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Study of Charging and Discharging of Capacitor in Electrical & Electronics Circuits

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Introduction:-

*Just like the resistor the **Capacitor**, sometimes referred to as a **Condenser**, is a simple passive device that is used to "store electricity".The capacitor is a component which has the ability or "capacity" to store energy in the form of an electrical charge producing a potential difference (Static Voltage) across its plates, much like a small rechargeable battery.There are many different kinds of capacitors available from very small capacitor beads used in resonance circuits to large power factor correction capacitors, but they all do the same thing, they store charge.*

*In its basic form, a capacitor consists of two or more parallel conductive (metal) plates which are not connected or touching each other, but are electrically separated either by air or by some form of a good insulating material such as waxed paper, mica, ceramic, plastic or some form of a liquid gel as used in electrolytic capacitors. The insulating layer between a capacitors plates is commonly called the **Dielectric**.*

A Typical Capacitor

Due to this insulating layer, DC current can not flow through the capacitor as it blocks it allowing instead a voltage to be present across the plates in the form of an electrical charge.

The conductive metal plates of a capacitor can be either square, circular or rectangular, or they can be of a cylindrical or spherical shape with the general shape, size and construction of a parallel plate capacitor depending on its application and voltage rating.When used in a direct current or DC circuit, a capacitor charges up to its supply voltage but blocks the flow of current through it because the dielectric of a capacitor is non-conductive and basically an insulator. However, when a capacitor is connected to an alternating current or AC circuit, the flow of the current appears to pass straight through the capacitor with little or no resistance.There are two types of electrical charge, positive charge in the form of Protons and negative charge in the form of Electrons. When a DC voltage is placed across a capacitor, the positive (+ve) charge quickly accumulates on one plate while a corresponding and opposite negative (-ve) charge accumulates on the other plate. For every particle of +ve charge that arrives at one plate a charge of the same sign will depart from the -ve plate.Then the plates remain charge neutral and a potential difference due to this charge is established between the two plates. Once the capacitor reaches its steady state condition an electrical current is unable to flow through the capacitor itself and around the circuit due to the insulating properties of the dielectric used to separate the plates.

The flow of electrons onto the plates is known as the capacitors **Charging Current** which continues to flow until the voltage across both plates (and hence the capacitor) is equal to the applied voltage Vc. At this point the capacitor is said to be "fully charged" with electrons.

The strength or rate of this charging current is at its maximum value when the plates are fully

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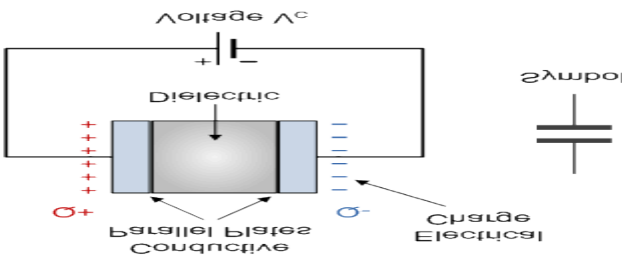
discharged (initial condition) and slowly reduces in value to zero as the plates charge up to a potential difference across the capacitors plates equal to the source voltage.

The amount of potential difference present across the capacitor depends upon how much charge was deposited onto the plates by the work being done by the source voltage and also by how much capacitance the capacitor has and this is illustrated below.



The parallel plate capacitor is the simplest form of capacitor. It can be constructed using two metal or metallised foil plates at a distance parallel to each other, with its capacitance value in Farads, being fixed by the surface area of the conductive plates and the distance of separation between them. Altering any two of these values alters the the value of its capacitance and this forms the basis of operation of the variable capacitors.Also, because capacitors store the energy of the electrons in the form of an electrical charge on the plates the larger the plates and/or smaller their separation the greater will be the charge that the capacitor holds for any given voltage across its plates. In other words, larger plates, smaller distance, more capacitance.

By applying a voltage to a capacitor and measuring the charge on the plates, the ratio of the charge Q to the voltage V will give the capacitance value of the capacitor and is therefore given as: $C = Q/V$ this equation can also be re-arranged to give the more familiar formula for the quantity of charge on the plates as: $Q = C \times V$

Although we have said that the charge is stored on the plates of a capacitor, it is more correct to say that the energy within the charge is stored in an "electrostatic field" between the two plates. When an electric current flows into the capacitor, charging it up, the electrostatic field becomes more stronger as it stores more energy.Likewise, as the current flows out of the capacitor, discharging it, the potential difference between the two plates decreases and the electrostatic field decreases as the energy moves out of the plates.The property of a capacitor to store charge on its plates in the form of an electrostatic field is called the **Capacitance** of the capacitor. Not only that, but capacitance is also the property of a capacitor which resists the change of voltage across it.

The Capacitance of a Capacitor

Capacitance is the electrical property of a capacitor and is the measure of a capacitors ability to store an electrical charge onto its two plates with the unit of capacitance being the **Farad** (abbreviated to F) named after the British physicist Michael Faraday.

Capacitance is defined as being that a capacitor has the capacitance of **One Farad** when a charge of **One Coulomb** is stored on the plates by a voltage of **One volt**. Note that capacitance, C is always positive in value and has no negative units. However, the Farad is a very large unit of measurement to use on its own so sub-multiples of the Farad are generally used such as micro-farads, nano-farads and pico-farads, for example.

Standard Units of Capacitance

- Microfarad (μF) 1μF = 1/1,000,000 = 0.000001 = 10^{-6} F
- Nanofarad (nF) 1nF = 1/1,000,000,000 = 0.000000001 =

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- 10^{-9} F
- Picofarad (pF) 1pF = 1/1,000,000,000,000 = 0.000000000001 = 10^{-12} F

Then using the information above we can construct a simple table to help us convert between pico-Farad (pF), to nano-Farad (nF), to micro-Farad (μF) and to Farads (F) as shown.

Pico-Farad (pF)	Nano-Farad (nF)	Micro-Farad (μF)	Farads (F)
1,000	1.0	0.001	
10,000	10.0	0.01	
1,000,000	1,000	1.0	
	10,000	10.0	
	100,000	100	
	1,000,000	1,000	0.001
		10,000	0.01
		100,000	0.1

Capacitance of a Parallel Plate Capacitor

The capacitance of a parallel plate capacitor is proportional to the area, A in metres^2 of the smallest of the two plates and inversely proportional to the distance or separation, d (i.e. the dielectric thickness) given in metres between these two conductive plates.

The generalised equation for the capacitance of a parallel plate capacitor is given as: $C = \varepsilon(A/d)$ where ε represents the absolute permittivity of the dielectric material being used. The permittivity of a vacuum, ε_o also known as the "permittivity of free space" has the value of the constant 8.84 x 10^{-12} Farads per metre. To make the maths a little easier, this dielectric constant of free space, ε_o, which can be written as: $1/(4\pi \times 9\times10^9)$, may also have the units of picofarads (pF) per metre as the constant giving: 8.84 for the value of free space. Note though that the resulting capacitance value will be in picofarads and not in farads.

Generally, the conductive plates of a capacitor are separated by some kind of insulating material or gel rather than a perfect vacuum. When calculating the capacitance of a capacitor, we can consider the permittivity of air, and especially of dry air, as being the same value as a vacuum as they are very close.

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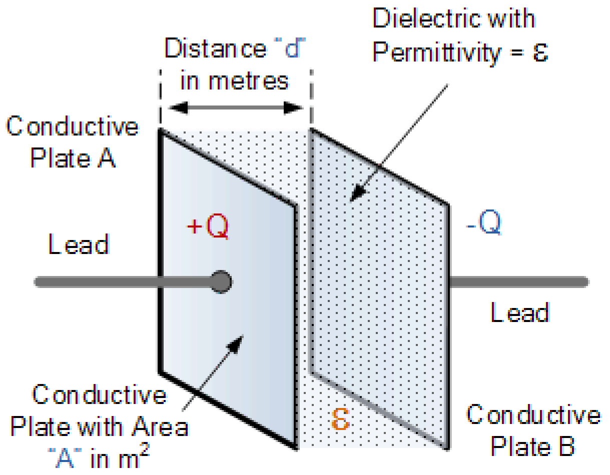

The Dielectric of a Capacitor

As well as the overall size of the conductive plates and their distance or spacing apart from each other, another factor which affects the overall capacitance of the device is the type of dielectric material being used. In other words the "Permittivity" (ε) of the dielectric.

The conductive plates of a capacitor are generally made of a metal foil or a metal film allowing for the flow of electrons and charge, but the dielectric material used is always an insulator. The various insulating materials used as the dielectric in a capacitor differ in their ability to block or pass an electrical charge.This dielectric material can be made from a number of insulating materials or combinations of these materials with the most common types used being: air, paper, polyester, polypropylene, Mylar, ceramic, glass, oil, or a variety of other materials.

The factor by which the dielectric material, or insulator, increases the capacitance of the capacitor compared to air is known as the **Dielectric Constant**, **k** and a dielectric material with a high dielectric constant is a better insulator than a dielectric material with a lower dielectric constant. Dielectric constant is a dimensionless quantity since it is relative to free space.

The actual permittivity or "complex permittivity" of the dielectric material between the plates is then the product of the permittivity of free space (ε_o) and the relative permittivity (ε_r) of the material being used as the dielectric and is given as:

Complex Permittivity

$$\varepsilon = \varepsilon_o \times \varepsilon_r$$

In other words, if we take the permittivity of free space, ε_o as our base level and make it equal to one, when the vacuum of free space is replaced by some other type of insulating material, their permittivity of its dielectric is referenced to the base dielectric of free space giving a multiplication factor known as "relative permittivity", ε_r. So the value of the complex permittivity, ε will always be equal to the relative permittivity times one.

Typical units of dielectric permittivity, ε or dielectric constant for common materials are: Pure Vacuum = 1.0000, Air = 1.0006, Paper = 2.5 to 3.5, Glass = 3 to 10, Mica = 5 to 7, Wood = 3 to 8 and Metal Oxide Powders = 6 to 20 etc. This then gives us a final equation for the capacitance of a capacitor as:

$$\text{Capacitance, } C = \frac{\varepsilon_o \varepsilon_r A}{d} \text{ Farads}$$

One method used to increase the overall capacitance of a capacitor while keeping its size small is to "interleave" more plates together within a single capacitor body. Instead of just one set of parallel plates, a capacitor can have many individual plates connected together thereby increasing the surface area, A of the plates.For a standard parallel plate capacitor as shown above, the capacitor has two plates, labelled A and B. Therefore as the number of

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capacitor plates is two, we can say that n = 2, where "n" represents the number of plates.

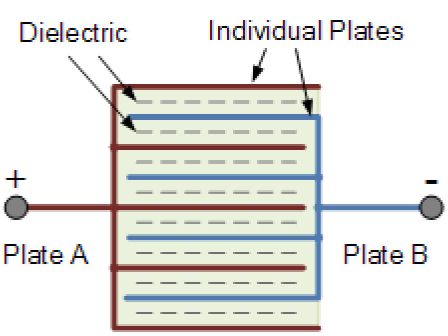
Then our equation above for a single parallel plate capacitor should really be:

$$\text{Capacitance, } C = \frac{\varepsilon_0 \varepsilon_r (n-1) A}{d} \text{ Farads}$$

However, the capacitor may have two parallel plates but only one side of each plate is in contact with the dielectric in the middle as the other side of each plate forms the outside of the capacitor. If we take the two halves of the plates and join them together we effectively only have "one" whole plate in contact with the dielectric. As for a single parallel plate capacitor, n – 1 = 2 – 1 which equals 1 as C = ($\varepsilon_o.\varepsilon_r$ x 1 x A)/d is exactly the same as saying: C = ($\varepsilon_o.\varepsilon_r$.A)/d which is the standard equation above.

Now suppose we have a capacitor made up of 9 interleaved plates, then n = 9 as shown.

Multi-plate Capacitor



8 mini capacitors in one

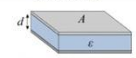
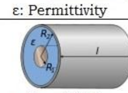
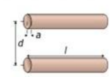
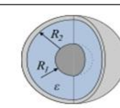
Now we have five plates connected to one lead (A) and four plates to the other lead (B). Then BOTH sides of the four plates connected to lead B are in contact with the dielectric, whereas only one side of each of the outer plates connected to A is in contact with the dielectric. Then as above, the useful surface area of each set of plates is only eight and its capacitance is therefore given as:

$$C = \frac{\varepsilon_0 \varepsilon_r (n-1) A}{d} = \frac{\varepsilon_0 \varepsilon_r (9-1) A}{d} = \frac{\varepsilon_0 \varepsilon_r 8A}{d}$$

Modern capacitors can be classified according to the characteristics and properties of their insulating dielectric:

- Low Loss, High Stability such as Mica, Low-K Ceramic, Polystyrene.
- Medium Loss, Medium Stability such as Paper, Plastic Film, High-K Ceramic.
- Polarized Capacitors such as Electrolyte's, Tantalum's.

Capacitance of Simple Systems

Type	Capacitance	Comment
Parallel Plate Capacitor	$\varepsilon A / d$	 ε: Permittivity
Coaxial cable	$\frac{2\pi\varepsilon l}{\ln(R_2/R_1)}$	 ε: Permittivity
Pair of parallel wires	$\frac{\pi\varepsilon l}{\operatorname{arcosh}\left(\frac{d}{2a}\right)} = \frac{\pi\varepsilon l}{\ln\left(\frac{d}{2a} + \sqrt{\frac{d^2}{4a^2} - 1}\right)}$	
Wire parallel to wall	$\frac{2\pi\varepsilon l}{\operatorname{arcosh}\left(\frac{d}{a}\right)} = \frac{2\pi\varepsilon l}{\ln\left(\frac{d}{a} + \sqrt{\frac{d^2}{a^2} - 1}\right)}$	a - Wire Radius; d - Distance, d > a; 1 - Wire Length
Two Parallel Coplanar Strips	$\varepsilon l \frac{K\left(\sqrt{1-k^2}\right)}{K(k)}$	d - Distance; w1, w2 - Strip Width; km - d/(2wm+d); k² - k1k2; K - Elliptic Integral; 1 - Length
Concentric Spheres	$\frac{4\pi\varepsilon}{\frac{1}{R_1} - \frac{1}{R_2}}$	 ε: Permittivity
Two Spheres, Equal Radius	$2\pi\varepsilon a \sum_{n=1}^{\infty} \frac{\sinh\left(\ln\left(D+\sqrt{D^2-1}\right)\right)}{\sinh\left(n \ln\left(D+\sqrt{D^2-1}\right)\right)}$ $= 2\pi\varepsilon a \left\{1 + \frac{1}{2D} + \frac{1}{4D^2} + \frac{1}{8D^3} + \frac{1}{8D^4} + \frac{3}{32D^5} + O\left(\frac{1}{D^6}\right)\right\}$ $= 2\pi\varepsilon a \left\{\ln 2 + \gamma - \frac{1}{2}\ln\left(\frac{d}{a} - 2\right) + O\left(\frac{d}{a} - 2\right)\right\}$	a - Radius; d - Distance, d > 2a; D = d/2a; γ - Euler's constant
Sphere in front of wall	$4\pi\varepsilon a \sum_{n=1}^{\infty} \frac{\sinh\left(\ln\left(D+\sqrt{D^2-1}\right)\right)}{\sinh\left(n \ln\left(D+\sqrt{D^2-1}\right)\right)}$	a - Radius; d - Distance, d > a; D = d/a
Sphere	$4\pi\varepsilon a$	a - Radius
Circular Disc	$8\varepsilon a$	a - Radius
Thin Straight Wire, Finite Length	$\frac{2\pi\varepsilon l}{\Lambda}\left\{1 + \frac{1}{\Lambda}(1 - \ln 2) + \frac{1}{\Lambda^2}\left[1 + (1 - \ln 2)^2 - \frac{\pi^2}{12}\right] + O\left(\frac{1}{\Lambda^3}\right)\right\}$	a - Wire Radius; 1 - Length; Λ - ln (1/a)

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

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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.

(i) **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 flowing 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:

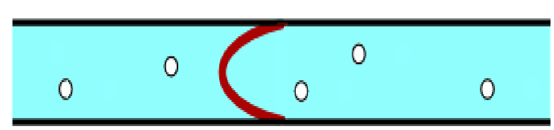
- *The flow of current alters the charge on a capacitor*, just as the flow of water changes the position of the membrane. More specifically, the effect of an electric current is to increase the charge of one plate of the capacitor, and decrease the charge of the other plate by an equal amount. This is just like how, when water flow 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 flow through the pipe even though no water molecule can pass through the rubber membrane. Of course, the flow cannot continue the same direction forever; the capacitor will experience dielectric breakdown, and analogously 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.

(ii) **Discharging of capacitor**:-

Using hydraulic analogy only we can understand that when the capacitor is charged the membrane is stretched, but now if you allow the water to come out slowly and let the membrane relax, then it is called discharging of capacitor. In other words when the charge on each of the plates becomes zero and the potential difference across its terminals drops to zero. Below is a graphical description of capacitor as a pipe with a membrane:-

1. relaxed membrane (uncharged)

2. Streched membrane (charged)



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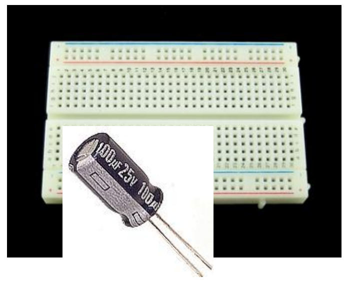
1. **Materials Required**:-
   1. Breadboard
   2. 100µF capacitor



   3. 1 MΩ resistor

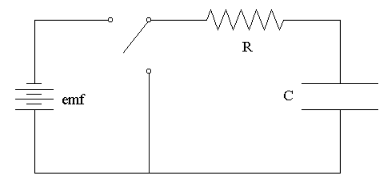
   4. multimeter

   5. 9V battery

   6. Wire stripper, connecting wires, battery connector and stopwatch

2. **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.
   $V \alpha e^{xt}$

The circuit diagram for this experiment is g



Applying Kirchhoff's law in the above circuit during charging, i.e. capacitor is connected to the battery

$E - V_c - iR=0$…………….. (i)

$V_c=\frac{Q}{C}$

Putting above value in eq. (i)

$E - \frac{Q}{C} - iR=0$

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

Therefore, $E - \frac{Q}{C} - \frac{dQ}{dt}R=0$

$E - \frac{Q}{C} =\frac{dQ}{dt}R$

$Ec-Q=\frac{dQ}{dt}RC$

Integrating both sides

$$\int_0^t \frac{1}{RC}\,dt=\int_0^Q \frac{1}{EC-Q}\,dQ$$

$$-\ln\frac{EC-Q}{EC} =\frac{t}{RC} \quad \text{............ (ii)}$$

$$1-\frac{Q}{EC} = e^{\frac{-t}{RC}}$$

Hence we get, $Q=EC\left(1 - e^{\frac{-t}{RC}}\right)$

Since $EC=Q_0$ for a capacitor

Therefore,

$Q=Q_0\left(1 - e^{\frac{-t}{RC}}\right)$……………….. (iii)

Here, Q → charge at time t

Q_o → max charge

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Also Q=CV and $Q_o=CV_o$, where V and V_o are voltage at time t and max voltage respectively

Therefore from eq (iii),

$$CV=CV_o\left(1-e^{\frac{-t}{RC}}\right)$$

$V=V_o\left(1-e^{\frac{-t}{RC}}\right)$, this is the required expression.

[NOTE:- This is the charging equation only, for discharging equation proceed the same way but only remove E from Kirchhoff law's equation]

Thus equation for discharging,

$$V=V_0\left(e^{\frac{-t}{RC}}\right)$$

When RC=t, then equation becomes,

$$V=V_o(1-e^{-1})$$

Which on solving gives

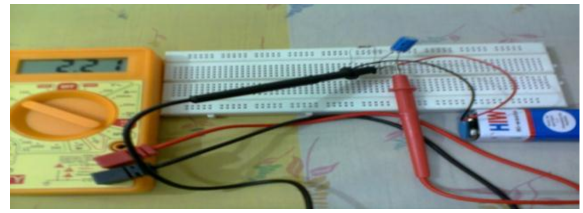
$V=0.63V_o$, i.e. the voltage on capacitor at time t=RC becomes 63% of the max voltage, which means 63% of total charge has been stored in the capacitor.

This product of R and C has been given a new name, i.e. **time constant** and is denoted by τ, which means for any capacitor in RC circuit 63% of total charge is stored at time constant.

In my experiment I have used a 100µF capacitor and a 1MΩ resistor thus time constant = $100\times10^{-6}\times10^{6}$=**100 sec**.

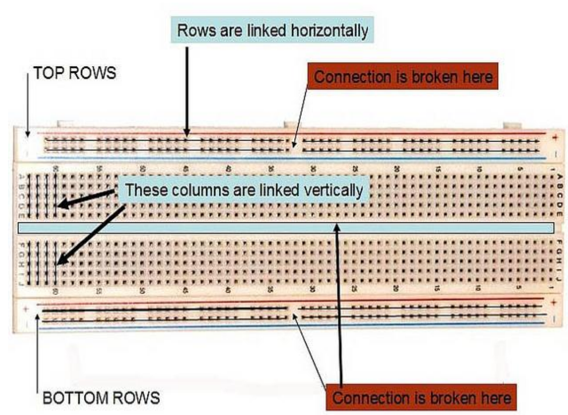
3. Procedure:-

(i) Connect all the components in the breadboard as shown in the following picture,



(ii) Now take multimeter leads and place them in the two terminals shaped like .

(iii) Before proceeding further we must have a bit of knowledge about breadboard. A breadboard is a simple circuit building device used to build temporary circuits just to test their working. It is very simple to work with as it does not require any soldering or attachment of components. The components could be just pushed in the holes and connections could be made easily. A straight line pattern of holes resembles a wire and the arrangement of these holes are shown below:-



S no.	Multimeter reading while charging (in volt)	Multi meter reading while discharging(in volt)	Time (in seconds)
1.	0	8.95	0
2.	1.65	7.34	20
3.	3.02	6.00	40
4.	4.11	4.91	60
5.	4.90	4.03	80
6.	**5.69**	**3.30**	**100 (τ)**
7.	6.72	2.21	140
8.	7.00	1.54	180
9.	8.12	0.74	250
10.	8.40	0.43	300

(iv) Now take the battery and connect its terminals across the terminals of the capacitor and start the stop watch. Note the readings at 20sec intervals and write them down. [NOTE:- Reading the previous statement could be astonishing as it says that measure voltage at 20sec interval but one could question that current move at very high speed so how could one measure the changing readings! But believe me it wasn't an easy task but since the voltage depends on reciprocal of exponential function and as time passes by the changing readings will get slowed down and even after infinite time the capacitor could not be charged up to max voltage. Also since its time constant is 100sec which is quite practical to measure at and hence this experiment is very much justified.]. Take 10

(v) readings and if required the 20sec gap could be increased because as the time passes by the change in voltage becomes smaller and smaller.

(vi) Now let the capacitor be charged up to 460 sec because then it will become 99.99% charged [since we have a limited time and we can't wait for infinite time for it to charge completely!]. Now remove the battery and now attach a wire in place of the battery terminals and again note the multimeter readings changing and record them.

(vii) Plot a graph between voltage and time for charging as well as discharging.

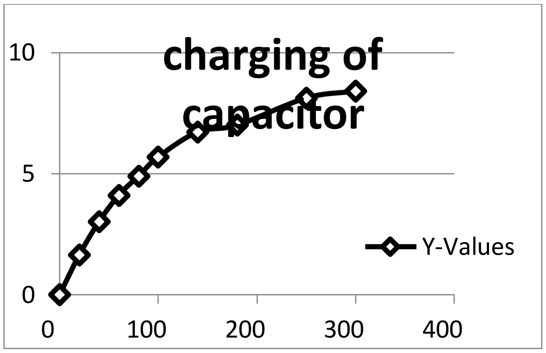
4. Results and Discussion

Graph:-

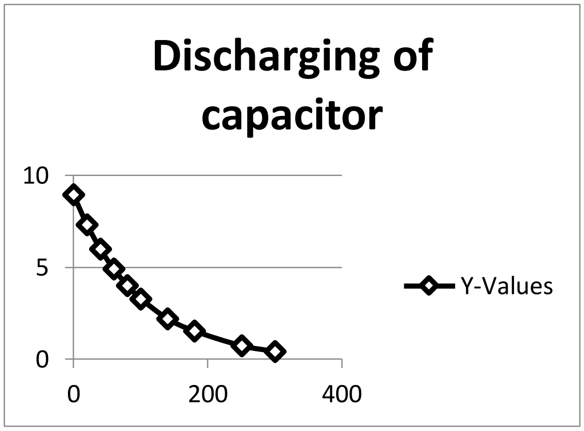
Plot of voltage v/s time

Time on x-axis and voltage on y-axis

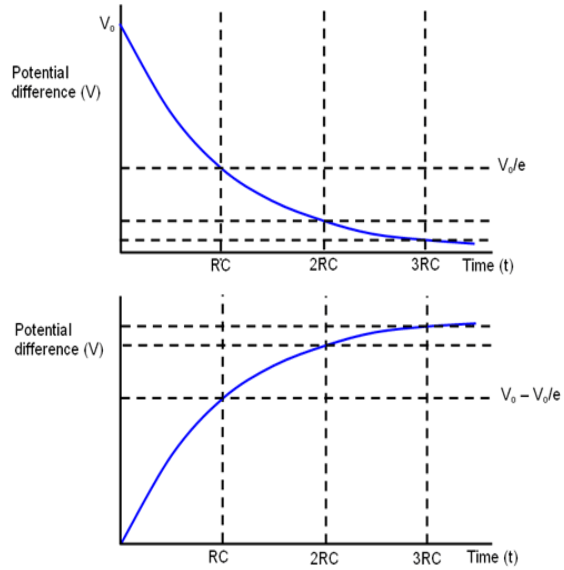
(i) For charging:-



(ii) For discharging:-



The original graphs for discharging and charging respectively are:-



Calculations:-

Now since the graphs are very much similar to the graphs of charging and discharging of capacitor.

At τ=100sec, during charging of capacitor the voltage on capacitor is 5.69 volt as it is observed in the experiment. Now using the charging formula:-

$V=9(1-e^{\frac{-t}{t}})$

$V=9(1-\frac{1}{e})$

$V=5.67\approx 5.69$ which is achieved experimentally as well.

Similarly during discharging,

$V=9*e^{-1}$

$V=3.32\approx 3.30$ which is achieved experimentally as well

Application of Capacitors

One of the most ubiquitous passive components used is the capacitor, found in nearly every electronic device ever made. Capacitors have a number of essential applications in circuit design, providing flexible filter options, noise reduction, power storage and sensing capabilities for designers.

Filter Applications

Combined with resistors, capacitors are often used as the main element of frequency selective filters.

The available filter designs and topologies are numerous and can be tailored for frequency and performance by selecting the proper component values and quality. Some of the types of filter designs include:

- High Pass Filter (HPF)
- Low Pass Filter (LPF)
- Band Pass Filter (BPF)
- Band Stop Filter (BSF)
- Notch Filter
- All Pass Filter
- Equalization Filter

Decoupling/By-Pass Capacitors

Capacitors play a critical role in the stable operation of digital electronics by protecting sensitive microchips from noise on the power signal which can cause anomalous behaviors. Capacitors used in this application are called decoupling capacitors and should be placed as close as possible to each microchip to be most effective, as all circuit traces act as antennas and will pick up noise from the surrounding environment. Decoupling and by-pass capacitors are also used in any area of a circuit to reduce the overall impact of electrical noise.

Coupling or DC Blocking Capacitors

Since capacitors have the ability to pass AC signals while blocking DC, they can be used to separate the AC and DC components of a signal. The value of the capacitor does not need to be precise or accurate for coupling, but it should be a high value as the reactance of the capacitor drives the performance in coupling applications.

Snubber Capacitors

In circuits where a high inductance load is driven, such as a motor or transformer, large transient power spikes can occur as the energy stored in the inductive load is suddenly discharged which can damage components and contacts. Applying a capacitor can limit, or snub, the voltage spike across the circuit, making operation safer and the circuit more reliable. In lower power circuits, using a snubbing technique can be used to prevent spikes from creating undesirable radio frequency interference (RFI) which can cause anomalous behavior in circuits and cause difficulty in gaining product certification and approval.

Pulsed Power Capacitors

At their most basic, capacitors are effectively tiny batteries and offer unique energy storage capabilities beyond those of chemical reaction batteries. When lots of power is required in a short period of time, large capacitors and banks

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of capacitors are a superior option for many applications. Capacitor banks are used to store energy for applications such as pulsed lasers, radars, particle accelerators, and railguns. A common application of the pulsed power capacitor is in the flash on a disposable camera which is charged up then rapidly discharged through the flash, providing a large pulse of current.

Resonant or Tuned Circuit Applications

While resistors, capacitors, and inductors can be used to make filters, certain combinations can also result in resonance amplifying the input signal. These circuits are used to amplify signals at the resonant frequency, create high voltage from low voltage inputs, as oscillators, and as tuned filters. In resonant circuits, care must be taken to select components that can survive the voltages that the components see across them or they will quickly fail.

Capacitive Sensing Application

Capacitive sensing has recently become a common feature in advanced consumer electronics devices, although capacitive sensors have been used for decades in a variety of applications for positions, humidity, fluid level, manufacturing quality control and acceleration.

Capacitive sensing works by detecting a change in the capacitance of the local environment through a change in the dielectric, a change in the distance between the plates of the capacitor, or a change in the area of a capacitor.

Capacitor Safety

A few safety precautions should be taken with capacitors. As energy storage components, capacitors can store dangerous amounts of energy that can cause fatal electrical shocks and damage equipment even if the capacitor was disconnected from power for a considerable amount of time. For this reason, it is always a good idea to discharge capacitors before working on electrical equipment.

Electrolytic capacitors are prone to fail violently under certain conditions, especially if the voltage on a polarized electrolytic capacitor is reversed. Capacitors used in high-power and high-voltage applications may also fail violently as the dielectric materials break down and vaporizes.

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 discharging.

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4.This project is completely created with the help of Microsoft word 2007 and the graphs, equations and observation tables are also created with the help of the same.