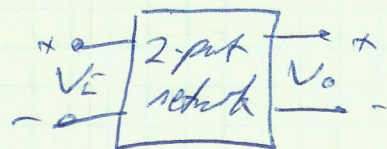


Waveform shaping circuits

• Consider a 2-port network.



• We are interested in the transfer function, V_o as func. of V_i

• We are used to this circuit

• Assume $R_L \rightarrow \infty$

(open loop transfer function)



Rectifier Circuits

for "open loop"

the entire diode current

flows through the resistor



$$V_i = V_o + R i_D$$

$$V_o = R i_D$$

} KVL

Diode OFF : $i_D = 0$, $V_o < V_{D0}$

$$V_o = R i_D = 0$$

$$V_i = V_o + R i_D \rightarrow V_i = V_o < V_{D0}$$

Diode is only off when $V_i < V_{D0}$, then $V_o = 0$

Diode ON : $V_o = V_{D0}$, $i_D \geq 0$

$$V_i = V_o + R i_D \rightarrow V_o = R i_D \rightarrow \underline{V_o = V_i - V_{D0}}$$

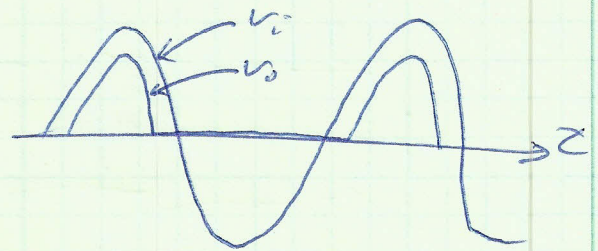
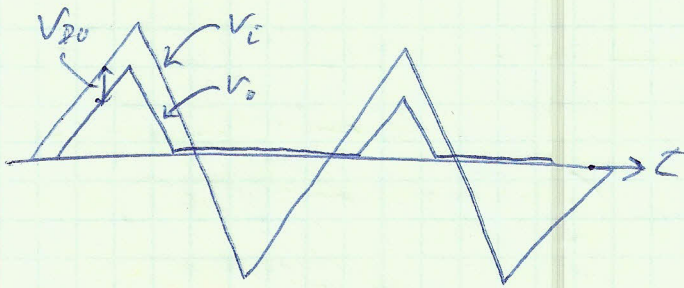
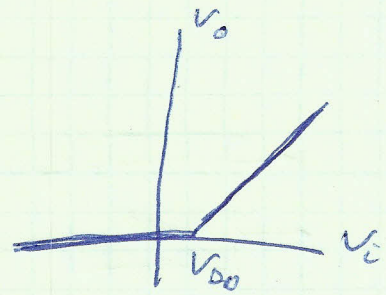
$$i_D = \frac{V_i - V_{D0}}{R} \quad i_D \geq 0 \text{ for } V_i \geq V_{D0}$$

Diode is on when $V_i \geq V_{D0}$, then $V_o = V_i - V_{D0}$

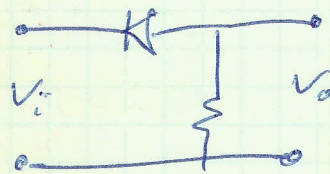
Transfer function:

$$V_i < V_{D0} \rightarrow \text{OFF} \rightarrow V_o = 0$$

$$V_i \geq V_{D0} \rightarrow \text{ON} \rightarrow V_o = V_i - V_{D0}$$

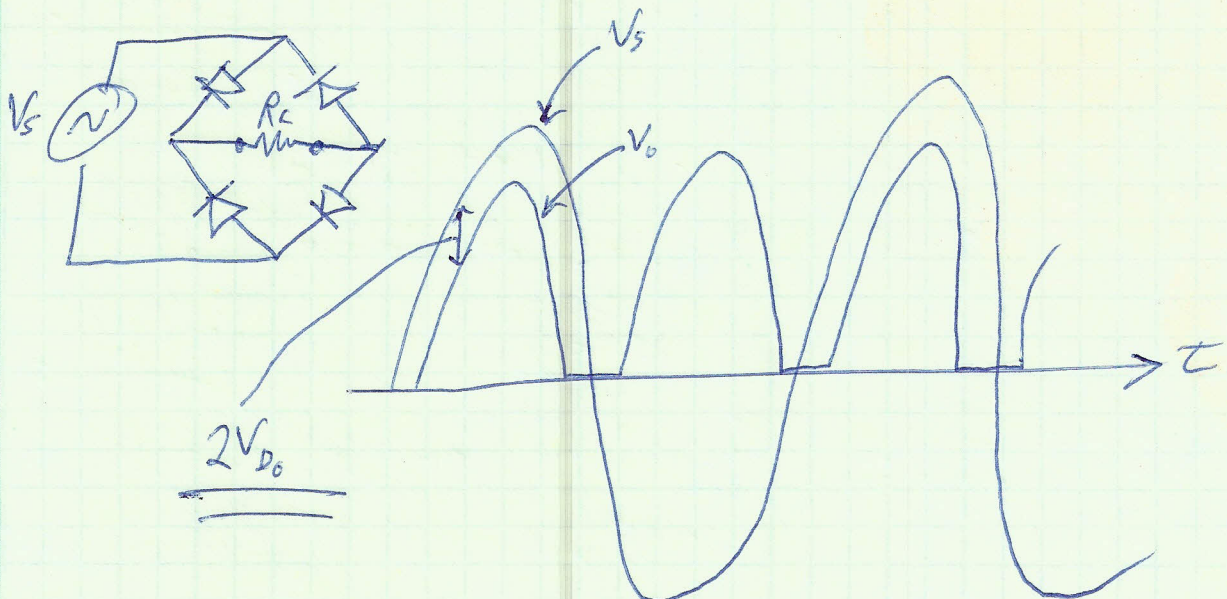


If diode is turned around, still rectifies, but with negative offset



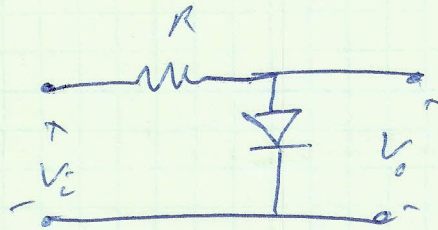
Both are known as "half-wave" rectifier circuits.

Full-wave rectifier circuit:



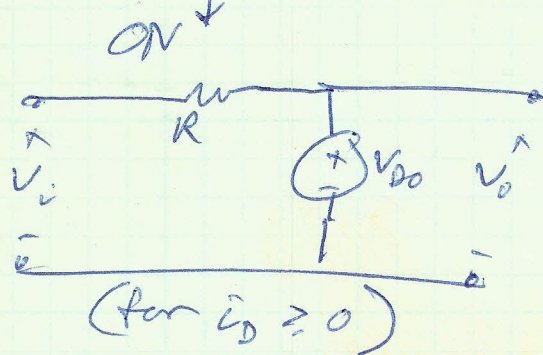
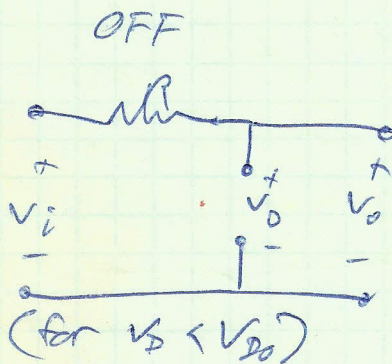
Clipper Circuits

$$\text{KVL: } V_i = R i_D + V_D, V_o = V_D$$



Diode OFF: $V_o = V_i \rightarrow$ for $V_i < V_{D0}$

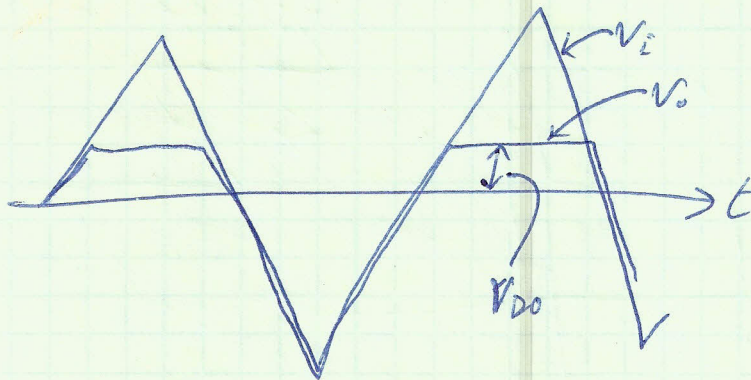
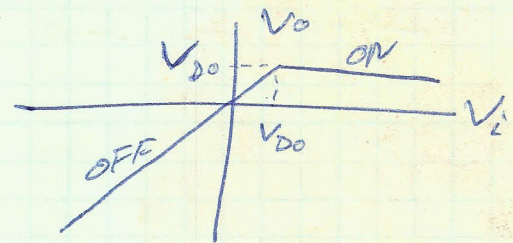
Diode ON: $V_o = V_{D0} \rightarrow i_D = \frac{V_i - V_{D0}}{R} \geq 0 \rightarrow V_i \geq V_{D0}$



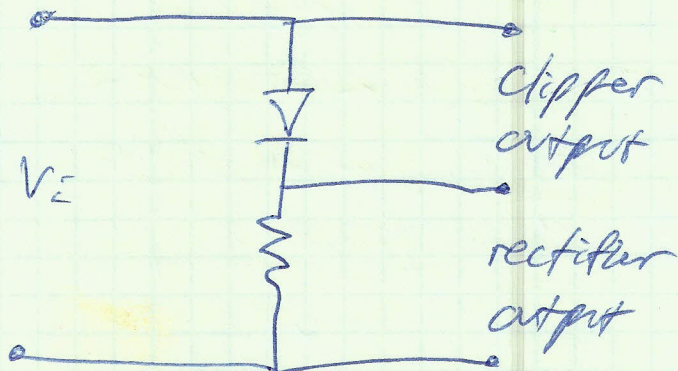
Transfer function

$V_i < V_{D0} \rightarrow \text{OFF}, V_o = V_i$

$V_i \geq V_{D0} \rightarrow \text{ON}, V_o = V_{D0}$

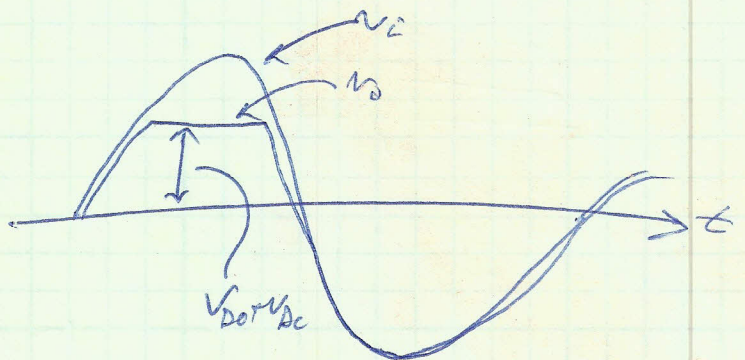
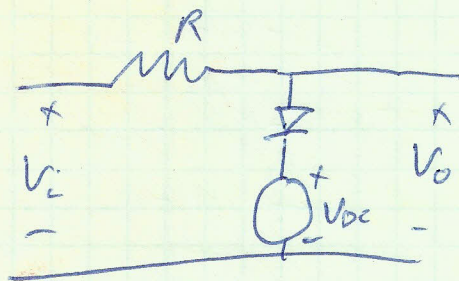


Note that the rectifier and clipper circuits are the same except with output taken at different points



- Voltage across diode can never exceed V_D
- Voltage across resistor can never be negative

Clipper circuits for values other than V_D



$$\begin{cases} V_o = V_D + V_{DC} \\ V_i = R I_D + V_D + V_{DC} = R I_D + V_o \end{cases}$$

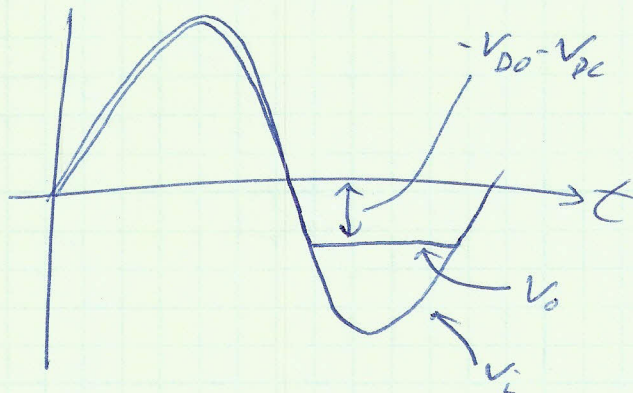
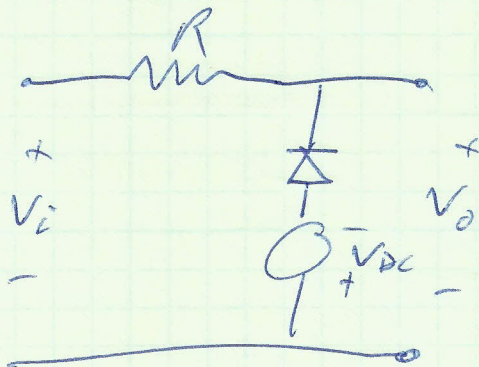
Diode ON:

$$V_o = V_D + V_{DC} \rightarrow I_D = \frac{V_i - V_D - V_{DC}}{R} \geq 0 \rightarrow \underline{V_i \geq V_D + V_{DC}}$$

Diode OFF:

$$V_o = V_i - 0 \times R = V_i, V_D = V_i - R I_D - V_{DC} < V_D \rightarrow \underline{V_i < V_D + V_{DC}}$$

Clipper circuit for negative voltages



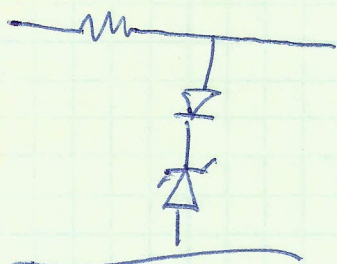
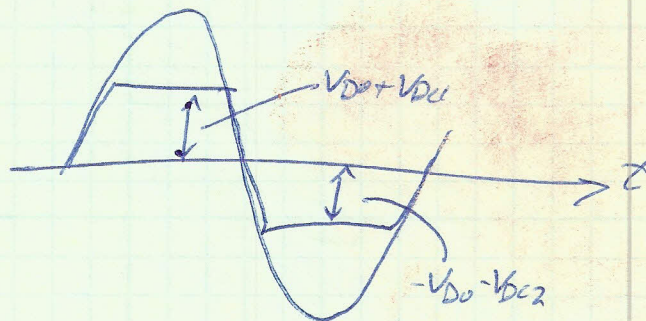
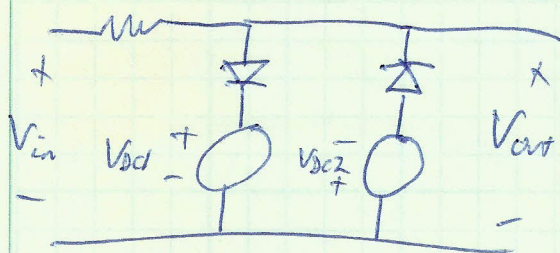
$$\text{KVL: } V_i = -Ri_D - V_D - V_{DC}$$

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

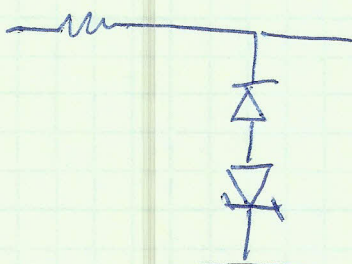
Diode ON: $V_o = -V_{D0} - V_{DC}$, $i_D = \frac{V_i + V_{D0} + V_{DC}}{R} \geq 0 \rightarrow V_i \leq -V_{D0} - V_{DC}$

Diode OFF: $V_o = V_i$, $V_D = -V_i - V_{DC} < V_{D0} \rightarrow V_i > -V_{D0} - V_{DC}$

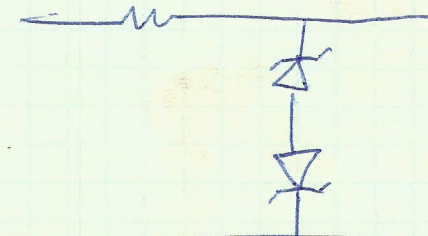
Other Clipper Circuits



clips $V > V_{Z2} + V_{D01}$



clips $V < -V_{D01} - V_{Z2}$



clips $|V| > V_{D0} + V_Z$
if diodes are identical