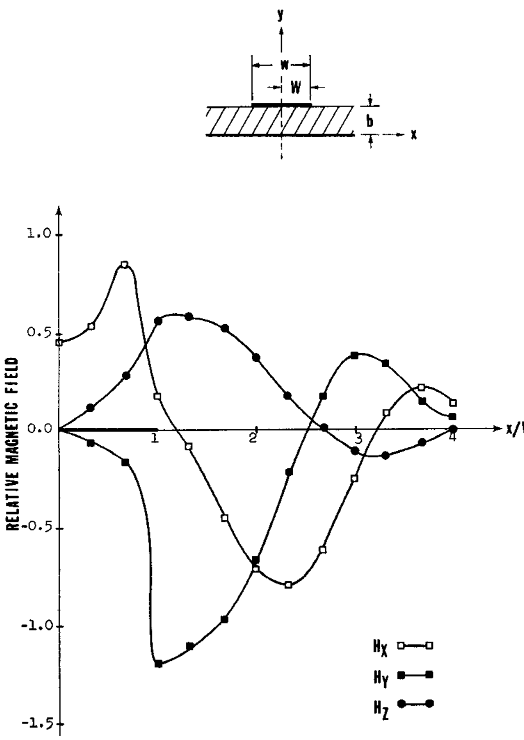

Fig. 7. Relative amplitudes of the numerically calculated magnetic field components for the 0.055-in alumina substrate with $w/b=2$ at 10.63 GHz.

magnetic field reaches its maximum just past the center strip edge. The x component of the magnetic field reaches its positive extremum just inside the center strip edge, passes through zero just past the edge, and then passes through a negative extremum a short distance from the edge. The y component of the magnetic field drops off zero just past the center strip edge. Note that the longitudinal magnetic field and consequently the longitudinal electric field of the microstrip mode along the interface are far from being negligible quantities.

At regions on the air–dielectric interface in the vicinity of the center strip edge, both the experimental plot (Fig. 6) and the theoretical plot (Fig. 7) reveal a relatively large component of circularly polarized RF magnetic field in planes normal to both the x and y axes. Experimental work by other investigators [1] had indicated that there was a circularly polarized component of the RF magnetic field in microstrip, but its relative location and amplitude were not known.

The only other reported experimental investigation for the field configuration was by Shafer [10]. He used a loop coupling technique to measure the average RF magnetic field distribution on an oversized microstrip line having a low dielectric constant substrate.

Conclusion

The fact that there is a substantial component of longitudinal magnetic field has been demonstrated both experimentally and theoretically. The experimental results corroborated the numerical findings and showed that the dominant propagating mode in microstrip is dispersive and is in fact a hybrid coupled TE–TM saddle mode. At low microwave frequencies, where the guide wavelength becomes much greater than the substrate thickness, the mode begins to approach a TEM mode. It was also shown that substantial amounts of circular polarization of the RF magnetic field exist in each of two orthogonal planes. It should be pointed out, however, that most of the energy in the microstrip mode is concentrated in the dielectric substrate under the center strip, and in this region the longitudinal fields are relatively weak. Consequently, one would expect TEM calculations of guide wavelength, phase constant, etc., to be reasonably close to the actual values.

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Octave-Band Microstrip DC Blocks

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Abstract—**The design of octave-bandwidth microstrip interdigital dc blocks is presented. Data for a 7.75- to 16.3-GHz design are given and correlated with an approximate equivalent circuit based on even and odd mode propagation in coupled microstrip. Additional data are tabulated reflecting the ability to shift the frequency band of operation.**

DC blocking capacitors are an important element in the design of several microwave components requiring dc-biased devices. In microstrip, chip and beamlead capacitors, as well as directly deposited thick- or thin-film capacitors, are extensively employed, but each has certain disadvantages. Chip and deposited capacitors are attractive at lower microwave frequencies [1], [2] typically through S band, although reported on as high as X band [3]. In these frequency ranges, they can be considered "lumped-element" components, but become distributed elements and sometimes introduce unwanted parasitics in higher frequency bands. Beamlead devices reduce these problems at high frequencies but are relatively expensive and more difficult to handle, requiring the use of microscopes and sophisticated bonding equipment for installation.

This short paper describes an empirical extension of the interdigital-type dc block reported on by Stinehelfer [4] which has the advantage of being "printed" simultaneously with other microstrip circuitry. The basic circuit, illustrated in Fig. 1, consists of a single

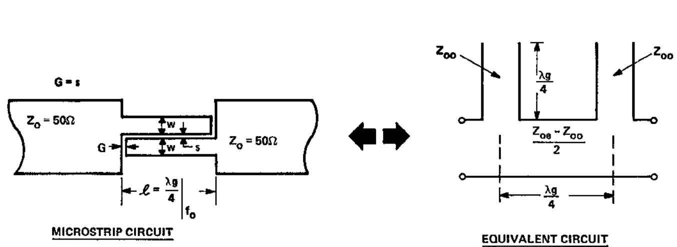

Fig. 1. DC block microstrip circuit and equivalent circuit.

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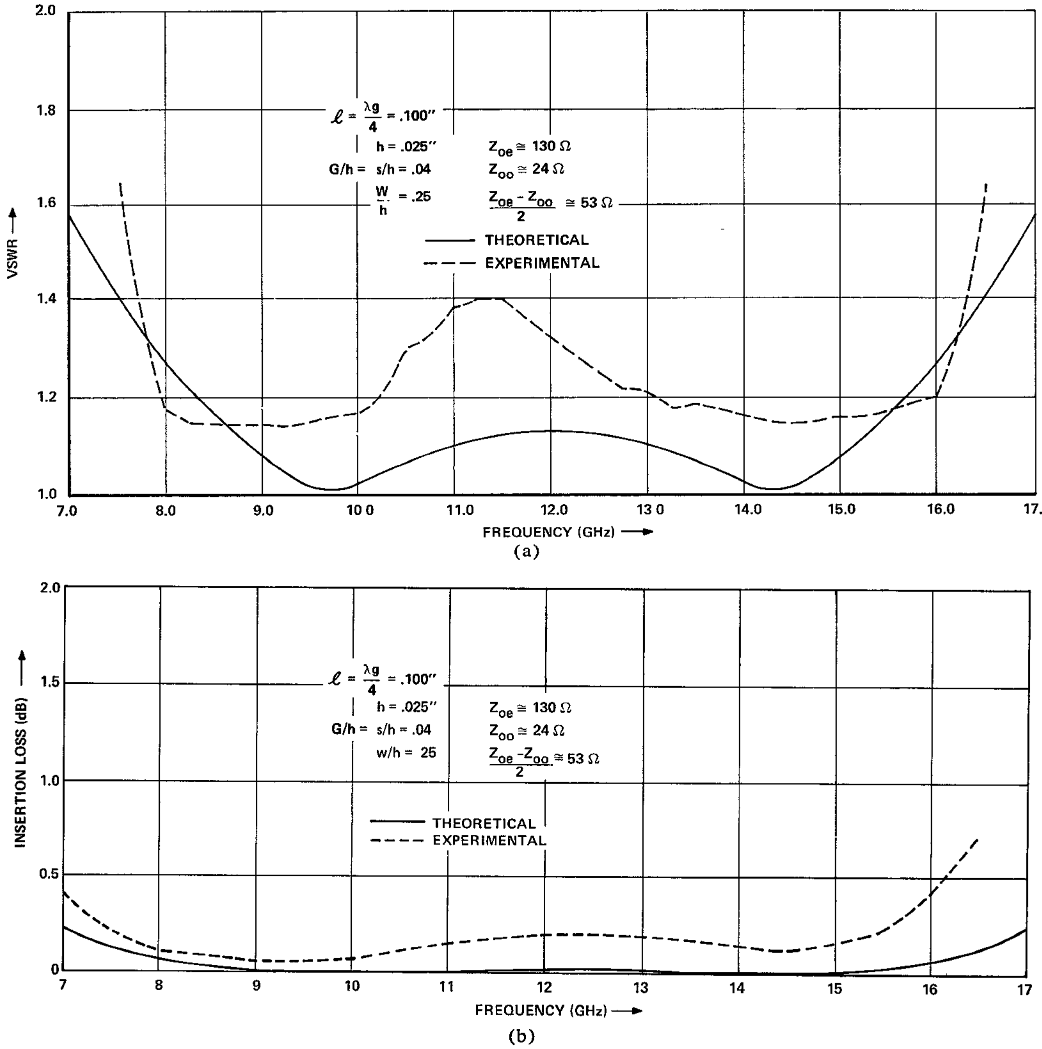

Fig. 2. (a) VSWR versus frequency—microstrip interdigital dc block. (b) Insertion loss versus frequency—microstrip interdigital dc block.

TABLE I

PERFORMANCE OF ADDITIONAL DC BLOCKS

CIRCUIT	S/h	W/h	l (inches)	f_l (GHZ)	f_o (GHZ)	f_2 (GHZ)	1.4 VSWR B.W.	OCTAVES
1 (FIG. 2)	.04	.25	.100	7.75	12.08	16.3	71.5%	1.11
2	.04	.25	.110	6.6	9.95	13.3	67.5%	1.05
3	.04	.25	.090	8.1	12.55	17.0	71 %	1.1
4	.04	.25	.050	15.2		> 18		

quarter-wavelength coupling section. Stinehelfer achieved about 55-percent bandwidth (0.78 octave) at L band; extended bandwidth and higher frequency circuits are presented herein. To achieve bandwidth enhancement, several interdigitations, or "fingers," within the quarter-wave coupling region were first investigated but with minimal success. Subsequently the number of fingers was reduced to two and, with the proper choice of linewidth and gap width, the desired broad-band performance resulted.

The data presented in Fig. 2 and Table I show a minimum of octave-band performance in the C- through Ku-band frequency ranges. All circuits were constructed on 0.025-in alumina substrates having a dielectric constant of approximately 10, and metallized with chrome/gold. The gap width for the circuit in Fig. 2 was 0.001 in ($s/h = 0.04$) and "finger" width of 0.00625 in ($w/h = 0.25$). The 1.4 VSWR bandwidth was 71 percent (1.1 octaves) with less than 0.6-dB insertion loss. The theoretical response of this circuit, shown in Fig. 2, is based on the equivalent circuit given by Matthaei, Young, and Jones [5], and using the microstrip even and odd mode impedance analysis of Ramadan and Westgate [6].

Table I summarizes performance obtained by modifying the length of the coupling gap. No attempt was made to optimize the finger widths with each change in length. The upper band edge of the last circuit in the table was not determined as measurement equipment above 18 GHz was not available. These data show that the frequency band of operation can be shifted by simply modifying the length of the coupling region while preserving octave-band performance.

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