NATIONAL UNIVERSITY OF SCIENCES & TECHNOLOGY

SCHOOL OF MECHANICAL AND MANUFACTURING ENGINEERING

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SEMESTER # 03 **CLASS: - ME 15 [SEC A]**

ELECTRICAL ENGINEERING

LAB No. 07

Half-Wave and Full-Wave Rectifiers

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Submitted to SANIA SHAHEEN

Assessment Rubrics for EE-103 Electrical Engineering Lab

	Excellent (9-10)	Good (7-8)	Fair (4-6)	Poor (1-3)
Introduction and Theory	Complete and well written; provides all necessary background principles for the experiment	Nearly complete, missing some minor points	Some introductory information, but still missing some major points	Very little background information provided, or information is incorrect
Experimental Procedure	Well-written in paragraph format, all experimental details are covered	Written in paragraph format, important experimental details are covered, some minor details missing	Written in paragraph format, still missing some important experimental details	Missing several important experimental details or not written in paragraph format
Results: data, figures, graphs, tables, etc.	All figures, graphs, tables are correctly drawn, are numbered and contain titles/captions.	All figures, graphs, tables are correctly drawn, but some have minor problems or could still be improved	Most figures, graphs, tables OK, some still missing some important or required features	Figures, graphs, tables contain errors or are poorly constructed, have missing titles, captions or numbers, units missing or incorrect, etc.
Discussion	All-important trends and data comparisons have been interpreted correctly and discussed, good understanding of results is conveyed.	Almost all the results have been correctly interpreted and discussed, only minor improvements are needed.	Some of the results have been correctly interpreted and discussed; partial but incomplete understanding of results is still evident.	Very incomplete or incorrect interpretation of trends and comparison of data indicating a lack of understanding of results.
Conclusion	All-important conclusions have been clearly made, student shows good understanding	All-important conclusions have been drawn, could be better stated	Conclusions regarding major points are drawn, but many are misstated, indicating a lack of understanding	Conclusions missing or missing the important points
Report Formatting, structure and referencing	All sections in order, well formatted, very readable. References provided appropriately	All sections in order, formatting generally well, but could still be improved. References provided, but not entirely	Sections in order, contains the minimum allowable amount of handwritten copy, formatting is rough but readable. Improper References	Sections out of order, too much handwritten copy, sloppy formatting. No referencing at all.

Plagiarism in any case will result in zero mark in that session. *LE Sania Shaheen*

Contents

LAB No. 07: Half-Wave and Full-Wave Rectifiers

➢ Objectives

1. To familiarize oneself with the use of diodes.
2. To learn how to test a diode.
3. To construct a half-wave rectifier circuit.
4. To construct a full-wave bridge rectifier.
5. To analyze the rectified circuit output using a Cathode Ray Oscilloscope (CRO).

➢ Tools Used

- Diodes
- Resistor
- Multimeter
- Oscilloscope (CRO)
- Function generator
- Connecting wires

Rectifiers are essential circuits in electronics that convert alternating current (AC) into direct current (DC). This is particularly useful because most electronic devices require DC to operate, while power sources, like wall outlets, usually supply AC. There are two primary types of rectifiers: **half-wave rectifiers** and **full-wave rectifiers**. In this experiment, we explore how these rectifiers work and their construction[1]

Diodes and Rectification

A **diode** is a semiconductor device that allows current to flow in only one direction. It has two terminals, the **anode** and the **cathode**. Diodes are essential components in rectifier circuits, as they can block half of the AC waveform (negative or positive half), allowing current to flow only during the desired half-cycle. [1]

1. **Forward Bias**: When the positive terminal of a voltage source is connected to the anode and the negative terminal to the cathode, the diode becomes forward-biased, allowing current to flow through it. In this state, the diode has a small voltage drop, typically around 0.7V for silicon diodes. [1]

2. **Reverse Bias**: When the polarity is reversed (positive to cathode, negative to anode), the diode is reverse-biased and blocks the current flow. This property makes diodes useful for controlling the direction of current in rectifier circuits. [1]

Half-Wave Rectifier

A **half-wave rectifier** is the simplest form of rectification circuit, employing a single diode in series with the load. In this circuit:

- During the positive half-cycle of the AC signal, the diode is forward-biased, allowing current to flow through the load resistor and produce a DC output.
- During the negative half-cycle, the diode is reverse-biased and blocks the current, resulting in no output for that half-cycle.

As a result, the half-wave rectifier only passes one half of the AC signal (either positive or negative), converting it into a pulsating DC output. However, this type of rectification is inefficient because it discards half of the input waveform, resulting in a lower average DC output voltage and a high ripple factor (variability in the DC output). [1]

Advantages of Half-Wave Rectifier:

- Simple construction and easy to implement.
- Requires only one diode and a few components.

Disadvantages of Half-Wave Rectifier:

- Low efficiency since it only utilizes half of the AC cycle.
- High ripple factor, resulting in an unstable DC output.
- Limited applications due to poor quality of DC output.

Ripple Factor: The ripple factor in a half-wave rectifier is relatively high due to the large gap between each pulse of output. The ripple factor is a measure of how much AC component remains in the DC output, which is undesirable in applications requiring smooth DC. [1]

Full-Wave Rectifier

A **full-wave rectifier** converts the entire AC waveform (both positive and negative halves) into DC, making it more efficient than a half-wave rectifier. This is achieved using a **bridge rectifier** configuration, which consists of four diodes arranged in a bridge structure. The full-wave rectifier works as follows:

- During the positive half-cycle of the AC signal, two of the diodes (D1 and D2) become forward-biased and allow current to pass through the load resistor in one direction.
- During the negative half-cycle, the other two diodes (D3 and D4) become forward-biased and conduct current in the same direction through the load resistor, effectively flipping the polarity of the negative half-cycle.

This arrangement ensures that both halves of the AC waveform contribute to the DC output, effectively doubling the frequency of the rectified output compared to the input AC frequency. The result is a smoother, higher average DC voltage with a lower ripple factor, making the output more suitable for practical applications. [1]

Advantages of Full-Wave Rectifier:

- Higher efficiency as it utilizes both halves of the AC cycle.
- Produces a higher average DC output voltage.
- Lower ripple factor, resulting in a smoother DC output.

Disadvantages of Full-Wave Rectifier:

- More complex construction, requiring four diodes in a bridge configuration.
- Greater power losses due to the presence of more diodes.

Ripple Factor: The ripple in a full-wave rectifier is much lower than in a half-wave rectifier due to the continuous flow of current through the load during both half-cycles. The ripple frequency is twice the input AC frequency, which makes it easier to filter and smooth out. [1]

○ Breadboard

A breadboard (sometimes called protoboard) is essentially the foundation to construct and prototype electronics. A breadboard allows for easy and quick creation of temporary electronic circuits or to carry out experiments with circuit design. [2]

○ Cathode Ray Oscilloscope (CRO)

A cathode ray oscilloscope is an electrical test device used to produce waveforms in response to several input signals. It was originally known as an oscillograph. The standard four components of a Cathode ray oscilloscope. Display, vertical controllers, horizontal controllers, and triggers. [3]

○ Function Generator

A function generator is an electronic test equipment that generates standard waveforms, such as sine, square, ramp, or sawtooth waves, to a device under test (DUT). [4]

Table 7-1 Comparison of Half Wave and Full-Wave Rectifiers

Aspect	Half-Wave Rectifier	Full-Wave Rectifier
Components Required	1 diode	4 diodes (in bridge format)
DC Output Voltage	Lower	Higher
Ripple Factor	Higher (more AC in output)	Lower (smoother output)
Efficiency	~40.6%	~81.2%
Frequency of Ripple	Same as input frequency	Twice the input frequency

➢ Procedure

- Begin by testing the diode using a multimeter to identify its positive terminal. Confirm the forward and reverse bias characteristics by checking the continuity and voltage readings.
- Connect the diode and a resistor in series with a function generator set to provide an AC voltage. Observe the output waveform on the Cathode Ray Oscilloscope (CRO), noting the half-wave rectified sinusoidal pattern.
- After completing the half-wave rectifier setup, construct a full-wave rectifier using four diodes arranged so that two diodes are forward-biased during each half-cycle of the AC signal. Position the resistor between the diode pairs to allow current flow through it regardless of the AC wave's polarity.
- Connect the full-wave rectifier circuit to the function generator, providing a sinusoidal AC wave, and observe the output waveform on the CRO. Note the full-wave rectified output, recognizing that it displays a continuous waveform with some fluctuations due to the lack of filtering.

➢ Lab task

In the lab, we first tested the diode using a multimeter to identify its positive terminal and check its forward and reverse bias. Then, we constructed a half-wave rectifier circuit by connecting a diode and resistor in series with a function generator, observing the resulting half-wave output on the CRO. Next, we built a full-wave rectifier using four diodes arranged to allow current flow through a resistor during both positive and negative AC cycles, producing a full-wave output observed on the CRO. This output showed a continuous but unfiltered waveform.

Half-Wave Rectifier

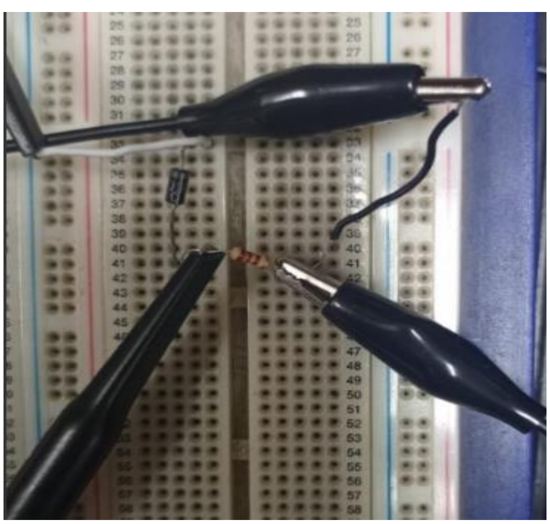

Figure 7-1 Circuit diagram of half wave rectifier

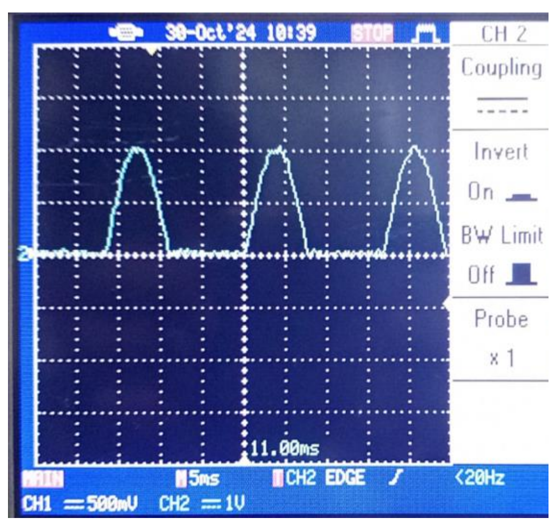

Figure 7-2 Output wave of half wave rectifier

Full-Wave Rectifier

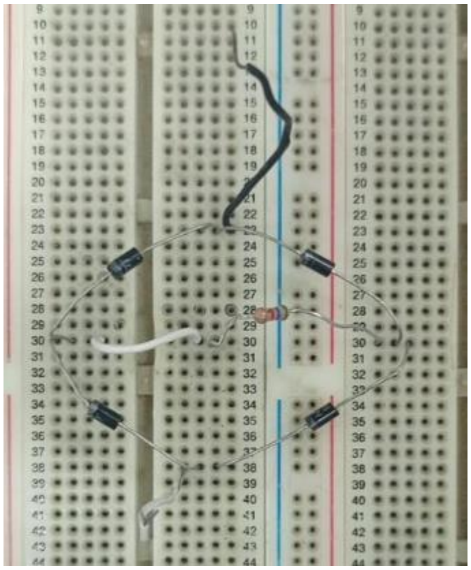

Figure 7-3 Circuit diagram of full wave rectifier

Figure 7-4 Output wave of full wave rectifier

➢ Discussion:

In this experiment, the aim was to get familiarized with the use of rectifiers. We began by constructing a half-wave rectifier circuit, connecting a diode and resistor in series with an AC source provided by a function generator. The function generator was set to generate sinusoidal waves at a frequency of 60 Hz. The AC source was connected across the input terminals of the circuit, while the output across the resistor was connected to a CRO. This allowed us to observe the rectified waveform on the CRO, where we noted that only the positive half-cycle of the AC wave was visible, as expected for a half-wave rectifier.

Next, we moved on to constructing a full-wave rectifier circuit, which involved connecting four diodes in a bridge configuration. In this setup, two diodes were oriented with the positive side facing the first path and the other two with the positive side facing down. When the positive half of the AC cycle was applied, current flowed through one path, and during the negative half, it flowed through the second path. This configuration allowed both halves of the AC wave to pass through the load resistor, effectively doubling the frequency of the output signal. The CRO was again connected across the resistor, allowing us to observe a waveform with both positive half-cycles, creating a continuous, pulsating DC output.

Although we observed a nearly rectified DC output, the waveform was not a flat line due to the absence of filtering. The output had fluctuations or ripples, which could have been reduced by adding a filter capacitor to smooth out the waveform.

➢ Results

Half-Wave Rectifier Output: On the CRO, we observed a waveform with only the positive half-cycles of the AC input. This confirms that the half-wave rectifier allowed only one half of the AC cycle to pass through, producing a pulsating DC output.

Full-Wave Rectifier Output: For the full-wave rectifier, the CRO displayed both positive half-cycles of the AC input, resulting in a more continuous waveform with double the input frequency. The waveform showed fluctuations or ripples due to the absence of filtering.

➢ Conclusions

This experiment successfully demonstrated the construction and operation of half-wave and full-wave rectifiers. The half-wave rectifier allowed only one half of the AC waveform to pass, resulting in a pulsating DC output with gaps between cycles. The full-wave rectifier, utilizing four diodes in a bridge configuration, allowed both halves of the AC cycle to pass, creating a more continuous DC output with a frequency that was double the input. However, due to the absence of a filter, the output had noticeable ripples, indicating that further smoothing could be achieved with additional circuitry.

➢ References

[1] "Rectifiers and Their Working Principles," OpenAI's ChatGPT, [Online]. Available: https://chat.openai.com/. [Accessed: 31-Oct-2024].

[2] "Breadboard," *ScienceDirect*, https://www.sciencedirect.com/topics/engineering/breadboard#:~:text=A%20breadboard%20(sometimes%20called%20protoboard,out%20experiments%20with%20circuit%20design. [Accessed: 24-Oct-2024].

[3] Cathode Ray Oscilloscope (CRO): Learn Definition, Working, Uses." *Testbook*, [Online]. Available: https://testbook.com/electrical-engineering/cro-cathode-ray-oscilloscope. [Accessed: 24-Oct-2024].

[4] Waveform and Function Generators." *Keysight*, [Online]. Available: https://www.keysight.com/us/en/products/waveform-and-function-generators.html. [Accessed: 24-Oct-2024].