ECE 65: Components & Circuits Lab

Lecture 7

Diode waveform shaping circuits

Clipper circuits

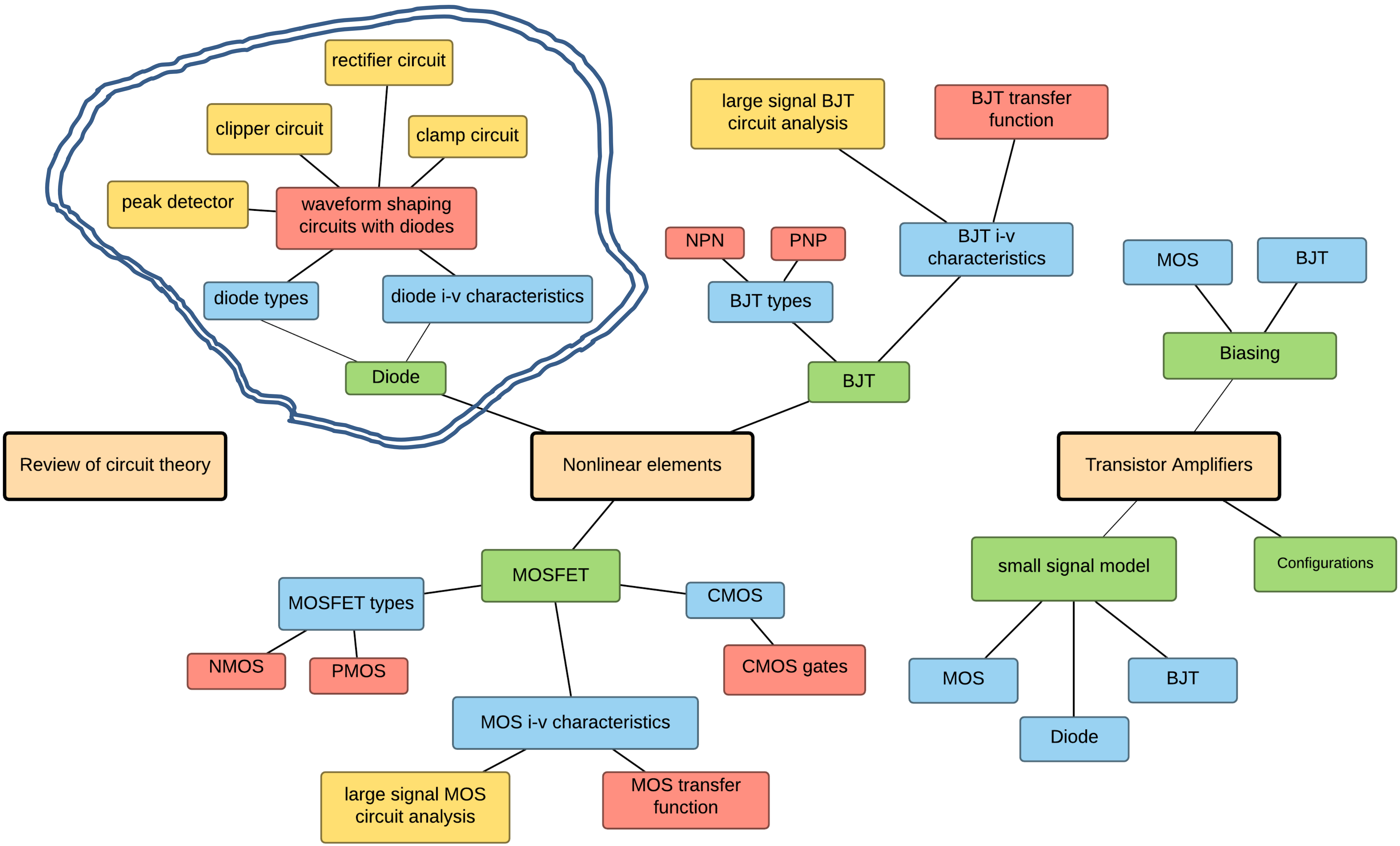
Reference notes: sections 2.9

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

Saharnaz Baghdadchi

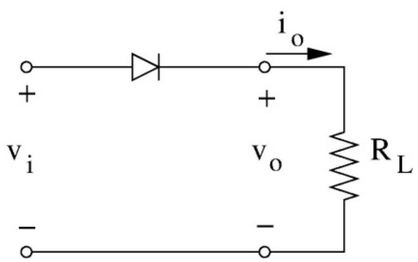
Course map

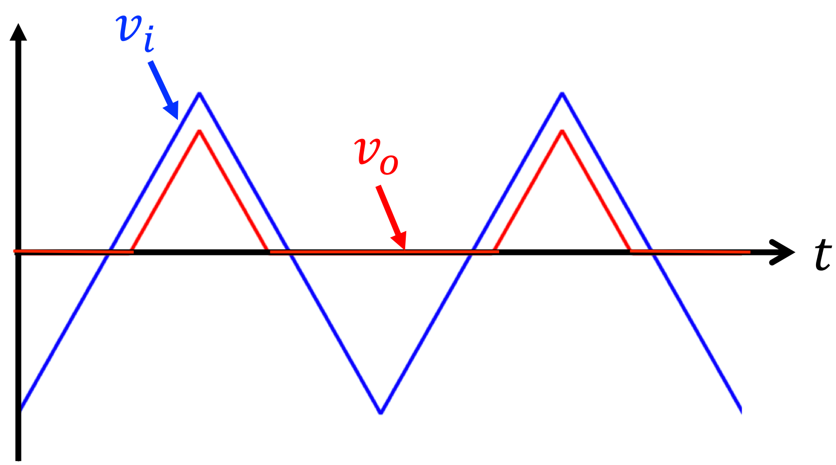
2. Diodes



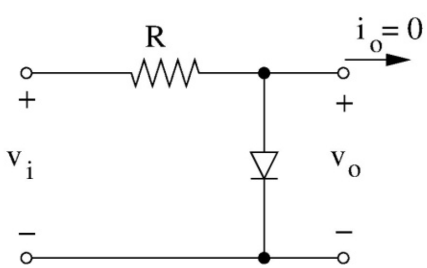
Rectifier & clipper circuits

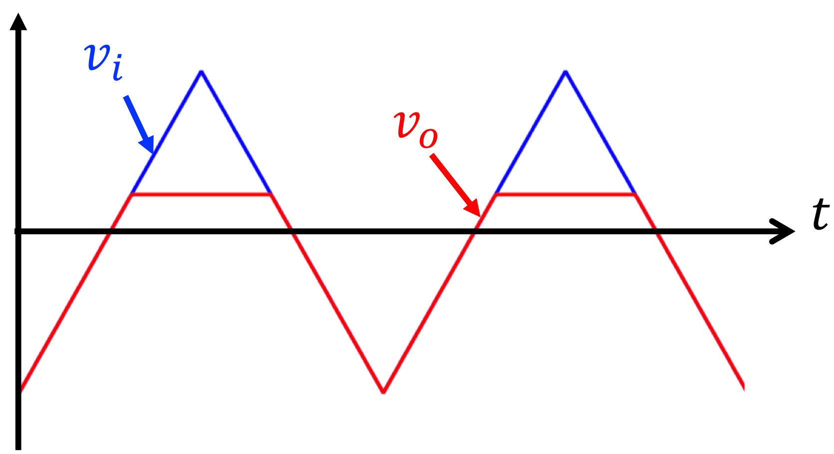
Half-wave Rectifier





Clipper



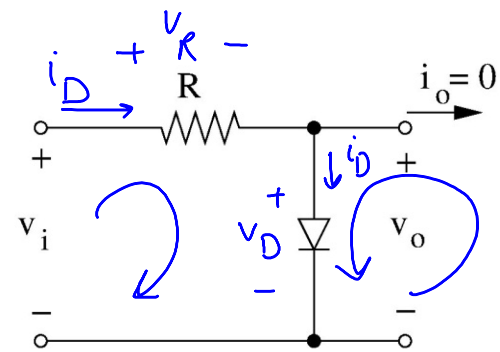


Clipper or Limiter Circuit

KVL: $v_i = v_R + v_D$ ✓

KVL: $v_o = v_D$ ✓

Ohm's law: $i_D = v_R/R$



$-v_o + v_D = 0$

$v_o = v_D$

Diode OFF: $i_D = 0$ & $\boxed{v_D < V_{D0}}$

$v_i = v_R + v_D = v_R + v_o = R \times i_D + v_o \longrightarrow v_i = v_o$

$v_i = v_R + v_D \longrightarrow v_i = v_D < V_{D0} \longrightarrow v_i < V_{D0}$

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

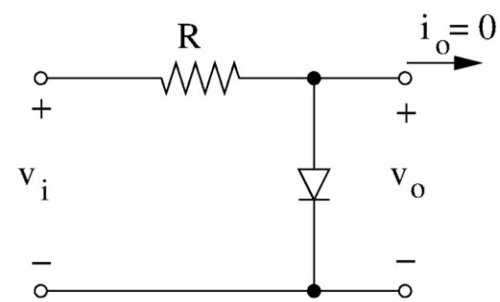
$v_o = v_D = V_{D0}$, $v_o = V_{D0}$

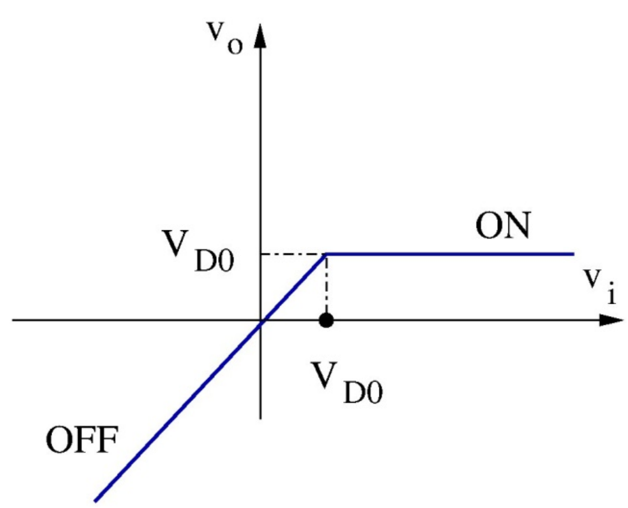
$i_D = \dfrac{v_i - V_{D0}}{R} \geq 0 \longrightarrow v_i \geq V_{D0}$

Clipper Circuit
open loop transfer function

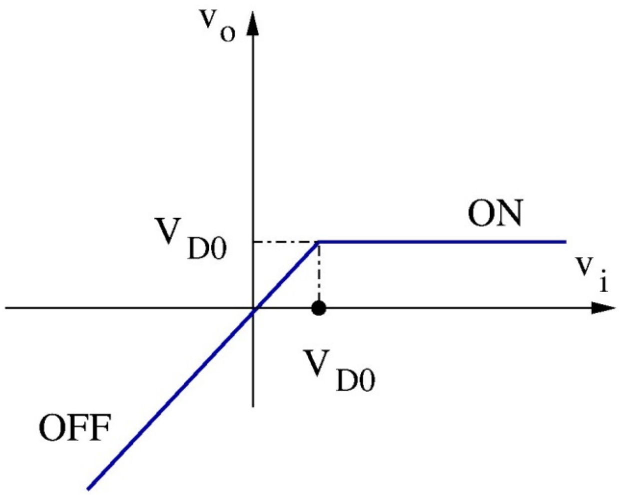
Transfer Function is non-linear:

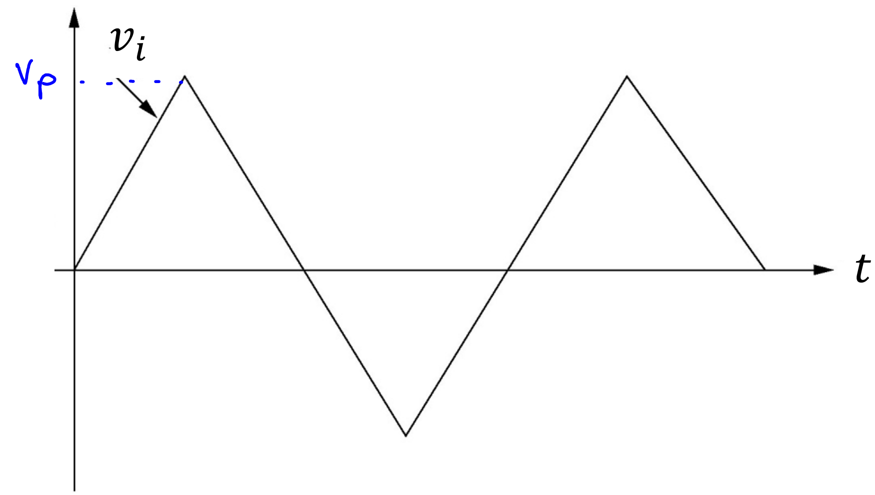
$$\begin{cases} \text{For } v_i \geq V_{D0}, \quad v_o = V_{D0} & \text{(Diode is ON)} \\ \text{For } v_i < V_{D0}, \quad v_o = v_i & \text{(Diode is OFF)} \end{cases}$$

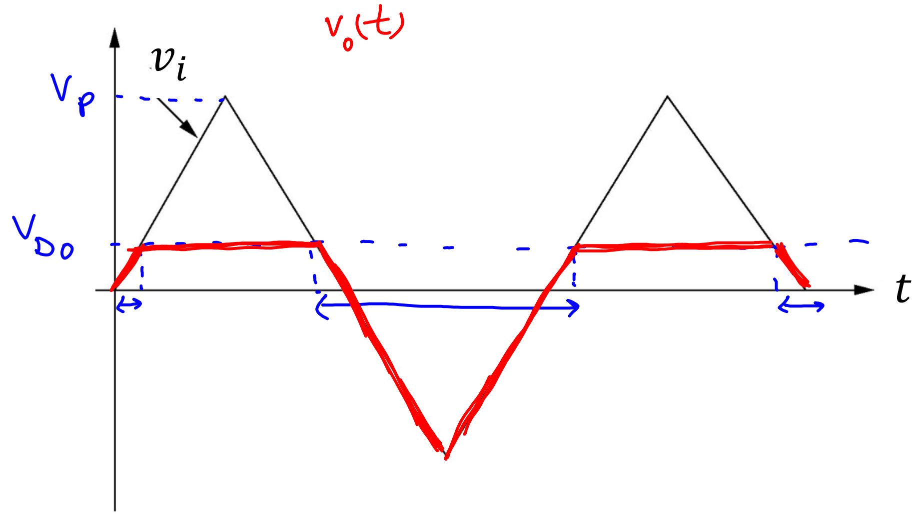




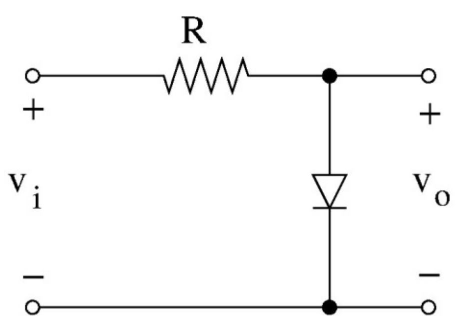
Clipper Circuit: example input-output waveforms

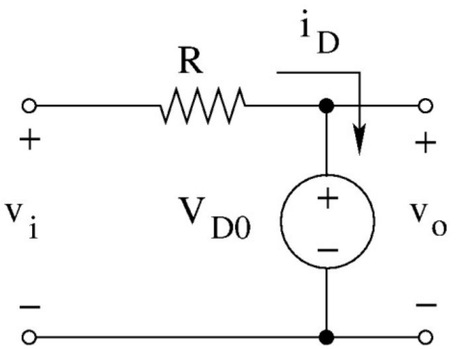


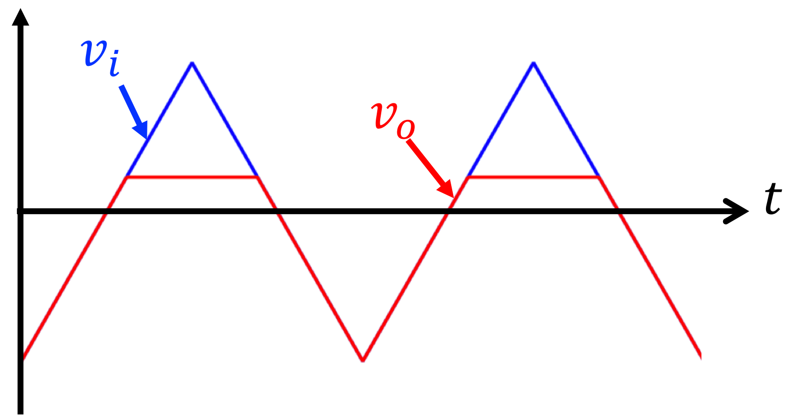


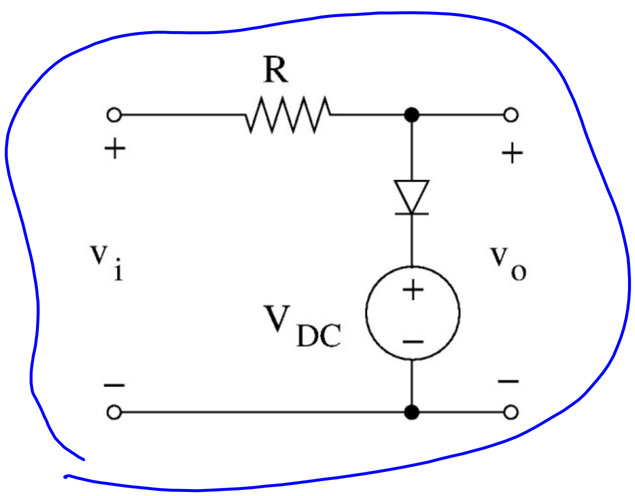


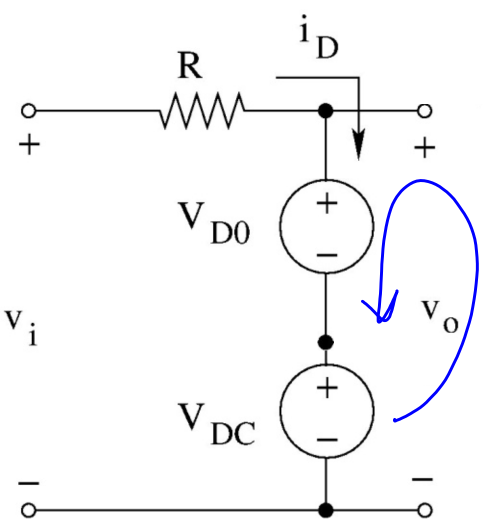
Adjusting the limiting voltage in the clipper circuit

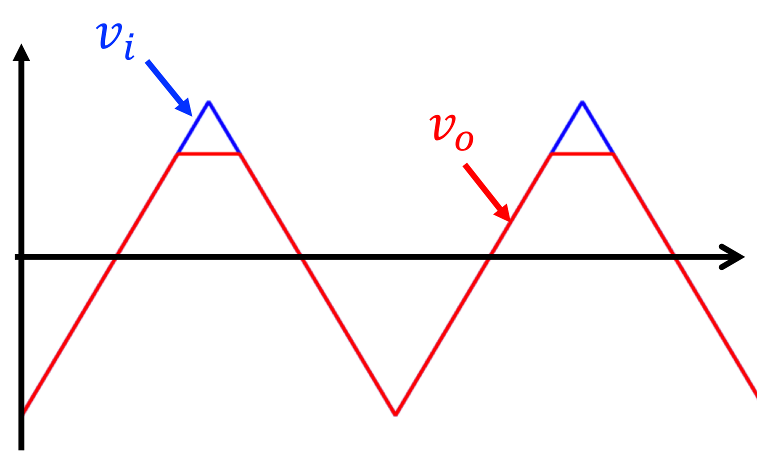






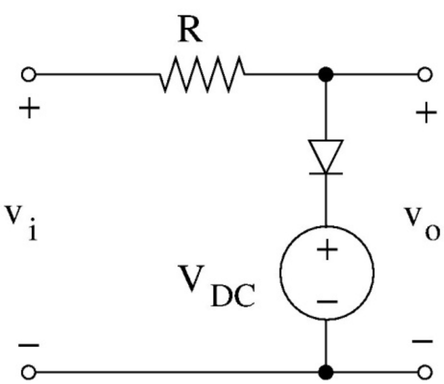




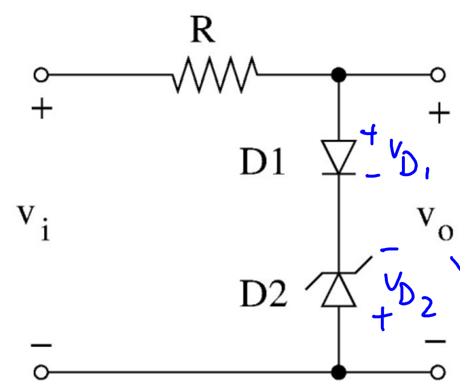


$V_o = V_{D0} + V_{DC}$

Using Zener diodes to adjust the limiting voltage in the clipper circuit



v_o limited to ≤ $V_{D0} + V_Z$



D_1 is ON

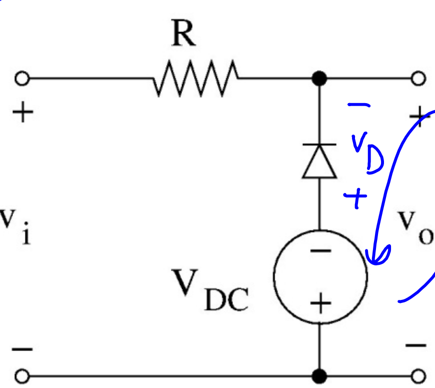
D_2 is Zener

$v_{D_1} = V_{D_0}$

$v_{D_2} = -V_Z$

$V_o = v_{D_1} - v_{D_2}$

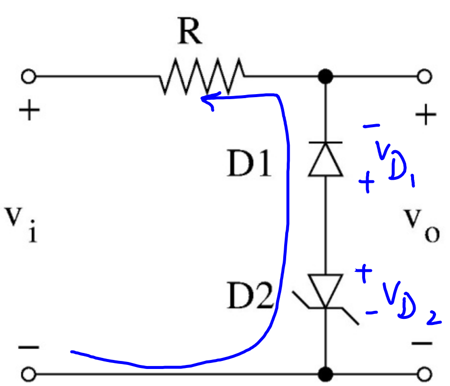
$V_o = V_{D_0} + V_Z$



$V_o = -V_D - V_{DC}$

$V_o = -V_{D_0} - V_{DC}$

v_o limited ≥ $-V_{D0} - V_Z$



$v_{D_1} = V_{D_0}$

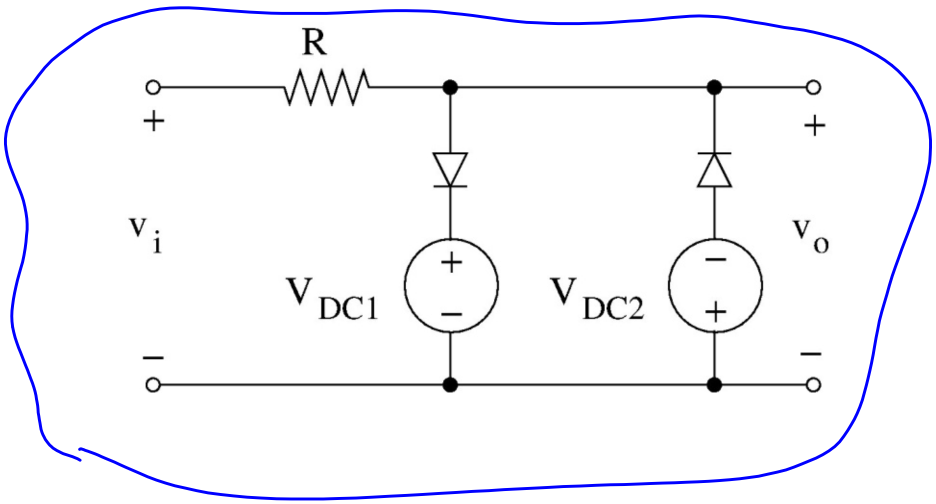
$v_{D_2} = -V_Z$

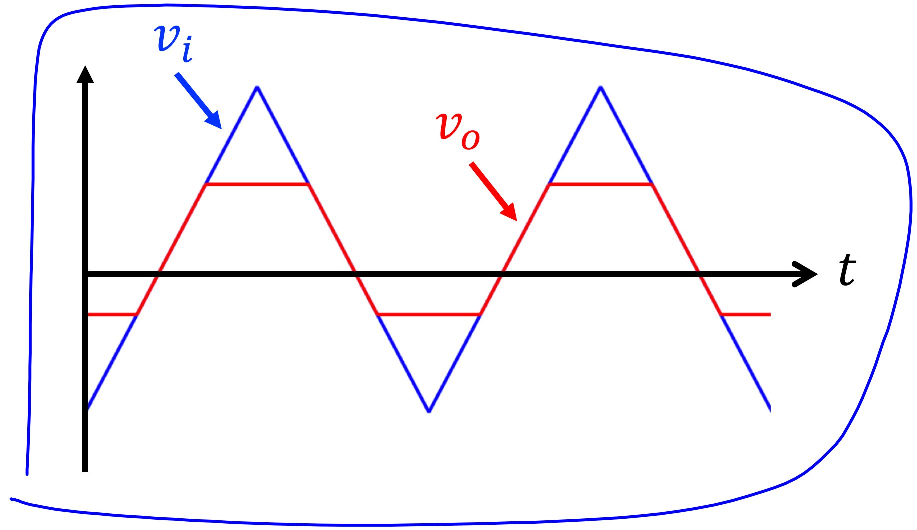
$v_o = -V_{D_0} - V_Z$

$V_o = -v_{D_1} + v_{D_2}$

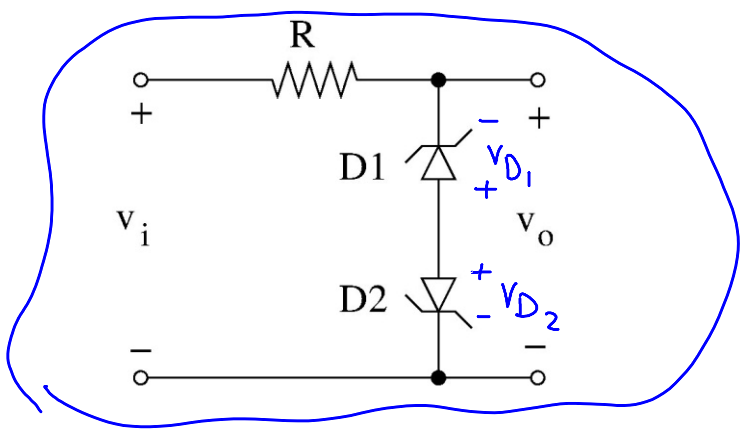
Clipping both the top & bottom portions of the signal simultaneously

v_o **limited to** $\leq V_{D0} + V_{DC1}$ **and** $\geq - V_{D0} - V_{DC2}$



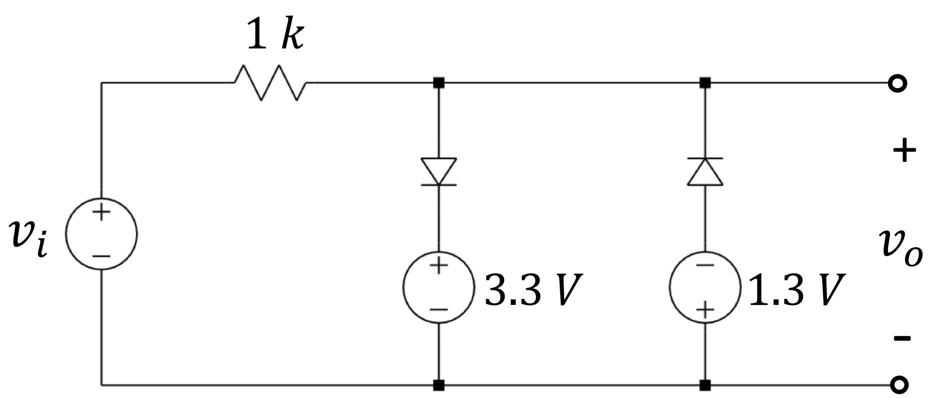


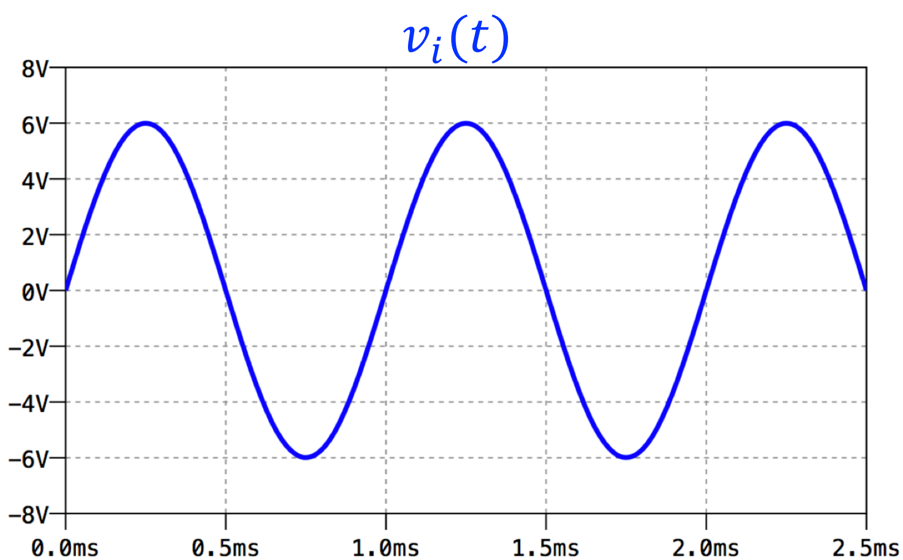
v_o **limited to** $\leq V_{D0} + V_{Z1}$ **and** $\geq - V_{D0} - V_{Z2}$



Lecture 7 reading quiz

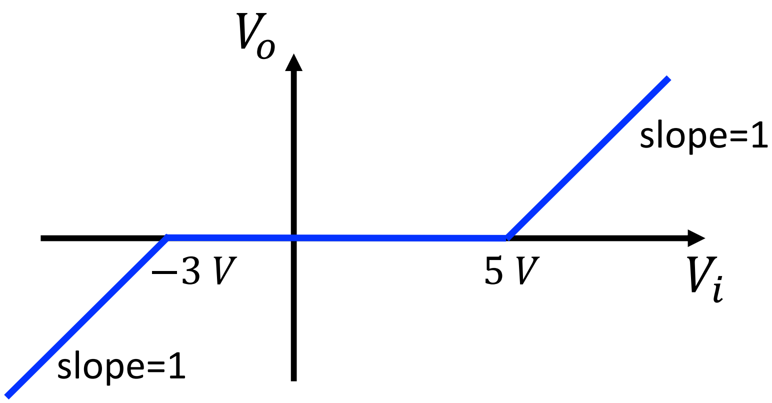
Calculate and draw the output of the following two-port network for the given input signal.



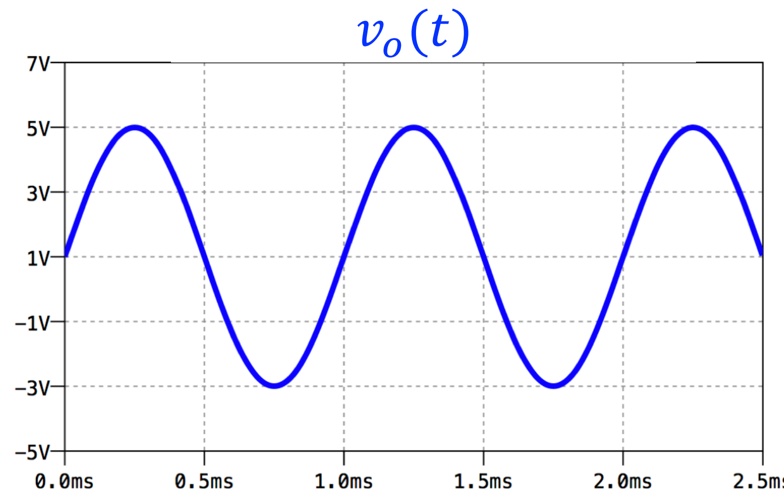


Clicker question 1

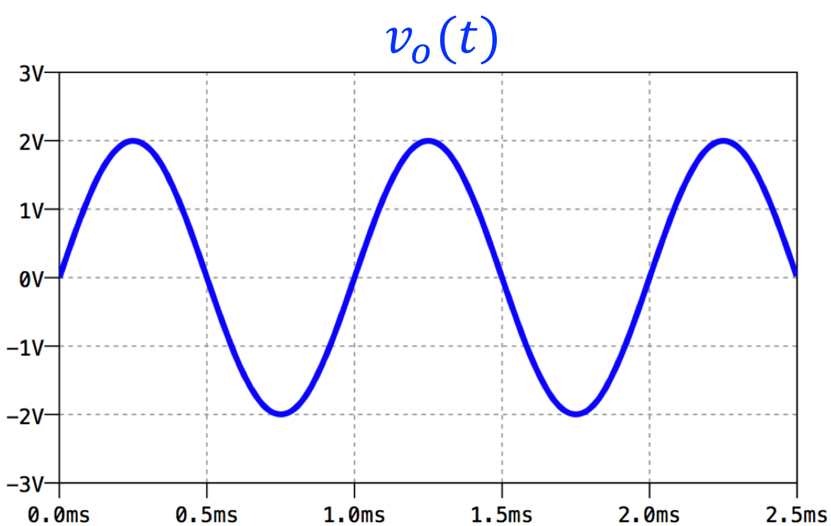
Which one of the waveforms could be the output of a two-port network with the below transfer function for the input $v_i(t) = 2\sin(\omega t)$?



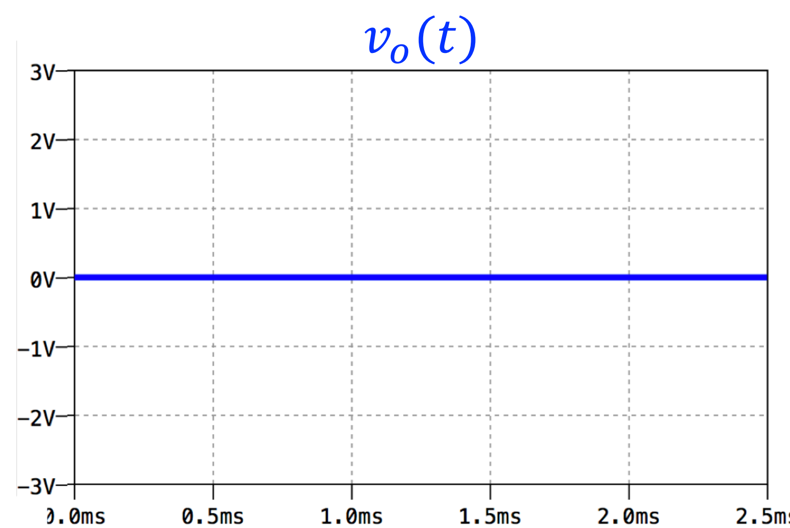
A.



B.



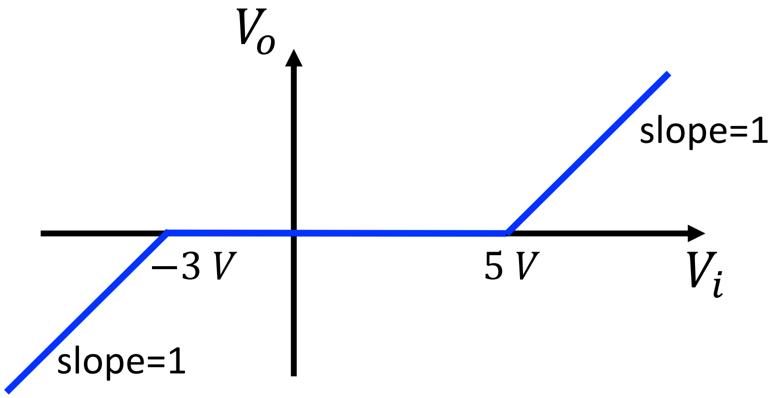
C.



Hints:

Clicker question 1

Which one of the waveforms could be the output of a two-port network with the below transfer function for the input $v_i(t) = 2\sin(\omega t)$?

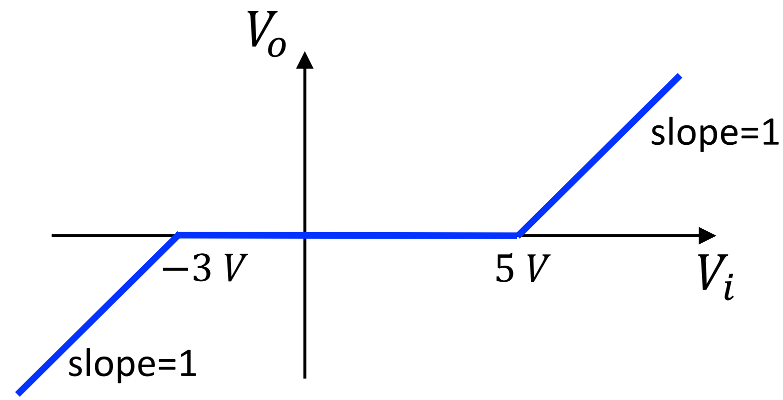


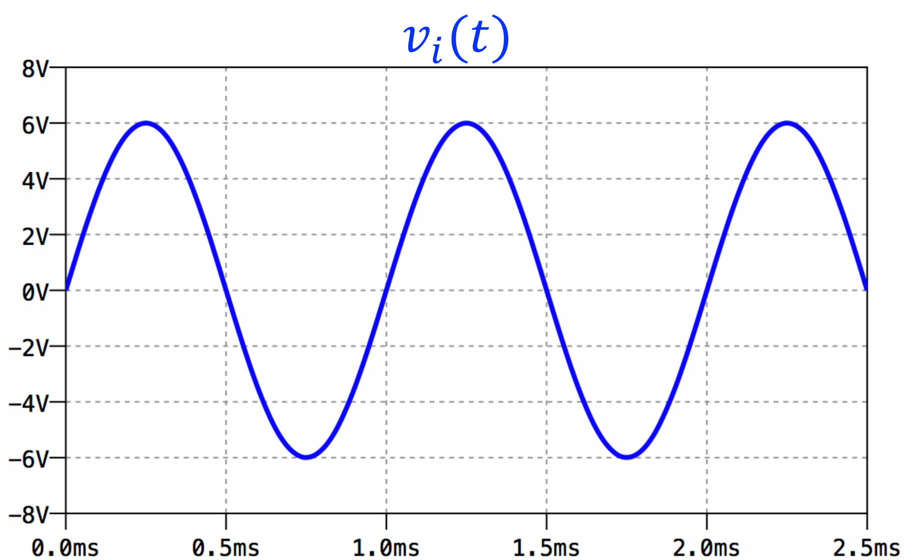
- Looking at the transfer characteristic graph, for what range of Vi values, will the output be equal to zero?

- What is the range of Vi values for the given input signal?

Discussion question 1.

Draw the output of a two-port network with the shown transfer function to the below input signal.





Hints:

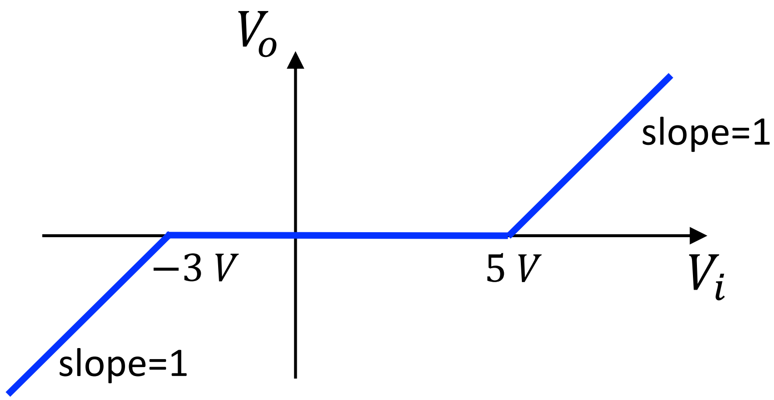
Discussion question 1.

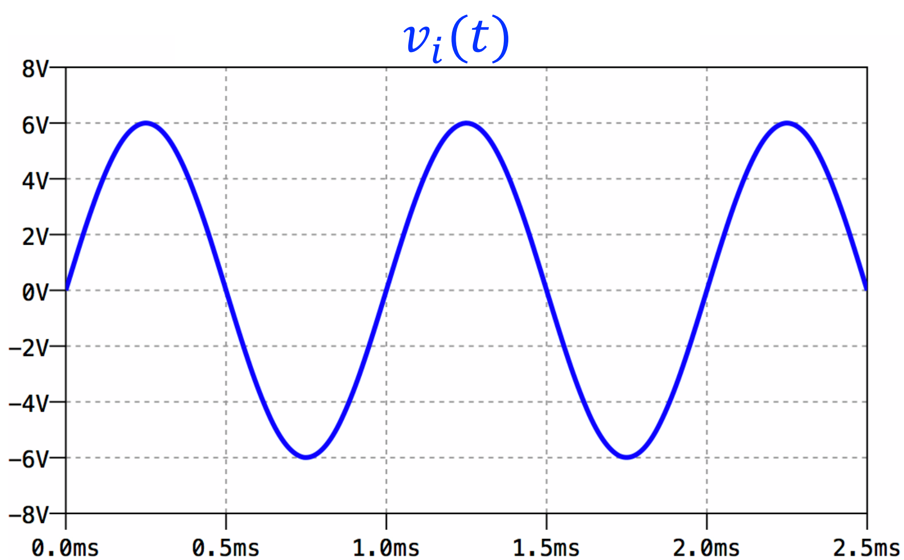
Draw the output of a two-port network with the shown transfer function to the below input signal.

- Write the equation of a line that relates Vo to Vi when Vi is greater than 5V?

- Write the equation of a line that relates Vo to Vi when Vi is less than -3V?

- On the graph of vi(t), find and label when vi is less than -3, greater than 5, and in between. Follow the Vi vs. Vo equations that you found and draw vo(t).

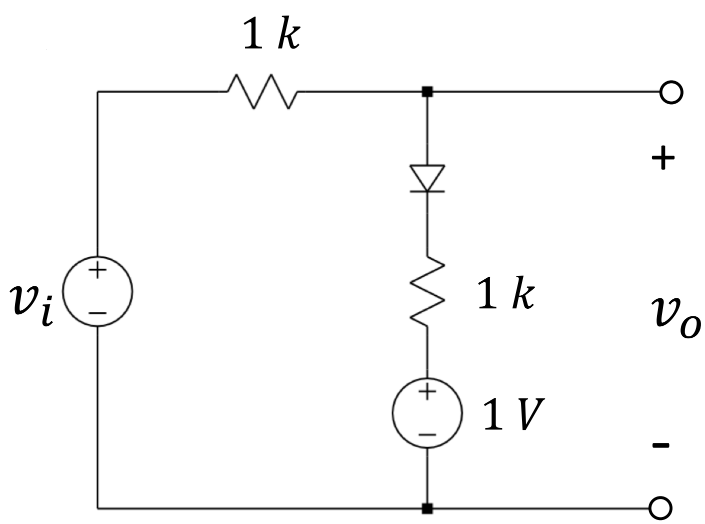




Discussion question 2

Calculate and draw the transfer function for the following two-port network.

$(V_{D0} = 0.7V)$

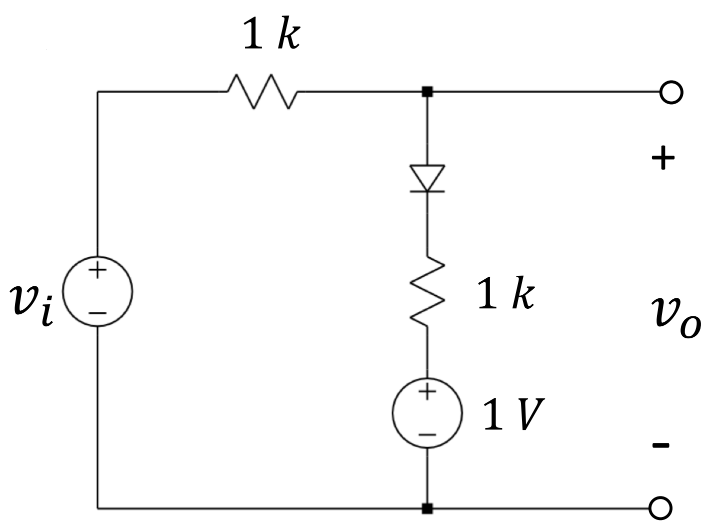


Hints:

Discussion question 2

Calculate and draw the transfer function for the following two-port network.

$(V_{D0} = 0.7V)$



- Label the diode voltage and current.

- List the cases of operation of the diode. You have two cases in this circuit.

- You need to find the range of vi values for each case and the relationship between vi and vo for each case.

- Use KVL to complete the above task.

- Using the ranges of vi and the relationship between Vi and Vo for each range, draw the transfer function or transfer characteristic graph, which is a graph showing the relationship between Vo and Vi.