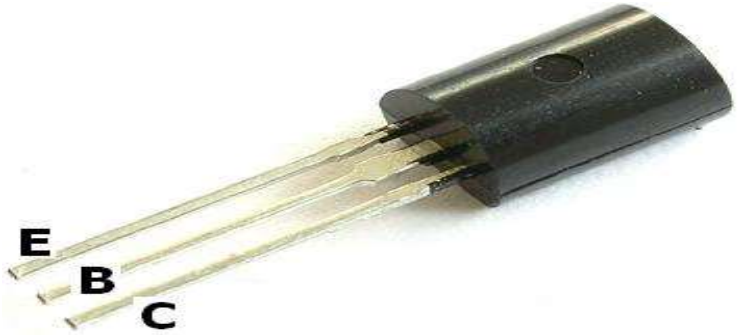
Analog Electronics

Semiconductor diodes

B. Sc. SY



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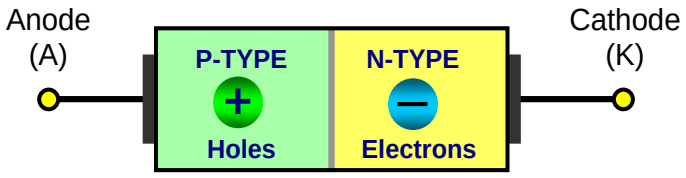
- Introduction
- Diode identification
- Diode Operation
- Testing a Diode
- Diode Application

Introduction

- A **diode** is a **semiconductor device** that acts as **one-way conductor** and therefore allows **current to flow in only one direction**.
- Simplest form of a diode is the p-n (positive-negative) junction diode as shown in Figure 1.1a



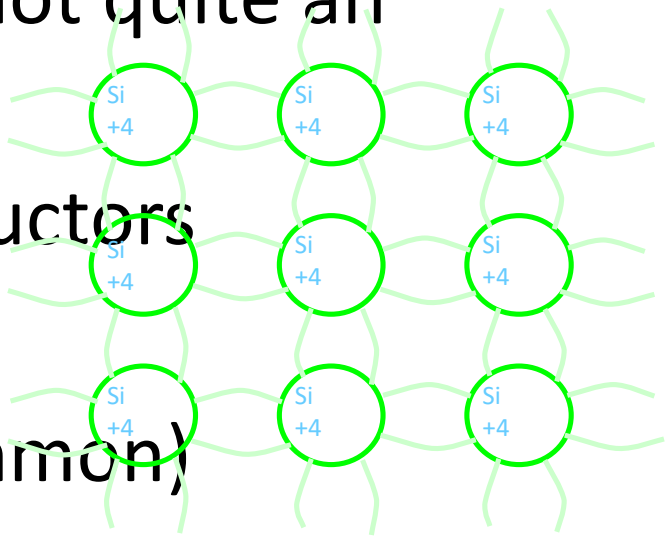
a) Diode Structure

What Is a Semiconductor?

- Many materials, such as most metals, allow electrical current to flow through them
- These are known as conductors
- Materials that do not allow electrical current to flow through them are called insulators
- Pure silicon, the base material of most transistors, is considered a semiconductor because its conductivity can be changed by the introduction of impurities.

Semiconductors

- A material whose properties are such that it is not quite a conductor, not quite an insulator
- Some common semiconductors
  - elemental
    - Si - Silicon (most common)
    - Ge – Germanium
    - Both are group 4 elements.
  - compound
    - GaAs - Gallium arsenide



Improving Conduction by Doping

- To make semiconductors better conductors, add impurities (dopants) to contribute extra electrons or extra holes
  - elements with 5 outer electrons contribute an extra electron to the lattice (donor dopant)-produces n type silicon
  - elements with 3 outer electrons accept an electron from the silicon (acceptor dopant)-produces p type silicon

Introduction to diodes

- The simplest form of a diode is the p-n (positive-negative) junction diode .
- The diode is contained in a small capsule made of glass or plastic and has two terminals or electrodes and hence the name diode (di ≡ two and ode ≡ electrode).
- The electrode connected to the p-type is called the ***Anode "A",*** and the electrode connected to the n-type is called the ***Cathode "K".***

Introduction to diodes

Figure 1.1b shows the symbol of the PN junction diode, where the arrow points to the direction of current flow.

b) Diode Symbol

The cathode (K) is marked with a silver color band as shown in Figure 1.1c.

c) Typical Diode

Diode Types

According to semiconductor material used:

- Germanium diodes
- Silicon diodes

Application

- Rectifier diodes.
- Zener diodes.
- Light emitting diodes (LEDs).
- Photo diodes.
- Small Signal (low power) diodes.

Typical diodes of different types

LED

Rectifier diode

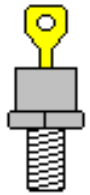
Low Power Diode

Zener Diode

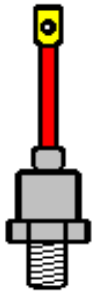
Photo Diode

Diode Packaging

- Diode is generally mounted in one of three basic packages shown in Figure 1.3.



DO-5



DO-8

DO-41

These are designed to protect the diode from mechanical stress and the environment.
The size of the package indicates the current rating (larger size means higher current rating).
(**DO**) refers to **D**iode **O**utline.

Diode identification: Pro-Electron System& JEDEC System

1.1 Pro-Electron Numbering or Coding System

First Letter Specifies Semiconductor Material		Second Letter Specifies type of Diode	
A	Germanium	A	Low power or signal
B	Silicon	P	Light detector
EXAMPLE: BZY74-C6V3 B = Si, Z = Zener diode, Y74 = Commercial or Industrial use, C = 5% of rating voltage. 6V3 = 6.3 Volt (Voltage rating)		Q	Light Emitting Diode (LED)
		Y	Rectifier
		Z	Zener (voltage reference)

1.2 JEDEC Numbering or Coding System

First Number		Second Letter		Subsequent numbers
1	Diode	N	Semiconductor	Serial number of device
2	Bipolar Transistor	**Example:** This code "1N4001" means: **1** ≡ Diode, **N** ≡ Semiconductor. **4001** ≡ Serial number.		
3	FET			
4&5	Photo Coupler			

Pro-Electron System originated in Europe and is widely used for semiconductor devices developed and manufactured by European manufacturers

JEDEC System: This numbering system originated in the USA and is widely used for semiconductors manufactured in North America

Diode Operation

- A diode conducts only in one direction.

the conduction is from anode to cathode.

- Biasing: Arranging a diode suitably in a circuit is called biasing

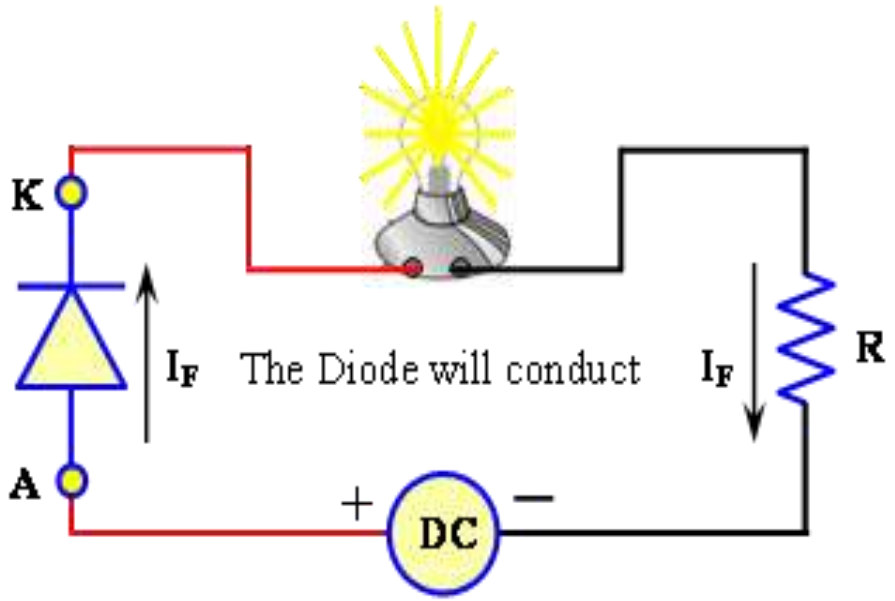
There are two types of diode biasing:

- Forward bias
- Reverse bias

Figure 1.4: Diode operated in forward bias

- When a diode is connected to the power supply such its anode (A) is connected to the positive terminal, and its cathode (K) is connected to the negative terminal as shown in figure ,we say that it is **forward biased (FB)**.

- The diode in FB-direction allows the current to flow from A to K as shown in Figure 1.4



Diode operated in reverse bias

Reverse biased:

A diode is ***reverse biased*** (**RB**) when its anode (A) is **negative** with respect to the cathode (K).

The diode in RB-direction does not allow the current to flow as shown in Figure 1.5.

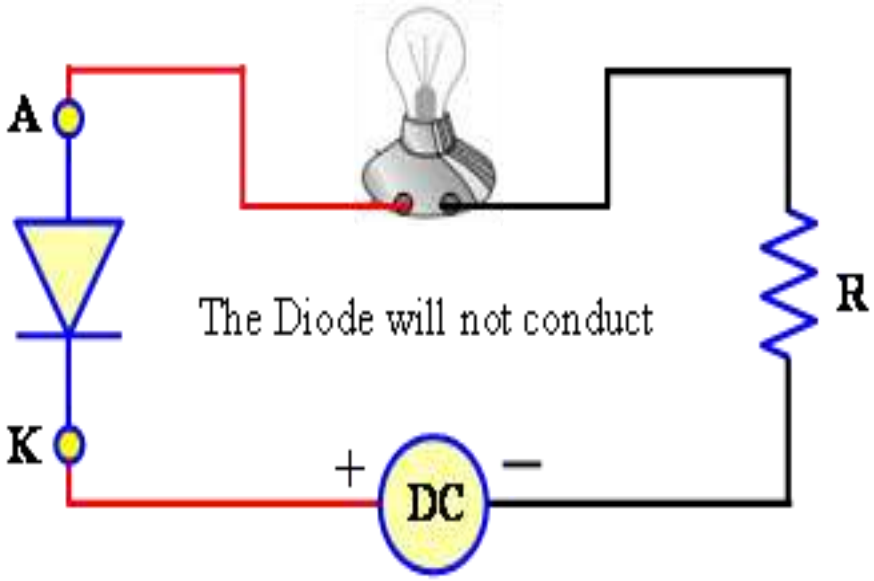
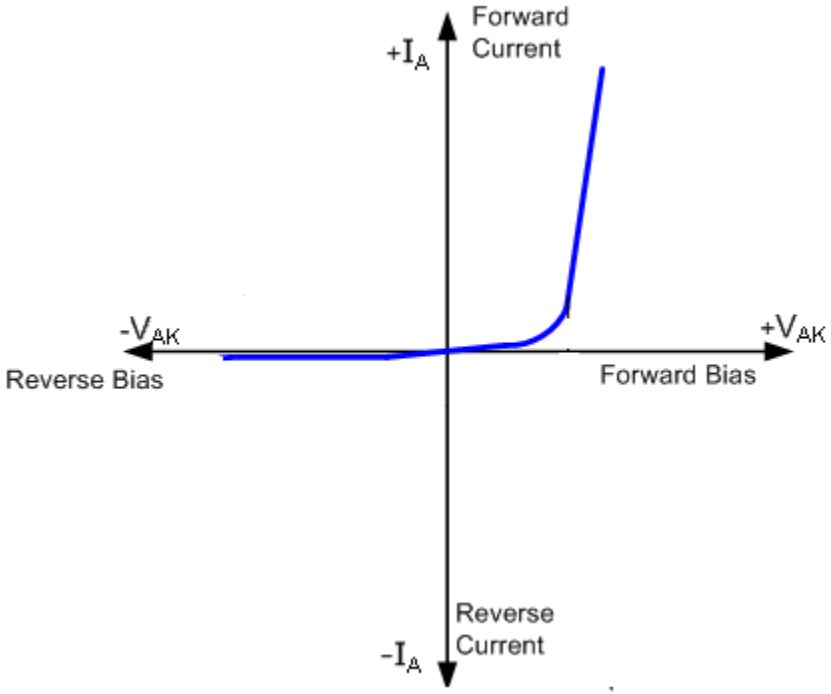


Figure 1.6: Diode characteristics curve



Diode characteristics curve

- Diode's forward voltage and reverse voltage are measured along the positive and negative x-axes respectively, while diode's forward current and reverse current are measured along the positive and negative y-axes respectively.
- Note that the diode needs a minimum voltage (called threshold or barrier or knee voltage) before it starts conducting (passing current) in the forward bias.

Testing the diode in FB direction using multimeter

- Set the digital Multimeter knob to ‘diode testing’ function.
- Now, connect the positive lead (Red) to the anode (A) and the negative lead (Black) to the cathode (K) as shown in Figure 1.8a.
- For a diode in a good condition the reading will be in the range of ≤ 0.3V for Ge and ≤ 0.7V for Si.

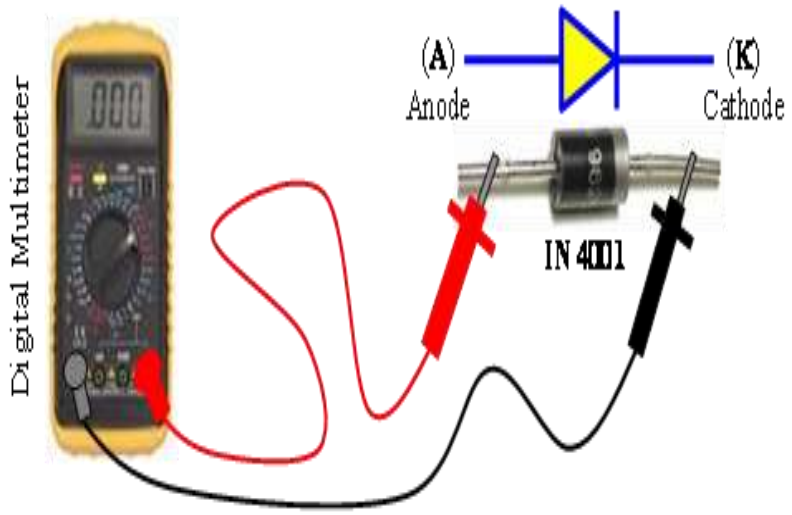
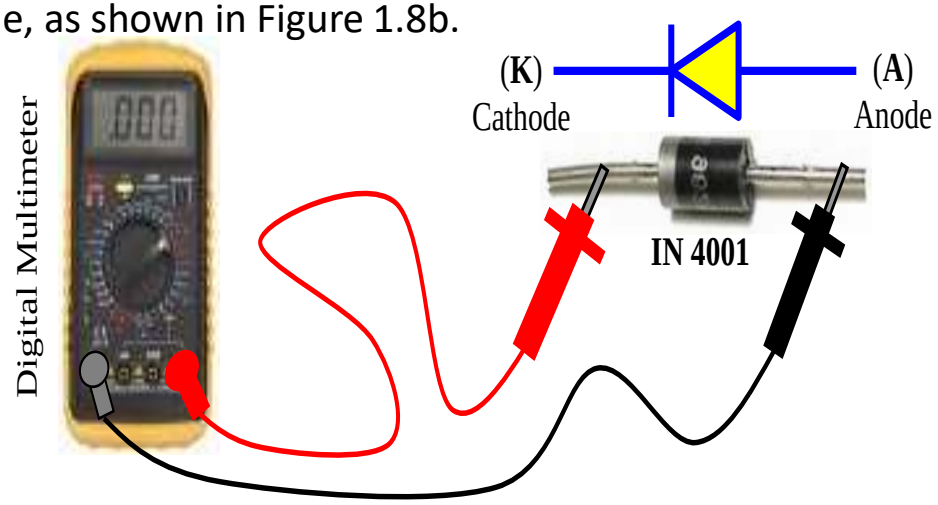


Figure 1.8b: Testing the diode in RB direction using multimeter

- Connect the positive lead to the cathode and negative lead to the anode terminals of the diode, as shown in Figure 1.8b.



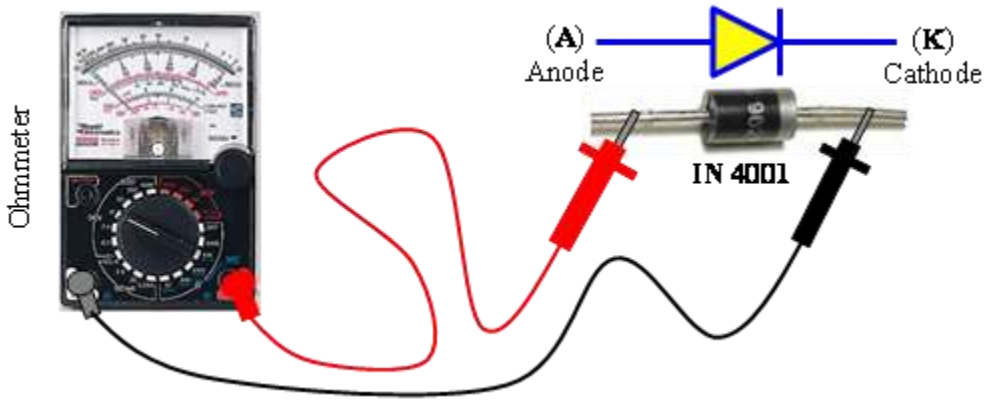
For a diode in good condition, the reading will be < 1.5V for both types.

Testing the diode in FB direction using ohmmeter

- Connect the positive meter-lead (Red) to the anode (A) and connect the negative meter-lead (Black) to the cathode (K) as shown in Figure 1.7a.

- A good diode must display low resistance (typically < 10Ω) in FB.

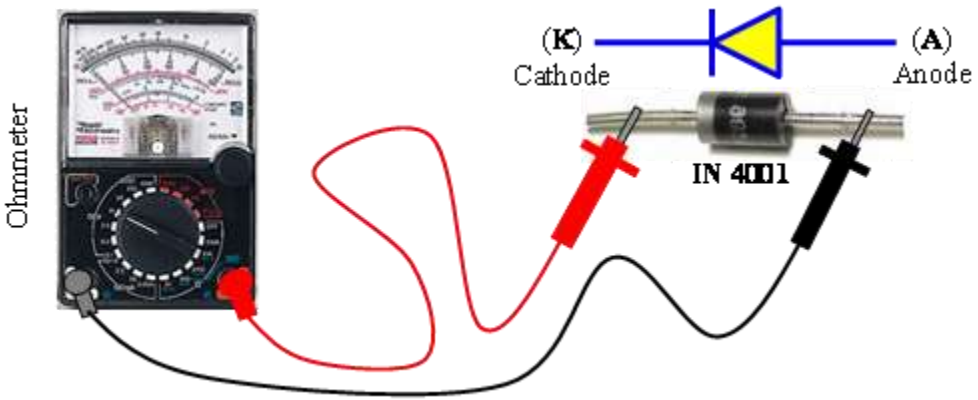
- Note that the ohmmeter consists of an internal battery (1.5 V), which can FB or RB a diode.



Testing the diode in RB direction using ohmmeter

- Connect the positive meter-lead (Red) to the cathode (K), and the negative meter-lead (Black) to the anode (A) as shown in Figure 1.7b.

- A good diode must display a very high resistance (>1000 MΩ) in RB.

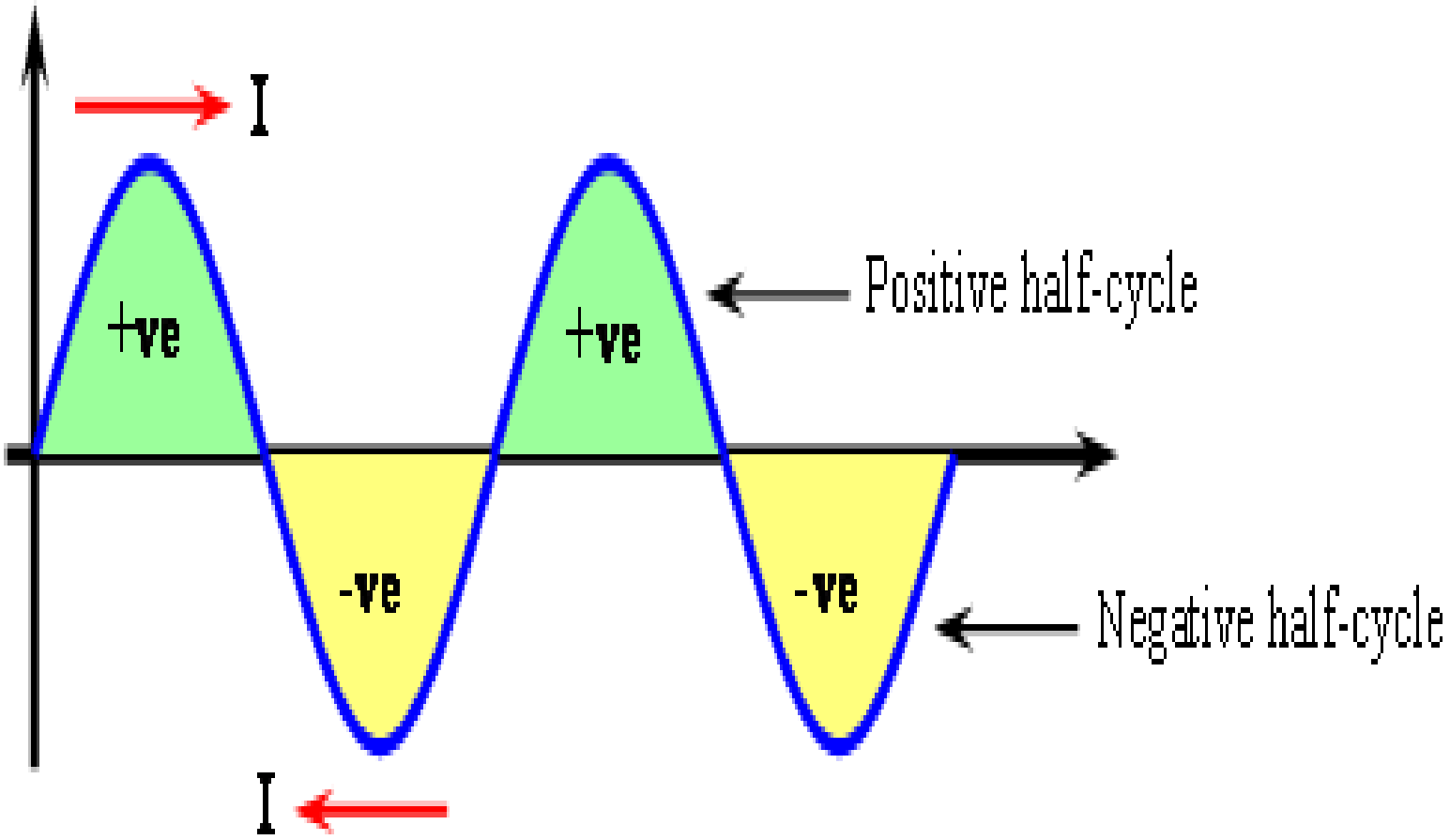


Diode Application

- Diode has a unique ability to offer very little resistance to current flow in the forward-bias direction, but maximum resistance to current flow when reverse biased. For this reason, diodes are used in rectification.
- *Rectification is the process of converting AC signal to pulsating DC signal, and the diodes used for this purpose are called rectifier diodes.*

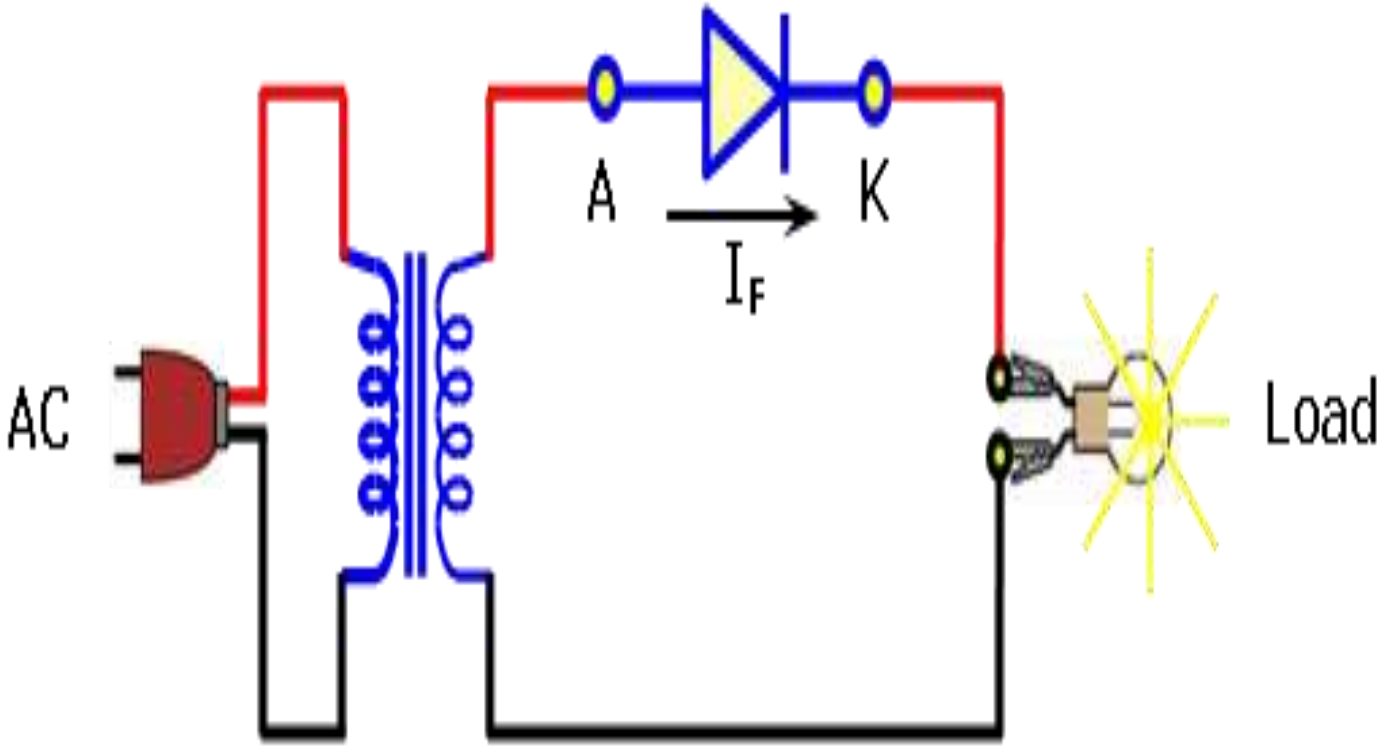
AC current behavior for a sine-wave:

Figure 1.9: Sine-wave AC current



Half-wave rectifier circuit

The *half-wave rectifier* circuit is constructed simply by connecting a diode between the secondary of a transformer and the load as shown in Figure 1.10.



Thank you