

$$1. f = 28 \text{ GHz} = 2.8 \times 10^{10} \text{ Hz} \quad C = 3 \times 10^8 \text{ m/s}$$

$$\therefore \lambda = C \cdot \frac{1}{f} = 1.07 \times 10^{-2} \text{ m} = 10.7 \text{ mm}$$

$$\therefore \frac{1}{2} \lambda = 5.4 \text{ mm}$$

∴ The maximum length of the antenna is 5.4 mm

$$2. (a) f = 1 \text{ GHz}, \sigma = 6.17 \times 10^7 \quad \mu_0 = 4\pi \times 10^{-7} = 1.3 \mu \text{H/m}$$

$$\text{skin depth } \delta = \sqrt{\frac{1}{\pi f \mu_0}} = 2.026 \times 10^{-6} \text{ m.}$$

$$d = 5b = \frac{5}{\sqrt{\pi f \mu_0}} = 1.013 \times 10^{-5} \text{ m.}$$

$$\text{when } f' = 28 \text{ GHz} = 28f$$

$$d' = \frac{5}{\sqrt{\pi f' \mu_0}} = \frac{5}{\sqrt{28} \sqrt{\pi f' \mu_0}} = \frac{1}{\sqrt{28}} d = 1.91 \times 10^{-6} \text{ m.}$$

$$(b) f'' = 4 \text{ GHz}, d'' = \frac{1}{2} d$$

$$\therefore \text{length difference} = d - d'' = \frac{1}{2} d = 5.065 \times 10^{-6} \text{ m} = 5.065 \mu\text{m.}$$

$$3. Z_C = 50 \Omega.$$

$$(a) Z_L = 60 \Omega.$$

$$T_L = \frac{Z_L - Z_C}{Z_L + Z_C} = \frac{1}{11}$$

$$RL(\text{dB}) = -20 \log_{10} |T| = 20.83 \text{ dB}$$

$$SWR = \frac{1+|T|}{1-|T|} = 1.2$$

$$(b) Z_L = 50 + j50 \Omega.$$

$$T_L = \frac{Z_L - Z_C}{Z_L + Z_C} = \frac{j50}{100 + j50} = \frac{1}{5} + \frac{2}{5}j$$

$$RL(\text{dB}) = -20 \log_{10} |T| = 6.99 \text{ dB}$$

$$SWR = \frac{1+|T|}{1-|T|} = 2.62$$

$$4. Z_C = 50 \Omega, Z_L = 100 \Omega$$

$$(a) T_L = \frac{Z_L - Z_C}{Z_L + Z_C} = \frac{1}{3} \quad X - \frac{1}{3}$$

$$(b) r = 2, x = 0$$

$$\theta_r = \tan^{-1}(0) - \tan^{-1}(0) = 0 \quad X \quad 180^\circ$$

$$(c) VSWR = \frac{1+|Z|}{1-|Z|} = 2$$

$$(d) l = 0$$

$$E_{x=0} = E_L e^0 = \frac{1}{3}, VSWR = \frac{1+|Z|}{1-|Z|} = 2$$

$$(e)$$

For capacitor,  $Z = jX = -\frac{1}{\omega C} = -\frac{j}{2\pi f C} = -15.9 \Omega$

$$\therefore Z'_L = Z + Z_L = 100 - j15.9 \Omega$$

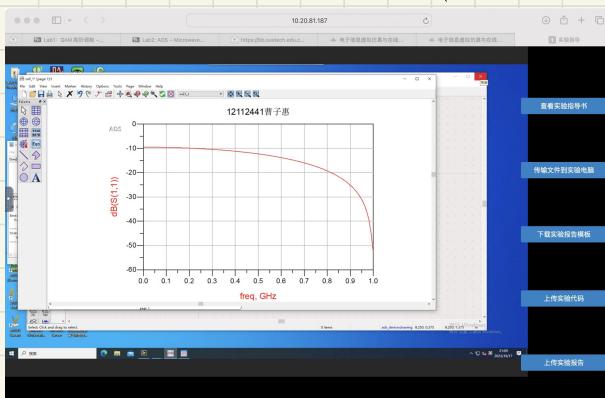
$$Z_{in} = Z_C \frac{Z'_L + jZ_C \tan(\theta)}{Z_C + jZ'_L \tan(\theta)} = Z'_L = 100 - j15.9 \Omega$$

$$E'_L = \frac{Z'_L - Z_C}{Z'_L + Z_C} = 0.34 - j0.07 = S11$$

$$|E'_L| = \sqrt{0.34^2 + 0.07^2} = 0.35 \quad \because \theta = \tan^{-1}\left(\frac{-0.07}{0.34}\right) = -11.63^\circ$$

$\therefore$  In phase,  $S11 = 0.35 e^{-j(-11.63)}$

(f)

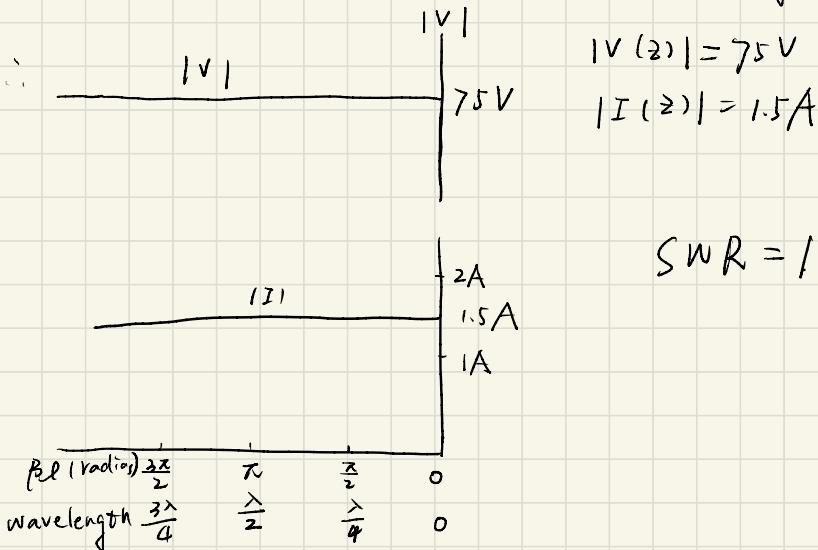


$$5. \text{ The skin depth } \delta = \frac{1}{\sqrt{\pi f \mu_0}}$$

$$\because d = 12.7 \mu m \gg \delta. \quad \therefore f = \frac{1}{\pi \mu_0 \delta} < \frac{1}{\pi f \mu_0 d} = \frac{1}{\pi f \mu_0 \cdot 12.7 \times 10^{-6}} = 4.36 \times 10^7 \text{ Hz} = 43.6 \text{ MHz}$$

And because the aluminum foil can keep electromagnetic signal away, so the signal can only out through the sixth side. As  $680 \text{ kHz} < 43.6 \text{ MHz}$ , the AM radio can work well inside the box. And  $108 \text{ MHz} > 43.6 \text{ MHz}$ , so the FM radio can't work.

6. (i)  $\Gamma_L = 0$   $S = 1$  and the input voltage is 75V.



$$(ii) \Gamma_L = \frac{100}{200} = \frac{1}{2}, \quad S = 3.$$

