Experiment 6: Simulation of Rayleigh & Rician Fading Channels using Simulink

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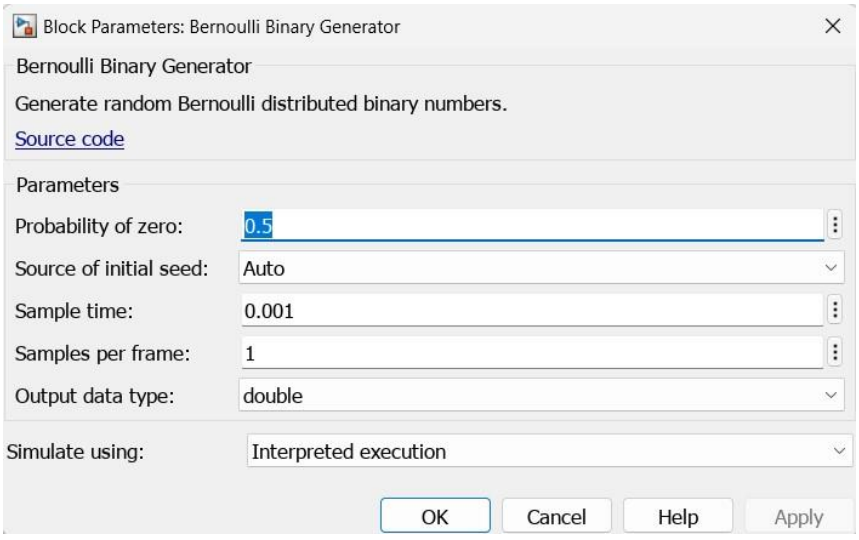
Aim:

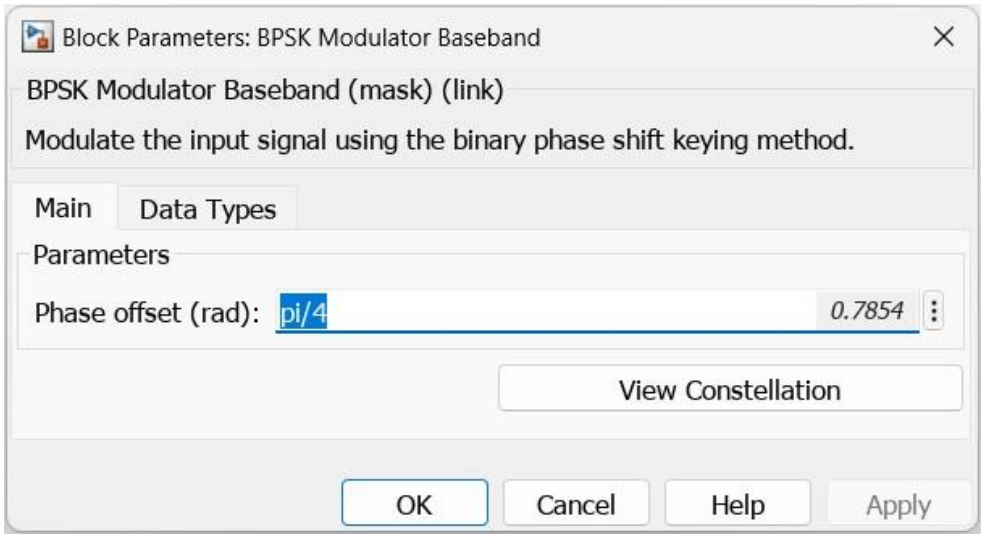
To perform the Simulation of Rayleigh and Rician Fading Channels using Simulink

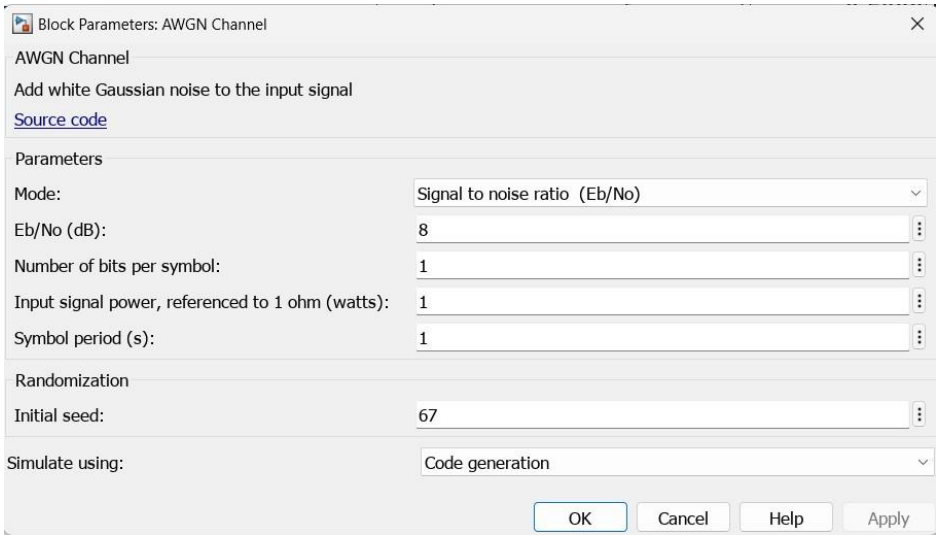
Algorithm:

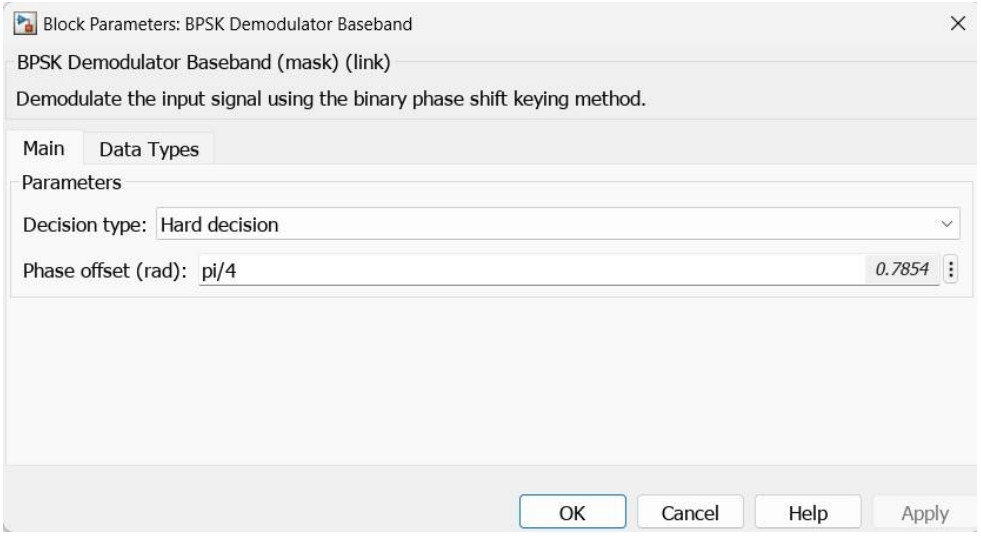
i. Generate the signal
ii. Use BPSK modulator
iii. Add the fading Channels
iv. Add AWGN noise
v. Demodulate the signal at Rx
vi. Calculate Error.

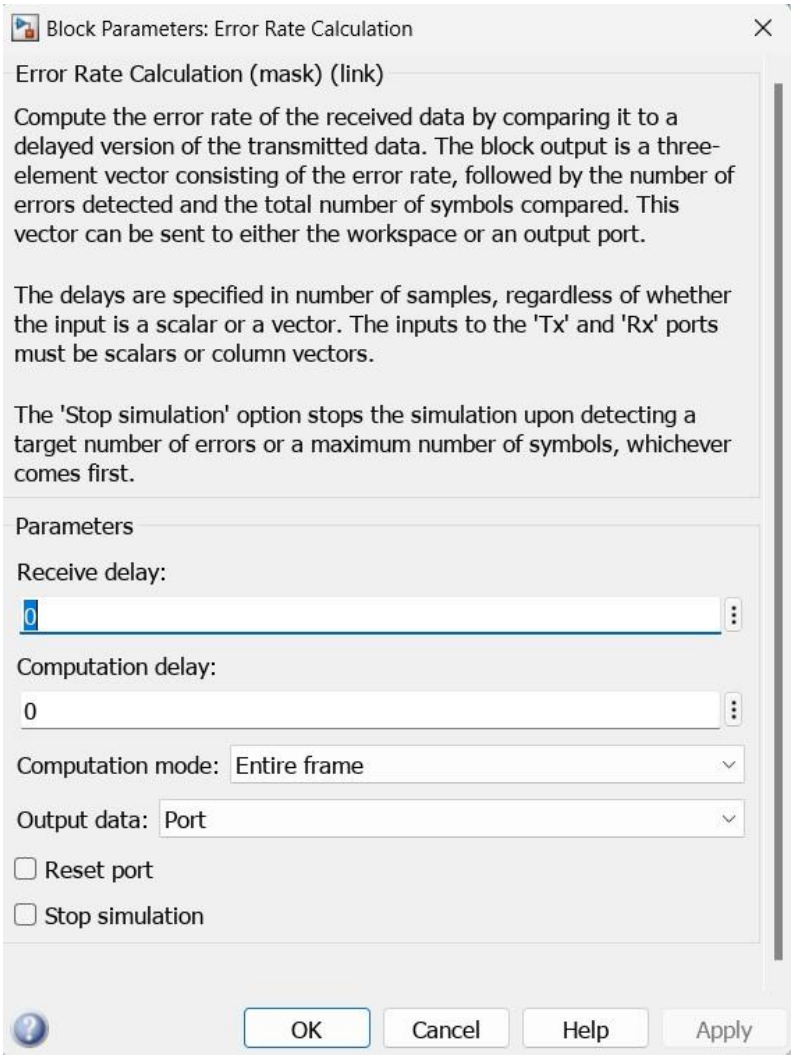
Block Configuration:

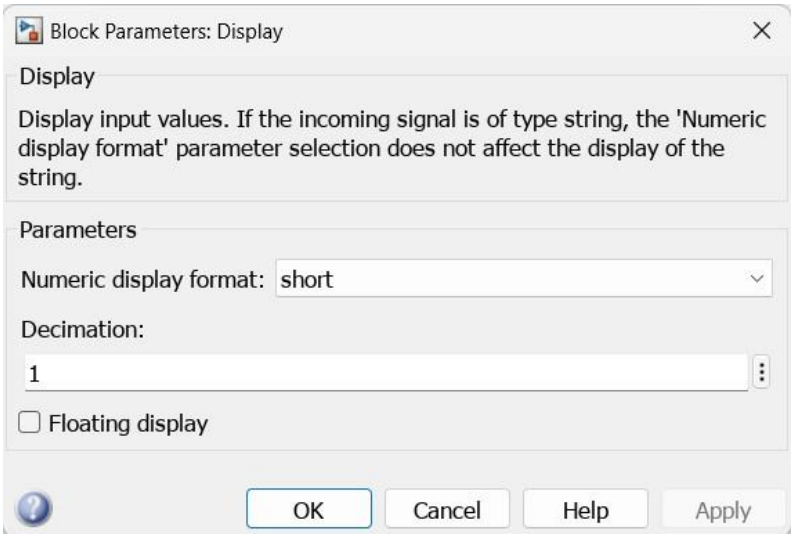


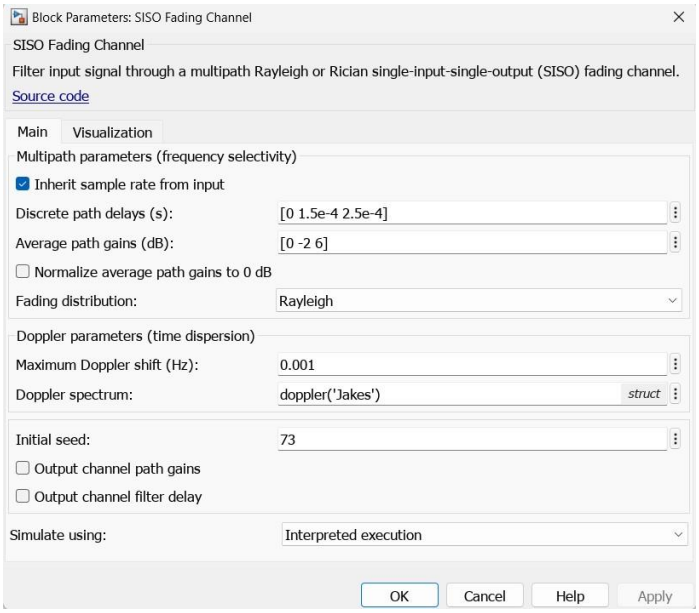

Block Parameters: BPSK Modulator Baseband
BPSK Modulator Baseband (mask) (link)
Modulate the input signal using the binary phase shift keying method.
Main
Data Types
Parameters
Phase offset (rad):
pi/4
0.7854
View Constellation
OK
Cancel
Help
Apply

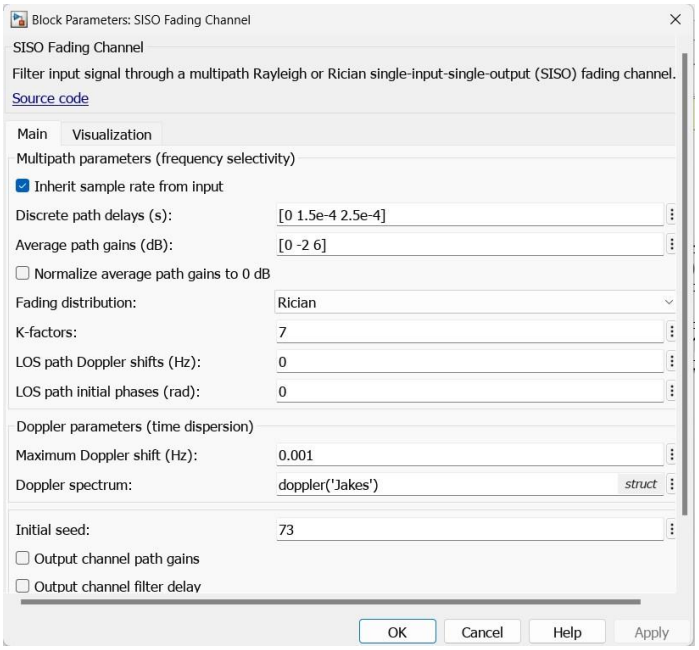

Block Parameters: AWGN Channel
AWGN Channel
Add white Gaussian noise to the input signal
Source code
Parameters
Mode:
Signal to noise ratio (Eb/No)
Eb/No (dB):
8
Number of bits per symbol:
1
Input signal power, referenced to 1 ohm (watts):
1
Symbol period (s):
1
Randomization
Initial seed:
67
Simulate using:
Code generation
OK
Cancel
Help
Apply


Block Parameters: BPSK Demodulator Baseband
BPSK Demodulator Baseband (mask) (link)
Demodulate the input signal using the binary phase shift keying method.
Main
Data Types
Parameters
Decision type:
Hard decision
Phase offset (rad):
pi/4
0.7854
OK
Cancel
Help
Apply


Block Parameters: Error Rate Calculation
Error Rate Calculation (mask) (link)
Compute the error rate of the received data by comparing it to a delayed version of the transmitted data. The block output is a three-element vector consisting of the error rate, followed by the number of errors detected and the total number of symbols compared. This vector can be sent to either the workspace or an output port.
The delays are specified in number of samples, regardless of whether the input is a scalar or a vector. The inputs to the 'Tx' and 'Rx' ports must be scalars or column vectors.
The 'Stop simulation' option stops the simulation upon detecting a target number of errors or a maximum number of symbols, whichever comes first.
Parameters
Receive delay:
0
Computation delay:
0
Computation mode: Entire frame
Output data: Port
Reset port
Stop simulation
OK
Cancel
Help
Apply

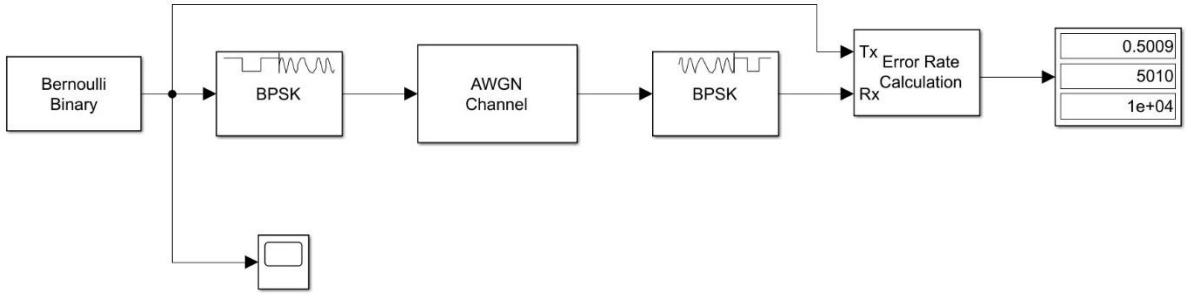

Block Parameters: Display
Display
Display input values. If the incoming signal is of type string, the 'Numeric display format' parameter selection does not affect the display of the string.
Parameters
Numeric display format: short
Decimation:
1
Floating display
OK
Cancel
Help
Apply


Block Parameters: SISO Fading Channel
SISO Fading Channel
Filter input signal through a multipath Rayleigh or Rician single-input-single-output (SISO) fading channel.
Source code
Main
Visualization
Multipath parameters (frequency selectivity)
Inherit sample rate from input
Discrete path delays (s):
[0 1.5e-4 2.5e-4]
Average path gains (dB):
[0 -2 6]
Normalize average path gains to 0 dB
Fading distribution:
Rayleigh
Doppler parameters (time dispersion)
Maximum Doppler shift (Hz):
0.001
Doppler spectrum:
doppler('Jakes')
struct
Initial seed:
73
Output channel path gains
Output channel filter delay
Simulate using:
Interpreted execution
OK
Cancel
Help
Apply

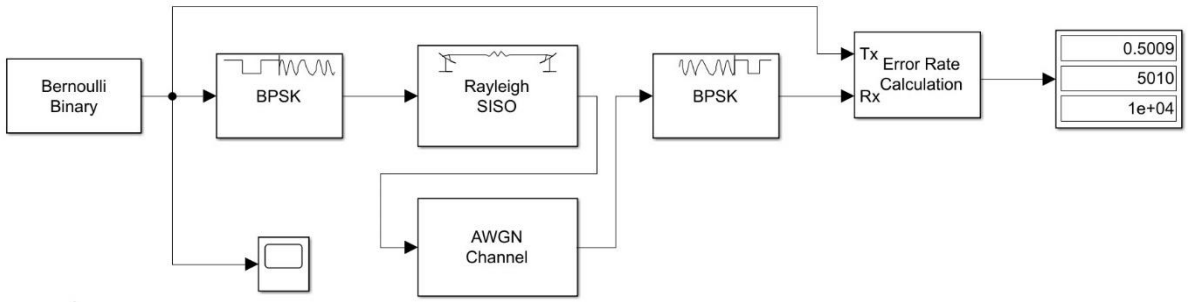

Block Parameters: SISO Fading Channel
SISO Fading Channel
Filter input signal through a multipath Rayleigh or Rician single-input-single-output (SISO) fading channel.
Source code
Main
Visualization
Multipath parameters (frequency selectivity)
Inherit sample rate from input
Discrete path delays (s):
[0 1.5e-4 2.5e-4]
Average path gains (dB):
[0 -2 6]
Normalize average path gains to 0 dB
Fading distribution:
Rician
K-factors:
7
LOS path Doppler shifts (Hz):
0
LOS path initial phases (rad):
0
Doppler parameters (time dispersion)
Maximum Doppler shift (Hz):
0.001
Doppler spectrum:
doppler('Jakes')
struct
Initial seed:
73
Output channel path gains
Output channel filter delay
OK
Cancel
Help
Apply

Block Diagram:

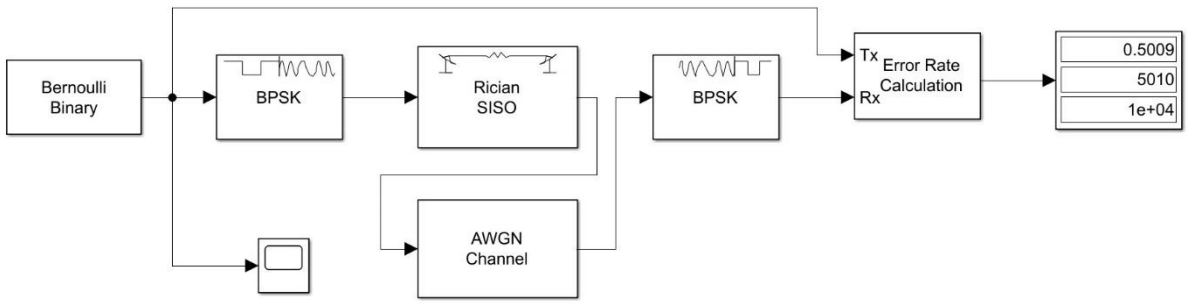
1. AWGN Only:



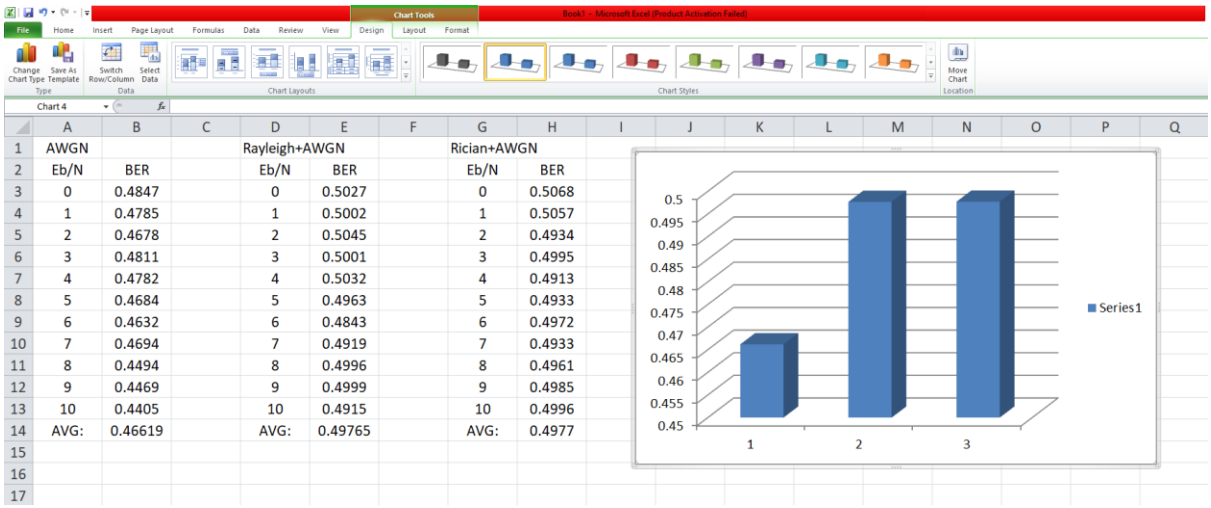
2. AWGN + Rayleigh:



3. AWGN + Rician:



Results:

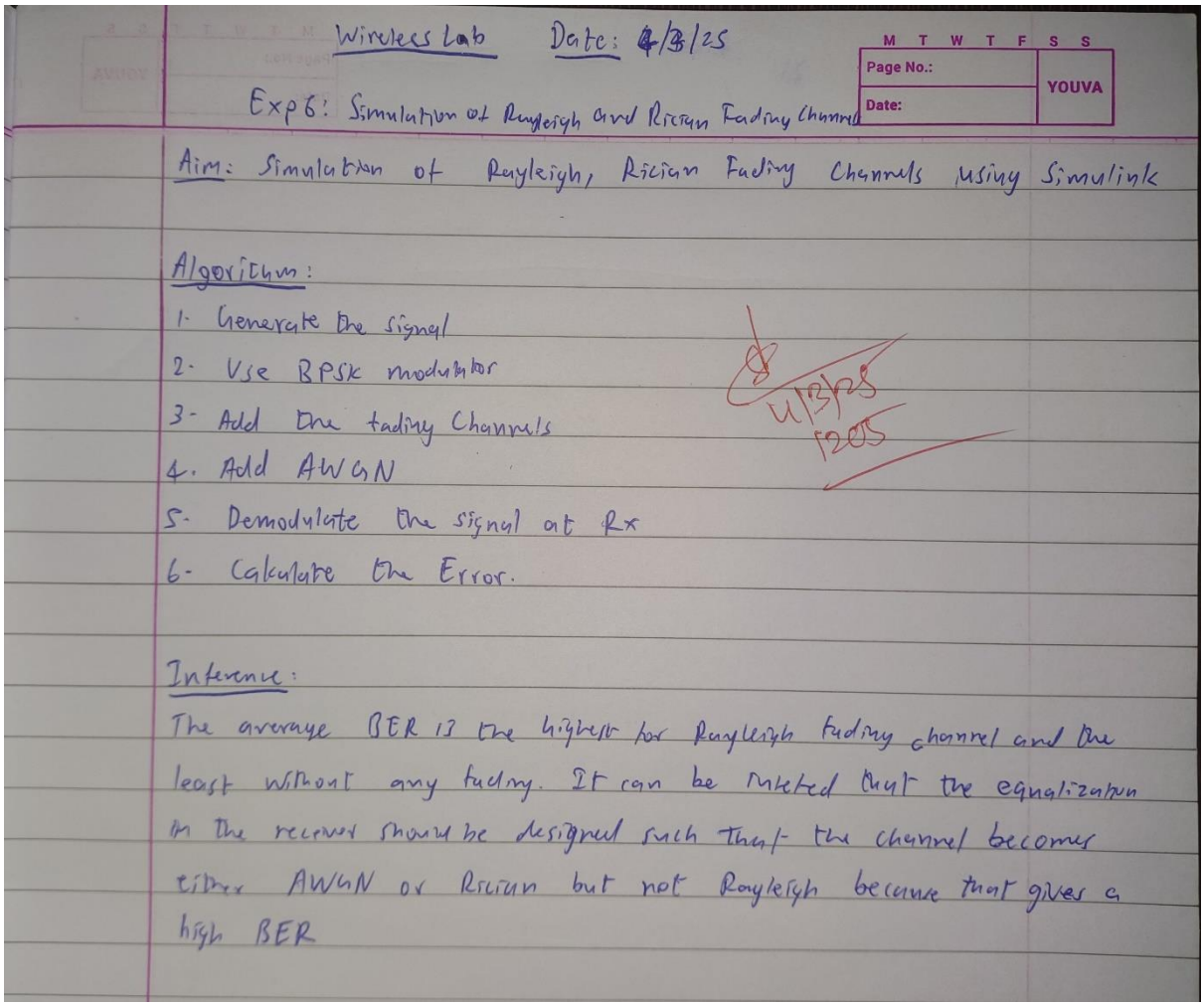


	A	B	C	D	E	F	G	H
1	AWGN			Rayleigh+AWGN			Rician+AWGN	
2	Eb/N	BER		Eb/N	BER		Eb/N	BER
3	0	0.4847		0	0.5027		0	0.5068
4	1	0.4785		1	0.5002		1	0.5057
5	2	0.4678		2	0.5045		2	0.4934
6	3	0.4811		3	0.5001		3	0.4995
7	4	0.4782		4	0.5032		4	0.4913
8	5	0.4684		5	0.4963		5	0.4933
9	6	0.4632		6	0.4843		6	0.4972
10	7	0.4694		7	0.4919		7	0.4933
11	8	0.4494		8	0.4996		8	0.4961
12	9	0.4469		9	0.4999		9	0.4985
13	10	0.4405		10	0.4915		10	0.4996
14	AVG:	0.46619		AVG:	0.49765		AVG:	0.4977

Inference:

The average BER is the highest for Rayleigh fading channel and the least without any fading. It can be inferred that the equalizer in the receiver should be designed such that the channel becomes either AWGN or Rician but not Rayleigh because that gives a high BER.

Output Verification:



Wireless Lab Date: 4/3/25

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5. Demodulate the signal at Rx
6. Calculate the Error.

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Inference:

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Observation and Result:

Hence, the Simulation and Observation of Rayleigh and Rician Fading Channels using Simulink was completed successfully.