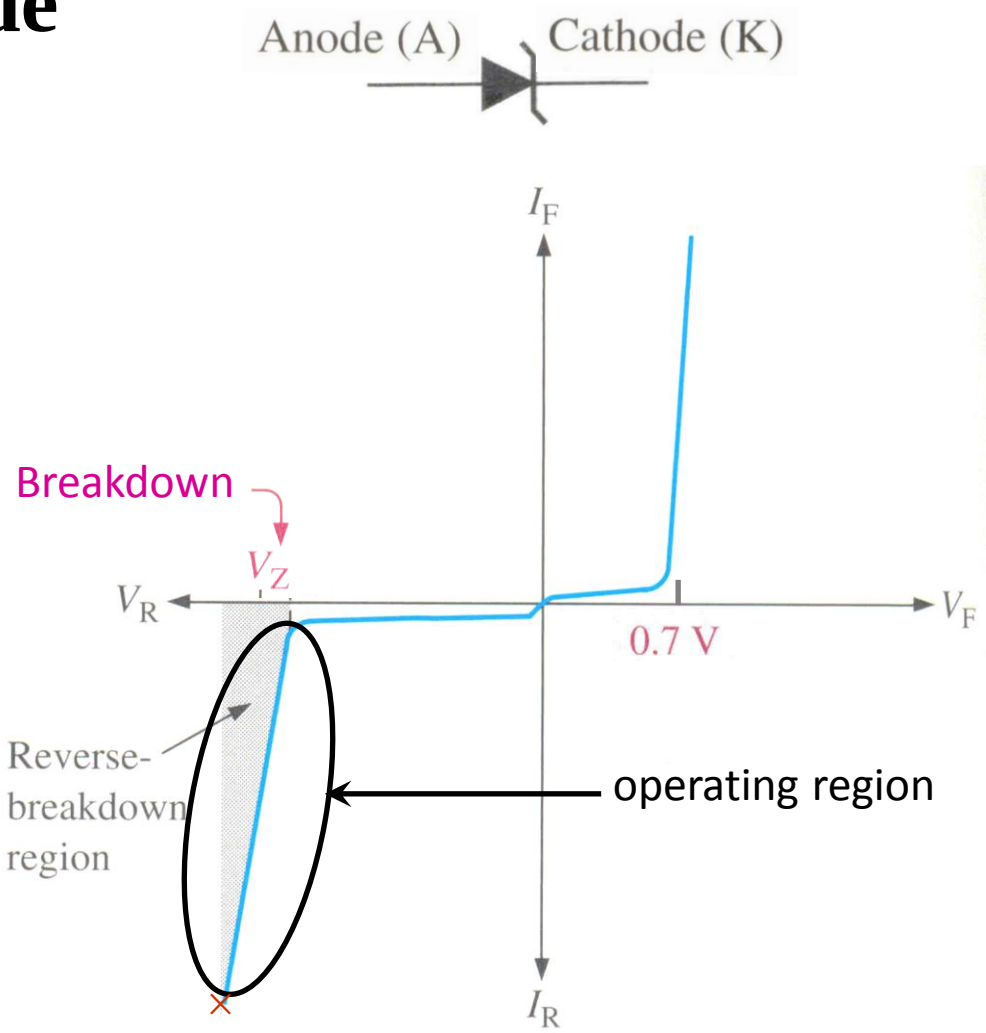
Lecture 9: Diodes (3)

Zener Diodes and their Applications, Examples

Zener Diode



Zener diode is a diode operating in the breakdown region

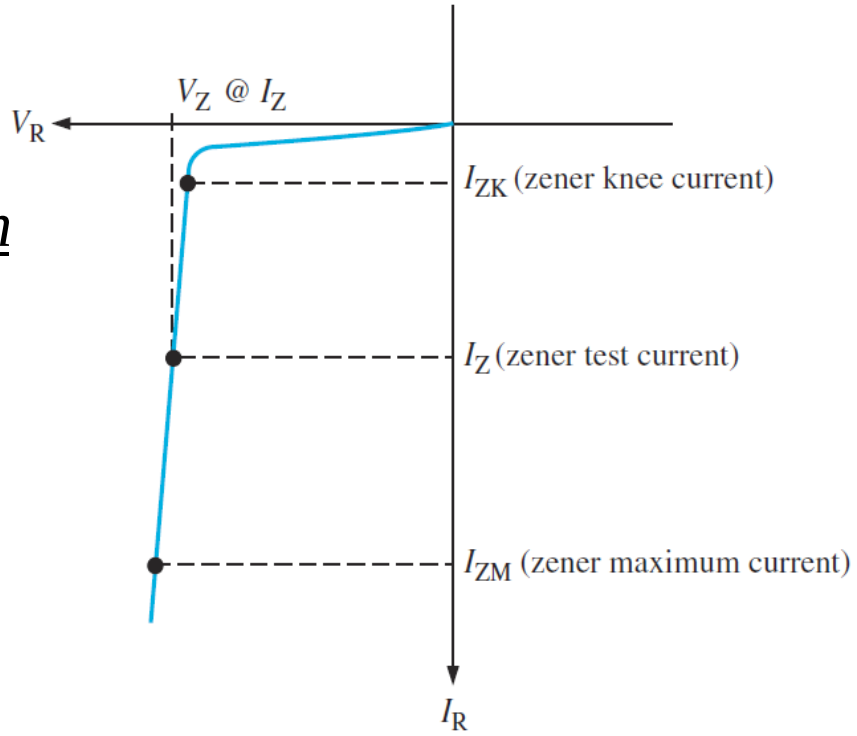
Zener as a Voltage Regulator

A Zener diode operating along the breakdown line acts as a *voltage regulator* as it maintains a nearly constant voltage across its terminals over a relatively wide range of the reverse-current ($I_{ZK} < I_Z < I_{ZM}$), where:

In addition to I_{ZK} and I_{ZM}, a Zener diode is characterized by a *test poin* along the breakdown line. The coordinates of this point are

$I_{ZT} \equiv$ Zener test current,

$V_{ZT} \equiv$ Zener test voltage



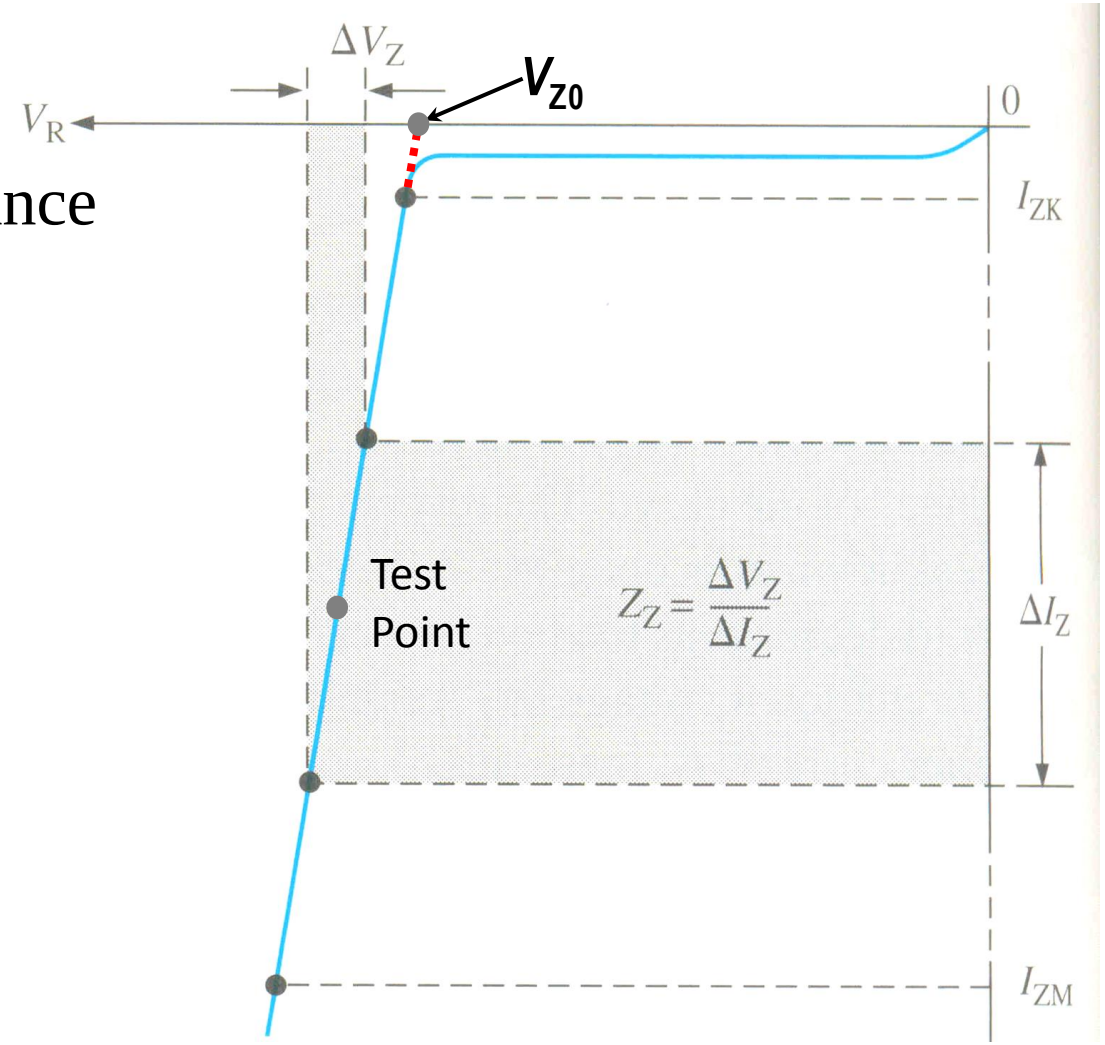
Dynamic Impedance

$$Z_Z \equiv \text{dynamic impedance}$$

$$= \frac{\Delta V_Z}{\Delta I_Z}$$

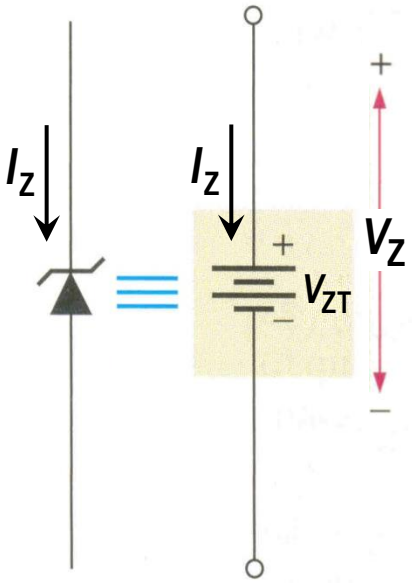
$$Z_Z = \frac{\Delta V_Z}{\Delta I_Z} = \frac{V_{ZT} - V_{Z0}}{I_{ZT} - 0}$$

$$V_{Z0} = V_{ZT} - Z_Z I_{ZT}$$



Ideal Zener Equivalent Circuit

Ideal Model

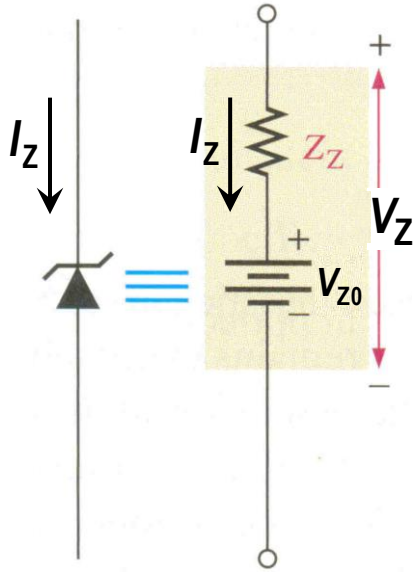


$$V_Z = V_{ZT}$$

The breakdown line is approximated by an ideal vertical line located at V_{ZT}

Practical Zener Model

Practical Model

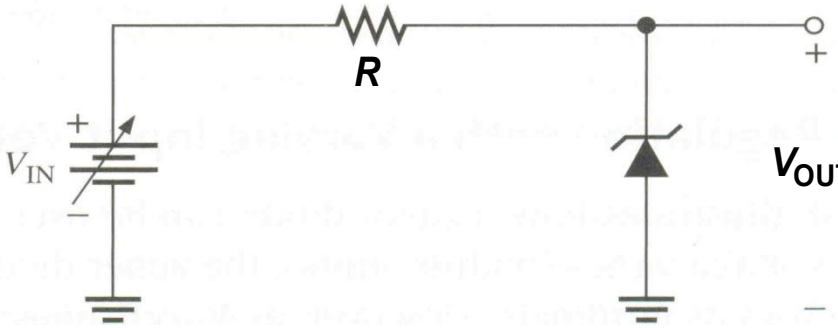


From CC Curve: $V_Z = V_{Z0} + \Delta V_Z = V_{Z0} + Z_Z \Delta I_Z$

$= V_{Z0} + Z_Z I_Z$

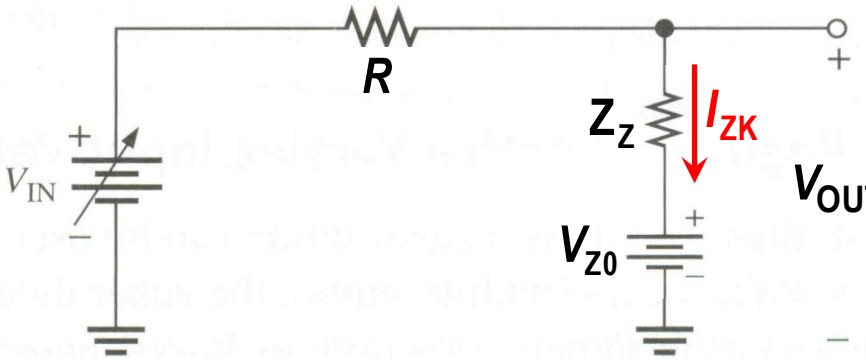
From Model: $V_Z = V_{Z0} + Z_Z I_Z$

Voltage Regulation Using Zeners

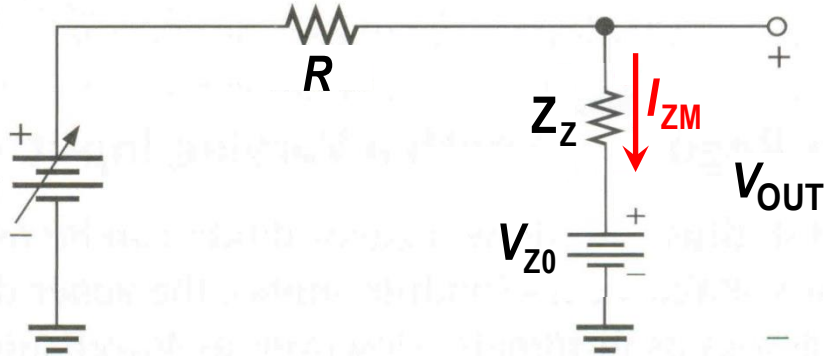


$$\text{Line regulation} \equiv \Delta V_{OUT} / \Delta V_{IN}$$
$$= \left[V_{OUT(max)} - V_{OUT(min)} \right] \Big/ \left[V_{IN(max)} - V_{IN(min)} \right]$$

K-Point ($I_Z = I_{ZK}$)

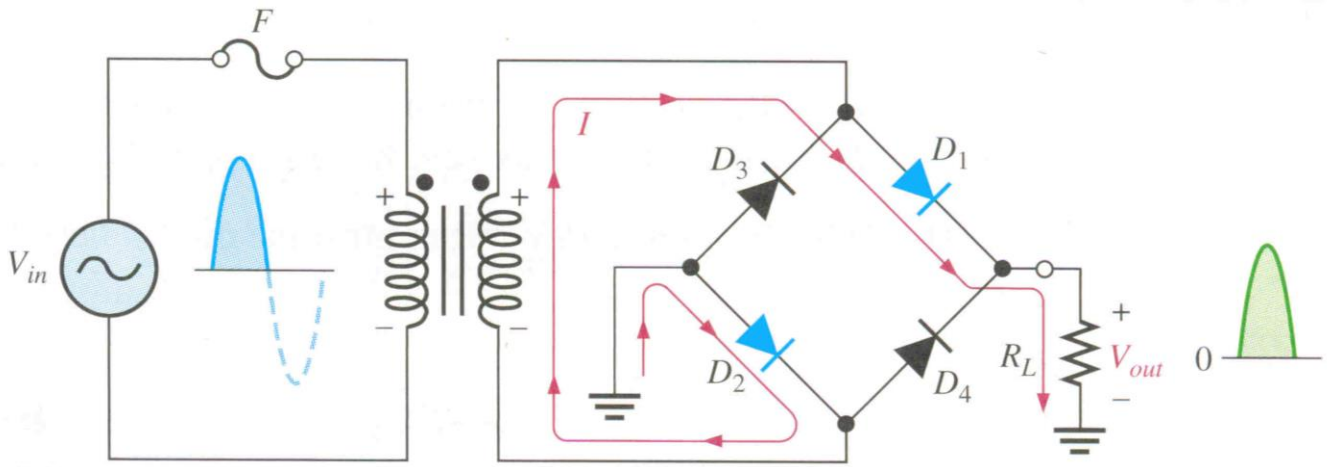


$$V_{OUT(min)} = V_{Z0} + I_{ZK} Z_Z,$$
$$V_{IN(min)} = V_{OUT(min)} + I_{ZK} R$$



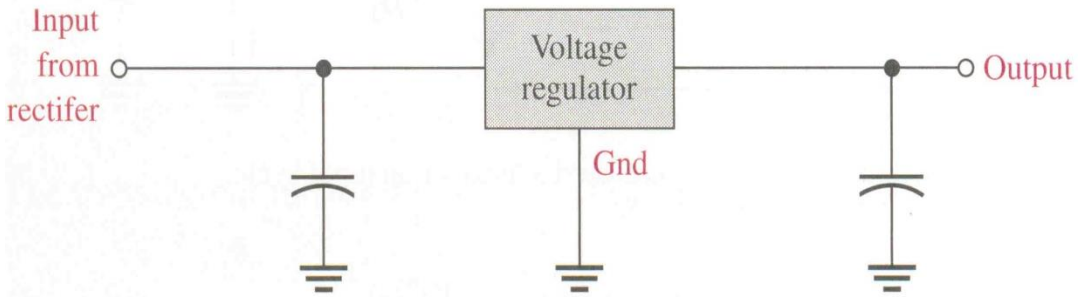
$$V_{OUT(max)} = V_{Z0} + I_{ZM} Z_Z,$$
$$V_{IN(max)} = V_{OUT(max)} + I_{ZM} R$$

Power Supply Regulator



Power Supply Regulators (Cont'd)

The voltage regulator is a three terminals device, which is used to suppress the residual ripples in the output of the filter



Its simplest form is a *Zener* diode in series with a resistor