AUTOMATED CALIBRATION OF
DIRECTIONAL-COUPLER-BOLOMETER-MOUNT ASSEMBLIES

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ABSTRACT

Although the application of automated methods to power calibration problems in the UHF and microwave region has been described by a number of authors, the primary orientation has been towards the calibration of bolometer mounts and similar items. Little has been published on the problem of calibrating directional-coupler-bolometer-mount assemblies, which also play a major role in the calibration and measurement of UHF and microwave power.

This paper describes several approaches to this measurement problem.

INTRODUCTION

Microwave power calibrations tend to center around devices of two basic types. The first is the terminating power meter, a common example of which is the bolometer or thermistor. The second basic device is the feed-through power meter which often takes the form of a directional coupler with a power meter (frequently of the bolometric type) attached to its sidearm. Although a number of authors [1,2,3] have described the application of automated techniques to the calibration of bolometer mounts, little has been done in the area of automating the calibration of directional-coupler-bolometer-mount (DCBM) assemblies. It is to this problem that this paper addresses itself.

In the prior and perhaps existing art as well, the measurand of greatest interest for a DCBM is the "cal factor" which is defined as the ratio between the net power delivered to a non-reflecting load at the coupler output port, to the indicated sidearm power,[1] P_b. A more recently proposed measurand, K_A, is defined as the ratio of the available power at the output port to P_b.

The proposed measurement technique calls for comparing P_b with the net (or incident) power into three or more suitably chosen main arm terminations. It is convenient to view the procedure in the context of using the DCBM in an amplitude stabilization or leveling loop as shown in figure 1. The reflection coefficient, Γ_g, of the equivalent generator, which thus obtains, is determined solely by the coupler parameters [4], while the available power, P_g, is proportional to the power level, P_b, at which the sidearm is stabilized. The proportionality factor, by definition, is equal to K_A, while the "cal factor," K_C, is given by $K_C = K_A(1-|\Gamma_g|^2)$.

THEORY

The proposed procedures are based on the well known equation,

$$P_{net} = P_g \frac{(1-|\Gamma_g|^2)(1-|\Gamma_\ell|^2)}{|1-\Gamma_g\Gamma_\ell|^2}, \qquad (1)$$

or alternatively,

$$P_{inc} = \frac{P_g(1-|\Gamma_g|^2)}{|1-\Gamma_g\Gamma_\ell|^2}. \qquad (2)$$

Here P_{net} and P_{inc} are the net and incident powers to the load of reflection Γ_ℓ. Equation (2) continues to be useful when $|\Gamma_\ell| = 1$ (e.g., a sliding short). In terms of K_A and K_C, (1) and (2) may be written,

$$\frac{P_{net}}{P_b} = \frac{K_A(1-|\Gamma_g|^2)(1-|\Gamma_\ell|^2)}{|1-\Gamma_g\Gamma_\ell|^2} \qquad (3)$$

and

$$\frac{P_{inc}}{P_b} = \frac{K_C}{|1-\Gamma_g\Gamma_\ell|^2} \qquad (4)$$

[1] The reciprocal of this definition is also in use.

In applying (3) or (4) to figure 1, the ratio of P_{net} (or P_{inc}) to P_b and Γ_ℓ are assumed to be known; the three parameters to be determined are K_A (or K_C) and the real and imaginary parts of Γ_g. This calls for three different terminations which yields three sets of values for Γ_ℓ and P_{net} (or P_{inc}). Substitution of these values in (3) or (4) leads to three simultaneous quadratic equations. Fortunately, only two sets of roots are possible, and if the Γ_ℓ are properly chosen, it is easy to eliminate one set of roots on the basis $|\Gamma_g| \leq 1$ or $K_A > 0$. In practice it is anticipated that one would use more than three terminations; here an iterative solution using a least squares fit is convenient.

It remains to consider the determination of P_{net} (or P_{inc}) and Γ_ℓ at the coupler output port. This is conveniently done by a small modification of the existing automated methods for characterizing bolometer mounts. In one version, shown in figure 2, the directional coupler under calibration is regarded as merely an extension of the output port of the existing "test set," at which both power and impedance may be measured. By performing the calibration procedure associated with the automated measurement system <u>at the output port of the coupler whose calibration is required</u> rather than at the output port of the test set, a direct means of measuring P_{net} and Γ_ℓ is realized.

One such calibration scheme, which is growing in popularity at the National Bureau of Standards, calls for a power standard, impedance standard (flat short), a weakly reflecting sliding termination, and a strongly reflecting sliding termination [5]. Unfortunately, this entire routine must be repeated for each DCBM whose calibration is required. Provided, however, one is willing to settle for K_A, rather than K_C, a simplified procedure is possible which requires only the power standard and a sliding short.

In another alternative mode, the coupler output port is connected to the output port of the test set, as shown in figure 3, and the coupler input port is terminated by a variable load (probably a sliding-short). With suitable reinterpretation, (3) and (4) may be applied to this mode of operation as well. This mode also has the advantage of requiring less operator effort, but places more stringent demands upon the accuracy of the automated measurement system. A definitive choice among the several methods awaits an experimental evaluation which has not been completed at this writing.

CONCLUSION

This paper describes several different possible approaches to the problem of calibrating a DCBM. As compared with the calibration of a bolometer mount, the proposed procedures are substantially more complex, but this unfortunately appears unavoidable. Because of space limitations, a more complete exposition of the theory must await publication in the conference proceedings.

ACKNOWLEDGMENT

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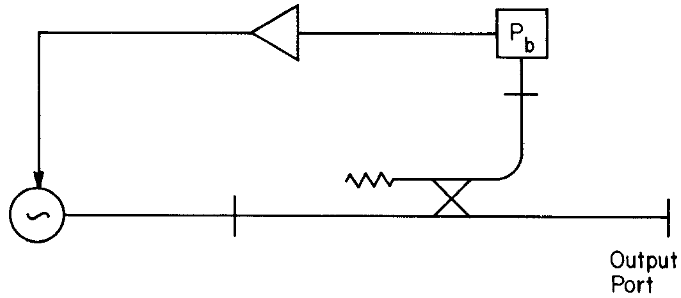

Figure 1. Basic Circuit for Discussion of Calibration Problem.

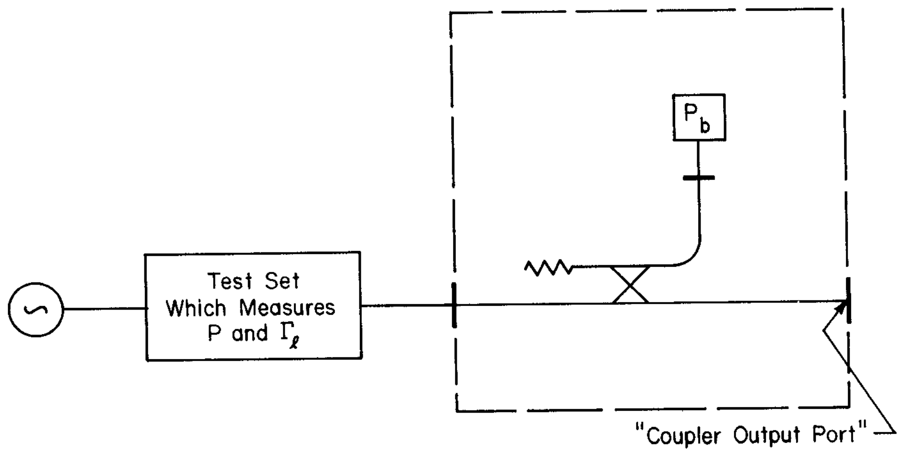

Figure 2. Illustration of Proposed Measurement Procedure.

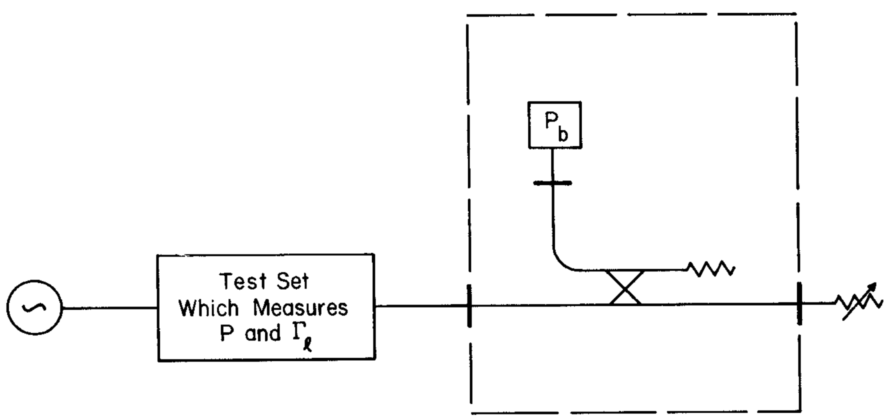

Figure 3. Illustration of an Alternative Measurement Procedure.