are DUTs precisely characterized by the manufacturer.


Fig. 1 The Rohde&Schwarz T-checker makes it easy to verify the quality of a calibration.

## Verifying the effective system data with a symmetrical T-piece

The simplest method of verifying the quality of a calibration is to perform the measurement with a symmetrical T-piece, for example the Rohde&Schwarz T-checker (Fig. 1). Its S-parameters have a defined relationship to each other and are measured after the calibration using the T-checker. The evaluation shows the deviation from theoretical results and supplies information about the quality of the calibration. The T-checker is recommended for use in production or in laboratory applications with average precision requirements, because only this one standard needs to be connected. That means information about the quality of the calibration will be delivered quickly.

## When maximum accuracy is required: Rohde&Schwarz verification kits

Verification kits, which include multiple standards, deliver the most accurate results for the measurement uncertainty. Verification kits from Rohde&Schwarz contain a male and a female offset short, a male and a female mismatch, an attenuator and a stepped through. The air line, which is difficult to handle, was purposely left out. All of these calibration standards differ substantially from the conventional standards – open, short and match – because they have a different impedance, meaning they can be used as verification standards. They are measured in steps of 250 MHz and specified together with their measurement uncertainty data at the Rohde&Schwarz calibration lab, which is certified by the DAkks (Germany's national accreditation body).

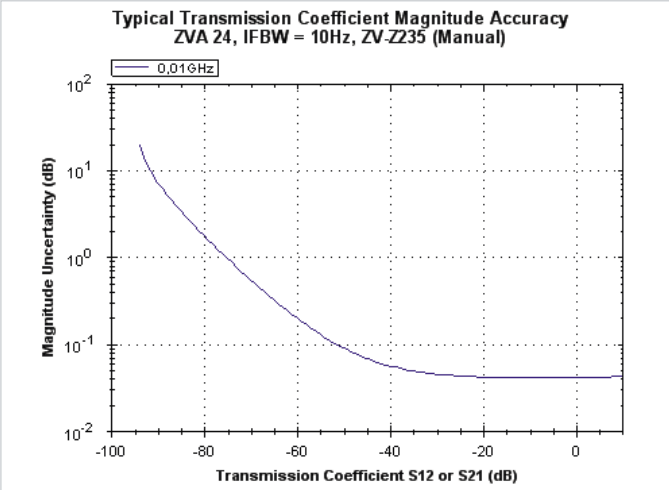


Fig. 2 The VNAMUC software calculates the theoretical measurement uncertainty.

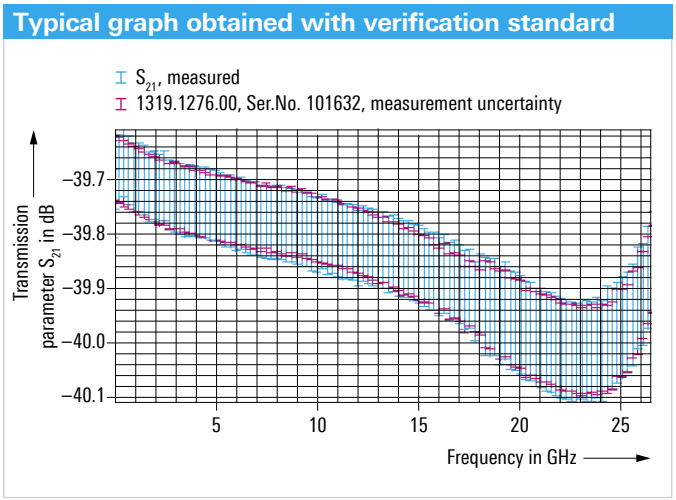


Fig. 3 Graphic display of results obtained with verification standards for a 40 dB attenuator.

## Determining the measurement uncertainty

The Rohde&Schwarz vector network analyzer measurement uncertainty calculator software (VNAMUC, Fig. 2) calculates the theoretical measurement uncertainty (without cables). The user needs to enter the type, options and settings of the Rohde&Schwarz analyzer and the calibration kit used; the software will then deliver the results and display them graphically.

In order to get precise information about the actual measurement uncertainty, the measurements must be carried out using verification standards. The results are compared with the results measured and documented at the Rohde&Schwarz calibration lab and graphically analyzed. As shown in Fig. 3, results should be within the tolerance band for the specific standard.

Presently, the Rohde&Schwarz product range includes two verification kits: the R&S®ZV-Z435 with 3.5 mm connectors for frequencies up to 26.5 GHz (Fig. 4) and the R&S®ZV-Z470 for N connectors and frequencies up to 18 GHz. Additional kits for 2.92 mm, 2.4 mm and 1.85 mm connectors will be available soon. Used together with the VNAMUC measurement uncertainty software, they are indispensable for precisely determining the measurement uncertainty and provide clear information about the accuracy of measurement results after calibration.

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Fig. 4 Standards included in the R&S®ZV-Z435 verification kit (from left): 2 × offset short, 2 × mismatch, one attenuator and one stepped through.