Lab 7: Charging and Discharging of RC circuits

DC: Direct current (DC) is the unidirectional flow of an electric charge. The electric current flows in a constant direction. So there is no change of current flow in respect to time. For this reason the frequency of direct current is 0 **(f = 0).**

AC: Alternating current (AC) is an electric current which periodically reverses direction, in contrast to direct current (DC) which flows only in one direction. As alternative current changes with time, frequency can be finding from the time period T.

$$\mathbf{f} = \frac{\mathbf{1}}{\boldsymbol{T}}$$

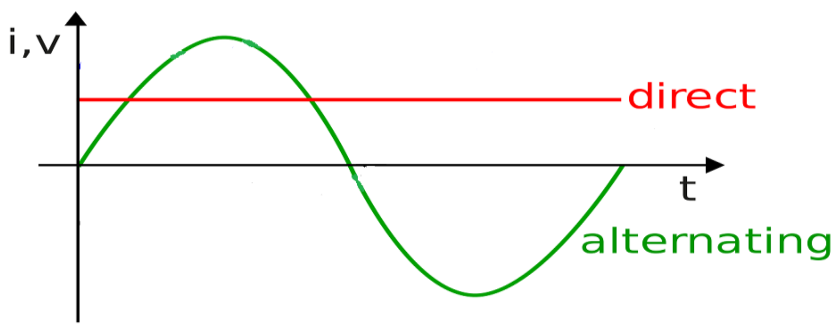
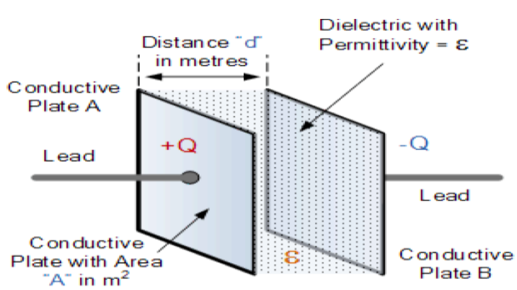


Figure: AC and DC voltage graph

Capacitor: Capacitor is an electronic component that stores electric charge.

Capacitor construction: The capacitor is made of 2 close conductors (usually plates) that are separated by a dielectric material, which is a poor conductor (or an insulator). When the two plates are connected to power supply (one connected to positive polarity, other connected to negative polarity) An electric field is generated across the dielectric (between the plates) due to which one plate accumulates positive charge and the other plate accumulates negative charge. There is no direct flow of current from one plate to other. The capacitance is the amount of electric charge that is stored in the capacitor at voltage of 1 Volt. It is measured in units of Farad (F).



$$C = \frac{\epsilon\ A}{d}$$

$$Q = CV$$

Figure: Internal structure of Capacitor

We Know, the capacitance of capacitor is

$$X_c = \frac{1}{jwC}$$

Where, w = angular frequency = 2πf

So, from the above equation, we see that when f = 0, 2π0, so angular frequency w = 0.
Placing w =0 in the above equation,

$$X_c = \frac{1}{j0C} = \frac{1}{0} = \infty$$

The capacitor is open circuit to direct current (DC) circuits and short circuit in alternating current (AC) circuits. That's why, we are using AC source for this experiment.

<u>RC circuits:</u>

AC Source:

Time varying signal: A signal whose values changes with time.

Peak Voltage = maximum voltage of a signal. It is often denoted by $\mathbf{V_p}$

Time period: Time required completing 1 cycle. It is denoted by **T.**

Frequency: No. of cycles completed in 1 second. It is denoted by **f.** Its unit is in Hz

A few examples of Time varying signals are:

1. Sin wave
2. Square wave
3. Triangular wave

A typical square wave looks like below:

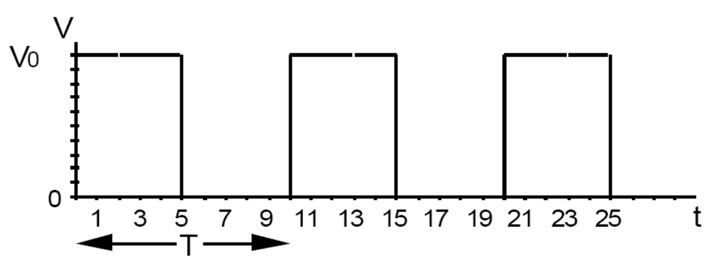


Figure: Square Signal

Where, V_0 = maximum voltage of amplitude

T = time period of the signal

Signal generator is a device that allows you to generate a time varying signal that have a particular frequency and amplitude (V_p). You can adjust your time period by adjusting your frequency.

Consider a series RC circuit with a time-varying input source (such as a square wave).

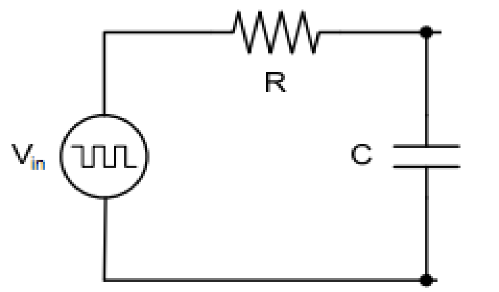


Figure: RC circuit

RC charging:

When the input is positive, the capacitor will charge up gradually through the resistor until the voltage across the capacitor reaches that of the supply voltage. The time also called the transient response, required for the capacitor to fully charge is equivalent to about **5 time constants or 5T**.

Voltage, V_c across the capacitor varies with time according to the formula:

$$\mathbf{V_c(t) = V_0\,(1 - e^{\frac{-t}{RC}})}$$

Where, V_0 = Amplitude of input signal

RC = Γ = time constant

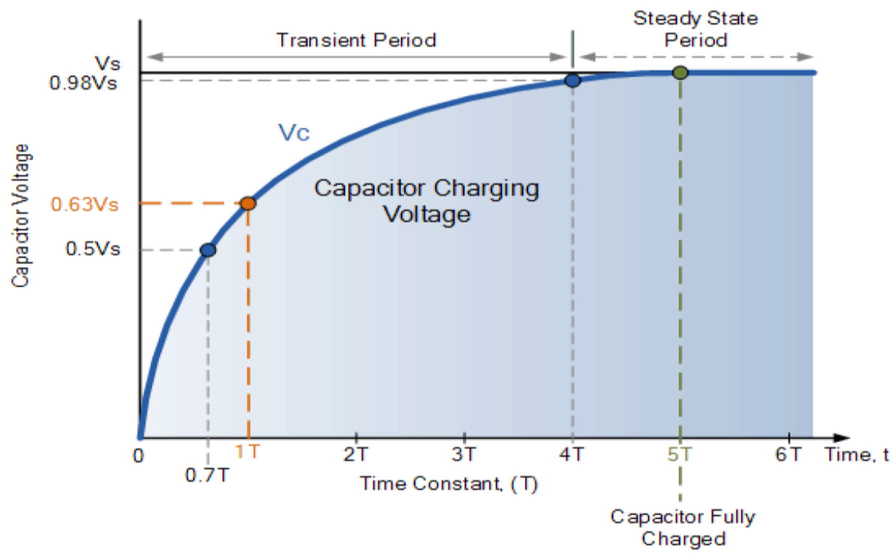


Figure: Capacitor charging graph

τ = R x C, in seconds, where R is the value of the resistor in ohms and C is the value of the capacitor in Farads. This then forms the basis of an RC charging circuit were 5T can also be thought of as “**5Γ**”.

RC discharging:

Now, when the input signal becomes negative, the capacitor would start discharging itself back through the resistor. For a RC discharging circuit, the voltage across the capacitor (V_c) as a function of time during the discharge period is defined as:

$$\mathbf{V_c\,(t) = V_0\, e^{\frac{-t}{RC}}}$$

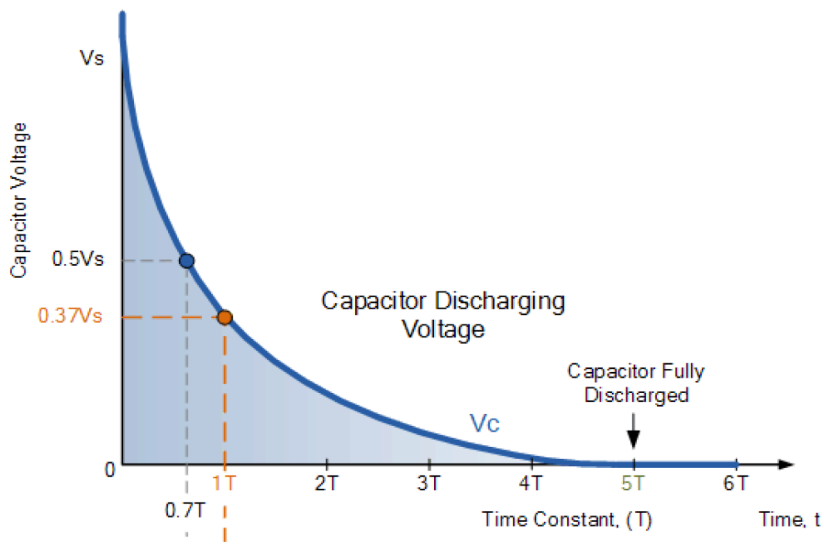


Figure: Capacitor discharging graph

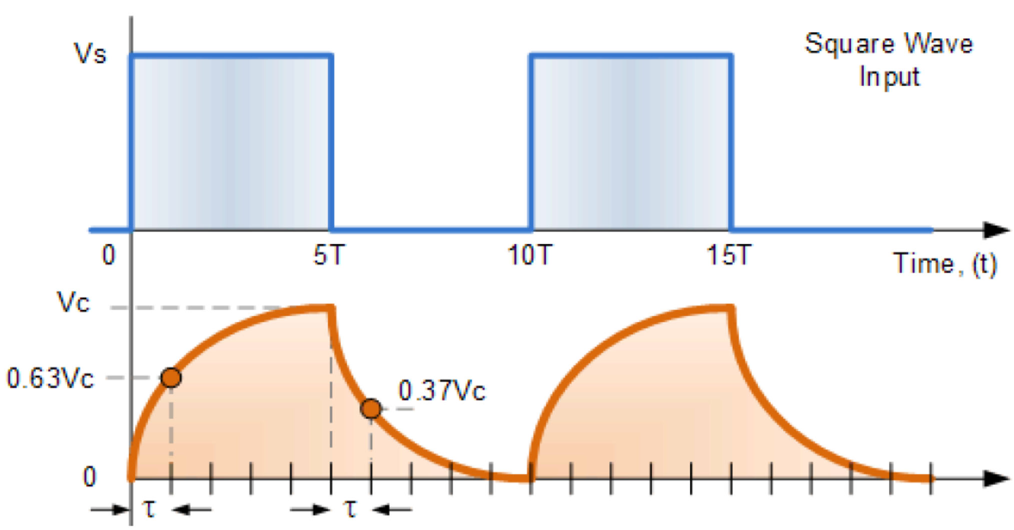


Figure: Input and Output voltage graph of RC circuit

From the above figure we can say that, the time when we get the maximum voltage across the capacitor is 5T or 5RC and maximum discharging time is 10T or 10 RC.

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Circuits: Simulate the following circuits using PSpice software

For both the circuits: V1 = VPULSE

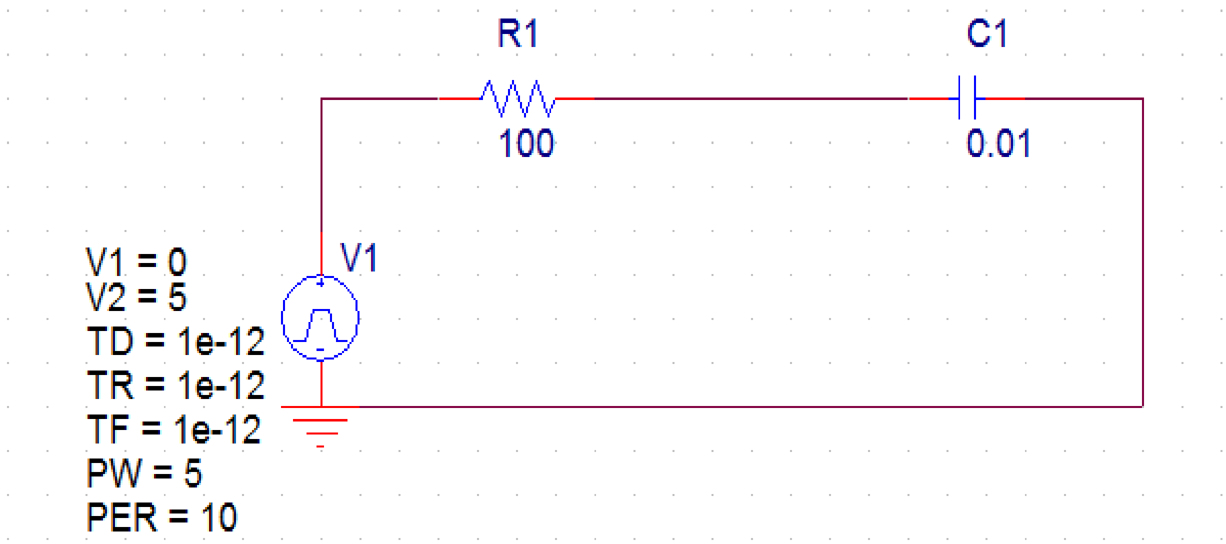

Figure 1

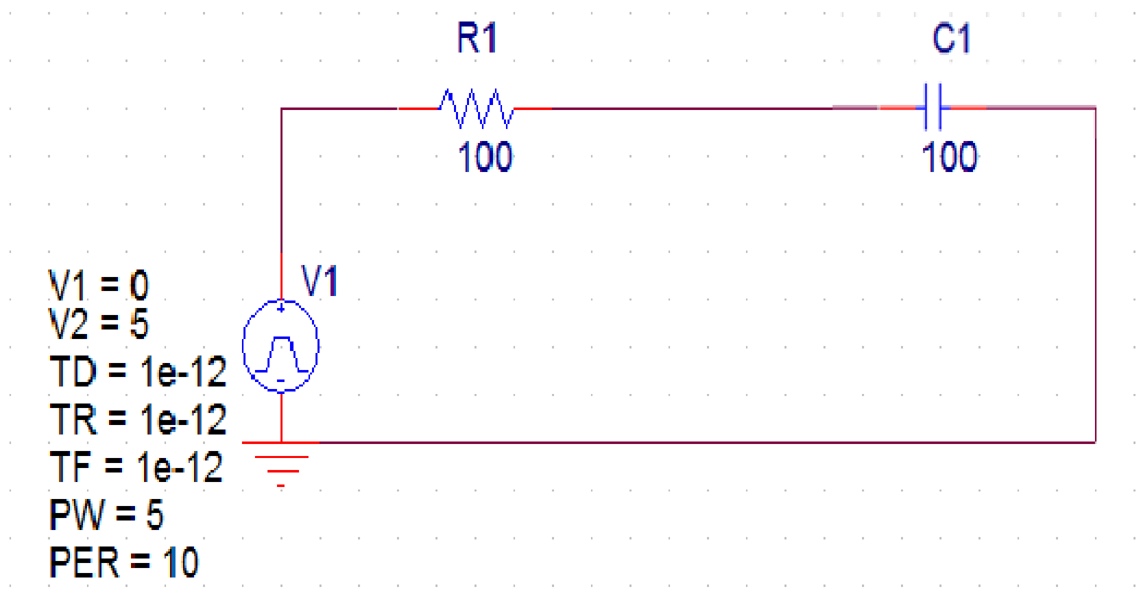

Figure 2

Data Sheet:

Input-Output graph of Circuit 1:

Input-Output graph of Circuit 2: