International Journal of Electronics, Communication & Soft Computing Science and Engineering (IJECSCSE)
Volume 1, Issue 1

An Active Down Conversion Mixer with Improved Linearity and Noise Figure

Jyoti J. Zunzunwala

Abstract - The performance of receiver is strongly affected by the parameters of mixer which should have high linearity and low noise figure. The flicker noise in mixer design is due to the on/off transition during the switching operation for mixing which affects the linearity and noise figure. In this paper three techniques for the improvement of noise figure and linearity using current bleeding circuit, inductive tuned PMOS switch circuit and source degeneration have been reviewed.

Keywords – Gilbert Mixer, Linearity, Current Bleeding, Source Degeneration, Noise Figure.

I. INTRODUCTION

Growth of the wireless communication technology needs increasing demand on low power, low cost and high performance receivers. RF mixer is the most significant building block in the front-end receiver. The attractiveness of CMOS technology because of cost reduction and scaling of devices has shown its feasibility for applications at high frequencies ranging from 900 MHz to 5GHz. (like GSM, DECT, DCS-1800, wireless LAN, Bluetooth)[2].

Figure 1 shows the block schematic of RF receiver front end. The mixer which down converts the RF signal passing through LNA into intermediate frequency (IF) signal strongly affects the performance of receiver. While designing a mixer, the parameters such as Noise figure, conversion gain, port to port isolation and linearity plays vital role.

In order to improve these parameters the double balanced Gilbert mixer is mostly used[1]. It comprises of three stages (i) RF transconductance amplifier stage (ii) Local oscillator (LO) switching stage (iii) Output load stage as shown in Figure 2.

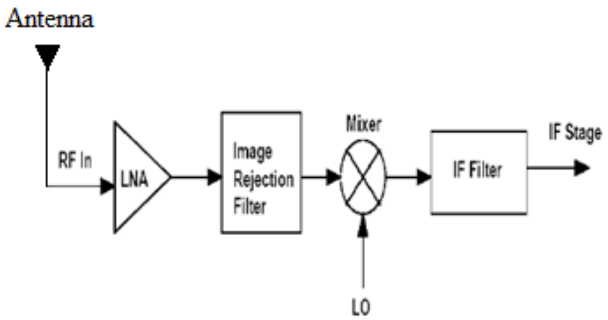


Figure 1 RF receiver front-end

RF Transconductance amplifier stage is voltage to current converter stage which amplifies input RF signal[1] .The output of first stage is downconverted to an intermediate frequency(IF) current signal by using LO switching stage. And finally it is converted into voltage signal using load impedance stage. This paper includes various techniques to improve mixer parameters.

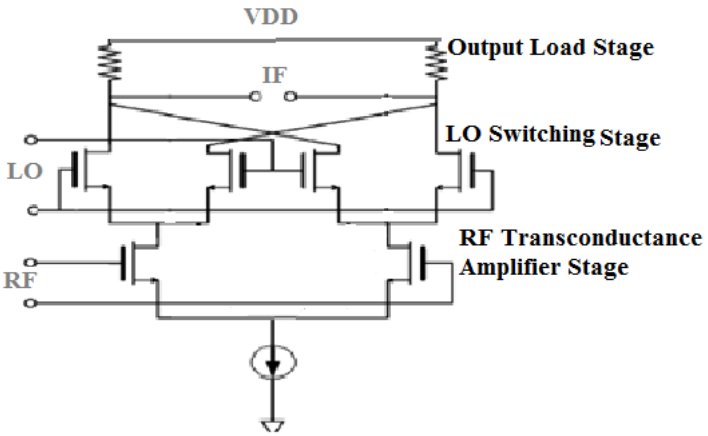


Figure 2 Double balanced Gilbert mixer

II. IMPROVEMENT FOR THE NOISE FIGURE AND LINEARITY OF GILBERT MIXER

For better performance of receiver mixer should have low noise figure and high linearity. In mixer design the source of flicker noise is the on/off transition during switching operation for mixing. In order to avoid this noise and for high linearity various techniques are used which are described as follow

A. Bleeding Current Technique With LC Filter

Soheil Ziabakhsh et al [3] discussed the bleeding current technique for the improvement of noise figure. The circuit illustrating this technique is shown in figure 3 which consist of cascode transconductance stage, LC filter, switching stage and the arrangement for current bleeding technique. Two MOSFET's M_{11} and M_{12} are used to implement the current bleeding technique for better performance of mixer. With this technique the current through switching transistor is reduced in order to improve flicker noise[3].

In order to remove the cause of flicker noise at the output (parasitic capacitances at the common source node of the switching pair) LC filter is used. In which inductor L cancels out the parasitic capacitor, responsible for flicker noise at the

output. And capacitor C is used to drain the intermodulation current otherwise a differential IM2 current would forced through the pair of cascode transconductanctance stage. Figure 3 shows the schematic for double balanced mixer with LC filter and current bleeding technique.

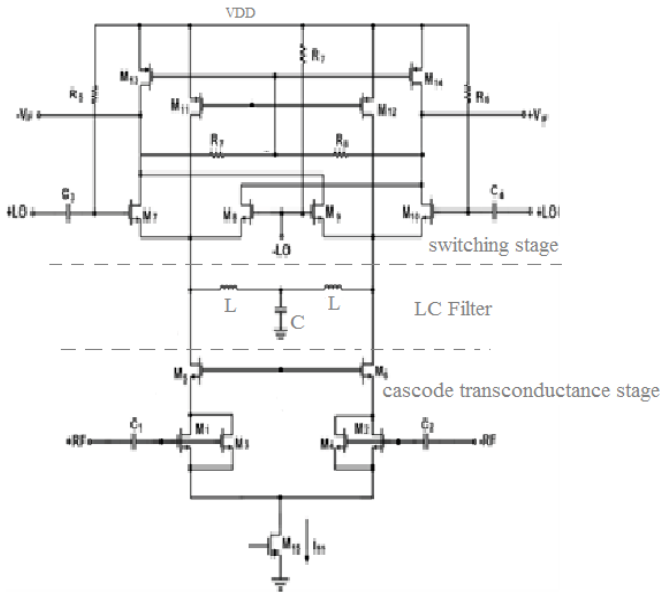
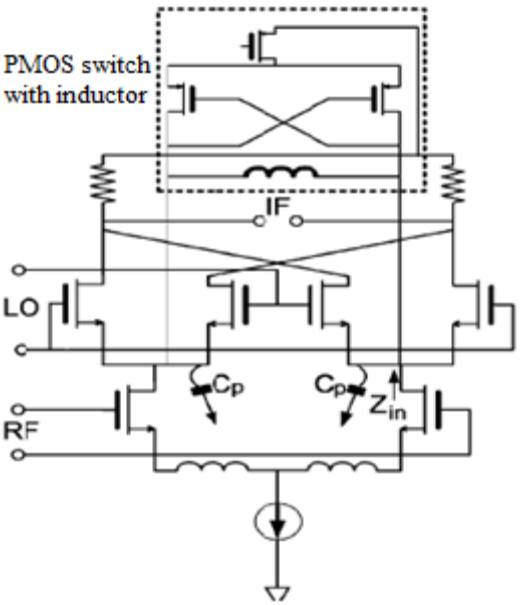


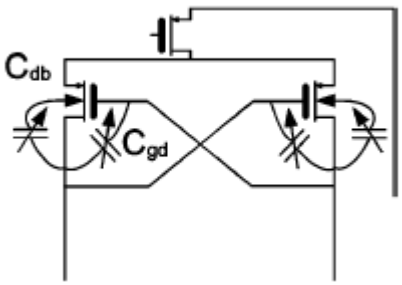
Figure 3 Double balanced Gilbert mixer with LC filter and current bleeding technique

B. Improvement Using Inductive Tuned PMOS Switch Circuit

Jehyung Yoon et al [5] discussed the technique to avoid the flicker noise during the on/off transition of switch operation for mixing which uses PMOS switch circuits. The PMOS sharpens the on/off of LO switch stage by inserting the current into the mixer core at the on/off instant. For sharper turn on/off, a large PMOS can be used which delivers more current but the non linear capacitances of the PMOS produce harmonics and form leakage paths for insertion current which can be minimized by using parallel inductor to tune the capacitances at $2f_0$. Figure 4 (a) illustrates the Gilbert mixer with inductive tuned PMOS switch circuit and (b) shows the nonlinearity components such as C_{gb} and C_{db} provided by PMOS switch. Due to nonlinear capacitances, the linearity of mixer is degraded which is improved by padding inductor.



(a)



(b)

Figure 4 (a) Gilbert mixer with PMOS switch (b) PMOS switch with parasitic capacitances

C. Improvement Using Source Degeneration

Shengchang Gao et al [4] discussed the technique to improve the linearity for better performance of mixer. This technique consists of a modified Gilbert- type and source degeneration circuitry as shown in figure5. Figure5 shows transconductance stage, switching stage and load stage. The load stage consists of RLC circuit. The use of degeneration resistor R_s improves linearity and stability of mixer. The tuned load is used to get more voltage headroom at the RF and IF ports and is designed off chip together with an off chip filter. The current sink composed of M7, M8, M9 resulted in larger gain of mixer.

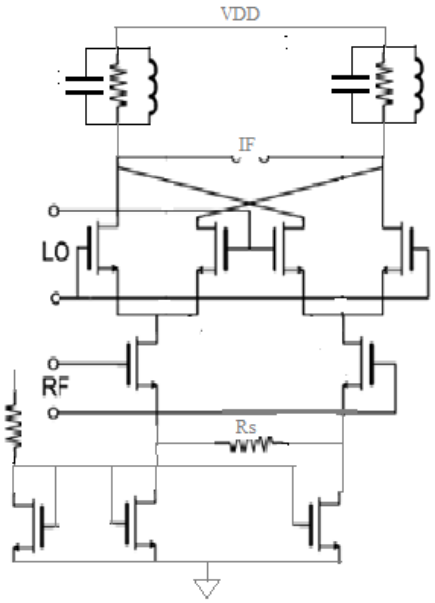


Figure 5 Gilbert mixer with source degeneration

III. Conclusion

First technique makes use of active loads to increase the conversion gain of mixer and LC filter to avoid flicker noise. LC filter reduces the effect of parasitic capacitances at the source terminal of switching stage and helps to improve noise figure and linearity. The second technique with the use of PMOS switch sharpens the on/off transition of switching core and inductor is used for better noise performance. And the third technique of using source degeneration helps to improve linearity. By making combination of these techniques the performance of mixer likely to be improved.

References

[1] Lee, Thomas H. "the Design of CMOS Radio Frequency Circuits". Cambridge University Press, Cambridge, United Kingdom, 1999. pp. 309-313, 319-321, 324.

[2] Razavi, Behzad. "RF Microelectronics". Prentice Hall, Upper Saddle River. N.J. 1998. pp. 38-41, 48- 50, 131-132, 138-143, 182-187.

[3] Soheil Ziabakhsh, Goodarz Cheraghi and Hosein Alavi-Rad. "A CMOS Down-Conversion Mixer with High Linearity and Low Noise Figure In 0.18-µm Technology", 5th European Conference on Circuits and Systems for Communications (ECCSC'10), November 23–25, 2010, Belgrade, Serbia.

[4] Shengchang Gao, Kaihang Li. "A High-linearity Low-noise Figure Active Mixer in 0.18um CMOS",IEEE 2009.

[5] Jehyung Yoon, Huijung Kim, Changjoon Park, Jinho Yang, Hyejeong Song, Sekyeong Lee, and Bumman Kim. "A New RF CMOS Gilbert Mixer With Improved Noise Figure and Linearity", IEEE transactions on microwave theory and techniques, vol. 56, no. 3, march 2008.

[6] C. H. Chen, P. Y. Chiang, and C. F. Jou. "A low voltage mixer with improved noise figure", *IEEE Microw. Wireless Compon. Lett.*, vol. 19, no. 2, pp. 92-94, Feb. 2009.

[7] Goo-Young Jung, Jae-Hoon Shin, Tae-Yeoul Yun, "A low-noise UWB cmos mixer using current bleeding and resonant inductor technique", Microwave and Optical Technology Letters, vol. 49, issue 4, pp.1595-1597, July 2007.

Author's Profile

Jyoti J. Zunzunwala
Department of Electronics and Telecommunication,
Shri Ramdeobaba Kamla Nehru Engineering College, Nagpur
Maharashtra, India
jyoti.zunzunwala@gmail.com