Transients in RC Circuits

Objective:

To Study the transient phenomenon in series RC Circuit.

Application:

1. RC circuit can be used to provide time delays. The warning blinkers usually found on road construction sites is an example. An electronic photoflash unit is another common example. ***It exploits the ability of the capacitor to oppose any abrupt change in voltage***
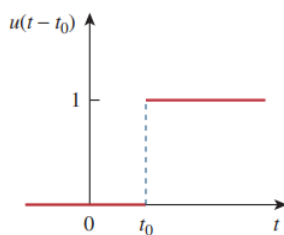
Simulation Tool:

   LTSpice – transient analysis

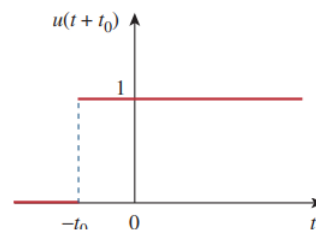**Switching Phenomenon in Circuits:**
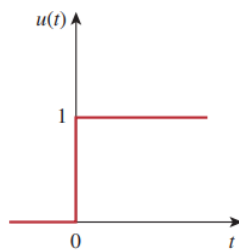
Unit Step Signal - Used to model a sudden change in dc voltage or switching

In mathematical terms,

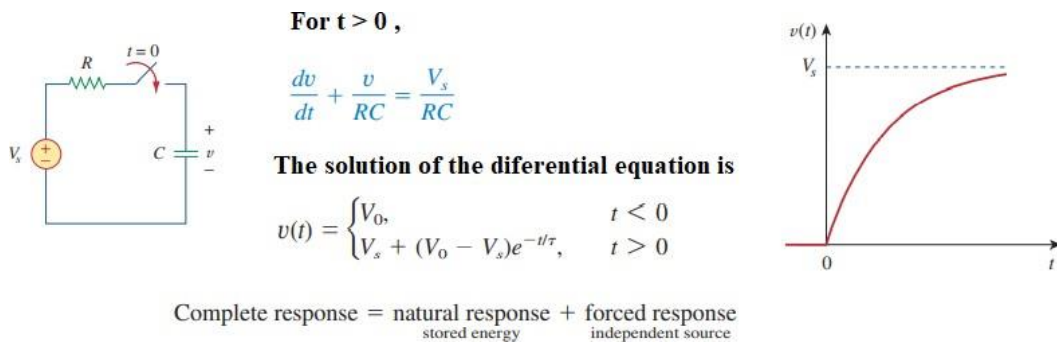$$u(t) = \begin{cases} 0, & t < 0 \\ 1, & t > 0 \end{cases}$$

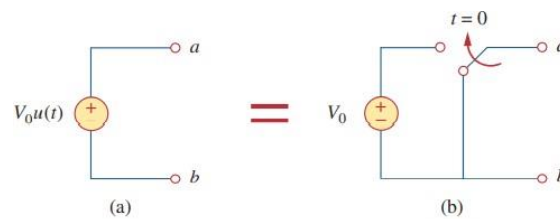$$u(t - t_0) = \begin{cases} 0, & t < t_0 \\ 1, & t > t_0 \end{cases}$$

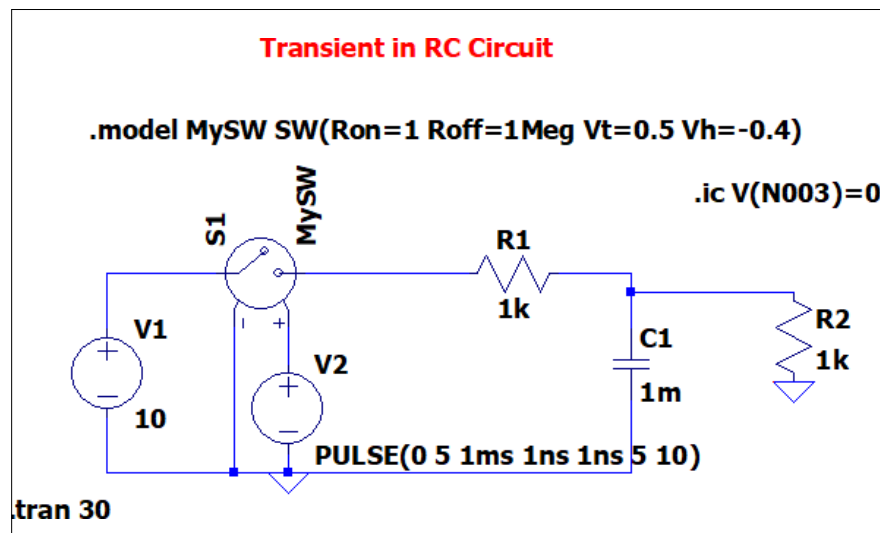$$u(t + t_0) = \begin{cases} 0, & t < -t_0 \\ 1, & t > -t_0 \end{cases}$$

Step Response of a RC Circuit

For t > 0 ,

$$\frac{dv}{dt} + \frac{v}{RC} = \frac{V_s}{RC}$$

The solution of the diferential equation is

$$v(t) = \begin{cases} V_0, & t < 0 \\ V_s + (V_0 - V_s)e^{-t/\tau}, & t > 0 \end{cases}$$

Complete response = natural response + forced response
$\qquad\qquad\qquad\qquad$ stored energy $\qquad$ independent source

Step Input – Modelled as Switch

(a) Voltage source of $V_0u(t)$, (b) its equivalent circuit.

Simulation Circuits:

Transient in RC Circuit

.model MySW SW(Ron=1 Roff=1Meg Vt=0.5 Vh=-0.4)

.ic V(N003)=0

S1 MySW

V1 10

V2

PULSE(0 5 1ms 1ns 1ns 5 10)
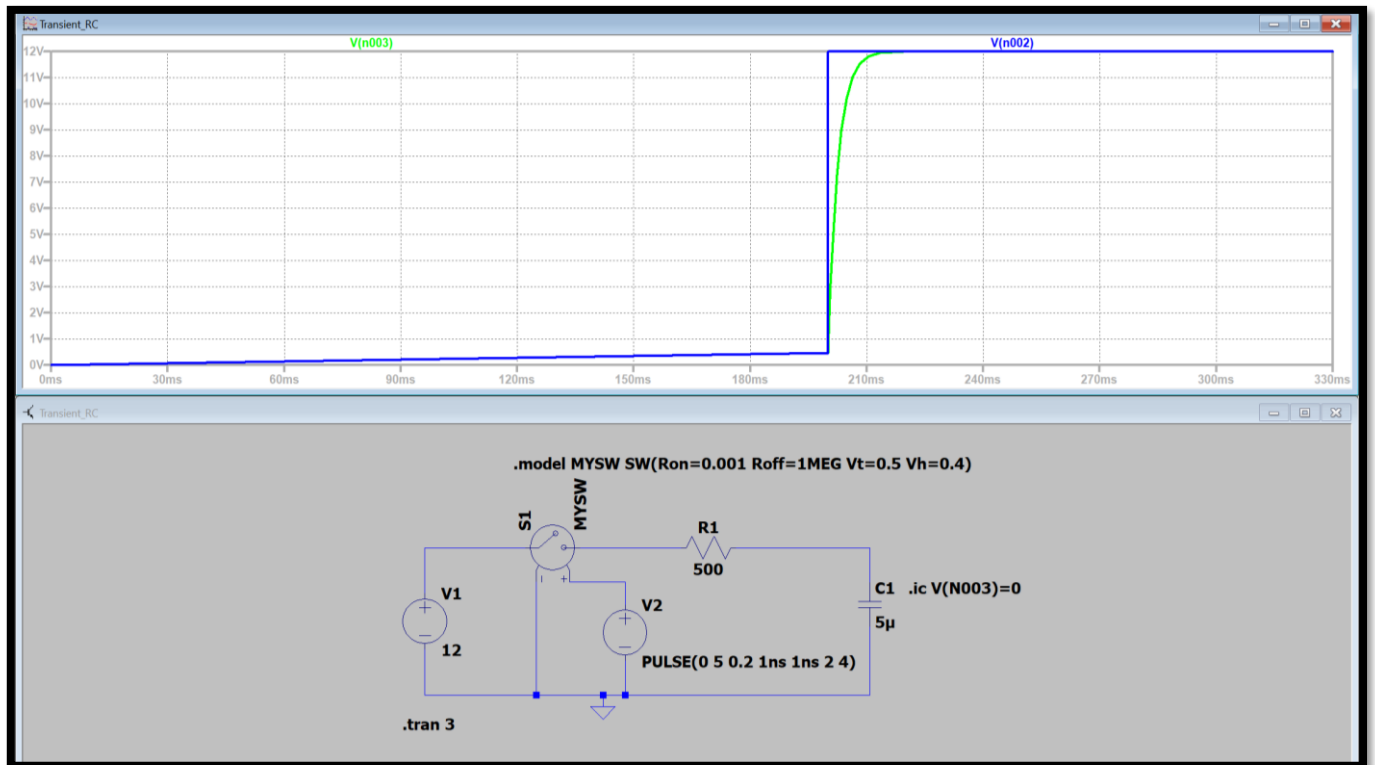
R1 1k

C1 1m

R2 1k

.tran 30

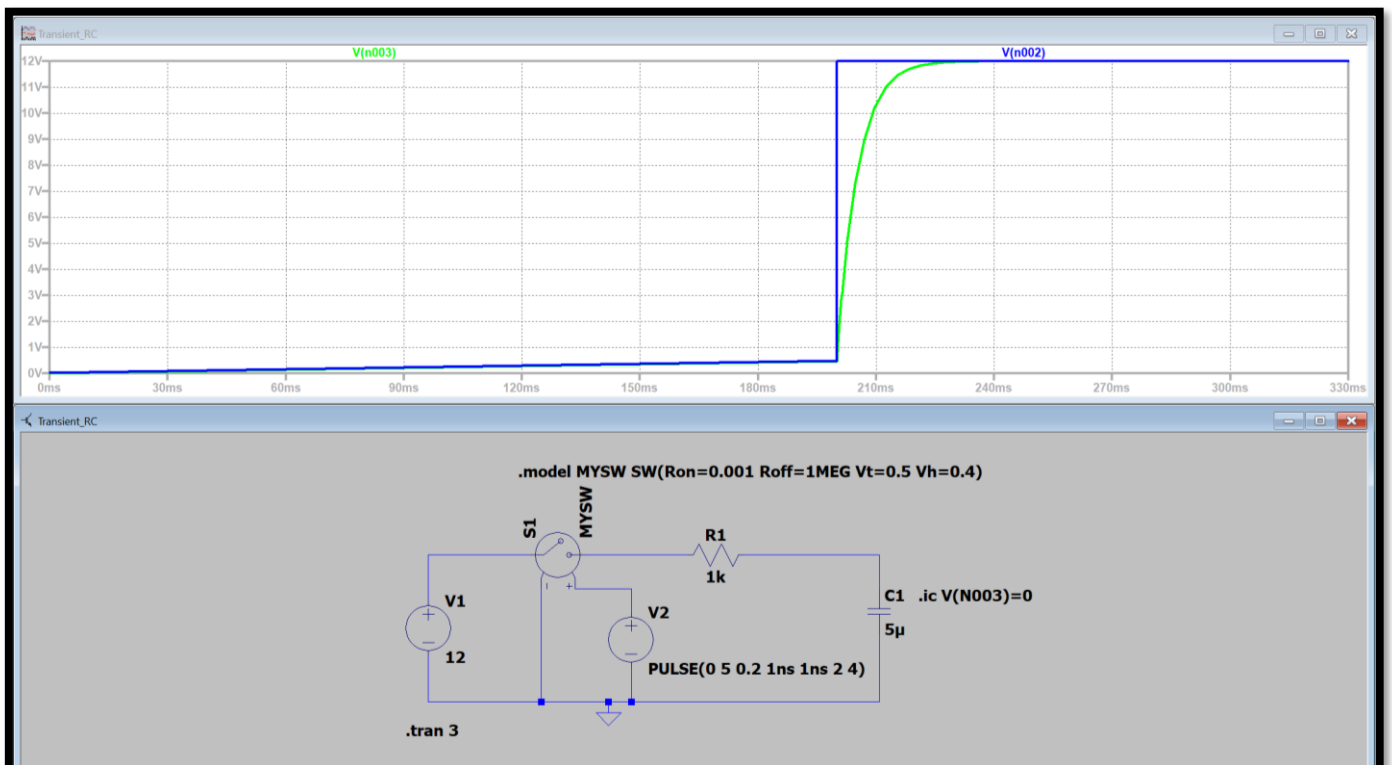Observe the step response of both the circuits with input being the step voltage, and output is the voltage across the capacitor.

Ref: (Voltage Controlled Switches)
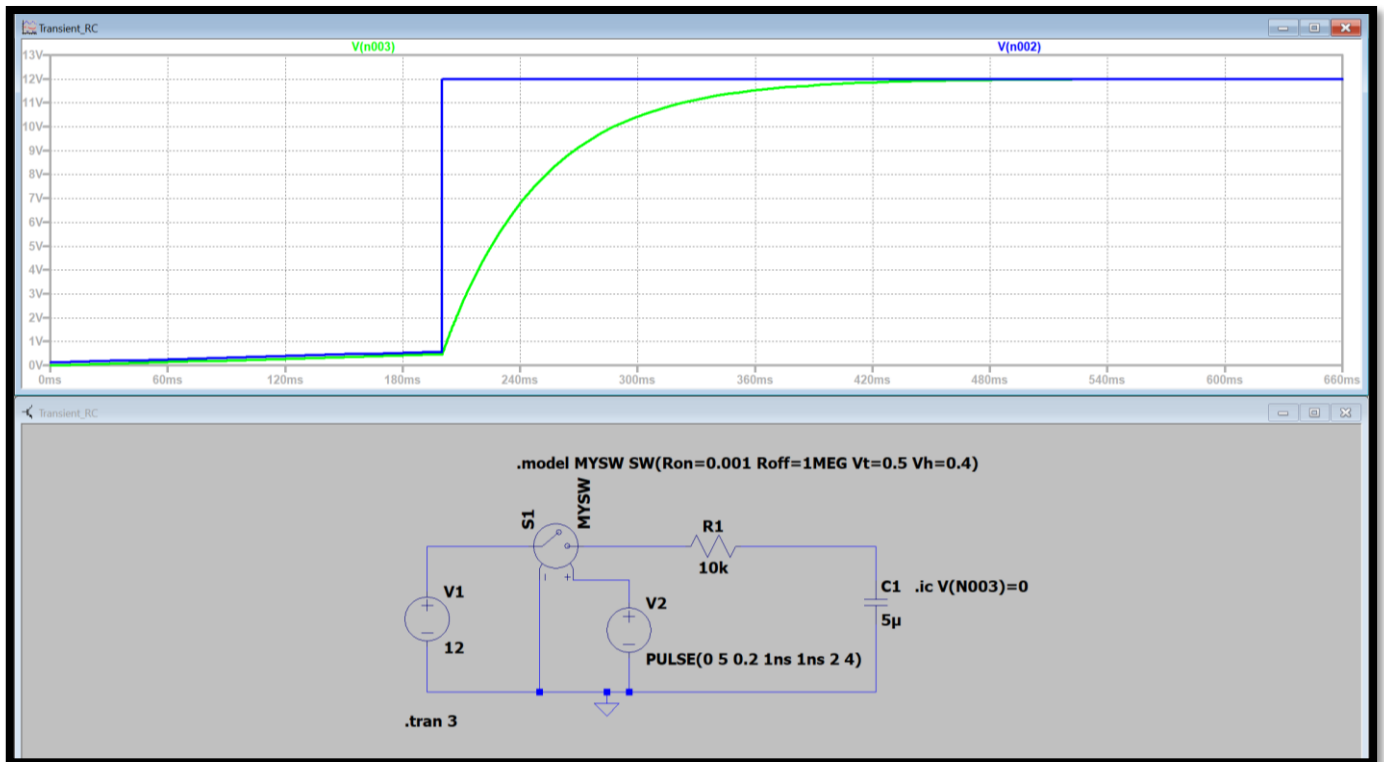https://www.analog.com/en/technical-articles/ltspiceiv-voltage-controlled-switches.html

1) R1 = 500Ω, C1 = 5μ

2) R1 = 1kΩ, C1 = 5μ

3) R1 = 10kΩ, C1 = 5μ

4) R1 = 1kΩ, C1 = 100