ECE 65: Components & Circuits Lab

Lecture 8

Diode waveform shaping circuits

Peak detector circuits

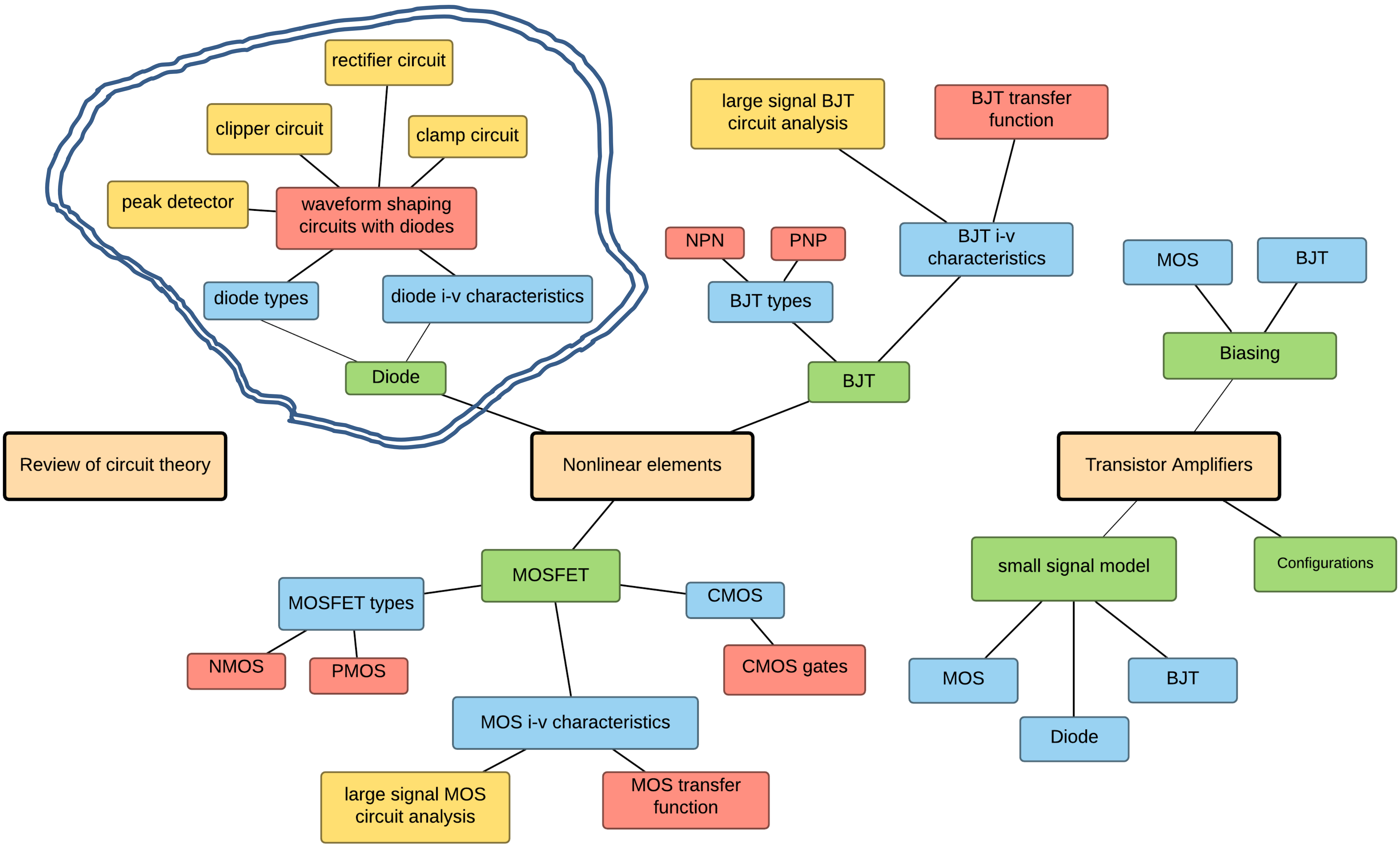
Reference notes: sections 2.9

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

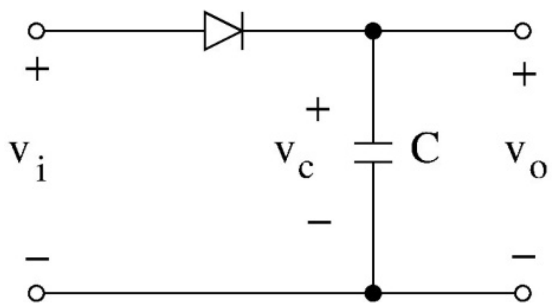
Saharnaz Baghdadchi

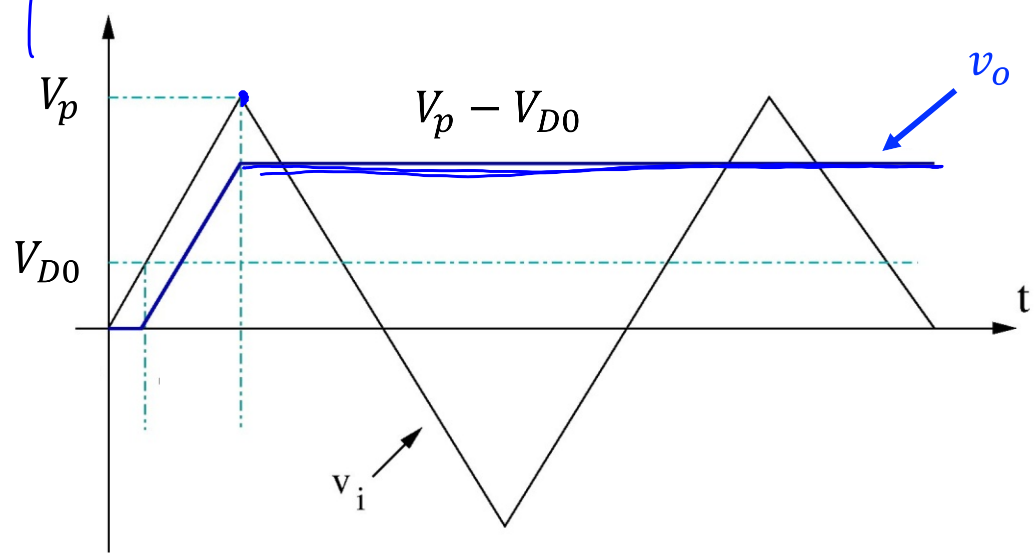
Course map

2. Diodes

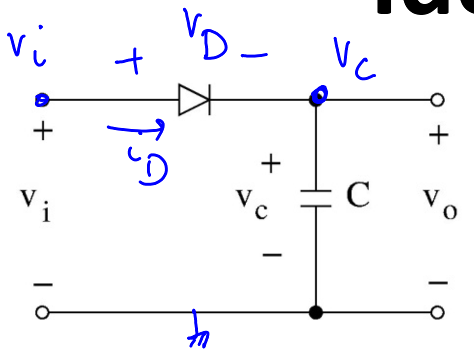


Ideal Peak Detector Circuit

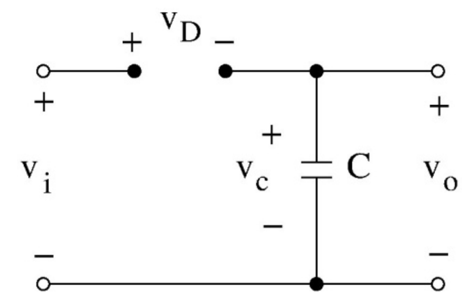




Ideal Peak Detector Circuit



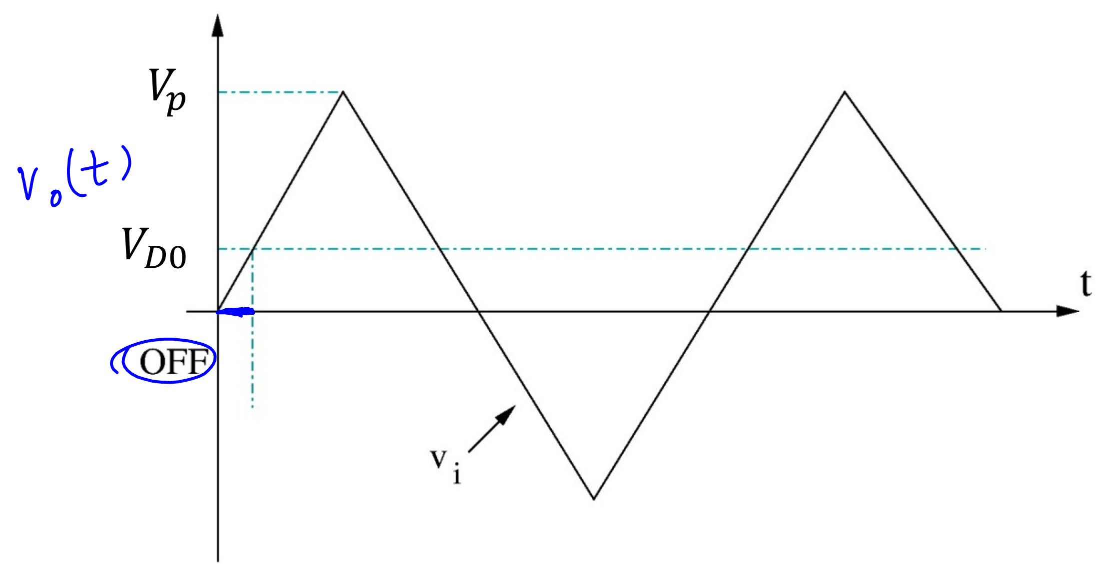
When the Diode is initially OFF:



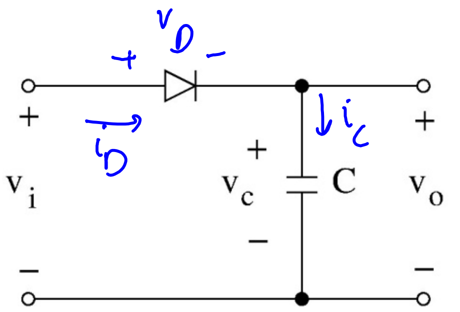
$v_D = v_i - v_c = v_i$

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

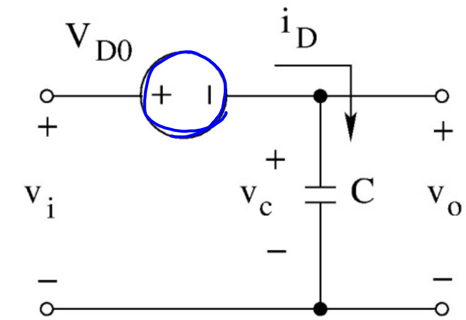
$\Rightarrow v_i < V_{D0}$



Ideal Peak Detector Circuit



When the Diode is ON:

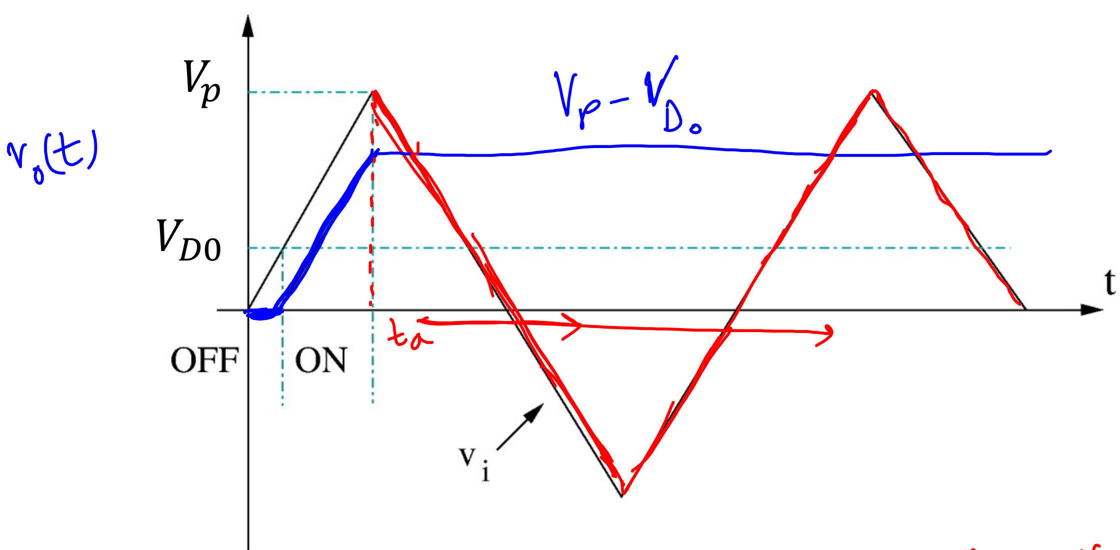


$$v_D = V_{D0}$$

$$i_D \geq 0$$

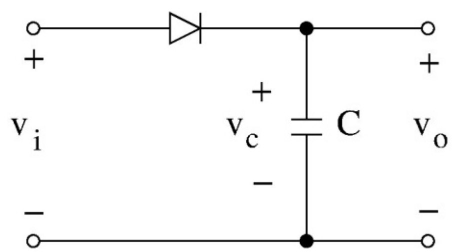
$$v_o = -v_D + v_i = -V_{D0} + v_i \quad , \quad i_D = i_c = C\frac{dv_c}{dt} = C\frac{d(v_i - V_{D0})}{dt}$$

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

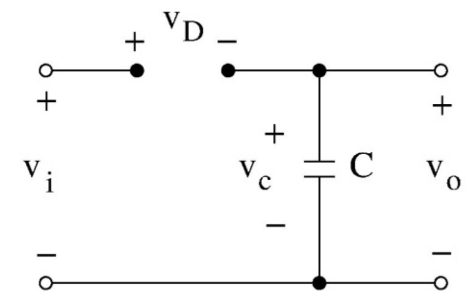


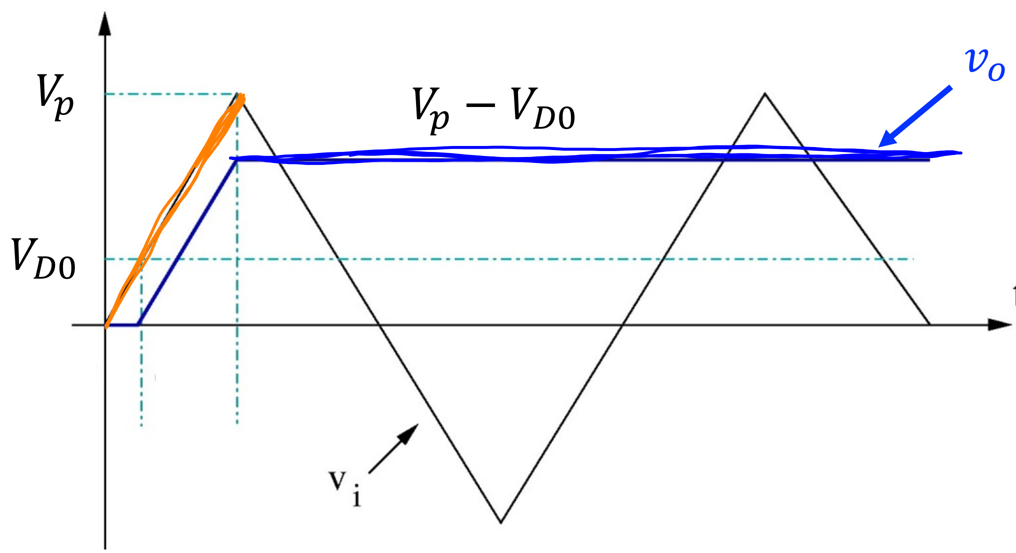
$$\text{at } t = t_a \quad , \quad v_i = V_p \quad , \quad v_c = V_p - V_{D0} \quad , \quad v_D = v_i - v_c = v_i - (V_p - V_{D0})$$

Ideal Peak Detector Circuit

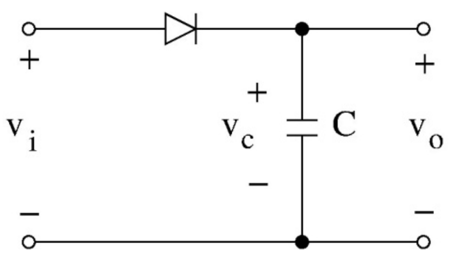


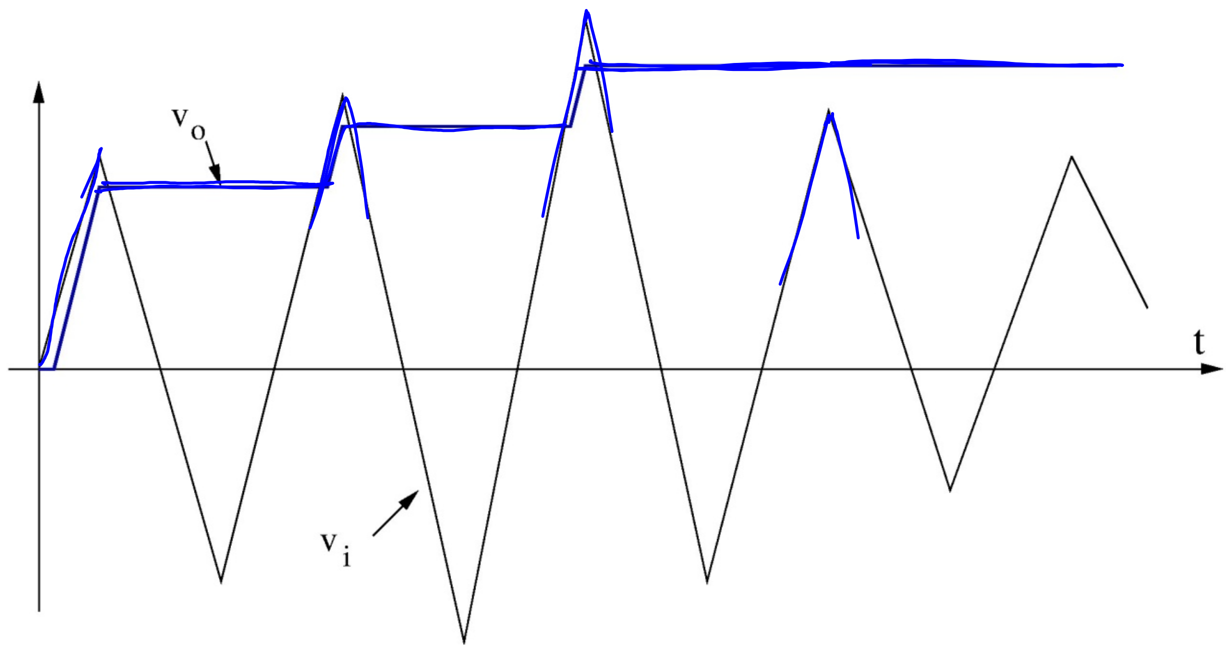
After v_i reached its peak value, the diode does not turn ON anymore.





Response of the Ideal Peak Detector (v_i amplitude changes)

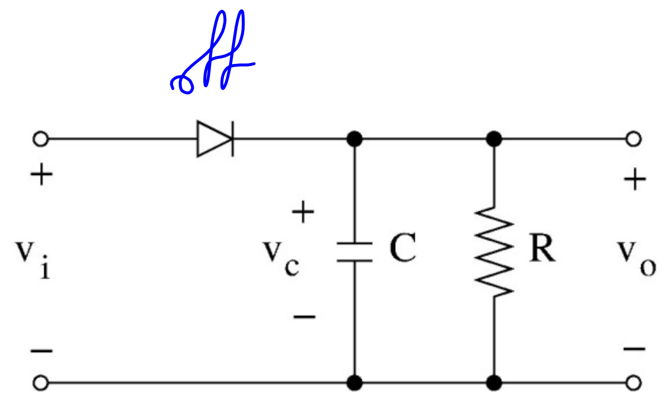


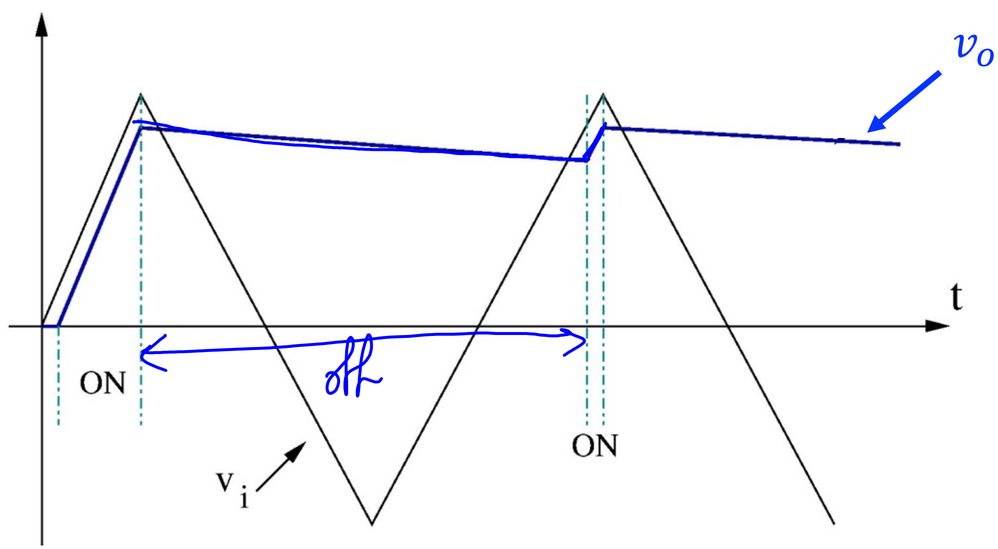


v_o is the "peak" value of input waveform ($V_p - V_{D0}$):

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

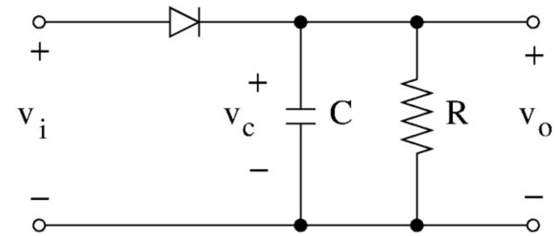
Practical Peak Detector Circuit



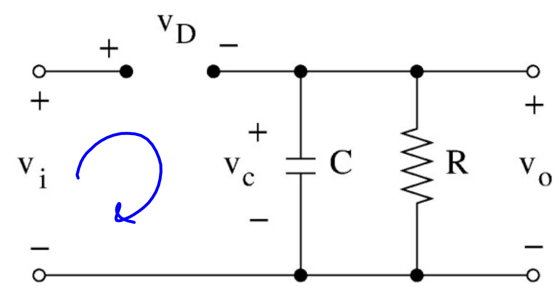


Practical Peak Detector Circuit

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



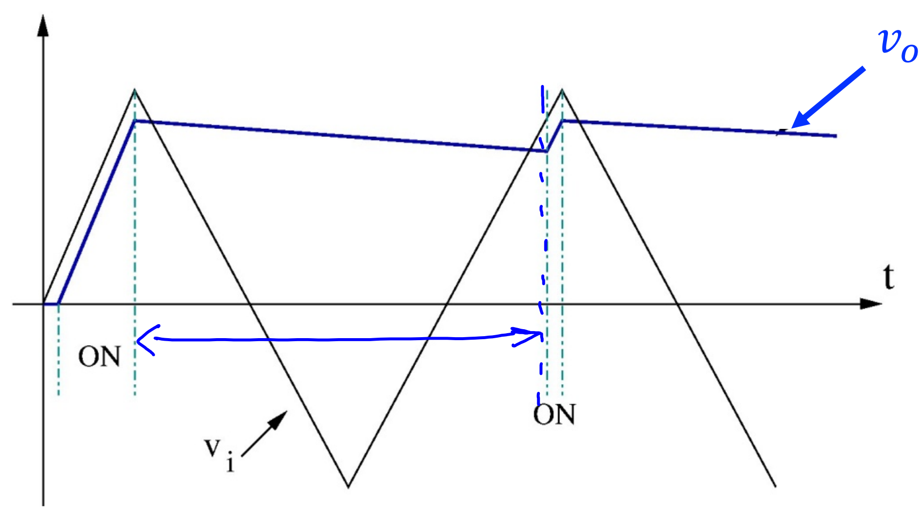
Capacitor discharges into the resistor with a time constant of $\tau = RC$



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

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

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

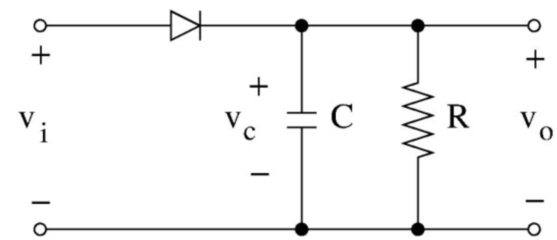


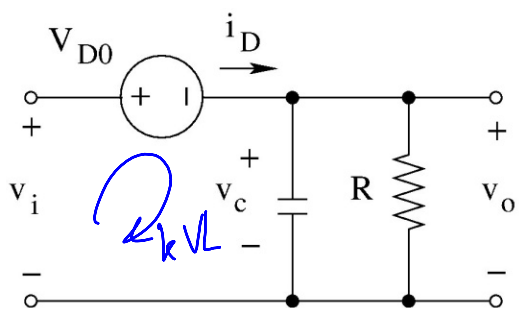
Practical Peak Detector Circuit

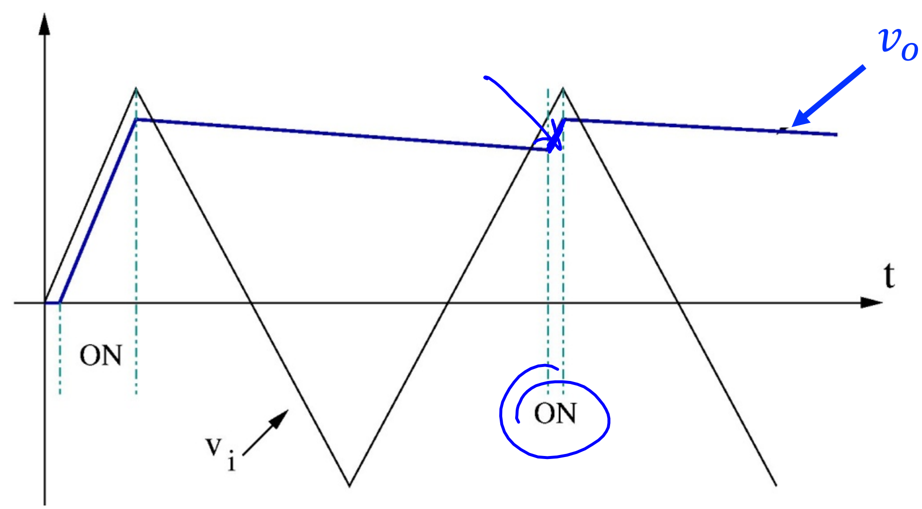
Diode ON: $v_D = V_{D0}$ and $i_D \geq 0$

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

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



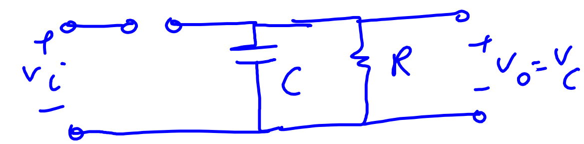




Response of the Practical Peak Detector

τ : time constant $= RC$

T : period of $v_i(t)$



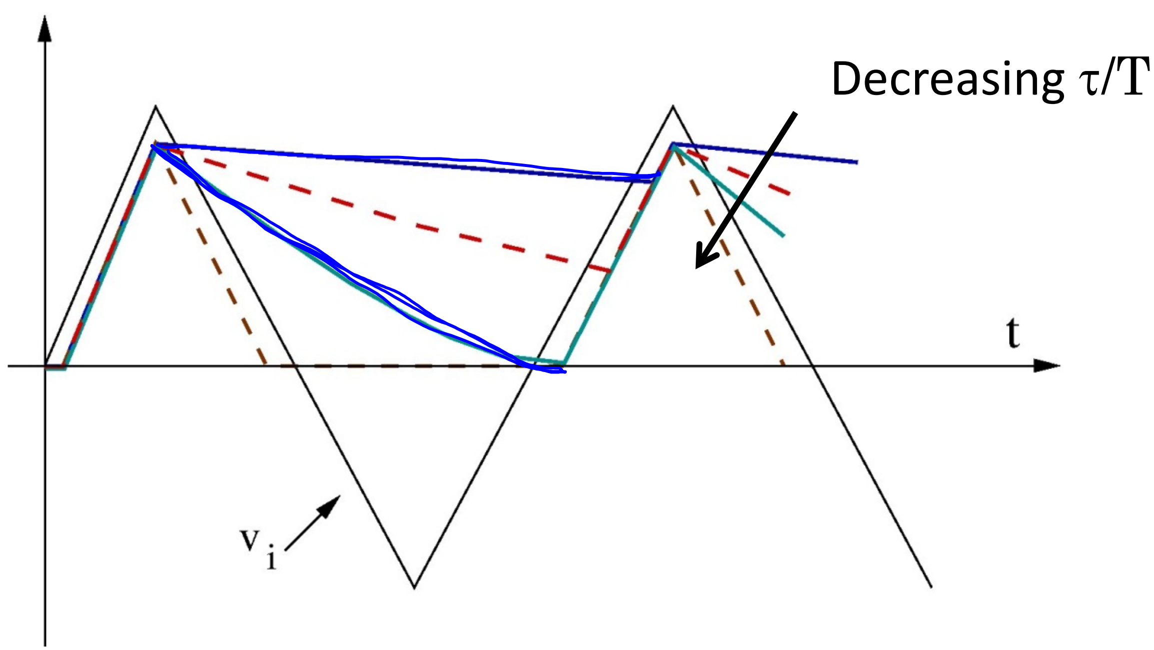
Shape of output signal depends on the ratio of τ/T

"ideal" peak detector: $\tau/T \rightarrow \infty$

"Good" peak detector: $\tau/T >> 1$

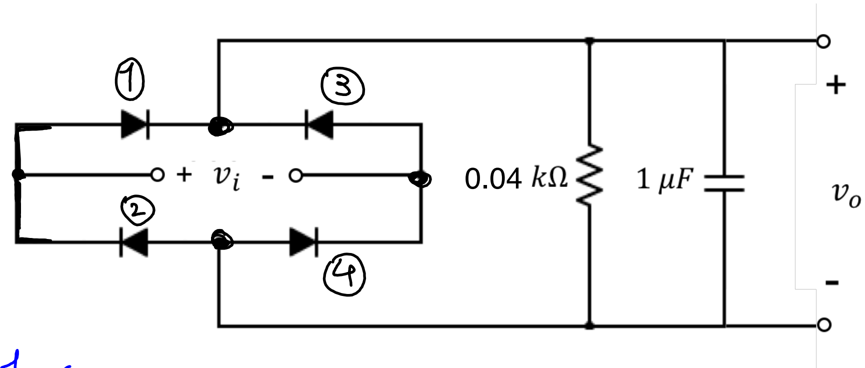
As τ/T decreases, the circuit departs from a peak detector.

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



Lecture 8 reading quiz.

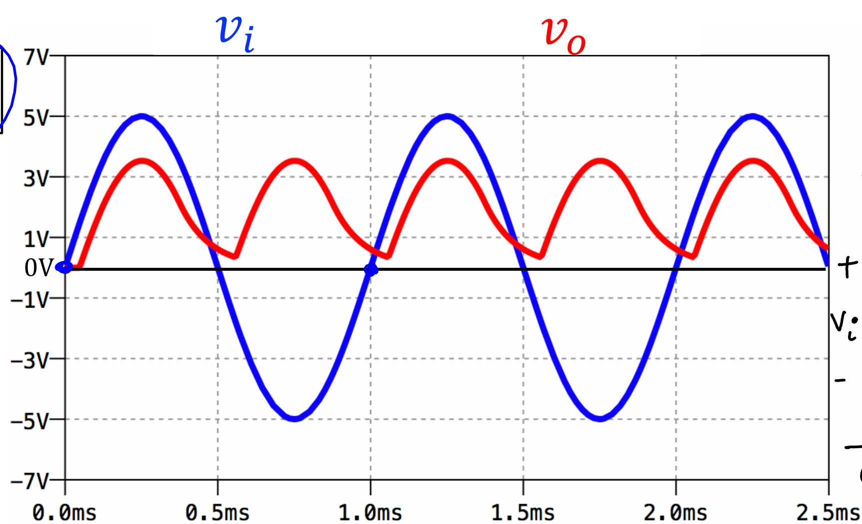
In the following diode circuit, which one of the options could be the input and output voltages for this circuit? $V_{D0} = 0.7\ V$.

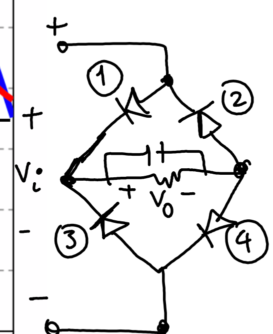


$T = 1ms$

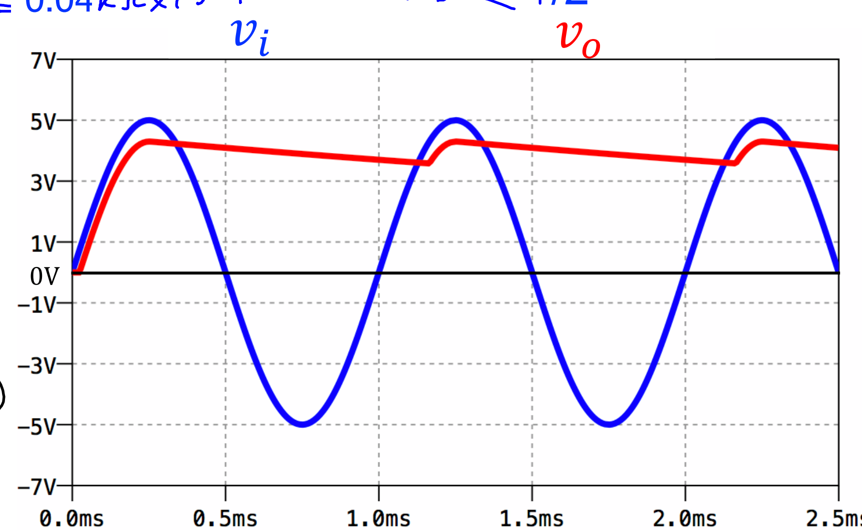
$\tau = RC = 0.04k\Omega \times 1\mu F = 0.04ms < T/2$

A.

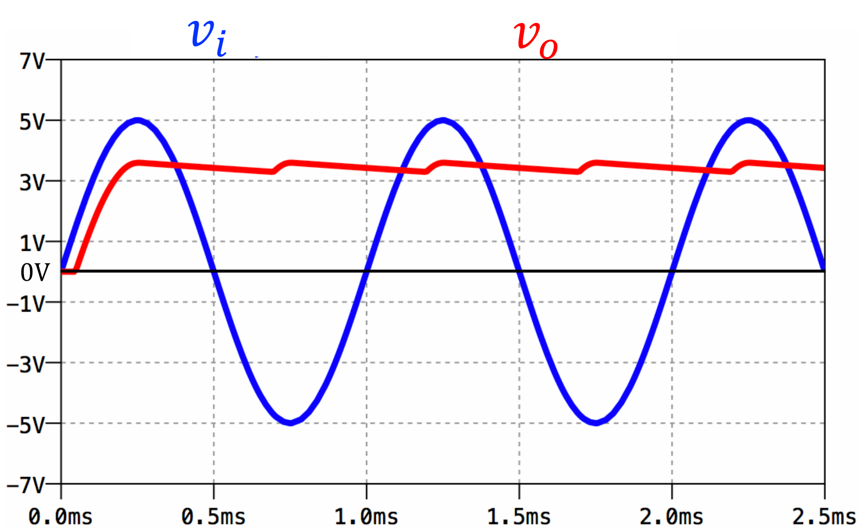




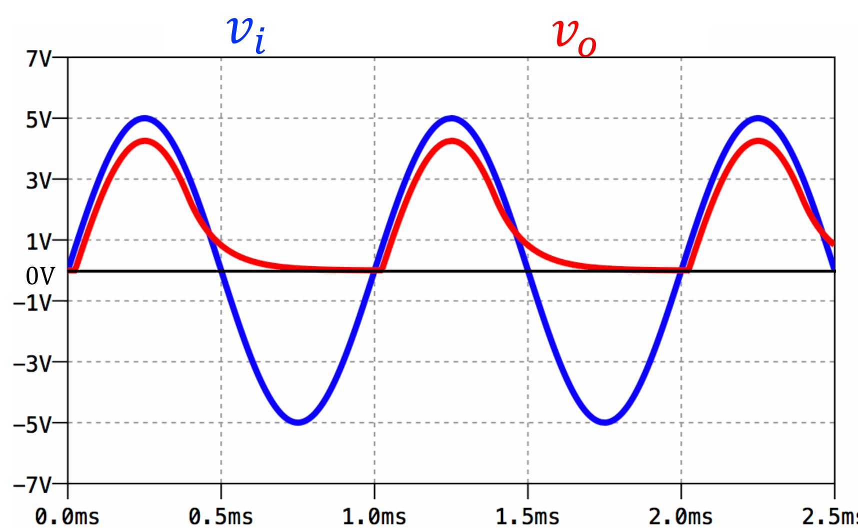
C.



B.



D.

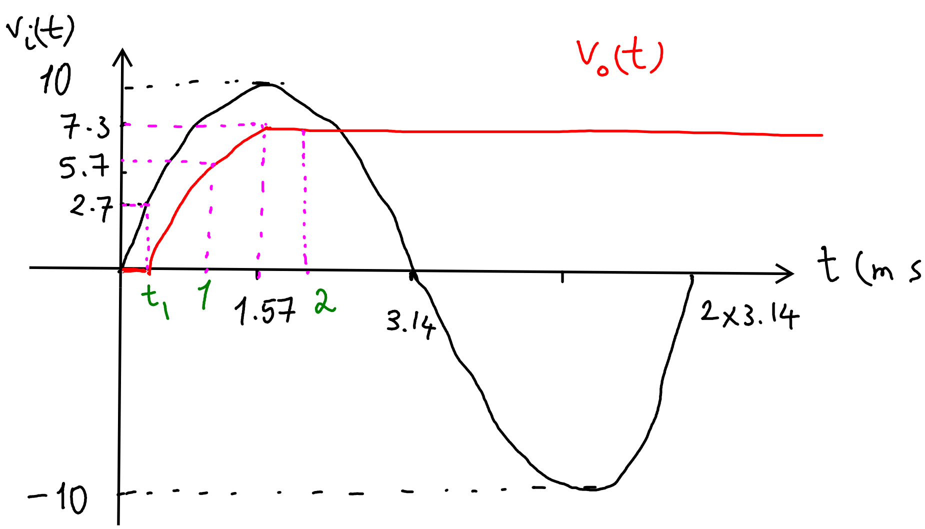


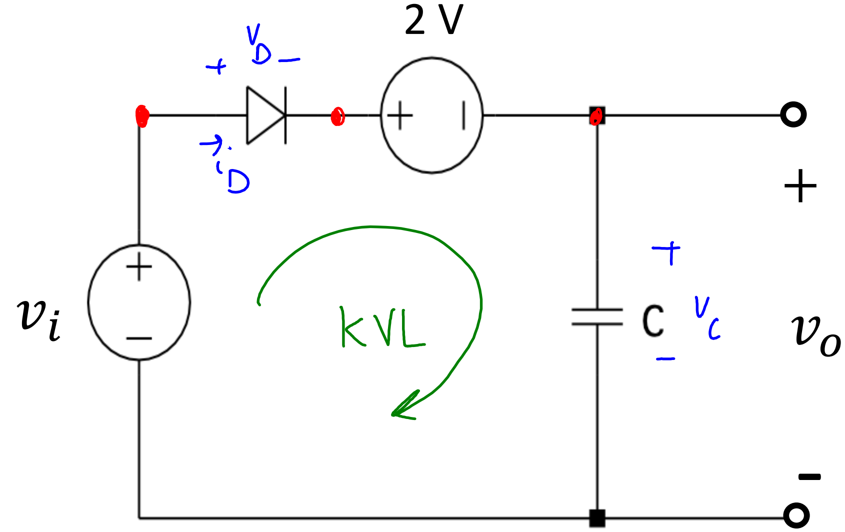
$$T = \frac{2\pi}{\omega} = \frac{2\pi\ (rad)}{1000\ (rad/s)} = 2\pi\ (ms) = 2 \times 3.14\ ms$$

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.





For $0 < t < t_1 \longrightarrow$ diode is off $\longrightarrow V_o = V_c = 0$

For $t_1 < t < 1.57ms \longrightarrow$ diode is ON and capacitor is charging $\Rightarrow V_D = V_{D_0}$ and

KVL: $-V_i + V_D + 2V + V_o = 0$, here: $-V_i + 0.7V + 2V + V_o = 0 \longrightarrow \boxed{V_o = V_i - 2.7V}$

$t = 1ms$ is before the peak of v_i, ($t_{peak} = 1.57\ ms$).

$V_i(t = 1ms) = 10 \sin(1000\ (rad/s) \times 1ms) = 8.4V$

$8.4V > V_i(t = t_1) = 2.7V \Longrightarrow$ diode is ON at $t = 1ms$ and the capacitor is charging.

$$V_0(t = 1ms) = V_i(t = 1ms) - 2.7V = 8.4V - 2.7V = 5.7V$$

$t = 2ms$ is after the peak of $v_i \Longrightarrow$ the diode is off and the voltage across the capacitor is constant even when v_i changes.

KVL still holds, and $V_D < V_{D_0}$.

After $t = 1.57\ ms$, $V_0 = V_c = 10\ V - 2.7\ V = 7.3\ V$