SLOT LINE - AN ALTERNATIVE TRANSMISSION MEDIUM FOR INTEGRATED CIRCUITS

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Current development of microwave integrated circuits has revived interest in microstrip transmission line as a means of interconnecting solid-state elements into signal-processing subsystems. This paper describes an alternative kind of transmission line on a dielectric substrate that may be used with or instead of microstrip. As shown in Fig. 1, this alternative consists of a narrow slot or gap in a conductive coating on one side of the substrate. The other side of the substrate is exposed directly to air.

Both resonant and propagating slots in thin conducting sheets have had extensive use as radiating elements in microwave antennas. To be practical as a transmission line, radiation must be minimized. This is accomplished through the use of a high-permittivity substrate, which causes the slot-mode wavelength λ' to be small compared to free-space wavelength λ, and thereby results in the fields being closely confined to the slot with negligible radiation loss. A zero-order approximation gives $\lambda'/\lambda = \sqrt{2/(\epsilon_r + 1)}$, while a precise but rather complex second-order solution gives values about 10 percent greater. For example, if $\epsilon_r = 20$, than $\lambda'/\lambda \approx 1/3$ and analysis shows the slot-mode fields to be sharply attenuated at a distance $r/\lambda = 1/8$, or $r = 0.5"$ at 3 GHz. A comparison between measured and computed λ'/λ is given in Fig. 2 as a function of frequency. Agreement with the second-order solution is seen to be excellent. The analysis also yields characteristic impedance, which in the case of Fig. 2 is about 44 ohms. Additional theoretical and experimental data will be included in the full-length paper.

Figure 3 shows the slot-mode fields in a cross sectional view. A voltage difference V exists between the edges of the slot. The electric field extends across the slot, while the magnetic field is perpendicular to the slot. A longitudinal section would show that in the air regions the magnetic field lines curve and return to the slot at half-wavelength intervals. Consequently, a propagating wave has circularly polarized regions that can be usefully applied in creating certain ferrite components. Because the slot mode's voltage difference occurs across a small gap on one side of the substrate, the configuration is especially convenient for connecting shunt elements such as diodes, resistors and capacitors.

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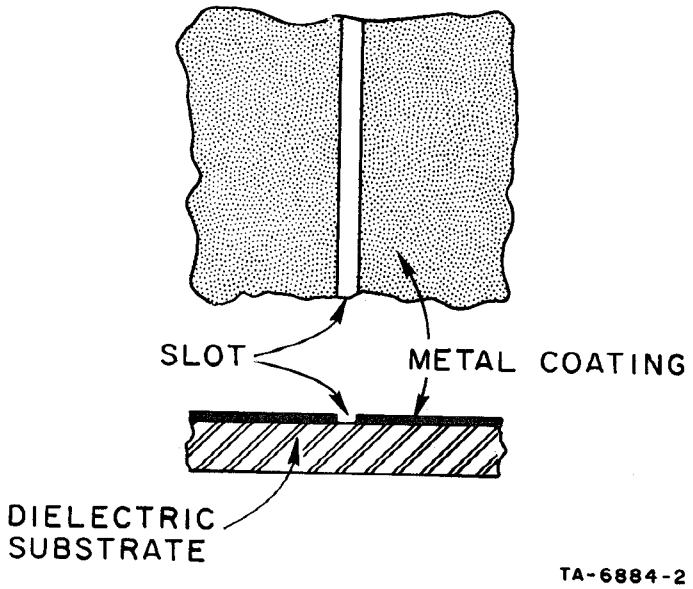
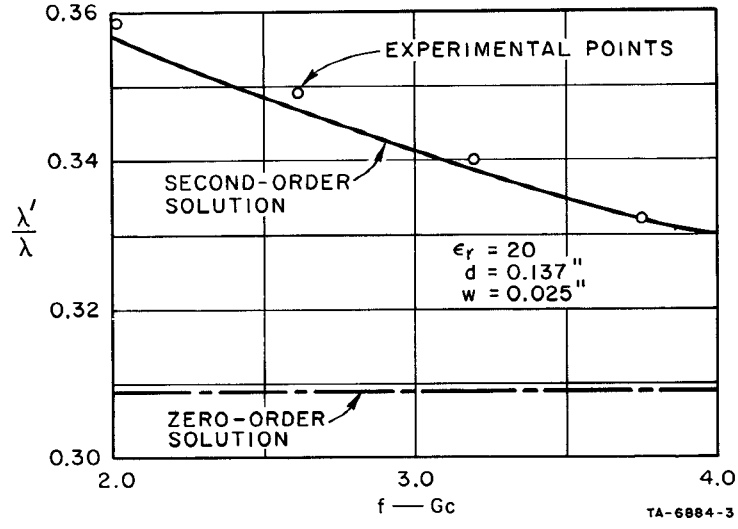
An interesting possibility is the use of slot lines on one side of a substrate and microstrip lines on the other. When close to each other, coupling between the two types of lines will exist, and when sufficiently far apart they will be independent. Coupling between a slot and a strip can be used intentionally in certain components. When a slot and strip cross each other at right engles, as in Fig. 4, coupling will be especially tight and a broad-band transition may be achieved.

Among other topics to be included in the complete paper will be excitation of the slot-line mode, slot-line resonators, band-pass and band-stop filters, application of slot line to ferrite circulators, isolators and phase shifters, and coupling between slots and between a slot and strip.



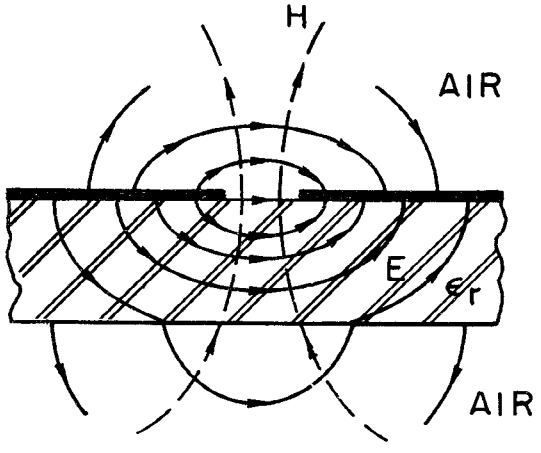
SLOT LINE ON A DIELECTRIC SUBSTRATE

FIG. 1



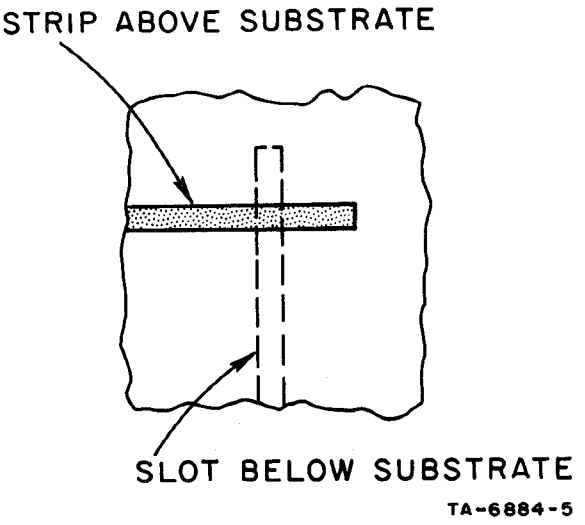
MEASURED AND COMPUTED RELATIVE WAVELENGTH

FIG. 2



FIELD DISTRIBUTION IN CROSS-SECTION VIEW

FIG. 3



TRANSITION BETWEEN SLOT LINE AND MICROSTRIP

FIG. 4