Linear Wire Dipole Antennas: Practical Approach

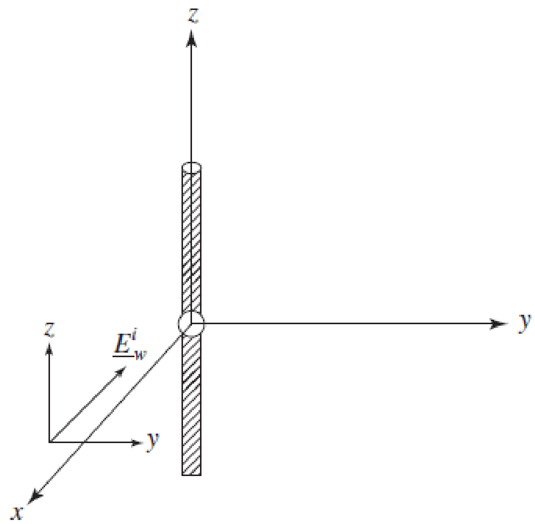
Antenna Polarization

$$W_i = 2\,\mu\text{W/m}^2 = 2\times 10^{-6}\text{W/m}^2$$

(a) $\underline{E}_w^i = (3\hat{a}_z + j\hat{a}_y)E_o e^{+jkx}$

$$\underline{E}_w^i = \left(\frac{3\hat{a}_z + j\hat{a}_y}{\sqrt{10}}\right)10E_o e^{+jkx}$$

$$\hat{\rho}_w = \left(\frac{3\hat{a}_z + j\hat{a}_y}{\sqrt{10}}\right)$$



Elliptical CCW
AR = 3/1 = 3

(b) $\underline{E}_a = \hat{a}_\theta j\eta \dfrac{I_0 e^{-jky}}{2\pi r}\dfrac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}$

$$= \hat{a}_\theta E_0 \frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}\Bigg|_{\theta=\pi/2}$$

$$\underline{E}_a = \underbrace{\hat{a}_\theta}_{\hat{\rho}_a} E_0$$

$\hat{\rho}_a = \hat{a}_\theta \Rightarrow$ Linear

$$\hat{\rho}_a = [\hat{a}_x\cos\theta\cos\phi + \hat{a}_y\cos\theta\sin\phi - \hat{a}_z\sin\theta]_{\theta=90^\circ}$$

$$\hat{\rho}_a = -\hat{a}_z$$

(c) $\text{PLF} = |\hat{\rho}_w\cdot\hat{\rho}_a|^2 = \left|\left(\dfrac{3\hat{a}_z + j\hat{a}_y}{\sqrt{10}}\right)\cdot(-\hat{a}_z)\right|^2 = \dfrac{9}{10} = 0.9 = -0.4576\,\text{dB}$

PLF = −0.4576 dB = 0.9

Dipole Antenna Impedance

A lossless, resonant, center-fed $\frac{3\lambda}{4}$ linear dipole, radiating in free-space is attached to a balanced, lossless transmission line whose characteristic impedance is $300\ \Omega$. Assuming $a = 0.03\ \lambda$, calculate:

(a) Approximate Radiation Resistance
(b) Approximate Input Resistance
(c) VSWR on the transmission line

For part (a) use the diagrams shown in figs. 4.9(a) and 4.9(b)

$$\frac{kl}{2} = \frac{3\pi}{4},\ kl = \frac{3\pi}{2},\ 2kl = 3\pi,\ a = 0.03\lambda$$

(a) Using (8-60a), (8-60b)

$$R_r = 185.808,\ X_r = 192.7967$$

(b) Using (8-61a), (8-61b)

$$\mathrm{R}_{in} = \frac{185.808}{\sin^2(3\pi/4)} = 371.617,\ X_{in} = \frac{192.7967}{\sin^2(3\pi/4)} = 385.5936$$

(c) $\Gamma = \frac{371.617 - 300}{371.617 + 300} = 0.10663$

$$\mathrm{VSWR} = \frac{1 + 0.10663}{1 - 0.10663} = 1.2387$$

Dipole Antenna Impedance and Resonance

$$l = \lambda/2, \quad Z_c = 50 \text{ ohms}$$

$$Z_{in} = 73 + j42.5, \quad Y_{in} = \frac{1}{Z_{in}} = \frac{1}{73 + j42.5}\frac{73 - j42.5}{73 - j42.5}$$

$$Y_{in} = 0.01023 - j0.0059563 = (10.23 - j5.9563) \times 10^{-3} = G_{in} - jB_{in}$$

$$B_{in} = \omega C_{in} = 2\pi f C_{in} \Rightarrow C_{in} = \frac{B_{in}}{2\pi f} = \frac{5.9563 \times 10^{-3}}{2\pi(10 \times 10^{8})} = 0.94797 \times 10^{-12}$$

$$\therefore\ C_{in} = 0.94797\ pF$$

$$G_{in} = 10.23 \times 10^{-3}$$

$$R_{in} = \frac{1}{G_{in}} = 97.75, \quad \Gamma_{in} = \frac{R_{in} - Z_c}{R_{in} + Z_c} = \frac{97.75 - 50}{97.75 + 50} = 0.3232$$

$$\text{VSWR} = \frac{1 + |\Gamma_{in}|}{1 - |\Gamma_{in}|} = \frac{1 + 0.3232}{1 - 0.3232} = 1.955$$

Antenna Communications

Use Friis Transmission Equation of (2-118) with:

- $e_{cdt} = e_{cdr} = 1$ because of lossless.
- $Z_a = 73$ because of resonant.
- $D_t = D_r\big|_{\theta=45^\circ} = D_0 \left[\frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}\right]^2_{\theta=45^\circ} = 1.643 \left[\frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}\right]_{\theta=45^\circ}$

$$= 1.643 \left|\frac{0.44417}{0.707}\right|^2 = 1.643(0.62824)^2 = 1.643(0.3947)$$

$$D_t(\theta = 45^\circ) = D_r(\theta = 45^\circ) = 1.643(0.3947) = 0.648$$

P. S. You could also use:

$$D_t(\theta = 45°) = D_r(\theta = 45°) \simeq 1.643 \sin^3 \theta \Big|_{\theta=45} = 1.643(0.3536) = 0.581.$$

$$R = \sqrt{2}(1{,}000) = 1{,}414 \text{ meters}$$

$$\lambda(1 \text{ GHz}) = \frac{v}{f} = \frac{3 \times 10^8}{3 \times 10^9} = 0.1 \text{ meters}$$

$$P_t = 100 \times 10^{-3} \text{ watts}$$

$$\text{PLF} = |\hat{\rho}_t \cdot \hat{\rho}_r|^2, \quad |\hat{a}_\theta \cdot \hat{a}_\theta|^2 = 1$$

$$\frac{P_r}{P_t} = e_{cdt} e_{cdr} (1 - |\Gamma_t|^2)(1 - |\Gamma_r|^2) \left[\frac{\lambda}{4\pi R}\right]^2 D_t D_r (\text{PLF})$$

$$|\Gamma_t| = |\Gamma_r| = \left|\frac{Z_a - Z_c}{Z_a + Z_c}\right| = \left|\frac{73 - 50}{73 + 50}\right| = \frac{23}{123} = 0.187$$

$$|\Gamma_t|^2 = |\Gamma_r|^2 = |0.187|^2 = 0.035$$

$$(1 - |\Gamma_t|^2) = (1 - |\Gamma_r|^2) = (1 - 0.035) = 0.965$$

$$\frac{P_r}{P_t} = (1)(1)(0.965)(0.965) \left[\frac{0.1}{4\pi(1{,}414)}\right]^2 (0.648)(0.648)(1)$$

$$\frac{P_r}{P_t} = 0.931228(5.6278 \times 10^{-6})(0.4199)$$

$$P_r = 0.931228(31.67438 \times 10^{-12})(0.4199)(100 \times 10^{-3}) = 12.3854 \times 10^{-13}$$

$$P_r = 1.23854 \times 10^{-12} \text{ Watts}$$