Radar and Remote Sensing

Formulas

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Contents

1 Constants

Constant which appear in the equations and useful quantities to help in computations.

$c \simeq 3 \cdot 10^8 \mathrm{m/s}$ [1] $\qquad \tau_c = 66.7\,\mathrm{ns/m}$ [2]

Notes

1. Speed of light
2. Time needed for light to travel for 1 m considering the full roundtrip. This is helpful for quick computations like "what's the range of an object if the time of flight is 120 ns?"

2 Generic Radar

2.1 Geometry

$$A_e = \frac{G\lambda^2}{4\pi} = \rho A \text{ [3]} \qquad \sigma = \frac{P_R \frac{4\pi}{\Omega}}{\frac{P_c}{A_{\text{target}}}} = G_{\text{target}} A_{\text{target}} \text{ [5]} \qquad \sigma_{\text{plate}} = \frac{4\pi A^2}{\lambda^2} \text{ [7]}$$

$$G = 4\pi \frac{A_e}{\lambda^2} \text{ [4]} \qquad \sigma_{\text{sphere}} = \pi r^2 \text{ [6]} \qquad \sigma_{\text{corner}} = \frac{4\pi A_{\text{eff}}^2}{\lambda^2} \text{ [8]}$$

2.2 Power

$$P_D = \frac{P_t}{4\pi R^2} G \text{ [9]} \qquad P_r = \frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 R^4} \text{ [10]} \qquad \mathrm{SNR} = \frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 k_B T_e B F L R^4} \text{ [11]}$$

Notes

3. Effective area of the antenna
4. Gain
5. Radar Cross Section
6. RCS of a sphere; r is the radius
7. RCS of a plate
8. RCS of a corner reflector
9. Transmitted power density over the surface of a sphere with radius R
10. Radar equation
11. Signal to Noise Ratio in the radar equation

3 Pulsed Radar

3.1 Characteristics

$$f_r = \frac{1}{T} \text{ [12]} \qquad \tau = \frac{1}{B} \text{ [13]}$$

3.2 Range

$$R = \frac{c}{2t} \text{ [14]} \qquad R_{\min} = \delta R = \frac{c}{2\tau} \text{ [16]} \qquad \theta_B = R\frac{\lambda}{d} \text{ [17]} \qquad M = \frac{R_{\max} - R_{\min}}{\delta R} \text{ [18]}$$

$$R_{\max} = \frac{c}{2T} \text{ [15]}$$

3.3 Power

$$d_t = \frac{\tau}{T}$$ [19]

$$P_{\text{avg}} = P_t \cdot d_t$$ [20]

Notes

12. Pulse Repetition Interval (PRF) versus Pulse Repetition Interval (PRI)
13. Bandwidth
14. Range
15. Max. unambiguous range
16. Min. range or range resolution
17. Azimuth resolution; d is the length of the antenna
18. Number of space bins
19. Duty Cycle
20. Average power

4 Doppler

$$f_d = \frac{2v_{\text{target}}}{c} \cos\theta_e \cos\theta_a$$ [21]

$$\delta f_d = \frac{\text{PRF}}{N}$$ [22]

$$\gamma = 1 + \frac{2v_{\text{target}}}{c}$$ [23]

Notes

21. Doppler frequency. Normally the cosines are not needed.
22. Resolution of the doppler frequency
23. Time dilation