



# CSE251: Electronic Devices and Circuits

Diodes – 3  
Rectifiers

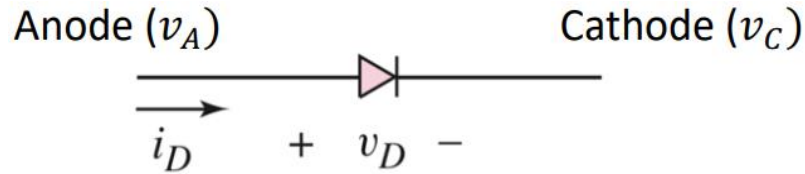
Prepared By:

**Shadman Shahid (SHD)**

Lecturer, Department of Computer Science and Engineering, School of Data and Sciences, BRAC University

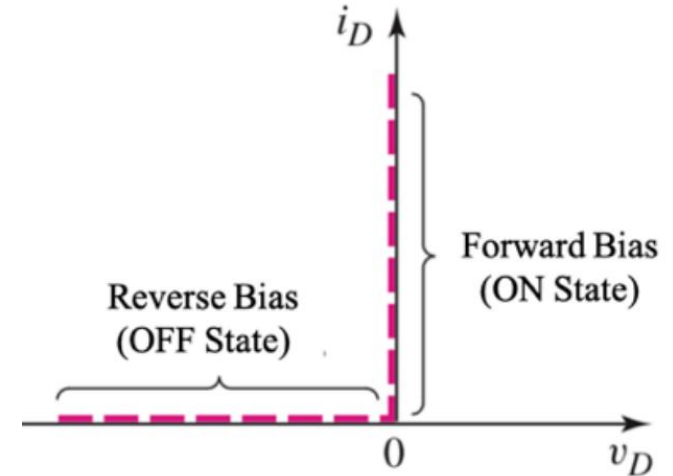
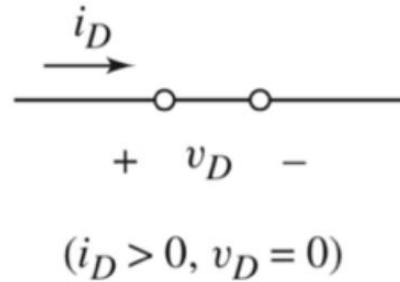
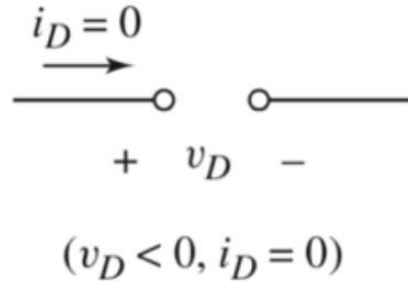
*Email: [shadman9085@gmail.com](mailto:shadman9085@gmail.com)*

# Review: Diode Models

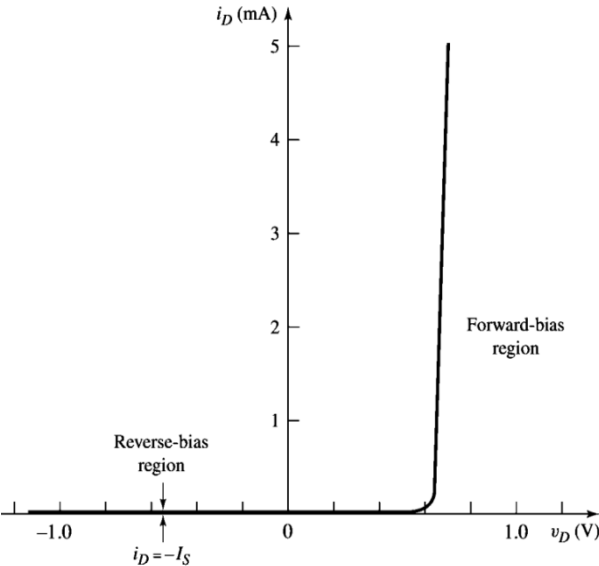


**OFF State: Open circuit**

**ON State: Short circuit**



# Real diode



**I-V characteristics of a  
real diode**

Relation between diode current and diode voltage:

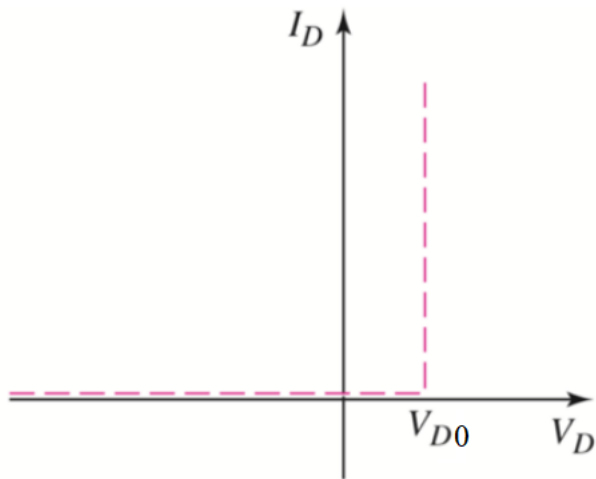
$$i_D = I_S \left( e^{\frac{v_D}{\eta V_T}} - 1 \right)$$

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  $T = 300K$ ,  $V_T = 25 \text{ mV}$ .

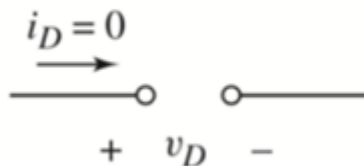
$\eta$  is called the ideality factor (try to recall, you measured this in the lab!)

# Modeling the real diode

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

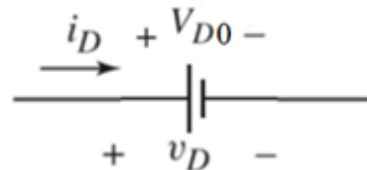


**OFF State: Open circuit**



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

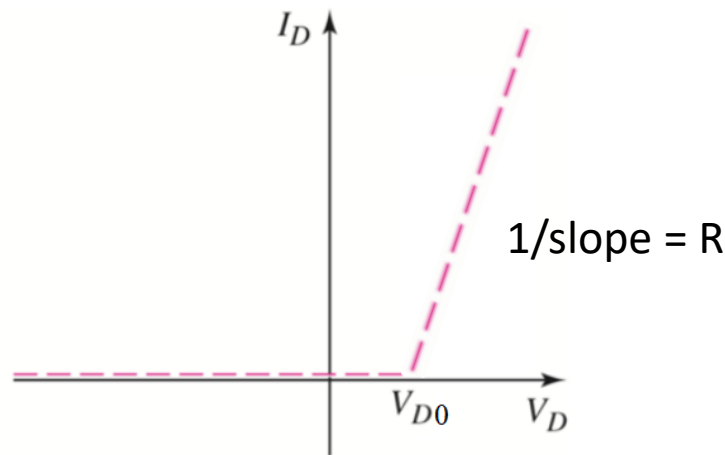
**ON State: Voltage source**



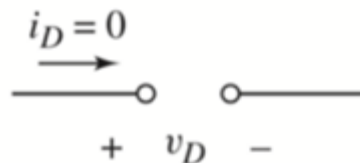
$$(i_D > 0, v_D = V_{D0})$$

# Modeling the real diode

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

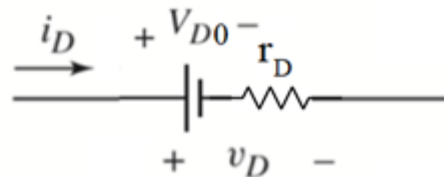


**OFF State: Open circuit**



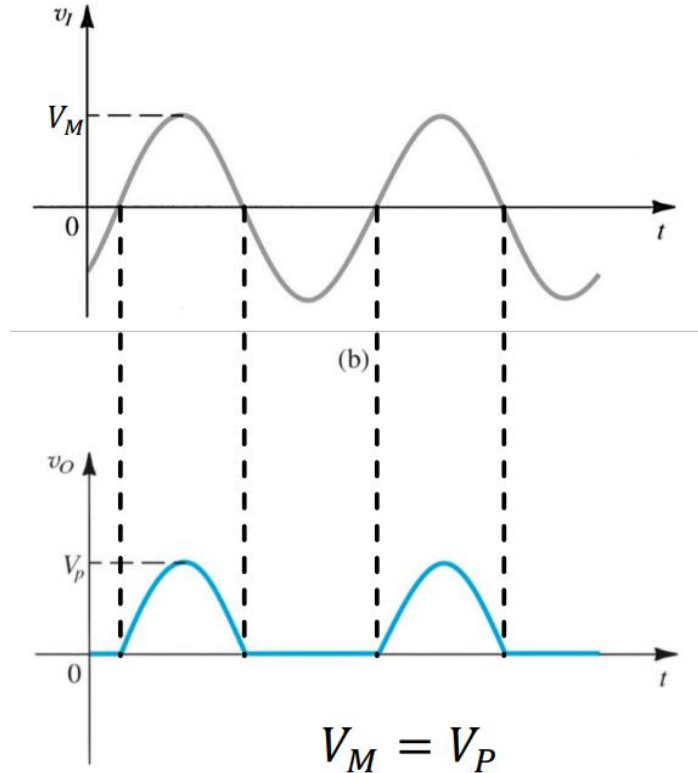
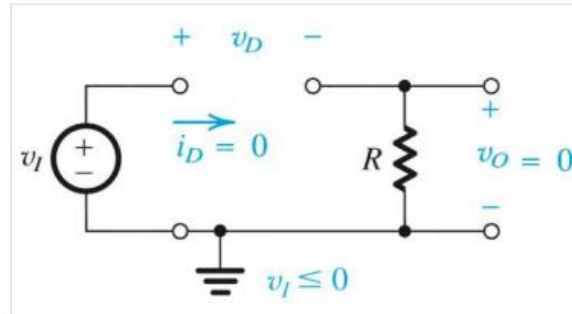
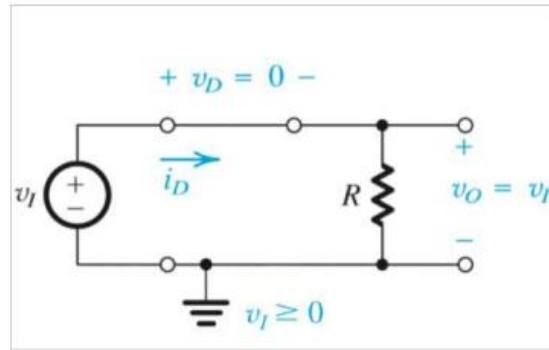
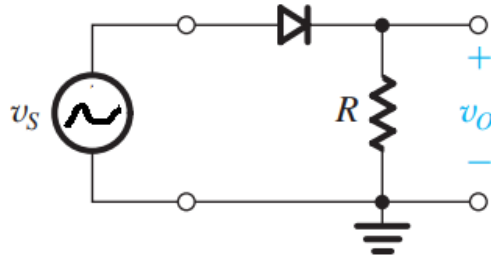
$$(v_D < V_{D0}, i_D = 0)$$

**ON State: Voltage source**

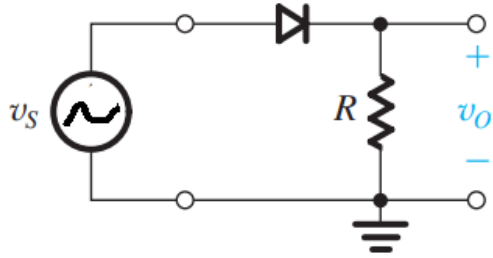


$$(i_D > 0, v_D = V_{D0} + i_D r_D)$$

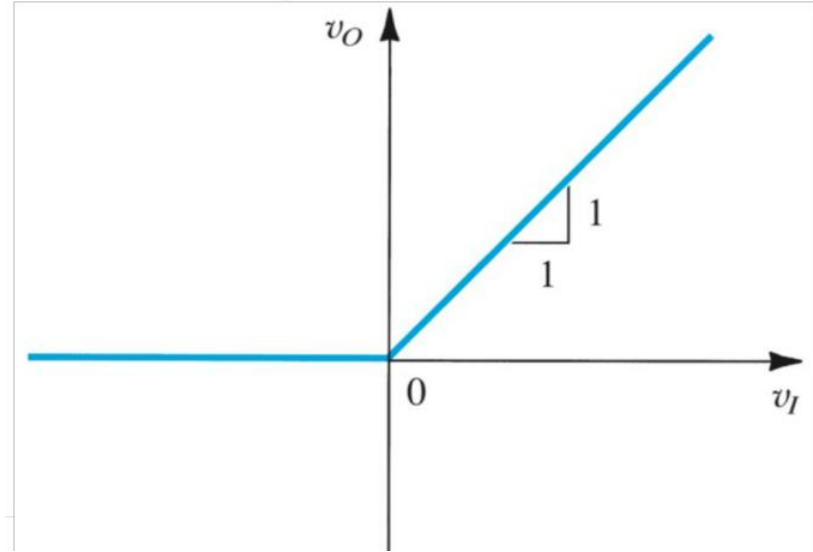
# Half-wave rectifier (ideal diode model)



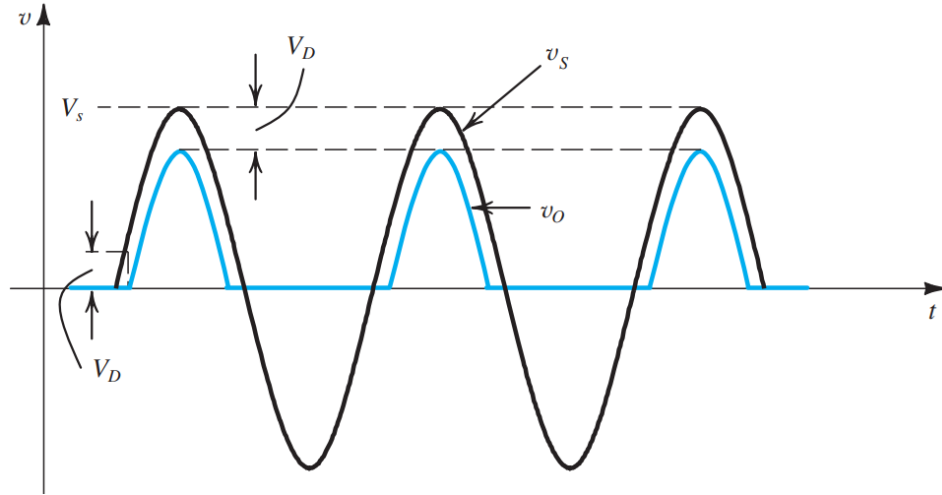
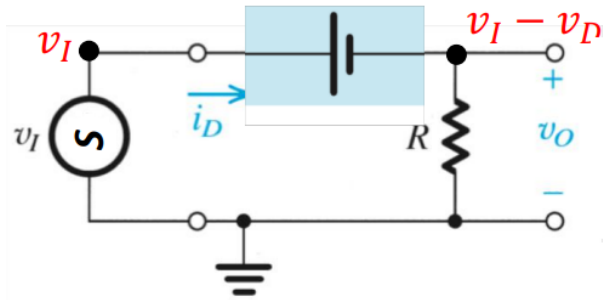
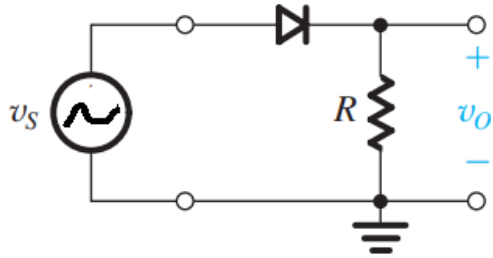
# Half-wave rectifier (ideal diode model)



*Transfer Characteristics*



# Half-wave rectifier (CVD model)



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

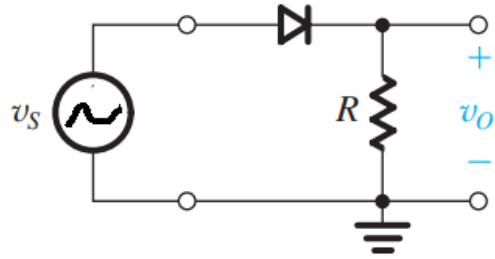
$$v_O = V_M \sin \omega t - V_D$$

$$V_p = \text{peak of output}$$

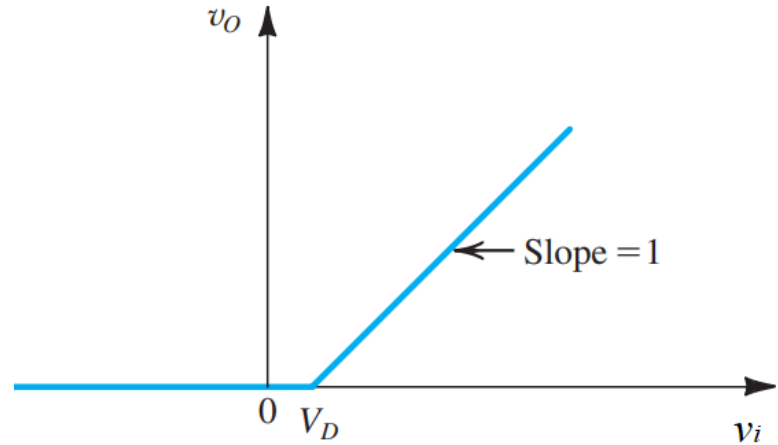
$$= V_M - V_D$$



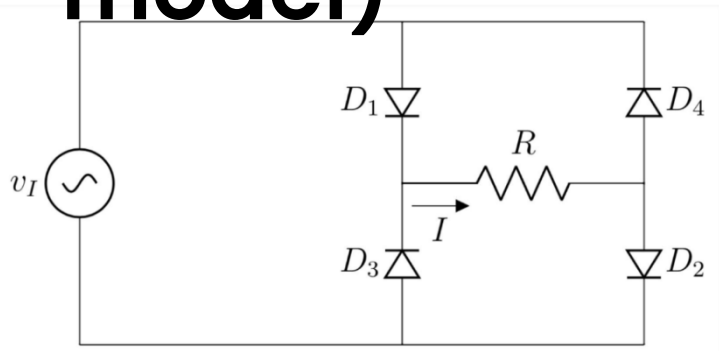
# Half-wave rectifier (CVD model)



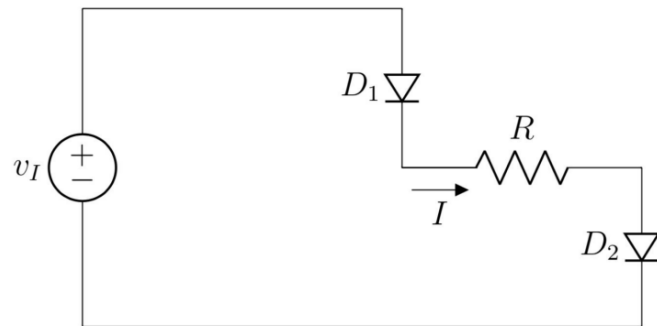
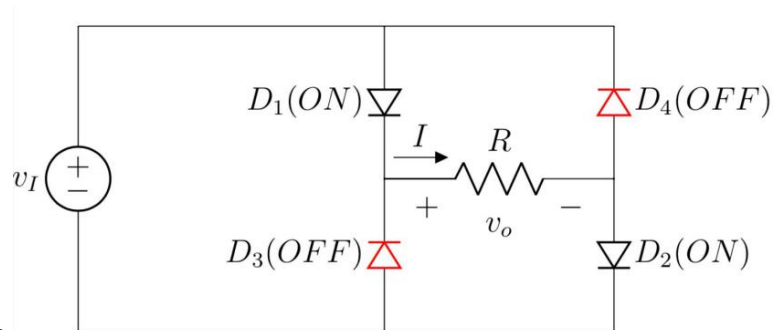
*Transfer Characteristics*



# Full-wave rectifier (ideal diode & CVD model)

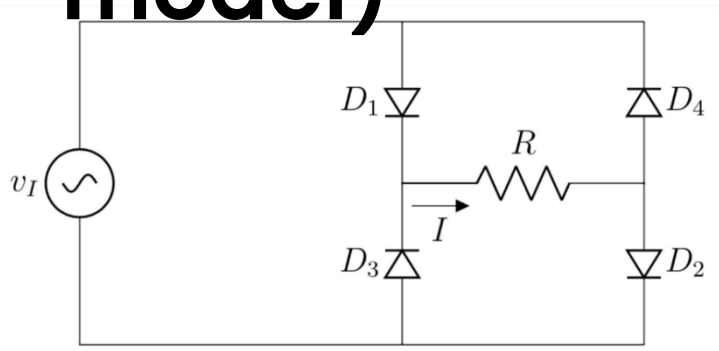


(+) half-cycle

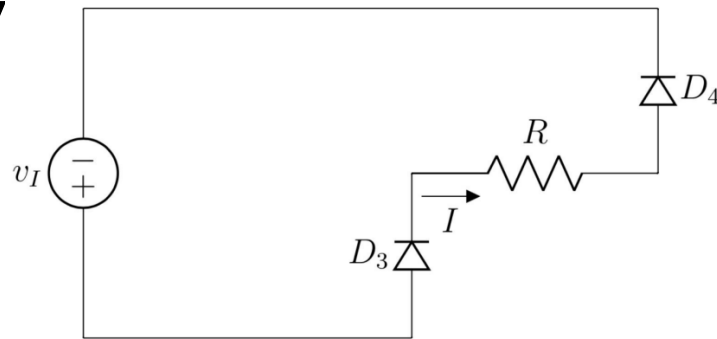
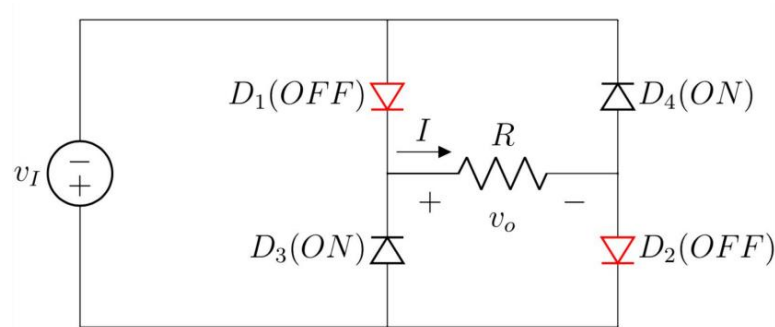


$$v_o = v_I - 2V_D$$

# Full-wave rectifier (ideal diode & CVD model)

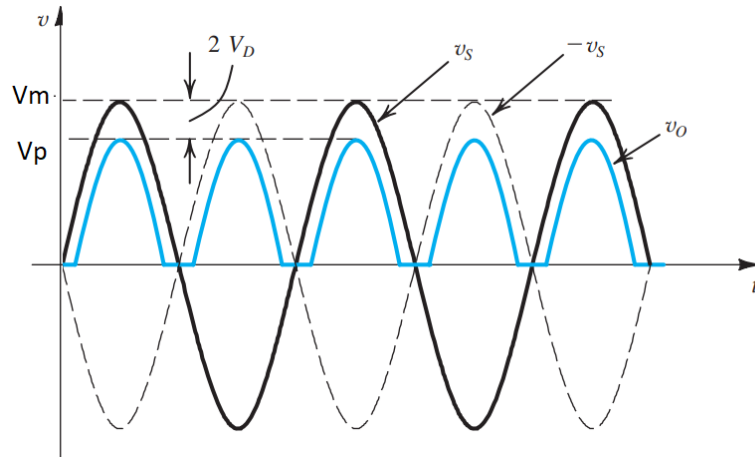
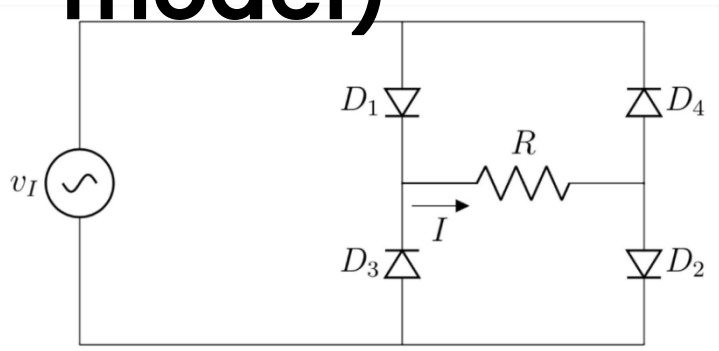


(-) half-cy

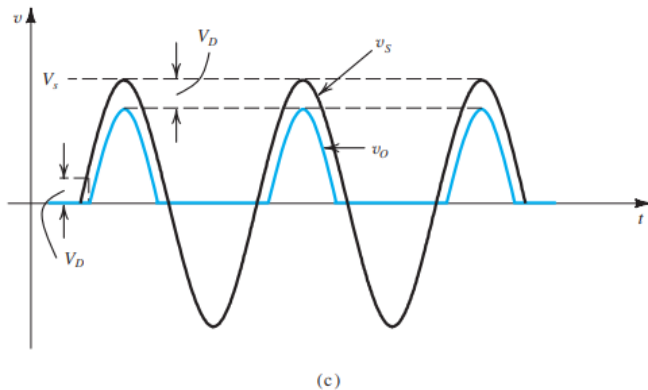
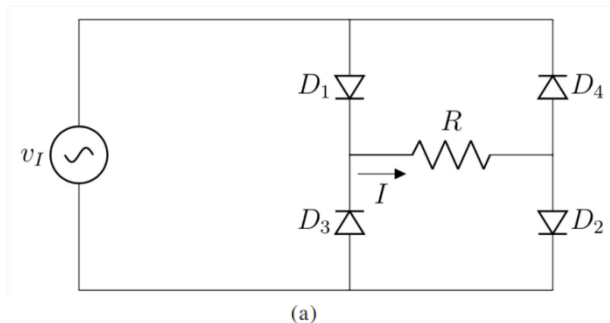
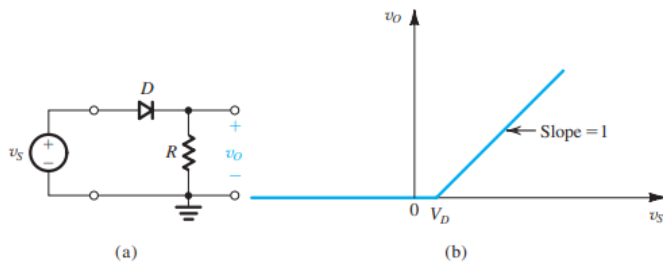


$$v_o = -v_I - 2V_D$$

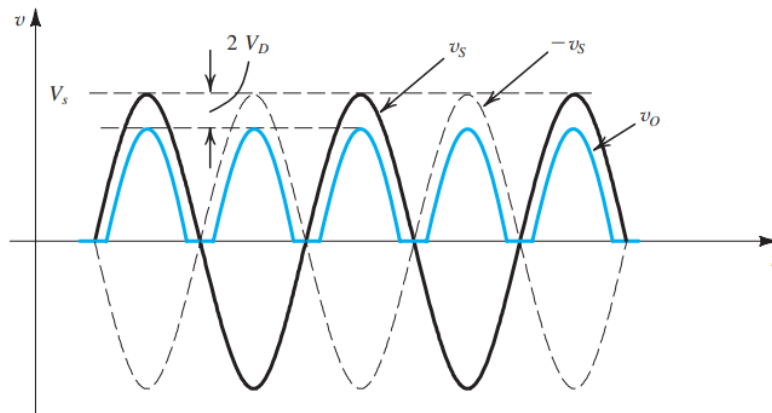
# Full-wave rectifier (ideal diode & CVD model)



# Half-wave and Full-wave rectifier

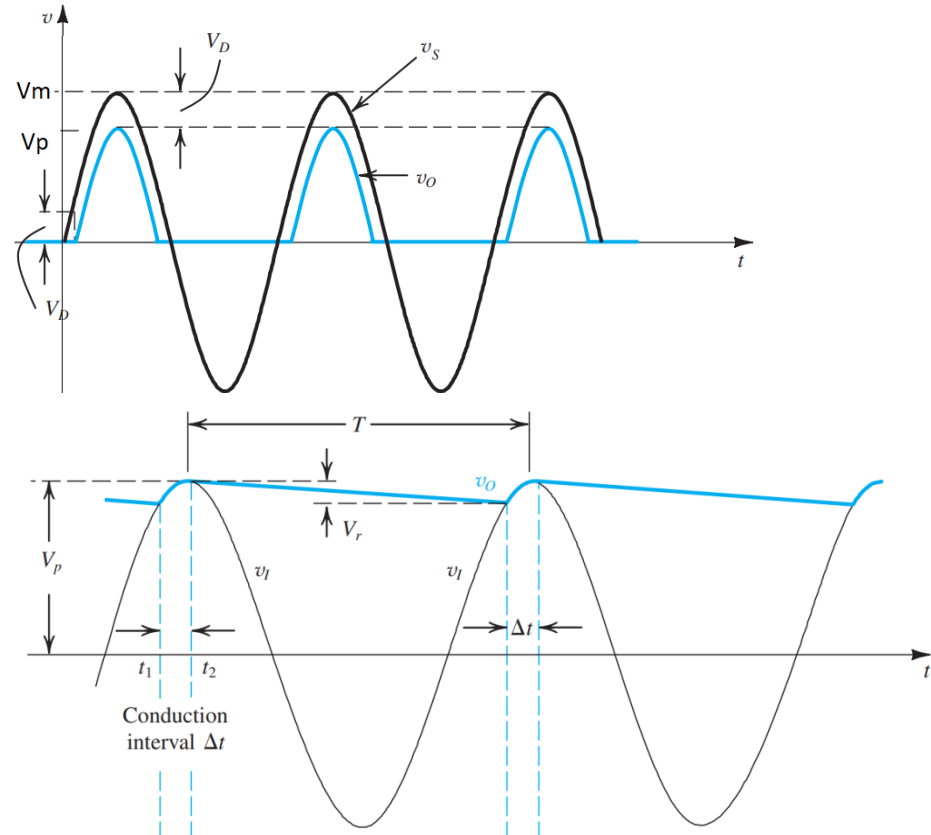
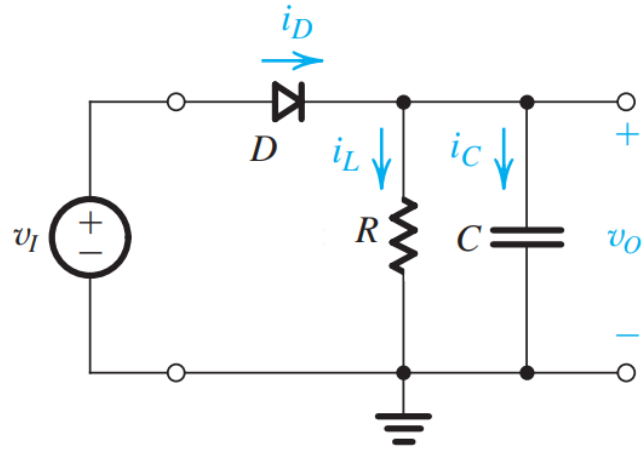


**Half-wave**

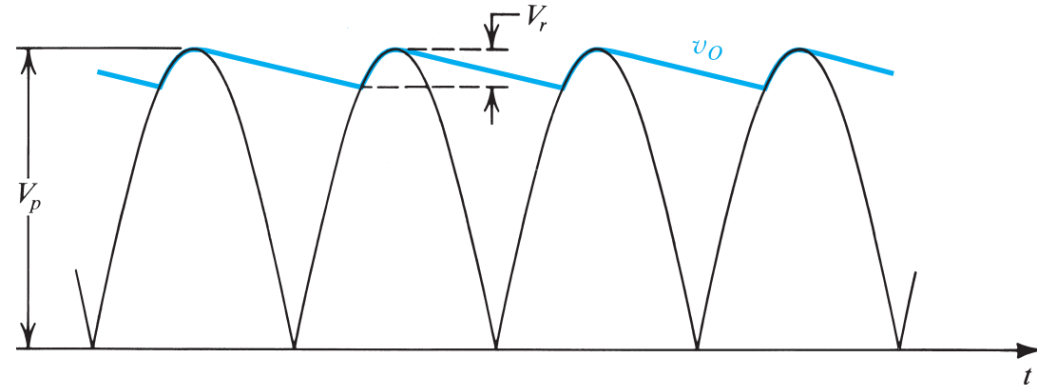
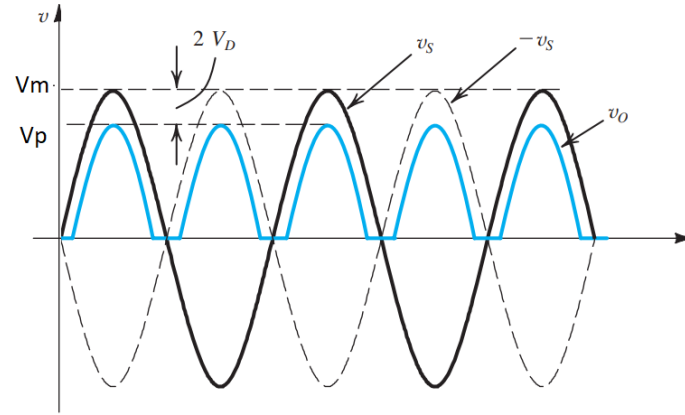
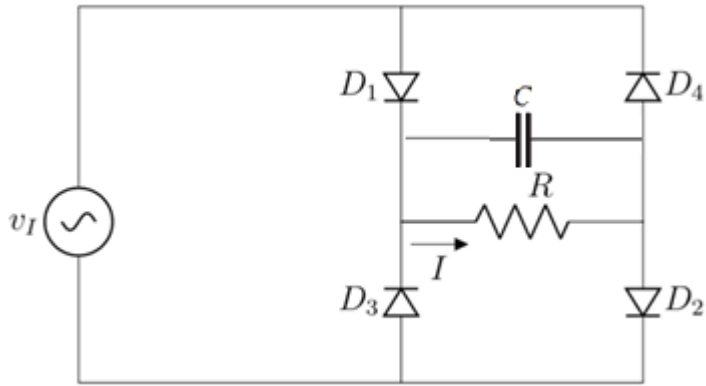


**Full-wave**

# Filtering: Half-wave rectifier



# Filtering: Full-wave rectifier



## 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	$V_M$	$V_P=V_M-2V_{Do}$	$f_r=2f_i$	$V_r=\frac{V_P}{f_r R C}$	$V_{avg}=V_{DC}=V_P-\frac{1}{2}V_r$

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



# Example

A voltage waveform  $v_i = 8\sin(2000\pi t)V$  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