



VNA E-calibration has spurious structure in wideband calibration

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Modern radio astronomy receivers require accurate calibration to achieve their scientific objectives. The Experiment to Detect the Global EoR Signature (EDGES) is a radio spectrometer that aims to achieve 0.01% relative accuracy within its approximately octave bandwidth centered near 100 MHz. Measurement of the receiver 1-port reflection coefficient (S_{11}) with a Vector Network Analyser (VNA) is a key component of the calibration. Any errors in the test equipment translate directly into bias in the measured spectrum. Here, we report evidence of small but significant errors in an automated VNA electronic calibration (E-cal) compared to traditional manual calibration. In E-cal, a module containing the calibration standards (open, short, and match) is connected to the VNA. Controlled by the VNA, the module automatically switches between the calibration standards using an internal RF switch. For a case study, we compared S_{11} measurements of several general-purpose loads after calibrating the Keysight E5062A VNA with the Agilent N4431-6006 electronic calibration (E-cal) module to measurements of the same loads after manually calibrating the VNA using Agilent 85033E standard mechanical calibration kit. Fig 1. shows the measurement setup for the case study. Three sets of measurements (Tr1, Tr2, Tr3) are taken at an interval of one hour and the comparison is shown in Fig 2. The S_{11} of all three general purpose loads after the VNA is calibrated by E-cal show an underlying spectral structure, while the S_{11} of the same loads after calibrating the VNA manually are smooth and stable without any structure. The E-cal spurious structure is 0.1% for the open case reducing to 0.001% for the matched load. This structure is within the manufacturer's absolute accuracy specification of the E-cal module, but it limits relative accuracy between sampled frequencies, reducing the performance of instruments like EDGES for some use cases.

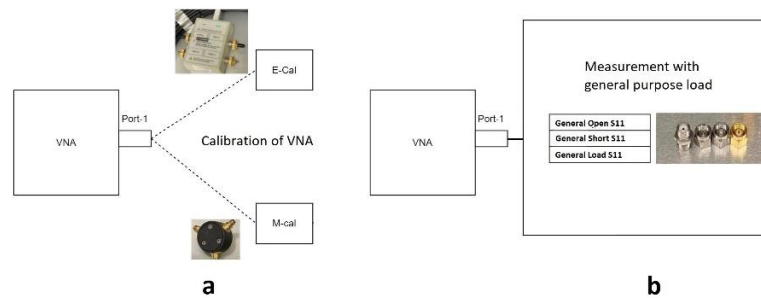


Figure 1. Notional schematics of a) VNA calibration setup using E-cal and M-cal, and b) measurement of S_{11} for general purpose open, short, and 50 Ohm load terminations.

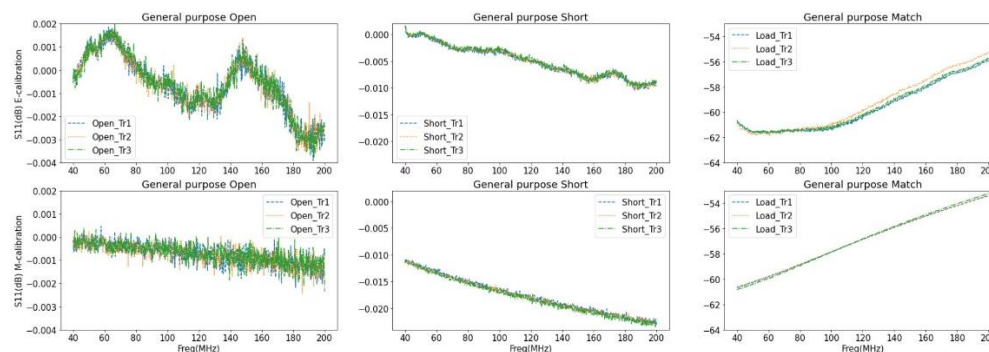


Figure 2. Comparison of three general load S_{11} after E-cal (top row) and M-cal (bottom row).