Design and Fabrication of Low LO Power V-band CPW Mixer Module

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Abstract : We designed and fabricated a low local oscillation (LO) power V-band CPW mixer module using a CPW-to-waveguide transition technology for the application of millimeter-wave wireless communication systems. The mixer was designed using a unique gate mixing architecture to achieve simultaneously a low LO input power, a high conversion gain, and good LO-RF isolation characteristics. The fabricated mixer exhibited a high conversion gain of 2 dB at a low LO power of 0 dBm. For data transmission of the 60 GHz wireless LNA systems, we fabricated a CPW-to-waveguide converter module of WR-15 type and mounted the fabricated mixer in the converter module.

The fabricated V-band mixer exhibited a higher conversion gain and a lower LO input power than other reported V-band mixers.

1. Introduction

Traditionally, the use of the millimeter-wave technology has been limited to military applications. In recent years, however, there has been an increasing interest in the commercial applications of millimeter-waves as the demand for high-speed and high-quality image data transmission is rapidly growing. A mixer is an important part for the millimeter-wave wireless LAN system. It should exhibit a high conversion gain and work at a low LO input power. Operation at a low LO input power is especially important at V-band, because it is very difficult to develop an oscillator with a high output level at such high frequencies. In this paper, a low LO power V-band mixer module for 60 GHz wireless LAN systems has been developed using CPW-to-waveguide transition technologies.

2. Design of V-band Mixer

GaAs PHEMT's with a 0.1-μm gate length were developed to realize the V-band mixer module. The epitaxial structure included a double delta doping and an AlGaAs/GaAs superlattice buffer. Fig. 1 shows a cross sectional view of the device and the epi-structure of GaAs PHEMTs. The fabricated devices exhibited a transconductance of 500 mS/mm, an f_{max} of 180 GHz, and an f_T of 113 GHz. To construct the CPW matching circuits, we have modeled transmission lines with various impedances including 35, 50, and 70 Ω. Also, 600 Å NiCr resistors and 1000 Å Si_3N_4 MIM capacitors were fabricated and modeled to complete the passive library. Measured thin film resistors have 50.2-50.9 Ω/□ of sheet resistance, and MIM capacitors have 0.485-0.538 fF/μm^2 of capacitance.

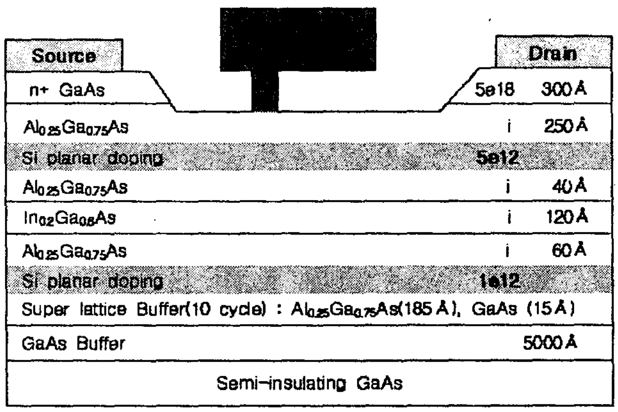

Fig. 1. Device and epi-structure of GaAs PHEMT.

The mixer was designed using a unique gate mixing architecture. Fig. 2 shows the designed circuit schematics of the V-band mixer. To achieve simultaneously a low LO input power, a high conversion gain, and good LO-RF isolation characteristics, PHEMT's (H1 and H2) were added to the LO port and the RF port, respectively. These active devices not only amplify LO and RF signals but also improve the LO-RF isolation due to the S_{12} characteristics of the devices. The RF, LO and IF frequencies were designed to be 60.4 GHz, 58 GHz and 2.4 GHz, respectively. Matching circuits for the RF and the LO ports were designed using CPW transmission lines. On the other hand, the matching circuit for the IF port was designed using lumped elements, because the IF frequency is relatively low. Also, we added a λ /4 open stub at the IF port to improve the LO-IF isolation characteristics by suppressing the LO signal. Simulation result showed a conversion gain of 1.08 dB and a 1 dB compression point of -6.9 dBm.

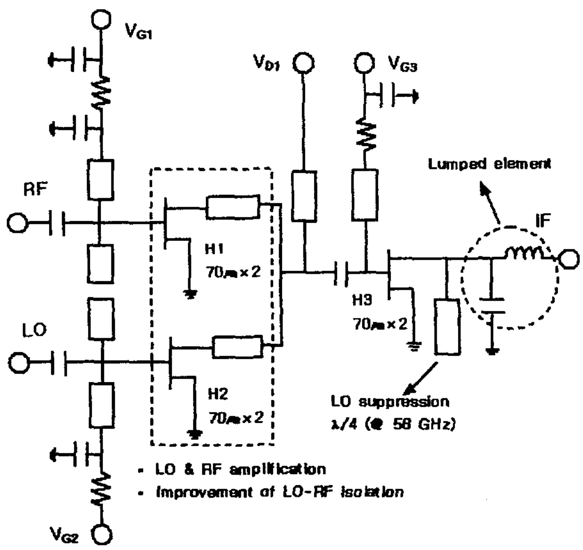

Fig. 2. Designed circuit schematics of the V-band mixer.

3. Fabrication and Measurement

The V-band mixer was fabricated using an MIMIC technology developed at our research center, MINT (Millimeter-wave Innovation Technology research center). This library includes GaAs PHEMT's, CPW transmission lines, NiCr resistors and MIM capacitors[1-2]. Fig. 3 is a photograph of the fabricated V-band mixer. The chip size is 1.8 mm × 1.7 mm.

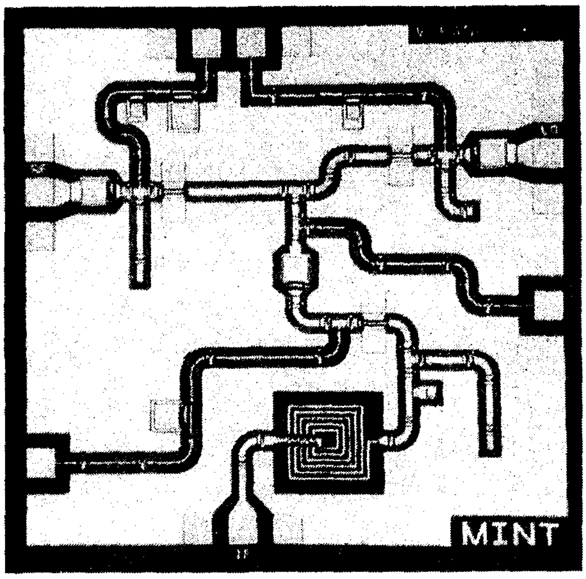

Fig. 3. A photograph of the fabricated V-band mixer.

Fig. 4 depicts the conversion gain versus the RF input power at 60.4 GHz for an LO input power of 0 dBm at 58GHz. Measured results demonstrated a high conversion gain of 2 dB at a low LO input power of 0 dBm. Fig. 5 shows the IF output power versus the RF input power characteristics. The 1 dB compression point is -5.2 dBm for an RF input power of -6 dBm.

Fig. 6 represents the conversion gain versus RF frequency for an RF power of –12 dBm and an LO power of 0 dBm at 58 GHz. The conversion gain is 2 dB for an LO input power of 0 dBm and RF frequency within the 58.4 GHz-61.4 GHz band. Fig. 7 exhibits the conversion gain against the LO input power for an LO frequency of 58 GHz. The conversion gain saturated at LO input power levels higher than 0 dBm. The measured results of fabricated V-band mixer exhibited a higher conversion gain and a lower LO input power than other reported V-band mixers. Table 1 shows comparison of the reported V-band mixers[3-6].

For data transmission of the 60 GHz wireless LNA systems, we fabricated a CPW-to-waveguide converter module of WR-15 type and mounted the fabricated mixer in the converter module. The fabricated V-band mixer module exhibited a conversion loss of 4 dB. Fig. 8 shows the fabricated V-band mixer module.

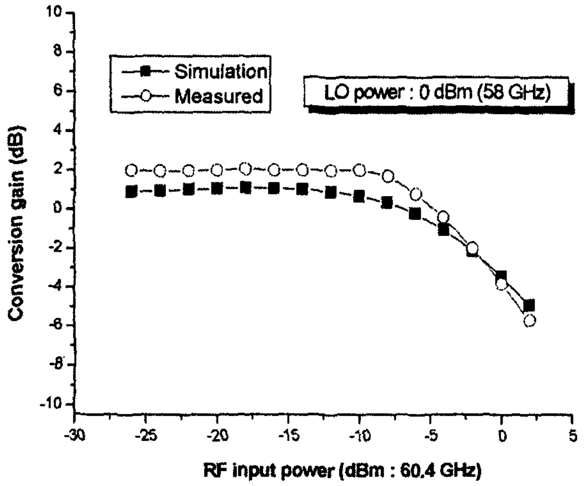

Fig. 4. Measured results of conversion gain vs. RF input power.

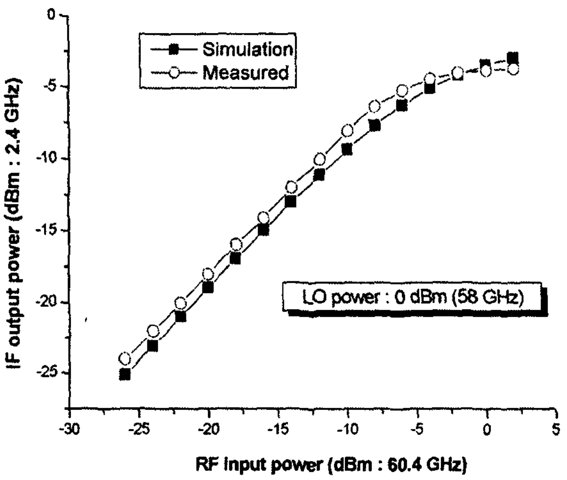

Fig. 5. Measured results of IF output power vs. RF input power.

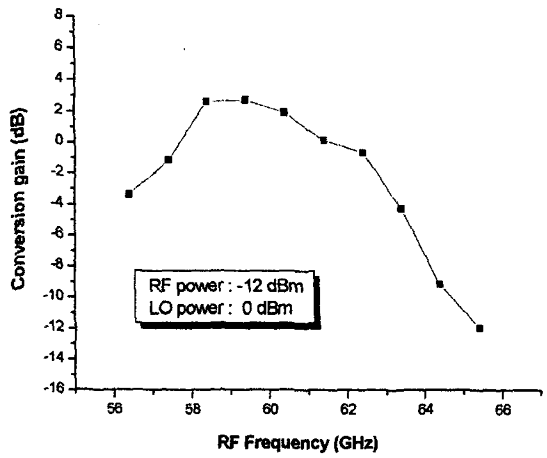

Fig. 6. Conversion gain vs. RF frequency of mixer.

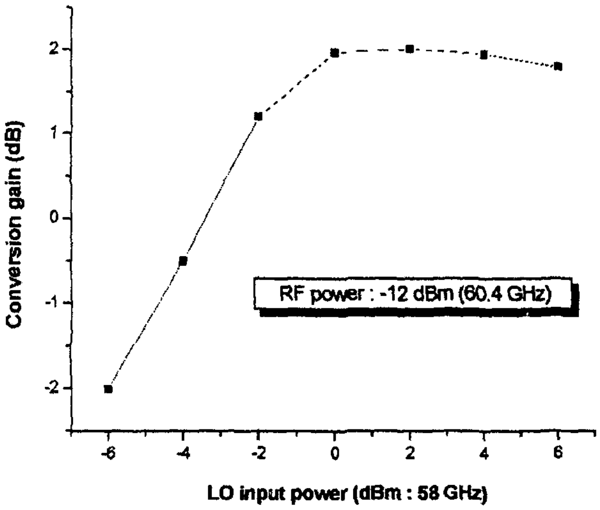

Fig. 7. Measured results of conversion gain vs. LO input power.

Table 1. Comparison of the reported V-band mixers.

	Conversion gain	LO input power
[3]	-8.5 dB	10 dBm
[4]	-10.0 dB	5 dBm
[5]	-8.0 dB	7 dBm
[6]	-10.0 dB	6 dBm
This work	**2.0 dB**	**0 dBm**

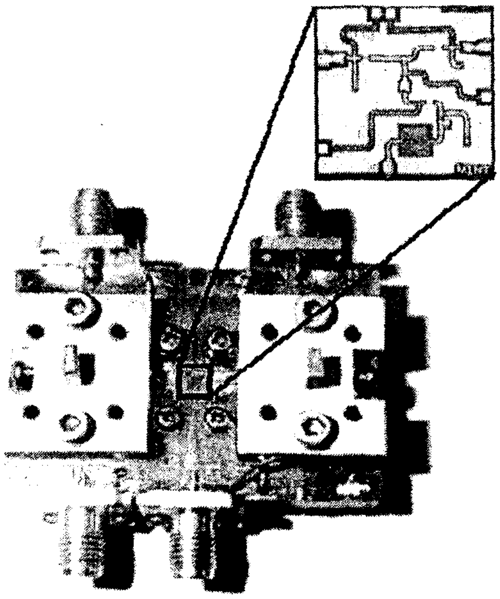

Fig. 8. The fabricated V-band mixer module.

4. Conclusion

In this paper, we designed and fabricated a low LO power V-band CPW mixer module using a CPW-to-waveguide transition technology for the application of millimeter-wave wireless communication systems. The mixer was designed using a unique gate mixing architecture to achieve simultaneously a low LO input power, a high conversion gain, and good LO-RF isolation characteristics. The fabricated mixer exhibited a high conversion gain of 2 dB at a low LO power of 0 dBm. For data transmission of the 60 GHz wireless LNA systems, we fabricated a CPW-to-waveguide converter module of WR-15 type and mounted the fabricated mixer in the converter module. The fabricated V-band mixer exhibited a higher conversion gain and a lower LO input power than other reported V-band mixers. We demonstrated a high quality image data transmission of 60 GHz wireless LAN system using the fabricated V-band mixer module.

Acknowledgment

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