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UHF RFID 리더를 위한 0.18mm CMOS LNA/Mixer

(0.18mm CMOS LNA/Mixer for UHF RFID Reader)

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요 약

본 논문에서는 900Mhz 대역의 UHF RFID에서 직접변환방식의 LNA/Mixer를 설계하였다. 설계된 회로는 3.3V로 동작하며, 0.18um CMOS 공정으로 구현되었다. 본 논문은 높은 self jamming 신호를 극복하기 위해 공통게이트 입력 구조를 사용였으며, 고이득, 저이득의 두가지 동작 모드를 갖도록 설계되었다. 측정결과, 설계된 LNA/Mixer는 고이득 모드와 저이득 모드에서 각각 4dBm과 11dBm 의 입력 p1dB를 갖고, 12dB와 3dB의 변환이득을 갖는다. 또한, 두가지 모드에서 각각 60mW와 79mW의 전력을 소비하며, 16dB와 20dB의 잡음지수를 갖는다.

Abstract

In this paper, a direct down conversion LNA/Mixer has been designed and tested for 900Mhz UHF RFID application. The designed circuit has been implemented in 0.18um CMOS technology with 3.3V operation. In this work, a common gate input architecture has been used to cope with the higher input self jamming level. This LNA/Mixer is designed to support two operating modes of high gain mode and low gain mode according to the input jamming levels. The measured results show that the input referred P1dBs are 4dBm of high gain mode and 11dBm of low gain mode, and the conversion gains are 12dB and 3dB in high and low gain mode respectively The power consumptions are 60mW for high gain mode and 79mW for low gain mode. The noise figures are 16dB and 20dB in high gain mode and low gain mode respectively.

Keywords : RFID, LNA Mixer, 1 dB compression point

I. Introduction

Fast development of wireless communication technology enables to detect the weak signals scattered back from a tag antenna, and find out the identification information from them. Such a radio frequency identification (RFID) technology is quite useful in a modern identification systems because of its superior performance to the previous barcode labels[1]. The low frequency RFID systems working around 13.56MHz have been well developed, but it has limited read range and lower data rate[2]. RFID system operating in the 860-960MHz UHF band has been studied to improve the read range and data rate[2]. RFID is increasing in the large industry line manufacture, physical distribution, and inventory control of large supply chain[1].

An UHF RFID system consists of the readers and passive tags. The communication between them is half duplex. RFID reader system reads out information from tag, and tag transmits back its information to the reader through the back scattering of tag antenna. The passive tags have no battery supply, so the reader should provide large enough energy to the tags by transmitting high RF carrier

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power about 30dBm. The tag harvests some dc power from the received microwave carrier signal, and send back some information to the reader by scattering the incoming RF carrier signal using tag antenna.

Therefore, the reader should detect the weak back scattered signal while it transmits a large continuous wave carrier power. An earlier RFID system has two antenna with sufficient spacing to improve the isolation level between transmitter carrier signal and receiver return signal. But it's not suitable for the mobile RFID system due to the physical dimension and the high cost[4].

In a single antenna RFID system, the back scattered signal coming from the tag is mixed with the transmitter carrier leakage signal which is the incoming self jamming level. These transmitter carrier leakages could make the receiver block become saturation and degrade the receiver sensitivity[4].

In such a high self jamming environment, A higher P1dB level is more important than the noise figure requirement[4].

Thus, this paper's goal is to design a mixer having a higher p1dB compression point to meet this situation.

Ⅱ. LNA/Mixer Design

Figure 1 shows a CMOS Gilbert cell mixer with a tail current source. The Gilbert cell gives a fine noise figure and high gain performance because of the good isolation from input to supply and common gate RF input stage. But this sort of mixer has a relatively low saturation level because of the multi-stack up topology which reduce the maximum output swing level. In a RFID reader applications, the high saturation level is quite important due to the high level of transmitting leakage in receiving operation. The receiver typically needs to tolerate at least 0dBm of transmitter-leakage signals. The high saturation requirement limits the amount of the receiver front end gain to about 0dB[4].

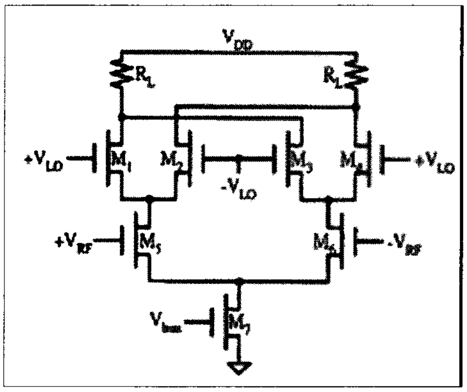


그림 1. CMOS 길버트 셀 Mixer 구조
Fig. 1. CMOS Gilbert cell mixer architecture.

In this work, a common gate input has been used to provide a higher output saturation level and better input impedance matching. The proposed circuit shows a lower supply noise rejection due to the poor input and output isolation property, but the output saturation level can be improved. The RFID reader has large noise figure margin about 39dB with 70dBm sensitivity level[4].

This LNA/Mixer has been designed for a direct conversion receiver, so the transmission leakage signals are moved to DC at the output of the mixer[3]. The DC offset can be cancelled out using capacitors. Figure 2 shows the designed LNA/Mixer circuit. For the limited front end gain, an common gate input active mixer has been designed to extend the output swing range similarly to the work in [3, 5]. The input impedance matched through the device size scaling, bias point control, and the source inductances.

The common gate input stage is biased at ground through the input matching inductor. Thus, this circuit is biased at a much lower voltage level for switching transistor saturation. As the result, it can increase the output swing range much higher than a conventional tail current Gilbert cell mixer. Although it has some poor good noise figure, the noise figure margin in RFID reader is quite high[4].

The proposed circuit has been design in two different modes of operation. In some cases of mobile RFID applications, the transmission power levels can

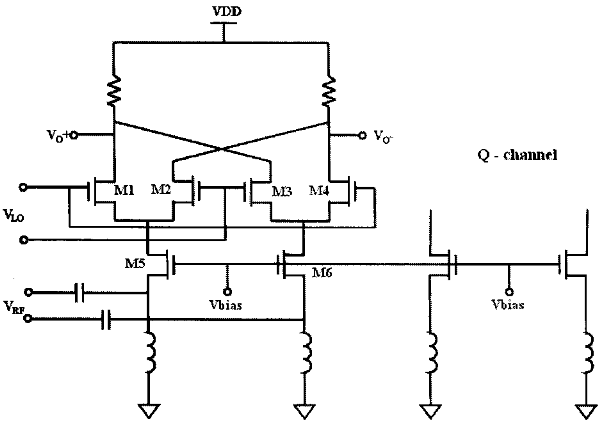


그림 2. 설계된 Mixer 스키메틱
Fig. 2. Designed Mixer Schematic.

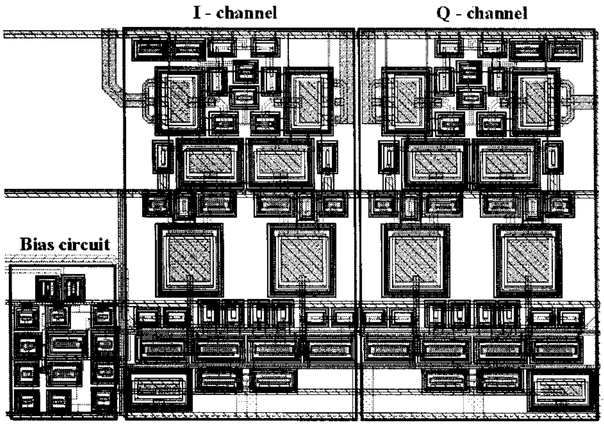


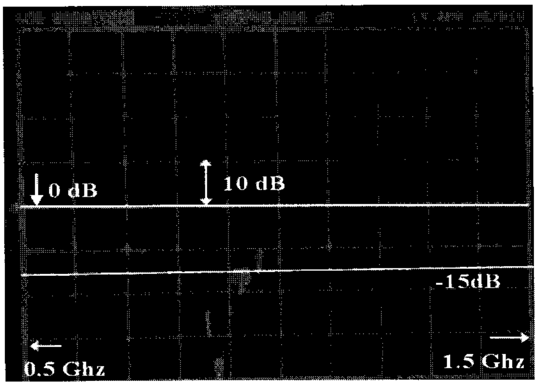
그림 3. 설계된 LNA/Mixer 레이아웃
Fig. 3. Designed LNA/Mixer Layout.

be lowered. Then, the transmission leakage level is low enough to allow some receiver front end gain. That will improve the input sensitivity level. In such case, the LNA/Mixer circuit operates as a high gain mode. Otherwise it works as a low gain mode with a full power transmission situation. The mode change is implemented through the input gate bias control.

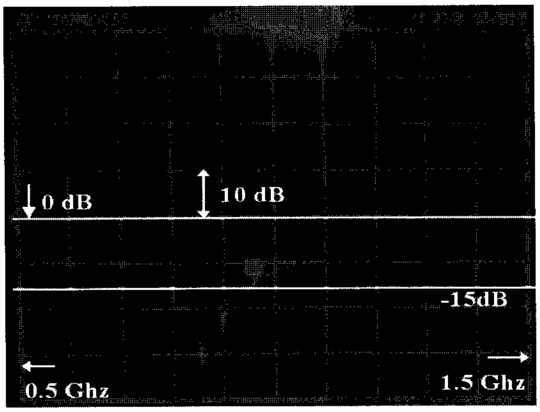
Figure 3 shows the designed LNA/Mixer layout. It consists of I/Q channel direct conversion mixer and the bias control circuit for the gain mode change. The chip area is 430um x 280 um.

Ⅲ. Measurement Result

The input return loss of the RF port is less than -15dB. Figure 4 shows the high gain and low gain mode input return loss measured in 0.5Ghz~1.5Ghz.



(a) High Gain mode input return loss



(b) Low Gain Mode input return loss

그림 4. 입력 반사손실
Fig. 4. Input return loss.

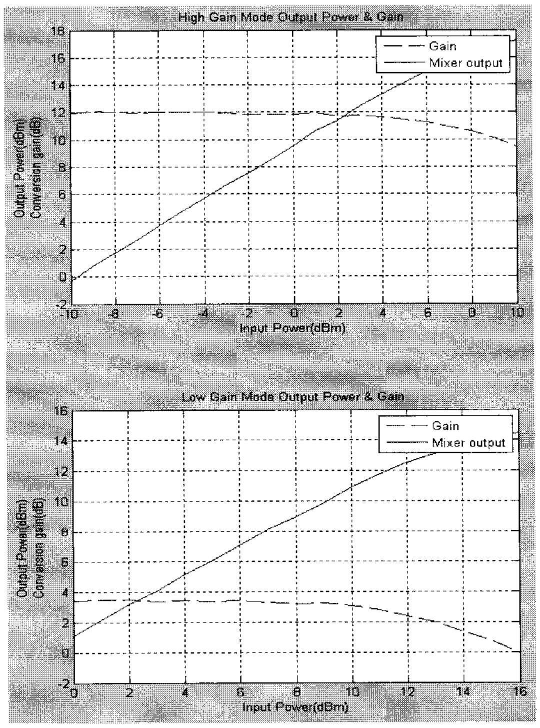


그림 5. 단일주파수 전력측정결과
Fig. 5. Single tone Power Measure Result.

표 1. 성능 측정 요약
Table 1. Summary of the measured performance.

Parameter	High gain	Low gain
Supply voltage	3.3V	3.3V
DC power dissipation	60mW	79mW
Conversion gain	12dB	3dB
NF	16dB	20dB
Input referred p1dB	4dBm	11dBm
Return loss @ 900M	-22dB	-21dB
LO frequency	900Mhz	
RF frequency	910Mhz	
LO power	0 dBm	
Technology	0.18um CMOS	

The conversion voltage gain is 12dB in high gain mode and 3dB in low gain mode over the frequency of 860Mhz~960Mhz. Figure 5 shows the measured output power by sweeping the input power for each mode. It shows that the input referred 1 dB compression points of 4dBm for high gain mode and 11dBm for low gain mode. And the measured noise figures are 16dB and 20dB for high gain and low gain mode respectively.

Table 1 summarizes the measurement results. The measurement was performed with a 3.3V supply, the RF input frequency of 910Mhz. and the LO frequency of 900Mhz. Thus, the IF frequency becomes 10Mhz. The LO input power is 0 dBm. The measured DC power consumptions of each mode are 60mW and 79mW in high and low gain modes respectively.

Ⅳ. Conclusion

In this report, a direct down conversion LNA/Mixer has been reported for 900Mhz UHF RFID application using 0.18um CMOS. A common gate input architecture is used to provide higher output saturation level. The LNA/Mixer circuit operates in high gain mode for a moderate power transmission application or in low gain mode for a high power transmission condition. The DC power consumptions are measured 60mW in high gain mode and 79mW in low gain mode with 3.3V supply. The input referred P1dB measurements show the high gian mode of 4dBm and the low gain mode of 11dBm. Those are high enough P1dB level for the UHF RFID application. The noise figures are 16dB in high gain mode and 20dB in low gain mode. The proposed LNA/Mixer shows a good performance for UHF RFID application.

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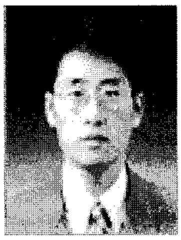

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