**COA031: Broadband Transmission Technology, 2026**
**Department of Communication Engineering, NCU**
**Homework #4**
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Date: 2026/5/25 Deadline: 2026/6/10

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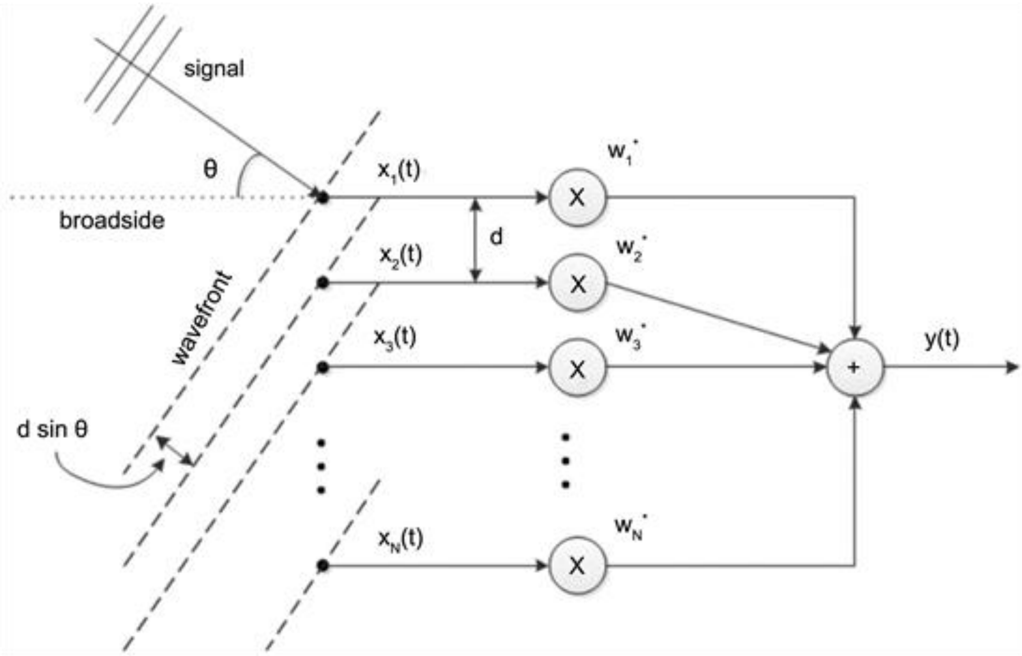
Consider four source signals (including one desired signal and three interferences) impinging on a uniform linear array (ULA) comprising $N$=16 antennas from different directions, as depicted in the following figure. Assume that the distance $d$ between two consecutive antennas is half of the wavelength of the desired signal.

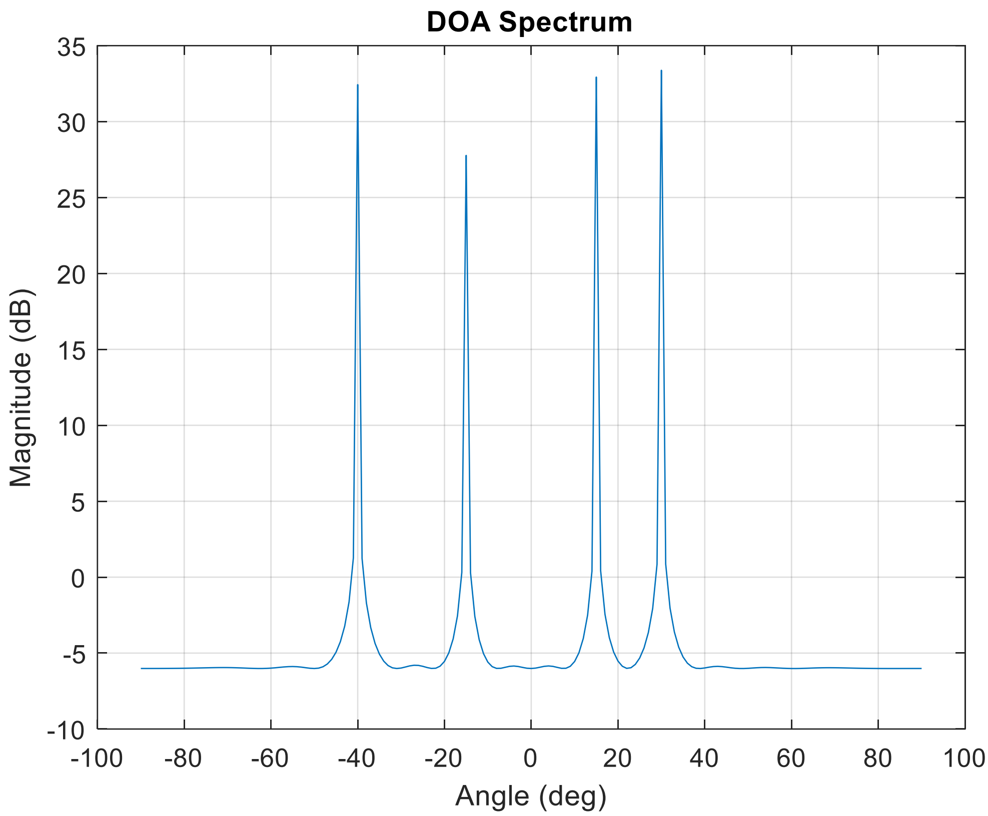



The output $y(n)$, where $n$ is the sample time index, is obtained by the array beamformer, in which $\mathbf{w}=[w_1\ w_2 \cdots w_N]^T$ is an $N\times 1$ complex vector of the beamforming weights to be estimated. Assume that $s_0(n)$ is the desired 64-QAM signal with normalized power and an unknown DOA $\theta$ possibly ranged from $-26^\circ$ to $-5^\circ$. Let the data file **r_hw4.mat** be the received signal matrix that recorded after the receiver antennas for $[x_1(n)\ x_2(n)\cdots x_N(n)]^T$, $n=1,2,\cdots,50000$. Use the MUSIC algorithm to determine the DOA of the desired signal and the MVDR algorithm for the beamforming receiver.

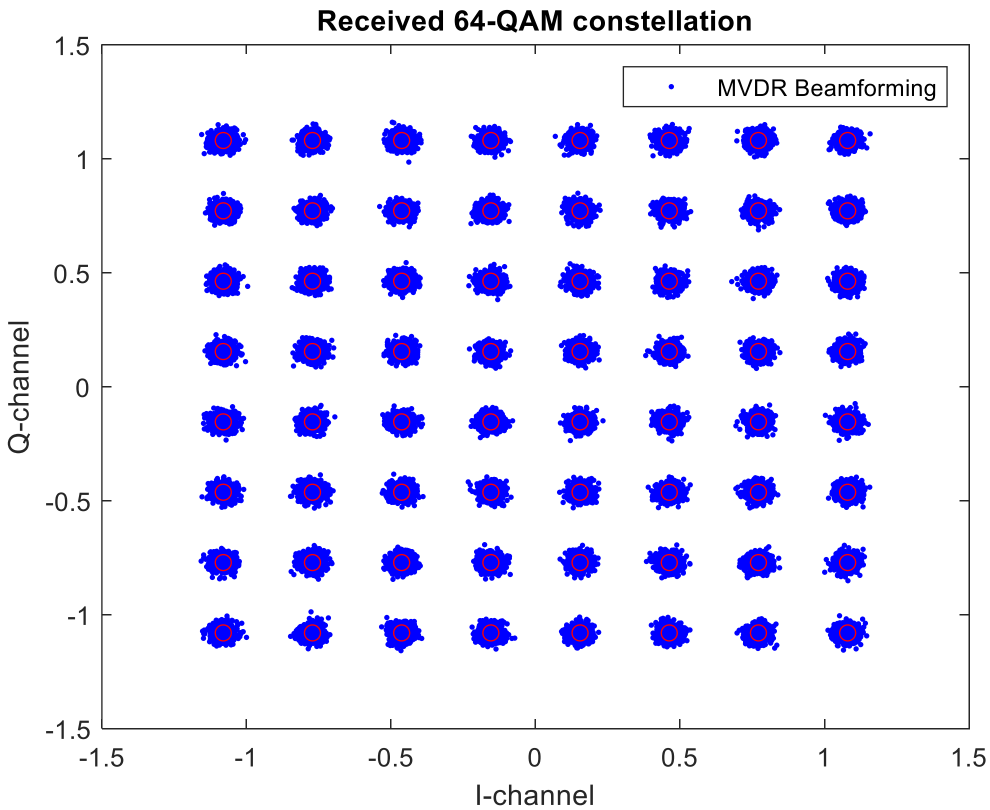
a) Plot the DOA spectrum obtained by the MUSIC algorithm and determine the DOA of the desired signal.
b) Show the received 64-QAM constellation obtained by the MVDR beamformer.
c) Plot the beampattern of the MVDR beamformer and show the DOA location of the desired signal.
d) Search for the MATLAB subroutine **polardb.m** from the internet to plot the polar beampattern of the MVDR beamformer.

**Note: r_hw4.mat** can be downloaded from https://pse.is/47hhbn.

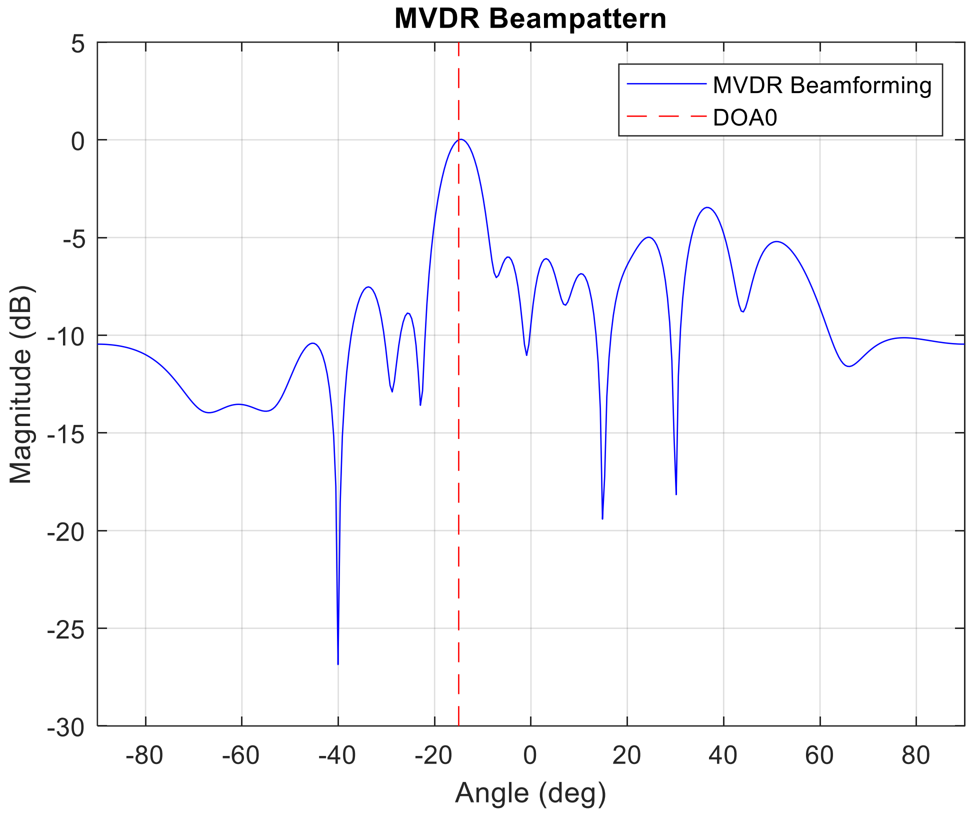
**References:**

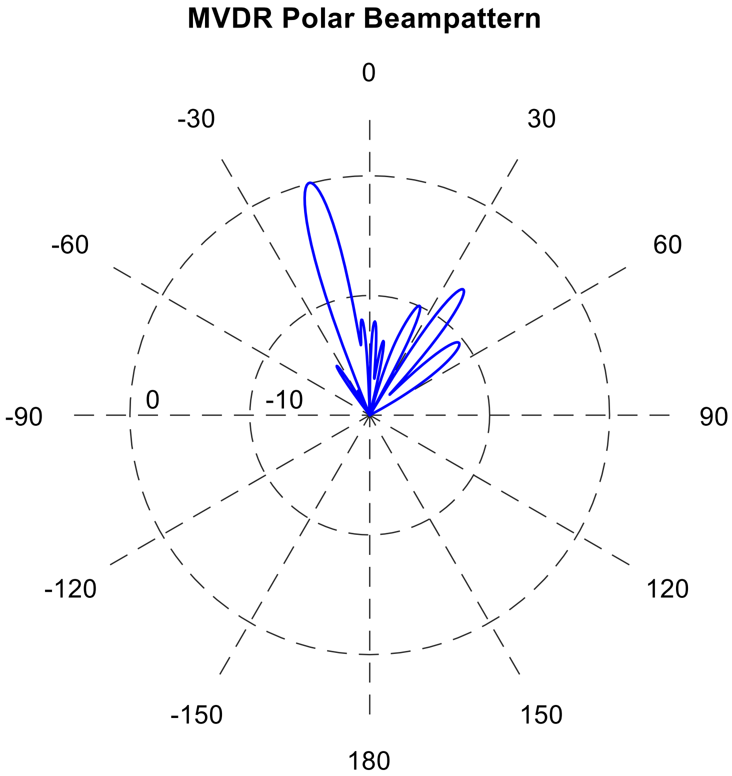


DOA Spectrum
Magnitude (dB)
Angle (deg)
35
30
25
20
15
10
5
0
-5
-10
-100
-80
-60
-40
-20
0
20
40
60
80
100

Received 64-QAM constellation
MVDR Beamforming
Q-channel
I-channel
1.5
1
0.5
0
-0.5
-1
-1.5
-1.5
-1
-0.5
0
0.5
1
1.5


MVDR Beampattern
MVDR Beamforming
DOA0
Magnitude (dB)
Angle (deg)
5
0
-5
-10
-15
-20
-25
-30
-80
-60
-40
-20
0
20
40
60
80


MVDR Polar Beampattern
0
30
60
90
120
150
180
-150
-120
-90
-60
-30
0
-10