1. **Objective**

The objective for conducting this experiment, To learn the use of Signal Generators and Oscilloscope as well as To Investigate the behavior charging and discharging of RC circuits with changing Time Period, T of the input Square wave

2. **List of Equipment**

- Trainer Board
- DMM
- 5 x 15kΩ resistor
- 3 x 5kΩ resistor
- Wires

3. **Theory**

Time varying signal

A Linear, time-varying (LTV) system is a linear system whose impulse response depends on the time at which the impulse has been applied. In the figure below, two impulses (red arrows) are applied to the system at different times. It is clear that the responses to both impulses are different: the dynamic behavior has changed from the instant of the first impulse to the second. This is why the system is called time-varying.

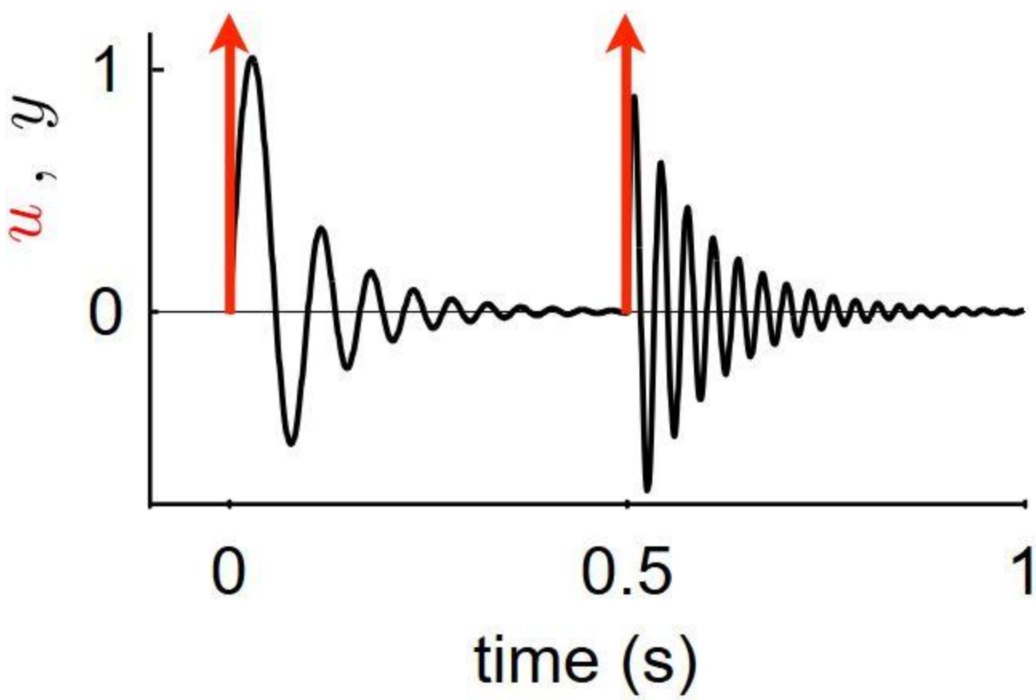
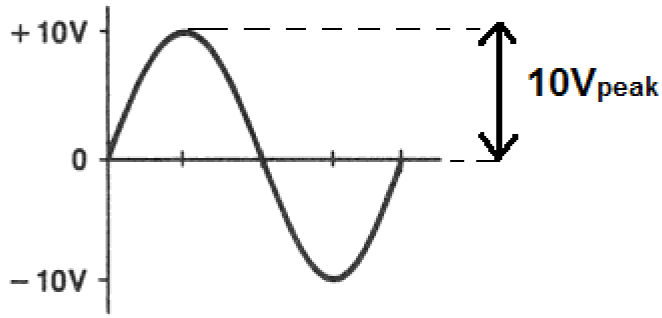


Fig (a): The impulse response of a time-varying system depends on the time at which the impulse has been applied

Peak voltage

Peak voltage, VP, is a voltage waveform which is measured from the horizontal axis (at the 0 height reference mark) to the top of the waveform, called the crest of the waveform.



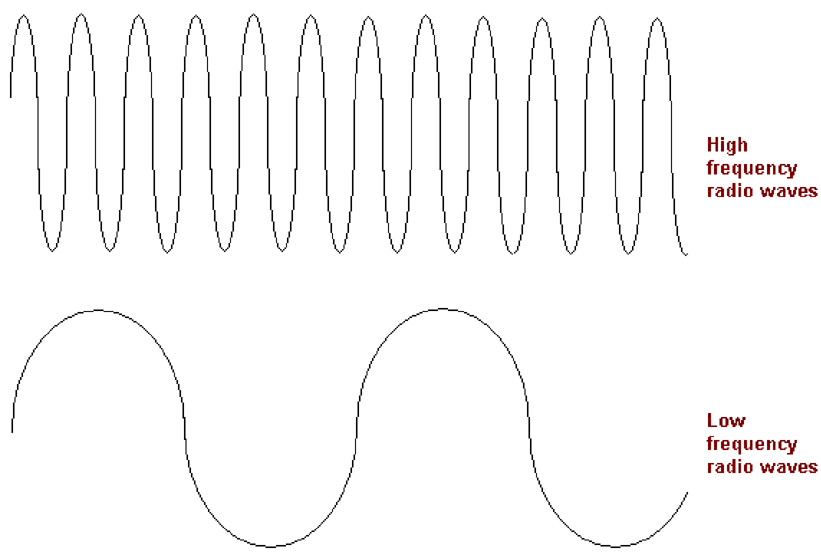
Horizontal is at the 0 reference line: 0 height above the positive voltage and 0 height below the negative voltage, meaning it is right between the positive and negative voltage waveforms. This 0 height reference line is the exact middle of the signal's transition from peak positive voltage to the peak negative voltage.

Time period

Time required completing 1 cycle. It is denoted by **T.** A time period is the time needed for one complete cycle of vibration to pass a given point.

Frequency

Frequency describes the number of waves that pass a fixed place in a given amount of time. So if the time it takes for a wave to pass is is 1/2 second, the frequency is 2 per second. If it takes 1/100 of an hour, the frequency is 100 per hour.



Signal generator

A signal generator is an electronic device that generates repeating or non-repeating electronic signals in either the analog or the digital domain. It is generally used in designing, testing, troubleshooting, and repairing electronic or electroacoustic devices, though it often has artistic uses as well.

There are many different types of signal generators with different purposes and applications and at varying levels of expense. These types include function generators, RF and microwave signal generators, pitch generators, arbitrary waveform generators, digital pattern generators and frequency generators.

Oscilloscope

An oscilloscope is a piece of equipment used to measure electronic signals, and is found in many scientific laboratories. It is used to observe varying-signal voltages on a two-dimensional grid representing time. When connected to a power source through a probe, the oscilloscope displays the corresponding real-time waveform immediately. Although mostly used in scientific and engineering fields, they are also used in other fields such as telecommunications and medicine.

Capacitor charged and discharged in the circuit

A Capacitor is a passive device that stores energy in its Electric Field and returns energy to the circuit whenever required. A Capacitor consists of two Conducting Plates separated by an Insulating Material or Dielectric. Figure 1 and Figure 2 are the basic structure and the schematic symbol of the Capacitor respectively.

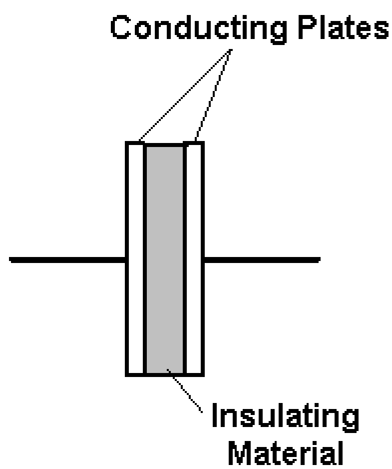


Figure 1: Basic structure of the Capacitor

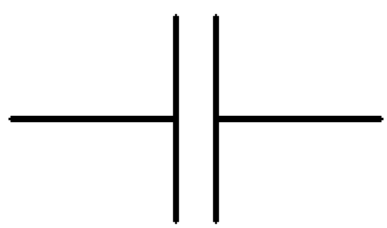


Figure 2: Schematic symbol of the Capacitor

When a Capacitor is connected to a circuit with Direct Current (DC) source, two processes, which are called "charging" and "discharging" the Capacitor, will happen in specific conditions.

In Figure 3, the Capacitor is connected to the DC Power Supply and Current flows through the circuit. Both Plates get the equal and opposite charges and an increasing Potential Difference, v_c, is created while the Capacitor is charging. Once the Voltage at the terminals of the Capacitor, v_c, is equal to the Power Supply Voltage, $v_c = V$, the Capacitor is fully charged and the Current stops flowing through the circuit, the Charging Phase is over.

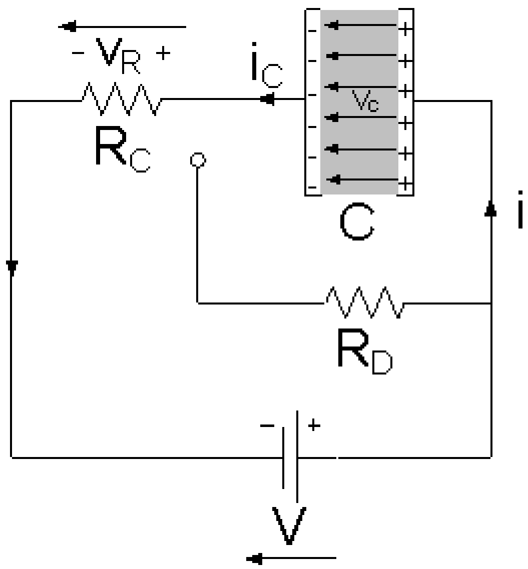


Figure 3: The Capacitor is Charging

A Capacitor is equivalent to an Open-Circuit to Direct Current, $R = \infty$, because once the Charging Phase has finished, no more Current flows through it. The Voltage v_c on a Capacitor cannot change abruptly.

When the Capacitor disconnected from the Power Supply, the Capacitor is discharging through the Resistor R_D and the Voltage between the Plates drops down gradually to zero, $v_c = 0$, Figure 4.

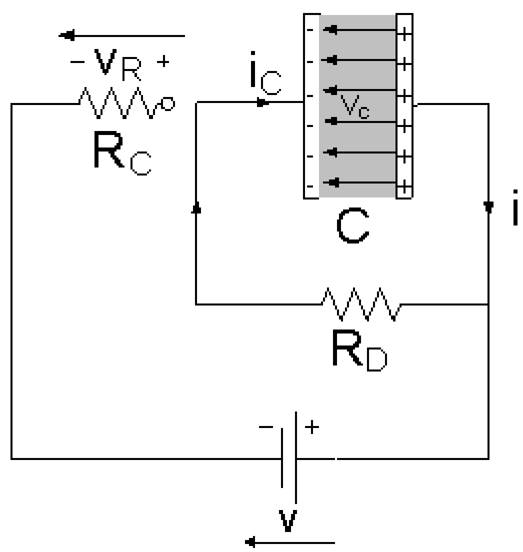


Figure 4: The Capacitor is Discharging

In Figures 3 and 4, the Resistances of R_C and R_D affect the charging rate and the discharging rate of the Capacitor respectively.

The product of Resistance R and Capacitance C is called the Time Constant τ, which characterizes the rate of charging and discharging of a Capacitor, Figure 5.

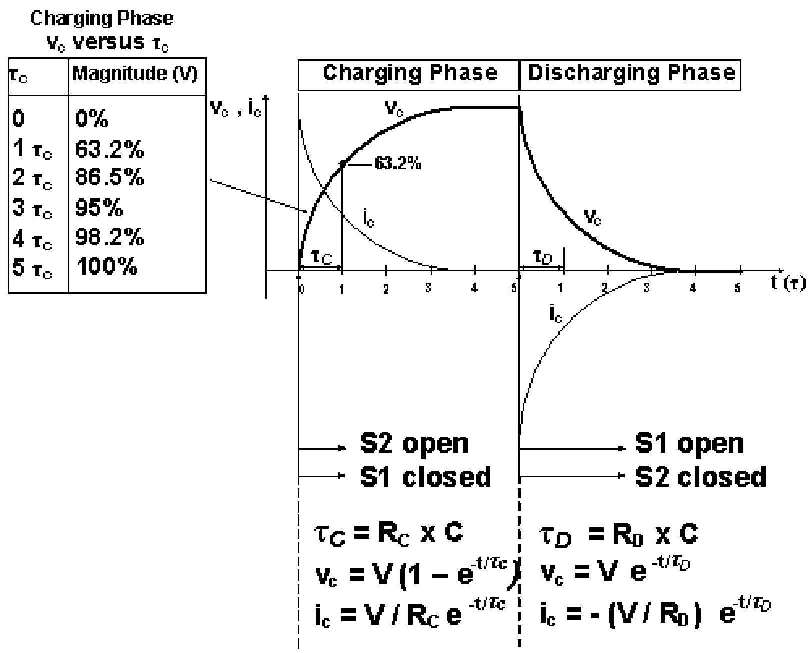


Figure 5: The Voltage v_c and the Current iC during the Charging Phase and Discharging Phase

The smaller the Resistance or the Capacitance, the smaller the Time Constant, the faster the charging and the discharging rate of the Capacitor, and vice versa.

Capacitors are found in almost all electronic circuits. They can be used as a fast battery. For example, a Capacitor is a storehouse of energy in photoflash unit that releases the energy quickly during short period of the flash.

Time constant

The RC time constant, also called tau, the time constant (in seconds) of an RC circuit, is equal to the product of the circuit resistance (in ohms) and the circuit capacitance (in farads), i.e.

It is the time required to charge the capacitor, through the resistor, from an initial charge voltage of zero to ≈63.2 percent of the value of an applied DC voltage, or to discharge the capacitor through the same resistor to ≈36.8 percent

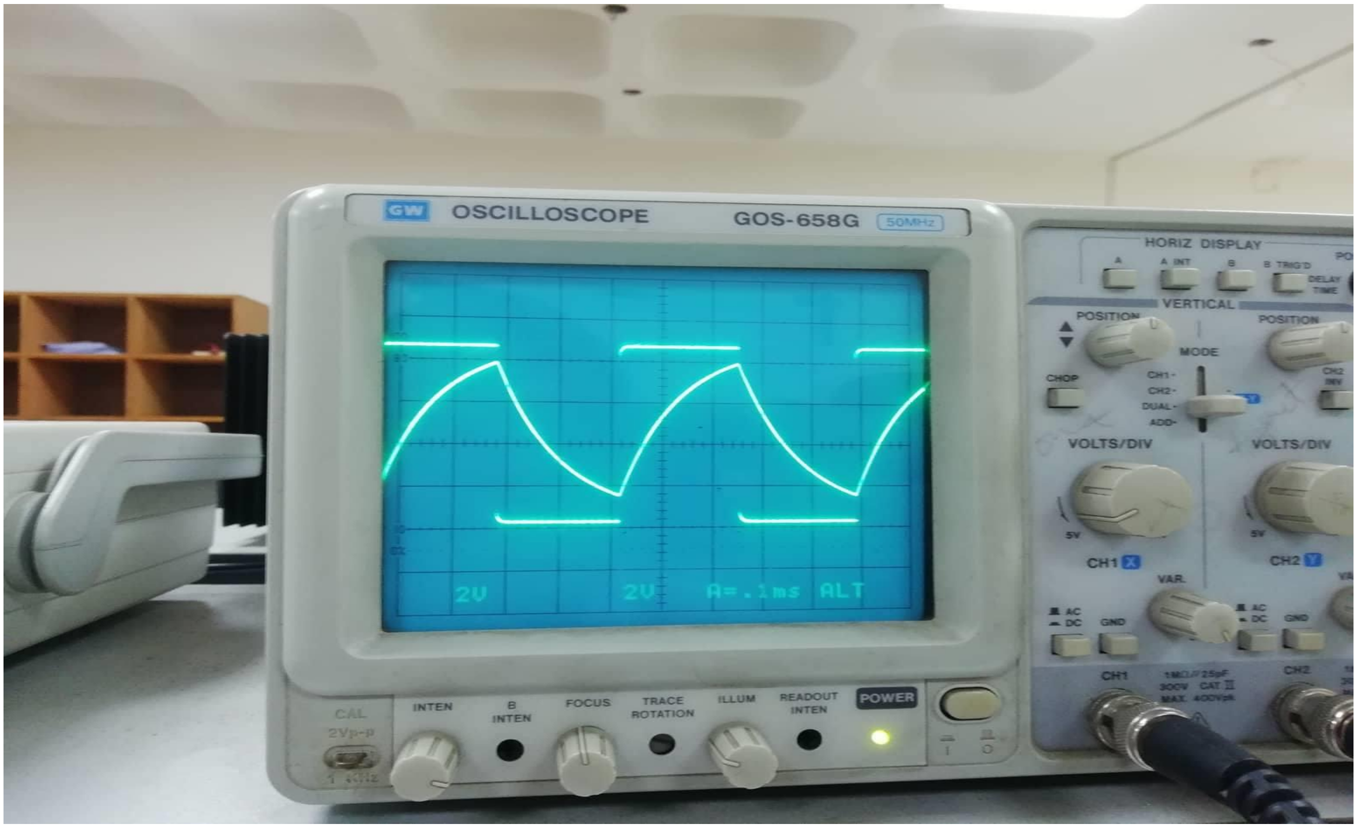
of its initial charge voltage. This value is derived from the mathematical constant e, specifically $1 - e^{-1}$ or e^{-1}, relating to the voltage across the capacitor versus time:

Charging toward applied voltage

$$V(t) = V_0\,(1 - e^{-t/RC}),$$

Discharging toward zero from initial voltage

$$V(t) = V_0 e^{-t/RC}$$


GW OSCILLOSCOPE GOS-658G 50MHz
2V 2V A=.1ms ALT
INTEN
B INTEN
FOCUS
TRACE ROTATION
ILLUM
READOUT INTEN
POWER
HORIZ DISPLAY
VERTICAL
POSITION
MODE
VOLTS/DIV
CH1
CH2


2.1421
k Hz
1M
100k
FREQUENCY
POWER
TTL/CMOS OUTPUT
DUTY
8

4. Result Analysis & Discussion

During this Experiment, our main aim was to understand the use of signals Generators and Oscilloscope and investigate the behavior of charging and discharging of RC circuits.

At first, to understand and become familiarized with the analysis of charging and discharging of RC circuits, we have gone through the theory portion of the conversion. From that part, we have learned about the use of signals Generators and Oscilloscope. After going through these parts, we have attained a brief understanding of the behavior of charging and discharging of RC circuits.

In the practical portion, we discuss about the difference between RC circuits and we saw the up-down and compression of sine-wave. We also found square wave which was compressed when the value is low.

From result analysis, we understood the charging and discharging RC.

Though we faced some problems the result was satisfactory.

8. Conclusion

We can saw that the behavior of charging and discharging of RC circuits was successful.