ECE 65: Components & Circuits Lab

Lecture 9

Diode waveform shaping circuits

Clamp circuits

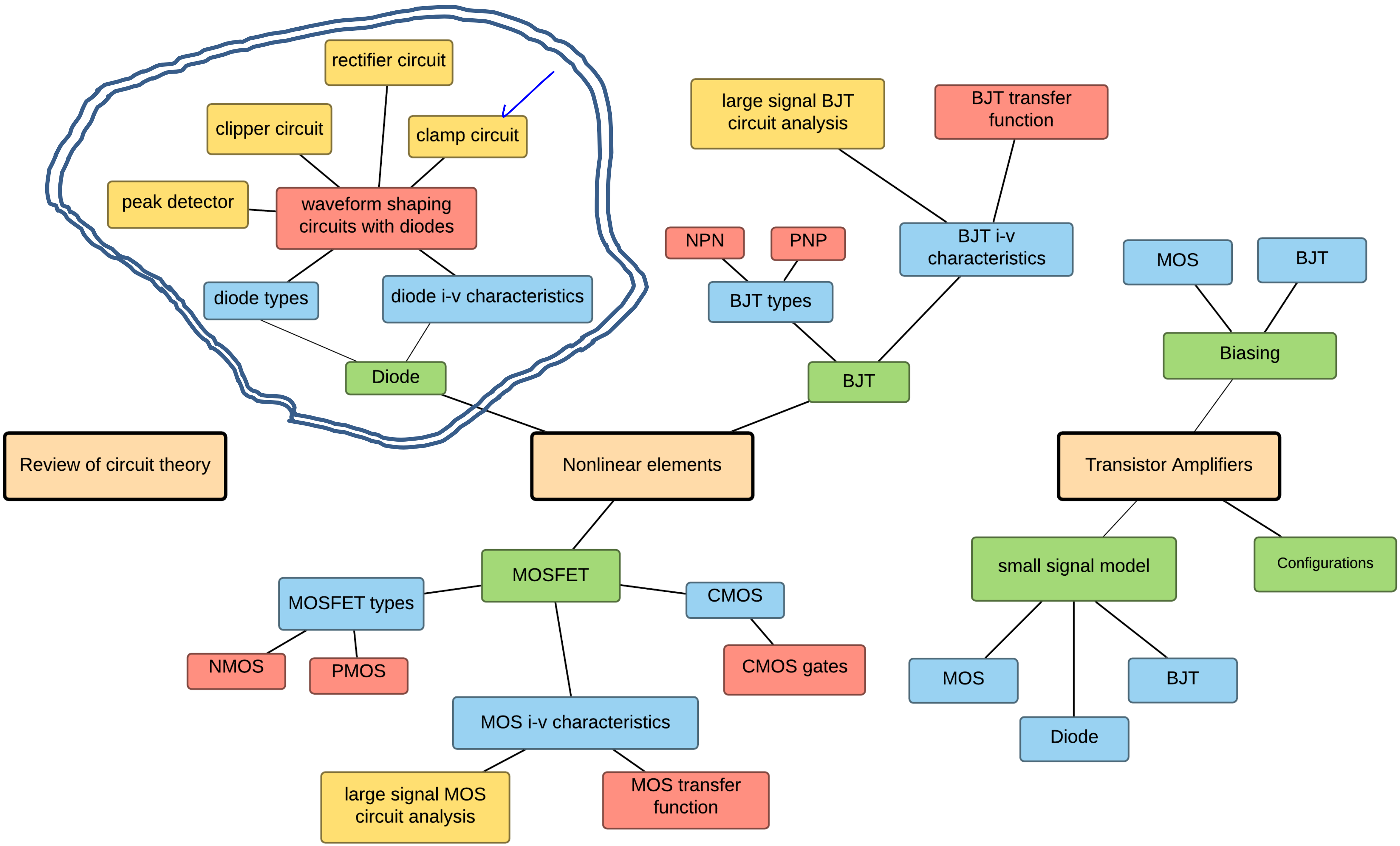
Reference notes: sections 2.9

Sedra & Smith (7^{th} Ed): sections 4.4-4.6

Saharnaz Baghdadchi

Course map

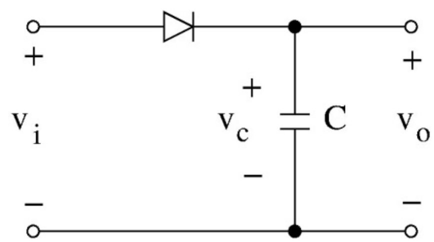
2. Diodes

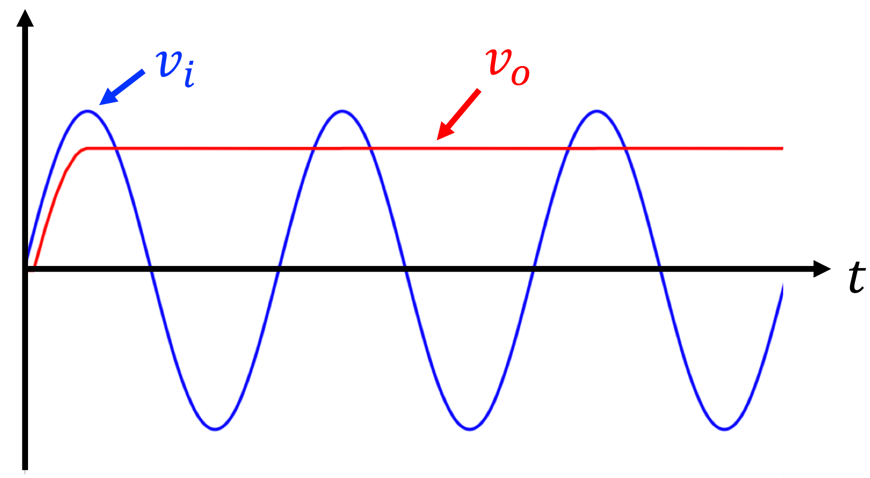


Clamp circuit and peak detector circuit

Ideal peak detector:

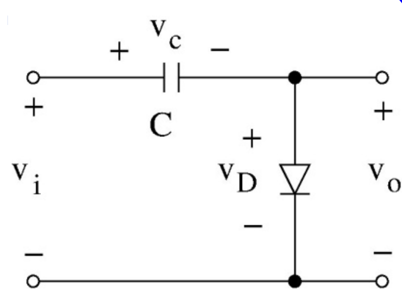
$$v_o = V_p - V_{D0}$$

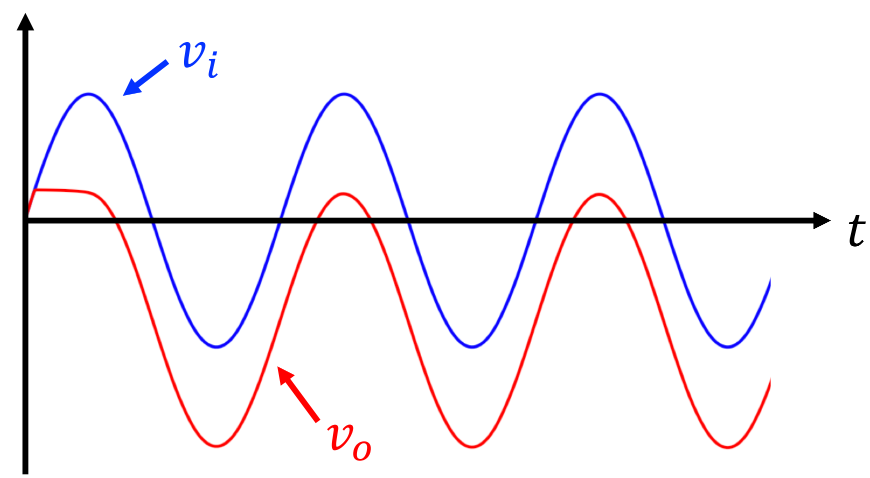




Clamp circuit:

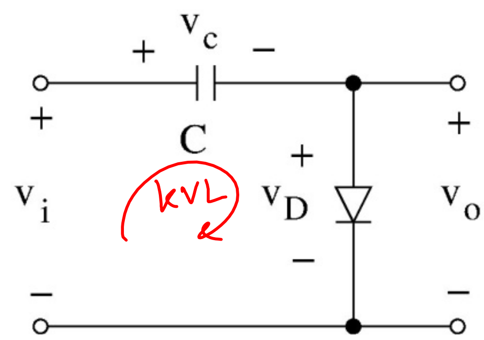
$$v_o = v_i - (V_p - V_{D0})$$



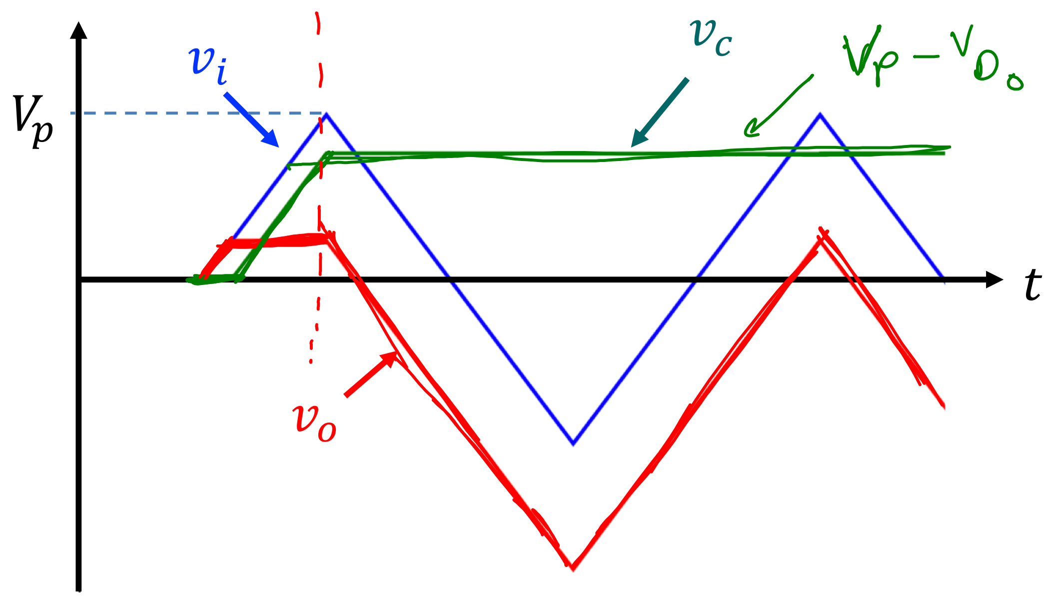


Clamp Circuit

$v_D = -v_c + v_i$



The diode turns OFF when the capacitor is charged to $v_c = \boxed{V_p - V_{D0}}$



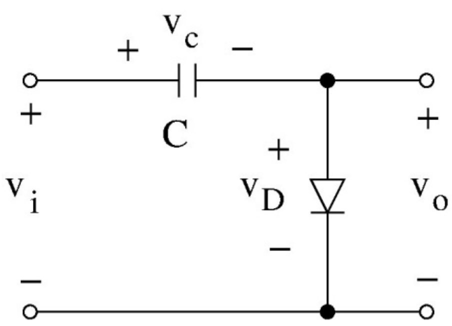
$$v_o = v_D = v_i - v_c$$

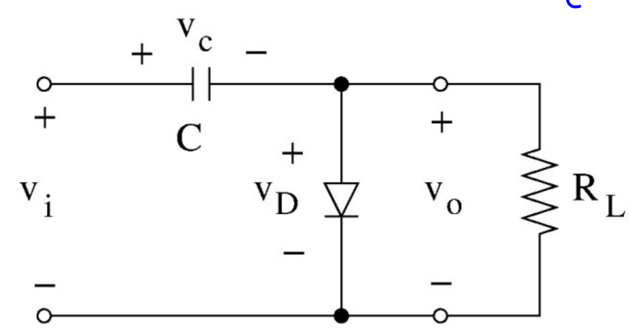
Diode off:

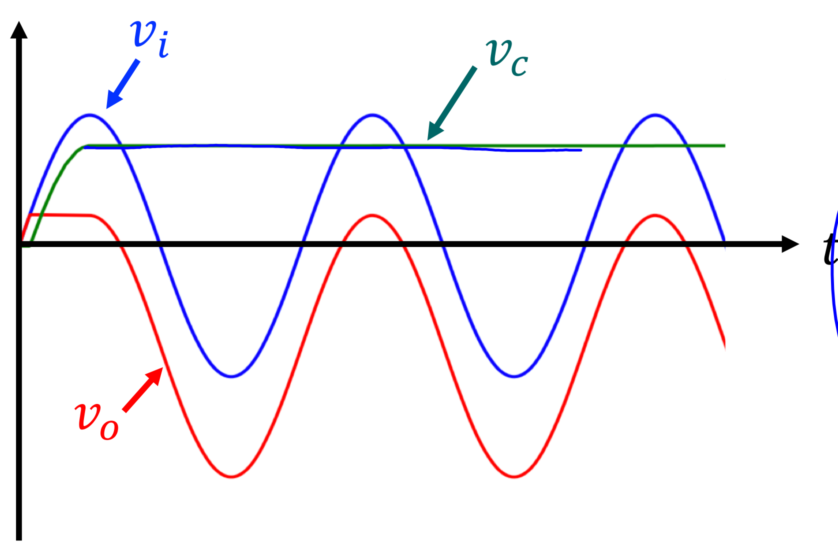
$$v_o = v_i - (V_p - V_{D0})$$

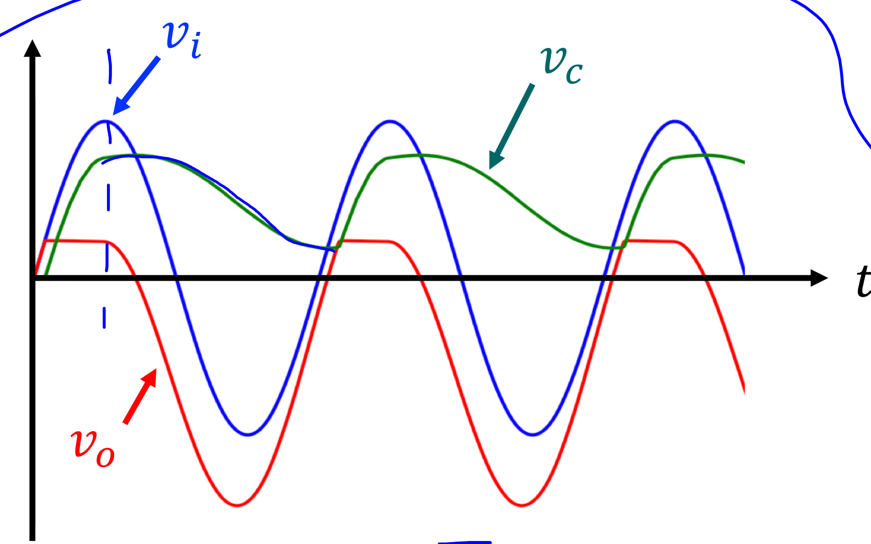
Clamp Circuit with a Load

$\tau = CR_L$





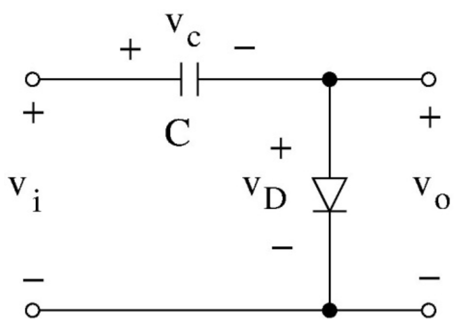




$RC = T$

If $\tau = R_L C >> T$ capacitor does not discharge substantially and clamp circuits works fine

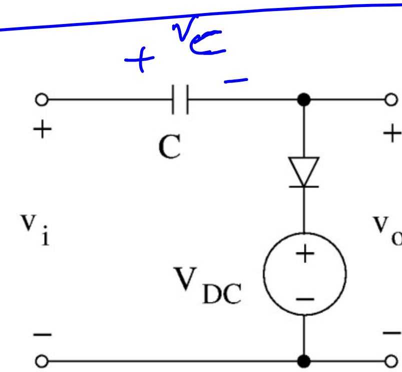
Voltage shift in a clamp circuit can be adjusted



$$V_C = V_p - V_{D_0}$$

$$V_o = -V_C + V_i$$

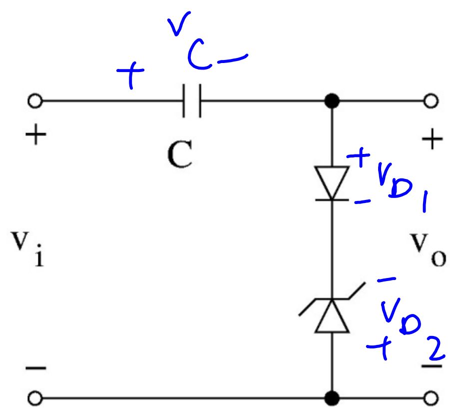
$$V_o = V_i - \boxed{(V_p - V_{D_0})}$$



$$V_C = V_p - (V_{D_0} + V_{DC})$$

$$V_o = -V_C + V_i$$

$$= V_i - \boxed{(V_p - V_{D_0} - V_{DC})}$$

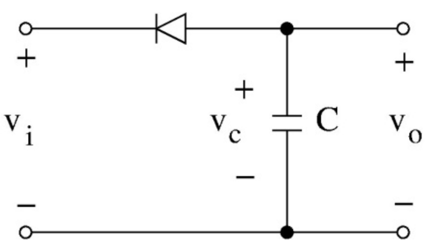


$$V_o = -V_C + V_i$$

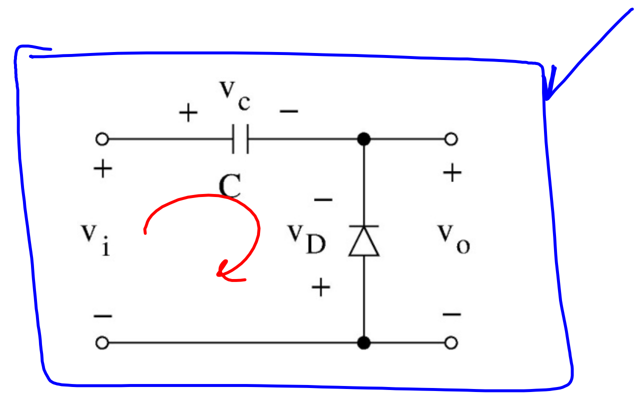
$$= V_i - (V_p - V_{D_0} - V_Z)$$

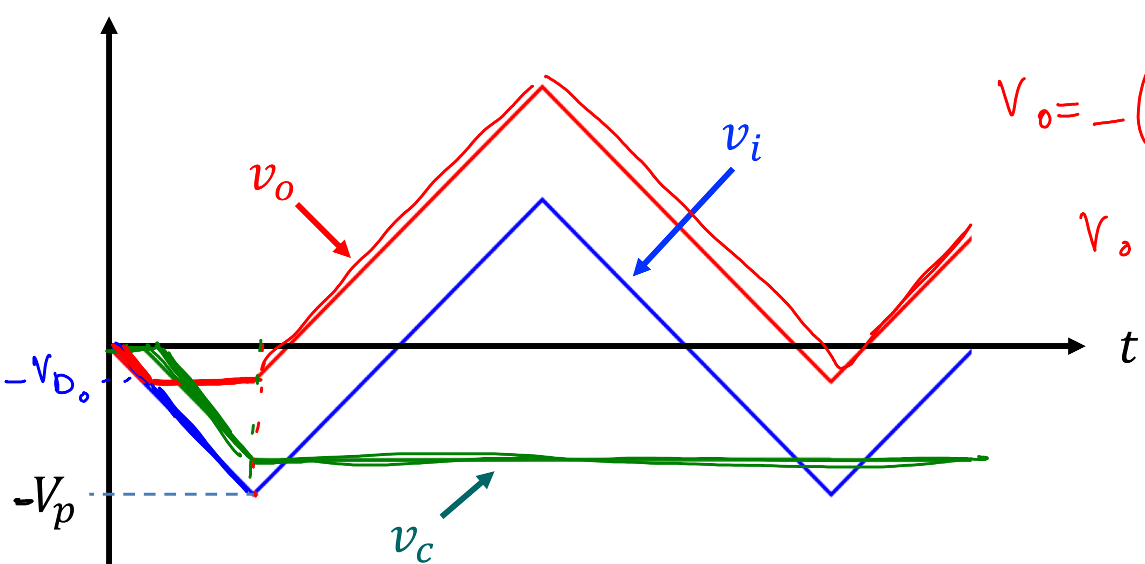
Clamp circuit can introduce a “positive” shift by reversing the diode terminals

Peak detector (diode is reversed):



Clamp circuit (diode reversed):





$V_o = -V_c + V_i$

$V_o = -(-V_p + V_{D_o}) + V_i$

$V_o = V_i + (V_p - V_{D_o})$

$V_D = -V_i + V_c = -V_i$

$V_o = -V_D$

$\Longrightarrow V_o = +V_i$

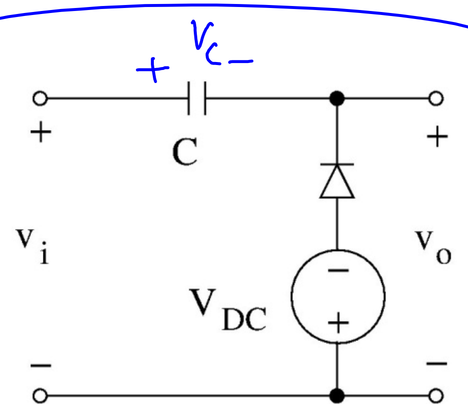
$V_o = -V_{D_o}$

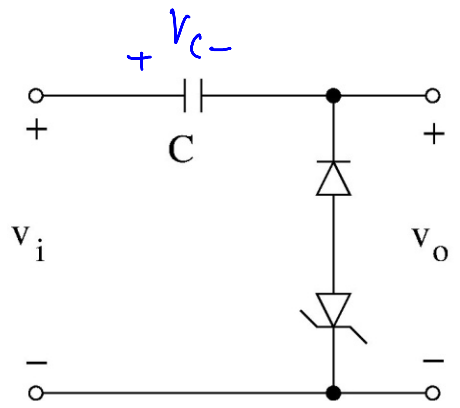
$V_c = V_i + V_{D_o}$

After the diode turned off

$\boxed{V_c = -V_p + V_{D_o}}$

The positive shift can also be adjusted.





$V_C = -V_p + V_{DC} + V_{D_0}$

$V_0 = V_i + (V_p - V_{DC} - V_{D_0})$

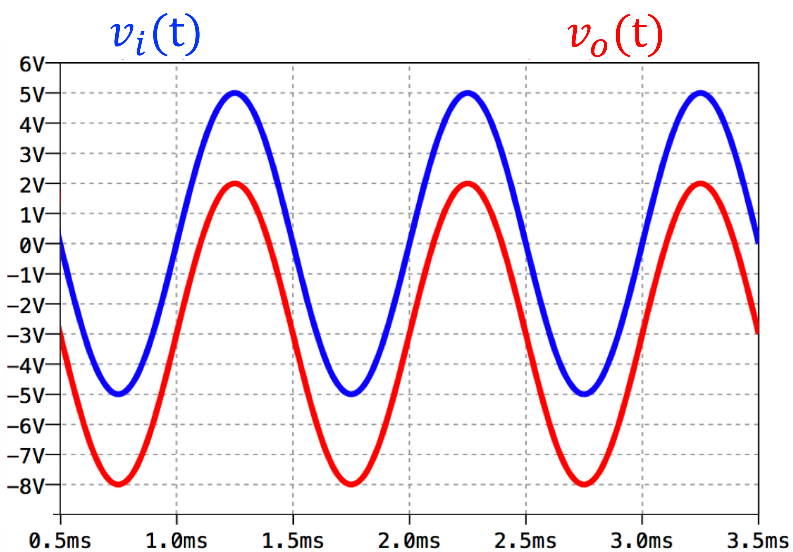
$V_0 = V_i + (V_p - V_Z - V_{D_0})$

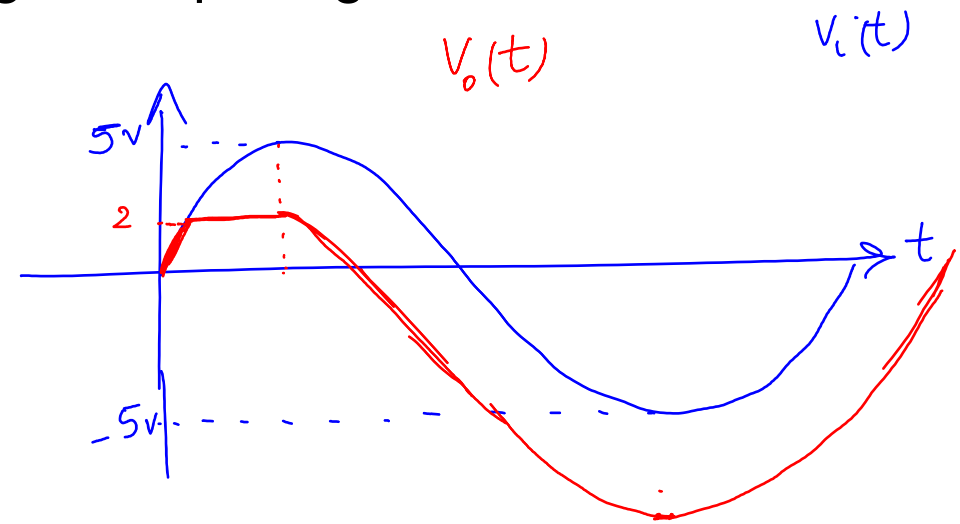
Lecture 9 reading quiz

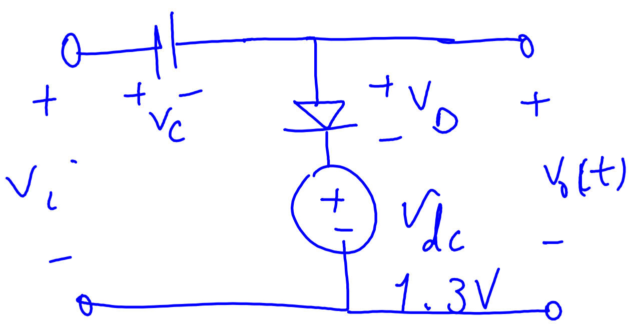
For $0 < V_i < 2$, the diode is off & $V_c = 0$

$V_o = -V_c + V_i = 0 + V_i = V_i$

Which one of the circuits in the provided options could produce the shown output waveform for the given input signal?







When the cap is charging:

$V_c(t) = V_i(t) - V_{dc} - V_D = V_i(t) - V_{dc} - V_{D_0}$

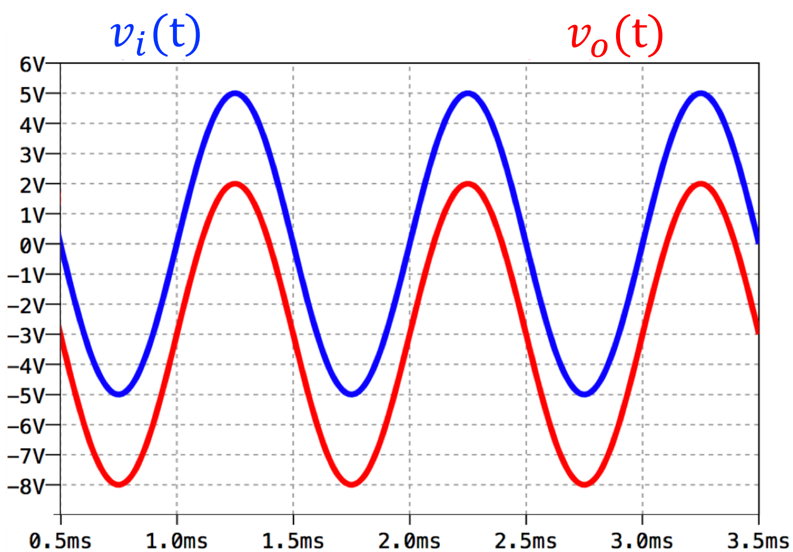
3 5 −1.3

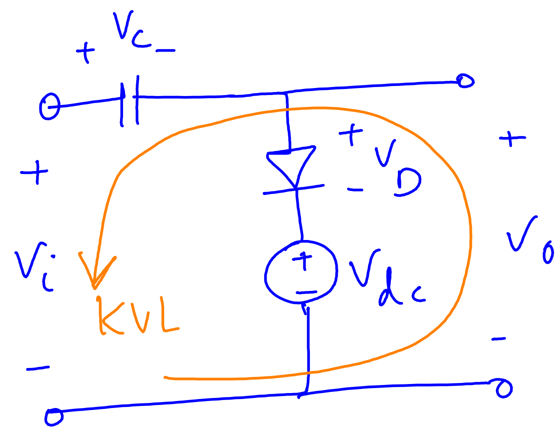
When the diode turns off:

$$\boxed{V_c = V_p - V_{dc} - V_{D_0}}$$

Lecture 9 reading quiz

Which one of the circuits in the provided options could produce the shown output waveform for the given input signal?





after the diode turns off:

$$V_C = \boxed{V_p - V_{dc} - V_{D_0}}$$

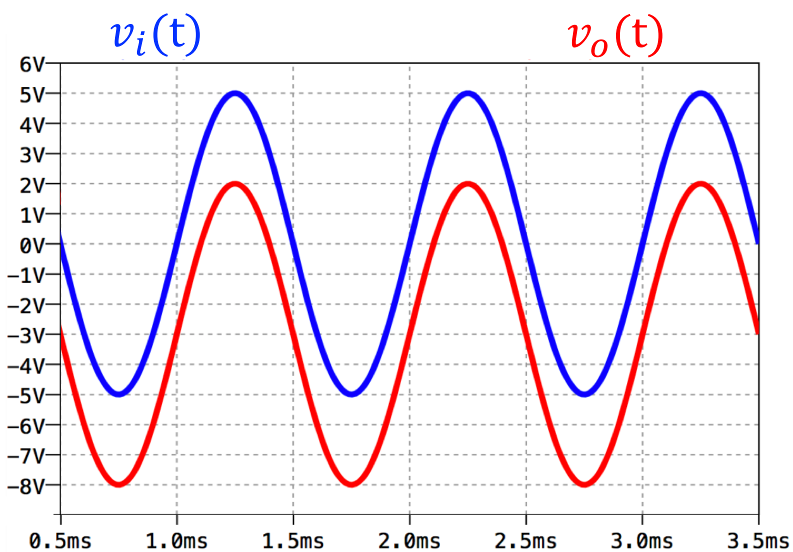
KVL: $V_o = V_i - \boxed{V_C}$

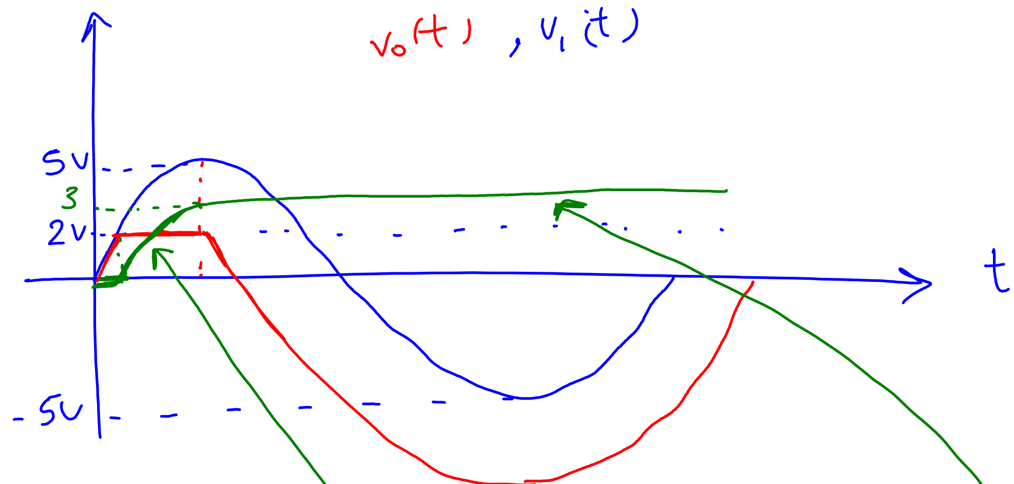
$$V_o = V_i - (V_p - V_{dc} - V_{D_0}) = V_i - 3V \Longrightarrow V_p - V_{dc} - V_{D_0} = 3V \rightarrow 5 - V_{dc} - 0.7 = 3$$

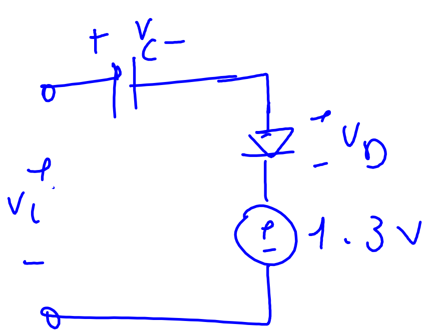
$$\rightarrow \boxed{V_{dc} = 1.3V}$$

Lecture 9 reading quiz

Which one of the circuits in the provided options could produce the shown output waveform for the given input signal?





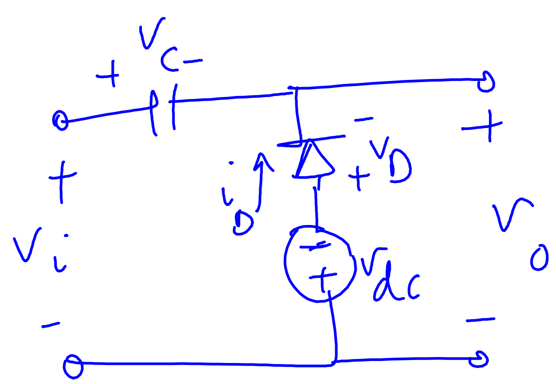


When the cap is charging : $\boxed{V_c(t) = V_i - V_{dc} - V_{D_0}}$

when the diode turns off : $\boxed{V_c(t) = V_p - V_{dc} - V_{D_0}}$

Discussion question 1

Consider a sinusoidal source $v_i(t) = 10\sin(\omega t)\,V$. Using a DC power supply, design a clamp circuit that adds a DC offset of 5V to $v_i(t)$. Draw two cycles of the input and output voltage waveforms.



KVL: $V_C = V_i + V_{dc} + V_D$

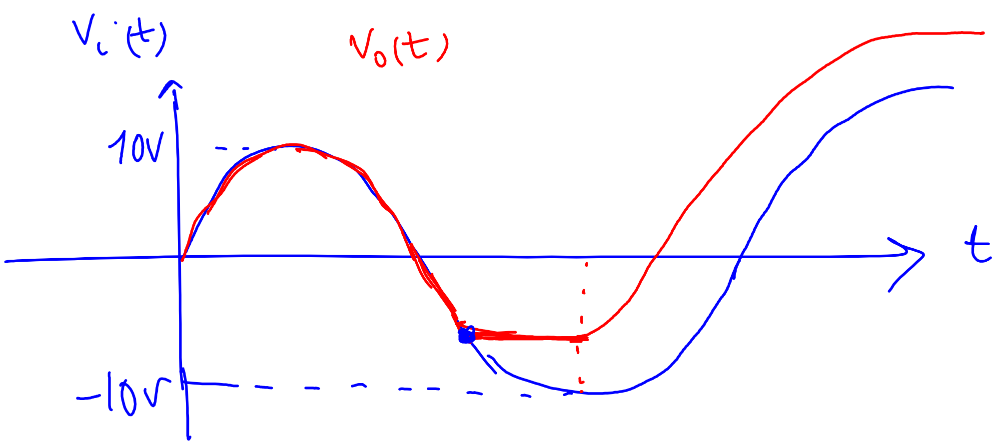
when the diode is ON

$V_C(t) = V_i(t) + V_{dc} + V_{D_0}$

when $V_i(t)$ reaches its negative peak

$$\boxed{V_C = -V_p + V_{dc} + V_{D_0}}$$

$V_{dc} = 4.3V$



$V_0 = -V_C + V_i = V_i - (-V_p + V_{D_0} + V_{dc})$

$= V_i - \underbrace{(-10 + 0.7 + V_{dc})}_{-5}$

$V_0 = V_i + 5V$

before the diode turns ON: $V_C = 0$, $V_0 = -V_C + V_i = V_i$