LDPC Code

- The LDPC code, namely low density parity check code, is essentially a linear block code.
- LDPC codes provide a means to control errors in data transmissions over unreliable or noisy communication channels.
- LDPC can be use in both BSC and BEC channel.

LDPC Code-Encoding

- LDPC code encode k message bit into n bit where n>k.
- n-k is the size of Syndrome vector which is used for error correction and detection.
- LDPC code transfer k-bit into n-bit by Generator matrix(G).
- The dimension of Generator matrix is n x k. This n x k matrix multiply with

k x 1 vector of message which will give n x 1 vector. That n x 1 vector is our codeword which will transfer through the channel.

C(nx1) =

C=Codeword Matrix

G=Generator Matrix

M=Information Matrix

$$
\begin{array}{c}
\begin{array}{ccccccccccccccc} c_0 & c_1 & c_2 & c_3 & c_4 & c_5 & c_6 & c_7 & c_8 & c_9 & c_{10} & c_{11} & c_{12} & c_{13} & c_{14} \end{array} \\
\begin{array}{c} i_0 \\ i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \\ i_6 \end{array}
\left[\begin{array}{ccccccccccccccc}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1
\end{array}\right] \\
\underbrace{\qquad\qquad\qquad\qquad}_{I}\ \underbrace{\qquad\qquad\qquad\qquad}_{X}
\end{array}
$$

LDPC-Decoding

- LDPC code decode n-bit to check whether it have an error or not,It uses Parity-check matrix(H) for decoding.
- The dimension of H matrix is (n-k) x k.
- It multiply the H matrix to the codeword which we have received over channel. it will the (n-k)x1 matrix which is called Syndrome Matrix,if that matrix is zero matrix then we can say that there is no error in the codeword but if it is non-zero then there is error in the codeword.

$$S(n-k \times 1) = H(n-k \times n) * C(n \times 1)$$

C=Codeword Matrix

H=Parity check Matrix

S=Syndrome Matrix

$$\mathbf{H} = \begin{bmatrix} 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

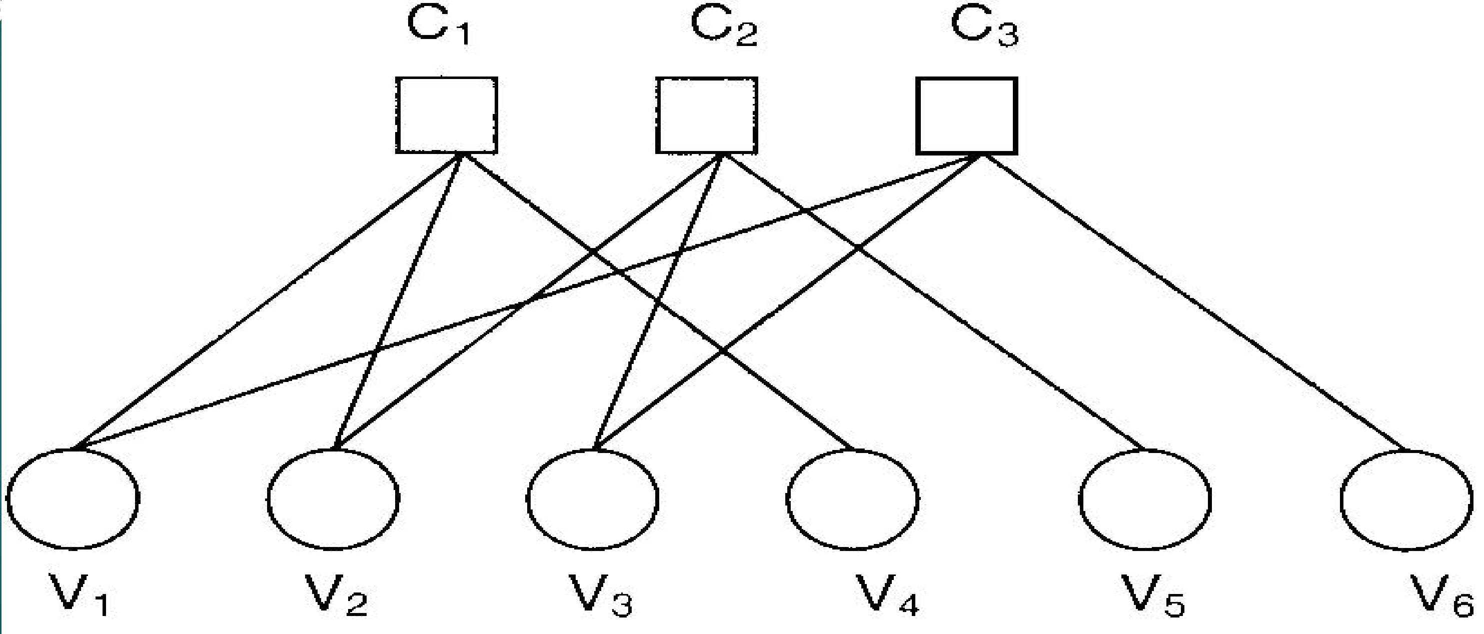
Product Code

- Product Codes are a special case of LDPC code.
- Product code are restricted as the last rows and last columns of H

  matrix is for parity checking,
- If k i.e. #message bits increases then the size of parity check matrix increases squarely, but the parity check bits in n-bit message increases linearly.
- Hence the power of product code decreases as k increases and hence on a noisy channel if data is transmitted with large k.

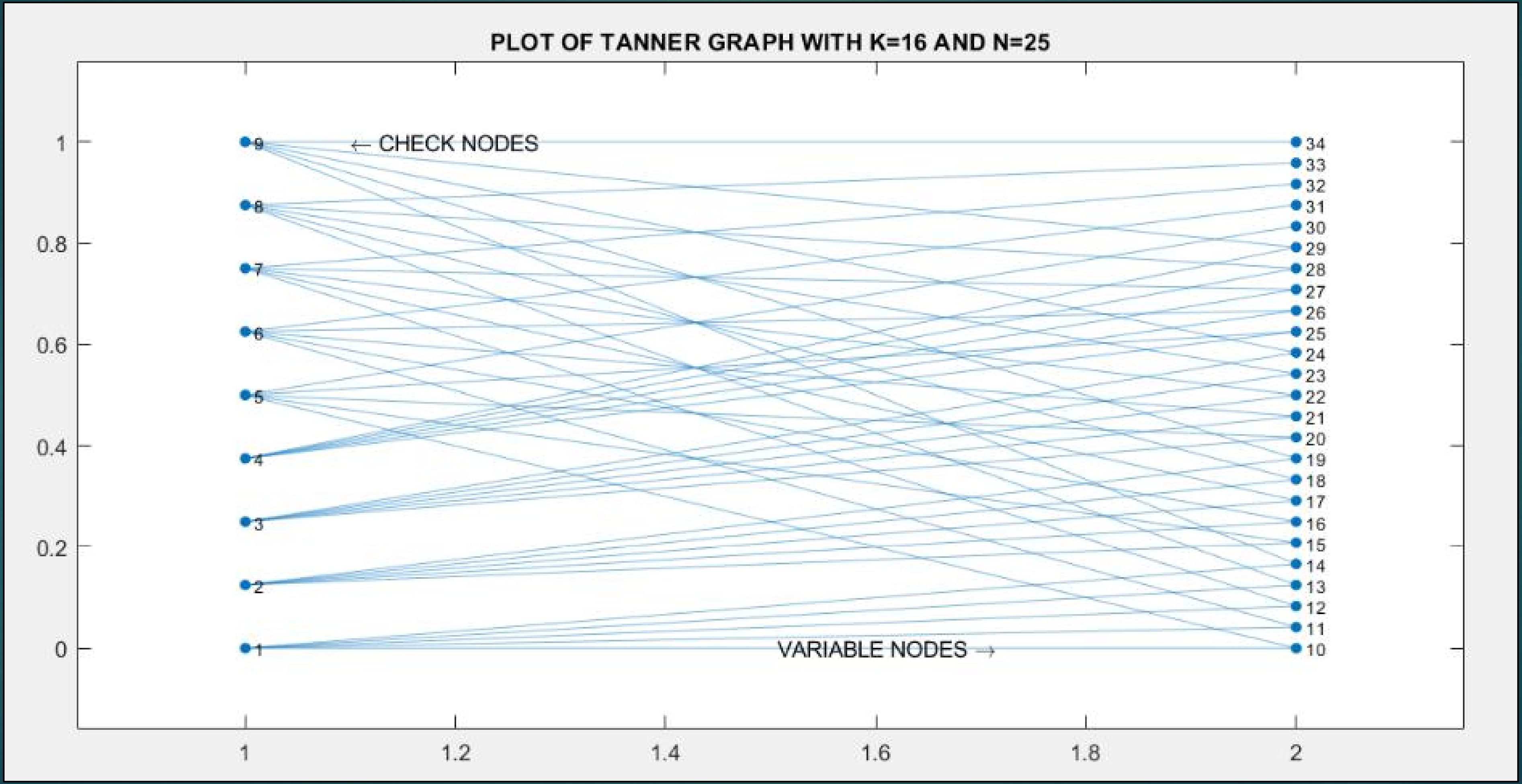
Message Passing

- Message Passing is for correction the error.Here,All the bit of codeword is called Variable nodes(VN) and all the bit Syndrome is called check nodes(CN).
- Message can be passed from VN to CN and CN to VN.But message can not passed from VN to VN or CN to CN.
- It will wo … ph.



Tanner Graph

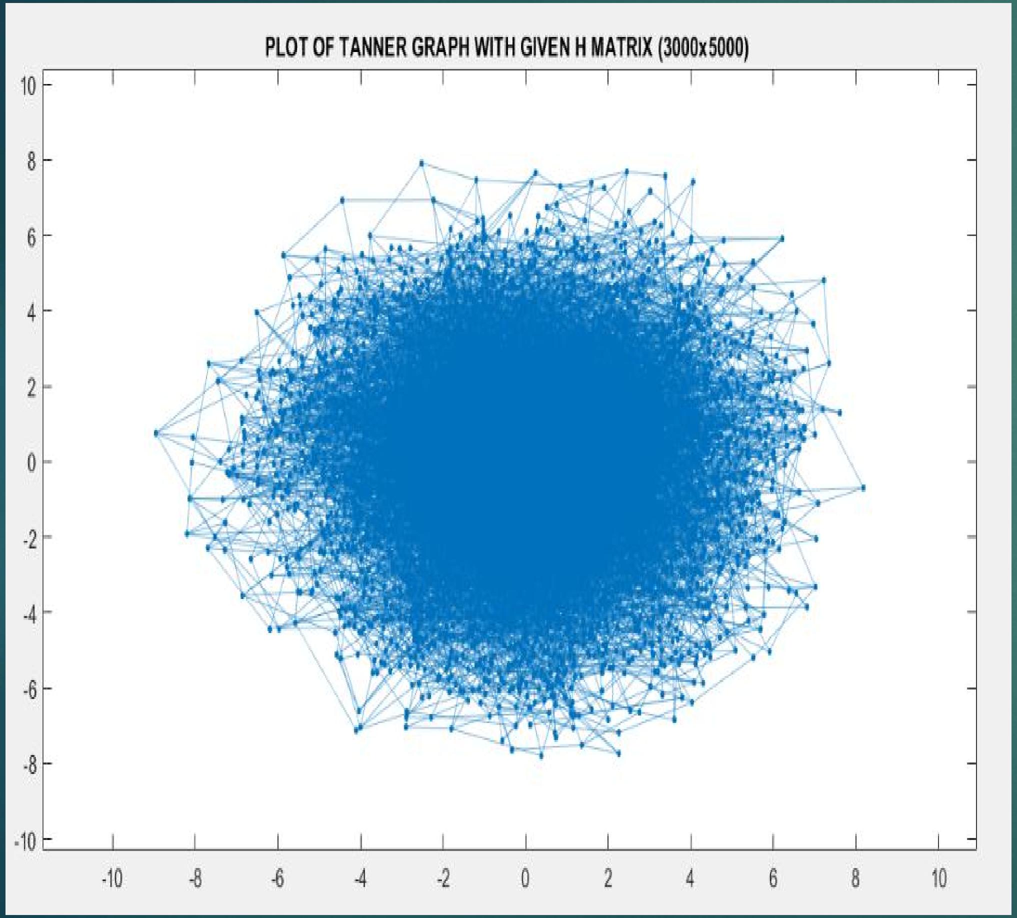
- For n=25 and k=16

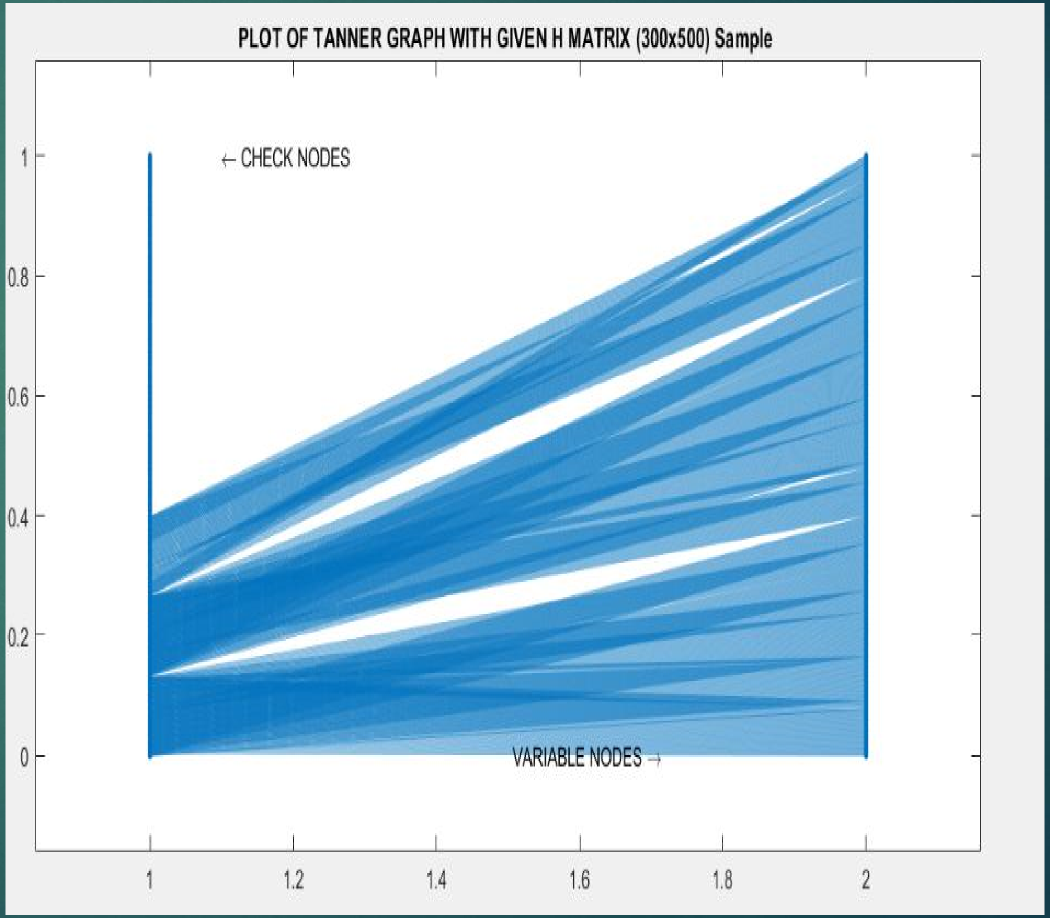


Tanner Graph

- For n=5000 and k=2000

for H(1:300,1:500)



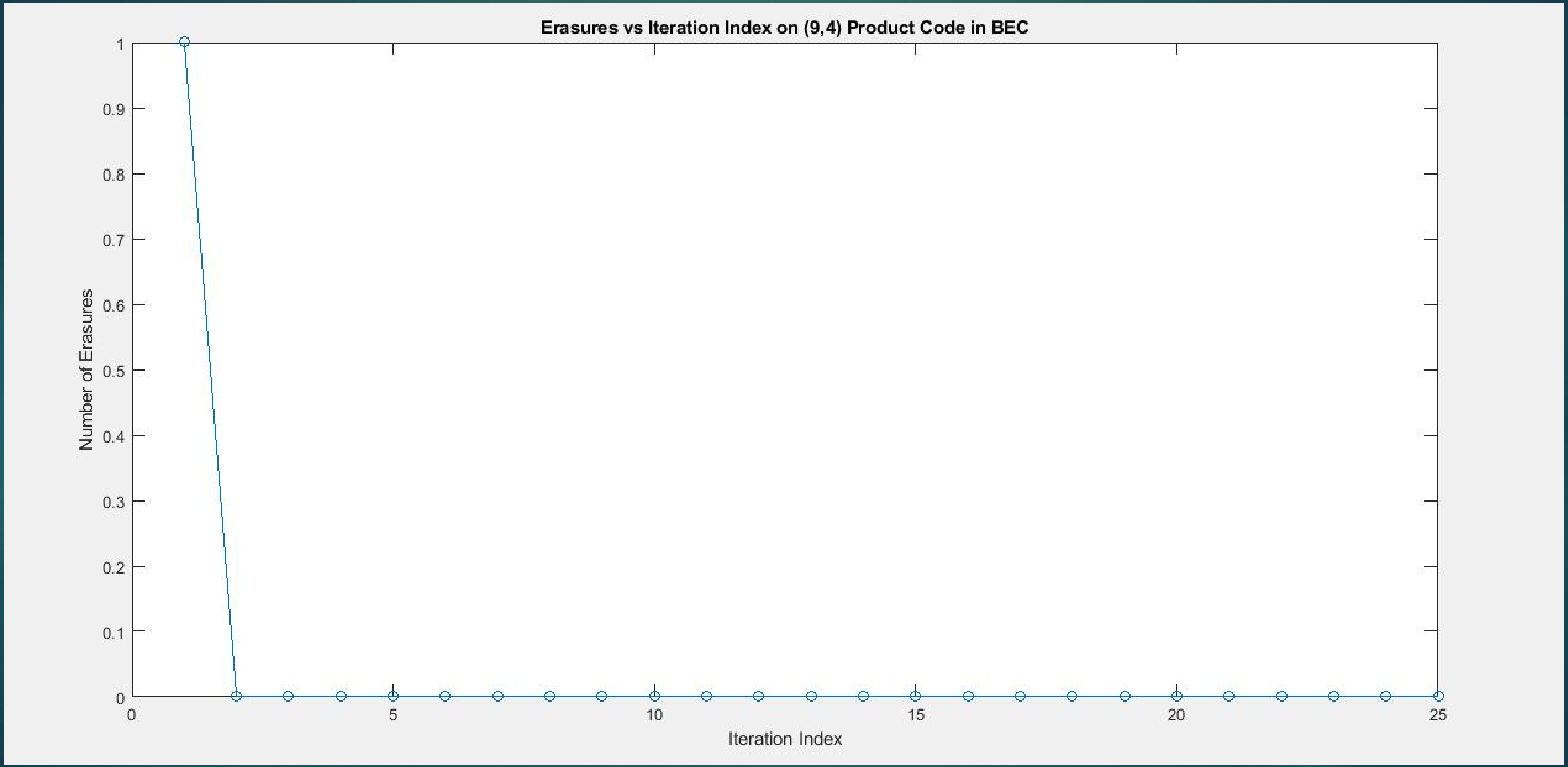


Message Passing Decoding on Product Code(9,4) over BEC

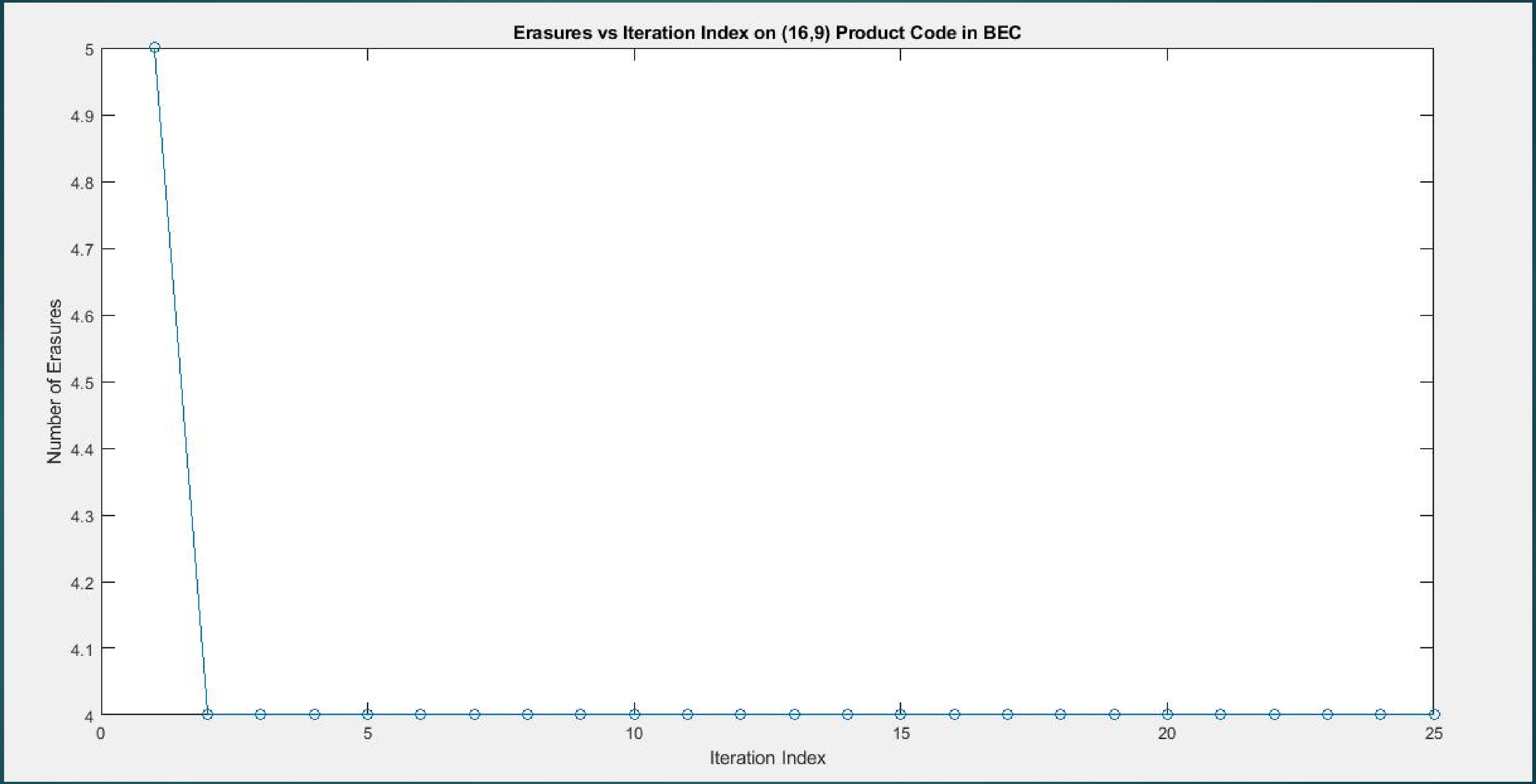
Command Window

```
>> codeword_reshaped

codeword_reshaped =

     1     1     0     0     1     1     1     0     1

>> codeword_noisy

codeword_noisy =

     1    -1     0     0    -1    -1     1     0     1

>> decoded_codeword

decoded_codeword =

     1     1     0     0     1     1     1     0     1

fx >>
```

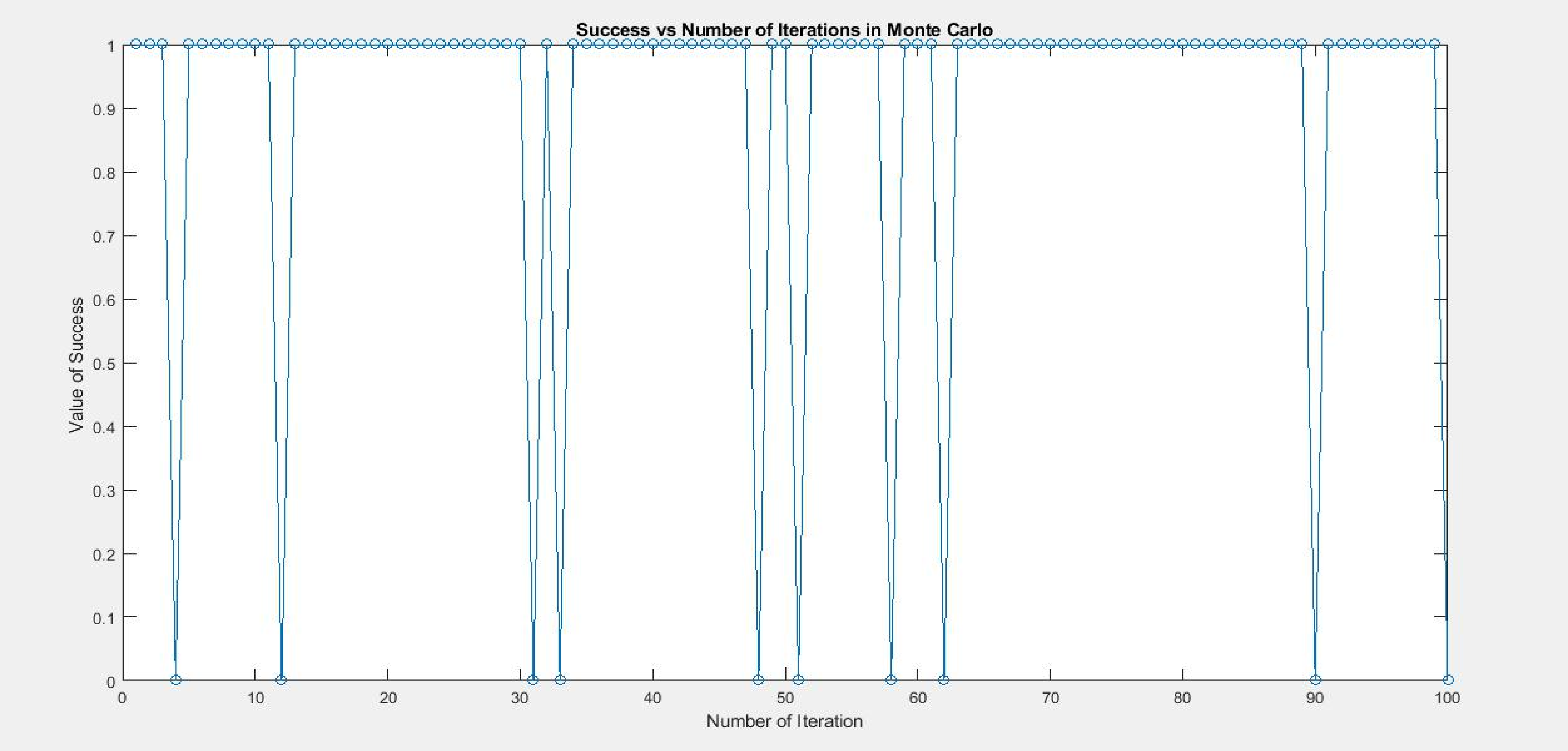
BEC Simulation- For (9,4) Product Code



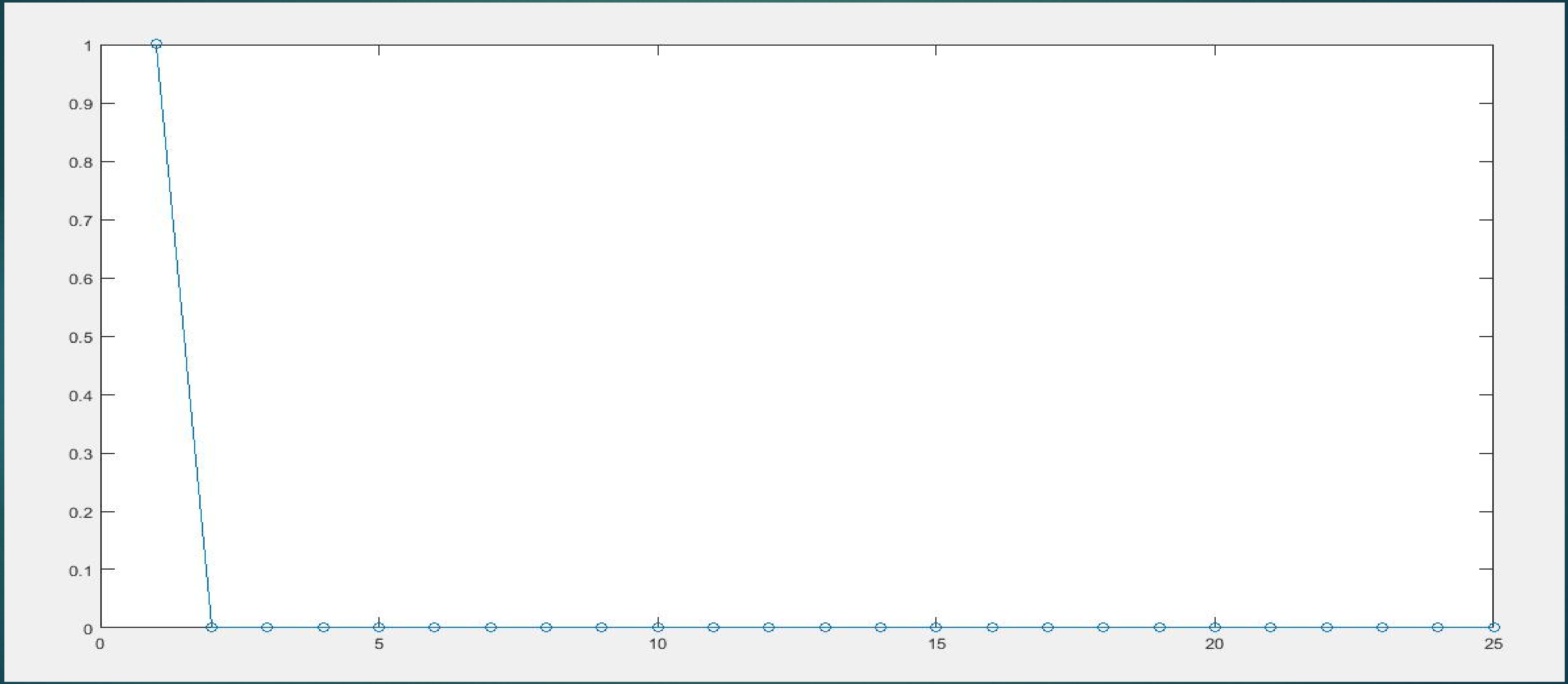
BEC Simulation- For (16,9) Product Code



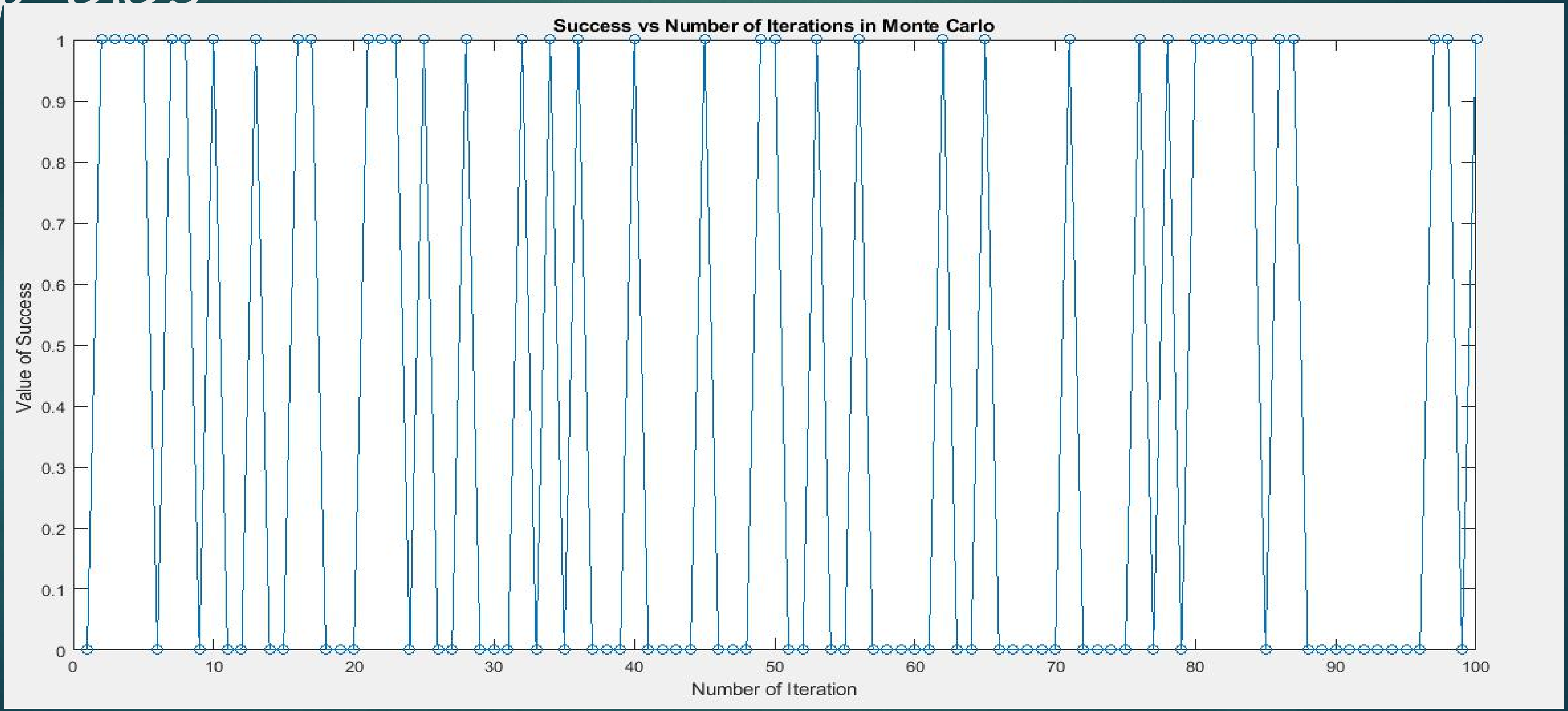
Monte Carlo Simulation- BEC Product Code(9,4)



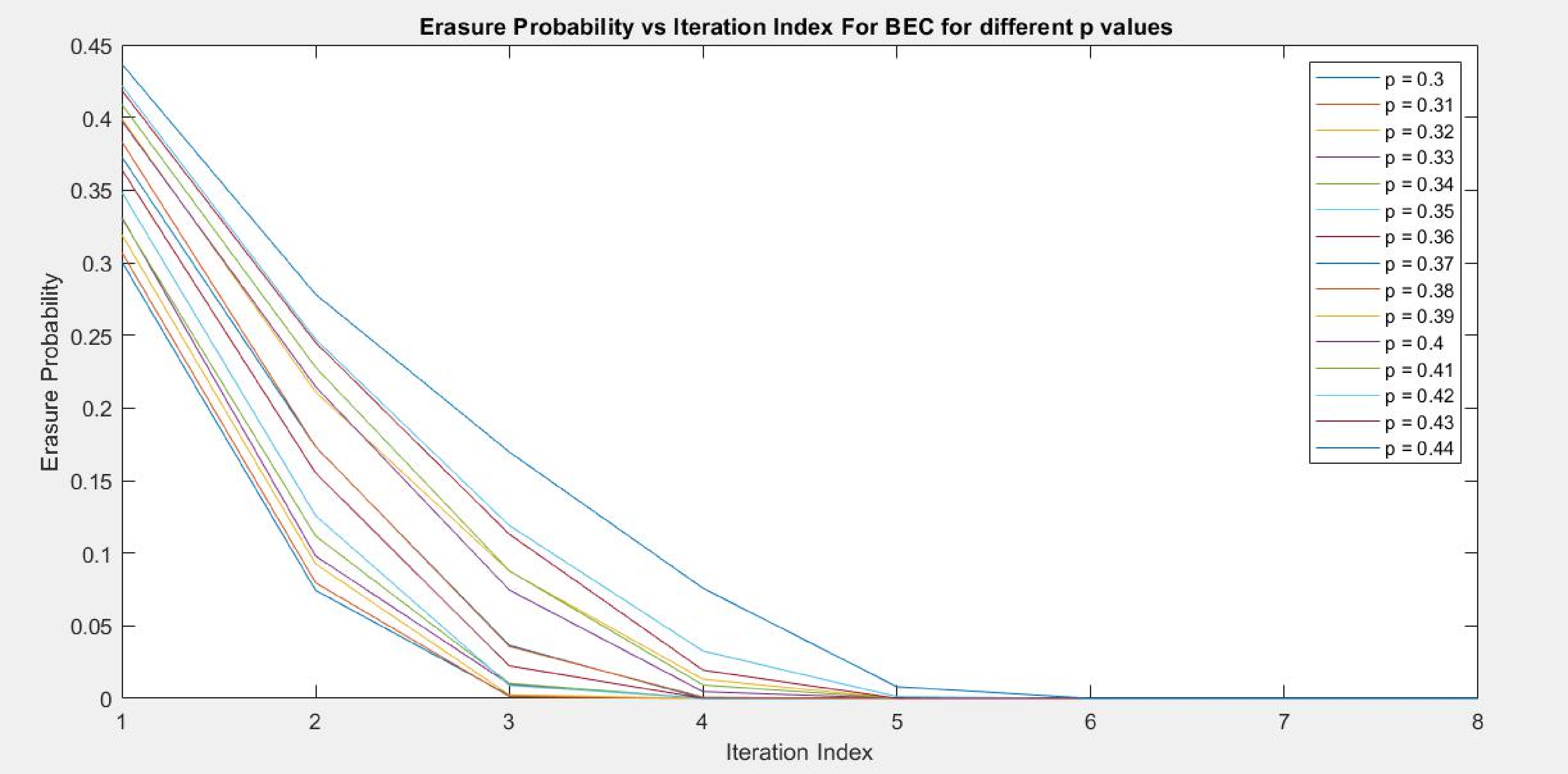
BSC Simulation- For (25,16) Product Code (Bit Errors vs Iteration Index)



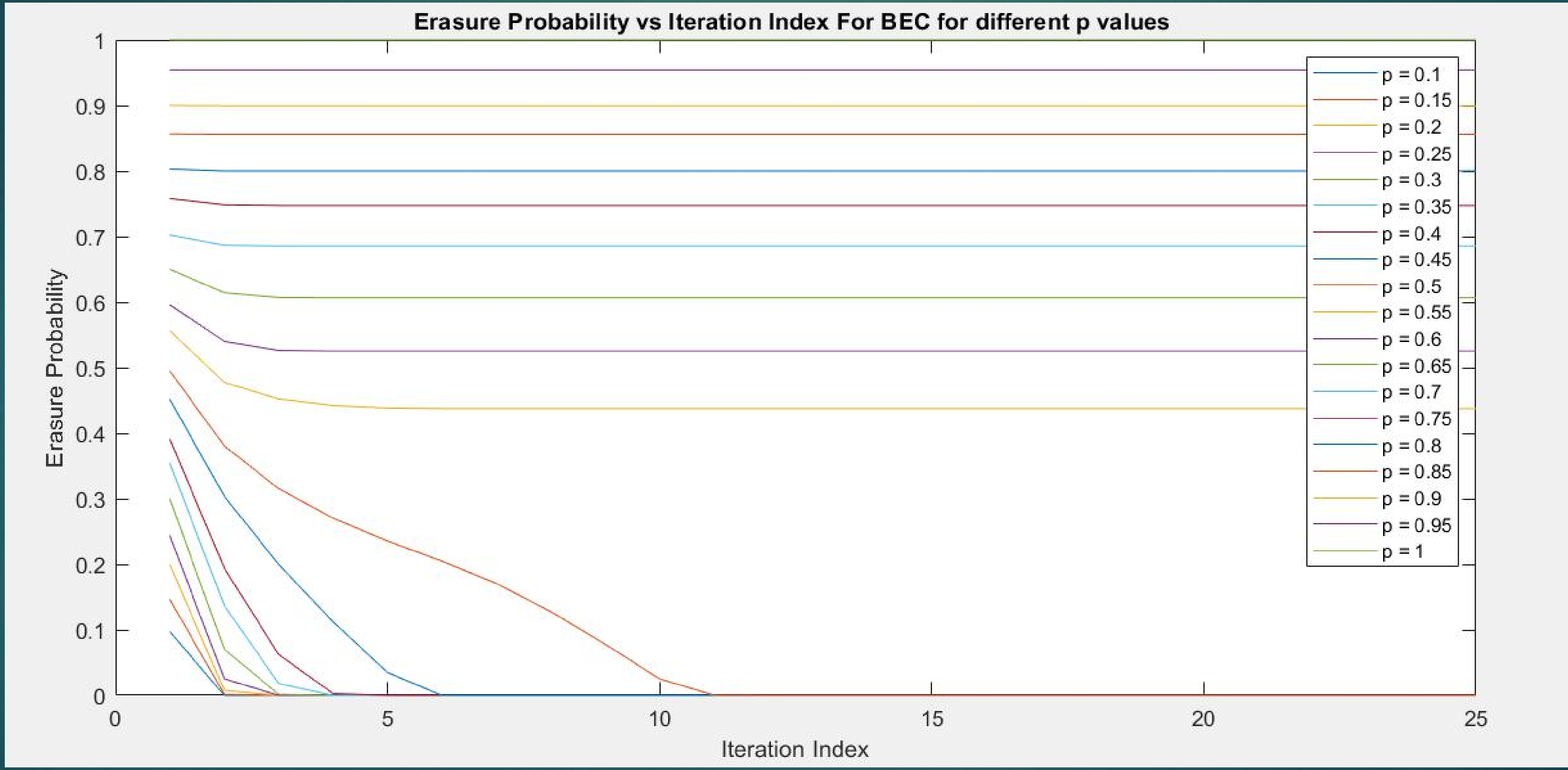
Monte Carlo Simulation- BSC Product Code(25,16)
p=0.05



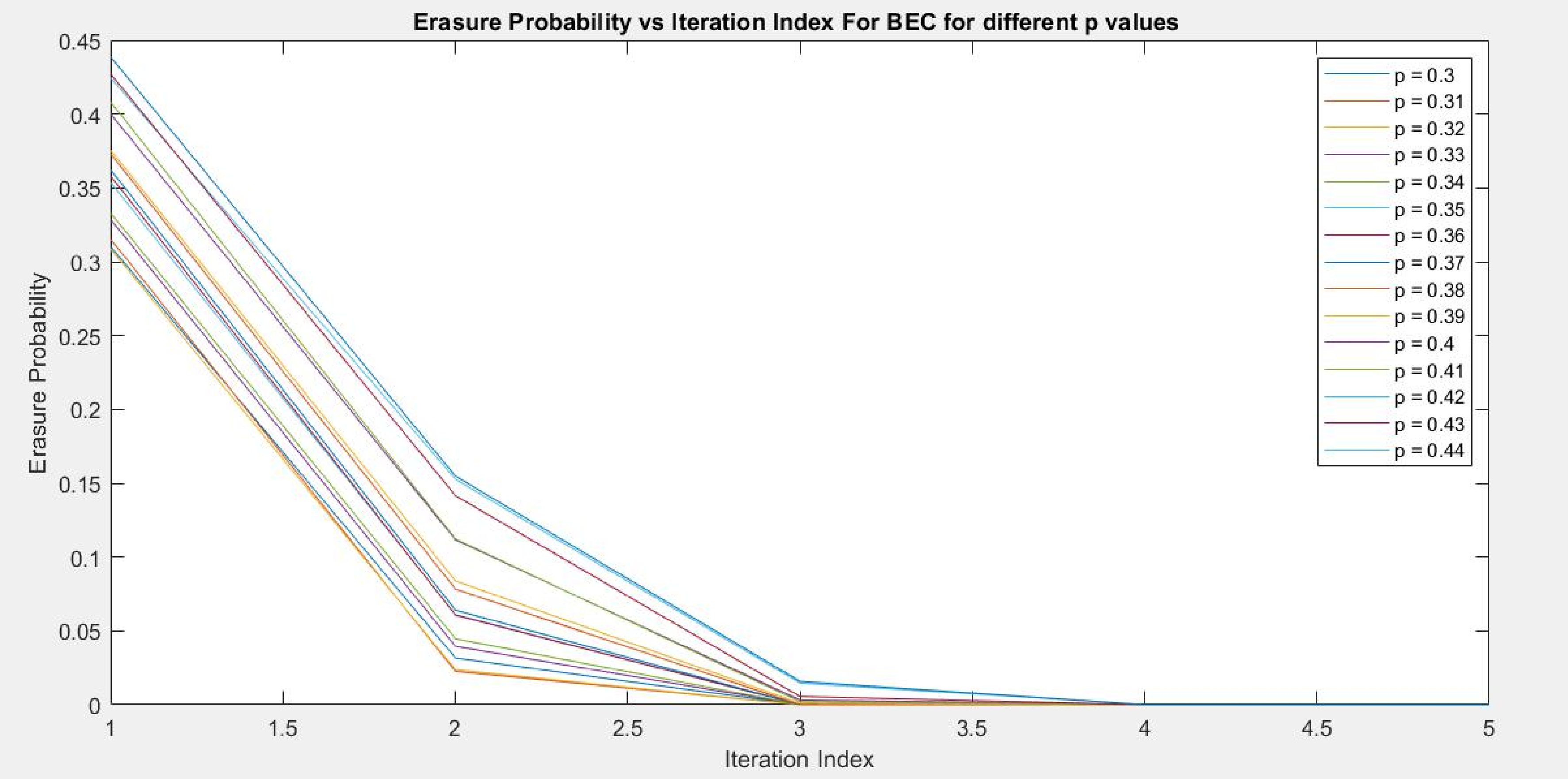
Erasure Probability vs Iteration Index For BEC for different p values(0.3-0.44) H(3000X5000)



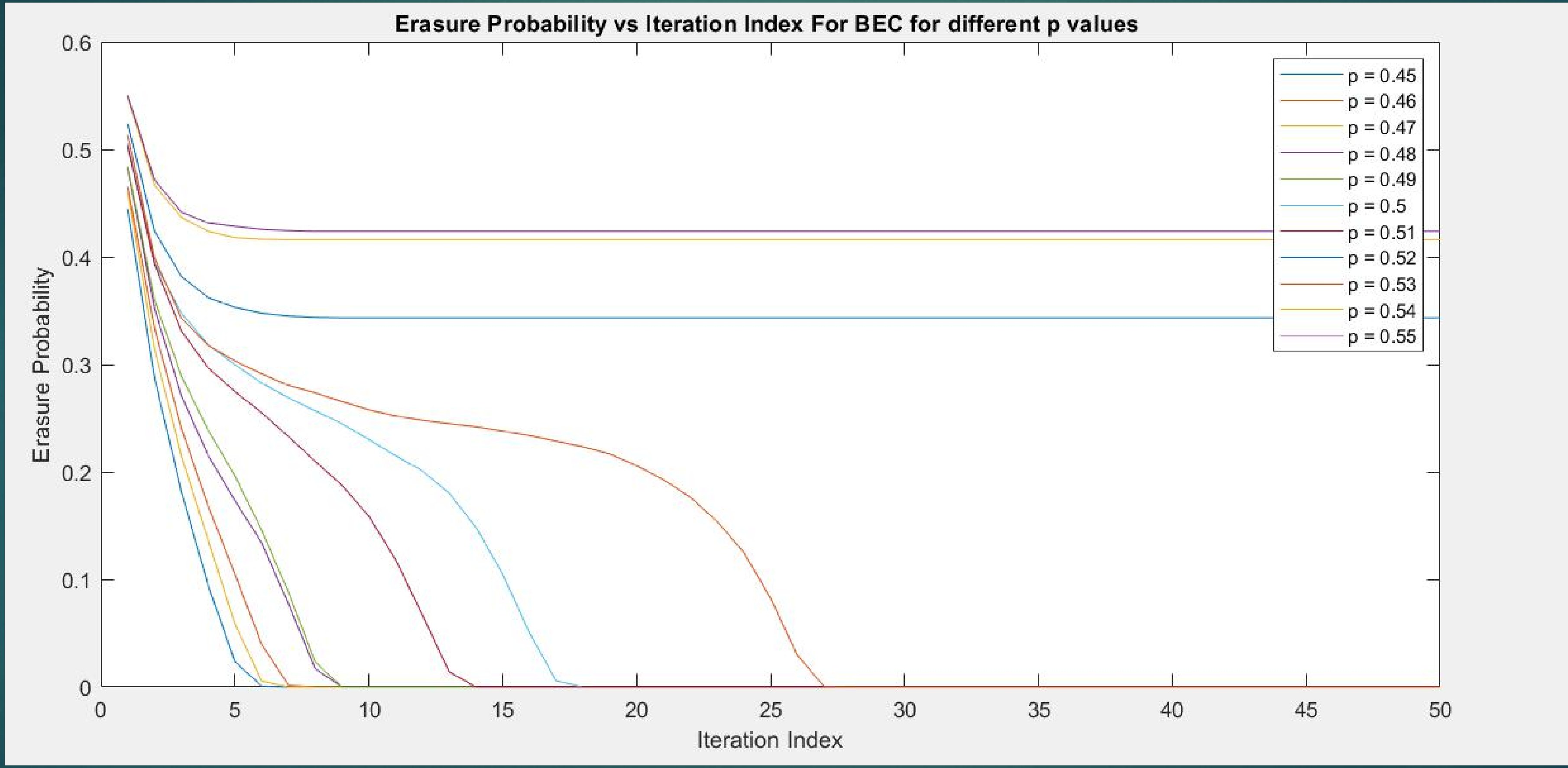
Erasure Probability vs Iteration Index For BEC for different p values(0.1-1) H(3000X5000)



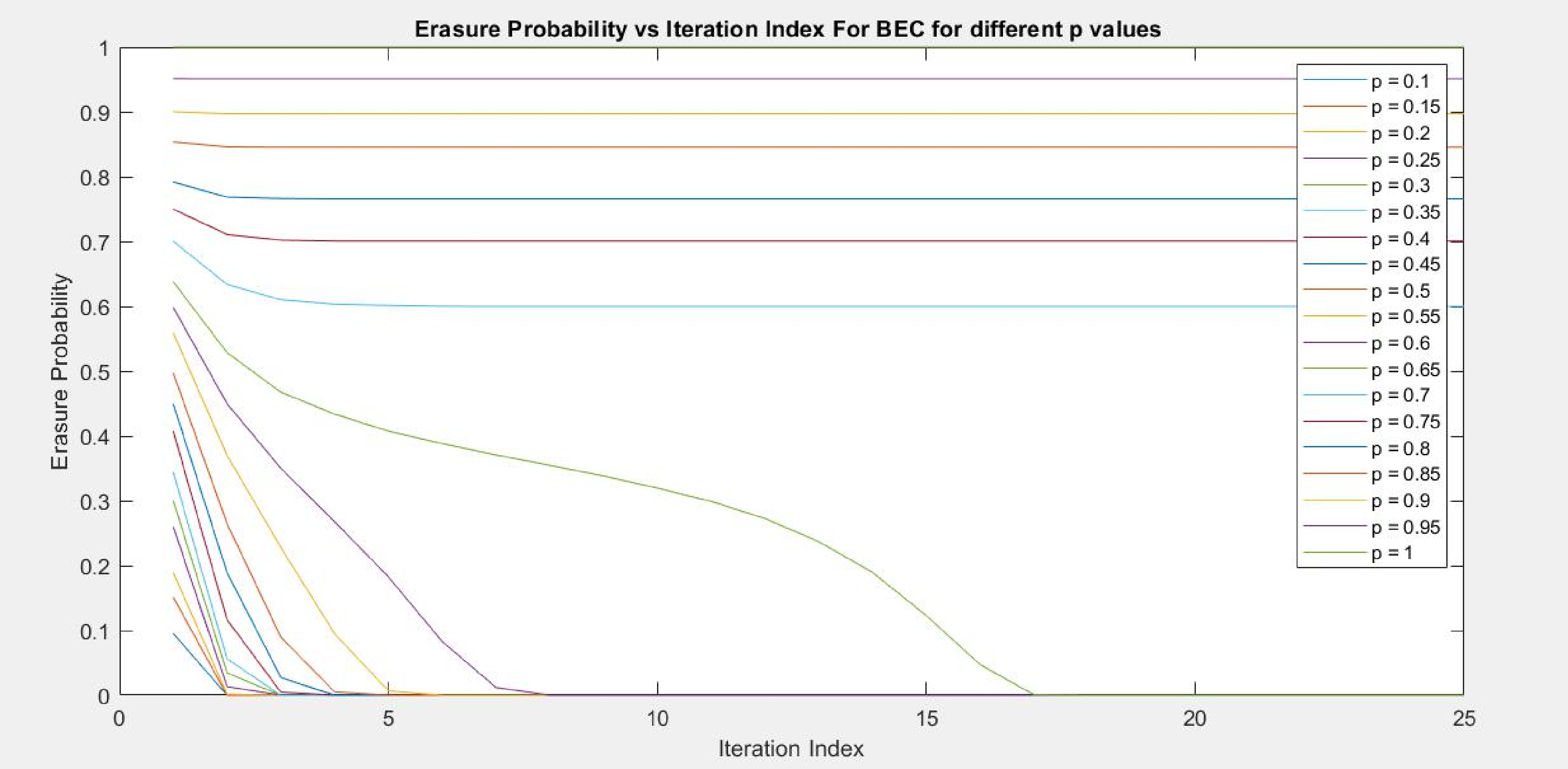
Erasure Probability vs Iteration Index For BEC for different p values(0.3-0.44) H(3792X5056)



Erasure Probability vs Iteration Index For BEC for different p values(0.45-0.55)
H(3000X5000) 50 Iterations this time.
Didn't get decoded for p=0.55,0.54 and 0.52



Erasure Probability vs Iteration Index For BEC for different p values(0.1-1) H(3792X5056)



THANK YOU…