RADAR RELATIONSHIPS

1. Radar Equation

$$\frac{S}{N} = \frac{PG^2 \lambda^2 \sigma}{(4\pi)^3 R^4 NF kTB L}$$

2. S/N at Range, R

$$\frac{S}{N} = \left(\frac{R_o}{R}\right)^4$$

Ro is the range at S/N = 1

3. Antenna Gain ✓ Skolnik, 13(2.49)

$$G = \frac{4\pi A}{\lambda^2} \cdot \rho$$

A = Aperture Area (ρ = antenna efficiency)

4. Antenna Beamwidth, Half Power

$$BW = \frac{51\lambda}{A} =$$

$$= \frac{65\lambda}{\ell} \quad [\text{Skolnik, 13.(2.50)}]$$

5. Duty Cycle of Pulsed Radar

Du = Pulse Width x PRF

6. Average Power = Peak Power x Duty Cycle

7. Range

$$R = \frac{T_r c}{2}$$

T_r = time (round trip)
c = velocity of propagation

8. Unambiguous Range, Single PRF

$$R_u = \frac{c}{2\ PRF}$$

PRF = Pulse Recurrence Frequency

9. Unambiguous Range, Multiple PRF

$$R_u = \frac{c}{2\ (PRF_1 - PRF_2)}$$

10. Interpulse Period

$$T = \frac{1}{PRF} - \tau$$

τ = Pulse Width

11. Velocity of Propagation (velocity of light).

c = 2.997925×10^8 meters/second
c = 186,282 statute miles/second
c = 161,875 nautical miles/second
c = 984 feet/microsecond

Time to travel one (1) nautical mile, round trip, = 12.34×10^{-6} seconds.

12. Doppler Frequency

$$F_d = \frac{2\ V_r F_o}{c}$$

V_r = Relative Velocity
F_o = Transmitted Frequency

13. Pulse Compression Ratio

Ratio = ΔF x Pulse Width

Compressed Pulse Length = $\frac{1}{\Delta F}$

Compressed Pulse Amplitude = $A\sqrt{\Delta F}$

A is transmitted peak power of pulse.

14. Wavelength

$$\lambda = \frac{c}{F}$$

c = Velocity of Propagation
F = Frequency

15. Receiver Bandwidth

(a) Low PRF Radars

$$BW = \frac{1}{\tau}$$

(b) High PRF Radars (Pulse Doppler)

$$BW \text{ (each filter)} = \frac{B}{T_i^2}$$

B = Antenna Beamwidth,
T_i = Target Illumination Time

16. Noise Figure of an Amplifier $\overline{NF}$

$$\overline{NF} = \frac{S/N \text{ In}}{S/N \text{ Out}}$$

17. Overall Noise Figure of a Series of Amplifiers, 1, 2 and 3.

$$\overline{NF} = \overline{NF_1} + \frac{\overline{NF_2} - 1}{G_1} + \frac{\overline{NF_3} - 1}{G_1 G_2}$$

G = Amplifier Gain

18. Thermal Noise Level

$$kTB = -204 \text{ dBW/Hertz}$$
$$= -114 \text{ dBm/MHz}$$

19. Boltzman's constant

$$k = 1.38 \times 10^{-23} \text{ joule/degree}$$

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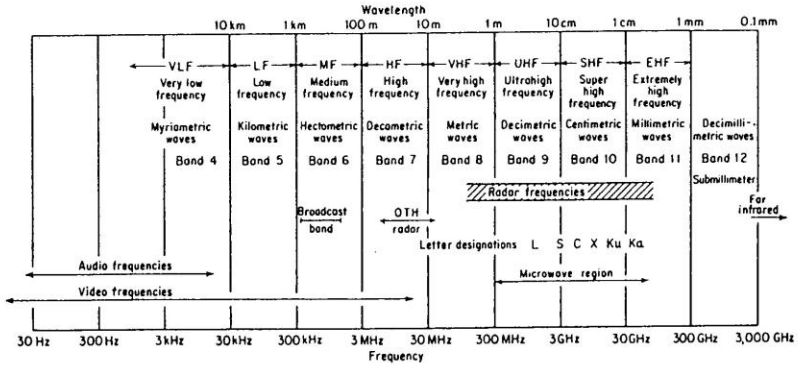

Figure 1.4 Radar frequencies and the electromagnetic spectrum.

Table 1.1 Standard radar-frequency letter-band nomenclature

Band designation	Nominal frequency range	Specific radiolocation (radar) bands based on ITU assignments for region 2
HF	3–30 MHz	
VHF	30–300 MHz	138–144 MHz
		216–225
UHF	300–1000 MHz	420–450 MHz
		890–942
L	1000–2000 MHz	1215–1400 MHz
S	2000–4000 MHz	2300–2500 MHz
		2700–3700
C	4000–8000 MHz	5250–5925 MHz
X	8000–12,000 MHz	8500–10,680 MHz
K_u	12.0–18 GHz	13.4–14.0 GHz
		15.7–17.7
K	18–27 GHz	24.05–24.25 GHz
K_a	27–40 GHz	33.4–36.0 GHz
mm	40–300 GHz	

(and Bibilo M. Skolnik, "Introduction to Radar Systems")