DR.BRR.GOVT.DEGREE COLLEGE, JADCHERLA

MAHABUBNAGAR. DIST. TELANGANA.

DEPARTMENT OF PHYSICS

Student study project on

CHARGING &DISCHARGING OF CAPACITOR IN R-C CIRCUIT

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CERTIFICATE

This is to certify that the project work entitled "**CHARGING&DISCHARGING OF CAPACITOR IN R-C CIRCUIT", Dr. BRR Government College Campus, Jadcherla, Mahabubnagar District, and Telangana.**"Is a bonafide work done by the students of III MPCs (EM). **A.RITHIK, A.M.SAIBALAJI, K .RAJKUMAR, T.PRADEEP KUMAR** my supervision for the award of Project Work in Physics, Department of Physics, Dr. BRR Government Degree College, Jadcherla and the work hasn't been submitted Physics other College / University either in part nor in full, for the award of any degree

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DECLARATION

We hereby declare that the project work entitled with " **CHARGING&DISCHARGING OF CAPACITOR IN R-C CIRCUIT** " is a genuine work done by us under the supervision of **B.Uday Kumar**, for the Department of Physics, Dr. BRR Government College, and it has not been under the submission to any other Institute / University either in part nor in full, for the award of any degree.

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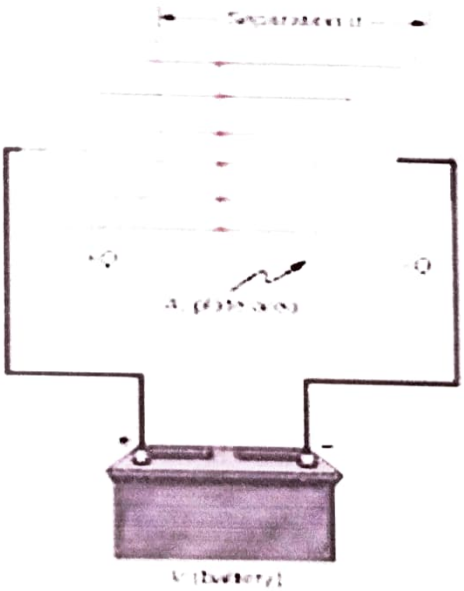
TOPIC

CHARGING & DISCHARGING OF CAPACITOR IN R-C CIRCUIT

AIM

To verify that 63% charge is stored in a capacitor in a R-C circuit at its time constant and 63% charge remains when capacitor is discharged and hence plot a graph between vo

lltage and time



INTRODUCTION

An R-C circuit is a circuit containing a resistor and capacitor in series to a power source. Such circuits Find very important applications in various areas of science and in basic circuits which act as building blocks of modern technological devices.

It should be really helpful if we get comfortable with the terminologies charging and discharging of capacitors.

1. Charging of Capacitor:-

A capacitor is a passive two-terminal electrical component used to store energy in an electric field. In the hydraulic analogy, charge carriers lowing through a wire are analogous to water flowing through a pipe. A capacitor is like a rubber membrane sealed inside a pipe. Water molecules cannot pass through the membrane, but some water can move by stretching the membrane. The analogy clarifies a few aspects of capacitors The low of current alters the charge a capacitor, just as the low of water changes the position of the membrane. More specifically, the effect of an electric current is to increase the charge of one plate of the capacitor, and decrease the charge of the other plate by an equal amount. This is just like how, when water low moves the rubber membrane, it increases the amount of water on one side of the membrane, and decreases the amount of water on the other side.

- The more a capacitor is charged, the larger its voltage drop; i.e., the more it "pushes back" against the charging current. This is analogous to the fact that the more a membrane is stretched, the more it pushes back on the water.

- Current can flow "through" a capacitor even though no individual electron can get from one side to the other. This is analogous to the fact that water can low through the pipe even though no water molecule can pass through the rubber membrane. the flow cannot continue the same direction forever; the capacitor will experience dielectric breakdown, and anologously the membrane will eventually break. The capacitance describes how much charge can be stored on one plate of a capacitor for a given "push" (voltage drop). A very stretchy, flexible membrane corresponds to a higher capacitance than a stiff membrane.A charged-up capacitor is storing potential energy, analogously to a stretched membrane.

2. Discharging of Capacitor:-

The capacitor remains fully charged as long as there is a constant supply applied to it. Now when this fully charged capacitor is disconnected from its DC battery supply, the stored energy accumulated during the charging process will stay indefinitely on its plates, keeping the voltage across its connecting terminals at a constant value.Now if the battery is replaced by a short circuit when the switch is closed, the capacitor would discharge itself back through the resistor, R as we now have an RC discharging circuit. As the capacitor keeps on discharging, its current through the series resistor the stored energy inside the capacitor is extracted with the voltage Vc across the capacitor that decays to zero finally.

REVIEW OF LITERATURE

The charging and discharging of capacitors is a fundamental concept in electrical engineering and plays a crucial role in various electronic systems. Here's a review of the charging and discharging processes of capacitors:

Charging of Capacitors:

- When a capacitor is connected to a voltage source, current flows into the capacitor, causing it to charge.
- Initially, the capacitor behaves as a short circuit, allowing maximum current to flow. As time progresses, the voltage across the capacitor increases, and the current gradually decreases.
- The charging process follows an exponential curve, where the voltage across the capacitor approaches the source voltage over time.
- The time constant (τ) of the charging process is determined by the product of the resistance and capacitance (RC). It represents the time it takes for the voltage across the capacitor to reach approximately 63.2% of its final value.

Discharging of Capacitors:

- When a charged capacitor is disconnected from the voltage source and connected to a resistor, it starts to discharge.
- Initially, the capacitor has a voltage equal to its initial charged voltage. As time progresses, the voltage across the capacitor decreases exponentially.
- The discharge process also follows an exponential curve, with the voltage across the capacitor decaying towards zero.
- The time constant (τ) of the discharging process is again determined by the product of the resistance and capacitance (RC).

Applications and Significance:Capacitors are used in various electronic applications, such as energy storage, power supply filtering, timin g circuits, and memory elements.

Understanding the charging and discharging processes of capacitors is essential for designing circuits, analyzing transient behaviors, and ensuring proper functionality of electronic systems.

Researchers have extensively studied the charging and discharging characteristics of capacitors in different circuit configurations, including series and parallel combinations, to optimize their performance and efficiency.

Overall, the charging and discharging of capacitors form the foundation for understanding transient responses and the behavior of electrical circuits. Through research and analysis, engineers have gained valuable insights into these processes, enabling the development of advanced electronic systems.

Materials Required: -

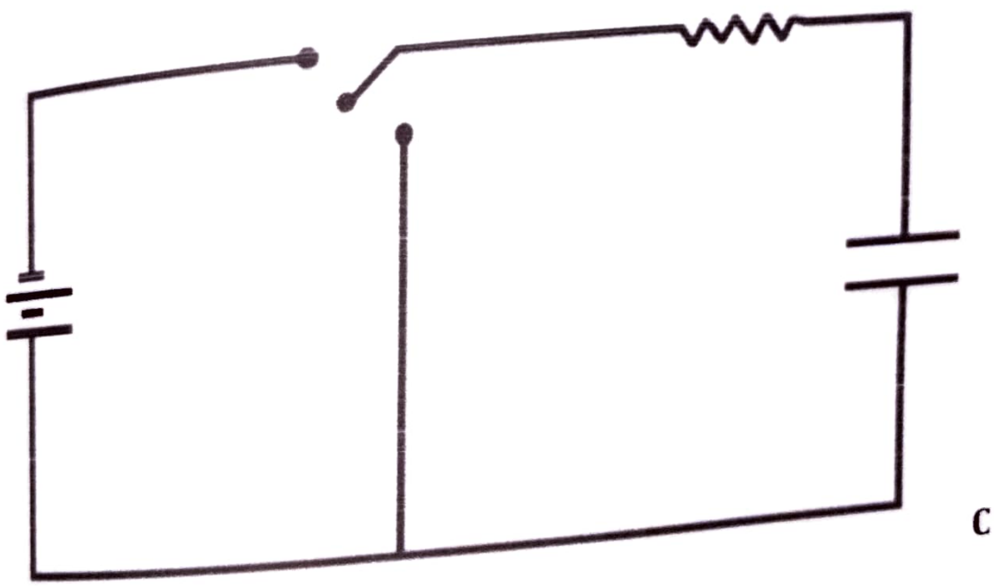
Materials are purchased from sri laxmi narsimha book store and Asro hard ware.

1. **Breadboard**
2. **100uF capacitor**
3. **1 MQ resistor**
4. **Multi-meter**
5. **9V battery**
6. **Wire stripper, connecting wires, battery connector**
7. **Stopwatch**

THEORY

When a capacitor of capacitance C is connected in series with a resistor of resistance R and then connected to a battery of EMF E it gets charged but since some resistance has been introduced, this charging process takes some time and hence the potential difference between the plates of the capacitor varies as an exponential function of time, i.e.

The circuit diagram for this experiment is given below:



Applying KIRCHHOFF'S LAW in the above circuit during charging i.e. Capacitor is connected to battery

Considering voltage law, the source voltage will be equal to the total voltage drop of the circuit.

Therefore,

$V = iR + v$ i-current

$V - v = iR$

$i = \frac{dQ}{dt}$

$Q = Cv$ Q-charge

$i = C\frac{dv}{dt}$, take C outside the derivative as it is a constant value

$V - v = R \cdot C\frac{dv}{dt}$

Rearrange the equation to perform the integration function,

$\frac{dt}{RC} = \frac{dv}{V - v}$

Intergrate both sides

$\int \frac{dt}{RC} = \int \frac{dv}{V - v}$

RHS simplification,

$u = V - v$

$\frac{du}{dv} = -1$

$du = -dv$

$-\int \frac{1}{u} du = -logu$

$-logu = -log(V - v)$

On integrating we get,

$\frac{t}{RC} + k = -log(V - v)$

$-\frac{t}{RC} + k = log(V - v)$

As we are considering an uncharged capacitor (zero initial voltage), the value of constant 'K ' can be obtained by substituting the initial conditions of the time and voltage. At the instant of closing the switch, the initial condition of time is t=0 and voltage across the capacitor is v=0.

Thus we get, logV=k for t=0 and v=0

Substitute the value of K as $logV$

$$-\frac{t}{RC} + logV = log(V - v)$$

$$-\frac{t}{RC} = log(V - v) - logV$$

$$-\frac{t}{RC} = log\frac{(V - v)}{V}$$

Taking exponential on both sides,

$$e^{-\frac{t}{RC}} = \frac{V - v}{V}$$

$$Ve^{-\frac{t}{RC}} = V - v$$

$$v = V - Ve^{-\frac{t}{RC}}$$

$$v = V(1 - e^{-\frac{t}{RC}})$$

From the above expression, it is clear that the instantaneous voltage will be a result of factors such as capacitance, resistance in series with the capacitor, time and the applied voltage value.

As the value of the constant RC increases, the value of exponential function $e^{-\frac{t}{RC}}$ also increases. That is the rate of voltage rise across the capacitor will be lesser with respect to time. That shows the charging time of the capacitor increase with the increase in the time constant RC.

As the value of time 't' increases, the term $e^{-\frac{t}{RC}}$ reduces and it means the voltage across the capacitor is nearly reaching its saturation value.

Formula

The whole process takes some time and during this time there is an electric current through the connecting wires and the battery. q=ϵC(1−eCR−t) where q is the charge on the capacitor at time t,CR is called the time constant, ϵ is the emf of the battery.

Methology

Connect all the components in breadboard

- Now take multimeter leads and place them in the two terminals.

Setting Up the RC Circuit

The RLC circuit board that you will be using consists of three resistors and two capacitors among other elements. In theory you can, have different combinations of resistors and capacitors. In this experiment you will use the 33-12 and 100-2 resistors and the two capacitors.

1 Connect the far right output terminal of the signal interface to the 33-12 resistor at point.

2. 2 To bypass the inductor, connect a wire from point 8 to point 9.

3 Connect point 6 to the second output terminal of the signal interface to complete the circuit.

4 Connect the voltage probe into analog channel A.

5. To measure the voltage across the capacitor, connect the black lead of the voltage probe to point 6 and the red lead to point 9.Make sure that the ground of the interface (the lead) is connected to the same side of the capacitor as the ground of the signal generator (power output). When show coordinates is active, a read-out of the voltage and time is displayed wherever youdrag it, Using this tool, determine and record the starting time (when the trace started upward from 0 volts) on the worksheet.

Calculate 63.2% of the maximum voltage. AV (which should be 5 V), the setting on the amplitude of the signal generator. Using Show Coordinates, determine and record the starting time (ie. when the trace startedupward from 0 volts) on the worksheet. 13 From these two time values, determine and record the time required for the signal to go from AV=0 10 AV = 0.632AV,. This is your experimental value for RC.

On the worksheet, fill in the accepted values for the resistance and the capacitance, which are printed on the circuit board.Compute the experimental value of the capacitance using your experimental value for RC andthe accepted value of R. Record this on the worksheet.Compute the percent error using the two values for the capacitance.

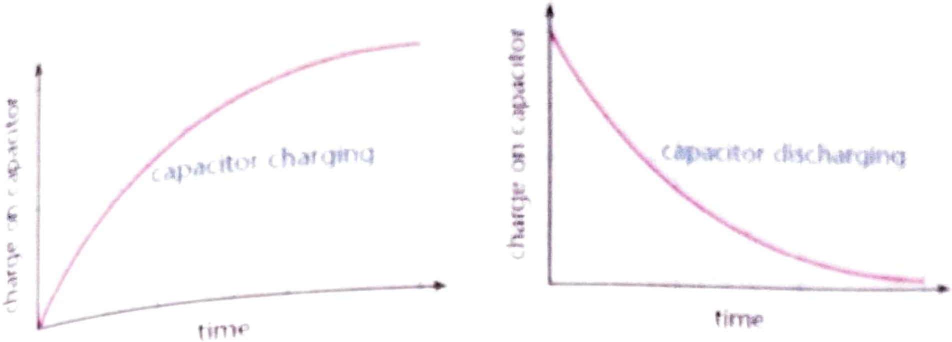
Procedure B: Calculation of Capacitance by Graphical Methods

Record the maximum voltage on the worksheet. From the recorded data, find the times at which AV1, 2, 3, and 4 volts on the rising part. of the curve using the smart tool. Record this information in Data Table I on the worksheet. Note: You might need to zoom in a lot to get the precision you need when using the smart tool plot -((AV-AV)/AV) versus time. Use the trendline option in Excel to draw the best fit line to your data, determine the slope of the line and record this value on the worksheet. From the value of the slope, determine the time constant and the capacitance. Compute the percent error between this value of the capacitance and the accepted value.

Procedure C: Measuring Effective Capacitance

Capacitance adds directly when capacitors are connected in parallel and inversely when con- nected in series. This is opposite of the rule for resistors. For capacitors in parallel, 2-1 Connect the second capacitor (330 μF) in parallel with the capacitor used in procedure A by connecting a wire from point 6 to point 7 Switch the resistor to the 10-12 resistor by moving the connection from point 2 to point 1. Once you have recorded the second data set, you might want to display only that data on the graph . You will be looking at just one wavelength in the graph display.

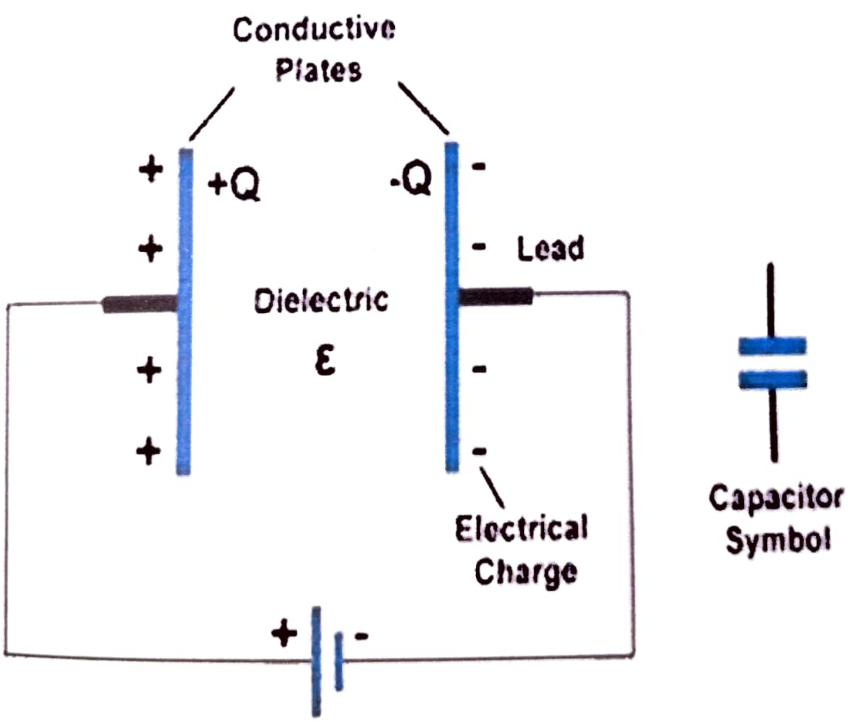
For this part of the experiment, you will consider the discharging portion of the curve Now the initial voltage AV will be the highest value of the peak before the graph starts to fall . find the times at which AV1, 2, 3, and 4 volts on the falling part of the curve using the smart tool. (Note: You might need to zoom in a lot to get the precision you need when using the smart tool). Record this information in Data Table 2 on the worksheet.Compare this experimental value with that you obtained from and the accepted values of the capacitance by computing the percent error between the two values.



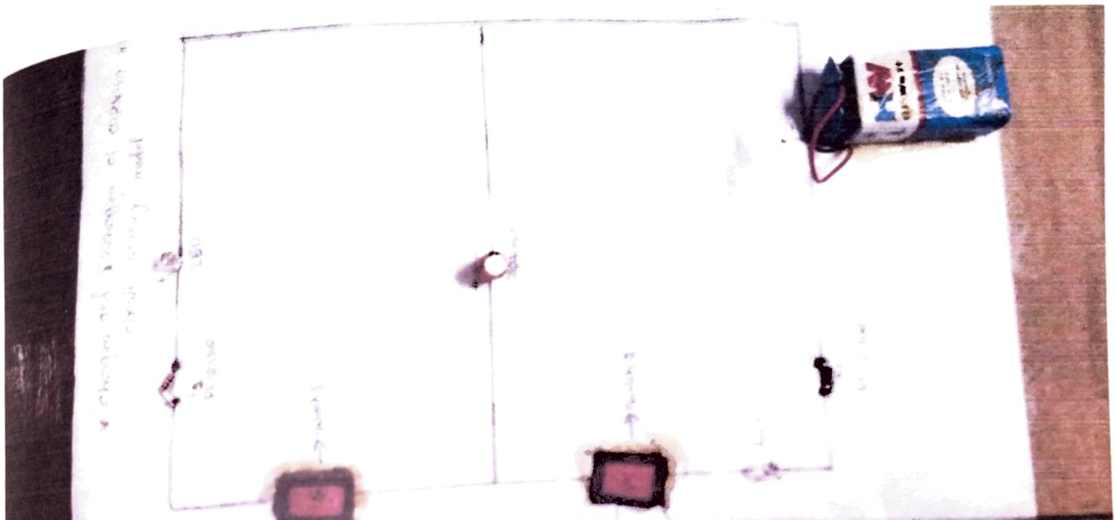
The charge on a capacitor during charging and discharging

CONCLUSION

Hence it is verified experimentally that 63% charge is there on capacitor after time constant during charging and 63% charge is lost at time constant during discacharging.



Making process



PRECAUTIONS

- Do all the connection carefully
- Do all the connection neat and tight
- Do not connect Led without resistance
- Keep yourself safe from high voltage

REFERENCES:-

1) Serway, R. Beichner, R. Physics for Scientists ans engineers with modern physics. Fifth edition. 2000.

2) Rentech.Experiments in electricity, student guide. 2013.