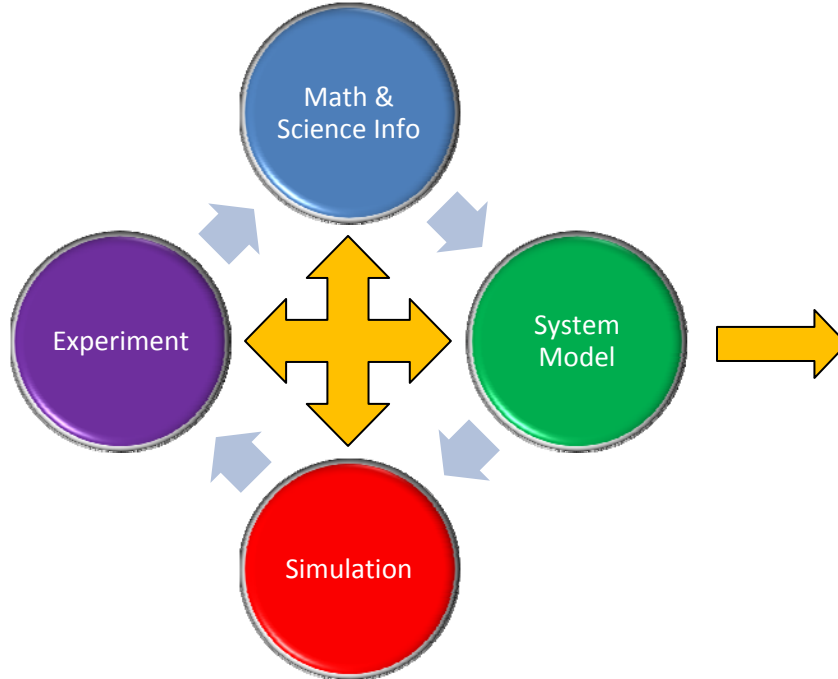


Verification that resistor values can be accurately read using the rules of the resistor color code



This is an application of the approach shown graphically above to the reading of resistor values and the measurement of resistance. The process usually starts in the top circle.

- **Collection of background information, math and science information, etc.** – Collect and understand how to apply the rules of the resistor color code which provide the design value for the resistor within a specified tolerance range (typically 5%)

Note that the next step can be any of the other three or can involve the collection of additional information. Also, any step can be returned to at any point if more work needs to be done. The goal of this exercise is to develop a process (system model) that verifies one's ability to select the correct resistor from a source of electrical components. The first version of the system model is to apply the color code rules.

- **System Model (version 1)** – Identify the colors of the stripes on the resistors with the naked eye (the resistor should be held as close to the eye as possible) in good lighting conditions and apply the color code to determine the value of the resistance with the given tolerance.
- **Experiment** – Apply the system model to a collection of resistors large enough to test its validity. 30 or so is a good number. The experiment is to read the colors and apply the rules for each resistor.

The next step will be to apply a simulation tool. In this case, we can use one of the resistance color code calculators.

- **Simulation** – Apply the simple Resistor Color Code Calculator from Hobby-Hour.com at http://www.hobby-hour.com/electronics/resistor_color_code.php to verify that one is applying the color code rules correctly.

The color code rules are very simple, so the simulation step should always confirm that the values associated with the given set of colors are indeed correct. At this point, there is still no confirmation that the values determined are correct, only that the procedure for determining the values from the colors has been applied correctly. Verification requires an experiment.

- **Collection of background information, math and science information, etc.** – Obtain a digital multimeter (DMM) and instructions on how to use it to measure resistance.
- **Experiment** – Use the Ohmmeter function of the DMM to measure each resistance and confirm that the value read is correct.

From this experiment it is learned that the values are being read correctly for the larger resistors but not for the smaller resistors. More information is needed.

- **Collection of background information, math and science information, etc.** – Collect more information on resistance and on resistance measurement methodology to identify possible sources of error. There are many ways to make resistance measurements more accurate, but the simplest step to add is based on the finite resistance of the wires used to connect to the resistor. The usual method for addressing this issue is to short the wires together and let the DMM provide the wire resistance.

The small resistance of the wires is seen to be insignificant when measuring large values of resistance, but can produce large % errors for small resistances. Thus, the experiment used to verify the application of the color code rules needs an additional step.

- **Experiment** – Use the Ohmmeter function of the DMM to measure each resistance and confirm that the value read is correct. First, measure the resistance of the wires by shorting them together and record the reading from the DMM. Obtain the measurement of the resistance for each resistor, subtract the wire resistance and then record the value. Compare the value obtained to the value read.

At this point, the measured values have sufficient accuracy to validate the system model. However, it is observed that there is at least one value obtained that does not fall within the specified tolerance range and the value falls in the range where the measurement error from the wire resistance is not significant. Thus, we conclude that identifying the colors of the stripes is not necessarily reliable. The system model should probably be modified. Two versions come to mind.

- **System Model (version 2)** – Identify the colors of the stripes on the resistors with a magnifying glass in good lighting conditions and apply the color code to determine the value of the resistance with the given tolerance.
- **System Model (version 3)** – Identify the colors of the stripes on the resistors with the naked eye (the resistor should be held as close to the eye as possible) in good lighting conditions and apply the color code to determine the value of the resistance with the given tolerance. Verify the value read using a DMM and subtract the resistance of the wires.

To test the second version, a magnifying glass is necessary. This is, in fact, a useful addition to any electronics part kit because so many of the components used are very small.

- **Experiment** – Use a magnifying glass in good light to check the colors read on the resistor whose measured value falls outside the 5% tolerance range.

Indeed it is difficult to tell the difference between brown and violet when the stripes are small. Using the new color observed, agreement is found with the measured and read values. Thus, it is confirmed that reading colors can be a problem, even for people without some form of color blindness. The paint colors used by different manufacturers are not standardized and all paints fade with age, so the sensible approach is to do the best one can reading the colors and verify the values using a DMM. Thus version 3 of the system model seems to be the best.

The purpose of this exercise was to develop the system model for the process one should use to identify the correct resistor for a particular electronics application. In Electronic Instrumentation, this process is made a bit more reliable by having the resistors stored in drawers, sorted by standard value. Thus, the final version of the procedure has an additional step.

- **System Model (version 4)** – Select a resistor from the drawer labeled with the value of interest. Do not rely on the resistor being correct, since resistors are sometimes incorrectly returned to the wrong drawer. To verify that the correct resistor has been selected, identify the colors of the stripes on the resistors with the naked eye (the resistor should be held as close to the eye as possible) in good lighting conditions (or use a magnifying glass if one is available) and apply the color code to determine the value of the resistance with the given tolerance. Verify the value read using a DMM and subtract the resistance of the wires.