Letters

Comments on "Spectral Domain Analysis of an Elliptical Microstrip Ring Resonator"

W. C. CHEW

Along with the above paper,[1] several other papers have been published recently by Sharma and his co-workers [2]–[3] on the analysis of the resonant frequencies of a microstrip disk using the quasi-static approach. The quasi-static approach has been proven to be incorrect in [4] and [5]. The quasi-static argument on the correction to the resonant frequencies of a microstrip disk is based on some intuitive arguments that are not rigorous. The only thing it predicts correctly is that the resonant frequencies of a microstrip disk should decrease compared to that of a magnetic-wall model. The author may argue that since the correction to the magnetic-wall model is small, any approximate method is viable. However, we have found that the quasi-static correction could be as much as 50 percent in error. Even when this correction is small, if we bother to calculate it, I think we should calculate it correctly.

The author's quasi-static correction has a new twist compared to earlier authors, but when $\epsilon_r = 1$, it does not differ from the quasi-static correction of earlier work.

Reply[2] by Arvind K. Sharma[3]

A procedure for the evaluation of resonant frequency of a microstrip resonant structure has been presented in the above paper[1] and in the related papers [2] and [3]. The approach consists of utilizing the quasi-static capacitance of the structure to quantitatively assess the effect of fringing of fields associated with the structure. The resonant frequency is then evaluated taking into account the effective structural parameters and effective dielectric constant. This is further verified with the experiment to assess the validity of the procedure. This approach has been utilized, in the past, to analyze other geometrical shapes [6]–[10].

Of course, it will be useful to have an accurate description of the effect of fringing of fields. It can be accomplished only through a rigorous full-wave analytical solution. But, for microstrip resonant structures of complex geometrical shapes, it is tedious and the numerical evaluation is extremely time consuming.

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[1]A. K. Sharma, *IEEE Trans. Microwave Theory Tech.*, vol. MTT-32, pp. 212–218, Feb. 1984.
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[2]Manuscript received October 29, 1985.
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On the other hand, the procedure described in the above paper[1] is relatively straight forward and simple to implement. Also, it can easily be incorporated in CAD programs, such as MIDAS [11]. In any case, since the theoretical resonant frequency is in good agreement (typically within ± 2 percent) with the experiments, the results can be used with confidence.

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Comments on "The Hybrid-Mode Analysis of Coupled Microstrip-Slot Resonators"

P. PRIBETICH AND P. KENNIS

We were interested to read the above paper,[1] but it calls for a remark concerning the extension of the hybrid-mode analysis to coupled microstrip-slot resonator. In fact, when the coupled strips are very close to each other, the basis functions used in the above paper does not allow one to obtain a satisfactory resonant

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[1]K. Kawano, *IEEE Trans. Microwave Theory Tech*, vol. MTT-33, pp. 38–43, Jan. 1985.

frequency. To do so, we must necessarily increase the number of basis function by using symmetric and antisymmetric basis functions with respect to the axis of a strip [1]. In this case, we must be sure that the criterion of relative convergence is satisfied [2]. Furthermore, the mathematical developments of this hybrid-mode analysis have been already published by the same author [3]. So it would have been better to focus the purpose of the above paper on the problem more specific to the coupling of the two strips.

Reply[2] *by Kenji Kawano*[3]

The comments by Pribetich and Kennis on the above paper[1] are appreciated. I knew that the computed results were affected by the choice of basis functions, i.e., their functional characteristics and number as reported in the papers referenced by them and a number of other references (e.g., [1], [2], [4]–[6]). Since the separation between two microstrips is small (as Pribetich and Kennis point out), field distributions may differ from those for a large separation case. Thus, a more suitable basis function for the current density distribution needs to be selected.

However, it should be noted that increasing the number of basis functions sometimes causes erroneous results in the Galerkin's method. The stability of the numerical results is not always secured in the mathematical sense when the number of basis functions is increased [7]–[9]. The resulting numerical convergence may be disturbed if inadequate basis functions are assumed in the direction in which the actual components are very small. To illustrate this problem, theoretical and experimental results regarding the effective dielectric constant for the microstrip line on a high-dielectric substrate are represented in Fig. 1. Here, the microstrip width, $2w$, was 135 μm, and the dielectric constant and thickness of the substrate were 39 and 1.94 mm. Experimental results were obtained using the microstrip ring resonator technique [10]. The numerical results were based on the spectral-domain approach, where the basis functions used in the computation were

$$\text{Set A:} \begin{cases} J_{x1}(x) = 0 \\ J_{z1}(x) = f(x) \end{cases} \tag{1}$$

$$\text{Set B:} \begin{cases} J_{x1}(x) = 0 \\ J_{z1}(x) = g(x) \end{cases} \tag{2}$$

$$\text{Set C:} \begin{cases} J_{x1}(x) = h(x) \\ J_{z1}(x) = f(x) \end{cases}. \tag{3}$$

Here

$$f(x) = \begin{cases} \dfrac{1}{2w}\left(1+\left|\dfrac{x}{w}\right|^3\right), & \text{for } |x|<w \\ 0, & \text{for } |x|>w \end{cases} \tag{4}$$

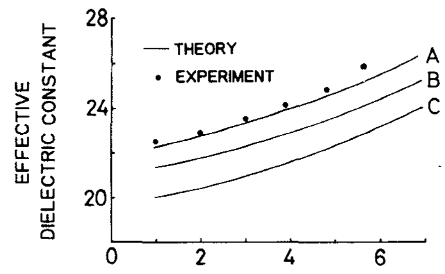

Fig. 1. Computed and measured effective dielectric constant for microstrip line on high-dielectric substrate as a function of frequency. Theoretical curves are obtained employing different sets of basis functions.

$$g(x) = \begin{cases} \dfrac{1}{\sqrt{w^2-x^2}} & \text{for } |x|<w \\ 0, & \text{for } |x|>w \end{cases} \tag{5}$$

$$h(x) = \begin{cases} \dfrac{1}{w}\sin\left(\dfrac{\pi}{w}x\right), & \text{for } |x|<w \\ 0, & \text{for } |x|>w. \end{cases} \tag{6}$$

As these relations show, numerical results based on only one basis function in the z-direction (Set A) are in good agreement with experimental results. On the other hand, when basis functions are used in both the x- and z- directions (Set C), results are poor agreement with the measured results. Computed results employing Set B fall between the numerical results based in Sets A and C.

There is another drawback in that increasing the number of basis functions is time consuming. Much more computer time is required with the use of a larger number of basis functions. This does not make the design process rapid.

Pribetich and Kennis state that mathematical development of the hybrid-mode analysis has already been published in my previous paper [3]. Thus, they say the above paper[1] should focus on the coupling problem between two strips. However, my intention in the above paper was to clarify the different effects of the tuning slot in the ground plane on even- and odd-mode resonant frequencies.

In any case, more detailed studies are necessary to clarify the relation between numerical results and the selection of basis functions, including coupling effects between two microstrips.

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Correction to "Magnetostatic Surface-Wave Propagation in Ferrite Thin Films with Arbitrary Variations of the Magnetization Through the Film Thickness"

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Equation (11) of the above paper[1] should read as follows:

$$(1+\chi)\frac{\partial^2\psi}{\partial x^2}+\frac{\partial(1+\chi)}{\partial x}\frac{\partial\psi}{\partial x}-i\frac{\partial\kappa}{\partial x}\frac{\partial\psi}{\partial y}+(1+\chi)\frac{\partial^2\psi}{\partial y^2}=0 \quad (11)$$

with $\psi=\psi(x,y)$. This correction does not affect the rest of the paper.

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