Group 6

Experiment 3
Electrical Experiment

Ferhat Kökleş - 110190065
Murathan Bakır - 110180137
Alp Uzun - 110190153
Kaan Özkan - 110190056

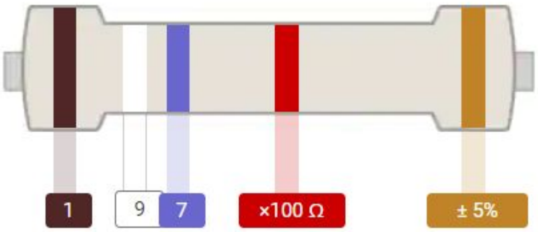
Instructor: **Asst. Prof. İsmail Bayezit**

A power source in an electrical circuit is a device that provides the electrical energy needed to power the circuit and enable the flow of electric current. A power source can be a battery, a generator, a power supply, or any other device that can deliver electrical energy to the circuit.

$$\mathbf{Vs = 4.7837\ V}$$

A resistor is an electronic component that is commonly used in electrical circuits to restrict the flow of electric current and it is designed to have a specific resistance value. In our experiment, the resistor’s value is,

$$\mathbf{R = 19.7x10^3\ \Omega}$$



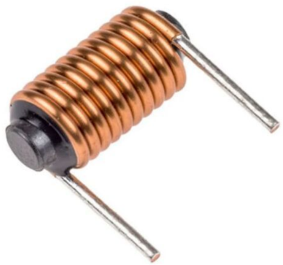
Resistor value:

19.7k Ohms 5%

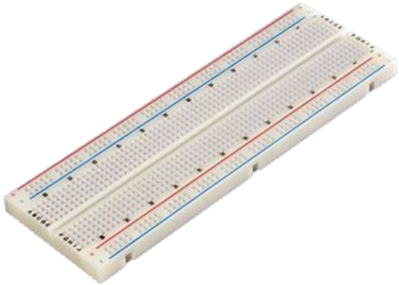
A capacitor is an electronic component that stores and releases electrical energy in an electrical circuit. It consists of two conductive plates separated by an insulating material and is used for tasks such as energy storage, filtering, coupling, and timing in electronic circuits. Capacitance is a measure of a capacitor's ability to store electrical charge, and it’s unit is Farad. In this experiment, our capacitance is,

$$\mathbf{C = 220x10^{-6}\ F}$$

An inductor is an electronic component used in electrical circuits that stores and releases energy in the form of a magnetic field. It typically consists of a coil of wire wound around a core made of a magnetic material. When an electric current passes through the coil, a magnetic field is generated, which stores energy. When the current changes, the magnetic field collapses, releasing the stored energy. Inductance unit is Henry, and it’s value in our experiment was,



$$\mathbf{L = 1x10^{-4}\ H}$$



A breadboard is a device used in electronics to create and test electronic circuits without the need for soldering. It is typically a plastic board with a grid of holes that are used to insert and connect electronic components, such as resistors, capacitors, and integrated circuits (ICs), using jumper wires. The holes on a breadboard are typically connected in rows and columns, with metal strips or clips underneath that provide electrical connectivity. They aren’t necessarily used, but they are used in this experiment for practicality.

An Arduino processor is a microcontroller board that is widely used in electrical circuits for a variety of purposes. Its main use is to provide a programmable and flexible control platform for controlling and automating tasks in electronic systems. The Arduino processor can interface with sensors, actuators, and other electronic components to sense inputs, process data, and control outputs. We used the Arduino processor to convert analog signals to digital signals so that we can see and observe their time-based changes on a computer using MATLAB.

Jumper cables are a type of wire used to connect the components on a breadboard together. They typically have male headers on each end that can be inserted into the holes on a breadboard, allowing for quick and easy connections between components. These cables come in various lengths and colors to make it easier to differentiate between different circuits and connections.

Multimeter is an electronic measuring instrument used to measure different electrical quantities such as voltage, current, and resistance. It typically consists of a digital or analog display, and several ports or probes for connecting to the circuit being measured. Multimeters can be used to troubleshoot electrical problems in various devices and systems, test the continuity of circuits, and check the voltage of batteries or power sources.

RC Circuit

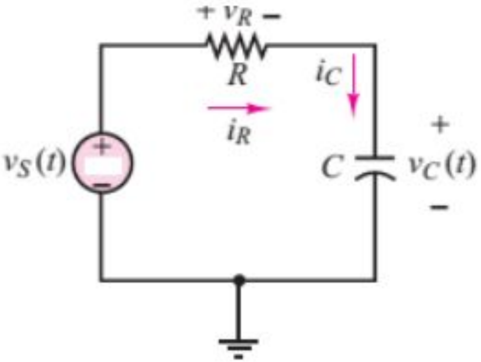


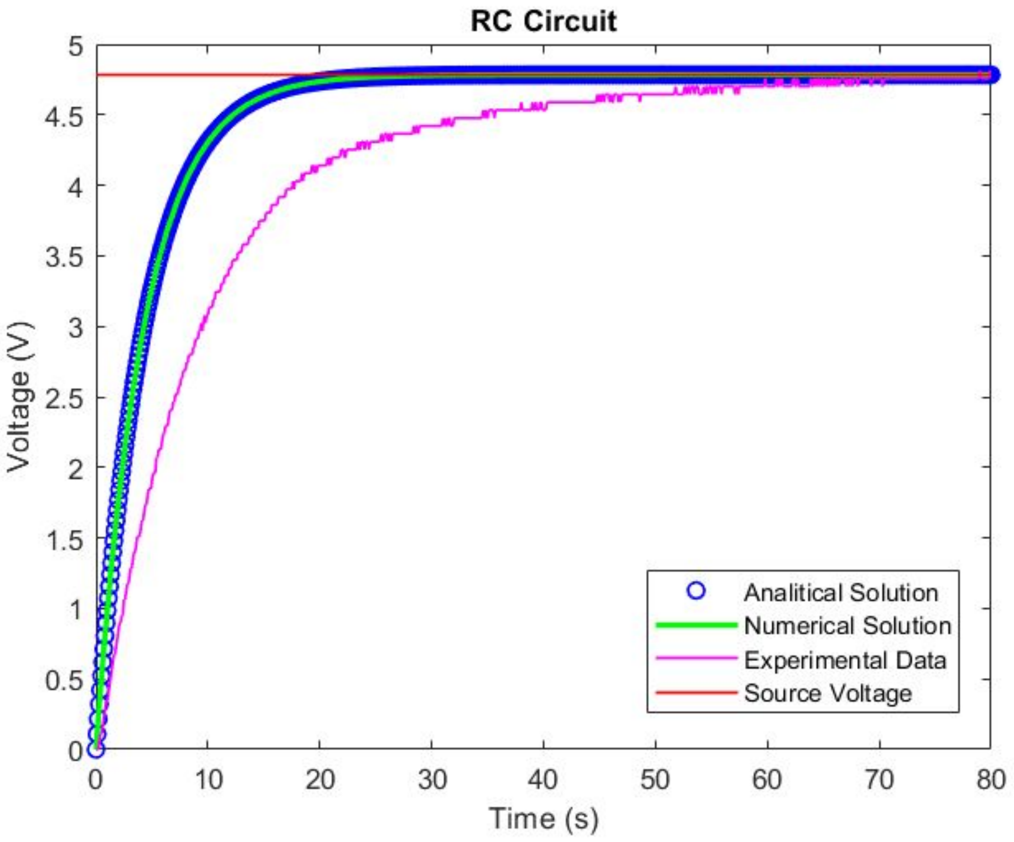
Figure 3: RC Circuit Representation.

$$\frac{dv_c}{dt} + \frac{1}{RC} v_c = \frac{1}{RC} v_S$$

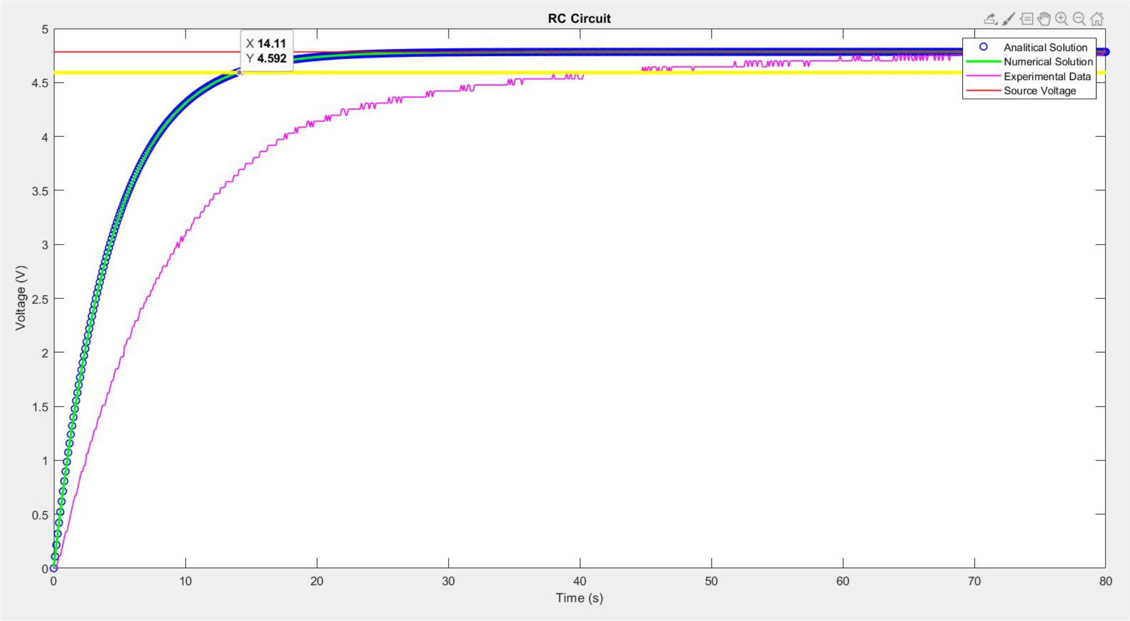
The equation for RC circuit is first order ordinary differential equation.

MATLAB Codes for RC Circuit

```
%**************** Electronical Components **********************
tata = transpose(RC);
data = transpose(RLC);

RC1 = tata(1:2219,1);
RC2 = tata(1:2219,2);
RC3 = tata(1:2219,3);

RLC1 = data(1:2219,1);
RLC2 = data(1:2219,2);
RLC3 = data(1:2219,3);

%**************** Electronical Components **********************
Vs = 4.7837;
C=220*10^-6;
L=0.0001;
R=19.7*10^+3;

%******************* Numerical Solution ***********************
time_interval = [0 80];
initials = 0;
group6 = @(t, Vc)(Vs/(R*C)-Vc./(R*C));
[t, Vc] = ode45(group6,time_interval,initials);

%******************* Analytical Solution ***********************
ti = [0:0.1:80];
analitical_solution = dsolve('DY =(Vs-Y)/(R*C)','Y(0)=0');
pretty(analitical_solution);
final_solution = simplify(analitical_solution);
solution_to_be_plotted = Vs - Vs*exp(-ti/(C*R));

%********************* Source Voltage **************************
x = 0:0.001:80;
c = Vs;
const = @(x)(c).*x.^(0);

%************************* Plots ******************************
plot(ti,solution_to_be_plotted,'bo','LineWidth',1);
hold on;
plot(t,Vc(:,1),'g-','LineWidth',2);
hold on;
plot(RC1(1:800,1),RC3(165:964,1),'m','LineWidth',1);
hold on
plot(x, const(x),'r','LineWidth',1);

legend('Analitical Solution','Numerical Solution','Experimental Data','Source Voltage');
xlabel("Time (s)");
ylabel("Voltage (V)");
title("RC Circuit");
```



Settling Time of RC Circuit



95% of the source voltage reached in 14.11 seconds, which is very close to the calculated settling time.

RLC Circuit

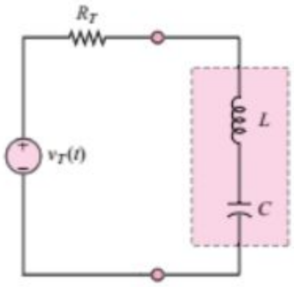


Figure 5: RLC Circuit Representation

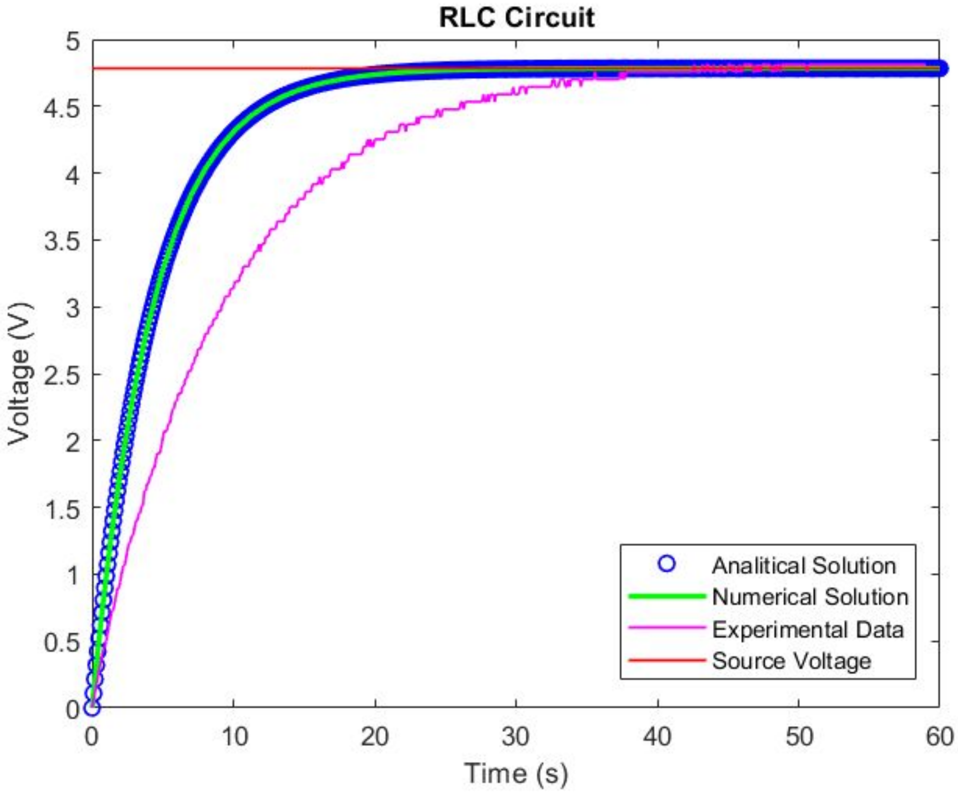
The ODE representing the system is as follows:

$$\frac{d^2 v_c(t)}{dt^2} + \frac{R_T}{L}\frac{dv_c(t)}{dt} + \frac{1}{LC}v_c(t) = \frac{1}{LC}v_T(t)$$

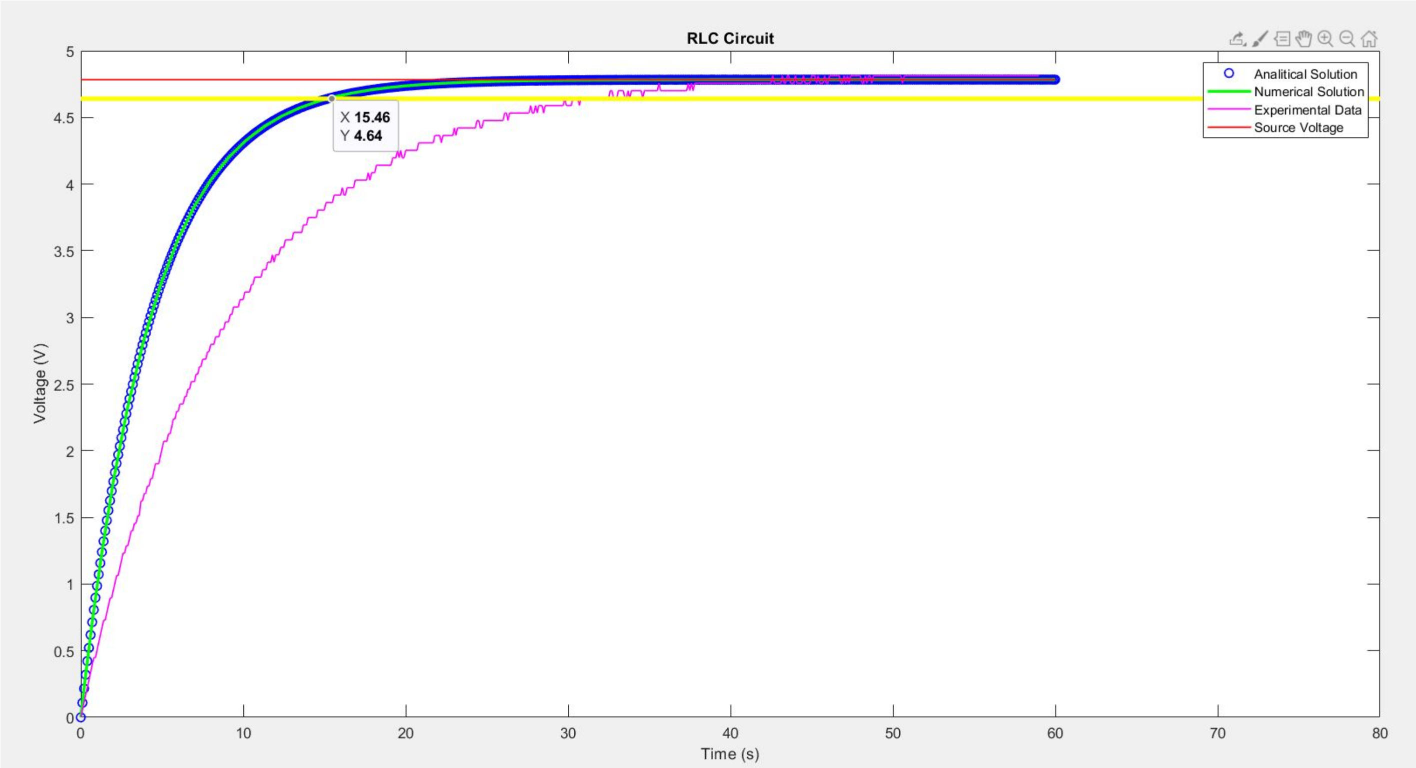
The equation for RLC circuit is second order ordinary differential equation.

MATLAB Codes for RLC Circuit

```
%**************** Electronical Components *********************
tata = transpose(RC);
data = transpose(RLC);

RC1 = tata(1:2219,1);
RC2 = tata(1:2219,2);
RC3 = tata(1:2219,3);

RLC1 = data(1:2219,1);
RLC2 = data(1:2219,2);
RLC3 = data(1:2219,3);

%**************** Electronical Components *********************
Vs = 4.7837;
C=220*10^-6;
L=0.0001;
R=19.7*10^+3;

%****************** Numerical Solution ***********************
time_interval = [0 60];
initials = [0 0];
group6 = @(t, Vc) [Vc(2);(-(R/L)*Vc(2)+(Vs-Vc(1))/(L*C))];
[t, Vc] = ode23s(group6,time_interval,initials);

%****************** Analytical Solution **********************
ti = [0:0.1:60];
analitical_solution = dsolve('D2Y = -(R/L)*DY + (Vs-Y)/(L*C)','Y(0)=0','DY(0)=0');
pretty(analitical_solution);
final_solution = simplify(analitical_solution);
solution_to_be_plotted = Vs-(Vs*exp(-(ti*((C^2*R^2 - 4*L*C)^(1/2) + C*R))/(2*C*L))*((C^2*R^2 - 4*L*C)^(1/2) -
C*R))/(2*(C^2*R^2 - 4*C*L)^(1/2)) - (Vs*exp((ti*((C^2*R^2 - 4*L*C)^(1/2) - C*R))/(2*C*L))*((C^2*R^2 -
4*L*C)^(1/2) + C*R))/(2*(C^2*R^2 - 4*C*L)^(1/2));

%******************** Source Voltage *************************
x = 0:0.001:60;
c = Vs;
const = @(x)(c).*x.^(0);

%************************ Plots ******************************
plot(ti,solution_to_be_plotted,'bo','LineWidth',1);
hold on;
plot(t,Vc(:,1),'g-','LineWidth',2);
hold on;
plot(RLC1(1:591,1),RLC3(97:687,1),'m','LineWidth',1);
hold on
plot(x, const(x),'r','LineWidth',1);

legend('Analitical Solution','Numerical Solution','Experimental Data','Source Voltage');
xlabel("Time (s)");
ylabel("Voltage (V)");
title("RLC Circuit");
```

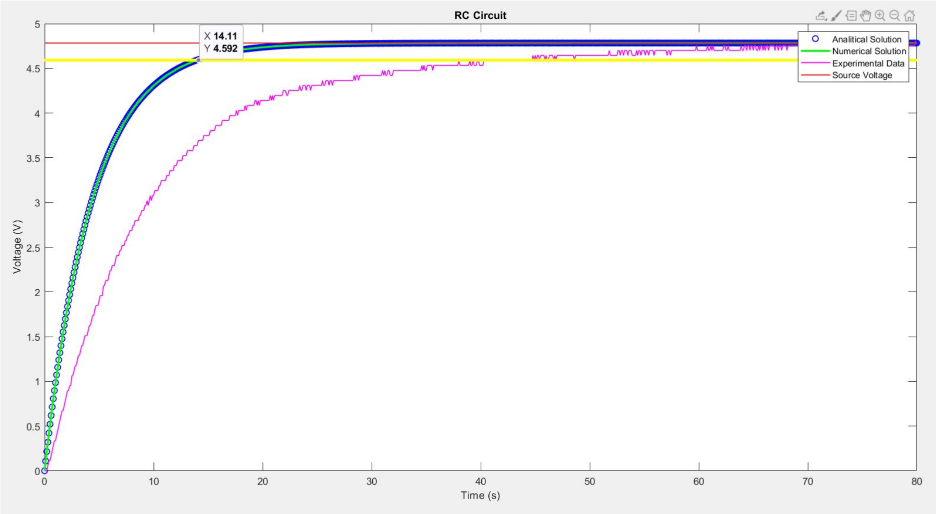


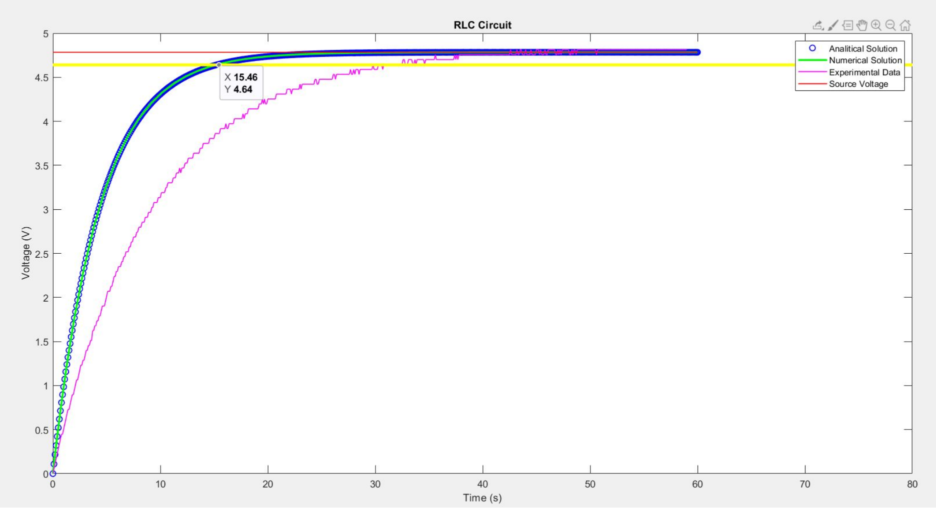
Settling Time of RLC Circuit



95% of the source voltage reached in 15.46 seconds.

Comparison





In both graphs, numerical and analytical solutions are nearly equivalent. However, experimental data delay with respect to the numerical and analytical solutions as seen in the graphs. When it comes to the settling time, we can see that settling time of RLC circuit is a bit greater than the settling time RC circuit. This discrepancy is 1.35 seconds. This difference may occur due to real world conditions such as temperature of the experiment environment, imperfections of the circuit components etc.