Lab Exercise No. 1
Resistor Color Code

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Abstract—**This laboratory exercise helps us understand and be familiar with the color codes on the resistors. Being familiar with said color codes will help us in measuring the resistance of each resistor and will additionally help in the calculation of voltage and current in a circuit.**

Keywords-resistors, resistor code, current, voltage

I. Introduction

The resistor is a passive electrical component that creates resistance in the flow of electric current. These resistors can be found in almost all electrical networks and electronic circuits. The resistance is measured in a unit of ohms(Ω). Ohms is what we call the resistance that occurs when a current of one ampere(A) passes through a resistor with a one volt(V) drop across its terminals. The resistance(Ω) can be measured by dividing the Voltage(V) with the current(I) which is represented by the formula below(Figure 1):

$$R = \frac{V}{I}$$

Figure 1: Ohms Law

Resistors have multiple purposes. Including the limiting of the electric current, voltage division, heat generation, matching and loading circuits , etc. .

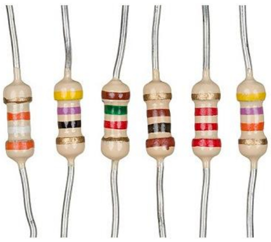

Figure 2: Resistors

As we can see from the image above(Figure 2), resistors are often designed with multiple different patterns of colors. Resistors usually have four bands, with the first three indicating the amount of resitance the resistor has, and the fourth indicating the tolerance of the resistor. To measure the resistance from these bands, we take note of the following:

(1) The first two bands represent the percision values otherwise known as the “Mantissa”.(2) The third band indicates the power of ten applied to the Mantissa. Some resistors do have more than 4 bands but were stated to not be used within this exercise.

Below is a table which indicates the values of each color in the resistor:

Color	**Value**
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

Table 1. Color Code Values

The table above(Table 1) shows the colors that apply only to the first three bands, the fourth band only has 2 possible colors(3 if you count none as a color), which is Silver and Gold. As stated before, these represent the tolerance of the resistor. With Gold having a tolerance of 5%, Silver with 10% and if there is no fourth band, the tolerance is 20%.

An example of how to read a resistors color code can be shown below:

Figure 3: Resistor Sample

Bands: Brown, Black, Red, Gold(You start reading with colors that aren’t Gold/Silver).

From those colors, lets get the values:

Brown – 1, Black – 0, and Red – 2. From this, we take the first two values, 1 and 0 and put them together to make 10 and multiply them to 10 to the power of the third band which is 2. Which will look as such: 10x10^2. Which will then give us a value of 1000 ohms which is then equal to 1 Kilo Ohm(k Ω).

$$1000\ \Omega = 1k\ \Omega$$

II. Procedure

To perform this experiment, you would need a Digital Multimeter.

A. Determining the Colors with Given Resitance and Tolerance Values

For the first part, we are given the a value of resistance and we are to find or determine the colors of the bands that correspond to given values. To do this, we will utilize the table given earlier(Table 1) to determine what colors match the given values. For example, the first given value is 27@10% or 27 Ω with a 10% tolerance. Lets get the value of the resistance first,

Knowing that 2 is represented by **Red**, and 7 is represented by **Violet** we already have the colors od the first two bands. To get the third band, since the number **27** does not require multiplication (i.e., its 27x1), the multiplier is 10^0, which corresponds to **Black.** And for the fourth band, 10% tolerance corresponds to **Silver**.

Value	Band 1	Band 2	Band 3	Band 4
27@10%	Red	Violet	Black	Silver

Table 1.2: Example Answer

B. Determining the Nominal Values from the Given Colors

This part is the opposite of the previous part. Where we determine the resistance value from the already given color code. In order to do this, we must first get the Nominal resistance value of the color code and then from there, determine its minimum and maximum values. For example, the first given color code is **Red-Red-Black-Silver.**

The Value of **Red** is 2, therefore the value of the first two bands is 22. As for the third band, its value is 0(**Black)** so from those values we get: **22x10^0** Ω or **22 Ω.** As for the value of the fourth band(Tolerance) Silver has a value of 10%.

To get the Maximum and Minimum values, we first must calculate the tolerance range of the resistor. We can get that by multiplying the tolerance value by the nominal resistance.

$$10\%\ x\ 22\ \Omega = 0.10\ x\ 22 = \pm 2.2\ \Omega$$

Given the tolerance range of ±2.2 Ω, we just need to simply add this to the nominal resistance to get the maximum and subtract to get the minimum.

Maximum value: 22 Ω + 2.2 Ω = 24.2 Ω
Minimum value: 22 Ω – 2.2 Ω = 19.8 Ω

Colors	Nominal	Tolerance	Minimum	Maximum
Red-red-black-silver	22 Ω	±2.2 Ω	24.2 Ω	19.8 Ω

Table 1.3: Example Answer

C. Determining the Deviation of Resistance

For this experiment we will now be utilizing the Digital Multimeter (DMM) to check for the actual resistance value of a given resistor and compare it to the calculated resistance and maximum and minimum values. To start, we should first determine the color code of the resistor we are going to use. The nominal values are already given so those are what we are going to use. For example, the first nominal value given is 22@10%, using the methods done in earlier experiments(part A.), we can conclude that the resistor we should use has a color code of **red-red-black-silver**. And also by using previous methods(part B.) we can calculate for the minimum and maximum values:

Maximum value: 22 Ω + 2.2 Ω = 24.2 Ω
Minimum value: 22 Ω – 2.2 Ω = 19.8 Ω

From here, we will start using the DMM. Set your DMM to measure for Resistance(Ω) and carefully measure the resistance of the resistor. Write the measured value on the table and do the same for the rest of the resistors.

After measuring the resistance, calculate the deviation percentage of the measured resistance from the nominal resistance. To get the deviation percentage, use the formula below:

$$100\ x\ (\text{measured}\ \Omega - \text{nominal}\ \Omega)/\ \text{nominal}\ \Omega$$

And write these values on the table.

III. Results and Analysis

This section will show our results and calculations for each activity, showing the formulas used and the Data gathered. As well as the insights and analysis we gain from these experiments.

A. Determining the Colors with Given Resitance and Tolerance Values

For this part, we were already given the nominal values, of the resistors, our task is to determine the color code that corresponds to the given nominal value. Our data is shown below.

Value	Band1	Band2	Band3	Band4
27@10%	Red	Violet	Black	Silver
56@10%	Green	Blue	Black	Silver
180@5%	Brown	Gray	Brown	Gold
390@10%	Orange	White	Brown	Silver
680@5%	Blue	Grey	Brown	Gold
1.5k@20%	Brown	Green	Red	None
3.6k@10%	Orange	Blue	Red	Silver
7.5k@5%	Violet	Green	Red	Gold
10k@5%	Brown	Black	Orange	Gold
47k@10%	Yellow	Violet	Orange	Silver
820k@10%	Gray	Red	Yellow	Silver
2.2M@20%	Red	Red	Green	None

Table 3.1

B. Determining the Nominal Values from the Given Colors

For this part we determined the nominal values, maximum, and minimum values from a given color code.

Formulas used:

Tolerance range: Tolerance (%) x Nominal Resistance(Ω)

Maximum: Nominal Resistance + Tolerance Range

Minimum Nominal Resistance – Tolerance Range

Data:

Colors	Nominal	Tolerance	Minimum	Maximum
red-red-black-silver	22 Ω	10%	19.7 Ω	24.2 Ω
blue-gray-black-gold	68 Ω	5%	64.6 Ω	71.4 Ω
brown-green-brown-gold	150Ω	5% 10%	142.5 Ω	157.5 Ω
orange-orange-brown-silver	330 Ω	10%	297 Ω	363 Ω
green-blue-brown –gold	560 Ω	5%	532 Ω	588 Ω
brown-red-red–silver	1.2k Ω	10%	1.08k Ω	1.32k Ω
red-violet-red–silver	2.7l Ω	10%	2.43k Ω	2.97k Ω
gray-red-red–gold	8.2 Ω	5%	7.79k Ω	8.61k Ω
brown-black-orange–gold	10k Ω	5%	9.5k Ω	10.5k Ω
orange-orange-orange–silver	33k Ω	10%	29.7k Ω	36.3k Ω
blue-gray-yellow–none	680k Ω	20%	544k Ω	816k Ω
green-black-green-silver	5M Ω	10%	4.5M Ω	5.5M Ω

Table 3.2

C. Determining the Deviation of Resistance

For this, we determine the deviation % of the measured resistance of a resistor compared to the nominal resistance which is based on the color code on the resistor.

Formulas used:

100 x (measured Ω – nominal Ω)/ nominal Ω

Data:

Value	Minimum	Maximum	Measured	Deviation%
22 @ 10%	19.8 Ω	24.2k Ω	21.8 Ω	-0.59
68 @ 5%	64.6 Ω	71.4 Ω	69.1 Ω	1.61

150 @ 5%	142.5 Ω	157.5 Ω	149.88 Ω	-0.08
330 @ 10%	297 Ω	363 Ω	330.42 Ω	0.12
560 @ 5%	532 Ω	588 Ω	561.37 Ω	0.24
1.2 k @ 5%	1.14k Ω	1.26k Ω	1.21k Ω	0.83
2.7 k @ 10%	2.43k Ω	2.97k Ω	2.69k Ω	-0.37
8.2 k @ 5%	7.79k Ω	8.61k Ω	8.29k Ω	1.096
10 k @ 5%	9.5k Ω	10.3k Ω	10.12k Ω	1.20
33 k @ 10%	29.7k Ω	36.3k Ω	33.2k Ω	0.606
680 k @ 10%	612k Ω	748k Ω	679k Ω	-0.14
5 M @ 20 %	4M Ω	6M Ω	5.01M Ω	0.2

Table 3.3

As we can see from Table 3.3, the measured value of resistance from the resistors varies from the nominal values. Some shown to have a larger value and some with smaller value. This is where the tolerance is in effect. Also, we can see that the measured values are all within the calculated maximum and minimum values.

D. *Questions*

- What is the largest deviation in Table 3.3? Would it ever be possible to find a value that is outside the stated tolerance? Why or why not?

  Ans: The largest deviation would be from 68 @ 5% with a deviation of 1.61%. Finding a value outside of the stated tolerance is not normally possible, the only way we can think of that this may happen is due to manufacturing errors of the resistor or a defective ohmmeter.

- If Steps 3 and 4 were to be repeated with another batch of resistors, would the final two columns be identical to the original Table 3.3? Why or why not?

  Ans: No. Though there might be some values that will be identical, not all of them will be, this would depend on the resistor being used and the ohmmeter, and the deviation will depend on the measured resistance of the resistor.

- Do the measured values of Table 3.3 represent the exact values of the resistors tested? Why or why not?

  Ans: No. This is because of the Tolerance which indicates how much the actual resistance can vary from the nominal value. Though it is not impossible for some resistors to have their exact nominal value, there is almost always a difference between the actual value and the nominal value.

IV. Discussion and Conclusions

This experiment taught us how to properly read resistor color codes, determine the maximum and minimum values of the resistor and we learned that the actual resistance of the resistor varies from its nominal value.

From the results, specifically Table 3.3, we can see that there is almost always a difference between the measured resistance and the nominal value of the resistor. This shows that the nominal value is not always accurate. However, the nominal value helps us determine the range of the value with the help of the tolerance value.

Therefore, the nominal resistance value stated by the color code is an approximation, within a specified tolerance range. The actual measured resistance can differ slightly due to manufacturing, tolerances, measurement inaccuracies, environmental conditions, aging, and other factors. These differences are usually small and within the expected tolerance, ensuring the resistor performs adequately in most applications.

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