# I-V characteristics of Schottky and Zener Diodes

Wadhwani Electronics Lab 2021-22 (Spring Semester)

# Aim of the experiment

- To plot i-v characteristics of Schottky diode and extract the parameters from the plot.
- To compare the above parameters with normal PN Junction diode.
- To plot i-v characteristics of Zener diode and find it's usage in Zener regulator.
- To design the circuit for the given transfer characteristics.
- To observe the output for a simple "Voltage Doubler" circuit using diodes.

# Schottky Diode

- In a Schottky diode, a semiconductor–metal junction is formed between a semiconductor and a metal, thus creating a Schottky barrier.
- N-type semiconductor acts as a cathode and the metal side acts as an anode of the diode.
- This Schottky barrier results in both, a low forward voltage drop and very fast switching.

# Schottky Diode-Simulation Exercise

1. Write the netlist to plot i-v characteristics of schottky diode same as you did for the Si diode and LEDs in Lab-1. **(Use BAT85 and BAT960 model files provided)**
2. Find cut-in voltage from i-v characteristics and compare it with normal PN Junction diode.
3. Now, replace a PN junction diode with schottky diode in the rectifier circuit and compare rectified outputs.
4. Find reverse recovery time of schottky diode by applying pulse input of 100 KHz and why it is different with normal Si diode
5. From the above measured reverse recovery time, comment about few applications where schottky diode can be used.

# Zener Diode I-V Characteristics

A Zener Diode is a special kind of diode which permits current to flow in the forward direction as normal, but will also allow it to flow in the reverse direction when the voltage is above the breakdown voltage or 'zener' voltage.

**The aims of the experiment:**

- To determine the forward and reverse I-V characteristics.
- To determine the break-down voltage of the Zener diode.
- How is it different from normal diode?
- How the Zener Diode can be used in different types of Voltage Regulator Circuits?

# Theory

- Two physical mechanisms give rise to the reverse-biased breakdown in a pn junction.
  - Zener Breakdown
  - Avalanche Breakdown
- A Zener breakdown occurs in highly doped pn junctions through a tunneling mechanism.
- In a highly doped junction, the conduction and valence bands on opposite sides of the junction are sufficiently close during reverse bias that electrons may tunnel directly from the valence band on the p-side into the conduction band on the n-side.

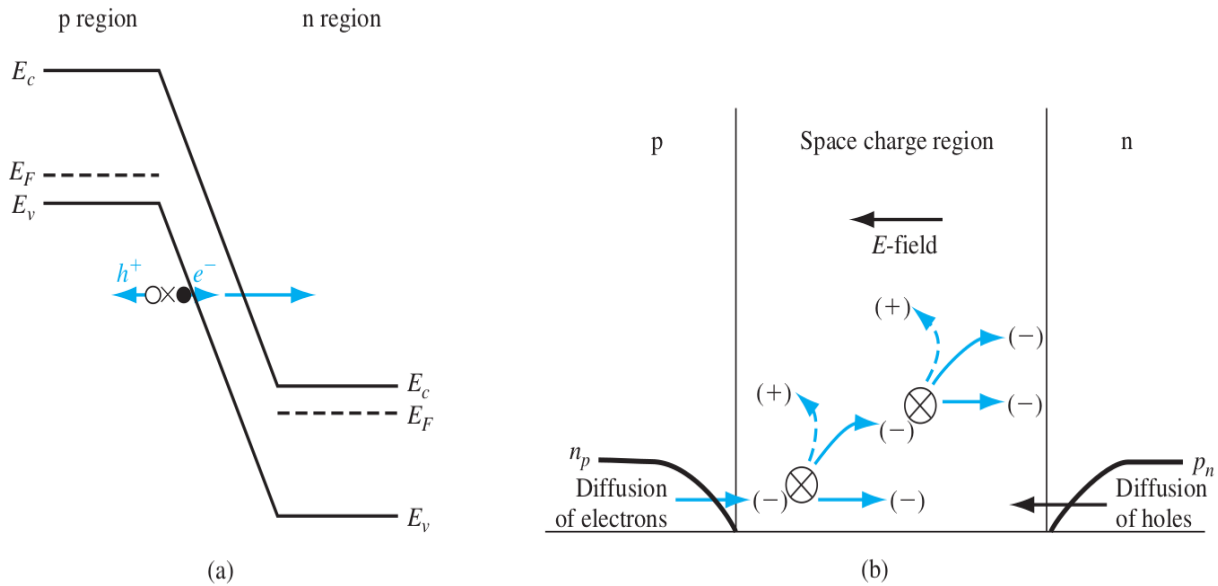



Figure: (a) Zener breakdown mechanism in a reverse-biased pn junction; (b) avalanche breakdown process in a reverse-biased pn junction.[1]

[1] **Semiconductor Physics and Devices by Neaman.**

# Zener Diode- Simulation Exercise

1. Write the netlist to plot i-v characteristics of Zener diode same as you did it for Si diodes and LEDs in Lab-1.
2. This time you have to do the simulation for both the positive and negative voltage range.

# Zener Diode in Voltage Regulator Experiment

1. Make the connections as per the circuit diagram.
2. Vs is the unregulated power supply. Unregulated power supply is the output of the full-wave bridge rectifier with capacitor filter.
3. Calculate the value of Rs if the maximum power rating of the Zener is 1 watt with break-down voltage of 5.6 V
4. Why the BJT is required in the circuit?

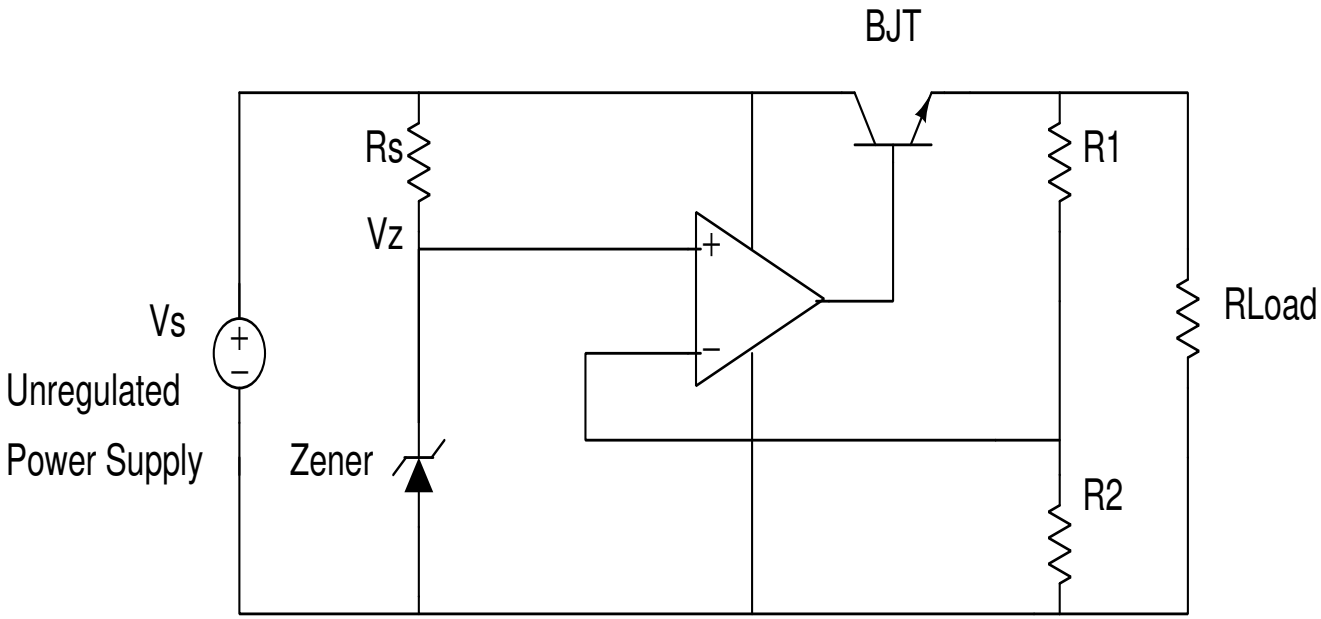



Figure: Voltage Regulator Circuit

# Components Required and Specification of the Regulator

Components are as follow:

1. BJT bc547
2. Zener diode
3. Op-Amp ua741
4. Un-regulated power-supply and Resistances as required

Specifications:

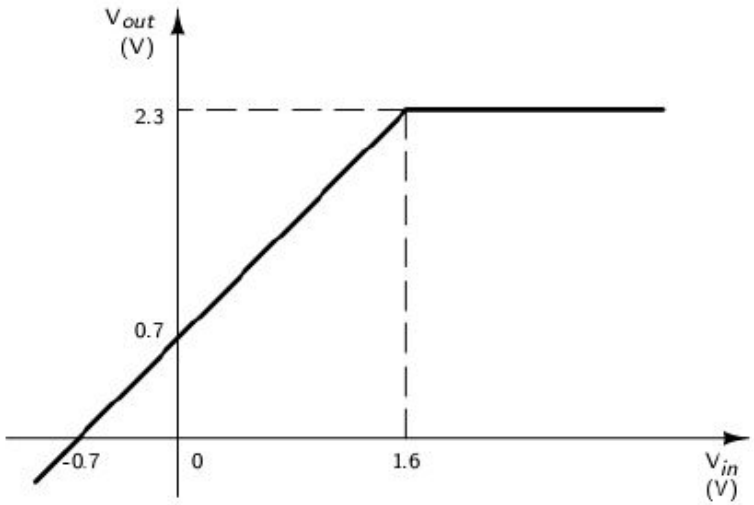
1. Regulated out-put is 9 V
2. Un-regulated input is 15 V

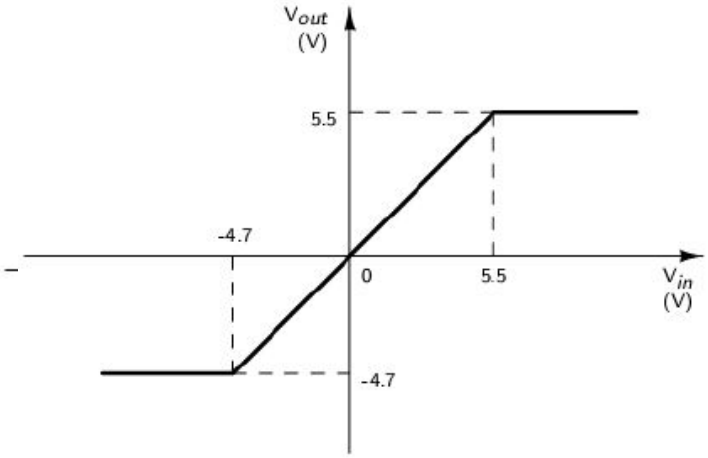
**Exercise:**

1. Plot the transfer characteristics of the regulator.
2. What are the limiting factors those will affect the limit of the load? How will you overcome those?
3. Why the BJT is required here?
4. Check the transient response also.

# Designing circuit from transfer characteristics

1. Design the circuits to generate the transfer characteristics shown in the below figures (Hint: Refer to the circuits which you have exercised in Lab-0)




2. Write ngspice netlist for the above designed circuits and run the simulations to verify your designs.

# Simple application circuit using diode and capacitor: Voltage Doubler

1. Try to analyze the circuit shown in the below figure
2. What are the voltages to which the capacitors C1 and C2 in the circuit charge?
3. What is the output of the circuit?
4. Write ngspice netlist and simulate the circuit. Verify your analysis.
5. What will be the change in output if the resistor is replaced by a 4.7 kOhms resistor?