

## Design of 4 Bit QPSK and 256 Bit QAM Using MATLAB

Poorva Mishra<sup>1</sup>, Shashank Mane<sup>2</sup>

<sup>1,2</sup>(Electronics and communication, SBITM Betul, RGPV University Bhopal, India)

**Abstract:** With the growing need of communication in our daily life good signal strength is a major issue. For this a signal must be transmitted in such a way that it should have low bit error rate. Here a 4-bit QPSK is compared with 256 bit QAM on the basis of SNR (signal to noise ratio) and BER (bit error rate). BER testing is a powerful tool for testing of digital transmission systems. A BER test shows the performance of the system. If the BER rises too high then the system performance will degrade. Outputs of both the techniques are shown on scatter plots. Result is calculated on the basis of better quality signal and greater efficiency.

**Keywords:** BER, Modulation, NRZ Coder, QAM, QPSK, Signal to noise ratio (SNR).

### I. Introduction

#### 1.1 Quadrature Phase Shift Key

Phase shift key modulation is a technique in which phase of carrier wave is varied in accordance with the modulating signal. QPSK (Quadrature phase shift key) or sometimes called as 4-PSK is a digital modulation technique. Here 4 represents 4 phase (45,135,225,315), in which carrier is send (fig 1). QPSK has 4 possible states i.e. QPSK can encode 2 bit per symbol. It provide phase shift of  $\text{Pi}/2$  ( $90^\circ$ ) multiple times.

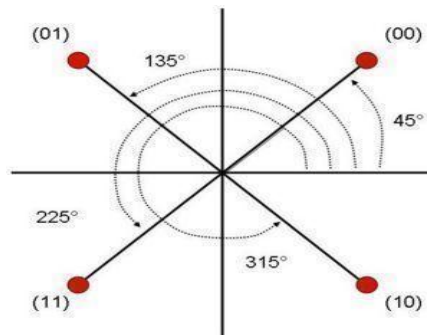


Fig. 1. constellation view of QPSK signal showing 4 possible phase i.e.  $45^\circ$ ,  $135^\circ$ ,  $225^\circ$  and  $315^\circ$ . Each symbol contains 2 bit as shown in above figure.

#### 1.2 Quadrature Amplitude Modulation

Amplitude modulation is a technique in which amplitude of the carrier signal is varied in accordance with the modulating signal. QAM (Quadrature amplitude modulation) is both analog and digital modulation technique. It is called Quadrature because of two carries waves that are out of phase with each other by  $90^\circ$ . Thus after modulation, the signal that we get varies by both amplitude and phase.

### II. Implementaion

#### 2.1 Implementing QPSK Using MATLAB

Firstly an integer generator is used to generate random uniformly distributed integer in the range  $[0, M-1]$ , where  $m$  is the  $M$ -ary number. Output from integer generator gets converted into bit, by integer to bit converter. A demultiplexer convert's single input into multiple outputs. These outputs after NRZ coding with 0.5 constant value along with the two components in-phase and Quadrature-phase are then separately modulated to give scope output (Fig 2). After that, the two signals are added, and the resulting signal obtained is the QPSK signal. Final output can be viewed on a Discrete-time scatter plot. A Discrete-time scatter plot is used to reveal the modulation characteristics, such as pulse shaping or channel distortions of the signal.

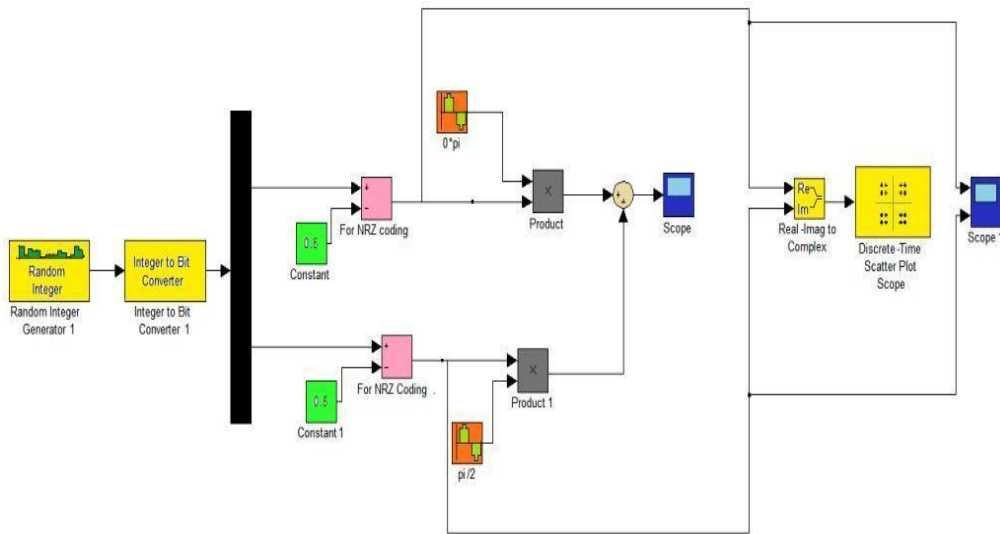


Fig. 2 Implementation Of QPSK Using MATLAB Simulink Showing Various Blocks.

### 2.2 Implementing QAM Using MATLAB

The random bit generator generates uniformly distributed integer in the range (0, M-1) when M is the M-ary number (Fig 3).

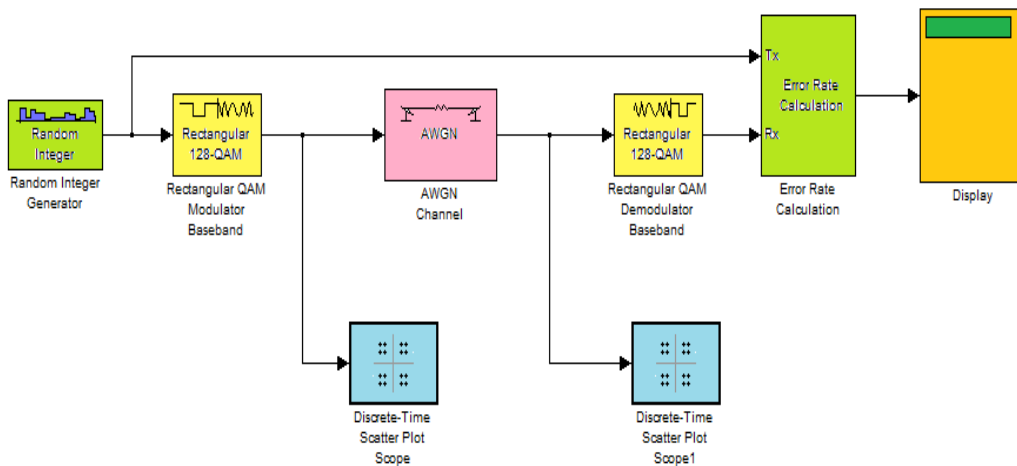


Fig.3 Implementation Of QAM Using MATLAB Simulink. Above Figure Shows Various Blocks Of QAM.

The signal then enters rectangular QAM modulator. It modulates the Input signal using the rectangular QAM method. The AWGN Channel block then adds white Gaussian noise to the modulated signal. The rectangular Demodulator QAM demodulates the input signals. Then an Error rate calculation block compares the received data with delayed of transmitted data. The output has three blocks showing error rate, followed by the number of errors detected & the total number of symbols compared. A discrete time scatter plot shows the result of modulation. Figure 4 shows a QAM model with two scope blocks to view before modulation signal and after modulation signal. Before modulation signal is randomly generated signal with In-phase components (Fig 10) and after modulation both In-phase and quadrature phase components are shown (Fig 11).

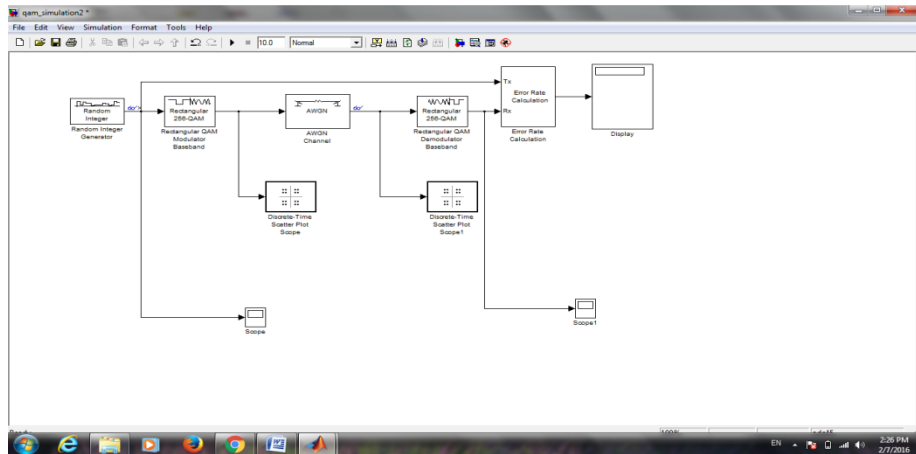


Fig5. Shows Block Diagram Of QAM With Two Scope Blocks To Show The Signals Before Modulation And After Modulation.

### III. Simulation Results

Simulation results of both QPSK and QAM are shown:

#### 3.1 Scatter Plot of QPSK

A Discrete-time scatter plot is used to reveal the modulation characteristics, such as pulse shaping or channel distortions of the signal. (Fig 5) shows discrete plot of QPSK signal. Time scatter plot used to display a modulated signal in its signal space with In-Phase on x-axis versus the Quadrature in y-axis.

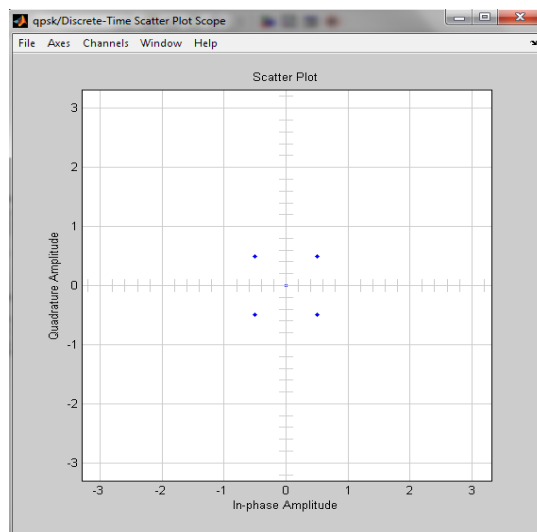


Fig.5 Scatter Plot Of 4 Bit QPSK. Discrete Plot Is Plotted Between Quadrature Amplitude And In-Phase Amplitude As Shown In Figure. 4 Dots Represent 4 Bits Of QPSK Modulation.

#### 3.2 Scope output of QPSK

Scope output defines the Quadrature phase shift keying output which is generated by the additive of product (whose phase is 0radian) & product (whose phase is  $\pi/2$  radian) blocks (Fig 6).

#### 3.3 Scope Output 1 of QPSK

Scope Output provide the two signals coming from two NRZ blocks individually which defines the no. of bits per Integer (fig 7).

#### 3.4 Scatter plot of QAM

Time scatter plot used to display a Transmitted signal constellation in its signal space by plotting the In-Phase component versus the Quadrature component. All 256 bits are divided in four quadrants (Fig 8). Total numbers of points displayed are 1000 and new points per display are 40.

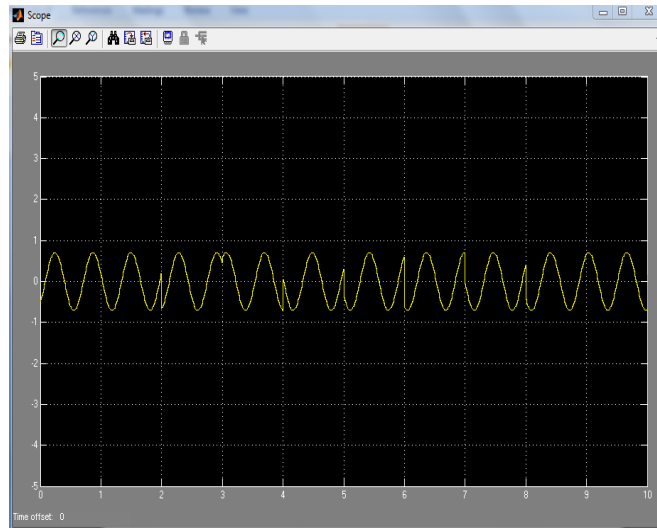


Fig.6 Scope Output Of QPSK Which Is Product Of Two Blocks Whose Phase Is 0 Radian And  $\pi/2$  Respectively With Frequency 10 Rad/Sec And Amplitude 1.

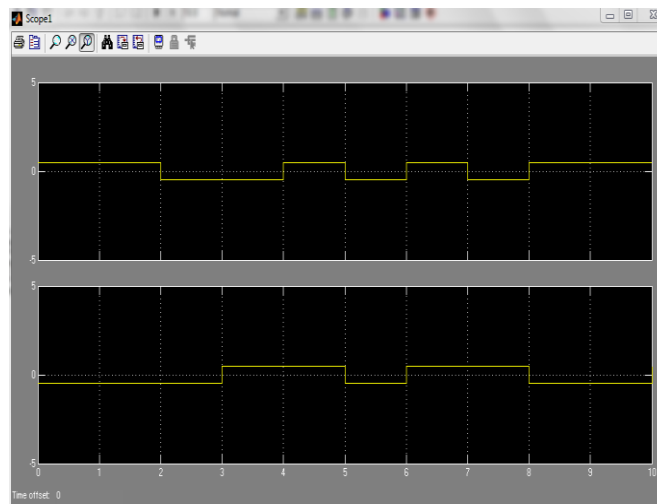


Fig.7 Scope Output 1 Of QPSK Which Shows Two Signals Coming From Two NRZ Blocks.

### 3.5 Signal with AWGN noise of QAM

Discrete Scatter plot 1 displays a modulated signal constellation in its signal space by plotting the in phase component versus the quadrature component with 20db SNR. An AWGN noise (additive white gaussian noise) is added to signal and output of 256 bits along with noise is shown in fig 9.

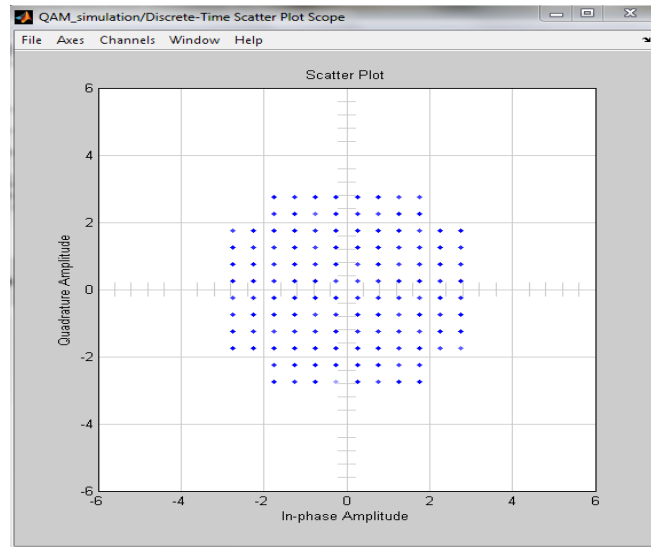


Fig.8 Scatter Plot Of QAM Showing Transmitted Signal Constellation In Its 4 Quadrants. Above Figure Shows All 256 Bits In Its Signal Space With Quadrature Amplitude On X-Axis And In-Phase Amplitude On Y-Axis.

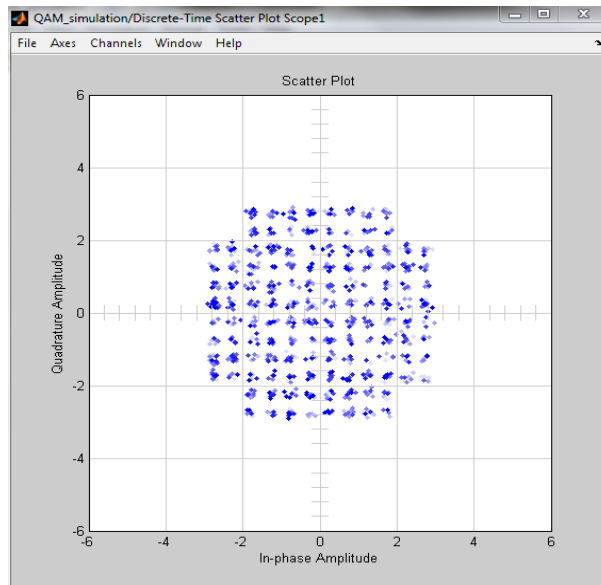


Fig.9 Scatter Plot Of QAM Showing Signal With 20db SNR With AWGN Noise, All 256 Bits Along With AWGN Noise Are Shown In Signal Space.

### 3.6 Before modulation in-phase randomly generated signal

Before modulation signals are randomly generated signals with in-phase components. Total no of lines shown are 256 with  $90^\circ$  phase shift. Eye Diagram is used to show signals clearly. An eye diagram is commonly used to indicate the quality of signals in high-speed digital transmissions (Fig 10).

### 3.7 After modulation in-phase and quadrature-phase generated signal

Eye diagram below shows the after modulation signals. Both in-phase and quadrature-phase components are shown. Total no of lines are 256 (Fig11).

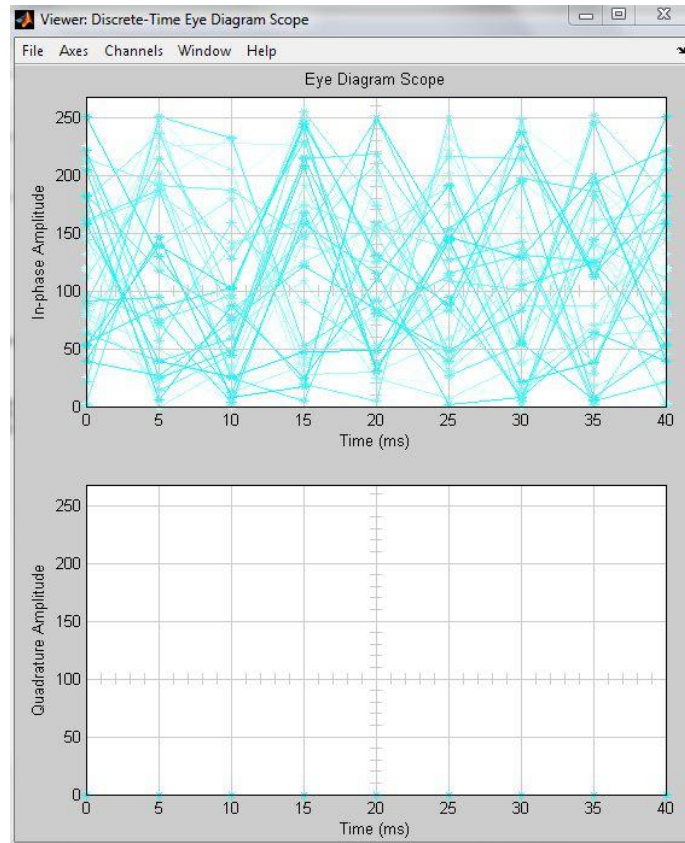


Fig10. Shows Eye Diagram Of Randomly Generated Signals Before Modulation. Total Numbers Of Lines Are 256 With 90° Phase Shift.

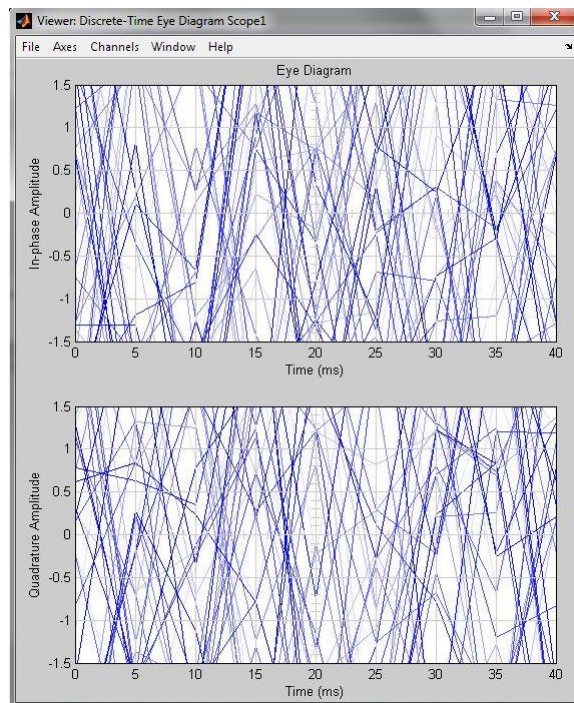


Fig11. Shows Eye Diagram Of After Modulation Generated Signals. Total Numbers Of Lines Are 256.

#### IV. Comparative Analysis

Therefore, with our operating point, we conclude to have the following ranges shown in table 1 for both modulation schemes.

Table.1 shows comparison of simulation parameters of QPSK and QAM. Above table clearly shows that 256 bit QAM is a better modulation technique than 4 bit QPSK modulation technique.

SimulationParameter	QPSK	QAM
Modulation	PSK	AM
BER	0.000465	0.001499
SNR	18db	20db with AWGN
SAMPLE TIME	1 sec.	5ms
SYMBOL( M-Ary Number)	4	256
INITIAL SPEED	20	37
New points per Display	8	40

### V. Conclusion

At this work a MATLAB simulation was carried out in order to analyze the QAM & QPSK Modulator. We have discuss all blocks used in the QPSK Simulink model as shown in Fig 2. We get the output in the Scatter plot which shows that QPSK has a quadrature modulation technique.

Also we have seen different output at different stages in the Simulink model in scope output & in scope output 1. Scope output defines the sum of two bits & scope output 1 defines the phase shift in the bits. Scatter plot is used to display a modulated signal constellation in its signal space by plotting the in phase component versus the quadrature component after the simulation.

In our project finally study of both modulations QAM & QPSK with comparing the BER, SNR, and Symbol Initial speed is done. We have discuss all blocks used in the QAM simulink model as shown in Fig.3. In this paper we got the output in the Scatter plot which shows that QAM has a quadrature modulation technique. Also we have seen the different output first is Transmitted signal & second is Signal with 20db SNR with AWGN noise. We have achieved the BER is 0.001499ms.

BER testing is a powerful method for end to end testing of digital transmission systems. A BER test provides measurable and useful information about the performance of the system that can be directly related to its operational performance. If the BER will be too high then the system performance will noticeably degrade. If it is within limits then the system will operate satisfactorily.

Advantages of QPSK

- Higher data rate than in PSK (2 bits per bit interval), while bandwidth occupancy remains the same
- 4-PSK can easily be extended to 8-PSK, i.e. n-PSK
- However, higher rate PSK schemes are limited by the ability of equipment to distinguish small differences in phase.

Applications:

- WLAN IEEE802.11b (2 Mbps, 5.5 Mbps, 11 Mbps)
- 3G WDMA
- DVB-T (with OFDM)

Advantage of QAM

- QAM increase the efficiency of transmission for radio communications systems by utilizing both amplitude and phase variations.
- QAM is very high Noise immunity.
- QAM is having high bit rates.
- QAM has Low error probability.
- Due to Baud rate is half the bit rate hence more effective utilization of the available bandwidth of the transmission channel.

Applications:

- 16QAM is used in Digital terrestrial television
- 64 QAM is used in Digital cable television
- 64QAM is used in Digital video Broadcasting
- 256QAM is used in Cable Modem Application In UK

### References

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