AN ALTERNATIVE CALIBRATION TECHNIQUE FOR AUTOMATED NETWORK ANALYZERS WITH APPLICATION TO ADAPTER EVALUATION

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Abstract

Although conceptually straightforward, the application of existing automated network analyzers to the problem of adapter evaluation is inhibited by the limited accuracy of the detection process, the requirement for several impedance standards at each frequency, and software problems. This paper describes a simple hardware modification, which for adapter evaluation yields an order of magnitude improvement in accuracy. A alternative calibration procedure is outlined which exploits this improved accuracy potential, and which requires only one impedance standard.

Summary

Existing, commercially available, automated measurement systems are generally designed around the reflectometer concept and include a complex ratio detector as shown in figure 1. Although this suffices, in principle, for the measurement of adapter efficiency, the performance of the complex ratio detector generally falls substantially short of what is required to achieve the accuracy of existing manual methods.

At the National Bureau of Standards, the test set of figure 1 has been replaced by that shown in figure 2. The key feature is the addition of two power meters, of high accuracy, which permit a measurement of the absolute levels at the sidearms. The existing complex ratio detector is retained for phase information.

The well known relationship between the complex ratio, w, and the reflection coefficient, Γ_ℓ, at the output port is given by,

$$w = \frac{a\Gamma_\ell + b}{c\Gamma_\ell + 1} \qquad (1)$$

where a, b, c are complex constants which characterize the measurement system in figure 2. The relationship between P_3, P_4 and w may be written,

$$|w|^2 = K\frac{P_3}{P_4} \qquad (2)$$

where K is a real constant. The parameter, K, can be easily evaluated by comparing the values $|w|^2$ and P_3/P_4 for several values of w and averaging.

The evaluation of a, b, c is generally referred to as a "calibration" of the system and is basic to automated measurements. The adapter parameters can be calculated from the values a, b, c, and a', b', c', where the latter are the constants which characterize the "augmented" system which results from the addition of the adapter of interest at the output port as shown in figure 3.

Although a variety of calibration techniques are known, these were considered unsuitable either because of the number of standards required, or the error due to mathematical or other approximations.

A convenient starting point in the development of a more exact procedure is the recent work by Kasa [1]. It is well known that the locus of w in response to a moving termination is a circle. By assuming the center and radius of the circle for two such terminations, (weakly & strongly reflecting) and a single impedance standard, Kasa was able to solve for a, b, c in closed form.

The present solution is an extension of Kasa's work in that the postulate for a lossless waveguide, in which the terminations move, has been eliminated. Instead of being circular, the locus is now a "distorted" spiral. Moreover, it is no longer possible to write the solution in closed form. Instead, an iterative procedure was devised, but which converges very rapidly. The details of this solution must, due to its length, be deferred to the full-length paper to be published in conference proceedings.

As inferred above, however, the mathematical model assumed for the moving terminations is of the form,

$$\Gamma_\ell = r_s\, e^{j\phi}\, e^{(\alpha+j\beta)(\ell-\ell o)} \qquad (3)$$

where $r_s e^{j\phi}$ is the reflection coefficient of the moving element and α,β the attenuation and phase constants of the associated line. The displacement relative to an arbitrary position ℓo is measured by ℓ. With the exception of ℓ, all of the parameters are assumed constant and none of them, including ℓ, need be known except in general terms to avoid an ill-conditioned system. This means that the problem in fabricating the moving loads is primarily a mechanical rather than electrical one.

Although only a limited amount of practical expertise has been obtained with this technique, the procedure promises to become a valuable tool in the microwave art.

[1] I. Kasa, "Exact Solution of Network Analyzer Calibration and Two-Port Measurements by Sliding Termination" (Publication details pending at this time.)

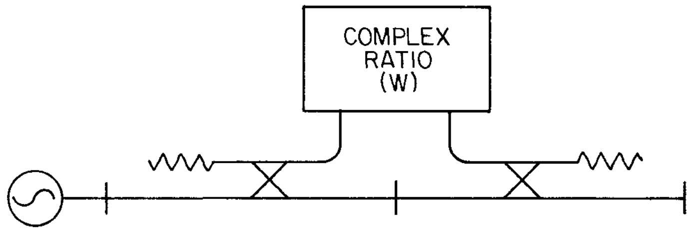

Fig. 1 Basic test set

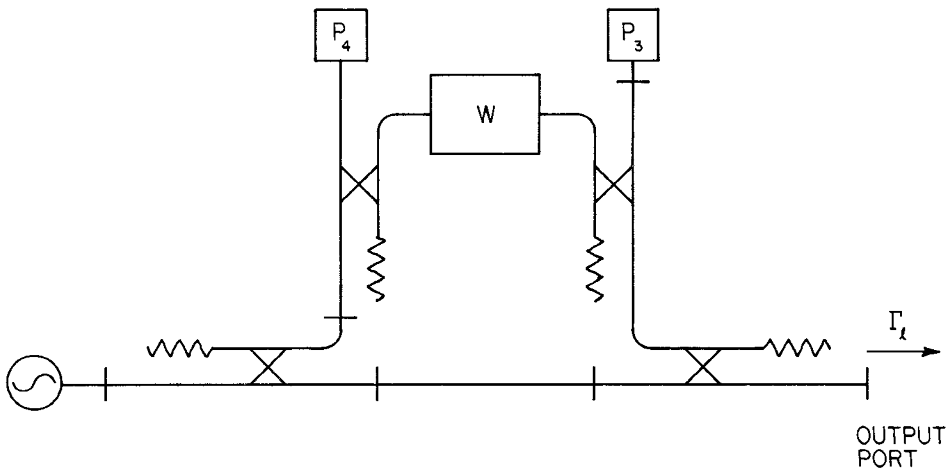

Fig. 2 Modified test set for adapter evaluation

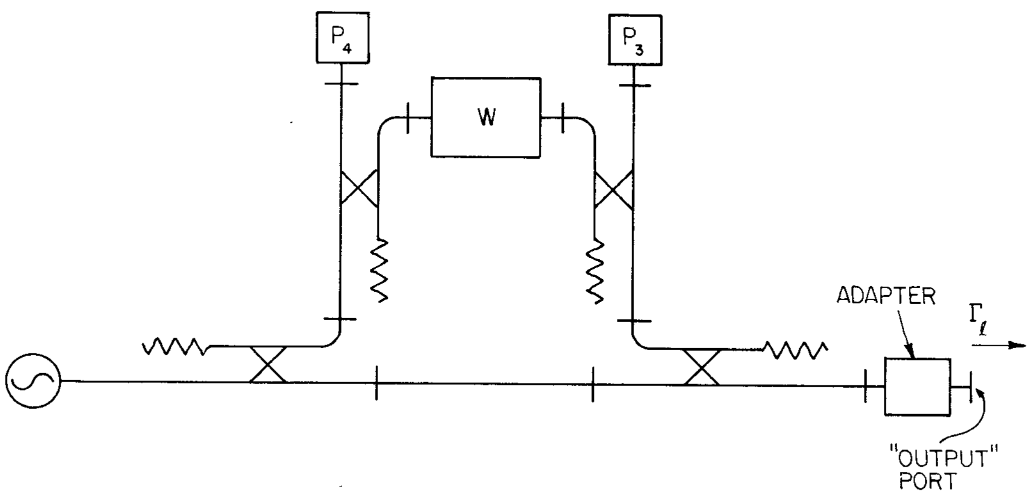

Fig. 3 Test set and adapter