Problem 2.72, Balanis 3nd edition

$$A_{em} = \frac{\lambda^2}{4\pi} e_t D_0 = \frac{\lambda^2}{4\pi} G_0$$

$$(a) \quad G_0 = 14.8dB \Rightarrow G_0\left(power\ ratio\right) = 10^{1.48} = 30.2$$

$$f = 8.2GHz \Rightarrow \lambda = 3.6585cm$$

$$A_{em} = \frac{\left(3.6585\right)^2}{4\pi} \cdot 30.2 = 32.167cm^2$$

$$A_p = 5.5 \cdot 7.4 = 40.7cm^2$$

Problem 2.72, Balanis 3nd edition

$$(b)\quad G_0 = 16.5dB \Rightarrow G_0\left(power\ ratio\right) = 10^{1.65} = 44.668$$

$$f = 10.3GHz \Rightarrow \lambda = 2.912cm$$

$$A_{em} = \frac{\left(2.912\right)^2}{4\pi}\cdot 44.668 = 30.142cm^2$$

Problem 2.72, Balanis 3nd edition

$$(c) \quad G_0 = 18.0dB \Rightarrow G_0\left(power\ ratio\right) = 10^{1.8} = 63.096$$

$$f = 12.4GHz \Rightarrow \lambda = 2.419cm$$

$$A_{em} = \frac{\left(2.419\right)^2}{4\pi} \cdot 63.096 = 29.389cm^2$$

Problem 2.81, Balanis 3nd edition

$$1\,status\ mile = 1.609.3\,meter, \quad 22300\,status\ mile = 3.588739\cdot 10^{7}\,m$$

$$(a) \quad P_i = \frac{P_{rad}}{4\pi R^2} = \frac{8\cdot 10^{-14}}{4\pi\cdot 3.58874} = 4.943\cdot 10^{-16}\,Watts/m^2$$

$$(b) \quad A_{em} = \frac{\lambda^2}{4\pi} e_t D_0, \quad D_0 = 60dB = 10^6, \quad \lambda = 0.15m$$

$$A_{em} = \frac{(0.15)^2}{4\pi} 10^6 = 1790.493 m^2$$

$$P_{received} = A_{em} P_i = 1790.493\cdot 4.943\cdot 10^{-16} = 8.85\cdot 10^{-13}\,watts$$

Problem 2.85, Balanis 3nd edition

$$\frac{P_r}{P_t} = \left|\hat{\rho}_t \bullet \hat{\rho}_r\right|^2 \left(\frac{\lambda}{4\pi R}\right)^2 G_{0t} G_{0r}$$

$$G_{0t} = 20dB \Rightarrow G_{0t}\left(power\ ratio\right) = 10^2 = 100$$

$$G_{0r} = 15dB \Rightarrow G_{0r}\left(power\ ratio\right) = 10^{1.5} = 31.623$$

$$f = 1GHz \Rightarrow \lambda = 0.3m$$

$$R = 10^3 m$$

$$\left(a\right) \quad for \left|\hat{\rho}_t \bullet \hat{\rho}_r\right|^2 = 1$$

$$P_r = \left(\frac{0.3}{4\pi \cdot 10^3}\right)^2 \left(100\right)\left(31.623\right)\left(150 \cdot 10^3\right) = 270.344 \mu Watts$$

Problem 2.85, Balanis 3nd edition

$(b)\quad when\ transmitting\ antenna\ is\ circularly\ polarized$

$and\ receiving\ antenna\ is\ linearly\ polarized, the\ PLF =$

$$\left|\hat{\rho}_t \bullet \hat{\rho}_r\right|^2 = \left|\left(\frac{\hat{a}_x \pm j\hat{a}_y}{\sqrt{2}} \cdot \hat{a}_x\right)\right|^2 = \frac{1}{2}$$

$$Thus \quad P_r = \frac{1}{2}\left(270.344 \cdot 10^{-6}\right) = 135.172 \cdot 10^{-6} = 135.172\,\mu Watts$$

Problem 4.

Repeat Problem 3 for the case of a reflecting ground and antenna height of both the receiver and transmitter of:

I. 3 meters

II. 5 meters

III. 10 meters

$$(a) \quad h_T = h_R = 3m$$

$$P_R = P_T \cdot G_T \cdot G_R \left(\frac{h_T h_R}{d^2} \right)^2 \quad eq\ 2.22,\ d \gg h_T, h_R$$

$$P_R = 150 \cdot 100 \cdot 31 \left(\frac{3 \cdot 3}{1000^2} \right) \sim 38 \mu W$$

$$(b) \quad h_T = h_R = 5m$$

$$P_R = P_T \cdot G_T \cdot G_R \left(\frac{h_T h_R}{d^2} \right)^2 \quad eq\ 2.22,\ d \overset{?}{\gg} h_T, h_R$$

$$P_R \sim 270 \mu W \Rightarrow same\ as\ \ free\ space$$

Problem 4.

$use\ equation\ 2.21\ as\ d\ is\ not \gg h_T, h_R$

$$P_R = 4P_T\left(\frac{\lambda}{4\pi d}\right)^2 G_T G_R \cdot \sin^2\left(\frac{2\pi h_T h_R}{\lambda d}\right)$$

$$P_R = 4\cdot 150\left(\frac{0.3}{4\pi \cdot 1000}\right)^2 \cdot 100\cdot 31\cdot \sin^2\left(\frac{2\pi\cdot 5\cdot 5}{0.3\cdot 1000}\right) \sim 296\mu W$$

explained by Fig 2.5, close to the breaking point!

i.e. Friis eq = flat reflecting surface

$eq\quad 2.119\ Balanis = 2.22\ Parson$

Problem 4.

$$(c) \quad h_T, h_R = 10m$$

$$P_R = 4P_T \left(\frac{\lambda}{4\pi d} \right)^2 G_T G_R \cdot \sin^2 \left(\frac{2\pi h_T h_R}{\lambda d} \right) = 4.74mW$$

$$\Rightarrow compare\ to\ \ free\ space, Wrong\,?\,or$$

$$why\,? \quad No\ grazing\ angle,\ \rho \neq -1$$

Compare to freespace, wrong or?

a) Max power will be 4x freespace due to doubel E-field. => Could be OK

b) Or reflection coefficient diffrent from -1 due to wrong assumption of grasing angle