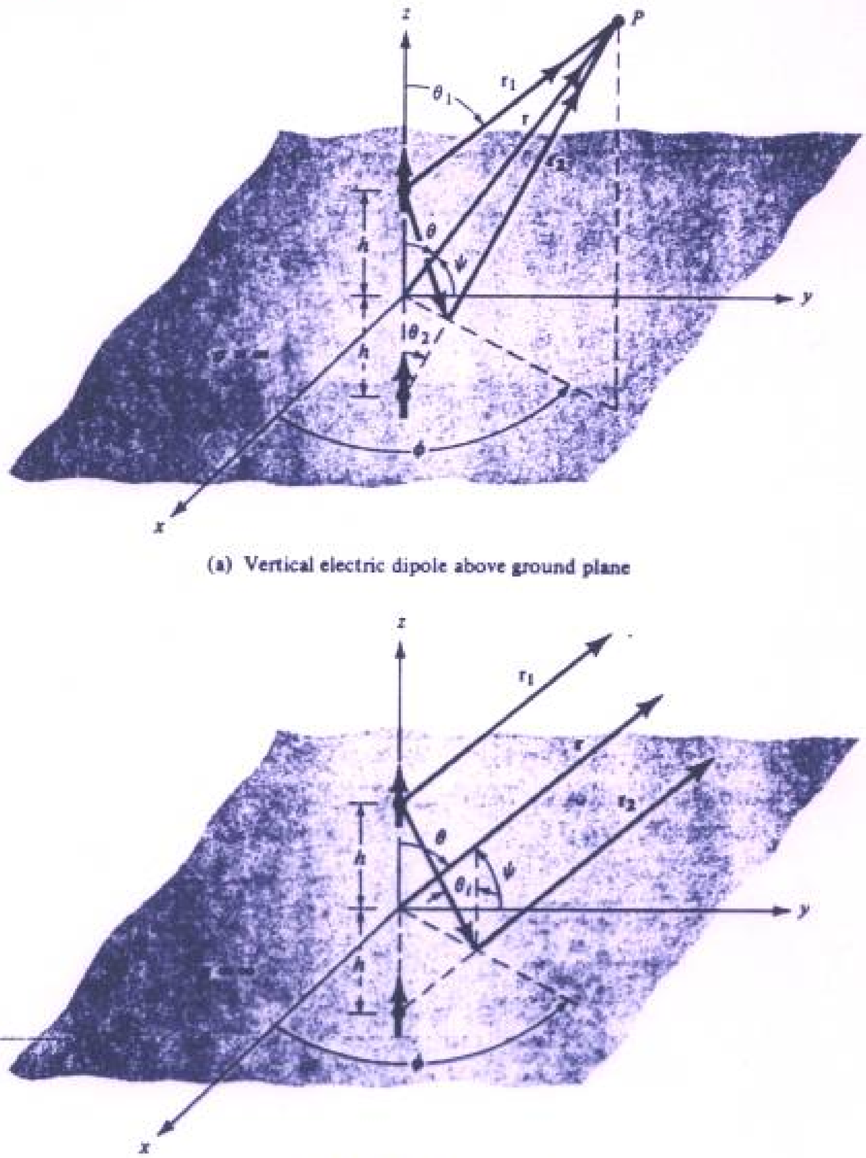
Vertical Electric Dipole :



(a) Vertical electric dipole above ground plane

(b) Far-field observations

Figure 4.13 Vertical electric dipole above infinite electric conductor.

For infinitesimal dipole of length l & height h above perfect ground plane:

direct $$E_\theta^d = j\eta \frac{k I_0 l\, e^{-jkr_1}}{4\pi r_1} \sin\theta_1$$

Reflected $$E_\theta^r = j R_v \eta \frac{k I_0 l\, e^{-jkr_2}}{4\pi r_2} \sin\theta_2$$

$R_v = 1$ for perfect conductor

Using far field approximation:

$$r_1 \simeq r - h\cos\theta$$

& $$r_2 \simeq r + h\cos\theta$$

$$E_\theta = E_\theta^d + E_\theta^r \simeq j\eta \frac{k I_0 l\, e^{-jkr}}{4\pi r} \sin\theta \left(e^{jkh\cos\theta} + e^{-jkh\cos\theta} \right)$$

$$= j\eta \frac{k I_0 l\, e^{-jkr}}{4\pi r} \sin\theta \left[2\cos(kh\cos\theta) \right]$$

for $z \geq 0$

& $E_\theta = 0$ $z < 0$

$\therefore E_\theta =$ Element factor $\times$ array factor

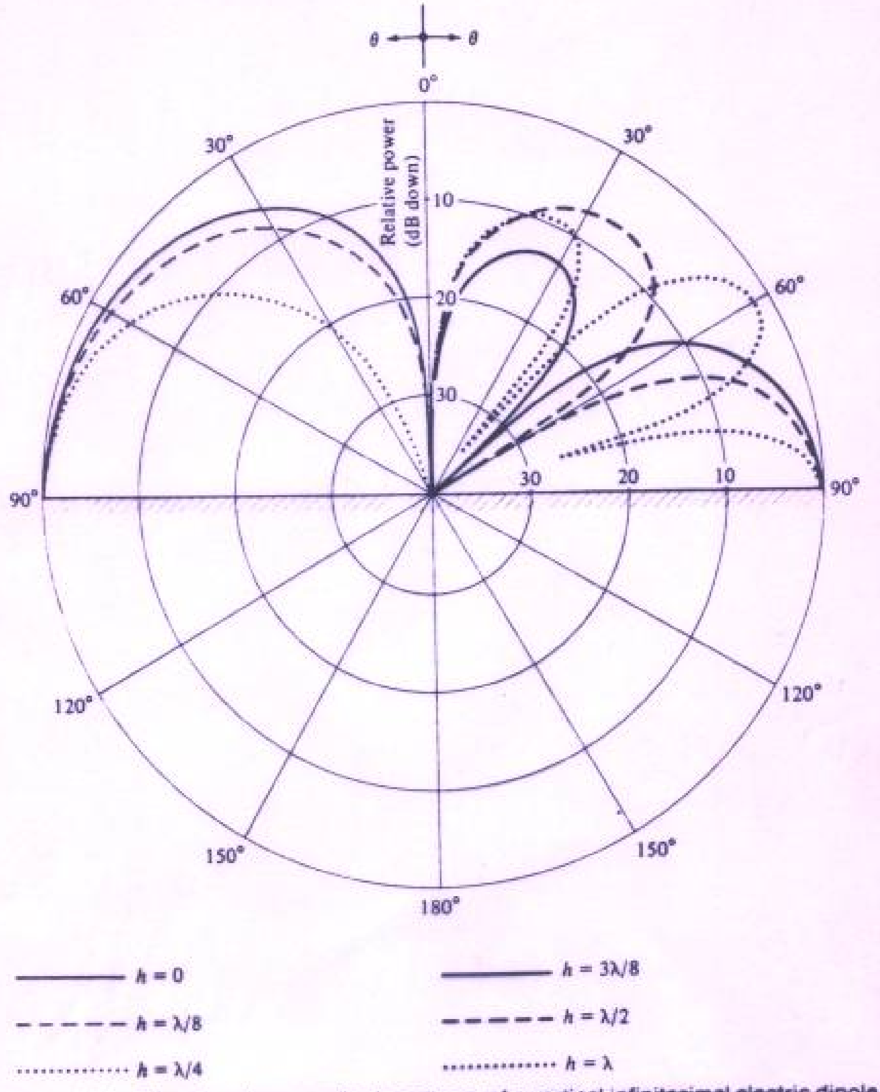


Figure 4.14 Elevation plane amplitude patterns of a vertical infinitesimal electric dipole for different heights above an infinite plane electric conductor.

In general! number of lobes $\simeq \frac{2h}{\lambda} + 1$

Directivity & radiation resistance:

$$P_{rad} = \oiint_S W_{av} \cdot ds = \frac{1}{2\eta} \int_0^{2\pi} \int_0^{\pi/2} |E_\theta|^2 r^2 \sin\theta \, d\theta \, d\phi$$

$$= \frac{\pi}{\eta} \int_0^{\pi/2} |E_\theta|^2 r^2 \sin\theta \, d\theta$$

$$= \pi\eta \left|\frac{I_0 l}{\lambda}\right|^2 \left[\frac{1}{3} - \frac{\cos(2kh)}{(2kh)^2} + \frac{\sin(2kh)}{(2kh)^3} \right]$$

As $kh \to \infty$ $\quad P_{rad} \to \frac{\pi}{3}\eta \left|\frac{I_0 l}{\lambda}\right|^2$

" Same as isolated element.

As $kh \to \infty$ $\quad P_{rad} \to 2 P_{rad}\big|_{\text{isolated element}}$.

$$U = r^2 W_{av} = \frac{\eta}{2} \left|\frac{I_0 l}{\lambda}\right|^2 \sin^2\theta \cos^2(kh\cos\theta)$$

$$U_{max} = U\big|_{\theta = \frac{\pi}{2}} = \frac{\eta}{2} \left|\frac{I_0 l}{\lambda}\right|^2$$

$$\therefore D_0 = \frac{4\pi U_{max}}{P_{rad}} = \frac{2}{\left[\frac{1}{3} - \frac{\cos(2kh)}{(2kh)^2} + \frac{\sin(2kh)}{(2kh)^3} \right]}$$

$kh = 0 \quad \to D_0 = 3$

Maximum D_0 occurs at $h = 0.4585\lambda$

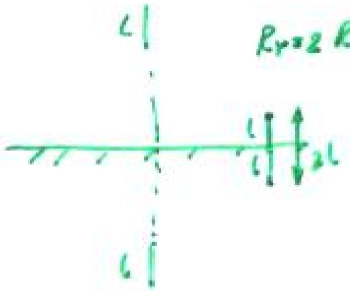
or $kh = 2.881$

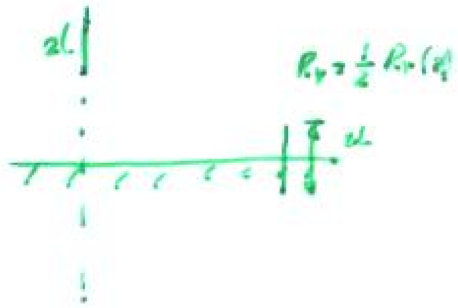
$D_{0\,max} = 6.566$

$$R_r = \frac{2P_{rad}}{|I_0|^2} = 2\pi\eta\left(\frac{l}{\lambda}\right)^2\left[\frac{1}{3} - \frac{\cos(2kh)}{(2kh)^2} + \frac{\sin(2kh)}{(2kh)^3}\right]$$

$kh \to \infty$ R_r Same as isolated element

$kh \to 0$ R_r twice that of the isolated element.





R_r of the element when $(h = 0)$ as shown

$= \frac{1}{2} R_r$ (isolated element of length $2l$)

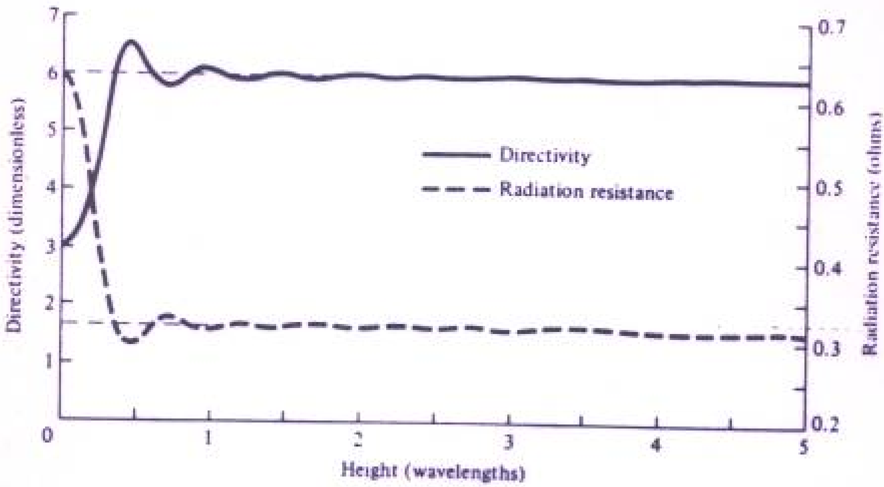
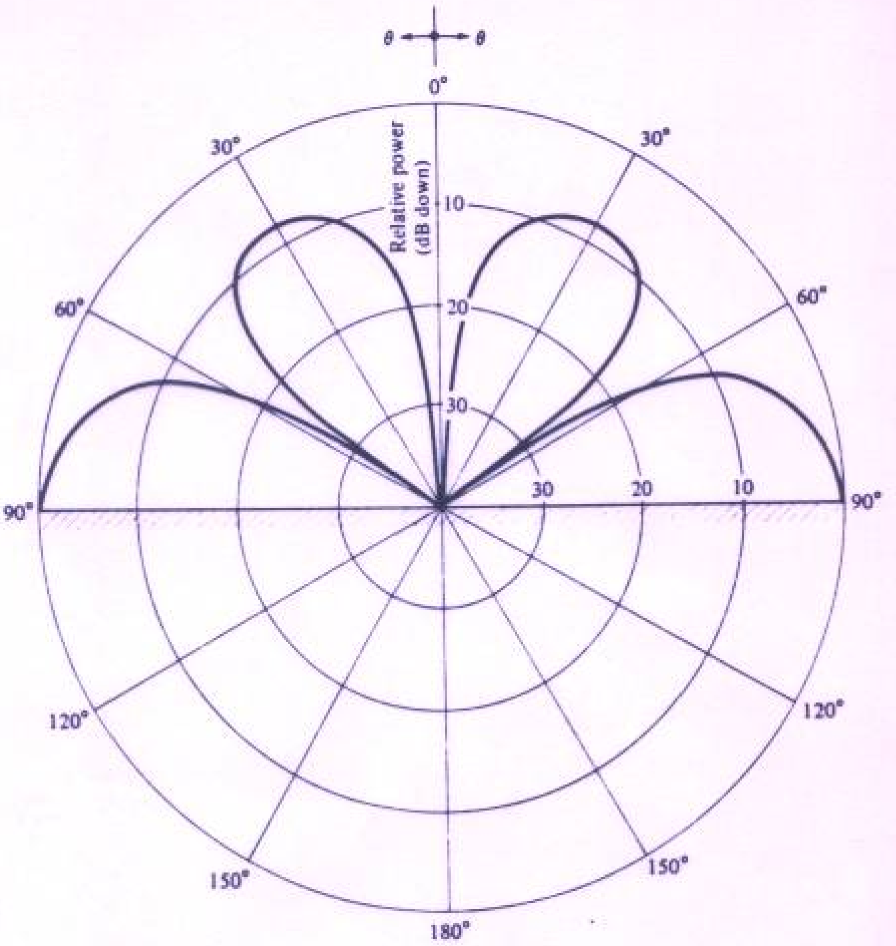


Figure 4.16 Directivity and radiation resistance of a vertical infinitesimal electric dipole as a function of its height above an infinite plane electric conductor.



——— $h = 0.4585\lambda$

Figure 4.15 Elevation plane amplitude pattern of a vertical infinitesimal electric dipole at a height of 0.4585λ above an infinite plane electric conductor.