EE 4382/5306 – Antenna Engineering
Homework #4 – Due October 16, 2017

Ground Effects: Practical Approach

Quarter-Wavelength Monopole

$$l = \lambda/4,\ f = 1.9\,\text{GHz},\ W_i = 10^{-6}\,\text{W/m}^2 \Rightarrow \lambda = \frac{3\times 10^6}{1.9\times 10^9} = 0.15789\,\text{m}$$

(a) The power pattern of a $\lambda/4$ monopole *above* a PEC is equivalent to that of a $\lambda/2$ dipole in free space. Since the same power radiated by the monopole above the PEC is concentrated only in the *upper* hemisphere, instead over the entire free space, its radiation intensity will be *twice* as strong/intense as that of the $\lambda/2$ dipole radiating in free space. Since the directivity is given by

$$D_0 = \frac{4\pi U_{\text{max}}}{P_{\text{rad}}}$$

The U_{max} of the monopole will be twice that of the dipole, or

$$D_0(l = \lambda/4) = 2(1.643) = \boxed{3.286 = 5.17\,\text{dB}}$$

Microwave Radiation Exposure

$f = 900\,\text{MHz},\ P_{\text{rad}} = 1{,}000$ Watts

(a) Isotropic

$$W_{r0} \le \frac{P_{\text{rad}}}{4\pi r^2}$$

$$r^2 \ge \frac{P_{\text{rad}}}{4\pi W_{r0}} = \frac{1{,}000}{4\pi(10)} = \frac{100}{4\pi} = 7.9558$$

$$\boxed{r \ge 2.821\ \text{meters}}$$

$\lambda/4$ monopole

$$D_0\ (\text{monopole}) = 2(1.643) = 3.286$$

$$W_{\text{rad}} \le D_0\, W_{r0} = D_0 \frac{P_{\text{rad}}}{4\pi r^2}$$

$$r^2 \ge D_0 \frac{P_{\text{rad}}}{4\pi W_{\text{rad}}} = 3.286\left(\frac{1{,}000}{4\pi(10)}\right) = 26.1492$$

$$\boxed{r \ge 5.114\ \text{meters}}$$

Half-wave dipole over ground

$$f = 200\,\text{MHz} \Rightarrow \lambda = \frac{3\times 10^8}{2\times 10^8} = 1.5\,\text{meters}$$

$$E_\theta(\text{normalized}) = \frac{\cos\left(\frac{\pi}{2}\cos\theta\right)}{\sin\theta}\cos(kh\cos\theta)$$

Since $\frac{\cos\left(\frac{\pi}{2}\cos\theta\right)}{\sin\theta}$ has a null only toward $\theta = 0°$, the only way to place a null toward $\theta = 60°$ will be through $\cos(kh\cos\theta)$.

$$|\cos(kh\cos\theta)|_{\theta=\theta_h=60°} = |\cos(kh\cos\theta_n)| = |\cos(kh\cos 60°)| = 0$$

$$\left|\cos\left(\frac{2\pi}{\lambda}h\frac{1}{2}\right)\right| = \left|\cos\left(\frac{\pi h}{\lambda}\right)\right| = 0$$

$$\frac{\pi h}{\lambda} = \cos^{-1}(0) = \frac{n\pi}{2},\ n = 1, 3, 5, \ldots$$

$$\boxed{h = \frac{n\pi}{2}\left(\frac{\lambda}{\pi}\right) = \frac{n\lambda}{2},\ n = 1, 3, 5, \ldots}$$

(a) $h|_{n=1} = h_1 = \frac{\lambda}{2} = \frac{3}{2}\left(\frac{1}{2}\right) = \frac{3}{4} = \boxed{0.75\text{ meters}}$

(b) $h|_{n=3} = h_3 = \frac{3\lambda}{2} = \boxed{2.25\text{ meters}}$

(c) $h|_{n=5} = h_5 = \frac{5\lambda}{2} = \boxed{3.75\text{ meters}}$