Bluetooth Communication System

CIE 437 - University of Science and Technology- Zewail City

Ibrahim Hamada Ibrahim – 201800739
Sohaila Islam Zaki – 201800998
Yossef Eldesoky – 201800504

Report Index:

❖ Overview:

Bluetooth is a short-range wireless technology standard that is used for exchanging data between fixed and mobile devices over short distances (up to 10 meters) using UHF radio waves in the ISM bands, from 2.402 GHz to 2.48 GHz, and building personal area networks (PANs). Portable devices can use Bluetooth as an alternative way to wired communication since it cannot only be used for file exchange, but also it can connect cell phones and music players. Bluetooth is offering an effective communication method rather than wireless communication and its performance is reliable against the interfered devices that are using the same range of frequencies. Frequency hopping technique is playing a crucial role to avoid interference. Using frequency hopping, the signals can move from one frequency to the next one at regular intervals as to avoid interference between the large number of users who are using ISM band. A Bluetooth transmission only remains on a given frequency for a short time, and if any interference is present the data will be re-sent later when the signal has changed to a different channel which is likely to be clear of other interfering signals.

❖ Modulation Schemes:

The modulation type for the first applied Bluetooth technology in version 1 was Gaussian frequency shift keying (GFSK), but with the requirement for higher data rates two forms of phase shift keying were introduced for Bluetooth 2 to provide the Enhanced Data Rate Capability.

1- Gaussian frequency shift keying:

As mentioned, GFSK is used for Bluetooth 1 in which the carrier frequency is shifted to carry the modulation. A positive frequency deviation is used to represent Binary one, while a negative frequency deviation is used to represent Binary zero. A Gaussian filter is used to filter the modulated signal and ensure that its sidebands don’t extend too far and hence the passband signal Bandwidth doesn’t exceed 1 MHz to prevent interference.

2- Phase shift keying:

Phase shift keying is the form of Bluetooth modulation used to enable the higher data rates achievable with Bluetooth 2 EDR (Enhanced Data Rate). Two forms of PSK are used:

- **π/4 DQPSK:**

π/4 differential phase shift keying is used in Bluetooth 2 and it enables the raw data rate of **2 Mbps** to be achieved.

- **8DPSK:**

8-ary phase shift keying is used in Bluetooth 2 when link conditions are good and it allows raw data rates of up to **3 Mbps** to be achieved.

❖ System Specifications:

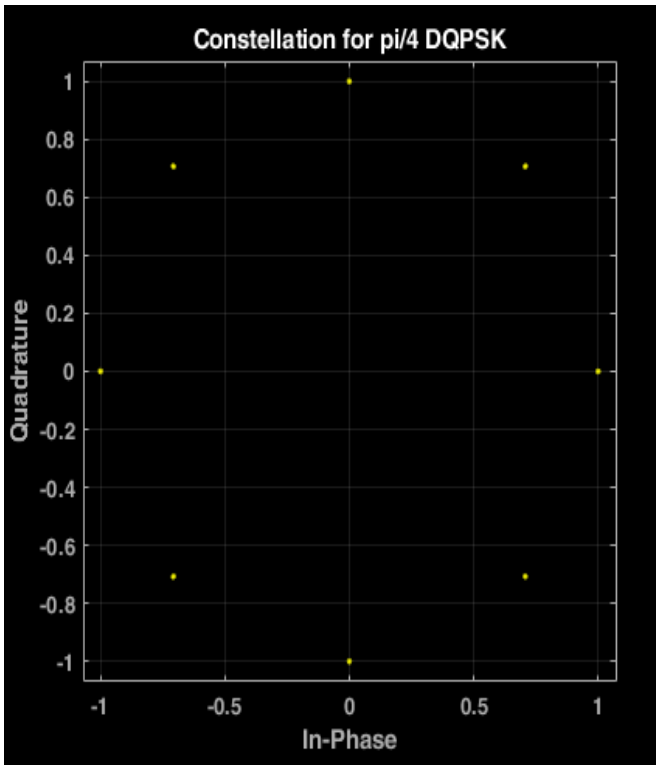
A) Modulation Technique: π/4 DQPSK, 8-DPSK
B) Frequency Band: 2.402 GHz – 2.48 GHz
C) Bit Rates: 2 Mbps, 3 Mbps
D) Transmission Bandwidth: 1 MHz

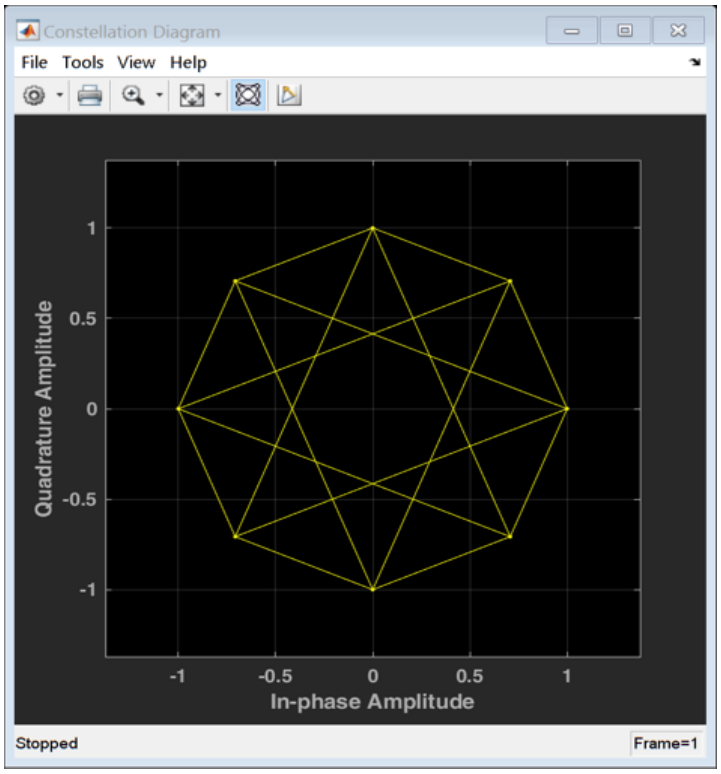
❖ Our Work:

We have simulated the Bluetooth Communication System especially for the modulation and demodulation parts (π/4 DQPSK, 8-DPSK) using MATLAB and LabView. We have plotted the constellation of the healthy signal and the noisy signals in both MATLAB and LabView. In addition, we have transmitted an audio signal using the system and the results were as follows.

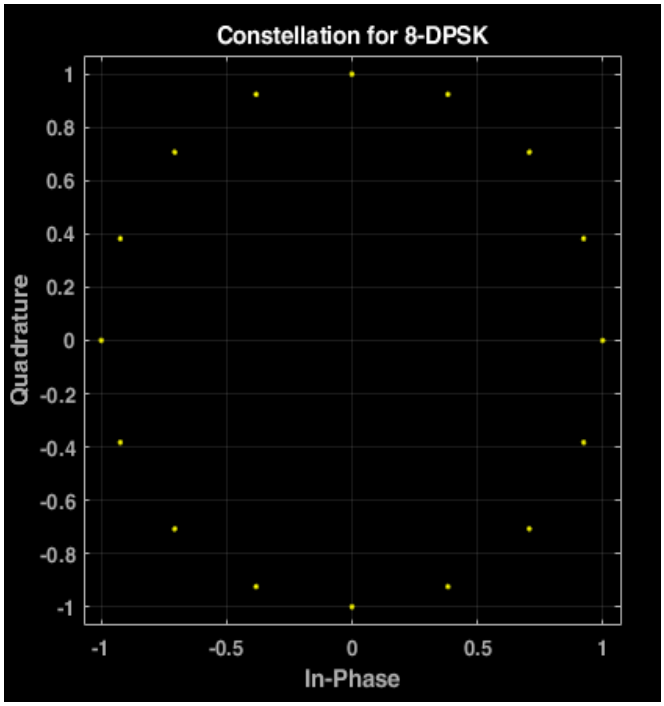
❖ MATLAB:

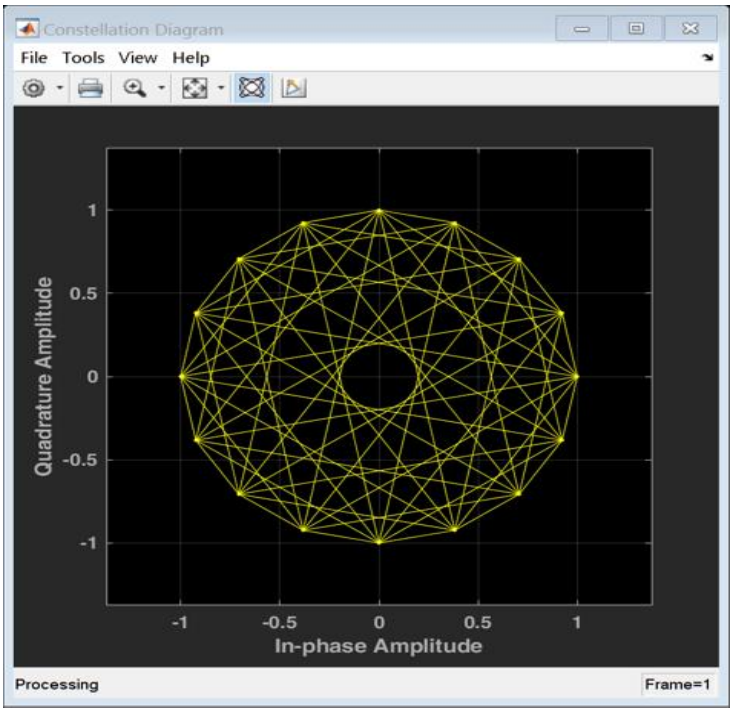
1- Constellation Diagram of the Modulated π/4 DQPSK Un-noisy Signal:





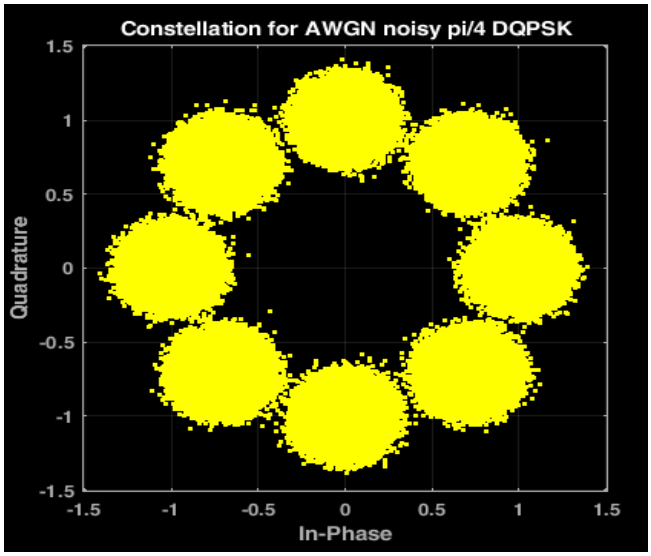
2- Constellation Diagram of the Modulated 8-DPSK Un-noisy Signal:



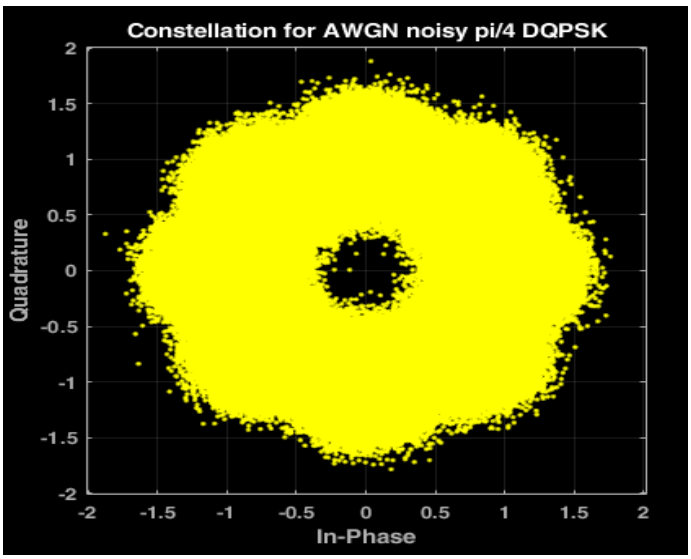


-After obtaining the Modulated Signals, three Transmission Channels (AWGN, Rayleigh, Rician) are formed with different channels' parameters and here are the results:

3- Constellation of the Modulated π/4 DQPSK Noisy Signal (AWGN):

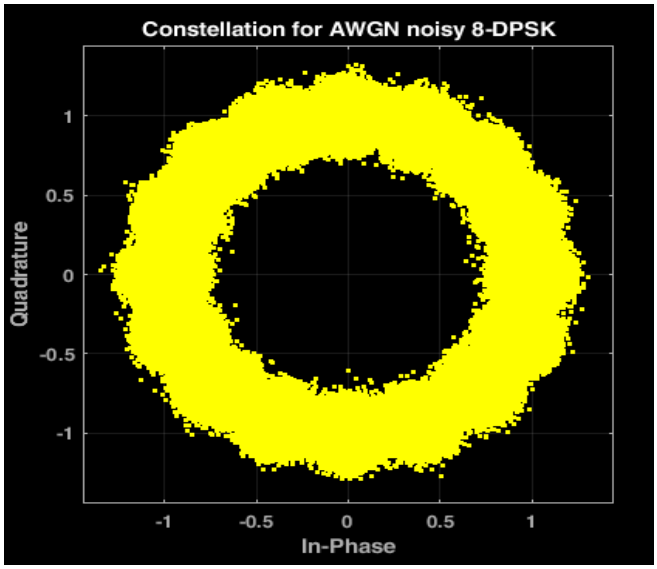


Eb_No = 15, BER = 0.0007

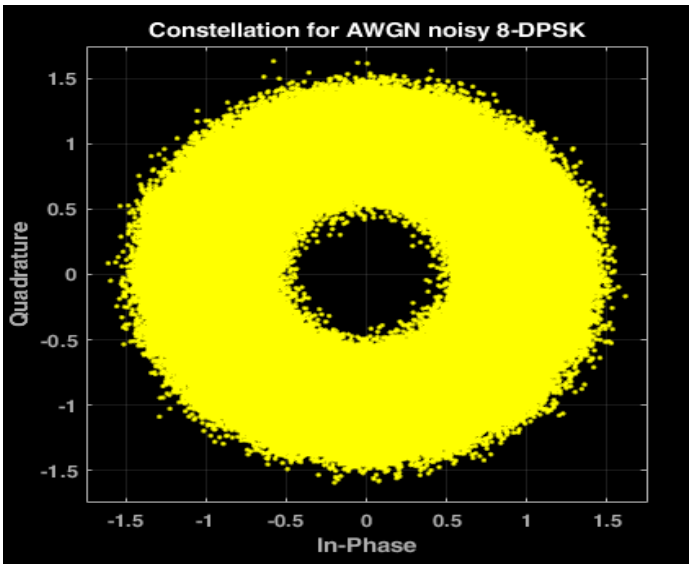


Eb_No = 8, BER = 0.0013

4- Constellation of the Modulated 8-DPSK Noisy Signal (AWGN)



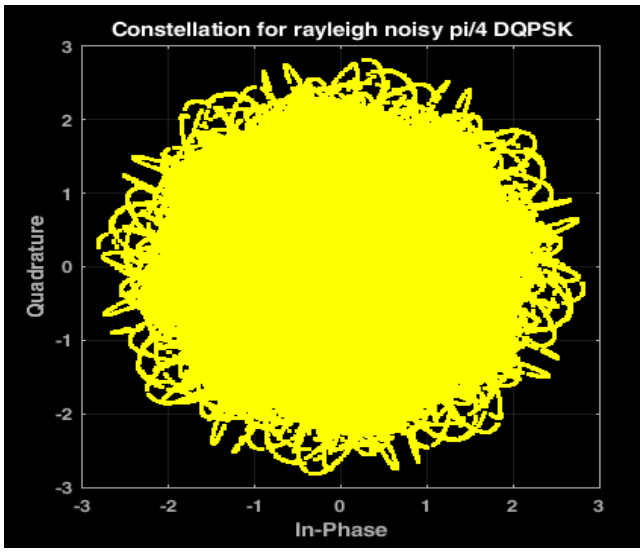
Eb_No = 15, BER = 0.0104



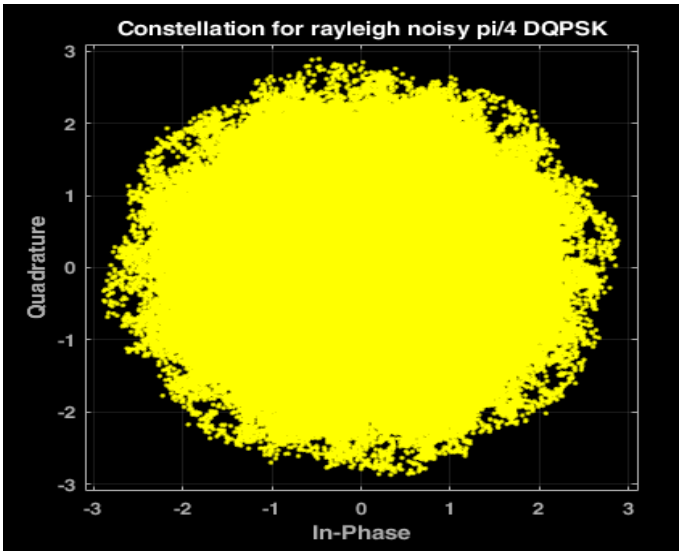
Eb_No = 8, BER = 0.0194

- **It can be clearly shown that as SNR (Eb_No) decreases, the probability of BER increases.**
- **It can be also clearly concluded that π/4 DQPSK shows better results than 8-DPSK, which is an expected result of increasing the bit rate in 8-DPSK.**

5- Constellation of the Modulated $\pi/4$ DQPSK Noisy Signal (Rayleigh):

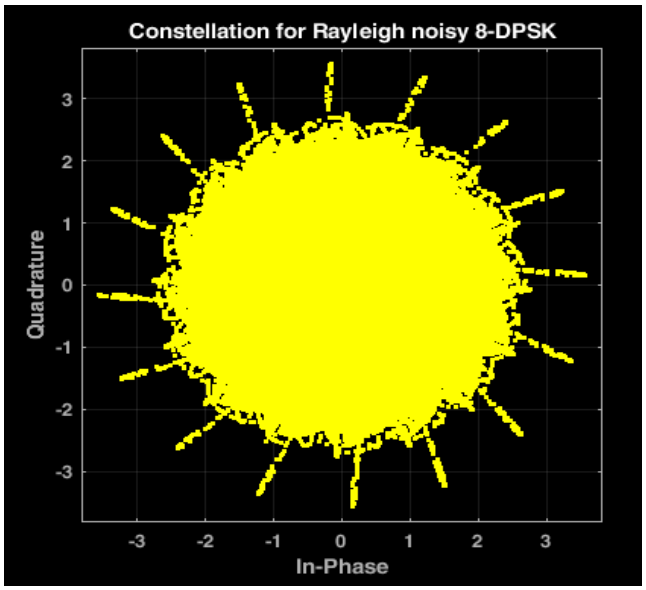


Low Path Delays, BER = 0.3703

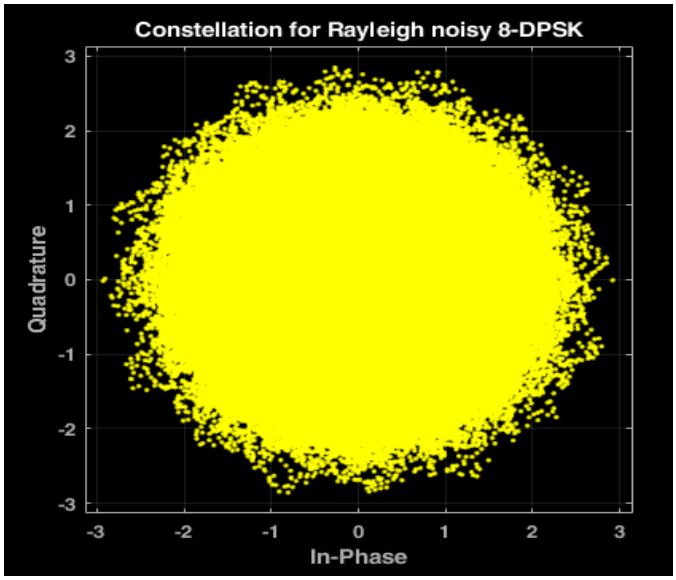


High Path Delays, BER = 0.5035

6- Constellation of the Modulated 8-DPSK Noisy Signal (Rayleigh):



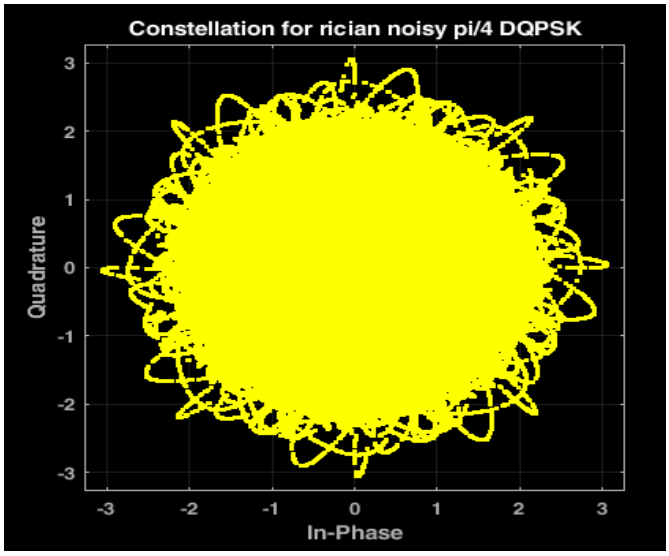
Low Path Delays, BER = 0.3813



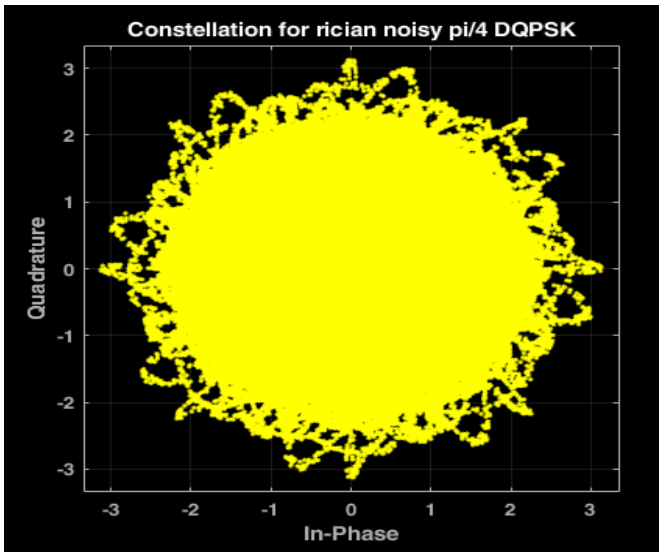
High Path Delays, BER = 0.5185

- **It can be clearly shown that as Rayleigh Channel with high path delays affects the BER negatively as it increases the BER.**

7- Constellation of the Modulated $\pi/4$ DQPSK Noisy Signal (Rician):

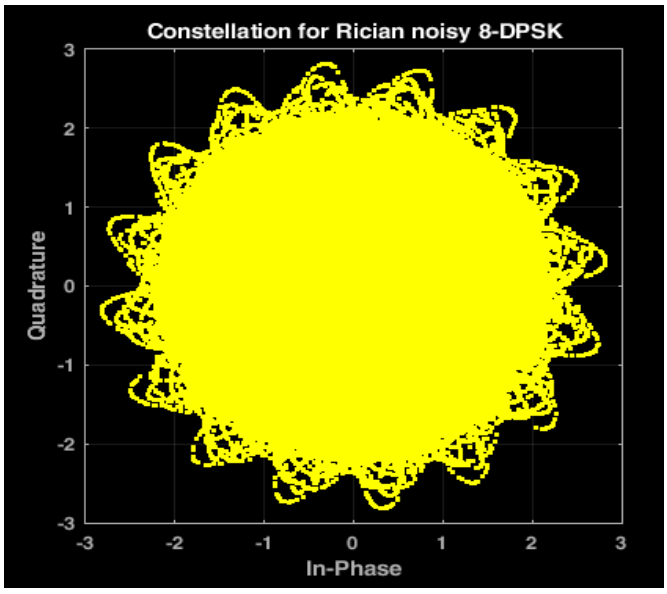


Low Path Delays, BER = 0.3122

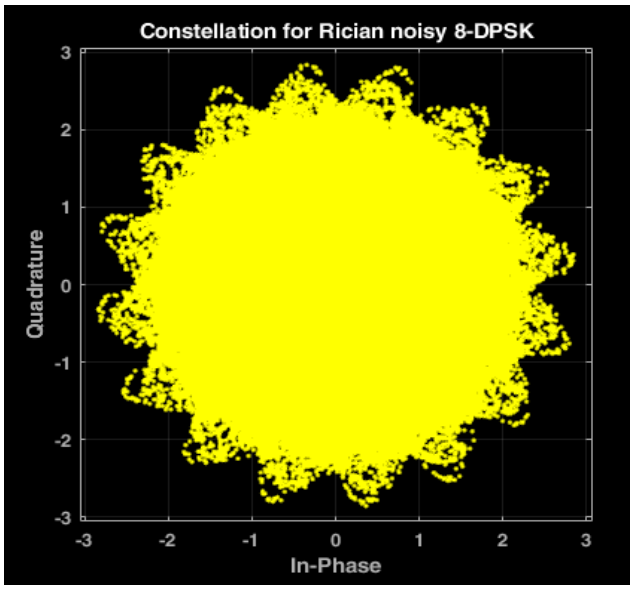


High Path Delays, BER = 0.4932

8- Constellation of the Modulated 8-DPSK Noisy Signal (Rician):

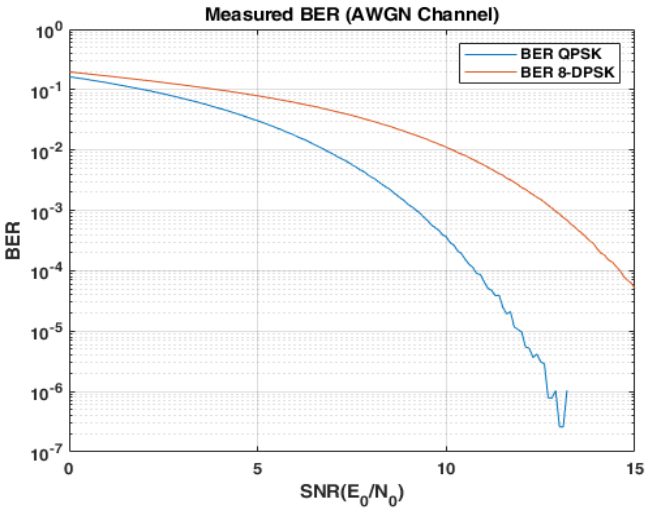


Low Path Delays, BER = 0.3006

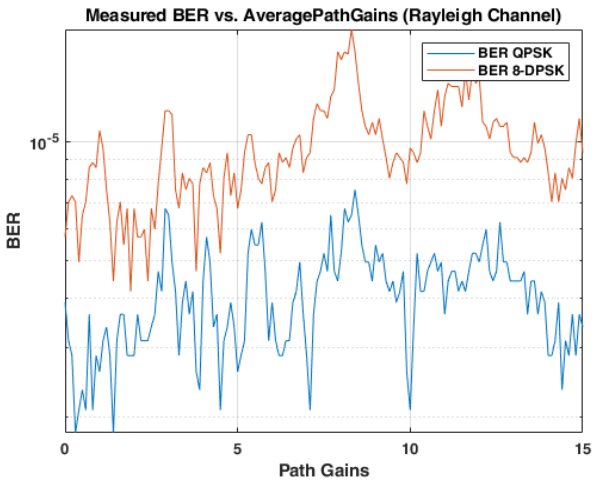


High Path Delays, BER = 0.5122

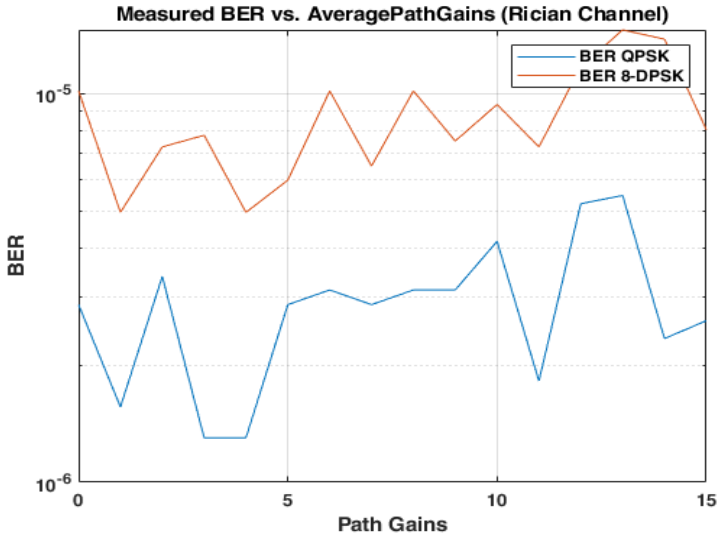
9- BER Comparison between π/4 DQPSK and 8-DPSK for different Channels:



AWGN



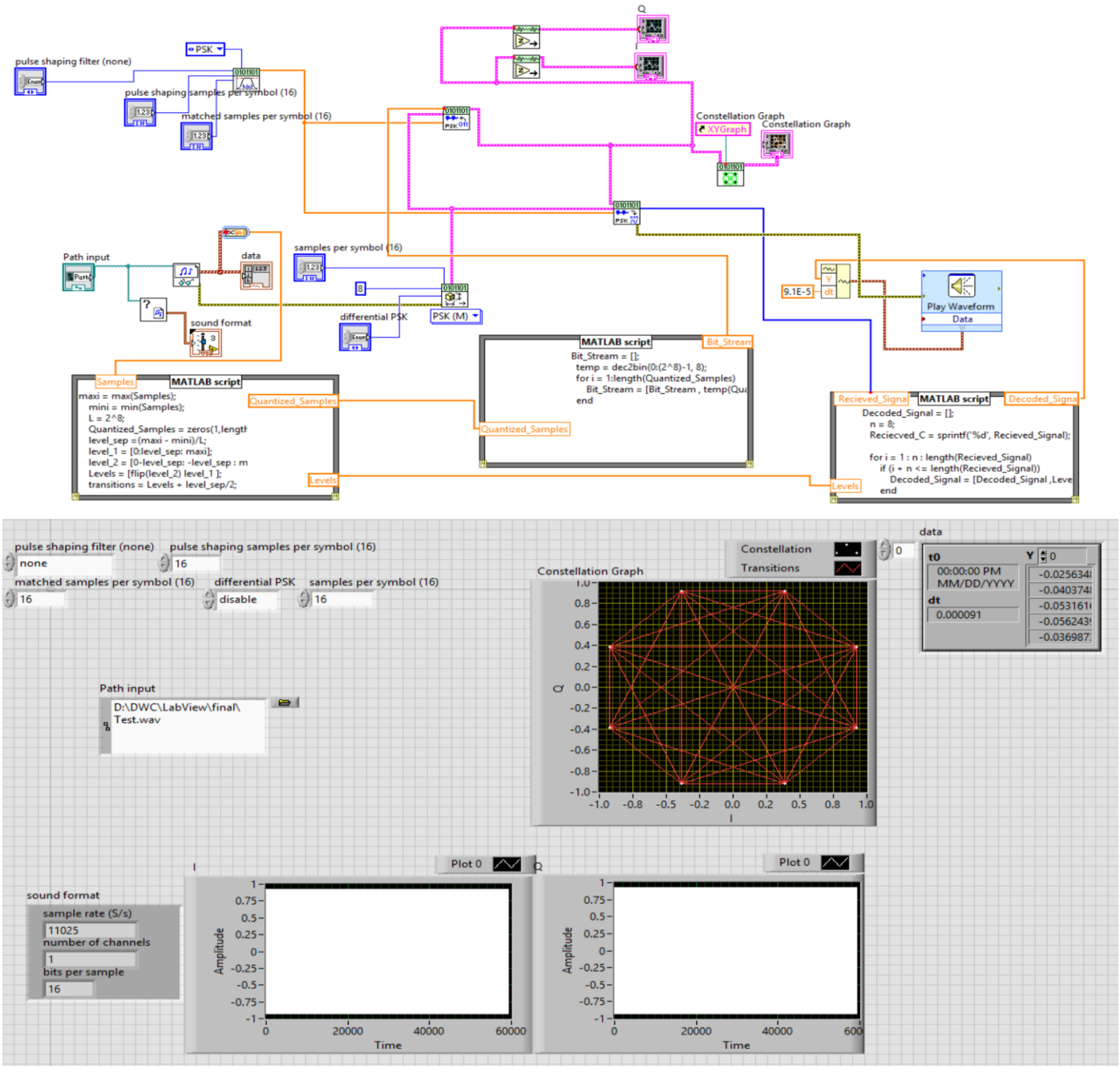
Rayleigh



Rician

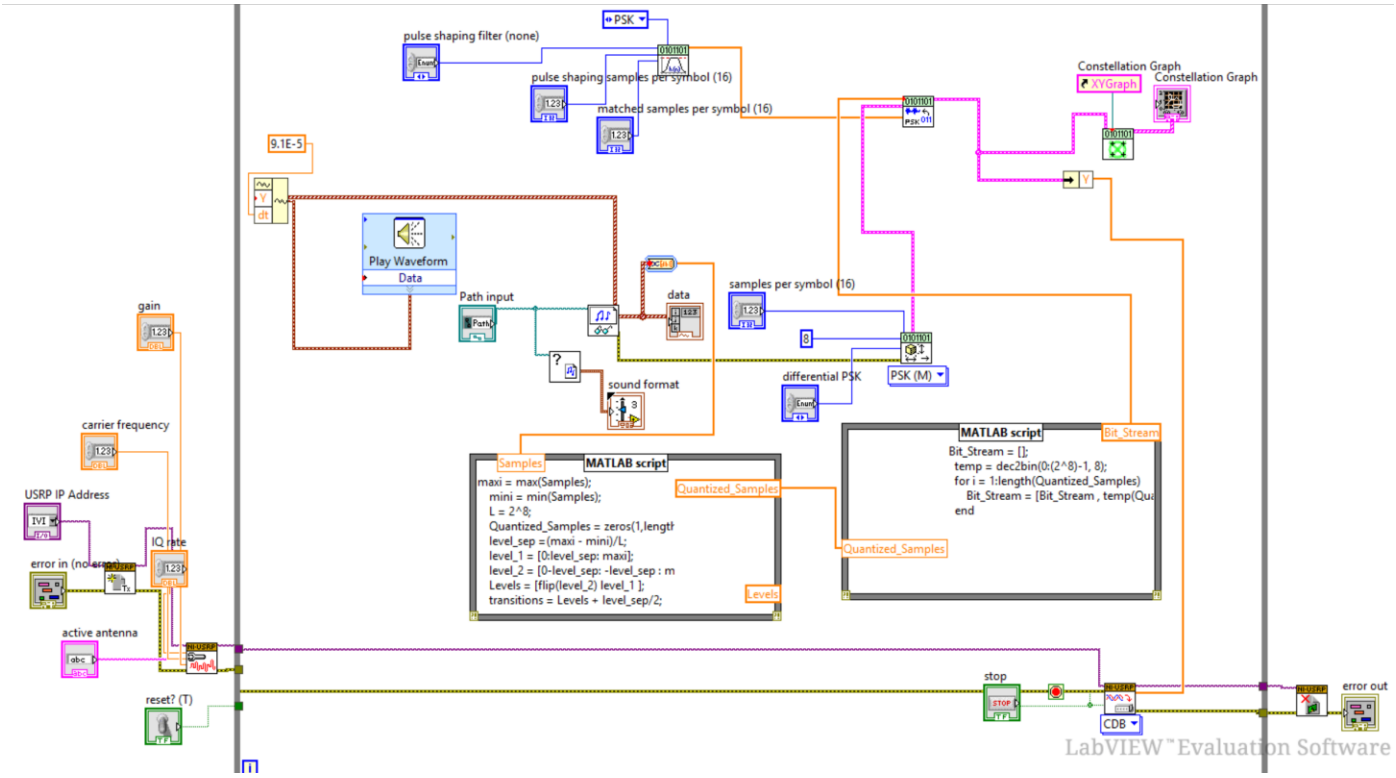
- **The above figures show that BER for Low Bit Rates Modulation Scheme (π/4 DQPSK) is less than High Bit Rates Modulation Scheme (8-DPSK).**

❖ LabView Simulation:

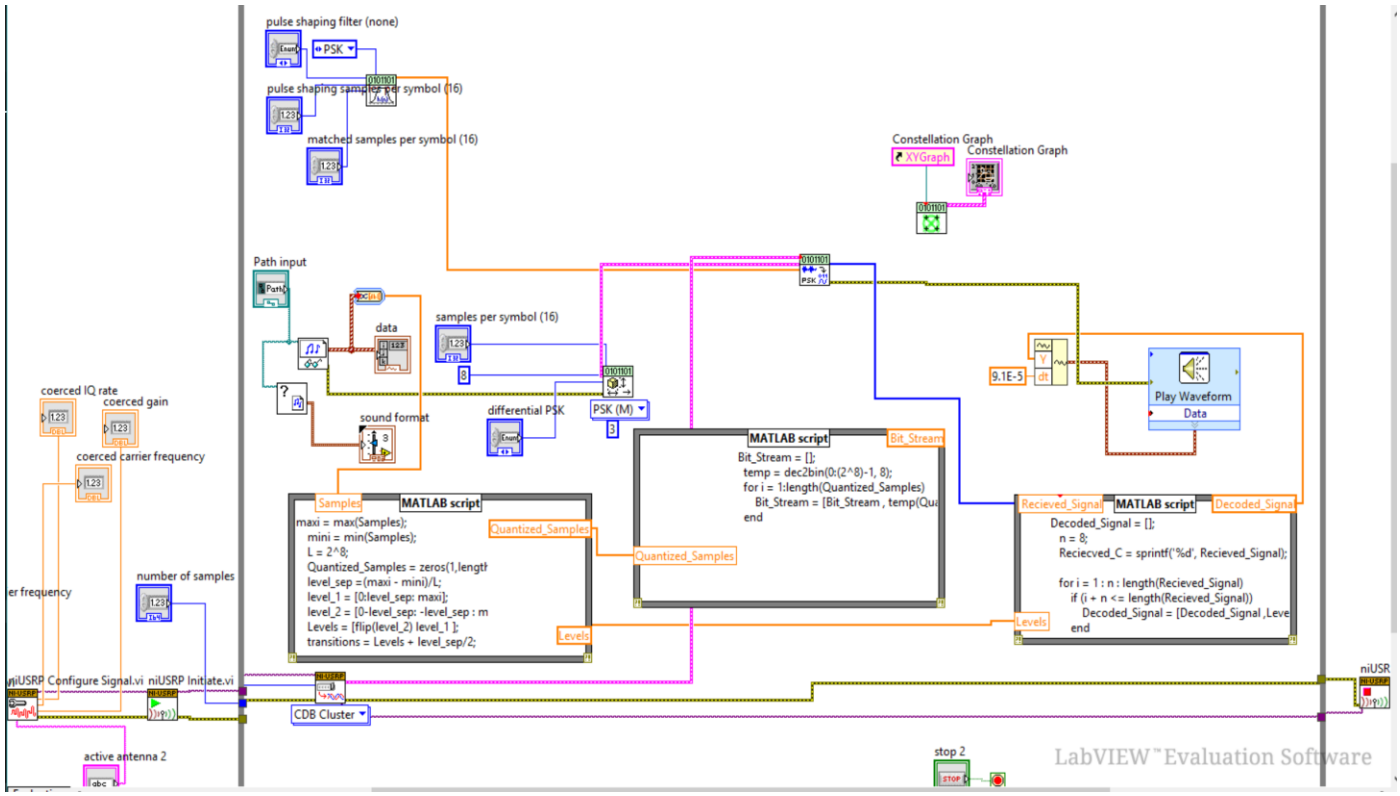


a) The input audio signal is quantized and converted to bit stream using MATLAB Script.
b) The Bit Stream is modulated using 8-DPSK modulator after setting the parameters.
c) The Constellation for the Modulated Signal is drawn.
d) The Modulated signal is then demodulated and MATLAB Script is used to decode the demodulated bits and restore the signal's samples.
e) The restored signal is played using Play Waveform Module.

❖ USRP Transmitter:



❖ USRP Receiver:



❖ Conclusion:

Bluetooth Communication System is simulated using MATLAB, LabView, and USRP.

- **MATLAB Simulation Results for the input Audio file are shown in OUTPUT Audio Files.**
- **LabView Simulation Results are shown in LabView Simulation Video.**
- **USRP Results are shown in USRP Video.**

For MATLAB, we implemented Bluetooth Communication using π/4 DQPSK and 8-DPSK Modulation Schemes. For LabView, we used 8-DPSK Modulation Scheme. For USRP, we used 8-DPSK Modulation Scheme. We introduced different kinds of channel effects (AWGN, Rayleigh, Rician) Channels and analyzed the results and the error rates corresponding to each effect.