Implementation of M-ary Phase Shift Keying (PSK) Baseband Modem on Texas Digital Signal Processor TMS320C6713

Suul Nufus Bt Ramlan
Faculty of Electrical Engineering
Universiti Teknologi MARA Malaysia
40450 Shah Alam, Selangor, Malaysia
e-mail: suulnufus@yahoo.com

Abstract— **This paper presents the implementation of Phase Shift Keying (PSK) baseband modem on Digital Signal Processor (DSP). Different level of PSK modulation schemes are being used which are 16-psk, 32-psk, 64-psk, 128-psk and 256-psk. MATLAB simulink software is used in this project to simulate the system. The system model consists of modulator, demodulator, noise channel and channel coding. Noise channel that is used in the system is Addittive White Gaussian Noise (AWGN). After the simulation, Matlab file is created. The purpose of creating Matlab file is to get the Bit Error Rate (BER) graph for all 6 level of modulation scheme. Then, the system is implemented on the DSP TMS320C6713 board. From the simulation, the result that is obtained is constellation point for all M-ary PSK before and after adding channel coding and AWGN. The BER graph that is obtained also follows the theory.**

Keywords-Phase Shift Keying (PSK); Additive White Gaussian Noise(AWGN); Channel coding; Bit Error Rate(BER)

I. INTRODUCTION

"Baseband" can mean basically one of three things. The first two describe telecommunication systems that carry a single unmultiplexed signal channel on the transmission medium, either in digital or analog form. This also pertains to baseband networks such as Ethernet and Token Ring local area networks. The third definition of baseband refers to any band on which information is superimposed regardless of whether the band is multiplexed and sent on subbands[1]. Baseband sends only one signal at a time, as opposed to broadband, which can carry several channels at once. Baseband systems will transmit baseband signal. Baseband modem is a digital modem that may be used to inter-connect computers, terminals, controllers and similar digital equipment over distances of up to 16km for LAN interconnection, campus networking or high speed leased line internet links, over a single, un-conditioned twisted copper pair (two wires).

There are many research regarding M-ary PSK simulation and performance[2]. Unfortunately, the problems that lead to this project is because there is no extensive research about the implementation of the M-ary PSK baseband modem.

The objective of this project is to simulate the baseband modem system model in the Matlab program and implement it in digital signal processing board. By doing this project, the cost to buy the baseband modem can be reduced and more knowledge about the baseband modem can be obtained.

The structure of this paper is began with section I which an introduction of baseband modem. Section II shows the structure of the modulation system. Section III is about the modulation scheme that is used. Methodology part is discussed in section IV. Result and discussion is shown in section V. Lastly, conclusion and recommendation is discussed in section VI and VII.

II. STRUCTURE OF MODULATION SYSTEM

Modem includes modulator and demodulator is a key component in the data communication system. Modulator converts a baseband signal to a passband counterpart. The inverse of modulation is demodulator, with the goal being to extract the original baseband signal with minimum noise and distortion [3].

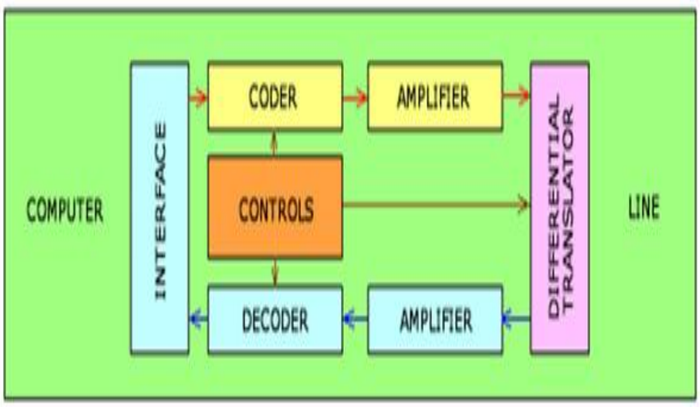

Figure 1. Block diagram of baseband data modem

Baseband refers to any band on which information is superimposed regardless of whether the band is multiplexed and sent on sub bands. It only sends one signal at a time different from broadband that can carry several channels at once. Baseband modems offer greater distances than line drivers but are more complex and expensive and it uses digital signaling technologies.

Because digital information cannot be transported directly over analog transmission media, the primary purpose of a data communications modem is to interface computers, computer networks and other digital terminal equipment to analog communications facilities. In the transmitter (modulation) section of a modem, digital signals are encoded onto an analog carrier. The digital signals modulate the carrier, producing digitally modulated analog signals that are capable of being transported through the analog communication media. In the receiver section of a modem, digitally modulated signal are demodulated. Therefore, modem receivers (demodulators) simply extract digital information from digitally modulated analog carriers[4]. Fig. 1 shows the block diagram of a baseband data modem.

III. Modulation Scheme

Nowadays, phase shift keying (PSK) is widely used in the military and communications system. PSK is being used and considered to be efficient for this application because it offers the lowest probability error[5].

Phase-shift keying (PSK) is another form of angle-modulated and constant amplitude digital modulation. With PSK, the input is binary digital signal and there is a limited number of output phases possible. PSK is an M-ary digital modulation scheme similar to conventional phase modulation. The input binary information is encoded into groups of bits before modulating the carrier. In PSK, the number of bits in a group ranges from 1 to 12 or more. The number of output phases are defined by M as described in (1) and determined by n, number of bits in the group[4].

$$M=2^n \qquad (1)$$

The BER of M-ary PSK modulation technique is given by:

$$P(e)=1/[(\log_2 M)]\, erf(z) \qquad (2)$$

where

erf = error function

$z= \sin(\pi/M)\,(\log_2 M)^{1/2}\,(Eb/No)^{1/2}$

IV. Methodology

Block of baseband modem is designed and simulated using the simulink tool in Matlab R2008a software. The model is designed and also simulated using this software. After the simulation, the M file will be created to get the bit error rate (BER) graph.

Fig. 2 shows flow chart for developing and creating the PSK baseband modem. First, basic phase shift keying (PSK) baseband modem is designed using simulink. Then, the model is simulated using the Matlab software. The output of the model is observed. The bit error rate (BER) and total error must equal to zero in order to proceed to the next step. When the desired output is obtained, channel coding and AWGN are added to the model. Then the bit error rate (BER) and total error is more collected. After that, M file is created to get the bit error rate (BER) graph. Finally, the simulink model is implemented in the Digital Signal Processing (DSP) TMS320C6713 board.

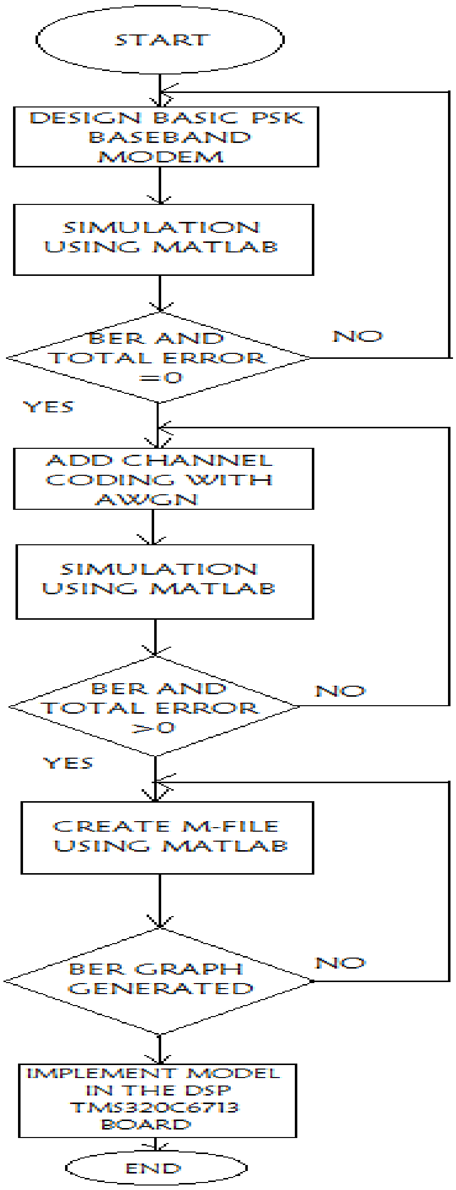

Figure 2. Flow chart for creating and developing M-ary PSK baseband modem

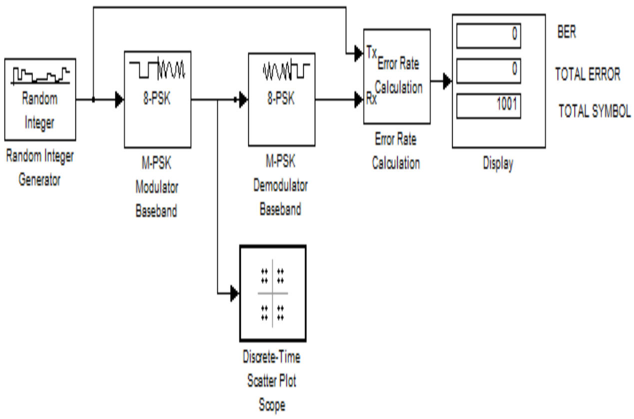

Figure 3. System model for 8-psk before AWGN is inserted

Fig. 3 shows a system model for 8-psk before AWGN is inserted. This model is created to check the total error and bit error rate is equal to zero. If there is a value, so its mean the model is wrong and the parameter of each block of the model need to be change. The model is designed for all M-ary PSK starting from 8-psk, 16-psk, 32-psk, 64-psk, 128-psk and 256-psk.

Fig. 4 shows the model when the noise channel is added. The noise channel that is being used in this model is Additive white gaussian noise (AWGN). Channel coding (convolutional encoder and viterbi decoder) block also is added to the model.

AWGN is a noise that is produced by combining sounds of all different frequencies together. Function of channel coding is to reduce information rate through the channel and increase the reliability. The channel coding that is being used in this system is convolutional encoder and viterbi decoder. The constraint length, k that is being used in the viterbi decoder is 7.

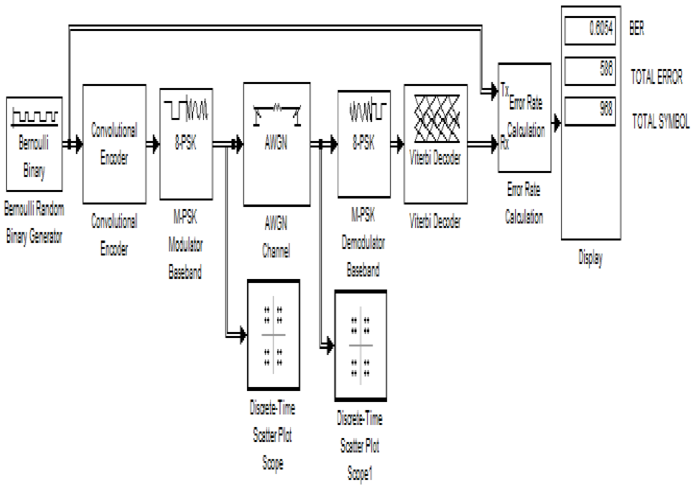

Figure 4. System for 8-psk with AWGN and channel coding

Table I shows the type and function of each block that is used in this model. The convolutional encoder and viterbi decoder is used to encode and decode binary data. Both of this block used poly2trellis function to create a trellis using constraint length and code generator. Constraint length 7 and code generator 171 and 133 is used in this model. The poly2trellis function accepts a polynomial description of a convolutional encoder and returns the corresponding trellis structure description[6].

TABLE I. TYPE AND FUNCTION OF EACH BLOCKS IN M-PSK BASEBAND MODEM

Type	Block	Function
Data source	Bernoulli random binary generator	Generate random binary number using a Bernoulli distribution
Channel coding	Convolutional encoder	Encode a sequence of binary input vectors to produce a sequence of binary output vectors
	Viterbi decoder	Decode input symbols to produce binary output symbols
Modulation scheme	M-psk modulator	Modulate using the M-ary phase shift keying method
	M-psk demodulator	Demodulate a signal that is modulated using the M-ary phase shift keying method
Phase noise	AWGN	Add white Gaussian noise to a real or complex input signal
Display	Error rate calculation	Compare input data from a transmitter with input data from a receiver
	Display	Show the value of its input on its icon
	Scope	Display its input with respect to simulation time

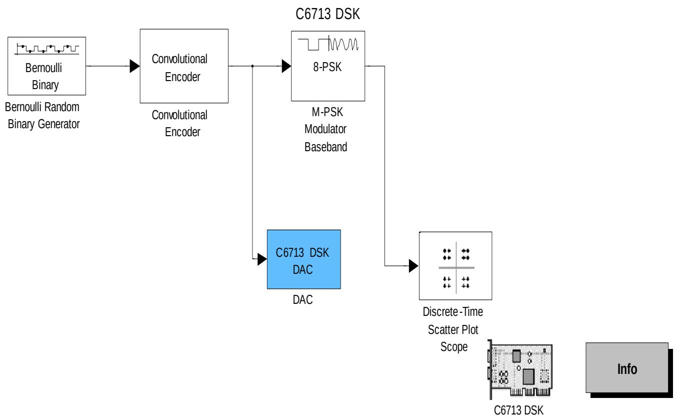

Figure 5. Model to be implement in the DSP TMS320C6713 board

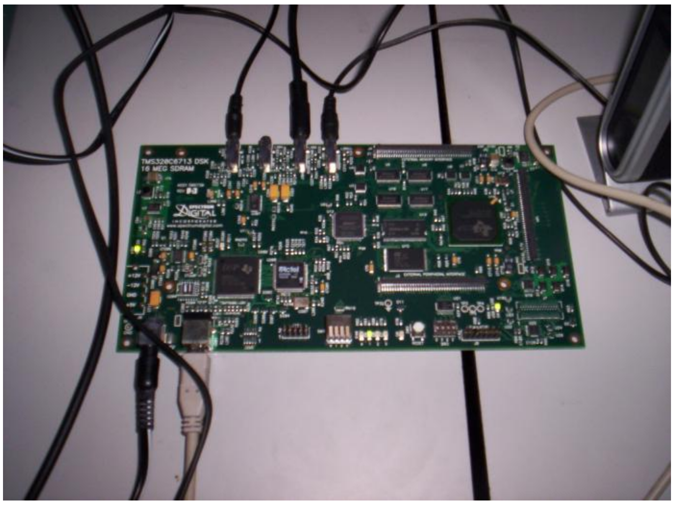

Figure 6. TMS320C6713 Digital Signal Processing Board

Figure 7. Lab setup for implementation on the DSP TMS320C6713 board

Fig. 5 shows the model for the M-psk that is used to implement in the TMS320C6713 DSP board. The simulink model is generated into the Code Composer Studio v3.3 and then it will load into the TMS320C6713 board. Fig. 6 shows the DSP TMS320C6713 board and Fig. 7 shows the DSP board that has been set up with the computer, speaker and oscilloscope.

V. RESULT AND DISCUSSION

From Fig. 3, after the model is simulated using Matlab software, constellation diagram for each PSK is obtained. Constellation diagram is a representation of a signal modulated by digital modulation. Constellation diagram display signal as a two-dimensional scatter diagram in the complex plane at symbol sampling instants.

Fig. 8 shows the constellation points for 8-psk, M=3. It can be seen that the angular separation between any two adjacent phasors is 45°. An 8-psk signal can undergo almost a 22.5° phase shift during transmission[4].

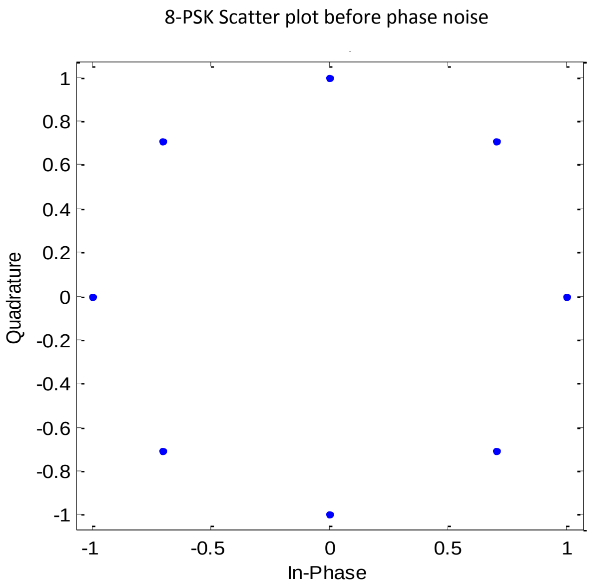

Figure 8. Scatter plot for 8-psk before phase noise

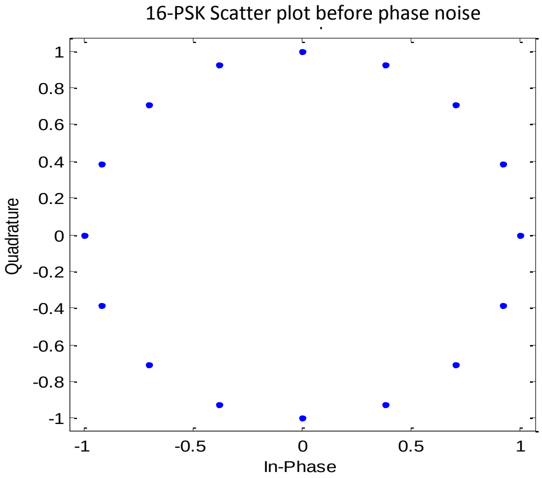

Figure 9. Scatter plot for 16-psk before phase noise

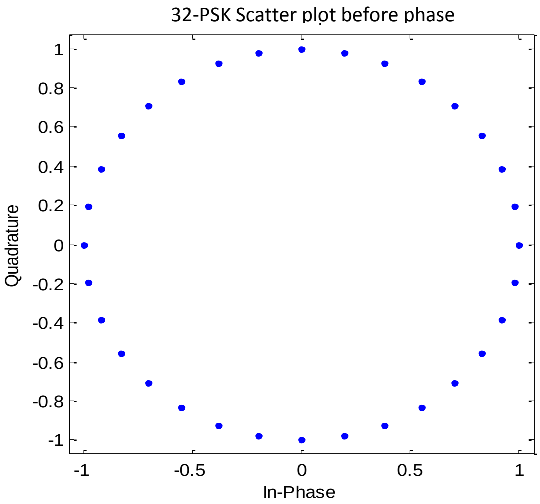

Figure 10. Satter plot for 32-psk before phase noise

Fig. 9 shows the 16-psk encoding technique which has possible 16 different output phases. In 16-psk, the angular separation between adjacent output phases is 22.5°. So, 16-psk can only undergo an 11.25° phase shift during transmission.

Fig. 10 shows constellation points for 32-psk with possible 32 different output phases. In 32-psk, the angular separation between adjacent phases is 11.25°. So, 32-psk can only undergo 5.6° phase shift during the transmission.

In Fig. 11, for an M-ary PSK system with 64 output phases, M=64 and n=6, the angular separation between adjacent phases is 5.6°. 64-psk can only undergo 2.8° phase shift during transmission.

While in Fig. 12 and 13, it shows the constellation diagram for 128-psk and 256-psk. At this point, receivers cannot discern the phase of the received signaling element. When the psk modulation become to higher, the phase impairments have a tendency to shift the phase of the psk signal and it can produced errors.

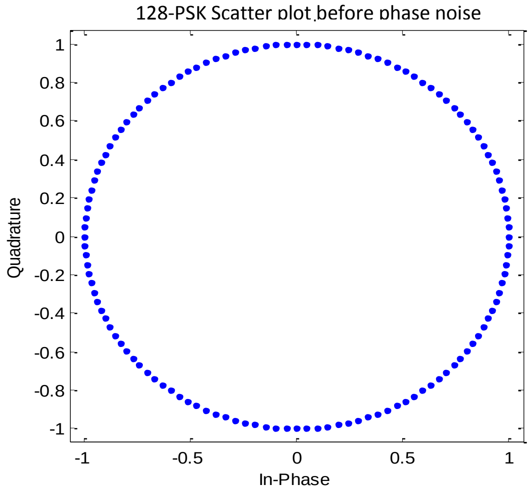

Figure 11. Scatter plot for 64-psk before phase noise

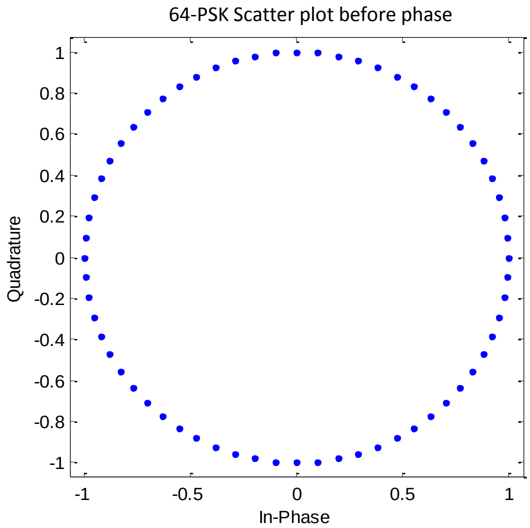

Figure 12. Scatter plot for 128-psk before phase noise

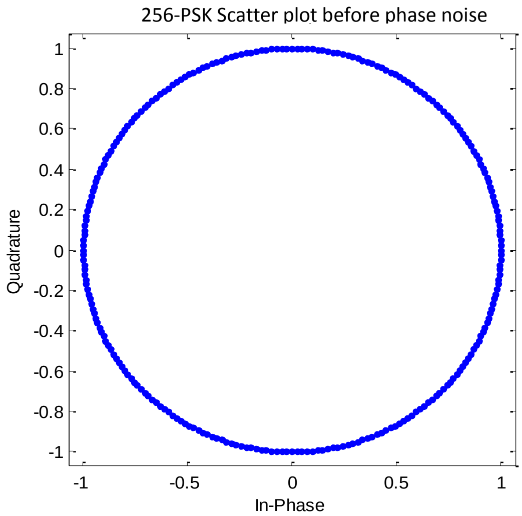

Figure 13. Scatter plot for 256-psk before phase noise

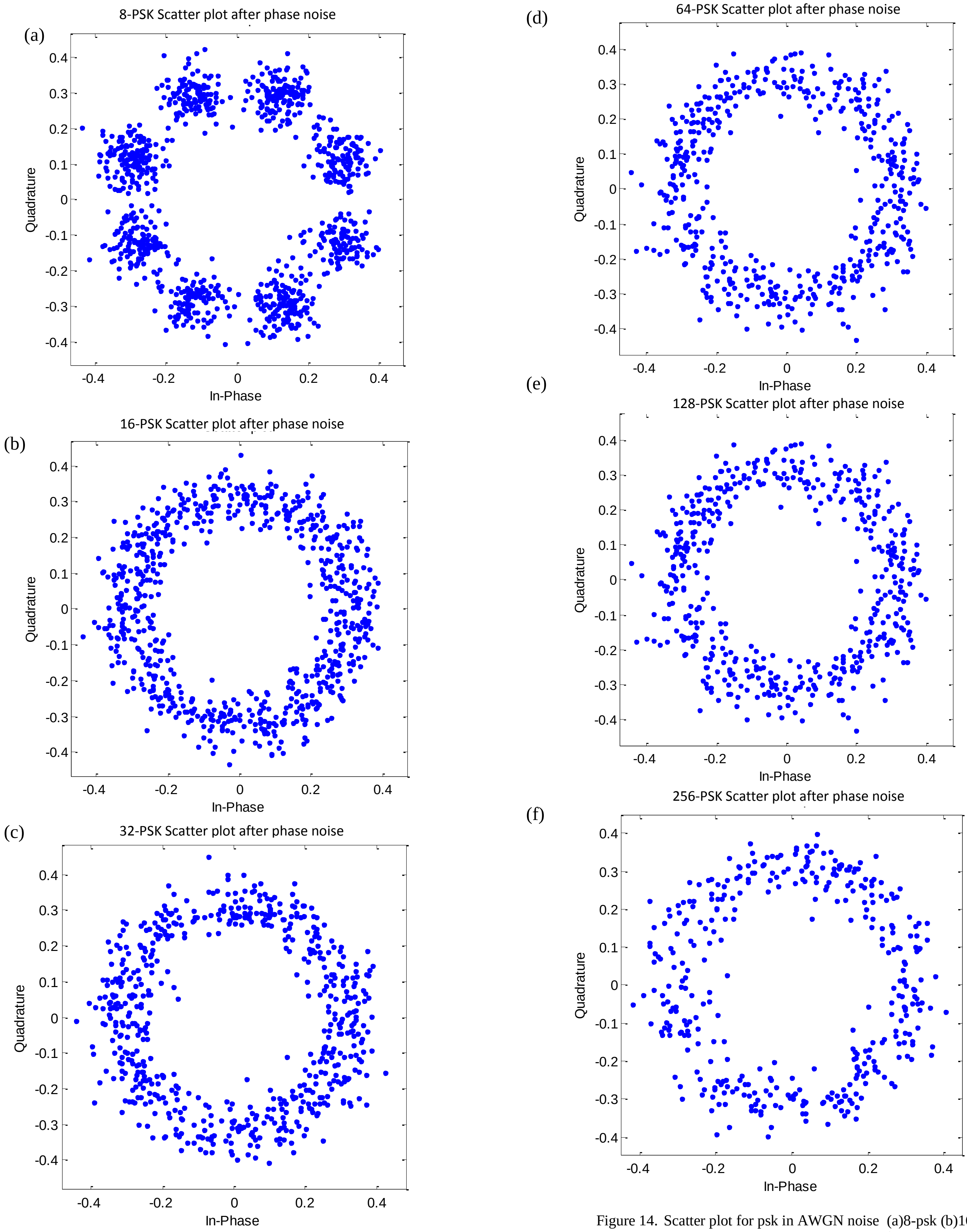

Figure 14. Scatter plot for psk in AWGN noise (a)8-psk (b)16-psk (c)32-psk (d)64-psk (e)128-psk (f)256-psk

Meanwhile in Fig. 4, after AWGN channel is added to the system, there are a bit errors and interference occurred when the model is simulated. From the Fig. 14, it shows that there is noise occurred during the simulation. So, to investigate about the error that occurred at all type of the modulation scheme, the bit error rate (BER) over the energy per bit over noise density ratio (Eb/No) graph is plotted.

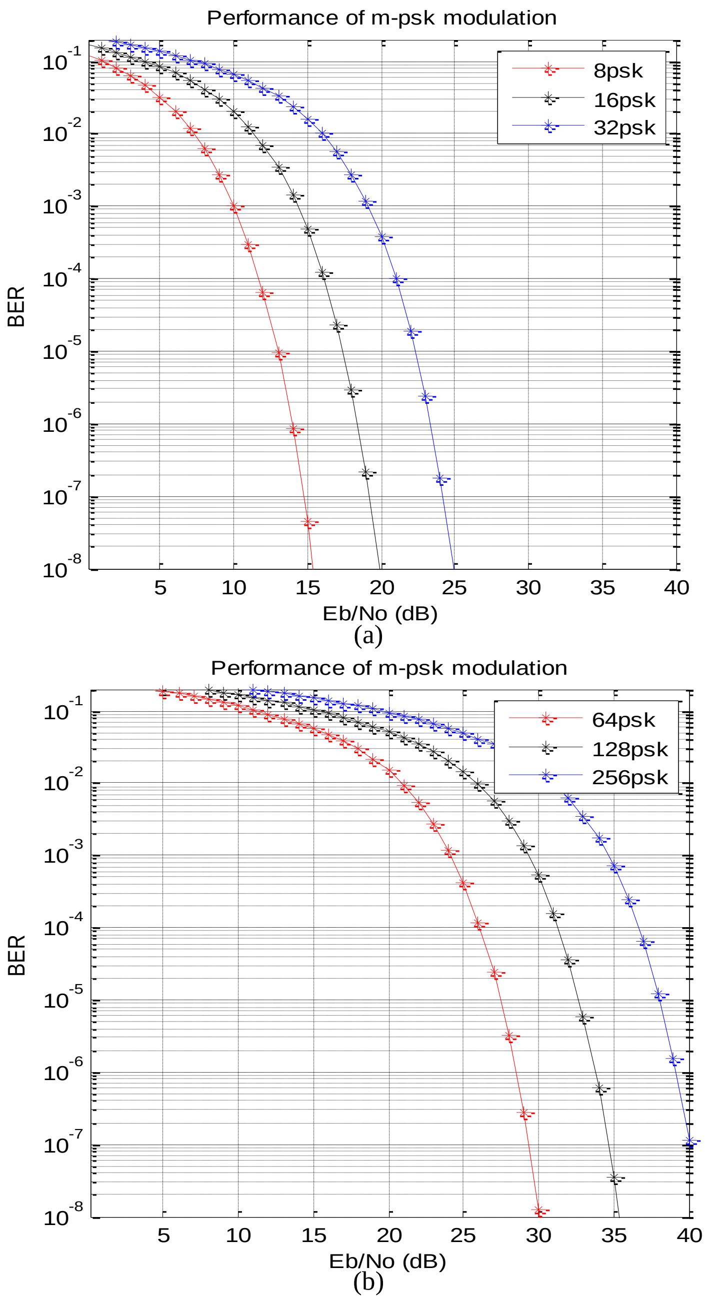

Figure 15. Bit Error Rate Graph (BER) (a) BER for 8-psk, 16-psk and 32-psk (b) BER for 64-psk, 128-psk and 256-psk

From Fig. 15, it shows that when the number of M-ary PSK modulation scheme is increased, the total of probability of error or BER also will be increasing. This is because the higher the levels of modulation, the greater energy per bit to noise power density ratio is required to reduce the effect of the noise interference. Therefore, the higher the level of modulation, the smaller the angular separation between signal points and the smaller the error distance[7].

After the BER graph is obtained, the PSK baseband model is implemented in the DSP TMS320C6713 board. Fig. 16 shows the output for the DSP TMS320C6713 board from oscilloscope. The graph is not exactly the desired output that needs to be obtained because there is some noise occurred. The desired output cannot be obtained because there is no equipment to connect from the DSP board to the oscilloscope.

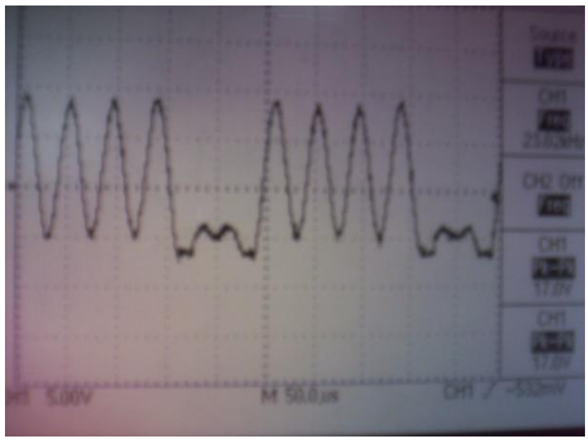

Figure 16. Output for DSP TMS320C6713 board

VI. Conclusion

As a conclusion, from the constellation points, it shows when the level of modulation scheme increase, the angular separation between adjacent phases will be decreases. The BER graph also shows that as the level of modulation scheme increase, the energy per bit to noise power density is higher. Channel coding can be used to reduce the bit error rate. By using Shannon's channel capacity formula, it is found that theoretically the BER will approach zero as long as Eb/No is above -1.59db when optimum (unknown) coding is used on an infinite bandwidth channel[8].

VII. Recommendation

For recommendation, the faculty need to provide sufficient equipment and also always update the version of the software needed so that it will be easier for student to complete the project given to them.

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