Introduction to Electrical Engineering Practice

Course Code: EE 113

Department: Electrical Engineering

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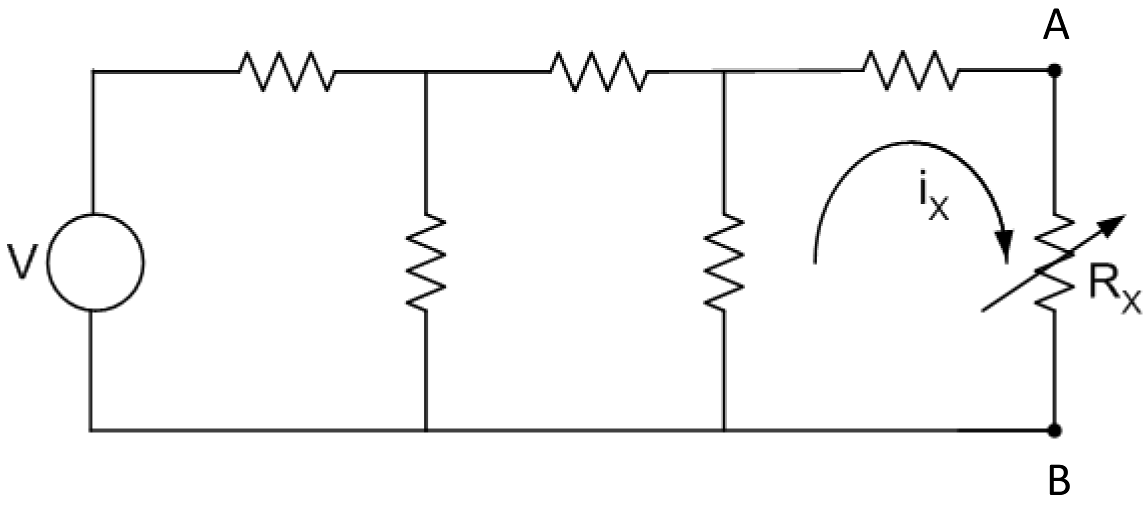
Review of Previous Lecture

- Mesh Current Analysis ⇒ Apply KVL
- Node Voltage Analysis ⇒ Apply KCL

- Thevenin's Theorem



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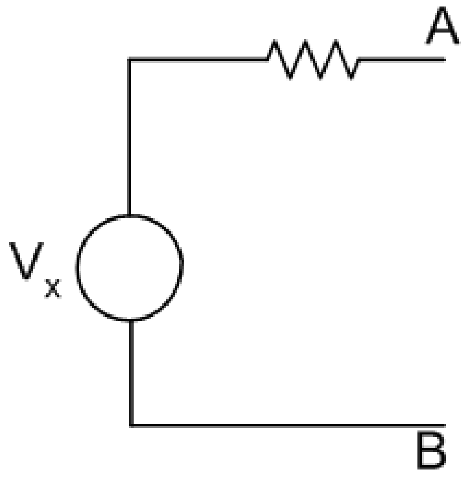
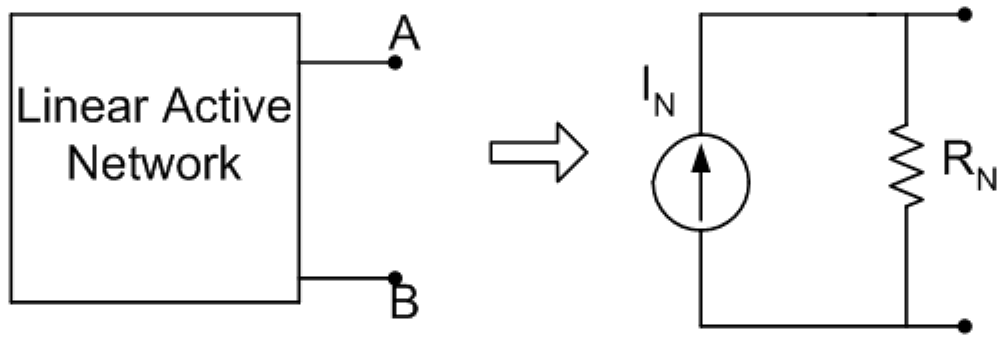
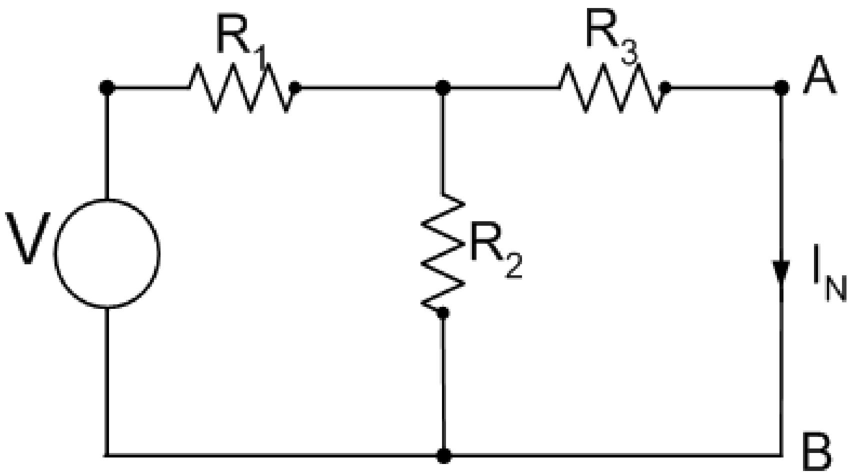


Thevenin's Equivalent Circuit

Norton's Theorem



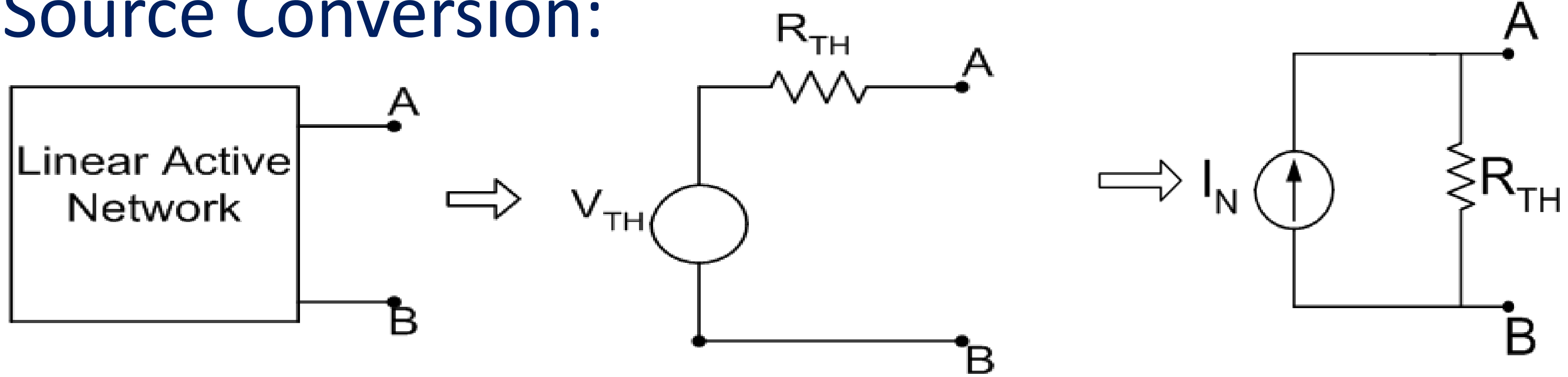
$I_N \longrightarrow$ Current through the short circuit applied to the terminals AB



$R_N = R_{TH}$

$$I_N = \frac{V}{\left(R_1 + \frac{R_2 R_3}{R_2 + R_3}\right)} \frac{R_2}{R_3 + R_2}$$

Source Conversion:



Short circuit the terminals AB

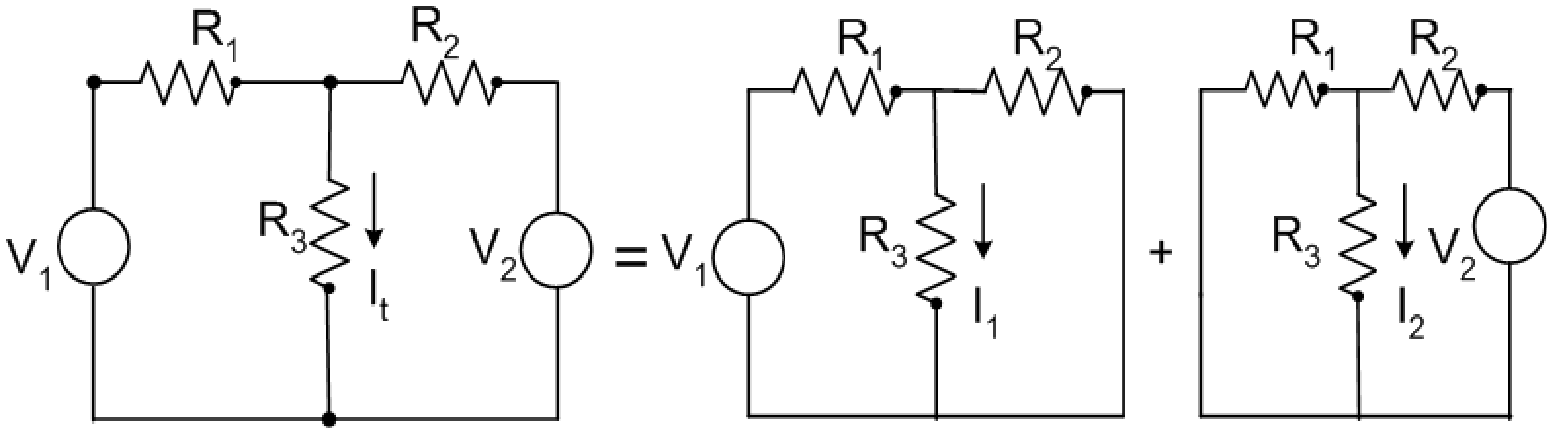
Using Thevenin's theorem, $I_{AB} = \dfrac{V_{TH}}{R_{TH}}$

From Norton's theorem, $I_{AB} = I_N$

$$\Rightarrow \frac{V_{TH}}{R_{TH}} = I_N \qquad \therefore V_{TH} = I_N R_{TH}$$

Superposition Theorem:

The response in any element of linear network having two or more sources is the sum of responses obtained by each source acting separately, with all other sources set equal to zero.



$$I_t = I_1 + I_2$$

If $x_1 \longrightarrow y_1$

& $x_2 \longrightarrow y_2$

For a linear system, if $(x_1+x_2) \Longrightarrow (y_1+y_2)$

Time domain response of RC and RL circuit

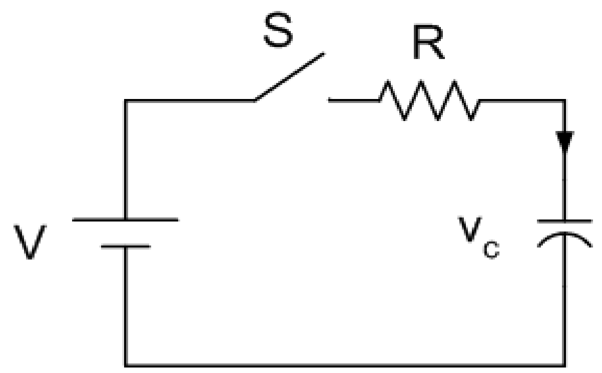
- No transients in purely resistive circuit
- Current cannot change instantaneously in an inductor
- Voltage across a capacitor cannot change instantaneously

Series R-C Circuit

- Step response: DC voltage or current is suddenly applied to the circuit

- For a series R-C circuit

$$V_c = V_f + (V_{ci} - V_f)e^{-\frac{t}{\tau}}$$



where, τ = time constant,
V_{ci} is capacitor voltage at t = 0, (Intial Value)
V_f is the final value

- Circuit is assumed to attain steady state at t = 5τ

Step response of R-C circuit

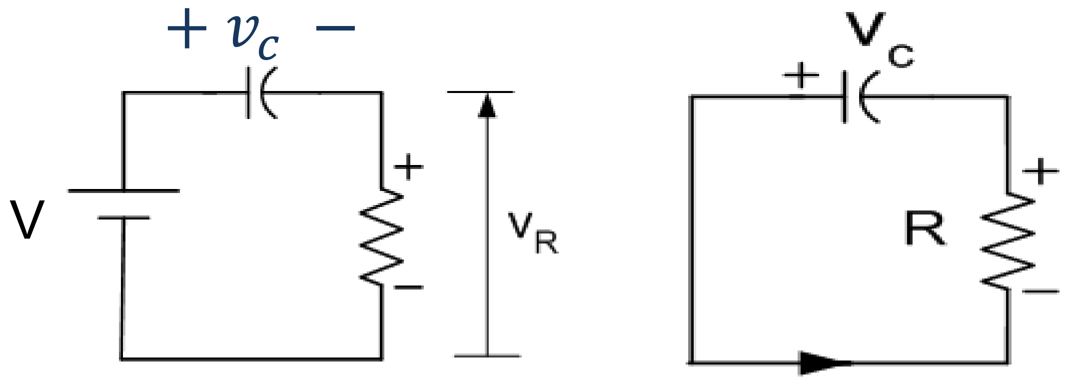
Case (i) $\tau \ll T$

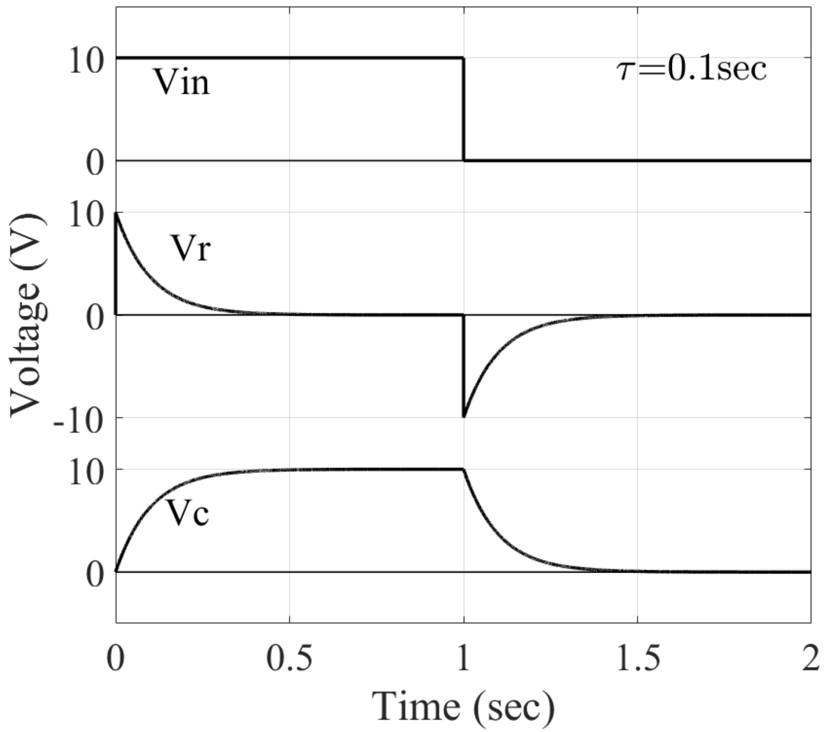
At $t = 0$, capacitor voltage, $v_c = 0$

At $t = 0^+$, $v_c = 0$, $v_R = V$ and $i = \frac{V}{R}$

In steady state $v_c = V$, $i = 0$, $\therefore V_R = 0$

Steady state is attained at $t \approx 5\tau$





At t = T⁺

$v_R = -v_c$ and $i = -\frac{v_c}{R} = \frac{v_R}{R}$

At steady state, v_c and $i = 0$

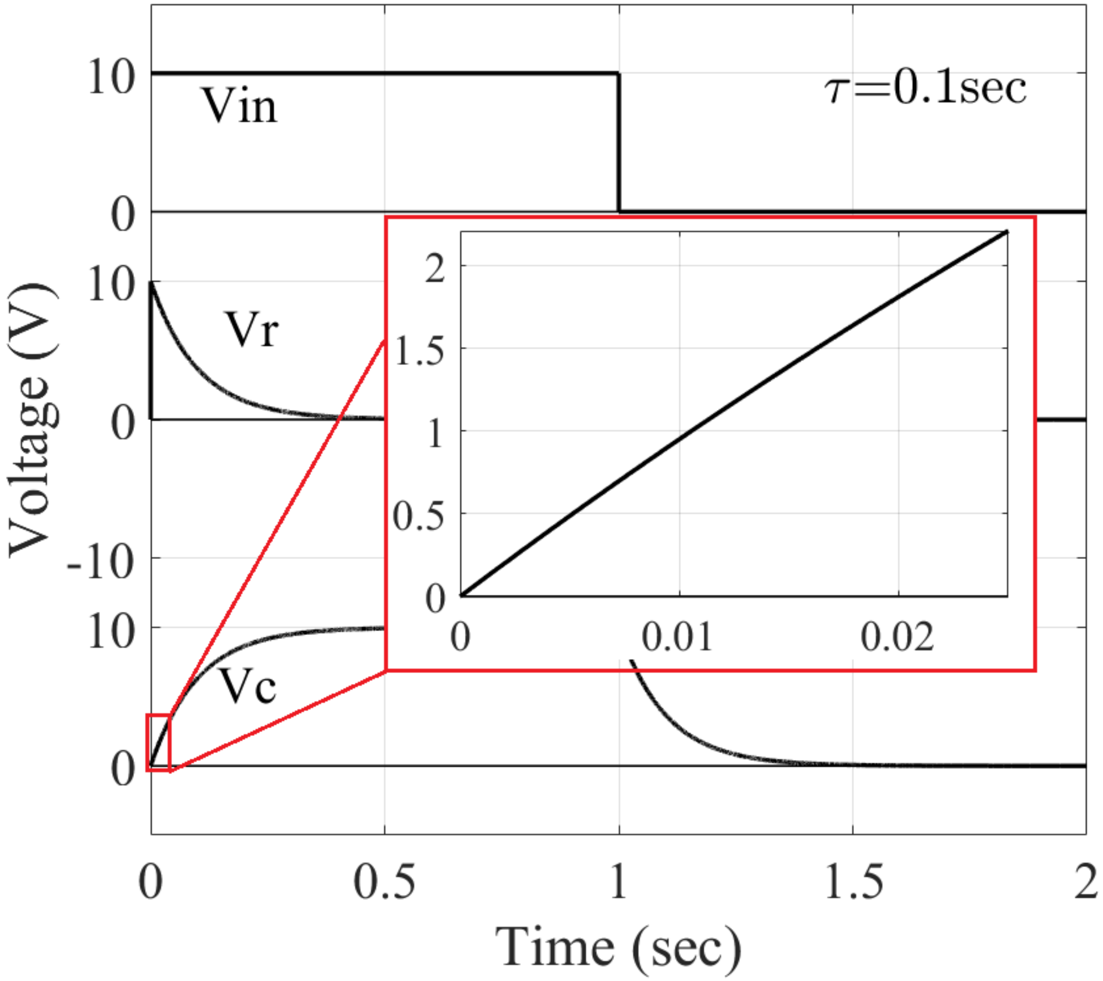
Observation: 'i' through 'C' can change instantaneously

Step response of R-C circuit

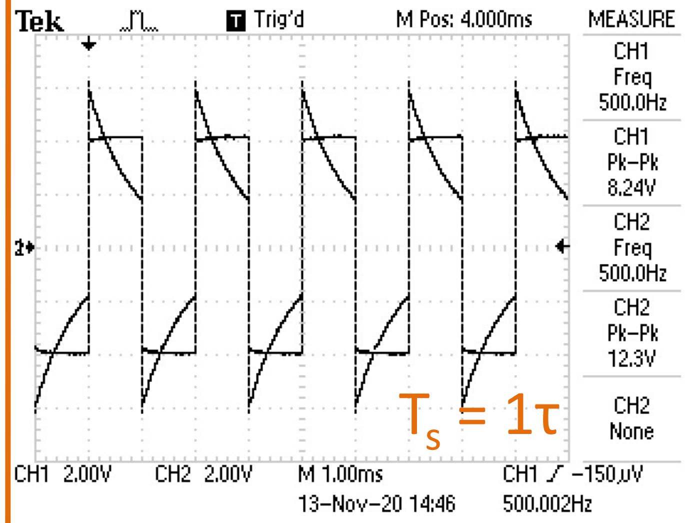
Case (ii) $\tau \gg T$

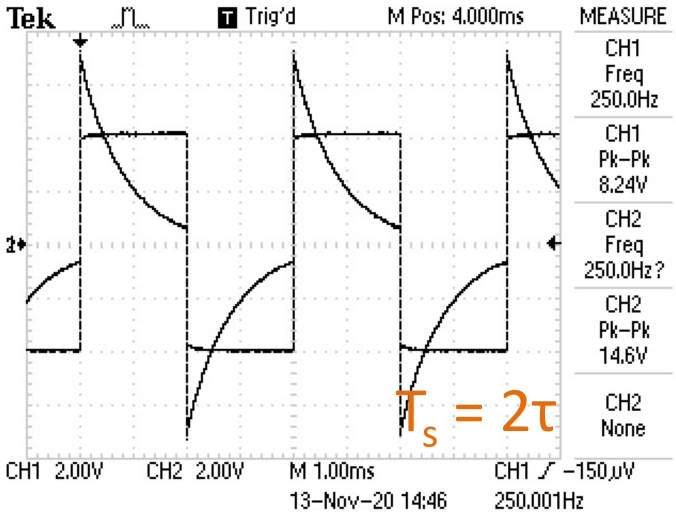
- v_c increases gradually
- So, $|v_c|$ is a small fraction of V at t = T
- Initial portion of v_c is linear
- v_c is the integral of V

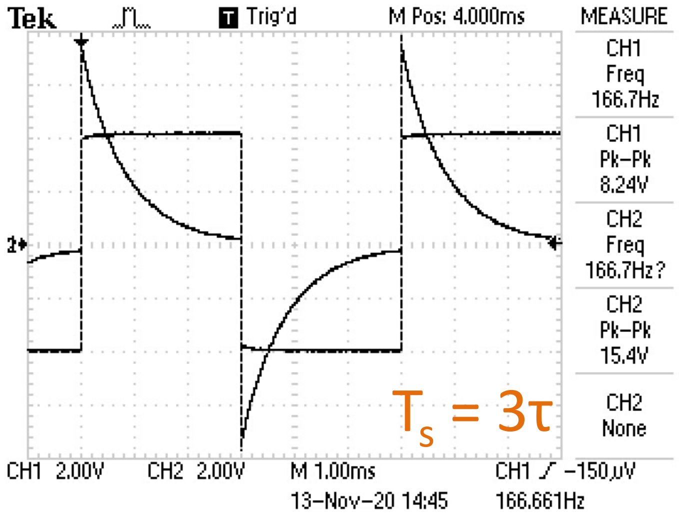
➔ Integrator

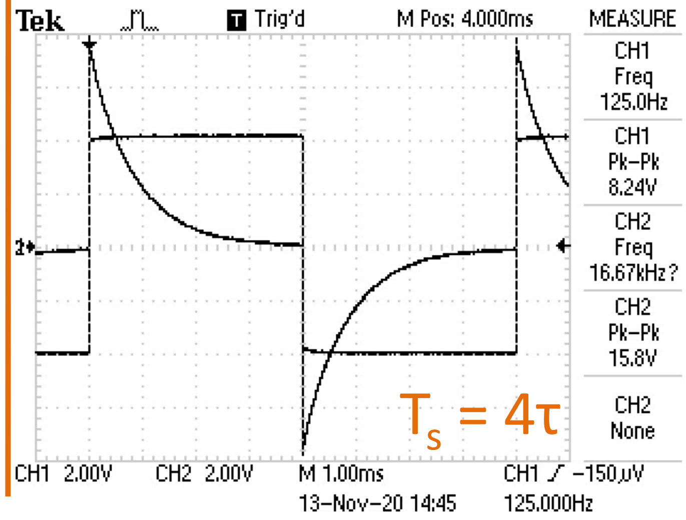


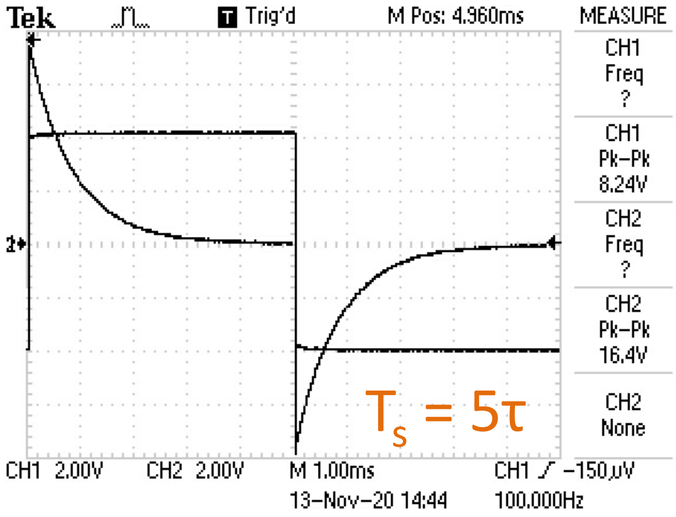
RC Differentiator Experimental Results

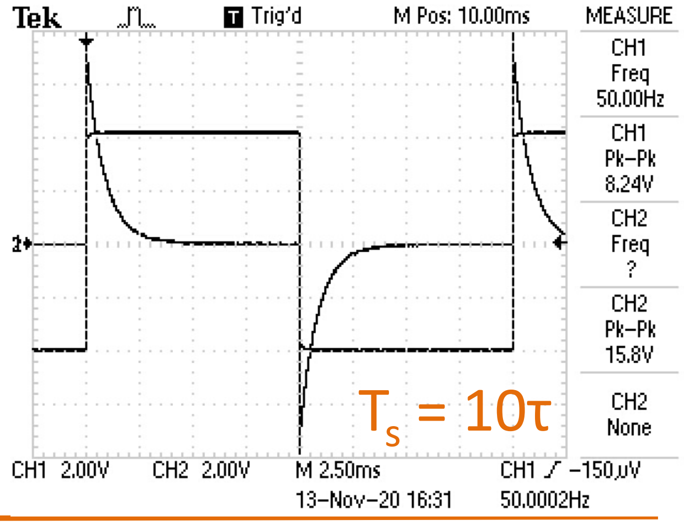




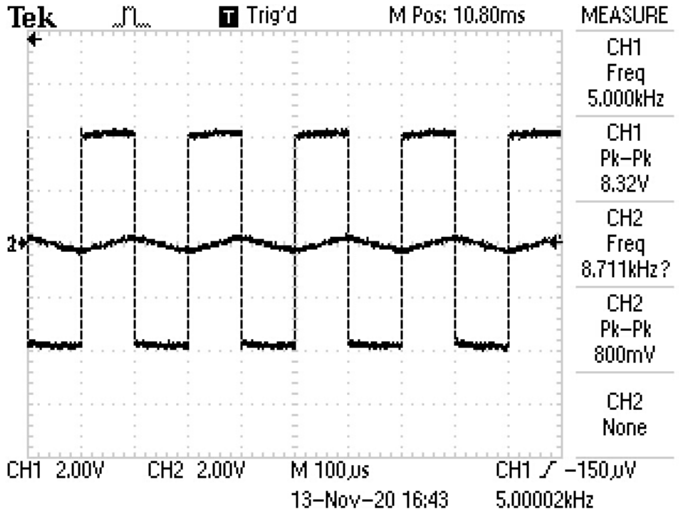




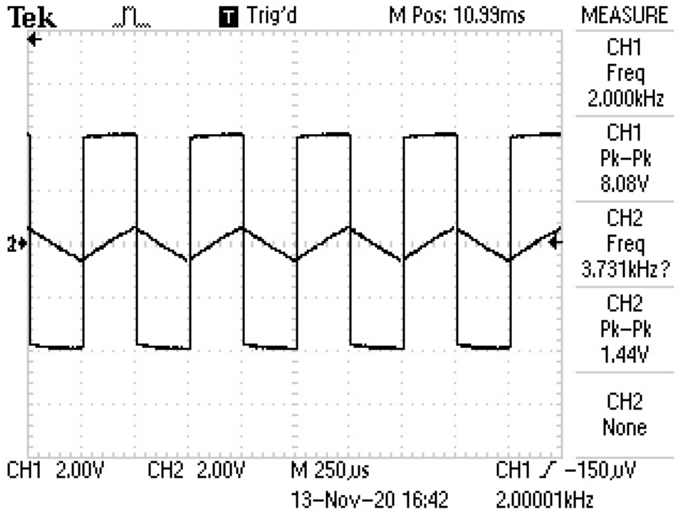




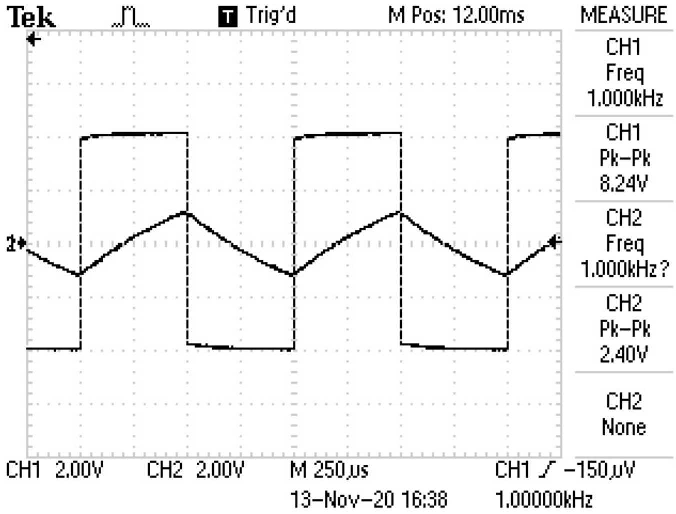
RC Integrator Experimental Results



$T_s = 0.1\tau$
(τ is very large compared to T_s.)

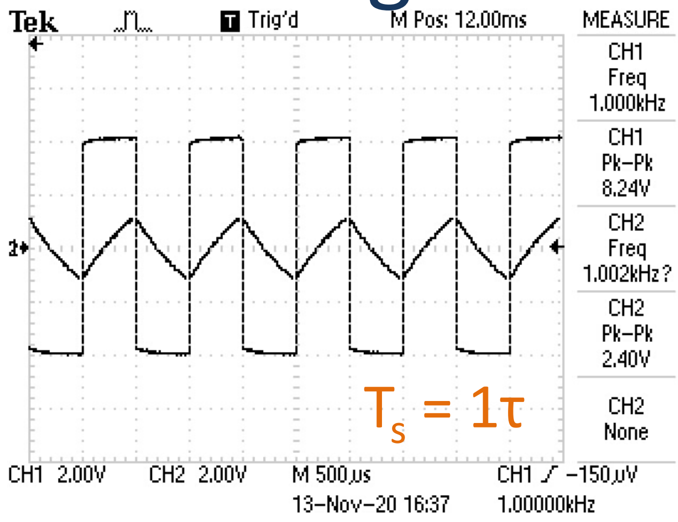


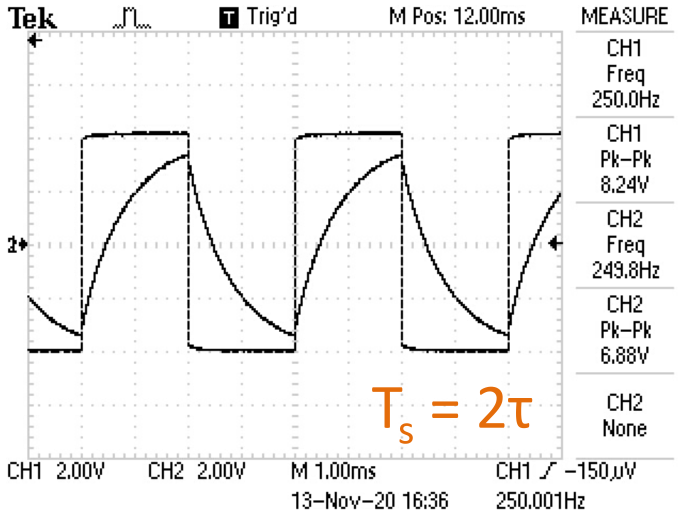
$T_s = 0.25\tau$

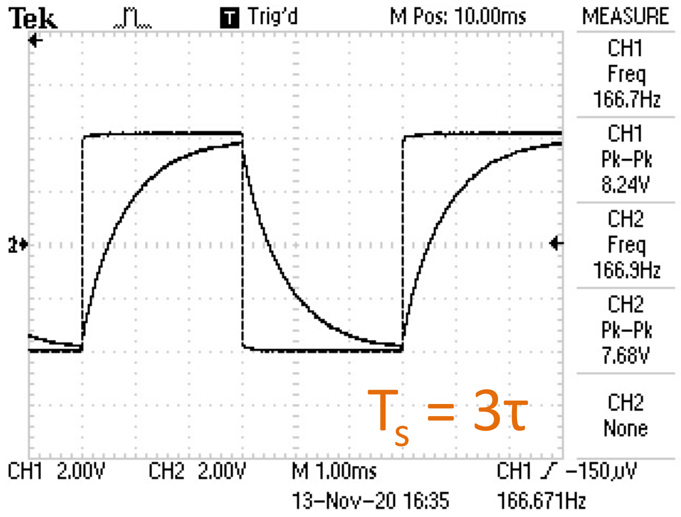


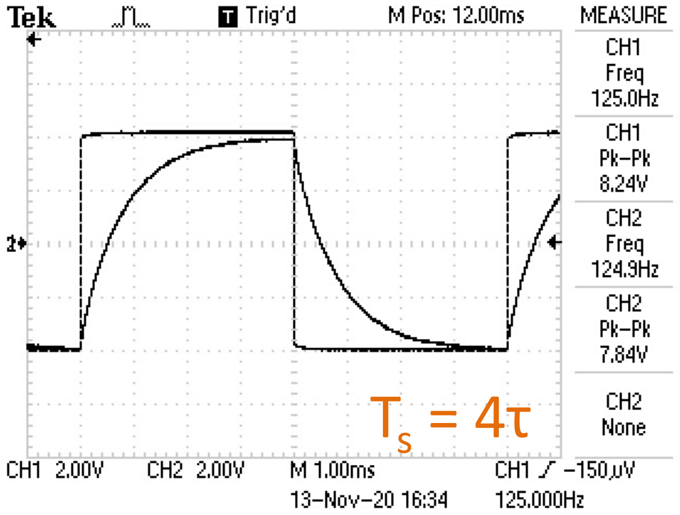
$T_s = 0.5\tau$

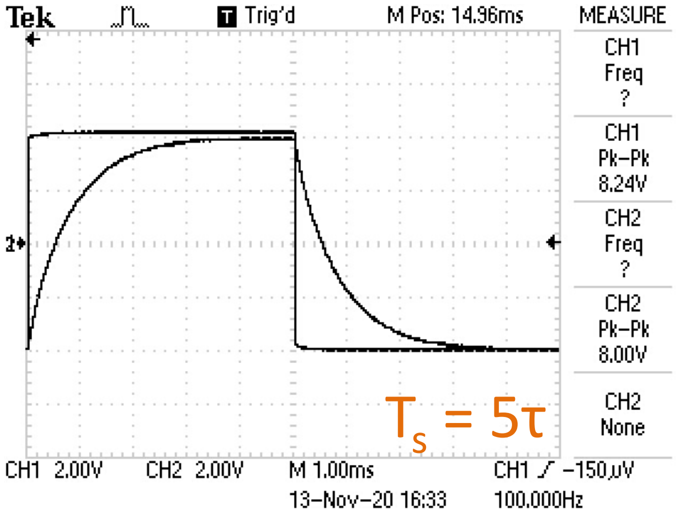
RC Integrator Experimental Results

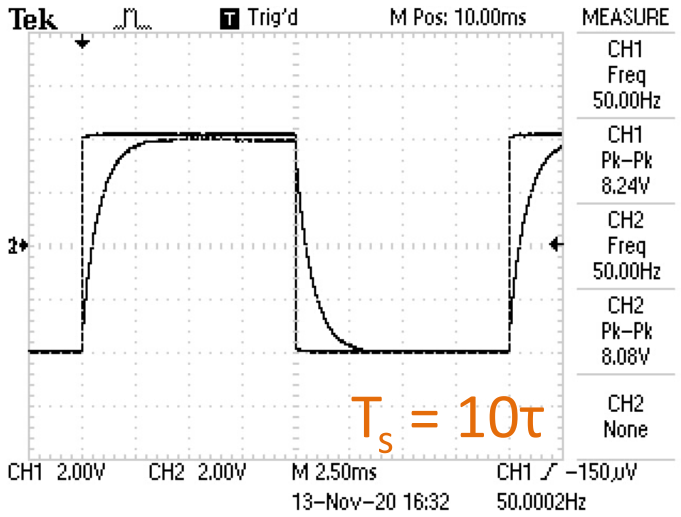




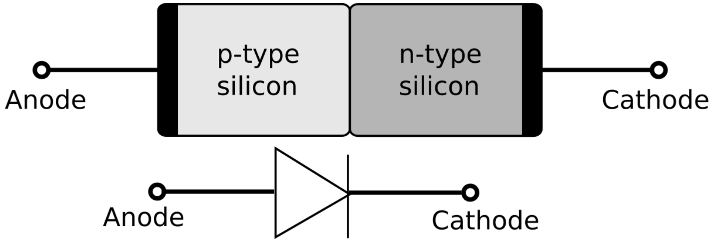






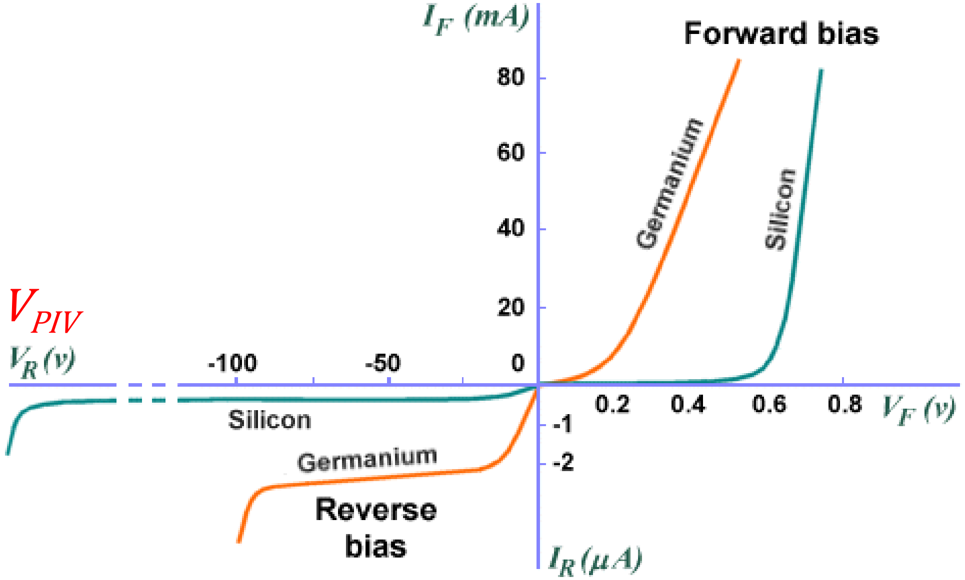


P-N Junction Diode



Ideal diode equation: $I = I_0\left(e^{\frac{V}{\eta V_t}} - 1\right)$

Where:
I is the net current flowing through the diode;
I_0 is reverse saturation current;
V is the applied voltage across the terminals of the diode;
V_t=26mV at room temperature;



η = 1 for Ge

= 2 for Si

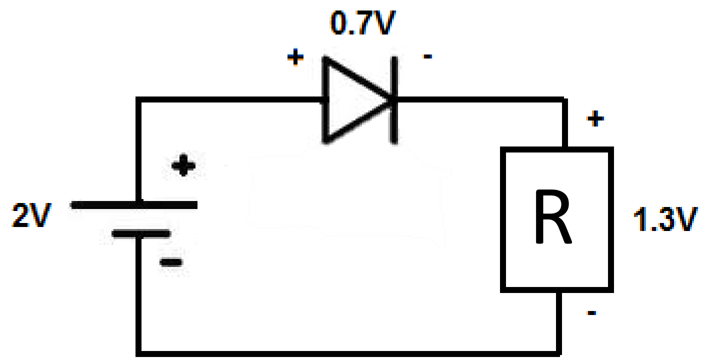
If $V \gg V_t \rightarrow I = I_0 e^{\frac{V}{\eta V_t}}$, I rises exponentially with V

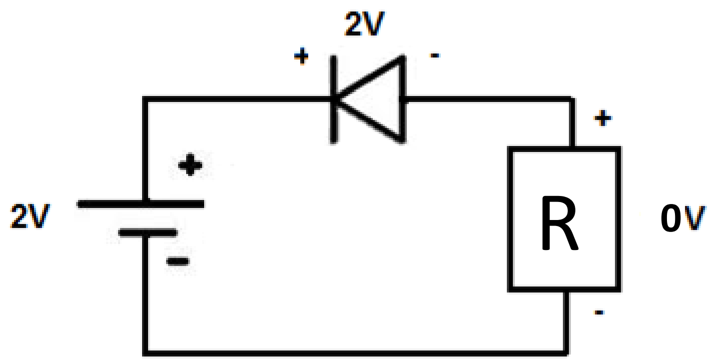
When reverse biased $\rightarrow I \cong -I_0$, Independent of V till V_{PIV}

When $V > V_{PIV}$, large reverse current flows

$\rightarrow$ diode will get damaged if V applied is greater than V_{PIV}

PN Junction Diode Circuits





Diode **forward** biased

Current flows

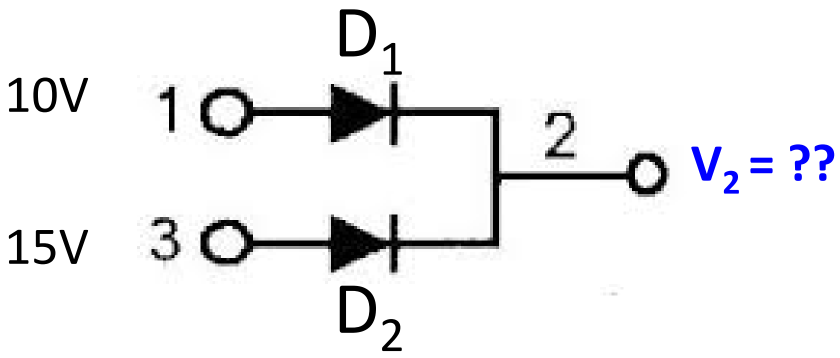
$$I_{Load} = \frac{2V - 0.7V}{R_{Load}}$$

Diode **reverse** biased

Current does NOT flow

$$I_{Load} = \frac{2V - 2V}{R_{Load}} = 0$$

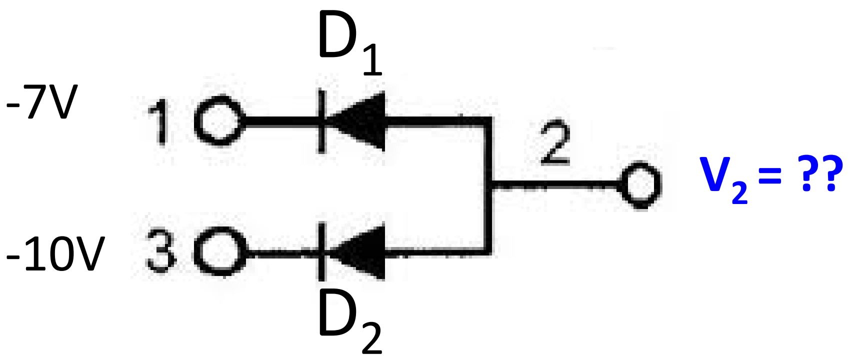
PN Diode Circuits



Common Cathode configuration

D_2 is conducting

V_2= 14.3



Common Anode configuration

D_2 is conducting

V_2= -9.3