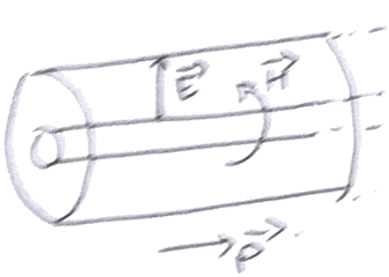
7.1) Given conductivity $\sigma = 4\ S/m$, $\nu = 10^4\ Hz$

Skin depth $\delta = \frac{1}{\sqrt{\pi \nu \mu \sigma}}$

$$= \frac{1}{\sqrt{\pi \times 10^4 \times 1.256 \times 10^{-6} \times 4}}$$

$$= \underline{\underline{2.517\ m}}$$

7.2) $\vec{P} = \vec{E} \times \vec{H}$



$$\vec{E} = \frac{Q}{2\pi \epsilon r}\,\hat{r}$$

$$\vec{H} = \frac{I}{2\pi r}\,\hat{\theta}$$

$$\vec{P} = \frac{Q}{2\pi \epsilon r} \cdot \frac{I}{2\pi r}\,\hat{r} \times \hat{\theta} = \frac{QI}{(2\pi r)^2 \epsilon}\,\hat{z}$$

$$\int_A \vec{P} = \int_{r=r_i}^{r_o} \int_{\theta=0}^{2\pi} \frac{QI}{(2\pi r)^2 \epsilon}\, r\, d\theta\, dr$$

$$= \int_{r_i}^{r_o} \frac{QI}{(2\pi)^2 \epsilon} \cdot \frac{2\pi}{r^2}\, r\, dr = \frac{QI}{2\pi \epsilon} \int_{r_i}^{r_o} \frac{1}{r}\, dr$$

$$\int_A \vec{P} = \frac{QI}{2\pi\epsilon} \ln r \Big|_{r_i}^{r_o}$$

$$= \frac{QI}{2\pi\epsilon} \ln\left(\frac{r_o}{r_i}\right)$$

$$= \underline{\underline{VT}}$$

7.5) (a) $L = \frac{\mu_0}{2\pi} \ln\left(\frac{r_o}{r_i}\right)$ H/m

$$= \frac{4\pi \times 10^{-7}}{2\pi} \ln\left(\frac{1.48}{0.406}\right) = 2.587 \times 10^{-7} \text{ H/m}$$

$$\left(= \frac{2\pi\epsilon_r\epsilon_0}{\ln(r_o/r_i)} = 10.97\epsilon_0 \text{ F/m} = 9.716 \times 10^{-11} \text{ F/m}\right.$$

Characteristic impedance $Z = \sqrt{\frac{L}{C}} = \underline{\underline{51.6\Omega}}$

(b) Transmission velocity $v = \frac{1}{\sqrt{LC}} = \frac{1}{5 \times 10^{-9}} = 0.2 \times 10^9$ m/s

$$= \underline{\underline{2 \times 10^8 \text{ m/s}}}.$$

(c) Delay = 1ns, velocity = 2×10^8 m/s

Length = $1ns \times 2 \times 10^8$ m/s

$= 0.2$ m

(d) Given $r_o = 15$ mil $= 381\ \mu m$

$$z = \sqrt{\frac{L}{C}} = \sqrt{\frac{\frac{\mu_0}{2\pi} \ln(r_o/r_i)}{2\pi\epsilon / \ln(r_o/r_i)}}$$

$$= \sqrt{\frac{\mu_0 (\ln r_o/r_i)^2}{\epsilon\ (2\pi)^2}} = \sqrt{\frac{\mu_0}{\epsilon}} \cdot \frac{\ln\left(\frac{r_o}{r_i}\right)}{2\pi}$$

$$\ln\left(\frac{r_o}{r_i}\right) = 51.6 \times 2\pi \sqrt{\frac{2.26 \times 8.854 \times 10^{-12}}{4\pi \times 10^{-7}}}$$

$$\ln\left(\frac{r_o}{r_i}\right) = 51.6 \times 2\pi \sqrt{1.26^2 \times 10^{-5}} = 1.29.$$

$$r_i = \frac{381\ \mu m}{3.63} = 104.95\ \mu m = 4.13 \text{ mil}$$

7.5(e) $v = f\lambda$ $\quad f = \frac{v}{\lambda} = \frac{2\times10^8 \text{ m/s}}{2.96\times10^{-3}}$

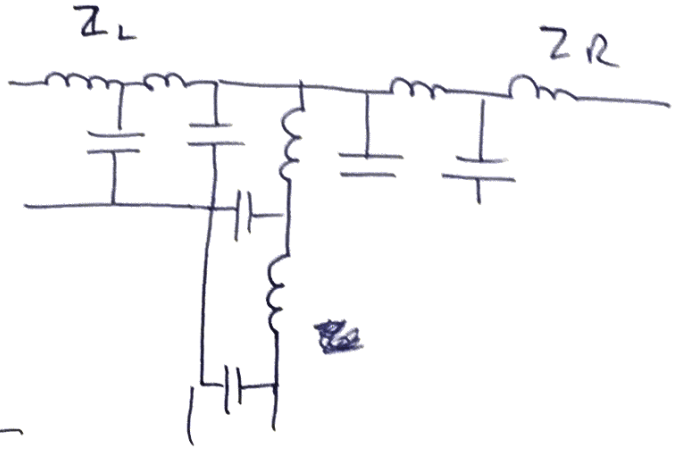
$= 6.7\times10^{10}$ Hz

$= 67$ GHz

7.6) (a) Data rate $= 10$ Mbit/s $= 10^7$ bit/s.

Physical length of bit $= 1/10^7$ s $= 100$ ns.

(b) $\frac{1}{Z_{eff}} = \frac{1}{Z_L} + \frac{1}{Z_R}$



$Z_L = Z_R = Z$

$\frac{1}{Z_{eff}} = \frac{2}{Z}$ $\quad Z_{eff} = Z/2 \Rightarrow 50/2 = 25\ \Omega$

Reflection coefficient $= \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{25-50}{25+50} = -1/3$

7.4) Capacitance of between plate $= \frac{\epsilon A}{d} = \frac{\epsilon w}{h}$ F/m