A High Performance CMOS Cascode Mixer For Application to Wireless Maritime Communication System

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***Abstract*— In this work, a cascade-type gate mixer employing TSMC 0.18 µm CMOS technology was developed for application to marine disaster early warning system. The proposed gate mixer showed good RF performances. Concretely, the mixer exhibited a conversion gain of 9 dB and P_{1dB} of 0 dBm. Especially, it showed a very low LO input power of -7 dBm due to the optimum bias design.**

I. Introduction

Recently, natural disaster such as tsunami has been increasing world wide due to climate change and environmental pollution. For this reason, many research groups have been developing the early warning and monitoring systems to prevent a serious damage from the natural disaster. Concretely, NOAA(National Oceanic and Atmospheric Administration) deployed the final two tsunami detection buoys in the South Pacific this week, completing the buoy network and bolstering the U.S. tsunami warning system [1]. This vast network of 39 stations provides coastal communities in the Pacific, Atlantic, Caribbean and the Gulf of Mexico with faster and more accurate tsunami warnings. Recently, we also started to develop ocean monitoring system employing wireless/underwater maritime communication system.

Figure 1 shows a concept figure of marine disaster early warning system. As is well known, tsunami originates from a submarine earthquake. In this case, sensor detects a vibration of the ocean floor as shown in figure 1. And then, the information of tsunami is transmitted to the buoy floating on the sea through underwater communication. Next step, buoy sends the tsunami information to disaster warning center through wireless communication. Through this process, we can recognize quickly and accurately disaster information such as tsunami.

In this work, we developed a CMOS cascade mixer on silicon RFIC (Radio frequency Integrated Circuit) for application to wireless communication between buoy and disaster warning center.

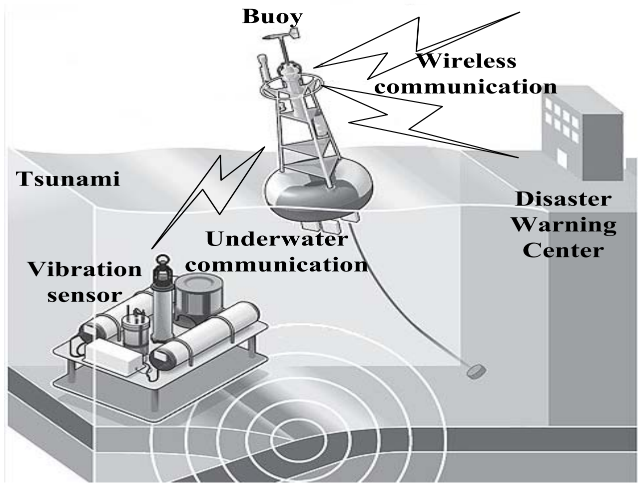

Fig 1. A concept of marine disaster early warning system

II. Circuit Design

In marine disaster early warning system, mixer is the most critical element for performances. For satisfied RF characteristic, frequency conversions should be successfully performed in operation band. For the down conversion mixer, high conversion gain, high linearity, low noise figure, low power consumption, and high linearity characteristic and required [2-5].

Figure 2 shows a schematic circuit of single-end cascade type gate mixer. The proposed mixer was designed for a realization of fully integrated ICs, and additional external circuits are not necessary. For a fabrication of the mixer, TSMC 0.18 µm CMOS RF process was used in this work. The gate length of n-MOS device is 0.18 µm and gate width is 6 µm, and total finger number is 20.

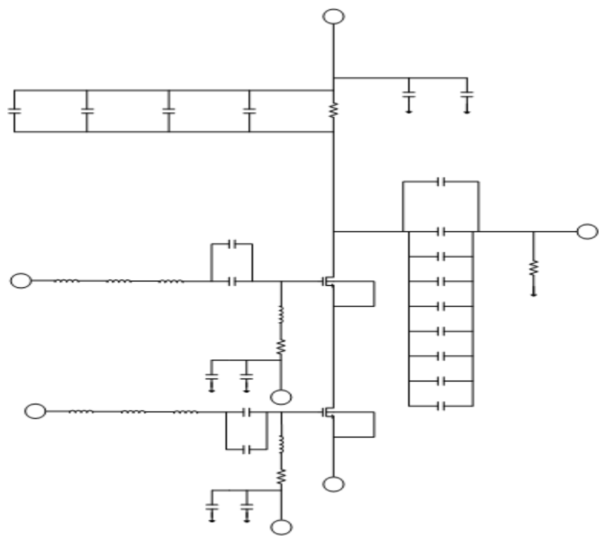

Fig. 2. The schematic CMOS cascode mixer on silicon RFIC

In conventional gate mixer, a high LO input power (higher than 0 dBm at least) was required for normal operation. Therefore, LO amplifiers were necessary to drive them, which increased the power consumption. In this work, an optimal gate bias voltage was determined to minimize the LO input power. This process can be explained as follows. The conversion transconductance g_1 is given by

$$g_1 = \frac{1}{2\pi}\int_0^{2\pi} g_m(t)e^{-j\omega_o t}d(\omega_o t) \quad (1)$$

,where g_m (t) and ω_O are time-varying transconductance and LO frequency. Using Equation (1), the LO power dependencies of conversion transconductance were extracted from measured transconductance g_m of the FET, and the LO power which is required for a saturation of conversion transconductance (P_{LO_SAT}) was plotted for various bias voltages. According to the result, for a low LO power operation of the mixer, gate bias voltage should be set near pinch-off. In this work, the LO power required for a saturation of conversion transconductance is -7 dBm, which is lower value than conventional gate mixers.

III. Measured Results

In this work, the performance of gate mixer using 0.18 μm CMOS RF technology was investigated at an RF frequency of 1020 MHz. Figure 3 shows measured conversion gain of the mixer. RF performances of the mixer are summarized in Table I. As shown in Table I, the proposed mixer shows good RF performances. Concretely, the mixer shows a conversion gain of 9 dB and P_{1dB} of 0 dBm. Especially, it shows a very low LO input power of -7 dBm due to the optimum bias design. Due to the low very low LO input power, an LO amplifier is not required for the operation of the mixer, which highly reduces the consumption power and RF circuit size.

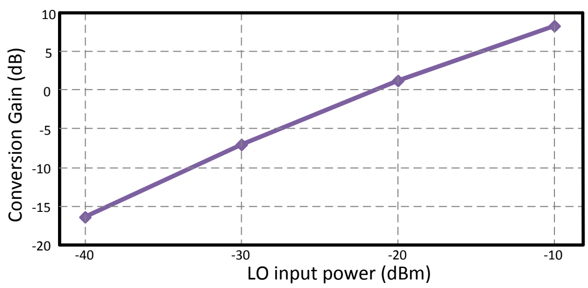

Fig. 3. A measured conversion gain characteristic of the cascode gate mixer

Table 1. Measured RF performances of the cascode mixer

RF performances	
Conversion gain	9 dB
P_{1dB}	0 dBm
LO input power	-7 dBm
RF-LO isolation	-17 dB

IV. Conclusion

In this work, we fabricated a cascade-type gate mixer using TSMC 0.18 μm CMOS technology for application to marine disaster early warning system. The proposed gate mixer showed good RF performances. Concretely, the mixer exhibited a conversion gain of 9 dB and P_{1dB} of 0 dBm. Especially, it showed a very low LO input power of -7 dBm due to the optimum bias design.

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