Homework 10

P7.2.16 R_L in Figure P7.2.16 is restricted to the range 1 to 8 Ω. Determine the value of R_L that results in maximum power transfer to it and calculate the value of this power.

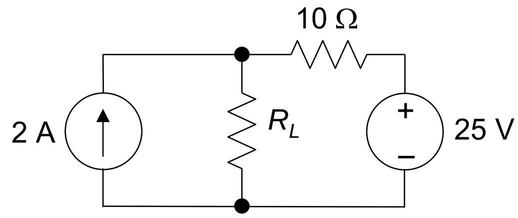

Figure P7.2.16

Solution P7.2.16

If R_L is removed, and superposition applied, it follows that $V_{Th} = 25 + 2\times10 = 45$ V.

When both sources are set to zero, $R_{Th} = 10\ \Omega$.

Maximum power is transferred to R_L if R_L is closest to this value, i.e., $R_L = 8\ \Omega$.

Under these $I_L = 45/18 = 2.5$ A, and the power dissipated in R_L is $(2.5)^2\times8 = 50$ W.

P7.2.20 (a) Assuming B = 30 S, determine the turns ratio a in Figure P7.2.20 so that maximum power is absorbed in the 10 S resistor and calculate this power. (b) Assuming $a = 2$ and G_x = 10 S, determine B that results in maximum power absorption in G_x and calculate this power. (c) Assuming $a = 2$ and B = 15 S, determine G_x that results in maximum power absorption in this resistor and calculate this power. (d) Assuming $a = 2$ and G_x and B are variable, determine G_x and B that will result in maximum power absorption in G_x and calculate this power.

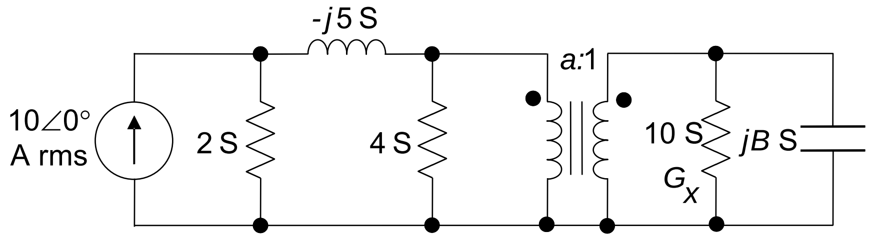

Figure 7.2.20

Solution P7.2.20

We first derive NEC of the circuit connected to the primary side.

$\mathbf{I_N} = \dfrac{-j5}{2-j5}\times 10 = \dfrac{50}{29}(5-j2) = 9.285\angle\text{-}21.8$ A;

$Y_N = 4 - \dfrac{j10}{2-j5} = \dfrac{166}{29} - j\dfrac{20}{29} = 5.766\angle -6.87^\circ\ \Omega.$

(a) Reflected to the secondary, Y_N is multiplied by a^2; $|Y_x| = |10 + j30|\ \Omega$. Hence $a = \sqrt{\dfrac{10\sqrt{10}}{5.766}} = 2.34$.

Assuming this value of a, $|\mathbf{V_L}| = \dfrac{|aI_N|}{2|Y_x|} = \dfrac{2.34\times 50/\sqrt{29}}{2\times 10\sqrt{10}} = 0.344$ V;

power dissipated in $Y_x = (0.344)^2\times 10 = 1.18$ W.

(b) When $a = 2$, NEC reflected to the secondary becomes $\dfrac{100}{29}(5-j2)$ A in parallel with $Y_N = \dfrac{664}{29} - j\dfrac{80}{29}$ S;

maximum power is transferred when $B = \dfrac{80}{29}$ S. $|V_L| = \dfrac{100}{\sqrt{29}}\times\dfrac{1}{(10+664/29)} = 0.565$ V;

power dissipated in $Y_x = (0.565)^2\times 10 = 3.19$ W.

(c) $G_x = \sqrt{(664/29)^2 + (15 - 80/29)^2} = 25.96$ S;

$$|\mathbf{V_L}| = \frac{100}{\sqrt{29}} \times \frac{1}{\sqrt{(G_x + 664/29)^2 + (15 - 80/29)^2}} = 0.369 \text{ V};$$

power dissipated $= (0.369)^2 \times 25.96 = 3.53$ W.

(d) In this case $G_x = \dfrac{664}{29}$ S and $B = \dfrac{80}{29} = 2.76$ S.

$$|\mathbf{V_L}| = \frac{100}{\sqrt{29} \times 2 \times (664/29)} = 0.406 \text{ V};$$ power dissipated $= (0.406)^2 \times 22.9 = 3.77$ W.

P7.3.3 In Figure 7.3.3, the voltmeter has a full-scale reading of 800 V and a 1mA/100 mV D'Arsonval movement. Determine the % error in the reading of the voltmeter.

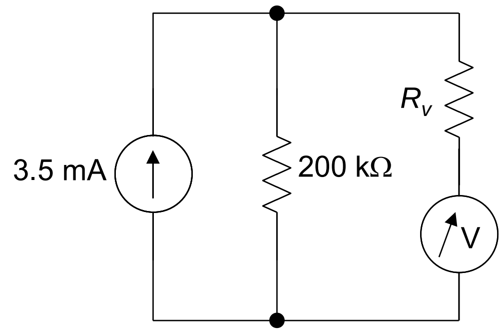

Figure P7.3.3

Solution P7.3.3

The total resistance of the voltmeter is $\frac{800\text{ V}}{1\text{mA}} = 800\text{ k}\Omega$. The current through the voltmeter is $3.5\times\frac{200}{1000} = 0.7$ mA. The meter reading is $800\times\frac{0.7}{1} = 560$ V. The true reading is 3.5×200 = 700 V. The percentage error is $\left(\frac{560-700}{700}\right)\times 100 = -20\%$.

P7.3.5 A series resistance is used with a 100 μA/100 Ω D'Arsonval movement to make it read 1000 V full scale. The meter, including the series resistance, is to be converted to a voltmeter that reads 400 V full scale. Determine the resistance required.

Solution P7.3.5

To read 1000 V the total resistance is (1000 V)/(0.1 mA) = 10 MΩ. The series resistance is R_{s1} = 10 MΩ – 100 Ω. To read 400 V, the total resistance in series with the meter should be (400 V)/(0.1 mA) = 4 MΩ. The series resistance should be R_{s2} = 4 MΩ – 100 Ω. The resistance that must be connected in parallel with R_{s1} is $\frac{1}{1/R_{s2}-1/R_{s1}}$ = 6,666,433 Ω.

P7.3.6 A shunt is used with a 100 μA/100 Ω D'Arsonval movement to make it read 1 mA full scale. The meter, including the shunt, is to be converted to a voltmeter that reads 500 V full scale. Determine the series resistance required.

Solution P7.3.6

The meter with the shunt becomes a 1 mA meter, the combined resistance being (10 mV)/(1 mA) = 10 Ω.

To read 500 V, the total resistance must be (500 V)/(1 mA) = 500 kΩ.

The resistance that must be added is 500 kΩ – 10 Ω = 499,990 Ω.

P7.3.7 A 50 μA/100 Ω meter is converted to a voltmeter that reads 20 V full scale by adding a series resistance R_v. (a) Determine R_v. This same resistance is added in series with a 100 μA/100 Ω meter. (b) Determine the full-scale reading of the resulting voltmeter. (c) The two voltmeters are connected in series across a voltage supply as shown in Figure P7.3.7. What should be the values of R_1 and R_2 if each voltmeter is to read full scale, with the current from the supply being 200 μA?

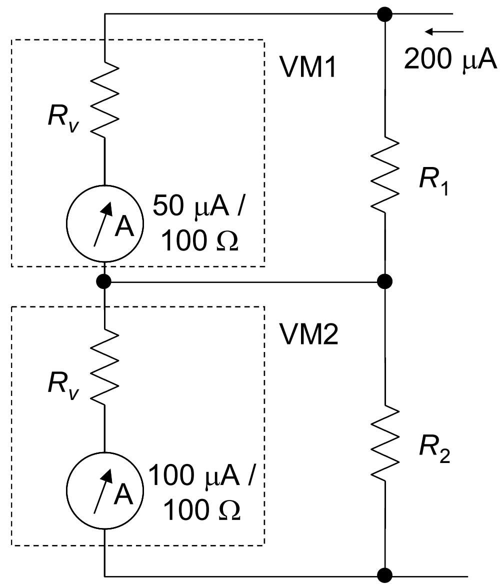

Figure P7.3.7

Solution P7.3.7

(a) $R_V = \dfrac{20\text{ V}}{50\ \mu\text{A}} - 100 = 399{,}900\ \Omega$.

(b) When this resistance is added in series with a100 μA/100 Ω meter, the total resistance is 400 kΩ. The FSD is therefore 100 μA×400 kΩ = 40 V.

(c) When the voltmeters connected as required, $R_1 = \dfrac{20\text{ V}}{150\ \mu\text{A}} = \dfrac{400}{3}$ kΩ and $R_2 = \dfrac{40\text{ V}}{100\ \mu\text{A}} = 0.4$ MΩ.