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A MEASUREMENT AND CALIBRATION TECHNIQUE FOR ACCURATE MEASUREMENT OF AMPLIFIER S PARAMETERS

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With the current emphasis on active systems it is becoming more important to accurately measure amplifiers. Due to the nature of current measurement systems, and the requirements of two port error correction it is difficult to measure a device which cannot be reversed. This paper describes a means for this measurement and calibration.

INTRODUCTION

Current system design requirements are causing interest in an active network's phase as well as amplitude transfer characteristics. Due to the accuracy required corrected S parameter measurements are a must. The nature of current vector network analysis and calibration make it very difficult to correct for all the errors when measuring amplifiers. This is due to the need to measure both the forward and reverse parameters to obtain a complete correction. Engineers have used various load pull approaches, techniques which measure with multiple known loads to make this measurement. These techniques have been difficult to calibrate and set up and thus see little use in volume measurements. Our technique users a four-port network analyzer, a two state unknown small reflection, and a traceable calibration approach to simplify the measurement The measurement and calibration is no more difficult than that for a passive two-port and gives equivalent accuracy.

Prior Art

Currently these measurements are performed using variations of the load pull technique as shown in Figure 1.

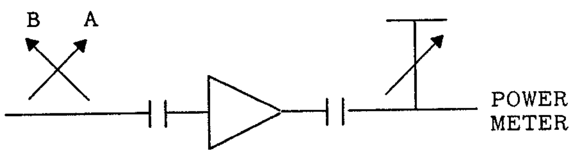

Figure 1. Load Pull Measurement

As this measurement can give exact impedances and their resulting power outputs, it is the technique of choice when designing amplifiers. However due to the time consuming nature and the difficulty of calibration, this technique is rarely used to test the resulting amplifiers.

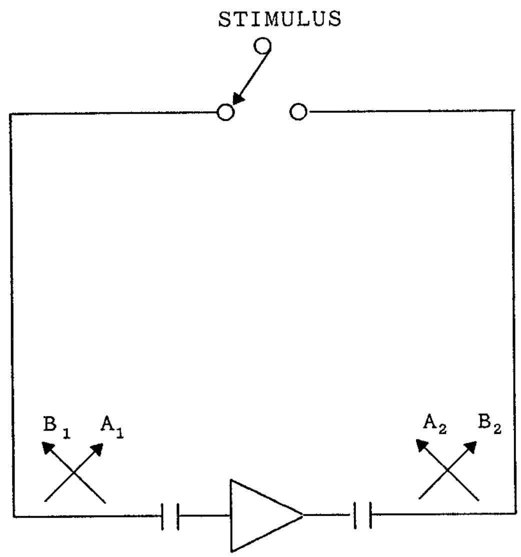

Figure 2. Standard Network Analyzer

The standard network analyzers of today (Figure 2), which require reversing the device to do a completely characterized measurement, are limited to measuring the amplifiers with only one-port correction techniques. This approach limits the accuracy of all the S parameters and gives no results for S21 or S22.

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Our Solution

By using a four-port analyzer to obtain all four wave parameters simultaneously and a bi state reflection (Fig. 3) we were able to design a system that can completely measure an amplifier at power yet is no more complex than the standard measurement. The technique involves measuring the device while terminated by two unknowns of relatively low reflection and then calculating the device's S parameters. The key to this is determining a calibration technique which retains traceability while not requiring new absolute calibration standards.

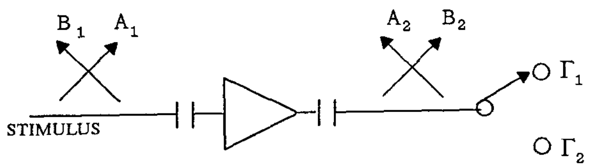
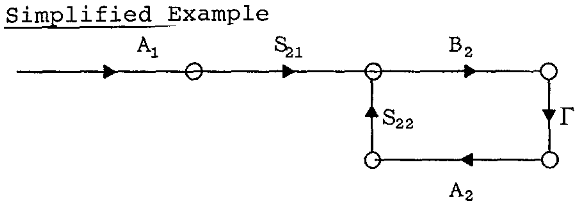


Figure 3. Proposed Technique

Simplified Example



Let $S_{21} = 10$

$S_{22} = .33$

$\Gamma = .15$

Figure 4. Example

Figure 4 shows a simplified amplifier measurement using typical state of the art values. From a simple flow graphs calculation we see that

$$S_{21_M} = \frac{B_2}{A_1} = \frac{S_{21_A}}{1 - \Gamma S_{22}}$$

Taking the worst case phasing of Γ and S22, we see that S21 = 20.45 dB S21 measurement of 1.05 dB p-p. Now if Γ has two values and A2 can also be measured then:

$$S_{21_M} = \frac{S_{21_A}}{1 - \frac{A_2}{B_2} S_{22_A}}$$

Since we have two values for the ratio $\frac{A2}{B2}$ we can solve for both S21 and S22 thus improving the accuracy of our measurement.

Calibration Technique

A major requirement was to be able to calibrate the system using current standards. This is made difficult by the lack of stimulus at port 2. Because of this, techniques which involve measuring a known 1 port and port 2 are inappropriate. We used a variation of the LRL technique (3) as it depends on line lengths as the main calibration standards. The only variation required was to replace the short on port 2 with some other transfer standard. (This step sets the reference plane of port 2). We chose a reversible mismatch for this step as it gives a high reflection at one port while still allowing stimulus to pass.

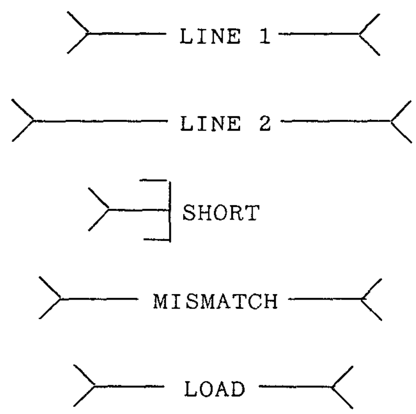


Figure 5. Calibration Standards

Bi State Load

The key microwave component for this technique is a two valued, low reflection. For best results a load with constant magnitude and a 180 degree phase shift between states was desired. The final version consists of a 5 dB pad followed by a PIN diode. Measured results are shown in Figure 6.

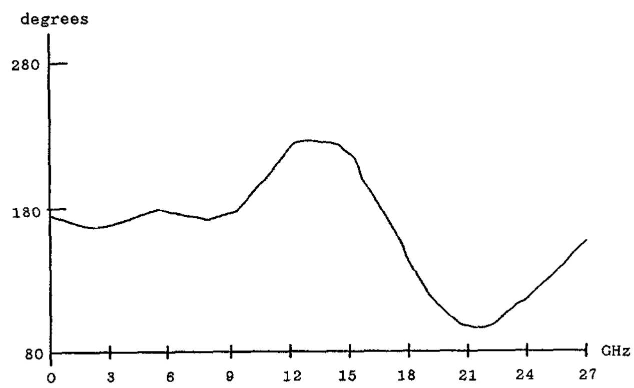


Figure 6. Delta Phase

SUMMARY

We have advanced the work of various researchers in the art of measuring devices which cannot be reversed. The technqiue is well suited for the production test of amplifier modules where S parameters at power are required. Due to the lack of constraints it is possible to make broadband corrected measurements with current measurement technology. Our contributions are in the area of measurement architecture where the implementation of a simple unidirectional measurement is novel and in the area of calibrating a system to make traceable measurements of a non-reversible device.

ACKNOWLEDGMENTS

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