2.68 A 1-m long dipole antenna is driven by a 150 MHz source having a source resistance of 50 ohms and a voltage of 100 V. If the ohmic resistance of the antennas is given by R_L = 0.625 ohms, find the:

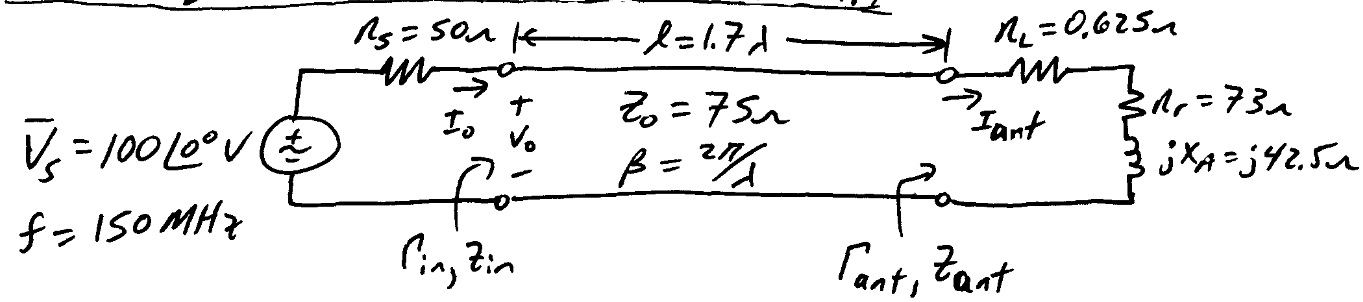
(a) Current going into the antenna (I_{ant});
(b) Power dissipated by the antenna
(c) Power radiated by the antenna;
(d) Radiation efficiency of the antenna

- Assume a lossless 75 Ω transmission line of length 1.7λ connects source and dipole. [Hint: look at Chapter 4 section on λ/2 dipoles.]

$$\lambda = \frac{c}{f} \simeq \frac{3\times10^8}{150\times10^6} = 2\,m \Rightarrow 1m \text{ dipole is } \lambda/2 \text{ long!}$$

From Chap. 4 (4-93a), $Z_{\lambda/2} = \underbrace{73}_{R_r} + j\underbrace{42.5}_{X_A}\,\Omega$

<u>Draw equivalent microwave circuit</u>

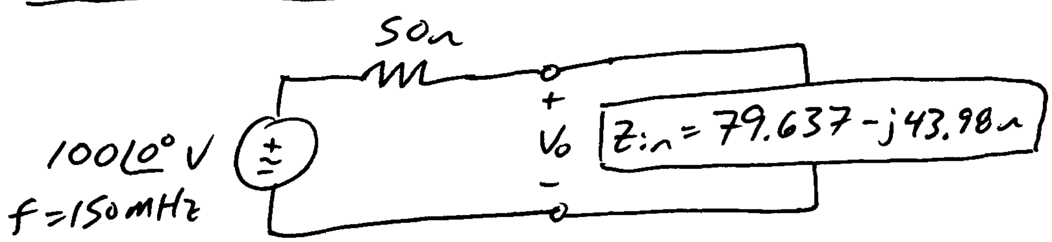


$$\Gamma_{ant} = \frac{Z_{ant} - Z_o}{Z_{ant} + Z_o} = \frac{(73.625 + j42.5) - 75}{(73.625 + j42.5) + 75} = 0.27508\angle 75.895°$$

$$\Gamma_{in} = \Gamma_{ant}\, e^{-j2\beta\ell} = (0.275\angle 75.9°)\, e^{-j2\frac{2\pi}{\lambda}1.7\lambda} = 0.27508\angle -68.105°$$

$$Z_{in} = Z_o \frac{1+\Gamma_{in}}{1-\Gamma_{in}} = 75\,\frac{1 + 0.275\angle -68.1°}{1 - 0.275\angle -68.1°} = 79.637 - j43.9805\,\Omega$$

<u>Reduced equivalent circuit</u>



$$V_o = 100\angle 0°\,\frac{79.637 - j43.98}{50 + (79.637 - j43.98)} = 66.456\angle -10.17°\,V$$

Find forward propagating voltage wave amplitude

$$V_o^+ = \frac{V_o}{1+\Gamma_{in}} = \frac{66.456\angle{-10.17^\circ}}{1+0.275\angle{-68.1^\circ}} = 58.7204\angle{2.8636^\circ}\ V$$

a) Now, we can calculate the current going into the antenna.

$$I_{ant} = \frac{V_o^+}{Z_o} e^{-j\beta\ell}\left(1-\Gamma_{ant}\right) = \frac{58.72\angle{2.86^\circ}}{75} e^{-j\frac{2\pi}{\lambda}1.7\lambda}\left(1-0.275\angle{75.9^\circ}\right)$$

$$\underline{\underline{I_{ant} = 0.75973\angle{94.9055^\circ}\ A}}$$

b) Per (2-77), $P_L = \frac{1}{2}|I_{ant}|^2 R_L = \frac{1}{2}(0.7597)^2(0.625)$

$$\underline{\underline{P_L = 0.18037\ W = 180.37\ mW}}$$

c) Per (2-76), $P_{rad} = \frac{1}{2}|I_{ant}|^2 R_r = \frac{1}{2}(0.7597)^2(73)$

$$\underline{\underline{P_{rad} = 21.06745\ W}}$$

d) radiation efficiency (2-90)

$$e_{cd} = \frac{P_{rad}}{P_{rad}+P_L} = \frac{R_r}{R_r+R_L} = \frac{73}{73+0.625}$$

$$\underline{\underline{e_{cd} = 0.99151 = 99.151\%}}$$