Physics 261 setup for Feb 28th

Multimeter and Power Supplies in Active DC Circuits

Objective: Learn how to measure Voltage and Current in active circuits.

Introduction:

Circuit components, such as, resistors and capacitors that do not supply energy themselves are passive components. **An active circuit** includes energy sources, usually in the form of power supplies that provide currents and voltages to circuit components. A circuit made of DC (direct current) voltage sources and passive components is an active DC circuit. In this lab, we will make DC circuits and measure the current and voltage on each component. Refer to **Appendix A** for the correct use of Multimeter (as ammeter or voltmeter in the simulator) to measure current and voltage.

Simulation:

We will use the same circuits we made in the previous lab shown in figures 1 and 2. Construct your simulation using four resistors with values, $R_1 = 100\Omega$, $R_2 = 220\Omega$, $R_3 = 1k\Omega$, and $R_4 = 2.2k\Omega$.

Step 1. Make a passive circuit according to **figure 1(a)** first. Measure the total resistance to make sure the circuit is correct. Add a two-terminal voltage source to the two open ends of the passive circuit. **Set the voltage to 5V**. Connect ammeters and voltmeters in the circuit to measure current and voltage on each component including the power supply. If you know some of the variables are identical, for example, the current through R1, R2 and the source are the same in circuit 1(a), you can use one ammeter to measure them. Assuming you have unlimited ammeters and voltmeters, try to reduce the use when possible. Figure 3 shows an example of the simulation circuits of figure 1a with three voltmeters and one ammeter connected. Reading on the meters can be positive or negative depending on how the two ports of a meters are connected to the component. The positive value on an ammeter means the current flows along the arrow. A negative value on a voltmeter means the voltage is lower at the port marked "+". Switching the terminals will change the sign. There are other variations to connect this circuit. Make an excel data table to record you results (see the sample table attached on next page). Use **I1, I2... (V1, V2...)** to label current (voltage) on **R1, R2....** Use **Is (Vs)** for voltage source current (voltage). If any of these quantities I1=I2=Is, then use one column with proper label and unit. Calculate the instrument uncertainty in current and voltage as if you were measuring them with a handheld DMM using the specification sheet in the appendix.

Step 2. Repeat the same simulation for the circuit in figure (1b). You will have to figure out how many ammeters/voltmeters to use and where to put them.

Steps 3 and 4. Set the voltage source to **10V** in **Figure 2(a)** and **20V in 2(b)**. Repeat the measurement.

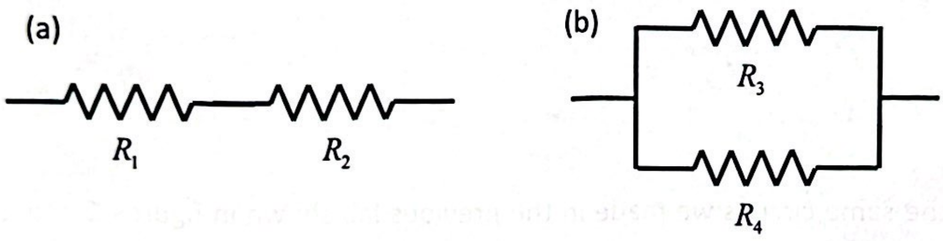

Figure 1. Circuit diagrams for two resistors in series (a) and in parallel (b).

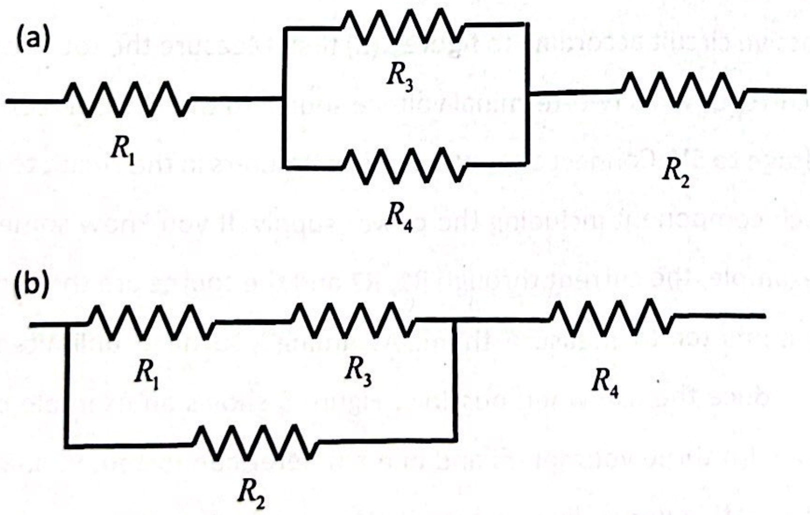

Figure 2. Circuit diagrams with combination of in series and parallel parts.

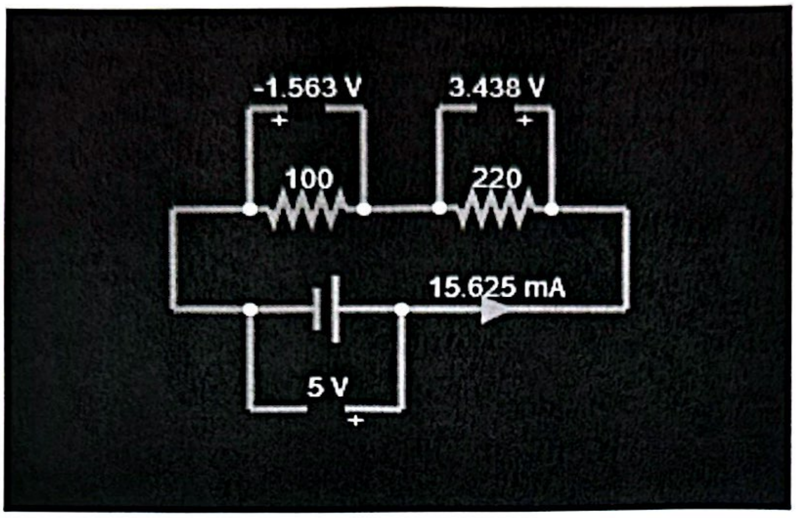

Figure 3. An example of complete simulation circuit of figure 1a.

Table 1: Sample table for Circuit 1(a)

Circuit (1a)	Voltage, V (V)	Scale (V)	Uncertainty σ_v	Current, I (mA)	Scale (mA)	Uncertainty σ_I
R1 = 100 Ω		2			200	
R2 = 220 Ω		20			200	
Req = 320 Ω		20			200	

- Voltage Scale: use 2 V for 100 Ω and 20 V for rest of the voltage values
- Current Scale: always use 200 mA

Discussion:

Q1. For figure 1b, predict which components (resistors and source) have the same current? Voltage? Does your prediction agree with the simulation?

Q2.3. Same questions for figure 2a, and 2b.

Your prediction does not have to agree with simulation, but you should discuss what causes the difference.

Lab Report:

1. Snapshot of your simulation circuits. **(2 points)**
2. Data table(s) with measured value and instrument uncertainty. **(4 points)**
3. Answer the discussion questions. **(3 points)**

Appendix A: Measure Current and Voltage with DMM

Figure 4 shows pictures of the multimeter (TENMA 72-7720) that can be used as an ammeter or voltmeter with the correct connection ports and dial setting.

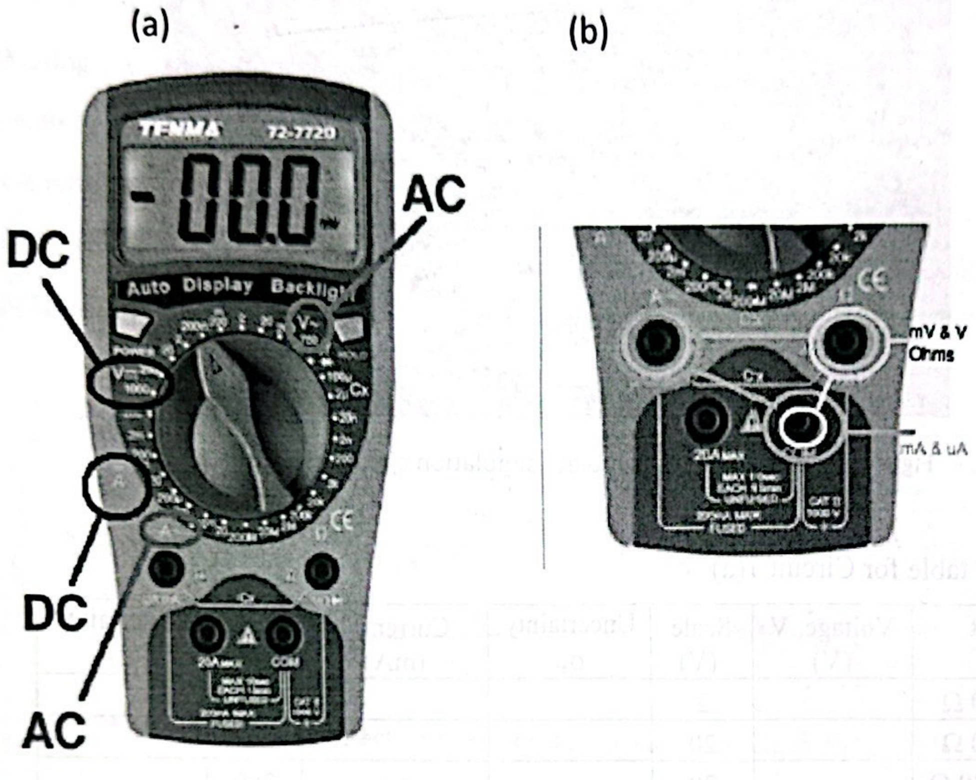

Figure 4. (a) Multimeter TENMA 72-7720, (b) Zoom in on connection ports. Resistance, current, and voltage share the same "COM" port.

Measuring Voltage:

A voltmeter has a HIGH (typically 10MegaOhms) internal resistance and should be placed in PARALLEL with the component to be measured (a power supply or resistor in this lab) as shown in figure 4. If a voltmeter reads a positive value, it means the voltage in the circuit at the point connected to the "COM" port is lower than the point connected to the other port. The opposite is true if the reading is negative.

Measuring Current:

An ammeter or current meter has a LOW (typically << 1 Ohm) internal resistance. It should be inserted directly into the circuit path so that it is in SERIES with the component to be measured. It monitors the flow of current without substantially affecting the circuit including equivalent resistance, current, and voltage.

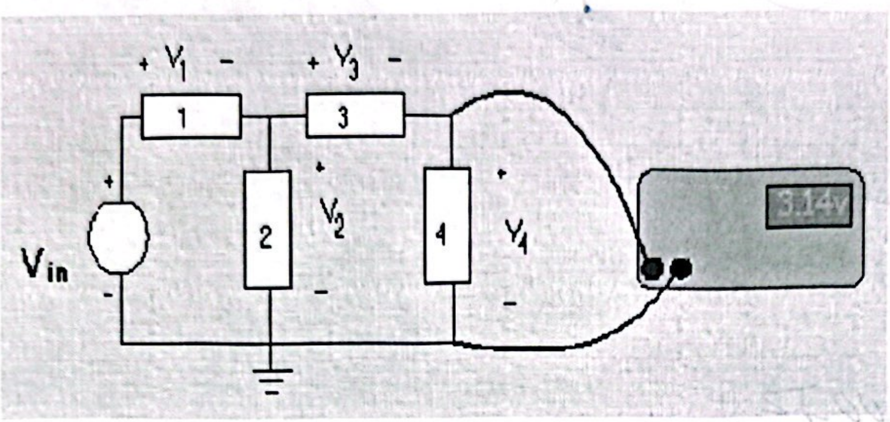

Figure 5. Voltmeter setup to measure voltage on R4. It is in PARALLEL with R4

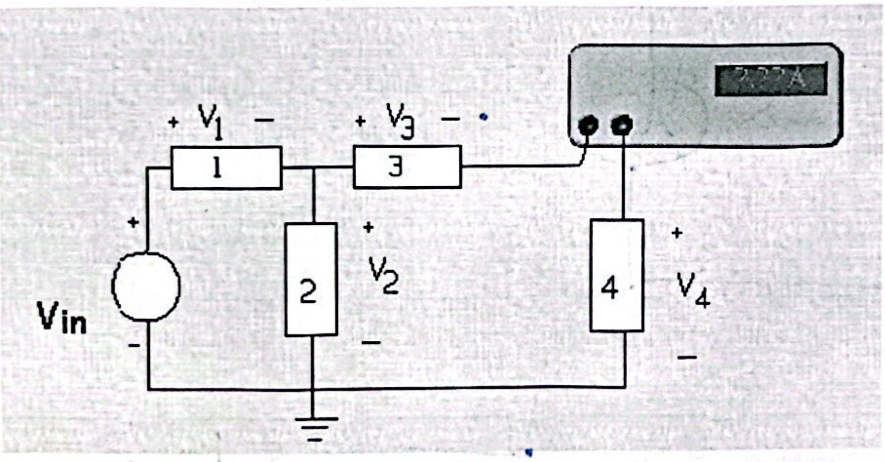

Figure 6. Ammeter setup to measure current in R3 and R4. IT is in SERIES with both R3 and R4.

Instrument uncertainty (Tenma 72-- - 7720 Multimeter Specifications)

DC Voltage

All ranges: ± 0.5% rdg + 1 lsdp

DC current

2mA range: ± 0.8% rdg + 1 lsdp

200mA: ±1.5% rdg + 1 lsdp

20A: ± 2.0% rdg + 1 lsdp

Resistance

200 Ω: ± 0.8% +3 lsdp

2k Ω - 2M Ω: ± 0.8% +1 lsdp

Note: rdg: read value; lsdp = least digit place