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NASA TECH BRIEF
NASA Pasadena Office

High-Power Microstrip Switch

The problem:

The successful completion of lengthy space missions in the future requires improvement of the state of the art in the hardware design of the spacecraft radio system. The RF switches, used for switching between antennas and redundant receivers and transmitters, should be extremely reliable and as simple and free from interference with other subsystems as possible.

The solution:

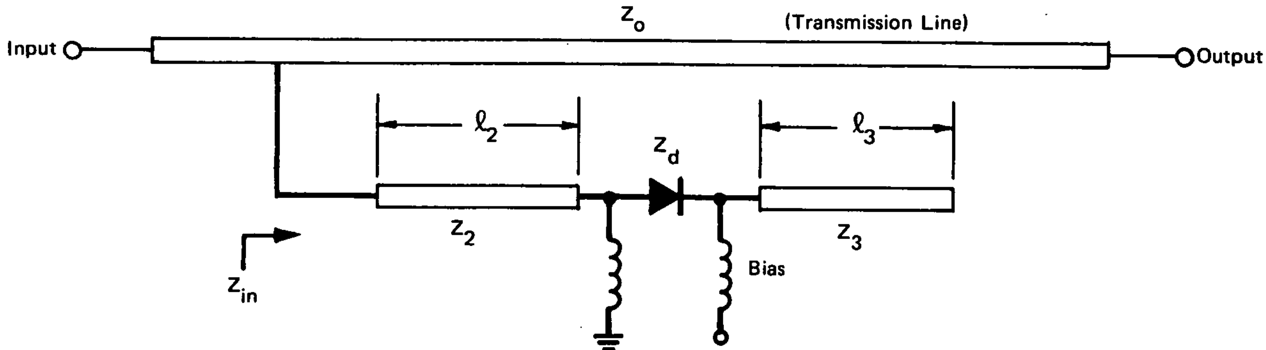
A microstrip-type RF switch, which uses only two PIN (p-intrinsic n) diodes on a microstrip substrate, has been developed for application in spacecraft radio systems. The single-pole double-throw (SPDT) switch is fabricated by a 5-by 5-by 0.127-cm (2-by 2-by 0.050-in.) alumina substrate, and it can handle as much as 100 watts of CW RF power easily. It weighs only 6 oz (0.2 kg) whereas its currently used counterpart (circulator switch) weighs 6 lbs (2.7 kg).

How it's done:

The switch uses PIN diodes exclusively as switching elements, because of their extremely high impedance under a reverse-biased condition and low impedance under a forward-biased condition. In a PIN diode, highly-doped p and n regions are separated by a layer of intrinsic semiconductor. When the diode is forward biased, carriers are injected into the intrinsic region and it exhibits a very low impedance during the entire RF cycle. When the diode is reverse biased, all the carriers in the intrinsic region are swept out and the region appears as a low-loss dielectric.

The microstrip circuits used in the switch are fabricated on 99.5% pure alumina substrates 1.27 mm (0.050 in.) thick, with a 0.05-μm surface finish on the circuit side and a 0.25-μm finish on the ground-plane side. The thickness of the gold metallization is 7.62 μm, which is about six times the skin depth at 2295 MHz. The relative permittivity and loss tangent of 99.5% pure alumina at 10 GHz are 9.7 and 0.001, respectively. The dielectric loss and the conductor loss for a transmission line 1.27 mm (0.050 in.) wide, at 2.3 GHz, are calculated to be 5.1×10^{-4} dB/cm and 0.02 dB/cm, respectively. The adapter used between the microstrip line and the coaxial line (called the launcher) has an insertion loss of 0.02 dB, at 2.3 GHz.

The figure shows a new single-pole single-throw (SPST) switch configuration used as part of the RF switch. As shown, the configuration does not require the previously-used dc blocking capacitor or a ground



Schematic Diagram of the Shunt Stub SPST Switch

(continued overleaf)

post for the diode. The elimination of one capacitor and one ground post per stub amounts to considerable improvement in reliability and ease of manufacturing for multipole switches. The stub lengths ℓ_2 and ℓ_3 shown should be approximately one-quarter wavelength long at the band-center frequency, to make the input impedance Z_{in} maximum for the switch on and minimum for the switch off.

An SPDT switch is formed by combining two of these SPST switches, with the bias so arranged that one port is on and the other off. Typical performance of the switch is as follows:

Band center frequency	2295 MHz
Input voltage-standing-wave-ratio	Lower than 1.07
Insertion loss	0.25 dB over 30 MHz
Isolation (minimum)	36 dB over 30 MHz
Input to bias port isolation	Greater than 45 dB

Notes:

1. The developed switch features improved power drain, weight, volume, magnetic cleanliness, and reliability, over the currently-used circulator and electromechanical switches.
2. Requests for further information may be directed to:
   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: TSP73-10451

Patent status:

NASA has decided not to apply for a patent.

Source: Soon D. Choi of
Caltech/JPL
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