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Method Free from Mismatching Errors for Measuring the Loss of Attenuators

In his recent communication,[1] Weinschel called attention to a method by Rabinovich[2] which employs two directional couplers for the measurement of the insertion loss of a microwave component. Rabinovich reports that his measurement technique results in a substantial reduction in mismatch error compared with the mismatch error which occurs with conventional attenuation measurement techniques. Specifically, Rabinovich states that a mismatch error (ΔN)

$$\Delta N = 20 \log_{10} \left| (1 - S_{22}\Gamma_l) \right| \qquad (1)$$

exists with his method, compared with a mismatch error

$$\Delta N = 20 \log_{10} \left| \frac{(1 - \Gamma_0\Gamma_1)(1 - S_{22}\Gamma_l)}{(1 - \Gamma_0\Gamma_l)} \right| \qquad (2)$$

which exists with conventional attenuation techniques.

It should be noted that (1) is based on Rabinovich's analysis of his technique with ideal couplers utilized in the measurement system. I should like to point out that if the effects of finite coupler directivity and coupler main line VSWR are considered in the analysis, the following expression for mismatch error will result:

$$\Delta N = 20 \log_{10} \left| \frac{(1 - \Gamma_g\Gamma_1)(1 - S_{22}\Gamma_l)}{(1 - \Gamma_g\Gamma_l)} \right| \qquad (3)$$

where Γ_1 is the reflection coefficient looking toward the input port of the component under test, with the output port terminated in Γ_l, Γ_0 is the generator reflection coefficient, and Γ_g is the equivalent generator coefficient[3] of coupler 1 (installed between the generator and the component under test).

Comparison of (2) and (3) reveals that the mismatch error is identical with either conventional attenuation measurement techniques or Rabinovich's technique (assuming $\Gamma_0 = \Gamma_g$, and Γ_1 and Γ_l are the same in both measurement systems). Even if the reflection coefficients are not the same, the reported method does not result in complete elimination of two of the three mismatch error terms as claimed by Rabinovich.

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Manuscript received April 7, 1964.

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[2] B. E. Rabinovitch, "Method free from mismatching errors for measuring the loss of attenuators," *Izmeritelnaya Tekh.*, pp. 44–47; March, 1962. English translation in *Meas. Tech.*, pp. 238–243; September, 1962.
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Microwave and High-Frequency Calibration Services of the National Bureau of Standards

INTRODUCTION

Calibration services in the microwave and high-frequency regions available from the National Bureau of Standards presently extend in frequency from approximately 30 kHz to 26.5 GHz.[1] These services include most of the usual electrical quantities of interest in precision measurements with limitations in frequency range, magnitude of quantity, and accuracy of calibration.

The calibration services listed are excerpted from NBS Miscellaneous Publication 250 which was issued November 22, 1963. This document contains reprints from the Federal Register, as well as other information and is for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. The price is 70 cents.

Because the listing of calibration services in the microwave and high-frequency regions is too lengthy to be included in one issue of the TRANSACTIONS, the services will be published in parts for the next several issues. Included below are the calibration services for the measurement of CW power and effective noise temperature. In subsequent issues of the TRANSACTIONS the services for

1) attenuation and field strength,
2) reflection coefficient and immittance, and
3) voltmeters and signal generators will be presented.

In the listing of services, a number appears under the heading "Item" which identifies the specific calibration to be performed. It is desirable to use these numbers when requesting or referring to the specific calibration services. A description of the calibration to be performed is given. For the calibration services listed, a preliminary letter, stating clearly the calibrations desired, should be sent to the Engineering Division, Radio Standards Laboratory, National Bureau of Standards, Boulder, Colo. 80201, prior to shipment of interlaboratory standards, to determine if and when the requested calibrations can be made. A formal purchase order covering the calibrations to be performed should accompany or precede the shipment of interlaboratory standards. The time for completion of a calibration in this listing of regularly scheduled services usually is one month after receipt of an acceptable interlaboratory standard and a valid purchase order.

Following the listing of calibration services is a series of charts indicating the magnitudes of quantities, the frequency range, and the over-all estimated accuracy of calibrations performed.

Some of the calibration techniques and systems used in performing the listed services have been reported in more detail in the literature,[2] and an indication of present developments and future plans also have been made.[3,4] The announcement of calibration services for microwave power[5,6] and noise[7] have appeared in the *NBS Technical News Bulletin*. Also, the calibration services available from the Boulder Laboratories of the National Bureau of Standards have been presented in a brochure which is available free upon request. It may be obtained from the Office of the Coordinator, Calibration Services, National Bureau of Standards Boulder, Colo. 80301.

MICROWAVE REGION

201.900 *General*

1) Microwave calibration services presently available include measurements in power, impedance, frequency, attenuation, and noise. The frequency range covered for each of the measurements is given below.

In performing microwave calibrations, a considerable amount of time usually is needed to prepare the system for measurement operation. Much of this preparation is related to the adjustment of the system to the frequency of operation selected for the calibration. Time and cost often can be reduced by minimizing the number of times the operating frequency of the calibration system must be readjusted. To help in achieving this reduction in costs, a list of suggested calibration frequencies is presented in the following table. These frequencies are suggested for use in connection with this schedule and for interlaboratory standards utilizing terminations consisting of the standard waveguide sizes given below

Manuscript received April 20, 1964.

[1] *Note:* Although low-frequency (dc) calibration services are not included here, many services in this frequency area are available from NBS at both Washington, D. C., and Boulder, Colorado.

[2] R. E. Larson, "Microwave measurements in the NBS electronic calibration center," *Proc. IEE*, vol. 109, pt. B, Suppl. No. 23, pp. 644–650; 1962.
[3] R. C. Powell, "Current Developments in High-Frequency Calibration Services," NBS Misc. Publ. 248, pp. 45–48; August 16, 1963, for sale by Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., 20402. Price $1.75.
[4] R. E. Larson, "Development of Improved Microwave Calibration Systems," NBS Misc. Publ. 248, pp. 49–54; August 16, 1963.*
[5] "Waveguide power calibration service," *NBS Tech. News Bull.*, vol. 47, p. 31; February, 1963.
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