Frequency Modulation System using ADF4351 and AD831

Joon Yeon Kim

Professor Kyusun Choi

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Abstract

The purpose of this project is to create a frequency modulation circuit/ model that can enhance the overall resolution of MRI images.

One of the most useful RF processes is that of mixing. When two signals passed through a non-linear circuit, then additional signals on new frequencies are formed, as shown in *Figure 1*.

In this project, two different signals generated from two separate ADF4351 frequency synthesizers are mixed using a single AD831 Mixer. And the resultant frequencies are overserved via 100MHz bandwidth oscilloscope.

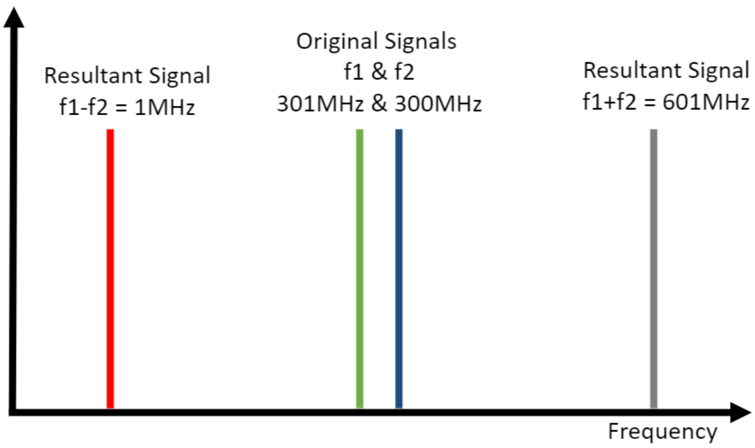

Figure 1: Mixing two RF signals

Introduction

Two of ADF4351, an integrated voltage-controlled oscillator are connected to the two input ports of a low distortion 500MHz bandwidth frequency mixer, AD831. Resultant frequencies then will be passed through the low-lass filter, extracting only (f1-f2) component of resultant frequency.

As can be seen in Figure 2, f1 frequency represents the frequency generated from MRI. And, f2 is the frequency from the ADF4351 frequency synthesizer.

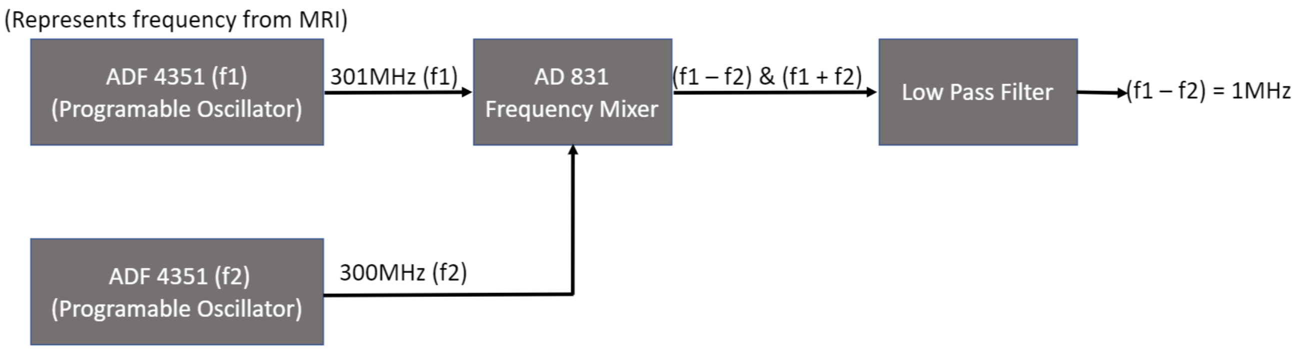

Figure 2: Block diagram of frequency modulation

Technical Summery and Theory of Operation

AD831 has two input ports, RF_{in} and LO_{in}. RF_{in} is connected to one of the output ports from ADF4351 for f1. LO_{in} is for f2. AD831 mixer can be powered by various DC voltage range: from ±5.5VDC to +11VDC.

AD831 mixer PCB, designed for a single power supply, is shown in Figure 3. IF_{out} is then directly connected to the scope to observe the modulated frequencies.

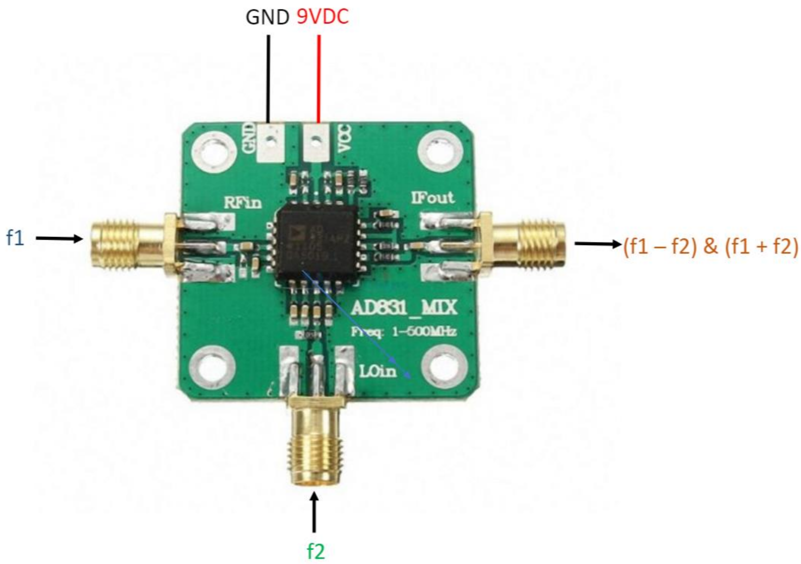

Figure 3: AD831 high frequency RF mixer

The ADF4351 evaluation board, *Figure 5*, allows the user to evaluate the performance of the ADF4351 chip with user-friendly software. The accompanying software directly controls the synthesizer functions from the PC. As can be seen for the *Figure 4*, the once the user types in the desired output frequency and click "write all registers," the software automatically writes all the registers values needed for ADF4351 to generate such frequency.

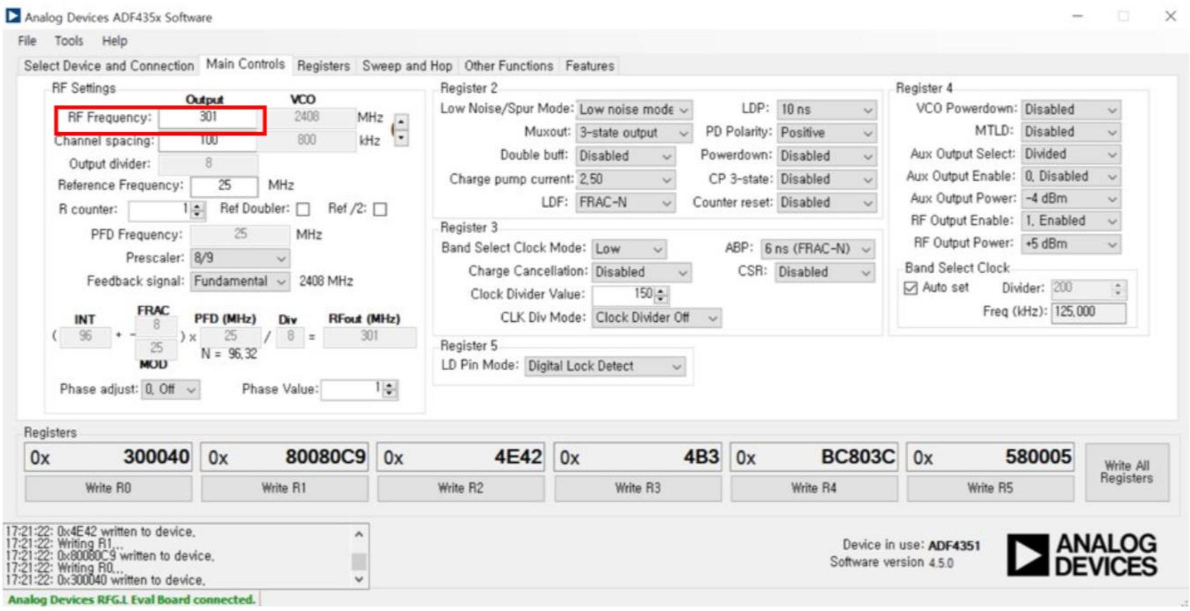

Figure 4: ADF4351 software interface, registers written to output 301MHz

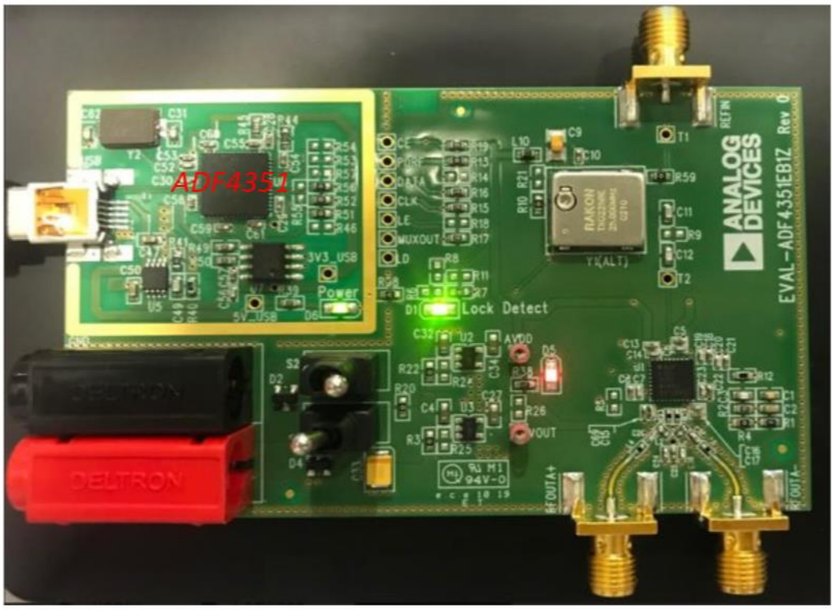

Figure 5: ADF4351 evaluation board

The elevation board has been set up with 50ohm termination tip on *RF OUT A*$^{+}$, and have *RF OUT A*$^{-}$ to be the port for frequency output- *Figure 6*.

Then by using 15cm SAM male to male coaxial cable, the ports RF OUT A- from the evaluation board is connected to RF_{in} and Lo_{in} ports of AD831 mixer. The full schematic is shown in *Figure 7*.

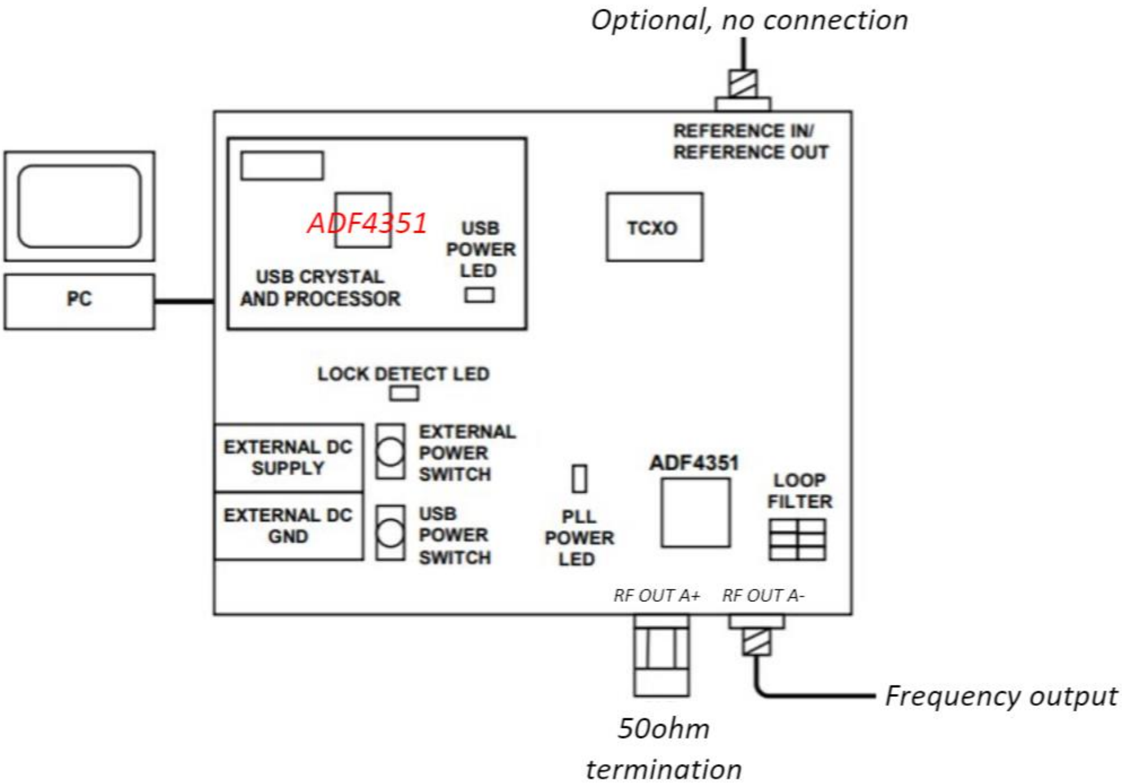

Figure 6: Evaluation board setup

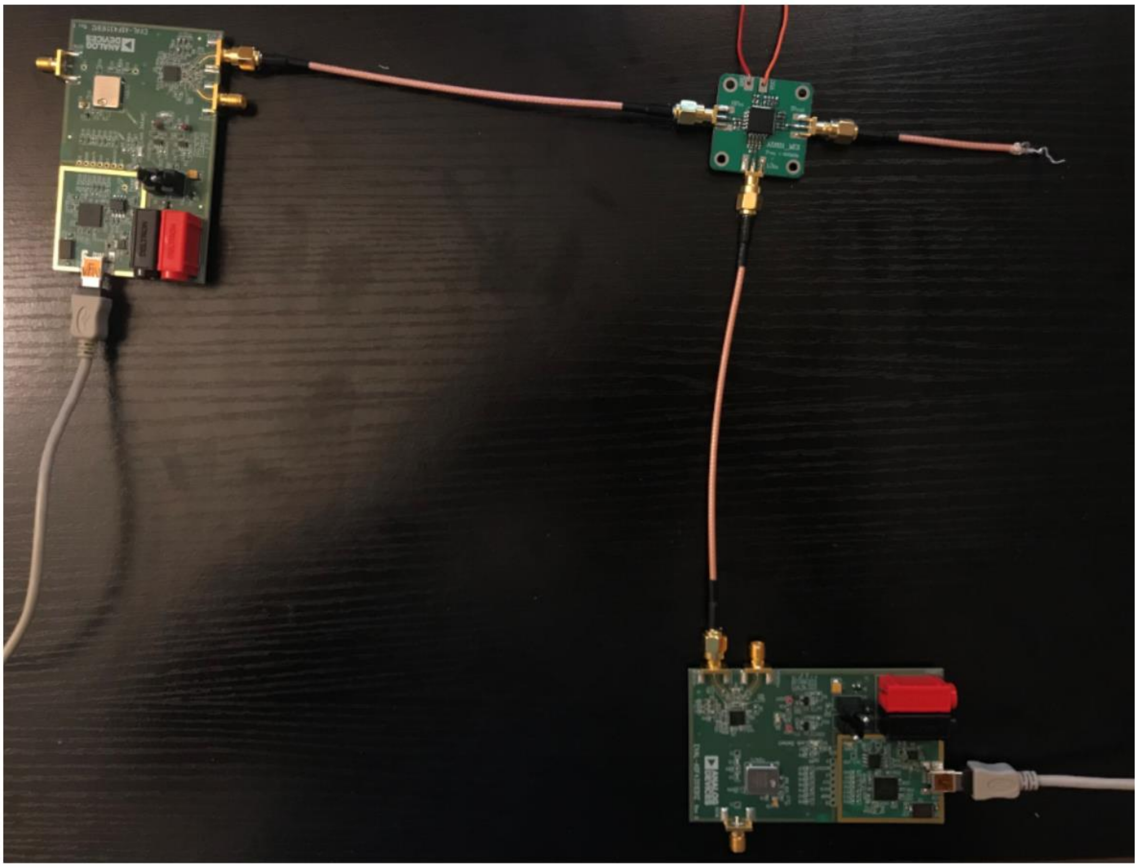

Figure 7: Full schematic of modulation system

Simulation

Before running the actual modulation process and observing the empirical data via oscilloscope, modulation of f1 and f2 frequencies are simulated using LT SPICE.

Because of limitation with the computing power, for the simulation, 301KHz and 301KHz are simulated instead of 301MHz and 300MHz. *Figure 8* shows the simple schematic used for the modulation simulation.

Figure 9 is the simulated result: green represents f1, blue represents f2, and red represents the resultant frequency. In order to easily differentiate the f1 and f2, the amplitude of f2 is half the amplitude of f1.

After taking the Fourier Transform of the resultant frequency, 1KHz (f1- f2) resultant frequency is indicated with the red arrow- *Figure 10*.

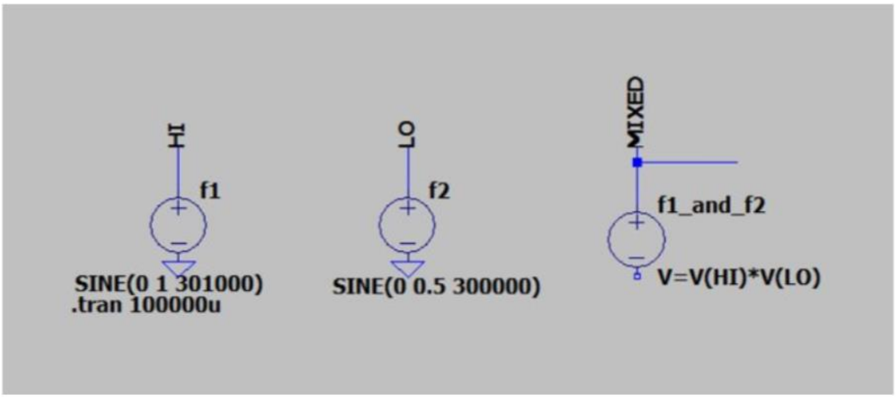

Figure 8: Simulation schematic

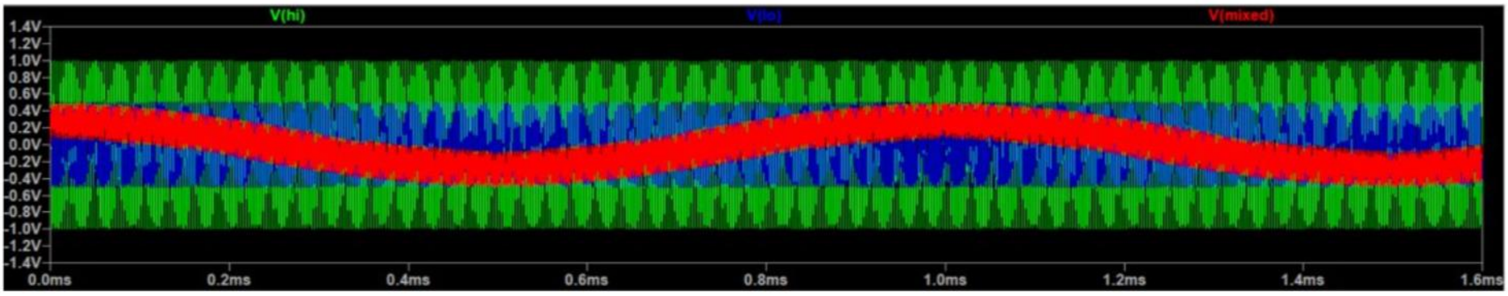

Figure 9: Simulated result

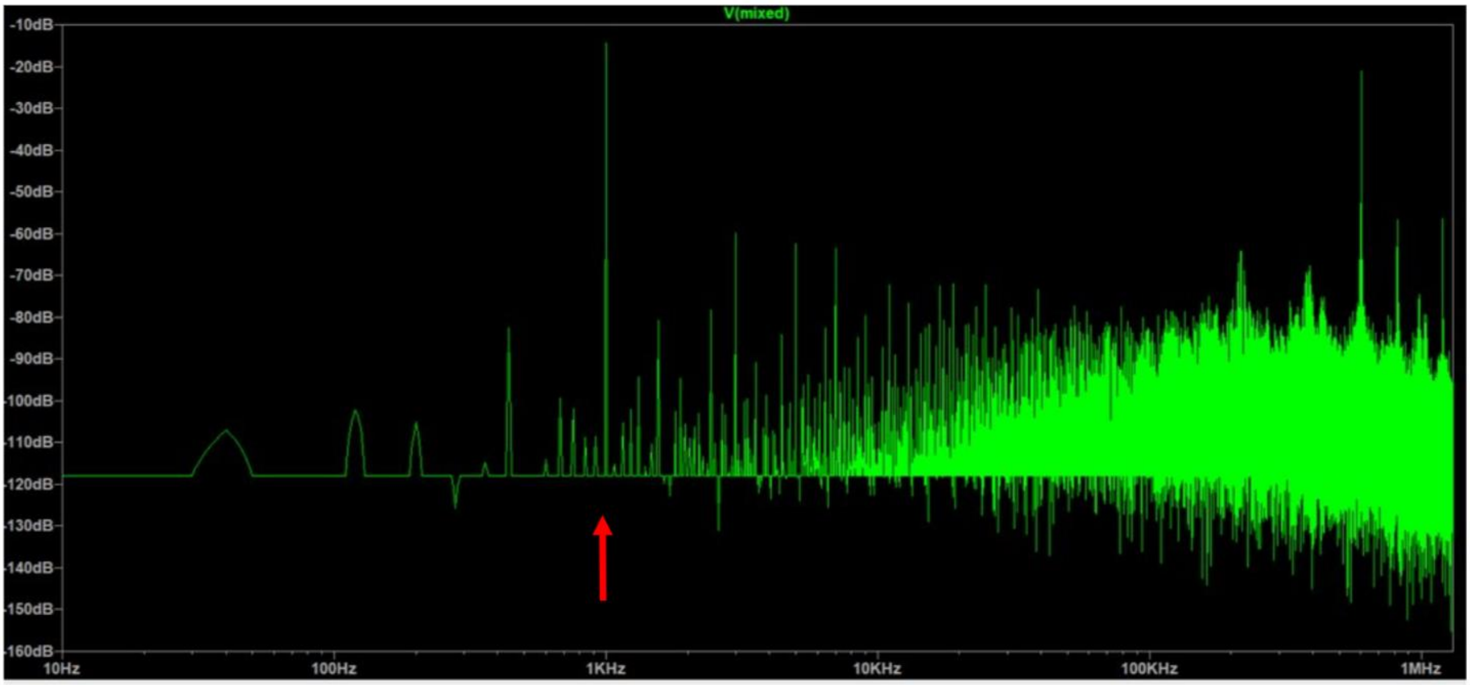

Figure 10: Simulated result after FFT

Empirical Result

Since only 100MHz bandwidth oscilloscope is available at the time of measurement, 110KHz and 100KHz frequencies are used for the modulation. As shown in *Figure 7* set up, 110KHz is generated from the top evaluation board, and 100KHz is coming from the bottom evaluation board. The measurement of modulated frequencies is shown in *Figure 11*. As expected, the resultant frequency of f1-f2, 10KHz, is measured using the scope.

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Figure 11: Empirical result for resultant frequency

Conclusion

Through this circuit set up, it is clear that AD831 can successfully mix two frequencies. In application, f1 will come from MRI, and f2 will come from ADF4351 oscillator. By modulating the two frequencies and later converting those frequencies into digital signals, the overall resolution of MRI images, therefore, is enhanced significantly.

This project confirms that ADF4351 can successfully mimic the frequency from MRI (301MHz), and AD831 operates sufficiently, although it is not powered via its most ideal voltage level.