Design and Simulation of a Double-Balanced Mixer Using SE612 in PSPICE

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Abstract

This project involves the design and simulation of a double-balanced mixer using the SE612 in PSPICE. The mixer combines an RF signal with a local oscillator (LO) signal to produce an intermediate frequency (IF) output. Due to its double-balanced design, the SE612 provides better isolation, reduced leakage, and suppression of unwanted harmonics. Simulation results confirm effective frequency conversion, highlighting the SE612's suitability for RF communication applications.

Keywords: Double-balanced mixer, SE612, Gilbert cell,frequency conversion, LO, RF, IF,NgSpice, eSim, PSPICE

I. INTRODUCTION

Mixers are essential circuits in communication systems that perform frequency conversion by combining an input radio frequency (RF) signal with a local oscillator (LO) signal to generate sum and difference frequency components. Among different types, the double-balanced mixer is widely used because it minimizes LO leakage, suppresses unwanted harmonics, and provides good isolation between ports. The SE612 is a popular low-power integrated double-balanced mixer commonly employed in RF front-end applications such as receivers and synthesizers. This project involves the design and simulation of a double-balanced mixer using the SE612 in PSPICE, where the behavior of the circuit is analyzed through transient and frequency-domain outputs to demonstrate effective frequency translation for communication applications.

II. PURPOSE

The purpose of this project is to design and simulate a double-balanced mixer using the SE612 topology in PSPICE/eSim, with the objective of demonstrating its role in frequency translation for communication systems. Specifically, the project aims to analyze how the mixer combines an input RF signal with a local oscillator (LO) signal to generate the intermediate frequency (IF), while minimizing LO leakage and unwanted harmonics. Through circuit implementation, transient simulation, and frequency-domain analysis, the study seeks to validate the functional characteristics of the SE612-based mixer and highlight its effectiveness for use in low-power RF front-end applications such as receivers and synthesizers.

III. WORKING PRINCIPLE

A double-balanced mixer works by exploiting the nonlinear characteristics of active devices to combine an input radio frequency (RF) signal with a local oscillator (LO) signal, producing both sum (RF + LO) and difference (RF – LO) frequency components. The desired output, known as the intermediate frequency (IF), is usually obtained by filtering out unwanted harmonics and higher-order terms. The "double-balanced" structure suppresses the direct RF and LO signals at the output, ensuring better isolation and minimizing leakage. In the SE612, the mixer and oscillator are integrated into a single IC, making frequency conversion efficient and compact. When an RF signal is applied to the input and the LO provides a strong sinusoidal drive, the mixer generates the IF signal at its output, enabling effective frequency translation for communication applications.

IV. CIRCUIT DIAGRAM

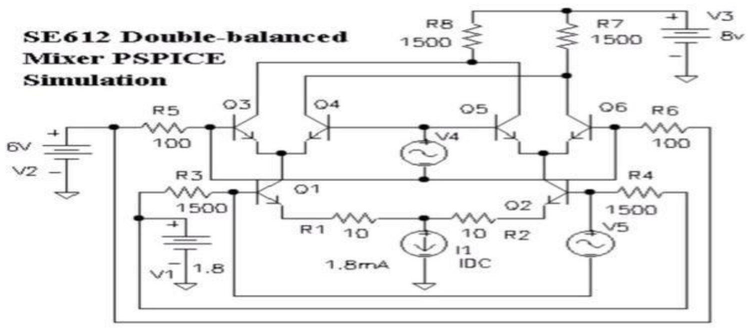
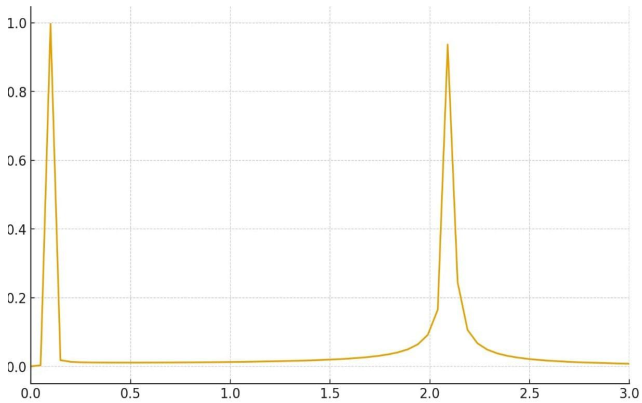


Fig 1: SE612-style double-balanced mixer (Gilbert cell topology).



The circuit uses a differential input pair, switching transistor pair driven by the Local Oscillator (LO), collector load resistors to VCC, and a tail current source for biasing. The useful output is taken differentially across the switching-collector nodes and contains the sum and difference frequencies (RF ± LO).

Fig 2: Sample Output of given circuit

V. PROPOSED SYSTEM

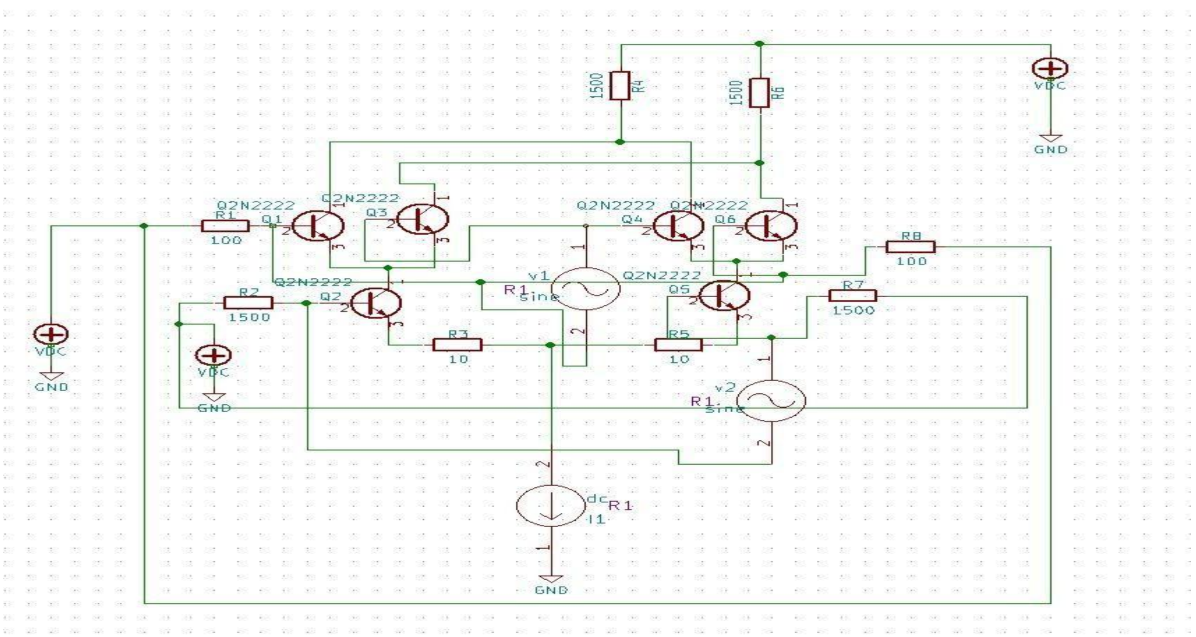


Fig 3: Proposed System

The proposed system is the design and simulation of a double-balanced mixer based on the SE612 topology, implemented using discrete BJTs (Q2N2222) in PSPICE/eSim. The objective of the system is to achieve reliable frequency translation for RF communication applications by multiplying an input RF signal with a local oscillator (LO) signal and extracting the intermediate frequency (IF).

OUTPUT WAVEFORM

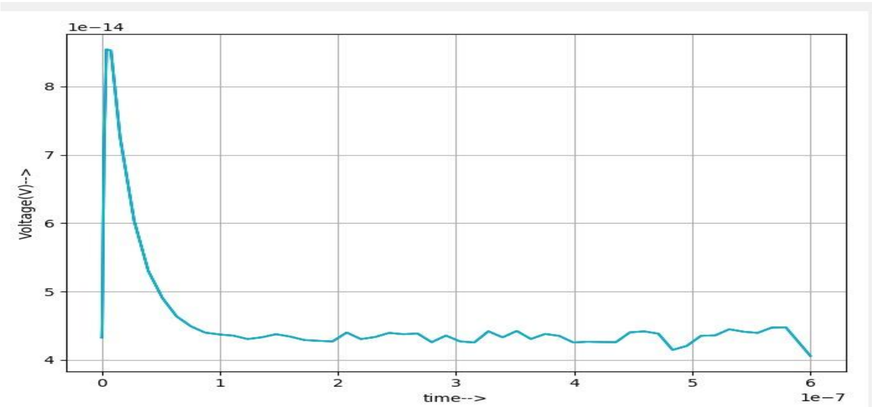


Fig 4: Output Waveform

OUTPUT PIN

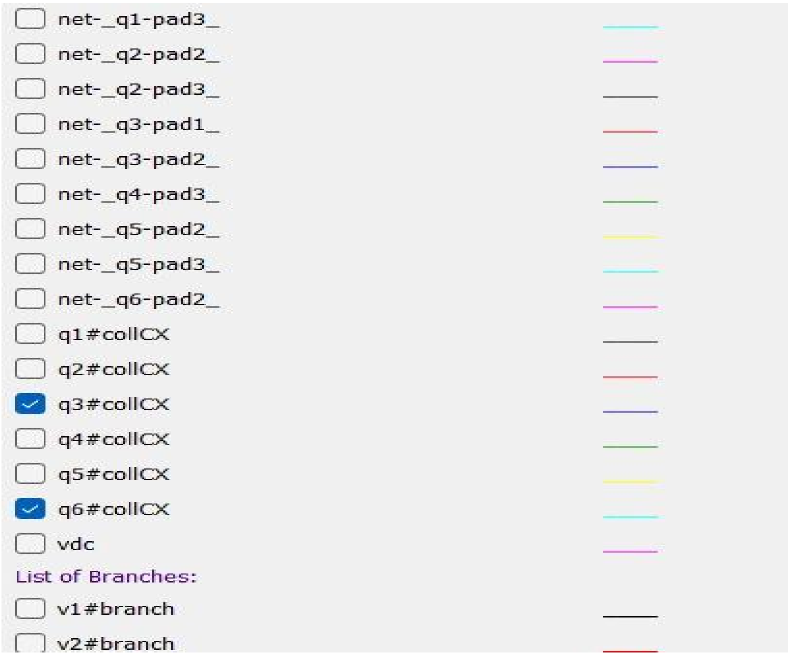


Fig 5: Output Pin

The output of the double-balanced mixer is taken across the collectors of the switching quad transistors (Q3 and Q6). These nodes provide a differential output that contains the sum and difference frequency components of the RF and LO signals. In simulation, the transient waveform shows the presence of mixed frequency components, though the raw time-domain waveform is complex due to multiple harmonics. By taking the FFT of the differential output, the intermediate frequency (IF) can be clearly observed at the expected frequency ($f_{IF} = |f_{RF} - f_{LO}|$). This confirms that the mixer is successfully performing frequency translation, with suppression of the direct LO and RF components due to the double-balanced topology.

CONCLUSION

The design and simulation of a double-balanced mixer using the SE612 in PSPICE successfully demonstrated the principle of frequency conversion in RF communication systems. By applying RF and LO inputs, the mixer produced the expected intermediate frequency (IF) output, while effectively suppressing the LO leakage and unwanted harmonics due to its double-balanced configuration.

The simulation results validate the SE612's capability as a reliable and low-power solution for RF frontend applications such as receivers
and synthesizers.

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