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F-band Bidirectional Transceiver using 75-nm InP HEMTs

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Abstract

In this paper, an F-band (90 to 140 GHz) bidirectional transceiver MMIC using 75-nm InP HEMTs is presented. This technology will contribute to miniaturization of multi-gigabit wireless communication systems and reduction of signal loss between transceiver circuits and an external antenna.

1. Introduction

Simpler transceiver block has advantages for miniaturization of devices or lowering costs. From this view point, we have proposed a bidirectional transceiver as shown in Fig. 1. In this system, a Tx/Rx antenna is connected to an RF bidirectional amplifier. Bidirectional amplifier is a type of amplifier that can change the direction of amplification by control signals. A bidirectional mixer, which can both work as an up- and down-conversion mixer, is subsequent device. In the case of conventional transceiver system, steering devices, such as switch, circulator, or duplexer, are required, when an antenna is connected both to transmitter and receiver. Those components of millimeter/submillimeter wave band usually have rectangular waveguide interfaces which make system size larger and more expensive. Therefore bidirectional transceiver can realize simple and low cost RF configuration.

In this paper, an F-band bidirectional transceiver MMIC is presented. This is attractive frequency band in the use of short-range high-speed wireless communications. For example, multiband receiver using CMOS technology was reported in this frequency band [1].

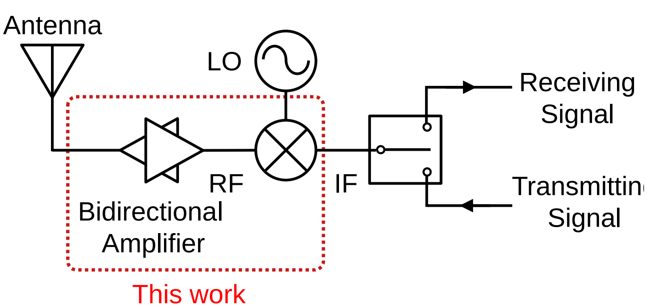

Fig. 1 Block diagram of a bidirectional transceiver system.

2. Circuit Design

A bidirectional amplifier based on common-gate amplifier circuit [2] was developed. As matching circuits, parallel circuits consisting of an inductor and a switch were inserted at the input and the output parts [3]. In this study, one finger transistor layout was employed to improve symmetric characteristics of amplifier in forward and reverse direction. This type of bidirectional amplifier achieved S12 components lower than -30 dB. This is good enough for the isolation of bidirectional transceiver. Owing to high reverse isolation of the bidirectional amplifier, transceiver block can be composed without external isolator, which is large in size.

Fig. 2 shows the circuit schematic of the bidirectional transceiver MMIC. For the bidirectional mixer, a single FET resistive mixer [4] was employed. An LO signal was injected into gate terminal of a transistor. RF and IF were connected to drain terminal, and separated by using on chip wide band diplexer. In this case, both RF and IF can use the nonlinearity of the transistor.

3. Device Fabrication

A 75-nm InP HEMT technology [5] was used for designing F-band bidirectional transceiver. The current cutoff frequency (f_T) of a 75-nm InP HEMT was 390 GHz. The conductor layer for two-layer routing was made of Au. The interlayer insulator was BCB, having a relative permittivity of 2.8.

Fig. 3 shows a chip photograph of the F-band transceiver MMIC. The chip size was 1.0 × 1.2 mm.

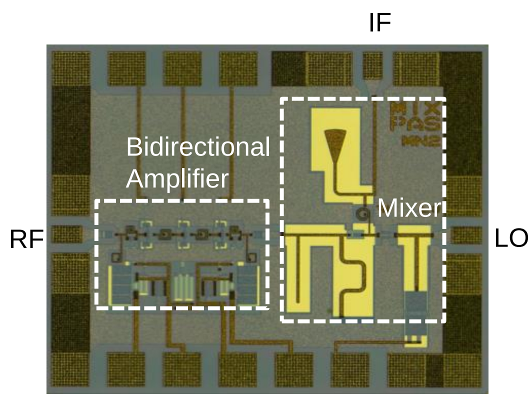

Fig. 3. Chip photograph of bidirectional transceiver.

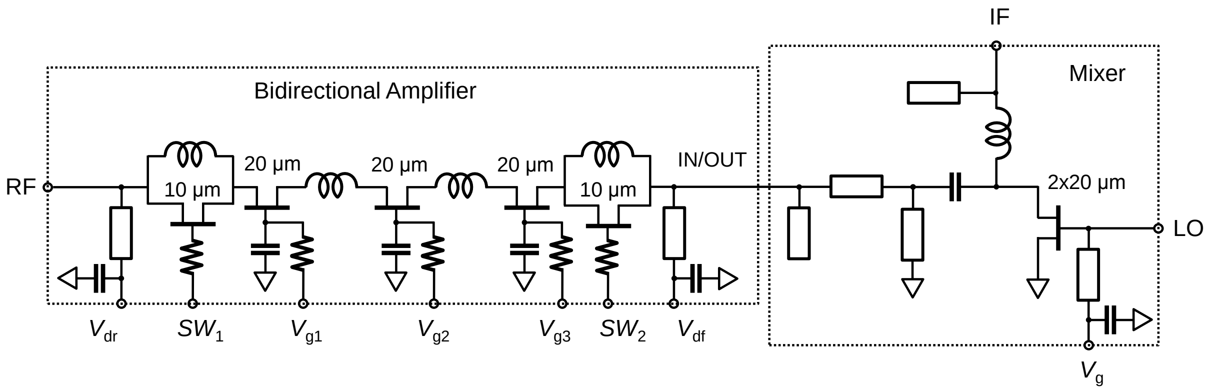

Fig. 2. Circuit schematic of the bidirectional transceiver MMIC.

4. Measurement Results

The conversion gain and return losses were measured on wafer by using network analyzer with frequency extenders. Fig. 4 shows frequency characteristics of the MMIC. DC bias voltage for the amplifier was 2.4V, and the current was 7 mA. In the receiver operation, DC bias was applied at V_{df}, and V_{dr} was connected to GND. In the transmitter operation, the bias condition was in an opposite manner.

The measured maximum conversion gains were 4 dB in receiver operation and 1 dB in transmitter operation. 3-dB band widths were above 30 GHz for both directions. Return losses were less than -7 dB.

5. Conclusions

An InP HEMT transceiver MMIC using bidirectional amplifier and mixer was described. The MMIC achieves conversion gain in wide bandwidth for both directions.

This technology is suitable for short-range wireless communication system, which requires compact size and comparably less RF power.

Acknowledgements

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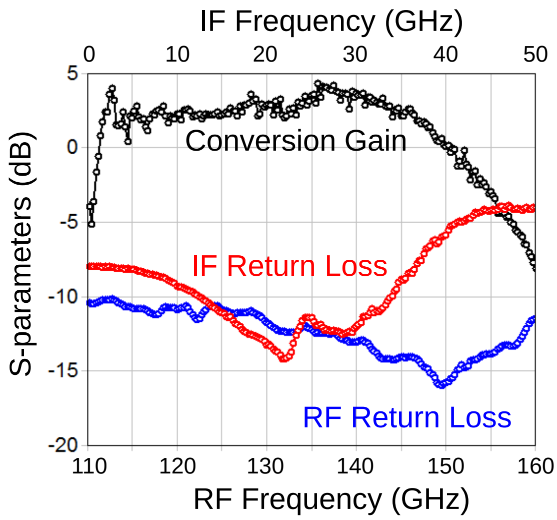
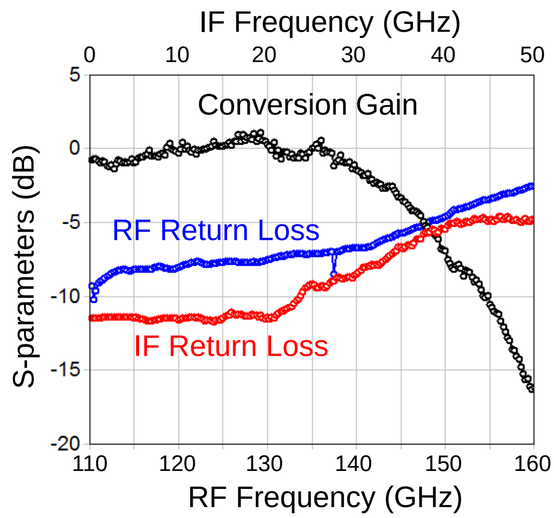


(a) Receiver operation (RF to IF)



(b) Transmitter operation (IF to RF)

Fig. 4. Frequency characteristics of bidirectional transceiver. LO signal was 110 GHz and -8 dBm. Input RF/IF power was -20 dBm.