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# A GaInP/GaAs HBT MICROMIXER FOR 2.4/5.2/5.7-GHz MULTIBAND WLAN APPLICATIONS

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**ABSTRACT:** *A GaInP/GaAs HBT micromixer for 2.4/5.2/5.7-GHz multiband WLAN applications is demonstrated. Our experimental results show that the input return loss* $|S_{11}|$ *is below* $-25$ *dB from DC to 10 GHz with power-conversion gains of 11.7, 11.9, and 11.5 dB at frequencies of 2.4, 5.2, and 5.7 GHz, respectively. The wideband matching characteristic makes the micromixer very suitable for multiband applications. Input* $P_{1dB}$ *is* $-4$ *dBm and* $IIP_3$ *is 2.36 dBm. Port-to-port isolation is also quite satisfactory. In addition, the single-to-differential input stage in the Gilbert micromixer eliminates the need for common-mode rejection.* © 2004 Wiley Periodicals, Inc. Microwave Opt Technol Lett 43: 87–89, 2004; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20383

**Key words:** *InGaP; HBT; micromixer; multiband; WLAN*

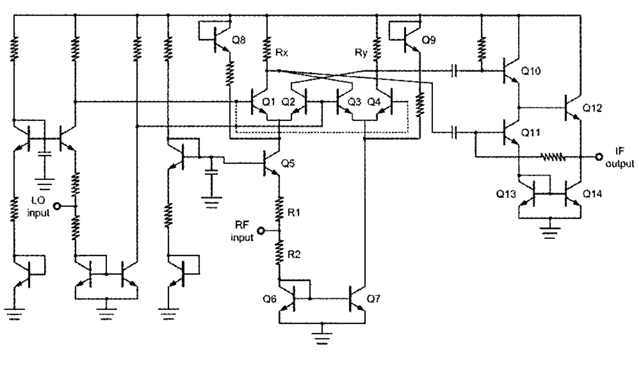


**Figure 1** Schematic of the GaInP/GaAs HBT double-balanced Gilbert micromixer

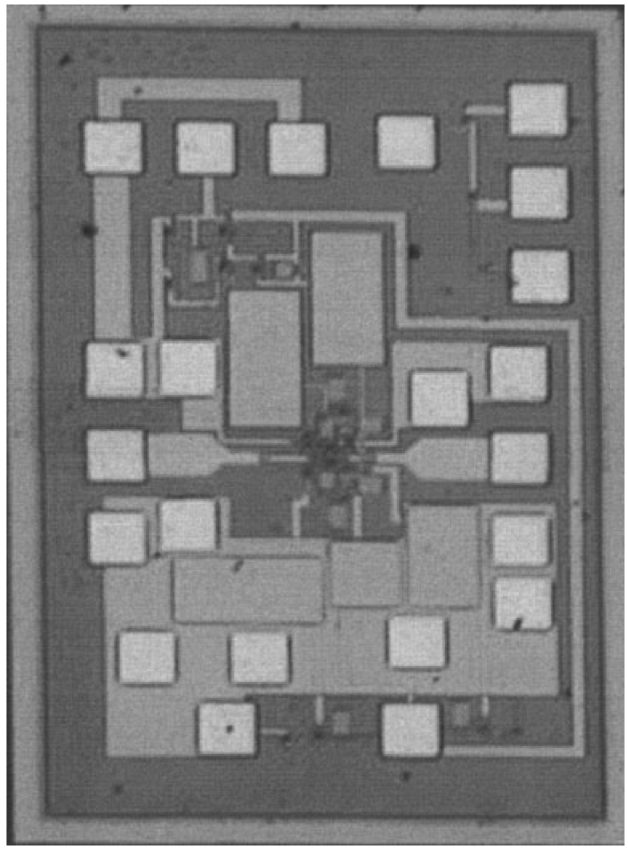

**Figure 2** Die photo of the GaInP/GaAs HBT double-balanced Gilbert micromixer

## 1. INTRODUCTION

Wireless communication has evolved into a world of multistandards/multiservices with operating frequencies of 900-MHz/1.8-GHz/1.9-GHz bands for GSM, 1.5-GHz band for GPS, and 2.4/5.2/5.7-GHz bands for WLAN. Typical design strategies used different receive/transmit paths for different frequency bands. Recently, a large number of efforts have been made to develop concurrent multiband antennas, filters, and low-noise amplifiers [1]. That is, it is desirable to combine two or more standards in one mobile unit. In heterodyne receivers, such as ISL3685 [2] or RF2444 [3], the input impedance of a mixer has to be matched to 50Ω. Therefore, for 2.4/5.2/5.7-GHz multiband WLAN applications, there is a need for a mixer whose input impedance can be matched to 50Ω at these frequencies. In this work, an integrated GaInP/GaAs HBT mixer, which can handle 2.4/5.2/5.7-GHz triple bands, is reported. The multiband input impedance matching is accomplished by the parallel combination of a common-base transistor and a diode-connected transistor, which renders an impedance controlled by their transconductance. This variant of the Gilbert mixer is called a micromixer [4].

## 2. CIRCUIT DESIGN

The schematic of our GaInP/GaAs HBT multiband micromixer is depicted in Figure 1. A single-to-differential stage is constructed with $Q5$, $Q6$, and $Q7$ and two resistors, $R1$ and $R2$. The common-base-biased $Q5$ and common-emitter-biased $Q7$ provide equal but out-of-phase transconductance gain when $Q6$ and $Q7$ are connected as a current mirror. The common base configuration possesses good frequency response, while the speed of the common-emitter-configured $Q7$ is improved drastically by adding the low-

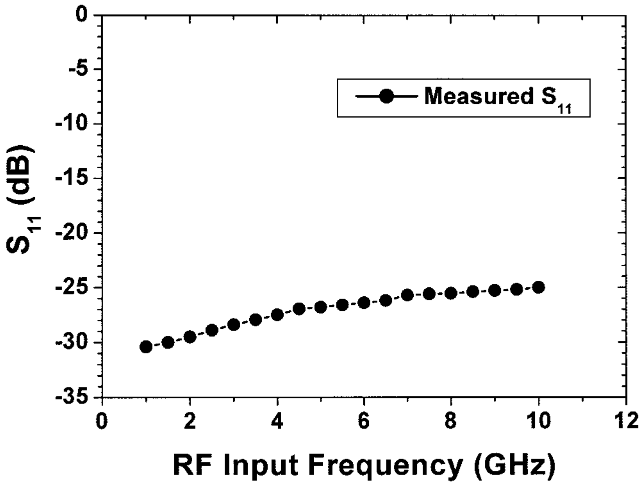


**Figure 3** Input-matching characteristics of the GaInP/GaAs HBT double-balanced Gilbert micromixer

impedance diode-connected $Q6$ at the input of the common-emitter-configured $Q7$. Thus, the single-to-differential stage shown in Figure 1 is very suitable for high-frequency operation. The resistance looking into point RF input in Figure 1 is equal to the parallel combination of the $R1$-$Q6$ branch and the $R2$-$Q6$ branch. Therefore, 50Ω at the point of RF input can be achieved by choosing appropriate biases of $Q5$, $Q6$, and $Q7$. Note that the bias-current source in a conventional Gilbert mixer contributes noise and deteriorates the common-mode rejection ratio rapidly at high frequency. In contrast, the single-to-differential input stage in the Gilbert micromixer renders good frequency response and eliminates the need for common-mode rejection, necessary in a conventional Gilbert mixer. The current-injection-bias technique [5] is applied (see Fig. 1) to enhance the conversion gain of the mixer. Because of the current injection from $Q8$ and $Q9$, the DC tail current of the Gilbert quad ($Q1$, $Q2$, $Q3$, and $Q4$) can be reduced and hence large load resistors ($R_x$, $R_y$) can be used, which results in a higher power conversion gain of the mixer. The single-to-differential technique is also applied in the LO input and a differential amplifier is used to convert the differential IF signal to the single-ended signal.

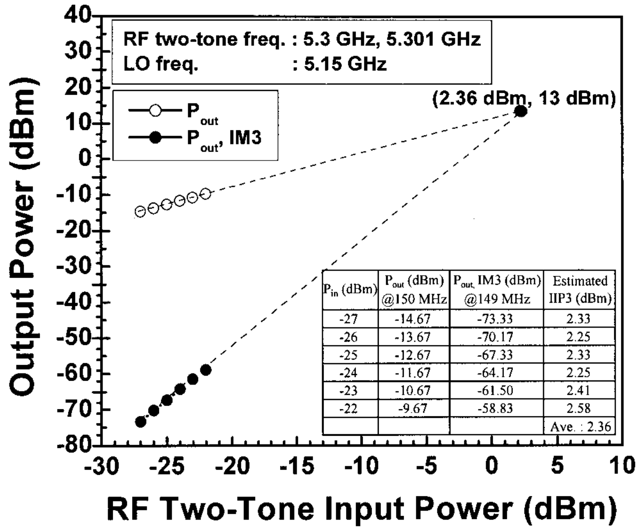


**Figure 5** Measured two-tone $3^{rd}$-order intermodulation characteristics of the GaInP/GaAs HBT double-balanced Gilbert micromixer

### 3. RESULTS AND DISCUSSION

The micromixer is implemented using a 1.4-$\mu$m emitter width GaInP/GaAs HBT process. The die photograph of the fabricated GaInP/GaAs HBT micromixer is shown in Figure 2. On-wafer measurement is performed. The supply voltage is 5 V.

The input return loss $|S_{11}|$ is below $-25$ dB from DC to 10 GHz, as shown in Figure 3, thus indicating a very wideband matching characteristic. The characteristics of power-conversion gain versus RF input power (RF frequency: 5.15 GHz) with a fixed LO power of $-8$ dBm (LO frequency: 5 GHz) are plotted in Figure 4, and an input $P_{1dB}$ of $-4$ dBm is obtained. The power-conversion gain characteristics as a function of LO input power are also shown in Figure 4. In addition, two-tone intermodulation measurement is performed and the results are shown in Figure 5. $IIP_3$ of 2.36 dBm is obtained.

The characteristics of power-conversion gain as a function of RF frequency with a fixed IF frequency of 150 MHz and a fixed LO power of $-8$ dBm are plotted in Figure 6. The power-conversion gain is 11.7, 11.9, and 11.5 dB at frequencies of 2.4, 5.2, and 5.7 GHz, respectively. The isolation characteristics of the

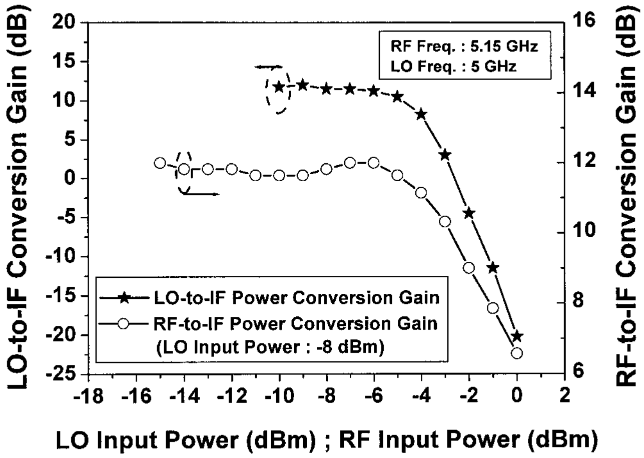


**Figure 4** Measured power-conversion gain characteristics as a function of both LO input power and RF input power of the GaInP/GaAs HBT double-balanced Gilbert micromixer

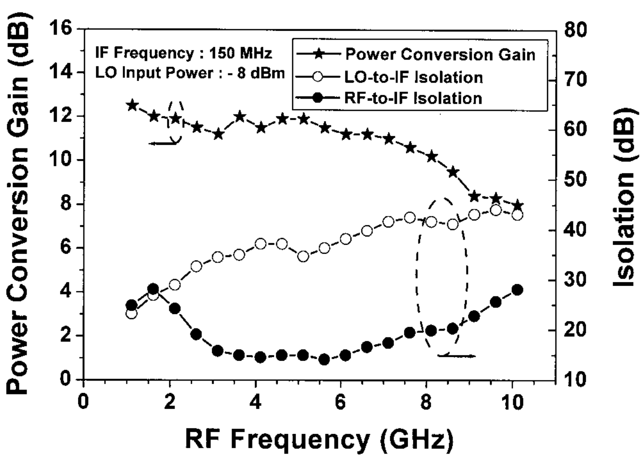


**Figure 6** Measured power-conversion gain and isolation characteristics as functions of RF frequency of the GaInP/GaAs HBT double-balanced Gilbert micromixer

mixer are also shown in Figure 6. The LO-IF isolation is 31.1, 35, and 37 dB at frequencies of 2.4, 5.2, and 5.7 GHz, respectively. The RF-IF isolation is 21.1, 14.8, and 14.3 dB at frequencies of 2.4, 5.2, and 5.7 GHz, respectively. Clearly, the isolation characteristics of the micromixer are quite satisfactory.

#### 4. CONCLUSION

A micromixer has been demonstrated using GaInP/GaAs HBT technology for multiband WLAN. The intrinsic wideband matching characteristics of the micromixer make it very suitable for multiband applications. Conversion gains of 11.7, 11.9, and 11.5 dB at frequencies of 2.4, 5.2, and 5.7 GHz, respectively, are obtained. Good isolation and linearity are also achieved.


#### ACKNOWLEDGMENT

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# ERRATUM: RESONANCE CHARACTERISTICS OF WHISPERING GALLERY MODES IN PARALLEL-PLATES-TYPE CYLINDRICAL DIELECTRIC RESONATORS


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In our paper [1], Figure 1 was supposed to be depicted as follows:

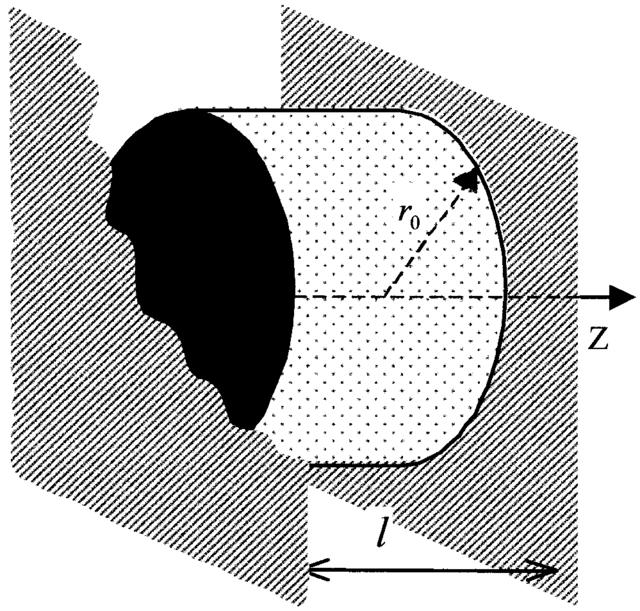


**Figure 1** Parallel-plates type dielectric resonator

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