ECE 65: Components & Circuits Lab

Lecture 8

Diode waveform shaping circuits

Peak detector circuits

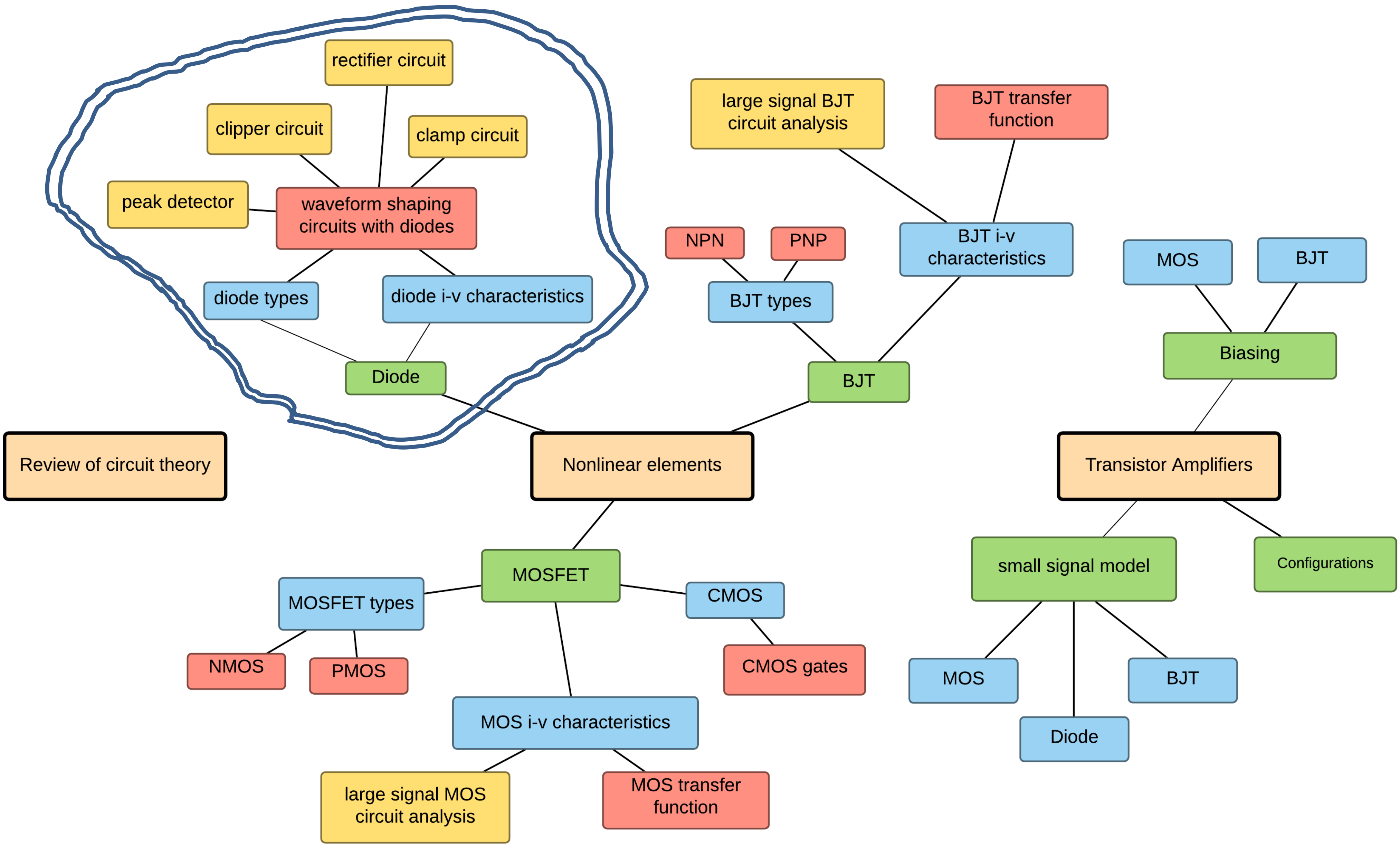
Reference notes: sections 2.9

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

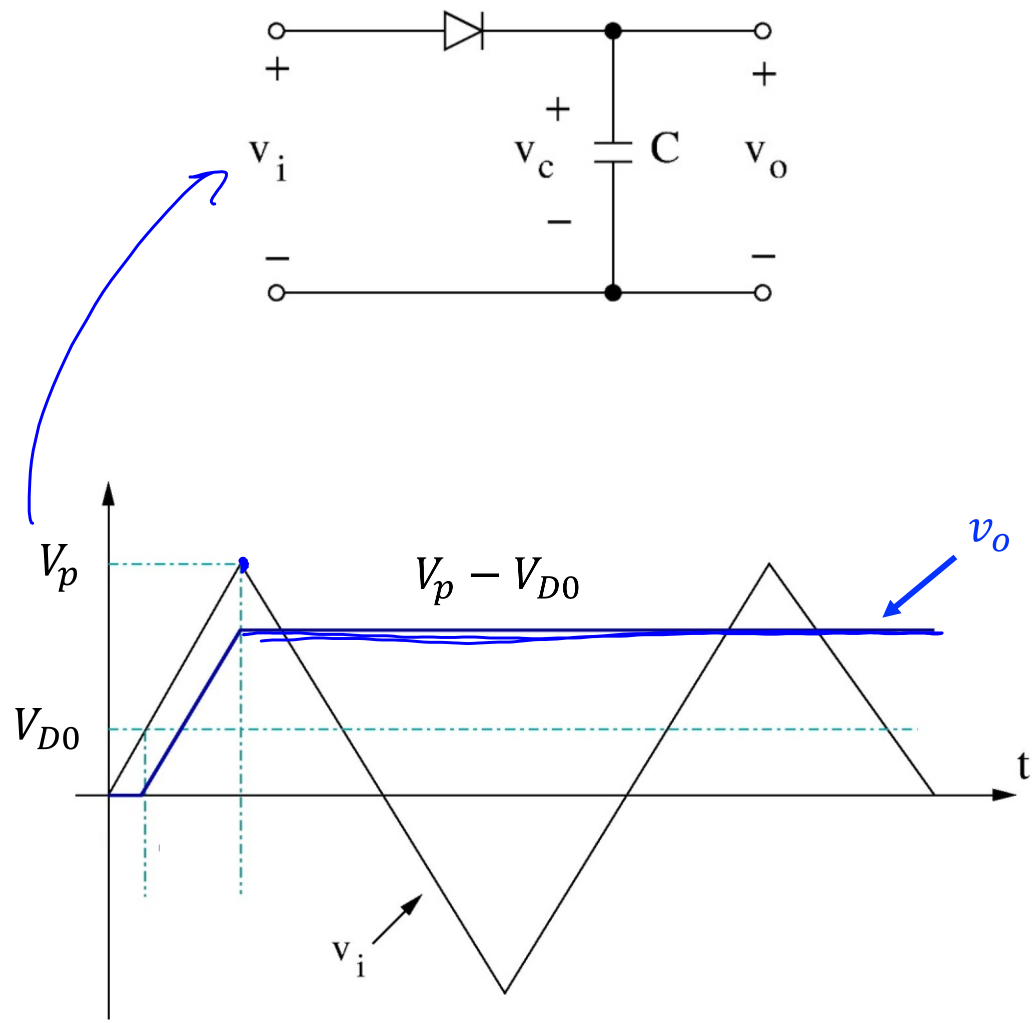
Saharnaz Baghdadchi

Course map

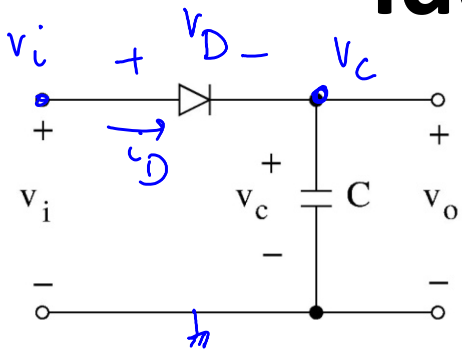
2. Diodes



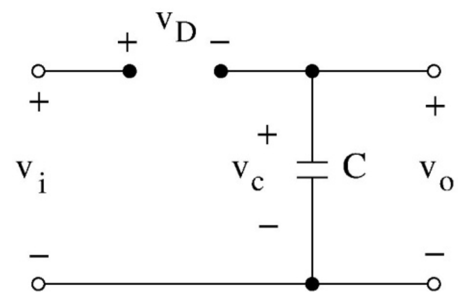
Ideal Peak Detector Circuit



Ideal Peak Detector Circuit



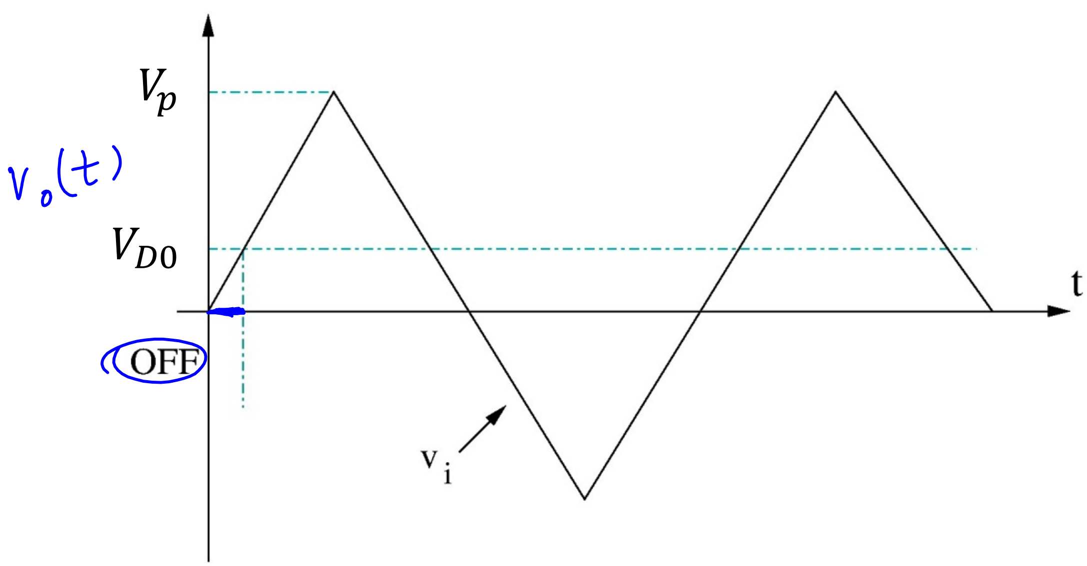
When the Diode is initially OFF:



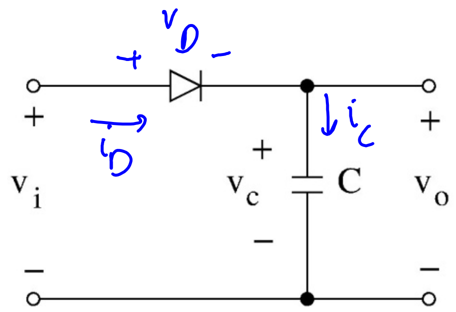
$$V_D = V_i - V_C = V_i$$

$$i_D = 0, \quad V_D < V_{D0}$$

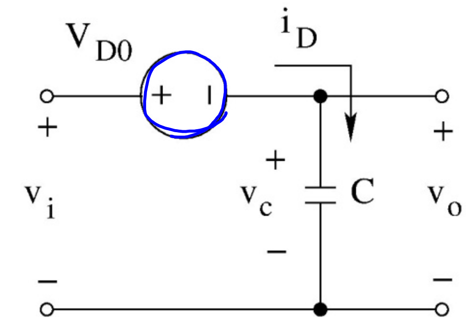
$$\Rightarrow V_i < V_{D0}$$



Ideal Peak Detector Circuit



When the Diode is ON:

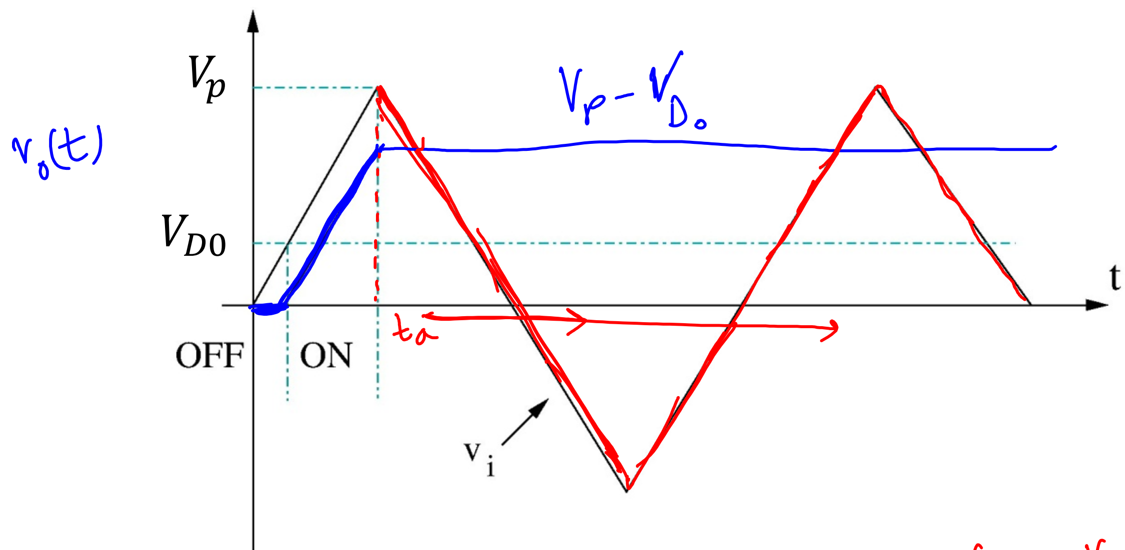


$V_D = V_{D_0}$

$i_D \geq 0$

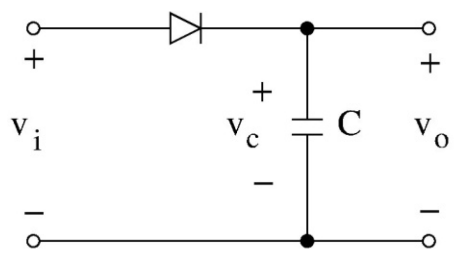
$V_o = -V_D + V_i = -V_{D_0} + V_i$, $i_D = i_C = C\dfrac{dv_C}{dt} = C\dfrac{d(v_i - V_{D_0})}{dt}$

$= C\dfrac{dv_i}{dt}$

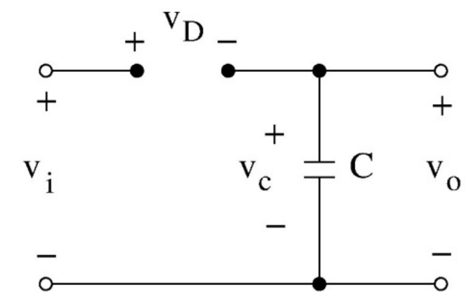


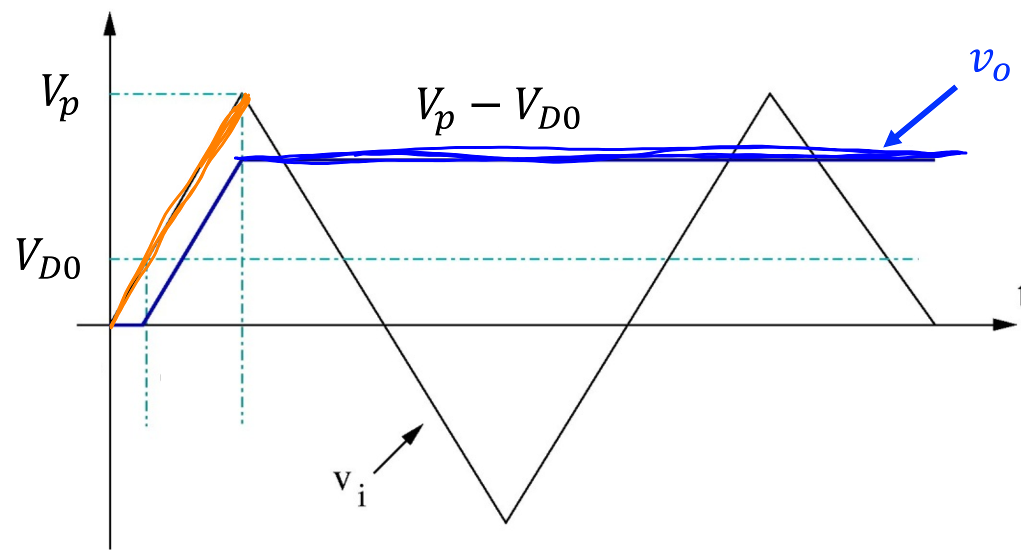
at $t = t_a$, $V_i = V_p$, $V_C = V_p - V_{D_0}$, $V_D = V_i - V_C = V_i - (V_p - V_{D_0})$

Ideal Peak Detector Circuit

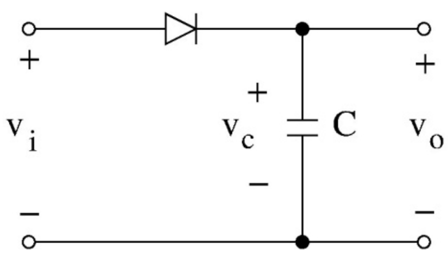


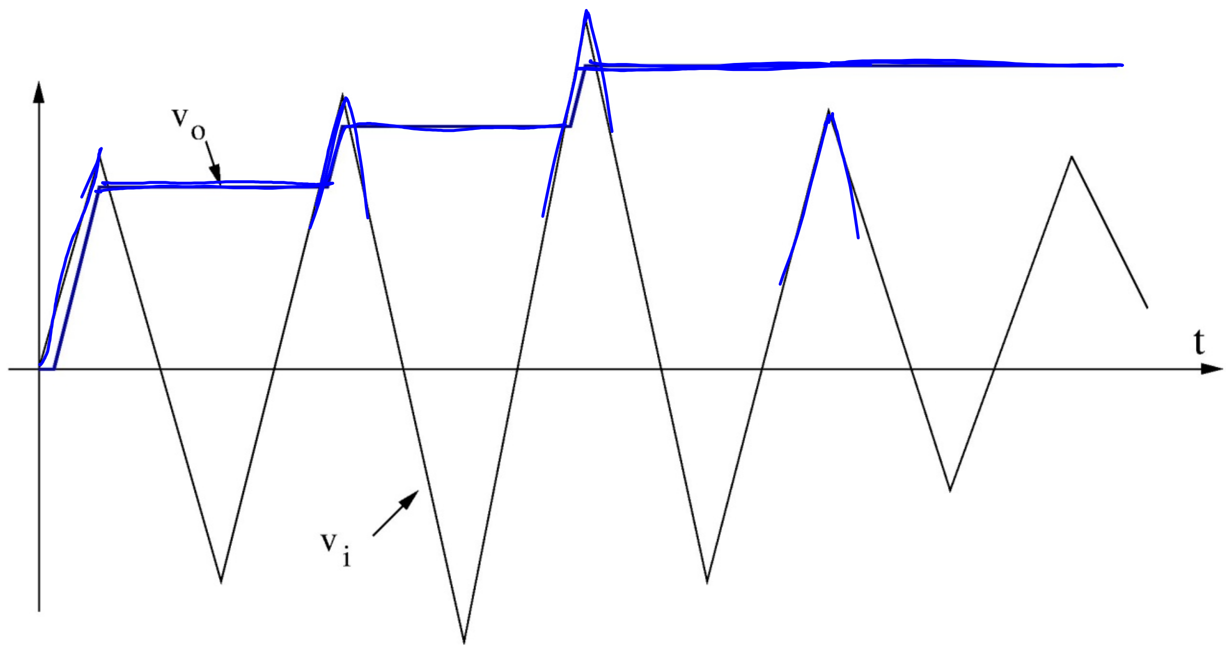
After v_i reached its peak value, the diode does not turn ON anymore.





Response of the Ideal Peak Detector (v_i amplitude changes)

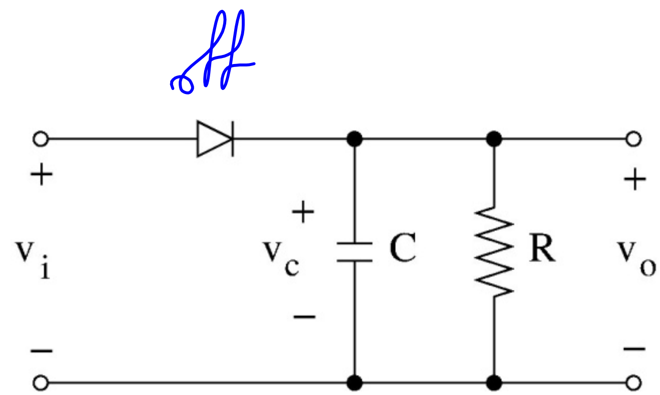


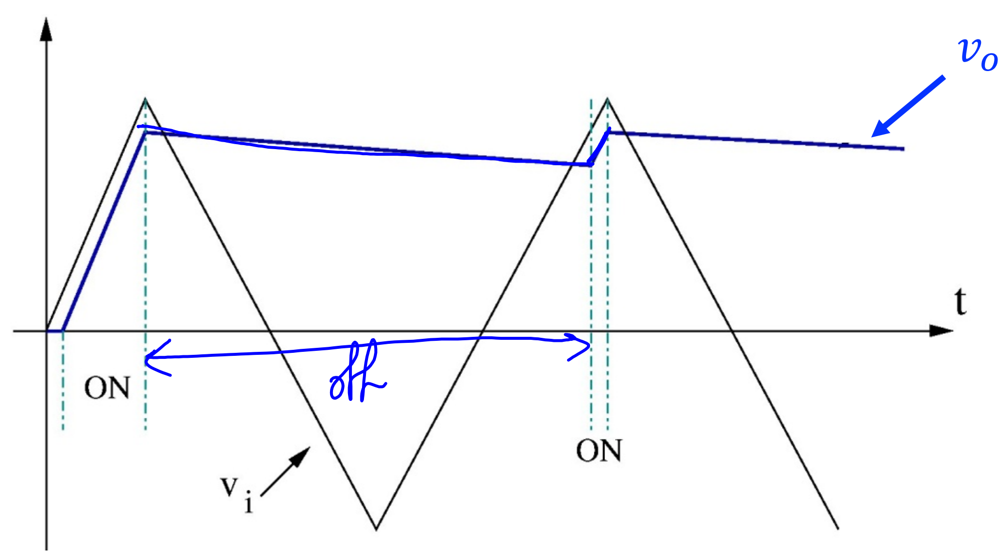


v_o is the "peak" value of input waveform ($V_p - V_{D0}$):

Note v_o did not "drop" after the peak was decreased in the 3rd cycle.

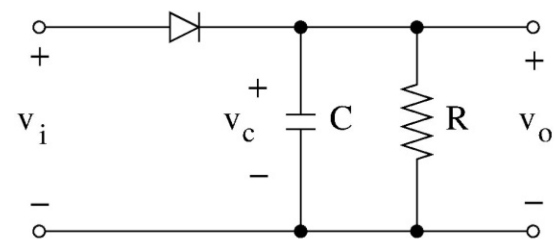
Practical Peak Detector Circuit

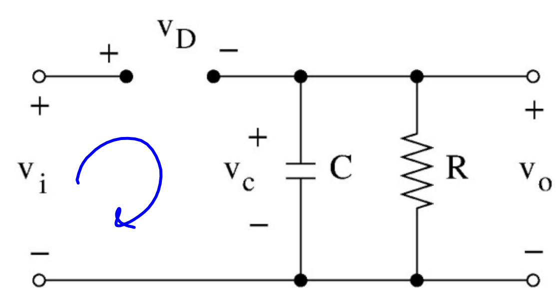




Practical Peak Detector Circuit

Diode OFF: $i_D = 0$ and $v_D < V_{D0}$



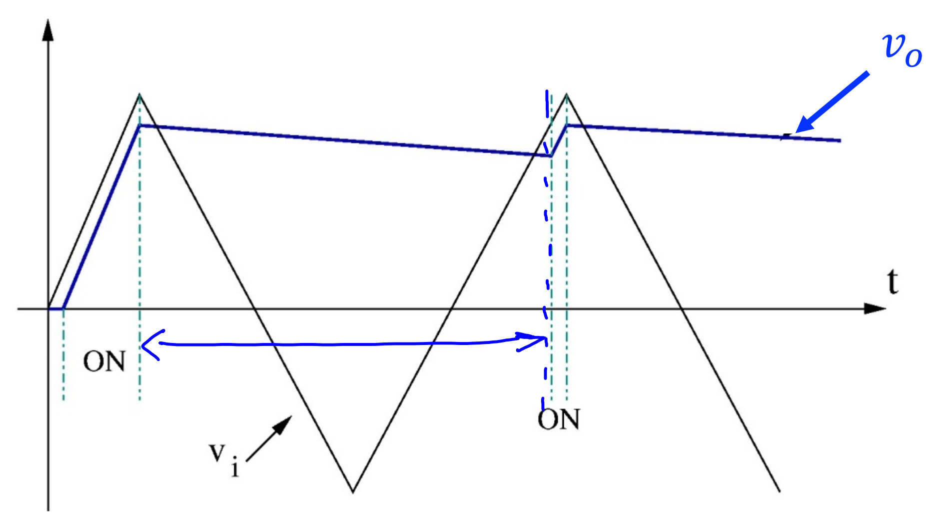


Capacitor discharges into the resistor with a time constant of $\tau = RC$

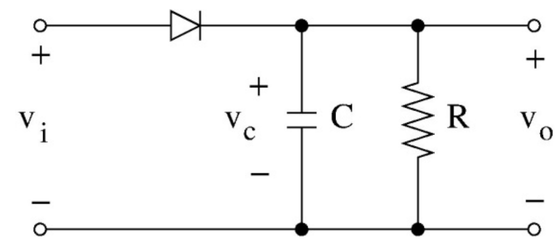
$$v_o = v_c(t) = v_{c_0}\, e^{-(t-t_0)/\tau}$$

$$v_D = v_i - v_c < V_{D0}$$

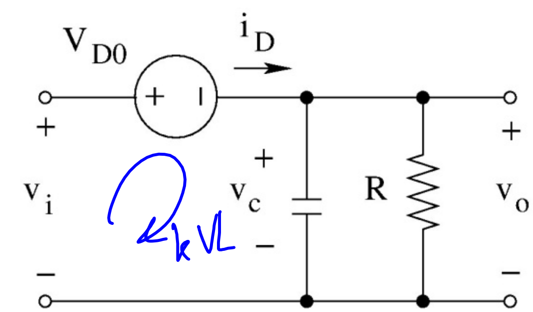
$$\rightarrow v_i < v_c(t) + V_{D0}$$



Practical Peak Detector Circuit

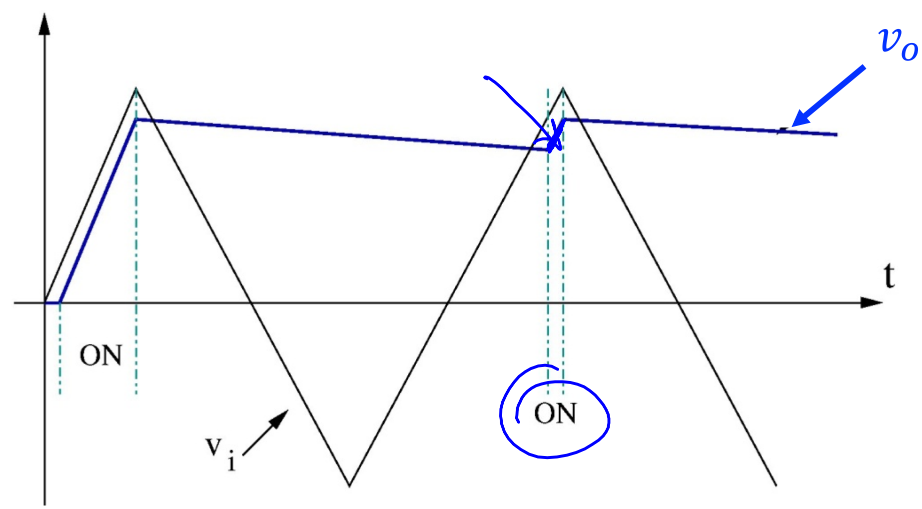


Diode ON: $v_D = V_{D0}$ and $i_D \geq 0$



$$v_o = v_C = v_i - V_{D0}$$

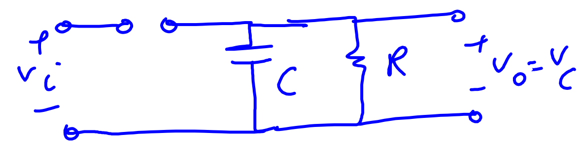
$$i_C = C\frac{dv_C}{dt} = C\frac{d(v_i - V_{D0})}{dt} = C\frac{dv_i}{dt}$$



Response of the Practical Peak Detector

τ : time constant $= RC$

T : period of $v_i(t)$



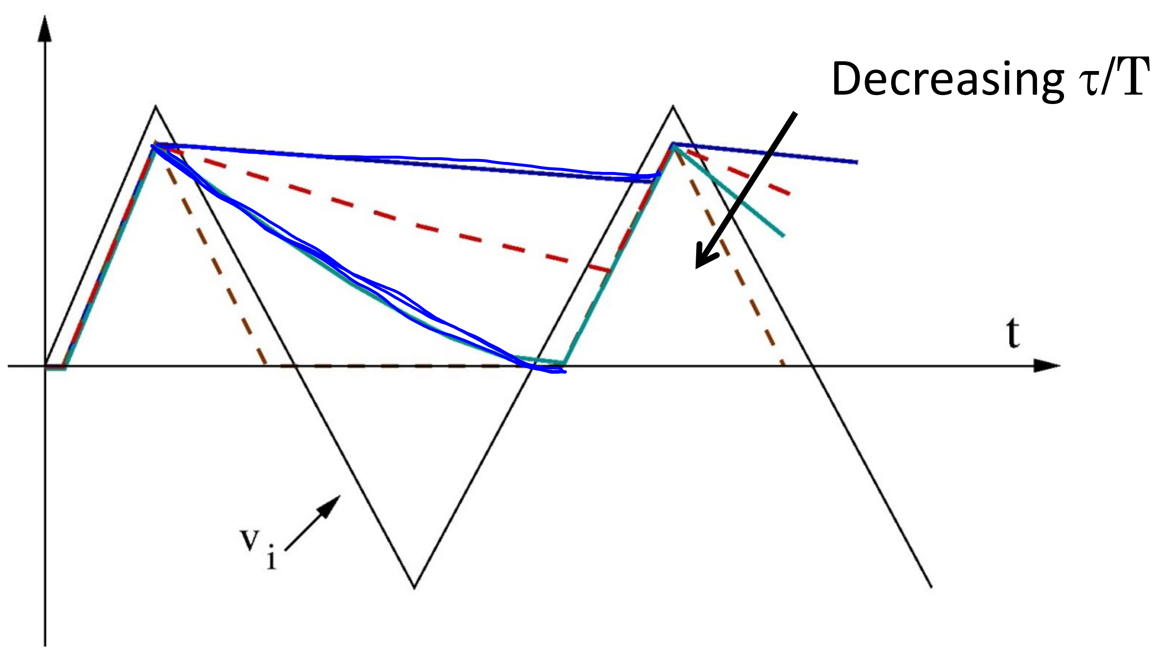
Shape of output signal depends on the ratio of τ/T

“ideal” peak detector: $\tau/T \to \infty$

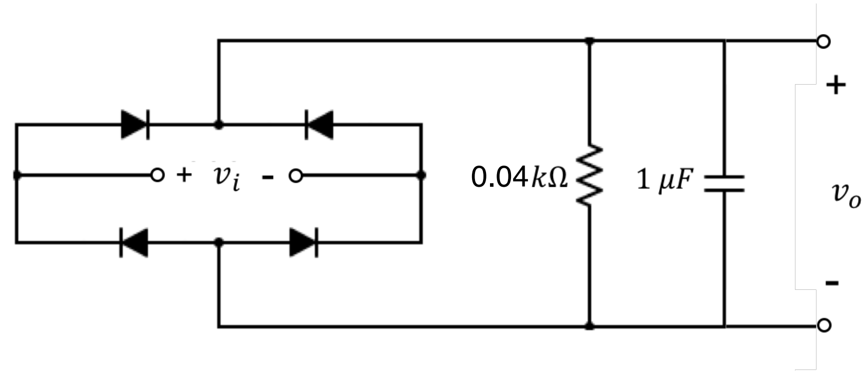
“Good” peak detector: $\tau/T >> 1$

As τ/T decreases, the circuit departs from a peak detector.

For $\tau/T << 1$, capacitor discharges very fast and circuit resembles a rectifier circuit

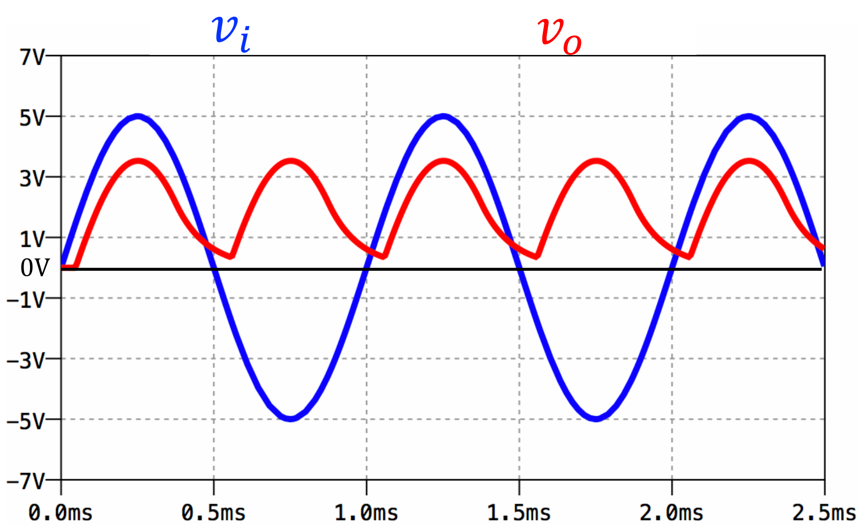


Lecture 8 reading quiz.

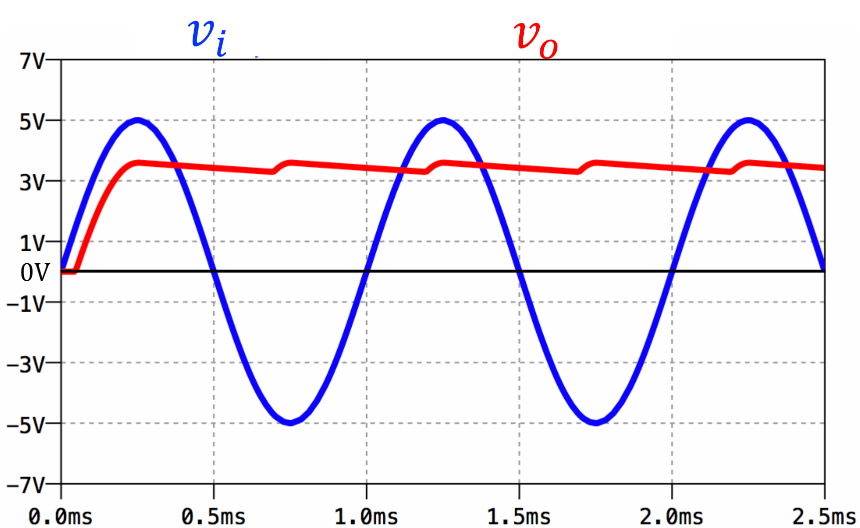


In the following diode circuit, which one of the options could be the input and output voltages for this circuit? $V_{D0} = 0.7\ V$.

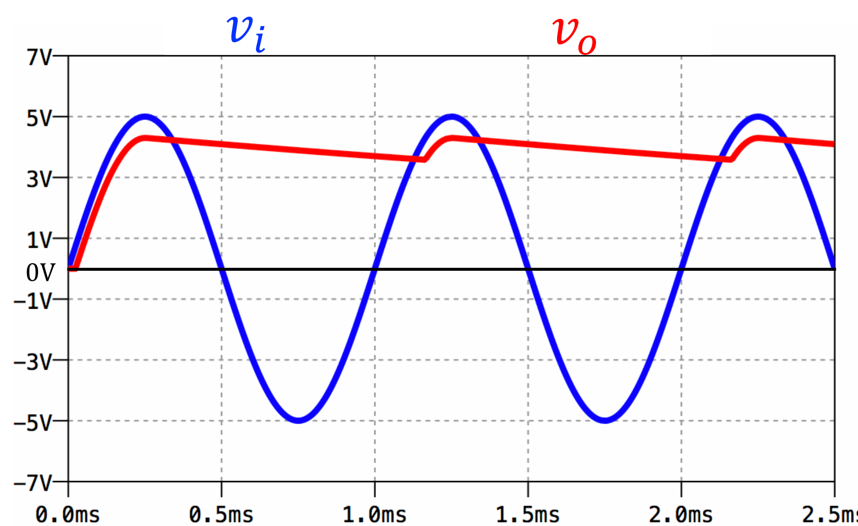
A.



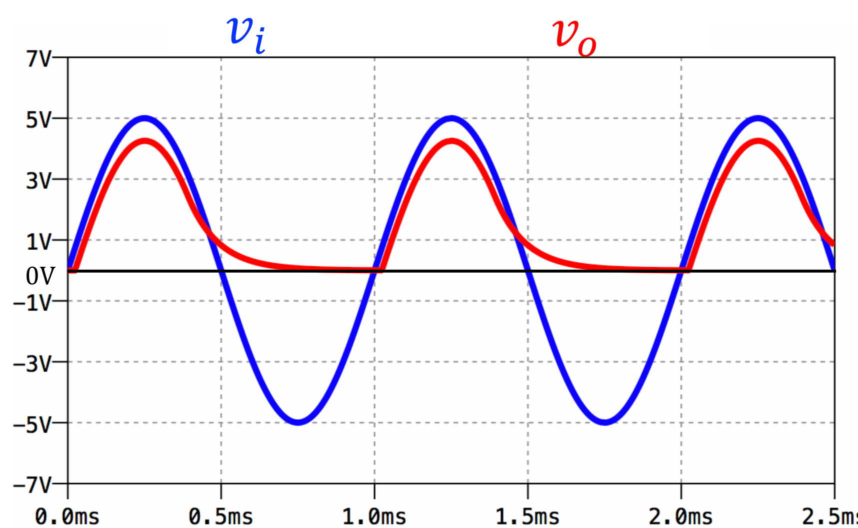
B.



C.



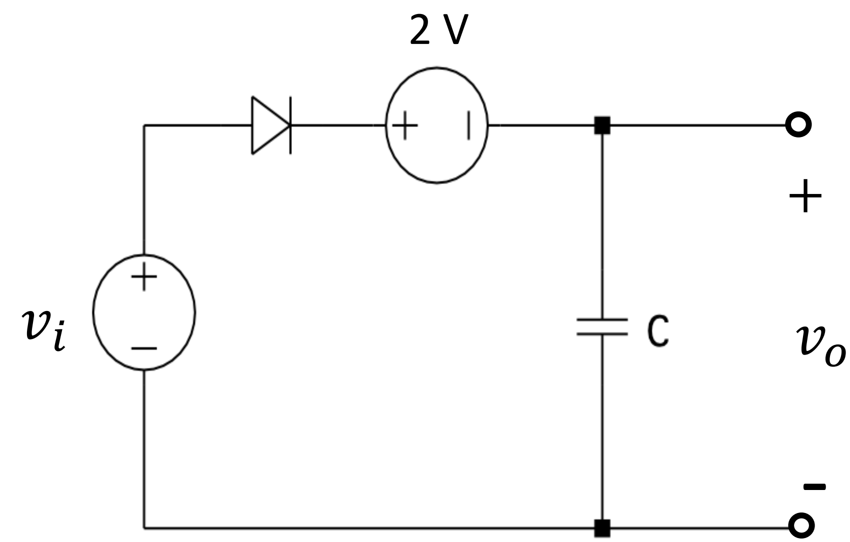
D.



Discussion question 1.

In the circuit below, $v_i(t) = 10\sin(\omega t)$ where ω=1000 rad/s, $v_c(0) = 0$.

$V_{D0} = 0.7\ V$. What is the value of $v_o(t)$ at t = 1ms and t=2 ms? Draw one cycle of the input and output waveforms.

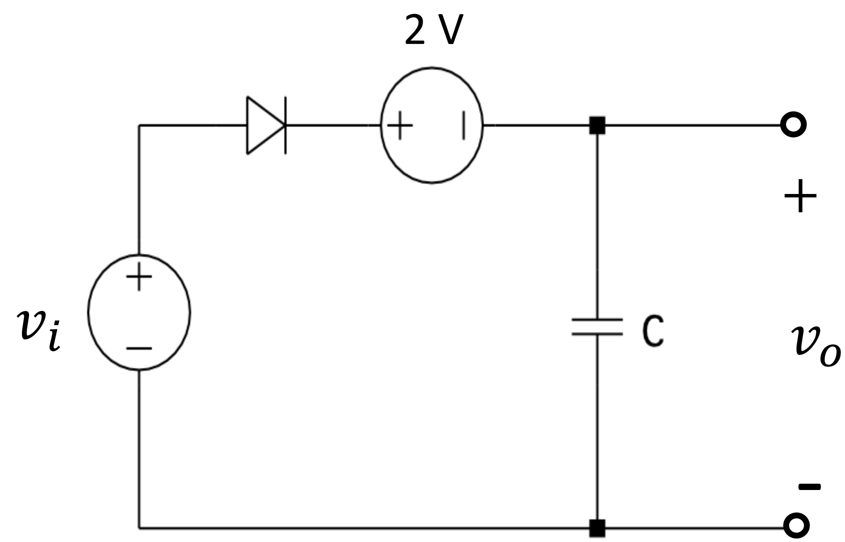


Hints:

Discussion question 1.

In the circuit below, $v_i(t) = 10\sin(\omega t)$ where ω=1000 rad/s, $v_c(0) = 0$.

$V_{D0} = 0.7\ V$. What is the value of $v_o(t)$ at t = 1ms and t=2 ms? Draw one cycle of the input and output waveforms.



- Find the period of the input sinusoidal waveform.
T = 2pi/w

- Find the minimum amplitude of vi to turn the diode ON. You should write a KVL in the circuit to get the answer. Note that Vc(0)=0

- The diode will conduct until vi reaches its peak amplitude. Then, it will disconnect.

- Find the time point at which vi reaches it's peak amplitude and compare it with the given time points, t = 1ms and 2ms. The relationship between vout and vi will be different at different time points.

Discussion question 2.

Design a clipper circuit that limits voltages above 6 V. You can use any combination of regular PN junction diodes, Zener diodes or DC sources.

Extra problem for practice

Find v_R and i in the below circuit for $-5\ \mathrm{V} \leq v_i \leq 5\ V$.

(Assume Si diodes with $V_{D0} = 0.7\ V$)