Review Test Submission: Test 2 (2020-2021)

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Course	ELEC97004/ELEC97005 - Advanced Communication Theory (BW202010)
Test	Test 2 (2020-2021)
Started	25/04/21 09:26
Submitted	25/04/21 09:44
Status	Completed
Attempt Score	92 out of 100 points
Time Elapsed	18 minutes out of 1 hour and 12 minutes
Instructions	

You can have a maximum of 5 attempts.

There are 12 multiple-choice questions numbered 1 to 12. Mark the answers you think are correct. There is only one correct answer per question.
Duration: 72min.

You should open MATLAB before starting the test.
One question will be presented at a time and you will not be able to go to the previous question and change the answer.
You will have to complete the test in a single attempt. Please make sure that your browser is compatible.

Question 1

8 out of 8 points

Which of the following statements is correct?

(a) mmWave channels present very low level of penetration loss.

(b) In a mmWave digital beamformer the weights are in the bandpass.

(c) ADC/DAC operating at mmWave sampling rates are power efficient.

(d) A massive MIMO has high hardware complexity but low evergy comsumption.

(e) None of the above.

Question 2

9 out of 9 points

Consider a beamformer which employs a uniform array of N antennas with half-wavelength inter-antenna spacing. This beamformer operates in the presence of a desired signal with direction $(\theta = 30^0, \phi = 0^0)$ and two co-channel interferences of known directions $(50°, 0)$ and $(120°, 0)$. The weight vector, normalised to have unity norm magnitude, to complete supression of the two cochannel interferences is

(a) $[0.4391+0.1619i,-0.3796-0.2400i,0.3981-0.0000i,-0.3796+0.2400i,0.4391-0.1619i]^T$

(b) $[0.4391-0.1619i,-0.3796-0.2400i,0.3981-0.0000i,-0.3796+0.2400i,0.4391+0.1619i]^T$

(c) $[0.4391-0.1619i,0.3796-0.2400i,0.3981-0.0000i,0.3796+0.2400i,0.4391+0.1619i]^T$

(d) $[0.4391-0.1619i,0.3796+0.2400i,0.3981-0.0000i,0.3796-0.2400i,0.4391+0.1619i]^T$

(e) None of the above

Question 3

9 out of 9 points

Consider a beamformer which employes a uniform array of N antennas and operates in the presence of a single signal with direction $(\theta = 30^0, \phi = 0^0)$. The carrier frequency is 2.4 GHz and the manifold vector for the Direction-of-Arrival $(\theta = 30^0, \phi = 0^0)$ is

$$[-0.1125 + 0.9936i, 0.6661 + 0.7458i, 1.0000, 0.6661 - 0.7458i, -0.1125 - 0.9936i]^T$$

Consider that the array steers its main lobe towards the direction $(\theta = 30^0, \phi = 0^0)$, the power of the received signal is 1 and the channel noise is additive white Gaussian noise of power 0.01. If at the output of the beamformer P_{out} is the power of the desired signal and SNR_{out} denotes the signal-to-noise ratio, which of the following statements is correct?

(a) P_{out}=5 and SNR_{out}=100.

(b) P_{out}=25 and SNR_{out}=100.

(c) P_{out}=5 and SNR_{out}=500.

(d) P_{out}=25 and SNR_{out}=500.

(e) None of the above.

Question 4

8 out of 8 points

Consider a beamformer which employes a uniform linear array of N antennas and uses the following weight vector:

$$[-0.1125 + 0.9936i, 0.6661 + 0.7458i, 1.0000, 0.6661 - 0.7458i, -0.1125 - 0.9936i]^T.$$

If the channel noise is additive white Gaussian noise with power $\sigma_n^2 = 0.001$ then the noise power at the beamformer's output is:

(a) 0.00025;

(b) 0.0005;

(c) 0.005;

(d) 0.025;

(e) none of the above.

Question 5

8 out of 8 points

Consider that one of the paths from the transmitter of a CDMA user arrives at the reference point of an antenna array CDMA receiver from direction (azimuth, elevation)= $(30°, 0°)$. The corresponding PN-sequence, of period N_c, is generated by the polynomial $D^2 + D + 1$ in GF(2) while the discrete path delay (mod-N_c) is equal to two. If the Cartesian coordinates of the antenna array elements are given by the columns of the following matrix

$$[\underline{r}_1, \underline{r}_2, \underline{r}_3] = \begin{bmatrix} -2, & 0, & +2 \\ 0, & 0, & 0 \\ 0, & 0, & 0 \end{bmatrix} \text{ in units of half-wavelength.}$$

then the spatio-temporal array manifold vector of the path is

(a) 1st column of $\mathbb{H}$;

(b) 2nd column of $\mathbb{H}$;

(c) 3rd column of $\mathbb{H}$;

(d) 4th column of $\mathbb{H}$;

(e) none of the above.

where

$$\mathbb{H} = \begin{bmatrix}
0 & 0 & 0 & 0 \\
0 & \text{-0.6661} + 0.7458i & 0 & 0 \\
\text{-0.6661} + 0.7458i & 0.6661 + 0.7458i & 0 & \text{-0.6661} + 0.7458i \\
\text{-0.6661} + 0.7458i & 0.6661 - 0.7458i & 0 & \text{-1} \\
0.6661 - 0.7458i & 0 & 0 & \text{-0.6661} - 0.7458i \\
0 & 0 & 0 & 0 \\
0 & 0 & \text{-0.6661} + 0.7458i & 0 \\
0 & 0 & \text{-1} & 0 \\
-1 & -1 & \text{-0.6661} - 0.7458i & \text{-0.6661} + 0.7458i \\
-1 & -1 & \text{-0.6661} + 0.7458i & \text{-1} \\
1 & 1 & \text{-1} & \text{-0.6661} - 0.7458i \\
0 & 0 & \text{-0.6661} - 0.7458i & 0 \\
0 & 0 & 0.6661 - 0.7458i & 0 \\
0 & \text{-0.6661} - 0.7458i & 1 & 0 \\
\text{-0.6661} - 0.7458i & \text{-0.6661} - 0.7458i & 0.6661 + 0.7458i & 0.6661 - 0.7458i \\
\text{-0.6661} - 0.7458i & 0.6661 + 0.7458i & 0 & 1 \\
0.6661 + 0.7458i & 0 & 0 & 0.6661 + 0.7458i \\
0 & 0 & 0 & 0
\end{bmatrix}$$

Question 6

8 out of 8 points

For a uniform linear array of 5 sensors operating at 2.4GHz frequency with an inter-antenna spacing 6.25cm the beamwidth is

(a) $11.537°$;

(b) $23.074°$;

(c) $45.537°$;

(d) $47.156°$;

(e) none of the above.

Question 7

9 out of 9 points

Consider a SIMO communication system operating in the presence of a desired signal with signal power 100mW and one interferer with double-sided PSD(f) of 10^{-2} W/Hz. The noise is assumed to be AWGN with double-sided PSD(f) of 10^{-2} W/Hz. The receiver employs a complete intereference cancellation subspace beamformer and utilises a ULA of 10 antennas. If the channel bandwidth is 8 kHz what is the system/channel capacity?

(a) 0 bits/sec.

(b) 14.4 bits/sec.

(c) 72 bits/sec.

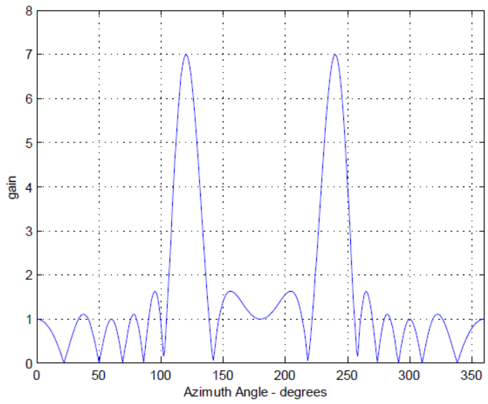
(d) 144 bits/sec.

(e) infinity bits/sec.

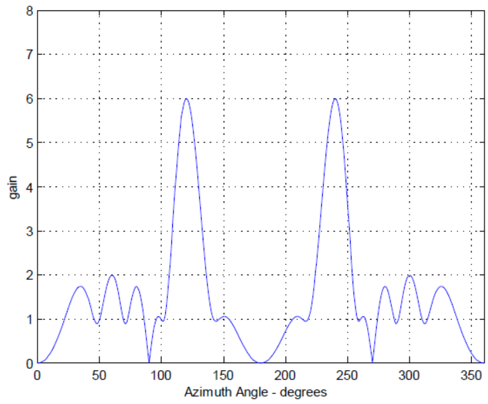
Question 8

8 out of 8 points

The two figures below show the array patterns of two different linear arrays.



(1)



(2)

Which of the following statements is correct?

(a) In Figure (1) the array is a uniform linear array of 6 sensors.

(b) In Figure (1) the array has no weights (i.e. weights equal to 1)

(c) In Figure (2) the array is a uniform linear array of 6 sensors.

(d) In Figure (2) the array has no weights (i.e. weights equal to 1)

(e) None of the above.

Question 9

9 out of 9 points

Consider a beamformer which employs a uniform array of N antennas with half-wavlength interantenna spacing. This beamformer operates in the presence of a desired signal with direction $(\theta = 30^0, \phi = 0^0)$ and two unknown co-channel interferences. The covariance matrix of the received signal $\underline{x}(t)$ has the covariance matrix of the received signal $\underline{x}(t)$ is

7.8000 - 0.0000i, -0.7327 + 2.1623i, 5.5846 - 3.7594i, 2.9266 + 4.3835i, 1.3609 - 3.8965i;
-0.7327 - 2.1623i, 7.8000 + 0.0000i, -0.7327 + 2.1623i, 5.5846 - 3.7594i, 2.9266 + 4.3835i;
5.5846 + 3.7594i, -0.7327 - 2.1623i, 7.8000 + 0.0000i, -0.7327 + 2.1623i, 5.5846 - 3.7594i;
2.9266 - 4.3835i, 5.5846 + 3.7594i, -0.7327 - 2.1623i, 7.8000 - 0.0000i, -0.7327 + 2.1623i;
1.3609 + 3.8965i, 2.9266 - 4.3835i, 5.5846 + 3.7594i, -0.7327 - 2.1623i, 7.8000 + 0.0000i;

(please copy the above matrix to MATLAB)

The Wiener-Hopf weight vector, normalised to have unity norm magnitude, is

(a) $[0.4326\text{-}0.3057\text{i},\text{-}0.3849\text{-}0.2593\text{i},\text{-}0.0903\text{+}0.0000\text{i},\text{-}0.3849\text{-}0.2593\text{i},0.4326\text{-}0.3057\text{i}]^T$

(b) $[0.4326\text{+}0.3057\text{i},0.3849\text{+}0.2593\text{i},\text{-}0.0903\text{+}0.0000\text{i},0.3849\text{-}0.2593\text{i},0.4326\text{-}0.3057\text{i}]^T$

(c) $[0.4326\text{+}0.3057\text{i},\text{-}0.3849\text{-}0.2593\text{i},\text{-}0.0903\text{+}0.0000\text{i},\text{-}0.3849\text{+}0.2593\text{i},0.4326\text{-}0.3057\text{i}]^T$

(d) $[0.4326\text{+}0.3057\text{i},\text{-}0.3849\text{+}0.2593\text{i},\text{-}0.0903\text{+}0.0000\text{i},\text{-}0.3849\text{-}0.2593\text{i},0.4326\text{-}0.3057\text{i}]^T$

(e) None of the above

Question 10

0 out of 8 points

Consider a beamformer which employes the following uniform linear array of N antennas.

$$\begin{bmatrix} \text{-0.0938}, & \text{-0.0313}, & 0.0313, & 0.0938 \\ 0, & 0, & 0, & 0 \\ 0, & 0, & 0, & 0 \end{bmatrix} \text{ in metres}$$

The carrier frequency is 2.4 GHz and to steer the main lobe of the array towards the direction ($\theta = 30^0, \phi = 0^0$), the weight vector $\underline{w}$ should be

(a) $[1, \quad 1, \quad 1, \quad 1]^T$;

(b) $[-0.5902 - 0.8072i, 0.2089 + 0.9779i, 0.2089 - 0.9779i, -0.5902 + 0.8072i]^T$;

(c) $[+0.5902 - 0.8072i, -0.2089 + 0.9779i, -0.2089 - 0.9779i, +0.5902 + 0.8072i]^T$;

(d) $[-0.5902 + 0.8072i, 0.2089 - 0.9779i, 0.2089 + 0.9779i, -0.5902 - 0.8072i]^T$;

(e) none of the above

Question 11

8 out of 8 points

With reference to a Wiener-Hopf beamformer, which of the following statements is correct?

(a) It is a superresolution beamformer.

(b) It is robust to errors associated with the direction of the desired signal.

(c) It provides, asymptotically, complete interference cancellation.

(d) It is optimum with respect to SNIR criterion.

(e) None of the above.

Question 12 8 out of 8 points

Consider a linear array of 5 antennas with locations

$$\begin{bmatrix}-2, & -1, & 0, & 1, & 2\end{bmatrix}$$

operating in the presence of 3 sources transmitting the signals $m_1(t)$, $m_2(t)$ and $m_3(t)$. The directions-of-arrival of the three signals are correctly estimated to be equal to $(30°,0°)$, $(35°,0°)$ and $(90°,0°)$ and the noise power is 0.1. If the covariance matrix of the received signal $\underline{x}(t)$ is

10.2040 - 0.0000i -0.5788 + 4.1396i 6.7444 - 4.5482i 4.5234 + 6.4366i 1.2585 - 4.0588i
-0.5788 - 4.1396i 7.2210 + 0.0000i -1.7454 + 0.1726i 5.9678 - 4.3653i 1.4498 + 3.4004i
6.7444 + 4.5482i -1.7454 - 0.1726i 8.0986 + 0.0000i -0.6623 + 4.4220i 4.8585 - 3.4939i
4.5234 - 6.4366i 5.9678 + 4.3653i -0.6623 - 4.4220i 9.5774 + 0.0000i -1.5253 + 1.1245i
1.2585 + 4.0588i 1.4498 - 3.4004i 4.8585 + 3.4939i -1.5253 - 1.1245i 6.5210 + 0.0000i

(please copy the above matrix to MATLAB)

which of the following results is correct?

(a) $\mathcal{E}\{m_1(t).m_2^*(t)\} = 0.2457 - 0.1721\mathrm{i}$,

(b) $\mathcal{E}\{m_1(t).m_2^*(t)\} = 0.3536$

(c) $\mathcal{E}\{m_1(t).m_3^*(t)\} = -0.4500$

(d) $\mathcal{E}\{m_1^2(t)\} = 2.1$

(e) $\mathcal{E}\{m_3^2(t)\} = 3.2$

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Sunday, 25 April 2021 09:44:48 o'clock BST

← **OK**