Implementation of AM and DSB-SC Modulation Techniques on FPGA

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ABSTRACT: This research work explicates the various simulation results using Simulink and System Generator and its implementation on FPGA. Initially the most important analog modulation techniques which are AM and DSB-SC modulation techniques are elucidated. Afterwards these modulation techniques are constructed and tested with in Simulink. Prior to realization of this design within System Generator the audio signal is imported to the Simulink and the simulation results are investigated on FPGA.

KEYWORDS: Simulink, System Generator, FPGA, AM and DSB-SC.

I.INTRODUCTION

In the following steps, Simulink is used to generate an input sine signal that was transmitted through wire connection to the FPGA, and finally the output result was captured on an oscilloscope. This configuration is illustrated in Figure 1.
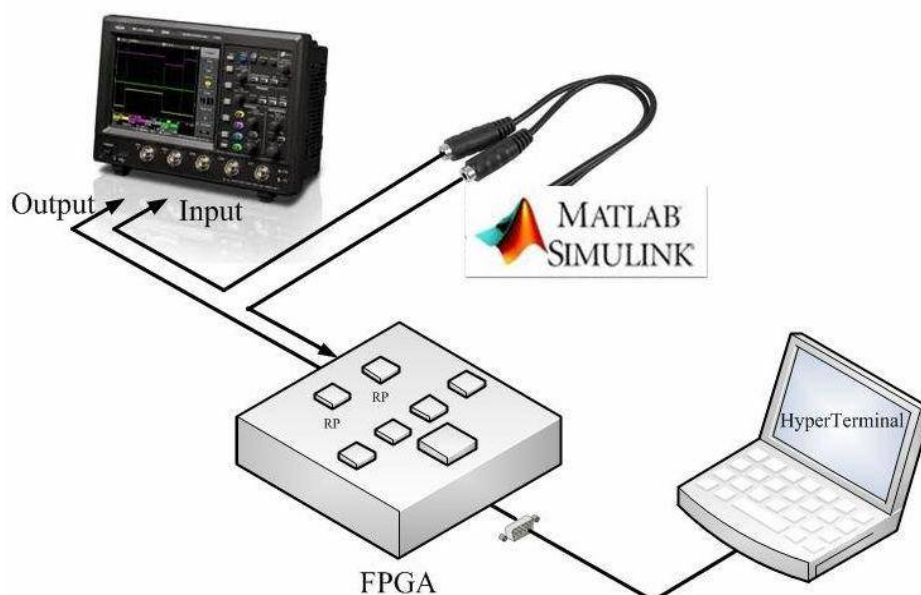

Fig 1. FPGA Input/Output Configurations

II. DSB-SC MODULATION AND ITS RESULTS

DSB-SC modulation is implemented on the FPGA which is shown in Figure 2. The processing of implementing this modulation is conducted within System Generator by generating netlist file and then used the generated netlist file for generating partial bitstreams in PlanAhead. Figure 3 shows the input signal and the modulated signal of DSB-SC modulation. In this figure, the signal in the upper portion of the figure represents the input sine wave which is generated from Simulink and lower signal shows the output signal of the FPGA [1]. The carrier frequency is generated within System Generator by DDS block.
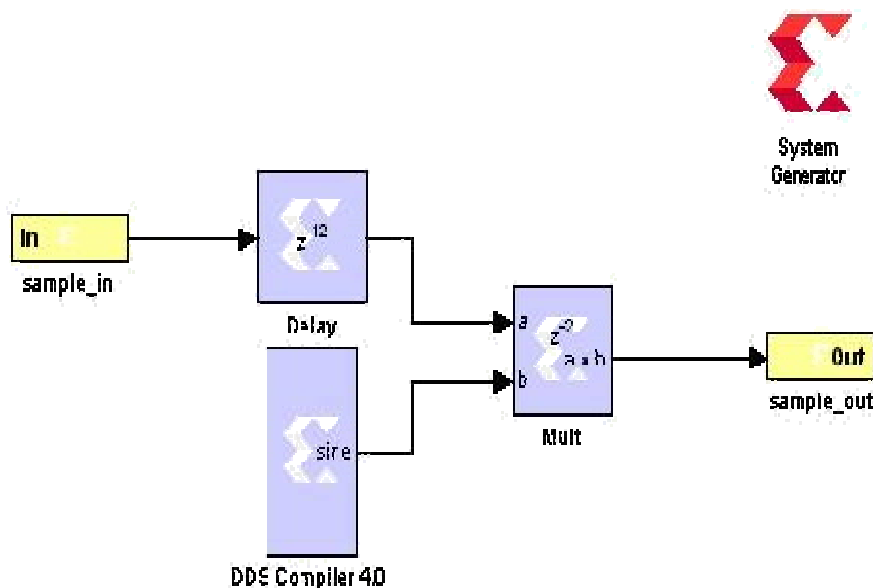

Fig 2. DSB-SC Modulation Process

In addition, this configuration was tested with an audio signal input, and the output signal was observed on the oscilloscope [2]. Figure 4 shows the output results of a DSB-SC modulated of an audio signal on the FPGA. The results in this section are compared with the Simulink and the System Generator simulation results which show the similar results among all of them [3].
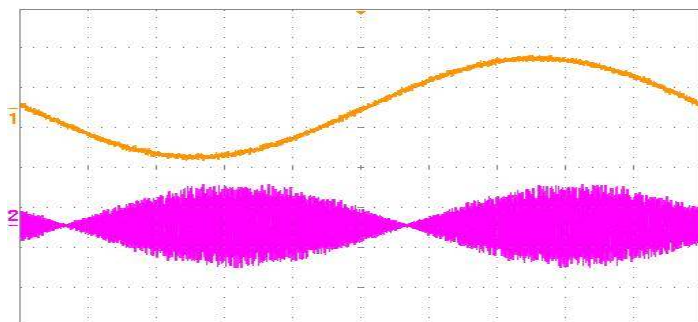

Fig 3. Input Signal and Output Results of Modulated Signal (DSB-SC Modulation) on the FPGA (1) Input Signal (2) Output Signal

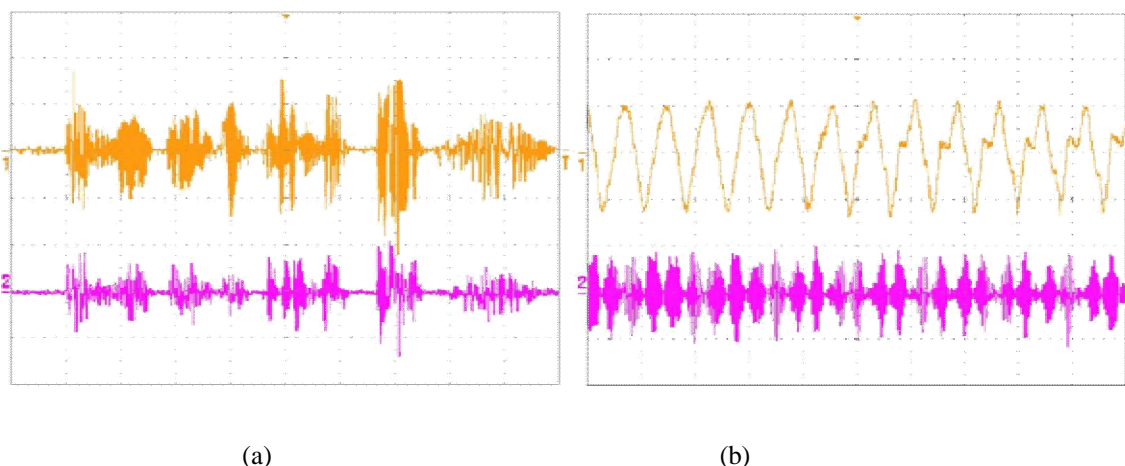(a)   (b)

Fig 4. Output Results of Modulated Signal (DSB-SC Modulation) on the FPGA (a) 0ms Sec/Div (b) 5ms Sec/Div

III. ANALOG MODULATION AND ITS RESULTS

Similarly, the next implemented modulation technique is modulating an AM signal which is shown in Figure 5. In this figure, Constant1 block with value of 0.5 represents k_a for AM modulation [4]. The input signal and output result of this modulation was captured on the same oscilloscope.

Figure 6 illustrates the output result of this modulation process. Again, the signal in the upper portion of this figure represents the input sine signal which is generated from Simulink and lower signal shows the output modulated signal [5]. The carrier frequency is generated within System Generator by DDS block. Moreover, this configuration was tested with an audio signal input and the output signal was captured on the oscilloscope which is shown in Figure 7.

The results of these measurements after implementation on an FPGA well matched to the simulation results of Simulink and System Generator which shows this reconfigurable system.
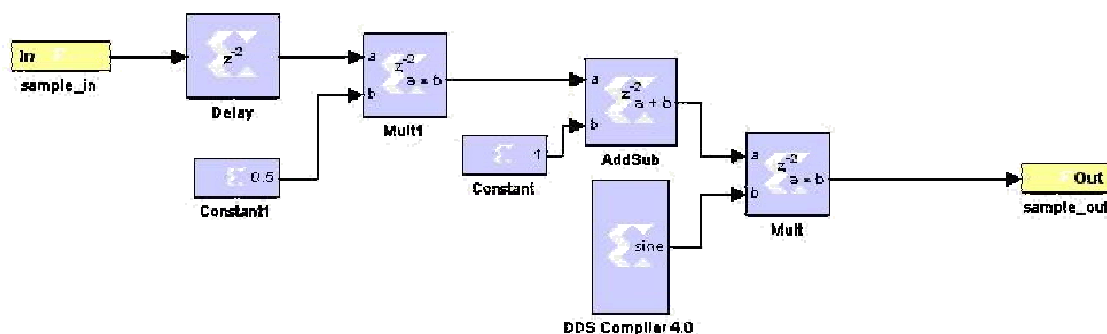

Fig 5. AM Modulation Block Diagram in System Generator

In the next configuration, the entire of DSB-SC modulation and demodulation is implemented within a same module which is shown in Figure 8. This figure shows that the carrier frequency is generated within System Generator by DDS block and then directly multiplied by the input signal (message signal).
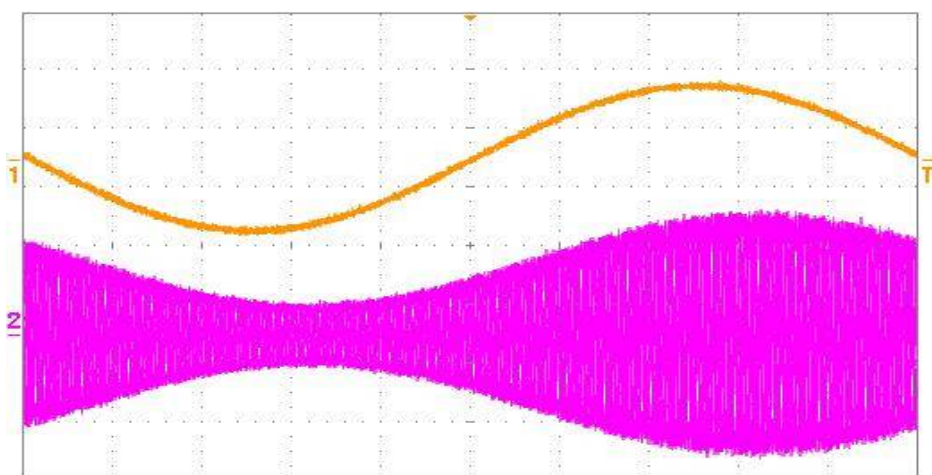

Fig 6. Output Results of Modulated Signal (AM Modulation) on the FPGA (1) Input Signal (2) Output Signal
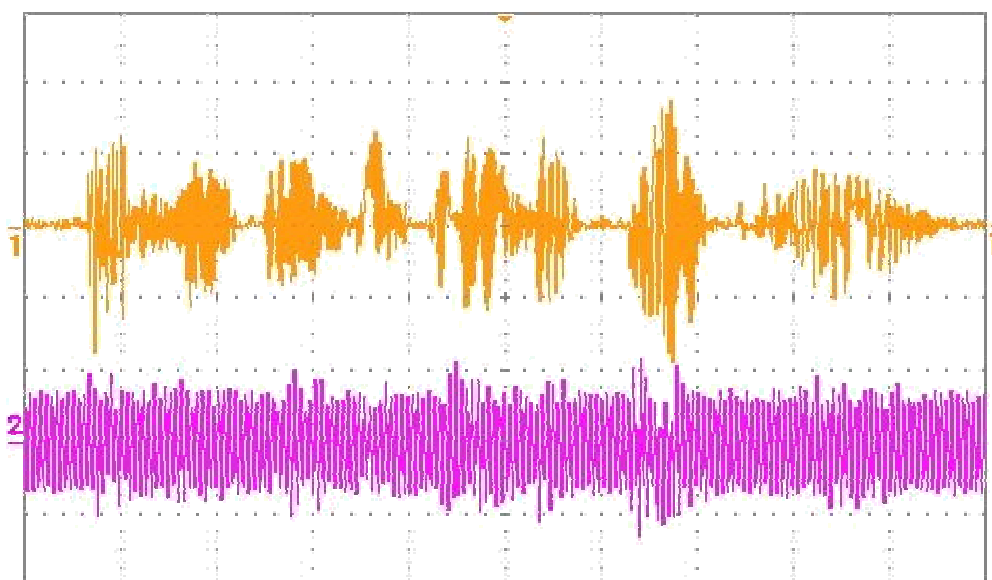

Fig 7. Output Results of Modulated Signal (AM Modulation) on the FPGA (1) Input Audio Signal (2) Output Audio Signal

Since the recovered signal has a lower gain compared with the input signal the CMult block is used in this design to amplify the output signal. CMult in System Generator is similar to Gain block in Simulink. In addition, the FIR Compiler 5.0 and Xilinx FDAtool are used to remove higher frequency components of the recovered signal. The output result of this modulation was captured and the result is shown in Figure 9. Again, the signal in the upper portion of this figure represents the input sine signal which is generated from Simulink and lower signal shows the recovered signal after demodulation process [7]. Also, this configuration is tested with an audio signal input and the output signal

is captured on the oscilloscope which is shown in Figure 10. The results of these measurements well matched to the simulation results of Simulink and System generator.
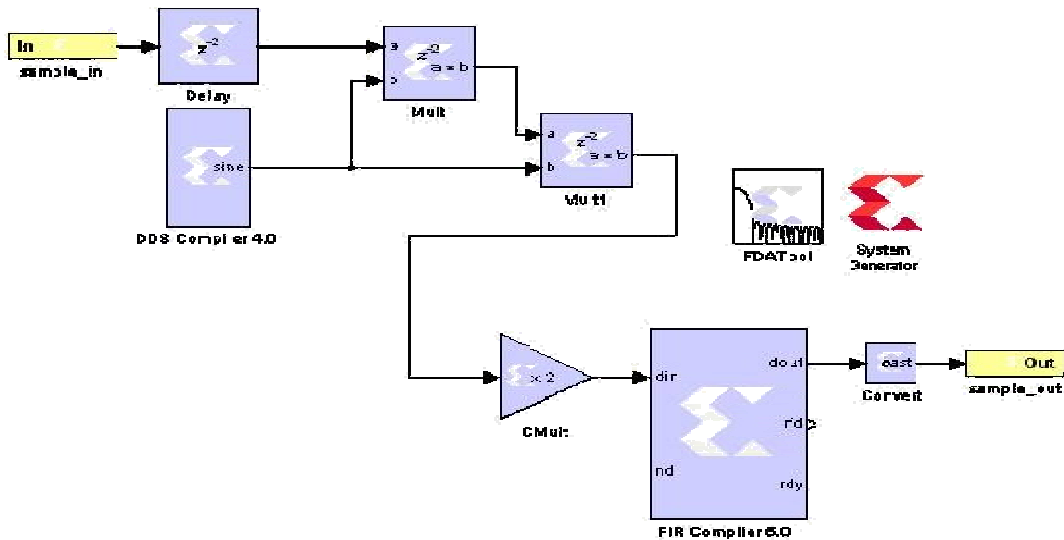

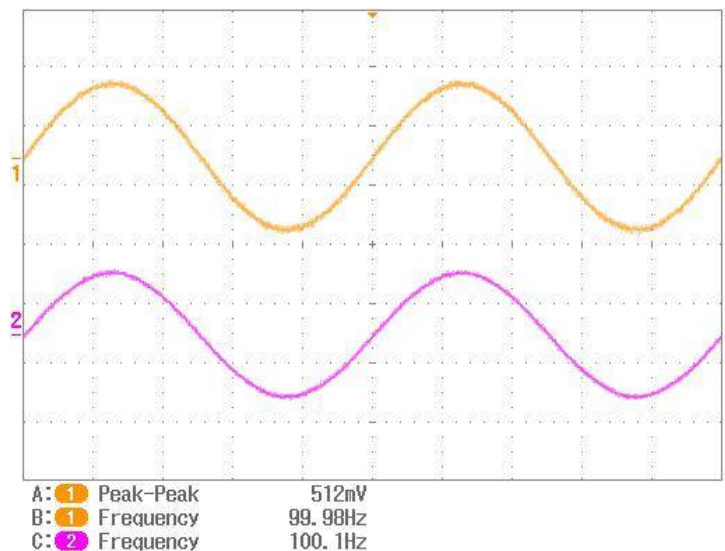Fig 8. Entire DSB-SC Modulation and Demodulation on a Same Module

A:	●	Peak-Peak	512mV
B:	●	Frequency	99.98Hz
C:	●	Frequency	100.1Hz

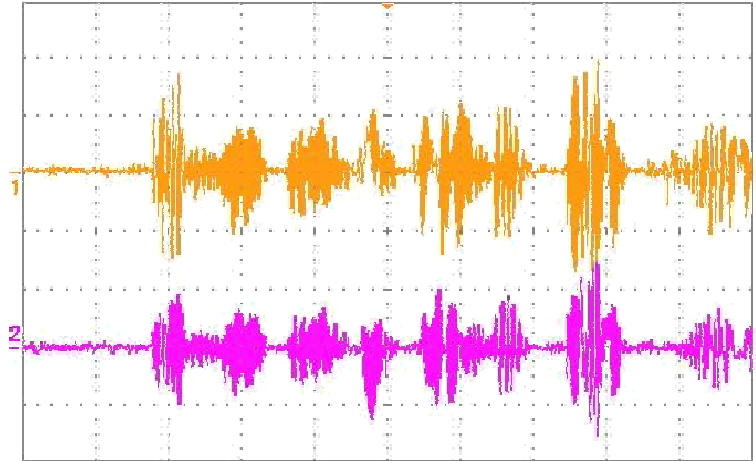Fig 9. Output Results of DSB-SC Modulation on the FPGA (1) Input Signal (2) Output Signal

Fig 10. Output Results of DSB-SC Modulation on the FPGA (1) Input Audio Signal
(2) Output Audio Signal

In the next configuration, entire AM modulation and demodulation is implemented within a same module which is shown in Figure 11.
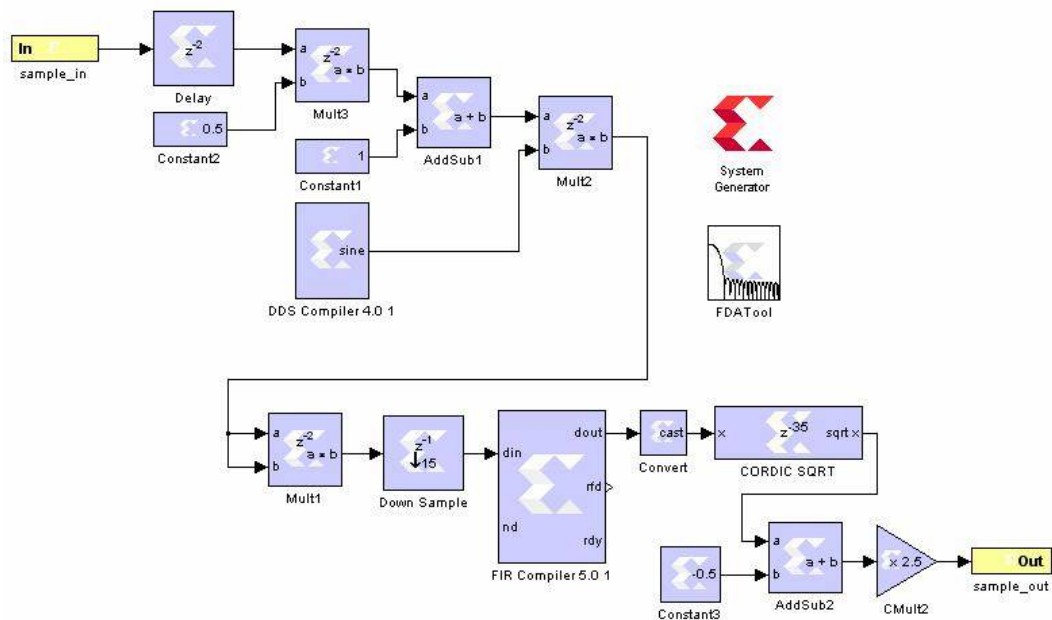

Fig 11. Entire AM Modulation and Demodulation on a Same RP

In this figure, the FIR Compiler 5.0 and Xilinx FDAtool are used to remove higher frequency components of the recovered signal [8]. The output result of this modulation process is illustrated in Figure 12. Again, the signal in the upper portion of this figure represents the input sine signal which is generated from Simulink and lower signal shows the recovered signal after demodulation process. The carrier frequency is generated within System Generator. Also, this configuration was tested with an audio signal input and the output signal was captured on the oscilloscope which is shown in Figure 13. The results of these measurements are similar to the simulation results of Simulink and System generator in previous chapter.

In the following step, a DSB-SC modulated signal is generated within Simulink and transmitted to the FPGA through a wire connection [9]. The FPGA now works as a DSB-SC demodulator (radio receiver). The implementation of this demodulation is illustrated in Figure 14. The output result of this demodulation process is shown in Figure 15.
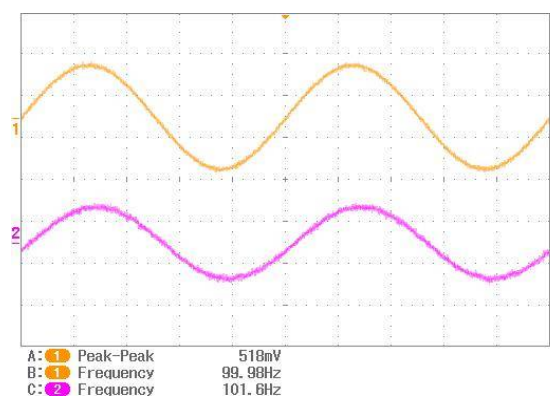

Fig 12. Output Result of AM Modulation on the FPGA (1) Input Signal (2) Output Signal
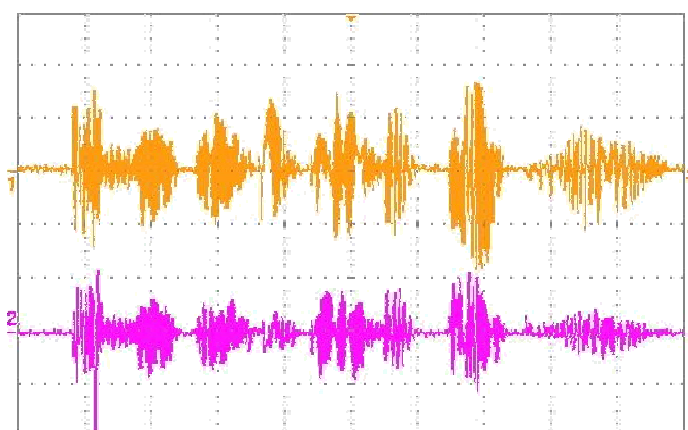

Fig 13. Output Result of AM Modulation on the FPGA (1) Input Signal (2) Output Signal

Since, the Simulink (Computer) clock frequency and FPGA clock are not well synchronized in this configuration the modulation and recovering of the signal did not occur at the exact desired frequency. In addition, this configuration was tested with a modulated audio signal input and the output signal was viewed on the oscilloscope which is illustrated in Figure 16.
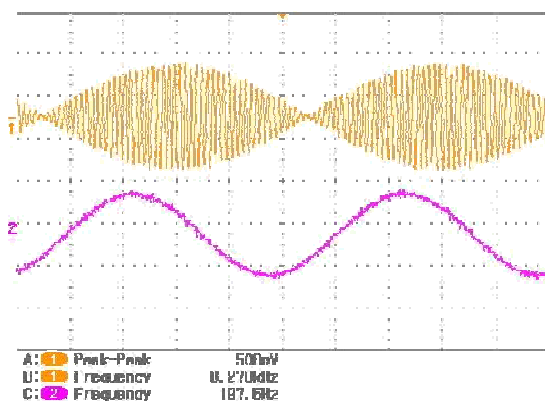
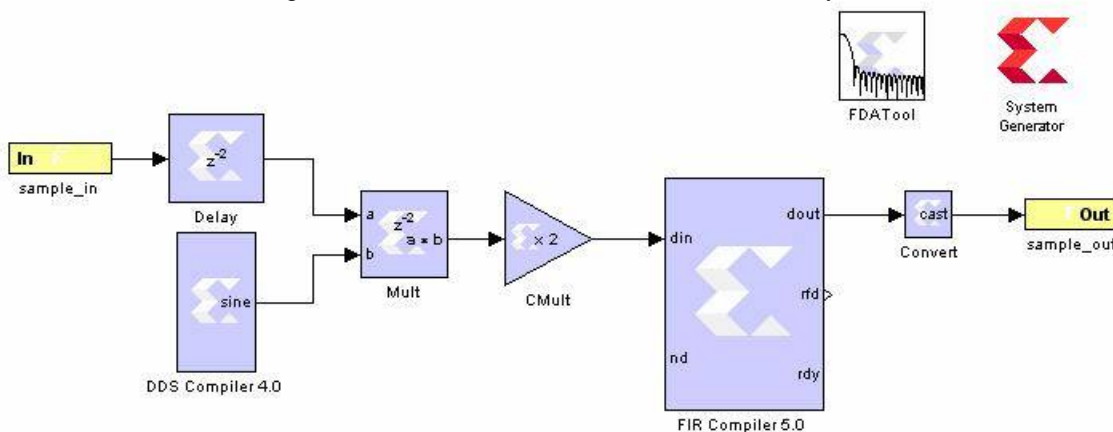Fig 14. DSB-SC Demodulator (Radio Receiver) in System Generator

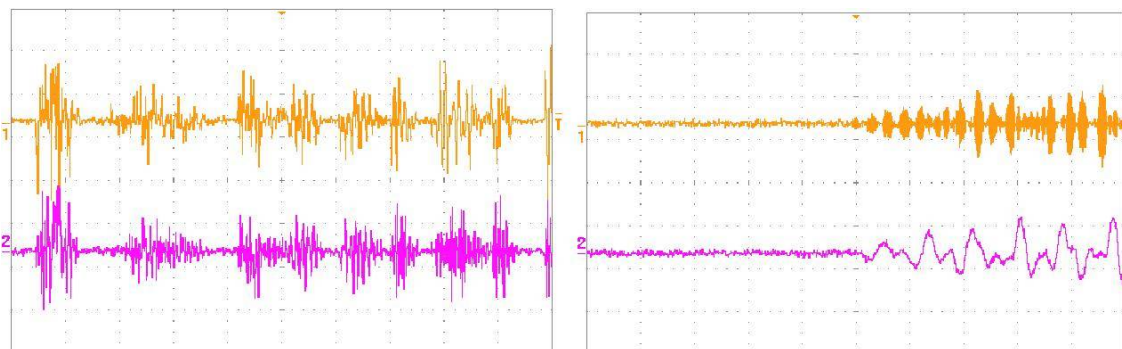Fig 15. Output Result of DSB-SC Demodulation on the FPGA (1) Input Signal (2) Output Signal

Fig 16. Output Result of DSB-SC Demodulation on the FPGA (1) Input Audio Signal
(2) Output Audio Signal

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