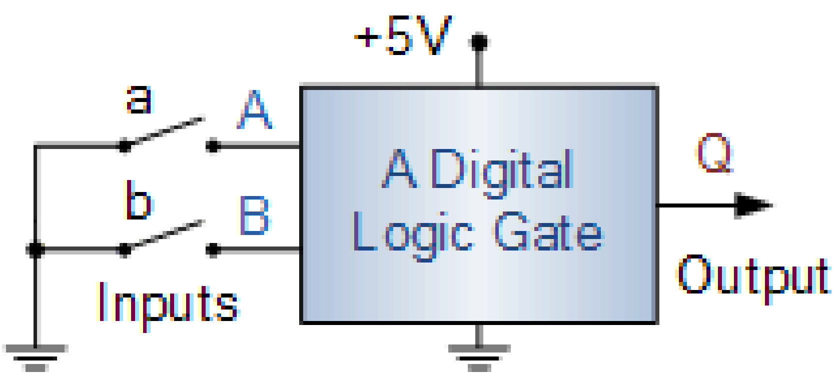
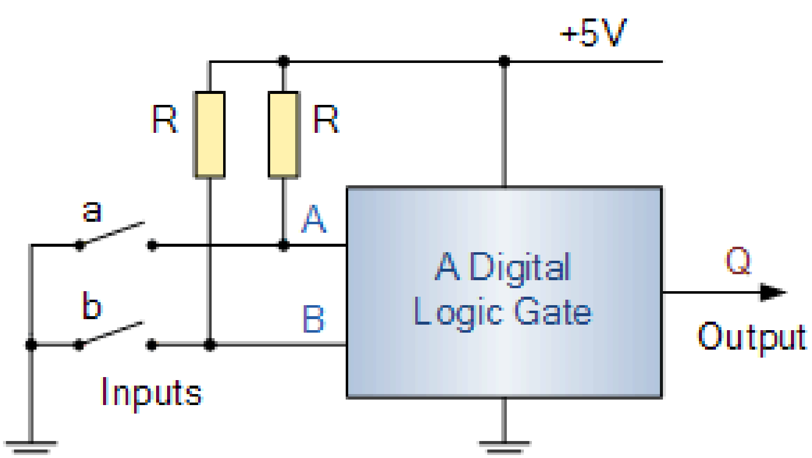
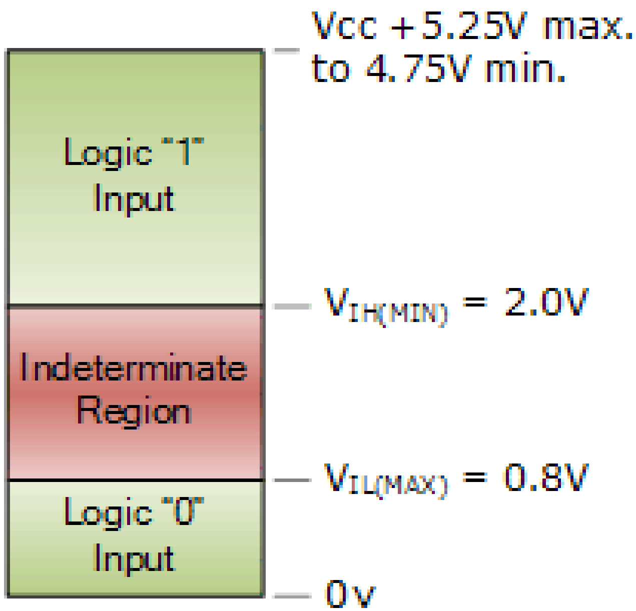
Pull Up and Pull Down Registor

- Pull-up and Pull-down resistors are used to correctly bias the inputs of digital gates to **prevent them from floating** about randomly when there is no input condition





Calculating Pull-Up Resistor Value



LS - TTL Input Voltage Levels

- TTL 74LSxxx series:
  - Input high: $V_{IH(min)} = 2.0V$, $I_{IH(max)} = 20\mu A$
  - Input low: $V_{IL(max)} = 0.8V$, $I_{IL(max)} = 0.4mA$

Single Gate Pull-up Resistor Value

$$R_{MAX} = \frac{V_{CC} - V_{IH(MIN)}}{I_{IH}} = \frac{5-2}{20\times 10^{-6}} = 150K\Omega$$

Multiple Gate Pull-up Resistor Value (10 inputs)

$$R_{MAX} = \frac{V_{CC} - V_{IH(MIN)}}{10\times I_{IH}} = \frac{5-2}{10\times 20\times 10^{-6}} = 15K\Omega$$

Calculating Pull-Up Resistor Value

- A *Pull-down resistor* works in the same way as the previous pull-up resistor, except this time the logic gates input is tied to ground, logic level “0” (LOW)

$$R_{MAX} = \frac{V_{IL(MAX)} - 0}{I_{IL}} = \frac{0.8 - 0}{400 \times 10^{-6}} = 2K\Omega$$

Example

- TTL 74LS00 NAND Gates along with a single-pole double-throw switch are to be used to make a simple set-reset bistable circuit signal. Calculate:

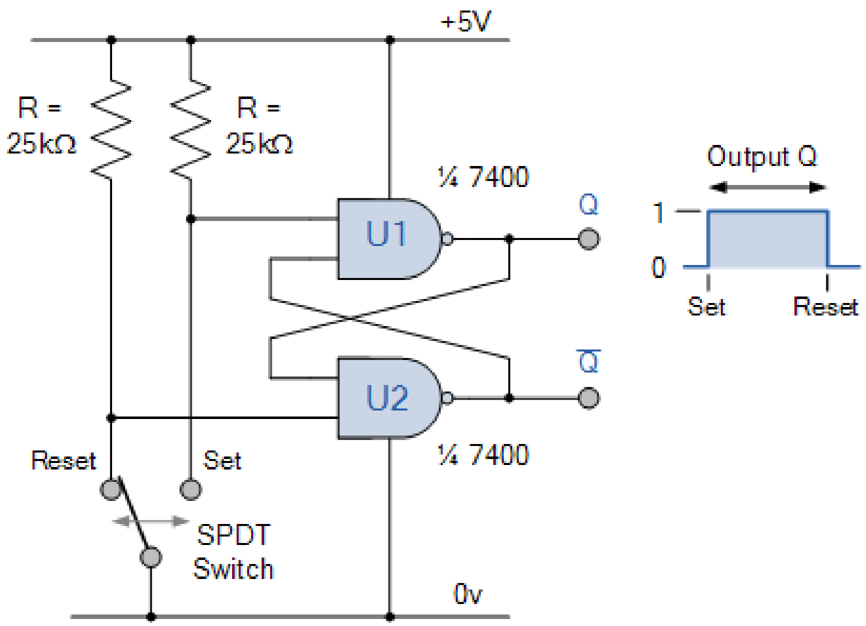
  1). The maximum pull-up resistor values if the voltage representing a logic HIGH input is to be held at 4.5 volts when the switch is open, and

  2). The current flowing through the resistor when the switch is closed (assume zero contact resistance). Also draw the circuit.

- Data given: Vcc = 5V, V_{IH} = 4.5V, and $I_{IH(max)}$ = 20μA

Answer

Set-Reset Bistable Circuit

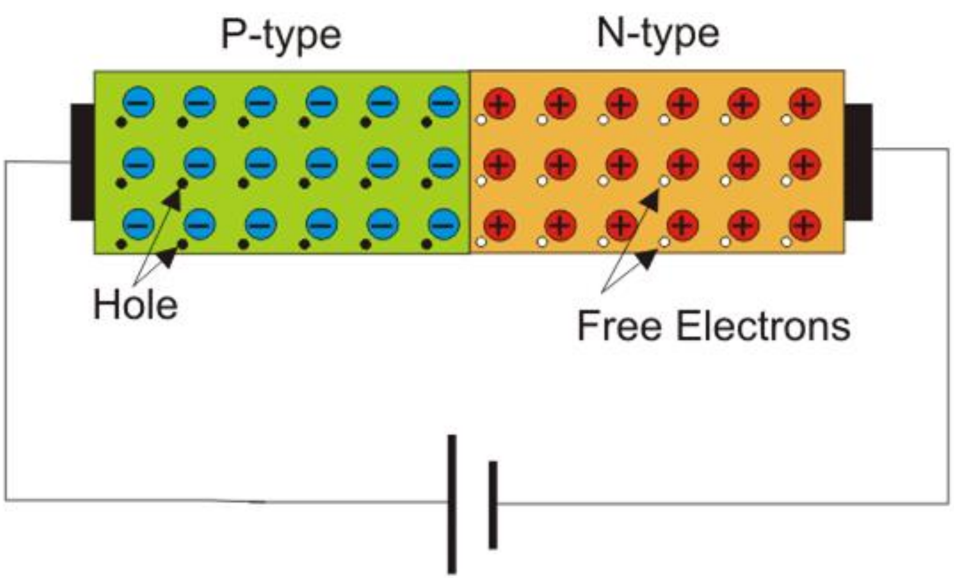


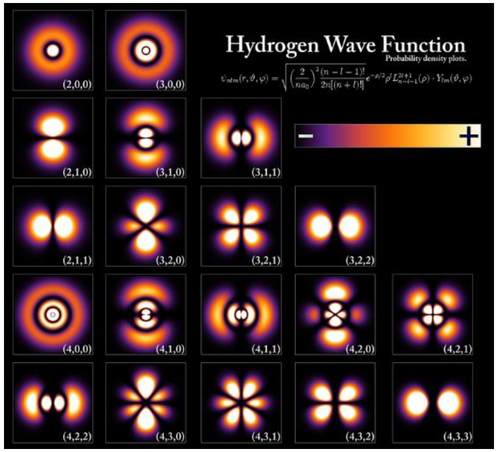
$$R_{MAX} = \frac{V_{CC} - V_{IH}}{I_{IH}} = \frac{5 - 4.5}{20 \times 10^{-6}} = 25K\Omega$$

$$I_R = \frac{V_{CC}}{R} = \frac{5V}{25k\Omega} = 200\mu A \text{ or } 0.2mA$$

CO2015

Diode & Its Applications





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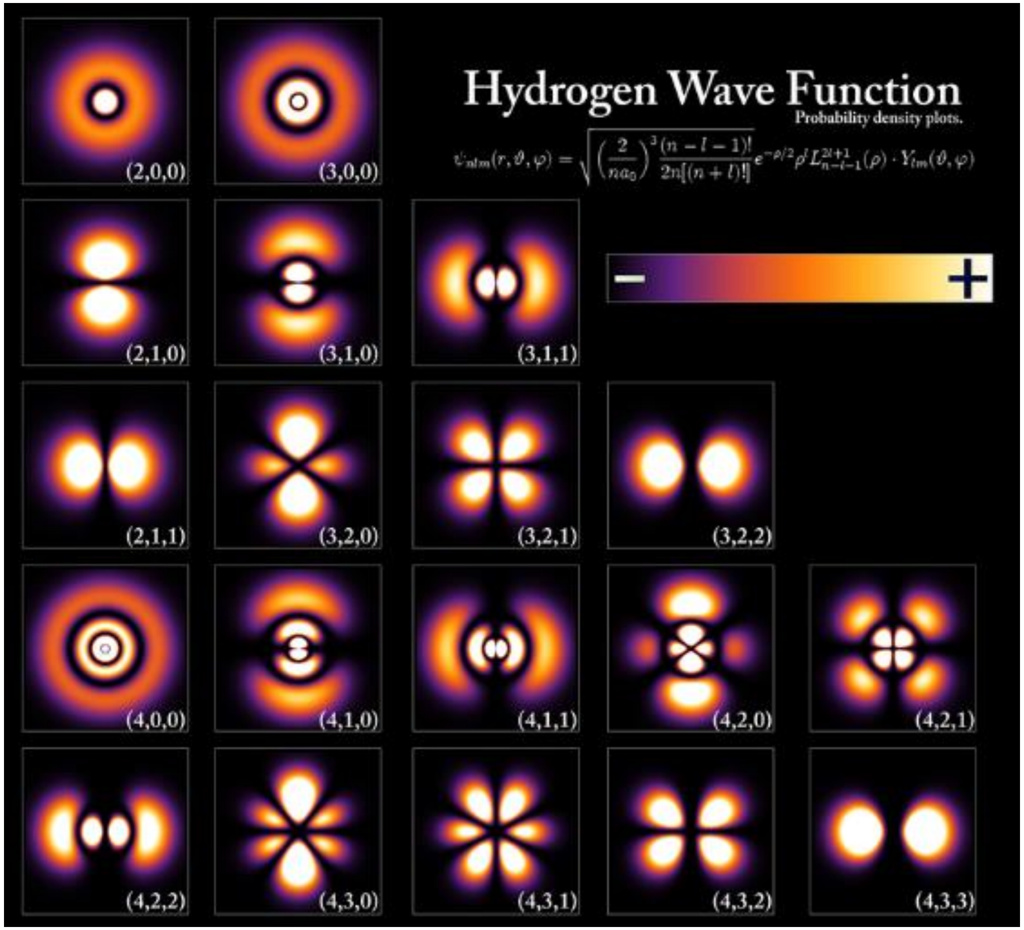
Diode and Its Applications

- Introduction to semiconductor
- Diode
- Applications



Semiconductor

- Semiconductors are a special class of elements having a conductivity between that of a good conductor and that of an insulator.
- Two classes: single-crystal and compound

- The three semiconductors used most frequently in the construction of electronic devices are Ge, Si, and GaAs.

Germanium (Ge)

- The discovery of the diode in 1939 and the transistor in 1947 germanium was used almost exclusively

- Advantages
  - Easy to find
  - Fairly large quantities
  - Easy to refine to obtain very high levels of purity

- Disadvantage
  - Sensitivity to changes in temperature

Silicon (Si)

- 1954 the first silicon transistor was introduced

- Advantages
  - Less temperature sensitive
  - The most abundant materials on earth
  - High levels of purity

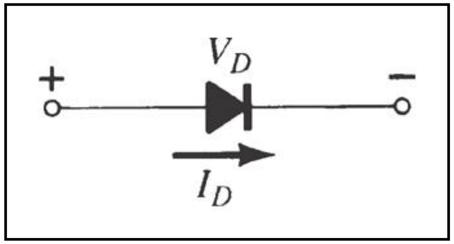
- Disadvantage
  - Sensitive to issues of speed.

Gallium Arsenide (GaAs)

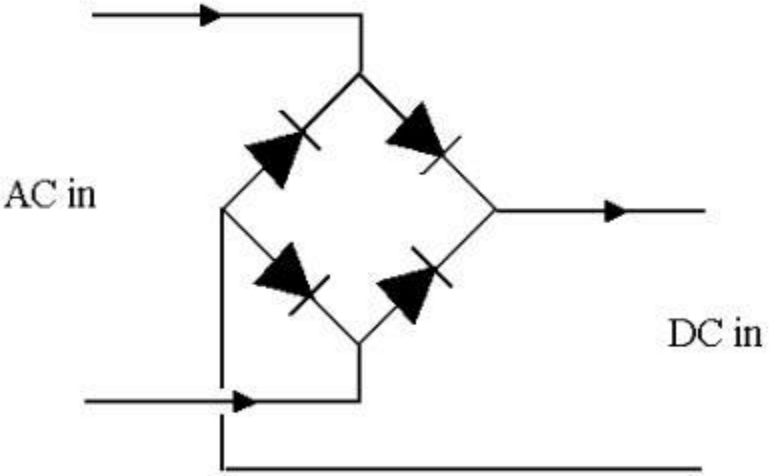
- The first GaAs transistor in the early 1970s.
- New transistor had speeds of operation up to five times that of Si.
- GaAs was more difficult to manufacture at high levels of purity, was more expensive.
- Today, it is often used as the base material for new high-speed, very large scale integrated (VLSI) circuit designs.

Diode

- The diode is the simples and most fundamental non-linear circuit element

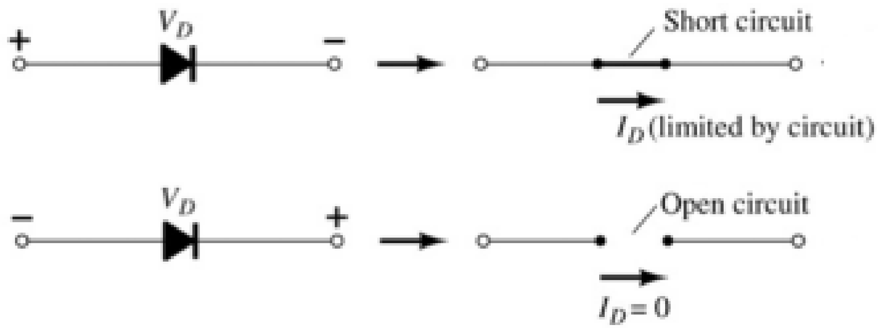


- Like a resistor, it has two terminals
- Unlike a resistor, it has a non-linear current-voltage characteristics.
- Its use in rectifiers is
  the most common application



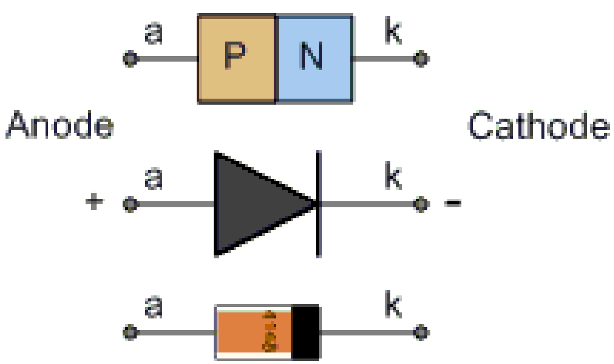
Diode

- Diode is an electric device which allows current to flow only in one direction.

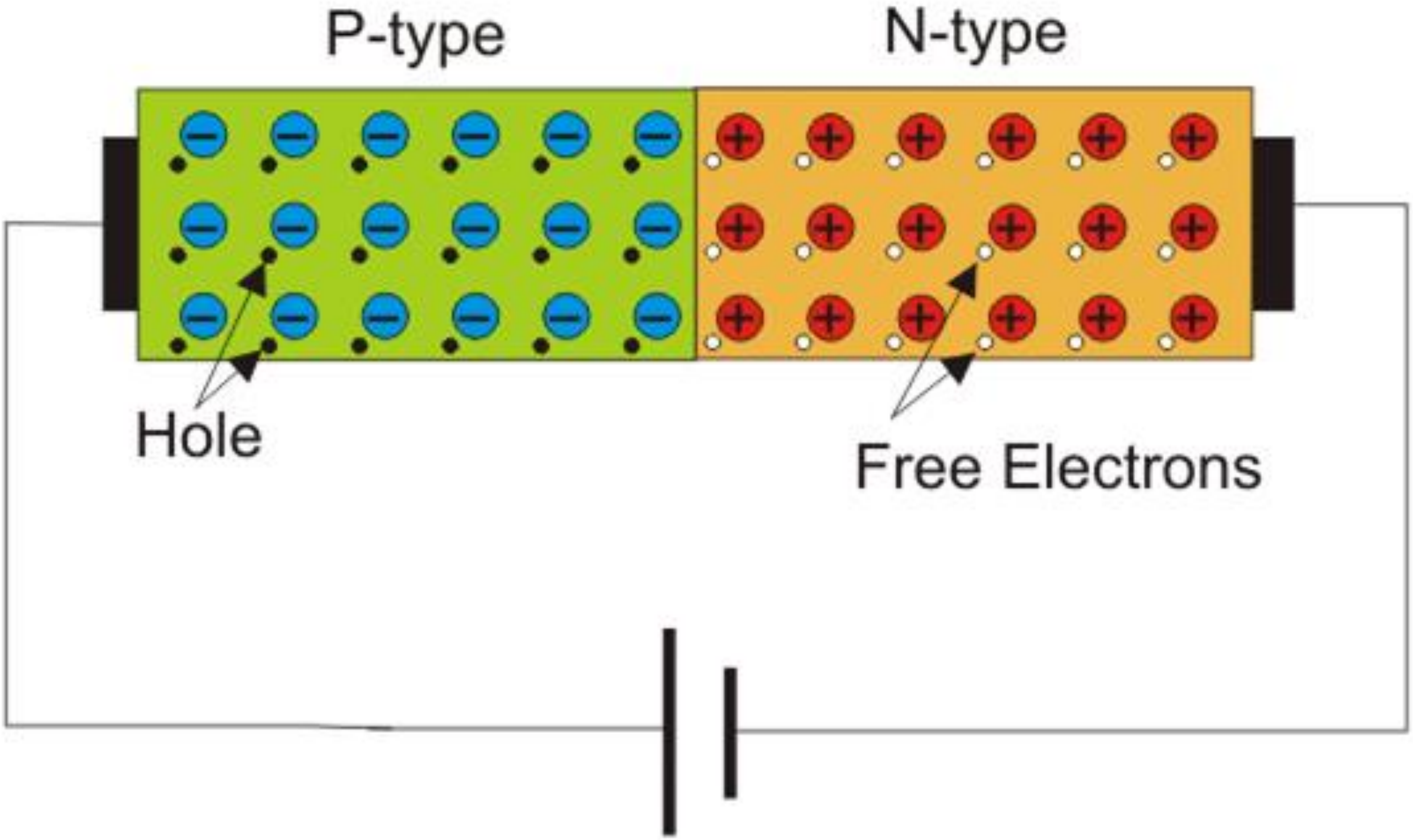


- The voltage applied to the semiconductor diode is referred to as bias voltage

- There are two types of bias voltage
  - Forward biased
  - Reversed biased

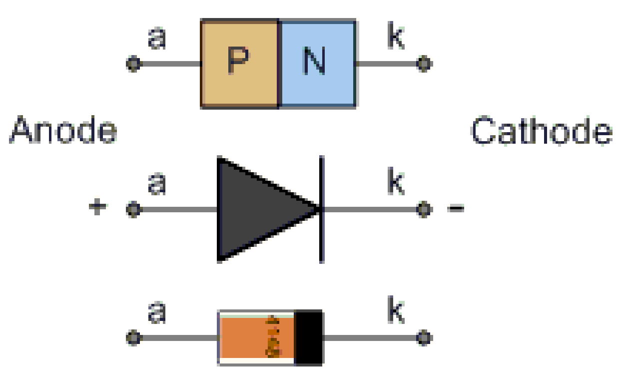


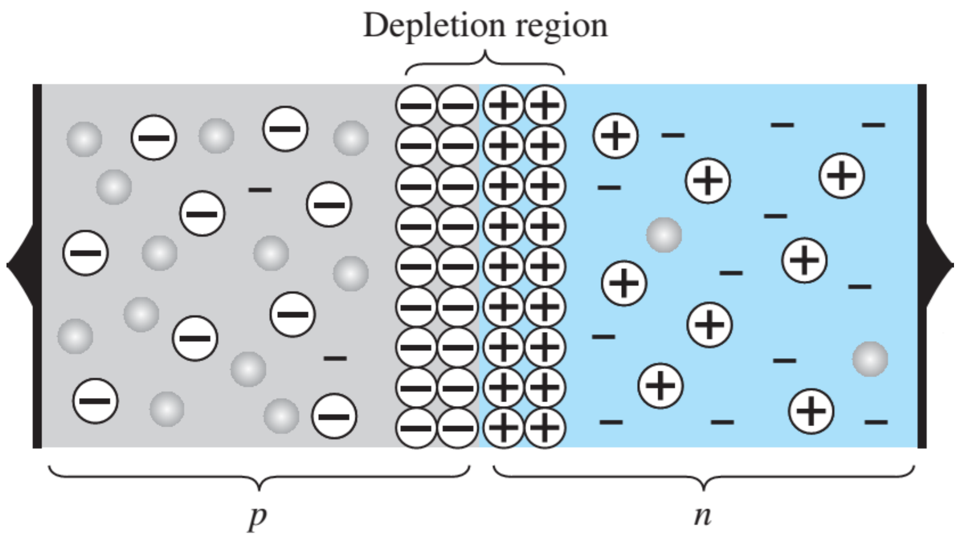
PN Junction and Diode



PN Junction and Diode

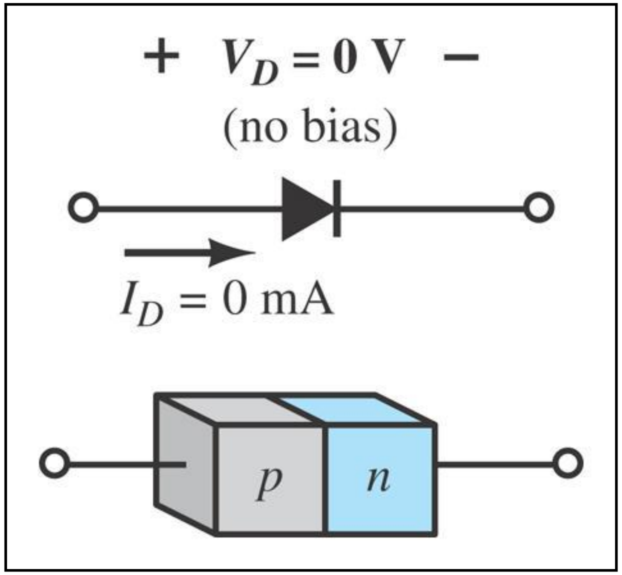
- One end of a silicon or germanium crystal can be doped as a p-type material and the other end as an n-type material.
- At the p-n junction, the excess conduction-band electrons on the n-type side are attracted to the valence-band holes on the p-type side.





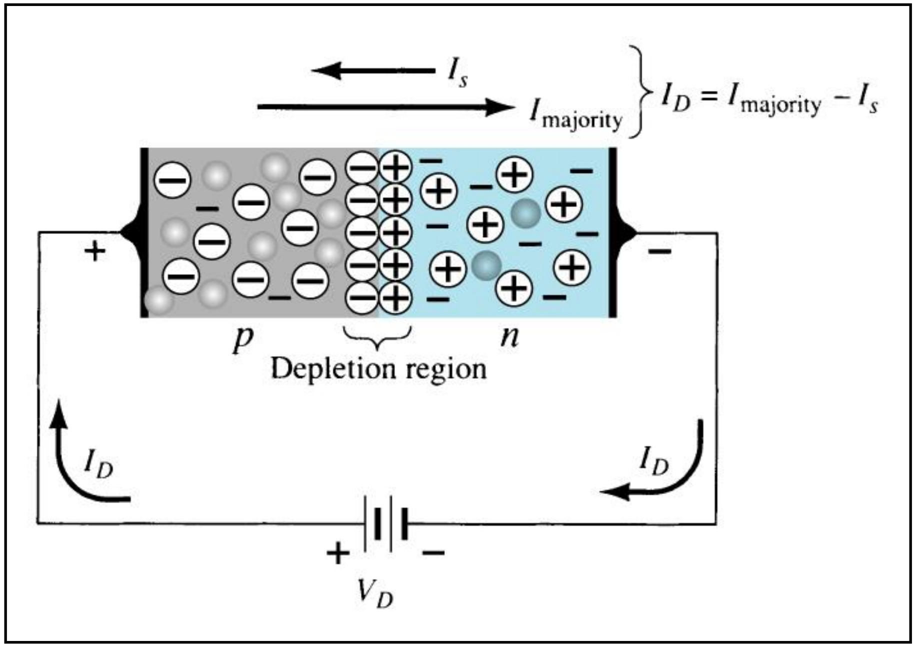
Diode – No Bias

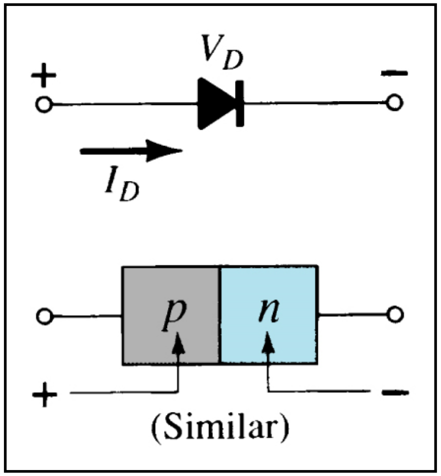
- No external voltage is applied: V_D = 0 V
- There is no diode current: I_D = 0 A
- Only a modest depletion region exists



Diode – Forward Bias

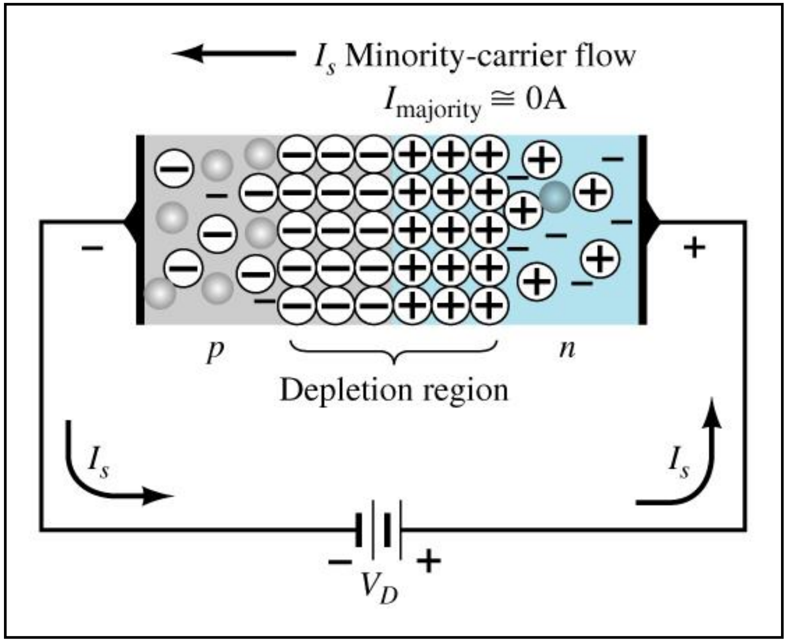
- External voltage is applied across the *p-n* junction in the same polarity as the *p-* and *n*-type materials.
- The forward voltage causes the depletion region to narrow.
- The electrons and holes are pushed toward the *p-n* junction.
- The electrons and holes have sufficient energy to cross the *p-n* junction

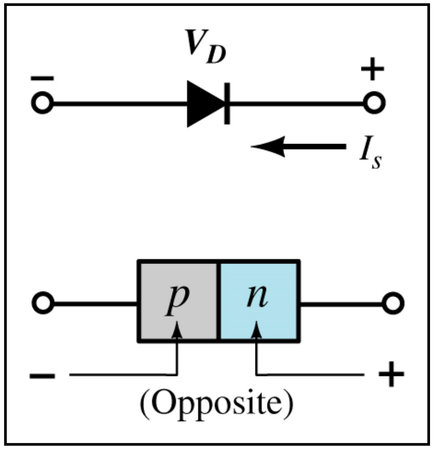




Diode – Reverse Bias

- External voltage is applied across the *p*-*n* junction in the opposite polarity of the *p*- and *n*-type materials.
- The reverse voltage causes the depletion region to widen.
- The electrons in the *n*-type material are attracted toward the positive terminal of the voltage source.
- The holes in the *p*-type material are attracted toward the negative terminal of the voltage source.





Diode Equivalent Circuit

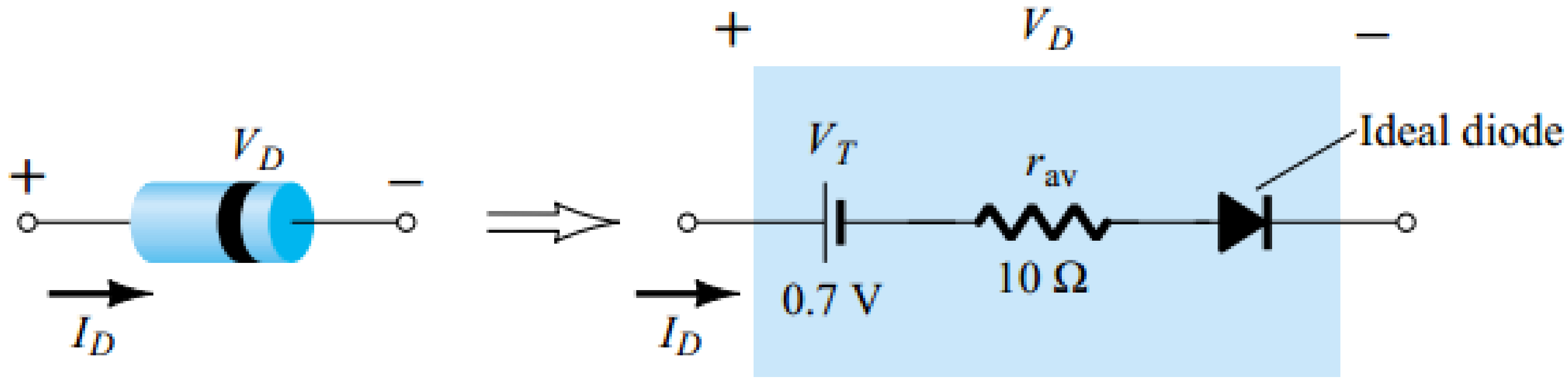
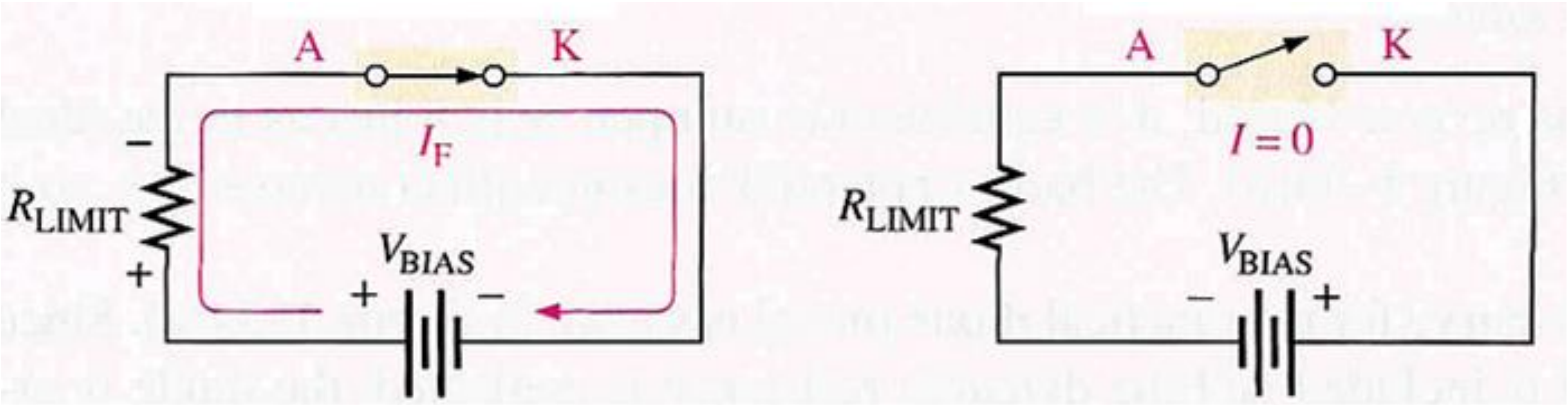


Figure 1.32 Components of the piecewise-linear equivalent circuit.

Ideal Diode Model

- Works as a switch
  - Forward bias (switch is close)
  - Reverse bias (switch is open)
- Threshold battery voltage and internal resistance are ignored.

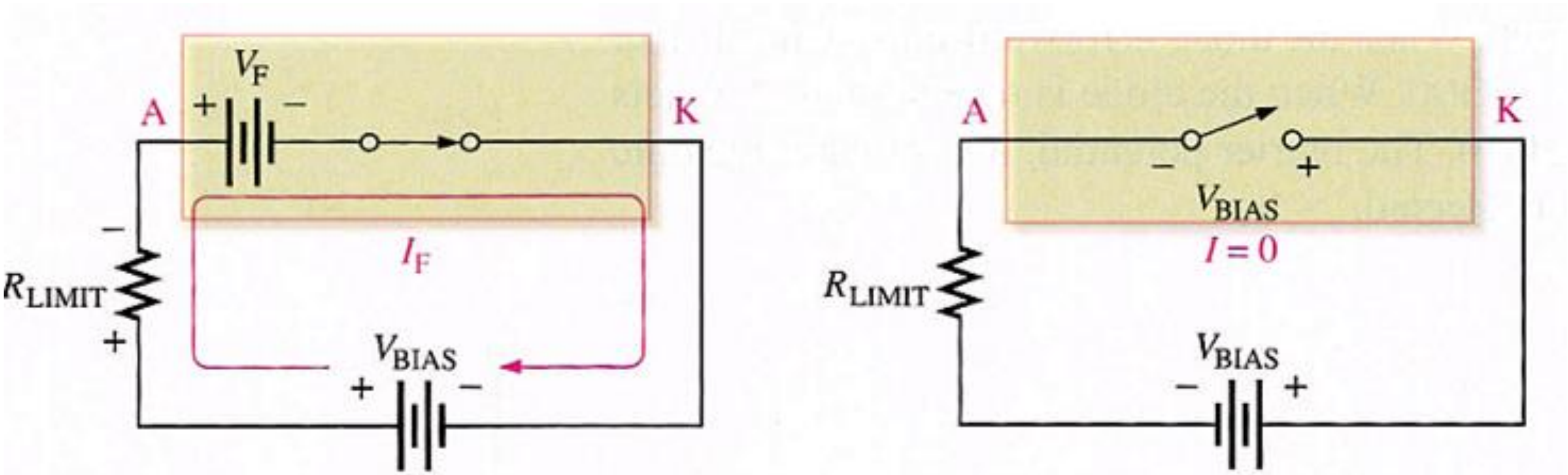


$$I_F = \frac{V_{BIAS}}{R_{LIMIT}}$$

Forward bias **Reverse bias**

Practical Diode Model

$$I_F = \frac{V_{BIAS} - V_F}{R_{LIMIT}}$$



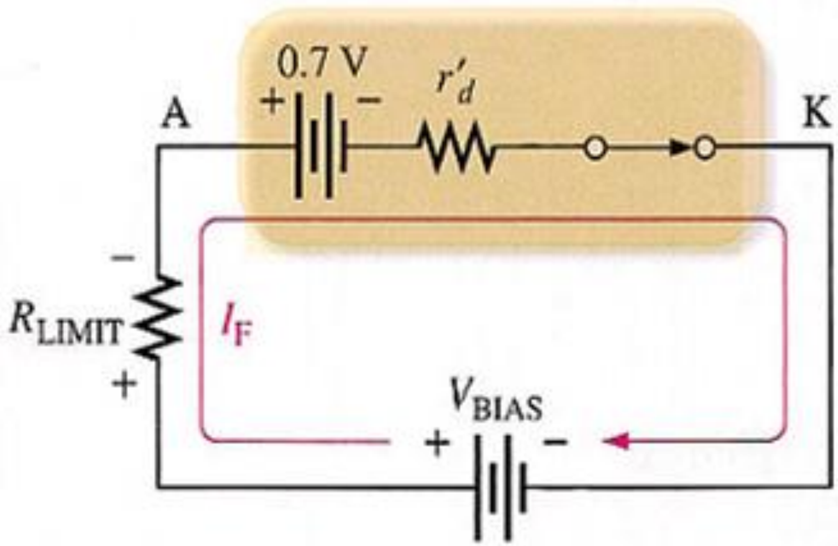
Forward bias **Reverse bias**

- Constants
  - Silicon Diode: $V_F = 0.7V$ ($V_F = V_{BIAS}$ if $V_{BIAS} < 0.7V$)
  - Germanium Diode: $V_F = 0.3V$ ($V_F = V_{BIAS}$ if $V_{BIAS} < 0.3V$)

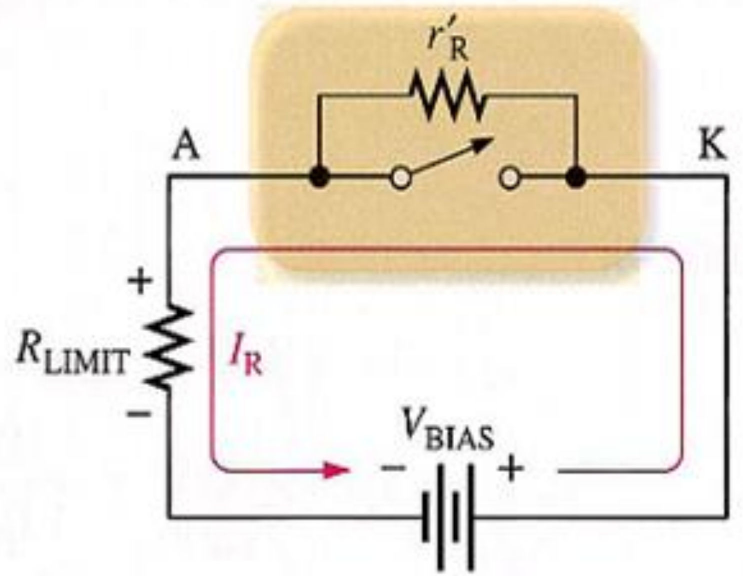
Complete Diode Model

$$I_F = \frac{V_{BIAS} - 0,7\,V}{R_{LIMIT} + r'_d}$$

$$I_R = \frac{V_{BIAS}}{R_{LIMIT} + r'_R}$$



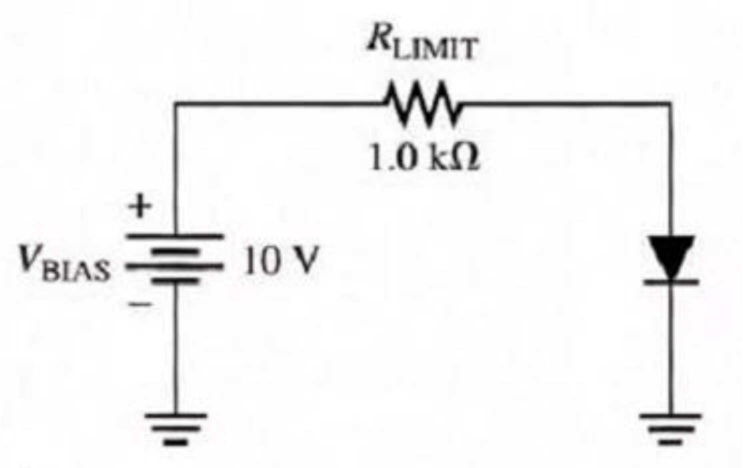
Forward bias



Reverse bias

Exercise 3

- Given circuit
  - Forward bias voltage $V_F = 0.7V$
  - Internal resistance $r'_d = 10\Omega$
- Determine V_F, I_F and V_{RLIMIT} for three diode models
  - Ideal diode model
  - Practical diode model
  - Complete diode model



Solution 3

- Ideal diode model

$$V_F = 0\,V$$

$$I_F = \frac{V_{BIAS}}{R_{LIMIT}} = \frac{10\,V}{1k\Omega} = 10\,mA$$

$$V_{R_{LIMIT}} = I_F \bullet R_{LIMIT} = (10\,mA) \bullet (1k\Omega) = 10\,V$$

- Practical diode model

$$V_F = 0,7\,V$$

$$I_F = \frac{V_{BIAS} - V_R}{R_{LIMIT}} = \frac{10\,V - 0,7\,V}{1k\Omega} = 9,3\,mA$$

$$V_{R_{LIMIT}} = I_F \bullet R_{LIMIT} = (9,3\,mA) \bullet (1k\Omega) = 9,3\,V$$

- Complete diode model

$$I_F = \frac{V_{BIAS} - 0,7}{R_{LIMIT} + r'_d} = \frac{10\,V - 0,7\,V}{1k\Omega + 10\,\Omega} = \frac{9,3\,V}{1010\,\Omega} = 0,00921\,A = 9,21\,mA$$

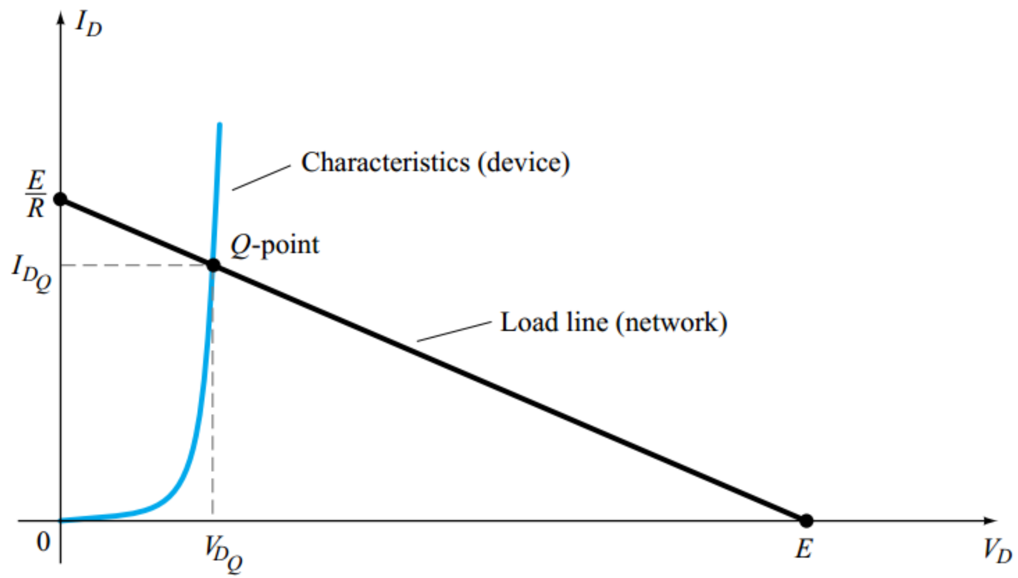
$$V_F = 0,7\,V + r'_d . I_F = 0,7\,V + (10\,\Omega) \bullet (9,21\,mA) = 792\,mV$$

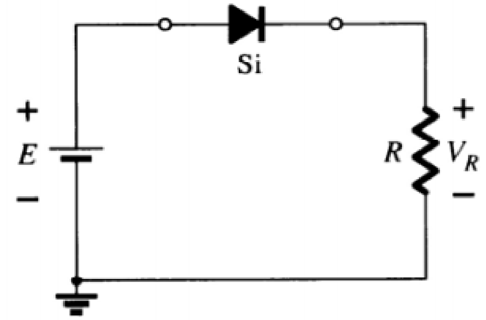
$$V_{R_{LIMIT}} = I_F \bullet R_{LIMIT} = (9,21\,mA) \bullet (1k\Omega) = 9,21\,V$$

Load-Line Analysis

The load line plots all possible combinations of diode current (I_D) and voltage (V_D) for a given circuit. The maximum I_D equals E/R, and the maximum V_D equals E.

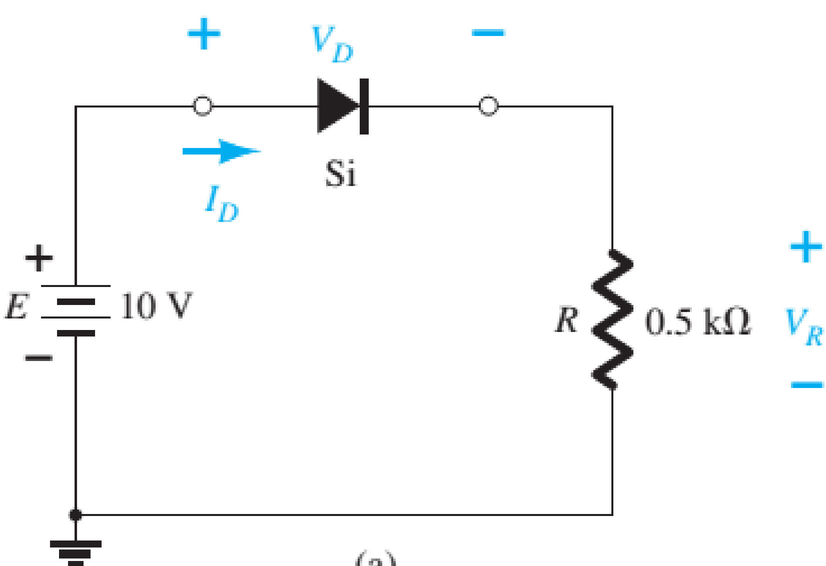
The point where the load line and the characteristic curve intersect is the Q-point, which identifies I_D and V_D for a particular diode in a given circuit.



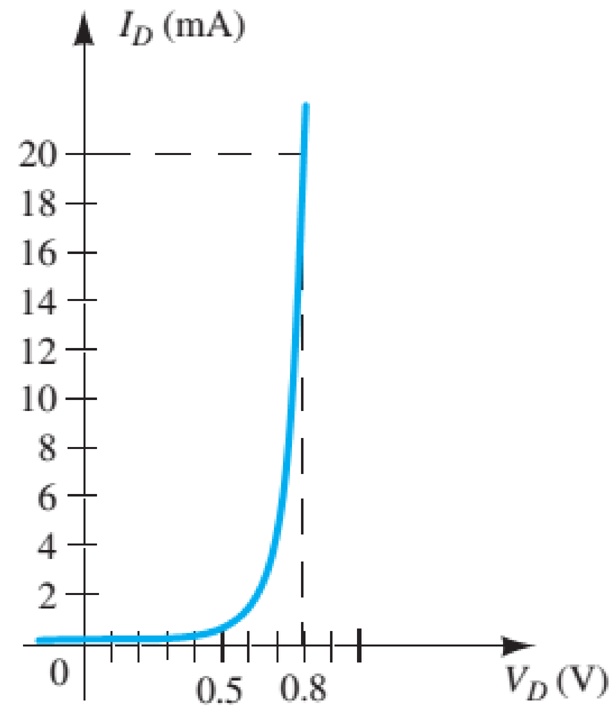


Exercise

- Determine V_D, I_D and V_R based on the characteristic of the diode given in the following figure.

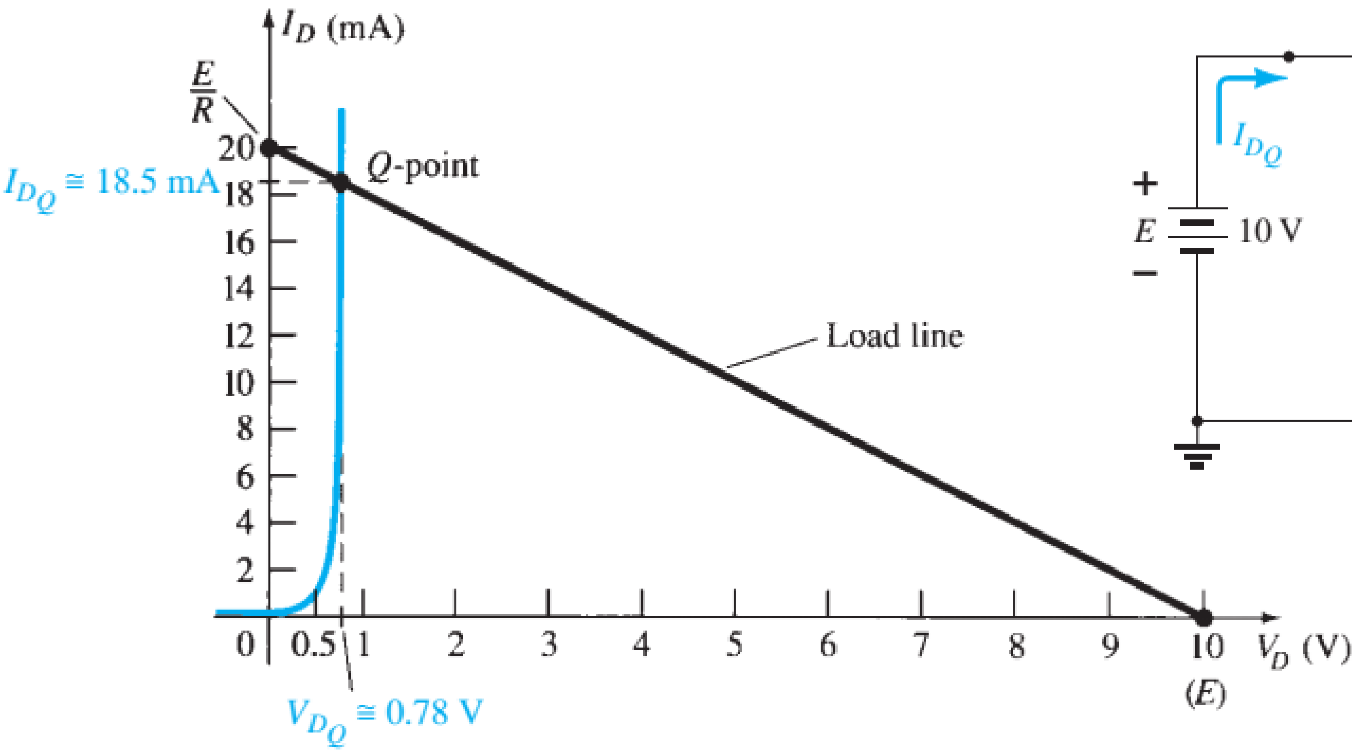


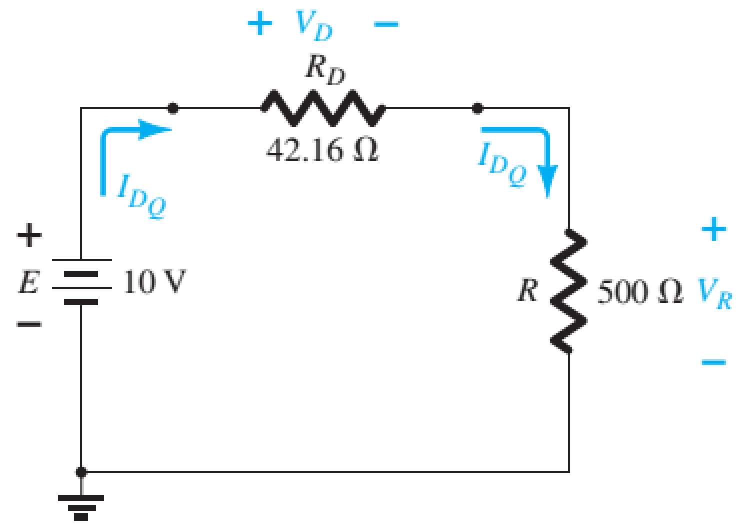
(a)



(b)

Solution

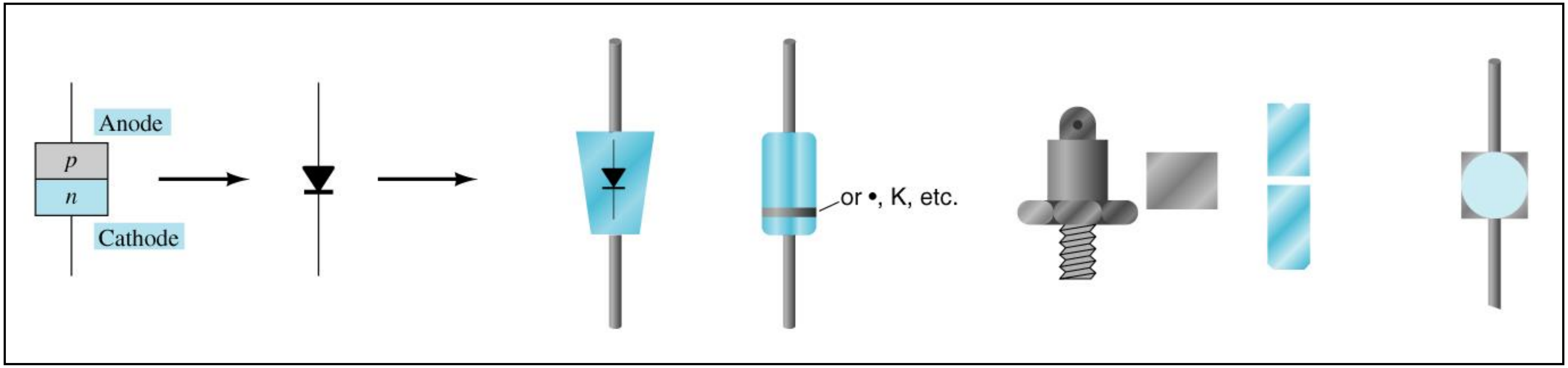




$$V_R = E - V_D = 10\text{ V} - 0.78\text{ V} = \mathbf{9.22\text{ V}}$$

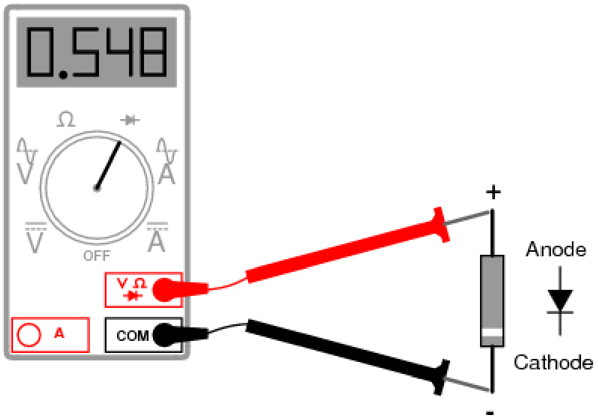
Diode Symbol and Packaging

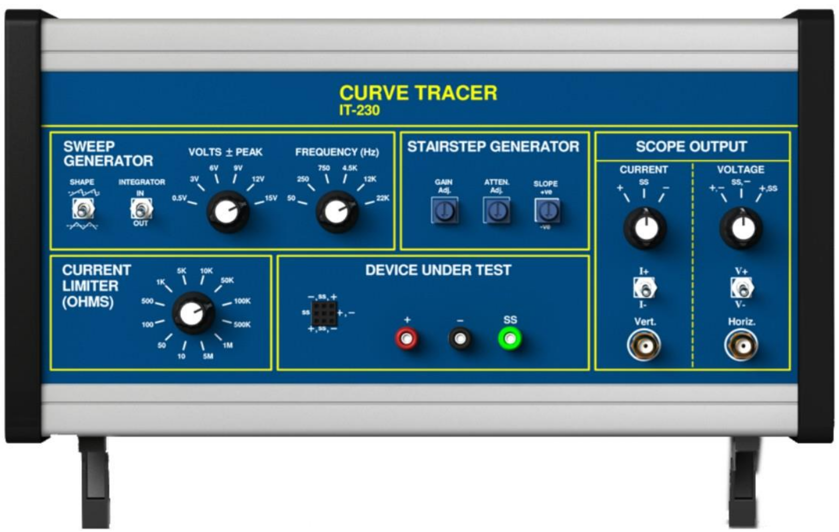
- The anode is abbreviated A
- The cathode is abbreviated K



Diode Testing

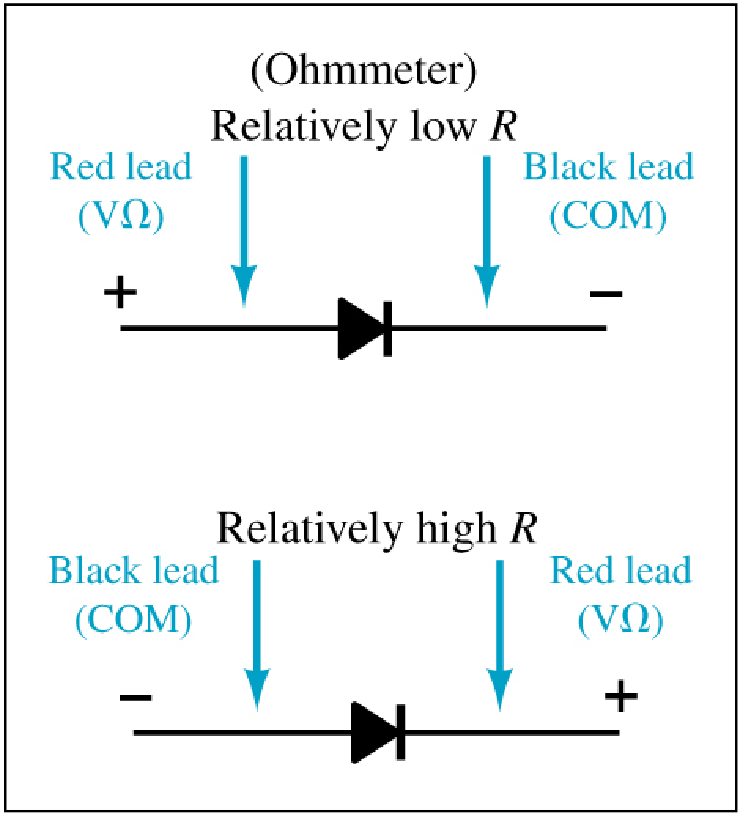
- Diodes are commonly tested using one of these types of equipment:
  - Diode checker
  - Ohmmeter
  - Curve tracer





Ohmmeter

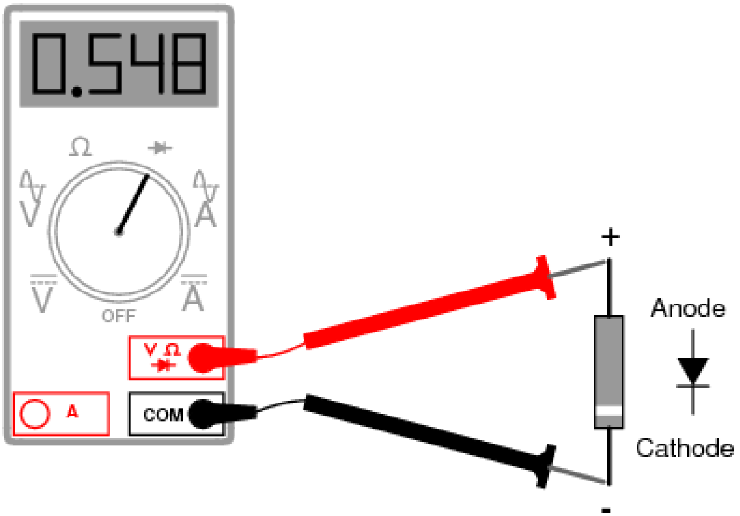
- An ohmmeter set on a low Ohms scale can be used to test a diode. The diode should be tested out of circuit.



Diode Checker

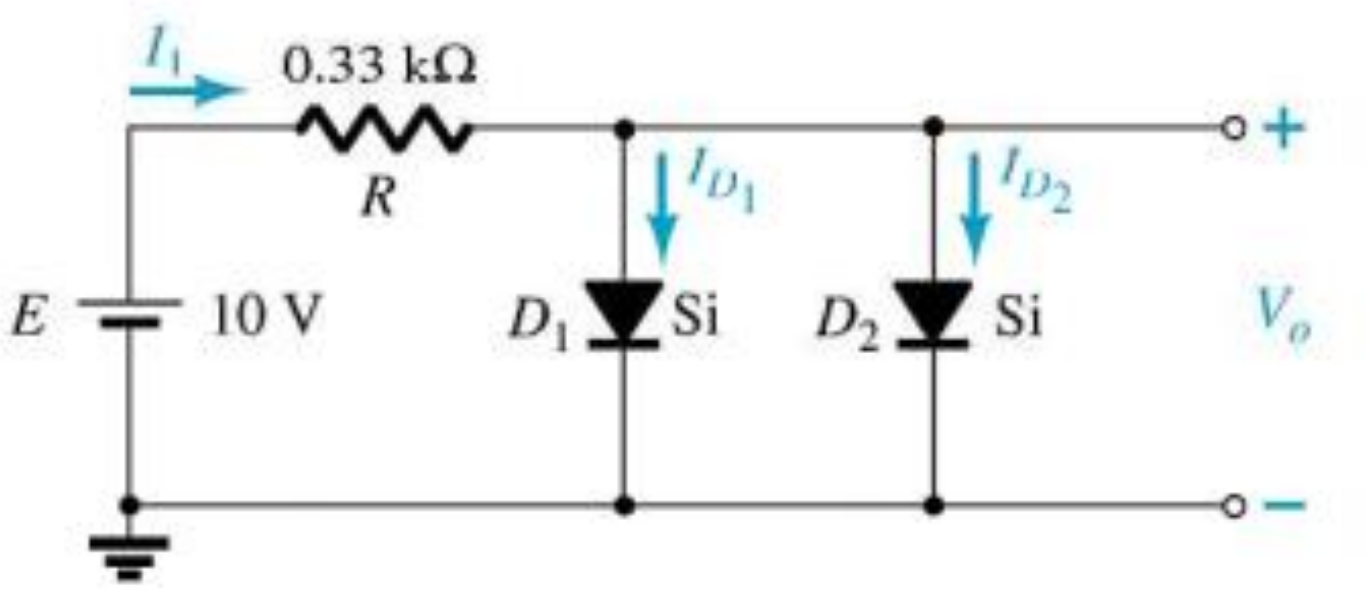
- Many digital multimeters have a diode checking function. The diode should be tested out of circuit.

- A normal diode exhibits its forward voltage:
  - Gallium arsenide ≈ 1.2 V
  - Silicon diode ≈ 0.7 V
  - Germanium diode ≈ 0.3 V



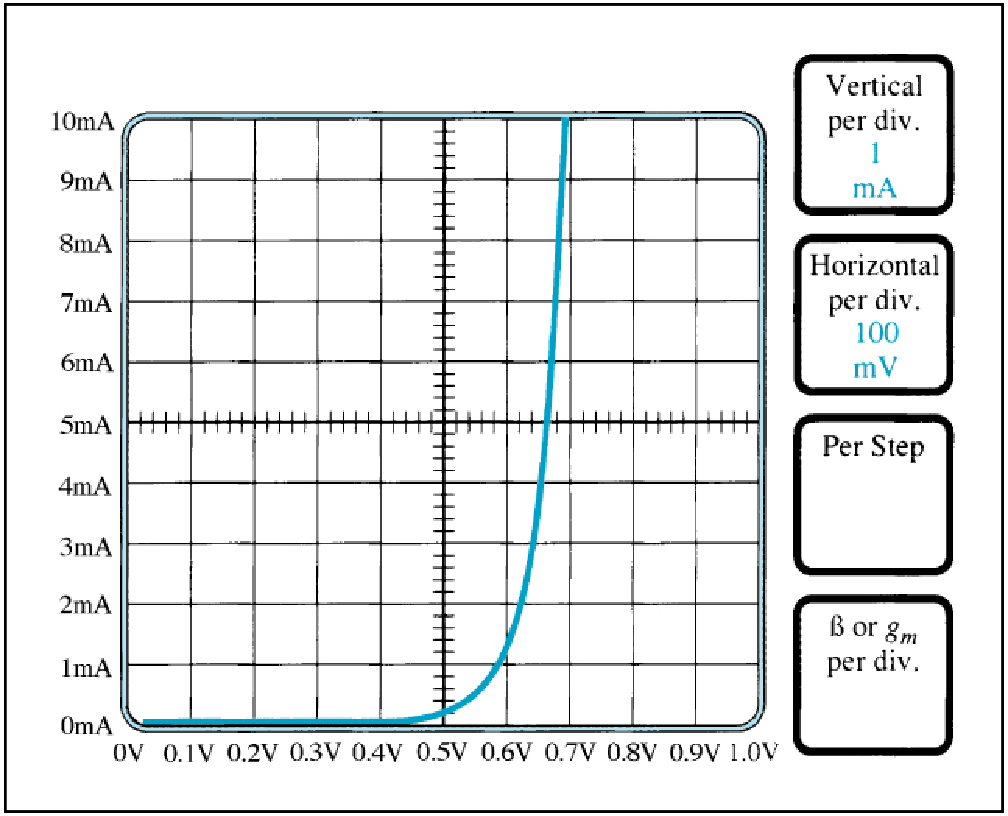
Exercise 2

- Determine
  - I_1, I_{D1}, I_{D2}



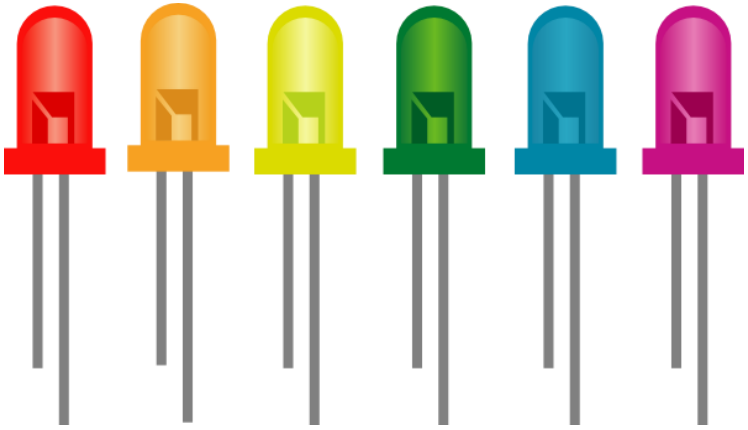
Curve Tracer

- A curve tracer displays the characteristic curve of a diode in the test circuit. This curve can be compared to the specifications of the diode from a data sheet.



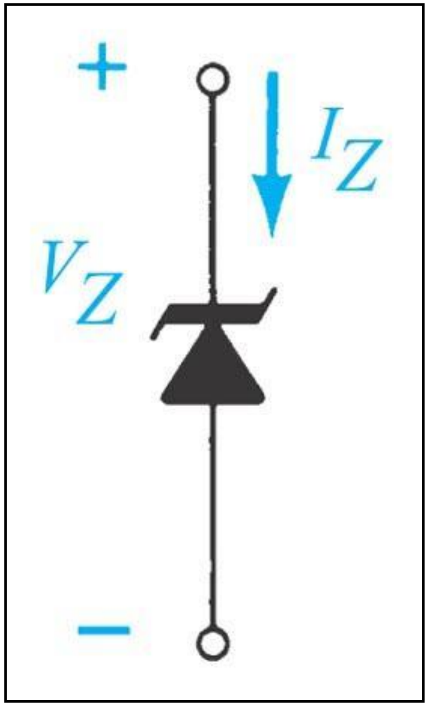
Other Types of Diodes

- There are several types of diodes besides the standard *p-n* junction diode. Three of the more common are:
  - Zener diodes
  - Light-emitting diodes
  - Diode arrays



Zener Diode

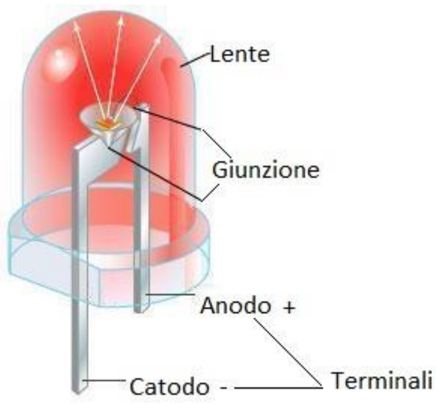
- A **Zener diode** is one that is designed to safely operate in its zener region; i.e., biased at the Zener voltage (VZ).
- Common zener diode voltage ratings are between 1.8 V and 200 V

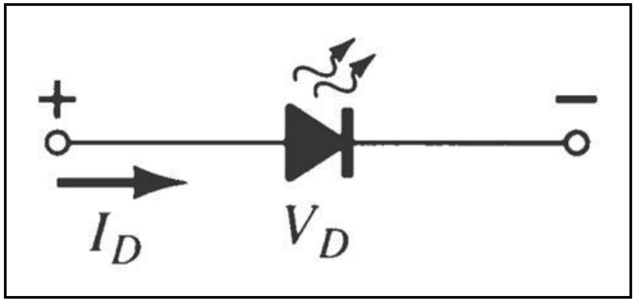


Light-Emitting Diode (LED)

- An LED emits light when it is forward biased, which can be in the infrared or visible spectrum.

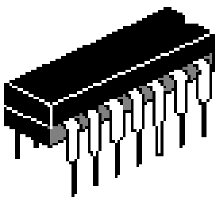
- The forward bias voltage is usually in the range of 2 V to 3 V.





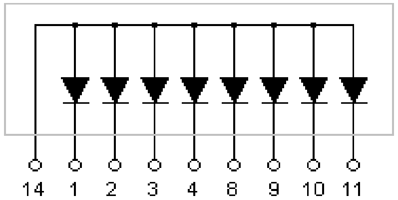
Diode Arrays

- Multiple diodes can be packaged together in an integrated circuit (IC).

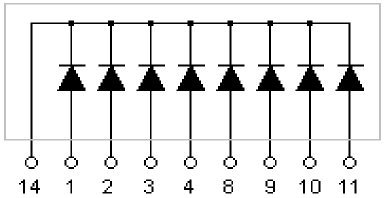


- A variety of diode configurations are available.

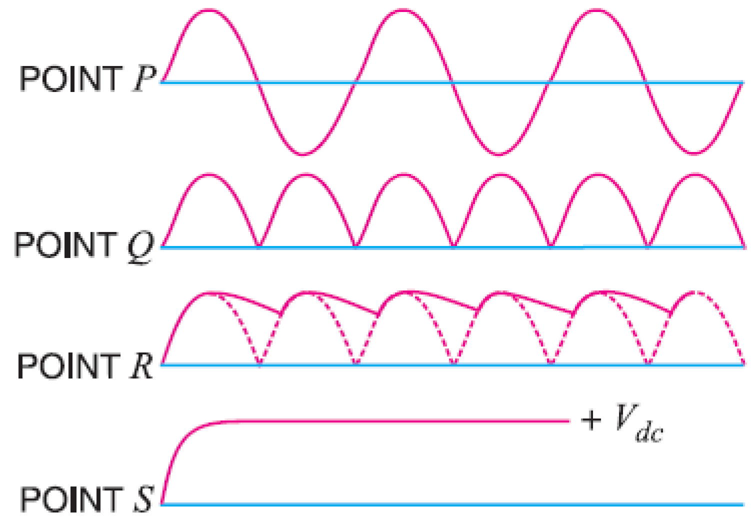
Common Anode

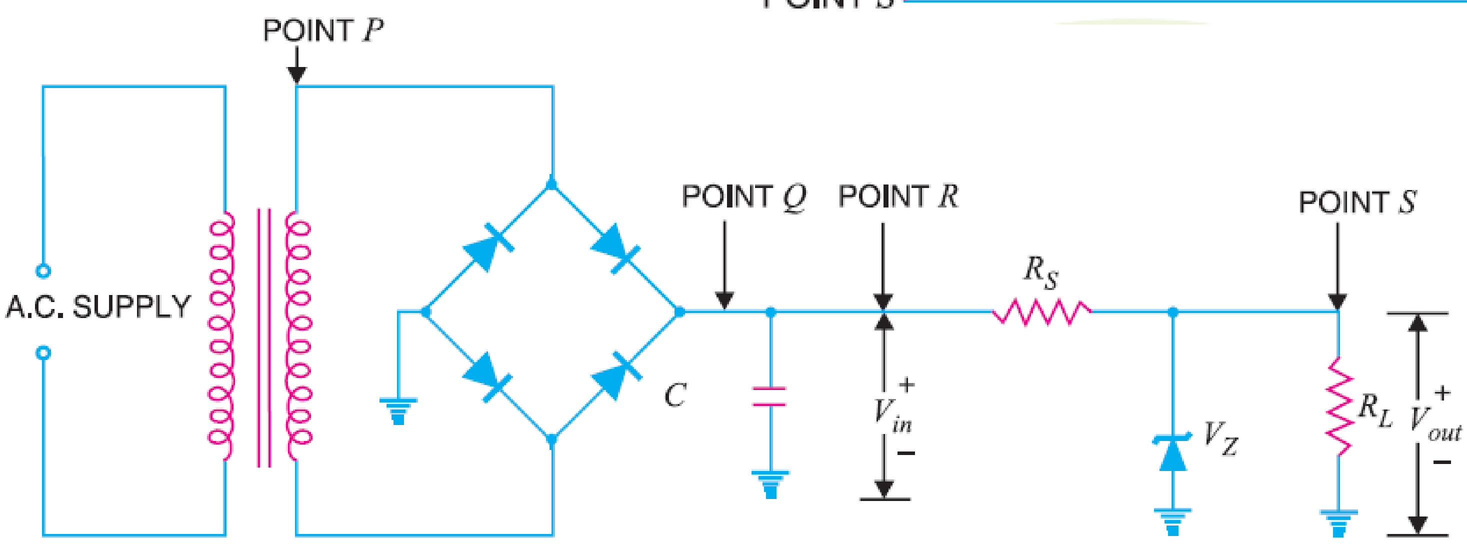


Common Cathode

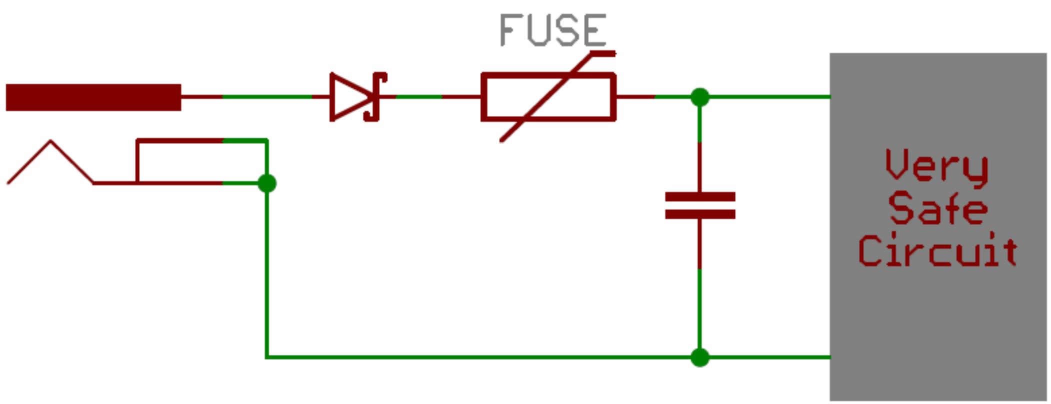


DC Adapter Circuits





Diode Application - Reverse Current Protection

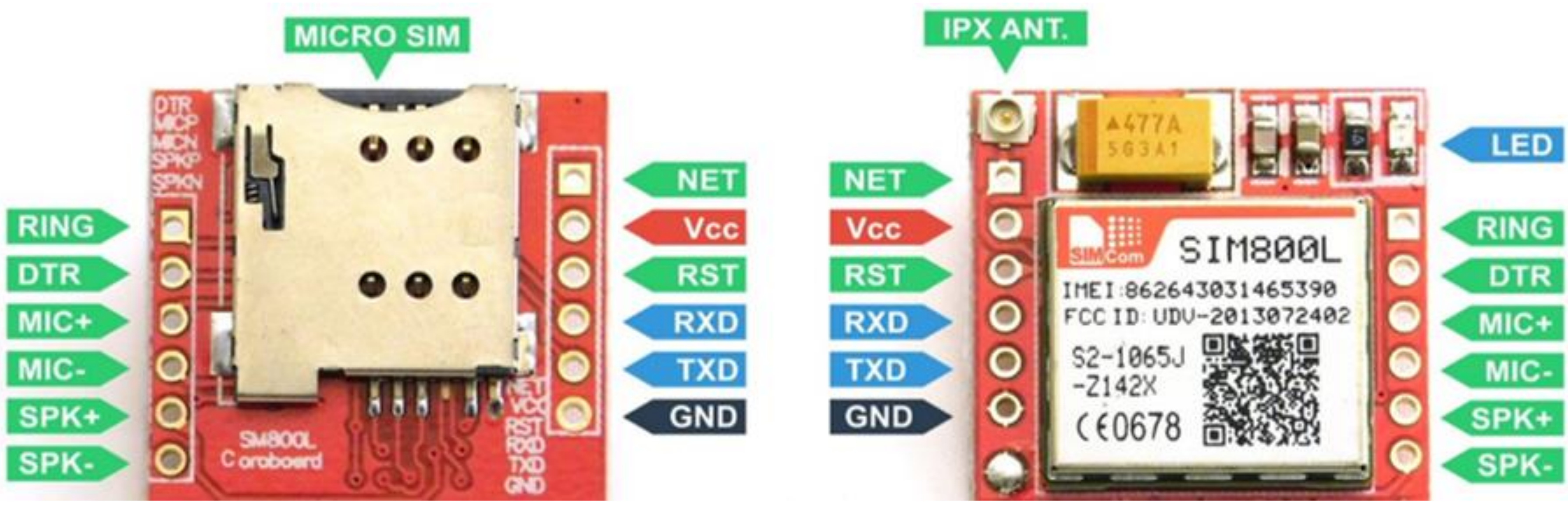


- Mandatory design for any system
- Drawback: around 0.7V loss because of the forward voltage drop.

Schottky diodes an excellent choice for reverse protection diodes.

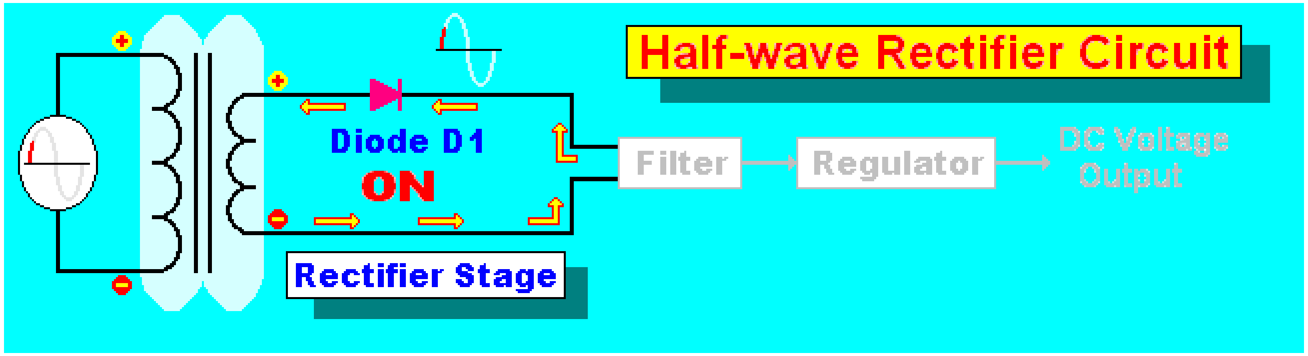
Diode Application – Reverse Current Protection

- SIM800L: 4.3V

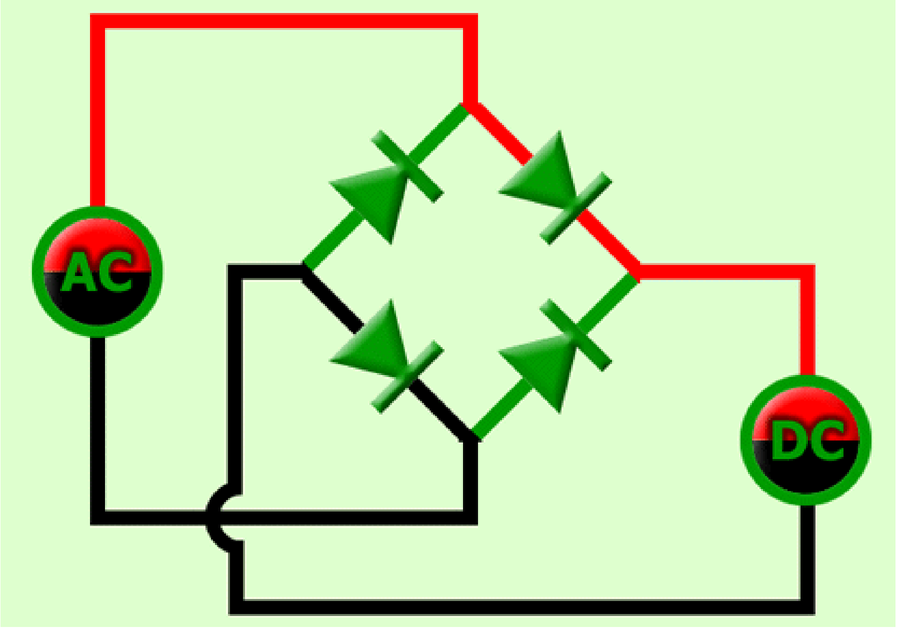


Diode and Its Application

- Half-wave Rectification

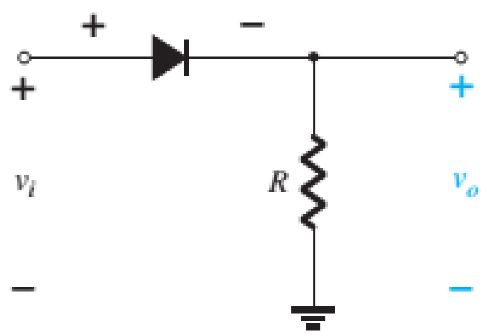


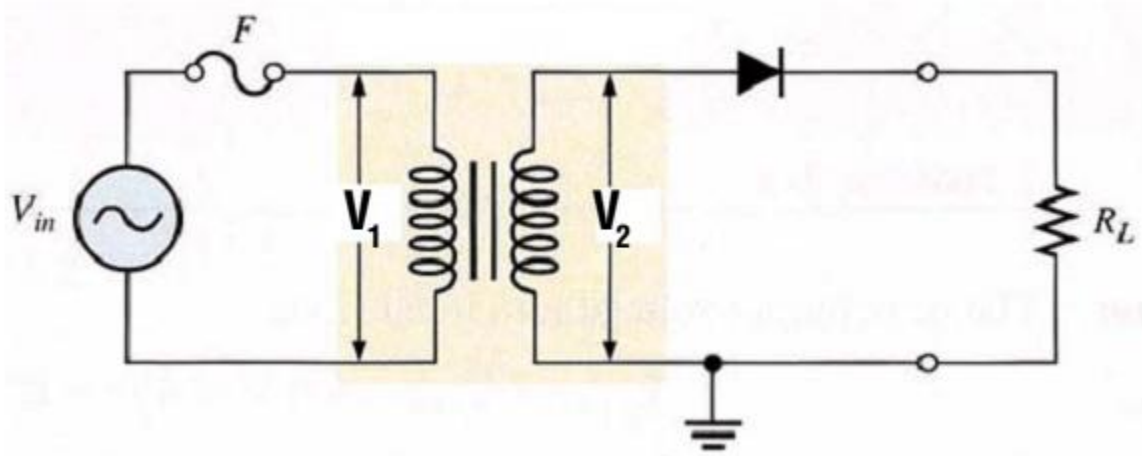
- Full-ware Rectification

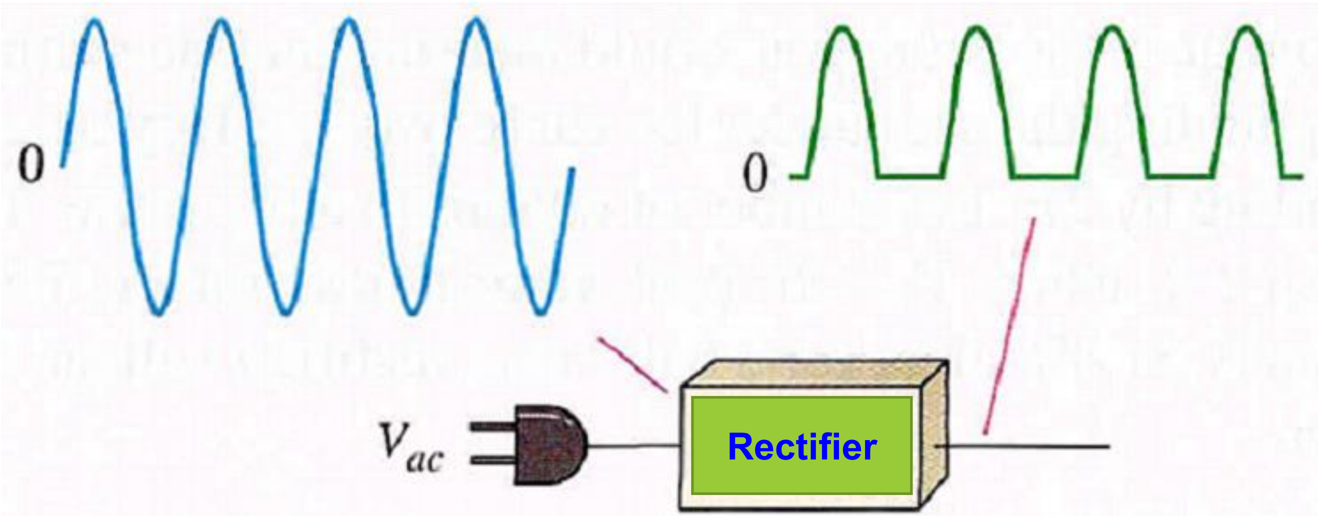


Half-Wave Rectification

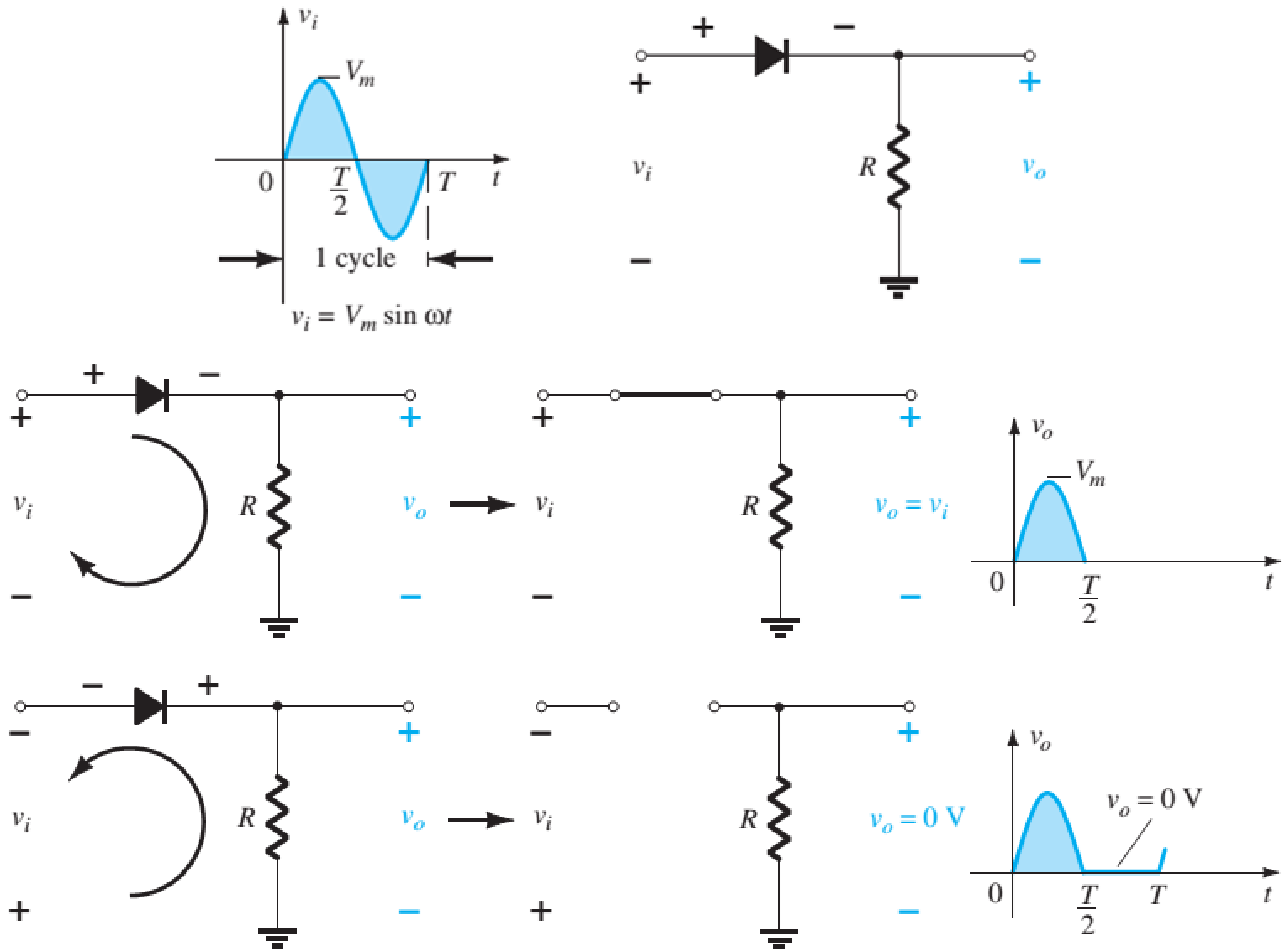
- Convert AC to DC using one Diode





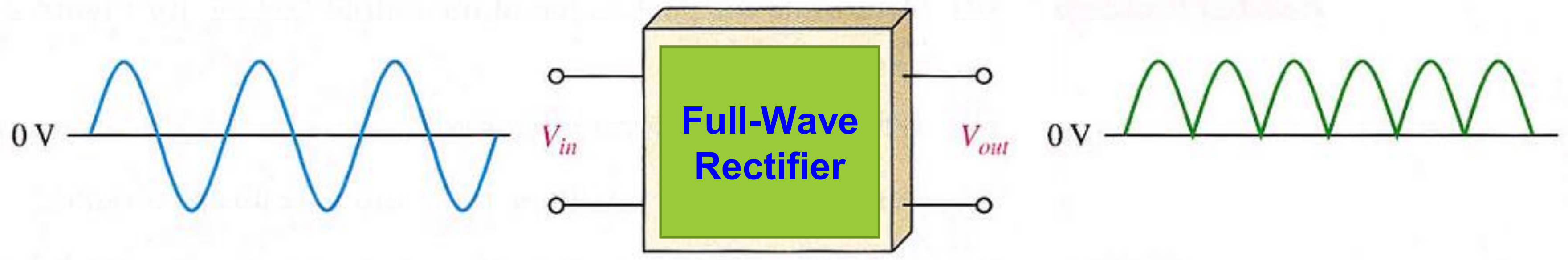


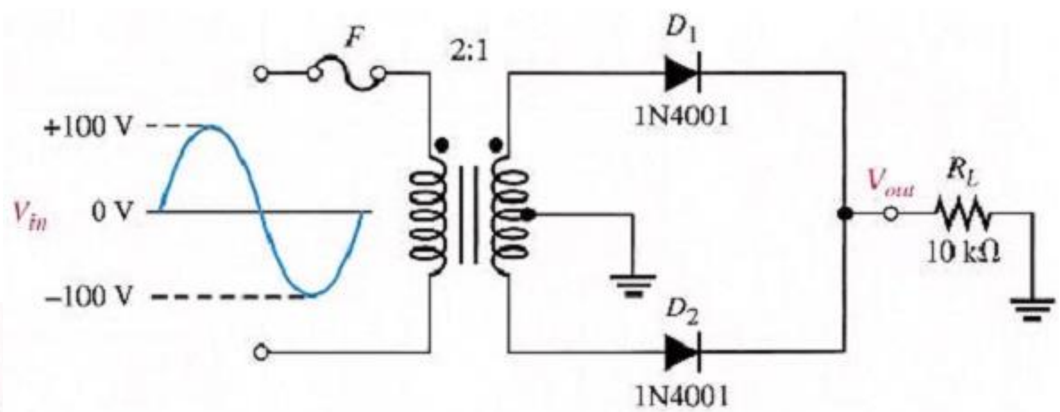
Half-Wave Rectification (cont.)

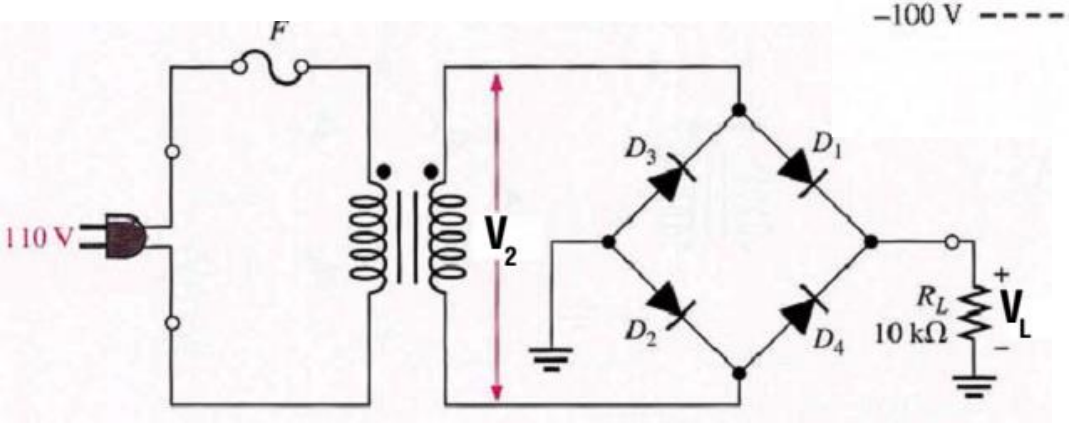


Full-Wave Rectification

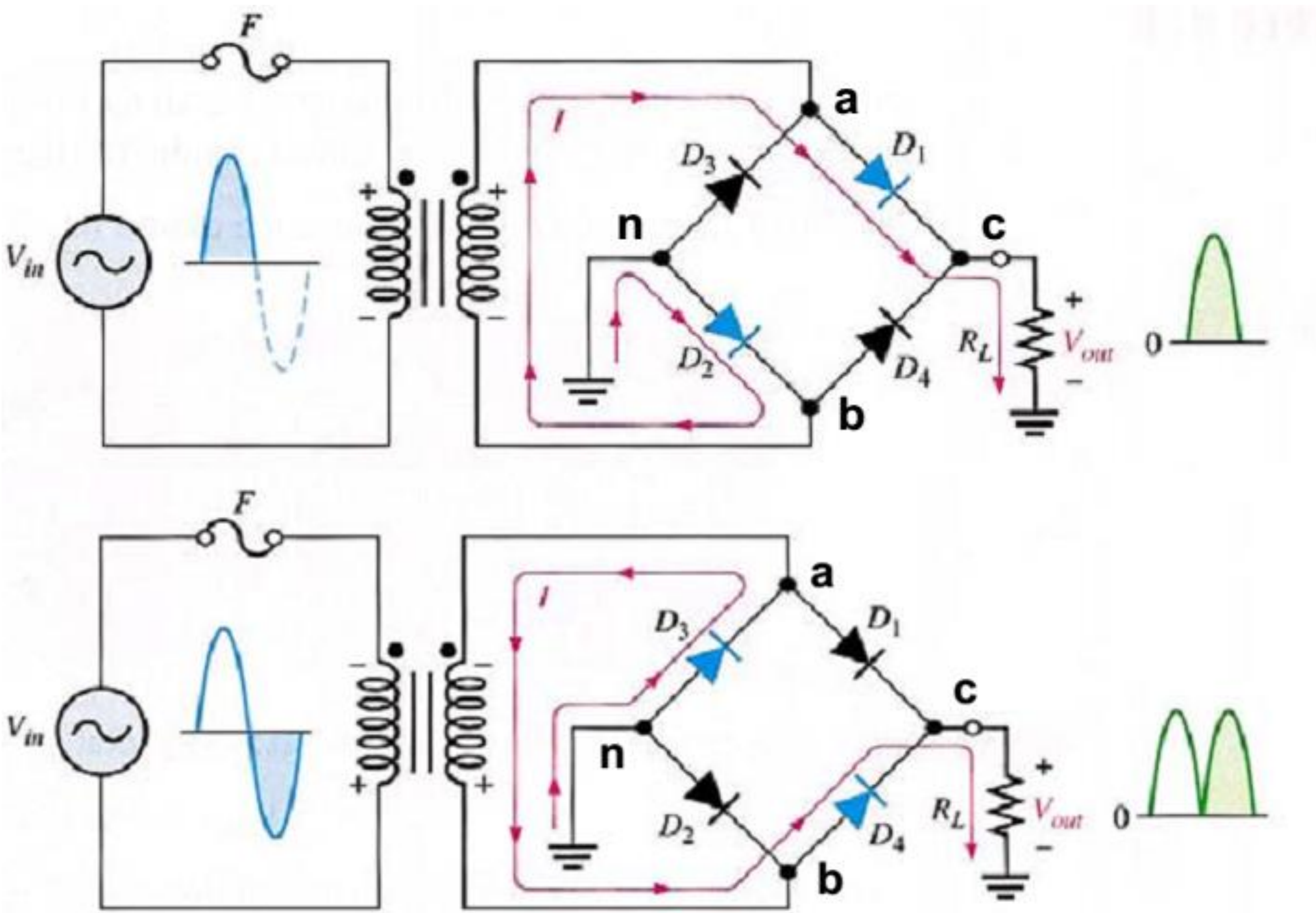
- Convert AC to DC using two or four diodes



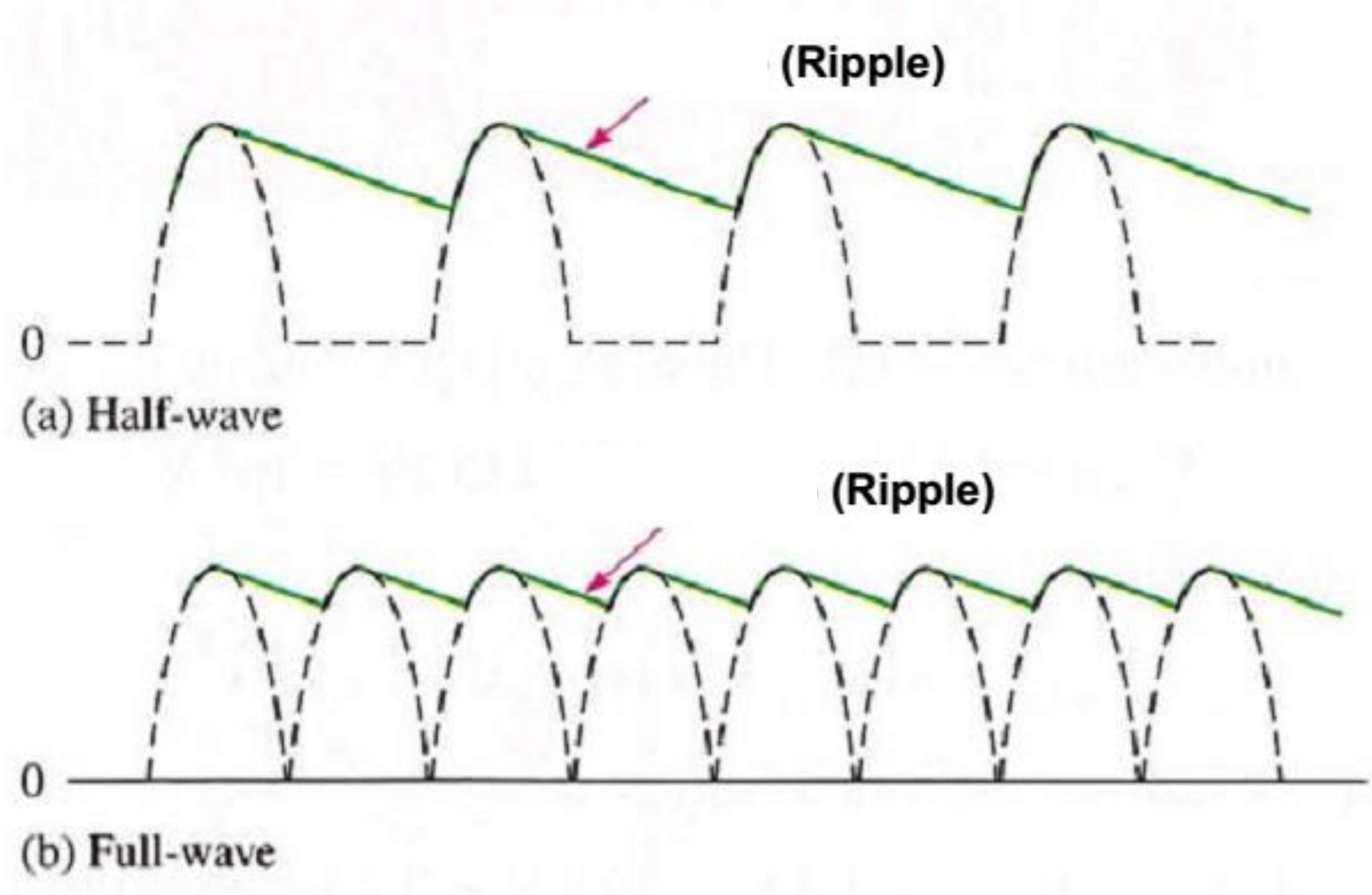




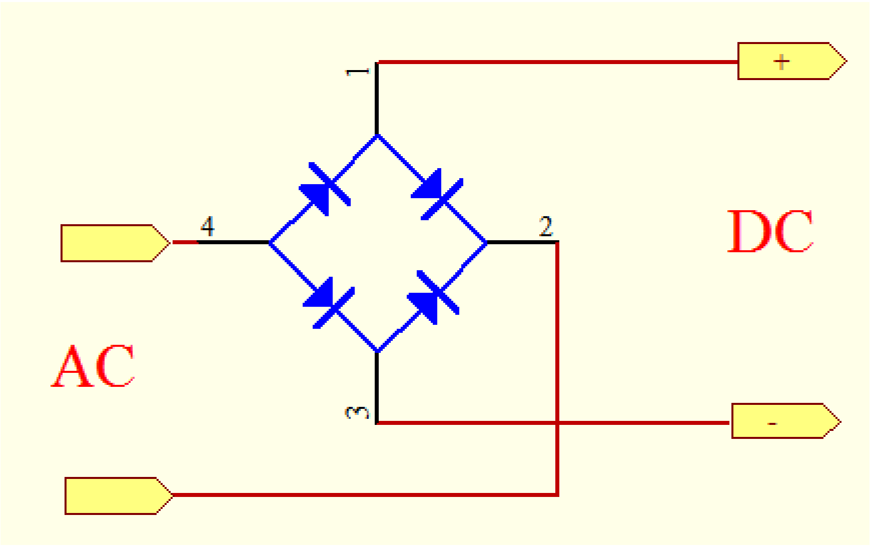
Bridge Rectifier

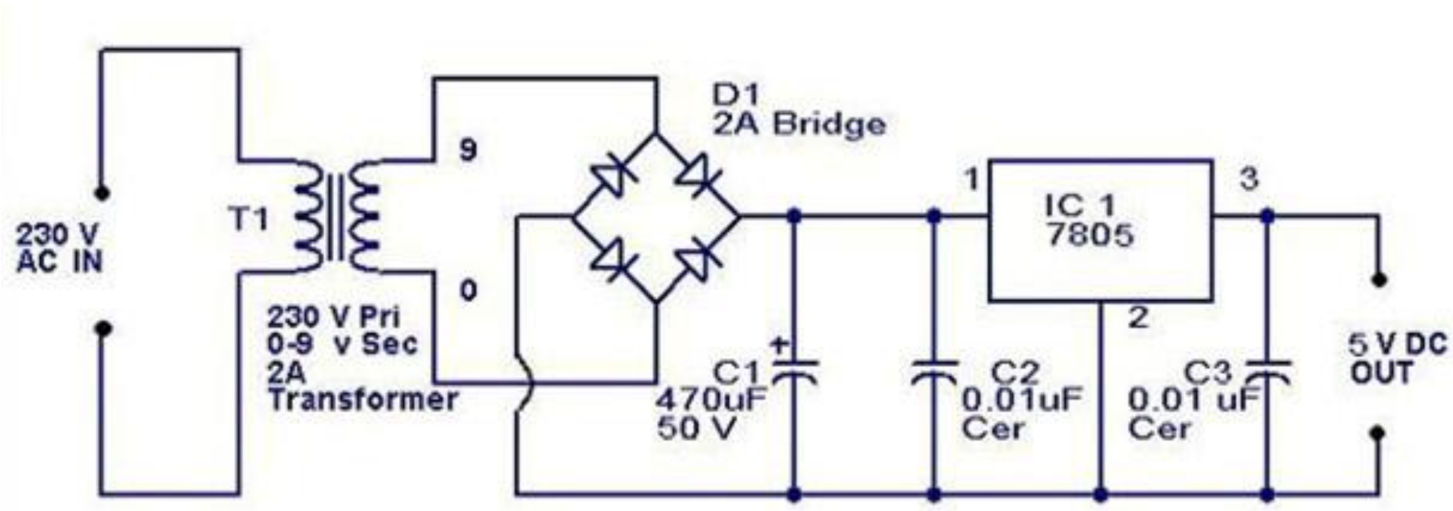


Ripple in Rectification

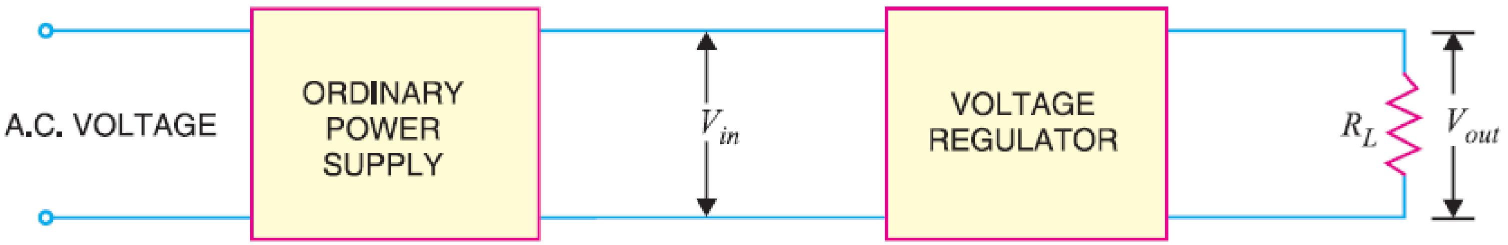


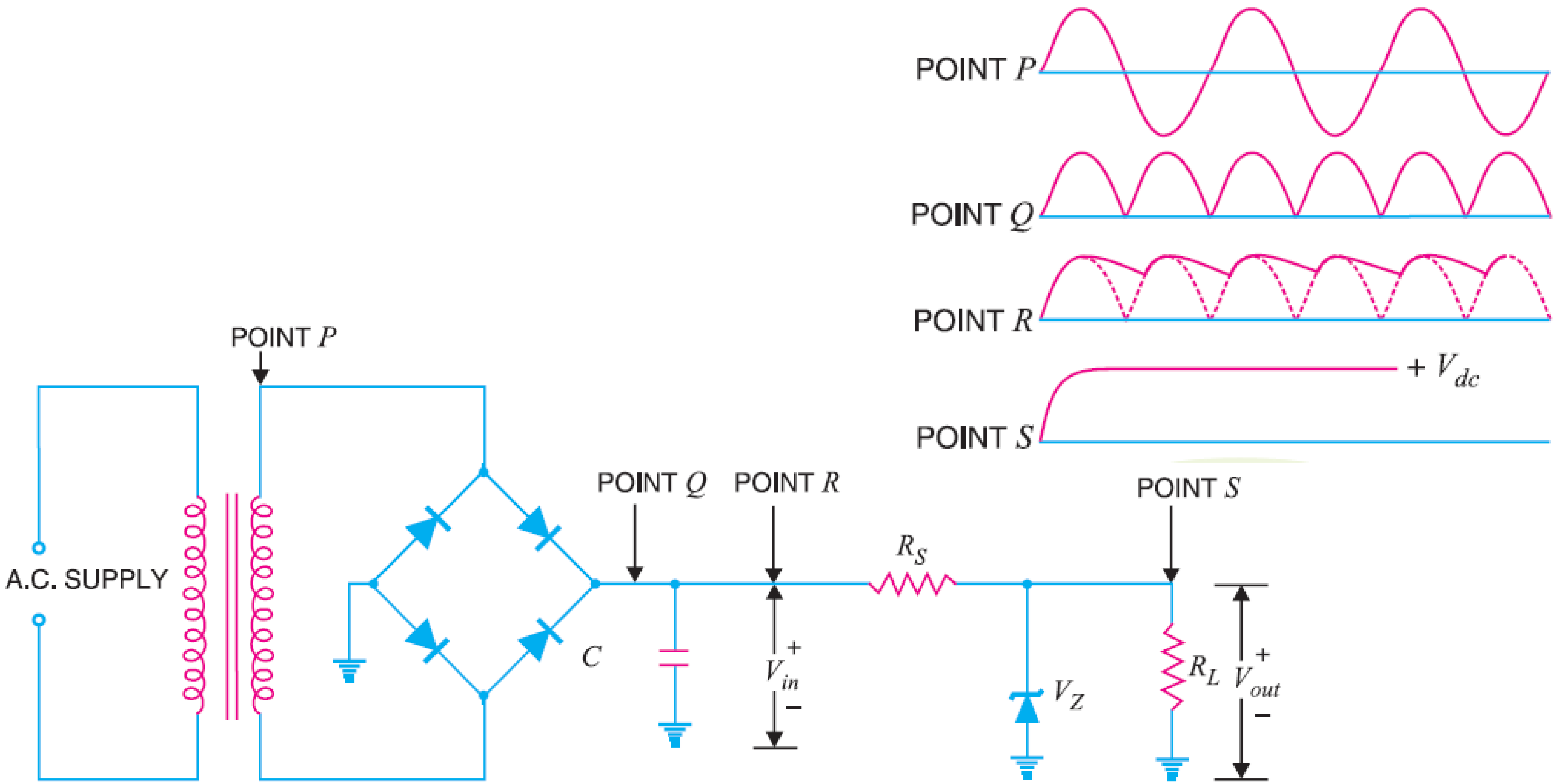
Diode Application - AC to DC Converter



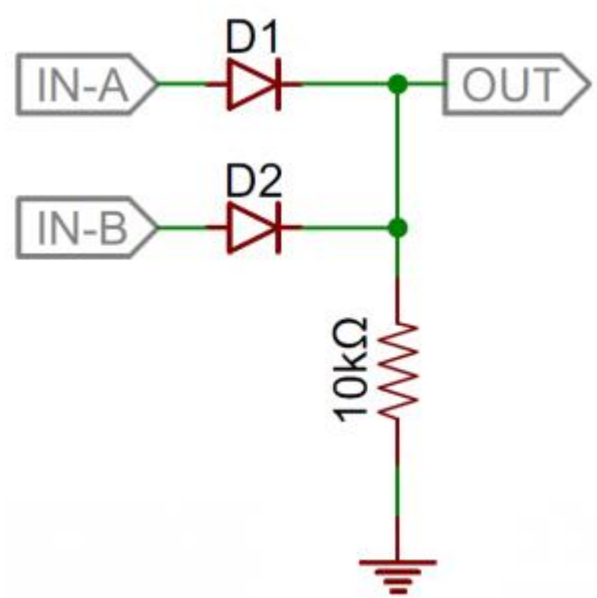


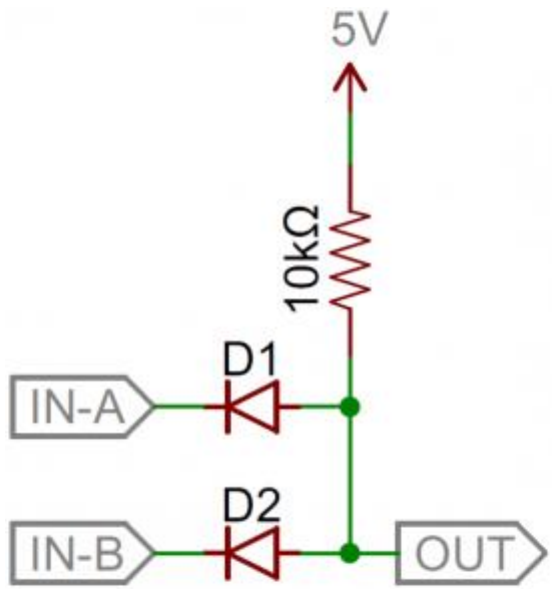
Complete AC/DC Power Circuit





Logic Gates

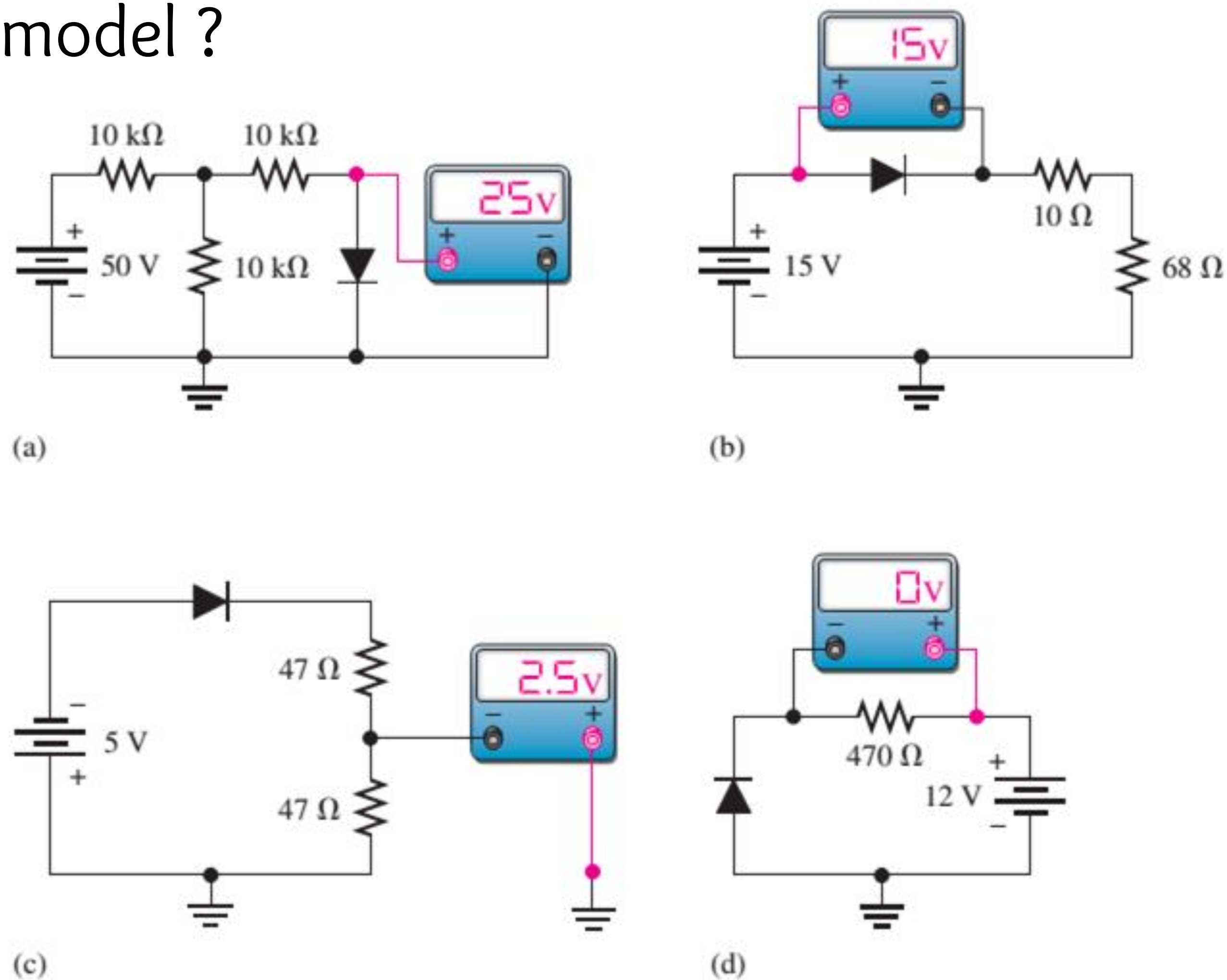


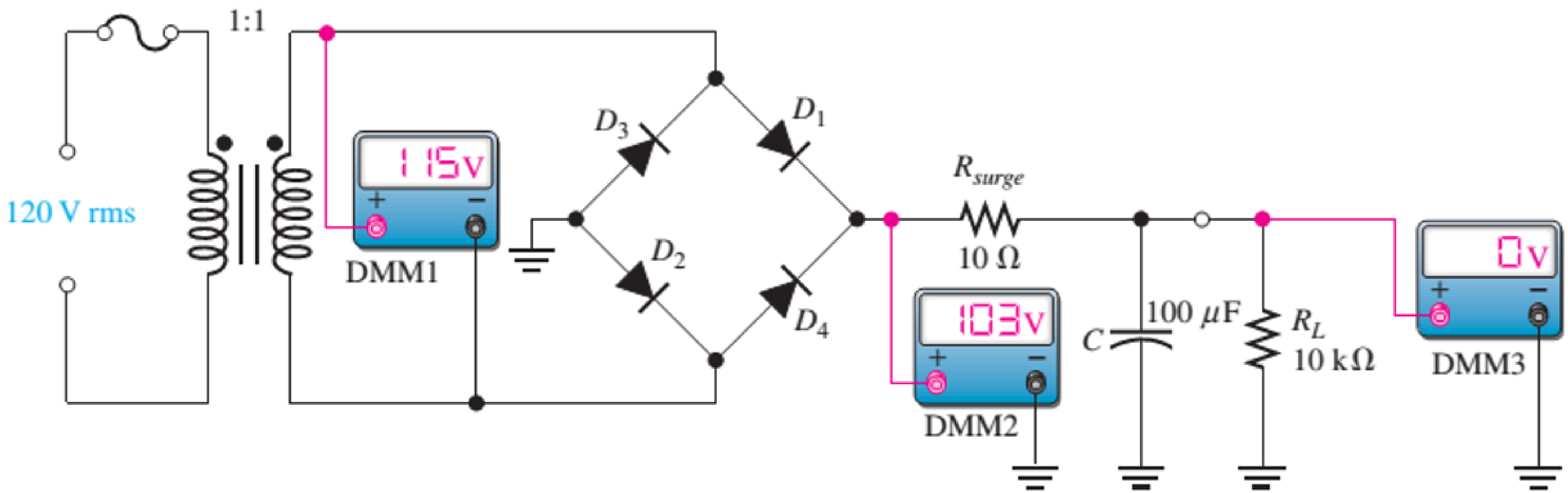


- OR
- AND

Exercise 5

- Analyze and validate the value of the voltmeter in case of using ideal diode model ?




1:1
120 V rms
115V
DMM1
D3
D1
D2
D4
Rsurge
10 Ω
103V
DMM2
C
100 μF
RL
10 kΩ
0V
DMM3