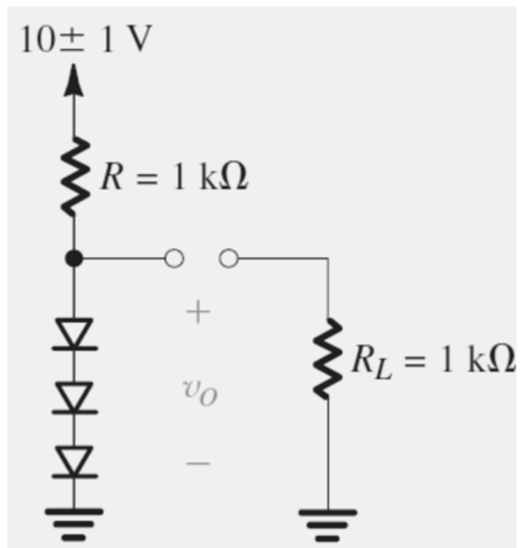
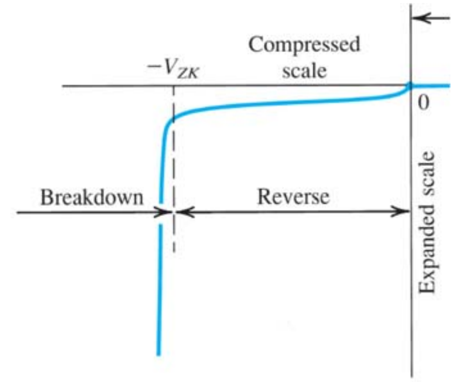
8. Use of the Diode Forward Drop in Voltage Regulation:

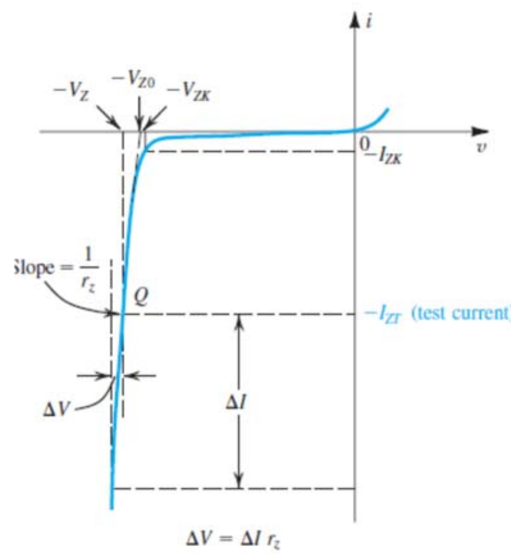
- An application is the use of diodes to create a regulated voltage.
  - A **voltage regulator** is a circuit whose purpose is to provide a constant dc voltage between its output terminals. The output voltage is required to remain as constant as possible in spite of:
    a) Changes in the load current drawn from the regulator output terminal and
    b) Changes in the dc power-supply voltage that feeds the regulator circuit. Since the forward-voltage drop of the diode remains almost constant at approximately 0.7 V while the current through it varies by relatively large amounts, a forward-biased diode can make a simple voltage regulator.

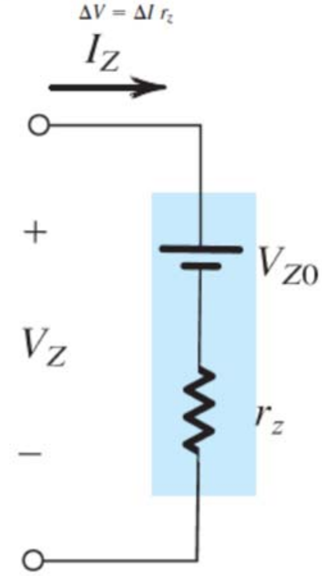
Consider the circuit shown in Fig. 4.17. A string of three diodes is used to provide a constant voltage of about 2.1 V. We want to calculate the percentage change in this regulated voltage caused by (a) a ±10% change in the power-supply voltage, and (b) connection of a 1-kΩ load resistance.



Operation in the Reverse Breakdown Region—Zener Diodes:







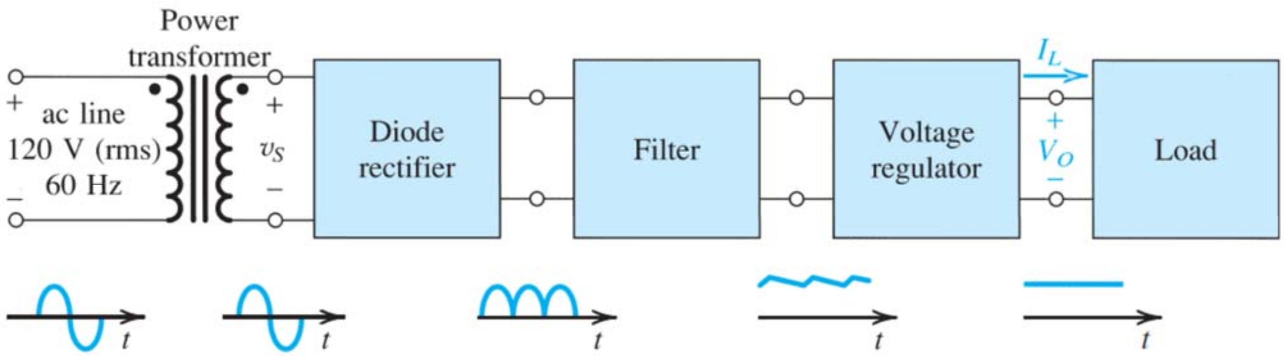
Temperature Effects:

- The dependence of the Zener voltage V_z on temperature is specified in terms of its **temperature coefficient TC**, or **temco** as it is commonly known, which is usually expressed in mV/°C.
- The value of TC depends on the Zener voltage, and for a given diode the TC varies with the operating current.
- Zener diodes whose V_z are lower than about 5 V exhibit a negative TC.
- On the other hand, Zeners with higher voltages exhibit a positive TC.
- The TC of a Zener diode with a V_z of about 5 V can be made zero by operating the diode at a specified current.
- Another commonly used technique for obtaining a reference voltage with low temperature coefficient is to connect a Zener diode with a positive temperature coefficient of about 2 mV/°C in series with a forward-conducting diode.
- Since the forward-conducting diode has a voltage drop of $\approx$ 0.7 V and a TC of about –2 mV/°C, the series combination will provide a voltage of (V_z + 0.7) with a TC of about zero.

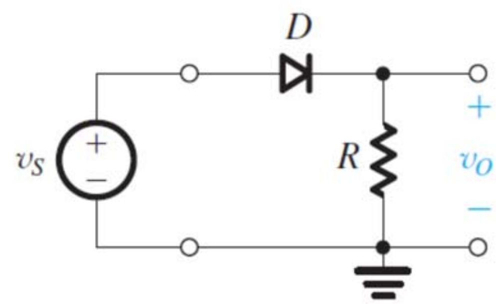
4.16 A zener diode whose nominal voltage is 10 V at 10 mA has an incremental resistance of 50 Ω. What voltage do you expect if the diode current is halved? Doubled? What is the value of V_{Z0} in the zener model?

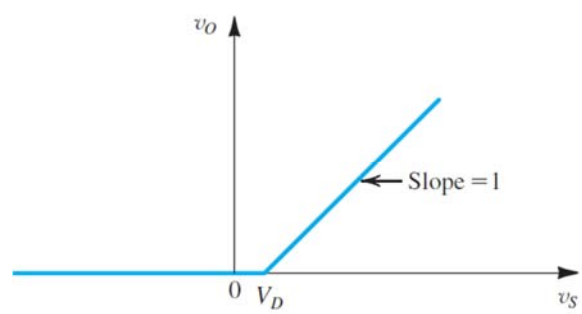
4.17 A zener diode exhibits a constant voltage of 5.6 V for currents greater than five times the knee current. I_{ZK} is specified to be 1 mA. The zener is to be used in the design of a shunt regulator fed from a 15-V supply. The load current varies over the range of 0 mA to 15 mA. Find a suitable value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

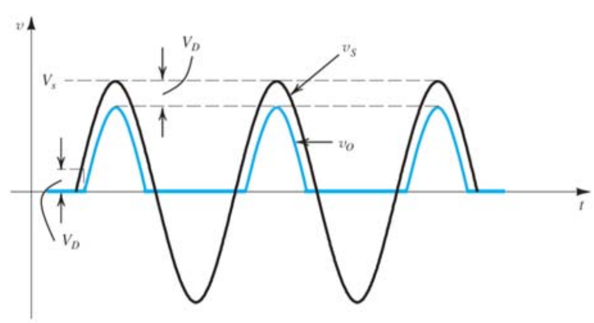
Rectifier Circuits:



The Half-Wave Rectifier:

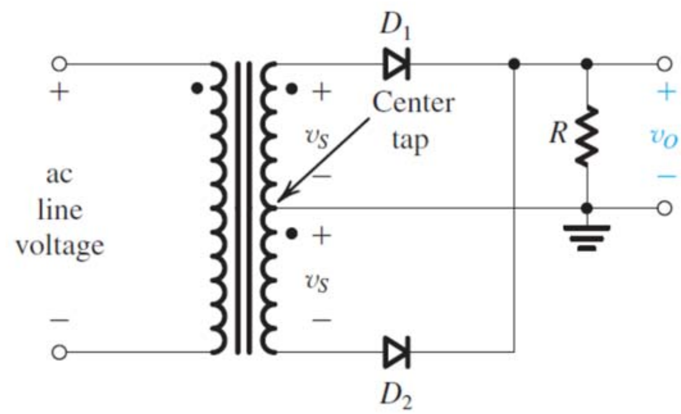


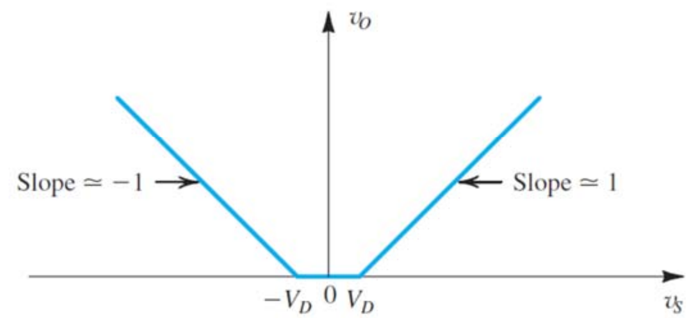


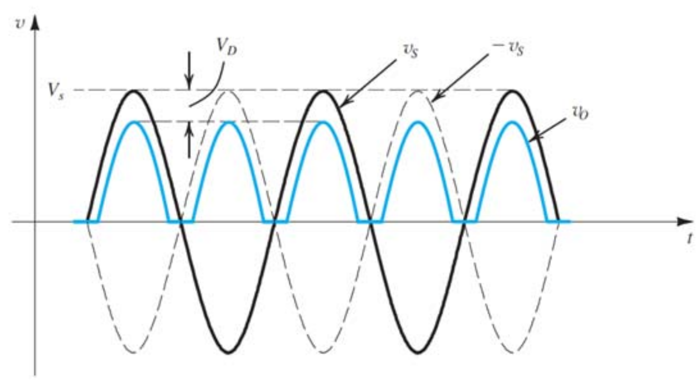


The Full-Wave Rectifier:

The full-wave rectifier utilizes both halves of the input sinusoid. To provide a unipolar output, it inverts the negative halves of the sine wave.





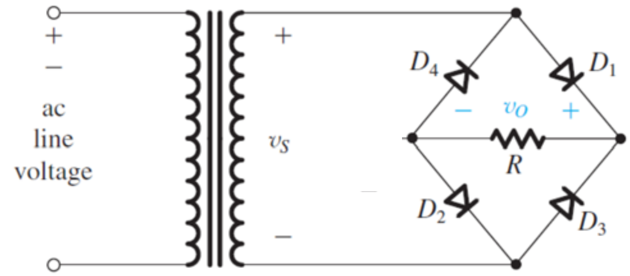


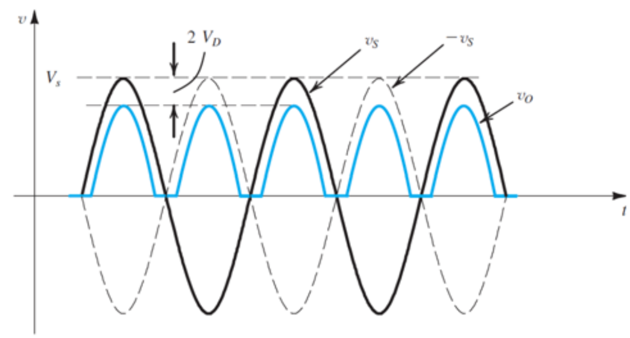
The Bridge Rectifier:

- An alternative implementation of the full-wave rectifier.

- This circuit, known as the bridge rectifier because of the similarity of its configuration to that of the Wheatstone bridge, does not require a center-tapped transformer, a distinct advantage over the full-wave rectifier circuit.

- The bridge rectifier, however, requires four diodes as compared to two in the previous circuit.





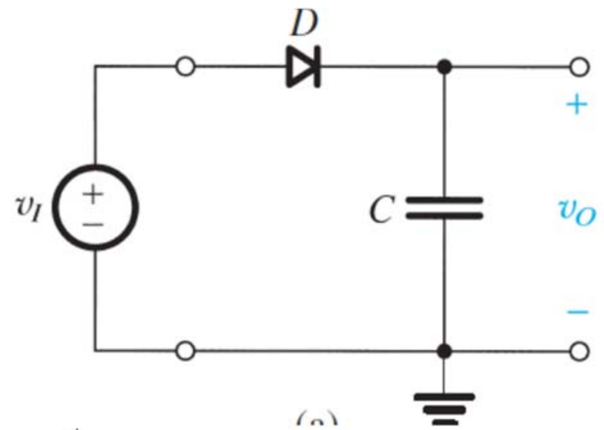
The bridge-rectifier circuit operates as follows:

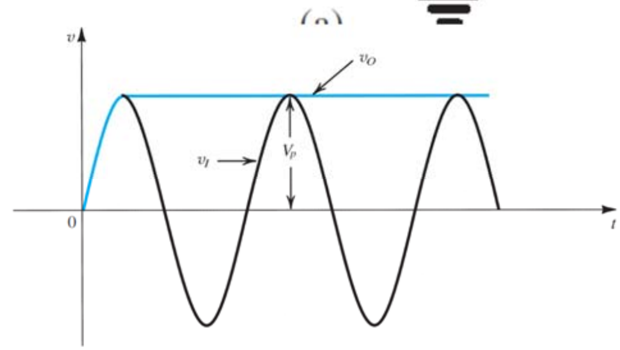
- During the positive half-cycles of the input voltage, v_s is positive:
  - Thus current is conducted through diode D_1, resistor R, and diode D_2.
  - Meanwhile, diodes D_3 and D_4 will be reverse biased.
  - Observe that there are two diodes in series in the conduction path, and thus v_o will be lower than v_s by two diode drops (compared to one drop in the circuit previously discussed). *This is somewhat of a disadvantage of the bridge rectifier.*

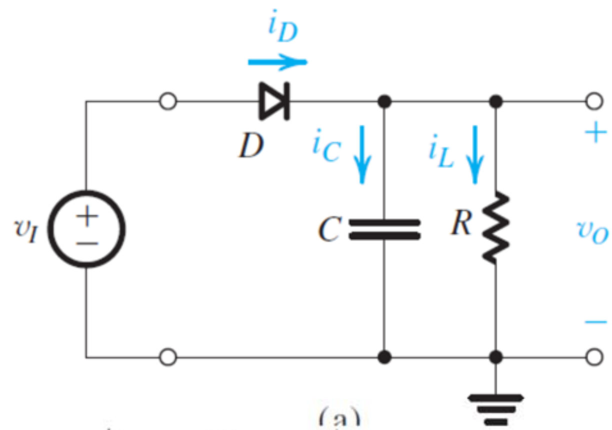
- Next, consider the situation during the negative half-cycles of the input voltage:
  - The secondary voltage v_s will be negative, and thus $-v_s$ will be positive, forcing current through D_3, R, and D_4.
  - Meanwhile, diodes D_1 and D_2 will be reverse biased.
  - The important point to note, though, is that during both half-cycles, current flows through R in the same direction (from right to left), and thus v_o will always be positive.

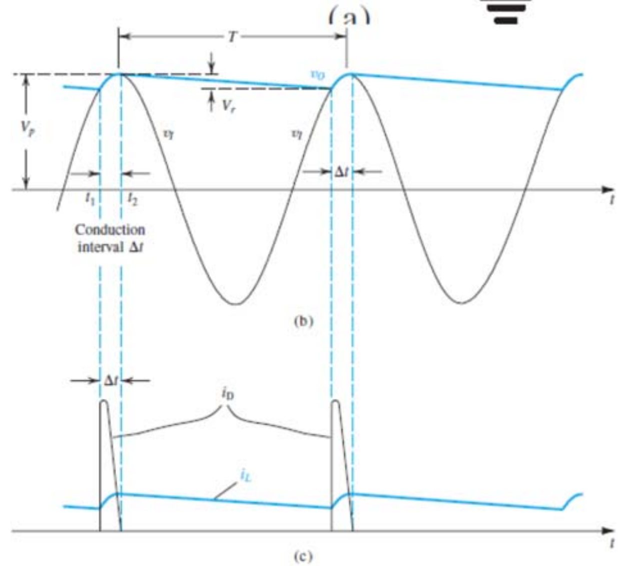
The Rectifier with a Filter Capacitor—The Peak Rectifier:

The pulsating nature of the output voltage produced by the rectifier circuits discussed above makes it unsuitable as a dc supply for electronic circuits. A simple way to reduce the variation of the output voltage is to place a capacitor across the load resistor. It will be shown that this **filter capacitor** serves to reduce substantially the variations in the rectifier output voltage.

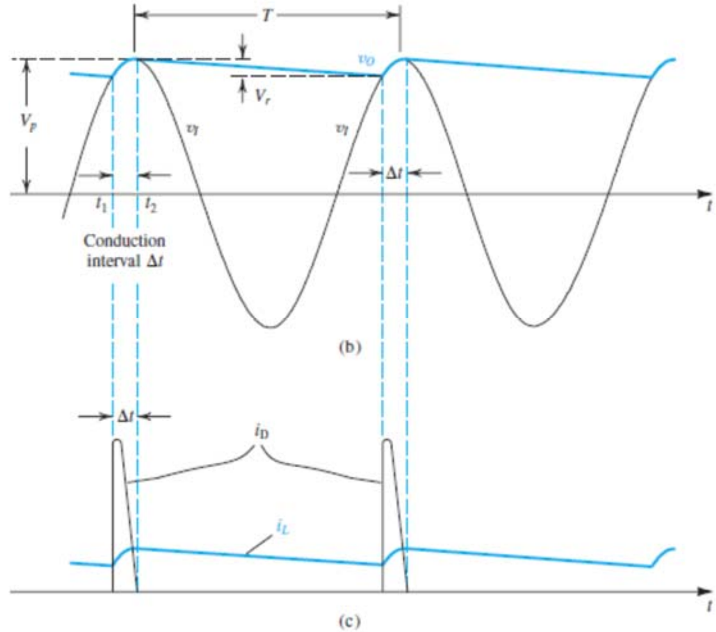




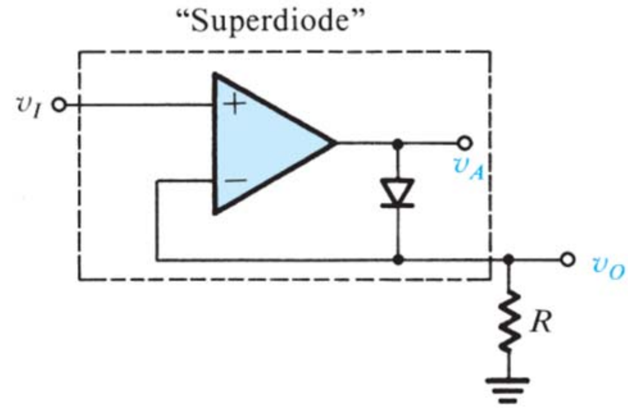


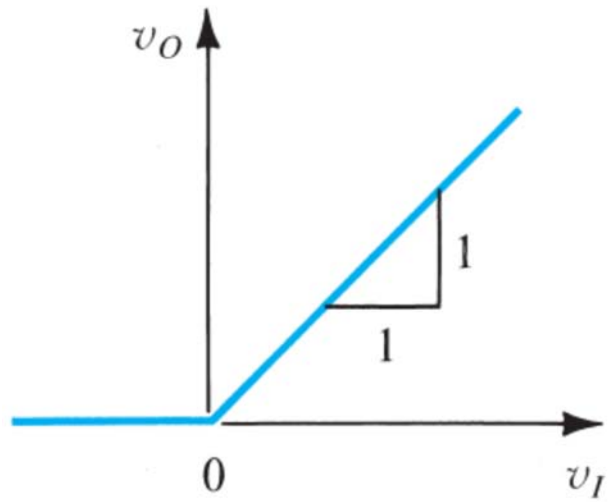


Rectifier with a Filter Capacitor..Cont'd

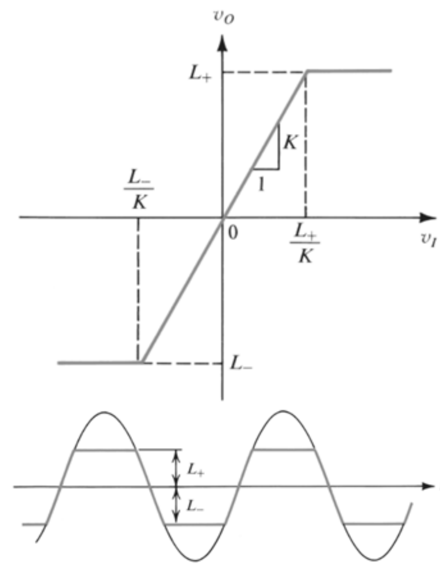


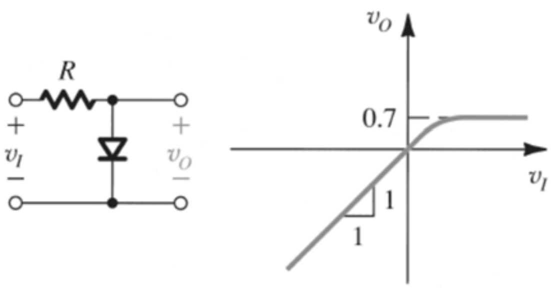
Precision Half-Wave Rectifier - The Superdiode:



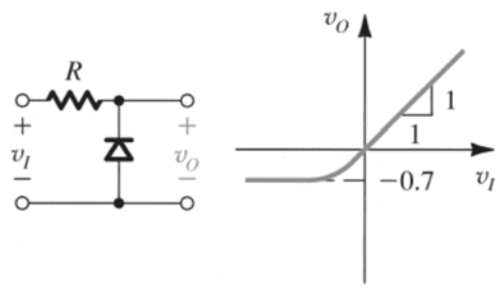


Limiting and Clamping Circuits:





(a)



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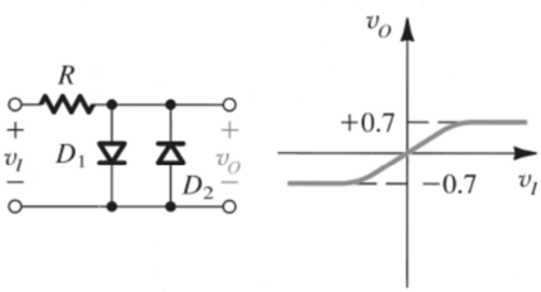

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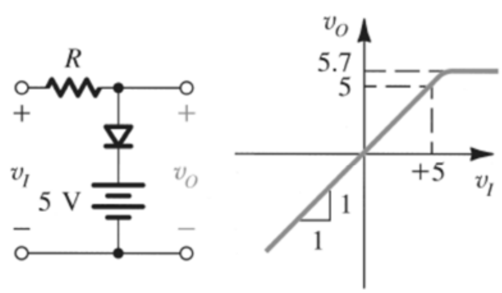

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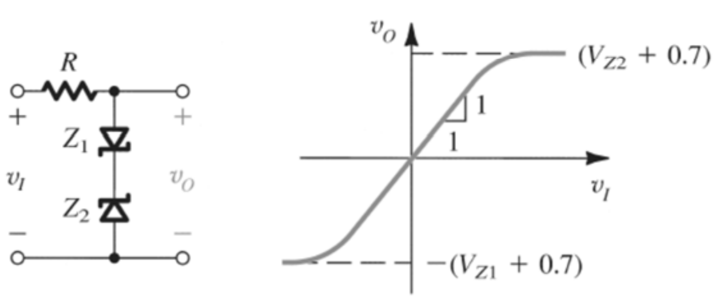

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