EEE 321, ETE 321 L – Introduction to Communication Systems

Experiment No: 09

Bit Error Rate (BER) and Signal to Noise Ratio (SNR) in Digital Modulation

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Making the comparison through the Bit Error Rate tool (bertool) of MATLAB® Communication toolbox

1) Write bertool in matlab® command window
   `>> bertool`

2) Then you will see similar window like this

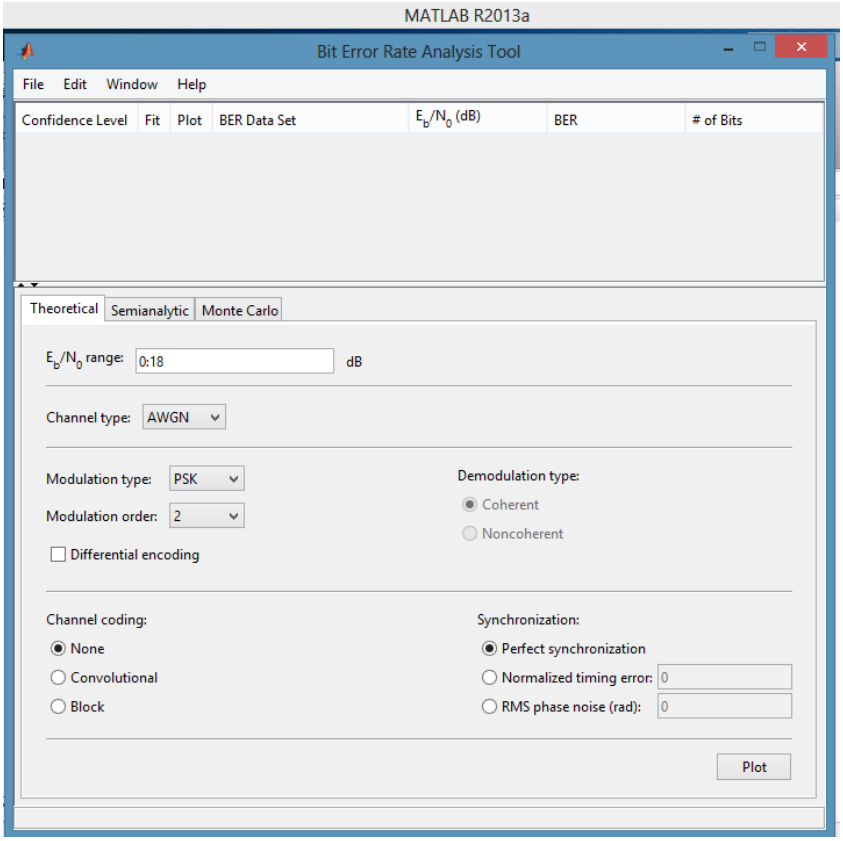

Figure 1: Matlab Bit Error Rate Analysis Tools Interface

3) Specify the channel type AWGN

4) Choose PSK Signals as a modulation type and then plot BPSK, QPSK, 8PSK, 16PSK etc and compute the bit error rate vs SNR curve. You may get similar to the graph given below.

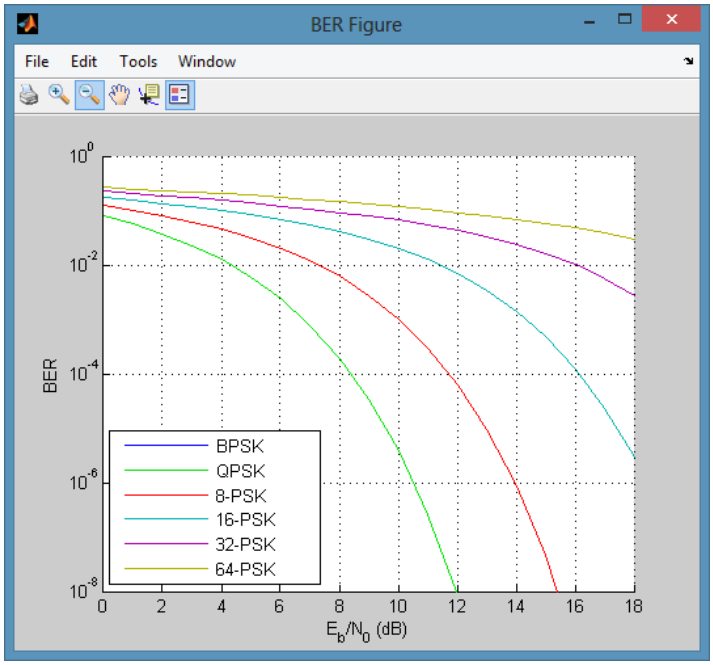

Figure 2: SNR (E_b /N_0) in dB vs BER Graph for M-ary PSK Signal

5) Similar way to 4 you can get the comparison for QAM Signals.

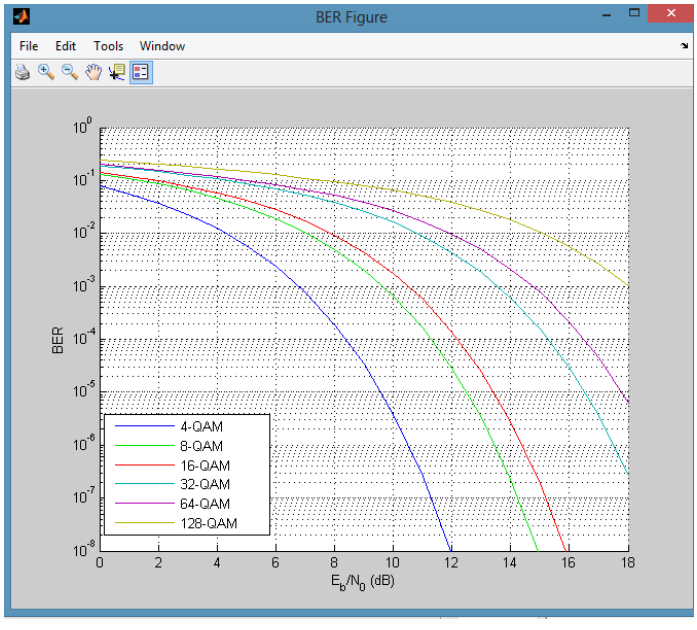

Figure 3: SNR (E_b /N_0) in dB vs BER Graph for M-ary QAM Signal

6) From fig. 3 and fig.4 compare how much SNR required for similar signaling (*eg.* 8-PSK and 8-QAM). Which requires high Signal to Noise Ratio and why? Try to explain it.

Matlab® Implementation:

```
clc; clear all; close all

SNR=0:1:10; % Es/Ep

for k=1:1:length(SNR);
     BER_BPSK(k) = qfunc(sqrt(2*SNR(k)));
     BER_DPSK(k)= 0.5* exp(-SNR(k));
     BER_FSK_NC(k) = 0.5*exp(-(0.5*SNR(k)));
end

semilogy(SNR,BER_BPSK,'-o'); hold on
semilogy(SNR,BER_DPSK,'-s'); hold on
semilogy(SNR,BER_FSK_NC,'-*')

xlabel('Signal to Noise Ratio')
ylabel('Bit Error Rate')
legend('BPSK','DPSK','FSK-NC')
grid on
```

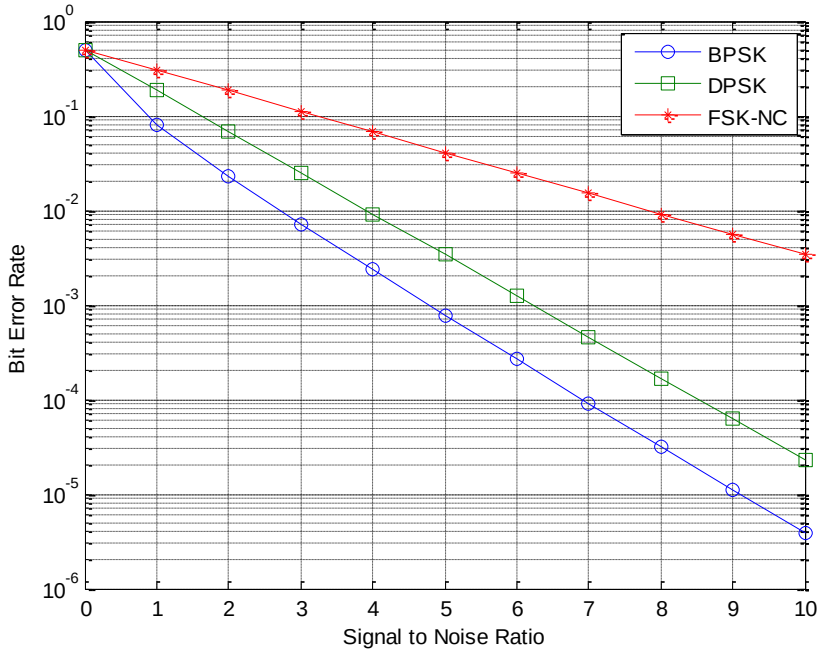

Figure 4: BER Vs. SNR Curve

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Equations to compute BER vs. SNR for M-ary QAM and M-ary PSK Signals

$$P_{e,BPSK} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$$

$$P_{e,QPSK} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$$

For M-ary PSK Signal, $P_e \cong 2Q\left(\sqrt{\frac{2E_S}{N_0}}\sin\left(\frac{\pi}{2M}\right)\right)$

For M-ary QAM Signal, $P_e \cong 4\left(1-\sqrt{\frac{1}{M}}\right)Q\left(\sqrt{\frac{3E_{av}}{(M-1)N_0}}\right)$

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