Antenna Theory and Design

4.5-4)

given receiver operating frequency $f = 152.65 MHz$

$N=1$ — Loop antenna constructed of copper band with

width $w = 3.65 mm$

height ~~length~~ $h = 0.10 mm$

length $L = 41.6 mm$

width $W = 13 mm$

(a) Radiation Efficiency :-

$$e = \frac{R_r}{R_r + R_w}$$

$$R_r = 31200\left(\frac{S}{\lambda^2}\right)^2$$

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

$$\lambda = 1.98 m$$

$$S = WL$$

$$= (41.6 mm)(13 mm)$$

$$S = 540.8 \times 10^{-6} m$$

$$R_r = 31200 \frac{(540.8 \times 10^{-6})^2}{(1.98)^4}$$

$$R_r = 6.18 \times 10^{-4} \Omega$$

$$R_w = R_s\left[\frac{2(l+w)}{2(h+w)}\right]$$

$$R_s = \sqrt{\frac{2\pi f \mu_0}{2\sigma}}$$

$$= \sqrt{\frac{2\pi(152.65\times10^{6})(1.25\times10^{-6})}{2(5.67\times10^{7})}}$$

$$\boxed{R_s = 3.25\times10^{-3}\,\Omega}$$

$$R_w = 3.25\times10^{-3}\left[\frac{2(41.6+13)}{2(3.65+0.70)}\right]$$

$$\boxed{R_w = 0.0407\,\Omega}$$

Radiation Efficiency $e = \dfrac{R_r}{R_r + R_w}$

$$e = \frac{6.15\times10^{-4}}{6.18\times10^{-4}+0.0407}$$

$$e = 0.0149$$

$$\boxed{e = 1.49\%}$$

b) Effective Aperture and Gain:-

For ideal dipole $D = 1.5$

So Gain $G = eD$

$= (0.0149)(1.5)$

Gain $\boxed{G = 0.022}$

Effective Aperture $A_e = \dfrac{G}{\left(\frac{4\pi}{\lambda^2}\right)}$

$= \dfrac{0.022}{\left(\frac{4\pi}{1.96^2}\right)}$

$\boxed{A_e = 6.72 \times 10^{-3}\ m^2}$

c) Output power of the Antenna from input electric field intensity $E = 13\ \mu V/m$

~~$S_{inc} = \frac{1}{2}\left[\frac{E^2}{120\pi}\right]$~~

~~$= \frac{1}{2}\left[\frac{13\ \mu V/m \times 13\ \mu V/m}{120\pi}\right]$~~

~~$= 0.224 \times 10^{-12}\ W/m^2$~~

~~$P_R = S_P \cdot A_e$~~

~~$= (0.224\times10^{-12})(6.72\times10^{-3})$~~

~~$P_R = 1.5052\times10^{-15}$~~

~~$P_R = -118.08\ dBm$~~

$$S_P = \frac{1}{2}\left(\frac{E^2}{120\pi}\right)$$

$$= \frac{1}{2}\left(\frac{134\times134}{120\pi}\right)$$

$$S_P = 0.224\times10^{-12}\ W/m^2$$

Output power of the Antenna will be

$$P_R = S_P \cdot A_e$$

$$= \left(0.224\times10^{-12}\ \frac{W}{m^2}\right)\left(6.73\times10^{-3}\ m^2\right)$$

$$P_R = 1.505\times10^{-15}\ W$$

$$P_R = -118.09\ dBm$$

4.6-7)

given $P_r = 10^{-13}\,\omega$

$P_t = 100KW$

frequency $f = 3GHz$, $\lambda = \frac{c}{f}$

$= 0.1m$

$G_t = 40dB$

Substituting the given values in below formulae

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

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

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

$$= \left[\frac{10^8}{(4\pi)^3 10^{-13}}\right]^{1/4}$$

$R = 26.6km$