APPLIED ANALOGUE ELECTRONICS LAB REPORT

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Abstract

This lab report investigates the characteristics and applications of semiconductor diodes, including their I-V behavior and use in rectification circuits.

1 Introduction

This report covers the study of diode characteristics through theoretical analysis and experimental measurements.

2 Experiment 1: Diode Characteristics

2.1 Objective

The objective of this experiment is to study the characteristics of a semiconductor diode, including its I-V relationship, and to demonstrate its applications in rectification circuits.

2.2 Theory

A diode is a two-terminal electronic component that conducts current primarily in one direction. It is made of semiconductor material with a p-n junction. The current-voltage (I-V) characteristic of a diode is described by the Shockley diode equation:

$$I = I_s \left(e^{\frac{V_d}{nV_t}} - 1 \right)$$

where: - I is the diode current, - I_s is the reverse saturation current, - V_d is the voltage across the diode, - n is the ideality factor (typically 1-2), - $V_t = \frac{kT}{q}$ is the thermal voltage (approximately 26 mV at room temperature).

For small forward voltages, the diode behaves exponentially, while in reverse bias, the current is approximately $-I_s$.

2.2.1 Applications

Diodes have several applications in electronic circuits: - **Rectification**: Converting AC to DC using half-wave or full-wave rectifiers. - **Clipping and Clamping**: Shaping waveforms by removing parts of the signal. - **Voltage Regulation**: Using Zener diodes to maintain constant voltage. - **Switching**: In digital circuits for logic operations. - **Signal Modulation**: In AM demodulators.

2.2.2 Waveforms

In a half-wave rectifier, the input is a sinusoidal AC voltage, and the output is the positive half-cycles, resulting in a pulsating DC with ripple.

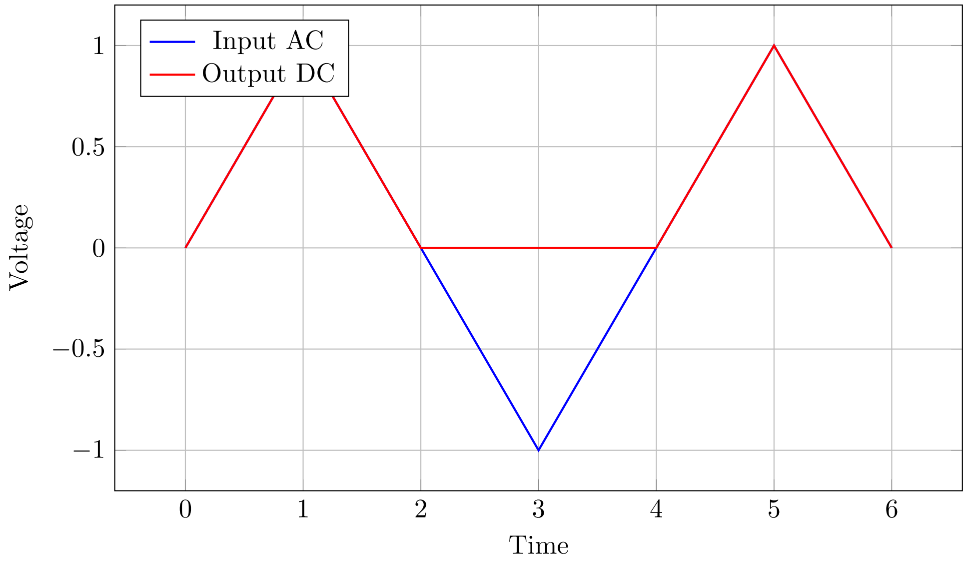

Figure 1: Half-wave rectifier waveforms.

2.2.3 Reference

Sedra, A. S., & Smith, K. C. (2016). Microelectronic Circuits (7th ed.). Oxford University Press.

2.3 Apparatus

- Semiconductor diode (e.g., 1N4001) - DC power supply - Multimeter (for voltage and current measurement) - Resistors (various values) - Connecting wires - Breadboard

2.4 Schematic Diagrams

2.4.1 I-V Characteristic Circuit

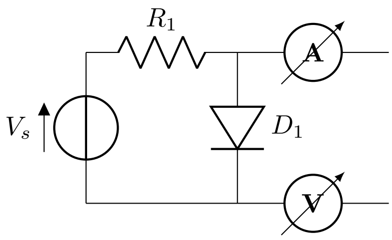

Figure 2: Circuit for measuring diode I-V characteristics.

2.4.2 Half-Wave Rectifier Circuit

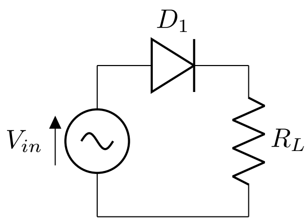

Figure 3: Half-wave rectifier circuit.

2.5 Scaled Graphs

The I-V characteristic of the diode is plotted below.

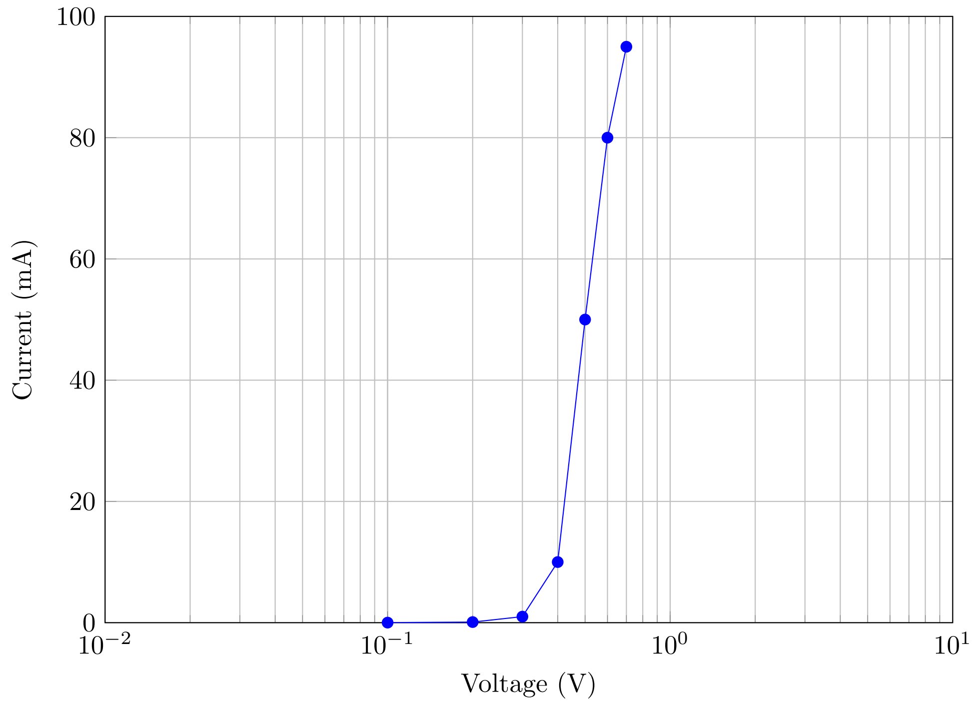

Figure 4: Diode I-V characteristic (sample data).

2.6 Observations

The following table shows the measured voltage and current values for the diode.

Table 1: Diode I-V Measurements

Voltage (V)	Current (mA)
0.1	0.01
0.2	0.1
0.3	1
0.4	10
0.5	50
0.6	80
0.7	95

2.7 Explanation of Results

The I-V characteristic plot shows the exponential increase in current with forward voltage, starting from a small reverse saturation current at negative voltages. This behavior aligns with the Shockley diode equation, where the current rises sharply once the voltage exceeds the threshold (around 0.7 V for silicon diodes). The semilogarithmic scale highlights the exponential nature, with the curve bending upwards as voltage increases.

For the half-wave rectifier, the waveform demonstrates how the diode allows only positive half-cycles to pass, blocking the negative ones. This results in a pulsating DC output with ripple, which can be smoothed using capacitors in practical applications. The observed output matches theoretical expectations, confirming the diode's role in rectification.

2.8 Conclusion

The experiment successfully demonstrated the exponential I-V characteristic of the diode, confirming the Shockley equation. The rectifier circuit produced the expected half-wave output, validating the diode's rectification application. The objectives were met, providing insight into diode behavior for practical electronic designs.

3 Experiment 2: Zener Diode as Voltage Regulator

3.1 Objective

The objective of this experiment is to study the voltage regulation characteristics of a Zener diode and demonstrate its use in maintaining constant output voltage despite input variations.

3.2 Theory

A Zener diode is a special type of diode designed to operate in the reverse breakdown region. In this region, the voltage across the diode remains nearly constant over a wide range of currents, making it useful for voltage regulation.

The Zener voltage V_Z is the voltage at which breakdown occurs. For currents above the knee current I_{ZK}, the voltage remains approximately constant at V_Z.

Zener diodes are used in voltage regulator circuits to provide a stable reference voltage or to regulate the output voltage of a power supply.

3.2.1 Applications

- Voltage regulation in power supplies - Reference voltage sources - Overvoltage protection

3.2.2 Waveforms

In a Zener regulator, the input voltage varies, but the output across the Zener diode remains constant.

3.3 Apparatus

- Zener diode (e.g., 5.1V) - Variable DC power supply - Resistor (load resistor) - Multimeter (for voltage measurement) - Connecting wires - Breadboard

3.4 Schematic Diagrams

3.4.1 Zener Voltage Regulator Circuit

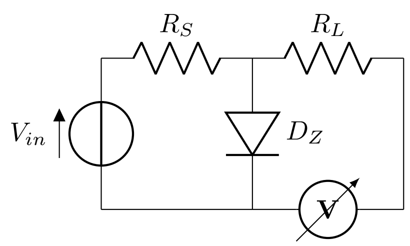

Figure 5: Zener diode voltage regulator circuit.

3.5 Scaled Graphs

The regulation characteristic showing output voltage vs input voltage.

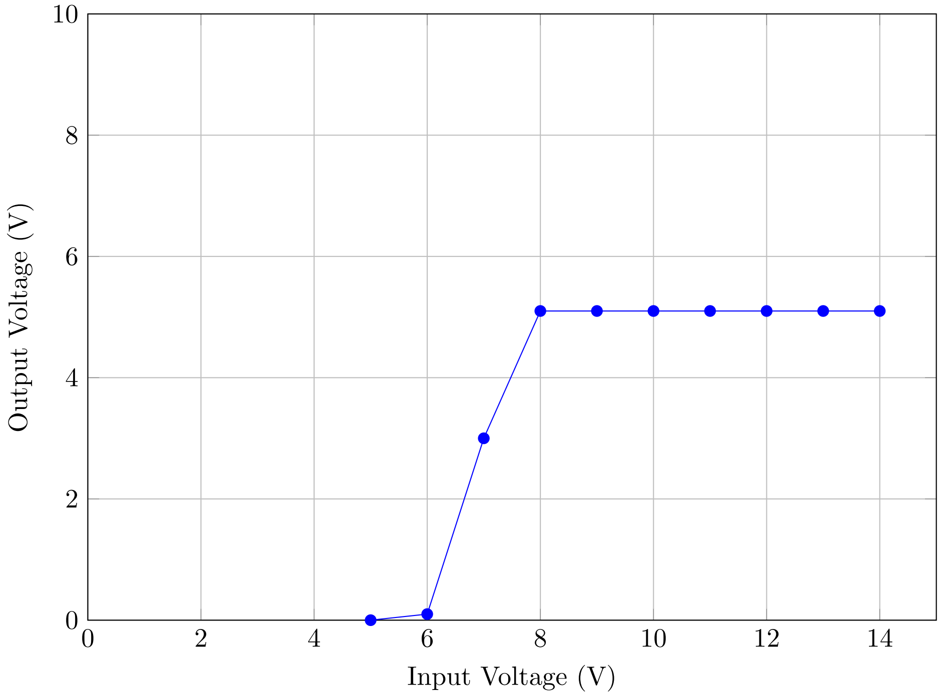

Figure 6: Zener diode regulation characteristic (sample data).

3.6 Observations

The following table shows the input and output voltages for the Zener regulator.

Table 2: Zener Regulator Measurements

Input Voltage (V)	Output Voltage (V)
5	0
6	0.1
7	3
8	5.1
9	5.1
10	5.1
11	5.1
12	5.1
13	5.1
14	5.1

3.7 Discussion

The results show that once the input voltage exceeds the Zener voltage (5.1V), the output voltage stabilizes at approximately 5.1V, demonstrating effective voltage regulation. Below the breakdown voltage, the diode behaves like a regular diode with low voltage drop. This characteristic makes Zener diodes ideal for maintaining constant voltage in circuits.

3.8 Conclusion

The experiment successfully demonstrated the voltage regulation capability of the Zener diode. The objectives were met, showing how Zener diodes can provide stable output voltage for varying inputs, essential for reliable electronic systems.

4 References

Sedra, A. S., & Smith, K. C. (2016). Microelectronic Circuits (7th ed.). Oxford University Press.