Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

ME Semester –III Examination Dec. - 2011

Subject code: 732602 **Date: 08/12/2011**

Subject Name: Radar Signal Processing

Time: 10.30 am – 01.00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Define the following with a neat sketch and mathematical relation: **07**
(i) Resolution cell (ii) Range resolution (iii) Angular Resolution (iv) Spatial frequency **(v)** pulse repetition frequency(vi) Doppler shift (vii) Volume scatterer

(b) An aircraft has a 2º azimuth 3 dB beamwidth. The RF frequency is 10 GHz and the antenna is steered to a squint angle ψ of 30º. If the aircraft flies at 150 m/s, what is the Doppler spread of the clutter echoes induced by the aircraft motion? **03**

(c) Explain with the help of schematic, the correspondence between the radar signal processing functions and operations on the radar data cube **04**

Q.2 **(a)** For a synthetic aperture radar of sidelooking stripmap system. The aircraft is flying straight and level at a constant velocity of 150 m/s to image a swath extending from 10 km to 20 km slant range from the aircraft with the swath length as *Ls* = 10 km. The radar operates at 15GHz . The physical antenna beamwidth is $\theta az = 2^\circ$ with resolution in both slant range and cross range of 1.0 meters and grazing angle δ is 0° **07**
(i)Estimate the azimuth size of the physical antenna aperture, *Daz*, in meters.
(ii)What pulse bandwidth β is required to obtain the desired range resolution?
(iii)What is the bound on the PRF due to the Doppler bandwidth of the received data? What is the bound on the PRF due to the swath length?

(b) Explain the principle of operation of a radar.Derive the expression for the radar range considering the effect of noise.and all losses. **07**
For a volume scatterer,obtain the expression for the received power P_r without noise factor.

(OR)

(b) Explain Doppler effect.For a monostatic radar, **07**
(i)Prove the relation for the received frequency for a target moving with a velocity ν toward the radar.
(ii) Obtain the expression for the received signal y(t) for the transmitter signal x(t) with frequency $F_1(t)$ as
$x(t) = \alpha(t)\exp(j2\pi F_1(t))$ .Deduce Doppler shift from this.

Q.3 **(a)** Show the flow of operations of a generic radar signal processor and signal conditioning operations **03**

(b) Compare Pulse-Limited Area Range and Beam -Limited Area Range. **04**

(c) Compare quantitatively sampling in Fast time and slow time of pulsed radar signals. **07**

OR

Q.3 **(a)** Explain the concept of moving target indication.State its limitations.Compare mathematically the frequency response of 2 pulse and 3 pulse delay line cancellers along with plots. **07**

(b) An MTI radar is operating at 3 GHz with a pulse period of 0.5 msec.Find its unambiguous range and fourth blind speed. **03**

Q.4 **(a)** Discuss the basis of detection of a target stating the hypotheses assumed. Explain briefly (i)Neyman-Pearson detection rule(ii) The likelihood ratio test **07**

(b) Consider a pulse-to-pulse staggered PRF system using a series of P = PRFs, namely { 750Hz, 1000Hz}. What is the first blind Doppler frequency Fb, of the staggered system? Find F_b/F_{us} where F_{us} is the blind speed Doppler frequency of a system having a PRF corresponding to the average PRI? **04**

(c) Name land and sea clutters and what are their effects on target detection. **03**

OR

Q.4 **(a)** Explain a uniform linear antenna array and give the expression for the relative field strength at a point and show its grahphical pattern . **03**

(b) What is a matched filter. Derive the expression for SNRof a matched filter for a simple pulse of duration τ sec. **06**

(c) Explain : (i) Matched filter for the pulse burst waveform **05**

(OR)

(ii) Linear Frequency modulated (LFM) waveform

Q.5 **(a)** What is a Synthetic aperture radar?For a SAR explain the following: **09**

(i) Cross range resolution .

(ii) The concept of SAR operation with the help of a neat diagram.

(iii) A Sidelooking Radar (SLR)

(iv) The relation between the effective Synthetic aperture size D_{SAR} and the aperture time T_a.

(v) Characterisics of SAR images and applications.

(b) A pulsed radar has peak power of 10 kW and average transmitted power of 6 KW and uses two PRFs, fr_1 = 10 KHz and fr_2 = 30KHz. Compute the required pulse widths for each PRF and pulse energy in each case. **05**

OR

Q.5 **(a)** Derive the fundamental SAR resolution using Doppler processing point of view.Show that Doppler difference between two scatterers separated by ΔCR meters is given by $\Delta F_D = \frac{2v\Delta CR}{\lambda R}$ and the aperture time $T_a = \frac{\lambda R}{2v\Delta CR}$ **07**

(b) Explain Doppler beam sharpening algorithm of SAR **07**

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