KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS
DEPARTMENT OF ELECTRICAL ENGINEERING
Electronic Circuits I - EE203

Experiment # 3

Applications of Semiconductor Diodes

OBJECTIVE

To study the properties of semiconductor junction diodes and investigate some of their applications.

COMPONENTS REQUIRED

- Rectifier Diodes — DIN4148 (2 No's)
- Zener Diodes — D1N750 (Vz=3.6V, 5.1V) (2No's)
- Resistors — 1KΩ, 4KΩ

PRELAB WORK

Students must perform the following calculations before coming to the lab.

1. For the logic gate circuit of Figure 1, generate the truth table by computing the output for all possible input combinations (0 or 5V). Assume diodes with a constant forward drop of 0.7 V.
2. For the circuit of Figure 2, assume a Zener diode with a forward drop of 0.7V and a Vz=5.1V. For a sinusoidal input of (5V, 5kHz) sketch the output and label the points. Does the output shape change if the input amplitude is increased to 10V (peak)?
3. For the limiter circuit of Figure 3. Sketch the output for 5kHz input sine wave with 10V (peak) amplitude. Does the output shape change if the input amplitude is decreased to 5V (peak)?

Perform Pspice session, before coming to the Lab and save it in disk and bring it to the Lab. For details you can refer at the end of this Experiment.

SUMMARY OF THEORY

Diode is a semiconductor device that, only allow current flow in one direction. The schematic diagram is shown in Figure 1, where the line denotes cathode or the N-material while the base is the anode or the P-material. Current flows from P toN or anode to cathode.

There are many specifications for each type of diode, the most important two are: (1) PIV (Peak inverse Voltage) maximum voltages the diode can tolerate in reverse direction. (2) I_F (Forward Current) maximum forward current though diode when it is conducting.

Diodes have small impedance to current flow in one direction (forward-biased) and large impedance in the reverse-biased mode. When diodes fail they either short-circuit (pass current in both directions – i.e. low resistance in both directions) or open-circuit (do not pass current at all). Since the low impedance path is the one from anode to cathode, one needs to know which end is which.

Diodes are widely used in applications such as mixers, detectors, protection circuits. In this experiment you will investigate few applications of diodes such as AND gate, halfwave rectfier and Zener limiter. Diode limiters are waveshaping circuits in that they are used to prevent signal voltage from going above or below certain levels. Because of this clipping capability, the limiter is also called clipper.

EXPERIMENTAL WORK

Before you connect the circuit test the diode using Digital multimeter (DMM) and Curve tracer; instructor will examine your procedure.

1. Connect the circuit of Figure 1 (See Diode Configuration); generate the truth table by computing the output for all possible input combinations (0 or 5V. Measure the output voltage using a voltmeter. What logic function does the circuit perform?

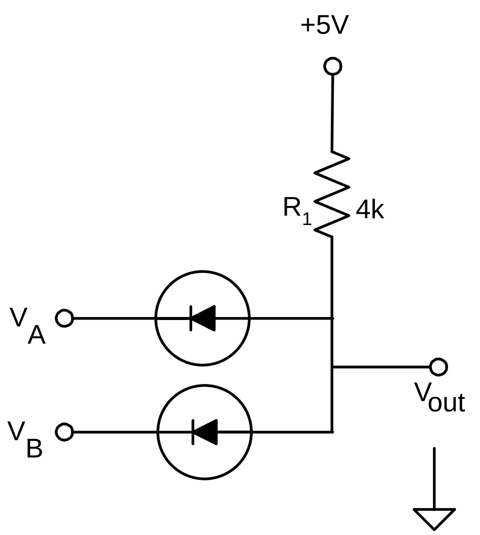
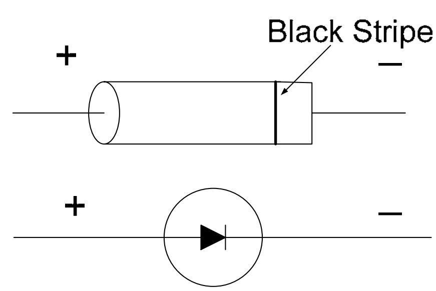


Figure 1



Diode Configuration

2. For the Circuit of Figure 2, set the signal generator with sinusoidal input of 5kHz with amplitude of approximately 5V. (Make sure the DC offset on your signal generator is zero.) Sketch the input versus the output as a function of time. Use the X-Y mode of Oscilloscope to plot transfer function.

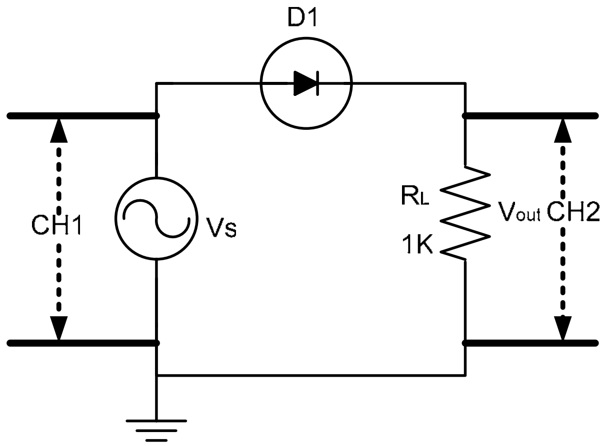


Figure 2

3. Reverse the polarity of the diode (turn it around). Now repeat the above exercise. What's the difference in output versus input signals with the diode reversed?
4. Replace the Rectifier diode with Zener diode. Sketch the output signal as observed on the oscilloscope. Increase the input signal amplitude until you notice a change in the output signal. Write down the input peak amplitude at which the output changes. What is the effect of the diode breakdown voltage on the output?
5. Connect the circuit of Figure 3 with similar (Vz=3.6V) zener diodes, Apply a 5 KHz sine wave with 10V (peak) amplitude. Sketch the output and transfer function as observed on the oscilloscope and label the important points. Vary the input amplitude and notice the effect on the output. What is the function of this circuit?
6. Use two different zener diodes (Vz=3.6V, 5.1V) and repeat step 5.

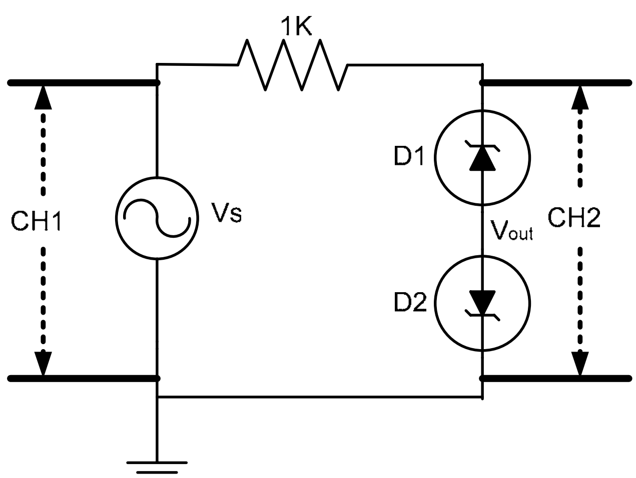


Figure 3

PSPICE WORK

Parts to be used in the PSpice:

Part Name	Pspice Name
Resister	R
Diode	D1N4148
Zener Diode	D1N750
DC source	VDC
Electrical Ground	EGND
Transient sine voltage source	VSIN
Voltage View Point	VIEWPOINT
Pulse voltage Source	VPULSE

DC Analysis

Q1. Draw PSPICE for the circuit in Figure 1. Apply DC inputs of 0 or 5V (you can use ground and VDC for 0 and 5V respectively). Measure the output voltage for all input combination (Use VIEWPOINT to observe output).Record the result in the table.

V_A	V_B	V_{out}
0	0	
0	5	
5	0	
5	5	

Transient Analysis

Q2. Draw the circuit in Figure 2, using PSPICE. Apply sinusoidal input voltage with 5V amplitudes and 5 kHz Frequency. (Double click the *VSIN* source and change only *Vamp* and *Freq*, and make all other values zero). Go to *analysis* →set up choose transient analysis, choose print step—20ns, Final time----1ms (5cycles), save and choose *Simulate* from *analysis*, you will observe a Probe Window, Go to *Trace* →to *Add Trace*, in that add the input and output traces. (Note: You can also use *voltage Marker* to plot the input & output directly). Repeat the same procedure for Zener diode with 5V and then 10V amplitude at 5 KHz Frequency.

Q3. For the limiter circuit, draw the circuit in Figure 3, using PSPICE. Follow same procedure used in previous question. Find the voltage output using the probe (show 5-cycles).

In your lab write-up make sure to include **printouts of the simulation results**.

DATA SHEET

Small Signal Diode

Absolute Maximum Ratings* T_A = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{RRM}	Maximum Repetitive Reverse Voltage	100	V
$I_{F(AV)}$	Average Rectified Forward Current	200	mA
I_{FSM}	Non-repetitive Peak Forward Surge Current Pulse Width = 1.0 second Pulse Width = 1.0 microsecond	 1.0 4.0	 A A
T_{stg}	Storage Temperature Range	-65 to +200	°C
T_J	Operating Junction Temperature	175	°C

*These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

NOTES:
1) These ratings are based on a maximum junction temperature of 200 degrees C.
2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

Table 1

A manufacturer's data sheet gives detailed information on a device so that it can be used properly in a given application. A typical data sheet provides maximum ratings, electrical characteristics, mechanical data and graphs of various parameters.

Table 1, shows the maximum ratings for a D1N4148 rectifier diode. These are the absolute maximum values under which the diode can be operated without damage to device. For general reliability and longer life, the diode should always be operated well under these maximums. Generally, the maximum ratings are specified at 25^{o}C and must be adjusted downward for higher temperatures.

Explanation of the parameters from Table 1.

- V_{RRM}----The maximum reverse peak voltage that can be applied repetitively across the diode, Notice in this case, it is 100 V. This is same as PIV ratings.
- I_{FSM}-----The maximum peak value of nonrepetitive (one cycle) forward surge current.

Other parameters are clear from Table1.

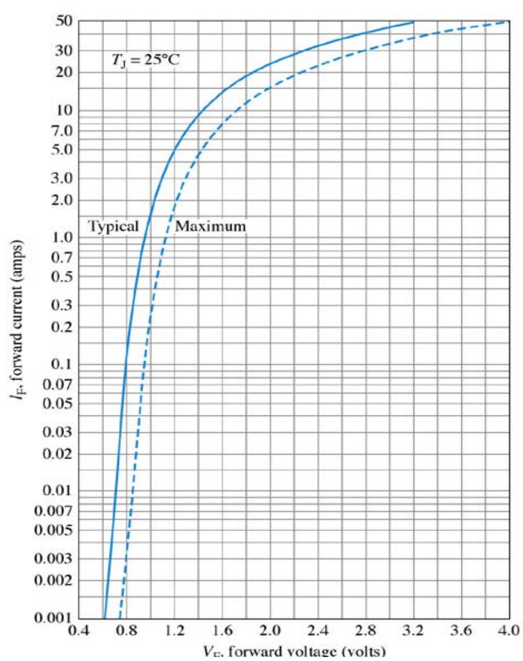
Table 2 shows, typical and maximum values for certain electrical characteristics. These items differ from the maximum ratings in that they are not selected by design but are the results of operating the diode under specified conditions. A brief explanation of these parameters follows.

Electrical Characteristics T_A = 25°C unless otherwise noted

Symbol	Parameter		Test Conditions	Min	Max	Units
V_R	Breakdown Voltage		I_R = 100 µA I_R = 5.0 µA	100 75		V V
V_F	Forward Voltage	**1N914B/4448** **1N916B** **1N914/916/4148** **1N914A/916A** **1N916B** **1N914B/4448**	I_F = 5.0 mA I_F = 5.0 mA I_F = 10 mA I_F = 20 mA I_F = 20 mA I_F = 100 mA	620 630	720 730 1.0 1.0 1.0 1.0	mV mV V V V V
I_R	Reverse Current		V_R = 20 V V_R = 20 V, T_A = 150°C V_R = 75 V		25 50 5.0	nA µA µA
C_T	Total Capacitance	 **1N916A/B/4448** **1N914A/B/4148**	 V_R = 0, f = 1.0 MHz V_R = 0, f = 1.0 MHz		 2.0 4.0	 pF pF
t_{rr}	Reverse Recovery Time		I_F = 10 mA, V_R = 6.0 V (60mA), I_{rr} = 1.0 mA, R_L = 100Ω		4.0	ns

Table 2

- V_F---- The instantaneous voltage across the forward-biased diode for different forward current at 25^0C. Figure below shows how forward voltage vary with forward current for a typical diode.



- I_R--- The maximum current when the diode is reverse-biased with a dc voltage
- V_R---The maximum reverse dc voltage that can be applied across the diode. Other parameters are clear from Table 2.