EE 602(2020-1): End Semester Examination

Date: 23rd Nov 2020 **Total Marks: 40**

Note: Assume data if necessary and state the assumption clearly in the answer sheet

Q1 Select most appropriate choice(s) from given options. Write an explanation for the same. (1X3=3 Marks)

(i) A pulsed radar uses 8 μs transmit pulse coded with 4 bit Barker code. Pulse Repetition Frequency (PRF) is 10 KHz, Peak power is 100 kW. What is the average transmit power?
(a) 2 kW (b) 8 kW (c) 4 kW (d) 800 W

(ii) What will be range resolution with the system having parameters given in Q1 (i)?
(a) 150m (b) 1.2km (c) 300m (d) 120m

(iii) An amplifier has two-stages. The noise factors (noise Figure expressed as ratio) and gains of individual stages are (F1=1.8, G1= 100) and (F2=2, G2=300). What will be noise figure of the cascaded (stage1 followed by stage2) amplifier?
(a) 1.81 (b) 1.8033 (c) 1.82 (d) 2.18

Q2: Write short answers. Illustrations/ sketches may be to explain justify. (14 Marks)

(i) DME system provides the slant range, VoR provide bearing (angular position/ direction) from a known DME/VoR station. An altimeter provides height from the MSL/ground. What combination of these Instruments would facilitate an aircraft to fix its own 3-D location? (Explain with only diagram or diagram and a couple of lines.) (2 marks)

(ii) Where are the 'localizer antenna' positioned? How does it guide the landing aircraft? Explain in 1-2 sentences, how is the extent of misalignment derived? (2 marks)

(iii) Delay jamming technique involves detecting the radar transmission and re-transmitting the replica of radar pulses with random delays. How does this technique give false indication of the target range? (1 mark)

(iv) A continuous wave radar 'ranging system' transmits a fixed frequency sine wave with wavelength 'λ'. Echo received by this radar, is down converted to the base band using the part of the transmitted signal as local oscillator (LO). What is the maximum interval over which this system offers unambiguous range detection? (1 mark)

(v) Pulsed Doppler radar at 50 MHz, transmits the pulses at PRF of 1 kHz. The receiver performs 'complex sampling with of the baseband signal and performs 'coherent integration' of the echoes by accumulating (adding the signal strength) the corresponding echoes from 40 consecutive pulses. These coherently integrated signals are treated as time samples forming a 'time sequence' of the target echoes. This sequence is then subjected to 1k (1024) -point DFT (discrete Fourier transform) for ± Doppler analysis. Find the
(a) Sampling rate of the 'coherent integrated time series'. (1 mark)
(b) What is the total unambiguously represented bandwidth (1 mark)
(c) The maximum base band Doppler frequency and frequency resolution (1 mark)
(d) Maximum velocity and velocity resolution of target. (1 mark)

(vi) The 'integrator' is a single pole IIR filter while the 'comb filter' is an FIR filter.
(a) What is the filter type of N-stage CIC decimation filter (FIR or IIR)? (1 mark)
(b) Justify with 'z-domain transfer function'. (2 marks)

(c) Following diagram gives the normalized frequency response of a decimation CIC filter. How many 'integrator-comb' stages are there in this CIC filter (find N)? Justify. (1 mark)

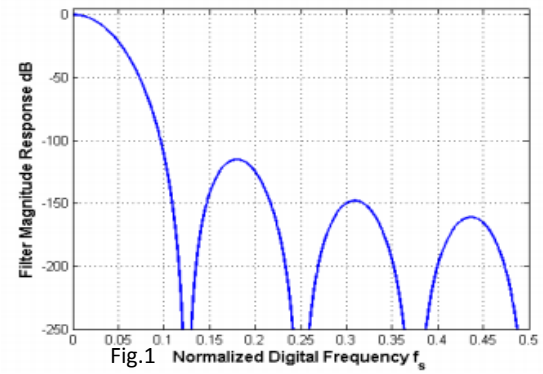

Fig.1

Q3 (7 marks)

A wind Profiler (Mono-static pulse-Doppler radar for atmospheric observations) is operates at 600 MHz. Transmitter generates 20 kW. Pulse width is 1 μs. Effective area of array antenna is 7X7 m^2. Antenna feed network has a loss of 1.25dB. Total insertion loss of duplexer and blanking switch is 0.5 dB. The volume reflectivity of target (air mass) is $\eta=10^{-17}$ $m^2.m^{-3}$. (Clarification: The radar cross-section of a homogenous target is proportional to the volume occupied by the beam in a range-bin). Receiver sensitivity is -150 dBm.

(a) What is the gain of the antenna? What will be the beam-width? (2)
(b) What will be the radar cross-section of the target range-bin at distance of 5 km.? (1)
(c) Calculate the power echo density incident on the radar antenna in terms of 'R' (1)
And with target at 5 km (1)
(d) Find the received power received from target range-bin at 5km. (1)
(e) Knowing the sensitivity, compute the range of the radar
(Maximum range for which the echo from the target range-bin can be detected) (1)
(Make convenient assumptions, if required. and mentioned those assumptions)

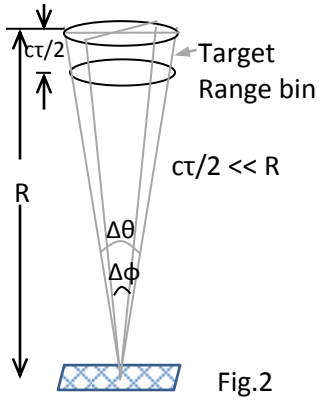

Fig.2

Q4 (7 marks)

Synthetic aperture radar:

An aircraft travels in a straight line at a height of 15,000m and performs a ground vigilance survey of a territory parallel to the track as shown in following figures. The speed is $100ms^{-1}$. The radar operates at 15 GHz and its antenna makes an angle of $\theta = 45^0$ from the nadir (direction directly down). The beam widths $\Delta\theta$ and $\Delta\phi$ are equal 14^0.

(a) Calculate 'Swath' (width of the land strip under surveillance) (2 marks)

(b) If the transmission pulse width is 0.25μs? Fine the minimum and maximum 'range-bin dimensions'? How many range-bins does Swath have? (3 marks)

(c) If the air craft collects the data for the period of 300ms, what is the angular resolution (in azimuth or within Δϕ shown by the 'Resol Synth' in Fig 2) (2 marks)

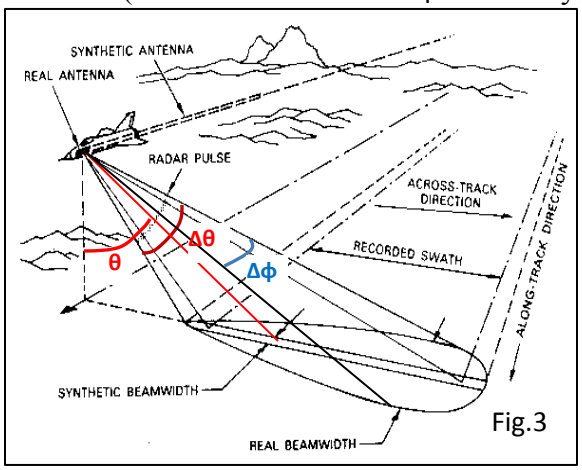

Fig.3

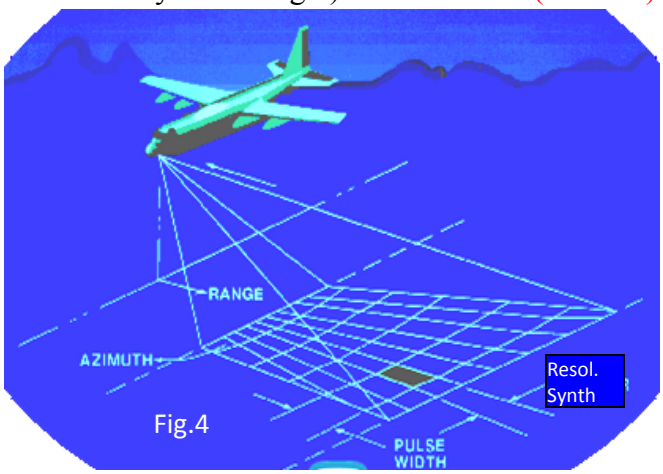

Fig.4

Q5 (9 marks)

Beam steering with phased array antenna (2 D)

A two dimensional array of the antenna elements is set up on X-Y plane. This array has 64 (8X8) elements (located at the grid intersections). The inter-element distance is 2cm. The grid lines are placed at $x = \pm1, \pm3, \pm5, \pm7$ cms and $y = \pm1, \pm3, \pm5, \pm7$ cms; see following figure. The radiation frequency is 7.5 GHz.

(a) What is the gain of the antenna? When the beam is pointing to the zenith, what is the beam width of the antenna beam in X-Z plane and in Y-Z plane? (2 marks)

(b) If the elements are fed with signals with triangular amplitudes distribution along Y axis. This means that the elements with co-ordinates y = ±1, ±3,±5, ±7 shall have amplitudes 7A, 5A, 3A, A respectively. Beam width in which plane be affected? What is the new value? What will be side-lobe level (SLL) in that plane? (4 marks)

(c) If the beam is required to be tilted in the direction shown in the following figure. The desired beam direction is in the plane formed by lone OP and Z axis, making angle of approximately 53.13^0 with respect to Z axis. Compute the unit vector in direction of the beam. (1 mark)

Compute the phase difference between the signals to be fed to the elements P(7,5) and Q(1,1). In transmit mode, which element gets leading phase? (2 marks)

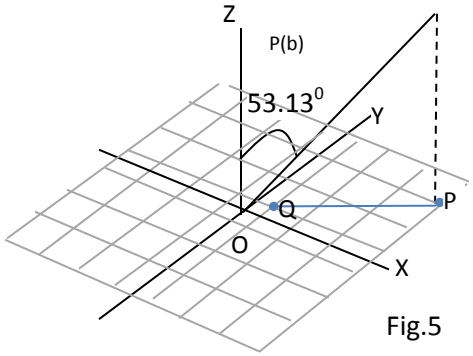

Fig.5