REAL TIME AUDIO SIGNAL PROCESSING THROUGH DSB-SC USING SIMULINK

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***ABSTRACT*: This research work explicates the various simulation results using Simulink and System Generator. Initially the most important analog modulation techniques which is DSB-SC modulation technique is elucidated. Afterwards this modulation technique is 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.**

***Keywords*: Simulink, System Generator, simulation results and DSB-SC modulation.**

I. Introduction:

Communication system can transmit and receive analog or digital signals. Analog modulation can be characterized as Amplitude Modulation (AM), Frequency Modulation (FM), or Phase Modulation (PM). In these modulations the information or baseband signal will be attached to corresponding properties of carrier signal, for example in AM modulation the information is attached to the carrier amplitude [1]. This section covers two modulation schemes. These modulations are AM and DSB-SC modulations. First, AM modulation is discussed then looked into DSB-SC modulation.

II. AM modulation:

In order to analyze AM modulation first a message m(t) and a carrier wave c(t) are defined. These waves are illustrated in Equation 1. In this equation, A_m is m message signal amplitude, A_c is carrier signal amplitude, f_m is message signal frequency, and f_c is carrier signal frequency.

$m(t) = A_m \cos(2\pi f_m t)$, …… (1)

$c(t) = A_c \cos(2\pi f_c t)$

Now the AM modulated wave s (t) is defined by

$s(t) = A_c [1 + k_a m(t)]\cos(2\pi f_c t)$ …... (2)

In equation 2 the k_a is called the amplitude sensitivity. In order to detect envelope of modulated wave s (t) properly and avoid envelope distortion the amplitude of $k_a m(t)$ should be less than one. Demodulation of the AM modulated wave is done by envelope detection method. This method of the demodulation recovers the baseband signal by removing half of the envelope, and after this process uses a low-pass filter to remove high frequency components of the recovered signal. AM modulation was one the first modulations that was developed but it is still used in standard AM frequency spectrum from 535 to 1605 kHz [2]. Next, the AM modulation and demodulation is constructed and analyzed.

III. DSB-SC modulation:

Next, the characteristic of the Double SideBand-Suppressed Carrier (DSB-SC) modulation is discussed. The DSB-SC has an advantage of simple modulation which is multiplying the message signal and carrier signal directly. However, it required a much more complex demodulator circuit. In addition, this modulation reaches to zero when the message signal is turned off [3]. In this section only coherent detection or synchronous demodulation method is discussed, which assumed that local oscillator is synchronized with AM modulated signal. This method also can be implemented on FPGAs since both modulator and demodulator partitions use the same clock [4].

IV. Simulation within Matlab / Simulink

In this section, coherent detection was built and simulated in Simulink. Similarly, several methods for modulation and demodulation process were considered and simulated within Simulink. Figure 1 illustrates these DSB-SC modulations and demodulations within Simulink. In the same way, observed the simulation results of these blocks with sine wave inputs[5].

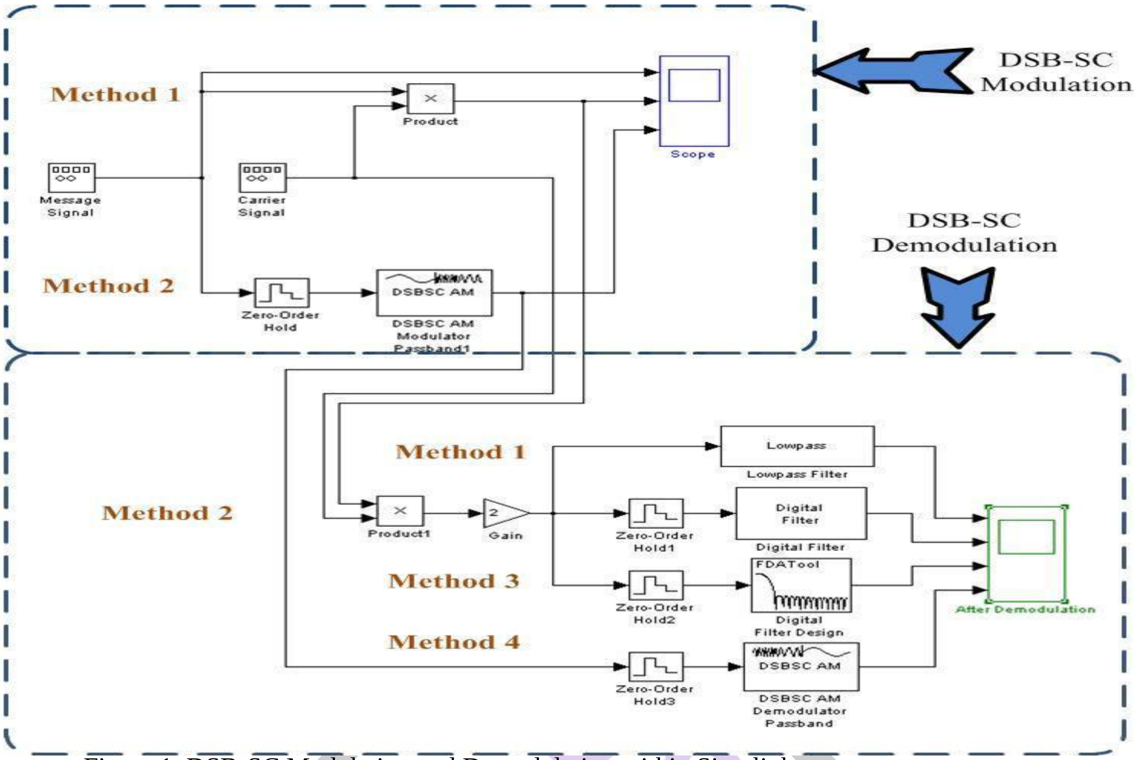

Figure 1. DSB-SC Modulation and Demodulation within Simulink

Figure 2 shows simulation results of input sine wave on the top, the DSB-SC modulation Method 1 in the middle, and the DSB-SC modulation Method 2 on the bottom. Figure 15 shows the demodulation result for the methods 1 through 4. In addition, this figure shows that using each method will lead to a similar result.

Simulation results from Simulink are shown in Figure 3. In Figure 3 the input sine signal is shown on the top, the modulation Method 1 is illustrated in the middle, and the modulation Method is shown on the bottom.

(a)

(b)

(c)

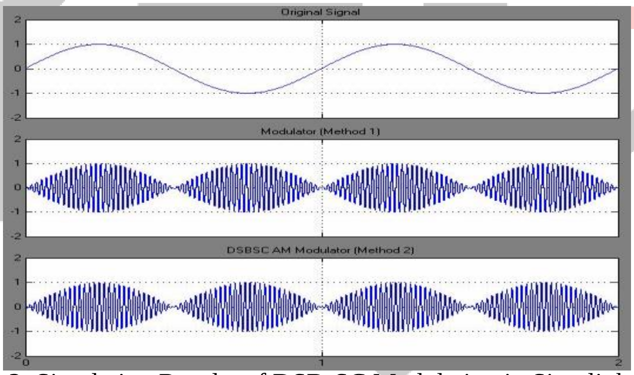

Figure 2. Simulation Results of DSB-SC Modulation in Simulink (a) Input Sine Signal
(b) Method 1 Modulation (c) Method 2 Modulation

(a)

(b)

(c)

(d)

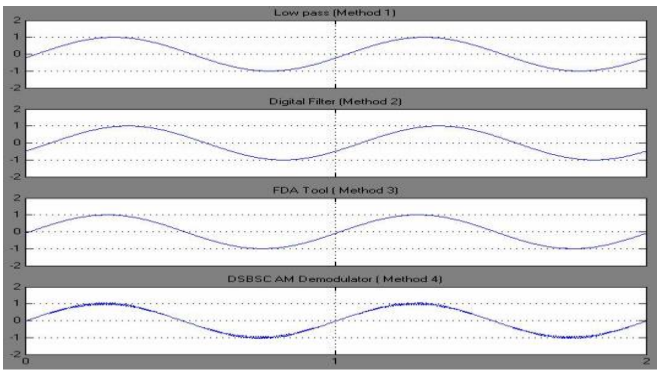

Figure 3. Simulation Results of DSB-SC Modulation in Simulink (a) Method 1 Demodulation (b) Method 2 Demodulation (c) Method 3 Demodulation (d) Method 4 Demodulation

Similarly, the selected modulation and demodulation methods analyzed with the same sample input audio signal by comparing differences between original audio, modulated, and demodulated signals. Figure 4 illustrates the representation of this DSB-SC modulation and demodulation in Simulink.

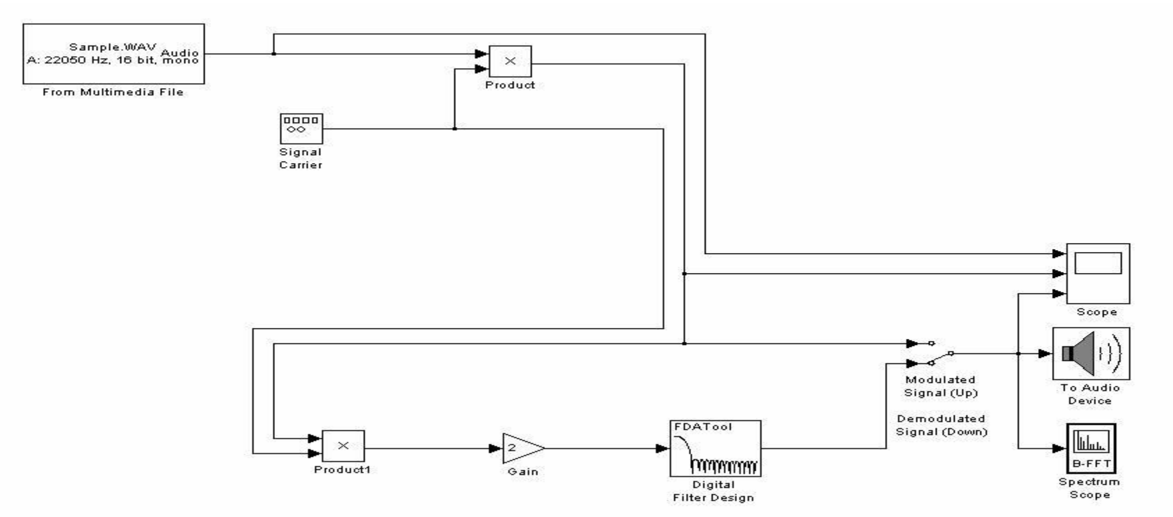

Figure 4. DSB-SC Modulation and Demodulation of an Audio Signal in Simulink

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Figure 5 again illustrates the comparison of this sample audio signal with its demodulated signal in a time domain. The results show that original signal was recovered after demodulation process. Figure 6 illustrates the similar comparison of this sample audio signal with its modulated signal in frequency domain.

(a)

(c)

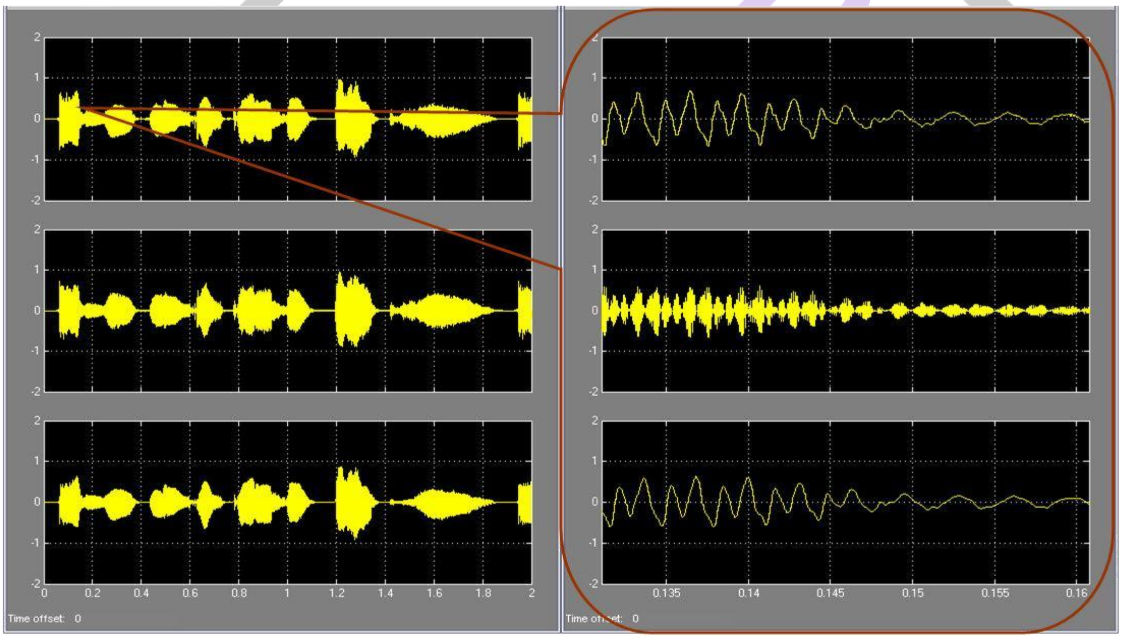
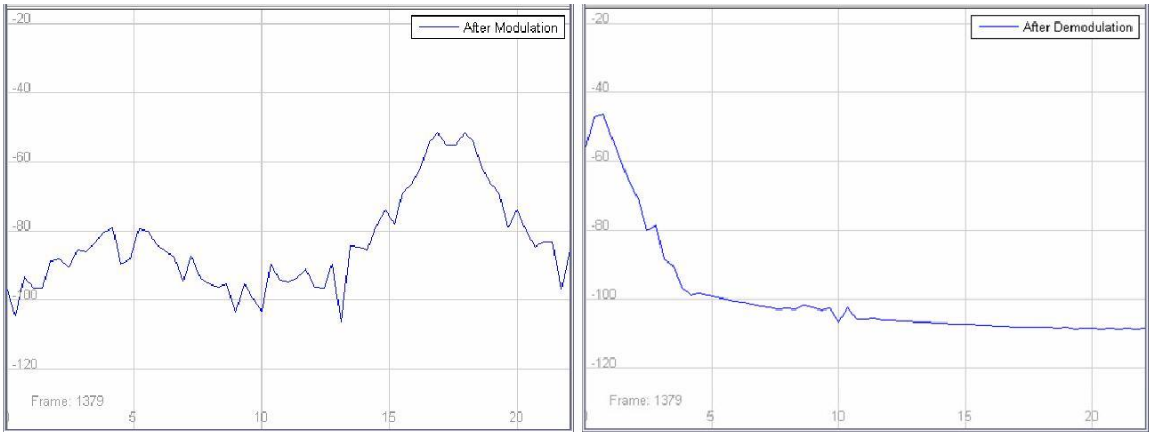


Figure 5. Simulation Results of DSB-SC Modulation of an Audio Signal in Simulink (a) Input Audio Signal (b) Audio Signal after Modulation (c) Recovered Audio Signal after Demodulation



a) (b)

Figure 6. Frequency Spectrum of an Audio Signal after Modulation (a) and Demodulation (b) for DSB-SC

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