ECE 548: Electronic Design

Lab 1: Review of Voltage and Current Measurement

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Objective: The purpose of this lab is to refresh your memory on how to measure voltages and currents both (AC and DC) from an electrical circuit, how to use a DC power source, a function generator, and an oscilloscope.

1. Measuring DC voltage and current
   - Construct the circuit in Figure 1 below, using the resistors available in the lab and a DC power source.

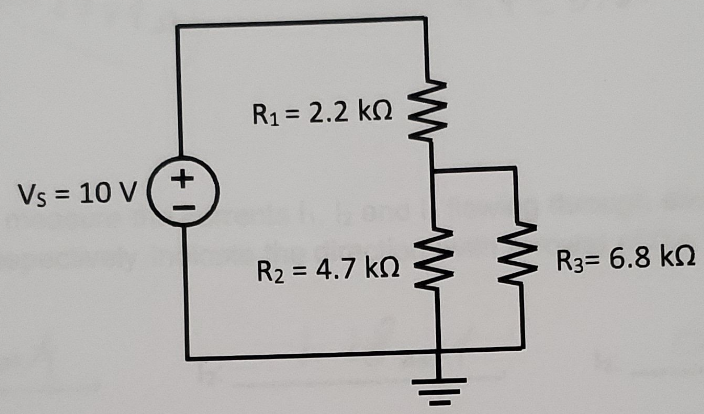


Figure 1

   - Using the digital multimeter (DMM), measure the actual resistance values of the R_1, R_2 and R_3.

R_1: 2.19 K Ω, R_2: 4.64 K Ω, R_3: 6.72 k Ω

   - What is the percentage of error between the measured resistance and the theoretical values as indicated in Figure 1?

R_1: 0.45 %, R_2: 1.27 %, R_3: 1.17 %

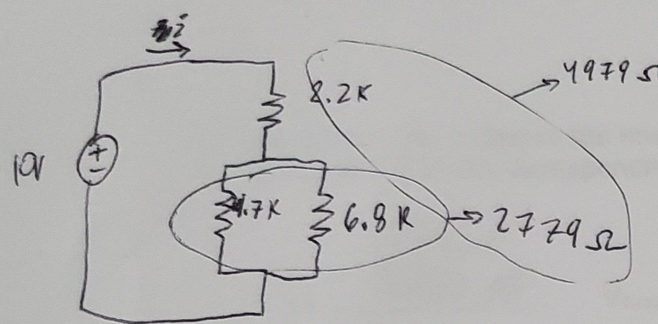
   - Using the DMM, measure the voltages V_1, V_2 and V_3 across each individual resistor R_1, R_2 and R_3, respectively. Indicate the polarity (+ and -) of the 3 measured voltages (V_1, V_2 and V_3) in Figure 1.

V_1: 4.44 V, V_2: 5.57 V, V_3: 5.57 V

- Using voltage division, calculate the theoretical values of the voltages V_1, V_2 and V_3 across the resistors R_1, R_2 and R_3, respectively. Do the calculated values of V_1, V_2 and V_3 match the measured values?

V_1: 4.4 V, V_2: 5.6 V, V_3: 5.6V

(Show your calculations below)



$i = \frac{V}{R_{eq}} = \frac{10}{4979} = 0.002\ A = 2mA$

$2.2K \cdot 2mA = 4.4V$

$10 - 4.4 = 5.6V$

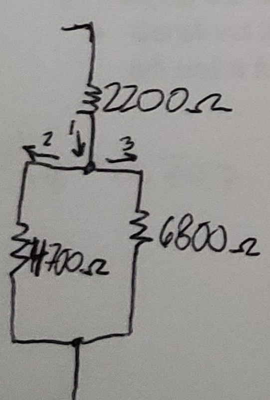
- Using the DMM, measure the currents I_1, I_2 and I_3 flowing through each individual resistor R_1, R_2 and R_3, respectively. Indicate the direction (with arrows) of the 3 measured currents in Figure 1.

I_1: 1.98 mA, I_2: 1.18 mA, I_3: 0.81 mA

- Using current division, calculate the theoretical values of the currents I_1, I_2 and I_3 that should flow through the resistors R_1, R_2 and R_3, respectively. Do the calculated values of I_1, I_2 and I_3 match the measured values?

I_1: 2mA, I_2: 1.19mA, I_3: 0.82mA

(Show your calculations below)



$2mA = i_2 + i_3$

$i_2 = 1.19mA$

$i_3 = 0.82mA$

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2. Measuring AC voltage and current
   - Replace the DC power source in Figure 1 with an AC power source using a function generator. Set the function generator to produce a sinusoidal voltage with a peak-to-peak amplitude of 2V and a frequency of 1kHz, i.e. Vs(t) = sin (ωt). What is the rms (root-mean-square) value of Vs(t)?

The rms value of the AC voltage source ($V_{s,rms}$): 682 mV

- Using the DMM, measure the rms values of the voltages V_1, V_2 and V_3, and the rms values of I_1, I_2 and I_3 for the corresponding resistors R_1, R_2 and R_3, respectively.
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$V_{1,rms}$: 295 mV, $V_{2,rms}$: 370 mV, $V_{3,rms}$: 370 mV

$I_{1,rms}$: 1.15 mA ~~115.4 μA~~, $I_{2,rms}$: 0.68 mA ~~68.5 μA~~, $I_{3,rms}$: 0.47 mA ~~47.5 μA~~

Verify that $V_{2,rms} = V_{3,rms}$ and $V_{1,rms} + V_{2,rms} = V_{s,rms}$. Also confirm that $I_1 = I_2 + I_3$.

68.5 + 47.5 = 116

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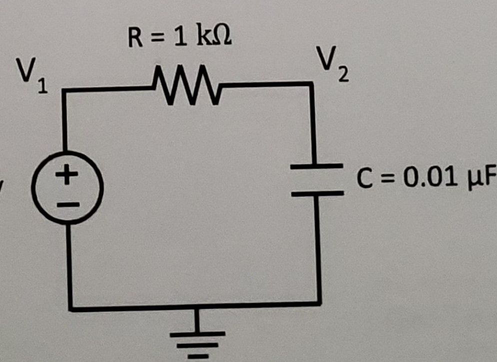
3. Plotting the waveform with the oscilloscope
   - Construct the circuit in Figure 2 below, using the resistors and capacitors available in the lab and a function generator.

$V_{rms} = V_{peak} \cdot 0.707$

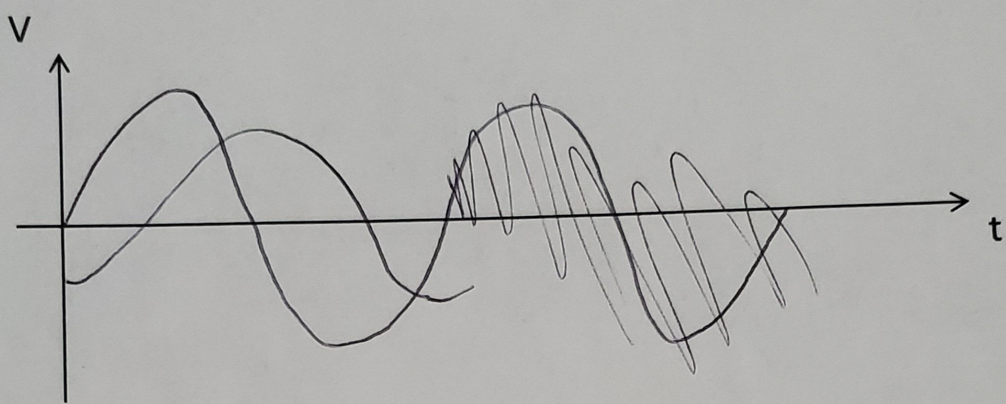


$V_{S,rms}$ = 1.4 V
f = 10kHz

$x(t) = x + (x_0 - x)e^{-\frac{(t-t_0)}{RC}}$

Figure 2

- Using the oscilloscope display the waveform from the function generator (V_1) in channel 1 and display the voltage across the capacitor (V_2) in channel 2. In the axes provided below, draw 1 period of V_1 and V_2 on the same graph.



- Use the oscilloscope to measure the phase shift between the function generator signal and the capacitor voltage.

Phase shift: 27.0 degrees = 0.47 radians

- Using the DMM, measure the RMS value of the capacitor voltage ($V_{2,rms}$)

$V_{2,rms}$ = 361mV

- What is the theoretical value of $V_{2,rms}$? Does it match the measured value?

$V_{2,rms}$ = 361 mV

(Show calculation below)

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