## Measurements of Intercavity Couplings

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The concept of determining intercavity couplings from frequency measurements used in the short paper by Atia and Williams [1] was described for the case of coupling between two cavities in [2], which was referred to and portions summarized in [3]. A variation of that technique which the author has found useful for rapidly measuring the coupling between adjacent resonators in VHF filters is as follows.

When a small probe or loop is inserted into one cavity of a coupled cavity pair, with all external loading removed and any other coupled cavities detuned, the probe impedance locus is as shown in Fig. 1, provided that the coefficient of coupling $K$ (or $M_{12}$) is greater than $1/Q_{II}$ where $Q_{II}$ is the unloaded $Q$ of the second cavity [2]. In Fig. 1 the circle represents the outer limits of the Smith Chart and the straight line represents the resistive axis. Depending on whether a probe or loop is used, the locus goes to either an open circuit or short circuit off resonance.

The coefficient of coupling $K$ or $M_{12}$ is given by

$$K = \left[\left(\frac{\delta f_K}{f_0}\right)^2 + \left(\frac{1}{Q_{II}}\right)^2\right]^{1/2} \tag{1}$$

where $\delta f_K$ is the difference between the frequencies at which the locus passes through the common point $T$, and $f_0$ is the center or cavity-resonant frequency [2]. The effect of varying the probe or loop insertion is to change the reference impedance level, and it is possible to make the crossover point $T$ as viewed on a network analyzer coincide with the center of the Smith Chart (perfect match). Therefore a simple reflection coefficient bridge can be used instead of a network analyzer, and the probe or loop coupling adjusted for a swept frequency bridge output display as shown in Fig. 2.

A measurement of the frequency separation between the two cases of perfect match (zero bridge output) gives $\delta f_K$. Usually $Q_{II}$ is known approximately but its effect on the calculation of $K$ from (1) is small. For example, even neglecting the contribution of $Q_{II}$ completely by use of the approximation

$$K = M_{12} \approx \frac{\delta f_K}{f_0}$$

gives less than 2-percent error if $K > 5/Q_{II}$.

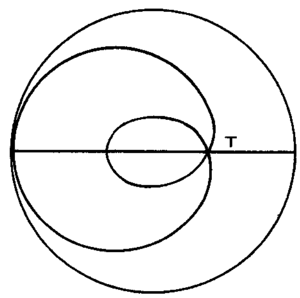


Fig. 1. Impedance locus.

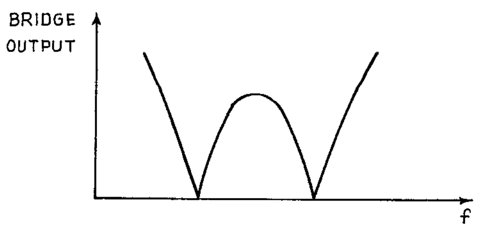


Fig. 2. Swept frequency bridge output.

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### REFERENCES


[1] A. E. Atia and A. E. Williams, "Measurements of intercavity couplings," *IEEE Trans. Microwave Theory Tech.* (Short Papers), vol. MTT-23 pp. 519–522, June 1975.

[2] N. A. McDonald, "Electromagnetic coupling through small apertures," Elec. Eng. Dep., Univ. Toronto, Toronto, Ont., Canada, Res. Rep. 45, 1971.

[3] ——, "Electric and magnetic coupling through small apertures in shield walls of any thickness," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-20, pp. 689–695, Oct. 1972.


## Correction to "Temperature-Stabilized 1.7-GHz Broad-Band Lumped-Element Circulator"

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In the above paper,[1] on page 691, from the duality relationship [1], (12) and (13) should read

$$\mu_{\pm \mathrm{eff}} = \frac{r}{1 - q_m + \dfrac{q_m}{\mu_\pm}} + \frac{1-r}{1 - q_m + \dfrac{q_m}{\mu}}$$

$$\mu_{i\ \mathrm{eff}} = \frac{1}{1 - q_m + \dfrac{q_m}{\mu}}.$$

Nonreciprocal filling factor $k_f$, which is given by ratio of $(\mu_{+\mathrm{eff}} - \mu_{-\mathrm{eff}})/(\mu_+ - \mu_-)$, becomes

$$k_f = \frac{q_m r}{1 + \dfrac{2\sigma P(1-q_m)}{\sigma^2 - 1} + \dfrac{P^2(1-q_m)^2}{\sigma^2 - 1}}.$$

However, it can be assumed in the usual below-resonance circulators that $\sigma \approx 0$ and $P(1 - q_m) < 1$. Thus (7) and (14) hold as the following approximate equations:

$$k_f \approx q_m r$$

$$\mu_{\pm \mathrm{eff}} \approx 1 \mp k_f P.$$

In the above paper,[1] on page 690 in (3), capacitance $12C_c$ should

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[1] H. Katoh, *IEEE Trans. Microwave Theory Tech.*, vol. MTT-23, pp. 689–696, Aug. 1975.