XMUT204 Electronic Design

Assignment 2: Diode Circuits and Applications

Due date: Friday, 4th April 2025 (online submission to XMUT204 website at VUW)

1. Calculate the built-in potential that will be formed across the p-n junction (no bias) between p-type silicon with a doping level N_A = 1 x 10^{15} cm^{-3} and n-type silicon with a doping level of N_D = 1 x 10^{16} cm^{-3}. Calculate the height of the potential energy barrier that will prevent majority carriers from crossing over this barrier. [10 marks]

2. Load line and the I-V curve of diode characteristics will enable you to determine the most efficient set up of diode-based circuit. Referring to the diode circuit shown in Figure 1 below,

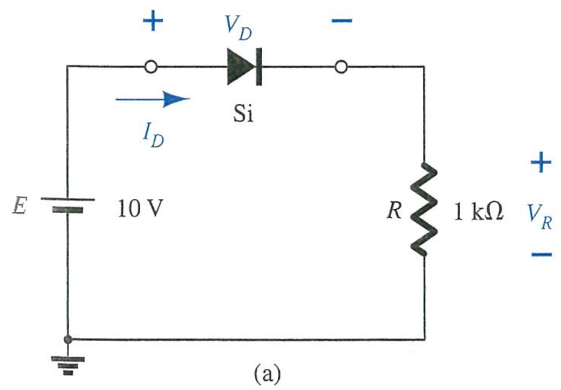

Figure 1: A diode circuit

   a. Referring to the lab exercise results, use the diode equation (Ebers-Moll) and a software package such as Excel or Matlab to accurately draw the theoretical I-V curve for a diode which has a value of I_S = 1 x 10^{-9} A. Sketch the resultant diode curve for both the forward bias and reverse bias regions (separate graphs). [10 marks]

   b. Use the forward bias diode curve of part a. above and the load line technique to calculate the diode current and diode voltage that will result if the diode is forward biased by a 10 V power supply and a 1kΩ current limiting resistor is placed in series.
   [5 marks]

   c. Repeat your calculations but for a 2k Ω current limiting resistor in place. [5 marks]

3. Use the ideal diode model and the assumed states method and determine state of the diodes and all important currents and voltages in the circuit in Figure 2 below: [10 marks]

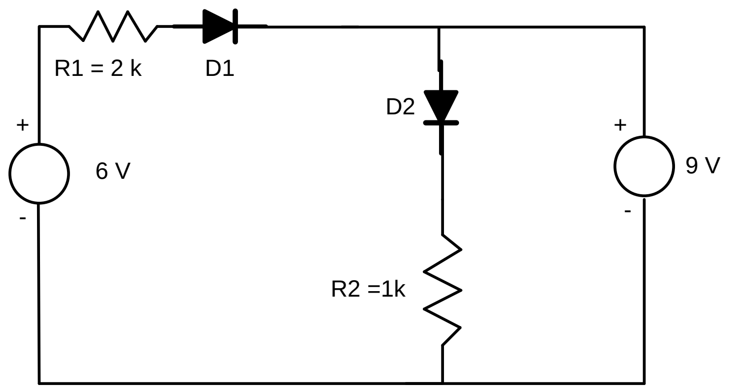

Figure 2: A diode circuit with two loops

4. Repeat Question 3, but use the ideal diode + voltage source model to achieve more accurate estimations of currents and voltages in the circuit. [10 marks]

5. Zener diode is quite often used in voltage stabilisation and regulation applications.

   a. For the circuit given in Figure 3 below calculate the minimum input voltage required for stable regulation if it is given that I_{zk} = 2.5 mA and V_Z = 5 V. [5 marks]

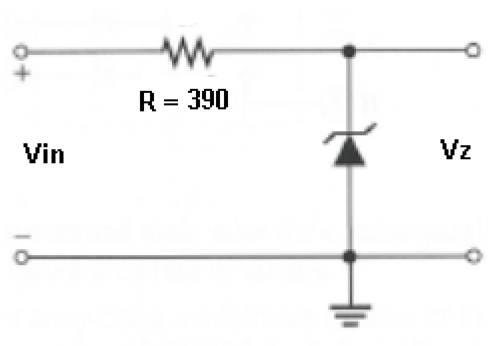

Figure 3: A Zener diode circuit

   b. Referring to the equivalent circuit shown in Figure 4 below, calculate the value to which R_v should be adjusted in order to have a current through the Zener I_Z = 30 mA at V_{in} = 15 V. It is given that V_Z = 12 V at 20 mA and R_Z = 30 Ω. [5 marks]

   Note: the resistance value calculated may be a negative value; explain how to resolve this problem (so that we get a positive resistance value).

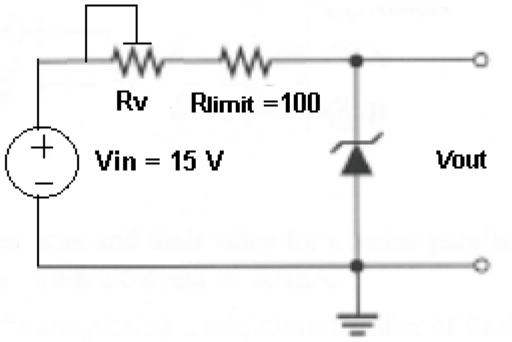

Figure 4: A Zener diode circuit with variable resistor

6. Determine the output waveform of the network in Figure 5 below and calculate the output DC level as well as the required peak inverse voltage of the diodes. [10 marks]

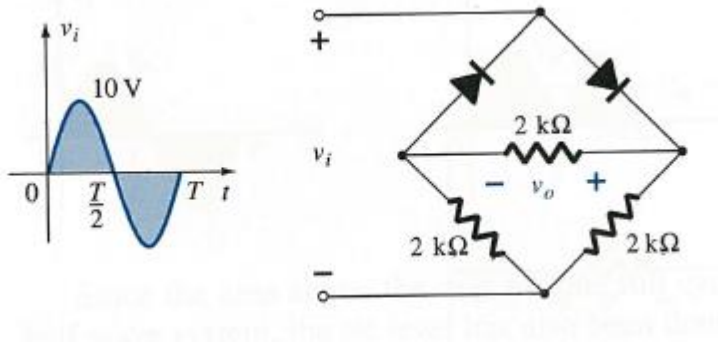

Figure 5: A modified full-bridge rectifier circuit with resistors

7. Referring to the network circuit given in the Figure 6 below, determine the output waveform for the given input waveform. Calculate the output voltages and the discharge time of the circuit. [10 marks]

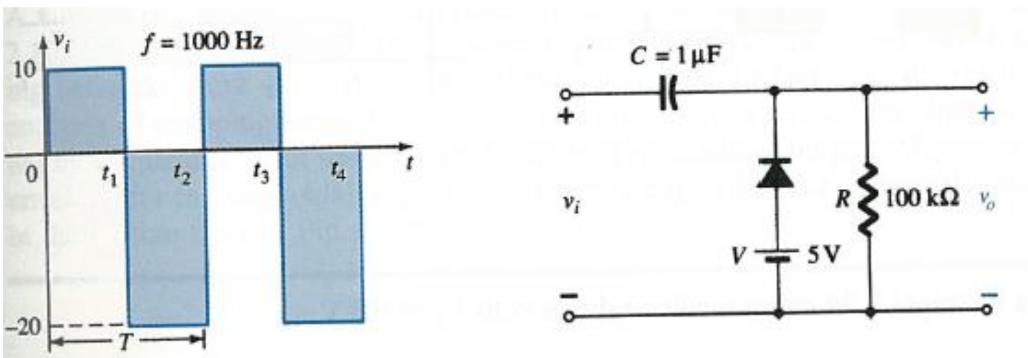

Figure 6: A diode-based signal clamper circuit

Marking Schedule

Student ID : ______________________________

Student Name : ______________________________

No	Description	Mark	Your Mark	Remarks
1	Built-in potential and height of potential energy barrier.	10		
2	a. Load line	10		
	b. The current and voltage of diode (1kΩ case).	5		
	c. The current and voltage of diode (2kΩ case).	5		
3	State of diodes, currents and voltages of ideal diode model.	10		
4	State of diodes, currents and voltages of ideal diode + voltage source model.	10		
5	a. Minimum input voltage.	5		
	b. Value of variable resistor.	5		
6	Output waveform, DC level voltage and PIV of the circuit.	10		
7	Output waveform, output voltage and discharge time of the circuit.	10		
	Total	80		

Comment: