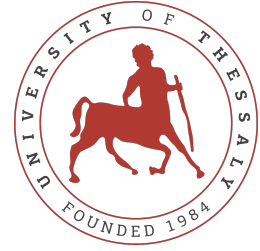


Advanced Telecommunication Systems

Project 3



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1193 Words

Keywords: Spatial Multiplexing, MIMO, Least Squares

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24th January, 2021

1 General Instructions

All files have been developed and tested in **Matlab 2017b 64-bit**. In the current folder there are five code files (.m files). Each one implements a different question of the project. Specifically, Question_A.m implements the project's question A, Question_B_SISO_Fading.m implements the project's question B by testing the 16-QAM modulation on a SISO telecommunication's model without flat fading, etc.

2 Question A

We implement the 2x2 MIMO telecommunication's system with flat fading, spatial multiplexing and Least Squares equalizer based on the flow diagram (2 flows) of Figure 1.

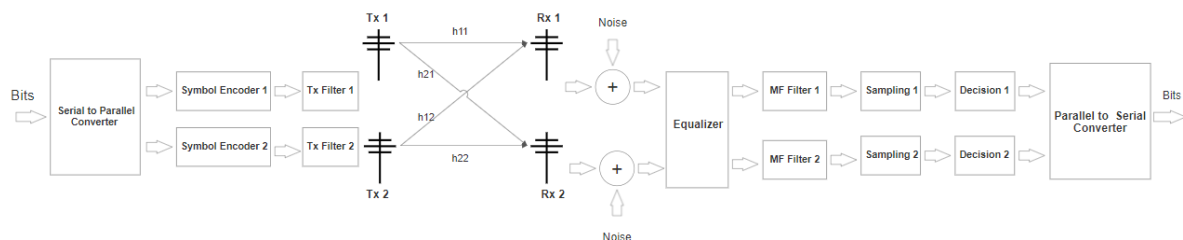


Fig. 1. Flow Diagram of 2x2 MIMO telecommunication's system (2 flows)

The results are:

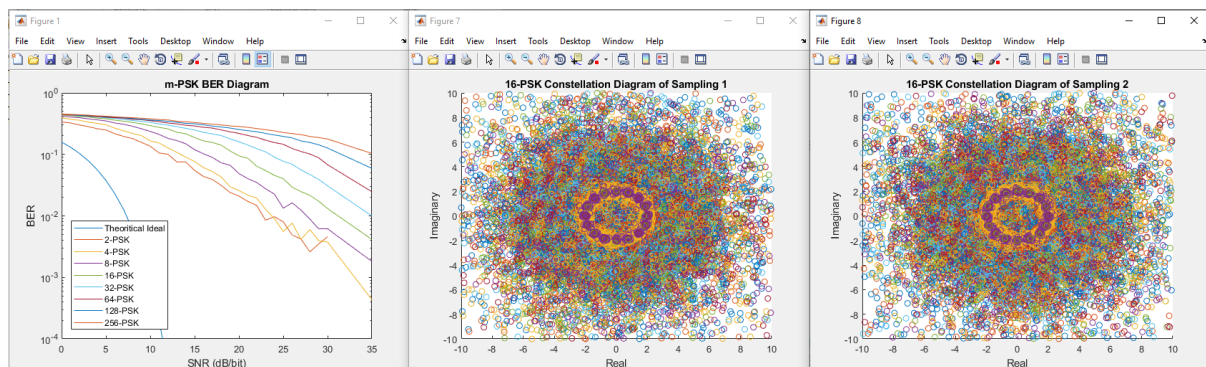


Fig. 2. m-PSK BER and Constellation Diagrams for Sampling 1, Sampling 2

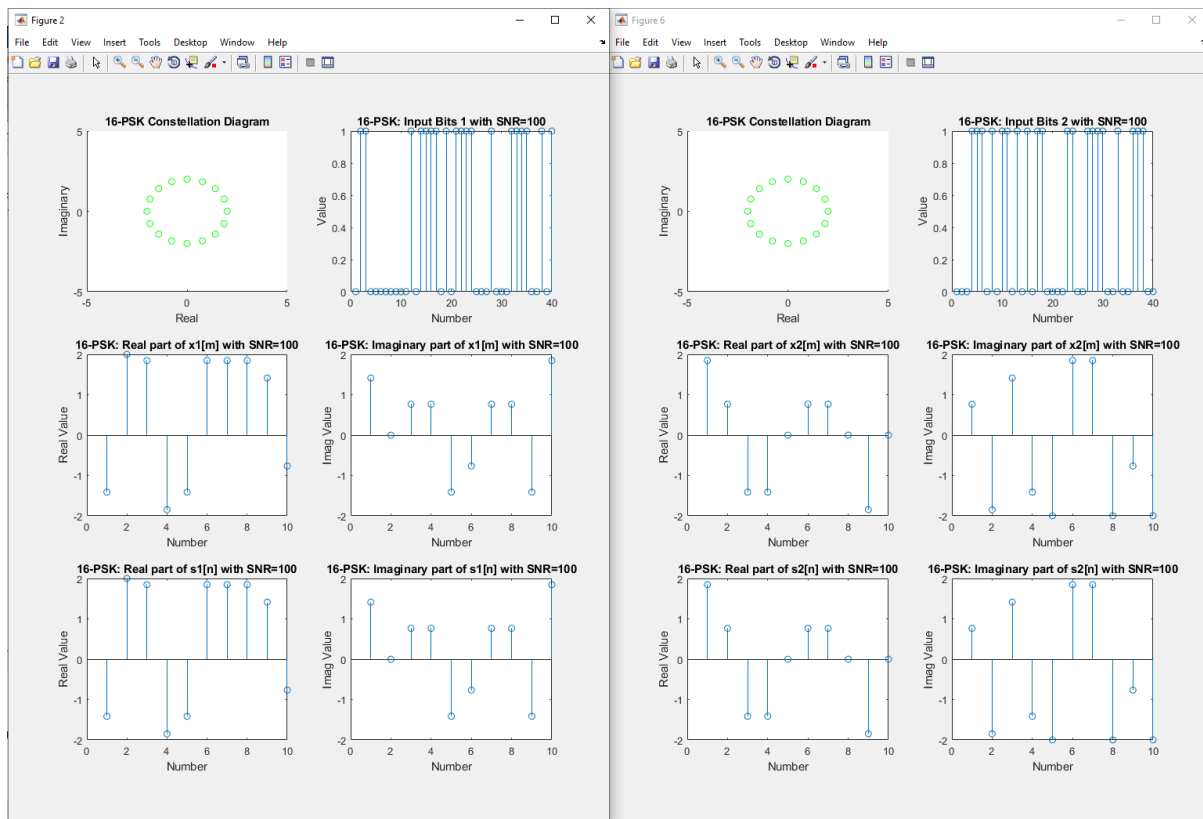


Fig. 3. 16-PSK Part A, Plots for Flow 1 and Flow 2

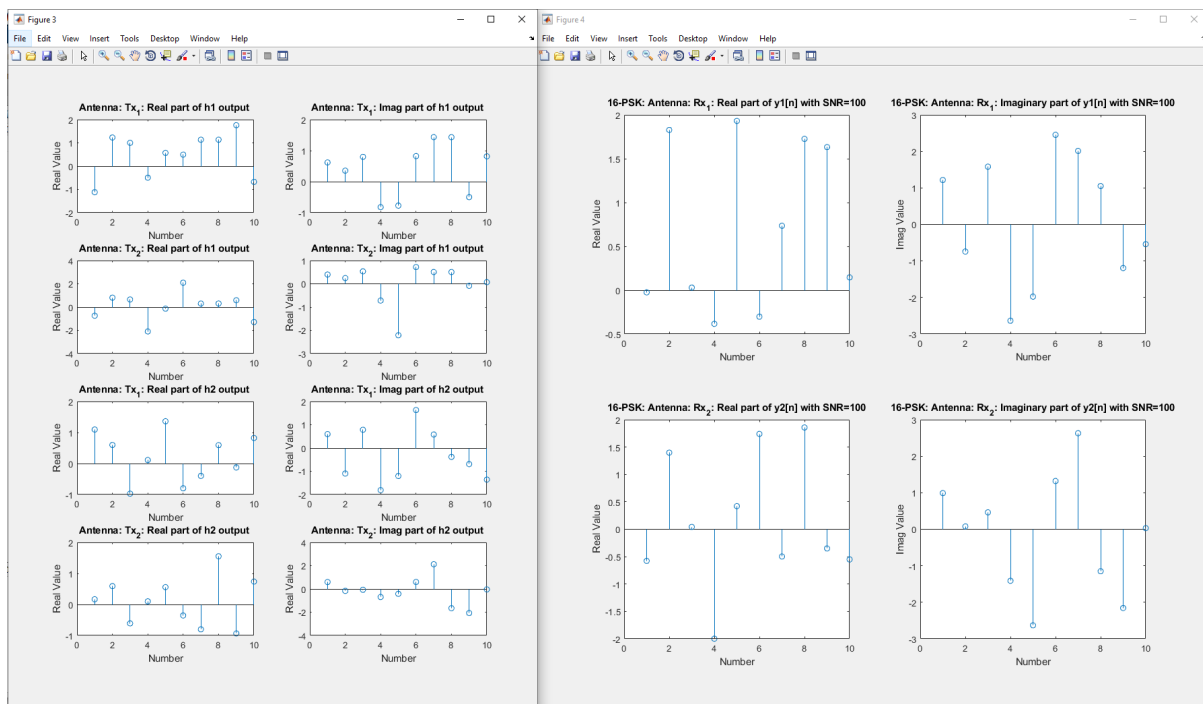


Fig. 4. 16-PSK Part B, Plots for Flow 1 and Flow 2

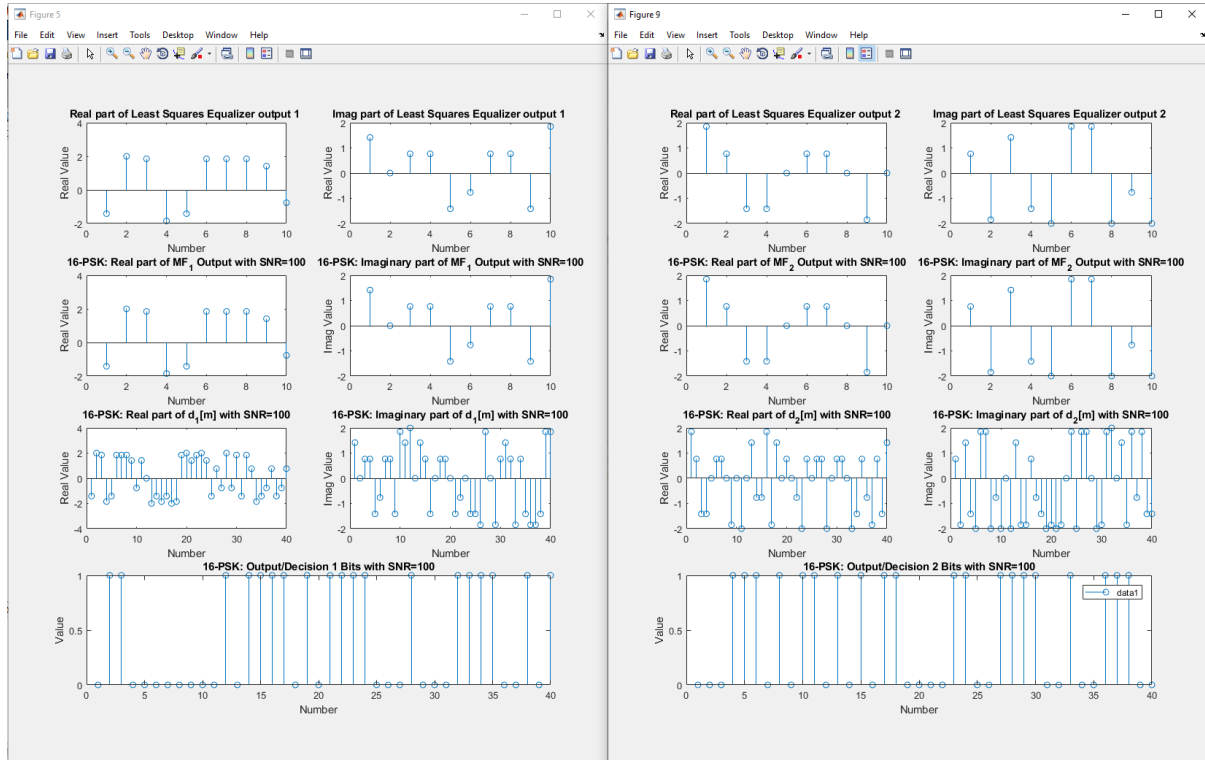


Fig. 5. 16-PSK Part C, Plots for Flow 1 and Flow 2

3 Question B

We implement 16-QAM modulation and tested on SISO without flat fading, on SISO with flat fading and on MIMO with flat fading telecommunication's system.

3.1 SISO without Flat Fading

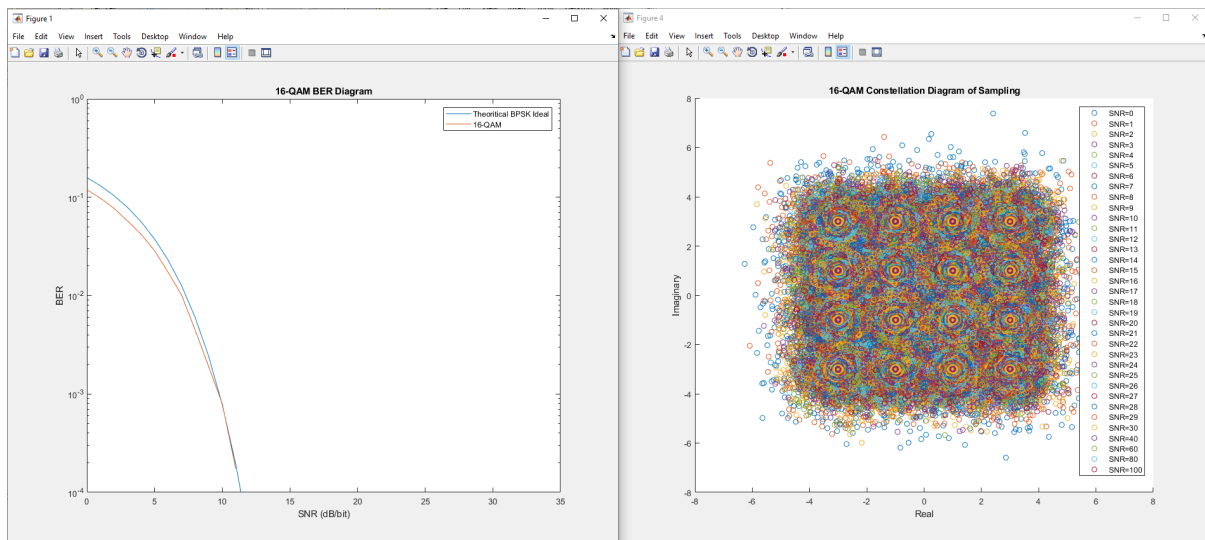


Fig. 6. 16-QAM BER and Constellation Diagram for Sampling

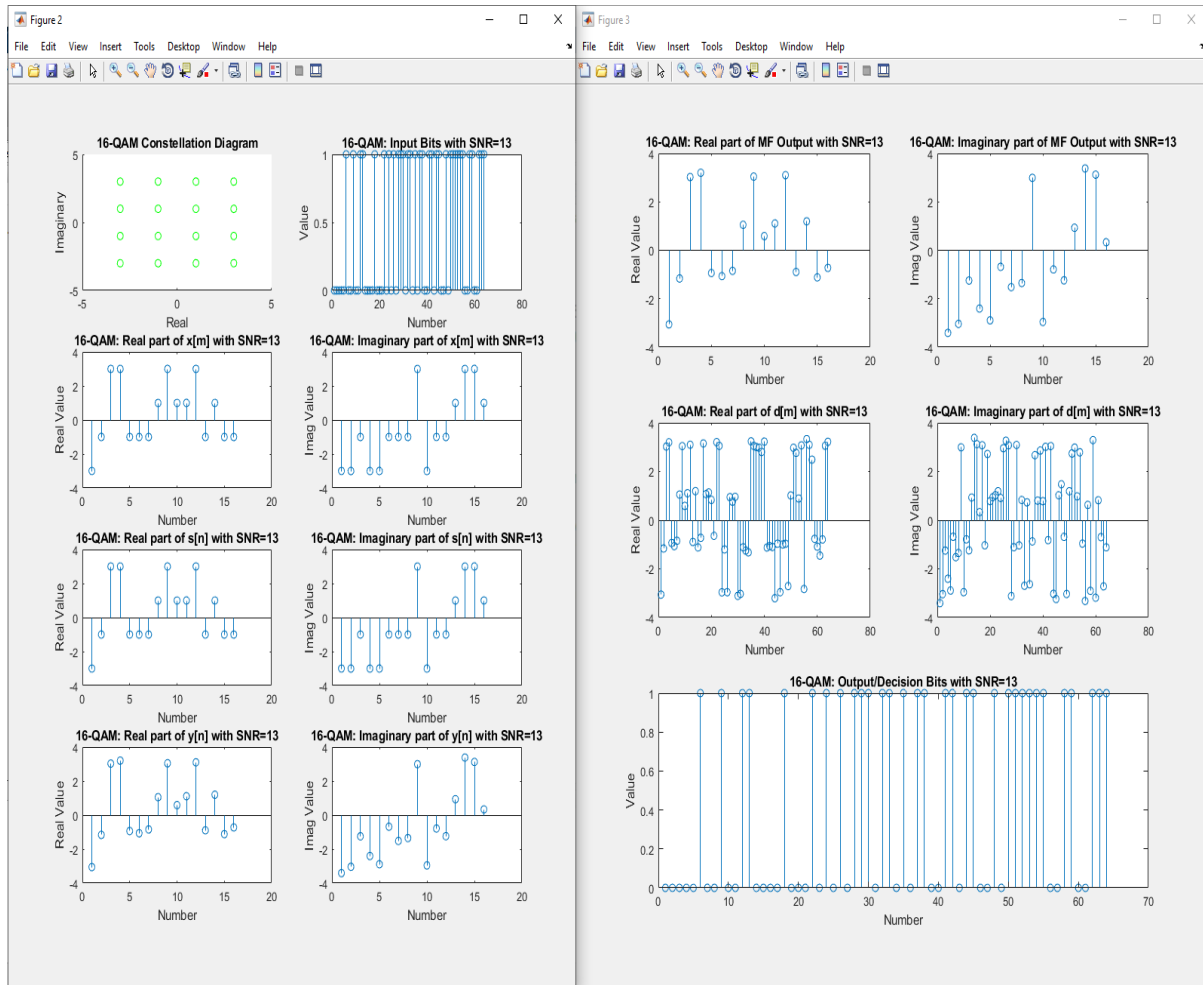


Fig. 7. 16-QAM Plots of Flow

3.2 SISO with Flat Fading

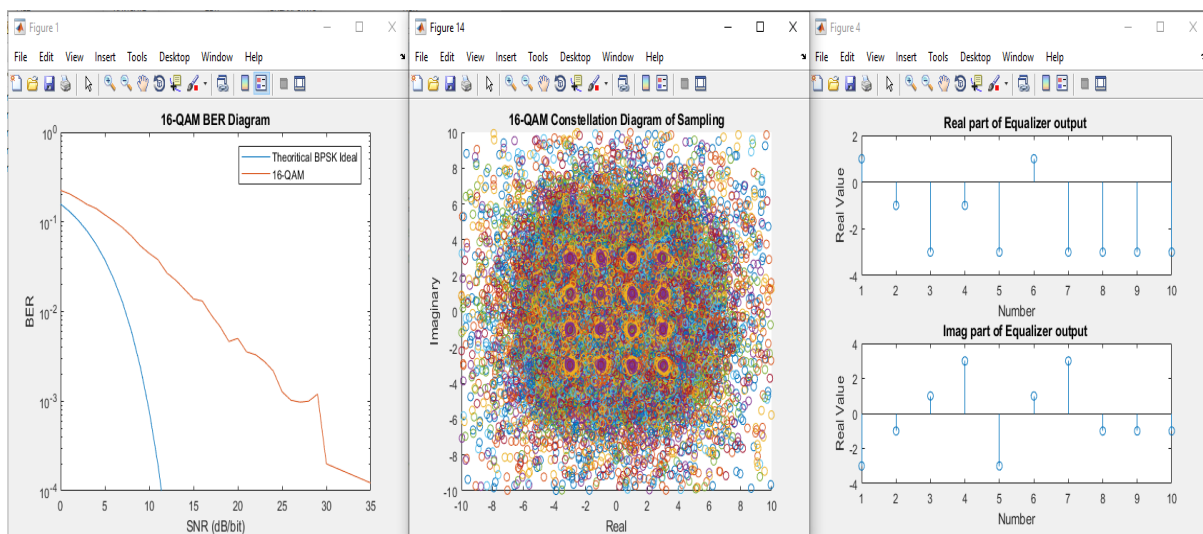


Fig. 8. 16-QAM BER, Constellation Diagram for Sampling and 16-QAM Equalizer

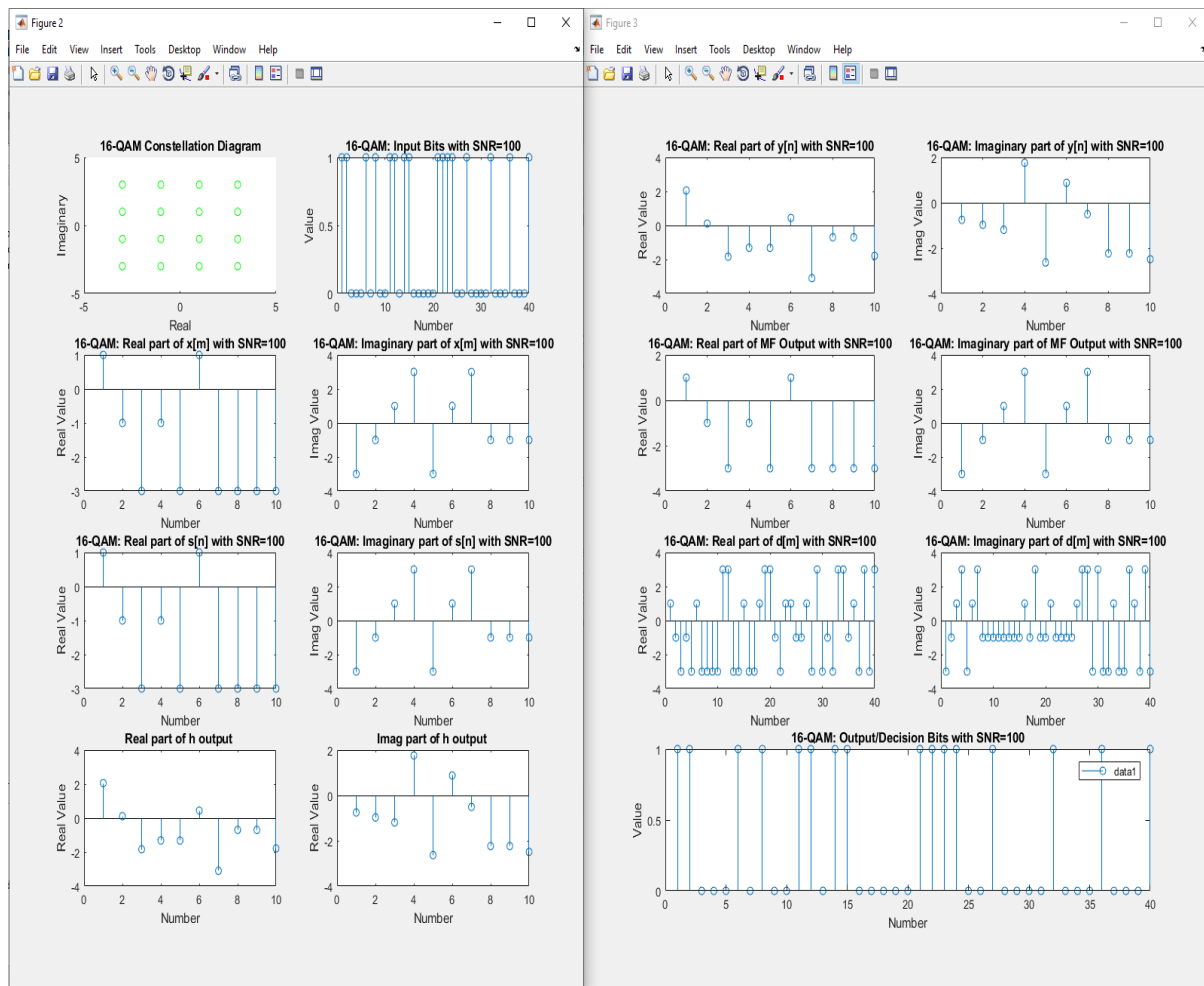


Fig. 9. 16-QAM Plots of Flow

3.3 MIMO with Flat Fading

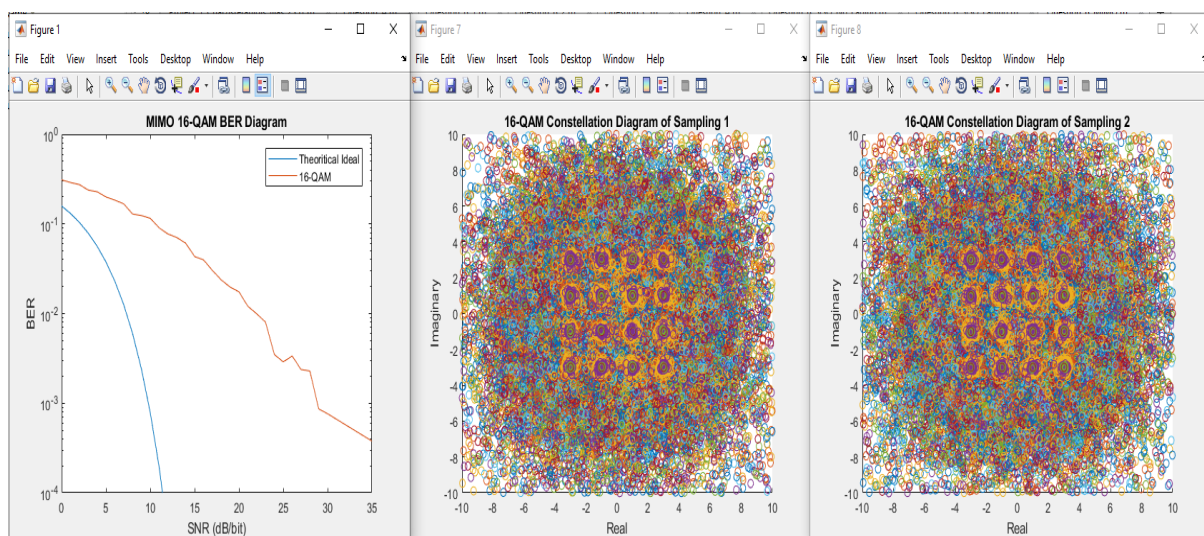


Fig. 10. 16-QAM BER and Constellation Diagrams for Sampling 1, Sampling 2

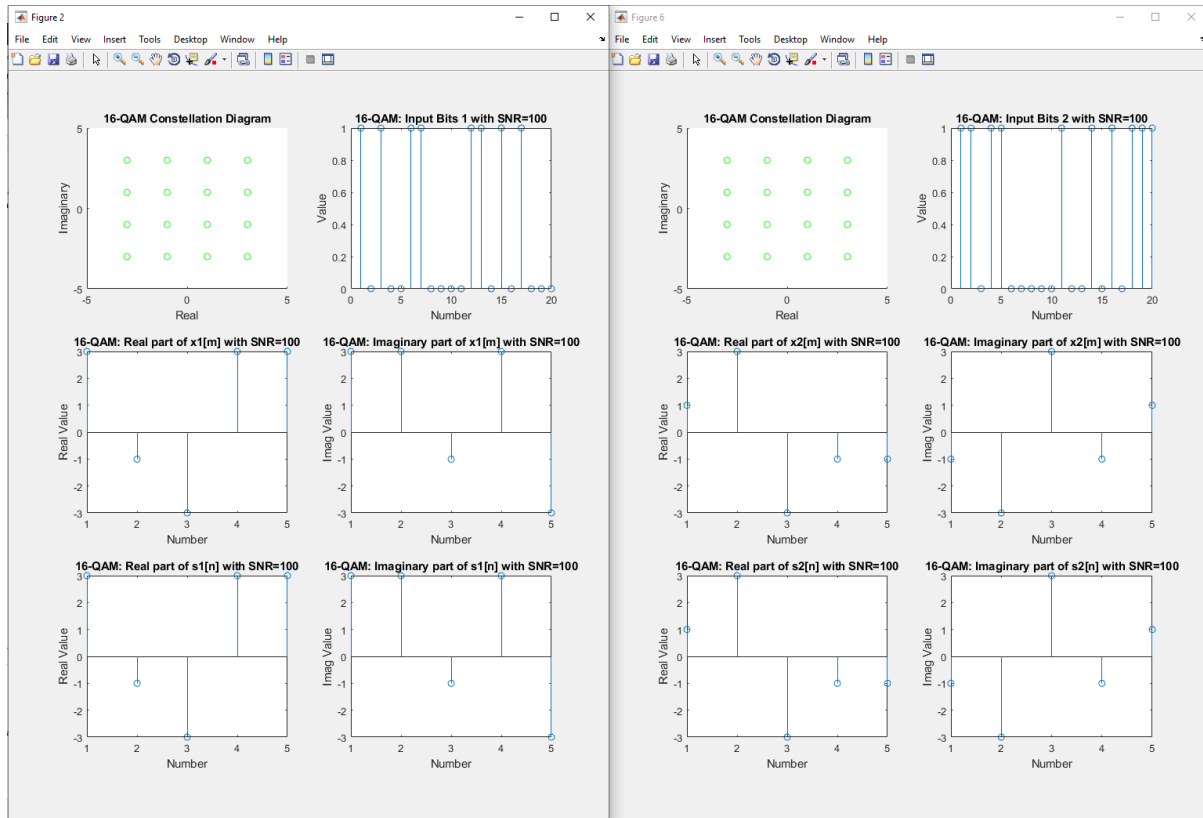


Fig. 11. 16-QAM Part A, Plots for Flow 1 and Flow 2

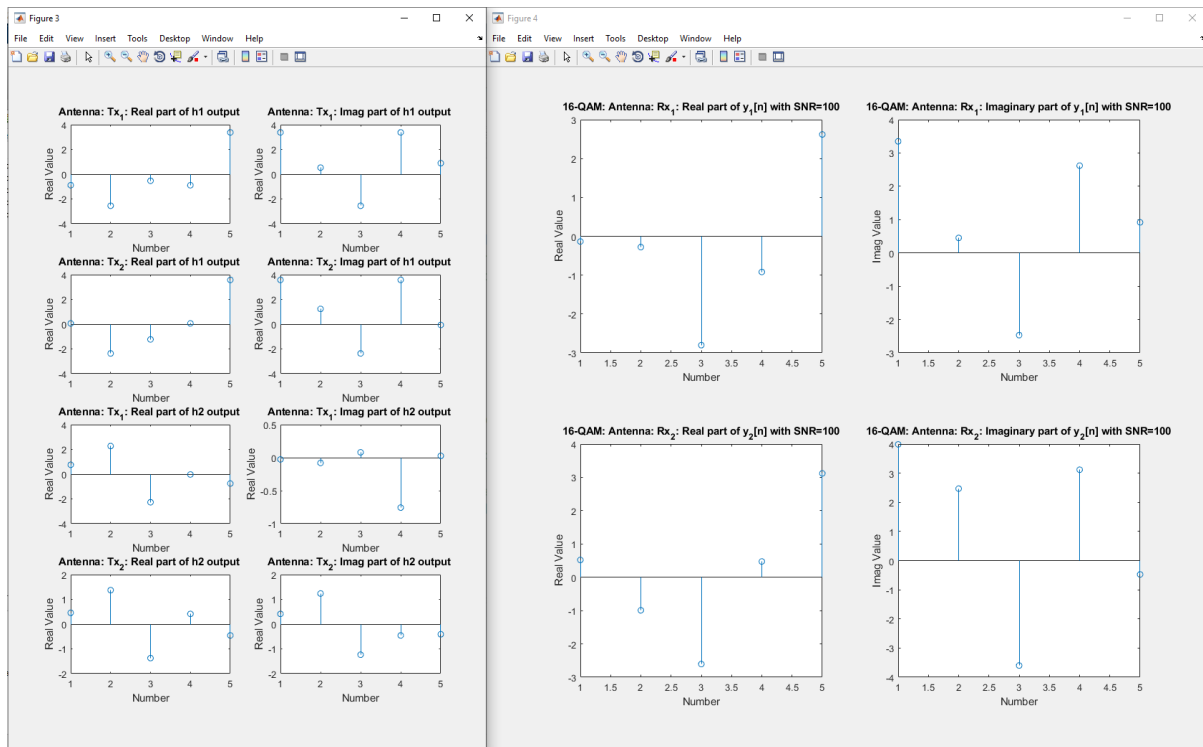


Fig. 12. 16-QAM Part B, Plots for Flow 1 and Flow 2

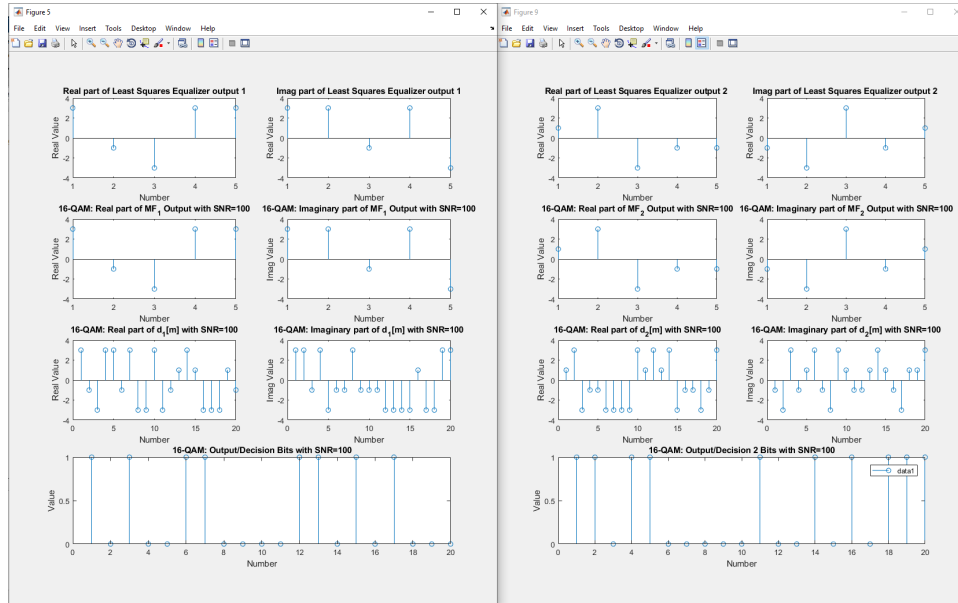


Fig. 13. 16-QAM Part C, Plots for Flow 1 and Flow 2

3.4 Question C

We obtain statistics about the Goodput (how many bits are received correct in a packet) and the total correct packets received for every modulation and for every SNR value:

Mod: 2-PSK ,SNR: 0, Goodput(Correct Bits in Packet): 64/100, Correct Packets: 0/49
 Mod: 2-PSK ,SNR: 1, Goodput(Correct Bits in Packet): 66/100, Correct Packets: 0/49
 Mod: 2-PSK ,SNR: 2, Goodput(Correct Bits in Packet): 71/100, Correct Packets: 0/49
 Mod: 2-PSK ,SNR: 3, Goodput(Correct Bits in Packet): 70/100, Correct Packets: 0/49
 Mod: 2-PSK ,SNR: 4, Goodput(Correct Bits in Packet): 71/100, Correct Packets: 0/49
 Mod: 2-PSK ,SNR: 5, Goodput(Correct Bits in Packet): 73/100, Correct Packets: 0/49
 Mod: 2-PSK ,SNR: 6, Goodput(Correct Bits in Packet): 76/100, Correct Packets: 0/49
 Mod: 2-PSK ,SNR: 7, Goodput(Correct Bits in Packet): 78/100, Correct Packets: 1/49
 Mod: 2-PSK ,SNR: 8, Goodput(Correct Bits in Packet): 79/100, Correct Packets: 0/49
 Mod: 2-PSK ,SNR: 9, Goodput(Correct Bits in Packet): 84/100, Correct Packets: 3/49
 Mod: 2-PSK ,SNR: 10, Goodput(Correct Bits in Packet): 87/100, Correct Packets: 3/49
 Mod: 2-PSK ,SNR: 11, Goodput(Correct Bits in Packet): 88/100, Correct Packets: 7/49
 Mod: 2-PSK ,SNR: 12, Goodput(Correct Bits in Packet): 92/100, Correct Packets: 8/49
 Mod: 2-PSK ,SNR: 13, Goodput(Correct Bits in Packet): 93/100, Correct Packets: 13/49
 Mod: 2-PSK ,SNR: 14, Goodput(Correct Bits in Packet): 96/100, Correct Packets: 23/49
 Mod: 2-PSK ,SNR: 15, Goodput(Correct Bits in Packet): 93/100, Correct Packets: 22/49
 Mod: 2-PSK ,SNR: 16, Goodput(Correct Bits in Packet): 96/100, Correct Packets: 30/49
 Mod: 2-PSK ,SNR: 17, Goodput(Correct Bits in Packet): 96/100, Correct Packets: 34/49
 Mod: 2-PSK ,SNR: 18, Goodput(Correct Bits in Packet): 98/100, Correct Packets: 36/49

Mod: 2-PSK ,SNR: 19, Goodput(Correct Bits in Packet): 98/100, Correct Packets: 34/49
Mod: 2-PSK ,SNR: 20, Goodput(Correct Bits in Packet): 98/100, Correct Packets: 41/49
Mod: 2-PSK ,SNR: 21, Goodput(Correct Bits in Packet): 98/100, Correct Packets: 38/49
Mod: 2-PSK ,SNR: 22, Goodput(Correct Bits in Packet): 99/100, Correct Packets: 39/49
Mod: 2-PSK ,SNR: 23, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 44/49
Mod: 2-PSK ,SNR: 24, Goodput(Correct Bits in Packet): 98/100, Correct Packets: 42/49
Mod: 2-PSK ,SNR: 25, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 46/49
Mod: 2-PSK ,SNR: 26, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 46/49
Mod: 2-PSK ,SNR: 27, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 47/49
Mod: 2-PSK ,SNR: 28, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 45/49
Mod: 2-PSK ,SNR: 29, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 49/49
Mod: 2-PSK ,SNR: 30, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 45/49
Mod: 2-PSK ,SNR: 40, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 49/49
Mod: 2-PSK ,SNR: 60, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 49/49
Mod: 2-PSK ,SNR: 80, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 49/49
Mod: 2-PSK ,SNR: 100, Goodput(Correct Bits in Packet): 100/100, Correct Packets: 49/49
Mod: 16-QAM ,SNR: 0, Goodput(Correct Bits in Packet): 16/25, Correct Packets: 0/799
Mod: 16-QAM ,SNR: 1, Goodput(Correct Bits in Packet): 16/25, Correct Packets: 2/799
Mod: 16-QAM ,SNR: 2, Goodput(Correct Bits in Packet): 16/25, Correct Packets: 5/799
Mod: 16-QAM ,SNR: 3, Goodput(Correct Bits in Packet): 17/25, Correct Packets: 3/799
Mod: 16-QAM ,SNR: 4, Goodput(Correct Bits in Packet): 17/25, Correct Packets: 11/799
Mod: 16-QAM ,SNR: 5, Goodput(Correct Bits in Packet): 18/25, Correct Packets: 13/799
Mod: 16-QAM ,SNR: 6, Goodput(Correct Bits in Packet): 18/25, Correct Packets: 26/799
Mod: 16-QAM ,SNR: 7, Goodput(Correct Bits in Packet): 19/25, Correct Packets: 40/799
Mod: 16-QAM ,SNR: 8, Goodput(Correct Bits in Packet): 20/25, Correct Packets: 54/799
Mod: 16-QAM ,SNR: 9, Goodput(Correct Bits in Packet): 20/25, Correct Packets: 121/799
Mod: 16-QAM ,SNR: 10, Goodput(Correct Bits in Packet): 20/25, Correct Packets: 146/799
Mod: 16-QAM ,SNR: 11, Goodput(Correct Bits in Packet): 21/25, Correct Packets: 187/799
Mod: 16-QAM ,SNR: 12, Goodput(Correct Bits in Packet): 22/25, Correct Packets: 245/799
Mod: 16-QAM ,SNR: 13, Goodput(Correct Bits in Packet): 22/25, Correct Packets: 287/799
Mod: 16-QAM ,SNR: 14, Goodput(Correct Bits in Packet): 23/25, Correct Packets: 368/799
Mod: 16-QAM ,SNR: 15, Goodput(Correct Bits in Packet): 23/25, Correct Packets: 424/799
Mod: 16-QAM ,SNR: 16, Goodput(Correct Bits in Packet): 23/25, Correct Packets: 496/799
Mod: 16-QAM ,SNR: 17, Goodput(Correct Bits in Packet): 24/25, Correct Packets: 545/799
Mod: 16-QAM ,SNR: 18, Goodput(Correct Bits in Packet): 24/25, Correct Packets: 581/799
Mod: 16-QAM ,SNR: 19, Goodput(Correct Bits in Packet): 24/25, Correct Packets: 620/799
Mod: 16-QAM ,SNR: 20, Goodput(Correct Bits in Packet): 24/25, Correct Packets: 664/799
Mod: 16-QAM ,SNR: 21, Goodput(Correct Bits in Packet): 24/25, Correct Packets: 681/799
Mod: 16-QAM ,SNR: 22, Goodput(Correct Bits in Packet): 24/25, Correct Packets: 679/799

Mod: 16-QAM ,SNR: 23, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 725/799
 Mod: 16-QAM ,SNR: 24, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 714/799
 Mod: 16-QAM ,SNR: 25, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 749/799
 Mod: 16-QAM ,SNR: 26, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 740/799
 Mod: 16-QAM ,SNR: 27, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 762/799
 Mod: 16-QAM ,SNR: 28, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 774/799
 Mod: 16-QAM ,SNR: 29, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 781/799
 Mod: 16-QAM ,SNR: 30, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 787/799
 Mod: 16-QAM ,SNR: 40, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 795/799
 Mod: 16-QAM ,SNR: 60, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 799/799
 Mod: 16-QAM ,SNR: 80, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 799/799
 Mod: 16-QAM ,SNR: 100, Goodput(Correct Bits in Packet): 25/25, Correct Packets: 799/799

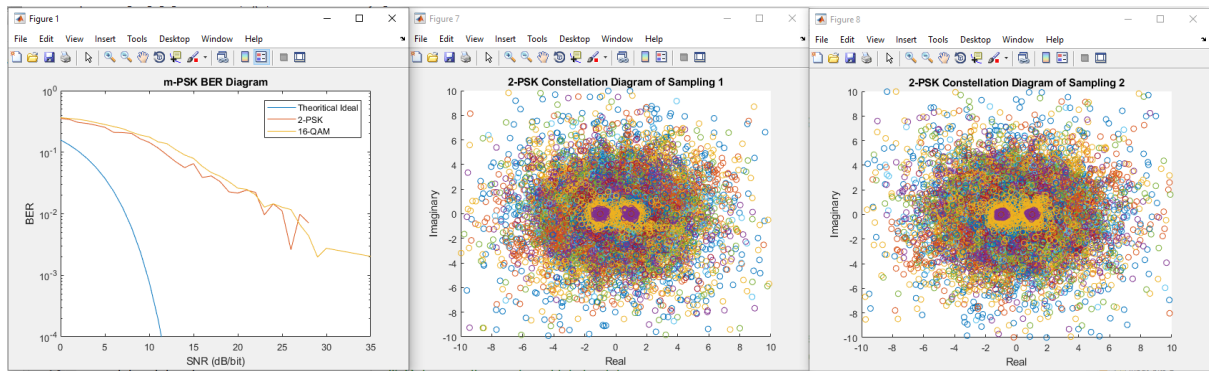


Fig. 14. BPSK BER and Constellation Diagrams for Sampling 1, Sampling 2

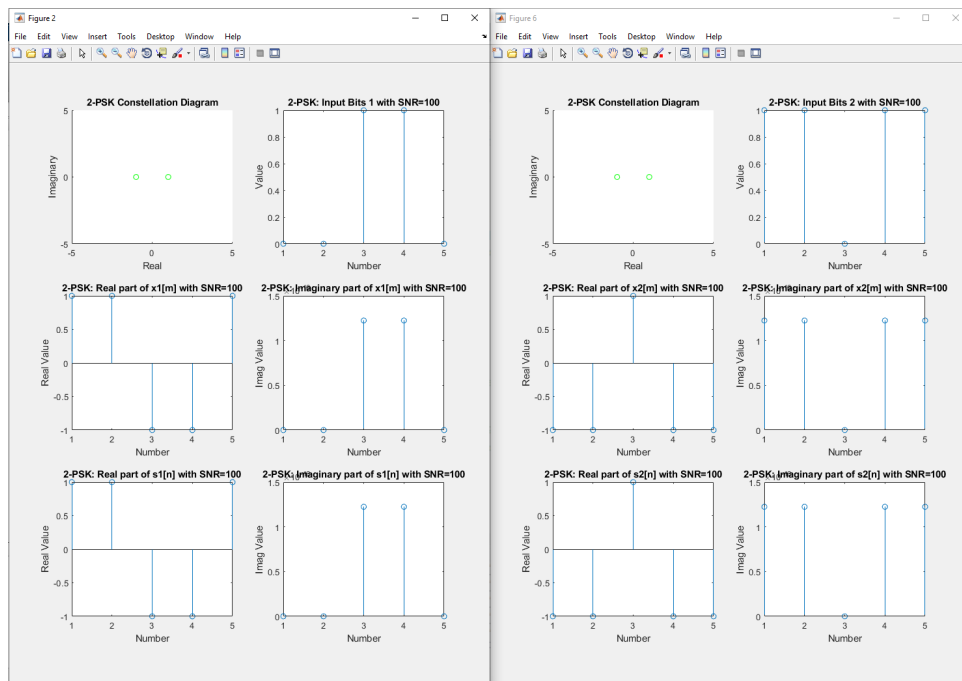


Fig. 15. BPSK Part A, Plots for Flow 1 and Flow 2

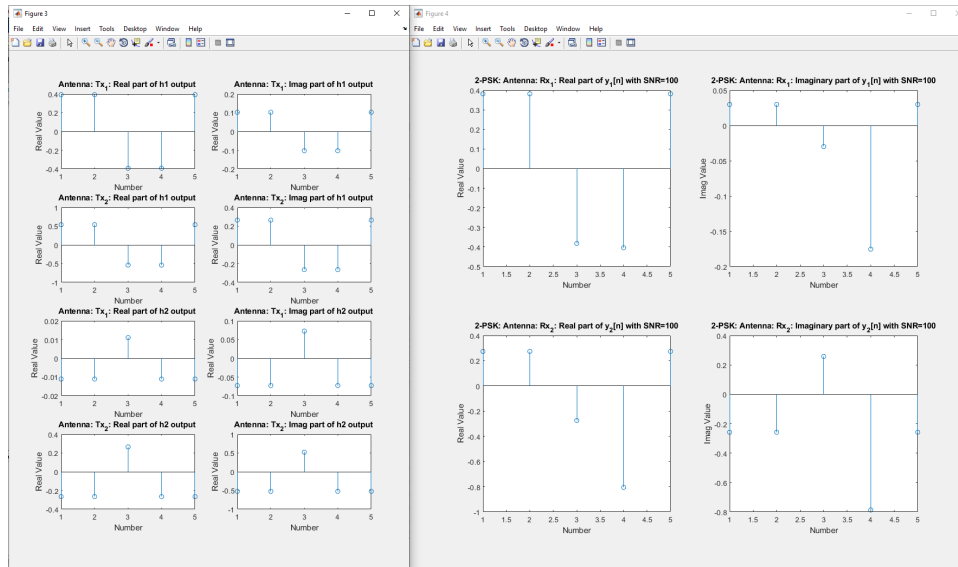


Fig. 16. BPSK Part B, Plots for Flow 1 and Flow 2

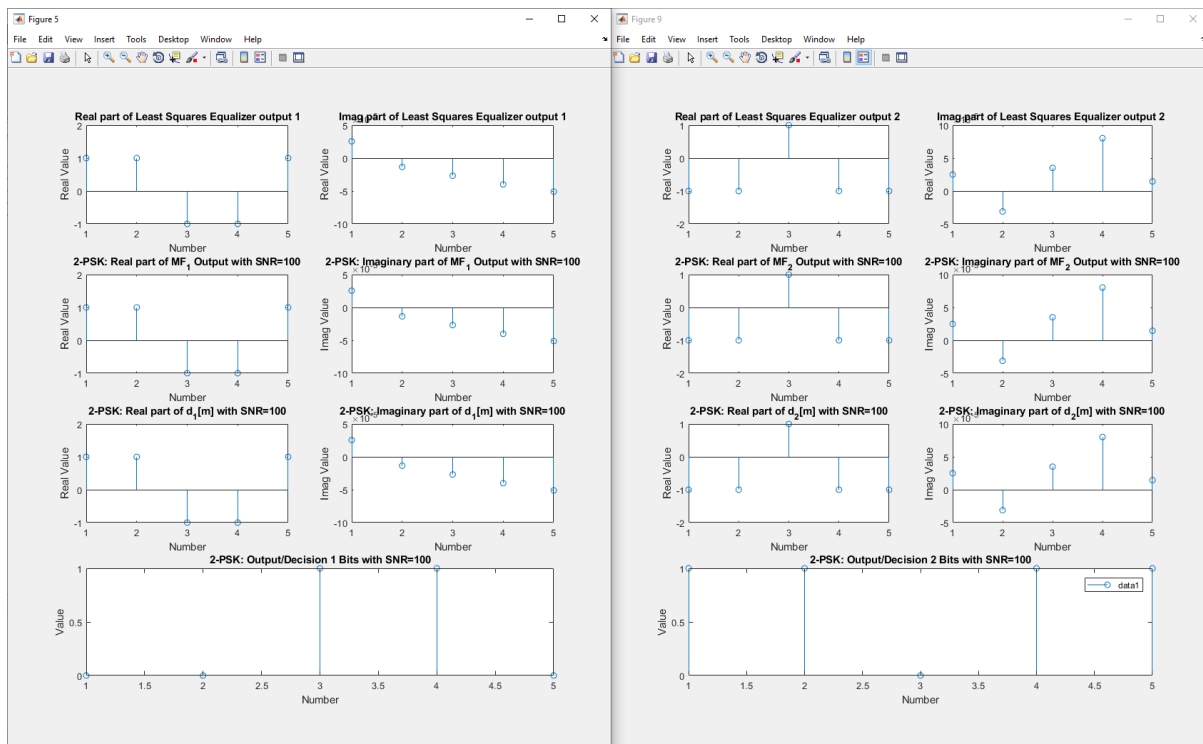


Fig. 17. BPSK Part C, Plots for Flow 1 and Flow 2