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The IoT for Visualization of RC Circuits Transient Phenomena

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Abstract

The development of a device for visualizing the transient phenomena of RC circuits on smartphones has been carried out, utilizing the IoT platform of NodeMCU as a solution to restrictions on attendance in laboratory during COVID-19 pandemic. The quantity displayed is the voltage and electric current during charging or discharging capacitor. NodeMCU is coupled with a CD4066 to switch the process, and a 74HC4051 multiplexer to select the voltage or current value of capacitor. At the end there is an RC circuit connected to the switch and the multiplexer and also a voltage source. User commands are sent from the smartphone to the NodeMCU via the Blynk server. The software consists of a program uploaded in NodeMCU and a Blynk graphic interface arranged on smartphone. The system can work quite well, including controlling the charging and discharging capacitor. The visual appearance of voltage and current on smartphone screen quite similar with those of theory.

Keywords: *IoT, transient, NodeMCU, RC circuit, smartphone*

Introduction

The development and utilization of IoT have been widely carried out for various purposes. The Internet of Things (IoT) allows many devices to connect and share data for example with the use of NodeMCU development board [1], [2]. NodeMCU is a microcontroller module with IoT platform and open source, able to speed up the process of developing the device [3]. Using NodeMCU, various tools have been developed, such as cardiac monitoring [4], smart home [5], geodesy [6], and environmental monitoring [7]. The field of education has also been done a lot.

Transient phenomena on resistor capacitor (RC) circuits is an essential and exciting topic in basic electronics learning [8], [9], [10]. Usually, students will be tasked to analyzes the model and visualizes the response of RC circuit caused by a sudden change on its DC voltage source. This understanding will becomes the student's capability to explain, for example, how to generates signal in the form of triangular, square, differentiator, integrator, also to determine RC time constant, and so on.

The Covid-19 pandemic caused such experiments to be constrained by restrictions on attendance in laboratories [11]. But currently, there are available means of data communication and device control by utilizing gadgets, such as smartphones.

This paper intends to describe how to develop an experimental device for transient phenomena of the RC circuit by using NodeMCU and a smartphone, along with the results. This is a continuation of previous research [9] so that students or users can access experimental devices through the smartphone without the need to be present in the laboratory.

The device to be developed utilizes electronic components widely available and cheap but with relatively good quality. The electronic circuit is arranged as simple as possible to simplify hardware connection and programming. The required software for the smartphone is the graphic interface to remotely manage connected electronics hardware, which is an android and IoT based digital dashboard, and customizable. Users can organize buttons and graphs as simple as drag and drop widgets or icons, and it is available for free. It is hoped that students or teachers will be interested in replicating or developing it.

Transient Phenomena of RC Circuits

The transient phenomena of the RC series circuit are the circuit's response in the event of a change from charge to discharge capacitor or vice versa [10]. The response can be observed in how the capacitor's voltage or electric current values changes. The electronic circuit of the RC series to be studied is like Fig. 1.

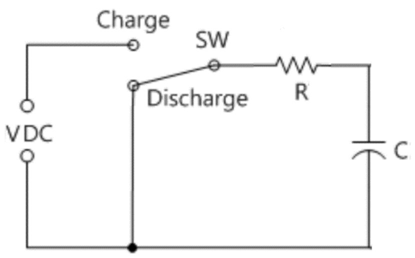

Fig. 1. Capacitor charging and discharging circuit

The SW switch will adjust the charge or discharge connection at C through R. The voltage value can be obtained from C while the current value can be obtained from the voltage R using Ohm's law.

Mathematical model of voltage C during charging and discharging is as in Equation 1.

$$V_c(t) = V(1 - e^{-\frac{t}{RC}}).$$
$$V_c(t) = V_c(0)\, e^{-\frac{t}{RC}} \tag{1}$$

While Equation 2 is mathematical model of current at C during charging and discharging

$$I_c(t) = \frac{V}{R} e^{-\frac{t}{RC}}$$
$$I_c(t) = -\frac{V_c(0)}{R} e^{-\frac{t}{RC}} \tag{2}$$

Visualization of equations 1 and 2 will look like the graph in Fig. 2. This graph will be displayed on the smartphone screen. However, it will be depicted without proper scaling to make the voltage and current profiles clearer.

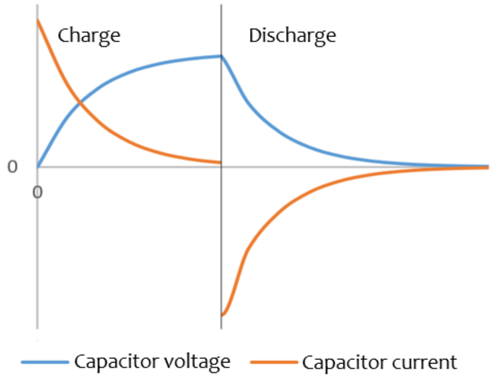

Fig. 2. Graphical visualization of the mathematical model of capacitor voltage and current

Method

The device design diagram to be developed is shown in Fig. 3.

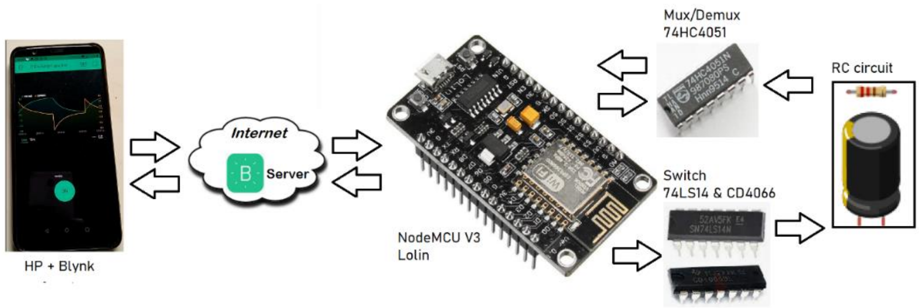

Fig. 3. Device design diagram

The RC circuit will provide data on the voltage and current of the capacitor, both during the charging process and during the discharging process alternately. This process changeover is controlled through a switch system consisting of 2 ICs, namely the CD4066 digital switch and the 74LS14 inverter. Next, the voltage and current values are sent to the analog input A0 NodeMCU alternately because only one analog input is available. This is done by the 74HC4051 multiplexer. Another task of the NodeMCU is to send the voltage and current values to the smartphone graphical interface via the Blynk server. Previously, a graphical interface has been designed on smartphones by editing the necessary Blynk widgets so that they can communicate with the NodeMCU and display a graph of the capacitor voltage and current in real time, both charging and discharging.

Result and Discussion

The realization of Fig. 3 in the form of a Fritzing electronic circuit, connections between components on a breadboard, and a software program that has been uploaded to the NodeMCU are presented as in Fig. 4, 5 and 6.

In this project NodeMCU V3 Lolin development board was chosen because it is easy to configure for IoT products development purposes. The software of digital dashboard for graphical interface development used is Blynk because it has many features to support IoT projects, it is also easy to use and has free version.

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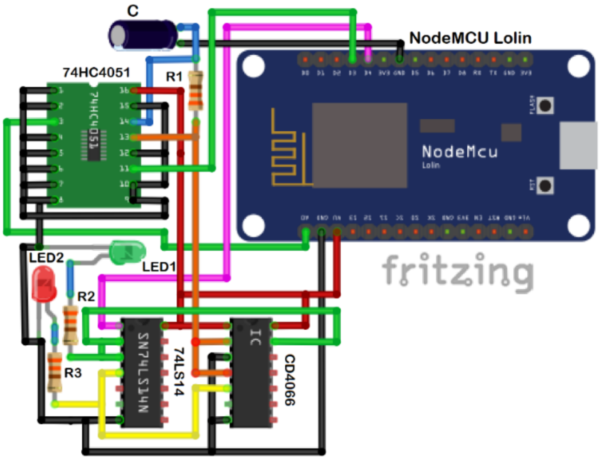

Fig. 4. Fritzing electronic circuit

As depicted in Fig. 4, the studied RC pairs are R1 and C. Resistors R2 and R3 are current limiters for LED1 and LED2 where these LEDs show C in the discharge (green) or charge (red) states. Fig. 5 shows the results of the circuit that can be used for various purposes. One of them can be used in practice. The use of breadboards aims to make the circuit easy to assemble so that students will also better understand how each component works.

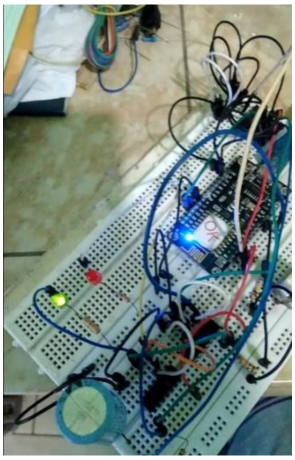

Fig. 5. Connections between components on breadboard

TEG_ARUS_PENGISIAN_PENGOSONGAN_KAPASITOR_NODEMCU | Arduino 1.8.12
File Edit Sketch Tools Help
TEG_ARUS_PENGISIAN_PENGOSONGAN_KAPASITOR_NODEMCU §

```
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
char auth[]="pv9aXH****";char ssid[]="***am**";char pass[]="**000*";
BlynkTimer timer;
void timerevent()
{ digitalWrite(D3,HIGH);int value_teg=analogRead(A0);float teg=value_teg/1023.0*3.3;
  digitalWrite(D3,LOW);int value_ars=analogRead(A0);
  float ars=(value_ars/1023.0*3.3 - teg)/330.0*500.0;
  Blynk.virtualWrite(V5,teg);Blynk.virtualWrite(V6,ars);}
void setup()
{ Serial.begin(9600);pinMode(D4,OUTPUT);pinMode(D3,OUTPUT);
  digitalWrite(D4,LOW);Blynk.begin(auth,ssid,pass);timer.setInterval(200L,timerevent);}
void loop()
{ Blynk.run();timer.run();}
```

Fig. 6. Program uploaded to NodeMCU

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Fig. 7 is a graphical interface that contains the required settings for Blynk widgets. The D4 widget refers to the D4 digital pin of the NodeMCU to control and select the charge or discharge process. Meanwhile, to run it, touch or click the triangle in the upper right corner. Fig. 8 is the display on the smartphone screen when the graphical interface is running. It shows the voltage and current of the capacitor during the charging and discharging state, as shown in Fig. 2. The graphic scale is intentionally not adjusted properly, so that the voltage and current graph display is clearly visible. The author has a video of this experiment.

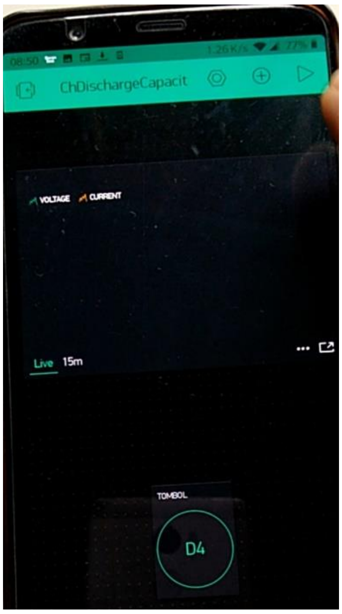

Fig. 7. Blynk widgets set up before running

Fig. 8. Resulted visualization of transient phenomena of capacitor on smartphone, voltage (green) and current (yellow).

These results can be used in an online practicum that can be accessed by students from anywhere. This tool can be combined with various learning strategies that support the achievement of competencies at various levels of education.

Conclusion

Based on the observations in Fig. 8, it is concluded that the graph form of the capacitor voltage and current is quite similar to the shape of the model in Fig. 2. In this experiment the voltage and current values were not recorded, due to further research. .

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