

COMPARISON OF VNA CALIBRATION TECHNIQUES BY COMPLEX S-PARAMETER MEASUREMENTS FOR COAXIAL COMPONENTS

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Abstract

For conventional network analysis, different parameters of any one-port or multi-port component can be measured at microwave frequencies using a Vector network analyzer (VNA) system by means of various calibration techniques available. In this paper, the study of various calibration techniques for VNA and the corresponding measurement practices performed have been presented for coaxial components. A program using C++ is developed to calculate the S-parameters of error box in respect to the Short-Open-Load-Thru (SOLT) and Thru- Reflect- Line (TRL) calibration techniques. A coaxial mismatch of VSWR 1.20 and a 20 dB attenuator were chosen to serve as device under test (DUT). The measured values of the standards used and DUTs have been employed in the program and then the actual S-parameters of DUTs have been calculated and compared. A comparison of the measured values of the S-parameters of the two DUTs obtained using the three calibration techniques, i.e., TRL, LRL, and SOLT techniques is also presented. This study helps in implementing a particular calibration technique for a specific application for coaxial systems.

I. Introduction

This paper presents a study of various VNA calibration techniques through the measurements of a coaxial mismatch (VSWR: 1.20) and an attenuator of 20 dB at National Physical Laboratory. A number of calibration method for VNA have been developed and studied over the decades [1,2,3,4]. A comparison between these techniques is needed for proper use based on device type, application and measurement accuracy. A few comparisons have been performed earlier, which are not so readily available in general [5,6]. The effects of deviation in the calibration standards in the measured S-parameters are also reported [7,8]. However one should have a proper knowledge and implementation of these techniques through its analysis before applying in real applications.

II. Experiment

During the exercise, three types of VNA calibration techniques were employed, namely, SOLT, TRL and LRL to measure the S-parameters of one and two-port components in Magnitude/Phase as well as in Real/Imaginary form on a Wiltron VNA 37247B. The S-parameters of the measurement standards employed in various calibration techniques were measured using the VNA. These S-parameters were then used to calculate the S-parameters of the error box for the respective calibration techniques. Using these error terms and the measured S-parameters of the respective DUT (mismatch and attenuator), the actual DUT parameters were calculated through the program codes developed in C++. The calculated DUT parameters using SOLT and TRL techniques were then compared with the measured DUT parameters over the frequency range of 2 to 18 GHz. A comparison between the three techniques is presented by means of graphs in Fig.1 and Fig.2.

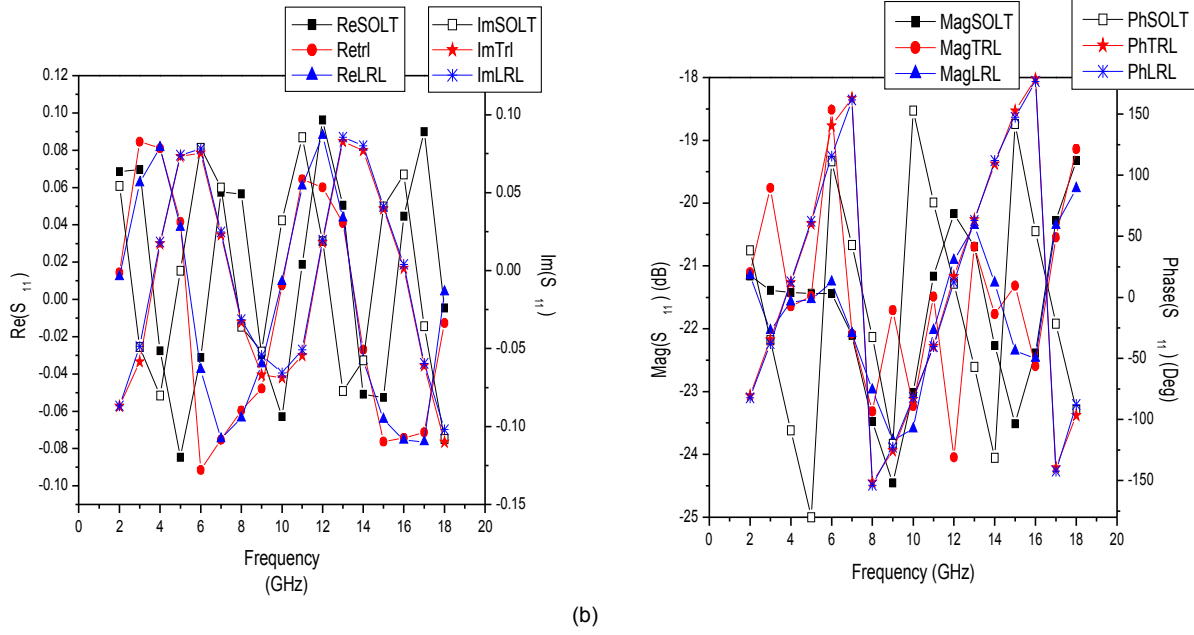


Fig.1 S_{11} of a mismatch of VSWR=1.2(a) in real-imaginary form, (b) in dB-phase form

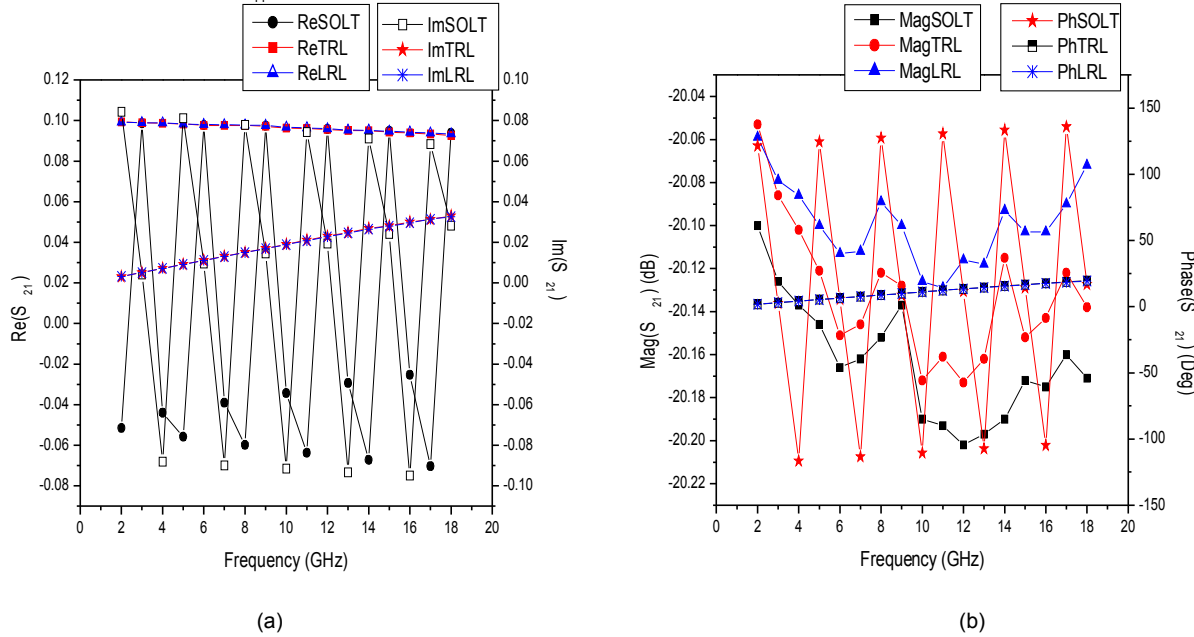


Fig 2 S_{21} of a 20 dB attenuator (a) in real-imaginary form, (b) in dB-phase form

III. Results

The S-parameter values of mismatch measured using LRL and TRL techniques are in good agreement with each other; whereas, the measured values obtained from SOLT are quite different from the other two but close to the nominal values. Therefore, TRL and LRL techniques do not find suitability in measuring S-parameter of one-port components in general. The measured S-parameters of attenuator using SOLT technique were quite different at certain frequency points from those measured using TRL and LRL techniques. The values of phase of S₂₁ measured using TRL and LRL are almost perfectly in sync with each other. The values of phase of S₂₁ measured using SOLT oscillate about the values measured using TRL/LRL acting almost as mean positions.

References:

- [1] R.A. Hackborn, An automatic network analyzer system, Microwave Journal, 11(1968) 45-52.
- [2] G.F. Engen, C.A. Hoer and R.A. Speciale, The application of 'Thru-Short –Delay' to the calibration of the dual six-port, IEEE MTT-S Int.Symp. Dig. , (1978) 184-185.
- [3] G.F. Engen and C.A. Hoer, Thru-reflect-line: An improved technique for calibrating the dual six-port automatic network analyzer, IEEE Trans. Microwave Theory tech., 27(1979) 987-993.
- [4] R.B. Marks, A multiline method of Network analyzer calibration, IEEE Trans Microwave Theory tech., 39 (1991) 1205-1215.
- [5] J.A. Reynoso-Hernandez, E. Inzunza-Gonzalez, Comparison of Irl (m), trm, trrm and tar calibration techniques using the straightforward de-embedding method, ARFTG Conference Digest, Spring (2002) 93-98
- [6] David K. Walker and Dylan F. Williams, Comparison of SOLR and TRL calibrations, NIST Publications
- [7] U. Stumper, Influence of nonideal LRL or TRL calibration elements on VNA S-parameter measurements, Advances in Radio Science, 3 (2005) 51-58.
- [8] U. Stumper, Uncertainty of VNA S-parameter measurement due to Non-ideal TRL calibration items, IEEE Trans. Instru. Meas., 54(2005) 51-58.