Review Test Submission: Test 1 (2020-2021)

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Course	ELEC97004/ELEC97005 - Advanced Communication Theory (BW202010)
Test	Test 1 (2020-2021)
Started	25/04/21 08:59
Submitted	25/04/21 09:25
Status	Completed
Attempt Score	100 out of 100 points
Time Elapsed	25 minutes out of 1 hour and 18 minutes
Instructions	You can have a maximum of 5 attempts.

There are 13 multiple-choice questions numbered 1 to 13. Mark the answers you think are correct.
There is only one correct answer per question.
Duration: 78min.

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

Consider uniform linear antenna array system of 5 elements of halfwavelength spacing operating in the presence of one desired and two co-channel interfering signals all of power equal to $P_s = 0.9$. The power of the noise is equal to $\sigma_n^2 = 1$. If $\mathbb{R}_{xx}$ is the theoretical covariance matrix of the received signal vector $\underline{x}(t)$ then which of the following statements is correct?

(a) The rank of $\mathbb{R}_{xx}$ is equal to 2.
(b) The rank of $\mathbb{R}_{xx}$ is equal to 3.
(c) The minimum eigenvalue of $\mathbb{R}_{xx}$ is equal to P_s.
(d) The principal eigenvalue of $\mathbb{R}_{xx}$ is equal to 3.9.
(e) None of the above.

Question 2

7 out of 7 points

Consider an antenna array systems of 5 elements operating in the presence of one desired and two co-channel interfering signals all of power equal to $P_s = 1$. The power of the noise is equal to $\sigma_n^2 = 10$. If $\mathbb{R}_{xx}$ is the theoretical covariance matrix of the received signal vector $x(t)$ then which of the following statements is correct?

(a) The rank of $\mathbb{R}_{xx}$ is equal to 2.

(b) The rank of $\mathbb{R}_{xx}$ is equal to 3.

(c) The rank of $\mathbb{R}_{xx}$ is equal to 5.

(d) The minimum eigenvalue of $\mathbb{R}_{xx}$ is equal to P_s.

(e) The principal eigenvalue of $\mathbb{R}_{xx}$ is equal to σ_n^2.

Question 3

8 out of 8 points

Consider a uniform linear array of N antennas with half-wavelength spacing.

The carrier frequency is 2.4 GHz and the manifold vector for a signal with Direction-of-Arrival $(\theta = 30^0, \phi = 0^0)$ is

$[-0.1125-0.9936i, 0.6661-0.7458i, 1.0000+0.0000i, 0.6661+0.7458i, -0.1125+0.9936i]^T$

The array aperture is

- 25 cm;
- 31.25 cm;
- 50 cm;
- 62.5 cm;
- none of the above

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

$[-0.1125-0.9936i, 0.6661-0.7458i, 1.0000+0.0000i, 0.6661+0.7458i, -0.1125+0.9936i]^T$

The array aperture is

- 25 cm;
- 31.25 cm;
- 50 cm;
- 62.5 cm;
- none of the above

Question 4

7 out of 7 points

With reference to 'multi-user (MU) CDMA receivers', which of the following statements is correct?

(a) A RAKE receiver is a multi-user receiver.

(b) A multi-user receiver is used to resolve paths (in a multipath environment), delayed by more than the chip period T_c.

(c) Decorrelating MU receiver is an optimum multi-user receiver.

(d) A minimum-mse MU receiver requires no knowledge the cross-correlation matrix of the PN-signals.

(e) None of the above.

Question 5

8 out of 8 points

Consider a linear array of 5 Rx-antennas having the following Cartesian coordinates:

$$[\underline{r}_1, \underline{r}_2, \underline{r}_3, \underline{r}_4, \underline{r}_5] = \begin{bmatrix} -5, & -1, & +1, & +2, & +3 \\ 0, & 0, & 0, & 0, & 0, \\ 0, & 0, & 0, & 0, & 0, \end{bmatrix} \text{ in units of half-wavelength.}$$

The rate of change of the arclength $\dot{s}(\theta)$ of the array manifold for a source with Direction-of-Arrival (azimuth) $\theta = 30^\circ$ is

(a) $\dot{s}(30^\circ) = 19.631$;

(b) $\dot{s}(30^\circ) = 9.9346$;

(c) $\dot{s}(30^\circ) = 5.4414$;

(d) $\dot{s}(30^\circ) = 3.1623$;

(e) none of the above.

Question 6

7 out of 7 points

Consider an array of 4 antennas with Cartesian coordinates given by the following matrix

$$\begin{bmatrix} -2, & 2, & 2, & -2 \\ -0.5, & -0.5, & 1, & 0.5 \\ 0, & 0, & 0, & 0 \end{bmatrix} \text{ in units of half-wavelength.}$$

The array aperture is

(a) 4.272;

(b) 4.0311;

(c) 4;

(d) 1.5;

(e) none of the above.

Question 7

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)= $(60°, 0°)$. For this path, if the Cartesian coordinates of the antenna array elements are given by the columns of the following matrix

$$[\underline{r}_1, \underline{r}_2, \underline{r}_3] = \begin{bmatrix} -1, & 0, & +1 \\ 0, & 0, & 0 \\ 0, & 0, & 0 \end{bmatrix} \text{ in units of half-wavelength,}$$

then manifold vector is

(a) $\underline{S}(\theta) = \begin{bmatrix} j, & 0 & -j \end{bmatrix}$;
(b) $\underline{S}(\theta) = \begin{bmatrix} -j, & 0 & j \end{bmatrix}$;
(c) $\underline{S}(\theta) = \begin{bmatrix} j, & 1 & -j \end{bmatrix}$;
(d) $\underline{S}(\theta) = \begin{bmatrix} -j, & 1 & j \end{bmatrix}$;
(e) none of the above.

Question 8

8 out of 8 points

Consider a MIMO wireless communication system, where the Cartesian coordinates of the Tx and Rx antenna array elements are given by the columns of the following matrices

$$\text{Tx} : [\overline{r}_1, \overline{r}_2] = \begin{bmatrix} 0, & 0 \\ -0.5, & 0.5 \\ 0, & 0 \end{bmatrix} \text{ in units of half-wavelength.}$$

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

Which of the following statements associated with the geometry (Cartesian coordinates) of its virtual MISO wireless communication system is correct?

(a) $\begin{bmatrix} -2, & 2, & -2, & 2 \\ -0.5, & -0.5, & 0.5, & 0.5 \\ 0, & 0, & 0, & 0 \end{bmatrix}$ (i.e. a planar array).

(b) $\begin{bmatrix} -0.5, & -0.5, & 0.5, & 0.5 \\ -2, & 2, & -2, & 2 \\ 0, & 0, & 0, & 0 \end{bmatrix}$ (i.e. a planar array).

(c) $\begin{bmatrix} -2.5, & 1.5, & -1.5, & 2.5 \\ 0, & 0, & 0, & 0 \\ 0, & 0, & 0, & 0 \end{bmatrix}$ (i.e. a linear array).

(d) $\begin{bmatrix} 0, & 0, & 0, & 0 \\ -2.5, & 1.5, & -1.5, & 2.5 \\ 0, & 0, & 0, & 0 \end{bmatrix}$ (i.e. a linear array).

(e) None of the above.

Question 9

8 out of 8 points

Consider a uniform linear array of N antennas. The carrier frequency is 2.4 GHz and the manifold vector for a signal with Direction-of-Arrival $(\theta = 30^0, \phi = 0^0)$ is

$$[-0.5902 - 0.8072i, 0.2089 + 0.9779i, 0.2089 - 0.9779i, -0.5902 + 0.8072i]^T$$

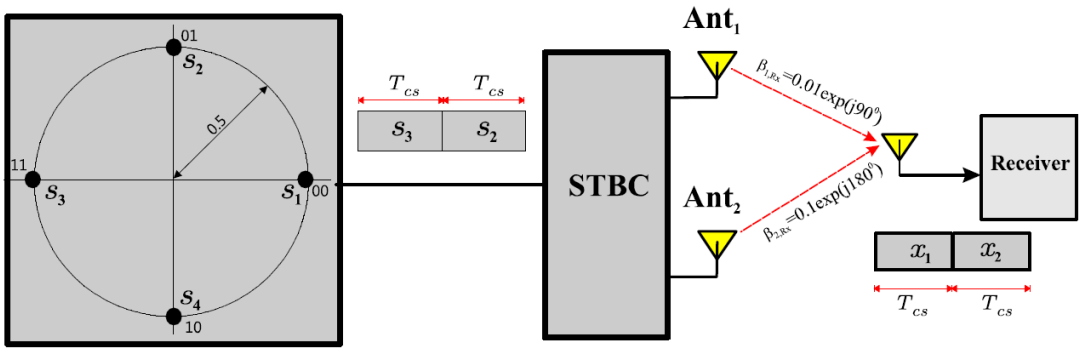
The origin of the Cartesian coordinates (array reference point) is the

(a) 1st antenna;
(b) 2nd antenna;
(c) 3rd antenna;
(d) 4th antenna;
(e) none of the above.

Question 10

8 out of 8 points

Consider the QPSK MISO system of 2 Tx antennas operating in a frequency flat wireless channel as shown the following figure:



If the QPSK symbols $[s_3, s_2]$ are transmitted using the above "Space-Time Block Coder" (STBC) then the receiver's input $[x_1, x_2]$, ignoring the noise, is

(a) $[0.045\text{j}, \quad -0.055]$;
(b) $[0.045, \quad -0.055\text{j}]$;
(c) $[-0.055, \quad 0.045\text{j}]$;
(d) $[-0.055\text{j}, \quad 0.045]$;
(e) none of the above.

Question 11

7 out of 7 points

With reference to SISO wireless channels, which of the following statements is correct?

(a) If the displacement of a wireless receiver is less than the "coherence distance" D_{coh} then the channel experiences small-scale fading.
(b) The "coherence distance" D_{coh} is the largest distance that a wireless receiver can move with the channel appearing to be variable.
(c) If the transfer function of a wireless channel varies with time then "space-selectivity" and "spatial-coherence" are identical concepts.
(d) "Fast fading" implies that the magnitude of the transfer function of a wireless channel varies with time in the interval $nT_{cs} < t < (n+1)\,T_{cs}$ with T_{cs} denoting a channel symbol duration and n is an integer.
(e) None of the above.

Question 12

8 out of 8 points

Consider an antenna array systems of N elements operating in the presence M co-channel sources ($M < N$). If $\underline{S}_i$ is the manifold vector associated with the i^{th} source and $\mathbb{E}_s$ and $\mathbb{E}_n$ denote the matrices with columns the signal eigenvectors and the noise eigenvectors respectively of data covariance matrix $\mathbb{R}_{xx}$ then which of the following expresssions is correct?

(a) $\mathbb{E}_n.\mathbb{E}_n^H.\underline{S}_i = \underline{S}_i$

(b) $\mathbb{E}_s.\mathbb{E}_s^H.\underline{S}_i = \underline{0}$

(c) $\left(\mathbb{I}_N - \mathbb{E}_n.\mathbb{E}_n^H\right).\underline{S}_i = \underline{0}$

(d) $\left(\mathbb{I}_N - \mathbb{E}_s.\mathbb{E}_s^H\right).\underline{S}_i = \underline{S}_i$

(e) None of the above.

Question 13

8 out of 8 points

Consider a single transmitter whose signal arrives at the receiver via 4 coherent (fully correlated) multipaths. The receiver consists of a uniform linear antenna array of 10 antennas with half-wavelength interantenna spacing. The dimensionality of the signal subspace is:

(a) 1.

(b) 2.

(c) 3.

(d) 4.

(e) 10.

Sunday, 25 April 2021 09:25:04 o'clock BST

← OK