Cairo University

Faculty of Engineering

ELCN476-Advanced topics in Communications-3

Credit Hours System

Project FEC (Block Codes)

Submitted By:

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Submitted to: Prof. Samy Soliman

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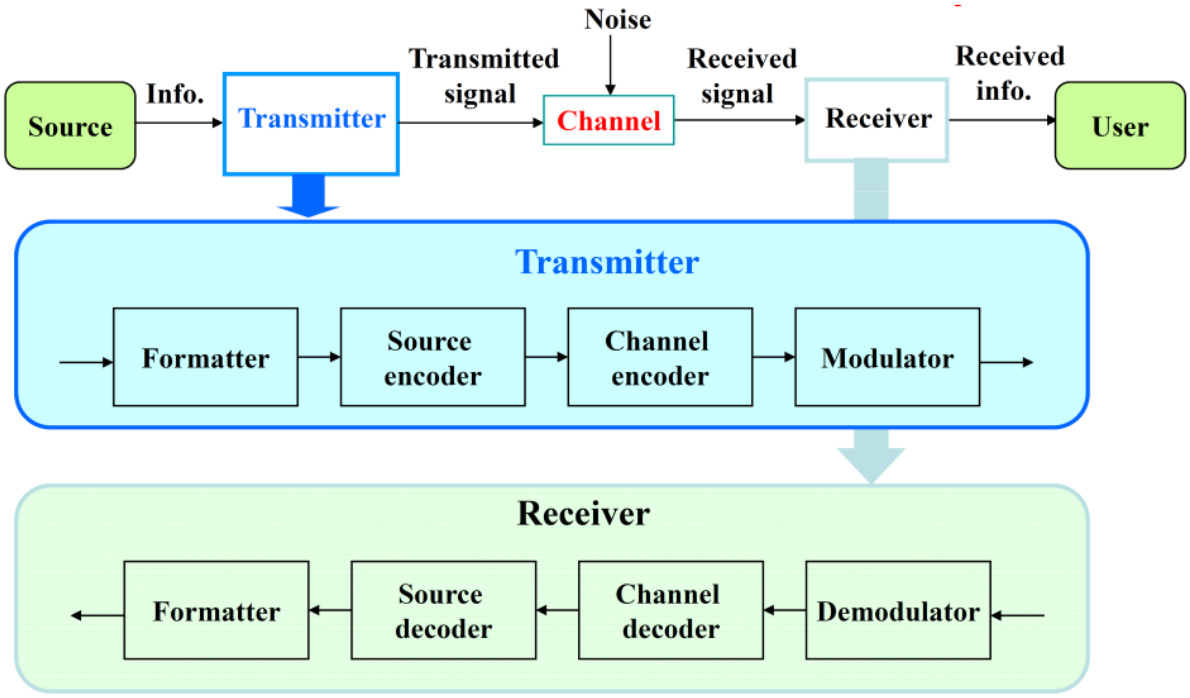

Figure 1 Structure of Communication Systems

Binary Phase-shift keying (BPSK) is a digital modulation scheme that transmits data by altering or modulating two different phases of a reference signal (carrier). The selected constellation points are normally equiangularly spaced around a circle. This gives the maximum phase separation between adjacent points and thus the best resistance to aliasing. They are arranged in a circle so that they all transmit with the same energy. Thus, the complex coefficients they represent are equal, and so are the required amplitudes of the cosine and sine waves.

Pulse amplitude modulation (PAM) : Transmission of data by varying the amplitude (voltage or power level) of individual pulses in a regularly clocked sequence of electrical or electromagnetic pulses. The number of possible pulse amplitudes can be infinite (for analog PAM), but they are usually powers of 2, so the resulting output signal can be digital. For example, in our project 8-level PAM, there are 2^3 possible discrete pulse amplitudes.

Difference between BPSK and 8-PAM: The main difference we can see in constellation as shown and number of bits that modulated.

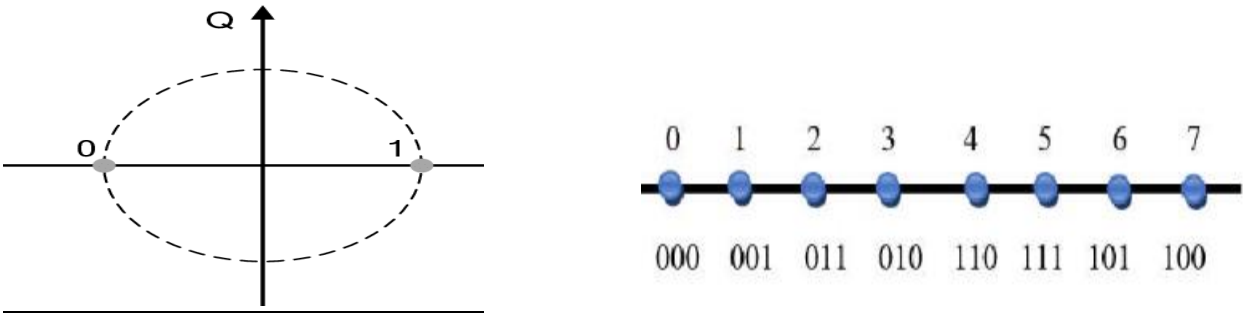

Figure 2 BPSK and 8-PAM Constellation

2.Descritption:

In this project, it is required to assess the performance of Forward Error Correction (FEC) on the average bit error rates (BER) of communication systems.

we are required to write software programs and implement a GUI to help users compare the BER of the following systems:

1) BPSK and 8-PAM system operating over AWGN, without FEC

2) BPSK and 8-PAM system operating with FEC

For the case of FEC systems, you are required to test the following methods of FEC:

1) Option 1: Repetition code of rate 1/n with hard decoding, where n is determined by the GUI user.

2) Option 2: A (n, k) Hamming block code, where n is selected by the GUI user from {7,15, 31}.

3.GUI:

User options

1- Radio Button for System Operating Choosing between BPSK and 8-PAM.

2- Range of SNR between minimum and maximum SNR.

3- Selecting the analysis It will appear in Channel and the user can be choosing from 2 options (FEC or None).

4- Choose the type of FEC It allows the user to select from 2 options Repetition Coding and Hamming Coding.

5- Write Number of Repetition Coding It will appear when Writing repetition coding .

6- Write Hamming Codes It will appear when Writing of Hamming Coding .

7- Label For Number of bits to enter the system.

8- Clear all Graphs:

It clears all graphs to start new comparison or new SNR Ranges.

9-Exit:

10- Multiple Graph to plot more than one graph over each other

11- Fair Compression to have fair basis of comparison

Closing The GUI.

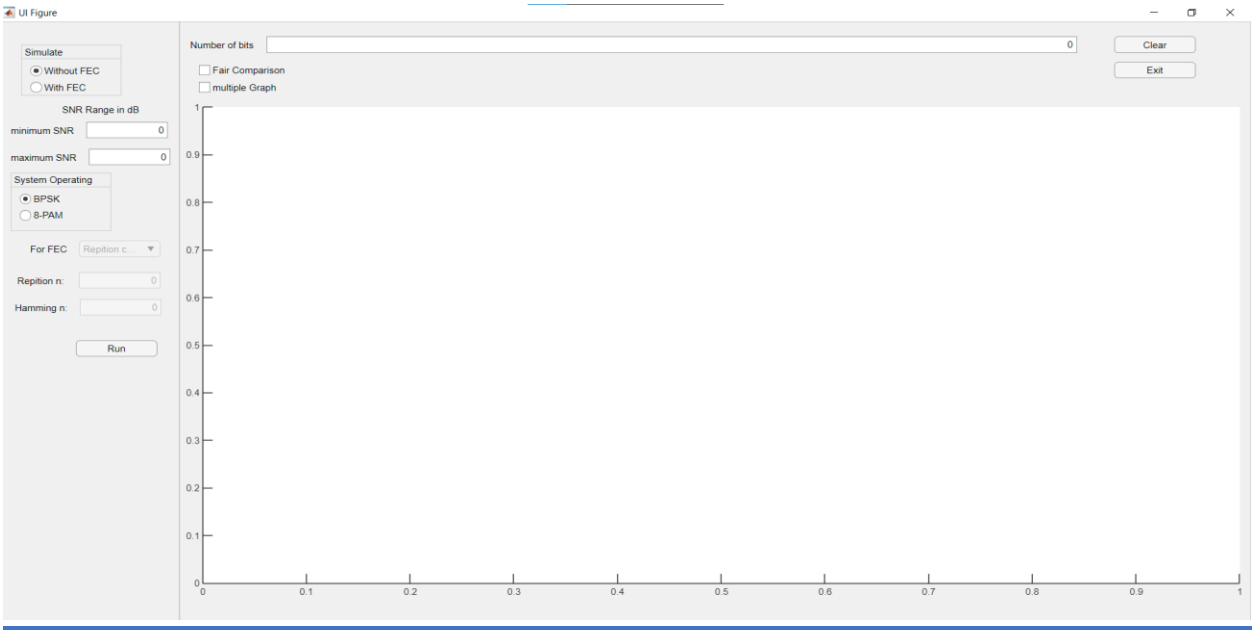

Figure 3 GUI

4.Simulation results and discussions.

4.1. Case 1: BPSK system operating over AWGN, without FEC

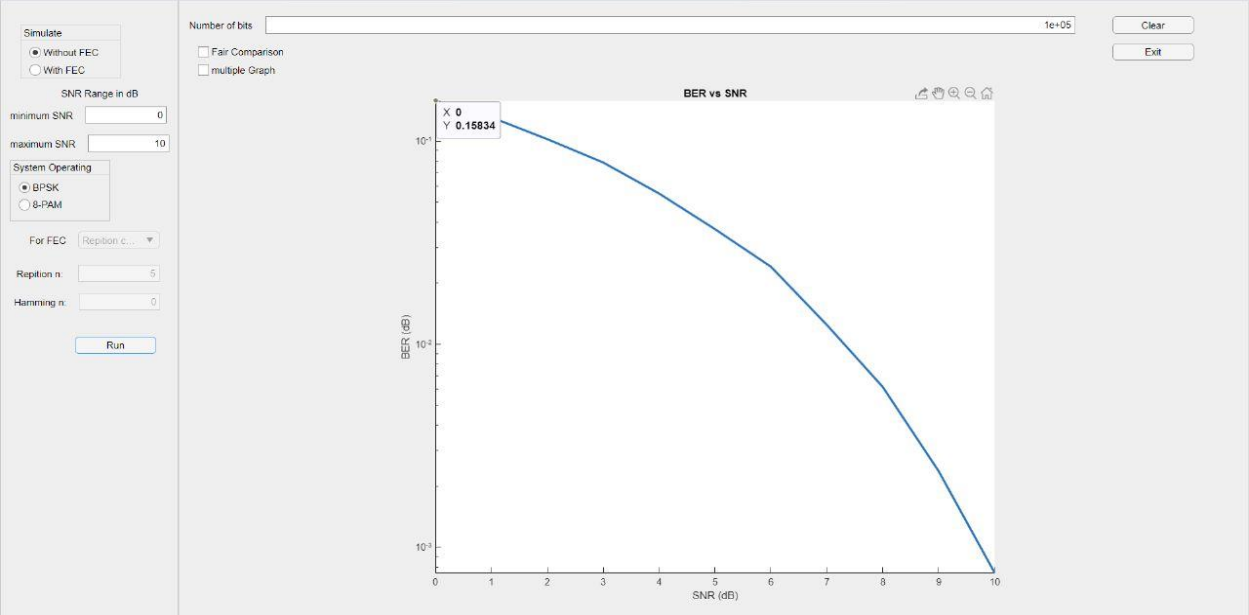

Figure 4 100000 bits using BPSK without FEC

4.2. Case 2: 8-PAM system operating over AWGN, without FEC

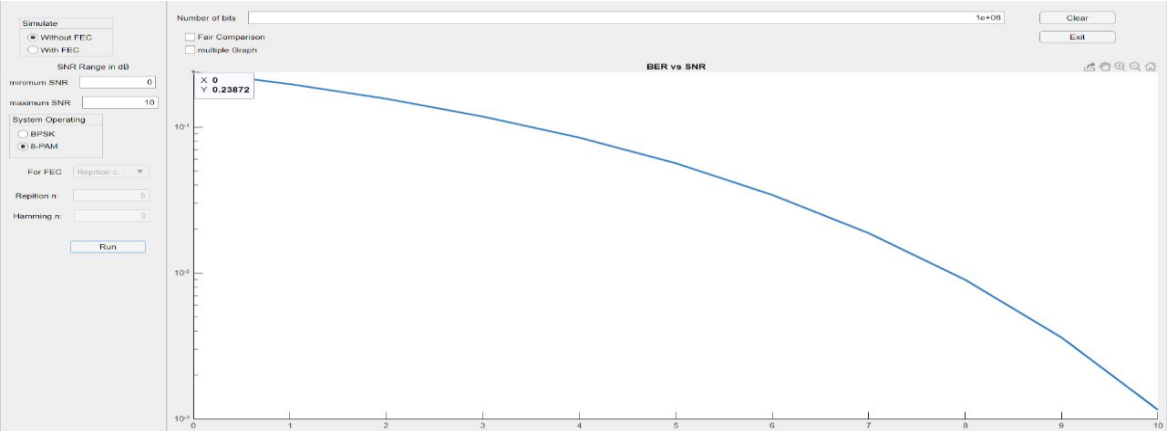

Figure 5 100000 bits of 8-PAM without FEC

4.3. Case 3: BPSK system operating with FEC with Specific N Repetition Code

@N=3

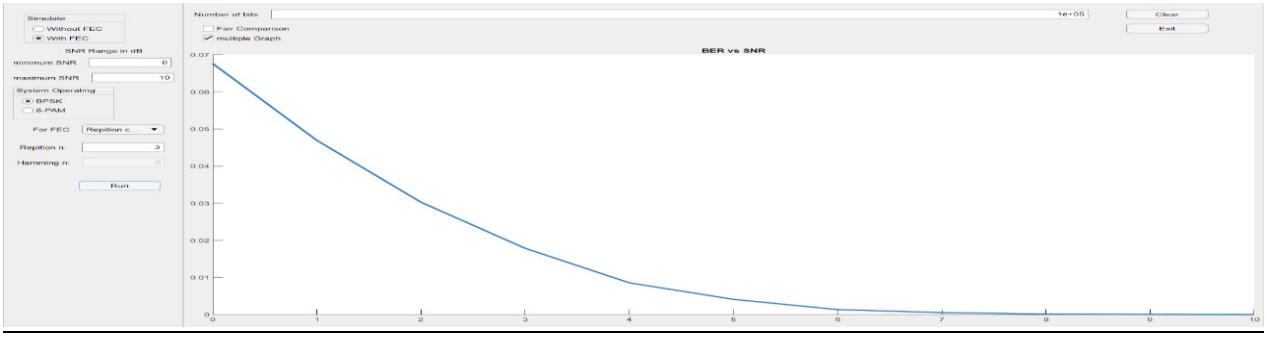

Figure 6 BPSK with FEC @N=3

@N=5

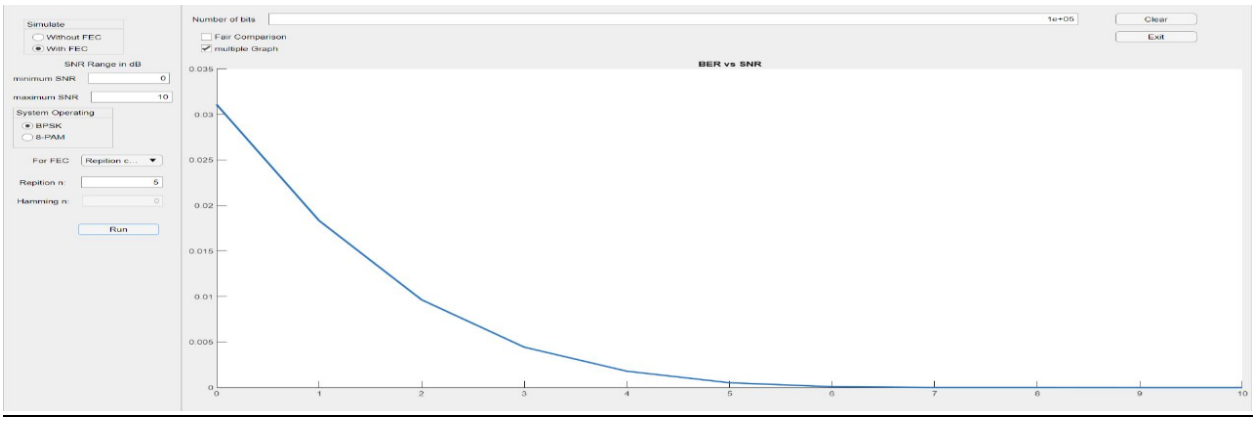

Figure 7 BPSK with FEC @N=5

4.4. Case 4: BPSK system operating with FEC with Hamming Code

A-Hamming Code (7,4)

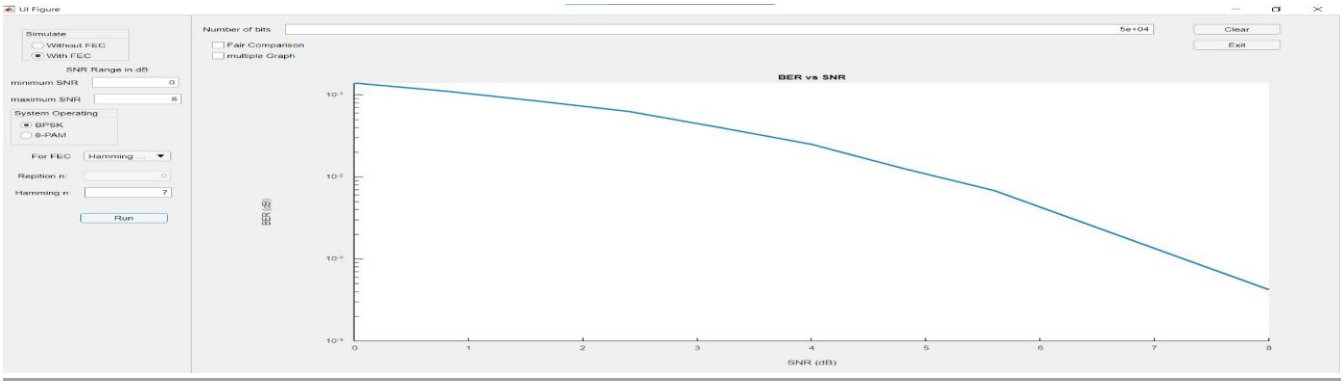

Figure 8 BPSK With FEC (7,4)

B-Hamming Code (15,11)

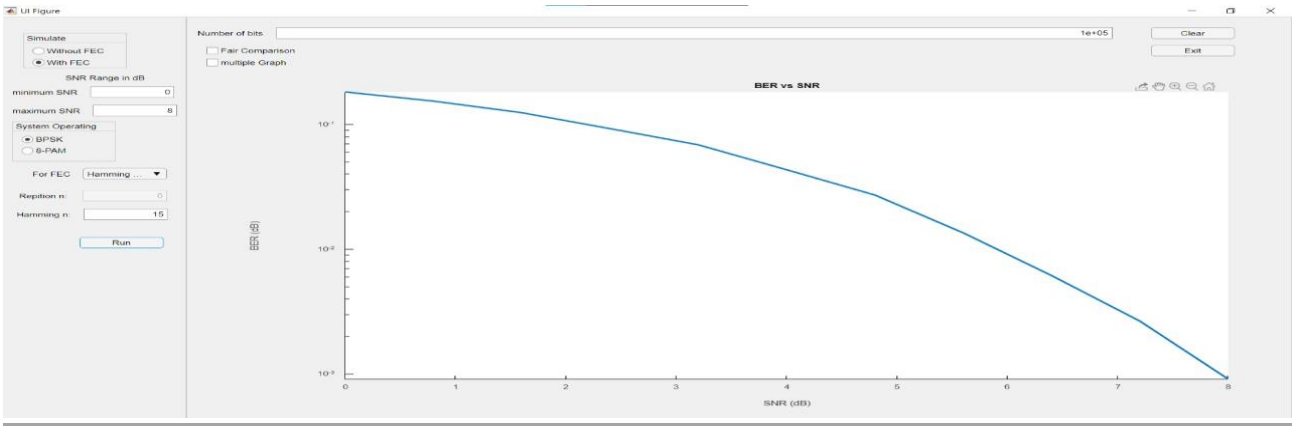

Figure 9 BPSK With FEC (15,11)

C-Hamming Code (31,26)

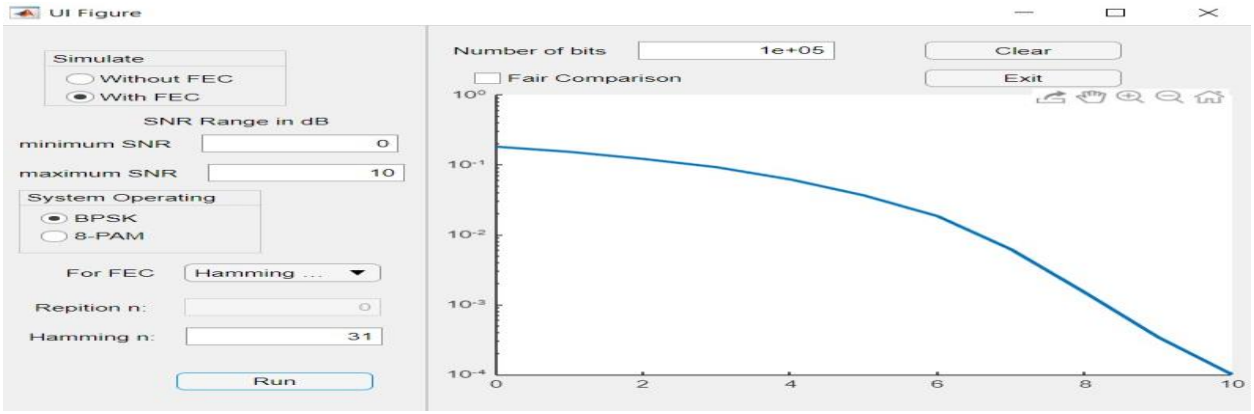

Figure 10 BPSK With FEC(31,26)

4.5. Case 5: 8-PAM system operating with FEC with Specific N Repetition Code

@N=3

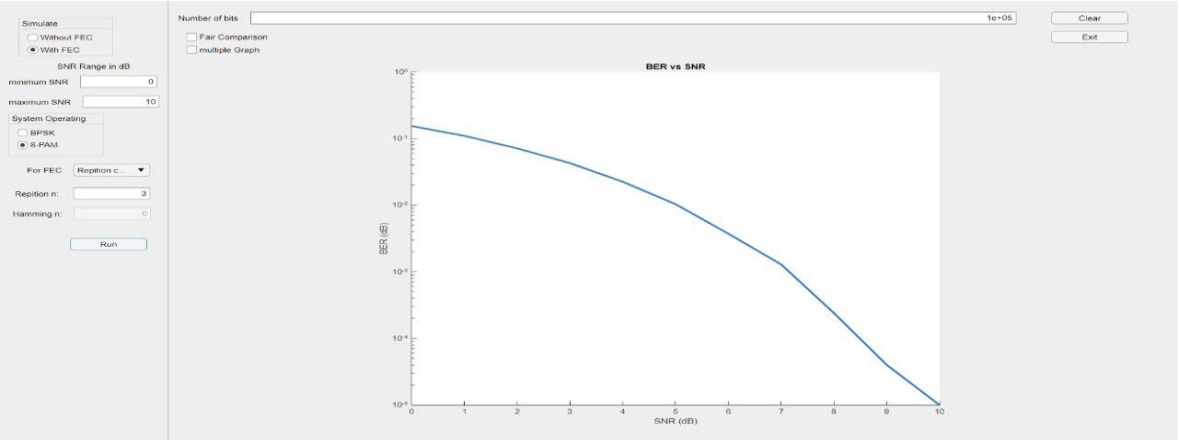

Figure 11 8-PAM With FEC @N=3 Repetition Code

@N=5

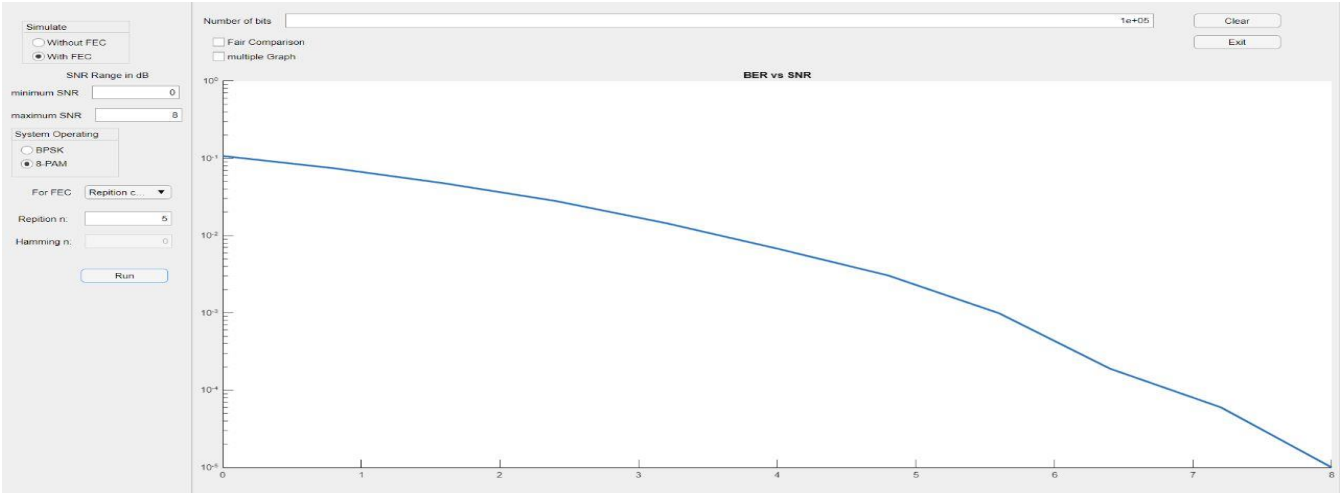

Figure 12 8-PAM With FEC @N=5 Repetition code

4.6. Case 6: 8-PAM system operating with FEC with Hamming Code

A-Hamming Code (7,4)

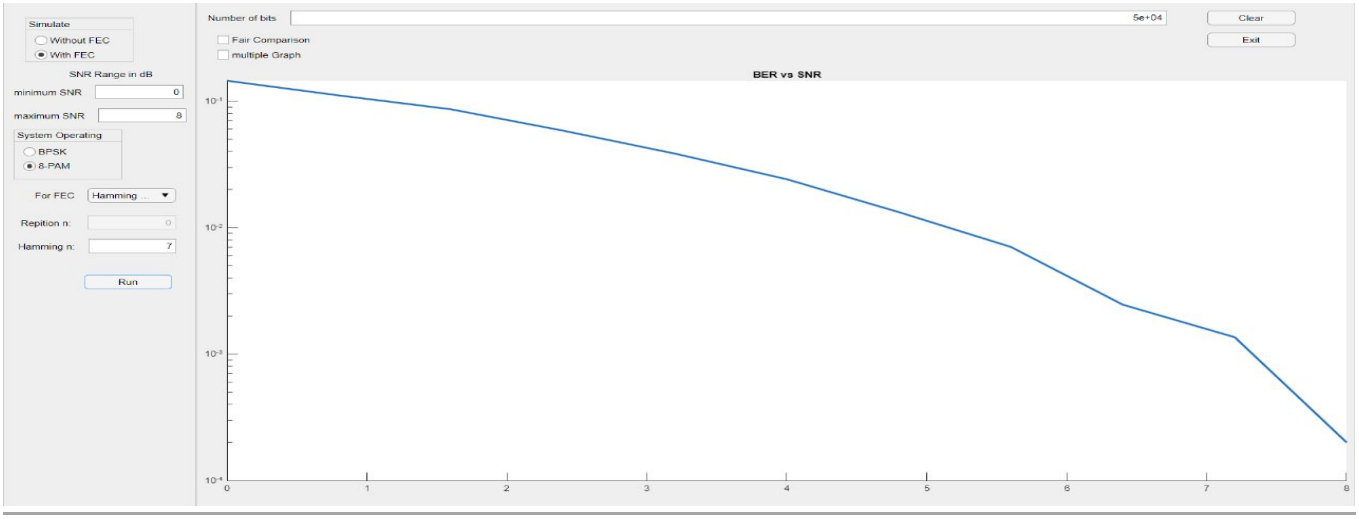

Figure 13 8-PAM With FEC with Hamming code(7,4)

B-Hamming Code (15,11)

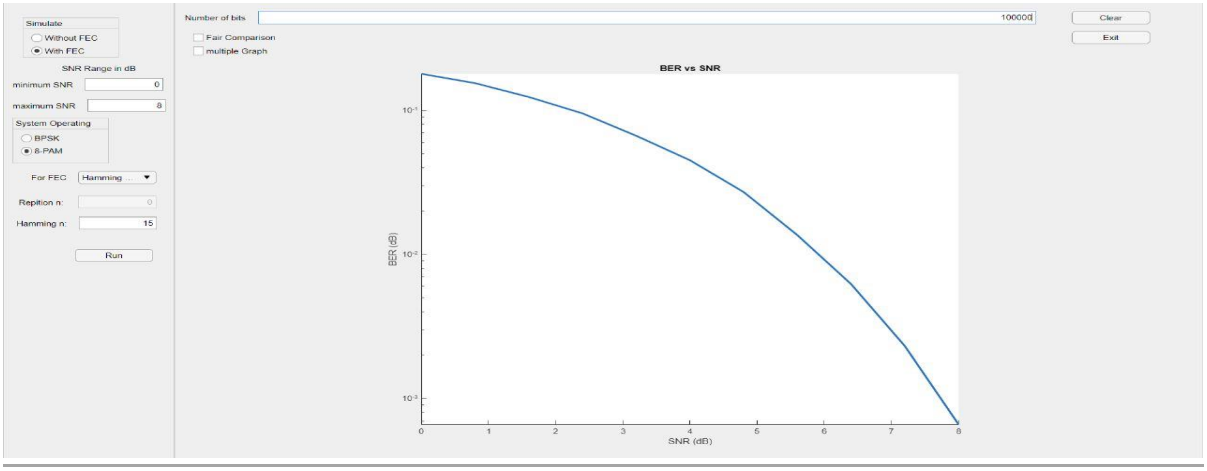

Figure 14 8-PAM With FEC with Hamming code(15,11)

C-Hamming Code (31,26)

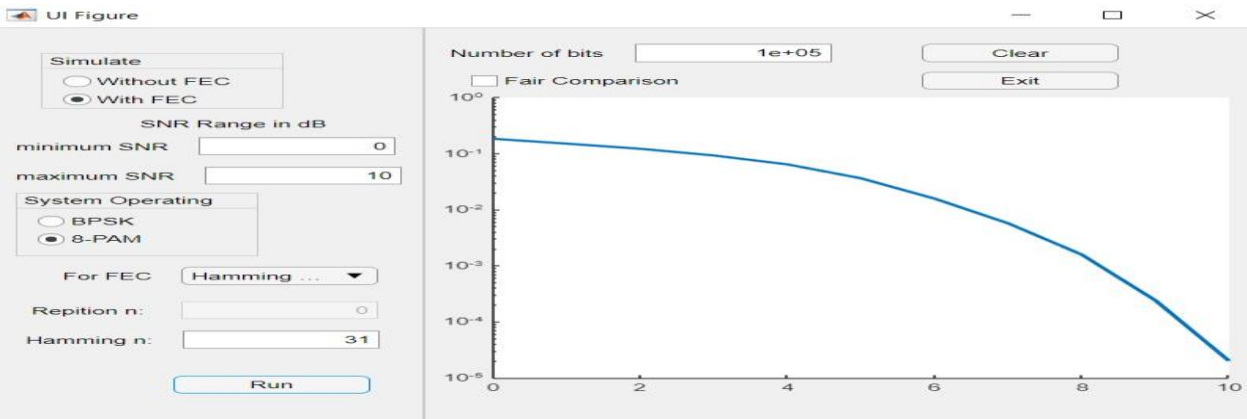

Figure 15 8-PAM With FEC With Hamming Code (31,26)

Comparison:

- BPSK Hamming (7,4) with and without Fair

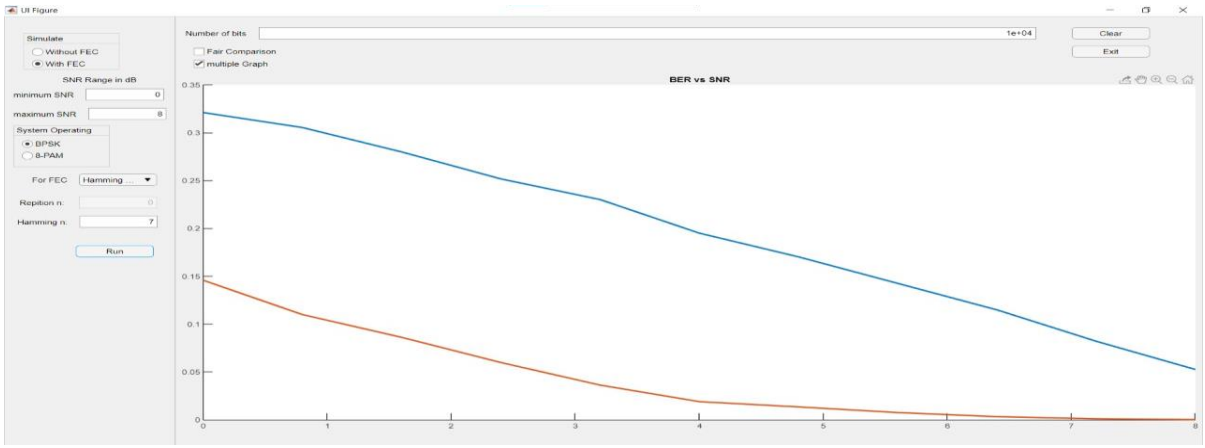

Figure 16 BPSK Hamming (7,4) Blue is Fair and orange without Fair @n=100000

- BPSK Repetition With and Without Fair @N=3

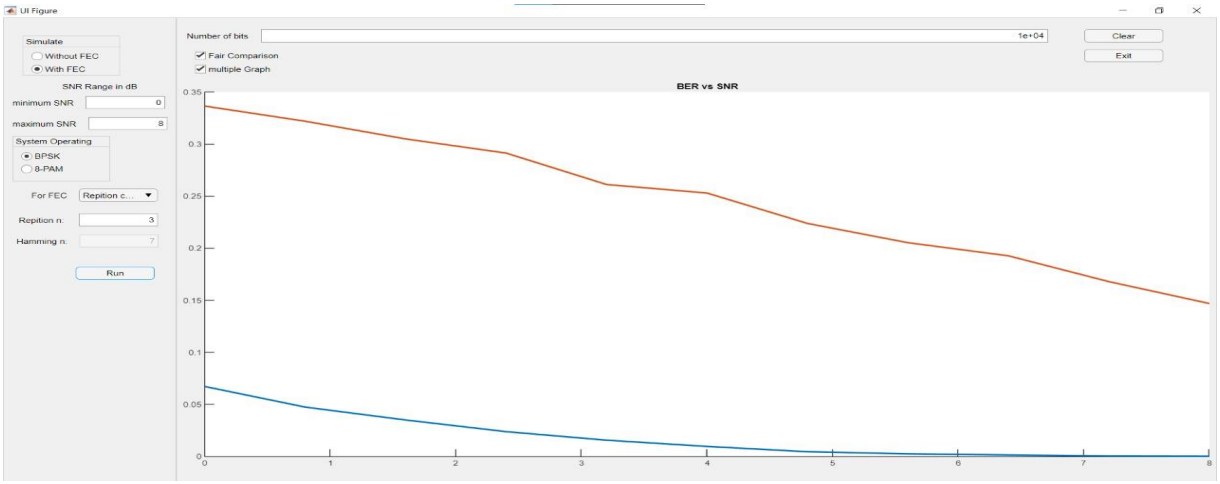

Figure 17 BPSK Repetition @N=3 Blue Without Fair and yellow with Fair

- 8-PAM With and Without Fair

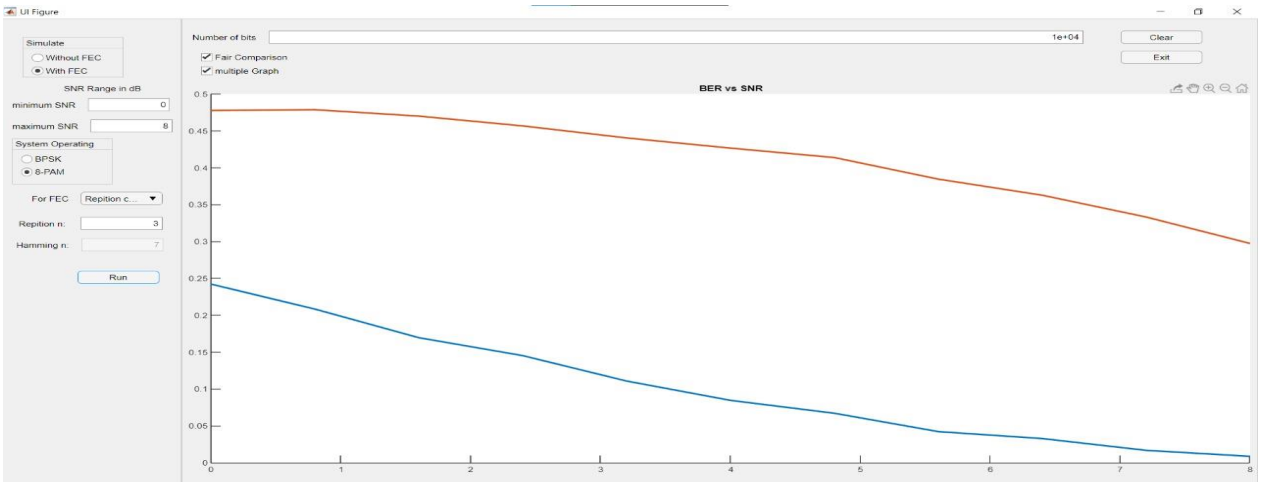

Figure 18 8-PAM blue without Fair and orange with Fair

- 8-PAM Repetition @N=3 With and Without Fair

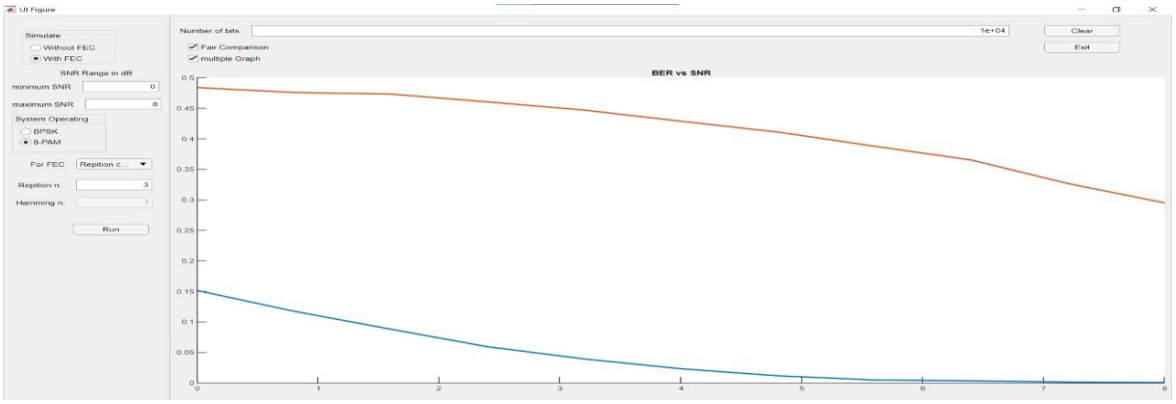

Figure 19 8-PAM Repetition @n=3 blue Without Fair and orange With Fair

- General comparison in 8-PAM

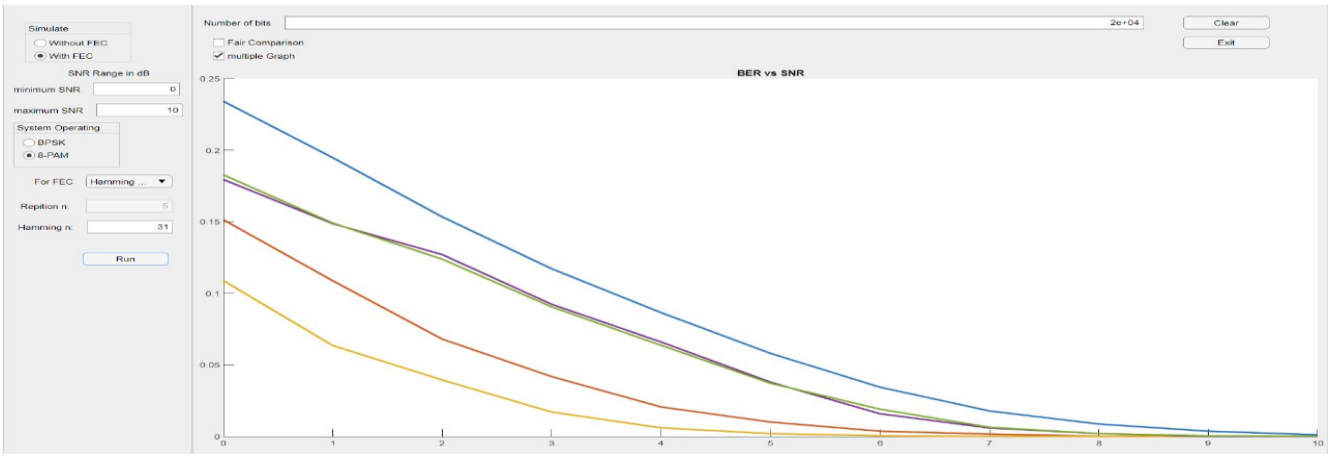

Figure 20 General comparison in 8-PAM

Here we will find BLUE:WITHOUT FEC, RED REPETITION N=3 ,YELLOW REPETITION N=5 ,PURPLE HAMMING N=15 ,GREEN:HAMMING N=31.

- *Repetition N @ 8-PAM and BPSK*

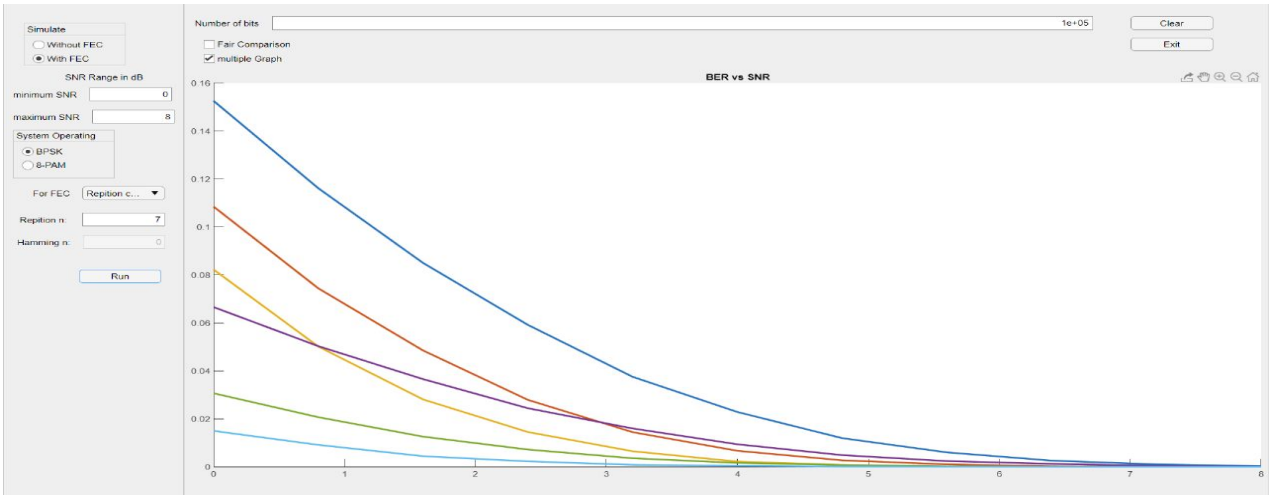

Figure 21 Repetition N @ 8-PAM and BPSK

We can find that 8-Pam for Blue @ 3, Orange @ N=5,Yellow@N=7 .we can conclude that by increasing N the BER decrease.

We can find that BPSK for Purple @ 3, Green @ N=5,Light blue @N=7 .we can conclude that by increasing N the BER decrease.

And BPSK has a less BER as shown in the graph.

- Without FEC For BPSK and 8-PAM

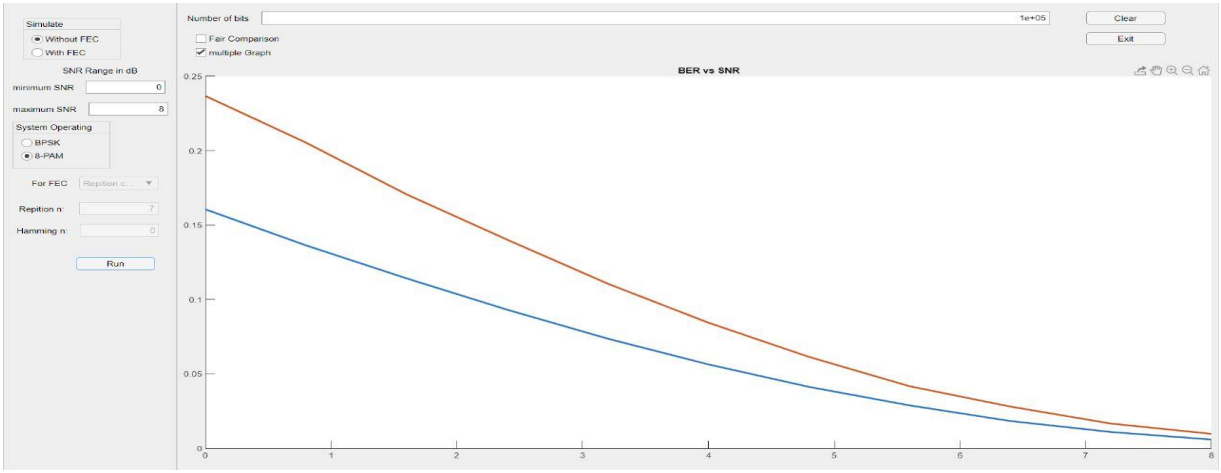

Figure 22 BPSK and 8-PAM Without FEC

Here is Orange For 8-PAM and Blue For BPSK and it's obvious that in modulation techniques BPSK has less BER.

- Comparison Between Hamming and Repetition and Without FEC

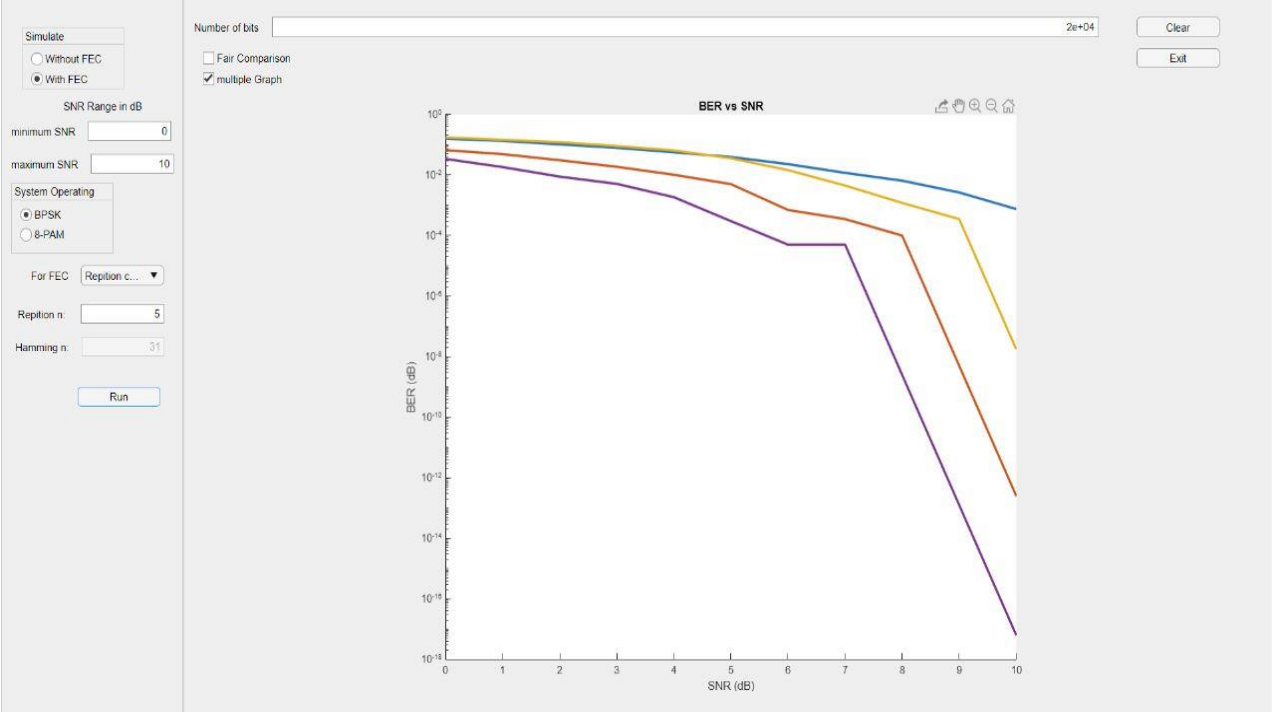

Figure 23 Comparison Between Hamming and Repetition and Without FEC

When repeated bits increased, we need to take majority role to retrieve correct data and in Hamming when increased by one we can't retrieve data as we get near to Bit rate .However ,it decreases BER .So, we have Tradeoff . Purple is BEST BER for having Repetition n=5.blue is without FEC .Yellow has hamming with 31.red has a repetition with n=3 and finally green has hamming with n=15.

Comments

- A fair case results in a lower performance.

- Fair cases have lowered performance slightly but still provide greater performance than no FEC.

- The trade-off between bit rate and BER performance exists.

- FEC produces better BER than without FEC.

-Bit rate is constant while amplitude has changed to maintain same information

energy.

-Repetition code with rate 1/5 has better BER performance than repetition code with

rate 1/3 as each bit has more parity bits to protect it. Nevertheless, Repetition

code with rate 1/5 has lower code rate hence lower information rate.

- Hamming code rate 11/15 has lower BER for a given SNR compared to hamming with

code rate 4/7 but it has a higher code rate.

- The BER curve for hamming codes is lower than that of repetition codes, but the code rate is higher, which is advantageous in terms of not wasting bandwidth.

- To achieve the Fair basis comparison (i.e. Same energy for each information bit), the amplitude became for repetition is A/sqrt(n) and for hamming is A/sqrt(n/k) or it could be achieved through snr where the snr range became equal snr - 10*log(n) for repetition and snr - 10*log(n/k) for hamming.