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Sheet (4)

Question (1) :-

$$R = \sqrt[4]{\frac{P_s G^2 \lambda^2 \sigma}{P_E (4\pi)^3}} = \sqrt[4]{\frac{1.5 \times (20000)^2 \times \left(\frac{3\times10^8}{24\times10^9}\right)^2 \times 200}{2\times10^{-10} \times (4\pi)^3}} = 2622 \text{ m}$$

Question (2) :-

$$f_D = \frac{2 v_r}{\lambda} \qquad v_r = \frac{f_D \lambda}{2} = \frac{f_D c}{2 f_R}$$

1) $v_r = \frac{3\times10^3 \times 3\times10^8}{2\times30\times10^9} = 15 \text{ m/s} = 54 \text{ Km/h}$

2) $v_r = 81 \text{ Km/h}$

3) $v_r = 198 \text{ Km/h}$

4) $v_r = 54 \text{ Km/h}$

∴ Targets (2, 3) will get a fine, because their speed is above the speed limit.

Note The (-Ve) sign indicates that their directions are towards the radar.

Question (3) :-

A] Bandwidth $= \frac{C}{2R} = \frac{C}{2 \times 0.5} = C = 3 \times 10^8$ Hz $= 0.3$ GHz

B] Chirp time $= 5.5 \times 2 \times \frac{R_{max}}{C} = \frac{5.5 \times 2 \times 100}{3 \times 10^8} = 3.67 \times 10^{-6}$ sec

C] Transmitted signal $= A \cos(2\pi f t)$

$= A \cos\left(2\pi \left[77 \times 10^9 + \frac{B}{T} t\right] t\right]$

$= A \cos\left[2\pi \left(77 \times 10^9 t + 8.17 \times 10^{13} t^2\right)\right]$

D] Sampling Rate $= 2B_{sweep} = 0.6$ GHz

E] 2 targets only

- (0) is a replicate of the transmitted signal
- (100 MHz) is out of range

F] Range $= \frac{C T_c f}{2 B_{sweep}}$

- 2 MHz → 3.67 m
- 11 MHz → 20.2 m
- 100 MHz → 183.5 m (out of range)

G] Received signal $= A \cos(2\pi f t)$

$= A \cos\left[2\pi \left(77 \times 10^9 t + \frac{B}{T} t^2 + f_{Beat}(t - \tau)\right)\right]$

$= A \cos\left[2\pi \left(77 \times 10^9 t + 8.17 \times 10^{13} t^2 + 2 \times 10^6 \left(t - \frac{2 \times 3.67}{3 \times 10^8}\right)\right)\right]$

$+ A \cos\left[2\pi \left(77 \times 10^9 t + 8.17 \times 10^{13} t^2 + 11 \times 10^6 \left(t - \frac{2 \times 20.2}{3 \times 10^8}\right)\right)\right]$

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Question (4) :-

B] To apply the CFAR :-

1] Determine the first cell under test (CUT), which is cell number
[T+G+1 = 6]

2] Get noise level = Sum of the leading training cells.

3] Threshold = $\frac{\text{Noise level}}{T} \times \text{offset} = \frac{2}{3} \times \text{Noise level}$

4] If signal value at CUT < Threshold, then assign (0) to CUT

(Note) ∞ We have 15 received points
∞ Number of points after applying CFAR = N - (T+G) = 15 - 5 = 10

CUT_s = [2.32 18 1.98 3.8 27 0.52 22 0.78 3.47 0.89]
NL_s = [5.31 7.84 21.65 22.54 36.32 22.3 23.78 32.78 31.32 49.52]
Threshold = [3.54 5.23 14.43 15.03 24.21 14.87 15.85 21.85 20.88 33.01]
CUT_s After CFAR = [0 18 0 0 27 0 22 0 0 0]

D] 3 Targets are detected