**Name**_____ **Lab Section**_____ **Date**_____

## OVERVIEW:

This laboratory introduces resistors, proto-boards, and multi-meters.  The focus will be on resistor identification both by color code and by multi-meter.  The student will take measurements with a Simpson 260 analog Volt-Ohm-Milliammeter and an Agilent U1242B digital multi-meter (DMM).

## INTRODUCTION:

A fixed molded carbon composition resistor may have 4 or 5 color bands to identify it.  The first two bands are the first and second digit of the resistance value.  The third band is the multiplier, or the number of zeros that will follow the first two digits.  The fourth band is the tolerance band and the fifth (when used) is the reliability factor.

An example of resistor identification follows.

First band –      red
Second band –    yellow
Third band –      orange
Fourth band –    gold

The bands may be decoded as follows:

   Red   Yellow       Orange       Gold
    2      4    x    $10^3$  +/-   5%   =     24000 +/- 5%

This resistor has a nominal value of 24 kΩ +/- 1.2 kΩ.  Thus, the resistor value can be anywhere between the minimum value of 22.8 kΩ and the maximum value of 25.2 kΩ.  Use Figures 3.22 and 3.25 along with Table 3.5 in the textbook as references.

When asked to compare values, such as A (measured) with B (nominal), the preferred method is:

$$Rd = \frac{A - B}{B} \times 100\%$$

in other words,

$$Rd = \frac{measured - nom}{nom} \times 100\%.$$

**Proto-board**

Shown below is a Global Specialties PB60 photo blatantly lifted from the web address, http://www.globalspecialties.com/pb60.html. The photo on the left shows the top side of the proto-board. The photo on the right shows the bottom side of the proto-board.
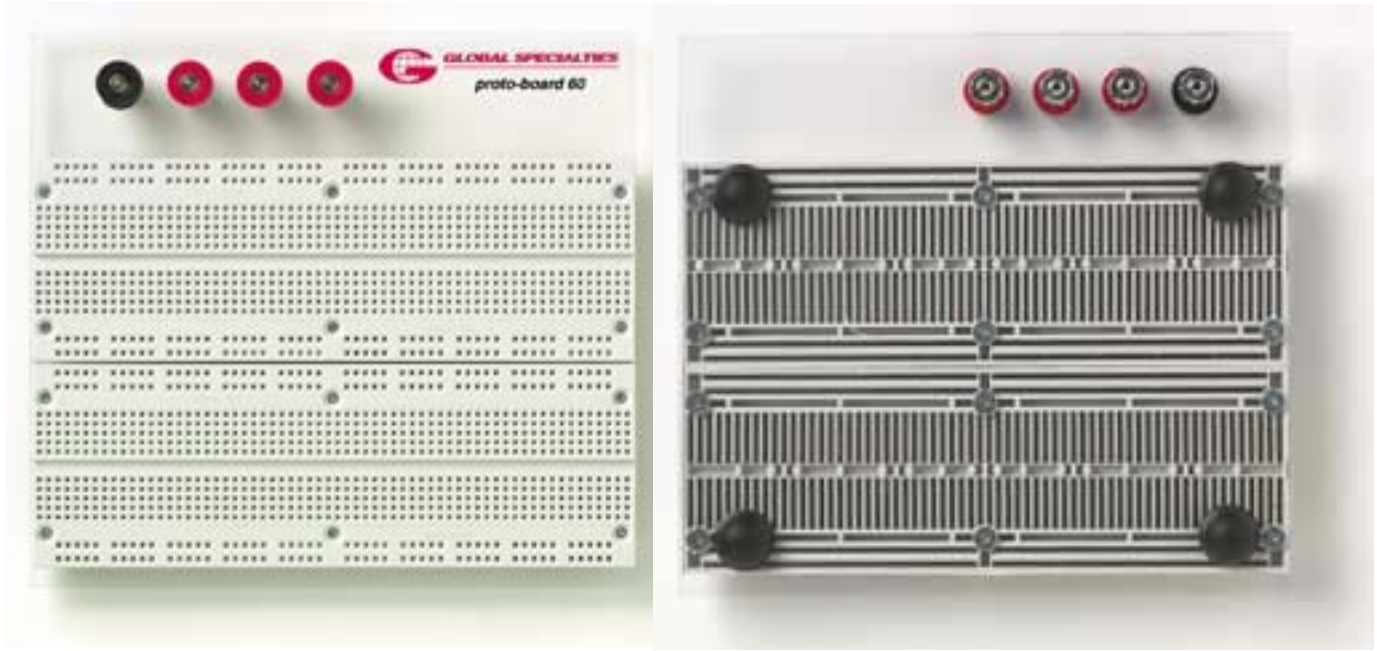


Figure 1: Global Specialties PB60 Proto-board
Left: top view        Right: bottom view

The dark, silver lines in the right photo of Figure 1 are the bus connections of the proto-board. The vertical silver bus lines correspond to the vertical holes in the left photo. The five vertical holes form a bus to connect up to five #22 AWG external wires. The horizontal bus lines in the left photo correspond to the twenty-five, horizontal holes in the right photo.

Use two jumper wires from the parts kit and the Agilent DMM set to $\Omega$, to determine which holes form bus lines. If a connection exits, the Agilent DMM will register $0\Omega$. Otherwise, the meter will register OL for overload.

**Simpson 260 Analog Multi-meter**

The Simpson 260 analog meter is shown in Figure 2. The Simpson meter can be used to measure DC voltage, AC voltage, DC current, and DC resistance. In this laboratory exercise, the meter will be used to measure DC resistance. The rated accuracy of the DC resistance reading is 2% of full scale length.

Table 1: Simpson 260 8XPI Resistance Specifications

| Selector | Range | Accuracy |
|----------|-------|----------|
| Rx1 | 0-2,000 Ω | 2.5% of Arc |
| Rx100 | 0-200,000 Ω | 2% of Arc |
| Rx10,000 | 0-20 MΩ | 2% of Arc |

The Simpson 260 8XPI instruction manual defines accuracy in the following way. "The voltage and current accuracy of this instrument is commonly expressed as a percent of full scale. This should not be confused with accuracy of reading (indication). For example, +2% of full scale on the 10 volt range allows an error of +-0.20V at any point on the dial. This means that at full scale, the accuracy reading would be +-2%, bat at half scale it would be +-4%. Therefore, it is advantageous to select a range which gives an indication as near as possible to full scale."



Figure 2: Simpson 260-8XPI

To measure DC resistance:

1) Connect a black probe lead to the terminal labeled COMMON. Connect a red probe lead to the (+) terminal to the right of common.
2) Turn the left selector knob to +DC.
3) Turn the center main selector knob to the appropriate resistance scale. For example, if the resistor to be measured is 1kΩ, select the Rx100 position and multiply the reading by 100.
   - Use Rx1 for resistance reading from 0 to 200 Ω.
   - Use Rx100 for resistance readings from 200 to 20,000 Ω.
   - Use Rx10,000 for resistance reading above 20,000 Ω.

4) Prior to taking a resistance measurement, the meter must be calibrated. To do this, short the red and black test leads together by simply touching the probes tips together. While the probes are shorted, turn the ZERO OHMS adjustment knob so that the meter reads 0 OHMS. This step is commonly referred to as "zeroing out the meter".
5) Place one probe on each side of the resistor while the resistor is held firmly in place on an unused section of the proto-board. Then read the OHMS on the top black scale. Multiply the value read by the range switch factor. For example, a reading of 10 on the Rx100 setting would be 1kΩ.
6) Each time the center knob is moved to a different resistance scale, the meter must be "zeroed out" as described in step 4.
7) When finished taking measurements, turn the right-hand, range selector switch to the OFF position.


**Agilent U1242B Digital Multi-meter**

The Agilent U1242B digital multi-meter (DMM) is shown in Figure 3. The Agilent DMM can measure DC voltage, DC current, AC voltage, AC current, DC resistance, capacitance, conductance, continuity, voltage in dB, frequency in Hz up to 1MHz, duty cycle, and pulse width. The meter has a 11,000 count display which translates to 4 digits.

The Agilent DMM will be used in this laboratory exercise to measure DC resistance. The resolution and accuracy is outlined in Table 1 below.

Table 2: Agilent U1242B Resistance Specifications

| Range | Resolution | Accuracy |
|---|---|---|
| 1000.0 Ω | 0.1 Ω | 0.3%+ 3 |
| 10.000 kΩ | 0.001 kΩ | 0.3%+ 3 |
| 100.00 kΩ | 0.01 kΩ | 0.3%+ 3 |
| 1000.0 kΩ | 0.1 kΩ | 0.3%+ 3 |
| 10.000 MΩ | 0.001 MΩ | 0.8%+ 3 |
| 100.0 MΩ | 0.01 MΩ | 1.5%+ 3 |



To measure DC resistance:

1) Connect a black probe lead to the black COM post. Connect a red probe lead to the red V-Ω post.
2) Turn the main selector switch clockwise to the Ω setting.
3) Place one probe on each side of the resistor. Then read the LCD display and note the units to the right of the numbers.
4) When finished taking measurements, turn the main selector switch to the OFF position.
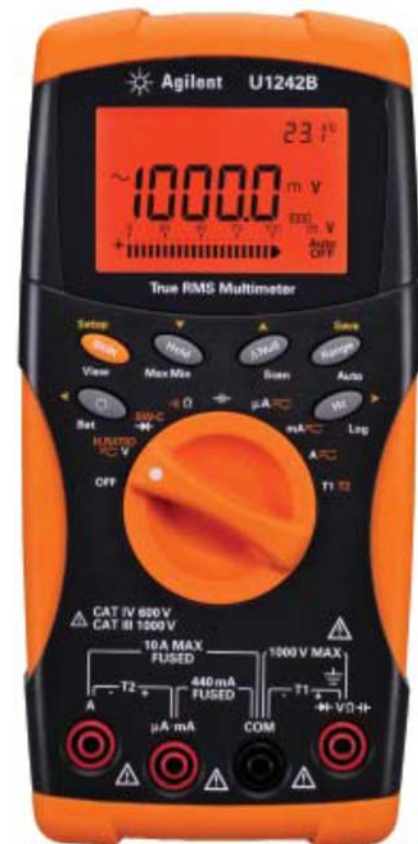
Figure 3: Agilent U1242B

### PROCEDURE:

1. Position a proto-board at your lab station. In this experiment, nine resistors will be measured from the ECET 1101 Parts Kit and the tenth will be provided by the instructor. Identify each of the ten resistors by the color bands and record the colors below. Calculate the range of values expected for the given tolerance and record in the table. For example, if the nominal resistance is 470 Ω and the tolerance is 5%, multiply by 0.95 to calculate the minimum value to be expected. Calculate the maximum expected value by multiplying by 1.05. Example values are recorded in the first row of Table 3.

Table 3: Resistor Color Coding and Tolerance Range Calculations

| Nominal Resistance | 1st Color | 2nd Color | 3rd Color | 4th Color | 5th Color | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|---|
| 470 Ω | Yellow | Violet | Brown | Gold | NA | 446.5 Ω | 493.5 Ω |
| 510 Ω | | | | | | | |
| 1 kΩ | | | | | | | |
| 3.6 kΩ | | | | | | | |
| 10 kΩ | | | | | | | |
| 27 kΩ | | | | | | | |
| 33 kΩ | | | | | | | |
| 100 kΩ | | | | | | | |
| 1 MΩ | | | | | | | |
| 10 MΩ | | | | | | | |

2. Appropriately place each of the resistors of Table 3 onto the proto-board. This will securely hold the resistors while the actual resistance is measured. Measure and record the actual resistance of each resistor using the Simpson meter then the Agilent meter. Record the values in Table 4. Calculate the relative difference of the measured value to the nominal value using both meters. Then calculate the relative difference using the Agilent measurement as the nominal and the Simpson measurement as the measured value.

Table 4: Resistor Measurements using the Simpson and Agilent Multi-meters

| Nominal Resistance | Simpson 260 | Rd using Simpson | Agilent U1242B | Rd using Agilent | Rd using the Agilent measurement as the nominal and the Simpson measurement as the measured |
|---|---|---|---|---|---|
| 470 Ω | | | | | |
| 510 Ω | | | | | |
| 1 kΩ | | | | | |
| 3.6 kΩ | | | | | |
| 10 kΩ | | | | | |
| 27 kΩ | | | | | |
| 33 kΩ | | | | | |
| 100 kΩ | | | | | |
| 1 MΩ | | | | | |
| 10 MΩ | | | | | |

3. Qualitatively compare the accuracy of measure using the Simpson 260 compared to the Agilent U1242B.

**Approved by:**    _____          **Date:** _____