ECE 65: Components & Circuits Lab

Lecture 9

Diode waveform shaping circuits

Clamp circuits

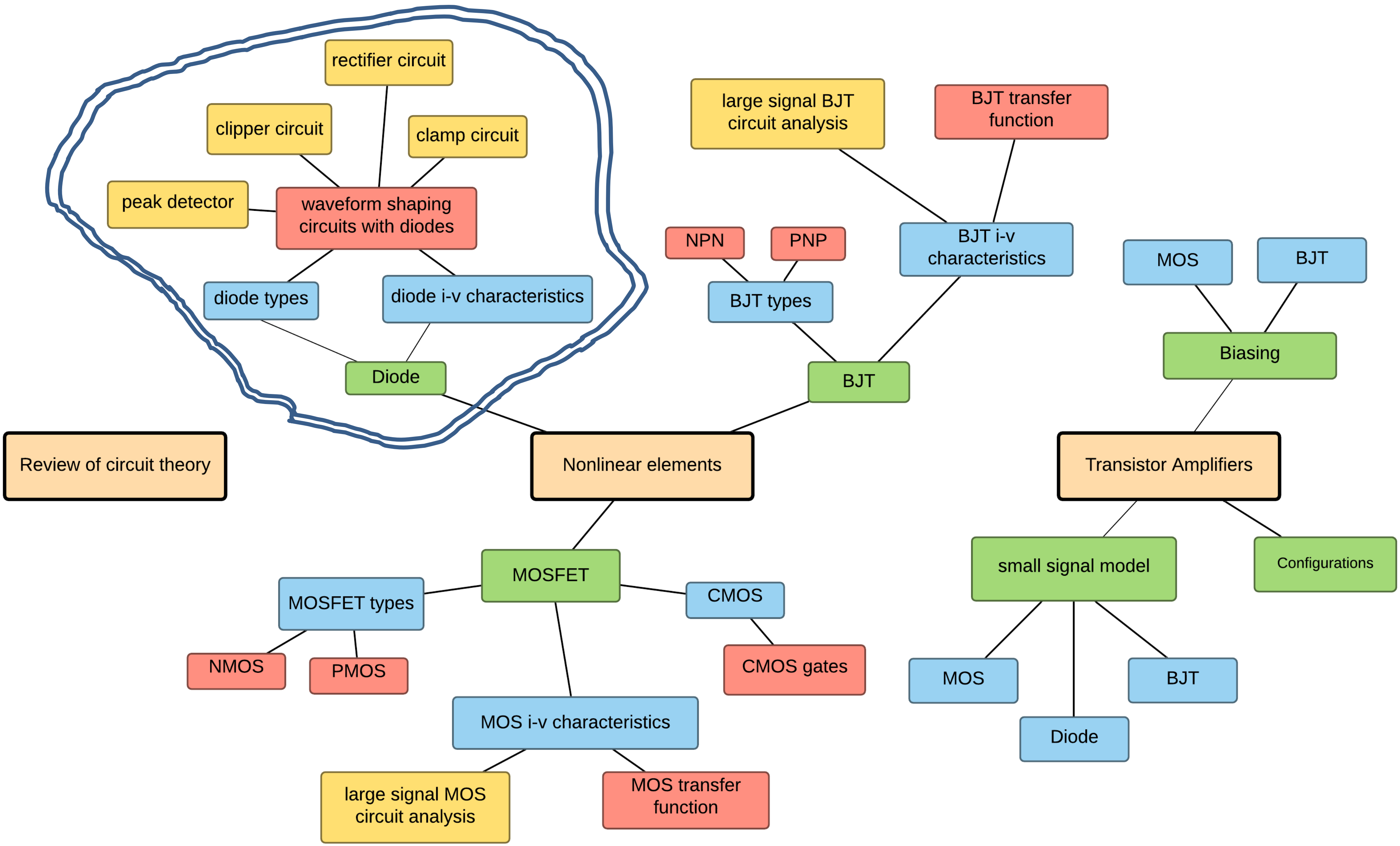
Reference notes: sections 2.9

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

Saharnaz Baghdadchi

Course map

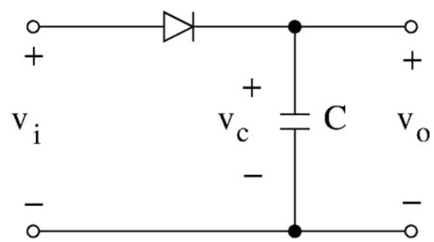
2. Diodes

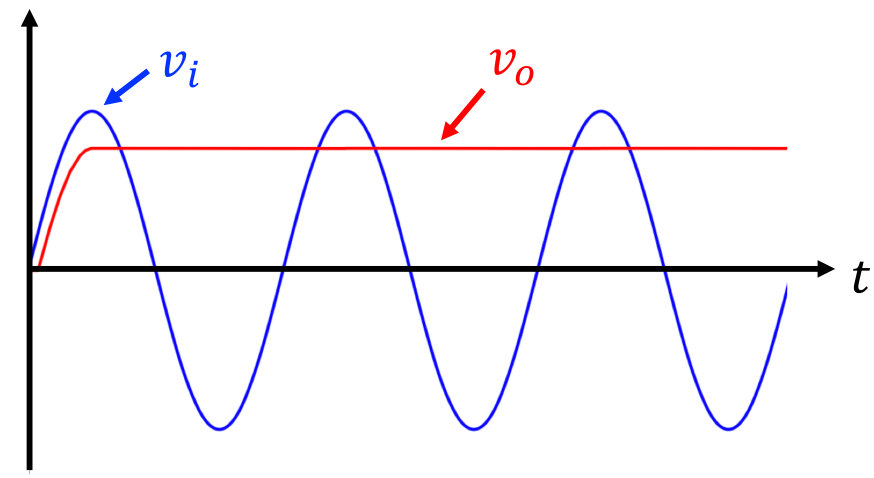


Clamp circuit and peak detector circuit

Ideal peak detector:

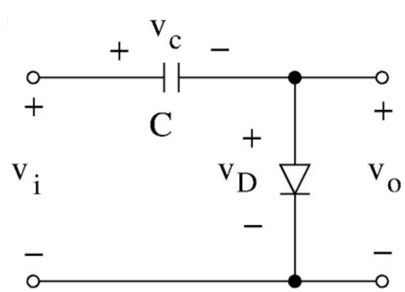
$$v_o = V_p - V_{D0}$$

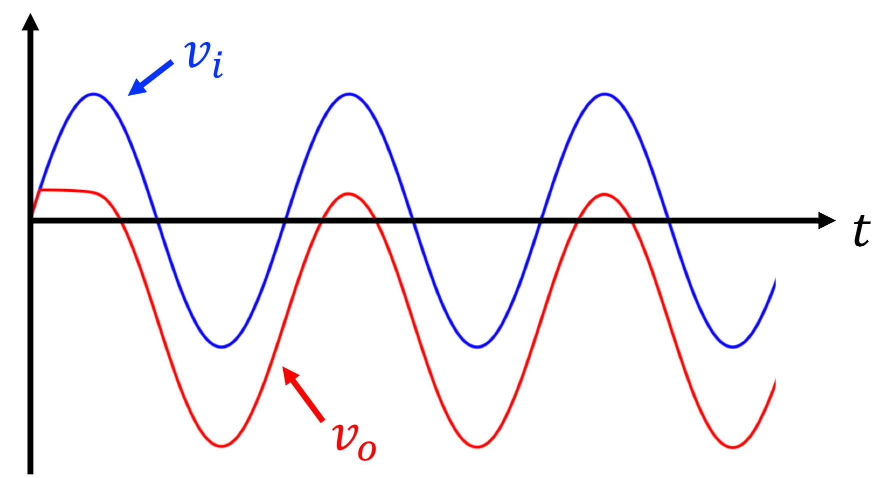




Clamp circuit:

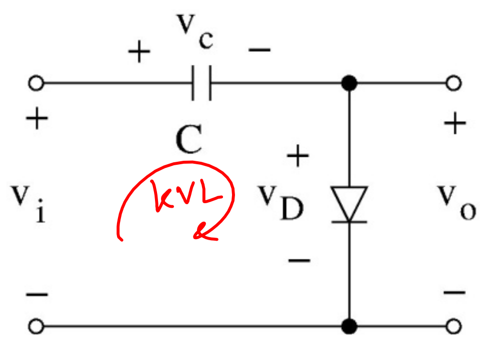
$$v_o = v_i - (V_p - V_{D0})$$



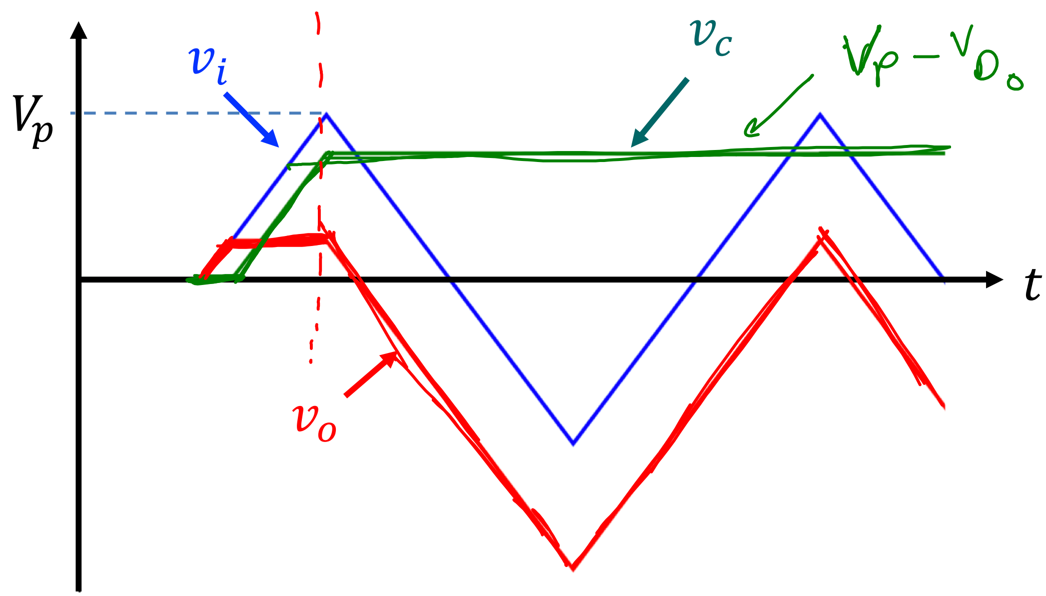


Clamp Circuit

$v_D = -v_c + v_i$



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

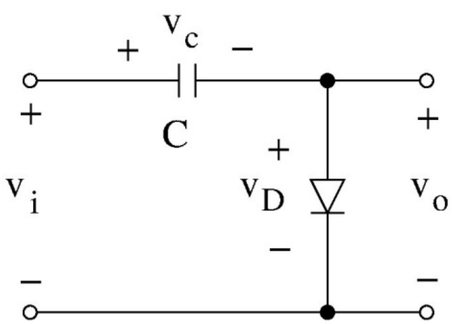


$$v_o = v_D = v_i - v_c$$

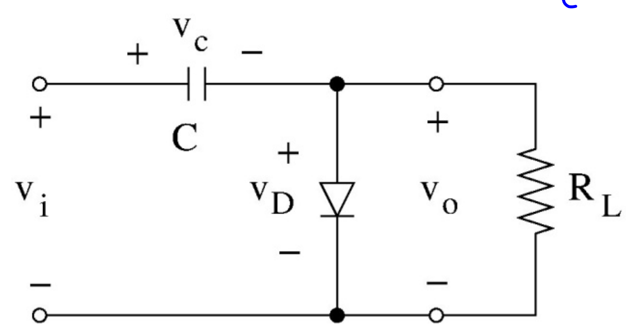
Diode off:

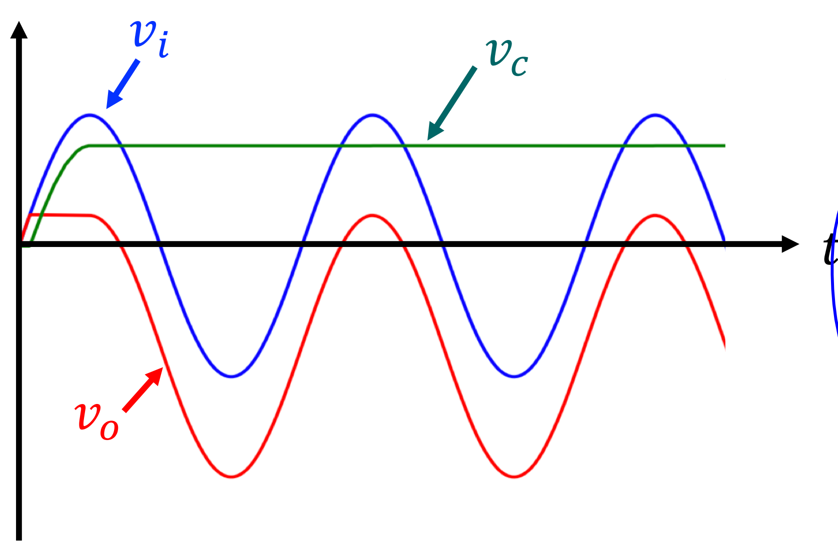
$$v_o = v_i - (V_p - V_{D0})$$

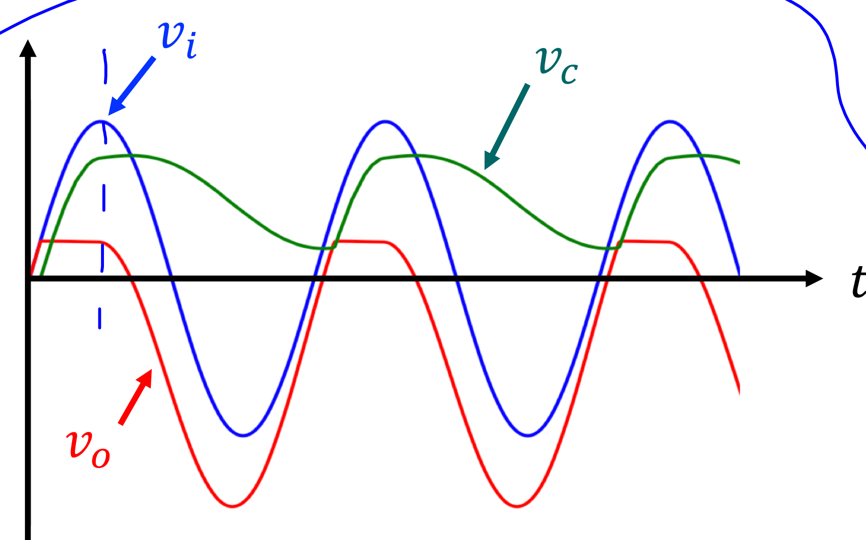
Clamp Circuit with a Load



$\tau = CR_L$



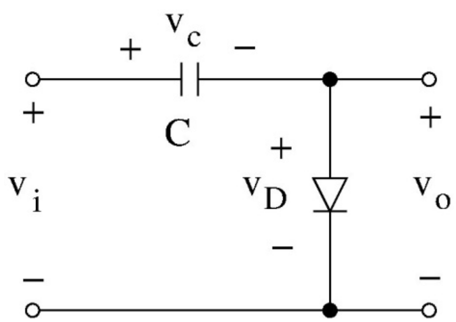




$RC = T$

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

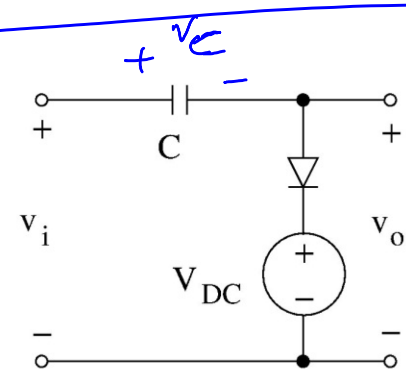
Voltage shift in a clamp circuit can be adjusted



$V_C = V_p - V_{D_0}$

$V_o = -V_C + V_i$

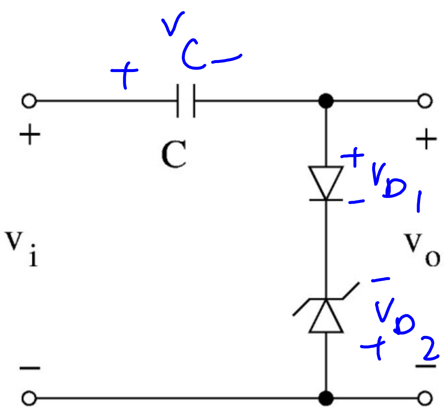
$V_o = V_i - \boxed{(V_p - V_{D_0})}$



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

$V_o = -V_C + V_i$

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

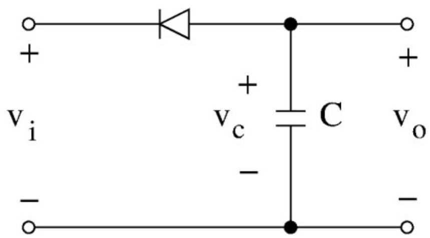


$V_o = -V_C + V_i$

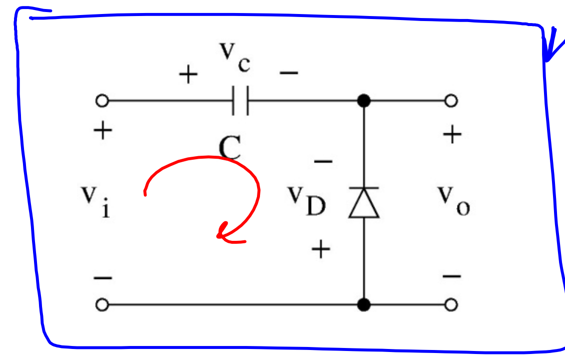
$= V_i - (V_p - V_{D_0} - V_Z)$

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

Peak detector (diode is reversed):



Clamp circuit (diode reversed):



$V_o = -V_c + V_i$

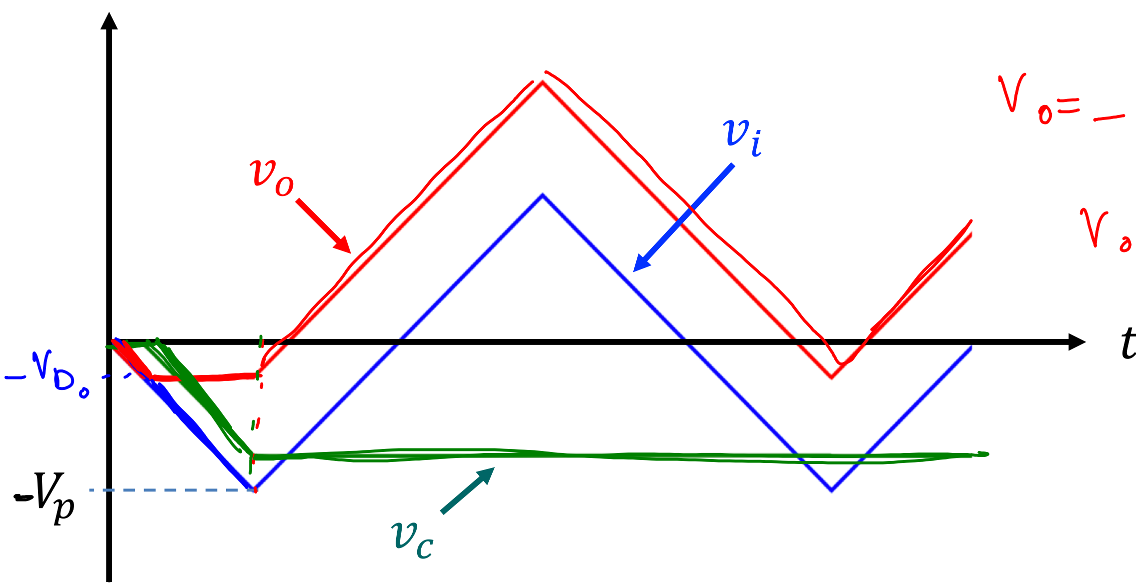
$V_D = -V_i + V_c = -V_i$

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

$V_o = -V_D$

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

$\Rightarrow V_o = +V_i$



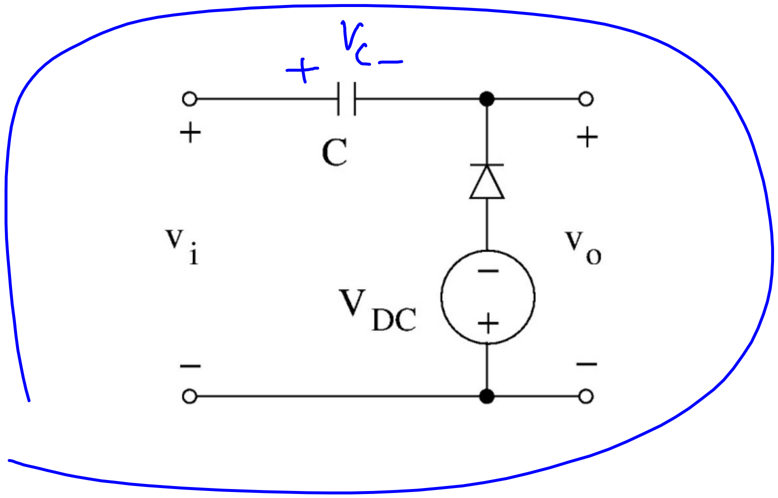
$V_o = -V_{D_o}$

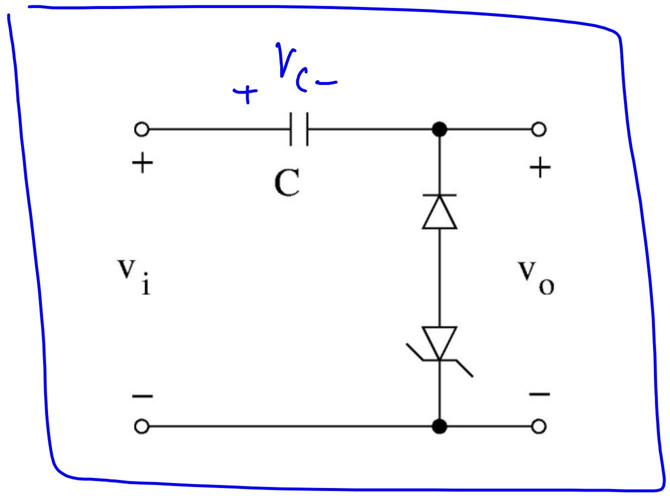
$V_c = V_i + V_{D_o}$

After the diode turned off

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

The positive shift can also be adjusted.





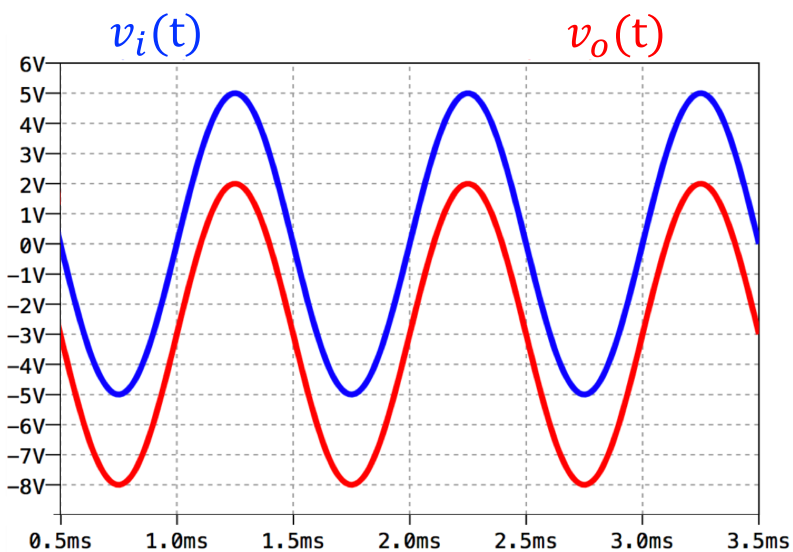
$$V_C = -V_p + V_{DC} + V_{D_o}$$

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

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

Lecture 9 reading quiz

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



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.

Hints:

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.

- Check the lecture notes to see the structure of the clamp circuit that can add a positive DC shift to input signals.

- You can use the equations included in the lecture notes to find the required amplitude of VDC to have the +5V DC shift.

-After drawing the circuit structure, solve the circuit to find vout as a function of vi for different time intervals.

- You need to find the minimum value of vi to turn on the diode. You also need to find out for how long the diode can stay on and what happens when the diode turns off.

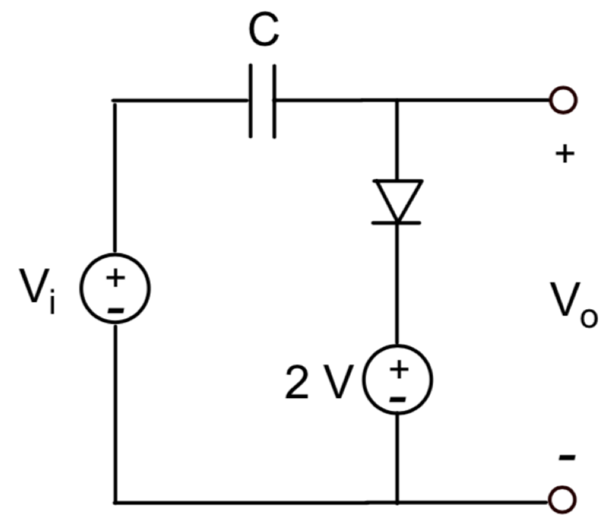
- Draw vi(t) and vout(t) on the same graph.

- You can also draw the clamp circuit structure with a DC source with an unknown amplitude and solve the circuit to find the amplitude of the DC source.

Clicker question 1.

In the circuit below, $v_i(t) = 10\ \sin(\omega t)$ where ω=1000rad/s, $v_o(0) = 0.\ V_{D0} = 0.7\ V$

What is the value of $v_o(t)$ at t = 2 ms?



A. $v_o(t = 2\ ms)$ = 1.8 V

B. $v_o(t = 2\ ms)$ = 6.4 V

C. $v_o(t = 2\ ms)$ = 2.7 V