

6. W. Ng, R. Stephens, D. Persechini, and K. V. Reddy, Ultra-low jitter mode locking of Er-fibre laser at 10 GHz and its application in photonic sampling for analogue-to-digital conversion, *Electron Lett* 37 (2001), 113–115.
7. Y. Hu, M. Dubov, and I. Khrushchev, Spectrally-controlled, gain-switched operation of InGaN diode laser, *Electron Lett* 40 (2004), 702–703.

© 2006 Wiley Periodicals, Inc.

## 5.2 GHz HIGH ISOLATION SiGe BICMOS CMFB GILBERT MIXER

Chinchun Meng,<sup>1</sup> Tzung-Han Wu,<sup>1</sup> Tse-Hung Wu,<sup>1</sup> and Guo-Wei Huang<sup>2</sup>

<sup>1</sup>Department of Communication Engineering, Chiao Tung University, Hsinchu 300, Taiwan, Republic of China

<sup>2</sup>National Nano Device Laboratories, Hsinchu 300, Taiwan, Republic of China

Received 5 July 2006

**ABSTRACT:** Active PMOS loads with common mode feedback to stabilize the bias points are employed in the Gilbert mixer loads to increase the mixer gain. Good device matching and the deep trench isolation technique in the SiGe HBT technology can improve the port-to-port isolations. A 16 dB conversion gain,  $IP_{1dB} = -21$  dBm and  $IIP_3 = -11$  dBm using  $0.35 \mu\text{m}$  SiGe BiCMOS Gilbert downconversion micromixer is demonstrated when  $RF = 5.2$  GHz and  $LO = 5.17$  GHz with  $-66$  dB LO-IF,  $-52$  dB LO-RF, and  $-24$  dB RF-IF isolations. © 2006 Wiley Periodicals, Inc. *Microwave Opt Technol Lett* 49: 450–451, 2007; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.22152

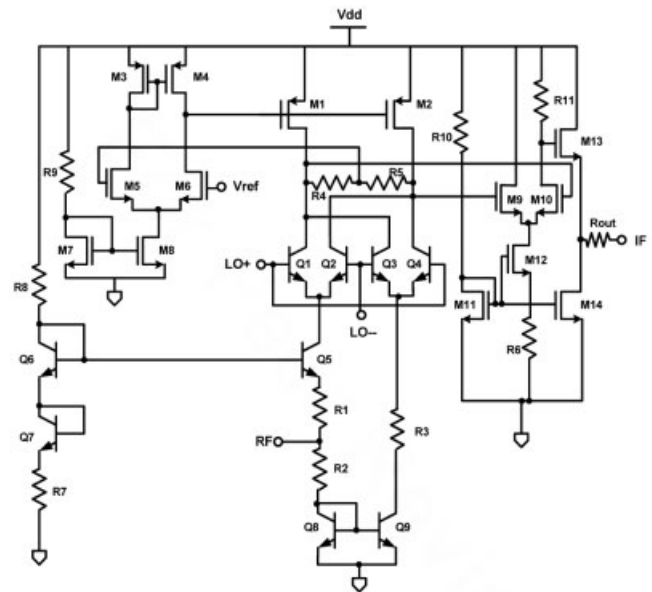
**Key words:** SiGe BiCMOS; deep trench isolation; Gilbert mixer; CMFB

### 1. INTRODUCTION

RFIC systems contain various circuit components such as PAs, LNAs, Mixers, and VCOs. The double balanced Gilbert mixer is an ideal circuit topology for active RF mixer designs because of the good port-to-port isolations and the small chip size [1]. However, the high isolation property requires highly device matching to insure the truly balanced operation. The SiGe HBT device has better matching properties than the MOS device has because the matching in the former depends on the bandgap while the matching in the latter relies on the fabrication process. Moreover, a deep trench technology is available in this SiGe BiCMOS technology to further improve by the isolations among devices. In this letter, a high port-to-port isolation downconversion micromixer as shown in Figure 1 is demonstrated at 5.2 GHz using  $0.35 \mu\text{m}$  the SiGe BiCMOS technology.

### 2. CIRCUIT DESIGN

One popular variation of the Gilbert mixers is the micromixer topology [2]. The micromixer input stage possesses high speed response. The micromixer input stage consists of a common-base input single balanced mixer (transistors  $Q_1$ ,  $Q_2$ , and  $Q_5$ ), a common-emitter input single balanced mixer (transistors  $Q_3$ ,  $Q_4$ , and  $Q_9$ ), and a current mirror (transistors  $Q_8$  and  $Q_9$ ). The frequency response of transistor  $Q_9$  is improved by adding a diode-connected transistor  $Q_8$  at the base of transistor  $Q_9$ . The micromixer input stage also facilitates the input impedance matching. The common-base biased transistor  $Q_5$  and the diode-connected transistor  $Q_8$  have low impedance level.



**Figure 1** Schematic diagram of the high isolation SiGe BiCMOS common mode feedback downconversion micromixer

The differential active PMOS loads instead of resistive loads are used in order to increase the conversion gain and the signal headroom of the downconversion mixer. The differential active loads need a common mode feedback loop to bias the transistor in the proper region and a resistive sensing CMFB (Fig. 1) is employed to adjust PMOS current source loads. The high IF gain can be achieved with large resistors of the  $R_4$  and  $R_5$  at the cost of lower IF bandwidth.

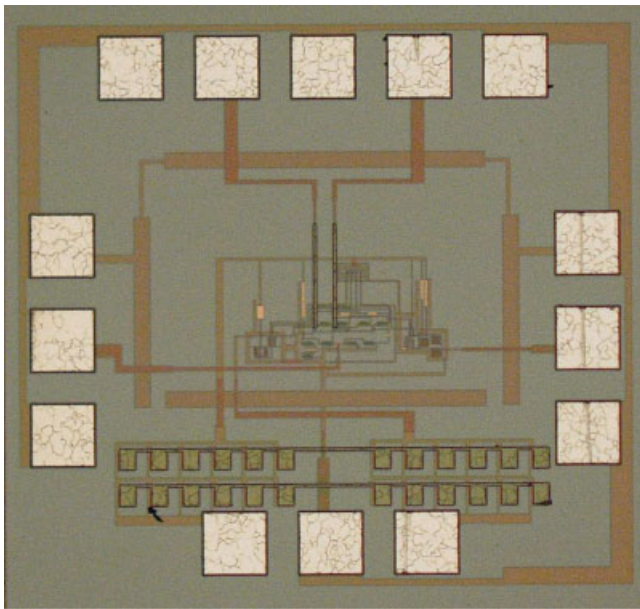
A differential amplifier formed by NMOS transistors  $M_9$  to  $M_{12}$  functions as a differential-to-single active balun and a common drain stage,  $M_{13}$ , converts the output to the low impedance level as required by the output return loss consideration. By this arrangement, the circuit topology in Figure 1 has a single-ended broad band input stage and a single-ended broad band output stage. The arrangement also can be used to observe the isolation property in the on-wafer RF measurement.

### 3. MEASUREMENT RESULTS

Figure 2 shows the photograph of the  $0.35 \mu\text{m}$  SiGe BiCMOS micromixer. An off-chip rat-race hybrid, which provides balanced LO signals, are used to feed GSGSG LO port in the on-wafer measurement. The die size is  $0.9 \times 0.9 \text{ mm}^2$ . The circuit only occupies a small percentage of the die area and most of the areas are the probing pads for on-wafer measurements.

The maximum conversion gain of the downconversion micromixer is 16 dB and occurs at 3 dBm LO power when  $LO = 5.17$  GHz and  $RF = 5.2$  GHz. The LO-IF isolation, LO-RF isolation, and RF-IF isolation measurement results are shown in Figure 3 when the difference between the RF and the LO frequency is fixed at 30 MHz. Isolations,  $-66$  dB LO-IF,  $-52$  dB LO-RF, and  $-24$  dB RF-IF, are achieved in our downconversion micromixer when  $RF = 5.2$  GHz and  $LO = 5.17$  GHz as shown in Figure 3. The RF-IF isolation is much less than the LO-IF isolation because RF signals experience the RF gain stage.

The power performance in Figure 4 shows that  $IP_{1dB} = -21$  dBm and the  $IIP_3$  of the mixer is  $-11$  dBm. All the power measurements are performed in the condition that the RF frequency is 5.2 GHz and the LO frequency is 5.17 GHz with 3 dBm LO power at 5 V supply voltage and 35.7 mA current consump-



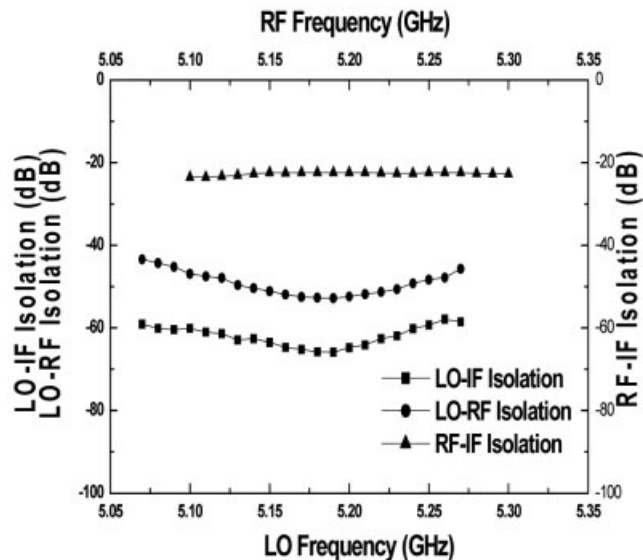
**Figure 2** Photograph of the high isolation SiGe BiCMOS common mode feedback downconversion micromixer. [Color figure can be viewed in the online issue, which is available at [www.interscience.wiley.com](http://www.interscience.wiley.com)]

tion. The input return loss is better than 13 dB for frequencies up to 10 GHz.

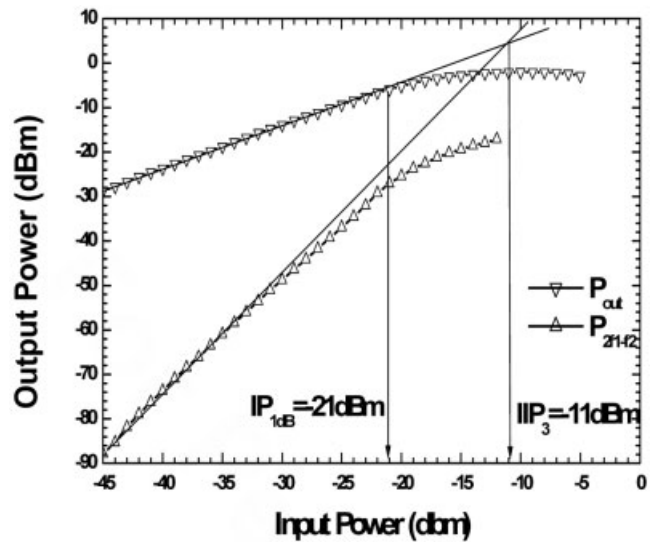
The downconversion micromixer demonstrated in this work has fully utilized the advantages of both SiGe HBT and MOS transistors. The isolations are very good when compared with other published results [3, 4] because the SiGe HBT devices used in this work naturally possess better device matches and the deep trench isolation technology, which eliminates the signal coupling through the silicon substrate, helps to improve the port-to-port isolation.

#### ACKNOWLEDGMENTS

This work is supported by National Science Council of Taiwan, Republic of China under contract numbers NSC 94-2752-E-009-



**Figure 3** Measured LO-IF, LO-RF, and RF-IF isolations of the high port-to-port isolation SiGe BiCMOS common mode feedback downconversion micromixer



**Figure 4** Two-tone power measurement of the high isolation SiGe BiCMOS common mode feedback downconversion micromixer

001-PAE, NSC 94-2219-E-009-014 and by the Ministry of Economic Affairs of Taiwan, Republic of China under contract number 94-EC-17-A-05-S1-020. The authors also thank the Chip Implementation Center (CIC) for its support.

#### REFERENCES

1. K.-Y. Yeh, S.-S. Lu, and Y.-S. Lin, Monolithic InGaP-GaAs HBT receiver front-end with 6 mW DC power consumption for 5 GHz Band WLAN applications, *IEE Electron Lett* 40, (2004).
2. B. Gilbert, The MICROMIXER: A highly linear variant of the Gilbert mixer using a bisymmetric Class-AB input stage, *IEEE J Solid-State Circuits* 32 (1997), 1412-1423.
3. T.K. Johansen, J. Vidkjr, and V. Krozer, Analysis and design of wide-band SiGe HBT active mixers, *IEEE Trans Microwave Theory Tech* 53 (2005), 2389-2397.
4. C. Viallon, J. Graffeuil, and T. Parra, High performance K-band active mixer using BiCMOS SiGe process, *Electron Lett* 41 (2005).

© 2006 Wiley Periodicals, Inc.

## NOVEL APPROACH TO OPTIMIZING A BROADBAND RIGHT-ANGLE COAXIAL-TO-MICROSTRIP TRANSITION

Jin-Eep Roh,<sup>1</sup> Jun-Wen Li,<sup>1</sup> Bierng-Chearl Ahn,<sup>1</sup> Chan-Sik Park,<sup>1</sup> and Eun-Jong Cha<sup>2</sup>

<sup>1</sup>School of Electrical and Computer Engineering, Chungbuk National University, #12, Gae-Shin Dong, Cheong-Ju City, Chungbuk 361-763, South Korea

<sup>2</sup>Department of Medicine, Chungbuk National University, #12, Gae-Shin Dong, Cheong-Ju City, Chungbuk 361-763, South Korea

Received 5 July 2006

**ABSTRACT:** A new approach to the optimization of a broadband right-angle coaxial-to-microstrip transition is presented. The right-angle transition finds many applications where printed circuits need to be fed from behind the ground plane using coaxial connectors. To obtain low reflections over the whole operating frequency range of the transition, dimensional parameters, such as ground aperture and probe diameters, ground aperture offset, and microstrip stub length are optimized using a