

EE2025 Independent Project (2019-20) Programming Assignment-1

Team Members :

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Transmitted bit sequence: [1 1 1 ... 0 0 0]
Transmitted Waveform (in terms of discrete values) is given by : [-1.      -1.22076639 -1.36184086 ...  0.36415666  0.69855681
 0.987355 ]
Received Waveform at Eb/No=-10 (in terms of discrete values) is given by : [ 15.28705283 -13.15499574 -6.3098823 ... 15.57206787  4.30762687
-22.37355794]
Received Bit Sequence at Eb/No=-10: [0. 1. 1. ... 0. 1. 0.]
No. of pixels that are wrongly pointed at Eb/No=-10: 3664
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Received Waveform at Eb/No=-5 (in terms of discrete values) is given by : [-8.347949  -10.14872977 -1.97356704 ... -3.06408992 11.96747275
-7.58038333]
Received Bit Sequence at Eb/No=-5: [1. 1. 1. ... 0. 0. 0.]
No. of pixels that are wrongly pointed at Eb/No=-5: 2384
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Received Waveform at Eb/No=0 (in terms of discrete values) is given by : [-2.36969107 -3.4758385  -1.28594201 ... -0.75244385 -5.76340878
 6.12308927]
Received Bit Sequence at Eb/No=0: [1. 0. 0. ... 1. 1. 0.]
No. of pixels that are wrongly pointed at Eb/No=0: 809
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Received Waveform at Eb/No=5 (in terms of discrete values) is given by : [-0.58795391 -2.10062572  0.5613966 ...  0.74779005 -0.09988949
 0.84211989]
Received Bit Sequence at Eb/No=5: [1. 1. 1. ... 0. 0. 0.]
No. of pixels that are wrongly pointed at Eb/No=5: 69
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In the above simulation (in terminal),

- (1) When $E_b/N_0 = -10\text{dB}$,Then the number of pixels that are wrongly pointed is equal to 3664.

We also can verify the above value by using \rightarrow the number of pixels that are wrongly demodulated will be approximately equal to $11000 \times \text{BER}$. And The bit error

rate (BER) of 4-QAM modulation scheme is $Q((2E_b/N_0)^{0.5})$ where Q is the Gaussian tail function.

Now E_b/N_0 in linear scale for this case ($E_b/N_0 = -10\text{dB}$) is equal to $10^{(-10/10)} = 0.1$. Therefore, $Q((0.2)^{0.5}) = 0.327360$ and hence the number of pixels that are wrongly demodulated will be approximately equal to $11000 \times 0.327360 = 3601$.

So There is not much difference between 3601 and 3664. So the simulated results can be assumed as true.

- (2) When $E_b/N_0 = -5\text{dB}$, Then the number of pixels that are wrongly pointed is equal to 2384.

In this case, E_b/N_0 in linear scale = $10^{(-0.5)} = 0.316228$.

Therefore, $Q((0.63245)^{0.5}) = 0.213228$ and hence the number of pixels that are wrongly demodulated will be approximately equal to $11000 \times 0.213228 = 2345$.

So There is not much difference between 2345 and 2384. So the simulated results can be assumed as true.

- (3) When $E_b/N_0 = 0\text{dB}$, Then the number of pixels that are wrongly pointed is equal to 809.

In this case, E_b/N_0 in linear scale = $10^{(0)} = 1$. Therefore, $Q((2)^{0.5}) = 0.0786810$ and hence the number of pixels that are wrongly demodulated will be approximately equal to $11000 \times 0.0786810 = 865$.

So There is not much difference between 865 and 809. So the simulated results can be assumed as true.

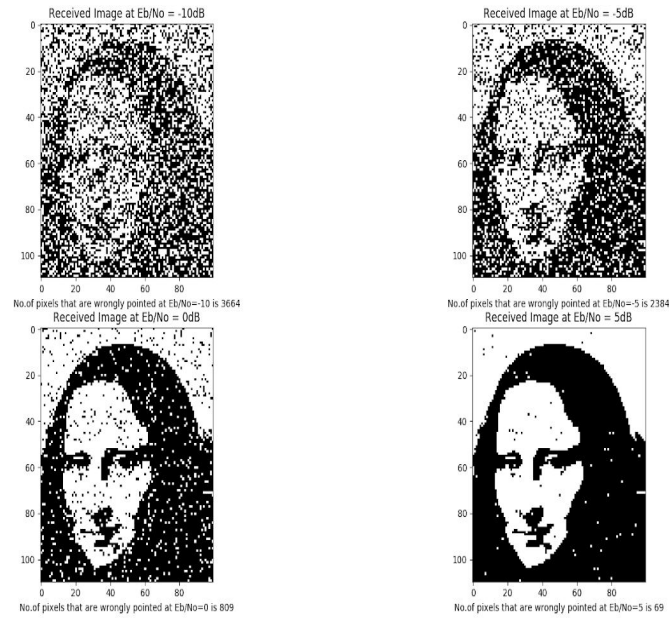
- (4) When $E_b/N_0 = 5\text{dB}$, Then the number of pixels that are wrongly pointed is equal to 69.

In this case, E_b/N_0 in linear scale = $10^{(0.5)} = 3.162278$.

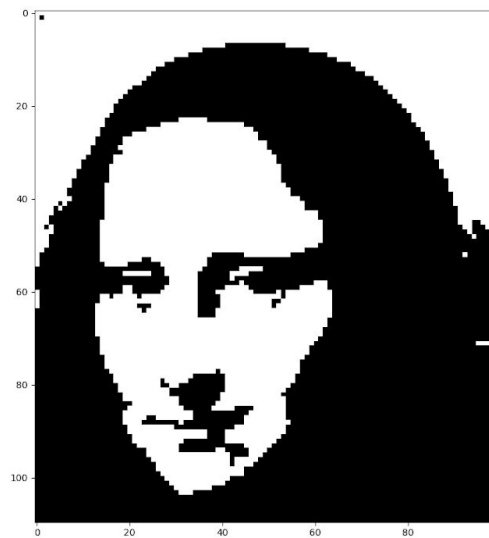
Therefore, $Q((6.3245532)^{0.5}) = 0.00595387$ and hence the number of pixels that are wrongly demodulated will be approximately equal to $11000 \times 0.00595387 = 65$.

So There is not much difference between 65 and 69. So the simulated results can be assumed as true.

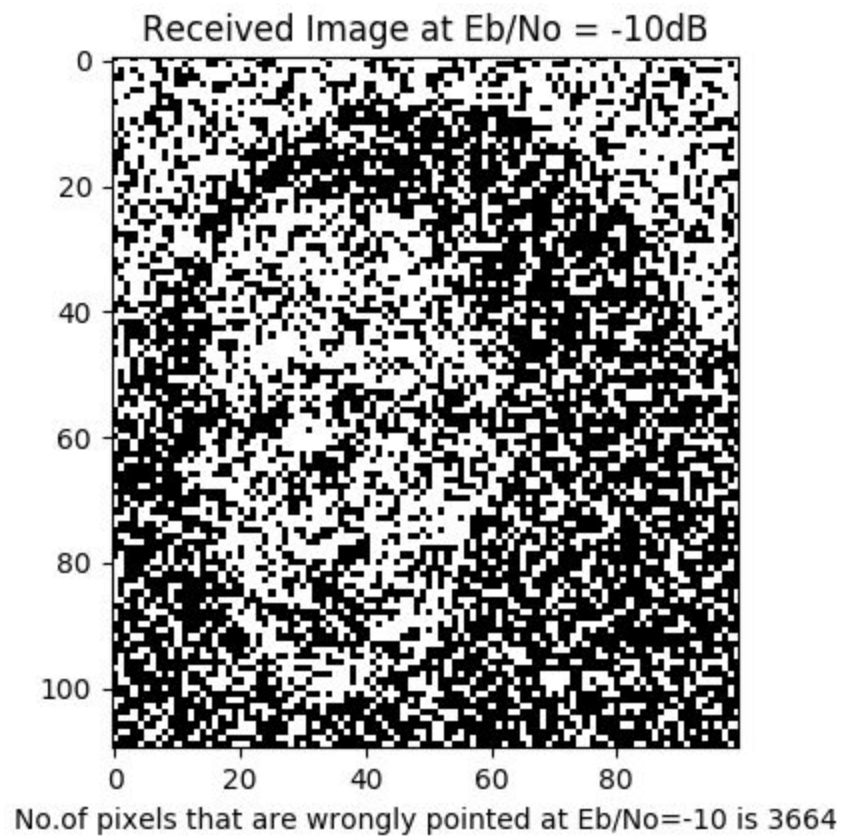
We got the following Figures (in combined form for all given Eb/No values) :

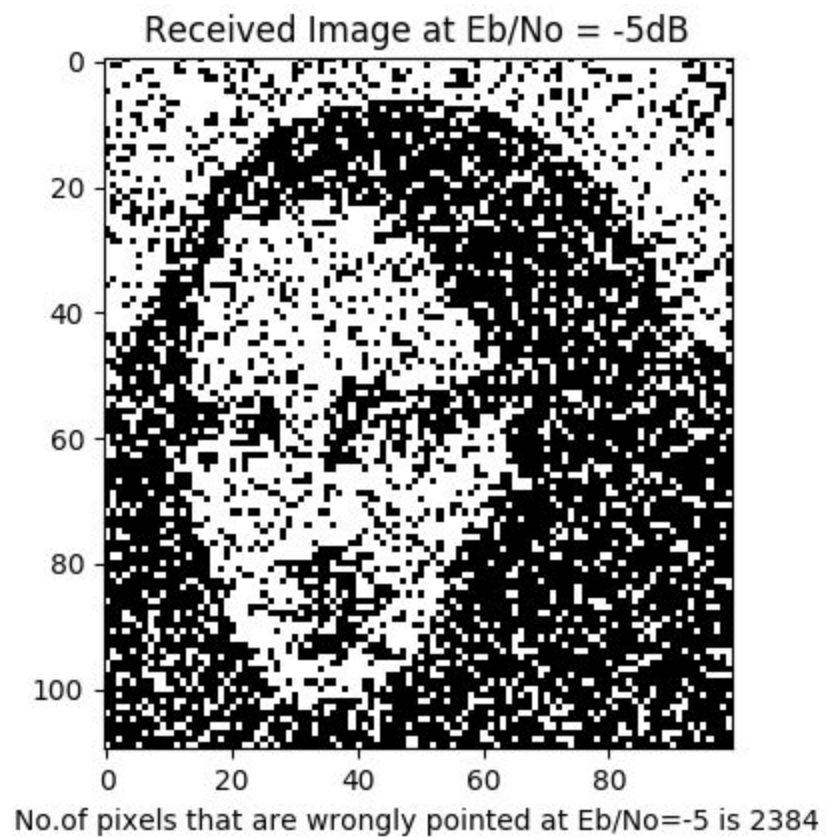


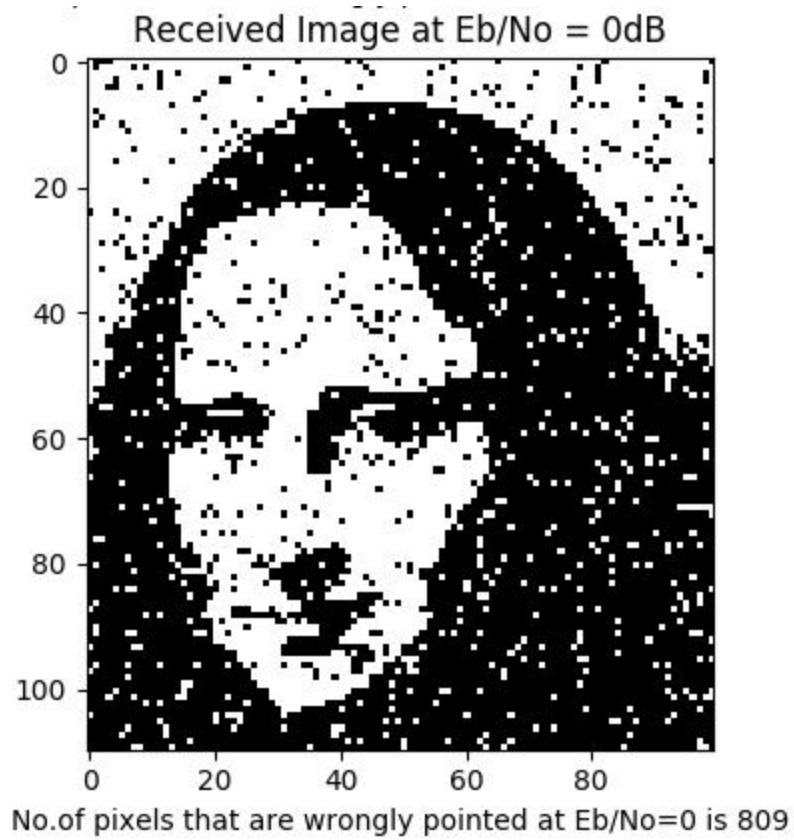
The original image is given by :

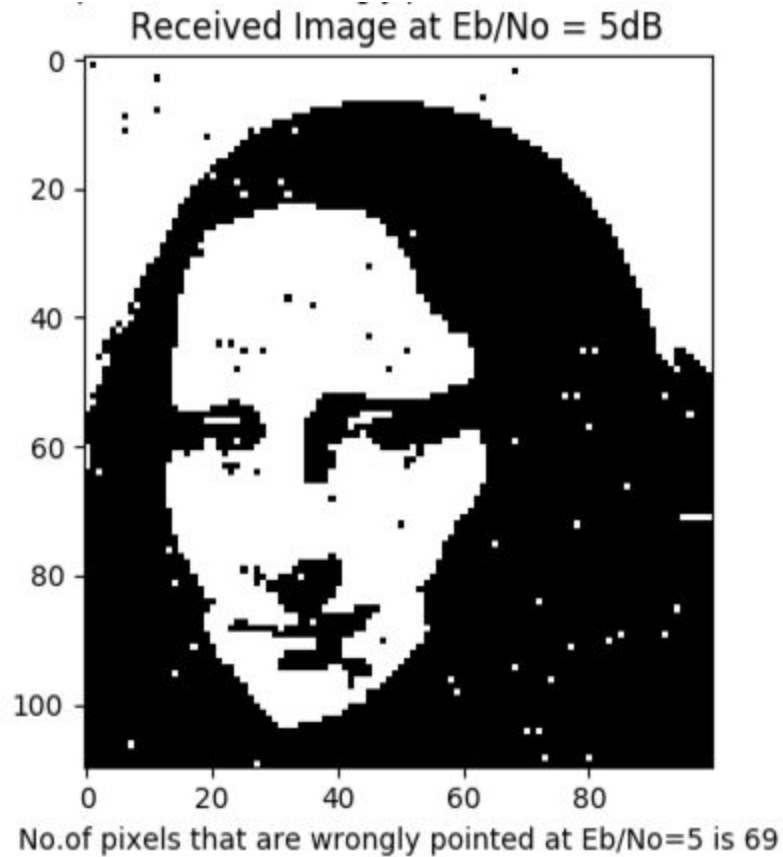


The individual figures that we got (Image plots) are:









These are the results that we got after simulation.

Also we will not get the same results each time after running the program because the AWGN noise can be random at each time of running.