Design and Analysis of a Gilbert Cell Mixer

Ajay G Nayak
Bangalore, India
ajaygnayak221@gmail.com

Abstract - This work presents the design and performance evaluation of a Gilbert cell mixer implemented using the IHP SG13G2 SiGe BiCMOS technology. Comprehensive DC, AC and transient analyses were conducted to verify circuit operation and frequency response. The DC analysis established a stable RF operating range between 0.6 V and 0.8 V, ensuring proper biasing and linear behavior. The AC response exhibited a maximum voltage gain of 2.5 dB with a 3 dB bandwidth of 5 GHz, while transient simulations confirmed accurate frequency translation. The results demonstrate that the mixer achieves wideband operation, stable gain, and linearity, making it suitable for high-frequency applications.

Index Terms - RF, mixer, gilbert cell

INTRODUCTION

Mixers are widely used circuits in radar systems, satellite communications, wireless communication systems, etc. A mixer is a non-linear circuit that multiplies two signals, typically Radio frequency (RF) signal and local oscillator (LO) signal to produce an output signal as shown in Figure 1.

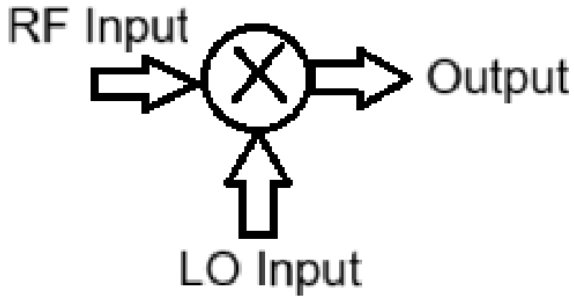


FIGURE 1. BLOCK DIAGRAM OF MIXER

CIRCUIT IMPLEMENTATION

The Gilbert cell is a classic mixer topology used in RF ICs. It is an analog multiplier that uses differential amplifier for linear input conversion and uses current steering switches to multiply input with LO signal.

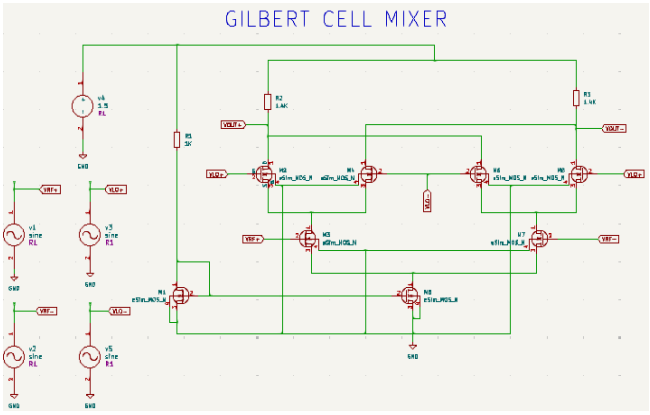


FIGURE 2. SCHEMATIC REPRESENTATION OF GILBERT CELL

RESULTS

The Gilbert cell mixer shown in Figure 2 is designed to operate with a 1.5V power supply on eSim Tool.

I. DC Analysis

Figure 3 shows the DC Analysis to establish a stable operating region for the RF transconductance stage between 0.6 V and 0.8 V, ensuring all MOS devices remain in the saturation region and confirming proper biasing and linear operation. This range defines the suitable common-mode voltage for the RF input stage, which maintains balanced drain currents and consistent transconductance.

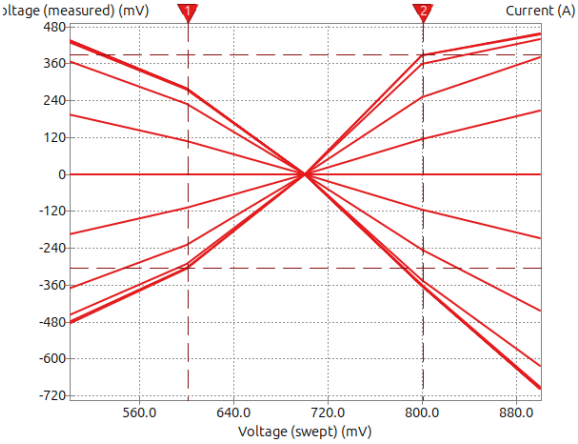


FIGURE 3. DC ANALYSIS

II. AC Analysis

The AC analysis shown in Figure 5 demonstrates a maximum voltage gain of 2.5 dB with a 3 dB bandwidth of 5 GHz, validating the mixer's wideband response.

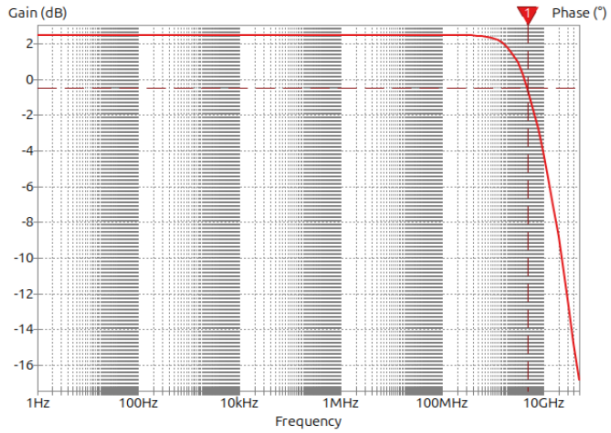
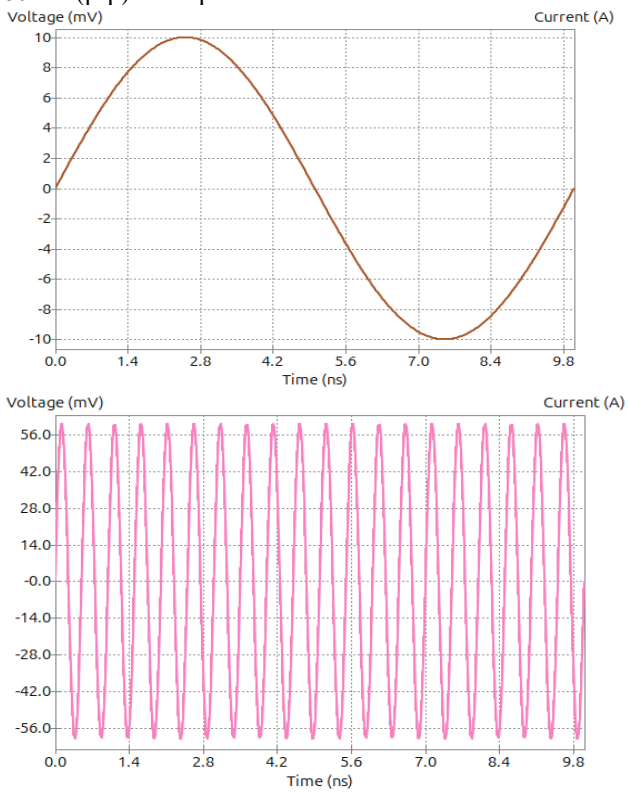


FIGURE 4. AC ANALYSIS

III. Transient Analysis

The transient analysis in Figure 5 verified correct mixing functionality for 10 mV(p-p) RF input at 0.1 GHz and a 60 mV(p-p) LO input at 2 GHz.



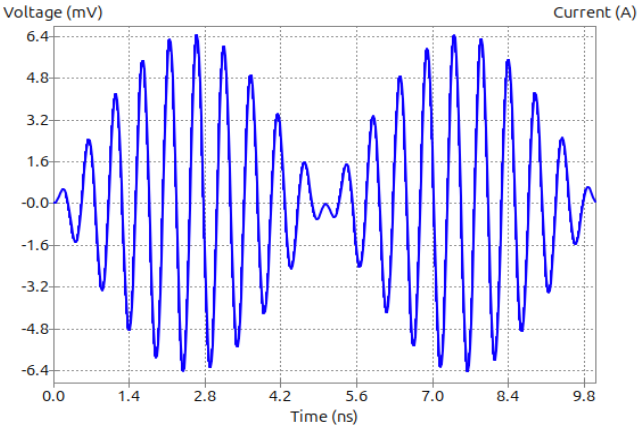


FIGURE 5. TRANSIENT ANALYSIS A) RF INPUT B) LO INPUT C) OUTPUT

CONCLUSION

The Gilbert cell mixer was successfully designed and analyzed using the IHP SG13G2 technology. DC, Transient and AC analyses were performed to verify its functionality and frequency response. The circuit achieved a maximum small-signal gain of 2.5 dB with a 3 dB bandwidth of 5 GHz. For future work, further analyses will be carried out to fully qualify the mixer's performance. These include noise figure analysis, conversion gain and loss characterization, linearity tests such as 1 dB compression point (P1dB) and third-order intercept point (IIP3/OIP3), isolation measurements between LO, RF, and OUT ports and power consumption evaluation. These parameters are essential to comprehensively assess the efficiency and suitability of the mixer for RF applications.

REFERENCES

[1] M. O. Bekkaoui, "Gilbert cell Mixer design in 65nm CMOS technology," 2017 4th International Conference on Electrical and Electronic Engineering (ICEEE), Ankara, Turkey, 2017, pp. 67-72.

[2] U. A. Belorkar, S. A. Ladhake and S. N. Kale, "2.45 GHz Gilbert Mixer using 45 nm CMOS technology," 2012 IEEE Business, Engineering \& Industrial Applications Colloquium (BEIAC), 2012.

GITHUB

GitHub ReadMe File: https://github.com/AJ-221/Gilbert-Cell-Mixer/blob/main/README.md

GitHub Repository: https://github.com/AJ-221/Gilbert-Cell-Mixer.git