X-3. A 35 GHZ LATCHING SWITCH

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Introduction. This paper describes the development of a lightweight fast-switching 35 GHz latching ferrite circulator, with an instantaneous bandwidth of 5%, and a switching time of less the 0.30 microseconds. The device is designed for use over the temperature range of -60° C to +100° C under dynamic operating conditions. It is particularly well suited for use as a switching element in those applications where high reliability, small size and weight, and fast switching time are required. Total weight of the device (excluding electronic driver) is less than 0.6 ounces, and total volume is less than 0.75 cubic inch. The unit is pictured in Figure 1.

Three-port junction circulators using externally-applied magnetic biasing fields have been investigated and reported on by many people[1-5]. Application of these devices as switching elements has required the use of electromagnets, resulting in large cumbersome units requiring continuous holding power and closely controlled power sources. In addition, these devices have been too slow for many proposed rf switching applications.

More recently, the novel application of latching ferrites to junction circulators has been reported by Goodman[6], describing the construction of an X-band waveguide circulator. Similar techniques were used to develop the device described in this paper. However, a different geometrical configuration was chosen for the latching element, as shown in Figure 2.

Circulator Design. The basic configuration for the design of the junction circulator is based on the work of Bosma,[4] as further extended by Fay and Comstock.[5] Minor modifications in the design procedure are incorporated to allow for operation in the remanent state, since the remanent magnetization of the material appears to provide the necessary magnetic biasing of the ferrite.

The latching ferrite element shown in Fig. 2 is designed to provide a closed magnetic path entirely within the ferrite material. The wire carrying the switching current pulse enters at the waveguide junction, encircles the latching element, as shown, and emerges at the same point from which it entered. The wire must be placed in a plane which is parallel to the rf H-plane so as to minimize the possibility of rf magnetic field coupling. Rapidly reversing the sense of magnetization of the material by reversing the polarity of driving current pulses results in reversing the direction of circulation in the device, and hence lends itself very well to fast switching applications.

Switching data are presented in Figure 3, where it can be seen that switching times of less than 0.30 microsecond have been achieved, at a specified switching rate of 1 KHz, over the temperature range of -60° C to +100° C. It was observed that the switching characteristics of the device appear to be a function of the physical volume, as well as specific material; this appears to be in agreement with previously published reports by earlier theoretical investigators.[7,8]

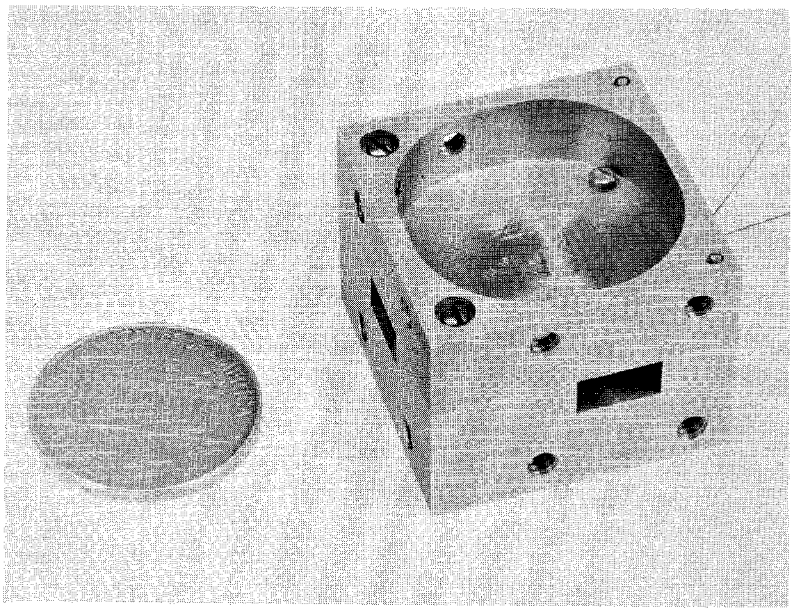

FIG. 1. 35 GHZ LATCHING SWITCH

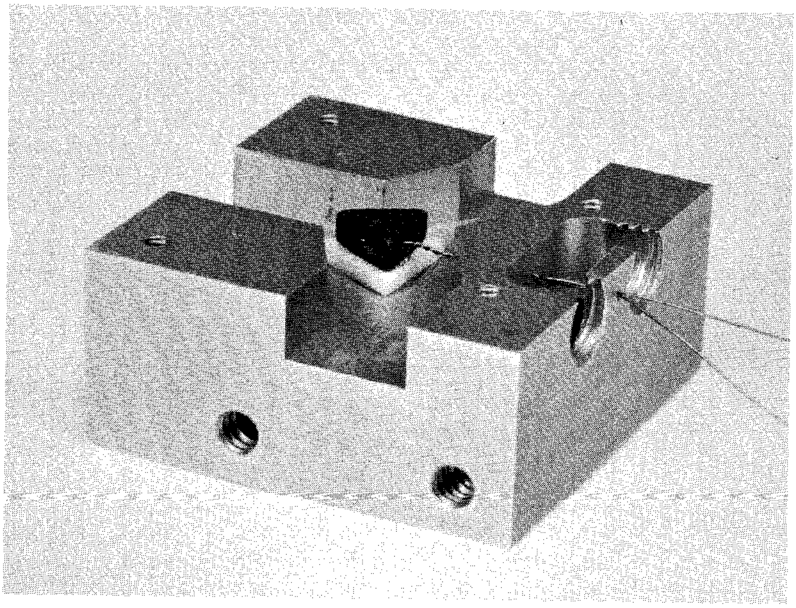

FIG. 2. TRIANGULAR FERRITE SWITCHING ELEMENT

Final matching of the junction was accomplished through the use of external reactive elements. Operating characteristics of the device at room temperature are shown in Figure 4, where it can be seen that the insertion loss has been kept to 0.5 dB maximum, while isolation in excess of 15 dB has been maintained. Figure 5 displays the performance of the device at -60^{o} C, while Figure 6 shows the operating characteristics at +100^{o} C.

Techniques similar to those described in this paper have been used to develop a single-junction four-port latching circulator operating in X-band, while three-port devices have been developed in both waveguide and strip line construction.

References.

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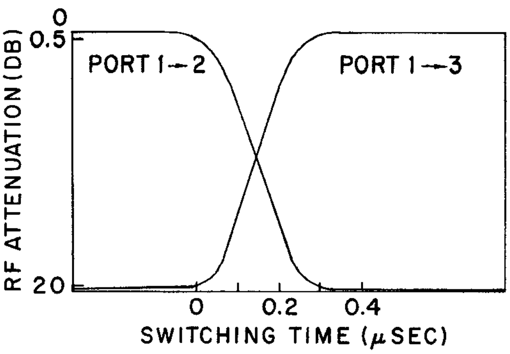

Fig 3. Switching Characteristics

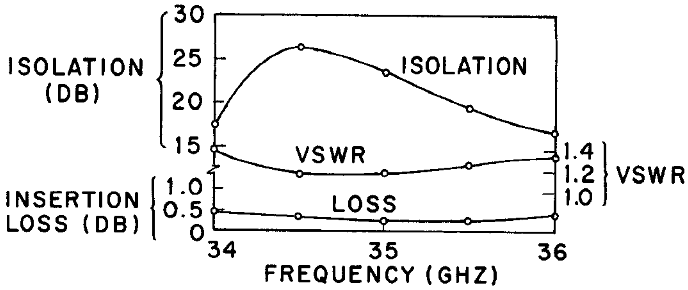

Fig.4. Performance Characteristics at Room Temperature

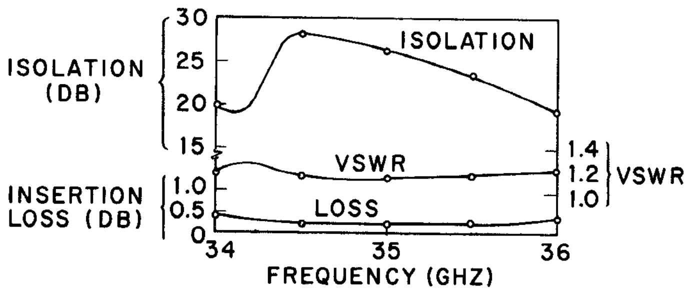

Fig.5. Performance Characteristics at -60°C

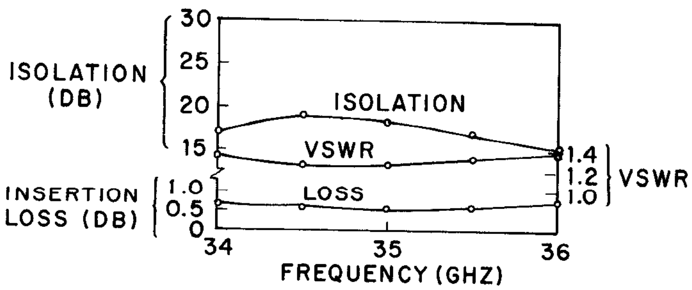

Fig. 6. Performance Characteristics at 100°C