# A Low Cost Scalar Network Analyzer

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Microwave measurements have been considered to be like a "black box," only possible with very expensive sophisticated equipments. In the past few years, many things have changed — global markets, the Internet, personal communications, etc. — but for most microwave engineers, measurements continue to be the same "black box." Yet, microwave devices like VCOs, detectors, power splitters, filters, etc., are both cheaper and more accessible. They may be ordered in small quantities using a credit card for payment.

So, we believe that with some sound theory and practical sense in mind, many things can now be done. In this article, a very simple and low cost scalar network analyzer (SNA) setup is presented. Although the principal application for the proposed SNA setup is a microwave classroom, it can be used in many other situations where exact numerical results are not required.

## The scalar network analyzer

The SNA has many uses throughout the microwave industry and is used to perform many tests on components and systems. It is very valuable when only the amplitude characteristics are required [1]. Depending on the device to be tested and the desired test parameters, many test setups could be presented. Figure 1 shows a block diagram for the measurement of transmission coefficient using the HP 8757D SNA.

Basically, the RF signal generated by the sweeper (S1) is divided by the power splitter in two parts, S1R and S1T. The signal S1R, after being converted by the detector to a DC signal, will be the reference (R). The S1T will reach the B input in the SNA only after traveling through the device under test (DUT). So, the ratio B/R, shown by the SNA as a function of the frequency, will be the transmission coefficient.

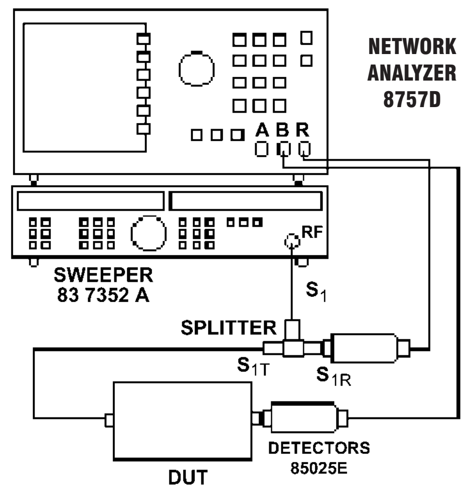
While the basic principles of the SNA are simple, when accurate measurements are required, precision components have to be used. Low VSWR detectors and high directivity bridges play a vital part in determining the overall SNA capabilities [1]. Fortunately, in microwave classrooms (and in many engineering laboratories) precision measurements are not essential.

## The proposed low cost setup

In the proposed setup the basic idea is the replacement of some parts of the system by others which are cheaper and readily available. In this setup the following substitutions are introduced:

1) The sweeper is replaced by an SP20 series VCO, from Terrasat, Inc. Provided in a metal, connectorized package, it is a robust and easy-to-use component, designed to operate as a stand alone part. The most important VCO specifications are presented in the Table 1 and the measured power and frequency are showed in Figure 2. If a non-connectorized package is used, the VCO cost can be drastically reduced.

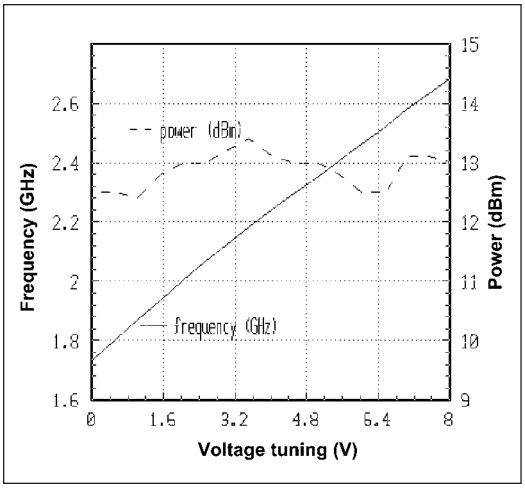
2) The detectors are replaced by DZM124NB detectors, from Herotek, Inc. Those detectors were described



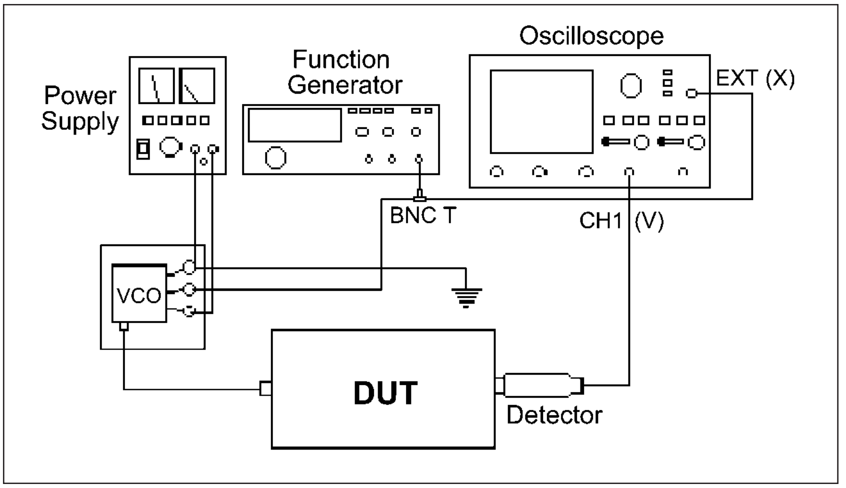

■ **Figure 1. HP 8757D SNA in a setup for measurement of transmission coefficient.**

| | |
|---|---|
| Frequency band: | 2.0 GHz to 3.5 GHz |
| Voltage tuning range: | 0.5 V to 20.0 V |
| $P_{out}$: | 13 dBm, min. |
| Supply voltage and current: | 10 to 15 VDC @ 80 mA |
| VSWR: | 2.5:1 (typical) |
| Specification temperature range: | 0° to 70° C |
| Output connector: | SMA female |

■ **Table 1. VCO specifications.**




■ **Figure 2. Plot of VCO measured power and frequency tuning characteristics.**




■ **Figure 3. Proposed SNA setup using a swept VCO.**

in a previous article [2] and their principal characteristics are presented in Table 2.

Considering the power and frequency stability, some simplifications were made — the reference signal detector and the power splitter were removed. The proposed SNA setup is presented in Figure 3. The tuning voltage and sweep signal are provided by a simple function generator with a 100 Hz sawtooth waveform. An analog oscilloscope is used as display.

## Experimental results

In order to validate the proposed SNA setup, the frequency response of a microstrip band pass filter was measured using the two SNA setups. The filter had cutoff frequencies of 1.76 GHz and 1.98 GHz. In the first measurement, using the proposed SNA setup, the frequency response presented in Figure 4 was obtained. A typical band pass characteristic may be observed. The measured result with the HP setup is showed in Figure 5 and it is similar to the presented in Figure 4. The more pronounced ripple in the band pass using the simple SNA setup may be due to two factors:

1) The different display scales. Using the detectors and oscilloscope, the amplitude scale is linear, while the HP 8757D SNA has a log scale.

2) The absence of the reference signal.

| | |
|---|---|
| Frequency range: | 0.01 to 12.4 GHz |
| Maximum VSWR: | 1.4:1 |
| Low level sensitivity: | 0.5 mV/mW |
| Maximum flatness: | ±0.5 dB |
| Connector input: | Type N male |
| Connector output: | BNC (f) |

■ **Table 2. Detector specifications.**

[*The ripple in Figure 4 appears to be about 2.5 dB, but may be much less, depending on the oscilloscope scale, DC offset and detector threshold. The ripple may also be influenced by the output impedance of the VCO. An isolating attenuator is recommended — editor.*]

## Conclusion

The proposed SNA setup gave useful results. The simplicity and low cost are relevant points. With the use of common electronic equipment, like a power supply, oscilloscope and function generator, together with an easy-to-use detector and VCO, the SNA measurement principles can be clearly understood. If a data acquisition system is included, computations would yield better results. For example, parameters such Q factor, cutoff frequencies and band pass, could be displayed without difficulty. If more accurate results are desired, a second detector may be used as a reference. Of course, many other setups are possible to make different measurements.

## Acknowledgments

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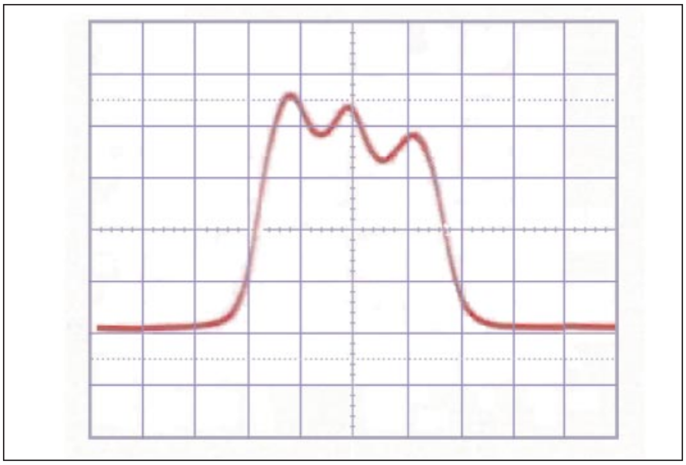
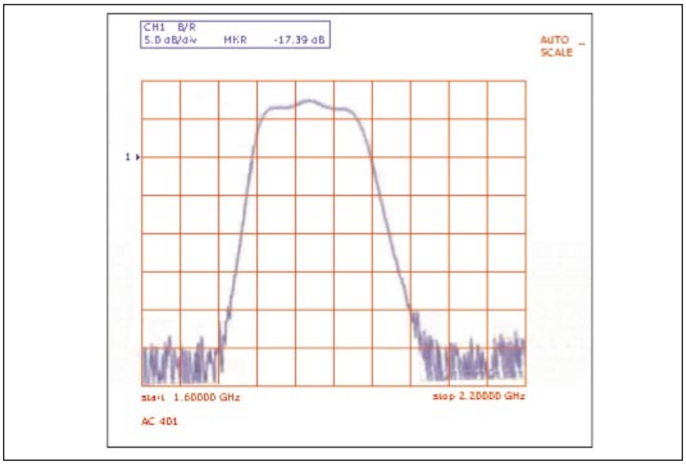


■ **Figure 4. Proposed SNA setup: microstrip band pass filter frequency response.**




■ **Figure 5. HP 8757D SNA setup: microstrip band pass filter frequency response.**

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