A Fully Integrated MMIC chip set Employing InGaP/GaAs HBT for Application to Ku band Satellite Communication System

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Abstract: A highly integrated monolithic microwave integrated circuit (MMIC) chip set employing InGap/GaAs/GaAs heterojunction bipolar transistor (HBT) were developed for satellite communication applications. Concretely, using InGap/GaAs/GaAs HBT, downconverter MMIC and an active balun were developed. The downconverter MMIC showed a conversion gain of 9.5 dB and an LO suppression of -30 dBc. The fabricated chip, including a mixer, 2 stage IF amplifier, and LO rejection filter, exhibited a small size of 0.8×2.4 mm^2. The size of the active balun was about 31.6 % of conventional passive branch-line coupler.

1. Introduction

For satellite communication applications, the Ku band RF devices have been reported in various literatures. In conventional satellite communication system [1-4], downconverter MMIC was fabricated using a high electron mobility field effect transistor (HEMT) for low noise characteristics, which prevented a realization of one chip transceiver solution because power amplifier was generally fabricated using heterojunction bipolar transistor (HBT) due to its high power and high efficiency characteristics. In addition, for power coupling and splitting in satellite communication system, passive coupler have mainly been employed However, the passive device such as branch-line coupler occupies a very large area in RF circuit.

In this work, we developed a highly integrated downconverter MMIC including a mixer, IF amplifiers, and LO rejection filter using HBTs. In addition, a highly miniaturized active balun circuit employing InGaP/GaAs HBT was also developed.

2. Highly Integrated Downconverter MMIC

Figure 1 shows a cross-sectional view of the InGaP/GaAs HBT. Figure 2 shows a layout of the downconverter MMIC. As shown in this figure, the mixer, IF amplifiers, and LO rejection filter were integrated on the downconverter MMIC.

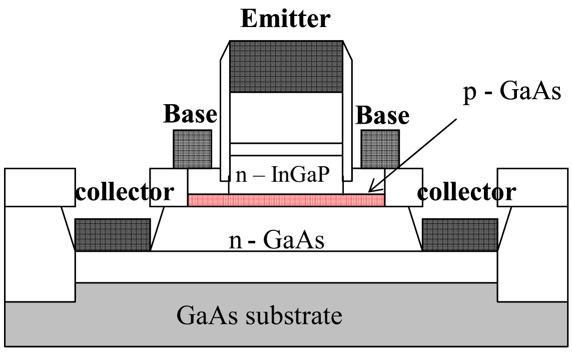

Fig. 1. A cross-sectional view of the InGaP/GaAs HBT

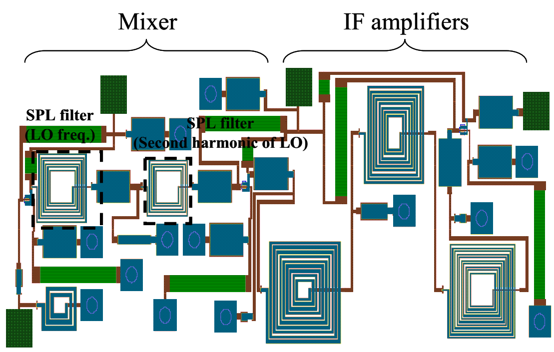

Fig. 2. shows a layout of the downconverter MMIC

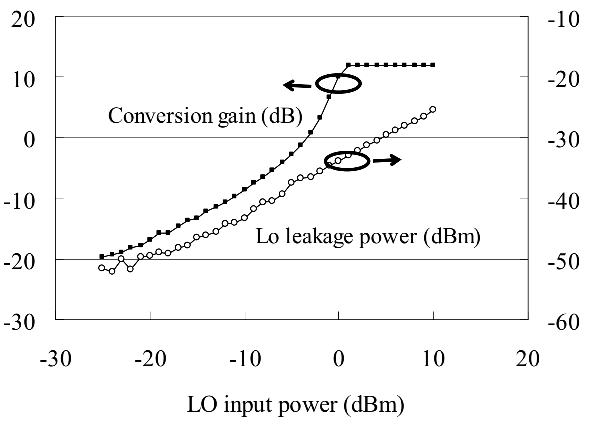

Fig. 3. An LO input power dependencies of conversion gain and LO leakage power

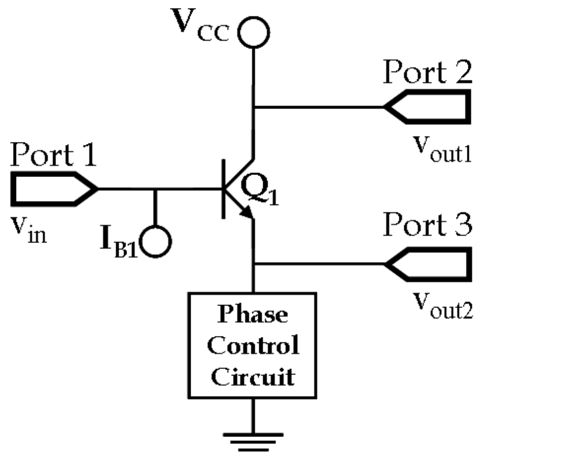

Fig. 4. A circuit structure of active balun for power splitting

For the fabrication of mixer and amplifier, InGap/GaAs/GaAs HBTs were employed. For the mixer, mixed signal (RF + LO) was applied to the base of the HBT, and IF output signal was extracted from the collector of the HBT. For an LO leakage power suppression at IF output, a spiral inductor which has band-rejection characteristics in the vicinity of LO frequency (11 GHz) was integrated on the MMIC (the layout of the spiral inductor for LO rejection is shown in Fig. 2, and it is connected at the collector of the HBT). The line width, the space between lines and size were designed to have self-resonance frequency in the vicinity of 11 GHz. The LO input power dependencies of conversion gain and LO leakage power at IF output are shown in Fig. 3, respectively. As shown in Fig. 3, at a LO power of 0 dBm, the conversion gain reaches 9.5 dB, and the LO leakage power at a LO power of 0 dBm exhibits a low value of –35 dBm due to the LO rejection characteristics of the spiral inductor. Therefore, additional LO rejection filter is not required for the normal operation of the downconverter MMIC, which enables a realization of fully integrated transceiver including on-chip filters.

3. Active baluns for power splitting

Figure 4 and 5 show a schematic circuit and layout of the active balun employing InGaP/GaAs HBT. As shown in Fig. 4, the size of the active balun for power splitting is 1.67 mm × 0.87 mm, which is 31.6% of a conventional passive branch-line coupler (if passive branch-line coupler with an operation frequency of 12 GHz is fabricated on GaAs MMIC, its size is 2.11 mm × 2.18 mm).

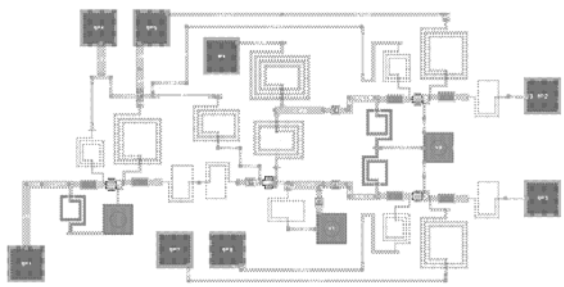

Fig. 5. A photograph of the active balun employing InGaP/GaAs HBT for power splitting

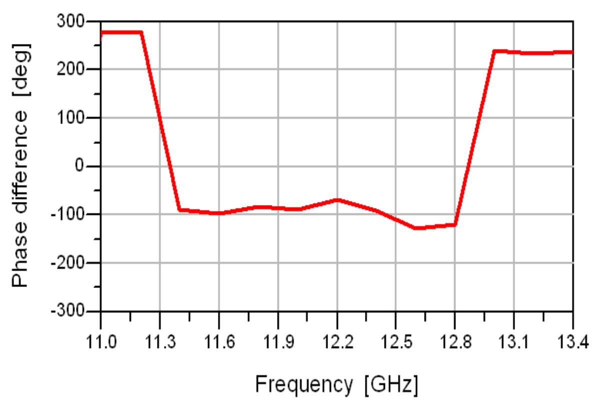

Fig. 6. Measured phase difference between S_{21} and S_{31} of active balun for power splitting

Figure 6 shows a measured phase difference between S_{21}

and S_{31} of active balun for power splitting. As shown in this figure, a phase difference characteristic of -90 ± 3.0° is observed from 11.8 GHz to 12.1 GHz. An output gain (S_{21} and S_{31}) of about 10 dB was observed at 12 GHz. Concretely, the proposed active balun for power splitting shows a gain of 10 ± 1 dB from 11.5 GHz to 12.7 GHz.

4. Conclusion

In this work, we developed highly integrated MMIC chip set employing InGap/GaAs/GaAs heterojunction bipolar transistor (HBT) for satellite communication applications. Concretely, using InGap/GaAs/GaAs HBT, downconverter MMIC and an active balun were developed. From the downconverter MMIC, we observed a conversion gain of 9.5 dB and an LO suppression of -30 dBc. The fabricated chip, including a mixer, 2 stage IF amplifier, and LO rejection filter, exhibited a small size of 0.8×2.4 mm^2.

The size of the active balun was about 31.6 % of conventional passive branch-line coupler. Form the active balun, we could observe good RF performances comparable to passive branch-line couplers.

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