ELP 725 Wireless Communication Laboratory

Experiment 3

"IMPLEMENTATION OF ADAPTIVE MODULATION(AMC) AND CODING USING SDR"

Submitted By:

Lt Col Charu Sharma – 2022EEE2807

Abhilash -2022JTM2391

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INTRODUCTION.

(a) Adaptive modulation and coding enable robust and spectrally efficient transmission over time-varying channels.

(b) The basic idea is to estimate the channel at the receiver and provide this as feedback to the transmitter, so that the transmission scheme can be adapted according to the channel characteristics.

(c) This technology dynamically adjusts the modulation order, coding method and coding rate of symbols to maximize throughput of the entire link transmission system, because throughput of the system is related to the modulation method, coding method and bit error rate. In general, the target error rate of the system is predefined. For the reason of maximizing the system's transmission performance and throughput under a fixed BER, system needs to dynamically adjust its modulation and coding method at the transmitting end so that the time-varying fading channel (such as a frequency-selective channel) adapts to the change of the channel, maintains the stability of the transmission of the system, as well as improves throughput.

(d) The visual description is that while the channel environment is better, we use a higher transmission rate to transmit data. If the channel environment is deficient, for the purpose of correctly receive the signal at the receiving end, a low transmission rate is used.

OBJECTIVES.

(a) Estimate the Channel quality.

(b) Assign the modulation (16QAM, MPSK) depending on the transmitter to satisfy Quality-of-Service in terms of Bit-error rate.

(c) Compare the performance of Adaptive modulation scheme with non-adaptive modulation scheme (Demonstrate the benefits of adaptive over non-adaptive).

EQUIPMENT USED.

(a) Two HackRf SDRs, Laptop, antennas.
(b) Laptop for programming the SDR
(c) GNU Radio

EXPERIMENTAL SETUP.

(a) Open the GNU radio(**gnuradio-companion)** on the laptop using keyboard inputs Ctrl+Alt+T.
(b) Design an M-PSK/QAM transmitter and receiver and do the channel estimation.
(c) Set the parameters for HackRf SDRs and then connect the Laptop with the SDR.
(d) Now based on the channel estimate, design an adaptive modulation scheme.

Channel Estimation

(a) Channel quality was estimated in terms of SNR (Signal to noise ratio) parameter and using QPSK modulation.
(b) The GNURadio flow chart used for channel quality estimation is as below
(c) For channel quality estimation (SNR), we have used MPSK SNR Estimator probe block and message Debug block. The MPSK SNR Estimator probe block computes the SNR

value and outputs the resulting SNR as a message which is outputted to the console using the Message Debug Block.

(d) The value of SNR received as can be seen is 8.26 dB.

(e) The constellation diagram using QPSK modulator and demodulator for different values of noise voltage in the channel is as below

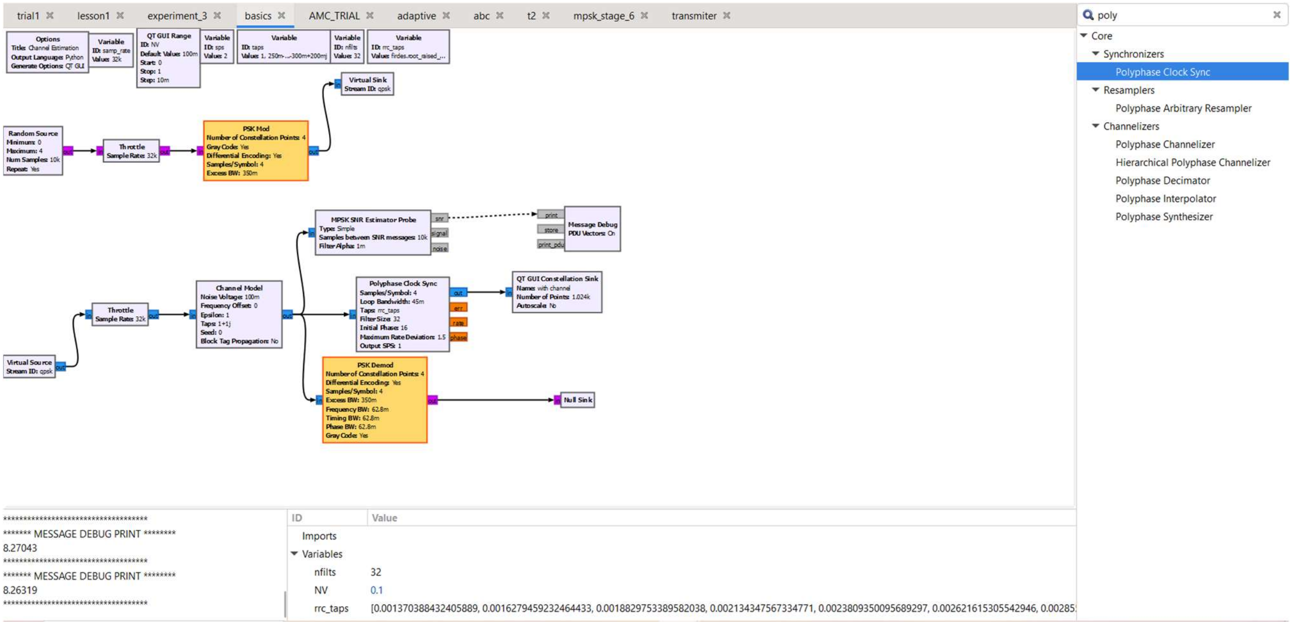

Figure 1

Channel Quality Estimation

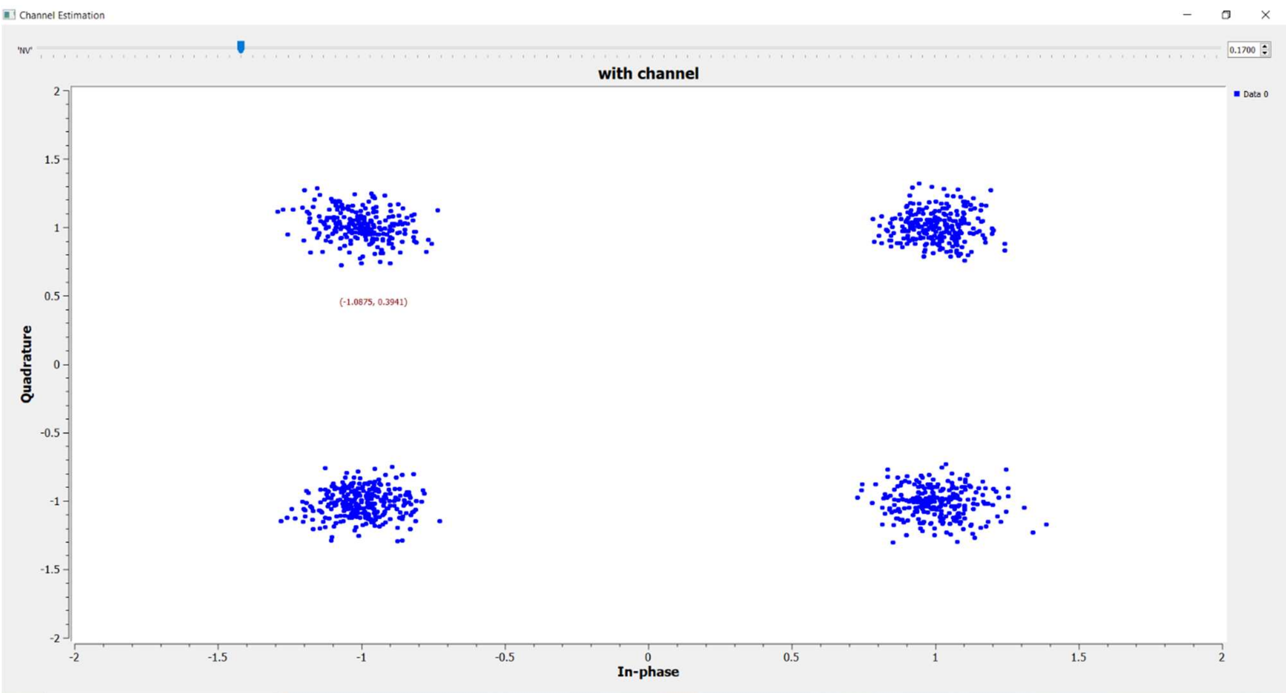

Figure 2

QPSK Modulation Received at the Receiver Side

Adaptive Modulation Coding

GnuRadio flow chart of the setup is as below:

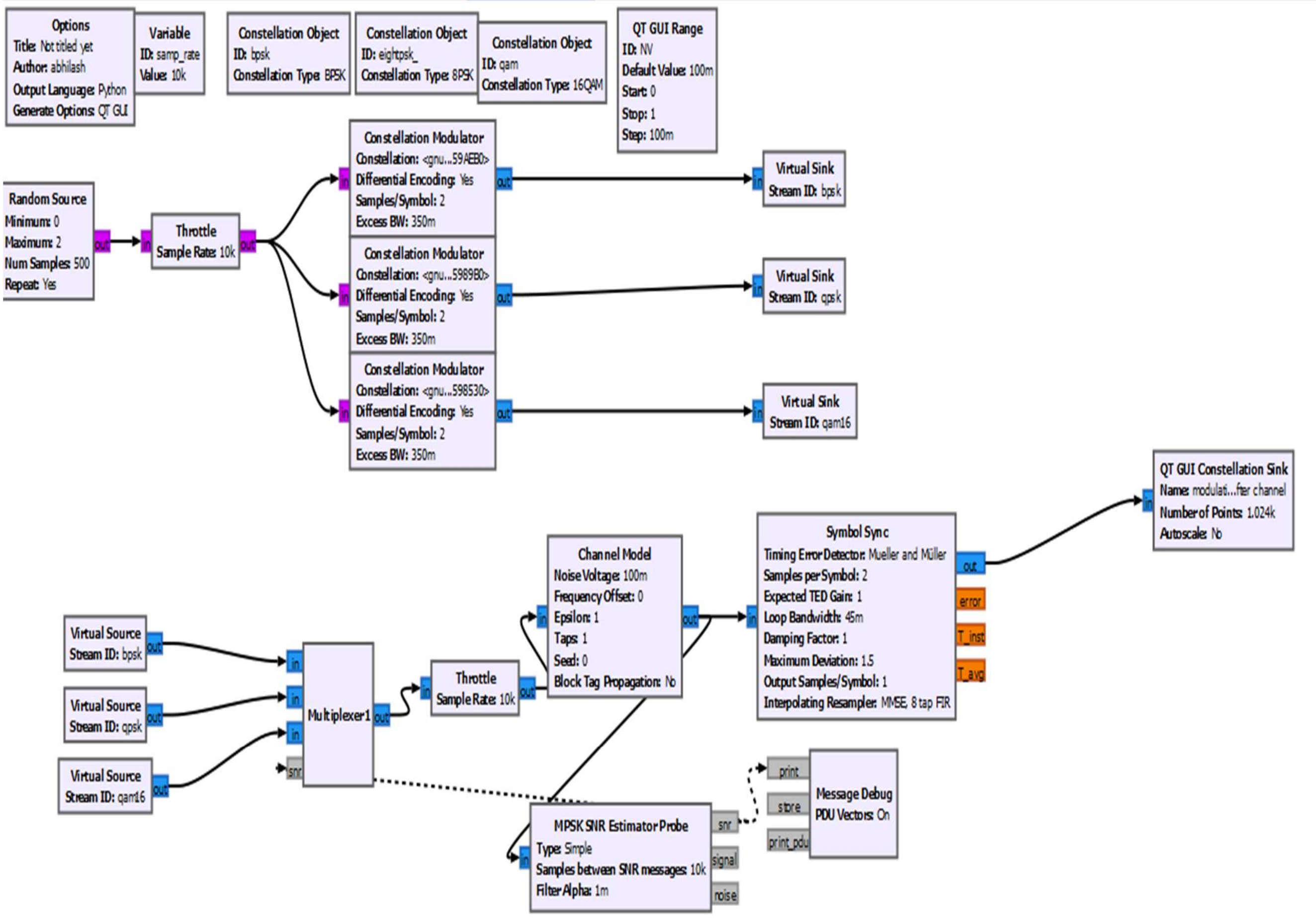

Figure 3

Adaptive Modulation and Coding

Constellation Diagram of Different Modulation

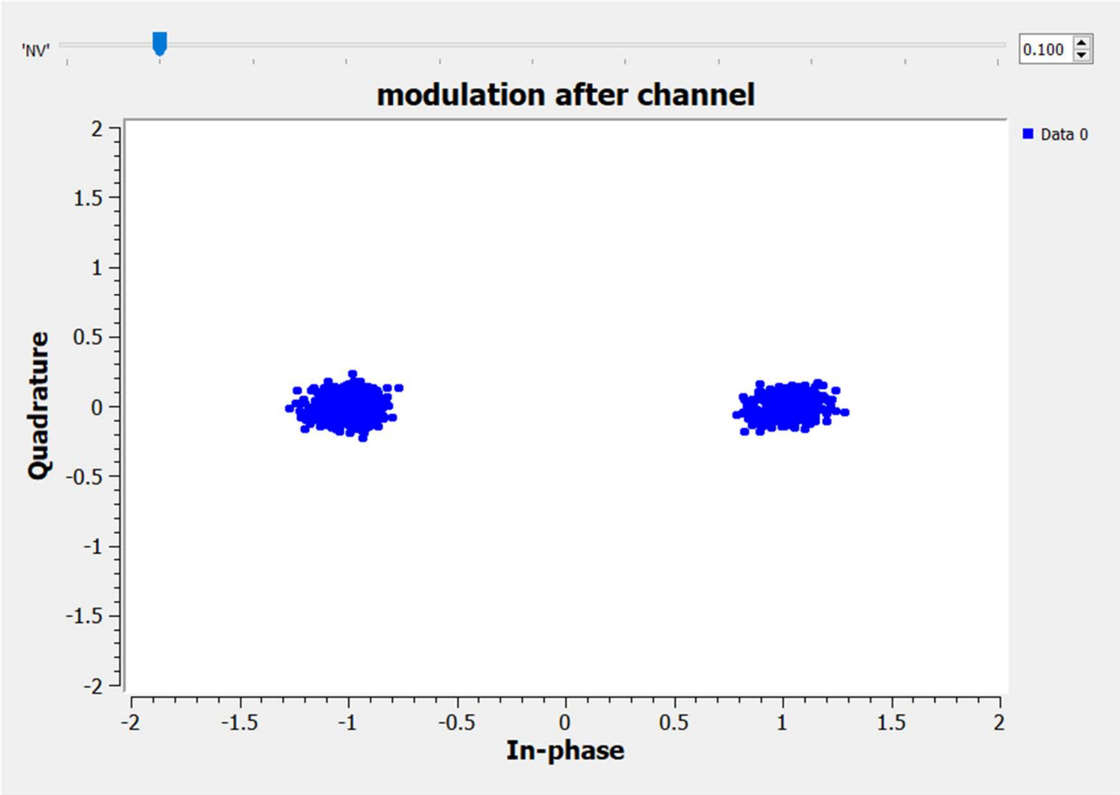

Figure-4

SNR = 8.67, Modulation = BPSK

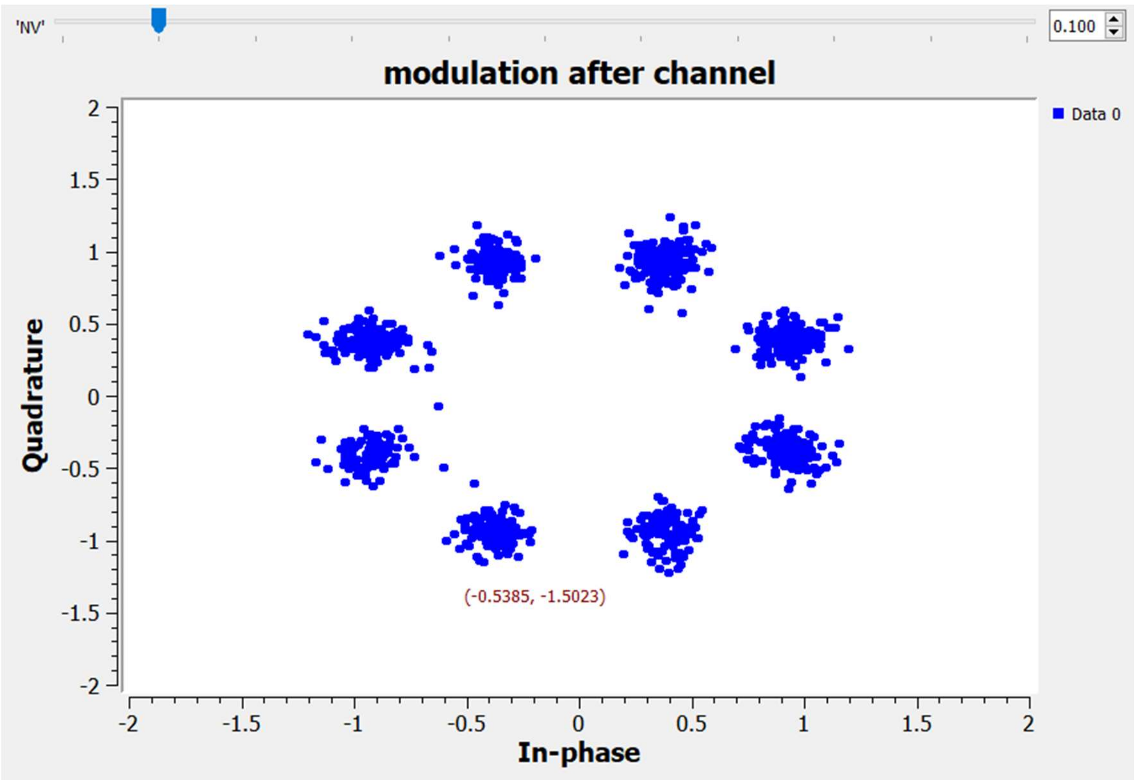

Figure-5

SNR = 9.8, Modulation = 8PSK

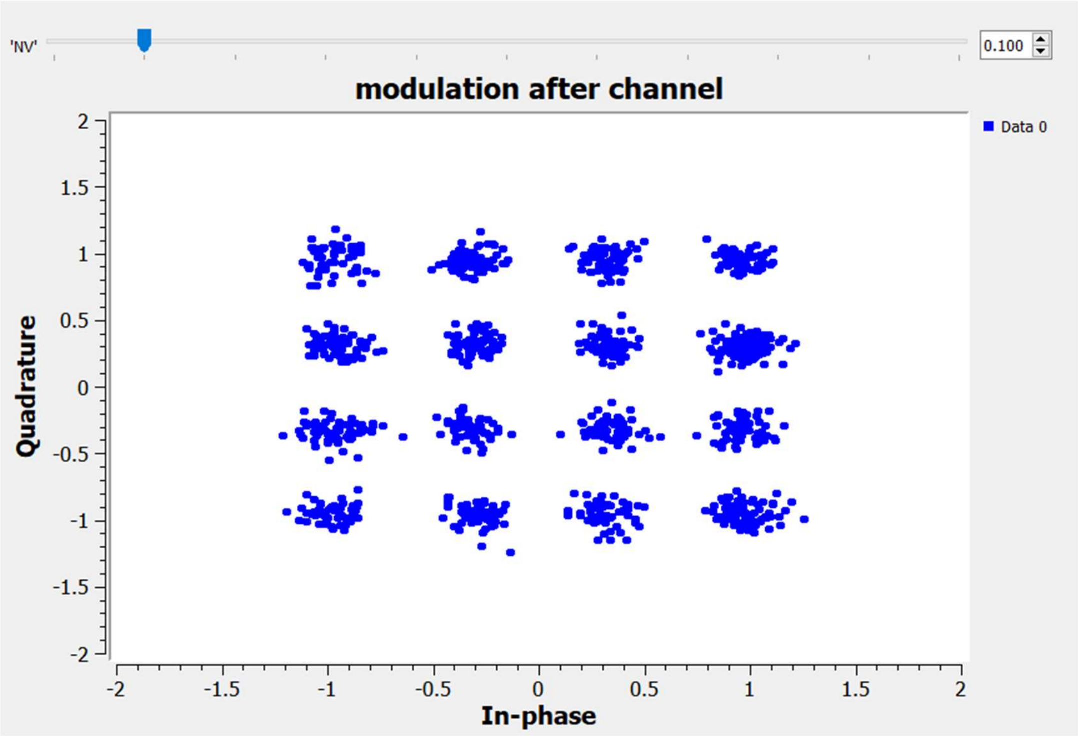

Figure-6

SNR = 10.8, Modulation = 16QAM

The Adaptive modulation was done using the following cut off boundaries of SNR.

S. no	SNR range in dB	Modulation Scheme
(i)	Less than 8	BPSK
(ii)	Between 9 & 10	8PSK
(iii)	Greater than 10	16 QAM

The SNR vs BER curve was plotted using MATLAB code and the scheme was implemented using GNU radio. The observations are as shown below:

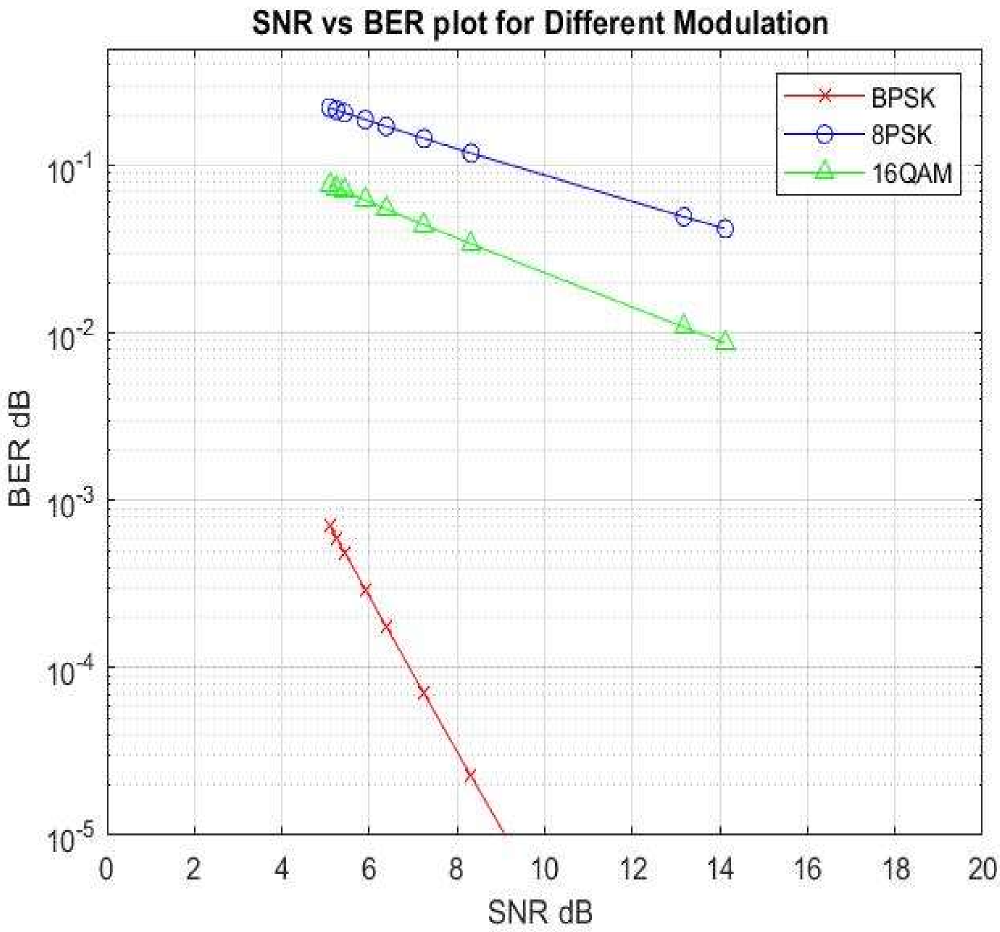

Figure 7

CONCLUSIONS.

(a) The channel quality was estimated using the SNR. The BER value obtained was erroneous and did not vary much on changing the noise voltage in the channel.

(b) The Adaptive modulation scheme required having feedback of the SNR value obtained using the channel estimate. However, the value stored in the Message Debug block could not be retrieved and used as a real time feedback to change the modulation scheme. On the contrary, the SNR value was defined as a variable and used in the Control block for changing the modulation scheme.

(c) The Modulation Selector Block was hard-coded and developed to choose from one of the input modulation schemes based on the output from the Control Block, however, the output being displayed changes after a finite amount of delay.

(d) The BER vs SNR curve was plotted using experimental values. It can be observed that the BER decreases as SNR increases.

(e) It was observed that for same SNR BPSK is falling more Rapidly than 8PSK and 16QAM means that for less snr BPSK performs better than 8PSK and 16QAM.

(f) Therefore it can be concluded that to increase the data rate, it is possible to use high spectrally efficient modulations. However, such modulations are more susceptible to noise. Meanwhile, low spectrally efficient modulations offer robust connections rather less data rate. One solution can be efficient spectrum usage. Depending on the requirements, the transmission bit rate can be dynamically adjusted.

Appendix-MATLAB Code For BER Vs SNR

```
clear all;
snrdb = [11.5 11.2 9.2 8.6 8.05 7.71 7.35 7.20 7.063 ];
snrdbrev = flip ( snrdb ) ;
snr = 10.^( snrdbrev /10)
ber_8psk =2*qfunc(sqrt(2*snr)*0.3826)
%ber = 10* log10 ( ber_qpsk )

ber_16qam =qfunc(sqrt((6/15)*snr));
%ber_16qam1 = 10* log10 ( ber_16qam ) ;

ber_BPSK = qfunc(sqrt(2*snr));
%ber_64qam1 = 10* log10 ( ber_64qam ) ;

figure ;
semilogy ( snr , ber_BPSK , 'rx -', snr , ber_8psk , 'bo -',
snr ,ber_16qam , 'g^ -') ;
title ('SNR vs BER plot for Different Modulation ')
xlabel ('SNR dB ')
ylabel ('BER dB ')
legend ('BPSK ', '8PSK ', '16QAM ')
axis([0 20 10^-5 0.5])
grid on ;
```

REFERENCE

- Goldsmith, A. (2005). Wireless Communications. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511841224
- https://www.gnuradio.org/