associated with the DiPPM technique make it an attractive modulation format for indoor infrared wireless transmission.

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A MONOLITHIC 5.2-GHz SINGLE-ENDED INPUT AND SINGLE-ENDED OUTPUT GaInP/GaAs HBT UPCONVERSION GILBERT MIXER WITH INTEGRATED OSCILLATOR

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Received 16 November 2004

ABSTRACT: *A truly balanced operation of a 5.2-GHz Gilbert micromixer with a single-ended input and a single-ended output is demonstrated using 2-μm GaInP/GaAs HBT technology. Because the micromixer has a single-ended input, a passive LC current combiner is used to convert the mixer-differential output into a single-ended output. A cross-coupled LC oscillator with oscillation frequency of 4.3 GHz and a cascode buffer amplifier are also integrated in the same chip. The fully integrated upconversion micromixer has conversion gain of -2.5 dB and OP_{1dB} of -12.5 dBm when input IF = 0.9 GHz and thus output RF = 5.2 GHz. The IF input return loss is better than 25 dB for frequencies up to 6 GHz, while the RF output return loss is better than 12 dB for frequencies from 5.15 to 5.35 GHz.* © 2005 Wiley Periodicals, Inc. Microwave Opt Technol Lett 45: 277–279, 2005; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20795

Key words: *GaInP; HBT; mixer; oscillator*

1. INTRODUCTION

A monolithic 5.2-GHz upconversion micromixer with an integrated oscillator, as shown in Figure 1, is demonstrated in this paper using a 2-μm GaInP/GaAs HBT technology. The micromixer [1] proposed by Gilbert is the ideal circuit for a mixer at RF frequencies because the intrinsic single-to-differential input stage of a Gilbert micromixer renders a high-speed response and facilitates wideband impedance matching. A passive LC current combiner can double the current gain [2–4] by converting the mixer-differential output into a single-ended output. A cross-coupled LC oscillator with a balanced cross-coupled cascode buffer amplifier is used here to provide balanced signals to the LO port of the mixer. Thus, a truly balanced operation of a Gilbert micromixer with a single-ended input and a single-ended output is achieved at 5.2 GHz.

The fully integrated GaInP/GaAs HBT upconversion micromixer demonstrated has a conversion gain of -2.5 dB and OP_{1dB} of -12.5 dBm when input IF = 0.9 GHz and thus output RF = 5.2 GHz. The oscillation frequency of the integrated oscillator is 4.3 GHz. The IF input return loss is better than 25 dB for frequencies up to 6 GHz, while the RF output return loss is better than 12 dB for frequencies from 5.15 GHz to 5.35 GHz. The die size is 1 mm^2.

2. CIRCUIT DESIGN

The circuit schematic of a GaInP/GaAs downconversion micromixer is illustrated in Figure 1 and a photograph of the fabricated circuit is shown in Figure 2. The GaInP/GaAs HBT device has a 35-GHz cutoff frequency. A double-balanced Gilbert mixer has been widely used to implement mixer-integrated circuits due to the excellent port-to-port isolations. However, the common-mode rejection provided by the biased current source in a conventional Gilbert mixer deteriorates rapidly at high frequencies [5] and degrades the port-to-port isolations. The single-to-differential input stage in a micromixer is not only used to turn an unbalanced signal into balanced signals, but also eliminates the need for

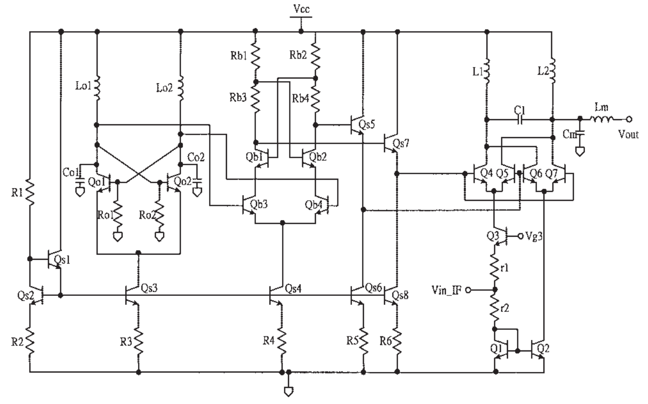

Figure 1 Schematic of an upconversion micromixer with integrated output LC-current combiner and oscillator

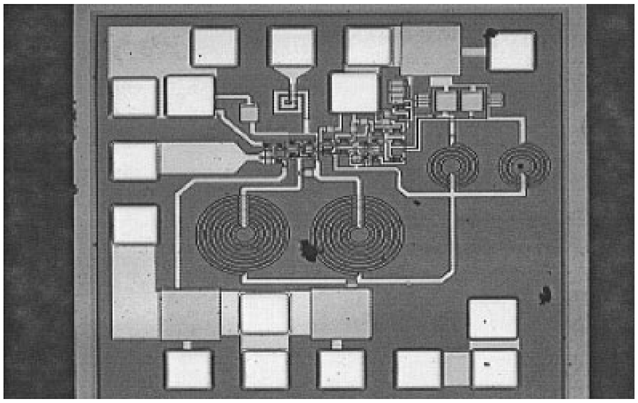

Figure 2 Photograph of the upconversion micromixer with integrated output LC-current combiner and oscillator

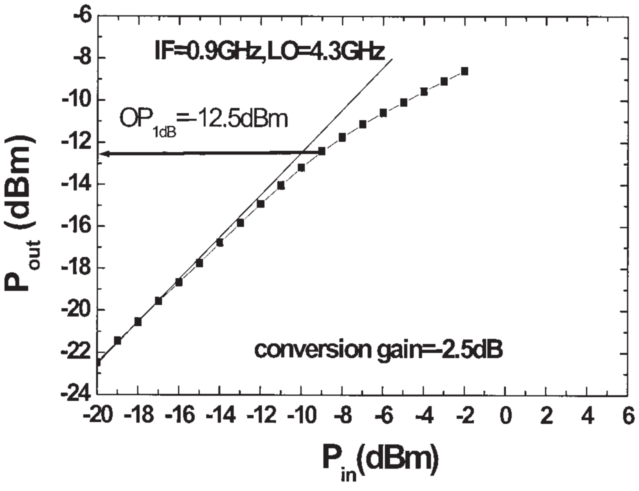

Figure 3 Power measurement of the upconversion micromixer with integrated output LC-current combiner and oscillator

common-mode rejection. The common-base-biased Q_3 and the common-emitter-biased Q_2 provide equal but out-of-phase transconductance gain when Q_1 and Q_2 are connected as a current mirror pair. The common-base-configured Q_3 possesses good frequency response, while the speed of the common-emitter-configured Q_2 is improved drastically by adding a low impedance diode-connected Q_1 at the input of the common-source-configured Q_2.

A cross-coupled LC oscillator with a cross-coupled cascode buffer amplifier is used to provide balanced signals to the LO port of a micromixer. The cross-coupled cascode buffer amplifier in Figure 1 [6] has a high-speed response with good reverse isolation and thus prevents the local oscillator-frequency pulling caused by the impedance mismatches at the mixer LO port. The cross-coupled cascode buffer amplifier also reduces the equivalent input capacitance and allows the output of the previous oscillator stage to bias at less current.

The Gilbert mixer core formed by Q_4, Q_5, Q_6, and Q_7 commutates balanced IF currents in order to generate RF collector output currents. A passive LC current combiner doubles the output current at the resonant frequency, $\omega_0 = [1/(2L_1C_1)]^{0.5}$, and the size of an LC passive current combiner at 5 GHz is reasonably small to be incorporated in the integrated circuit. An integrated passive LC current combiner at 5.2 GHz is thus designed and a subsequent L-matching network transforms the high output resistance of the combined current source to 50Ω at 5.2 GHz. Both the high-pass LC current combiner and the low-pass L-matching network form a desired bandpass filter at 5.2 GHz for upconversion-mixer application. The bandpass response of an LC current combiner also helps the port-to-port isolations.

3. MEASUREMENT RESULTS

The upconversion micromixer with a single-ended input and a single-ended output also facilitates on-wafer RF measurement. The measured oscillation frequency of the integrated cross-coupled LC oscillator is 4.3 GHz. The power performance is shown in Figure 3, with conversion gain of -2.5 dB and OP_{1dB} of -12.5 dBm when input IF = 0.9 GHz and thus output RF = 5.2 GHz.

The measured IF-port input return loss and RF-port output return loss are shown in Figure 4. A micromixer has a broad input-matching bandwidth and the IF input return loss is better than 25 dB for frequencies up to 6 GHz, as shown in Figure 4. The RF output has a limited matching bandwidth because of the high-pass LC passive current combiner and the low-pass L-matching network. Figure 4 shows that the RF output return loss is better than 12 dB for frequencies from 5.15 to 5.35 GHz.

The measured conversion gain as a function of IF frequencies up to 2 GHz is illustrated in Figure 5 and the conversion gain peaks around 0.9 GHz, as expected, due to the effectiveness of the LC-current combiner. The IF-RF isolation is better than 30 dB for IF frequencies up to 2 GHz.

4. DISCUSSION AND CONCLUSION

A truly balanced operation of a Gilbert micromixer with a single-ended input and a single-ended output has been demonstrated in this paper. GaAs has a high-resistivity semi-insulating substrate and is compatible with the microstrip-line structure. Thus, a differential-in differential-out topology is not needed in order to reduce the substrate-coupling effect in GaAs technology. A single-ended-output upconverter is preferred because the power amplifier is still dominant according to the single-ended topology. The fully integrated GaInP/GaAs HBT upconversion micromixer has a conversion gain of -2.5 dB and OP_{1dB} of -12.5 dBm when input IF = 0.9 GHz and thus output RF = 5.2 GHz. The IF input return loss is better than 25 dB for frequencies up to 6 GHz, while the RF output return loss is better than 12 dB for frequencies from 5.15 to

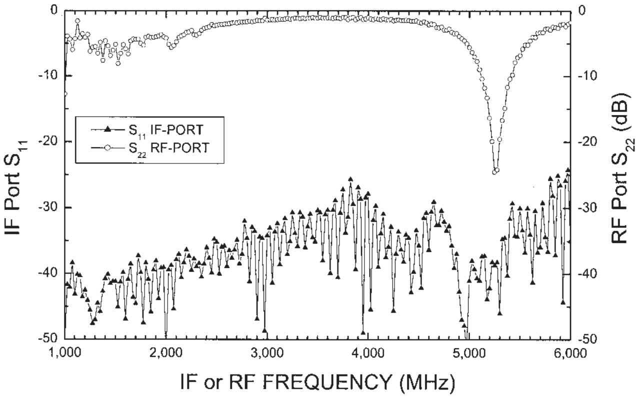

Figure 4 IF-port input return loss and RF-port output return loss of the upconversion micromixer with integrated output LC-current combiner and oscillator

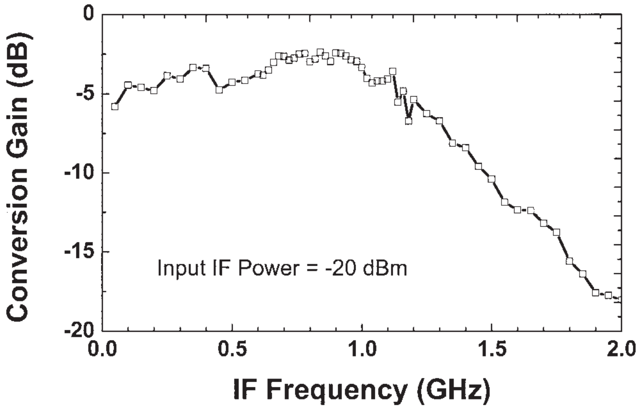

Figure 5 Conversion gain as a function of IF frequencies of the upconversion micromixer with integrated output LC-current combiner and oscillator

5.35 GHz. The IF-RF isolation is better than 30 dB for IF frequencies up to 2 GHz.

ACKNOWLEDGMENT

The authors would like to thank the National Chip Implementation Center (CIC) for technical support. This work was supported by the National Science Council of the Republic of China under contract nos. NSC 93-2752-E-009-003-PAE and NSC 93-2219-E-009-026, and by the Ministry of Economic Affairs under contract no. 92-EC-17-A-05-S1-020.

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A WIDEBAND CIRCULARLY POLARIZED MICROSTRIP PATCH ANTENNA FOR 5–6-GHz WIRELESS LAN APPLICATIONS

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Received 21 October 2004

ABSTRACT: *A wideband slotted circularly polarized (CP) patch antenna is introduced for 5–6-GHz WLAN applications. A small 14.6 × 14.6 mm square patch on Duroid 5880 substrate can provide a return-loss bandwidth of 11% and an axial-ratio bandwidth of 8% with a single feed. A possible reconfigurable design achievable using PIN diode or MEMS switches capable of left-hand or right-hand circular polarization is also introduced.* © 2005 Wiley Periodicals, Inc. Microwave Opt Technol Lett 45: 279–285, 2005; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20796

Key words: *microstrip; circularly polarized; WLAN; wideband; slot-loaded*

1. INTRODUCTION

Circularly polarized (CP) antennas are receiving much attention these days due to their increasing importance in commercial and defense wireless-communication applications. These include low-earth orbit (LEO) and medium-earth orbit (MEO) satellite communications as well as wireless local area network (WLAN) applications. Recent research also suggests that CP antennas are more fade resistant than linearly polarized antennas and hence help enhance wireless system capacity [1]. While using CP patches on a satellite handheld terminal is still a formidable challenge due to the limited ground-plane size available, such antennas can be readily used on platforms that can provide a reasonably sized ground plane and hence achieve higher gain.

Among many existing techniques, circular polarization can be achieved by designing a corner-truncated square patch, a circular patch with a cross slot (unequal slot lengths), or a microstrip-fed proximity-coupled ring design [2–4]. A single-fed design generally provides narrow axial-ratio bandwidth. Recently, a single-fed stacked patch antenna was proposed in [5]. This antenna operates in the PCS and PCN bands and has an axial ratio bandwidth of 13%. The antenna height is relatively large (about 13 mm for

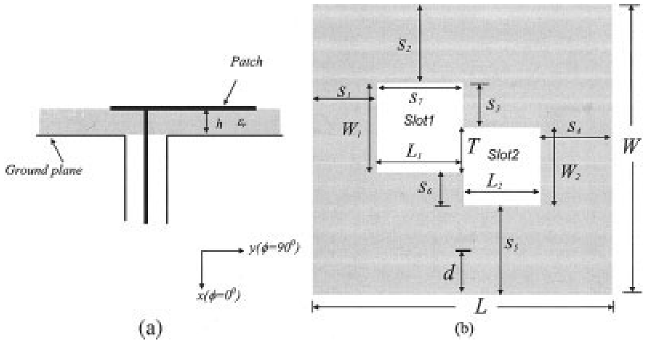

Figure 1 Antenna geometrical configuration: (a) cross section; (b) top view