A Wide-Band Push-Pull GaAs Monolithic Active Isolator

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***Abstract*—A novel 2-6 GHz push-pull GaAs monolithic active isolator has been designed and tested. This balanced MESFET isolator has better than 18 dB reverse isolation at 6 GHz and provides greater than 15 dB input and output return loss across the band. This small (actual chip area: 12 mils × 24 mils) isolator chip draws 20mA of current from a single +5V supply. The compact chip size makes it an ideal candidate for impedance matching for monolithic sub-systems where a ferrite isolator is not practical.**

I. Introduction

ISOLATORS are two port nonreciprocal components that allow microwave energy to pass in one direction with little attenuation but absorb power in reverse direction. In many microwave systems, isolators are needed to minimize mismatch reflections between various components in the system. The most familiar type of microwave isolators are generally constructed using passive magnetic ferrite technique. Ferrite isolators tend to be bulky in size and weight as compared to an MMIC. In monolithic circuit applications, it is desirable to have an isolator that can be fabricated on GaAs substrate along with other circuit components to be cascaded. Recently, the design and development of monolithic circulators [1], [2] and an active isolator [3] have been reported. In this letter, we present a GaAs monolithic push-pull active isolator [4] that is suitable for MMIC integration.

II. Circuit Description

GaAS MESFET's in common gate and common drain (source follower) configurations provide considerable advantage in terms of input and output reflection coefficients. By using a parallel combination of a source follower and a common gate stage to achieve good input and output match and a high ratio of forward to reverse transmission, we have successfully designed a 2-6 GHz push-pull GaAs monolithic active isolator.

A basic circuit of an active isolator for single-ended operation is shown in Fig. 1. Two 1 um × 250 um FET's are used for the source follower and the common gate configurations. A Schottky diode is used as the voltage level shifter and a 65 um FET has been used as a current source. A balanced isolator was formed using the basic circuit in Fig. 1 as a building block. The circuit schematic of this balanced isolator is shown in Fig. 2. A 2 pF output DC blocking capacitors are added to facilitate cascading of other circuits with this chip. The presence of a virtual ground in a push-pull design eliminates the need for critical RF grounding by means of via-holes and allows close packing of the various components. The circuit yield is also increased since via-holes are not longer required and the foundry process is less complex. These factors are of special significance in terms of low cost, high yield and small size.

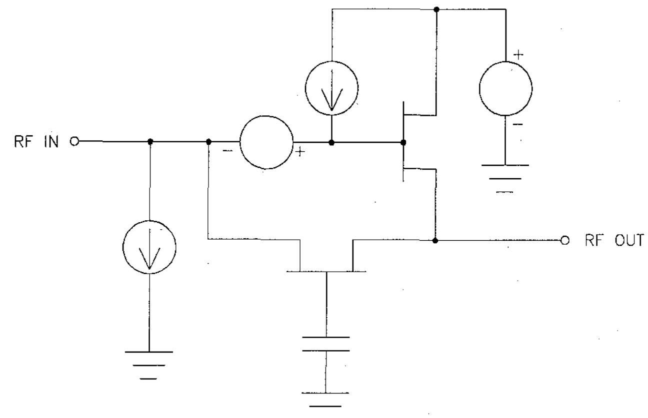

Fig. 1. Basic circuit of active isolator for single-ended operation.

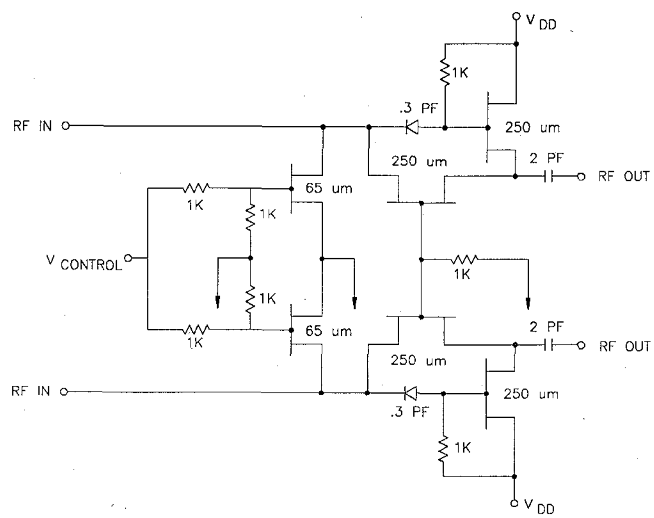

Fig. 2. Circuit schematic of push-pull active isolator.

Fig. 3 shows the photograph of the fabricated chip. The actual circuit area is 12 mils × 24 mils with the bonding pads being 4 mils square. This monolithic isolator was fabricated using Triquint's one-micron ion-implanted MESFET process. Interconnections were achieved using first metal and airbridge metallizations. MIM capacitors with silicon nitride passivation has been used for DC blocking.

III. Circuit Performance

The push-pull active isolator has been characterized both at the wafer level and on a carrier. Wafer level results showed excellent RF yield (70%) based on the test results of 30 devices.

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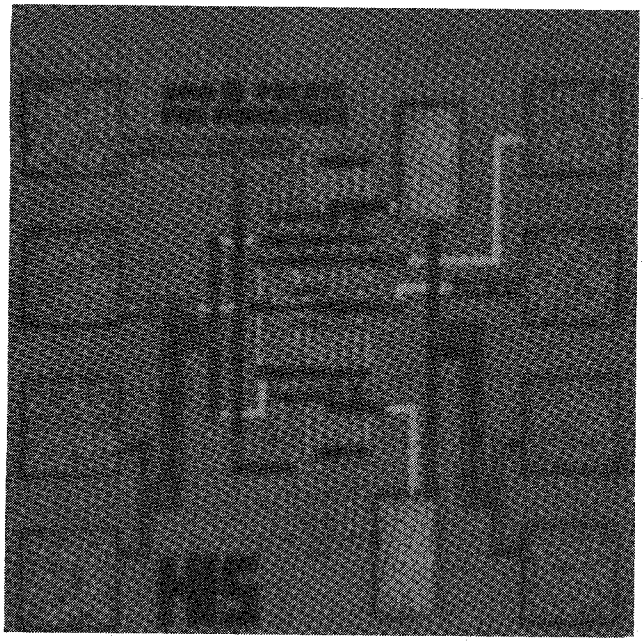

Fig. 3. Photograph of fabricated monolithic push-pull active isolator (actual chip area: 12 mils × 24 mils).

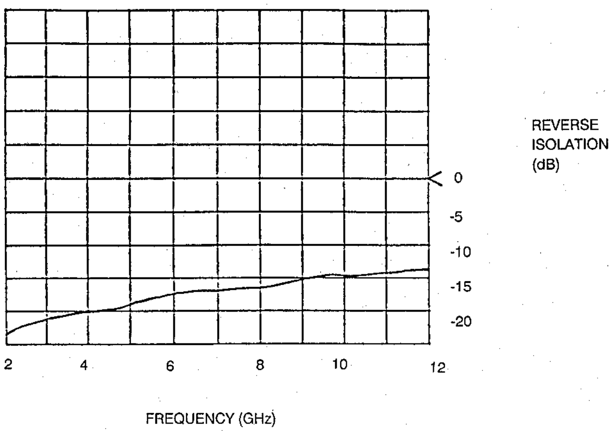

Fig. 4. Isolation performance of circuit.

Fig. 4 shows the reverse isolation of the circuit. It has better than 18-dB reverse isolation at 6 GHz and better than 20 dB below 4 GHz. The input and output return losses are better than 15 dB across 2–6 GHz band (Fig. 5). The balanced isolator has a measured maximum insertion loss of 1.2 dB at 6 GHz. Fig. 6 illustrates the output power as a function of input power at 4 GHz for various supply voltages. The measured output power of the isolator at 1 dB gain compression point is +13 dBm. A linear output power only 7 dB below the DC power input is exceptionally efficient operation, indicating suitability for higher power applications.

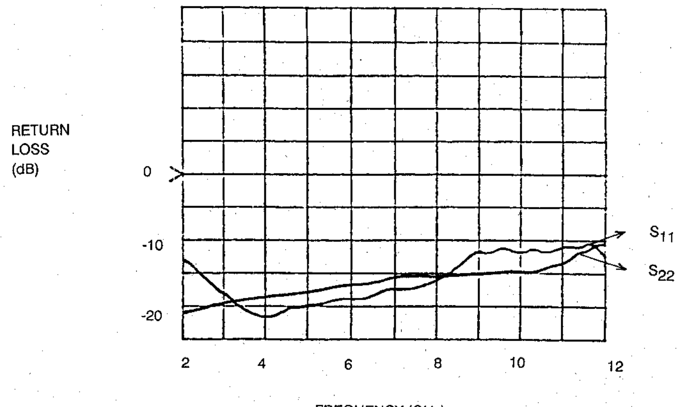

Fig. 5. Input and output return losses of active isolator.

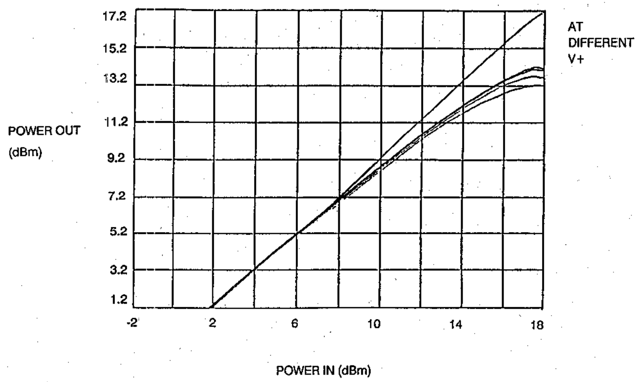

Fig. 6. Plot of active isolator's output power as function of input power at 4 GHz.

Summary

A novel 2–6 GHz push-pull GaAs monolithic active isolator has been successfully developed and tested. This isolator may be directly integrated into an MMIC or used in between MIC amplifier/circuits where a ferrite isolator is not practical. It has been used at the input of a *C*-Band monolithic 2-bit phase shifter circuit [5].

References

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