

# Performance Analysis of SDR(System Defined Radio) in Analog and Digital System Using Matlab Implementation

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**Abstract - Software Defined Radio (SDR) is a hot topic of wireless communication research in recent years. The idea of SDR is to use ultra-high speed sampling and ADC/DAC modules directly measure the received radio signal and decode whatever it contains. The aim of this project is to study and understand SDR using MATLAB in audio frequency band. In this work, both analog and digital modulation and demodulation methods are studied. Two Matlab sessions are set for sender and receiver respectively in Windows 7. A simulation of signal modulation and demodulation can be presented clearly just with Matlab.**

**Keywords - SDR, Radio, Analog, Digital, Matlab.**

## I. INTRODUCTION

Traditional radio communication systems need a lot of hardware components such as demodulator, detector, filter, etc. which makes the platform cost very high for undergraduate level study and research. But the Laboratory exercises and studies on that aspect are necessary for related teachers and students.

Software Defined Radio (SDR) makes it possible to implement the radio communication process simply with software. Comparing to the traditional radio communication systems, SDR omits all the hardware and replaces them by pure software. This solution also gives a great advantage in flexibility because a SDR receiver is able to decode all the signals.

However, the devices like A/D convertor, powerful signal processor still cost too much for undergraduate level studies, some modifications have been done to adjust the SDR to be suitable for students to use; it's what this project does. The frequencies used in this communication system are limited into audio band, and so it can be handled by a normal sound card. Thus the system can be constructed with simple facilities. With this system students even can study radio communication system at home only with a computer installed Matlab.

The project will employ one desktop PC with MATLAB installed and simulates the radio communication process. Two Matlab sessions are executed at the same time, one as transmitter, and the other as receiver. When the project works, the signal is produced in transmitter and transmitted as sound after modulated. Then the receiver will receive the signal by recording it. The information can be obtained after demodulation. There are five modulation methods studied in this project. The modulation and demodulation processes are designed according to the related theory.

## II. MATLAB IMPLEMENTATION

*General Structure of System:*

A realistic SDR implementation should have some equipment, such as high speed A/D convertor, powerful signal processor. That equipment makes the platform too expensive for us students to study radio communication. To solve this problem Matlab is used in this project and the radio signal's frequency is limited in audio band.



Figure 1 Schematic diagram of radio communication system

When set up transmitter and receiver two Matlab sessions are used; one works as transmitter and the other as receiver. All the modulation and demodulation works are completed with Matlab programming. When use this system the user just needs to choose the modulation and demodulation method and corresponding parameters.

There are two ways to transmit the signal; one is over the air to simulate radio communication, and the other is using a cable. The first one is major studied. Figure 12 shows the basic structure of this radio communication system.

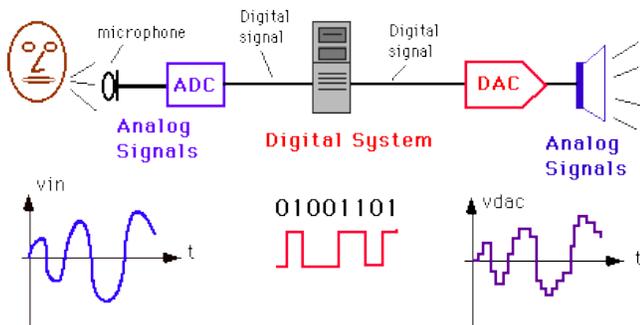


Figure 2 Model of radio communication system

Figure 1 and Figure 2 show the radio communication system exactly. It can be seen that just one laptop installed Matlab 2011Rb is enough to study the process of radio communication. Transmitting signal with cable has also been tested. It uses the same transmitter and receiver, but the signal is transmitted by the cable.

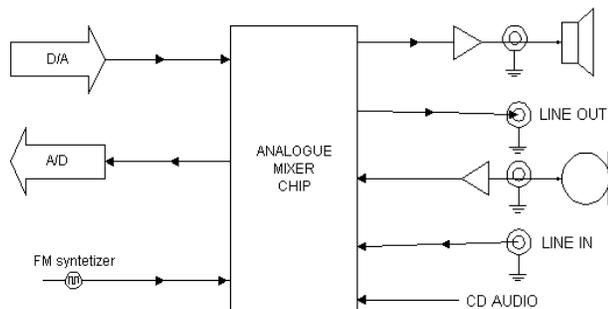


Figure 3 Block diagram of a normal communication system

Figure 3 shows the basic structure of a normal communication system simulated by the Matlab. One extra sound card is needed to offer “line in” and “line out” interfaces. One cable is also needed to transmit signal.

### III. RESULTS AND ANALYSIS

Three windows are designed using Matlab guide for proper analysis of modulation techniques. There is one window for analog modulation, one for digital modulation and one window is common for demodulation of both types – analog and digital. Figure 15 shows the Analog Modulation GUI. In this GUI, carrier, signal, analog modulation parameters and other parameters like time axis for signal, carrier etc can be set. After setting these parameters waveforms of signal, carrier and modulated waveforms can be generated. Also the sound generation can be done using sound pushbutton

designed separately for AM and FM. These parameters must be same in both two GUIs, or the result will be wrong.

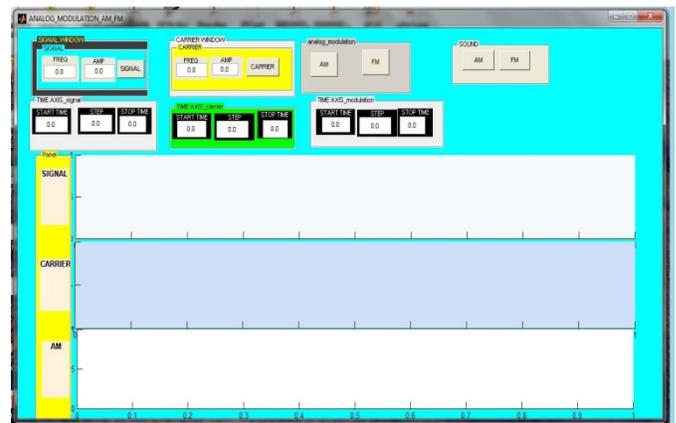


Figure 4 Analog Modulation GUI

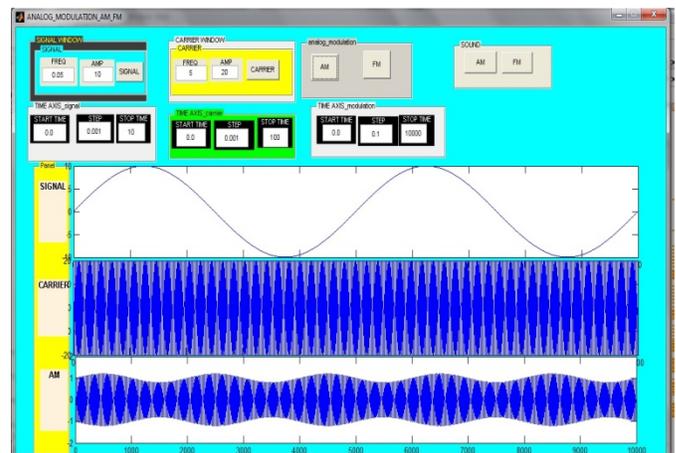


Figure 5 GUI with Amplitude Modulation

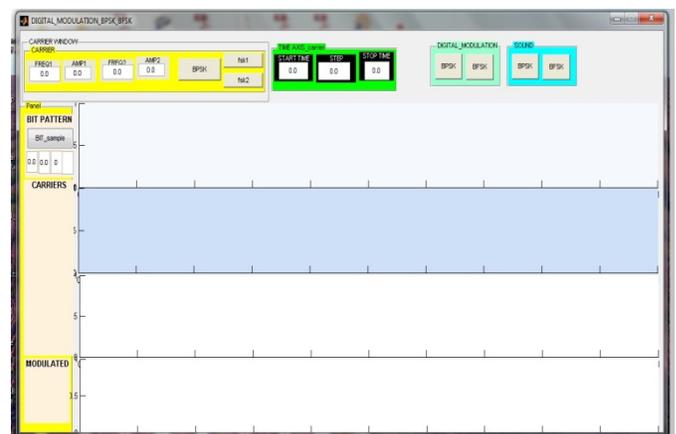


FIGURE : 6 Digital Modulation GUI

Figure 8 shows the Digital Modulation GUI. In this GUI, bit pattern can be set and varied to generate digitally modulated waveforms for different BIT patterns. Also carrier, signal, digital modulation parameters and other parameters like time axis for signal, carrier etc can be set. After setting this

parameters waveforms of signal, carrier and modulated waveforms can be generated. In addition, the sound generation can be done using sound pushbutton designed separately for BPSK and BFSK. These parameters must be same in both two GUIs, or the result will be wrong.



Figure 7 Demodulation GUI

Figure 7 show the Analog Modulation GUI. In this GUI, carrier, signal, analog modulation parameters and other parameters like time axis for signal, carrier etc can be set. After setting this parameters waveforms of signal, carrier and modulated waveforms can be generated. Also the sound generation can be done using sound pushbutton designed separately for AM and FM. These parameters must be same in both two GUIs, or the result will be wrong.

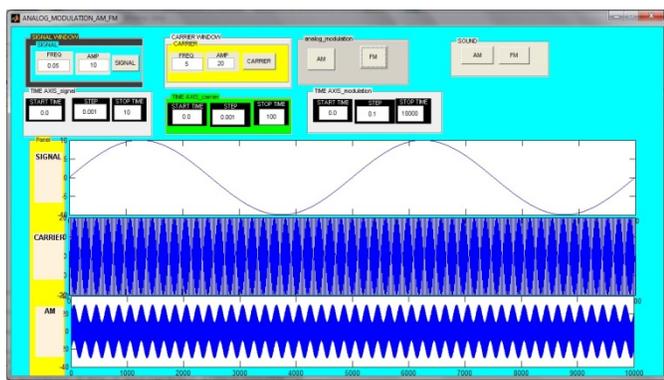


Figure 8 FM MODULATION GUI

However, it's still better to eliminate the amplitude variation in Figure 9, but it's difficult in this system. Many methods have been tried to handle this problem, for example adjust the value of frequency or the modulation index. Those methods don't work. It has also been tried to lower the amplitude of the transmitted FM signal for we guess maybe the sound card in laptop cannot handle that signal strength. But it still fails. At last, we find that maybe it's because the attributes of the laptop's speaker and microphone. There are other filters or amplifiers in those two equipments which

may change the signal a lot. If another better sound card is installed in the laptop the results can be improved.

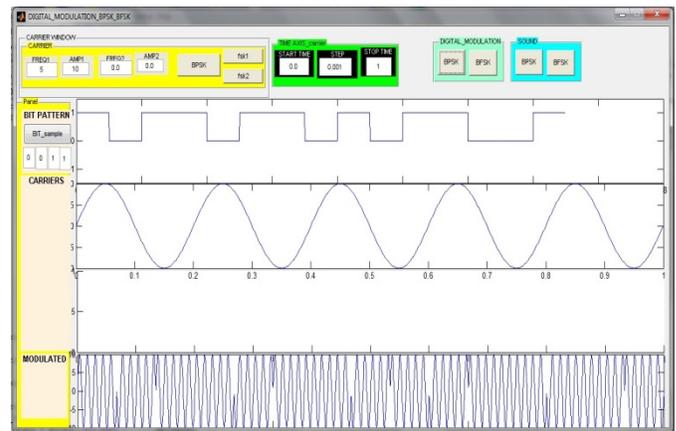


Figure 9 BPSK MODULATION GUI

#### IV. CONCLUSION

From this paper it can be known that phase modulation method is more difficult than frequency modulation method for the receiver has to know the phase it should receive. While in receiver the non-coherent demodulation method is usually used for it doesn't care what the suitable carrier signal is. And the non-coherent demodulation is also easier to be implemented with the circuits.

Through the construction process of this system, the modulation methods can be studied more than the class in which only the theory part is known. What's more, the equipment is simple and easy. To do this practice only one laptop installed with Matlab is enough. Thus this system is suitable for students to study radio communication by themselves. It is also can be a lab for students to enhance the understanding of concept of modulation and demodulation. This system is deserved to be studied.

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