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

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

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

$\therefore$ The maximum length of the antenna is 5.4mm

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

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

$d = 5\delta = \frac{5}{\sqrt{\pi f \mu \sigma}} = 1.013 \times 10^{-5} m$.

when $f' = 28GHz = 28f$

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

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

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

3. $Z_c = 50\Omega$.

(1) $Z_L = 60\Omega$.

$\Gamma_L = \frac{Z_L - Z_c}{Z_L + Z_c} = \frac{1}{11}$

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

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

(2) $Z_L = 50 + j50$

$\Gamma_L = \frac{Z_L - Z_c}{Z_L + Z_c} = \frac{j50}{100 + j50} = \frac{1}{5} + \frac{2}{5}i$

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

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

4. $Z_c = 50\Omega$. $Z_L = 100\Omega$

(a) $\Gamma_L = \frac{Z_L - Z_c}{Z_L + Z_c} = \frac{1}{3}$ X $-\frac{1}{3}$

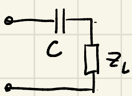
(b) $r = 2$. $x = 0$

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

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

(d) $l = 0$.

$\Gamma_{x=0} = \Gamma_L \cdot e^0 = \frac{1}{3}$, $VSWR = \frac{1+|\Gamma|}{1-|\Gamma|} = 2$.

(e) 

For capacitor. $Z = jX = -\frac{j}{\omega C} = -\frac{j}{2\pi f C} = -15.92i$

$\therefore Z_L' = Z + Z_L = 100 - j15.92\ \Omega$

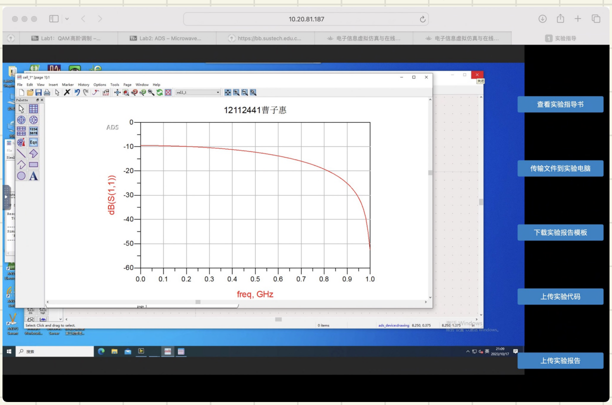
$$Z_{in} = Z_C \frac{Z_L' + jZ_C \tan(0)}{Z_C + jZ_L \tan(0)} = Z_L' = 100 - j15.92\ \Omega$$

$$\Gamma_L' = \frac{Z_L' - Z_C}{Z_L' + Z_C} = 0.34 - j0.07 = S_{11}$$

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

$\therefore$ In phase. $S_{11} = 0.35 e^{j(-11.63)}$

(f)

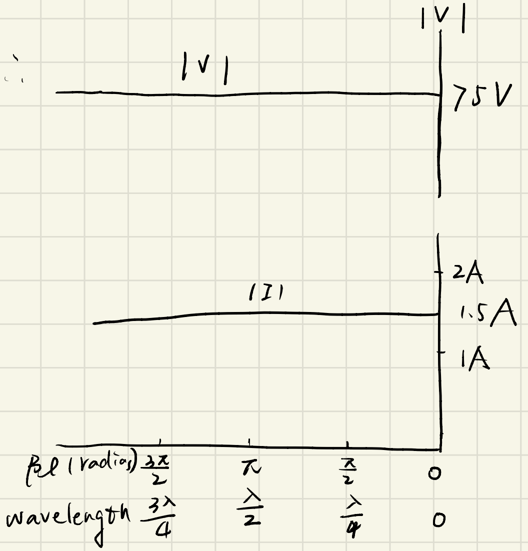


5. The skin depth $\delta = \frac{1}{\sqrt{\pi f \mu_0 \sigma}}$

$\because d = 12.7\mu m \geq \delta$. $\quad \therefore f = \frac{1}{\pi \mu_0 \sigma \delta^2} < \frac{1}{\pi f \mu_0 d^2} = 4.36 \times 10^7 Hz$
$= 43.6\ MHz$

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

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

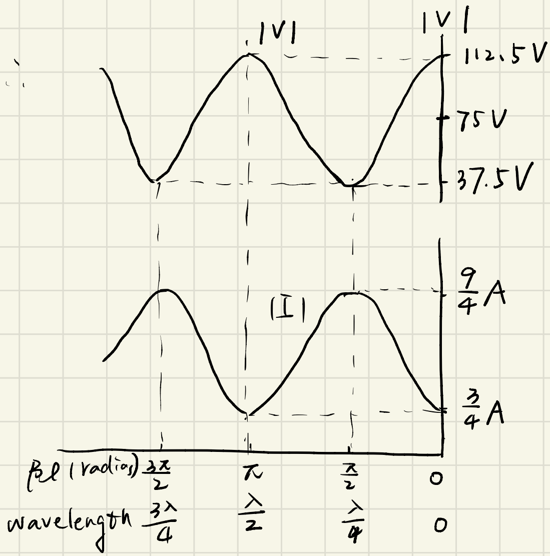


$|V(z)| = 75\,V$

$|I(z)| = 1.5A$

SWR = 1

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



SWR = 3