IV-4. A FOUR-BIT LATCHING FERRITE SWITCH

D. H. Landry and W. C. Passaro

Sperry Microwave Electronics Company, Clearwater, Florida

Latching ferrites are rapidly advancing a new era of solid state devices. Fast switching, light weight, minimal drive requirements, no bulky external magnets are some of the significant characteristics of these devices.

This paper deals with the application of latching ferrites to a novel approach for combining polarized input signals. Vertical, horizontal, right circularly polarized or left circularly polarized input signals are combined at a common output by selectively choosing the bit states of a four-bit latching ferrite switch. The heart of the device is a fast switching, low insertion loss, phase stable, temperature controlled, 90 degree latching bit shown in Figure 1.

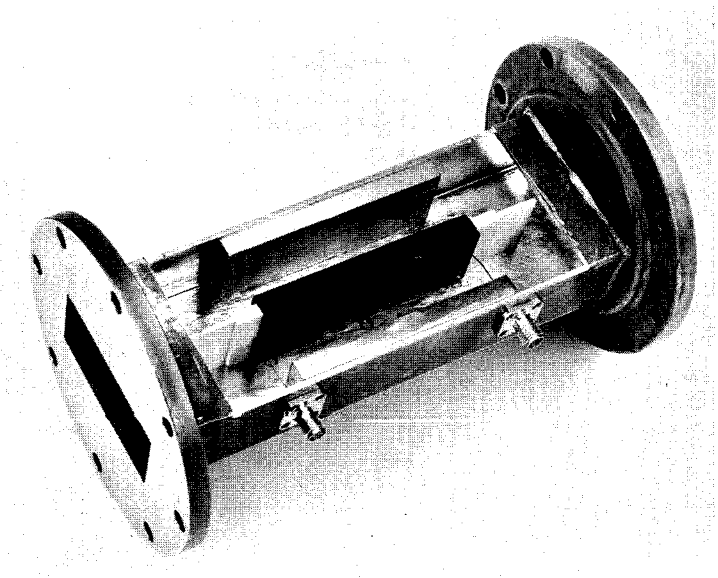


Figure 1. 90 Degree Latching Bit Assembly

The development of a 90 degree latching bit, and of the subsequent switch assembly, depends in great measure upon the proper selection of a suitable ferrite material. Namely, one that combines a high remanence ratio, low loss tangent, minimum coercive force, and a proper selection of saturation magnetization for the required frequency of operation.

Remanence ratios of 0.85 to 0.90 and loss tangents of less than 0.0001 are obtainable in the ferrite materials used for the latching bits. It is desirable to keep the coercive force low in order to minimize the switching power requirements. For the ferrite materials used, the coercive force was 0.6 to 0.8 oersteds. The saturation magnetization for operation over a given frequency band can be deduced from Figure 2. This data has been collected from previous empirical work with broadband circulators and is applicable to phase shifters. At a frequency of 5,500 mc, the shaded area of Figure 2 shows that a remanence magnetization between 1,100 gauss and 1,900 gauss is desirable. The linewidth of the ferrite material must be kept sufficiently narrow to prevent resonance losses from entering the frequency band of operation. A further materials restraint is that the saturation magnetization be stable with temperature. When each of the factors above is considered, the materials search is narrowed down to the gadolinium-aluminum substituted yttrium-iron-garnet family.

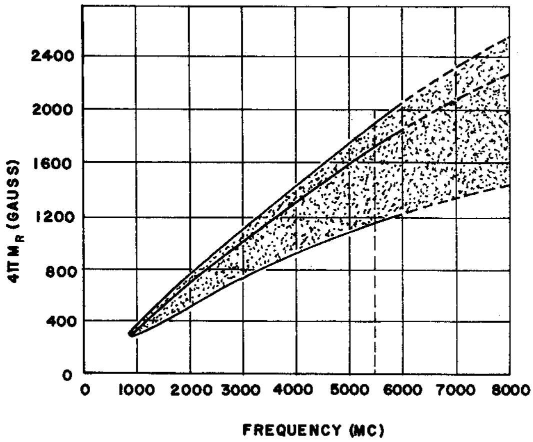


Figure 2. Envelope of Practical $4\pi M_r$ Values for Broadband Phase Shifters (References 3 and 4)

Since differential phase shift is a function of ferrite configuration, as well as ferrite selection, it is equally important, therefore, that the proper size and geometry be arrived at to produce optimum performance. In this case a rectangular toroid was selected, and constructed, as shown in Figure 3. The length and cross-sectional area of the toroid were optimized to provide a minimum variation in differential phase shift, with changes in frequency. More specifically, each latching bit was able to produce a differential phase shift of 90 degrees ± 4 degrees from 5,400 mc to 5,900 mc.

The high concentration of a dielectric (toroid), at the center of the waveguide, suggests the possibility of generating higher-order modes. To guard against these unwanted modes, the use of mode suppressors was included on both sides of the toroid. These were brazed into the waveguide walls as an integral part of the waveguide assembly.

Dielectric stepped transformers were designed, using procedures previously outlined by Cohn (Reference 1) and Vartanian (Reference 2) to match out the toroid. The VSWR thus obtained was less than 1.20 across the entire frequency range of 5,400 mc to 5,900 mc. However, it was found that any air gap that results, at the interface of the longitudinal dimension of the toroid and the waveguide top and bottom walls, results in compounding the matching problems of the transformers.

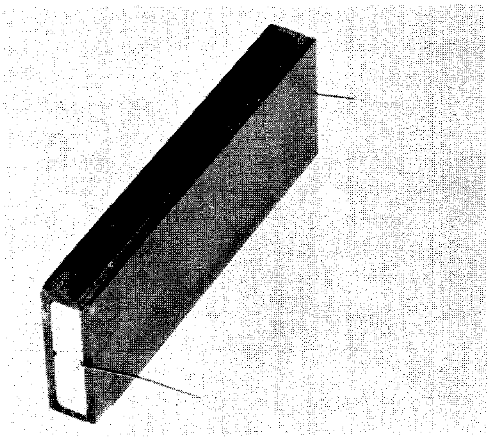
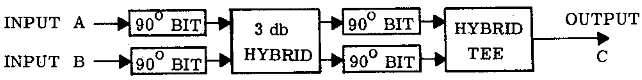


Figure 3. Ferrite Toroid Assembly

Therefore, extreme care should be taken when inserting the ferrite toroid into the waveguide section, making sure of good contact between the toroid and the waveguide. Further refinement of the VSWR match is accomplished by proper positioning of the transformers at both the leading and far edge of the toroid.

The position of the charging wire through the toroid presents still another problem. Although it is of no consequence where the wire enters the toroid, it is extremely important that both ends of the wire, leaving the toroid, travel a perfectly parallel path to the face of the waveguide wall. Any deviation from a parallel path will result in distorting both the differential phase shift and the VSWR, since magnetic coupling effects may be introduced.

The four-bit latching ferrite switch layout is shown in the block diagram of Figure 4. The input signals arriving at Ports A and B first pass through a set of 90 degree latching bits and then into a 3 db hybrid. The power is divided at the 3 db hybrid and progresses through the second set of



LATCHING MODE	TRANSMISSION
I	PORT A TO PORT C
II	PORT B TO PORT C
III	PORTS A & B TO PORT C
IV	PORTS A & B TO PORT C
	PHASE OF A & B 180° FROM ABOVE

Figure 4. Four-Bit Latching Ferrite Switch

latching bits into the folded hybrid tee. The bit states are so arranged that the power is combined in the folded hybrid tee and is transmitted out Port C. The table in Figure 4 shows the choice of transmission paths for the four possible latching modes. The unit operates over the frequency range of 5,400 mc to 5,900 mc at input power levels of 10 watts peak.

REFERENCES

1. Cohn, S. B., "Optimum Design of Stepped Transmission-Line Transformers," IRE Transaction of the PGMTT, p. 16, April 1955.

2. Vartanian, P. H., et al, "Propagation in Dielectric Slab Loaded Rectangular Waveguide," IRE Transactions of the PGMTT, p. 215, April 1958.

3. Simon, J. W., "Broadband Strip-Transmission Line Y-Junction Circulators," 1963 Western Electronic Show and Convention, to be published.

4. Taft, D. R. and Hodges, L. R., Jr., "Square Loop Garnet Materials for Digital Phase Shifter Application," presented at the Tenth Annual Conference on Magnetism and Magnetic Materials, November 19, 1964.