

Hardware Application of a Distributed Six-Port Reflectometer-Based VNA

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The Vector Network Analyzer (VNA) is the standard measurement tool used for characterizing multi-port networks. VNAs require that all ports be connected via cables to a central location (which is required to measure the phase). However, in applications where the measurement ports are far apart, such as the ports on imaging chambers used in grain storage monitoring, or communication antennas, large ships, etc., it can be a problem (e.g., cost, signal loss, and noise issues) to connect the measurement ports to a common location.

With the long term goal of making microwave imaging system data collection more reliable and affordable, we present a distributed VNA which uses two Six-Port Reflectometers (SPR) with independent RF sources to measure S-parameters without the need for cables that connect the two measurement ports, called a *distributed* SPR-based VNA. Although *non-distributed* SPR-based VNAs have been proposed in the past [C. A. Hoer, "A Network Analyzer Incorporating Two Six-Port Reflectometers," IEEE Trans Microwave Theory Tech, vol. 25, no. 12, pp. 1070–1074, 1977, doi: 10.1109/TMTT.1977.1129276], these devices still require a common RF source and cables linking the two measurement ports. While the concept of a distributed SPR-VNA was previously simulated [S. Aboud, "Six-Port Reflectometer Based Vector Network Analyzer with Two Independent RF Power Sources," University of Manitoba, 2022)], this work is the first presentation of a distributed SPR-based VNA working in practice.

We use two SPRs built using passive microwave integrated circuit components including 3dB hybrid couplers, attenuators and power dividers connected using co-planar waveguides with quasi-optimal topology. The frequency range of these SPR boards is approximately from 0.6 to 1.2 GHz. The powers at four ports of the SPRs are measured using a custom build power measurement board consisting of logarithmic voltage detectors and a four channel analog to digital converter. A micro-controller is used for I2C communication with the PC. Two bench top signal generators have been used as RF power sources.

Measurement results for the S_{21} of low-pass filter measured with a traditional lab VNA and the Distributed SPR-based VNA are shown in Fig 1. The use of two independent power sources creates additional difficulties for the distributed SPR-based VNA not seen in simulation, causing some differences between the two measurements. The causes of, and solutions to these issues will be discussed at the conference.

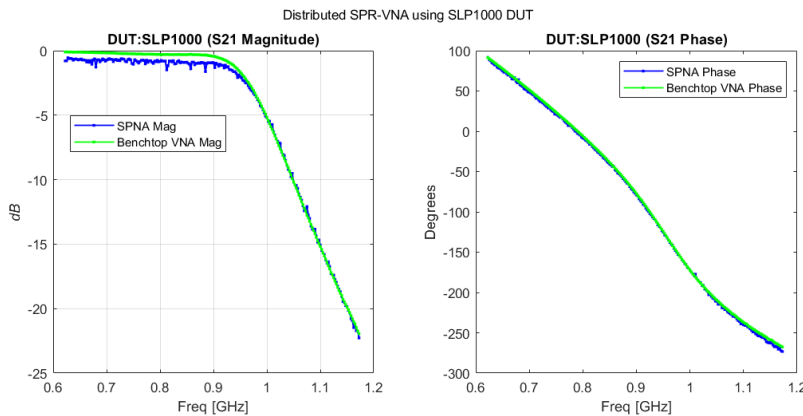


Figure 1: S_{21} of a Low Pass Filter as DUT using a distributed SPR-VNA.