Name: ____ **(Print)**

Signature ____

Date: _____________

ECE 2300 – Spring 2006, Quiz #2

S.R. Brankovic Section – TTh 8:30 AM

February 16th 2006

KEEP THIS QUIZ CLOSED AND FACE UP UNTIL YOU ARE TOLD TO BEGIN.

1. This quiz is closed book, closed notes. You may use one 8.5” x 11” crib sheet, or its equivalent.
2. Show all work on these pages. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit. A solution which is not given in a reasonable order will lose credit. **If your work continues on to another page, indicate clearly where your work can be found. Failure to indicate this clearly will result in a loss of credit.**
4. Show all units in solutions, intermediate results, and figures. Units in the quiz will be included between square brackets.
5. Do not use red ink. Do not use red pencil.
6. You will have30 minutes to work on this quiz.

________________/100 %

Problem #1.

The extended range ammeter and the circuit are shown in Figure 1. The ammeter consist of *d'Arsonval* meter connected in parallel with unknown resistor *R*. If this ammeter is connected into the circuit at point C the reading on *d'Arsonval* meter shows the current of 5 [A]. If the ammeter is connected into the circuit at point D, the reading on *d'Arsonval* meter shows the current of 0.5[A]. Find;

a) The value of unknown resistance R and the resistance of *d'Arsonval* meter R_M.
b) The error of the measurement when the d range meter is connected into the circuit at point D. Make the statement about your result.

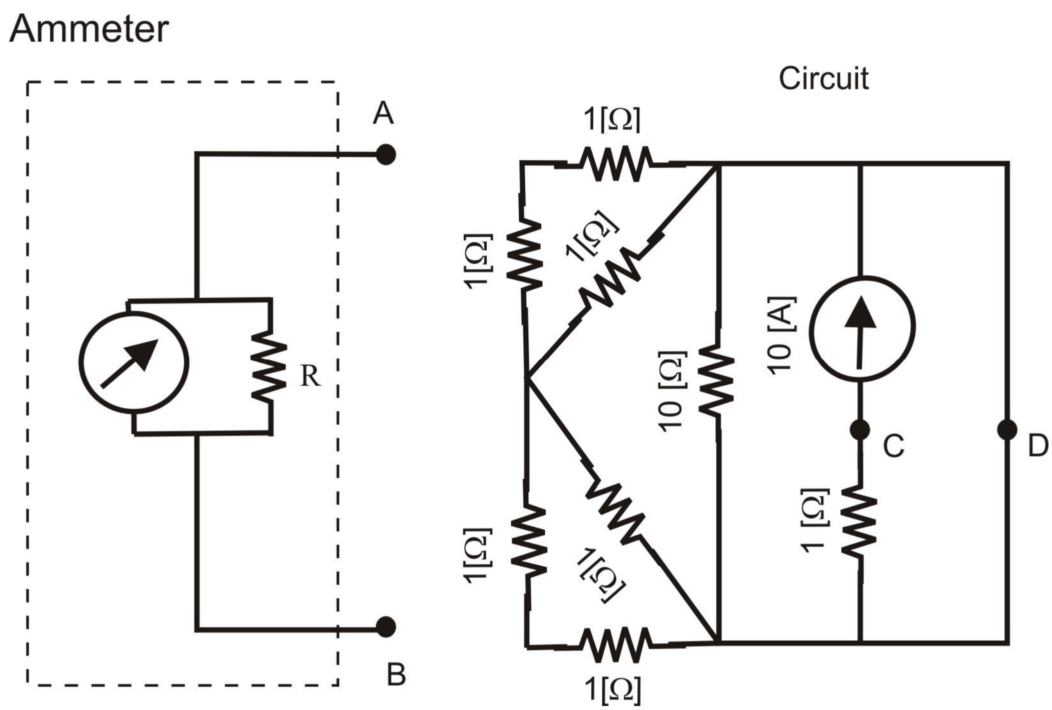

Figure 1.

Solution:

In order to start solving this problem it is important to realize few things. The first one is that we can model *d'Arsonval* ammeter as the resistor R_M. The second one is that ammeter is connected over its terminals to the circuit in serial between the voltage source and 1[Ω] resistor. The third one is that resistors combination on the left of the circuit is shorted and this situation does not change when the extended range meter is connected to the circuit at point C. The equivalent circuit for this situation is presented in Figure 2.

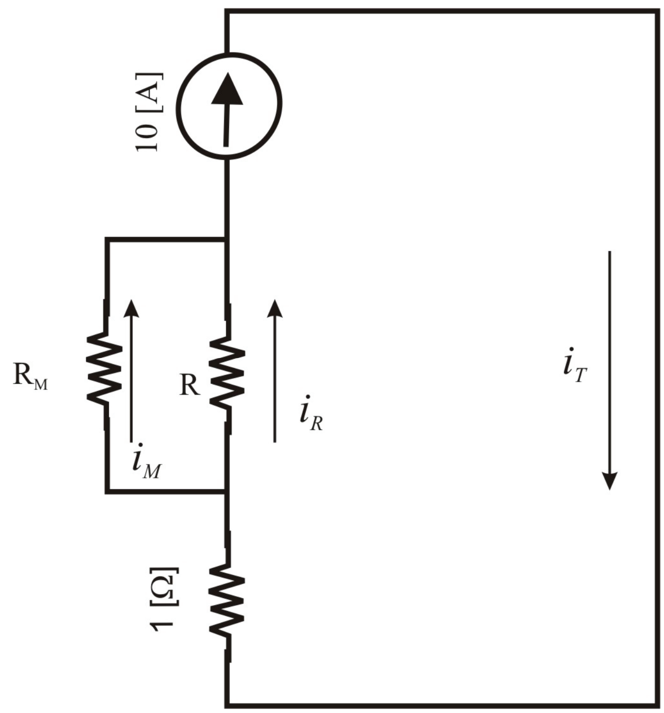

Figure 2.

Using the current divider rule or the formula for extended range ammeter, the current measured by the *d' Arsonval* ammeter, i_M is given as:

$$i_M = i_T \frac{R}{R_M + R}; \qquad (1)$$

For i_M = 5[A] and i_T=10[A] it follows:

$$5[A] = 10[A] \cdot \frac{R}{R_M + R} \Rightarrow \frac{R}{R_M + R} = 0.5 \quad \text{or } R = R_M \qquad (2)$$

Now, when we connect the extended range ammeter to the point D, situation is changed and the resistors combination on the left of the circuit is not shorted anymore. This resistor combination can be replaced with it's equivalent resistance R_{EQ}, and the circuit for this situation can be simplified, see Figure 3.

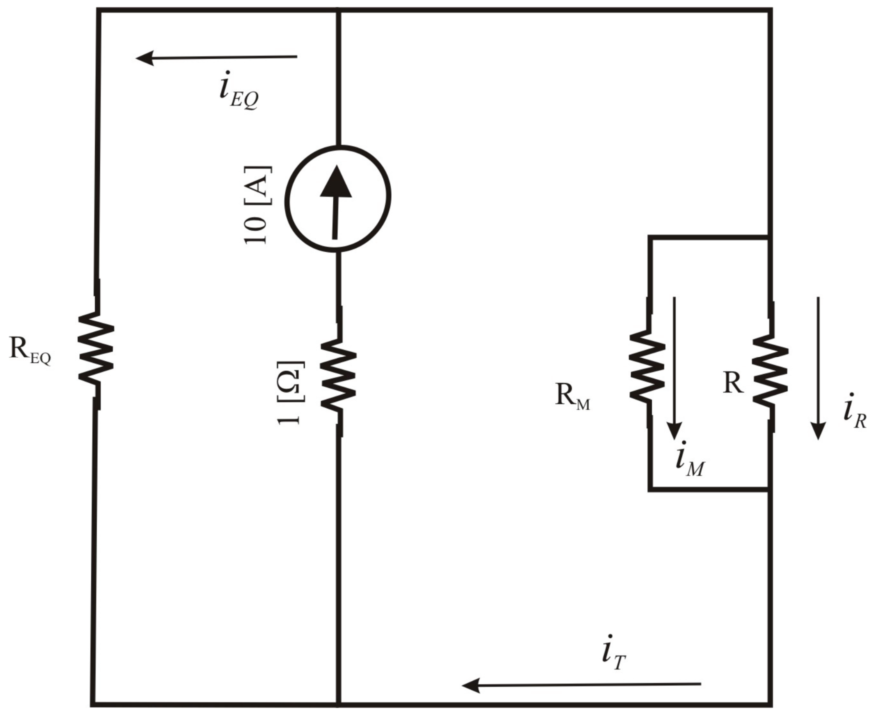

Figure 3.

$$R_{EQ} = 10[\Omega] \parallel \{1[\Omega] \parallel (1[\Omega] \parallel (1[\Omega] + 1[\Omega]) + 1[\Omega] \parallel (1[\Omega] + 1[\Omega]))\}$$

$$\boxed{R_{EQ} = \frac{10 \cdot \left\{ \frac{1 \cdot 2}{1+2} + \frac{1 \cdot 2}{1+2} \right\}}{10 + \left\{ \frac{1 \cdot 2}{1+2} + \frac{1 \cdot 2}{1+2} \right\}} [\Omega] = \frac{40}{34} [\Omega] = 1.176[\Omega]} \tag{3}$$

Applying the current divider rule the current i_T (Figure 3) can be expressed as

$$i_T = 10[A] \cdot \frac{R_{EQ}}{R_{EQ} + \frac{R \cdot R_M}{R + R_M}} \tag{4}$$

The same current i_T can be expressed using the formula for extended range ammeter as:

$$i_T = i_M \cdot \frac{R + R_M}{R} \tag{5}$$

Substituting (5) in to (4) we get:

$$i_M \cdot \frac{R+R_M}{R} = 10[A] \cdot \frac{R_{EQ}}{R_{EQ} + \frac{R \cdot R_M}{R+R_M}} \quad (6)$$

Using i_M=0.5[A] and R_{EQ}=1.176[Ω] and substituting (2) in to (6) it follows that:

$$\boxed{R_M = 18 R_{EQ} = 21.2[\Omega]} \quad (7)$$

From (2) and (7), we get:

$$\boxed{R = 21.2[\Omega].} \quad (8)$$

From (5) the measured value of current i_T is:

$$\boxed{i_T = i_M \cdot \frac{R+R_M}{R} = 0.5[A] \cdot 2 = 1[A]} \quad (9)$$

The error of the measurement is:

$$\boxed{eror(\%) = \frac{i_{mesured} - i_{real}}{i_{real}} \cdot 100\% = \frac{1[A] - 10[A]}{10[A]} \cdot 100\% = -90\%} \quad (10)$$

Expressing $i_{measured}$ in terms of (4), and substituting in (10), and knowing that $R=R_M$, after rearrangement we get:

$$\boxed{eror(\%) = \frac{i_{mesured} - i_{real}}{i_{real}} \cdot 100\% = \left(\frac{0.5 \cdot R_M}{R_{EQ} + 0.5 \cdot R_M} \right) \cdot 100\%} \quad (11)$$

Statement: There are two limiting situations:

1) If $R_{EQ} >> R_M$, than the denominator in (11) is ~R_{EQ} , $0.5\ R_M/R_{EQ} \rightarrow 0$ and the error of the measurement →0 as well,
2) If $R_{EQ} << R_M$ (our case in the problem) then the denominator in (11) is ~$0.5 R_M$ and the error of the measurement is→100%. Obviously our choice of the ammeter was not appropriate for the measurements of the circuit described in Figure 1. Note that expression in (11) looks similar but not the same to the CDR.

Answering correctly the last part (statement) assuming that the problem is done correctly would bring you extra 20% on top of 100% that you earned answering all steps including (11).