Smith chart, where the IRL of the amplifier is constant. The new chart has been added to the constant available gain and constant noise figure circles in order to obtain a more complete design tool in which a trade off between gain, noise figure, and IRL can be performed. In particular, for a conditionally stable active device, the optimum IRL and the corresponding available gain have been found as a function of the active device’s S parameters: this allows the preliminary knowledge of the optimum performances of the overall amplifier from the gain-and-input-match point of view. The usefulness of the proposed design charts is demonstrated by the design of a narrowband monolithic low-noise amplifier for X-band applications.

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MODELING CONTROL OVER DETERMINATION OF DIELECTRIC PROPERTIES BY THE PERTURBATION TECHNIQUE
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ABSTRACT: An accompanying numerical simulation for obtaining field patterns, resonant frequencies, and the Q factor is proposed to evaluate the experimental conditions of complex permittivity reconstruction by the perturbation method and thereby improve its accuracy and flexibility. This approach is illustrated by analyzing the measurement of dielectric constant and the loss tangent of wet movie film in a rectangular resonator. © 2003 Wiley Periodicals, Inc. Microwave Opt Technol Lett 39: 443–446, 2003; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.11243

Key words: complex permittivity; numerical modeling; perturbation method; Q factor; resonant frequency

INTRODUCTION
The measurement of complex permittivity \( \varepsilon = \varepsilon' - i\varepsilon'' \) has been of substantial interest for microwave engineers for many years, and numerous techniques for the determination of dielectric constant \( \varepsilon' \) and the loss factor \( \varepsilon'' \) have been developed [1, 2]. Reliable reconstruction of dielectric properties requires very precise and accurate handling of samples usually restricted with respect to their size and alignment in the cavity. Inaccessible for direct measurement, per-
The experimental setup is outlined by a chart in Figure 2. The wavemeter. Then the resonant frequency and the change of the frequency and the change of the
Dielectric properties are calculated from the shift of the resonant Q-factor. In order to find resonance positions A to C, as shown in Figure 3, refer to the locations of the cassette’s central plane with respect to the electric field: at the half-wavelength in the node of the standing wave (A), at the quarter-wavelength in the antinode (B), and in contact with the shorting wall in the node (C).

RESULTS AND DISCUSSION
The measured variations of \( \varepsilon' \) and \( \tan \delta \) of a piece of a film as functions of water content \( w \) are presented in Figure 4. The latter parameter is determined by weighing; on each measurement, the cassette is located at \( L_1 = 152 \text{ mm} \) (position B). The experimentally determined values of the resonant frequency of the empty cavity and its Q factor are \( f_0 = 2.970 \text{ GHz} \) and \( Q_0 = 3.500 \), respectively. Following [16], average errors of determination of \( \varepsilon' \) and \( \tan \delta \) are estimated as 5% and 14%, respectively.

In order to clarify the actual circumstances of the measurements, the resonant structure involved in this experiment is simulated with the use of a QW3D model in which the dielectric properties of the film are supposed to be known from the above measurements. When discretizing the structure, the cubic 5-mm cells are applied in air, whereas the cell size within the Teflon cassette and the film is \( 0.5 \times 5 \times 5 \text{ mm} \). In order to find resonance frequencies in the cavity with and without the sample, we perform an eigenvalue analysis of the structure with a special lumped source excited by a pulse. In particular, simulations show that \( f_0 = 2.975 \text{ GHz} \).

With the sinusoidal excitation at the resonance frequencies, the electric field in the central horizontal plane is computed in the empty resonator and in the resonator with the cassette for \( L_1 = 152 \text{ mm} \). The field patterns for several values of \( w \) are shown in Figure 5. In the absence of the dielectric sample, the mode is clearly identified as the TE\(_{103}\). It is seen that, with an increase in the water content, the field structure is destroyed, and the field demolition is notable (even for moderate values of \( w \)) and becomes stronger when it becomes higher. The results suggest that placement of the measured sample in the maximum of the electric field (position B) is feasible only for low water content (that is, for small \( \varepsilon' \) and \( \varepsilon'' \)), but for higher \( w \), it is reasonable to put it in
position A or C, thus weakening the field structure’s distortion and increasing the method’s accuracy.

Figure 6 shows the variation of the resonant frequency as a function of the water content; the curves are computed by the QW3D model and the first formula in Eq. (1). While numerical simulation represents the actual behavior of \( f_1 \), the perturbation method gives an error naturally increasing with \( w \); indeed, the larger the water content, the stronger the field distortion and thus the lower accuracy of Eq. (1).

Computation of the \( Q \) factor of the loaded resonator requires a preliminary determination of the losses in the setup’s resonator walls. Assuming that the measurement of \( Q_0 \) is sufficiently accurate, we run a series of QW3D simulations for different values of the wall conductivity \( \sigma_w \) and find that the \( Q \) factor of the empty resonator is equal to 3500 when \( \sigma_w = 1.7 \cdot 10^6 \) S/m, which is consistent with typical values for stainless steel. This parameter is then assigned to the model computing \( Q_0 \). The curves in Figure 7 show how the \( Q \) factor of the loaded resonator depends on the film’s water content in accordance with the second formula in Eq. (1). The QW3D model shows that, for each \( w \), computation is performed for corresponding values of \( f_1 \). The graphs are very close to \( w \approx 0.4 \) g/m and diverge for higher and smaller water content. It appears that the perturbation method’s performance is particularly inadequate in high-\( Q \) structures (\( w < 0.3 \) g/m, or \( \tan \delta < 0.4 \)).

The comparison of the characteristics of \( f_1 \) and \( Q_1 \) computed by Eq. (1) and the numerical model (Figs. 6 and 7) provides more specific estimations for the errors in finding dielectric parameters by the considered perturbation method: for dielectric constant, the results seem to be more accurate for low water content (small \( \varepsilon' \)), whereas for the loss tangent the lesser errors are generated for high \( w \) (large \( \varepsilon'' \)).

**CONCLUSION**

The supporting numerical simulations suggested in this paper allow one to employ the cavity perturbation technique in a better conditioned and more flexible mode. Evaluation of the field pattern’s distortion in the loaded resonator, along with a comparison
of the resonance frequencies and the $Q$ factor computed by the perturbation technique’s formulas, and an accurate numerical model constitute the means of keeping the experimental determination of dielectric properties (and therefore the accuracy of the method) under control. The measures taken in response to the knowledge acquired from this modeling may include changing the location of the measured dielectric in the cavity with respect to the field maximum/minimum, checking for larger/smaller sample, abstaining from measurements violating some limitations of the method or bringing less accurate results, and so forth. Although the approach illustrated here involves a rectangular resonator and working with QW3D, it is conceptually applicable to other (for example, cylindrical) cavities and capable of using other sources of reliable modeling data. All these factors extend the validity and accuracy of the perturbation method for the determination of the complex permittivity of materials.

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CHAOS AND SYNCHRONIZATION OF COLPITTS OSCILLATORS

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ABSTRACT: In this work we numerically investigate the nonlinear dynamics of the Colpitts oscillator. Bifurcation diagrams of consecutive plots of the values of electrical current minima are presented, according to the circuit parameters. By following observer-based synchronization, two identical Colpitts oscillators with scalar transmitted signals are developed. Computer simulation results are given. © 2003 Wiley Periodicals, Inc. Microwave Opt Technol Lett 39: 446–449, 2003; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.11244

Key words: Colpitts oscillator; chaos; synchronization; state observer