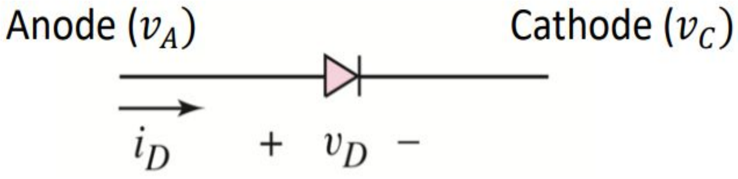
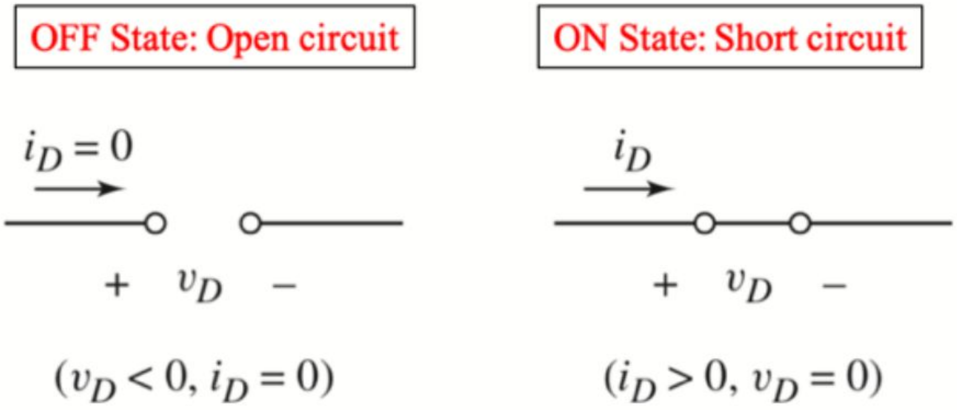
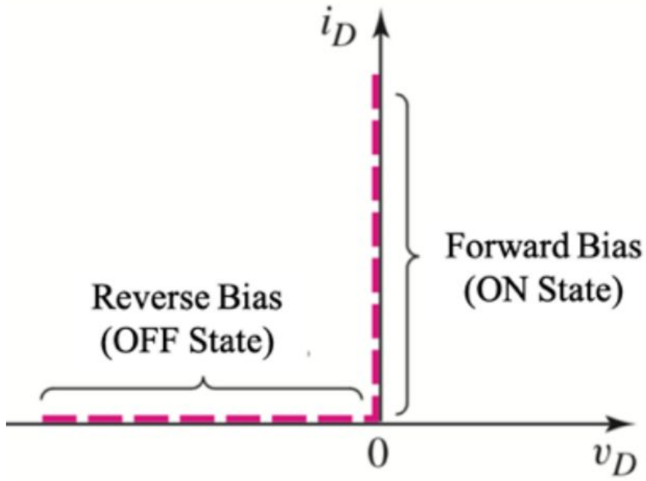
Lecture 9

Diode models & Rectifiers

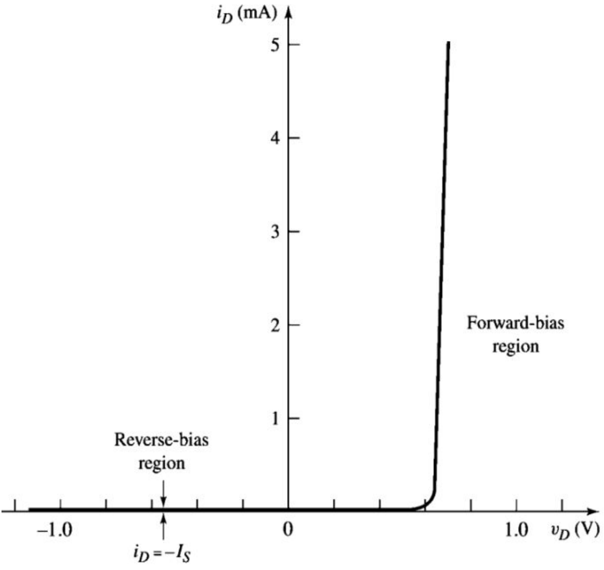
Review: Ideal Diode Model







Real diode



I-V characteristics of a real diode

Relation between diode current and diode voltage:

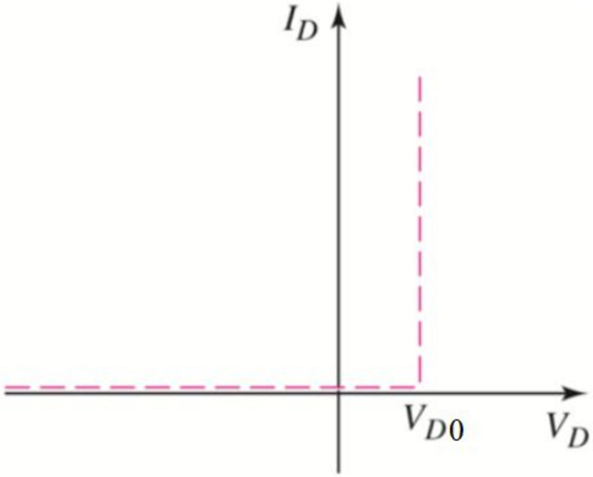
$$i_D = I_S\left(e^{\frac{v_D}{\eta V_T}} - 1\right)$$

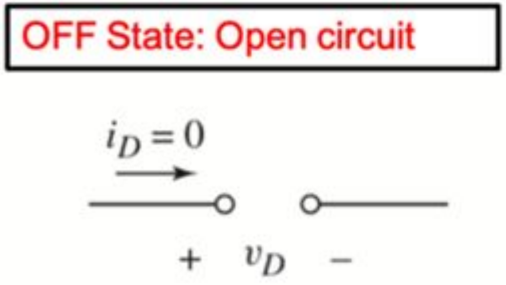
where v_D $(= v_A - v_C)$ is the voltage across the diode, i_D is the current through the diode (from anode to cathode) and V_T, called the thermal voltage, is a temperature dependent constant. For temperature $T = 300K$, $V_T = 25\ mV$.

η is called the ideality factor (try to recall, you measured this in the lab!)

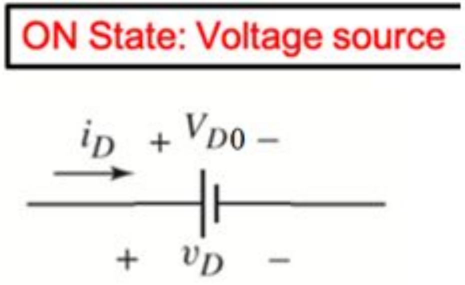
Modeling the real diode

1. Ideal diode model
2. **Constant voltage drop (CVD) model**
3. CVD+R model





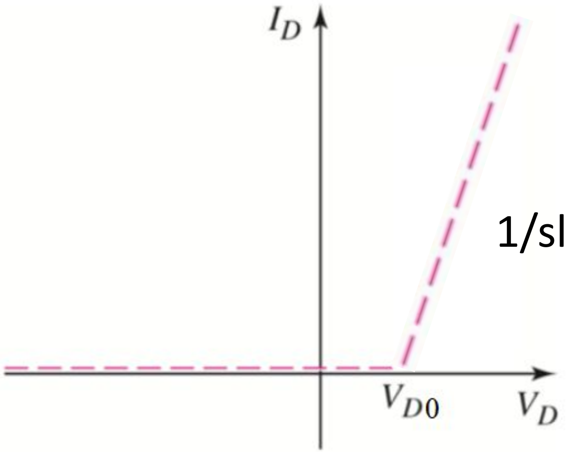
$(v_D < V_{D0}, i_D = 0)$



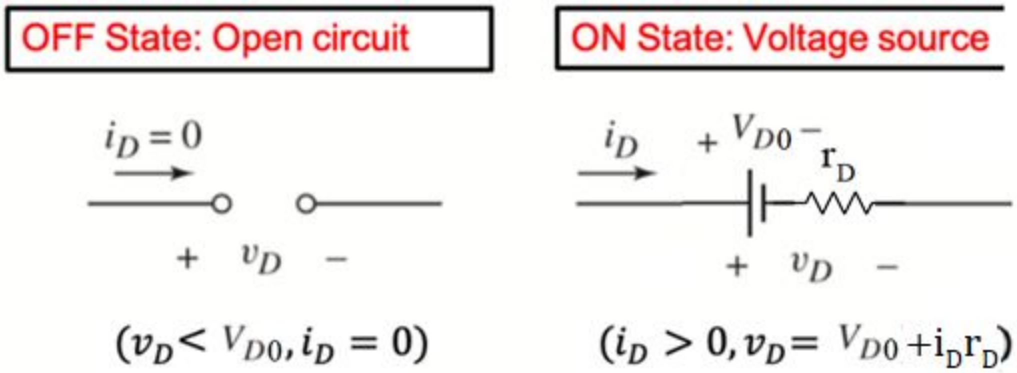
$(i_D > 0, v_D = V_{D0})$

Modeling the real diode

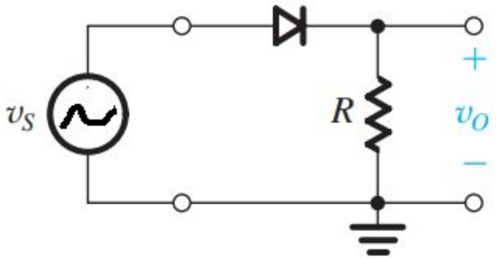
1. Ideal diode model
2. Constant voltage drop (CVD) model
3. **CVD+R model**

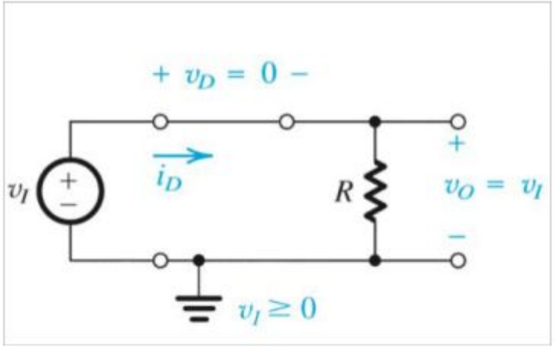


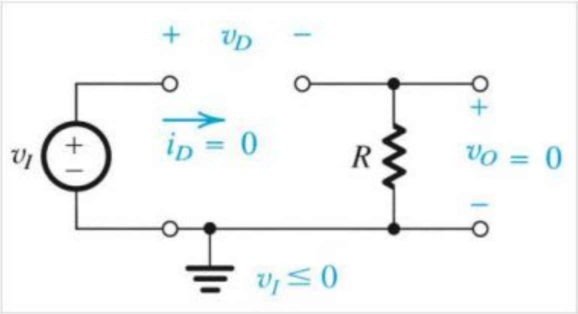
1/slope = R

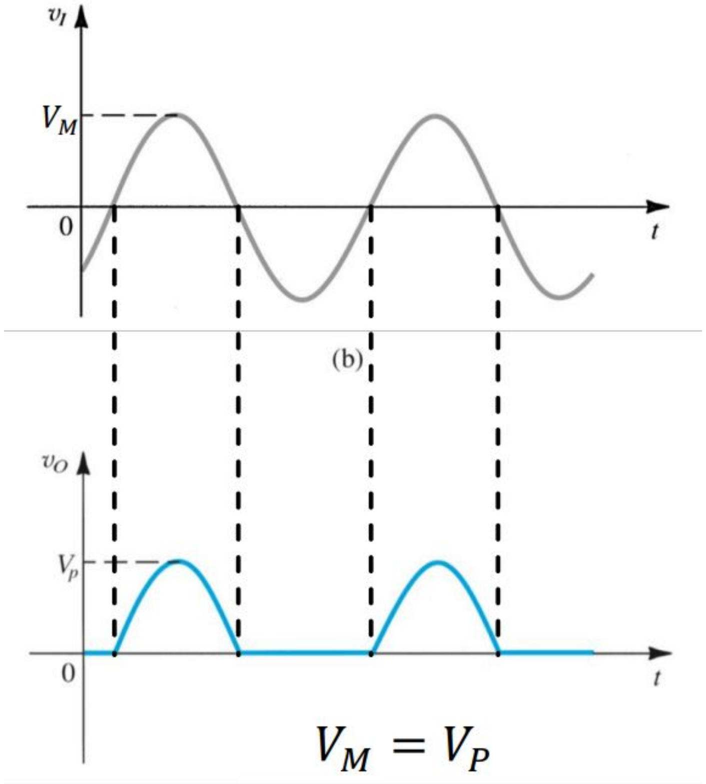


Half-wave rectifier (ideal diode model)









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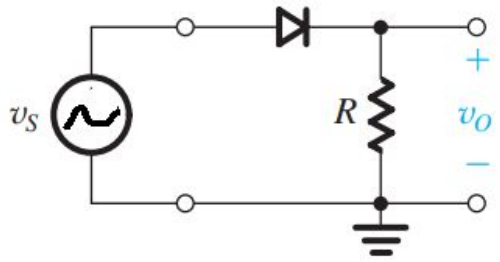

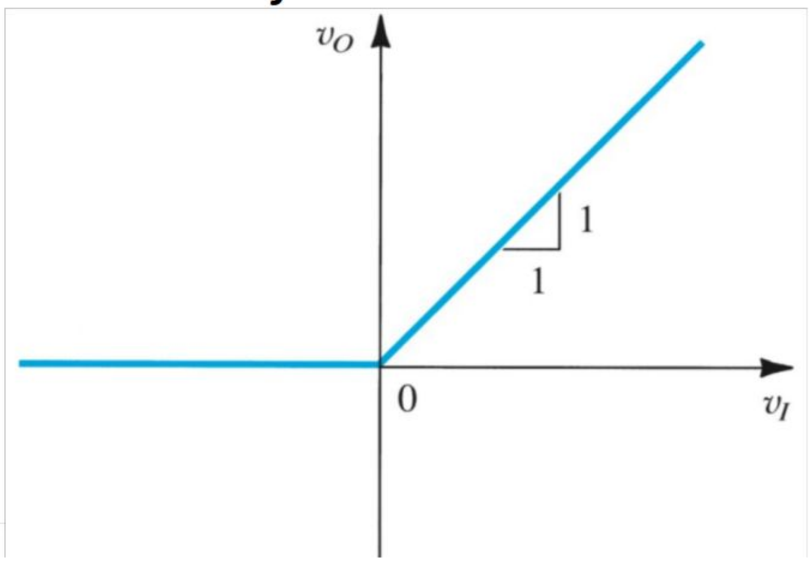

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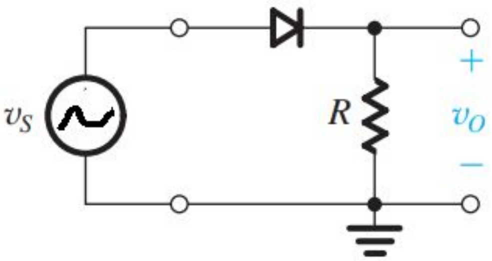
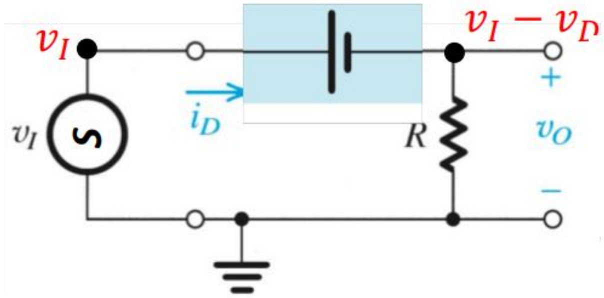
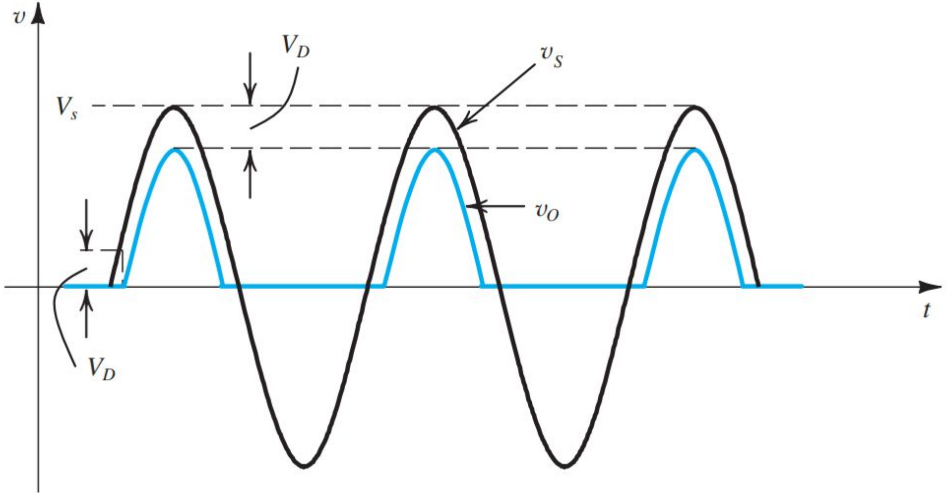
Half-wave rectifier (CVD model)





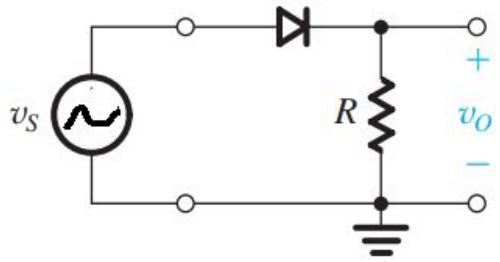


$$v_I = V_M \sin \omega t$$

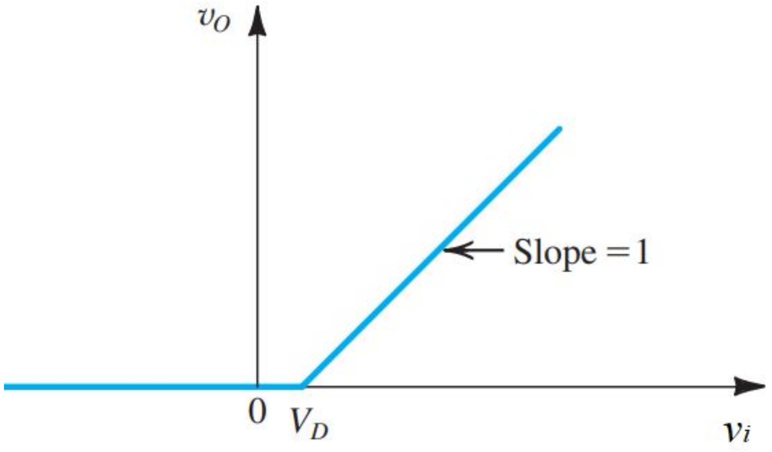
$$v_o = V_M \sin \omega t - V_D$$

$$V_p = peak\ of\ output$$
$$= V_M - V_D$$

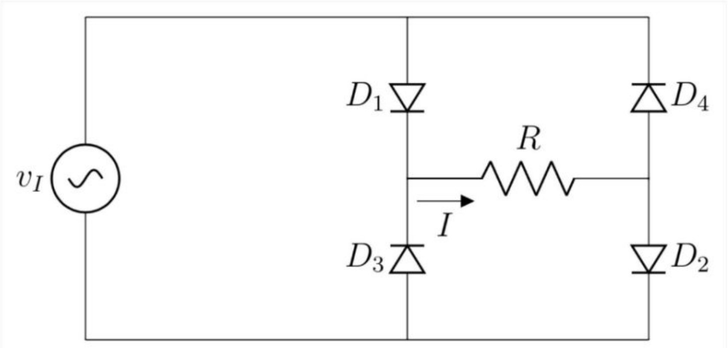
Half-wave rectifier (CVD model)



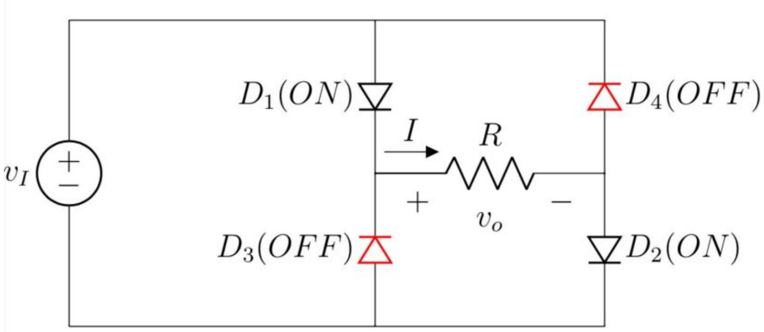
Transfer Characteristics

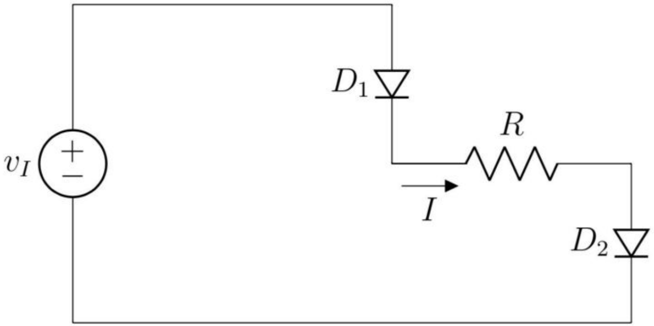


Full-wave rectifier (ideal diode & CVD model)



(+) half-cycle





$$v_o = v_I - 2V_D$$

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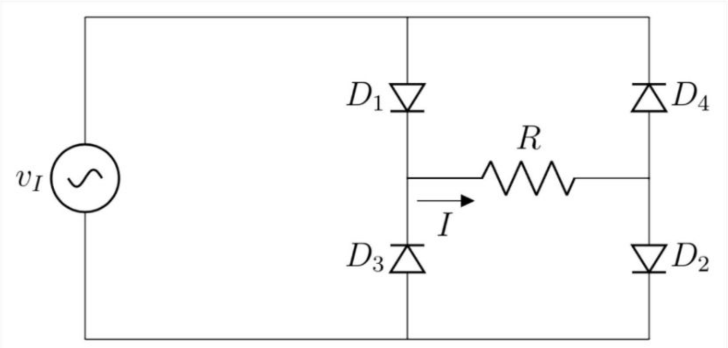
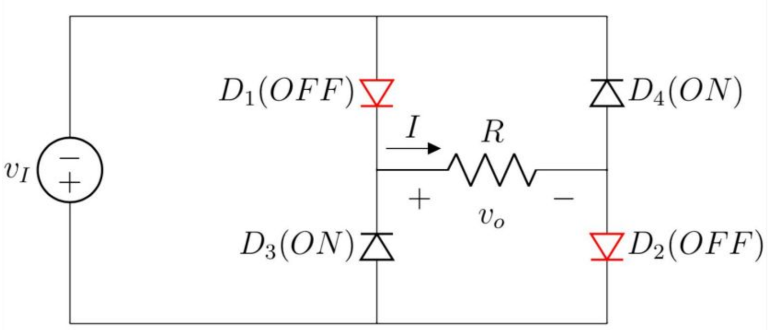
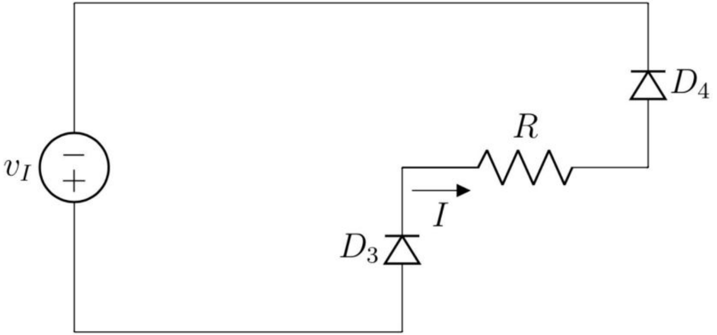
Full-wave rectifier (ideal diode & CVD model)

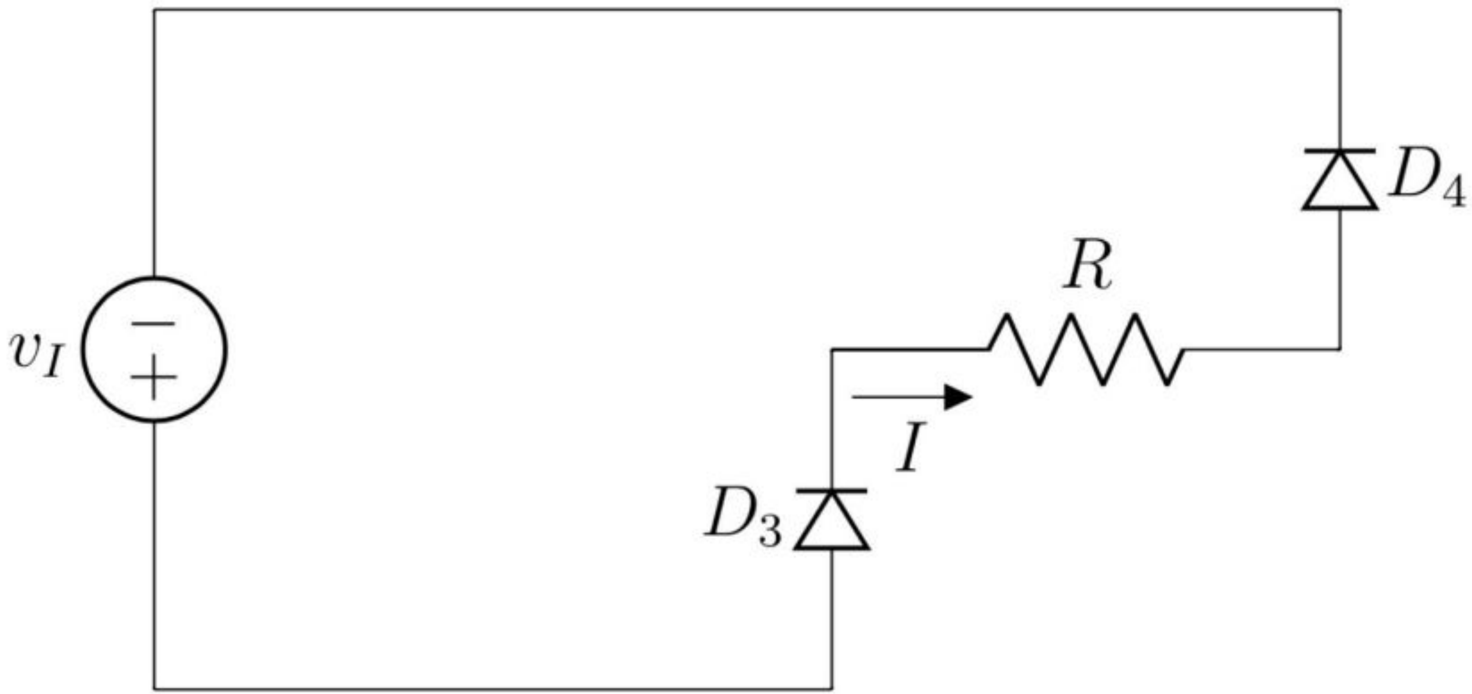


(-) half-cycle





Full-wave rectifier (ideal diode & CVD model)



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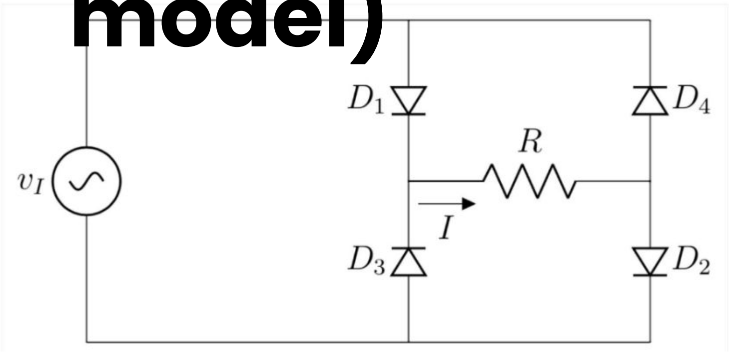

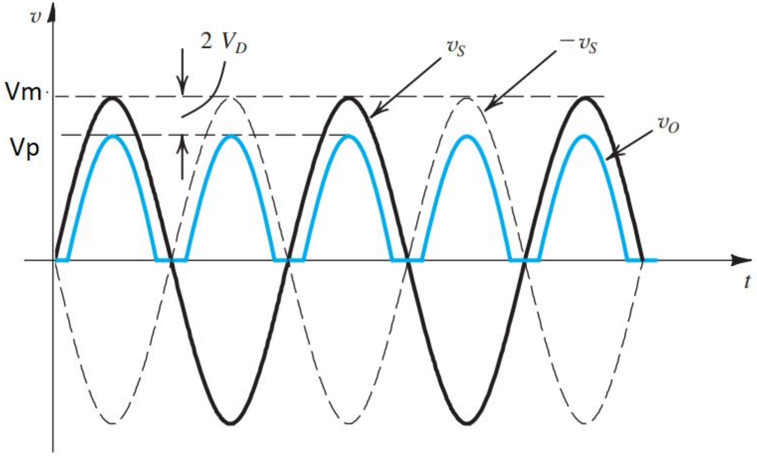

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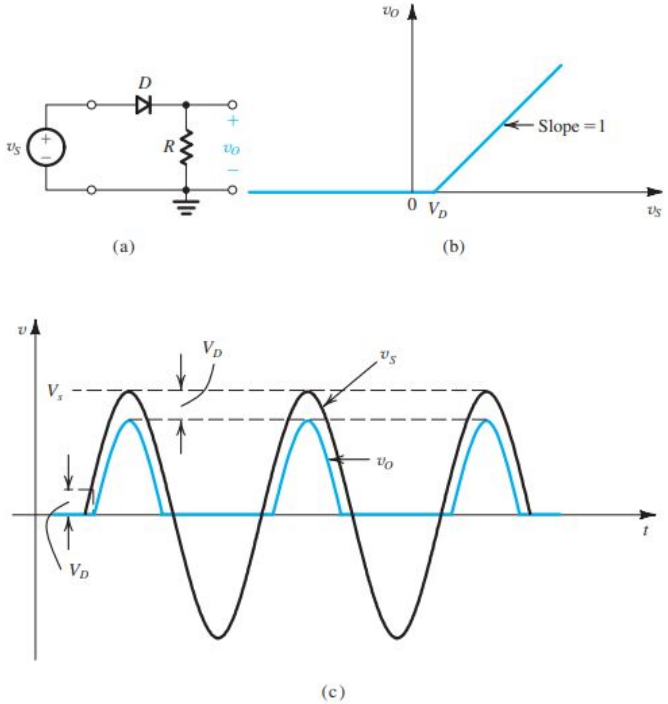
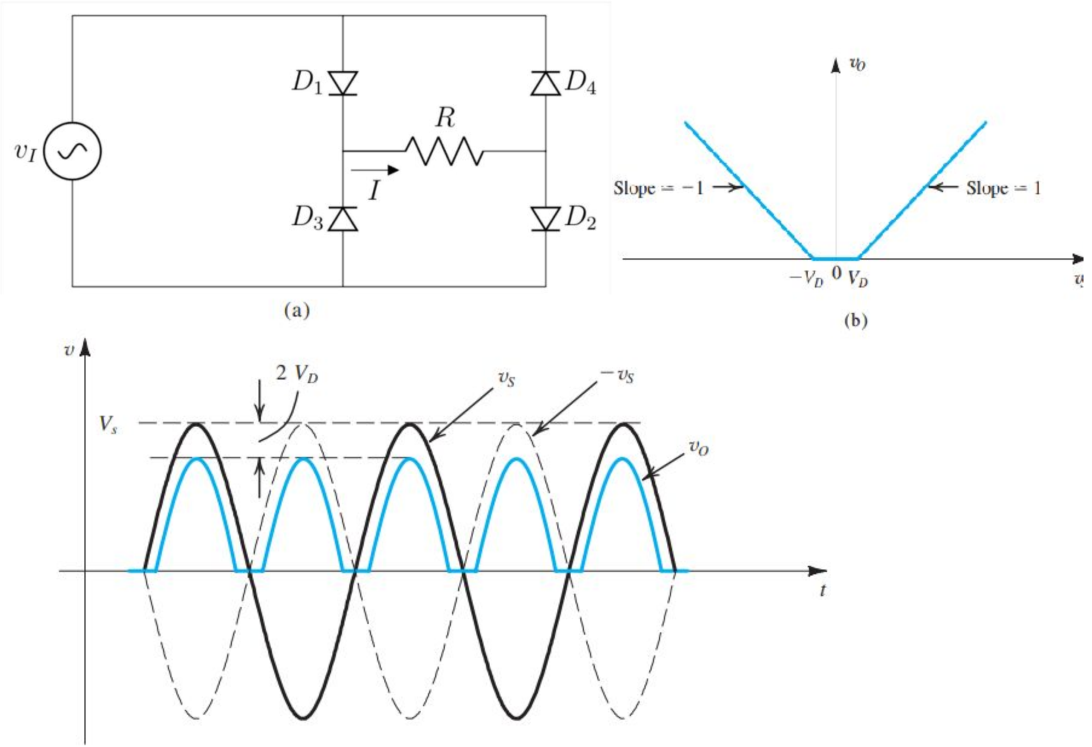
Half-wave and Full-wave rectifier

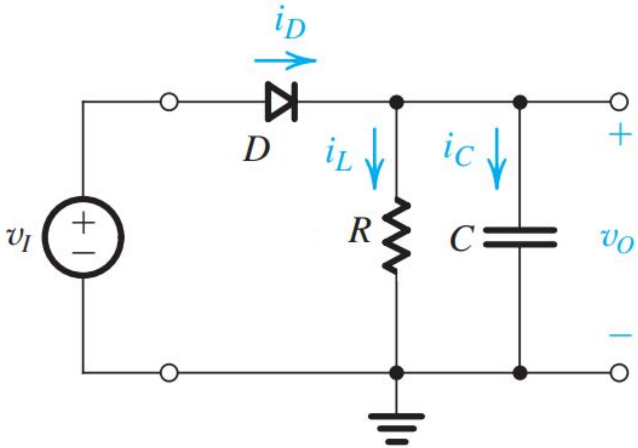


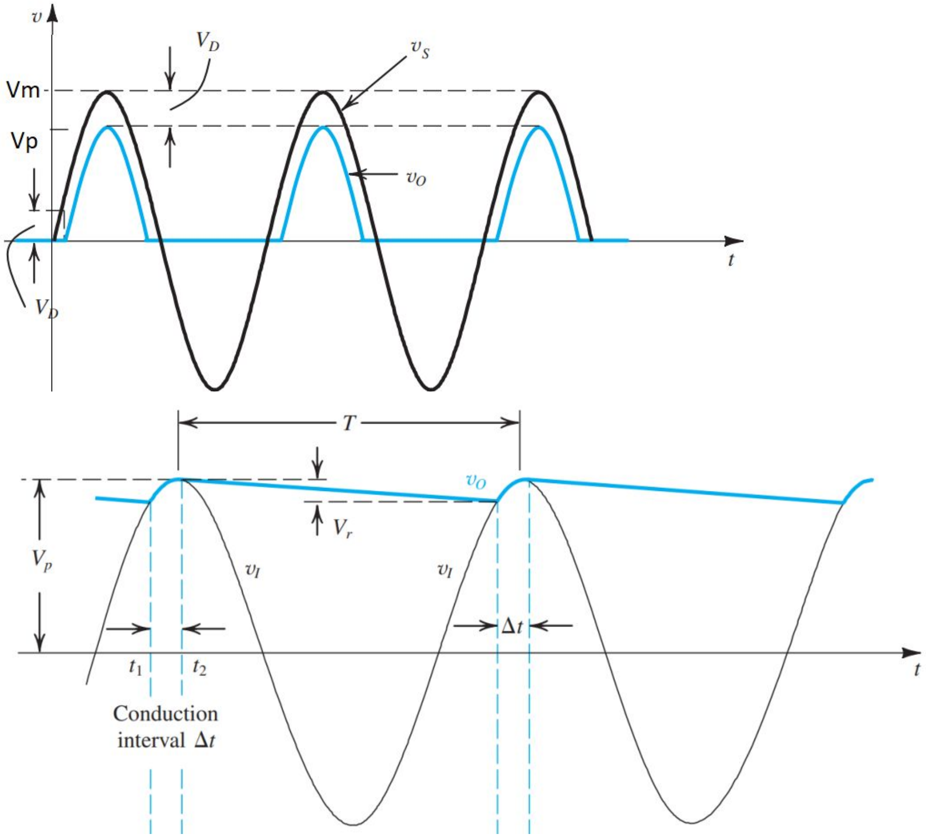


Half-wav
e

Full-wav
e

Filtering: Half-wave rectifier





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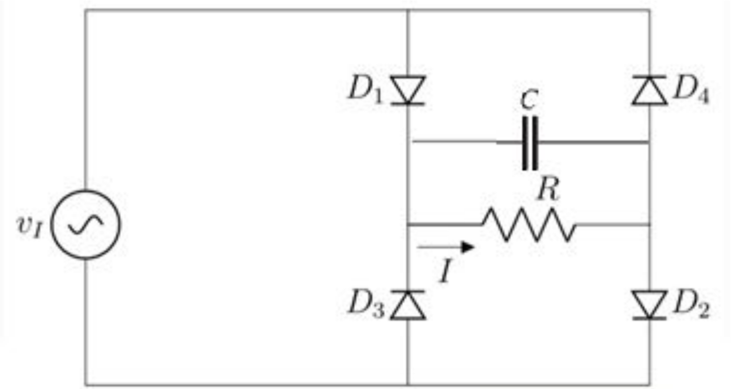
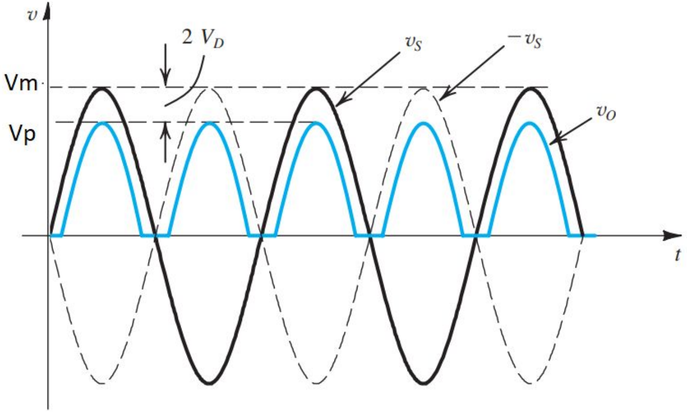
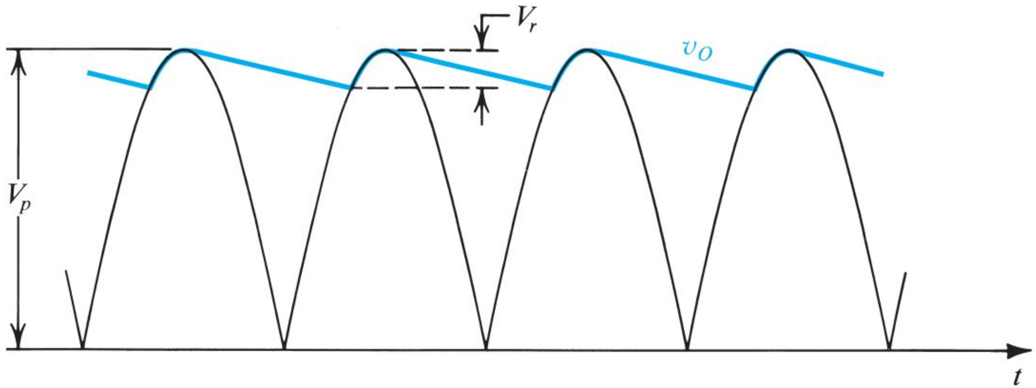
Filtering: Full-wave rectifier







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Without capacitor

Rectifier	i/p peak	o/p peak	average
H/W	V_M	V_P	$V_{avg}=V_{DC}=\frac{1}{\pi}V_M-\frac{1}{2}V_{Do}$
F/W	V_M	V_P	$V_{avg}=V_{DC}=\frac{2}{\pi}V_M-2V_{Do}$

With capacitor

Rectifier	i/p peak	o/p peak	frequency	Ripple voltage	average
H/W	V_M	$V_P=V_M-V_{Do}$	$f_r=f_i$	$V_r=\frac{V_P}{f_r R C}$	$V_{avg}=V_{DC}=V_P-\frac{1}{2}V_r$
F/W	V_M	$V_P=V_M-2V_{Do}$	$f_r=2f_i$	$V_r=\frac{V_P}{f_r R C}$	$V_{avg}=V_{DC}=V_P-\frac{1}{2}V_r$

$$I_{o,avg}=V_{o,avg}/R,\ V_{rms}=V_p/\sqrt{2}$$

before.

To sum up.

	HW	FW
V_p	$V_m - V_{D_0}$	$V_m - 2V_{D_0}$
f_r	f_s	$2f_s$
V_{DC} (without Cap)	$\frac{1}{\pi}V_m - \frac{1}{2}V_{D_0}$	$\frac{2}{\pi}V_m - 2V_{D_0}$

With Capacitor

$$V_r(p-p) = \frac{V_p}{f_r \cdot RC}$$

$$V_r(rms) = \frac{V_r(p-p)}{2\sqrt{3}}$$

$$V_r(rms) = \frac{V_p}{2\sqrt{3} f_r \cdot RC}$$

$$V_{DC} = V_p - \frac{V_r(p-p)}{2}$$

Example

A voltage waveform $v_i = 8sin(2000\pi t)V$ is input to a full-wave rectifier. A resistance of $R = 50k\ \Omega$ is connected at the load. [Assume that the diodes used in the circuit have a forward drop of 0.8V].

(a) Draw the circuit of the full wave rectifier. Label the input and output voltages properly. [1]

(b) Draw the waveforms of the input and output voltages. What are the peak values of input and output? Show them in the graph. [1+1]

(c) Find the average voltage measured at the output. [1]

Thank you