A 90 DB MICROSTRIP SWITCH ON A PLASTIC SUBSTRATE

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Summary

A SPDT microstrip switch has been designed on a plastic (polyolefin) substrate to switch two 10 watt cw carriers into a common load over the frequency range 1.7 to 2.3 GHz. No tuning adjustments are used over this 30% bandwidth to obtain a 90 dB minimum isolation, a 23 dB minimum return loss, and a one dB maximum insertion loss. Units now in production typically have a .6 dB insertion loss, a 26 dB return loss and isolation levels of 105 ±5 dB.

Switch Design

A microstrip design on a plastic (polyolefin) substrate was chosen for the 90 dB switch because of the success with this technique on other microwave circuits.[1] The discussions to follow will repeatedly refer to symbols and design criteria that appear in a published article for microstrip on a plastic substrate.[2]

The most suitable diode that could be found to switch the required cw power level of 10 watts was a shunt mounted PIN diode in a stripline (also microstrip) package that was matched to 50 ohms at a zero bias current.[3]

The RF equivalent circuit of the PIN diode was determined from insertion loss and isolation measurements using bias currents of zero and 100 milliampere respectively at the band center frequency of 1.95 GHz. The equivalent circuits provided by Hewlett Packard (HP) were altered to cause the calculated losses to agree with the measured losses. The diode package and the modified equivalent circuits for an average diode at the two bias levels appear in Figure 1.

A 4-terminal network analysis computer program having an optimization routine for selectable parameters was used to design the junction that joins the two transmitter legs to a common antenna line. Optimization of both the junction line lengths and impedances was performed over the operating frequency range. The two transmitter legs of the junction were defined to be equal and were varied independently with the antenna leg. The resulting junction layout is given in Figure 2.

The bias connection used a quarter wavelength high impedance line with one end connected to the switch line and the other end joined to the low impedance end of a broadband RF rejection filter.

Early in the development period, the DC blocking capacitors were determined to be the cause of an occasional high loss and high VSWR measurement, usually over a narrow frequency range. The size of the conductor gap also affected the capacitor behavior. These problems were solved by mounting the capacitors over a .020 inch conductor gap with the capacitor plates perpendicular to the microstrip conductor. Figure 2 describes the desirable capacitor mounting arrangement.[4]

The completed switch is shown in Figure 3. Between any two RF connectors, the separation of the metal boundaries were chosen to be less than one-half wavelength at the highest operating frequency to prevent the excitation of waveguide modes. It was not necessary to put absorbing material between the lid and the microstrip circuits, either to improve isolation or to avoid alteration of the microstrip impedance.

The capacitors and connectors each have a VSWR less than 1.05, which caused the total VSWR of the earlier model to exceed the 1.15 VSWR objective. This condition was anticipated since the computer optimization program assumed a perfect match for these components. A matching stub shown in Figure 3 was added to each transmitter leg to improve the broadband match.

Switch Performance

Measured data on the final engineering model is shown in Figure 4. All curves agree with the calculated performance except for the VSWR which shows the measured data to be better than theoretical because of the matching stub in each transmitter leg.

The isolation was measured with a 70 MHz IF amplifier and discriminator to reliably detect a signal level of -70 dBm. A TWT amplifier boosted the input signal to a +40 dBm which provides a 110 dB loss measurement range. RF leakage in the measurement setup was reduced below the discernible level.

The isolation obtained on the production switches exceeds the theoretical limit discussed earlier because the DC resistance of the PIN diode was reduced below one ohm at 100 mills bias current to meet all requirements of our production component specification.

[1] Patents pending on material included herein.

[2] Hallford, Ben R., "Low Noise Microstrip Mixer on a Plastic Substrate", GMTT 1970 Symposium Digest May 11-14 1970, p. 206, also Dec. 1970 GMTT Transaction.

[3] A selected version of the 5082-3040 Manufactured by Hewlett-Packard Associates, Palo Alto, Calif.

[4] Capacitors are Type ATC-100 Cubes Obtained from American Technical Ceramics, Huntington Station, New York.

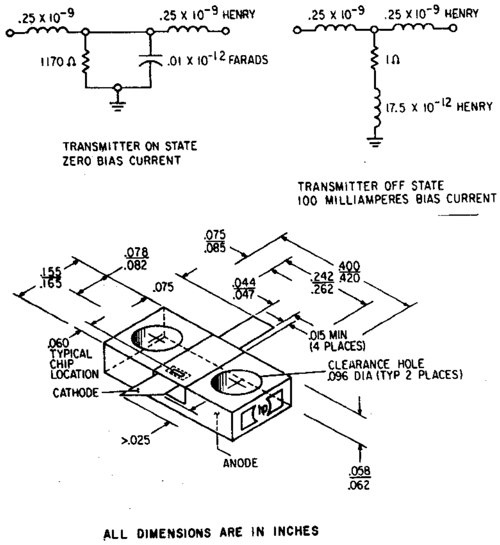
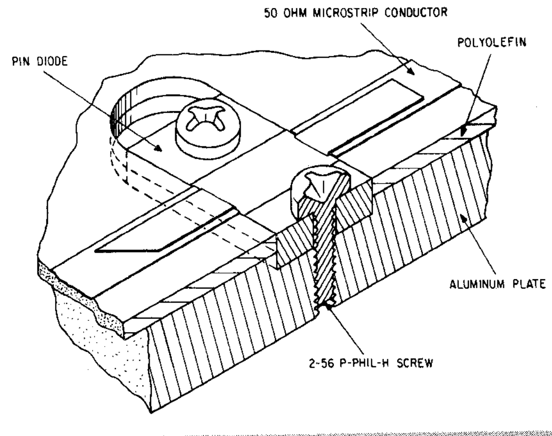


Figure 1. PIN Diode Description.



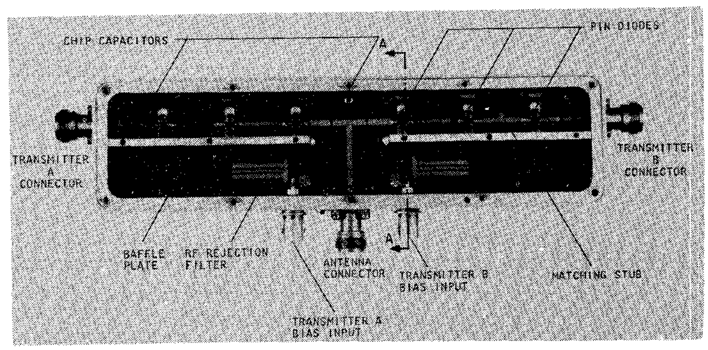


Figure 3. Construction Details of Final Switch.

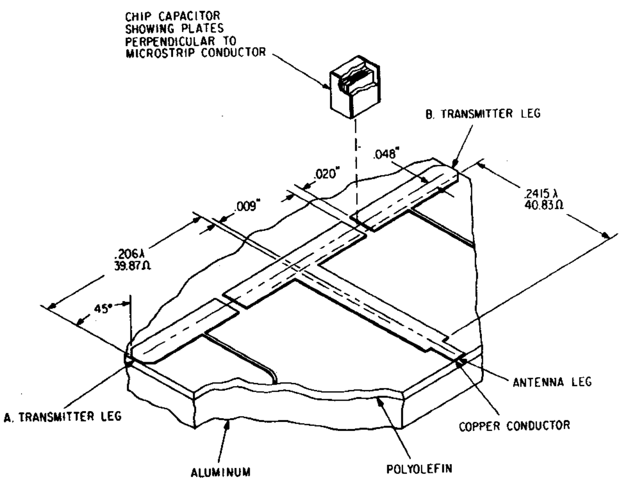
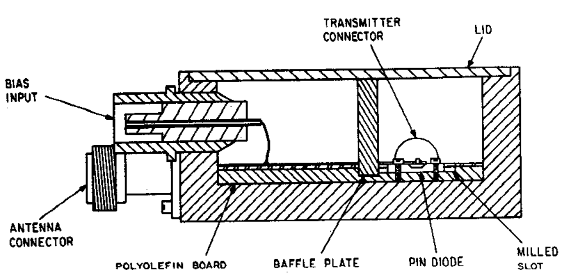


Figure 2. SPDT Switch Junction.



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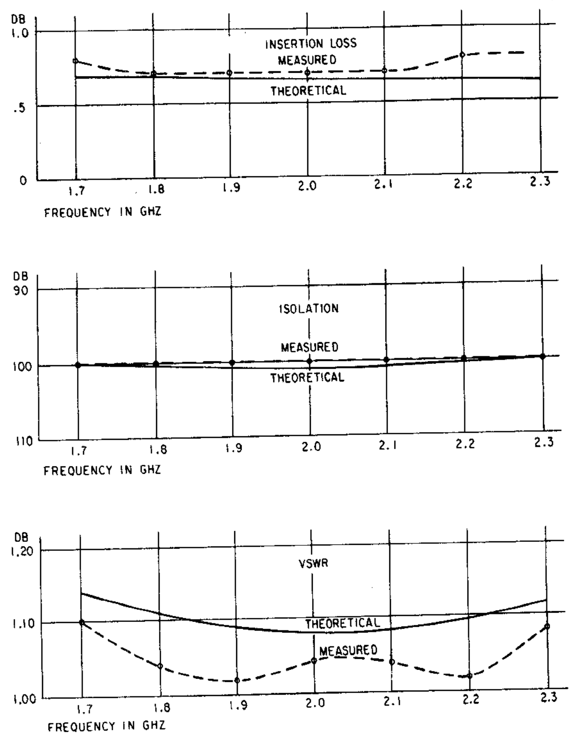

Figure 4. Performance Data.