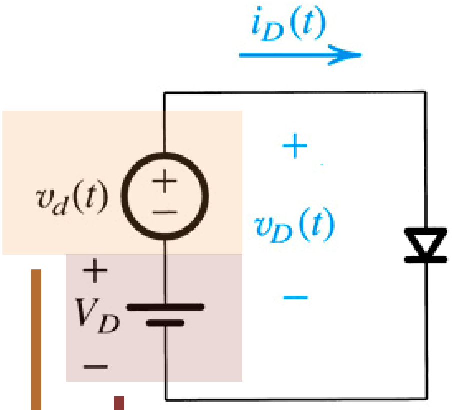
Last Lecture → Small Signal Model



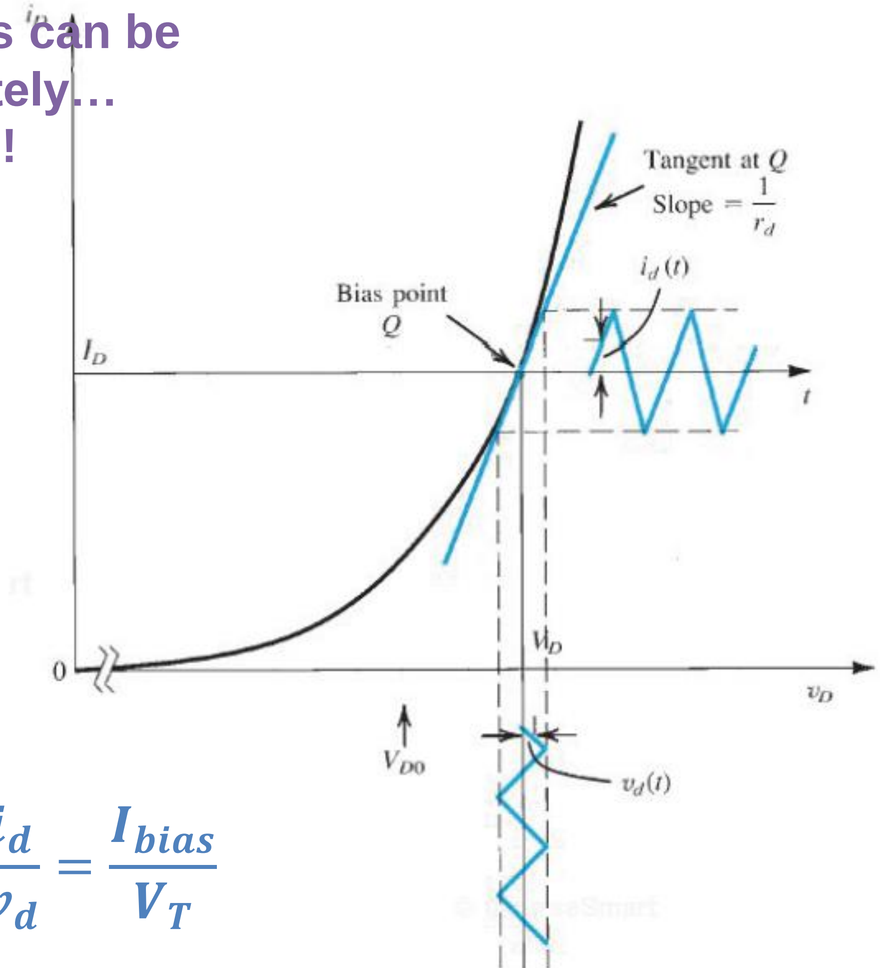
$$i_D = I_S e^{v_D/V_T}$$

$$i_D(t) = I_S e^{v_D(t)/V_T}$$
$$= I_S e^{(V_D + v_d(t))/V_T}$$
$$= I_{bias} e^{v_d(t)/V_T}$$

∴ DC and AC Analysis can be performed separately… superposition!

DC AC

$$i_D(t) \approx \underbrace{I_{bias}}_{DC} + \underbrace{\frac{I_{bias}}{V_T} v_d(t)}_{AC}$$



$$\frac{1}{r_d} = \frac{\Delta i_D}{\Delta v_D} = \frac{i_d}{v_d} = \frac{I_{bias}}{V_T}$$

DC Signal
→ stablishes the bias point

AC Signal
→ small changes at the bias point

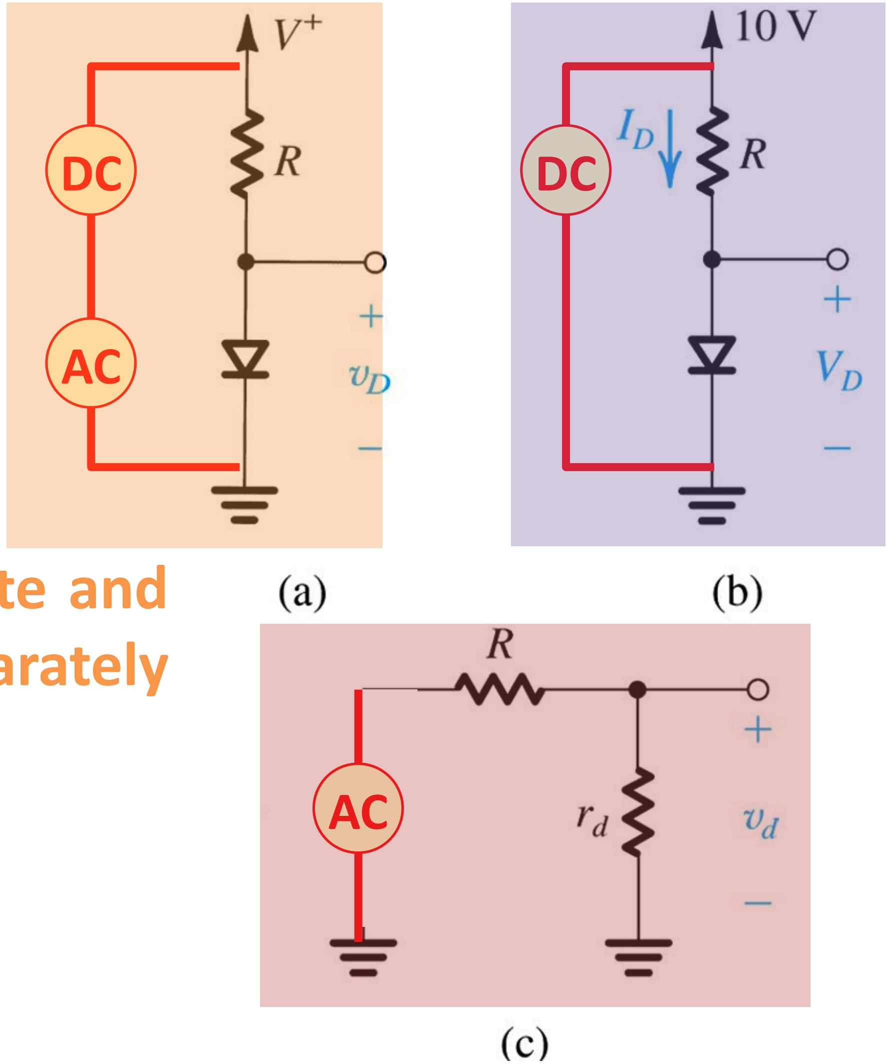
∴The AC behavior of the diode can be modeled as a resistor !

Last Lecture → Small Signal Model

- Diode y modeled as a variable resistor
- Its value is defined via linearization of exponential model
- Around bias point defined by constant voltage drop model

The total instantaneous circuit is divided into steady-state and time varying components, which may be analyzed separately and solved via algebra.

1) In steady-state, diode represented as CVDM.
2) In time-varying, diode represented as resistor.



Problem D 4.56

$I_S = 69x10^{-16}$ A

A particular design of a voltage regulator is shown below. Diodes D_1 and D_2 are 10-mA units; that is, each has a voltage drop of 0.7V at a current of 10mA. Use the diode exponential model and iterative analysis to answer the following questions:

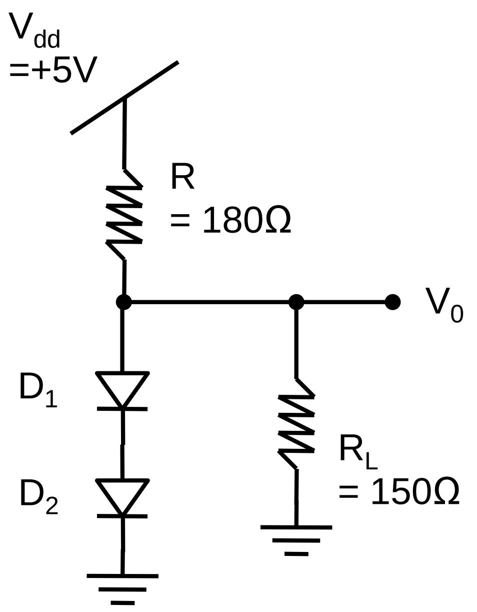
a) What is the regulator output voltage V_0 with the 150Ω load connected?

b) With the load connected, calculate the output voltage change when the supply decreases 1V / 0.1V / 0.01V of its nominal value?

I_D = 10.63mA
V_0 = 1.403V

** for part b) use both the large signal model (exponential) and the small signal

ΔV_{DD}	I_D large signal model	v_0 large signal model	Δv_0 large signal model	Δv_0 small signal model
1.0V				
0.1V				
0.01V				



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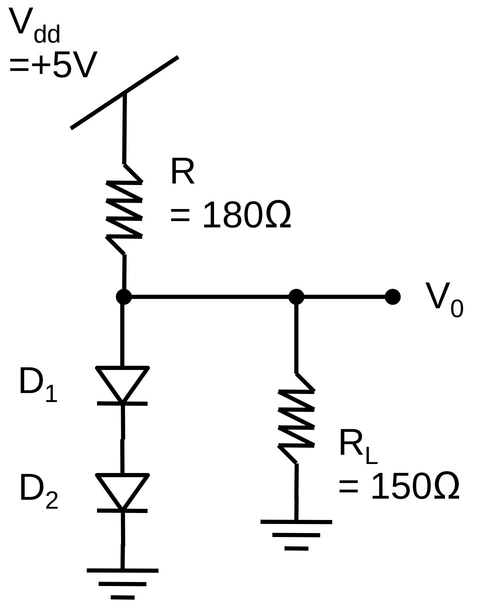
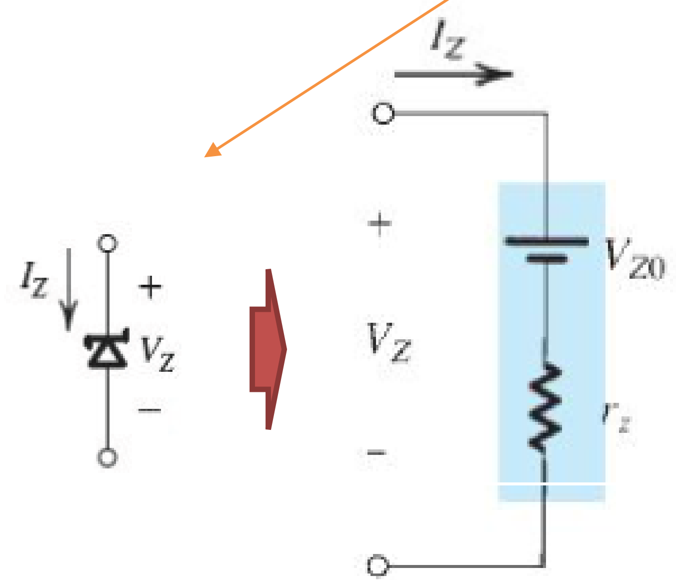
ΔV_{DD}	I_D large signal model	v_0 large signal model	Δv_0 large signal model	Δv_0 small signal model
1.0V	5.48mA	1.370	-33mV	-24mV
0.1V	10.10mA	1.400	-3mV	-2.4mV
0.01V	10.57mA	1.4028	-0.2mV	-0.2mV

Small Signal Behavior!



Zener Diodes → Chapter 4.4

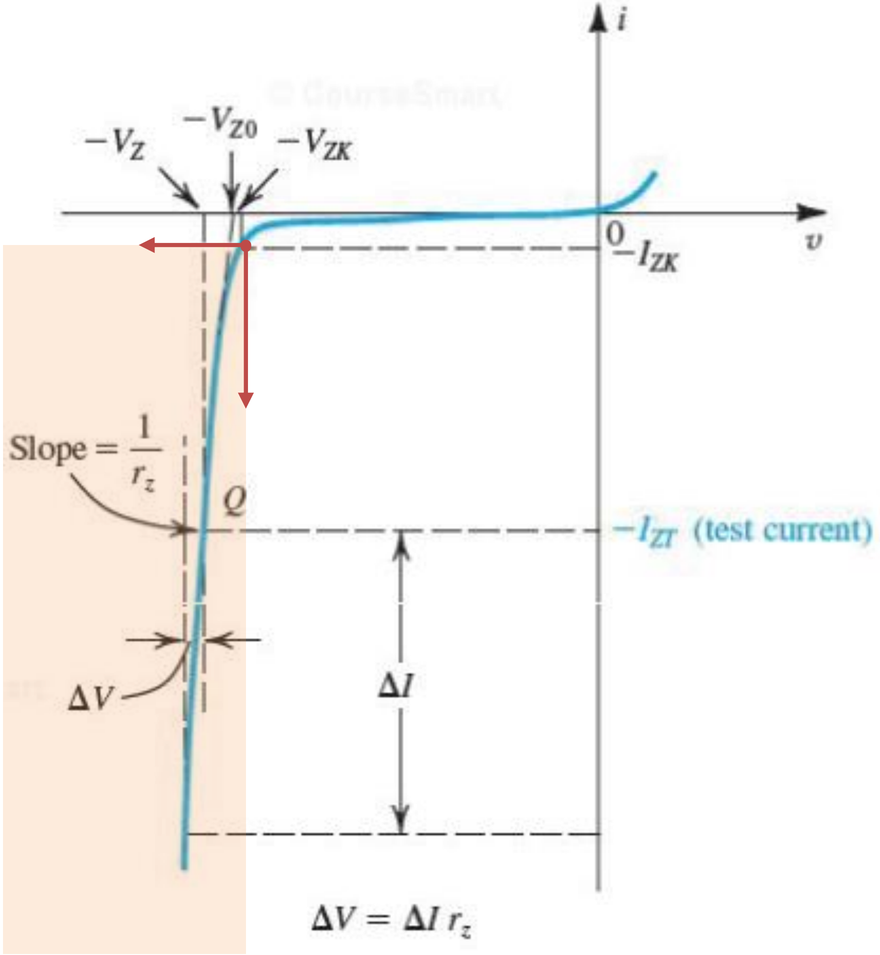
- **Under certain circumstances, diodes may be intentionally used in the reverse breakdown region.**
- **These are referred to as Zener Diodes.**



$$V_Z = V_{Z0} + r_z \cdot i_z$$

$= v_z \rightarrow$ small signal behavior

*** for $V_Z >= V_{Z0}$
$I_Z >= I_{ZK}$

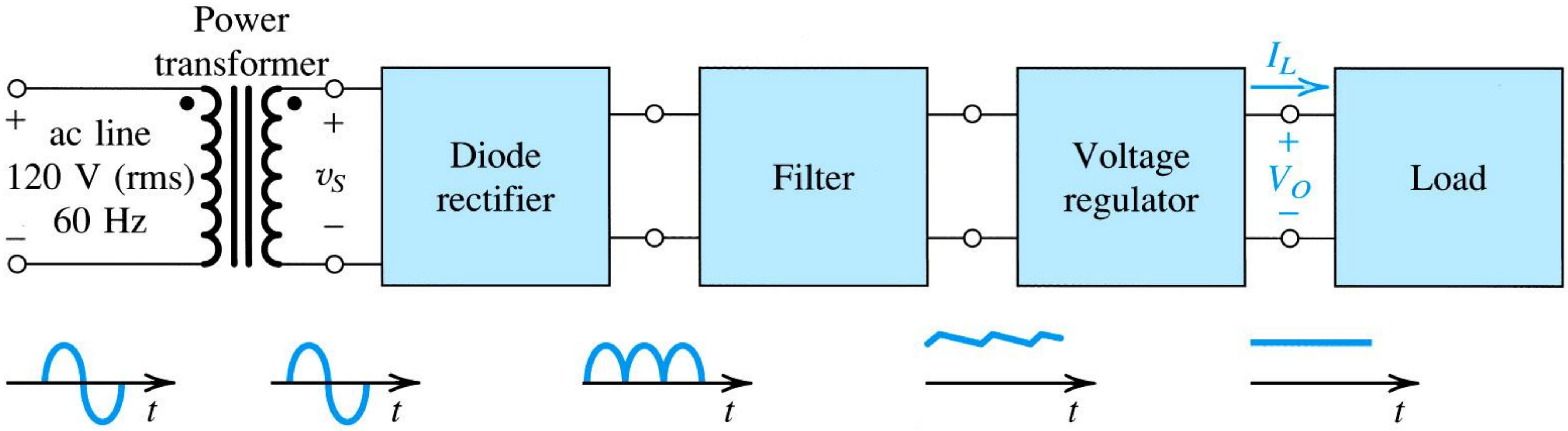


Exercise 4.17

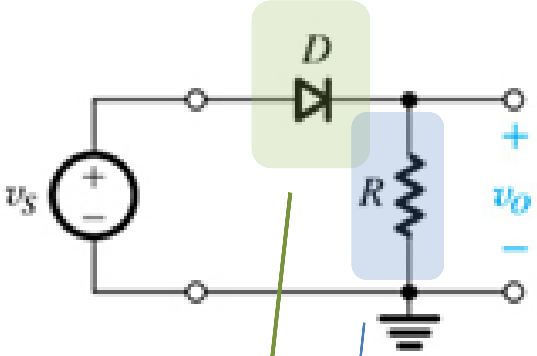
A zener diode exhibit a constant voltage of 5.6V for current greater than five times the knee current. I_{ZK} is specified to be 1mA. The zener is to be used in the design of a shunt regulator fed from a 15-V supply through a resistor R. The load current varies over the range of 0mA to 15mA. Find a suitable value for the resistor R. What is the maximum power dissipation of the zener diode?

DC Power Supply → Chapter 4.5

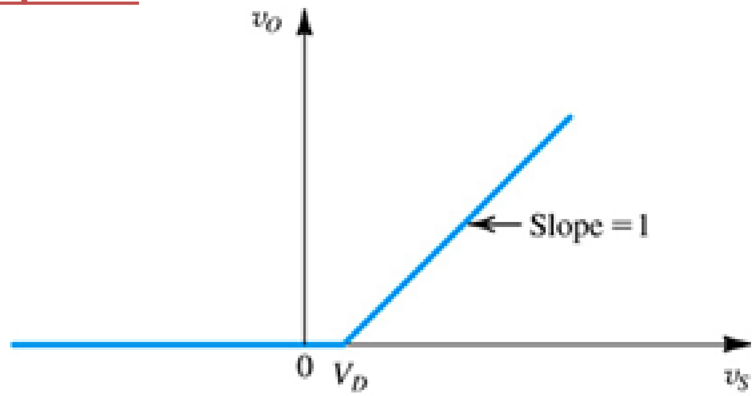
- **Power Transformer** – lowers down the 120V-AC input voltage and provides electrical isolation
- **Diode rectifiers** – converts the AC signal to an unipolar output
- **Filter** – reduces the voltage fluctuations of the rectified signal
- **Voltage Regulator** - reduces the ripple and stabilizes the output voltage from variations caused by changes in the load current



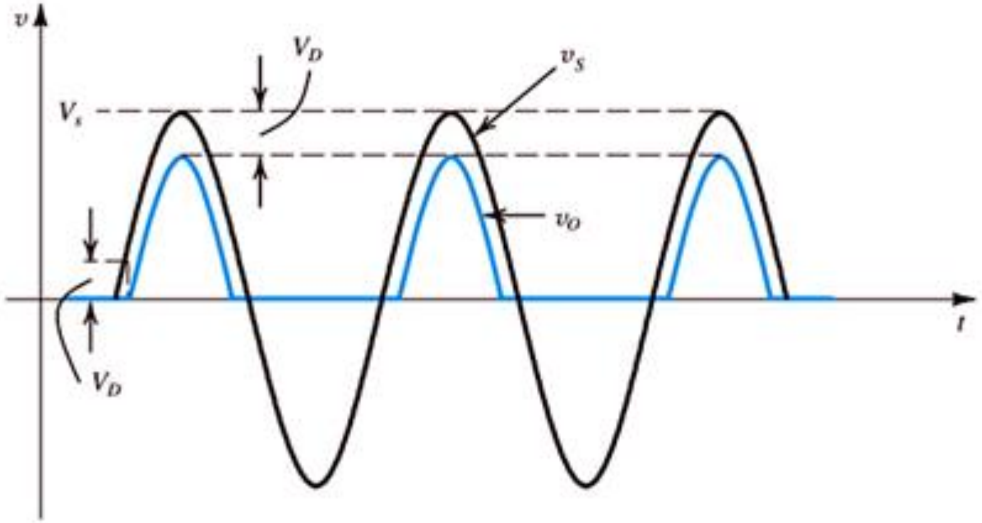
The Half-Wave Rectifier



DC Response



Transient Response



Diode Parameter Specifications:

- Current-handling capability – $I_D(max)$
- Peak inverse voltage – PIV = $V_R(max)$

Output Specifications:

- Average Voltage – $V_0(avg)$
- Average Current – $I_L(avg)$

- **Diode Ratings**

$$I_D(max) = \frac{V_S - V_D}{R}$$

$$PIV = V_S$$

- **Conduction Angle**

$$\theta = \sin^{-1}\left(\frac{V_D}{V_S}\right)$$

$$\Delta\theta = \pi - 2\theta$$

- **Average Output**

$$\overline{V_0} \approx \frac{V_S}{\pi} - \frac{V_D}{2}$$

$$\overline{I_L} \approx \frac{\overline{V_0}}{R}$$