International Journal of Computer Architecture and Mobility
(ISSN 2319-9229) Volume 3 -Issue 3, May 2015

Design and Performance Evaluation of Folded Mixer Topology for Ultra Wideband Communication

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Abstract – A wideband mixer using a commercial 0.18- µm CMOS technology process for ultra wideband (UWB) system applications is presented in this paper. To achieve wideband frequency response and low dc power consumption for ultra wideband system applications, the folded approach is used to reduce supply voltage as well as dc power consumption, and wideband input matching network is used to achieve wideband frequency response. The proposed mixer demonstrates wideband frequency response from .2 to 16 GHz with a conversion gain of better than 5.3 dB.

Keywords –Folded topology, ultra wideband, Gilbert mixer, input matching network, CMOS technology.

1. INTRODUCTION

Ultra-Wideband Communication (UWB) was first conceived in 1960s and used for radar, sensing, military communication and niche applications in the past 20 years[1]. In 2002, the FCC opened 3.1 to 10.6 GHz available for UWB applications and limited the output power to Tx to -41.3 dBm/MHz. It means that the UWB system designs are focused on providing a low power , low cost, and wideband performance in ashort distance. Compared to traditional, narrow band applications, design of elements in UWB systems is quite different and provides challenges.

Complexity , cost, power dissipation and the number of external components have been the primary criteria in selecting receiver architectures. Since filter requirements prohibit channel selection at RF, receiver first translate the input spectrum to a much lower frequency. Mixers are used for frequency conversion and are critical components in modern radio frequency system. A mixer converts RF power at one frequency into power at another frequency to make signal processing easier and also inexpensive. A fundamental reason for frequency conversion is allow to amplification of the received signal at a frequency other than the RF, or audio frequency.

The process of mixing can be viewed as the multiplication of two signals; the input signal (RF) is mixed by a fixed frequency signal generated by a local oscillator (LO) to produce an intermediate frequency (IF) signal. Multiplication results in output signals at the sum and difference frequencies of the input signals, whose amplitude are proportional to the product of the RF and LO amplitudes. Hence, if the LO amplitude is constant, any amplitude modulation in the RF signal is transferred to the IF signal.

A popular mixer topology in UWB receiver is the double- balanced Gilbert cell mixer and was reported in various MMIC (Monolithic Microwave Integrated circuits) technologies with impressive performances. For example, SiGe-based HBT Gilbert-cell mixers were reported from dc to 30.5 GHz [2] and from 10 to 40 GHz [3].With InGaP/GaAs HBT technology, awork was presented from 1-17 GHz [4]. In CMOS technology, Gilbert-cell mixers also demonstrated good performances from 9-50 GHz in [5], and 0.3 – 25 GHz in [6].The Gilbert-cell topology provides reasonable conversion gain, good rejection at RF and LO ports and a differential IF output connection. The first stage mixer must have very high linearity[5] to handle the power from the LNA (Low Noise Amplifier). To achieve linearity, source degeneration capacitor can be added just below the gain stage of the mixer, The transistors should be biased such that they have enough headroom to swing without leaving the saturation region. The overdrive voltage should be around 200mV to 400mV.

The mixer is required to provide a low noise figure, high conversion gain and high linearity. The simulation achievement of these requirements is a very challenging task in the mixer design. Noise figure is an important factor limiting the sensitivity of the system in the receiver. It can be improve by decreasing the size of the degeneration capacitor but it will lead to degrade the linearity of overall system. Also higher gain and better linearity can be achieved by increasing the bias voltage through the trans-conductance stage, but the power consumption can be excessive.

2. UWB BASICS

By traditional definition UWB technology employs very narrow pulses, of the order of few nanoseconds, in order to establish a high data rate communications [3]. These narrow pulses translates to energy spread over a wide frequency band, and hence the name ultra wideband (also called impulse radio). A very high data rates can be achieved over a short distance in devices employing the UWB technology.

On February 14, 2002, the federal communication commission (FCC) opened up the spectrum from 3.1 GHz to 1.6 GHz for unlicensed use of the UWB technology. Having such a huge and free spectrum at one`s disposal is especially alluring for the industry and academic purpose. However, one of the important condition is that the power levels of the UWB signal in this spectrum must be low enough to avoid interference with the already existing technologies. The FCC specifies the power emission levels suitable for co-existing with other technologies in the UWB allottedband [2]. The spectrum mask for both indoor and outdoor emission is shown in figure 1.

Figure 2 shows the power spectral density of the narrow band signal and UWB signal. The power spectral density of the UWB signal is lower than the narrow band signal. This is the advantage of UWB signal.

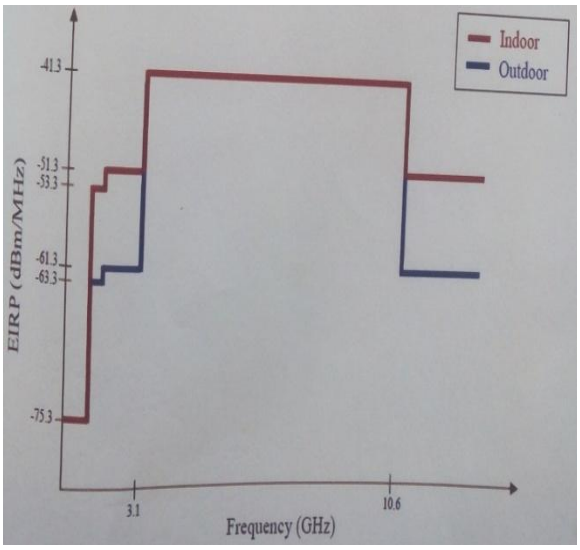

Figure 1: Acceptable Power Level
For Indoor and Outdoor Emissions

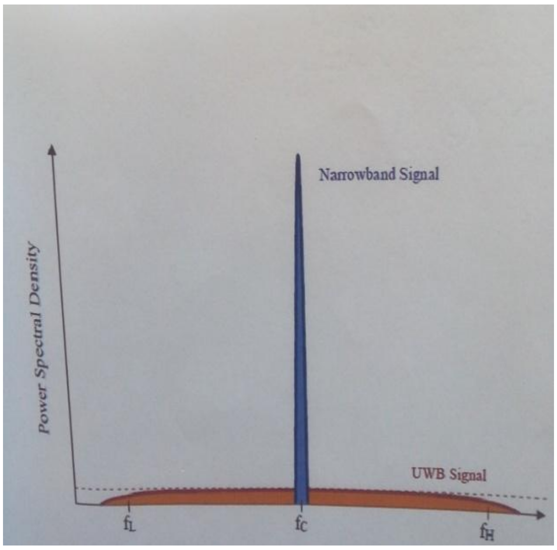

Figure 2: Power Levels of UWB Signals and a Typical Narrow Band Signals

3.FOLDED MIXER DESIGN

In wireless communication systems, there is demand for light weight, inexpensive, low power hand held terminals. So the designers evaluate the highly integrated RF receiver within the CMOS technology. The receiver front end section of the receiver in wireless communication system consists of different parts such as Band pass filter, low noise amplifier, mixer and IF amplifier. Each section in a receiver circuits has its own main contribution in the wireless communication. There are different type of mixers that consumes less power and requires low supply voltage. In this paper we introduce a folded mixer that reduce the power supply and dc power dissipation. A wideband matching network is used with the folded topology for UWB application.

3.1 Design Methodology

The double balanced Gilbert cell was chosen to initiate the design process. It is a popular mixer topology in CMOS receivers. The schematical representation of double balanced Gilbert mixer as shown in figure 3. It has been preferred since it can suppress (LO) leakage signals at the output. The Gilbert mixer can be operated into two modes (commutating made and non-commutating mode) depending on the LO signal shape and amplitude.

3.2 Advantages of Gilbert Mixer

>> Both LO and RF are balanced, providing both LO and RF rejection at the IF port.

>> All ports of the mixer are inherently isolated from each other.

>> Improve suppression of spurious (all even order products of the LO and/or the RF are suppressed).

>> High intercept point.

3.3 Disadvantages of Gilbert Mixer

>> Require a higher LO drive level.

>> Require two balun(although mixer will usually be connected to differential amplifiers).

>> Ports highly sensitive to reactive terminations.

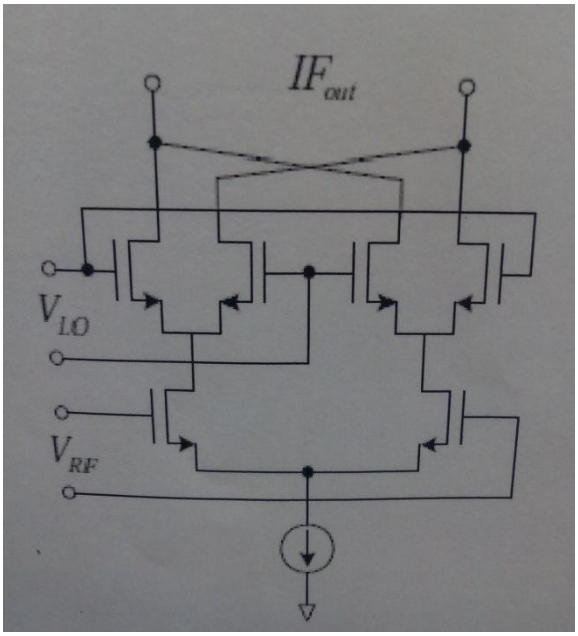

Figure 3: Gilbert Type Double Balanced Mixer

3.4 Mixer Design

The circuit schematic of the UWB mixer is shown in figure 4. The folded mixer is based on Gilbert cell mixer, which is composed of four parts- RF trans-conductance stage (M1-M4), local oscillation (LO) switch pairs (M5-M8), current mirrors, and IF buffer (M9-M10) amplifiers Different from the cascade structure of the conventional Gilbert cell mixer , the folded mixer is based on the folded structure. In this folded structure , the RF stage is moved out from cascade structure of conventional Gilbert cell mixer. This approach offers several advantages over conventional Gilbert cell mixer. The supply voltage can be reduced apparently less stacked layers. Also, the transistors of LO switch quad are biased in the saturation region and near cutoff where it consumes only 100µA of dc current. With small current flow through the load resistors stacked on the top of LO switch quad, the reduction in power dissipation across load transistors can be achieved.

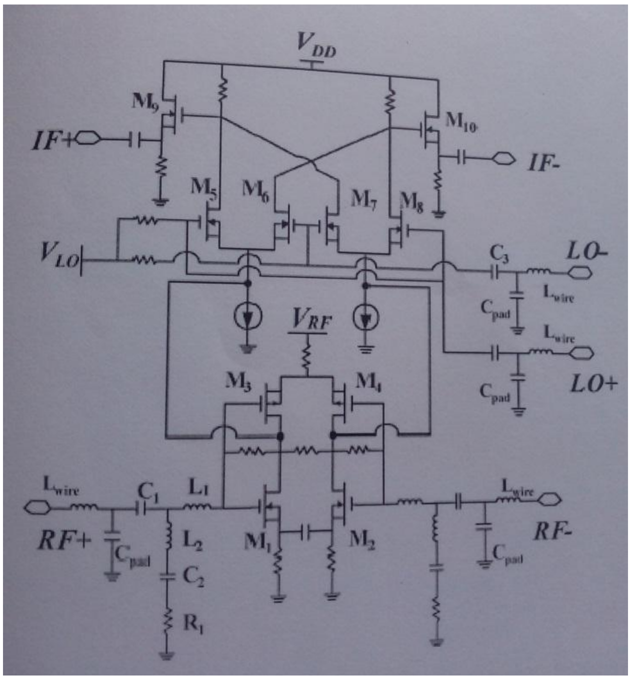

Figure 4: Circuit Schematic of Folded Mixer

3.5 Mixer Operation

The RF signal is applied to the transistor M1 and M2 which perform a voltage to current conversion. MOSFET M5 to M8 form a multiplication function, multiplying the linear RF signal current from M1 and M2 with the LO signal applied across M5 to M8.which provide the switching function. M1 and M2 provide +/_ RF current and M5 and M7 switch between them to provide the RF signal (or inverted RF signal) to the left hand load . M6 and M8 switch between them for the right hand load. The two load resistors form a voltage to current transformation giving differential output IF signal. This differential output further amplified using output buffer amplifiers (M9-M10).

In the case of double balanced Gilbert cell mixer, the single NMOS transistor is used as the trans-conductors.

3.6 Performance parameters

The performance parameters of typical down conversion mixer are:

I. Conversion gain – The voltage conversion gain of mixer is defined as the ratio of the rms voltage of the IF signal to the rms voltage of the RF signal. On the other hand, the power conversion gain of the mixer is defined as the IF power delivered to the load divide by the available RF power from the source. If the input impedance and load impedance of the mixer are both equal to the source impedance, then the voltage conversion gain and power conversion gain of the mixer are equal when expressed in decibels.

II. Noise figure- Noise figure is the signal to noise ratio (SNR) at input (RF) port divided by the SNR at the output (IF) port. In general case, where desired signal exists at only one frequency, the noise figure that can be measure is called the single side band noise figure (SSBNF). The rare case, where both the main RF and image signals contain useful information, leads to a double side band noise figure (DSBNF). The SSBNF will normally be 3dB higher than the DSBNF.

III. Port to Port Isolation: The isolation between each ports of a mixer is critical. The LO-RF feed-through results in LO leakage to the LNA and eventually the antenna, whereas the RF-LO feed-through allows strong interferers in the RF path to interact with the local oscillator driving the mixer The LO-IF feed-through is important because substantial LO signal exists at the IF output even after low pass filtering, then the following stages may be desensitized. Finally, the RF—IF isolation determines what fraction of the signal in the RF path directly appears in the IF.

IV. Linearity: Dynamic range requirements in modern, high performance telecommunication systems are quite severe, frequently exceeding 80 dB and approaching 100 dB in many instances. The floor is established by the noise figure, which conveys something about how small a signal may be processed. Following method are used for the measurement of linearity : 1 dB compression pointand Third order intercept point (IIP3).

4. CONCLUSION

An active broad band mixer is designed and simulated using a State-of-Art of 0.18 µm CMOS technology process to achieve specific aspects. The folded approach is applied to reduce supply voltage and dc power consumption. The broad band LC ladder input matching network achieves a wide band operating frequency from 0.2-16 GHz. The method is based on Gilbert cell structure. The folded approach is applied to Gilbert cell structure to reduce the dc power consumption. Linearity of mixer is improved by inserting degeneration capacitor, instead of degeneration inductor. We can increase the gain of mixer by increasing the load or by increasing the size of the transistors in trans-conductance stage. This is achieved at the cost of the linearity of the mixer.

ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude and heart-felt thanks to my supervisor Mr. Rajesh Khatri for their guidance, inspiration, critical discussion and constant support throughout of this work. I wish to thanks to Dr. D. K. Mishra , Professor and Head of Electronics and Instrumentation Department of SGSITS, Indore, for providing support to this work.

REFERENCES

1) V. Vidojkovic , J. Tang, A. Leeuwenburg, and A. H. M. van Roermund, ‘‘ A low voltage folded-switching mixer in 0.18 µm CMOS , ” IEEE J. Solid State Circuits, vol. 40, no. 6,pp.1259-1264,Jun. 2005.
2) M.D. Tsai and H. Wang, ‘‘ A 0.3-25 GHz ultra wideband mixer using commercial 0.18 µm CMOS technology, IEEE Microw. Wireless Component Letter, vol.14,no.11,pp. 522-524,Nov. 2004.
3) A.Q. Safarian, A. Yazdi, and P.Heydari, ‘‘ Design and analysis of an ultra-wideband distributed CMOS mixer,” IEEE Trans. VLSI Syst., vol.13,no. 5, pp. 1470-1478, MAY 2005.
4) A. Ismail and A. A. Abidi, ‘‘A 3-10 GHz low noise amplifier with wideband LC ladder ,matching network,” IEEE J. Solid Circuits, vol. 39, no. 12, pp. 2269-2277, Dec. 2004.
5) B. Razavi, ‘‘Design considerations for Direct-conversion Receivers,” IEEE Trans. Circuits and Systems, Part II, vol.44, pp. 428-435, June 1997.
6) I. Oppermann, M. Hamalainen, and J. Iinatti, UWB Theory and Applications. New York: Wiley, 2004.
7) B. Leung, ‘‘ VLSI for Wireless Communication”, Prentice Hall, 2003.