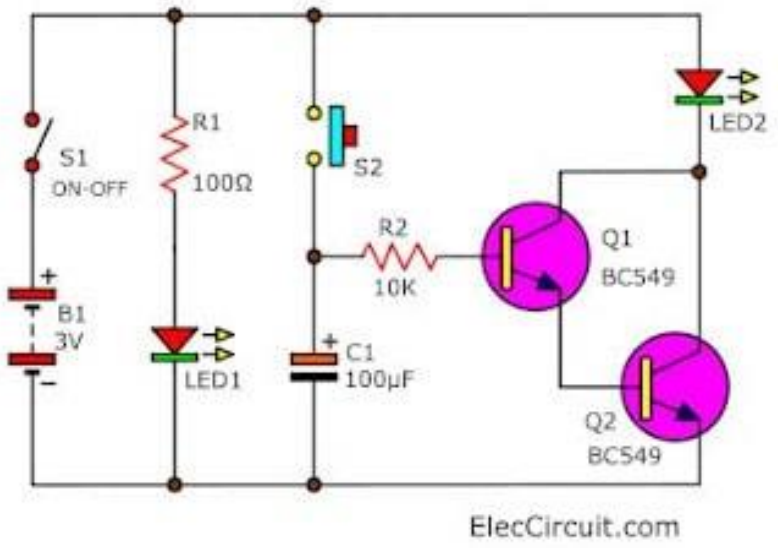
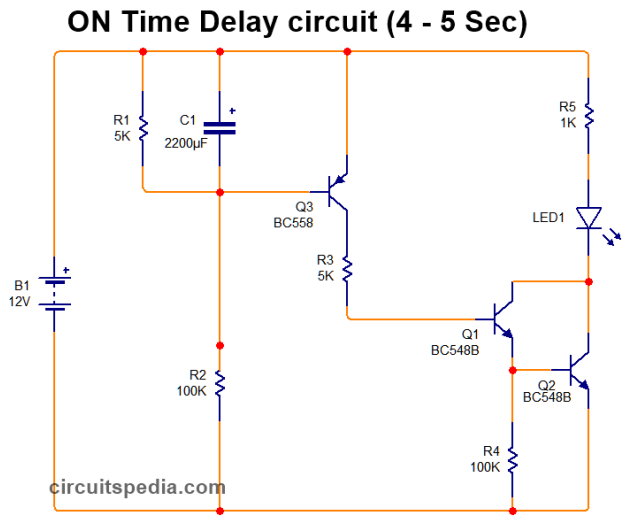
Aim:

To understand the working of an RC delay timer and simulate a simple delay timer with transistor as a switch

Introduction:

A time delay relay is a type of relay that has a built-in time delay function. This means the relay will not immediately activate when it is energized but will wait for a set amount of time before doing so. Time delay relays control the flow of electrical power and can be used to control power to many different types of electrical loads.

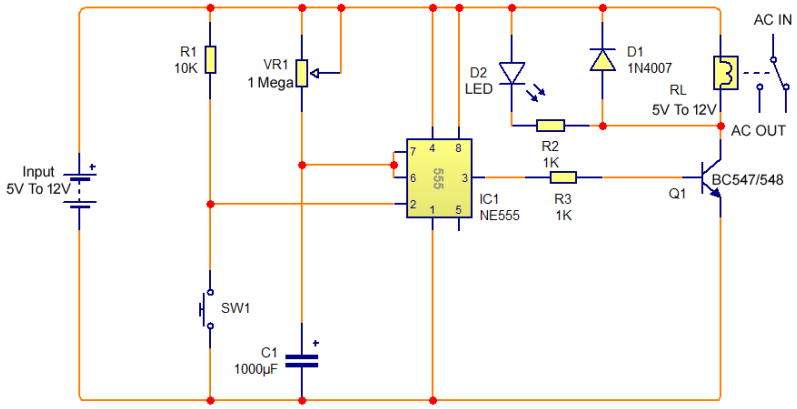




The types of time delays that are seen commonly are:

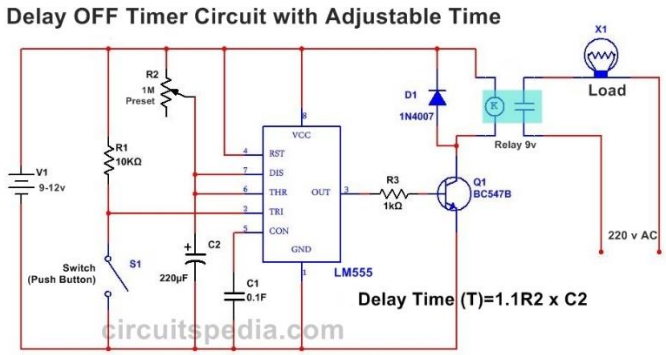
- ON-delay timers

  An ON-delay timer is a type of time delay relay used to control the activation of a circuit by delaying the initiation of current flow. ON-delay timers are typically used in applications where it is important to ensure that a circuit is not activated until after a certain amount of time has elapsed.



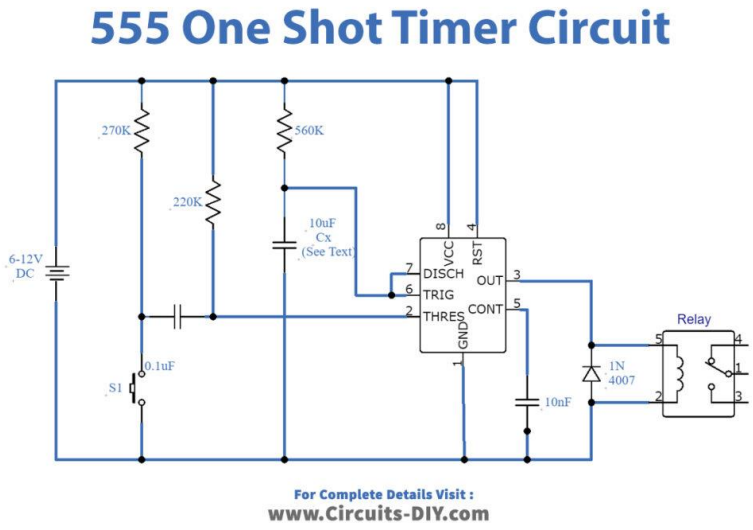
- OFF Delay Timers

  OFF-delay timers are a type of time delay relay that opens or closes the circuit as soon as power is removed. If you were to close the control switch again during timing, it would reset the time delay.



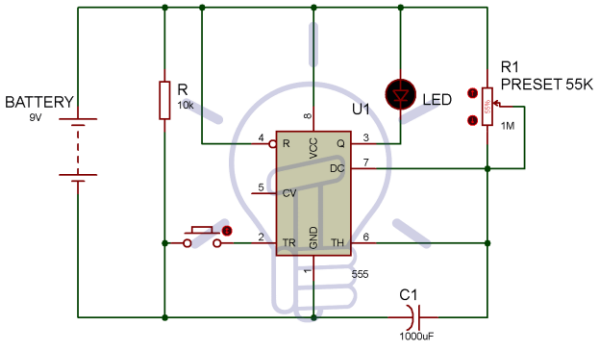
- One-Shot Timers

  One-shot timers are activated by power. As soon as power is applied, the contacts move to a different position. They stay in this new position for the time previously set and then return to their original spot.



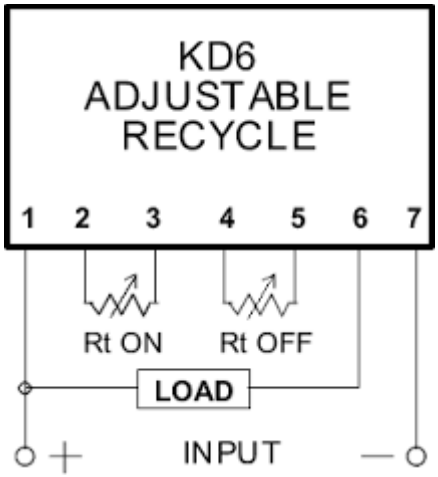
- Interval Timers

  These kinds of timers work by delaying the application of power to an electrical load until a specific time has elapsed. Once the timer has elapsed, the power is applied and remains on until the timer expires. At this point, power is removed from the load and remains off until power is reapplied.



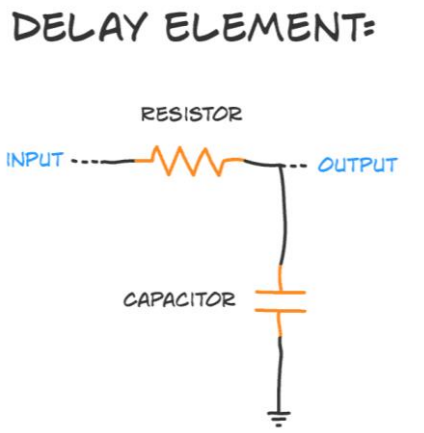
- Recycle Timers

  These timers conserve energy by turning a load off and on at regular intervals. They can also be used to create a flashing effect. Recycle timers are either single-function or multi-function devices.

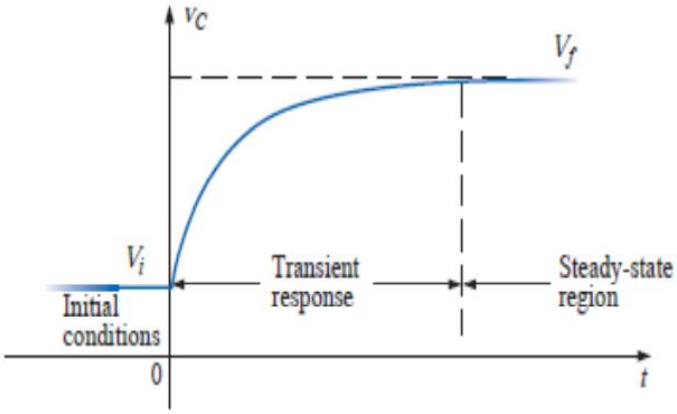


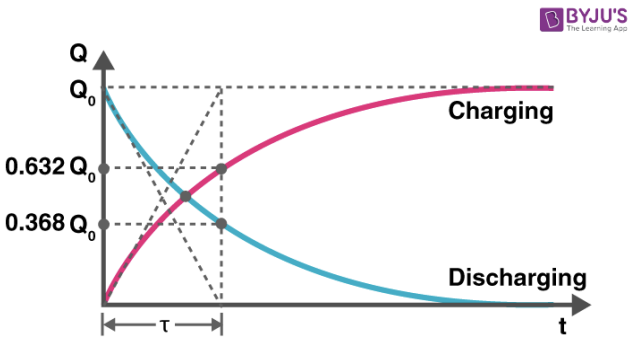
RC- Delay Timers:

The RC delay element is a way to create a time delay in your circuit by connecting a resistor and a capacitor.

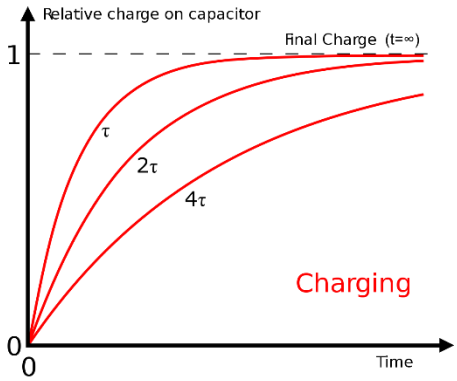


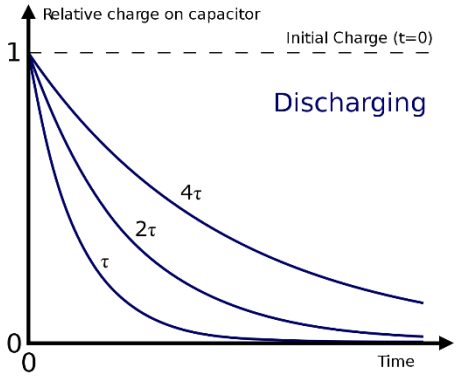
A capacitor is like a tiny little battery. You can charge it with a voltage. And you can use this voltage for a short time until the capacitor is discharged. The time it takes for the voltage to rise across the capacitor becomes our time delay.





A capacitor with a higher farad value can store more energy than one with a smaller value. Therefore, it also takes more time to charge a high-value capacitor versus a small-value capacitor. The “speed of the charging” is determined by how much current that flows through the capacitor. The more current that flows, the faster it charges.





The role of the resistor:

If we connect the capacitor directly to the battery, there is no restriction on the amount of current that flows through the capacitor.

So a lot of current flows, the capacitor charges really quick, and the delay becomes very small.

The task of the resistor is to reduce the flow of current to the capacitor to slow down the time it takes to charge it.

The RC Time Constant:

We calculate the delay time of the RC delay element with a simple formula:

$$\tau = R \times C$$

So, if your RC delay timer has only a resistor of 1 ohm and 1 capacitor of 1mF, then the delay time would be $\tau = 1\Omega \times 0.001F$

That would be 0.001 seconds of delay before there is power in the circuit.

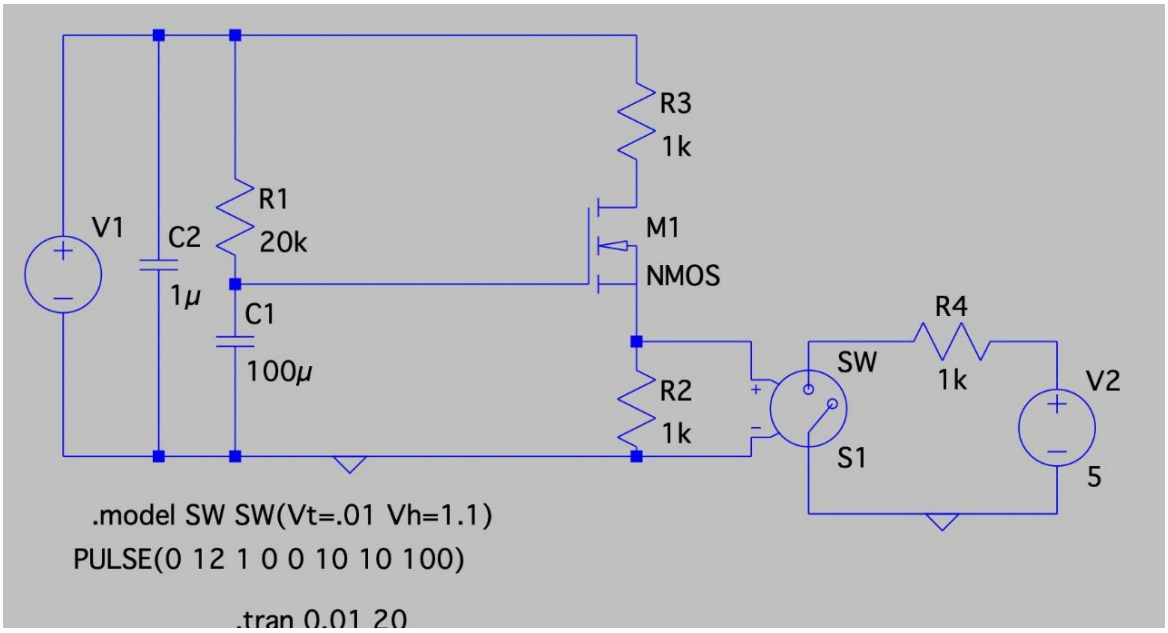
Instantaneous value :

Given a value of t and the transient phase the voltage or current at that time t (referred to as instantaneous value) can be found as

$$v_c(t) = V_f + (V_i - V_f)e^{-t/\tau} \quad \Rightarrow \quad t = \tau \times \ln\left(\frac{V_i - V_f}{v_c(t) - V_f}\right)$$

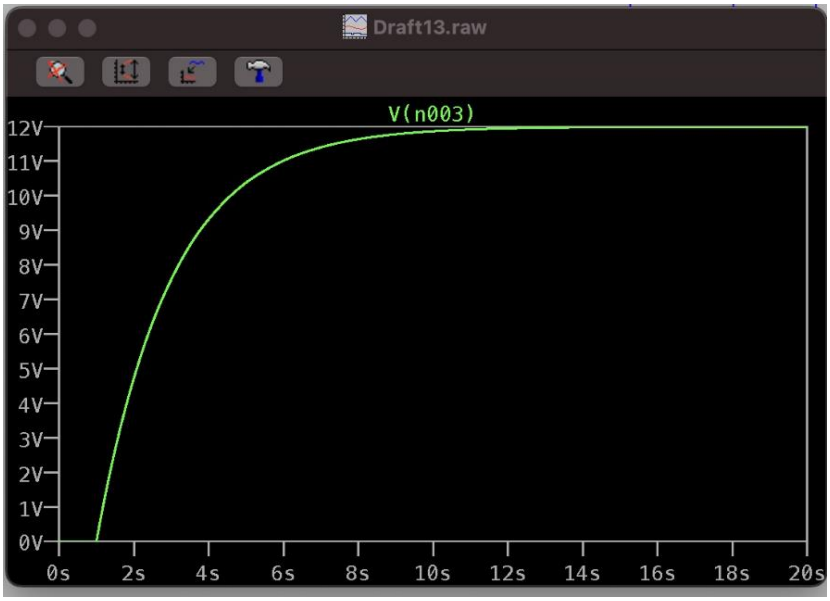
Simulation:

CIRCUIT

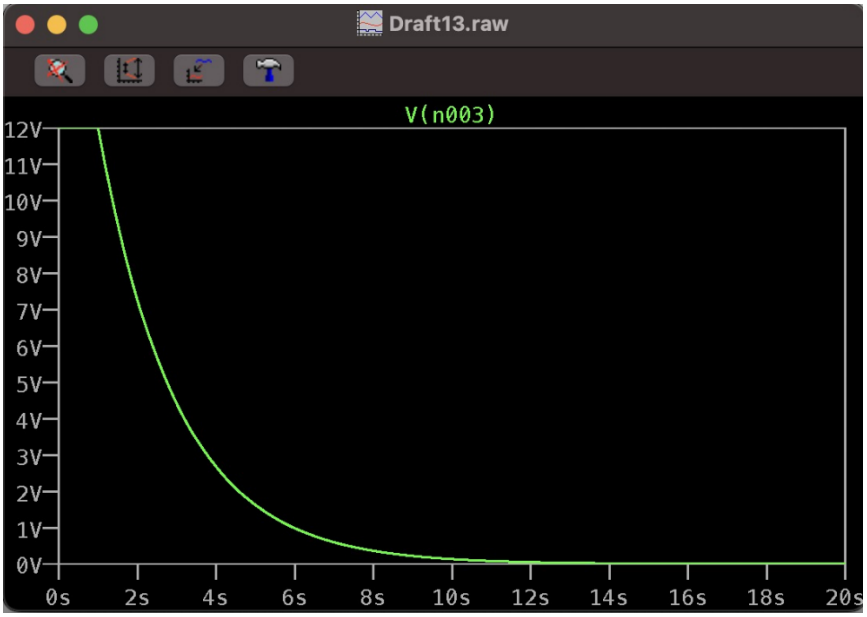


RESULT OF SIMULATION CIRCUIT – GRAPHS

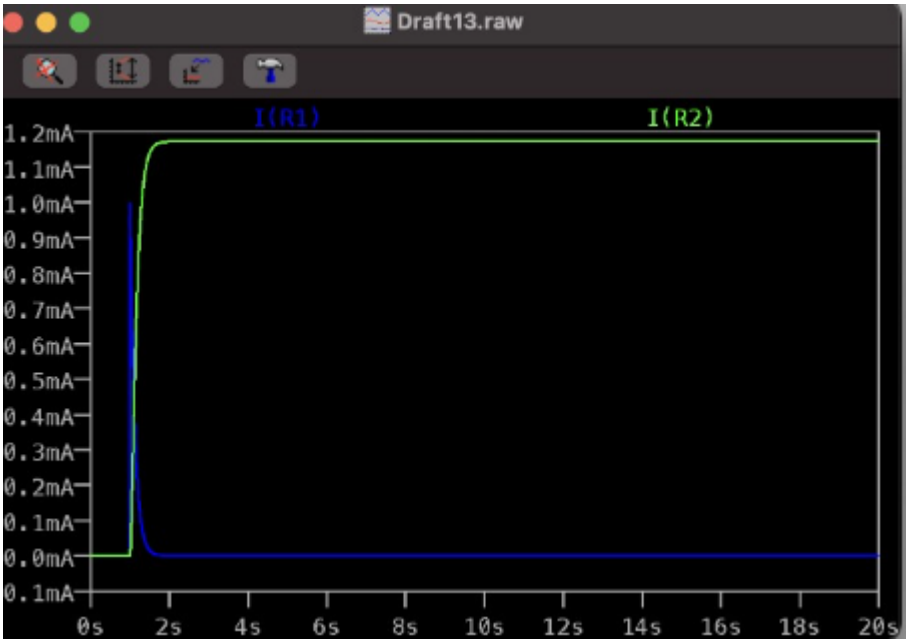
Capacitor charging



Capacitor discharging



Currents through R1 and R2

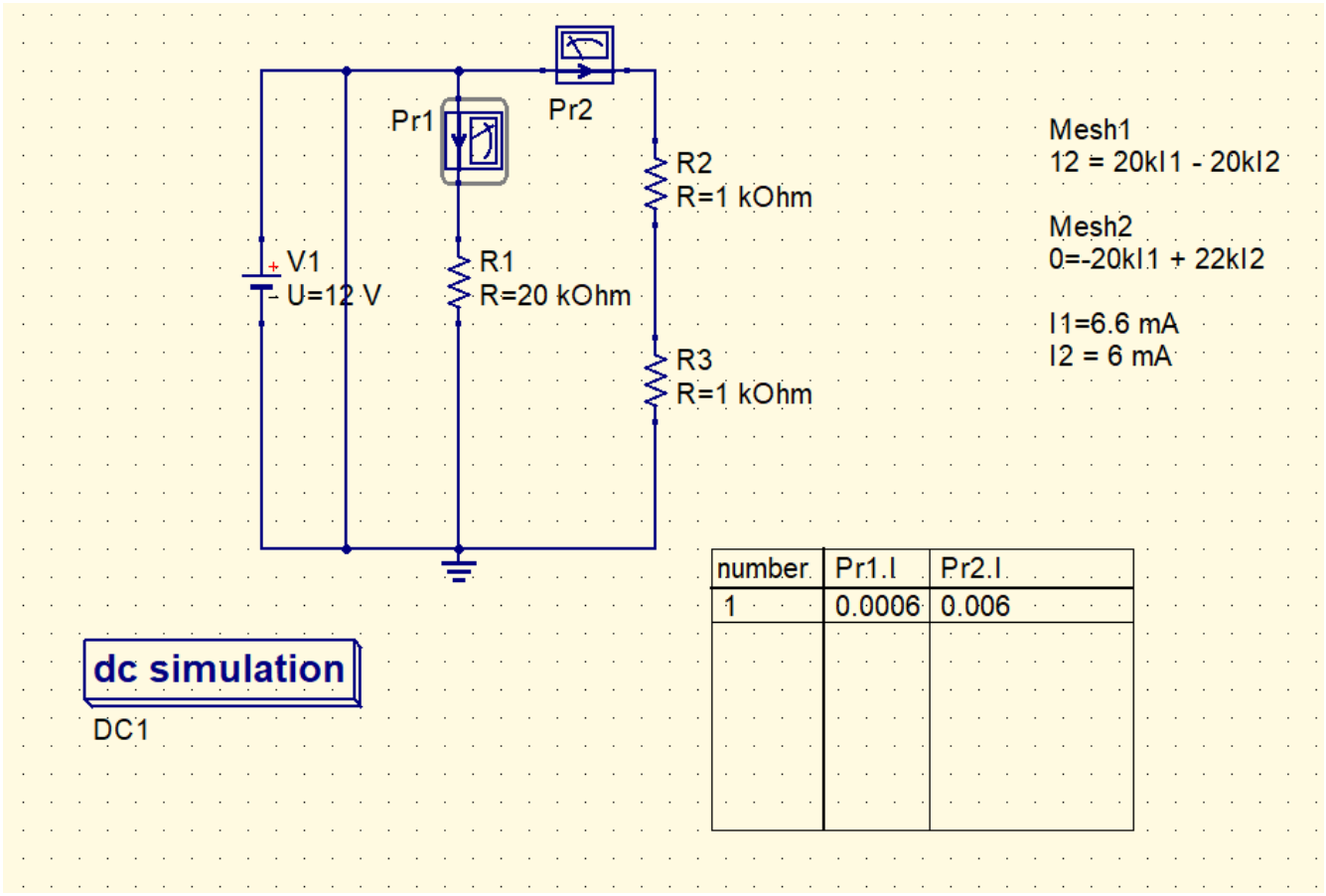


Analysis:

Mesh Analysis on the circuit

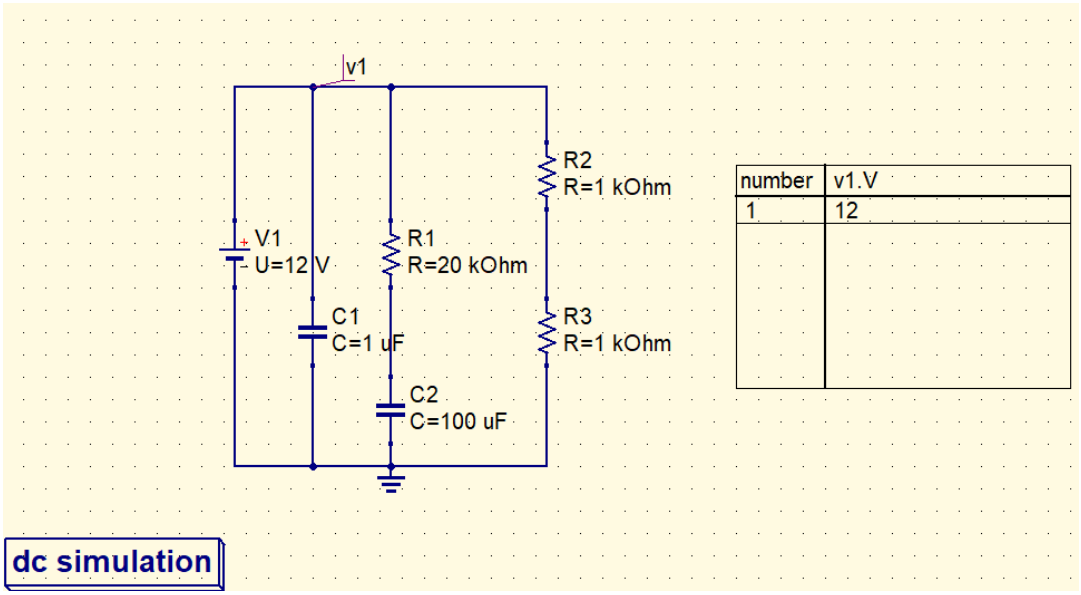
The capacitors in the circuit are functionally equivalent to storing and discharging energy. We shall consider

- capacitors as short-circuited elements when they're charging, and
- the MOSFET switch is OFF

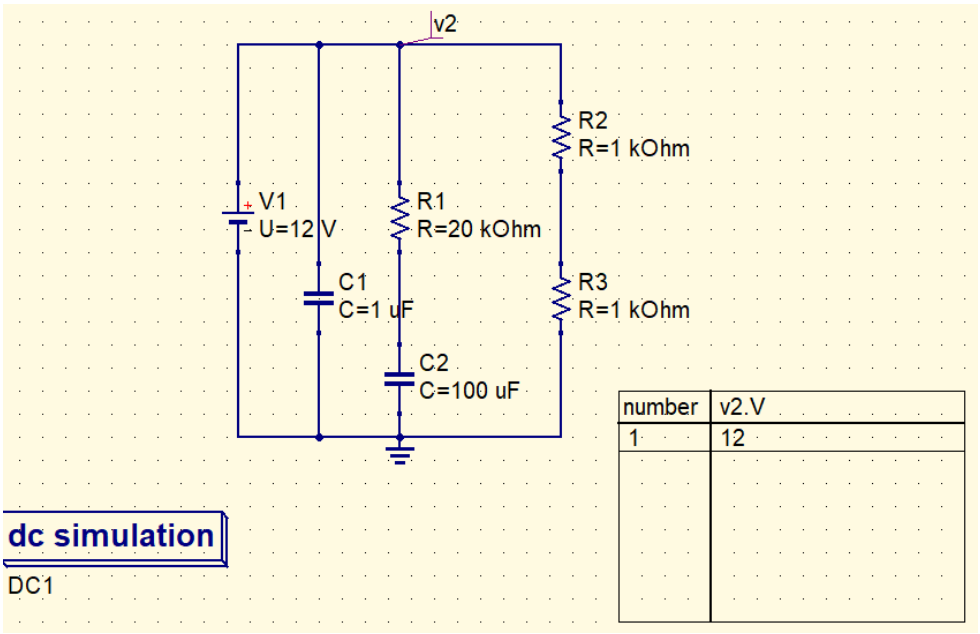


number	Pr1.I	Pr2.I
1	0.0006	0.006

Nodal Analysis:



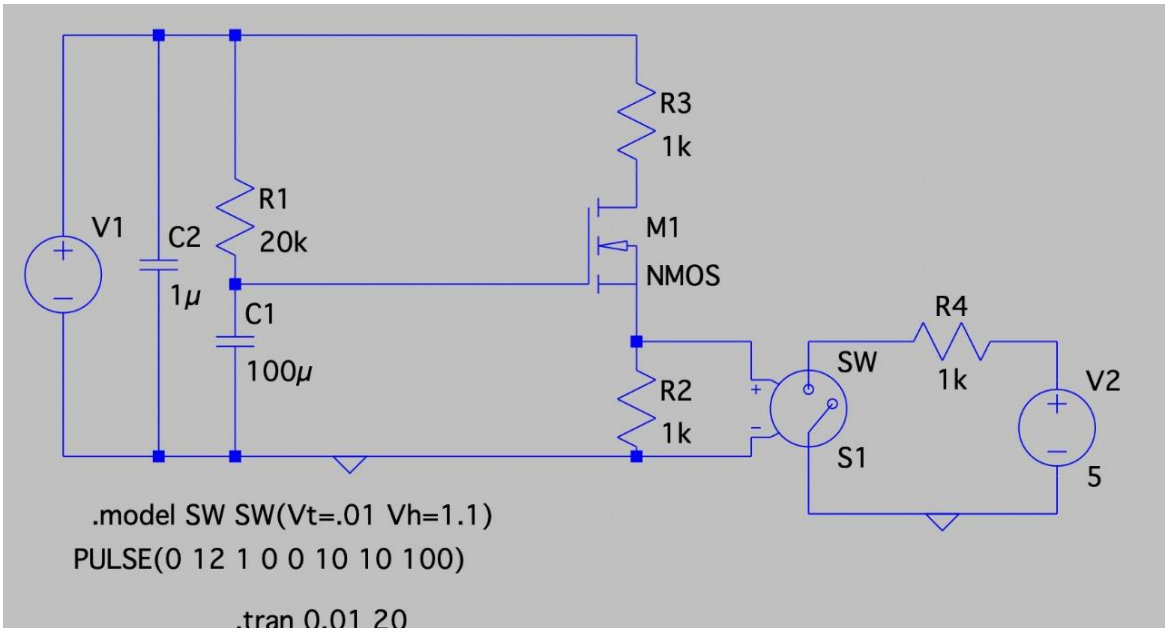
number	v1.V
1	12



number	v2.V
1	12

Observation:- There's no change in voltage at the two nodes. This is because of the nature of a capacitor which allows only AC current to pass through and blocks DC current

Transient Analysis:



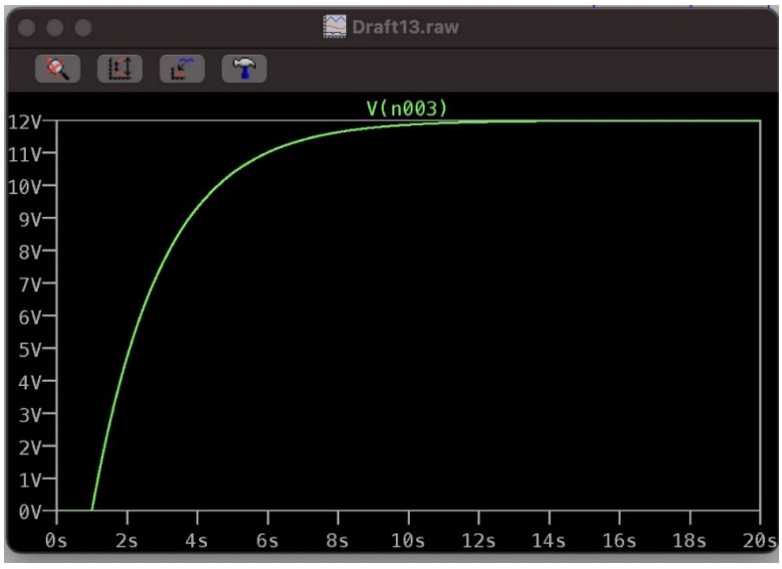
When capacitor is charging

$$v_c(t) = v_f + (v_i - V_f)e^{-t/\tau}$$

$$v_c(t) = 12\,(1 - e^{\frac{-t}{20k\ x\ 100u}})$$

$$v_c(t) = 12\left(1 - e^{\frac{-t}{2\,s}}\right)$$

$$i_c(t) = 600\ \mu A\ e^{-\frac{t}{2\,s}}$$

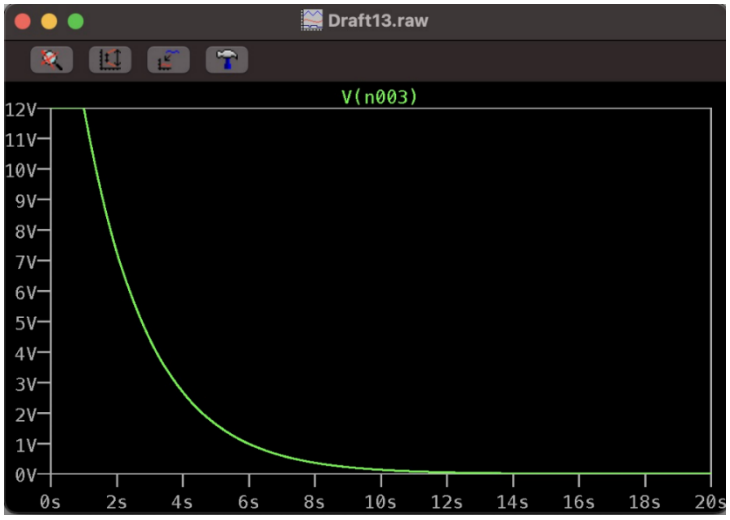


When capacitor is discharging

$$v_c(t) = 0 + (12 - 0)\, e^{-t/2s}$$

$$v_c(t) = 12\, e^{-t/2s}\, V$$

$$i_c(t) = -600\mu A\, e^{t/2s}$$



Conclusion:

The analysis of a simple RC delay timer has led to its use in industrial logic circuits. Some of them can be noted as: flashing light control, engine auto start control, furnace safety purge control, conveyor belt sequence delay etc. An RC delay is the simplest form of a time delay relay element that is widely used in many electronic systems.

References:

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