Unit – 2

Wave Shaping Circuits & Operational Amplifier

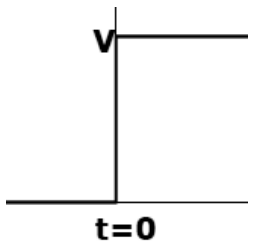
DELD, ECED SVNIT

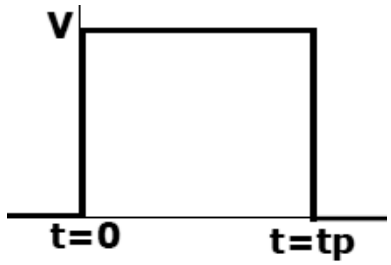
Wave Shaping

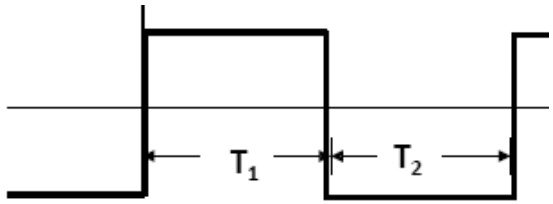
- A Signal is also called a wave.
- A Signal may be of different shape such as Sinusoidal, Square, Triangular etc.
- It is the process of changing the shape of input signal with linear / non-linear circuits.
- Wave Shaping can be of two types:
  - Linear Wave Shaping: Linear elements like Resistors, Capacitors, Inductors etc are employed.
  - Non-Linear : Non-Linear Devices are used (e.g Diode) Clippers

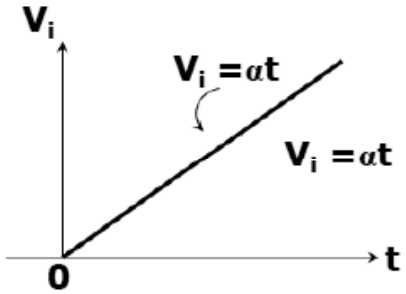
Linear Wave Shaping

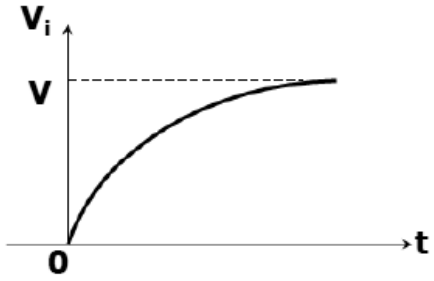
- The process where by the form of a non-sinusoidal signal is changed by transmission through a linear network is called Linear Wave Shaping
- Types:
  - High Pass RC Circuit.
  - Low Pass RC Circuit.
- Non-sinusoidal waveforms
  - Step
  - Pulse
  - Square Wave
  - Ramp
  - Exponential Wave









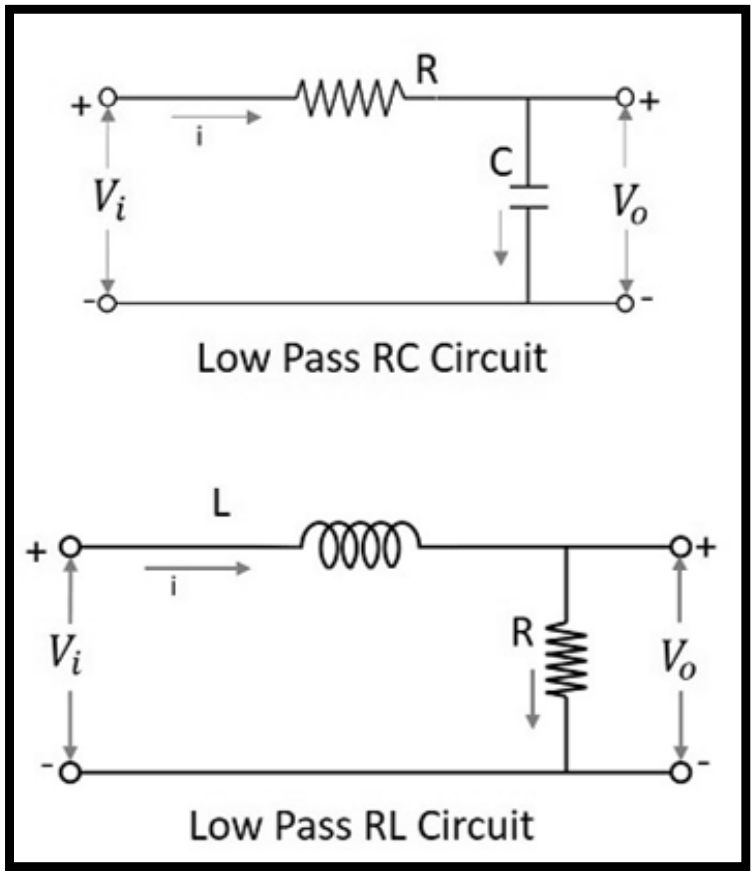


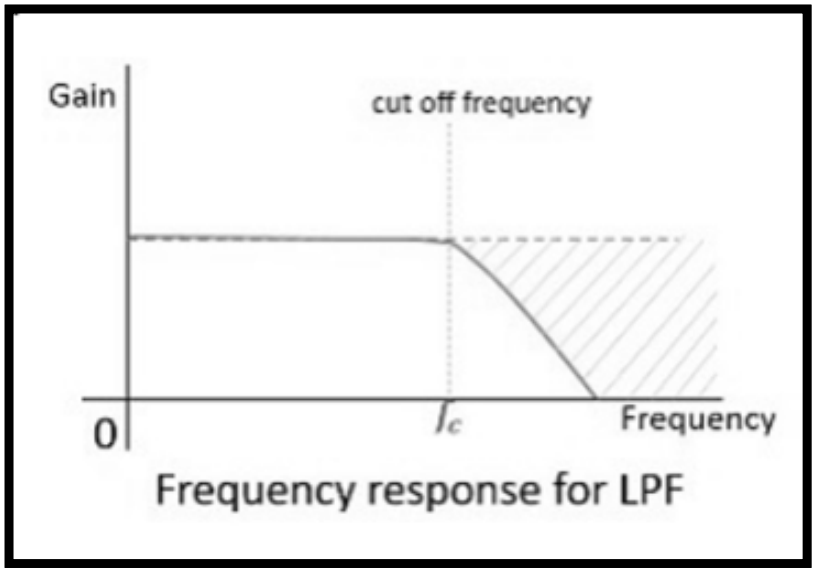
Filters

- A Filter is a circuit that is designed to pass the signals with desired frequencies and reject or attenuate the other frequencies.
- As a frequency-selective device, a filter can be used to limit the frequency spectrum of a signal to some specified band of frequencies.
- Filters are the circuits used in radio and TV receivers to allow us to select one desired signal out of a multitude of broadcast signals in the environment.
- A filter is a passive filter if it consists of only passive elements R, L, and C. It is said to be an active filter if it consists of active elements (such as transistors and operational amplifiers) in addition to passive elements R, L, and C.

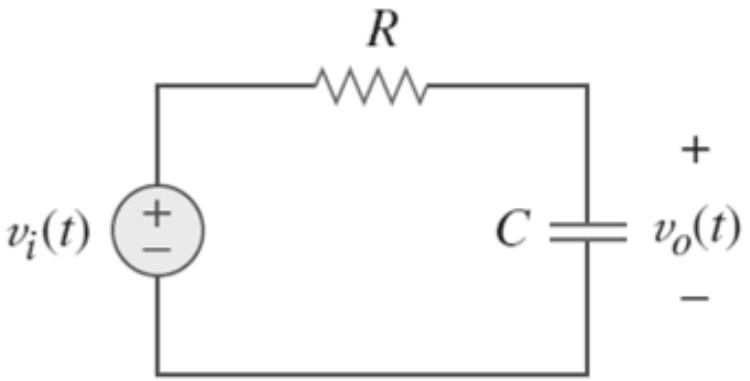
Low Pass Filter

- A Filter circuit which allows a set of frequencies that are below a specified value can be termed as a **Low pass filter**. This filter passes the lower frequencies.



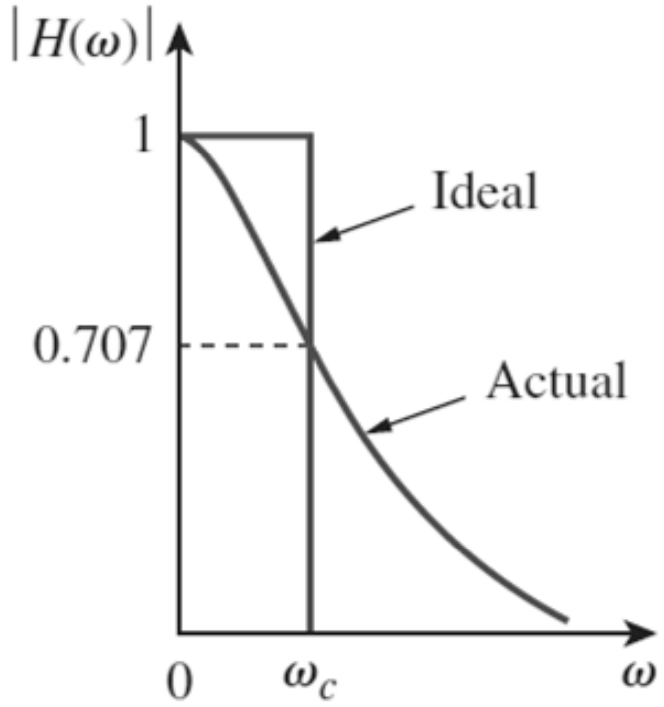


Low Pass Filter



$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{1/j\omega C}{R + 1/j\omega C}$$

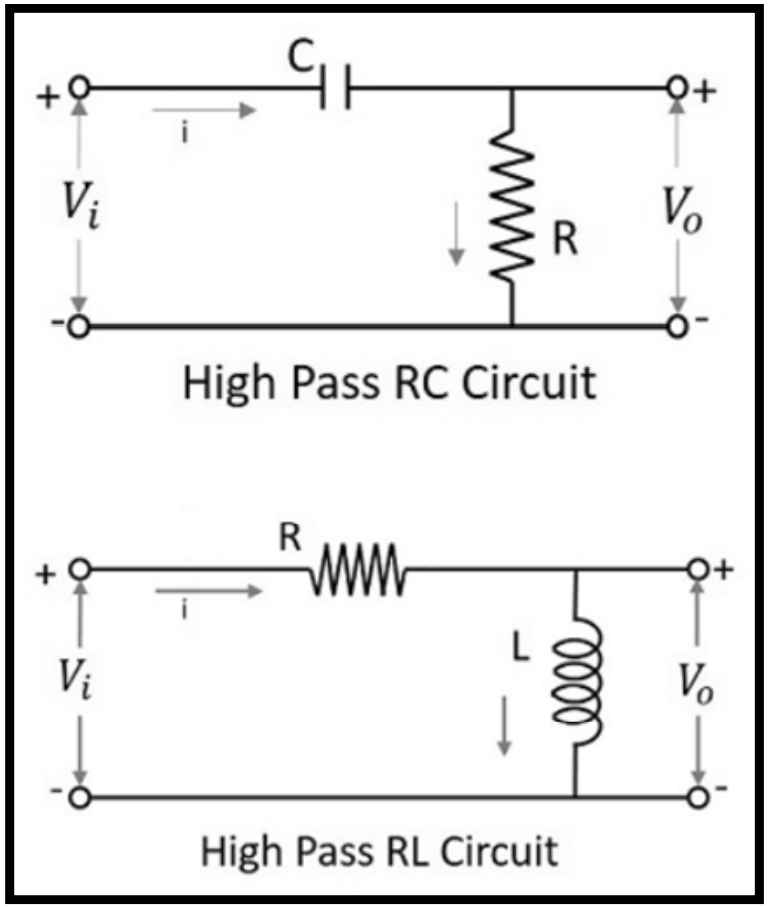
$$\mathbf{H}(\omega) = \frac{1}{1 + j\omega RC}$$

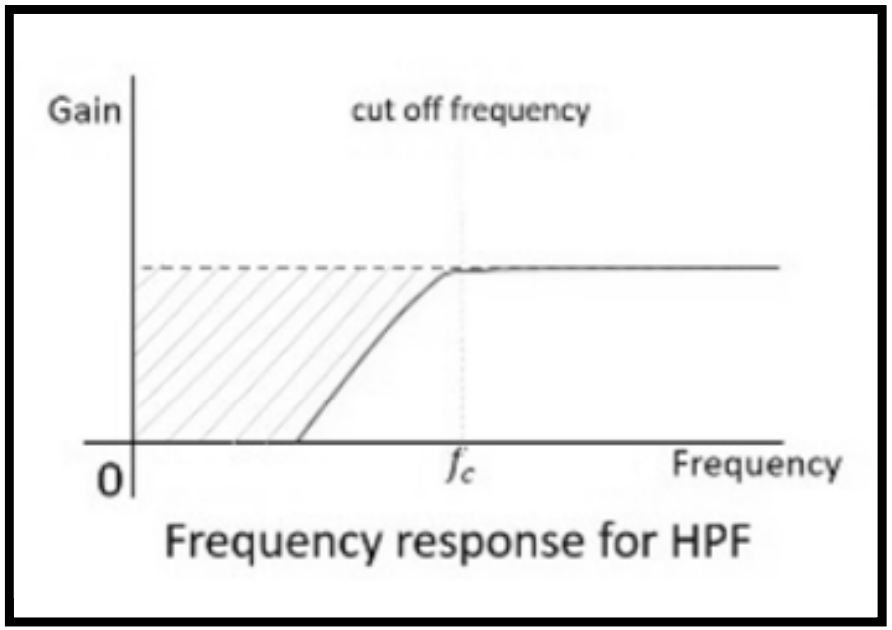


$$\omega_c = \frac{1}{RC}$$

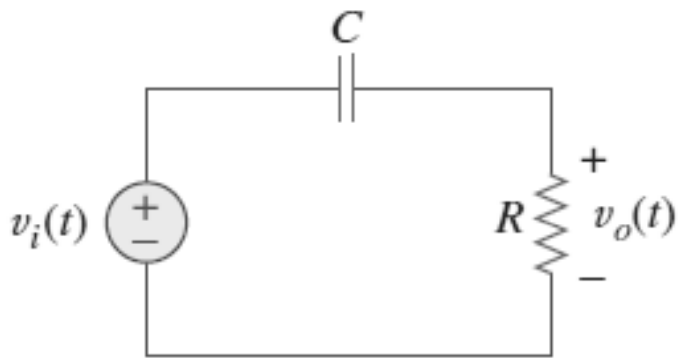
High Pass Filter

- A Filter circuit which allows a set of frequencies that are **above a specified value** can be termed as a **High pass filter**. This filter passes the higher frequencies.



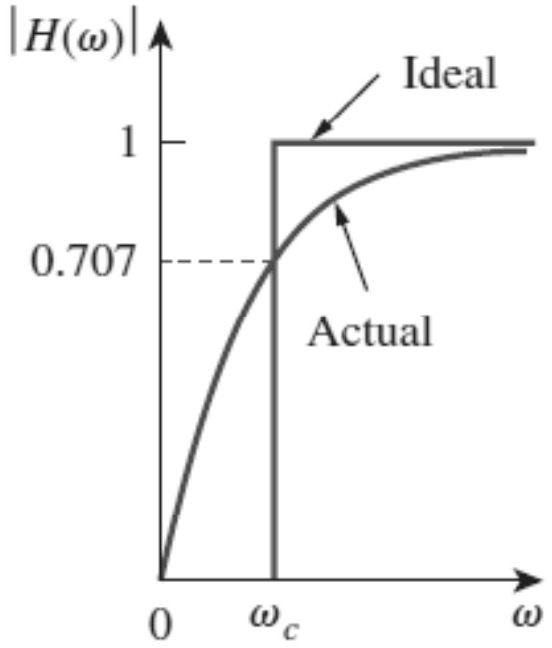


High Pass Filter



$$\mathbf{H}(\omega) = \frac{\mathbf{V}_o}{\mathbf{V}_i} = \frac{R}{R + 1/j\omega C}$$

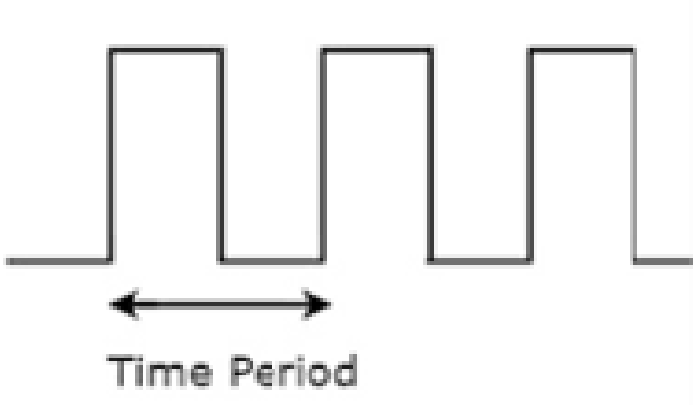
$$\mathbf{H}(\omega) = \frac{j\omega RC}{1 + j\omega RC}$$

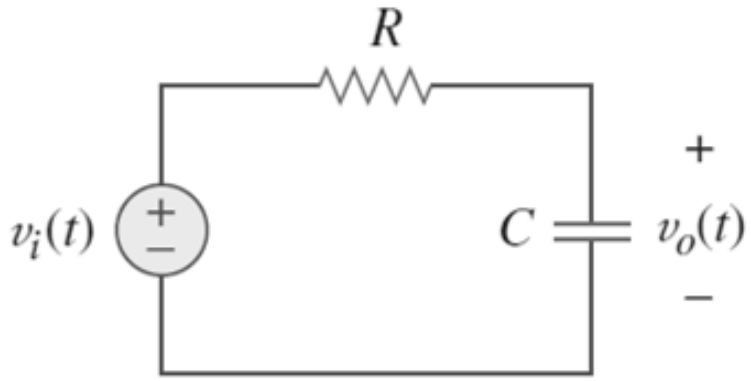


$$\omega_c = \frac{1}{RC}$$

RC Integrator

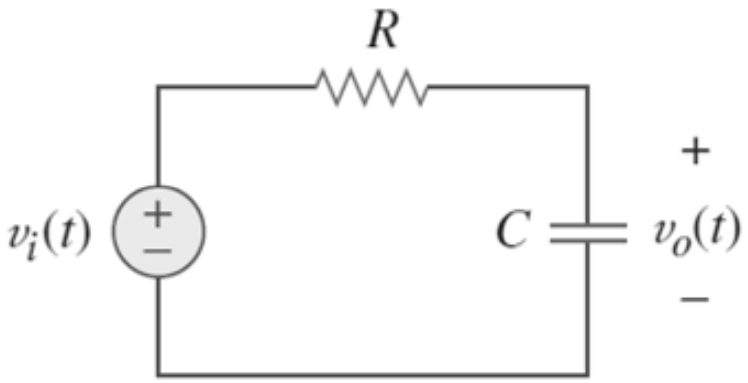
- If the time constant value is much greater than the time period of the input signal than the RC low pass circuit will act as an Integrator
- RC >> T





Derivation

- If the time constant value is much greater than the time period of the input signal than the RC Low pass circuit will act as an Integrator
- RC >> T
- Under this circumstances the voltage drop across C will be very small in comparison to the drop across R



$$V_i = iR$$

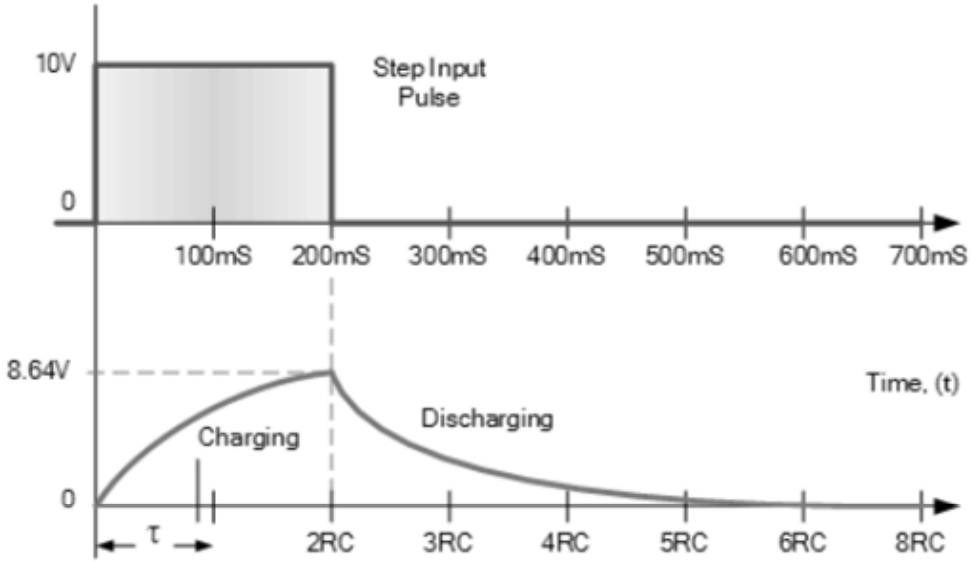
$$i = \frac{V_i}{R}$$

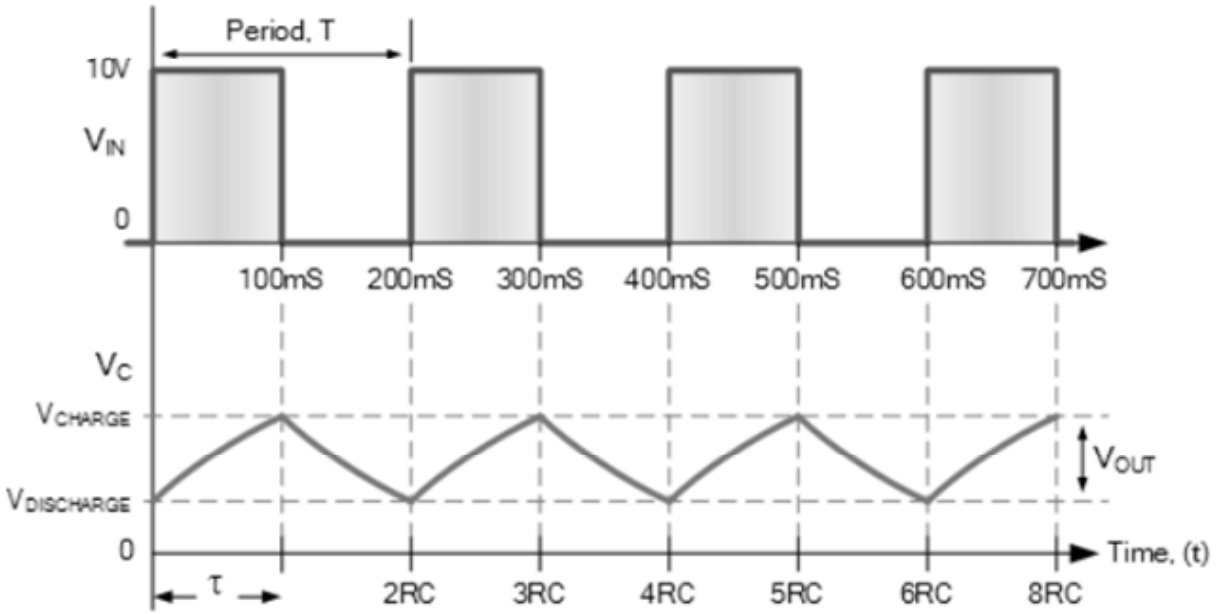
$$V_o = \frac{1}{C}\int i\,dt$$

$$V_o = \frac{1}{C}\int \frac{V_i}{R}\,dt$$

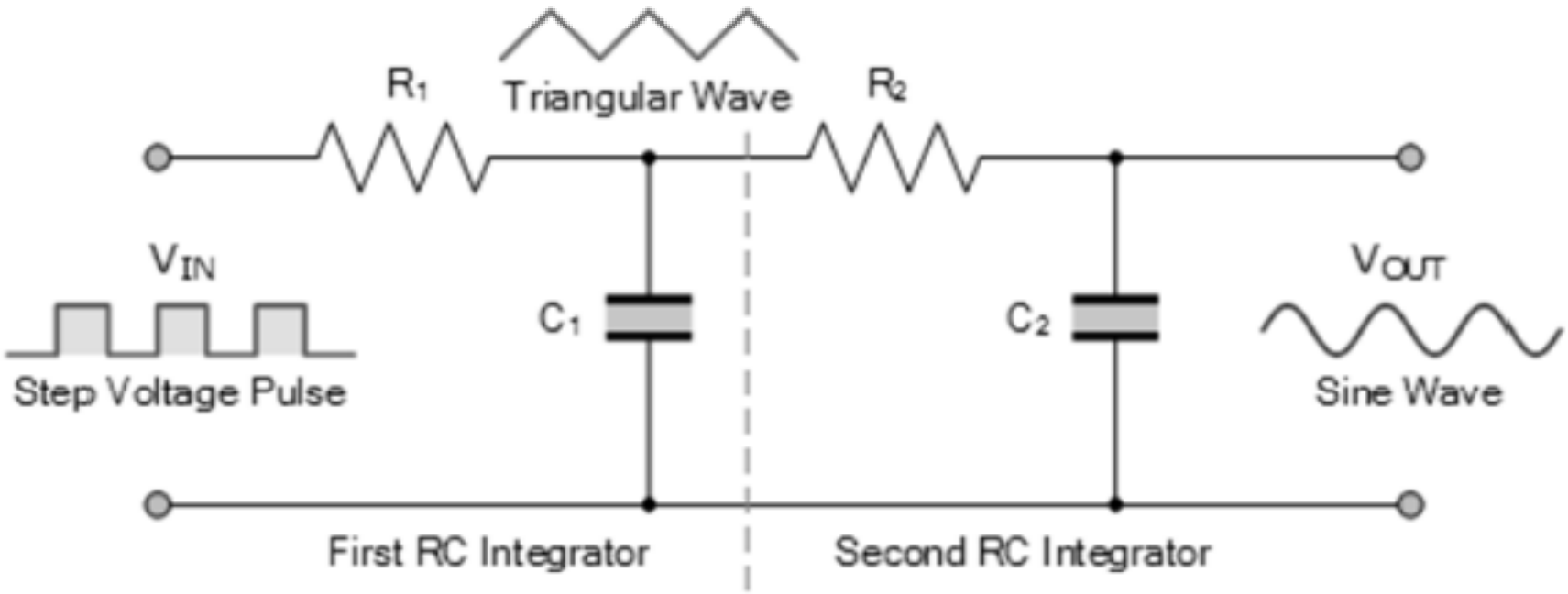
$$V_o = \frac{1}{RC}\int V_i\,dt$$

RC Integrator



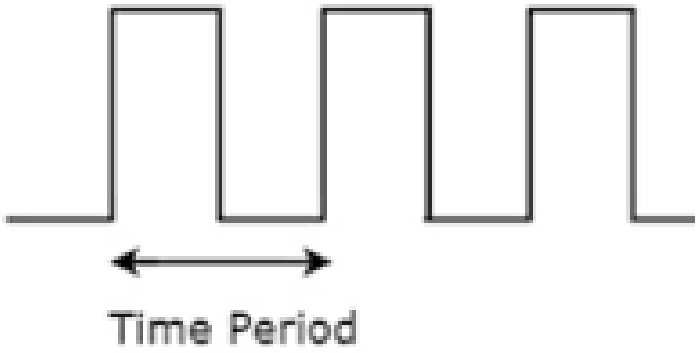


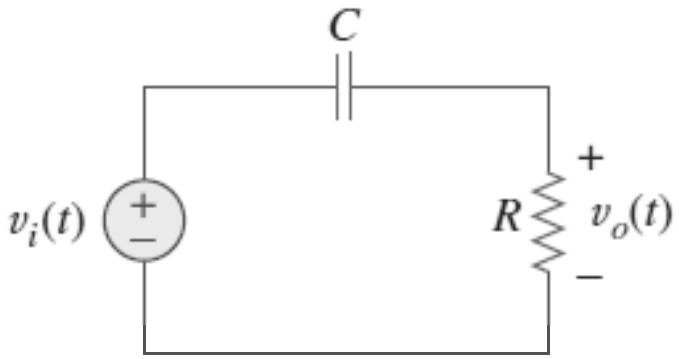
RC Integrator



RC Differentiator

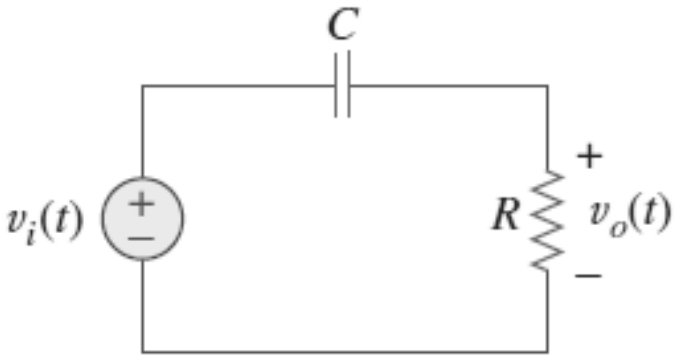
- If the time constant value is much smaller than the time period of the input signal than the RC High pass circuit will act as an Differentiator
- RC << T





Derivation

- If the time constant value is much smaller than the time period of the input signal than the RC High pass circuit will act as an Differentiator
- RC << T
- Under this circumstances the voltage drop across R will be very small in comparison with the drop across C. Hence we may consider that the total input Vi appears across C, so that the current is determined entirely by the capacitance.

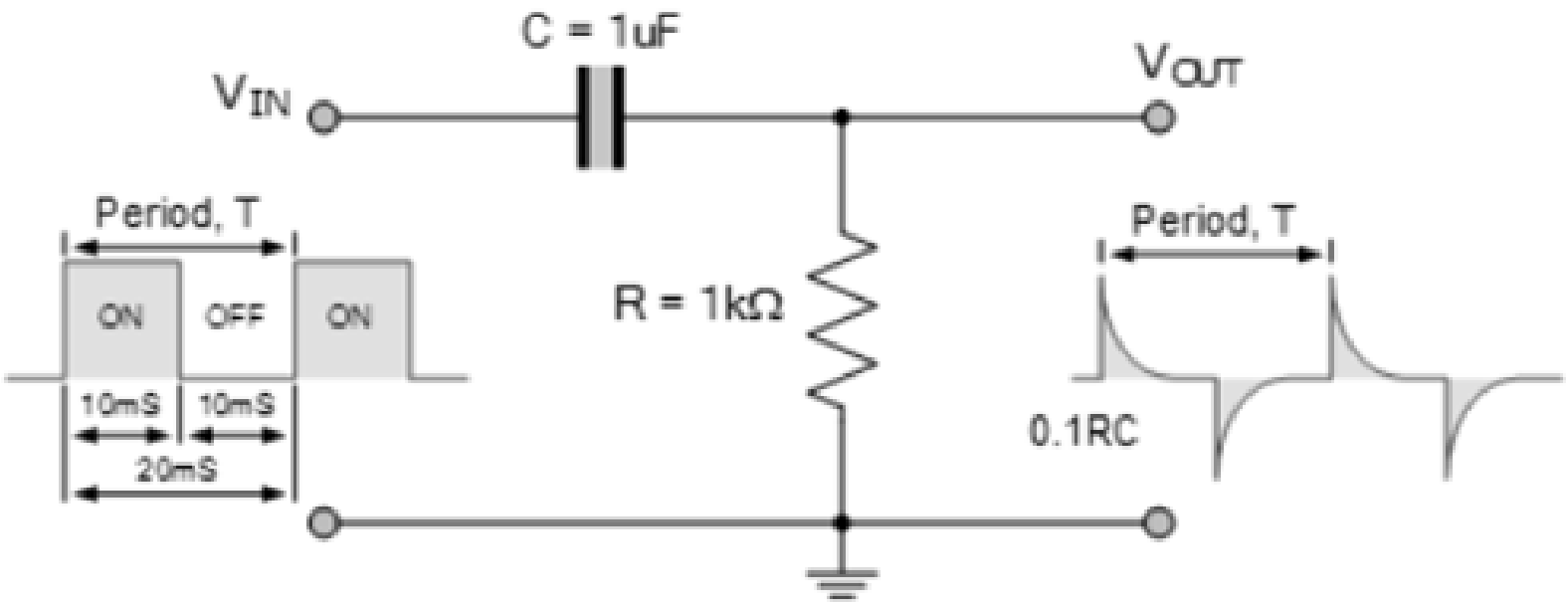


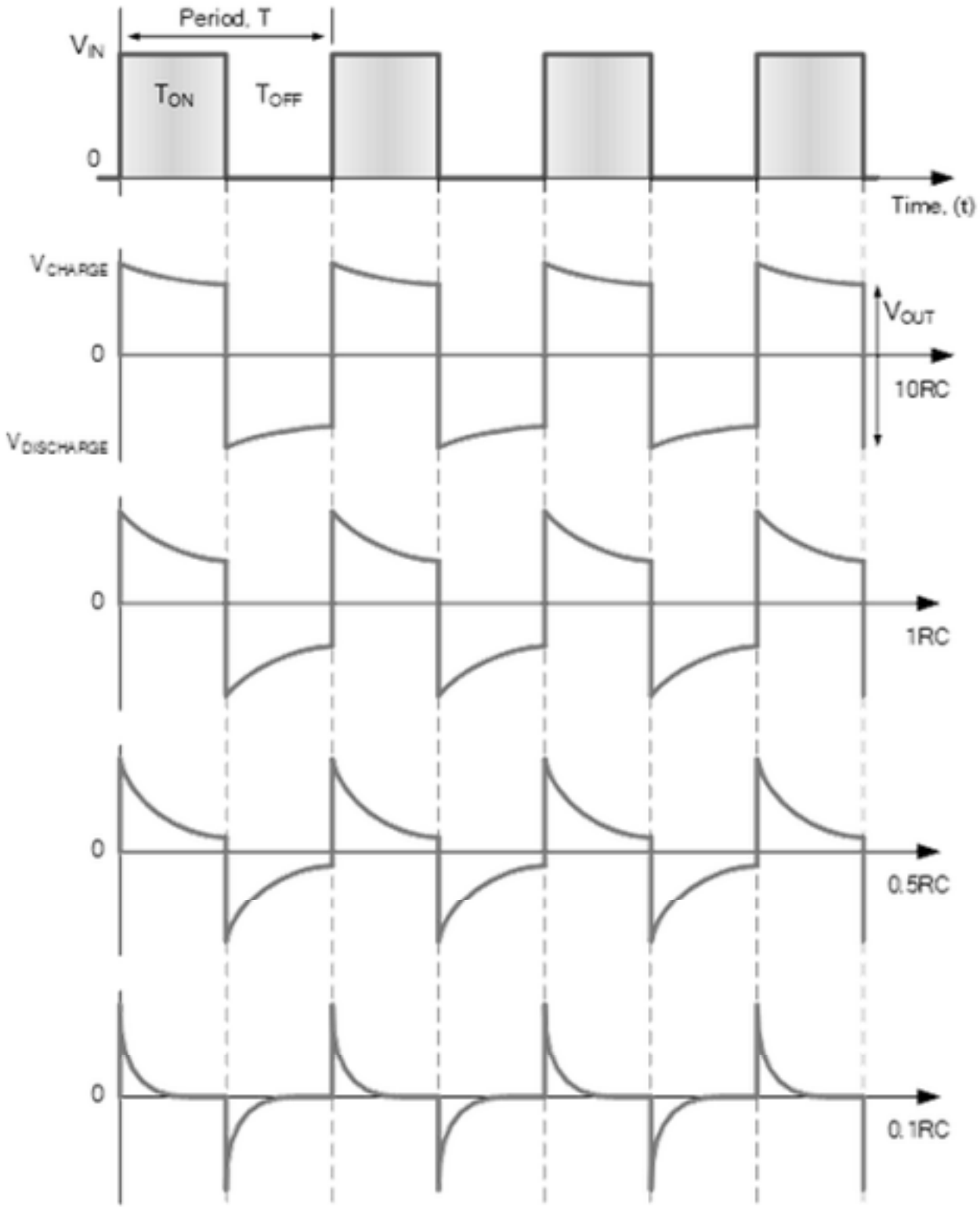
$$i = C\frac{dV_i}{dt}$$

$$V_o = iR$$

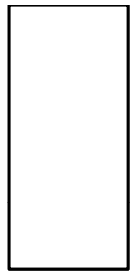
$$V_o = RC\frac{dV_i}{dt}$$

RC Differentiator




Period, T
V_{IN}
T_{ON}
T_{OFF}
0
Time, (t)
V_{CHARGE}
V_{OUT}
0
10RC
$V_{DISCHARGE}$
0
1RC
0
0.5RC
0
0.1RC

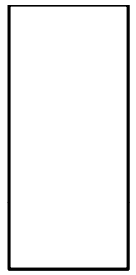
RC Integrator



- Sine – (-Cosine)
- Triangular – Sine
- Rectangular Wave - Trianlge

RC Differentiator

- Sine – Cosine
- Triangular Wave – Square Wave
- Rectangular Wave - Spikes



To Be Continued...