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.

$c \simeq 3 \times 10^8\,\mathrm{m/s}$ [1] $\quad \tau_c = 6.67\,\mathrm{ns/m}$ [2] $\quad k_B = 1.38 \times 10^{-23}\,\mathrm{m^2 kg/s^2 K}$ [3]

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?"
3. Boltzmann's constant

2 Generic Radar

2.1 Geometry

$A_e = \frac{G\lambda^2}{4\pi} = \rho A$ [4] $\quad \sigma = \frac{P_R \frac{4\pi}{\Omega}}{\frac{P_c}{A_{\text{target}}}} = G_{\text{target}} A_{\text{target}}$ [6] $\quad \sigma_{\text{plate}} = \frac{4\pi A^2}{\lambda^2}$ [8]

$G = 4\pi \frac{A_e}{\lambda^2}$ [5] $\quad \sigma_{\text{sphere}} = \pi r^2$ [7] $\quad \sigma_{\text{corner}} = \frac{4\pi A_{\text{eff}}^2}{\lambda^2}$ [9]

2.2 Power

$P_D = \frac{P_t}{4\pi R^2} G$ [10] $\quad P_r = \frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 R^4}$ [11] $\quad \text{SNR} = \frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 k_B T_e B F L R^4}$ [12]

Notes

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

3 Pulsed Radar

3.1 Characteristics

$f_r = \frac{1}{T}$ [13] $\quad \tau = \frac{1}{B}$ [14]

3.2 Range

$R = \frac{c}{2t}$ [15] $\quad R_{\text{min}} = \delta R = \frac{c}{2\tau}$ [17] $\quad \theta_B = R\frac{\lambda}{d}$ [18] $\quad M = \frac{R_{\text{max}} - R_{\text{min}}}{\delta R}$ [19]

$R_{\text{max}} = \frac{c}{2T}$ [16]

3.3 Power

$$d_t = \frac{\tau}{T}$$ [20]

$$P_{\text{avg}} = P_t \cdot d_t$$ [21]

Notes

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

4 Doppler

$$f_d = \frac{2v_{\text{target}}}{c} \cos\theta_e \cos\theta_a$$ [22]

$$\delta f_d = \frac{\text{PRF}}{N}$$ [23]

$$\gamma = 1 + \frac{2v_{\text{target}}}{c}$$ [24]

Notes

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