Antenna Theory
Thevenin Equivalent Circuit Problem

Problem 2.68

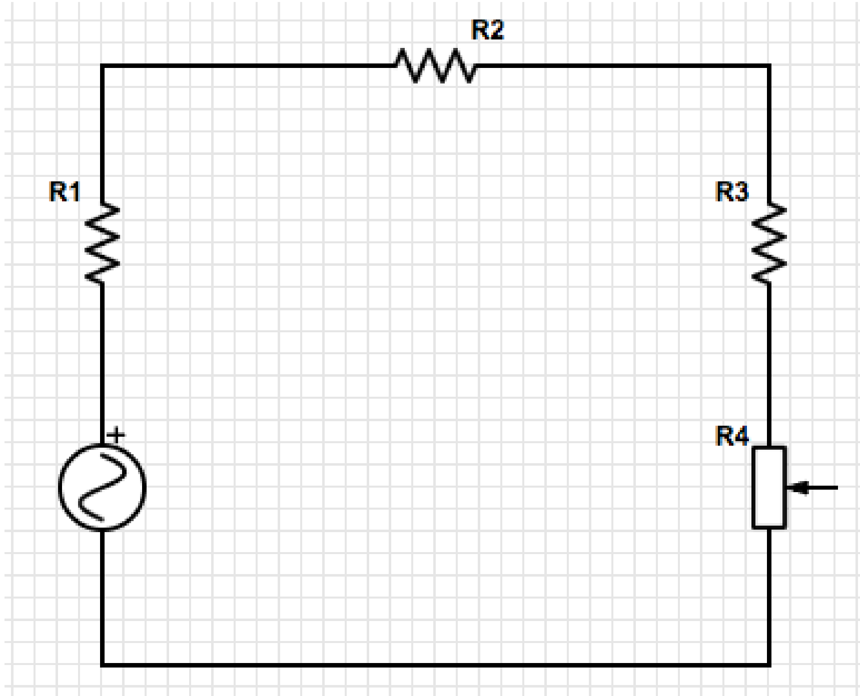

Figure1

Problem:

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

Symbols:

(a) I_{ant}: Antenna Current
(b) $R_2 = R_s = 50\ ohms$: Source Resistance
(c) $R_2 = R_{Loss} = R_L = 0.625\ ohms$: Loss Resistance of the Antenna
(d) $R_3 = R_r = 73\ ohms$: Radiation Resistance of the Antenna
(e) $R_4 = X_A = j42.5\ ohms$: Antenna Reactance at terminal a-b (up-down)
(f) e_{cd}: Radiation efficiency of the Antenna

Background:

Note that only R_r part contributes to the radiation. In short, this impedance will guide how much power will be radiated. R_L will guide how much power will be lost as heat. R_s is the internal resistance in the source. In addition, the current on this equivalent circuit and the desired resistance/impedance will be used to calculate the corresponding power.

First, we need to know the wavelength to find the electrical length of this antenna which can be computed by:

$$f = 150MHz$$
$$\lambda_0 = 2m$$

Therefore, the 1m long dipole antenna is $\frac{\lambda}{\lambda_0} = \frac{\lambda}{2}$ in electrical length and this information provides that the radiation impedance of this dipole antenna is already examined as (equation 4-93):

$$Z_{in} = 73 + j42.5\ ohms$$

Solved:

(a) The current on this circuit can be simply calculated by the division of voltage and the total impedance in the circuit.

$$I_{ant} = \frac{V_s}{R_s + R_L + R_r + jX_A} = \frac{100V}{50 + 0.625 + 73 + j42.5} = 0.723 - j0.249 = 0.765e^{-j19}$$

where the angle in degree.

(b) It should be carefully noted that the source resistance is not part of the antenna. Thus, the power dissipated by the antenna can be expressed:

$$P_{diss} = P_{Loss} = \frac{1}{2}|I_{ant}|^2 R_{Loss} = 0.183\ W = 183\ mW$$

(c) The power delivered to the Antenna can be computed by:

$$P_r = \frac{1}{2}|I_{ant}|^2 R_r$$

Note that R_r is a passive component in the circuit, which is a loss. In transmitting mode, this lost power will be used in radiation process. Antenna in receiving mode will take this power, ideally all this amount of power.

(d) The radiation efficiency can be computed by:

$$e_{cd} = \frac{R_r}{R_r + R_{Loss}} = \frac{73}{73 + 0.625} = 99.15\%$$

Reference:

[1] Antenna Theory: Analysis and Design, 4th Edition by Constantine A. Balanis