MULTIOCTAVE MULTITHROW ACTIVE SWITCHES*

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ABSTRACT

Multioctave, multithrow active switches have been developed to operate from 2 to 18 GHz. A SPDT switch and a SP4T switch have been constructed. The switches demonstrate 4 dB forward gain and 60 dB of isolation between the input and common port. The switches employ monolithic distributed amplifiers to obtain the forward gain.

INTRODUCTION

In recent years, much attention has been given to phased array radar, EW systems, and other systems which require control components. This has brought about the need to develop improved control components, such as switches and phase shift elements.

Switches are normally known to introduce a certain amount of insertion loss and isolation. Traditionally, it is necessary to accept lower isolation in order to obtain lower insertion loss, the converse is also true. Another parameter which can have an adverse affect on the insertion loss and isolation is the bandwidth. The larger the bandwidth, the more difficult it is to obtain low insertion loss and high isolation. In order to overcome these problems it is necessary to implement an active switch design. The active switch, unlike the passive switch, is capable of supplying high isolation and insertion gain, instead of loss, over a multioctave bandwidth.

CIRCUIT DESIGN AND PERFORMANCE

In order to achieve both gain and high isolation over a broad bandwidth, distributed amplifiers were employed. The isolation is further increased by inserting two series FET switches. Figure 1 shows the basic design concept of the SPDT switch and the SP4T switch. It can be seen that two distributed amplifiers are connected in cascade with the two series FET switches in each branch.

The distributed amplifiers were developed by Hughes at the Torrance Research Center (1,2). The amplifiers are capable of operating from 2 to 40 GHz. Each amplifier supplies 4 dB of gain. These amplifiers can supply approximately 24 dB of isolation at 18 GHz. Figure 2 shows the gain and isolation of two distributed amplifiers in cascade. It can be seen that the two amplifiers provide 30 dB of isolation.

In the SPDT and SP4T switches constructed so far, two series FET switches were used to provide higher isolation. Although the series-series configuration is not the optimum choice, it was chosen for its ease of implementation since it does not require a low inductance RF ground connection.

The switches which were constructed are shown in Figure 3. The SPDT switch performance is shown in Figure 4. We have achieved a gain of 4.25 dB with 1.75 dB ripple. The isolation is better than 59 dB from 2 to 18 GHz. The SP4T switch has similar performance as

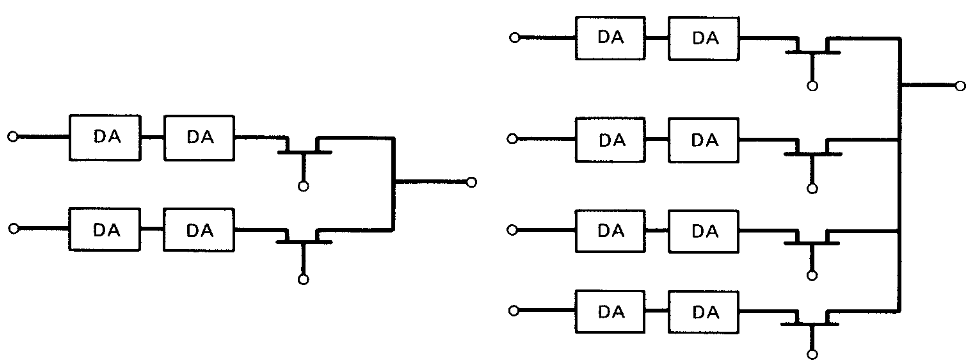

Figure 1. Schematic of active switches.

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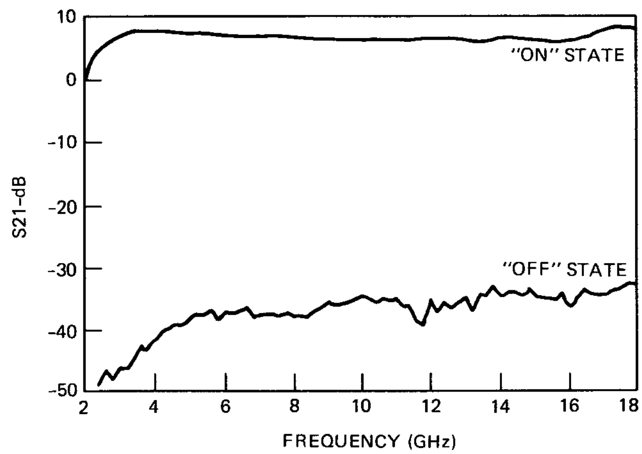


Figure 2. On and off state response of two DAs in cascade.

shown in Figure 5. However, the gain falls off to 0 dB at about 16.4 GHz. This is due to the nature in which the four throws are combined at the common pole. The isolation is greater than 60 dB for the entire frequency band of interest.

A new version of the SP4T switch has been fabricated. This switch is expected to provide 4 dB of gain from 2 to 18 GHz with 2 dB of ripple peak to peak. The isolation is expected to be greater than 63 dB. The switch will also be considerably smaller than the original switch. This SP4T switch measures 1.5 x 1.5 x 0.5 inches. These

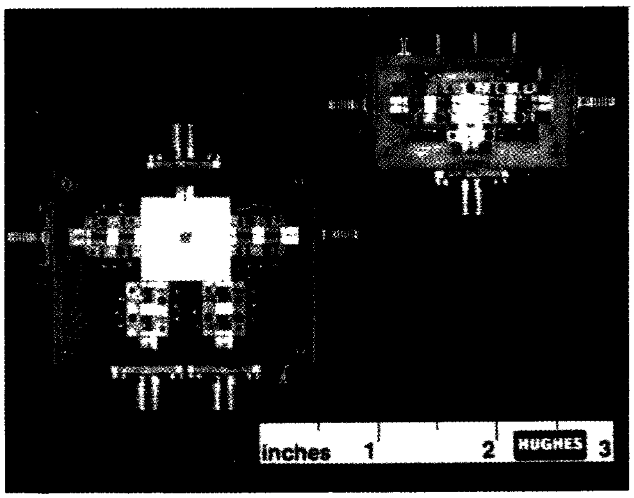


Figure 3. SPDT and SP4T switches.

improvements are the result of the development of a new monolithic SPDT switch. This switch uses a series-shunt configuration to obtain a near constant insertion loss across a wide bandwidth and to have improved isolation. A picture of this monolithic SPDT device is shown in Figure 6, the chip is 725.5 x 1096 x 101 micrometers in size. Its performance is shown in Figure 7.

The broadband active switch can be a useful component in systems which need to strive for gain, high isolation between ports, and minimize the number of components in order to reduce the overall size of the system. The results presented here demonstrate the feasibility of such devices.

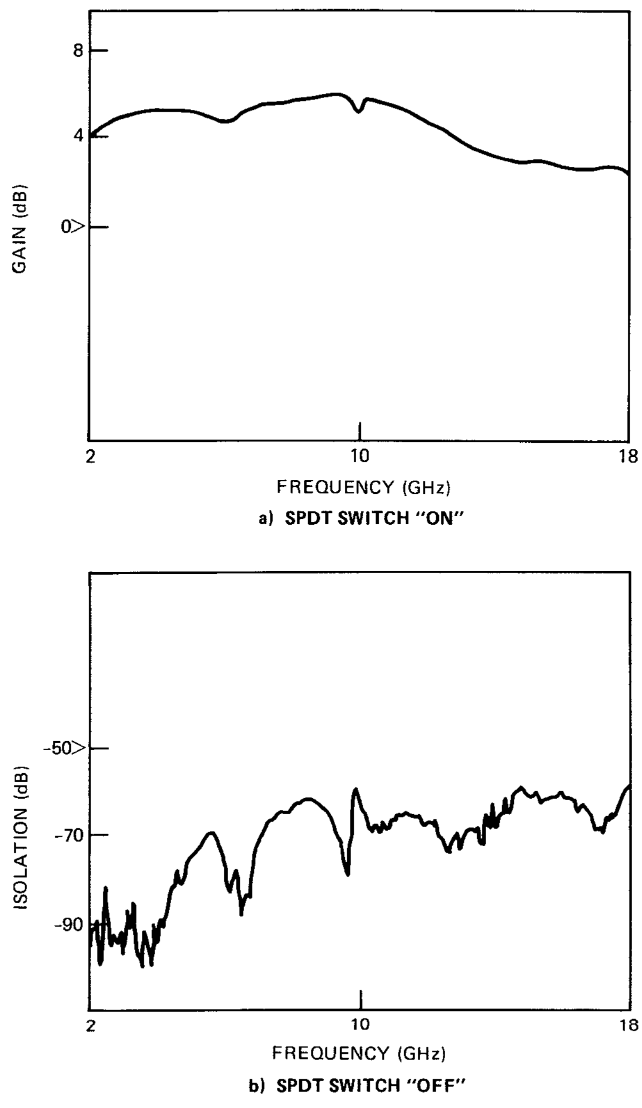
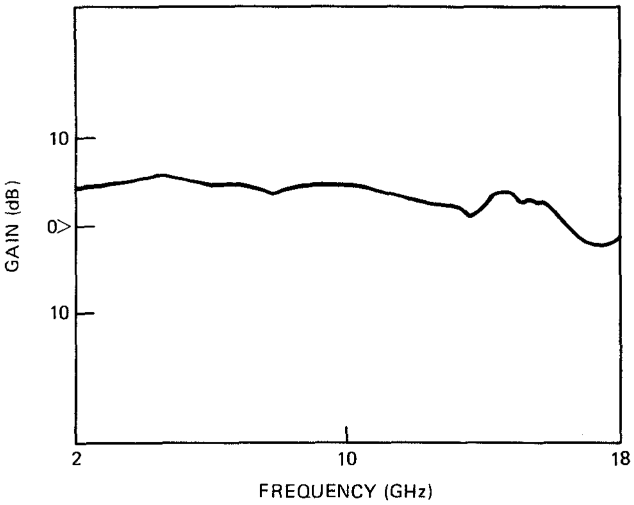
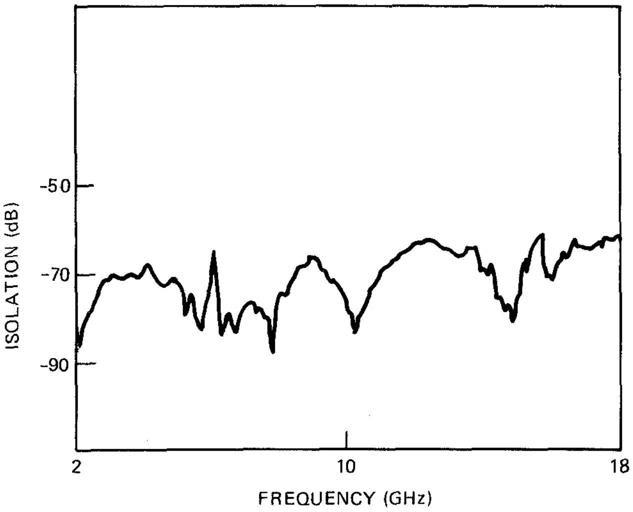


Figure 4. Performance of SPDT switch.



a) SP4T SWITCH "ON"



b) SP4T SWITCH "OFF"

Figure 5. Performance of SP4T switch.

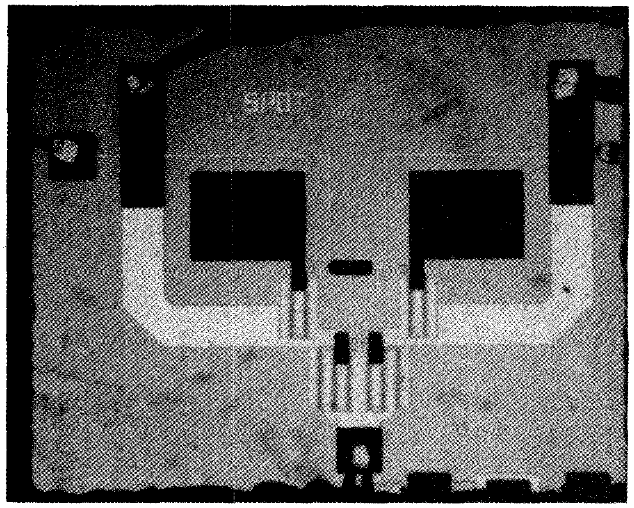


Figure 6. Monolithic GaAs SPDT switch.

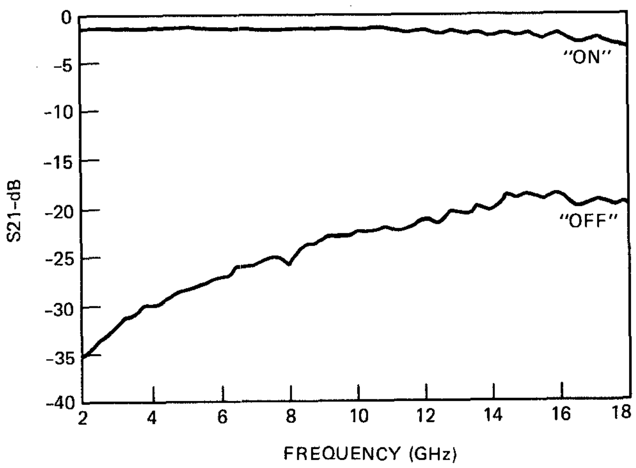


Figure 7. Insertion loss and isolation of GaAs monolithic SPDT switch.

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