HANDS-ON LAB INSTRUCTION SHEETS – Learning Kit MODULE 1

MEASURING RESISTANCE AND VOLTAGE

NOTES:

1) *Each student will be with a Learning Kit or be reimbursed for one.*
2) *All work is to be done individually,*
There are no "lab reports" in this course. You must turn in the Lab Module Results Sheet(s) once you have reviewed them with the instructor and completed the module. Keep Instruction Sheets for use when studying for exams.
3) *Enter all your lab results on both the Instruction Sheets, and the Results Sheet(s).*
4) *All measurements should be made with the Digital Multimeter in your Pratt Kit.*
To conserve your multimeter's 9V battery, be sure to turn the meter off if not in use for over 5 minutes. *Please check that your meter is turned* ***off*** *and when done for the day.*

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This first module is designed such that you become familiar with the breadboard, measuring resistance and voltage with the Multimeter, and reading basic schematic diagrams.

BILL OF MATERIALS

AC Adapter ("*9 volts at 1000 mA*")
Digital Multimeter (CenTech or equivalent) with mini-grabber/microhook leads
9VDC to 5v/3.3v Power Module
400 or 830 Tie-Point Breadboard
Four (4) 1000 Ohm, ½ Watt Resistors *with color code:* ***brown black red gold*** (*1KΩ at 5%*)
Miscellaneous connecting leads and wires

SECTION A. USING THE MULTIMETER

In the tool kit you will find a Digital Multimeter which should look similar to the one shown in Figure 1.1. The Multimeter will be used in this course for routine measurements of resistance (**Ohmmeter**) and direct current (**DC**) voltages (**Voltmeter**). Your Multimeter is a very powerful tool as it can also measure current, transistor current gain (**h_{FE}**), and alternating current (**AC**) voltages. There is also a 'battery charge' scale that provides info on the remaining energy in a 9v or 1.5v battery (*see instruction booklet*).

There are two special mini-grabber or microhook leads provided with a plug for the Multimeter on one end and a 'push-in' hook on the other.

The **RED** lead plugs into the **VΩmA** socket and the **BLACK** lead plugs into the **COM** socket on the meter. COM is another way of saying common connection, in most cases this is the electrical ground or **GROUND** for your circuit which is connected to the negative power of your power supply.

Figure 1.1 Digital Multimeter

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MEASURING THE RESISTANCE OF RESISTORS

CAUTION: *Whenever inserting components or measuring resistor values please be sure that the power to your circuit is **OFF** to avoid damaging your meter.*

To use your Multimeter to measure the resistance (ohms) it must be set on one of the **Ohmmeter** function modes in the lower left meter ranges of **200**, **2000**, **20K**, **200K** and **2000K** ohms. We will measure the resistance of a resistor with the markings: ***brown black red gold*** (1 0 x 100 = *1000 ohms = 1KΩ; +/- 5%*) for a 4-band resistor or ***brown black black brown brown*** (1 0 0 x 10 = *1000 ohms = 1KΩ; +/- 1%*) for a 5-band resistor. We typically select the meter range which is higher than our anticipated value, so in this case use the meter's **2000** range. Use the hook ends of the meter leads to grab the two leads of the resistor. **MOST Resistors have NO polarity**, so it does not matter which of their two leads is connected to the meter's **RED** and **BLACK** hooks.

1a.) What value of resistance do you measure? _______________ Ohms

If your result is more than 10% off (i.e. less than 900Ω or greater than 1100Ω); ***Consult your instructor****.*

THE SOLDERLESS BREADBOARD

Each student will use solderless breadboards on which to assemble the hands-on labs during the semester without needing to remove and re-wire your circuits every week. There are several sizes of solderless breadboards typically used. As shown in Figure 1.2 we will be using a 400 Tie-Point version.

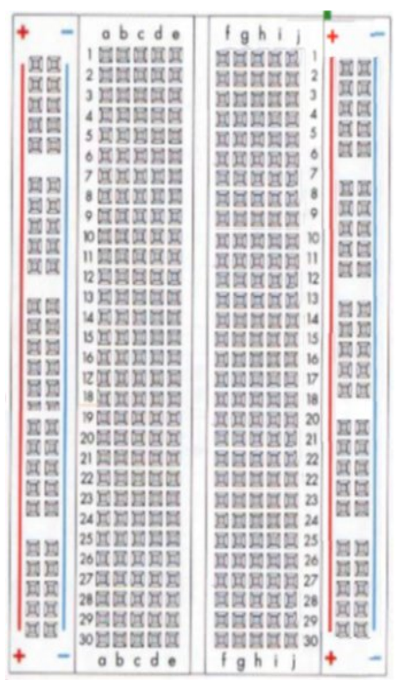

Figure 1.2 400 Tie-Point (top) and 730 Tie-Point (bottom) Solderless Breadboards

We will now see how simple it is to insert resistors into the breadboard to interconnect them and make it easier to create temporary circuits without soldering.

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INSERTING RESISTORS ONTO THE BREADBOARD

Gently bend the leads of the **1KΩ** resistor you just measured the resistance of close to the device's body to form a "**U**" and insert the resistor (**R_1**) into the breadboard's connection points **J1** and **J6** with four (4) empty rows (2, 3, 4, and 5) between the two leads (see Figure 1.2 - *YOUR breadboard might actually have "**A**" as the right, top most tie-point.*). The tie-points **F1**, **G1**, **H1**, and **I1** in that row are all connected to **J1**, similarly, tie-points **F6**, **G6**, **H6**, and **I6** are all connected to **J6** – each of those other tie-points are usable for other connections. This results in the schematic and pin locations of Figure 1.3.

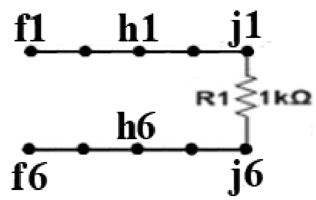

Figure 1.3 One Resistor Circuit Schematic with Breadboard Tie-Points Indicated

1b.) Repeat your resistance measurement (J1 to J6) _____________ Ohms
Did you read the same value as in 1a? YES ____ or NO ____ ?

*NOTE: Occasionally we may find slight differences in measurements made **directly**, and those made with components **in circuit**, but in this case the readings should be the same as nothing else is connected to the resistor at this time.*

MEASURING THE RESISTANCE OF TWO RESISTORS IN SERIES

Now bend and insert a second 1KΩ or 1000 ohms resistor (**R_2**) into the breadboard at pin connections **H6** and **H11** to create the two resistor series circuit shown in Figure 1.4.

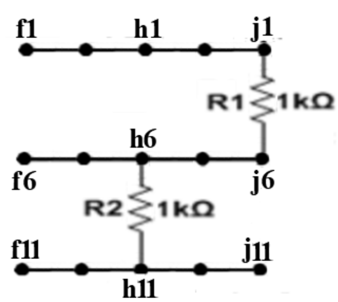

Figure 1.4 Two Resistor Schematic with Breadboard Tie-Points Indicated

Note that the pins numbers at the **right** are where the component leads are inserted and the pin numbers at the **left** are used for measuring the resistance in this circuit. Using the Multimeter on either the ***20K** or **2000*** scale at the lower left, measure the resistance of two **1KΩ** resistors in series by measuring between **J1** and **H11**. Using the **20K** scale 1000 ohms would read '**1.00**' (rather than **1000** on the **2000** scale).

1c.) Resistance of two 1KΩ resistors in series _____________ ohms

*If the resistance is not nearly 2000 ohms; **Consult your instructor**.*

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MEASURING THE RESISTANCE OF TWO RESISTORS IN PARALLEL

Now bend and insert a third 1000 ohm resistors (**R_3**) into the breadboard at **F1** and **F6** to create a two-resistor parallel circuit with the resistor in **J1 – J6** as indicated in Figure 1.5.

NOTE: DO NOT REMOVE RESISTOR R_2 (BETWEEN F23 AND K23) !!!

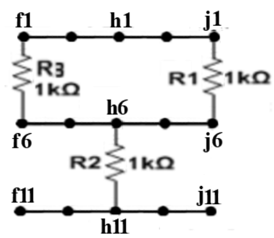

Figure 1.5 Resistor Schematic with Breadboard Tie-Points Indicated

Use the Multimeter on the **2000** scale at the lower left to measure the resistance of the two **1KΩ** resistors **R_1** and **R_3** in parallel between **F1** and **F6** ***(NOT F11)***.
*Note: Pins **F1** through **J1** are connected together internally as are **F6** through **J6**.*

1d.) Resistance of two 1KΩ resistors in parallel ____________ ohms
If the resistance is not nearly 500 ohms; consult your instructor.

FOUR RESISTOR SERIES CIRCUIT

Carefully remove resistor **R_3** from the breadboard at **F1** and **F6** and insert it instead between points **J11** and **J16** creating a three-resistor series circuit. Finally, bend and insert a fourth 1000 ohm resistor (**R_4**) between **H16** and **H21** to create a four-resistor series circuit as indicated in Figure 1.6.

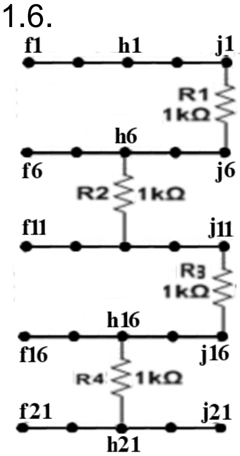

Figure 1.6 Four Resistor Series Circuit with Breadboard Tie-Points Indicated

Using the Multimeter on the **20K** scale at the lower left, measure the resistance in **KΩ** of the four **1KΩ** resistors **R_1** through **R_4** in series between **J1** and **H21**.
*Note: Pins **F1** through **J1** are connected together internally as are **F21** through **J21**.*

1e.) Resistance of four 1KΩ resistors in series ____________ ohms
If the resistance is not nearly 4000 ohms; consult your instructor.

DO NOT REMOVE THESE RESISTORS! – Instructor Check Point 1A

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SECTION B. LEADS, WIRES AND MEASURING VOLTAGES
USING INSULATED WIRE TO CONNECT DEVICES

To interconnect components on the breadboard we can either use ***#22 gage insulated wire*** or the special connection wires that are in the Learning Kit Arduino Starter Kit. As far as colors, **RED** is the standard color for direct connections to **positive** power voltage, **BLACK** is the standard color for direct connections to electrical **ground**, and any other color is used for non-power interconnections.

USING YOUR AC ADAPTER AS A POWER SOURCE

The Learning Kit includes a **9 volt, 1 ampere wall AC-DC adapter** as well as a **Power Module** for use in providing +5 volts of regulated DC power – up to 700 mA – to your circuits. Be sure that the jumpers on the Power Module are BOTH set for +5V as shown in Figure 1-7. The Power Module has an **ON-OFF Switch** to control power from the wall adapter connect to the solderless breadboard.

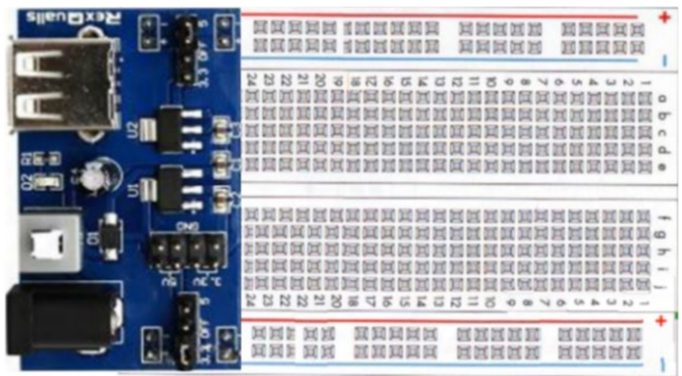

Figure 1.7 Power Module Plugged into the Breadboard

MEASURING VOLTAGES

To use your CenTech 7-Function Digital Multimeter to measure the voltage (in volts) it must be set up in the **Voltmeter** function mode with the rotary switch set on one of the upper right-hand **DC Voltage** ranges: **200m**, **2000m** (2000 millivolts = 2 volts), **20**, **200**, and **250**.

Figure 1.8 CenTech 7-Function Digital Multimeter (*from Harbor Freight*)

As we expect the Power Module output voltage to be 5 volts, use the "**20**" range with the **RED** lead from the meter connected directly (or via a **RED** alligator clip lead) to one of the 20 visible tie-points in the RED + line at the top breadboard (Figure 1.7), and the **BLACK** lead from the meter connected directly (or via a **BLACK** alligator clip lead) one of the 20 visible tie-points in the BLUE - line at bottom of the breadboard (electrical **GROUND**).

Figure 1.9 CenTech Meter – Volts Ranges (*set at 20 volts*)

All voltage measurements should be positive. *The voltmeter will show a* ***negative voltage*** *if the polarity is reversed, if that happens, please reverse the lead connections.*

MEASURING THE POWER MODULES +5 VOLT SUPPLY VOLTAGE

With your Power Module plugged into the breadboard as shown in Figure 1.7, plug the 9V AC-DC wall adapter into the Power Module and then plug your adapter into an AC power strip – or if you don't have one – directly into a wall socket.

The wall adapter was designed to deliver 9 volts at 1 ampere (1000 milliAmperes). The adapter voltage output is variable: when *less current* is drawn from it the output will be *greater* than 9 volts, however we will use the Power Module to provide us with a regulated +5V at up to 700 mA (a regulated +3.3Volts is also available with the module).

Without ANY load, *that is* ***open circuited*** *or* ***UNLOADED***, the 5V Module voltage should be very close to +5 volts. We will be calling $\mathbf{V_1}$ the Module's unregulated voltage. Make your measurement of the unloaded, but regulated, voltage $\mathbf{V_1}$ using the **20** volt range on the Multimeter.

1f.) Power Module's unloaded 5V voltage is (*5V expected*) **_______ volts**

MEASURING RESISTOR VOLTAGES AND LOADING EFFECTS

You have already created a four-resistor series circuit on your Console Breadboard using four each 1000 Ohm resistors per Figure 1.6 on Page 4.

Using a **RED** wire connect one of the **RED** voltage connection points to any *open* connection in the first, right-most, row with tie-points **F1-J1** (*note that a resistor is already in* ***J1***). ALWAYS use **RED** wires or leads for **+** voltages. Connect a **BLACK** wire to one of the ground points at the bottom BLUE voltage connection points of the Breadboard to the 21st right-most, row with tie-points **F21-J21** (*note that a resistor is already in* ***H21***). Wires connecting **ground** should always be **BLACK**.

VOLTAGE DIVIDER PROOF

Referring to Figure 1.6 on page 4, the **RED** wire at **F1** and **BLACK** wire at **F21** (across all four resistors), measure the voltage drop ***across each individual 1KΩ resistor***:

1g1.) $\mathbf{R_1}$**: J1** to **J6: ______ volts** **1g3.)** $\mathbf{R_3}$**: J11** to **J16: ______ volts**

1g2.) $\mathbf{R_2}$**: H6** to **H11: ______ volts** **1g4.)** $\mathbf{R_4}$**: H16** to **H21: ______ volts**

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MEASURING RESISTOR VOLTAGE LOADING EFFECTS

We will now measure the Module +5 volt output keeping the **RED** lead at **F1** and keeping the **BLACK** wire at **F21**.

1h1. Keep the **RED** multimeter lead at **F1** and the **BLACK** multimeter lead at **F21** for each of the series of loading tests:
For a 4000 ohm load measure the loaded voltage for all four resistors in series:
1h1.) A **"four series 1KΩ resistor = 4000Ω load", BLACK** at **F21: _________ volts**

We can now short out one or more resistors to lower the resistive load from the initial 4000 ohms to 3000, 2000 and finally 1000 ohms by placing a new wire (Black is good, but any color is actually OK) into tie-point **J21** and then shorting out first one resistor:

1h2. For a 3000 ohm load, place the black wire from **J21** into tie-point **I16** shorting out R4 leaving a three series resistor circuit:
1h2.) A **"three series 1KΩ resistor = 3000Ω load", BLACK** at **I16: _________ volts**

1h3. For a 2000 ohm load, take the BLACK wire from **J21** and move it from tie-point **I16** into tie-point **I11** shorting out R3 and R4 leaving a two series resistor circuit:
1h3.) A **"two series 1KΩ resistor = 2000Ω load", BLACK** at **I11: _________ volts**

1h4. For a 1000 ohm load, take the BLACK wire from **J21** and move it from tie-point **I11** into tie-point **I6** shorting out R2, R3, and R4 leaving a single resistor load circuit:
1h4.) A **"1KΩ resistor = 1000Ω load", BLACK** at **I6: _________ volts**

Proving the Voltage Divider Concept
1h5.) Does adding the (four) individual voltage drops **1g1** though **1g4** equal the same voltage you found in the four-resistor load circuit of **1h1**? **(Yes _____ or No _____ ?)**

DO NOT REMOVE THE RESISTORS FROM THE BREADBOARD - YOU WILL NEED THEM NEXT WEEK

This is Instructor Check Point 1B

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