DIGITAL BEAM FORMING TECHNIQUES
(ECEN 4243)

Time Allotted : 3 hrs   **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
<u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

   (i)   Electrical size of antenna is increased by which of the following?
           (a) Antenna Array   (b) Decreasing the coverage area
           (c) Increasing the coverage area   (d) Using a single antenna.

   (ii)   In an end-fire array, what should be the angle to the axis of the array such that there exists no radiation
           (a) 45°   (b) 180°   (c) 90°   (d) 0°.

   (iii)   Relation between directivity and effective area of transmitting and receiving antenna is
           (a) $D_t A_t = D_r A_r$ (b) $D_t A_r = D_r A_t$ (c) $A_t D_t = \in D_r A_r$ (d) $D_t A_t = \in D_r A_r$.

   (iv)   In space-time adaptive processing, ____ and equalization parameters are calculated ____
           (a) diversity, jointly   (b) diversity, independently
           (c) beamforming, jointly   (d) beamforming, independently

   (v)   Which method is used to calculate beamforming weights?
           (a) Sample matrix inversion   (b) Indirect matrix inversion
           (c) Convolution   (d) Correlation.

   (vi)   Interference with adjoining sectorized antennas can be avoided by
           (a) frequency nulling   (b) spatial nulling
           (c) spatial beam-forming   (d) frequency beam-forming.

   (vii)   A uniform linear array contains
           (a) N elements placed at equidistance and fed currents of equal magnitude and progressive phase shift
           (b) N elements at non-equidistance and fed currents of equal magnitude and progressive phase shift

(c) N elements at equidistance and fed currents of unequal magnitude and progressive phase shift

(d) N elements at equidistance and fed currents of unequal magnitude and equal phase shift.

(viii) Collinear array means
(a) an array in which the antennas are arranged perpendicularly
(b) an array in which the antennas are arranged co-axially
(c) an array in which the antennas are having cross polarization
(d) (a) and (c) both.

(ix) A RAKE receiver uses
(a) equalization   (b) channel coding
(c) diversity   (d) encryption.

(x) Which of the following statements is false?
(a) The intra cellular handoffs are less in adaptive array compared to switching beams
(b) Noise interference cannot be detected in adaptive arrays effectively compared to switching beams
(c) Advanced digital signal processors are used in adaptive arrays
(d) Algorithms used in adaptive array is more complex than switching beams.

Group – B

2. (a) Differentiate between analog and digital beam forming.
                                      [(CO2)(Remember/LOCQ)]
    (b) What is the function of ADC in element-space beam forming?
                                      [(CO2)(Understand/LOCQ)]
    (c) Establish a mathematical model to realize two dimensional beam forming?
                                      [(CO2)(Evaluate/HOCQ)]
                                          3 + 3 + 6 = 12

3. (a) Define advantages of phased array over linear array. [(CO1)(Understand/LOCQ)]
    (b) Define end fire array.   [(CO1)(Remember/LOCQ)]
    (c) If the array factor of a linear array has zeros at f = 90°, 180°, 270° and the elements are spaced at $\lambda/4$, design the array.   [(CO1)(Evaluate/HOCQ)]
                                          4 + 2 + 6 = 12

Group – C

4. (a) What do you mean by Signal to Interference Ratio (SIR)? Explain the method used to use SIR in finding optimum weight in an adaptive beam forming system.
                                      [(CO3)(Understand/LOCQ)]
    (b) Explain Least Mean Square Algorithm used in adaptive beam forming.
                                      [(CO3)(Analyze/IOCQ)]
                                          6 + 6 = 12

5. (a)   What do you mean by quantization error in DBF?   [(CO5)(Remember/LOCQ)]
    (b)   Develop a mathematical model to understand the effect of element failure in beam forming.   [(CO3)(Analyze/IOCQ)]
    (c)   Illustrate the effect of receiver non linearity on adaptive beam forming.
                                                          [(CO3)(Analyze/IOCQ)]
                                                          2 + 5 + 5 = 12

Group – D

6. (a)   Find relation between error tolerance with minimum number of elements required in case of various pointing error tolerance.   [(CO3)(Analyze/IOCQ)]
    (b)   Discuss beam space beam forming networks.   [(CO4)(Understand/LOCQ)].
                                                          6 + 6 = 12

7. (a)   Explain how DBF in FDMA is realized.   [(CO4)(Analyze/IOCQ)]
    (b)   How DBF in CDMA is different from that of DBF in FDMA technology?
                                                          [(CO4)(Evaluate/HOCQ)]
    (c)   A CDMA system is defined with the following parameters:
          Frequency reuse efficiency η_f = 0.55, E_b/N_0 = 10 dB, the information bit transmission rate is 16.2 kbp, system bandwidth W = 12.5 MHz. Neglecting all other sources of interference, determine the system capacity and spectral efficiency.   [(CO3)(Analyze/IOCQ)]
                                                          3 + 4 + 5 = 12

Group – E

8. (a)   Derive a mathematical model to understand BER performance with fading.
                                                          [(CO5)(Analyze/IOCQ)]
    (b)   What do you mean by co-channel interference? Define a method to reduce such interference in wireless communication.   [(CO5)(Evaluate/HOCQ)]
                                                          6 + 6 = 12

9. (a)   Design an algorithm based on cyclostationary properties for mobile communication system.   [(CO6)(Create/HOCQ)]
    (b)   Design a mobile terminal system such that EIRP is 10.6 dBW. (Assume other losses are 3 dB and propagation losses are 188.5 dB.) [(CO6)(Evaluate/HOCQ)]
                                                          8 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	33.33	31.25	35.42

Course Outcome (CO):

After the completion of the course students will be able to
1. Differentiate between analog and digital beam forming.
2. Understanding the necessity of adaptive beam forming.
3. Apply signal processing concepts in developing beam formers.
4. Understand different beam forming configurations.
5. Identify error and its corresponding effects in digital beam forming.
6. Apply digital beam concepts in wireless communication.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question