Signature
Name (print, please)

ECE 2300 Circuit Analysis

Summer 2011
Quiz 3

DO NOT OPEN THIS QUIZ BOOKLET UNTIL INSTRUCTED TO DO SO

This quiz has 3 pages including this cover page. If you are missing any pages, raise your hand. You have 30 minutes to complete the quiz.

Notes

1. Be sure your name and signature appear above.
2. The quiz is closed-book. You may have a calculator and one 8 ½ " x 11" crib sheet.
3. To receive full credit for a problem, you must:

- Show all work necessary to solve the problem;
- Define all variables and parameters and label them on circuit diagrams;
- Use the proper notation for all variables.
- Show all units explicitly in intermediate and final results;
- Indicate clearly whether power being calculated is absorbed or delivered;

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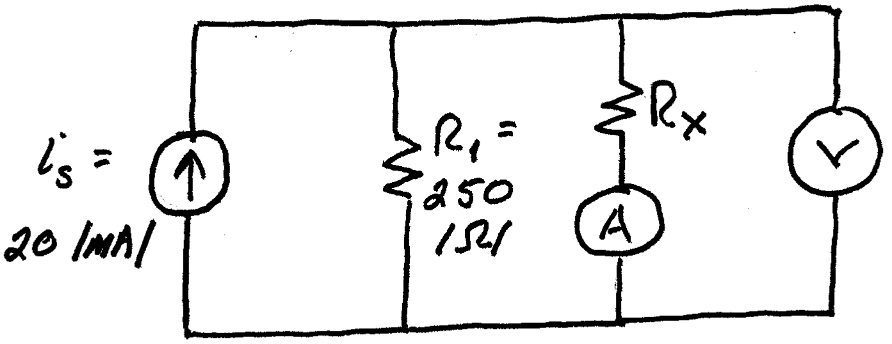
The ammeter and voltmeter in the circuit below are being used to measure the unknown resistance R_x. They are both made using d'Arsonval meter movements rated at 60 /mV/ and 2.5 /mA/. The ammeter is set for a full-scale current reading of 30 /mA/ and the voltmeter is set for a full-scale voltage reading of 5 /V/. When placed into the circuit as shown, the current meter reads 18.815 /mA/.

i. If the voltmeter reading is divided by the ammeter reading to measure R_x, what is the resulting measured value?
ii. What is the percent error between the measured value (determined above) and the actual value of the unknown resistance R_x?
iii. How much power is being dissipated in the d'Arsonval meter movement used to make the ammeter? (Find the power in the meter *movement*, not the entire ammeter.)



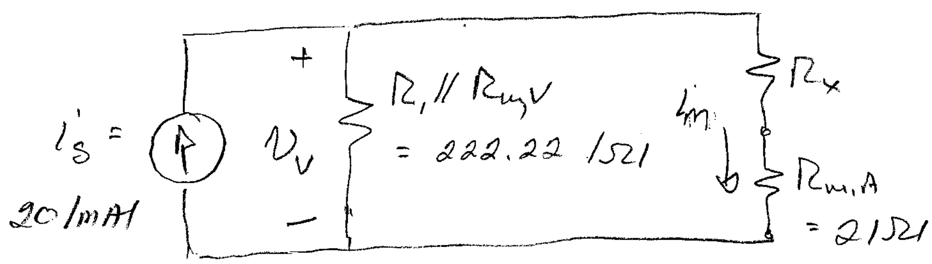
i) From the information given, we can find R_x:
First, the meter resistances are as follows:

Ammeter: $R_{m,A} = \frac{60\ /mV/}{30\ /mA/} = 2\ /\Omega/$

Voltmeter: $R_{m,V} = \frac{5\ /V/}{2.5\ /mA/} = 2\ /k\Omega/$

Now we re-draw, after combining the 2 /kΩ/ voltmeter resistance in parallel with R_1:

GIVEN: $i_m' = 18.815\ /mA/$



Room for Extra Work

Now by CDR,

$$i'_{d'A} = i'_s \cdot \frac{R_1 // R_{m,V}}{R_1 // R_{m,V} + (R_x + R_{m,A})}$$

$$0.018815 = 0.02 \frac{222.22}{222.22 + R_x + 2}$$

$$\Rightarrow \underline{R_x = 12\ [\Omega]}$$

$$\therefore V_V = 18.815\ [mV] \times (R_x + R_{m,A}) = 0.2634\ [V]$$

This is the voltage across the voltmeter and hence the voltmeter reading. Finally,

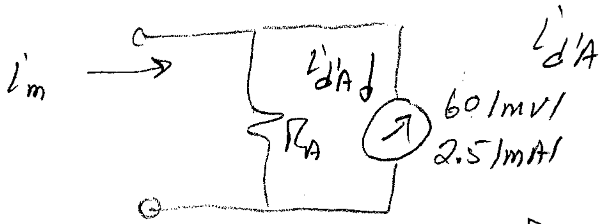
$$R_{x,meas} = \frac{V_V}{i'_{d'A}} = \frac{0.2634}{0.018815} = 13.995\ [\Omega] \simeq 14\ [\Omega]$$

which is what we expect because we are actually measuring the resistance of the ammeter in series w/ R_x

ii) The percent error is

$$\%E = \frac{14-12}{12} \times 100\% = 16.67\%.$$

iii) For this we need the current in the d'Arsonval meter movement.



$$i'_{d'A} = \frac{18.815}{30.000} \times 2.5\ [mA]$$

$$= 1.568\ [mA]$$

$$R_{d'A} = \frac{60\ [mV]}{2.5\ [mA]} = 24\ [\Omega]$$

$$\therefore P_{diss,d'A} = (1.568 \times 10^{-3})^2 (24)$$

$$= 59\ [\mu W]$$

We could have done iii) by finding R_A first:

$$R_A = \frac{60\,|mV|}{(30\,|mA| - 2.5\,|mA|)} = 2.1818\ |\Omega|$$

(current in R_A at full scale)

$$R_{d'A} = \frac{60\,|mV|}{2.5\,|mA|} = 24\,|\Omega|$$

Then if $i_m = 18.815\ |mA|$,

$$i_{d'A} = i_m \cdot \frac{2.1818}{2.1818 + 24} = 1.568\ |mA|$$

which is what we got before.