MID Semester Examination (EE602: 2021-2)

Date 19.10.2020 **Timings: 1800-2030 (Upload limit 2045, hard-limit 2115)** Max. marks =25

Note: Assume data if necessary and WRITE the assumption.
Calculations in dB and engineering approximations are encouraged.
Improper explanation, wrong or no units, late submission shall lead to reduces credits

Q1 Short Questions (2+1+3+2= **8 Marks**)

(i) A triode requires a supply of 9kV (1 amp) between cathode and anode. It also has a filament which a DC supply requires 5V (15A). In order to power this device, one has to ensure the right Voltage potentials (with respect to the ground) at the 4 terminals. Write the voltage potential values for V_{anode}, $V_{cathode}$, V_{fil+ve} and V_{fil-ve}. Justify your answers.

(ii) Consider a low flying airplane flying at an altitude (height from the ground) of 'h' meters. This target is being tracked by a radar operating at 1 GHz, at 40 km from the airplane the and located at the top of a hill. Assume that the radar altitude is also 'h' and the ground is flat. Find the minimum value of 'h' so that the signal gets no (or negligible) obstruction. (Hint: Fresnel Zone)

(iii) A pulsed radar designed to detect aircraft targets with the range resolution of 150m and up to the range of 150 km. Its receiver has a noise figure of 4dB and detects the presence of the target with simple threshold detection in to 50Ω; (this means using a detector of impedance 50Ω). The total gain of 100dB before the signal is subjected to the detector. If the Voltage threshold is adjusted to 300mV, compute the probability of false alarm.

(iv) A radar receiver requires RF gain of 33.8 dB in the front-end RF stage (before the first mixer). Two amplifier blocks A1 (G=16 dB, NF=0.5dB) and A2(G=17.8dB, NF=3dB). What is the sequence (from the antenna input of the receiver) in which they may be connected? Will it have any advantage on the maximum range? How much (in percentage increase or decrease of R_{max}).

Q2 Scanning radar (5 marks)

Ku band scanning radar operates at 15GHz. It scans a solid angle Ω =2sr (Steradian) by covering the scan volume by sequential spots of radar beam. The radar acquires the echoes from three pulses (*n*) for each beam spot. Assume that the total number of beam spots to be Ω/dθdφ; where, dθ and dφ being the widths of radar beam in orthogonal directions. Total scan time (time required for all beam spots) is T_{SC}=3 seconds. Effective antenna aperture= $3m^2$. Assume that there is no extra radio-noise from celestial or terrestrial sources.

(a) Compute the 'average transmitted power' power $\mathbf{P_{average}}$, for following parameters: signal-to-noise ratio SNR=10dB; cable losses L=9dB and noise figure F=4 dB. Assume target cross section of 11dB m^2 and range R=150 km. (Boltzmann constant= 1.38×10^{-23} m^2 kg s^{-2} K^{-1}). Derive relevant expression with proper explanation/ justification. Advice: It is easier to calculate in dB. (4 Marks)

(b) Also, compute the peak transmitted power corresponding to 10% duty factor. (1Mark)

Q3 (6 Marks)

A pulsed Doppler radar operating at 15GHz uses 3 pulse repetition frequencies (PRFs), namely 10kHz, 15 kHz and 20 kHz. It detects 3 targets, A, B, and C. The receiver performs complex (in-phase and quadrature) sampling followed by DFT computations for approaching as well as receding Doppler velocity measurements.

(a) Find the unambiguous range and unambiguous velocity for each of the PRF? (1 X 3 =3)

(b) Find the correct range and velocity of each of the target A, B, C. (1 X 3 = 3)

The range-Doppler data for three PRFs corresponding to A, B, C is given in following table.

	PRF 10 kHz		PRF 15 kHz		PRF 20 kHz	
	Range	**Velocity**	**Range**	**Velocity**	**Range**	**Velocity**
Target A	9km	-20ms^{-1}	9km	-20ms^{-1}	1.5km	-20ms-^{1}
Target B	4 km	30ms^{-1}	4 km	30ms^{-1}	4 km	30ms^{-1}
Target C	5km	+20ms^{-1}	5km	+70ms^{-1}	5km	-80ms^{-1}

Explanation with suitable diagrams is encouraged

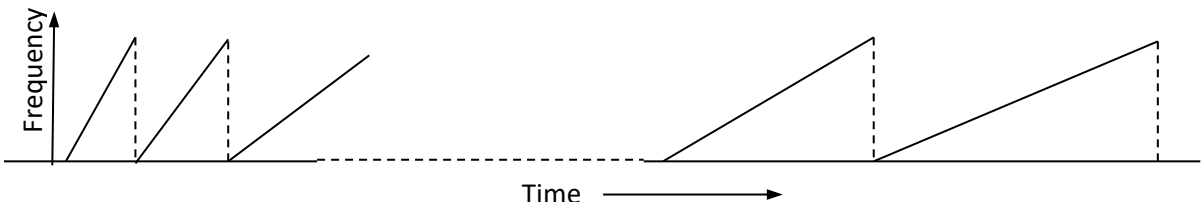
Q4. (6 marks)

FMCW radar altimeter is used to measure the height of a flying platform. The antennas of the radar are pointed towards the ground and the height is determined by analyzing the echo signal from ground and estimating the range. The operating frequency range is 2.925-3.075 GHz. This system measures the heights from 10m to 100m.

(a) Determine the sweep time of transmit linear chirp so that the beat frequency is in the range of LF frequency band (30 kHz to 300 kHz). Draw an appropriate diagram illustrating the design. Write the expression for height estimation. What will be height resolution? (2 marks)

The range estimation is using linear chirp signal can also be done by varying the frequency sweep rate as shown below. In this method, a narrow band receiver is used for the processing the beat frequency signal which can process narrow band beat frequency signals (say Δf_b). Due to this the echoes from a small range slice (ΔH , corresponding to Δf_b) can be processed from one sweep rate. To cover the complete range of interest, the FM signals at different chirp rates are transmitted one after another. The process stops when beat frequency in the range Δf_b is received. The sweep time is further adjusted so that the exact center frequency is obtained. Thus, the [product of sweep time and f_b (50 kHz, in this case) is indicative of the range.

$$H\left(\frac{2\Delta F}{cT}\right) = f_b \quad \Longrightarrow \quad \Delta H\left(\frac{2\Delta F}{cT}\right) = \Delta f_b \qquad \Delta H\left(\frac{2\Delta F}{c}\right) = \Delta f_b T$$



(b) If the distance estimation is performed by adjusting sweep rate to get 50 kHz (with the filter bandwidth 50 kHz ± 2.5 kHz) What is the minimum and maximum sweep time? Approximately how many sweeps are needed to span the complete range? (2 marks)

(c) What will be the advantage of the beat frequency detection method by changing the sweep rate? What will be the disadvantage? (1 mark)

(d) Give approximate quantification of these advantage and disadvantage. (The signal advantages in ratio of sensitivity/ signal power and the time advantage should be quoted in the approximate ratio of processing time. Make convenient assumptions) (1 marks)