A New Compact Double Conversion Gate Mixer using a Half-LO Frequency

Jae-Ryong Lee · Sang-Won Yun

Abstract

In this paper, the double conversion gate mixer using a half-LO frequency is described at 25 GHz band. The proposed mixer uses two HEMTs excited by a single LO signal of half-LO frequency in order to generate the second IF signal. That is, the LO signal having the half-LO frequency is only fed into the gate of the first HEMT mixer as a normal gate mixer. The LO signal through the first mixer is fed into the second mixer. The proposed mixer requires not only half of the normal LO frequency, but also lower LO power than the conventional subharmonically pumped mixers. Over the bandwidth of 500 MHz at 24.5 GHz, the conversion gain is 2.5 dB, the noise figure is 9 dB, and the isolation between RF and LO port is 32 dB when the LO power is 0 dBm at 12.65 GHz.

Key words : double conversion gate mixer, sub-harmonic mixer.

Ⅰ. Introduction

Recently, RF systems have been implemented at millimeter-wave band for the higher data rate. In this band, it is a difficult task to design the mixers that have good LO to RF isolation characteristics as well as conversion gains.

To achieve good mixer performances at high frequencies, several authors have proposed subharmonically pumped mixers [1]~[3]. Subharmonically pumped mixers are very common at millimeter-wave frequencies, because not only they use lower LO frequency but also they are cost effective. They also have good isolation characteristics between RF and LO ports. However, since the mixer performance is strongly dependent on the LO signal level, they require relatively high LO driving level in order to have moderate conversion losses[4].

In this paper, we present a new topology of the down-conversion gate mixer. In order to obtain a good LO to RF isolation performance in the millimeter-wave band, the proposed mixer employs a double conversion topology, in which two HEMT mixers are excited by a single LO signal having the half of the conventional LO frequency with lower LO power than the typical subharmonically pumped mixers.

Ⅱ. Architecture of the Mixer

The architecture of mixer that employs a double conversion scheme is shown in Fig. 1. In the proposed mixer, the LO signal is only fed into the gate of the first HEMT mixer which produces the first IF signal by a normal gate mixing mechanism. Then the first IF signal and LO signal amplified by the first HEMT mixer is again fed into the gate of the second HEMT mixer, generates the second IF signal. Since both of them are gate mixers, the bias points are located near the pinch off regions.

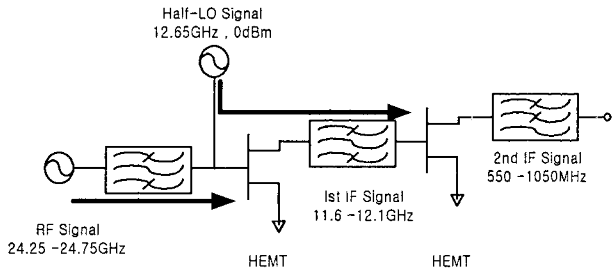

Fig. 1. Structure of a double conversion mixer.

In the bandpass filter design[5], the first bandpass filter that has low insertion loss to the RF signal and high rejection to the LO signal has to be designed in order to maintain the conversion gain as well as the noise figure. It is important to decrease the conversion loss as well as noise figure. The second bandpass filter located between the HEMT mixers rejects other spurious signals. Finally, low pass filter at the output stage rejects the spurious signals by using radial stubs.

This mixer has the same properties as sub-harmonic mixers, which use a half-LO frequency and have a good LO to RF isolation. However, this mixer has better conversion efficiency, where the LO power is lower than the general sub-harmonic mixers. The performance of conversion gain and LO/RF isolation is better than those of the single conversion mixers.

Ⅲ. Experimental Result

According to the above design procedures, the down

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converter that can be used for the Korean Broadband Wireless Local Loop (BWLL) system is designed and tested. The mixer was fabricated on the substrate with a relative dielectric constant of 3.0 and a thickness of 0.382 mm, using two FHX35LP HEMTs of Fujitsu. Fig. 2 shows the Gm plot of the modeled HEMT. The pinch off region is near −0.8 V. In experiment, the bias points are located at V_{ds}=2 V, V_{gs}=−0.9 V near the pinch off regions.

The center frequency is 24.5 GHz with 500 MHz bandwidth ,and the second IF frequency range is from 550 MHz to 1,050 MHz. Local oscillator at 12.65 GHz has output power of 0 dBm. We presented the gain budget of each stage in Table I.

Fig. 3 shows the mixer PCB layout. The size of the layout is 3.5×5cm^2. The ground of transistors can be connected by thru hole. Fig. 4 shows the simulated and measured conversion gain. Considering the losses on the transmission line, the measured results agree with the simulated ones. Fig. 5 shows experimental results of 1 dB compression point versus the LO power. From the above results, when LO power is 0 dBm, conversion gain is 2.5 dB and 1 dB compression point is 0.5 dBm.

To compare the performance of single conversion mixer and proposed mixer, the same HEMTs are used. In case of single conversion mixer having 0 dBm LO power at 25.3 GHz, the test

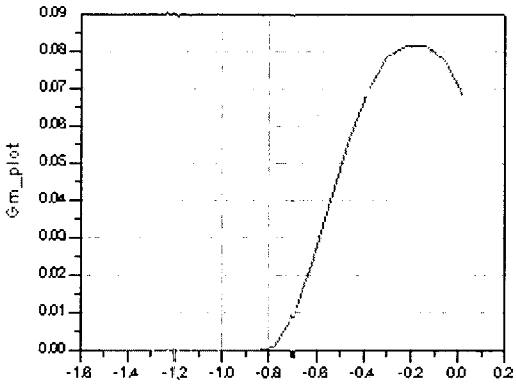

Fig. 2. Gm of the modeled HEMT.

Table 1. Characteristics of each components.

Component	Characteristics	
BPF1	I.L ≈ −1.8 dB	BW : 24.25~24.75 GHz RF/LO isolation >32 dB
1st Mixer	Gain = 2 dB	1st IF : 11.6~12.1 GHz
BPF2	I.L ≈ −0.7 dB	BW : 11.6~12.1 GHz −2 dB loss at f_{LO}
2nd Mixer	Gain = 3.1 dB	2nd IF : 550~1,050 MHz
LPF	I.L ≈ −0.1 dB	−35 dB loss at f_{LO}

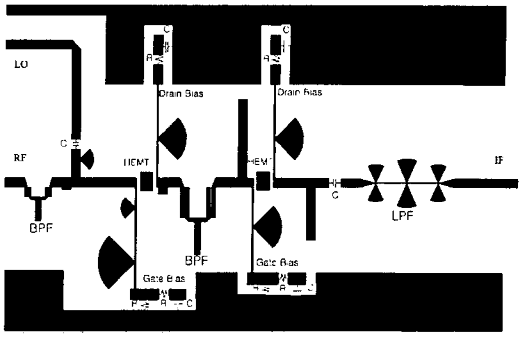

Fig. 3. PCB layout

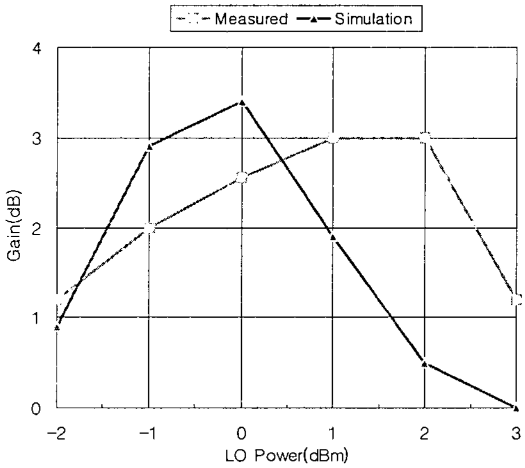

Fig. 4. Conversion gain versus LO power.

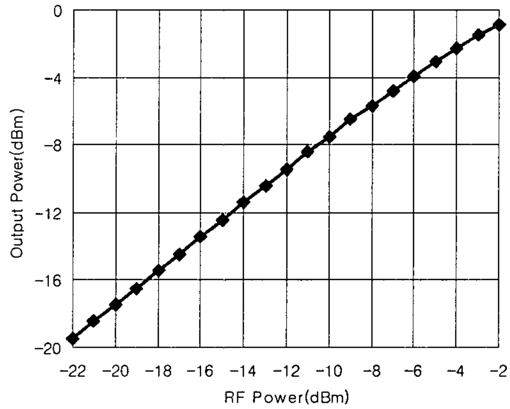

Fig. 5. IF output power versus RF input power.

results show −3 dB of conversion loss, 20 dB isolation between LO to RF ports, and 8 dB noise figure. On the other hand, the proposed double conversion gate mixer has 2.5 dB conversion gain, 32 dB LO to RF isolation, above 60 dB LO to IF isolation, above 42 dB RF to IF isolation and 9 dB noise figure. The simulated noise figure is 8.5 dB. The proposed mixer shows better conversion characteristics as well as better LO to RF isolation, even though the single conversion mixer shows better noise figure. The mixer designed by using a half-LO frequency has higher conversion efficiency than the subharmonically pumped mixer because the latter requires more LO power.

Ⅳ. Conclusion

We propose a double conversion gate mixer, which gives improved conversion gain and higher LO to RF isolation. The proposed mixer requires lower LO power and the half-LO frequency as subharmonically pumped mixers. In a quasi-millimeter wave band, the mixer which converts RF signal of 24.5 GHz band to second IF signal of UHF band has been designed by using two HEMTs and tested. The proposed compact mixer designed at the 25 GHz range has 2.5 dB gain, 32 dB of LO to RF isolation, 42 dB of RF to IF isolation, 60 dB of LO to IF isolation, and 9 dB of noise figure.

When we compare to the single conversion mixer using the same HEMTs, we observe that the improved conversion gain, better LO/RF isolation characteristics. When compared with the conventional subharmonically pumped a mixer, the proposed mixer not only require lower LO power but also has better conversion characteristics.

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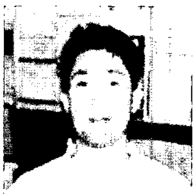

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