EE 302 PS 15 - SOLUTIONS

Chapter 14

Questions: 60, 65, 68, 69
Problems: None
Critical Thinking: None

Additional Problems: 1, 2

Question 60

Ground, sky and space waves.

Question 65

The ionosphere is the the outermost layer of the atmosphere (30-250 mi above the earth). It is so called because its constituent molecules are ionized by solar radiation. The ionosphere is capable of affecting radio waves via refraction.

Question 68

Multiple-skip transmission involves radio waves being refracted back to earth from the ionosphere and then being reflected back up to the ionosphere where the process repeats.

Question 69

Wavelength (or frequency) of the radio wave and its angle of incidence upon the ionosphere.

Additional Problem 1

1.a.

$$d = d_t + d_r = \sqrt{2h_t} + \sqrt{2h_r} \longrightarrow h_r = \frac{1}{2}(d - \sqrt{2h_t})^2$$

$$h_r = \frac{1}{2}\left(35 - \sqrt{2 \times 350}\right)^2 = 36.5 \text{ ft}$$

1.b.

$$P_r = \frac{P_t G_t G_r \lambda^2}{16\pi^2 d^2}$$

G_t and G_r must be ratios and they must be with respect to an isotropic point source. We're told that both antennae have the same gain as a dipole, so $G_r = G_t = 1.64$. Both d and λ must be in meters: $d = 56,327$ m (5280 ft/mi, and 12 in/ft, and 39.37 in/m together yield 1609.3 m/mi) and $\lambda = 1.92$ m.

$$P_r = \frac{(25 \text{ W})(1.64)(1.64)(1.92 \text{ m})^2}{16\pi^2(56,327 \text{ m})^2} = 496.3 \text{ pW}$$

1.c.

$$d = \sqrt{2h_t} + \sqrt{2h_r} = \sqrt{2 \times 6} + \sqrt{2 \times 36.5} = 12.01 \text{ mi}$$

Additional Problem 2

2.a. Recall

$$B = \frac{203}{(\sqrt{10})^x} \longrightarrow x = 2\log_{10}\frac{203}{B}$$

where x is one tenth of the gain in dBd and B is beamwidth in degrees. Thus, gain in dBd is $10x$:

$$gain\ [\text{dBd}] = 10x = 20\log_{10}\frac{203}{B}$$

First, an estimate of beamwidth must be made. The radiation pattern hits -3 dB at about 17° and at 343°. The beamwidth is the angular separation between the -3-dB points. Based on this reading of the plot the, beamwidth is 34°. Based on $B = 34°$, receiver gain is $G_{r,dBd}$:

$$G_{r,dBd} = 10x = 20\log_{10}\frac{203}{34} = 15.52 \text{ dBd}$$

Receiver gain, expressed as a ratio relative to a dipole, is:

$$G_{r,dipole} = 10^{G_{r,dB}/10} = 35.65$$

As a ratio relative to an isotropic point source, $G_{r,isotropic}$ can be found by multiplying the $G_{r,dipole}$ by the gain of a dipole with respect to an isotropic point source (1.64):

$$G_{r,isotropic} = G_{r,dipole} \times 1.64 = 35.65 \times 1.64 = 58.46$$

2.b. Maximum power received:

$$P_r = \frac{P_t G_t G_r \lambda^2}{16\pi^2 d^2} = \frac{(1000\text{ W})(1.64)(58.46)(6\text{ m})^2}{16\pi^2(40,000\text{ m})^2} = 13.66\ \mu\text{W}$$

Here, λ was found to be 6 m. Remember, G_t and G_r must be *ratios* relative to an *isotropic point source*.

2.c. Front power is 0 dB. Back power is -20 dB. Front-to-back ratio can be calculated as follows:

$$\text{F/B} = P_{\text{f,dB}} - P_{\text{b,dB}} = 0 - (-20) = 20\text{ dB}$$

As a ratio, this is $F/B = 10^{20/10} = 100$.