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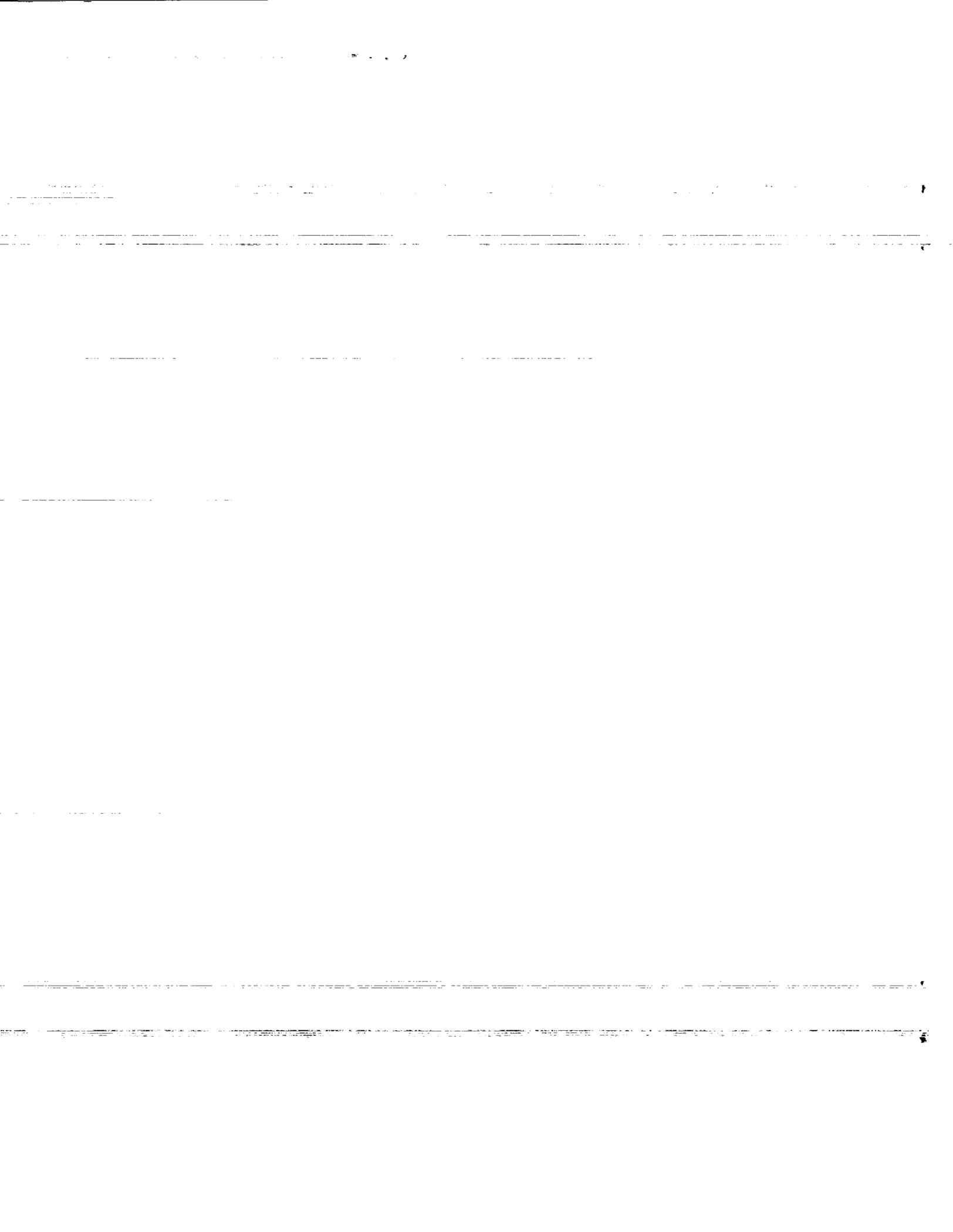
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Summary

A slot-coupled CPW fed patch antenna is analyzed using two different techniques: the Spectral Domain Method and the Finite Difference Time Domain Method. The results from both techniques are in good agreement with experimentally obtained data.

1 Introduction

Fig. 1 shows a patch antenna fed by a short-end coplanar waveguide(CPW) through a slot on the ground plane between the patch and the coplanar waveguide. A transverse slot on the CPW is used to increase the coupling efficiency. Due to the ground plane that separates the feeding network and the radiation elements, this kind of structure provides better isolation between the active circuit components and the antennas, and more flexibility in the choice of the design parameters. According to the experimental results of [1], this structure has excellent radiation pattern and coupling efficiency.

In this paper, two methods are used to analyze this structure: the full wave spectral domain moment method (MM) and the FDTD technique. The S_{11} of the structure is calculated numerically using both methods and good agreement is obtained with experimentally obtained results.

2 Theoretical Analysis

2.1 Spectral Domain Method

Similar structures have been fully analyzed by the same method in [2]-[4]. The original structure can be separated completely to 3 regions by closing the slot and CPW with perfect conductors. According to equivalence principle, suitable sources must be added on the position of the slot and CPW to maintain the same fields.

The total electric and magnetic fields in each region are obtained by superposition of fields due to the various currents. Each field can be represented by dyadic Green's function for each region such as

$$\bar{E}_b(\bar{M}_{ap}) = \iint_{slot} \bar{G}_{EM}^b(x, y, z | x_0, y_0, z_0) \cdot \bar{M}_{ap} dx_0 dy_0, \quad (1)$$

where \bar{G}_{EM}^b is the electric field at (x, y, z) due to an infinitesimal magnetic current at (x_0, y_0, z_0) radiating in the presence of a grounded dielectric slab. This and other Green's functions needed for the analysis are obtained by using spectral domain methods.

Three coupled integral equations are obtained for the three unknown currents $\bar{M}_f, \bar{J}, \bar{M}_{ap}$ by enforcing the boundary conditions: 1) \bar{H}^{tan} is continuous on the CPW, 2) \bar{H}^{tan} is continuous on the slot, and 3) $\bar{E}^{tan} = 0$ on the patch. Finally, expanding the unknown currents by suitable basis functions and applying Galerkin moment method, matrix equations are obtained which are solved to derive the S_{11} of this structure.

Since the CPW line is very narrow, only y -directed magnetic currents are used to model the currents on it. Also the aperture on the ground plane and the transverse slot on the CPW are assumed to be narrow enough that only x -directed magnetic currents are necessary to model the currents on them. The currents on the patch are assumed to be only y -directed too. Since infinite traveling wave modes produce extra poles in spectral domain, it is truncated at a sufficiently large distance from the end of the CPW. The fundamental mode of CPW is calculated by the method of [5]. Although there is a small imaginary part in the propagation constant, it is not taken into account since the ratio of imaginary part to real part is smaller than 1/100 in the frequency range of interest. All the basis functions used are piecewise sinusoidal (PSW) modes.

2.2 FDTD Technique

Recently, the FDTD method has been successfully applied to characterize planar printed antennas [6,7]. The interested reader may consult these references for a detailed description of the method.

In this research, the first order Mur boundary condition is used in the left, right, top and bottom walls in order to simulate an open structure. On the other hand, the super-absorbing first-order Mur condition is utilized in the front and back walls in order to simulate infinite lines.

To obtain $S_{11}(\omega)$, the incident and reflected fields must be known. Since the FDTD simulation calculates the total field (i.e., the sum of the incident and reflected waveforms), the incident field is obtained from that of an infinite extent line (i.e., from the source to far absorbing wall). Then, this incident field is subtracted from the total waveform to yield the reflected field.

3 Results

The dimensions of the structure are the same as those constructed in Fig. 2(a) of [1]. Fig. 2 shows the variation of $|S_{11}|$ v.s. frequency. The center of the position of the patch is the same as that of the slot in this figure. On the other hand, Fig. 3 shows the variation of $|S_{11}|$ v.s. frequency for a patch the center of which is shifted along the direction of the feed line by an amount of 0.10625 inch to the center of the slot. Experimental data for the structure shown in Fig. 2(c) of [1] is also included in the same figure. Two resonant frequencies are found around 10 GHz and 17.5 GHz. The discrepancies between the

FDTD and MM results may be attributed to the assumption of only a y-directed electric current on the patch. Results for cavity-backed, slot-coupled, CPW-fed patch antenna will be shown in the symposium.

4 Acknowledgment

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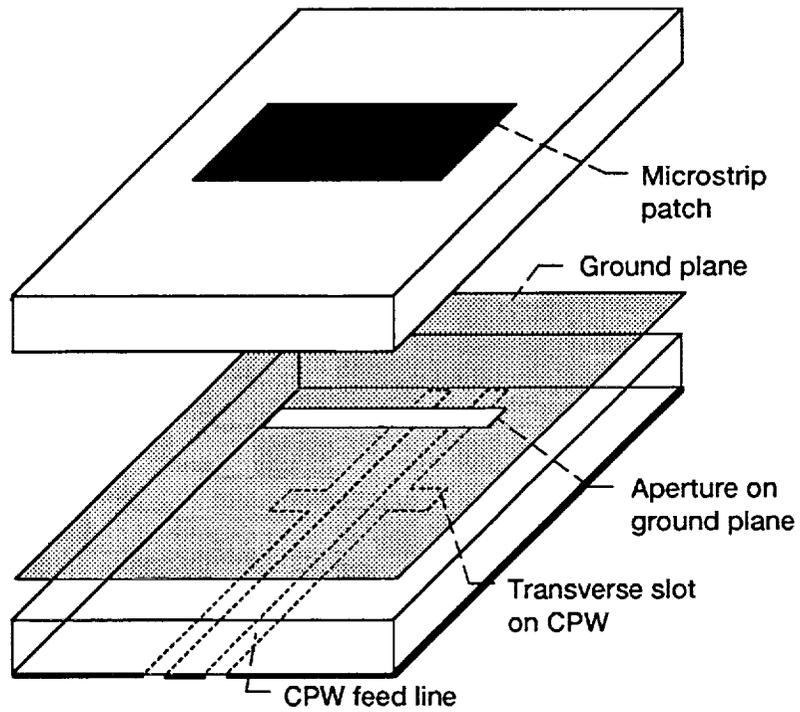


Figure 1.—The structure of a slot coupled CPW fed patch antenna.

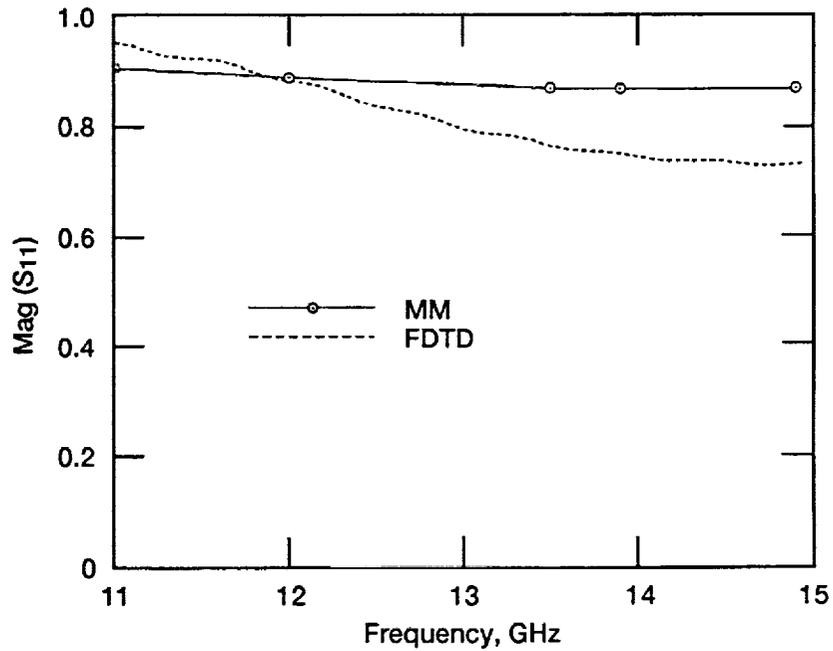


Figure 2.—Mag (S₁₁) as a function of frequency for a centered patch.

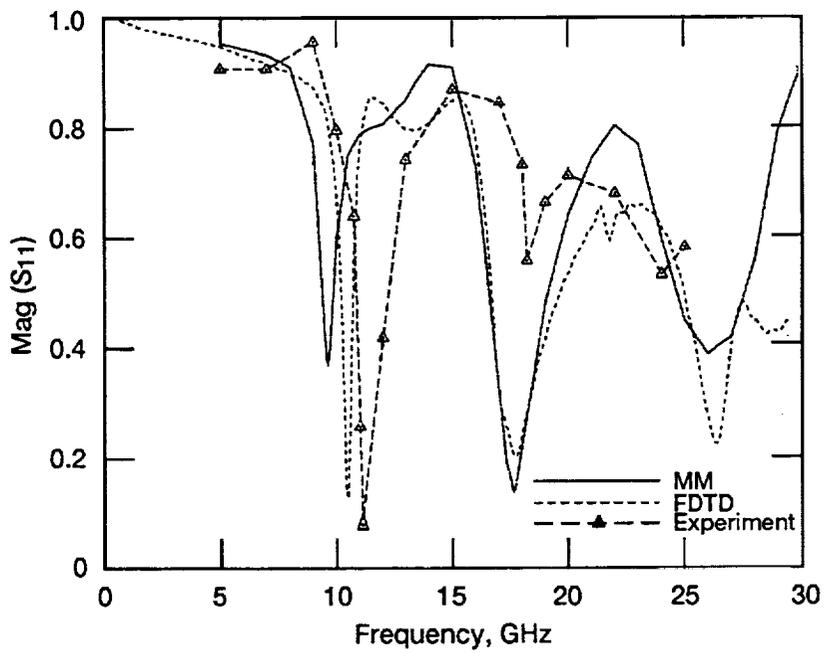


Figure 3.—Mag (S_{11}) as a function of frequency. The center of the patch and the slot are displaced by 0.10625 inch in the direction of the feed line.

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