# REVIEW OF PLANAR FERRITE DEVICES

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Major emphasis in the microwave components area today is on economy. In the early pioneering days of microwave development, performance was the criterion of excellence, and cost played a very subordinate role. Microwave components have traditionally been state-of-the-art devices, almost hand-tailored units with relatively small production runs. The increasing application of microwaves to communications systems, a growing urge to invade consumer markets, and the advent of electronically scanned arrays have all underscored a need for more economical (even cheap!) microwave devices. This trend is associated not only with a tightened federal R & D dollar, but also with a maturing industry. Today it is not so much a question of whether or not a circuit function can be done, but can it be done economically. Increasingly, the tradeoffs between cost and performance are being exhaustively studied.

Waveguide ferrite devices are capable of remarkably high performance levels. Waveguide ferrite digital phase shifters, for example, can be constructed to meet the electrical requirements of almost any system, but the overall cost of such an electronically scanned array would be prohibitively high. Thus, for the large volume production applications, we must determine what performance levels are realizable at a price.

Planar circuit fabrication techniques offer obvious economies when compared to waveguide structures, and the notable success of lower frequency integrated circuits has led to an investigation of possible planar transmission line geometries. To date, virtually all efforts reported in this area have utilized microstrip transmission line, a high dielectric constant substrate with metallized ground plane on one side and an etched strip on the other.

Major progress in this area has been made in the design and construction of junction circulators. Indeed, performance comparable to that of balanced strip line devices has been realized in microstrip versions. The junction circulator seems peculiarly suitable to microstrip construction, and equivalent success has not been achieved in resonant isolator or, more critically, phase shifter construction. Latching microstrip phase shifters have maximum figures of merit in the range of 160°/db and suffer from bandwidth and environmental limitations such that their performance does not compare favorably with their waveguide and balanced strip line counterparts. Ohmic loss in the microstrip conductor appears to be a basic limitation. This loss seems to be related to the high current densities present in microstrip line and the surface condition of the substrate.

## NOTES

Other types of planar transmission lines have been suggested and have received at least preliminary study. These include the slot line and the co-planar waveguide which have the advantage of providing a more readily apparent circularly polarized wave for gyromagnetic interaction; but they also seem to suffer from ohmic loss problems.

Certainly microstrip circulators and isolators will be extensively used in future microwave integrated circuitry. They offer both economy and excellence of performance. The application of ferrite digital phasers to future arrays will no doubt depend on our ingenuity in developing a planar phase shifter with an acceptable level of performance.