

1) A dipole antenna is designed to operate at a frequency of 100 MHz.

a) calculate the length of the dipole antenna.

b) calculate the length of each half of the dipole.

Soln:

$$f = 100 \text{ MHz}$$

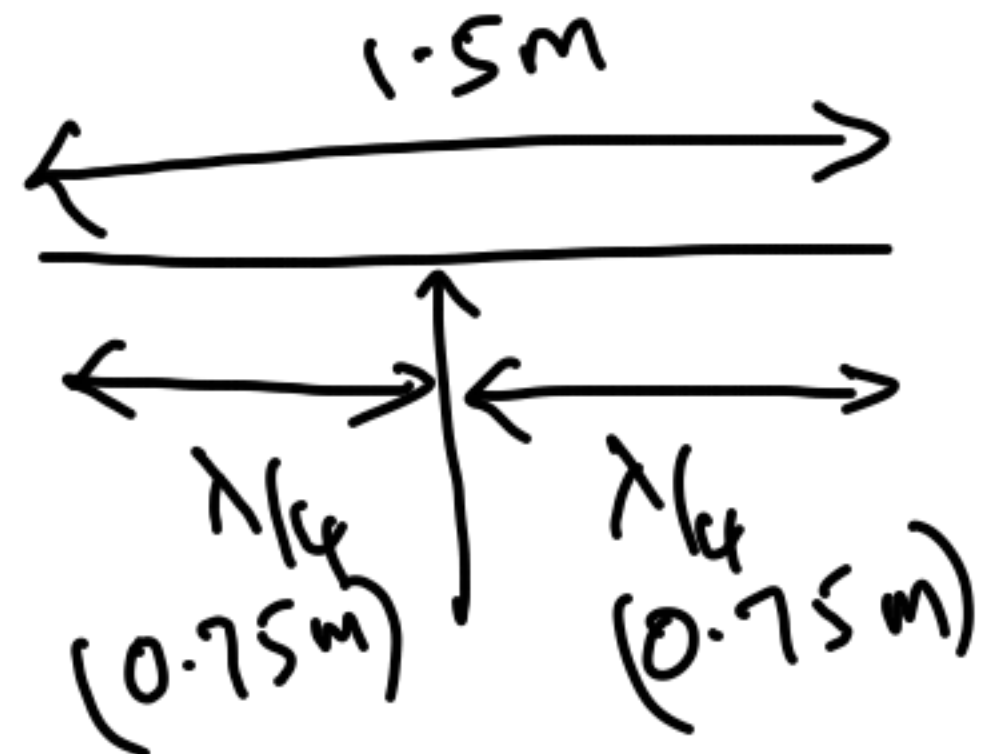
$$a) L = \frac{\lambda}{2}$$

$$\text{To find } \lambda = \frac{c}{f}$$

$$\lambda = \frac{3 \times 10^8}{100 \times 10^6}$$

$$\lambda = 3 \text{ m}$$

$$L = \frac{3}{2} = 1.5 \text{ m}$$



a) length of each half of the dipole

$$L_{\text{half dipole}} = \frac{L}{2} = \frac{1.5}{2} = 0.75 \text{ m.}$$

2) A half wave dipole antenna has a total length of 1.25m. Calculate the operating frequency of the dipole antenna.

Soln.
length of the antenna.

$$L = 1.25\text{m}$$

$$L = \frac{\lambda}{2}$$

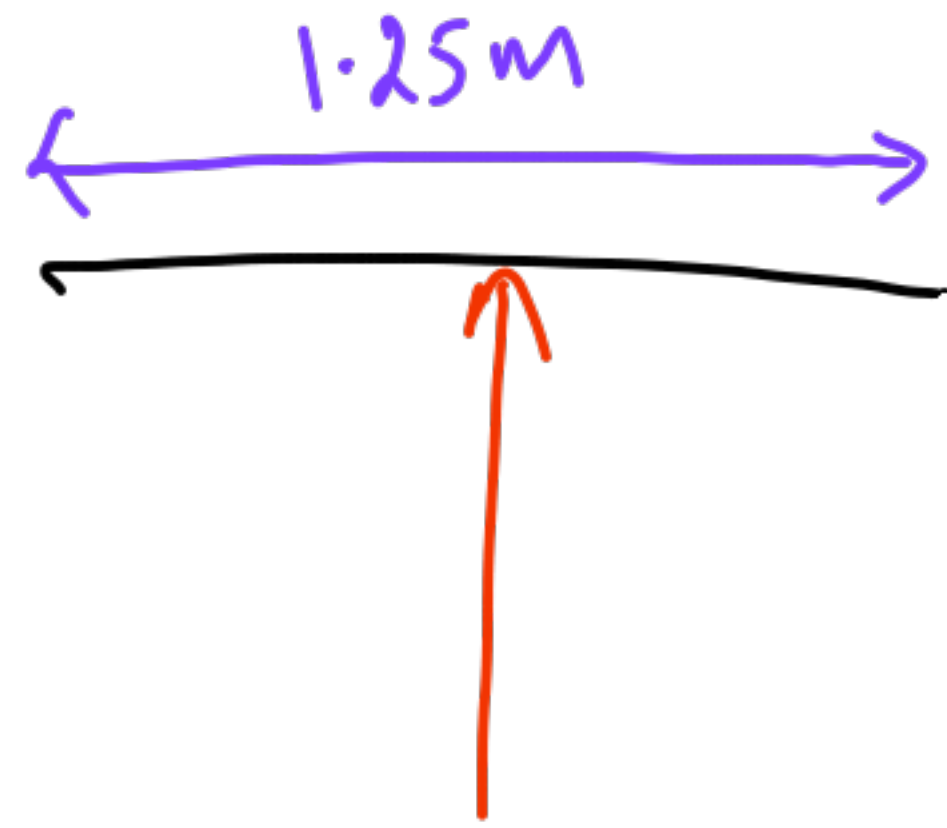
$$\lambda = 2L$$

$$\lambda = 2 \times 1.25$$

$$\lambda = 2.5\text{m}$$

$$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{2.5}$$

$$f = 120\text{MHz}$$



3) A RADAR System transmits a signal of frequency 5GHz. The system detects a moving target with a radial velocity of 1000m/s. Calculate the Doppler frequency shift.

Soln.

$$f_t = 5 \text{ GHz}$$
$$v = 1000 \text{ m/s}$$

$$v = \frac{\lambda f_{dp}}{2}$$

$$f_{dp} = \frac{2v}{\lambda}$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{5 \times 10^9}$$

$$\lambda = 0.06 \text{ m}$$

$$f_{dp} = \frac{2 \times 1000}{0.06}$$

$$f_{dp} = 33.3 \text{ kHz}$$

4) A RADAR System transmits a signal with a frequency of 2.6 GHz. The doppler shift signal has been calculated as 21 kHz. Calculate the velocity of the target.

Soln.

$$f_t = 2.6 \text{ GHz}$$

$$f_{dp} = 21 \text{ kHz}$$

$$V = \frac{\lambda f_{dp}}{2}$$

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

$$\lambda = \frac{3 \times 10^8}{2.6 \times 10^9}$$

$$\lambda = 0.115 \text{ m}$$

$$V = \frac{0.115 \times 21 \times 10^3}{2}$$

$$V = 1211.5 \text{ m/s}$$

5) A RADAR System detects an object at a distance of 1250m. Calculate the time delay.

Soln.

$$R = 1250 \text{ m}$$

$$\Delta t = \frac{2R}{c}$$

$$= \frac{2 \times 1250}{3 \times 10^8}$$

$$\Delta t = 8.3 \times 10^{-6} \text{ s} = 8.3 \mu\text{s}$$

6) A Continuous Wave RADAR System operates with the speed of light.

The RADAR measures a time delay of 5×10^{-6} seconds. Calculate the distance to the target.

Soln.

$$\Delta t = 5 \times 10^{-6} \text{ s}$$

$$R = ?$$

$$\Delta t = \frac{2R}{c}$$

$$R = \frac{c \cdot \Delta t}{2}$$

$$R = \frac{3 \times 10^8 \times 5 \times 10^{-6}}{2}$$

$$R = 750 \text{ m}$$

7) A RADAR System Operates at a frequency of 5 GHz and transmits a power of 150 kW. The RADAR System detects a target with a

Radar Cross-section $\sigma = 8 \text{ m}^2$ at a slant range of 20 km. The total system loss $L = 1.5$

a) Calculate the wavelength λ of the radar signal.

b) Calculate the power received by the radar from the target.

(The radar has a transmit antenna gain of 25 and a receive antenna gain of 20)

Soln.

$$f = 5 \text{ GHz.}$$

$$P_t = 150 \text{ kW}$$

$$\sigma = 8 \text{ m}^2.$$

$$G_t = 25$$

$$G_r = 20$$

$$L = 1.5$$

$$R = 20 \text{ km}$$

$$a) \lambda = \frac{c}{f}$$

$$= \frac{3 \times 10^8}{5 \times 10^9}$$

$$\lambda = 0.06 \text{ m}$$

$$b) P_r = \frac{P_t G_t G_r \sigma \lambda^2}{(4\pi)^3 R^4 \cdot L}$$

$$P_r = \frac{150 \times 10^3 \times 25 \times 20 \times 8 \times (0.06)^2}{(4\pi)^3 (2 \times 10^3)^4 \times 1.5}$$

$$P_r = 1.13 \times 10^{-14} \text{ W}$$

8) A RADAR System operates at a frequency of 5 GHz and transmits a power of 200 kW. The radar has a transmit antenna gain of 30 dB and a receive antenna gain of 25 dB. It detects a target with a radar cross section of 10 m^2 . The system experiences a total loss of 15 dB, and the minimum detectable power of the receiver is 10^{-13} W . Calculate the Range.

Soln.

$$f = 5 \text{ GHz.}$$

$$P_t = 200 \text{ kW}$$

$$P_r = 10^{-13} \text{ W}$$

$$L_{dB} = 15 \text{ dB}$$

$$G_{t_{dB}} = 30 \text{ dB}$$

$$G_{r_{dB}} = 25 \text{ dB}$$

$$\sigma = 10 \text{ m}^2.$$

Linear Scale

$$L = 10^{(L_{dB}/10)} = 10^{(15/10)}$$

$$L = 31.62$$

$$G_t = 10^{(G_{tdB}/10)}$$

$$G_t = 10^{(30/10)} = 1000$$

$$G_r = 10^{(G_{rdB}/10)}$$

$$= 10^{(25/10)}$$

$$G_r = 316.23$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{5 \times 10^9}$$

$$\lambda = 0.06 \text{ m}$$

$$R = \left[\frac{P_t G_t G_r \lambda^2}{P_r (4\pi)^3 L} \right]^{1/4}$$

$$R = \left[\frac{200 \times 10^3 \times 1000 \times 316.23 \times (0.06)^2 \times 10}{10^{-13} (4\pi)^3 \times 31.62} \right]^{1/4}$$

$$R = 24543. \text{ m}$$

$$R = 24.543 \text{ km}$$

4) The magnetic force per unit length between two parallel wires carrying currents of 3A and 6A in the same direction placed 5cm apart in free space. Given that the permeability of free space is $4\pi \times 10^{-7} \text{ H/m}$. Calculate the force per unit length between the wires

Soln.

$$F = \frac{\mu I_1 I_2 l}{2\pi d}$$

Given,

$$I_1 = 3 \text{ A} \quad I_2 = 6 \text{ A}$$

$$d = 5 \text{ cm}, \quad l = 1$$

$$\frac{f}{l} = \frac{\mu I_1 I_2}{2\pi d}$$

$$\frac{f}{l} = \frac{\mu_0 \mu_r I_1 I_2}{2\pi d}$$

$$f = \frac{4\pi \times 10^{-7} \times 1 \times 3 \times 6}{2\pi \times 0.05}$$

$$f = 7.2 \times 10^{-5} \text{ N/m}$$

$$f = 72 \times 10^{-6} \text{ N/m}$$

$$f = 72 \mu\text{N/m}$$

$\mu_0 \mu_r$

6) A Solenoid with $2 \times 2 \text{ cm}$ cross section has an iron core with $\mu_r = 1000$ and 4000 turns/m. It carries a current of 500mA. Find its Self-inductance

per meter
Soln.

$$L = \frac{\mu N^2 A}{l}$$

Given.

$$\mu_r = 1000$$

$$I = 500 \text{ mA}$$

$$N = 4000 \text{ turns/m}$$

$$A = 4 \times 10^{-4} \text{ m}^2$$

$$l = 1 \text{ m}$$

$$L = \frac{\mu_0 \mu_r N^2 A}{l}$$

$$L = \frac{4\pi \times 10^{-7} \times 1000 \times (4000)^2 \times 4 \times 10^{-4}}{1}$$

$$L = 8.04 \text{ H/m}$$