

DC to 11GHz Fully Integrated GaAs Up Conversion Mixer

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1. ABSTRACT.

This paper describes the design and realization of a wide band single balanced fully integrated up-conversion mixer. The mixer has a RF bandwidth from 1 to 11GHz and an IF at 14 GHz, with an 1GHz bandwidth. This requires a LO frequency range from 15 to 25GHz. This single balanced mixer needs a single RF signal and a differential LO signals. The wide LO band prevents the use of a passive single to differential converter. We choose to integrate an active single to differential converter on chip. The output of the mixer core needs to be buffered. This to prevent unwanted mixing due to reflected signals from the IF output. To have enough buffering two single amplifiers are included.

2. INTRODUCTION.

The mixer has been designed to use in the Alan Telescope Array, this is a project of SETI (Search for Extraterrestrial Intelligence). The Alan Telescope Array consists of an array of satellite dishes that will be used for astronomical purposes. This array will be used for the search of extra terrestrial life and possibly for radio astronomical surveys. To have a comprehensive look on the sky a wide frequency band of over a decade is chosen. The received frequency band is 1 GHz to 11 GHz. To study these signals they have to be down converted to a lower frequency so they can be converted to a digital signal. This digital signal can then be processed in a correlator. The down conversion will be done in two steps. The first step is to mix the signal to a higher frequency. Then the signal will be filtered to remove any unwanted signals. The last step is to mix the signal to a lower frequency where it can be digitized.

3. THE DESIGN

The design of the active integrated mixer can be divided in three parts:

- A Single to differential converter.
- A Gilbert cell mixer.
- Output buffering.

These parts will be discussed separately.

The layout of the active integrated mixer can be seen in figure 1. Figure 2 shows the schematic of the active integrated mixer. The design is made is the 0.2 μm Pseudomorphic HEMT process of OMMIC. The IC has been fabricated on a multi project wafer run at the GaAs factory of OMMIC in France.

The single to differential converter.

On the IC a single to differential converter is included. It is needed because the chosen single-balanced mixer needs a balanced LO signal. Normal signal sources provided a unbalanced signal. This has to be converted to a balanced signal. The conversion is done actively because of the wide frequency range, 15 GHz to 26 GHz.

The conversion is achieved by feeding the unbalanced signal to a balanced amplifier. This balanced amplifier is fed asymmetrically. The output of this amplifier is then symmetrical or balanced. The amplifier has two source followers at the output to provide better signal handling and improved buffering.

The single balanced mixer core.

The single balanced mixer core provides the actual mixing. In this configuration the RF-signal is connected to the single HEMT. The LO signal is connected to the differential pair. To have the best LO-suppression the LO signal has to have a perfect 180 degree phase difference. For optimal LO suppression the single to differential converter has to provide this balanced signal.

The IF output buffer.

The IF buffer is included to prevent the presented load to influence the mixer. If any reflections occur at the output, then these will be a source of extra mixing products. An amplifier with an high return suppression will minimize these unwanted mixing products. Because a pass-band filter will be placed behind the mixer IC many reflections might occur because of the low S_{11} of the filter outside the pass-band.

4. MEASUREMENT RESULTS.

The single to differential converters should provide the mixer core with a balanced signal with equal amplitude and a good 180 degree phase difference. The LO-buffer has been measured and the gain results can be seen in figure 3. The phase results can be seen in figure 4. The phase difference is 180 degree \pm 12 degrees up to 18 GHz. The power levels at the output pins differ up to 2 dB. This is because the biasing of the differential amplifier is not optimal. A redesign of the biasing circuit has been send to the wafer lab of OMMIC.

The measurements on the LO-buffer with the mixer core show the performance of the IC. Several measurements have been done over a wide frequency range and at different power levels. Figure 5 shows the conversion gain curves measured on 1 sample. The IF frequency for all these measurements was 14 GHz. The RF power used was -10 dBm. The LO power levels were at 0 dBm and 10 dBm.

The IF buffer has been measured separately and the gain curves can be seen in figure 6. The buffer has gain up to 8 GHz. The S_{12} , the return suppression, is high.

Summary table.

Phase difference LO buffer	180 \pm 12
Gain LO buffer	-4
Conversion gain	-7
Gain IF buffer @ 14 GHz	-5 dB

5. CONCLUSION.

This first design of a wide band up-conversion mixer is working fine. As the measured results show the mixer converts an RF frequency band of 1 to 11 GHz to an IF at 14 GHz. Some improvements have been inserted in a new design to optimize especially the IF buffer.

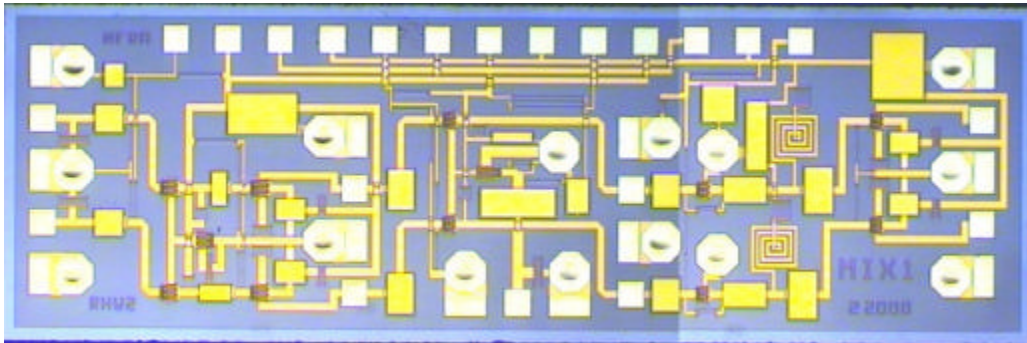


Figure 1, Photograph of the IC

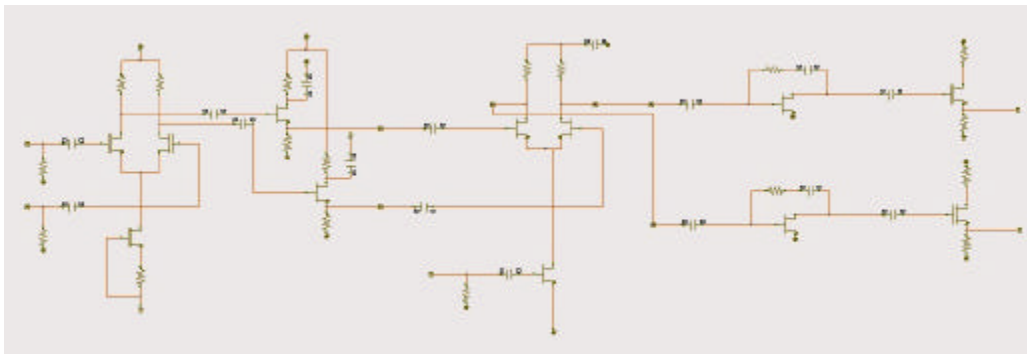


Figure 2, Schematic of the mixer

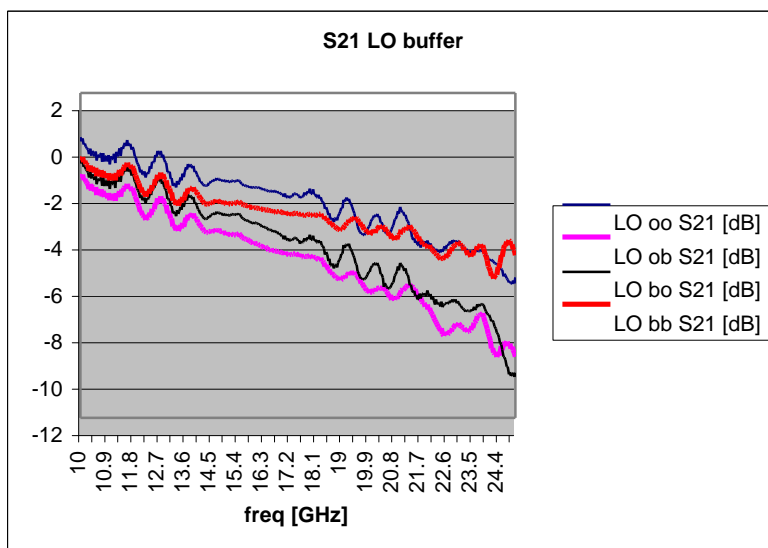


Figure 3, Gain curve of the LO-buffer

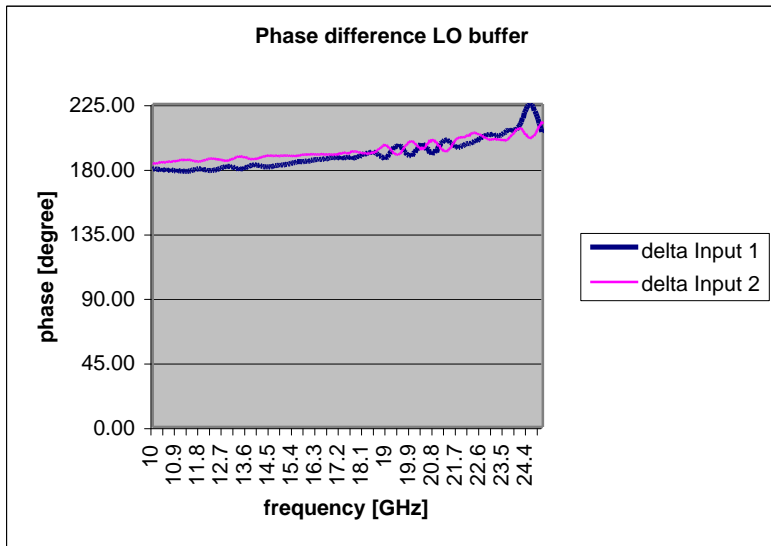


Figure 4, Differential phase of the LO-buffer

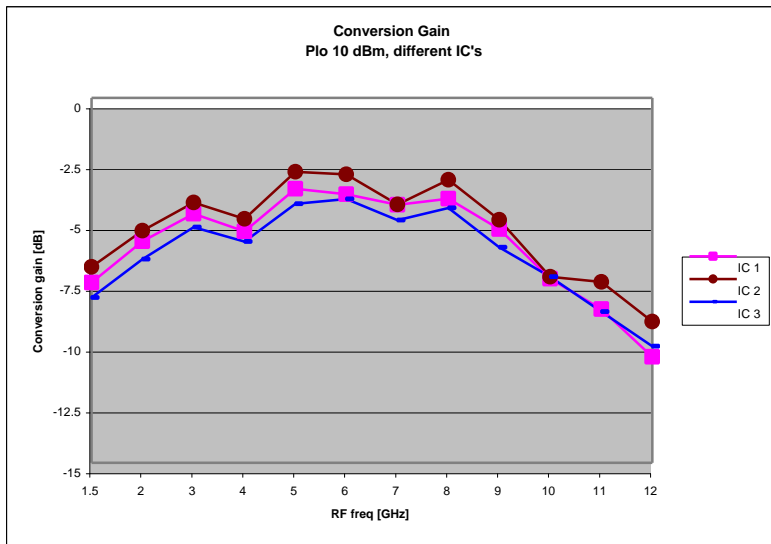


Figure 5, Conversion gain of the mixer

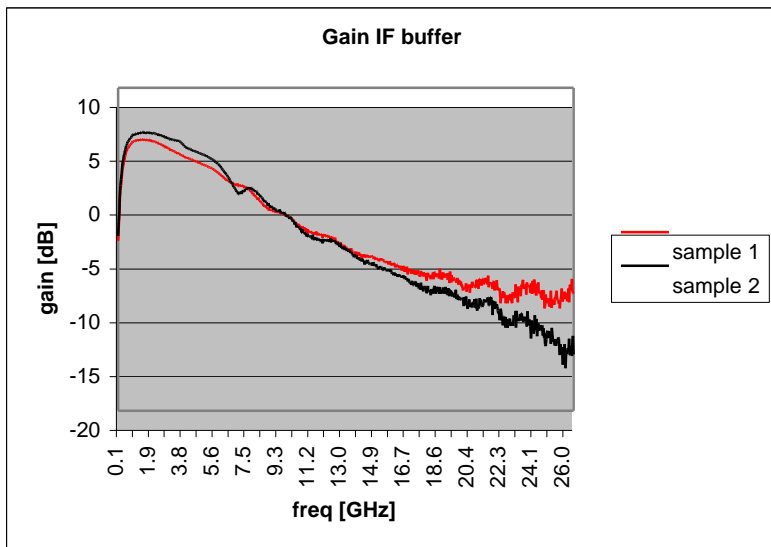


Figure 6, Gain of the IF buffer