EE-241. Introductory Electronics Laboratory
Lab 2 Handout*
Diodes and their applications

Fall 2009

Motivation

A diode is a two terminal semiconductor device which allows unidirectional flow of electricity. It is regarded as a one way valve that is used in many electronic appliances and gadgets. Some examples of devices where diodes are integral part include traffic lights, scoreboards, radios and vending machines. They are also used in various circuits, usually as a form of protection.

This is the first passive "non-linear" circuit element you have encountered in electronics. Recall that many other passive components like resistors, capacitors and inductors are linear elements.

Objectives

In this course we will only concentrate on the external voltage-current characteristics of diodes and study some of their applications. You will study the basic principle of diode operation and fabrication in your *Modern Physics* and EE240 course. At the end of this lab you should know about

- Current-voltage I-V characteristics of diodes.
- Diodes as rectifiers.
- Diodes wave-shaping circuits.

Theory

Background section in Experiment 9 of Y. Tsividis *pg*. 67 - 69 and handout on diode equation.

Prelab Problems

1. Look up the data sheets of 1N4007 diode from the internet. The specifications vary for each diode. Copy the maximum/minimum rates and the electrical characteristics 1N4007 diode. Understand the terms used in the specifications.

*LUMS School of Science & Engineering, Lahore, Pakistan.

2. Draw i_D vs. v_D curve for an ideal diode.
3. What happens if you keep on increasing the voltage for a reversed-biased diode? For the ideal case, the diode will not conduct. But in real life, the diode will start conducting when the voltage v_D is increased beyond certain limit. Study and briefly explain the behavior of the reversed-biased diode.
4. Look up Zener diode. It is a special kind of diode which exhibits special properties when operated in reversed-biased region. Briefly explain the advantage of using Zener diode instead of a conventional PN-junction diode.
5. Use eq. 2 from the handout on *diode equation* to plot i_D vs. v_D curve on MATLAB.
6. How can you get a very small ripple?
7. If the capacitor is uncharged at time t = 0, does the voltage waveform v in Fig. 5 on *page* 69 make sense?

Diode Equation

Equation 1 gives the exact current flowing through the diode, given the voltage dropped across the junction, the temperature of the junction, and several physical constants. It is commonly known as the *diode equation*:

$$i_D = I_{sat}(e^{\frac{qv_D}{NkT}} - 1) \tag{1}$$

where,
i_D = diode current (*in amps*).
I_{sat} = saturation current (*in amps*) typically 10^{-12}.
e = Euler's constant ~ 2.7183
q = charge of electron (1.6 x 10 $^{-19}$ Coulombs).
v_D = voltage applied across diode (*in volts*).
N = *non-ideality* or *emission* coefficient (*typically between 1 and 2*).
k = Boltzmann's constant (1.38 x 10^{-23}).
T = junction temperature (*in Kelvins*).

Thermal voltage $V_T = (\frac{kT}{q})$ is the voltage produced within the pn junction due to temperature. Its value at room temperature is about 26 mV. Assuming a *non-ideality* coefficient of 1, the diode equation can be simplified to:

$$i_D = I_{sat}(e^{\frac{v_D}{0.026}} - 1) \tag{2}$$

According to equation (1) and (2), current i_D is exponentially related to voltage v_D in forward-biased region. For typically used values of current, the resulting steepness of the $i_D - v_D$ characteristic curve means that a large range of current variation can be obtained by varying the voltage in a narrow range, as indicated in Fig. 1(c). That is why, for commonly used current values, forward-biased diode voltage is v_D sometimes considered to be to be approximately constant ($\simeq 0.7\ V$).