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Usability of the Colour Coded Resistor Identification tool for students of Tertiary institution

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Abstract: Functionalities of electronic and electrical designs and experimentations are based not only on accurate calculation, but also on the choice of correct components. However, the identification of passive electrical components is one of the major problems facing the students of tertiary institutions during design implementation and experimental works. This work is the development and testing of a visualization tool that can easily be applied to enhance the identification of the values of coded resistors during laboratory experiments and electrical design implementation. An algorithm was developed based on the standard British colour codes, and was coded using Microsoft Visual Basic 2010 programming language. Sample cases were considered to test the usability of the developed algorithm. To validate the usefulness of the tool, usability tests were carried out by sequentially assigning sixteen samples of coded resistors for identification to part III, part IV and part V students of electrical and electronic students. The results showed that when identifying without using the tool, only 19% of the students identified resistors values correctly, whereas 96% of the students identified them correctly when identification tool was used, indicating the usefulness of the tool to students of tertiary institution engaging in electrical laboratory and design works.

Keywords: Passive electrical component, rated values, colourcoded resistor, algorithm, design, visualization, identification tool

INTRODUCTION

In the past, identifying resistors with the colour codes to determine their ratings or actual values was not a problem to students of Electrical and electronics engineering. Electrical engineering undergraduate students were expected to memorize resistors colour codes against their values. The contemporary eras of integrated circuits(ICs) and Information Communication Technology (ICT) have almost made this tradition impossible again. It is becoming difficult for an undergraduate to build just a two-stage amplifier without consulting internet for already inbuilt circuit, which he might not be able to interpret.

To be able to build a functional circuit, or to choose correct values of electrical passive components during laboratory experiments, students are expected to know the correct values ofcomponents to use. Typical examples are resistors and capacitors. The values of these components are easily identified using their coded colours. The coding allows for the determination of the values and their allowable tolerances. To reduce value identification errors, a suitable visualization tool can therefore be employed to enhance the cognition of students in identifying electrical passive components values. This work therefore is the development of computer based visualization and identification tools for reading, measurement and identification of the values of colour coded resistors by students of tertiary institutions.

VALUES OF THE COLOUR CODED RESISTORS (CCR)

A resistor is a two-terminal passive electrical component. Resistance of a resistor is measured in ohms (Ω). When its value is high, resistor values are often given in K and M. 1 K = 1000 and1 M = 1000000. Resistor values are normally shown using coloured bands. Each colour represents a number as shown in the Table 1 (Hobby Hour, 2011).

Most resistors have 4 bands: The first band gives the first digit. The second band gives the second digit. The third band indicates the number of zeros. The fourth band is used to show the tolerance (precision) of the resistor as shown in table 1

Table 1: Standard Resistor Colour Code Table (Hobby Hour, 2011)

Color	Digit1	Digit2	Digit3*	Multiplier	Tolerance	Temp. Coef.	Temp. Coef.
Black	0	0	0	X 10^0		100ppm/K	1 %
Brown	1	1	1	X 10^1	$\pm$ 1%(F)	50ppm/K	0.1 %
Red	2	2	2	X 10^2	$\pm$ 2%(G)	15ppm/K	0.01 %
Orange	3	3	3	X 10^3		25ppm/K	0.001 %
Yellow	4	4	4	X 10^4			
Green	5	5	5	X 10^5	$\pm$ 0.5%(D)		
Blue	6	6	6	X 10^6	$\pm$ 0.25%(C)		
Violet	7	7	7	X 10^7	$\pm$ 0.1%(B)		
Gray	8	8	8	X 10^8	$\pm$ 0.05%(A)		
White	9	9	9	X 10^9			
Gold				X 0.1	$\pm$ 5%(J)		
Silver				X 0.01	$\pm$ 10%(K)		
None					$\pm$ 20%(M)		

*3rd digit – only for 5-band resistors

The resistor in figure 1for example, has red (2), violet (7), orange (3 zeros) and gold bands. So its value is 27000Ω otherwise referred to as 27K. On circuit diagrams the Ω is usually omitted and the value is written as 27K.

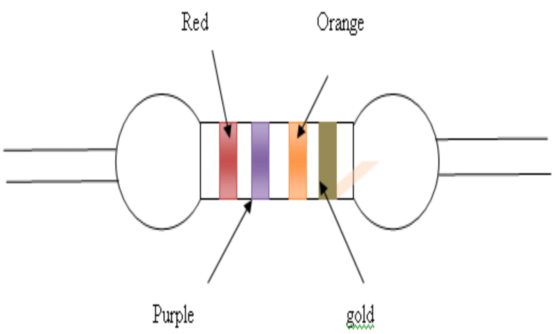

Figure1: Colour Coded Resistor

Small Value Resistors (Less Than 10 Ω)

The standard colour code cannot show values of less than 10. To show these small values two special colours are used for the third band: gold which means × 0.1 and silver which means × 0.01. The first and second bands represent the digits as normal. Hence, from Table 1, the generated equation following the general rule to determine the value of any given colour coded resistor is as shown in equation (1):

$$\text{Resistor Value} = (10 * A + B) * 10^{C} \pm D\% \qquad (1)$$

Where
A is the value of the colour in the first band
B is the value of the colour in the second band
C is the value of the colour in the multiplier
D is the value of the colour of the tolerance

For example, the value resistors with colours red, violet, gold bands and green, blue, silver bands are respectively 2.7 Ω and 0.56 Ω.

VISUALIZATION

The volume and complexity of knowledge and information in the modern era are such that unless a structure is superimposed upon it, it remains relatively meaningless. The requirement for “information at your fingertips” precludes a requirement for time-consuming interpretation (Wilde and Warren, 2008). Visualization is a process of transforming information into a visual form enabling the viewer to observe and understand such information with less stress (Yusuf et el., 2011)

Ware (2005) positioned that the power of a visualization comes from the fact that it is possible to have a far more complex concept structure represented externally in a visual display that can be held in visual and verbal working memories. Visualizations draw upon both the visual and working memory systems. Consensus seems to have been adopted amongst researchers that drawing on the breadth of the human cognition systems serves to mitigate the limitations of working memory in both the capacity and duration of stored information (Wilde and Warren, 2008).

Information visualization can be used for so many things in the field of science, engineering, education etc. Today most of the work reported in the field of visualization addresses methods to transform given data into an image for easy identification (Saad and Dimitrios, 2010). It aids the perception, interpretation and understanding of scientific information (Mark, 2004).

Peter et al., (2005) introduced a set of tools that augment the ability of operators to perceive the presence of failure in a system. This work is therefore the development and assessment usability of the resistor colour coded identification tool, employing method of graphical oriented visualization algorithm.

Developed Resistor Colour Coded Visualization Algorithm

In this work, Microsoft Visual Basic 2010 programming languages was adopted due to its object orientation. This was coded for visualization and identification of color coded resistors, following step by step the expression in equation(1) and the chart in table 1. Microsoft Visual Basic 2010 is an important upgrade and enhancement of the popular Visual Basic programming language and compiler, a technology that is much useful for this research. Visual Basic 2010 is not a stand-alone product but a key component of Microsoft Visual Studio 2010—a comprehensive development system that allows creation of powerful applications for Windows, the Web, handheld devices, and a host of other environments. (Michael, 2010). Hence, very useful for this work.

The program was designed in such a way that it was able to calculate and display the values of basic colour coded passive electrical components using the British Standard colour codes. Algorithms and flow charts to achieve these tasks is shown in figure 2.

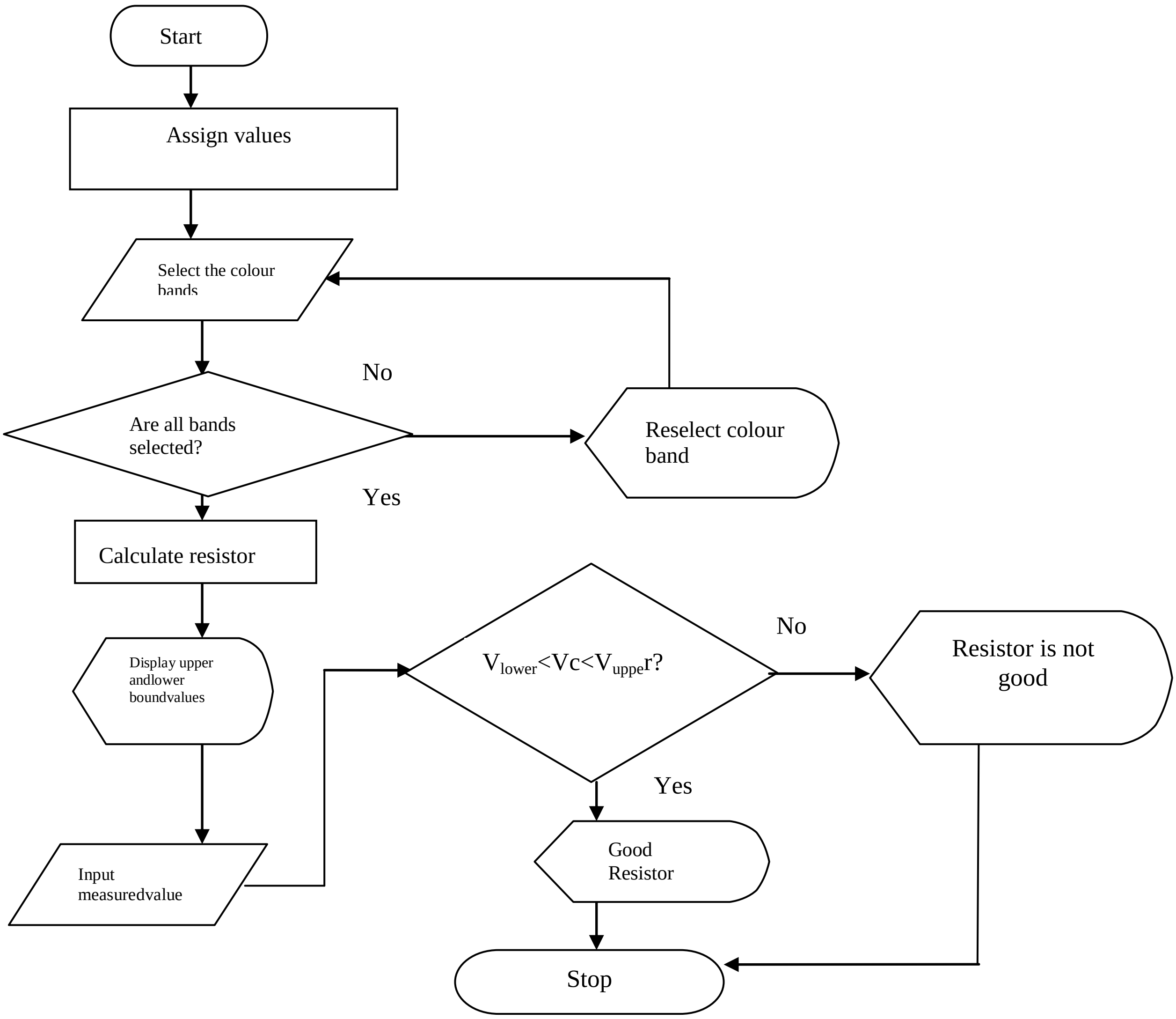

Figure 2: Flow Chart for Resistor Colour Coding (RCC)

Pseudo-coding the algorithm

This is the step by step coding of the equation 1 the assigning of colours.

Step1:
Assign the values to different colours as shown in table 1 above:
Define Colour1=C1, Colour2=C2, Colour3=C3, Colour4=C4,

Step2:
Input the four colours as seen on the resistors from the opposite side of the tolerance (usually gold or silver).

Step 3:
Compute the value of the resistance using the following equation:

$$V = ((C1x10) + C2)x\ 10^{C3} (4)$$

Step 4:
True Value (V_T) of Resistor = V $\pm$ C4

Step 5:
Displace the answer by:

Drawing the resistor showing the four colours on it;
Show "the value of this resistor is", V_T

Step 6:
Instruct the user to measure the resistance and see if its value falls in the range of the answer.

Step 7:
If it does not fall in the range, then the resistor is not good or fit for use using its colour

RESULTS AND DISCUSSION

The pre run stage of CCR visualization as displayed on the computer is shown in figure 3. The functionalstage ofCCR visualization with a sample case of 4M resistor is shown in figure 4, As the colours were being selected by the user, theywere displayed and visualized on the window in order to make the user compare between what he or she has chosen and what he or she actually intends to select. Finally at the bottom, colour red is used to depict an unfavourable result showing that the measured value is not within the allowable tolerance as shown in figure 4. Colour green is used to depict a favorable result showing that the measured value is within the allowable tolerance as shown in figure 5.

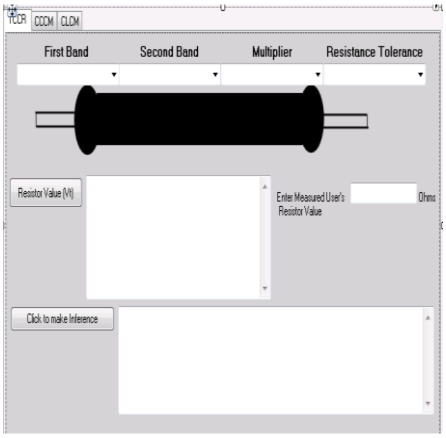

Figure 3: Pre-run Stage of RCC

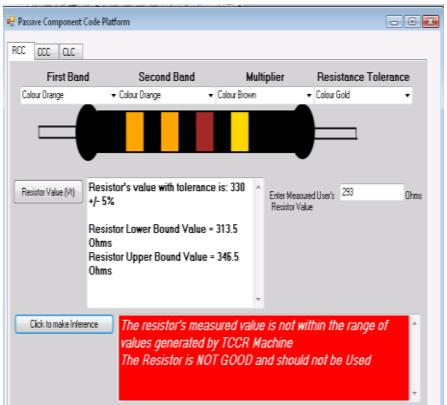

Figure 4: Run Stage of Resistor Color coding (RCC) Showing Faulty Resistor

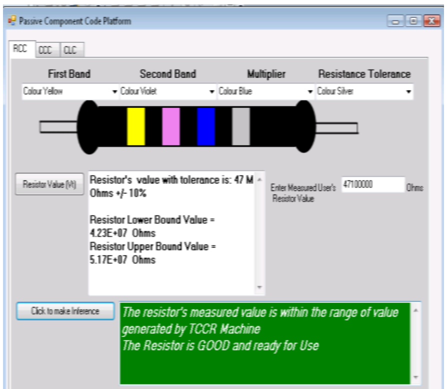

Figure5: Run Stage of Resistor Color coding (RCC) Showing Good Resistor

Usability Testing of CCR Visualization and Identification Tool

To validate the usefulness of the CCR tool fifteen students each from part III, part IV, and part V of Electrical Engineering department were allocated with sixteen (16) samples of resistors consecutively, to identify their values using the conventional experience of identifying values of colour coded resistors, and then verify their observations using the developed CCR identification tool. Table 2 is the samples of the

Colour Coded Resistors assigned to 16 students at each time, while Tables 3, 4and 5 show the summary results of the usability evaluations from the obtained readings when the two approaches were considered.

Table 2: Samples of the Colour Coded Resistor assigned to 16 students

Sample	1st Band	2nd Band	3rd Band	Tolerance	Nominal Value	Upper Band Value (Ω)	Lower Band Value(Ω)
1	Yellow	Purple	Yellow	Gold	470k+/- 5%	493500	446500
2	Red	Red	Orange	Gold	22k+/- 5%	23100	20900
3	Orange	Orange	Red	Gold	3k3+/- 5%	3465	3135
4	Red	Red	Brown	Gold	220+/- 5%	231	209
5	Brown	Red	Brown	Gold	120+/- 5%	126	114
6	Brown	Black	Orange	Gold	10k+/- 5%	10500	9500
7	Brown	Green	Orange	Gold	15k+/- 5%	15750	14250
8	Orange	Orange	Yellow	Gold	330k+/- 5%	346500	313500
9	Orange	Orange	Green	Gold	3m3+/- 5%	3465000	3135000
10	Orange	Orange	Orange	Gold	33k+/- 5%	34650	31350
11	Yellow	Purple	Silver	Gold	0.47 +/- 5%	0.4935	0.4465
12	Brown	Green	Brown	Gold	150+/- 5%	157.5	142.5
13	Yellow	Purple	Silver	Gold	0.47 +/- 5%	0.4935	0.4465
14	Green	Blue	Yellow	Gold	560k+/- 5%	588000	532000
15	Yellow	Purple	Yellow	Gold	470k+/- 5%	493500	446500
16	Yellow	Purple	Orange	Gold	47k+/- 5%	49350	44650

Table 3: Usability of CCR tool by Part III students

Sample	Student	Reading With conventional method	Reading Using Tool
1	1	No	Yes
2	2	Yes	Yes
3	3	No	Yes
4	4	Yes	Yes
5	5	Yes	Yes
6	6	Yes	Yes
7	7	No	Yes
8	8	No	Yes
9	9	No	Yes
10	10	No	Yes
11	11	No	Yes
12	12	No	Yes
13	13	No	Yes
14	14	No	Yes
15	15	No	Yes
16	16	No	Yes

Yes= Identified correctly, No=Not identified correctly

Table 4: Usability of CCR tool by Part IV students

Sample	Student	Reading With conventional method	Reading Using Tool
1	1	No	Yes
2	2	No	Yes
3	3	No	Yes
4	4	Yes	Yes
5	5	No	Yes
6	6	Yes	Yes
7	7	No	Yes
8	8	No	Yes
9	9	No	Yes
10	10	No	Yes
11	11	No	Yes
12	12	No	Yes
13	**13	No	No
14	14	No	Yes
15	15	No	Yes
16	16	No	Yes

Yes= Identified correctly, No=Not identified correctly,**=could not read colour correctly

Table 5: Usability of CCR tool by Part V students

Sample	Student	Reading with conventional method	Reading Using Tool
1	1	Yes	Yes
2	2	No	Yes
3	3	Yes	Yes
4	4	No	Yes
5	5	No	Yes
6	6	No	Yes
7	7	No	Yes
8	**8	No	No
9	9	No	Yes
10	10	No	Yes
11	11	No	Yes
12	12	Yes	Yes
13	13	No	Yes
14	14	No	Yes
15	15	No	Yes
16	16	No	Yes

Yes= Identified correctly, No=Not identified correctly,**=could not read colour correctly

CONCLUSION

Passive electrical components are very important elements in electrical circuit design and experimentation. However, students and designers often experience some difficulties in identifying their values during laboratory experiments and project designs. Based on standard British resistor colour codes , visualization tool was developed using Microsoft Visual Basic.NET 2010 for easy identification of the values of coded resistors during experimental and design works.

With this algorithm, the users need only the ability to identify colours and the bands of considered resistors. When carried out a sequential usability test by assigning sixteen(16) samples of colour coded resistors to sixteen students in parts III,IV and V of electrical and electronic students, results showed only about 19% of the 48 students were able to identify the values of the sample resistors without using the developed identification tool. However, when the tool were applied only 2 students (about 4%) out of 48 failed to identified the values of the samples given to them, the reason being their inability to identify colours correctly. The identification tool is useful to students of tertiary institution engaging in electrical laboratory and design works, for correctness and easy execution.

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