

1. Goals

Rectifiers are essential electronic devices used to convert alternating current (AC) into direct current (DC). They are commonly used in power supplies to provide DC voltage for electronic equipment. There are two main types of rectifiers:

- **Half-Wave Rectifiers:** These rectifiers use a single diode to pass only one half of the AC waveform (either positive or negative) while blocking the other. As a result, the output voltage is pulsating DC with a significant ripple.
- **Full-Wave Rectifiers:** These circuits utilize multiple diodes, often arranged in a bridge configuration, to pass both the positive and negative halves of the AC waveform. This results in a smoother DC output compared to half-wave rectification.

To improve the quality of the DC output, capacitors are commonly used as filters. These capacitors charge during the peaks of the rectified waveform and discharge during troughs, thereby reducing ripple and producing a more stable voltage.

2. Measurement scheme

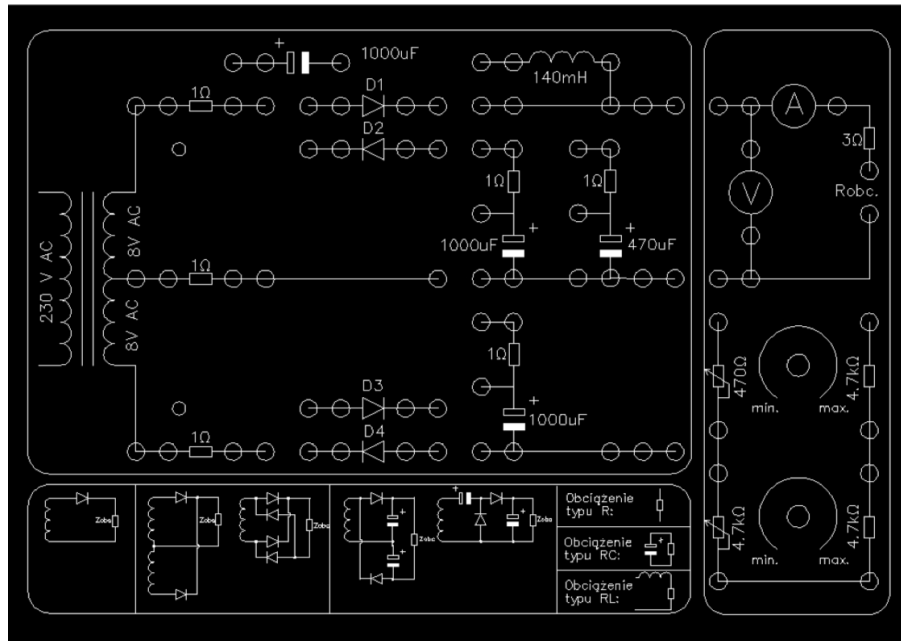


Figure 1 - General schematic setup for waveform analysis of rectifier circuits

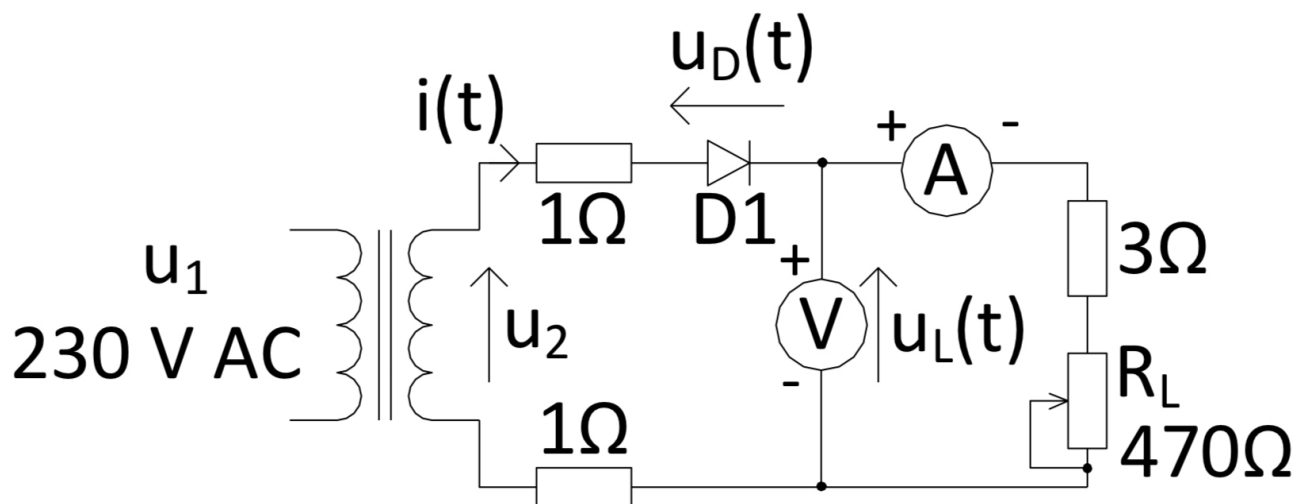


Figure 2 - Circuit diagram of the half-wave rectifier with a resistive load

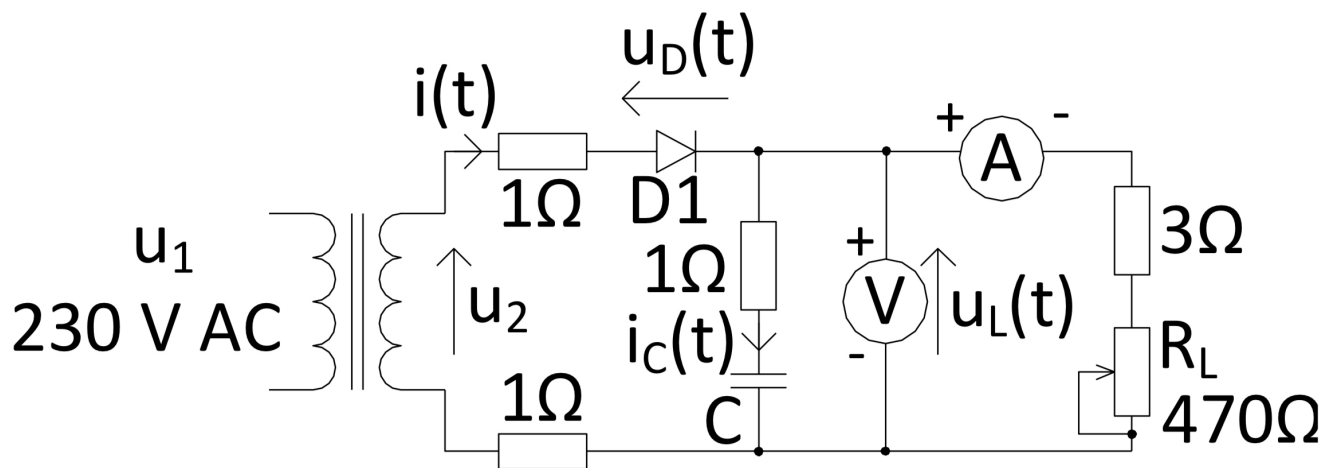


Figure 3 - Circuit diagram of the half-wave rectifier with a capacitive filter

3. Results

Half-wave rectifier

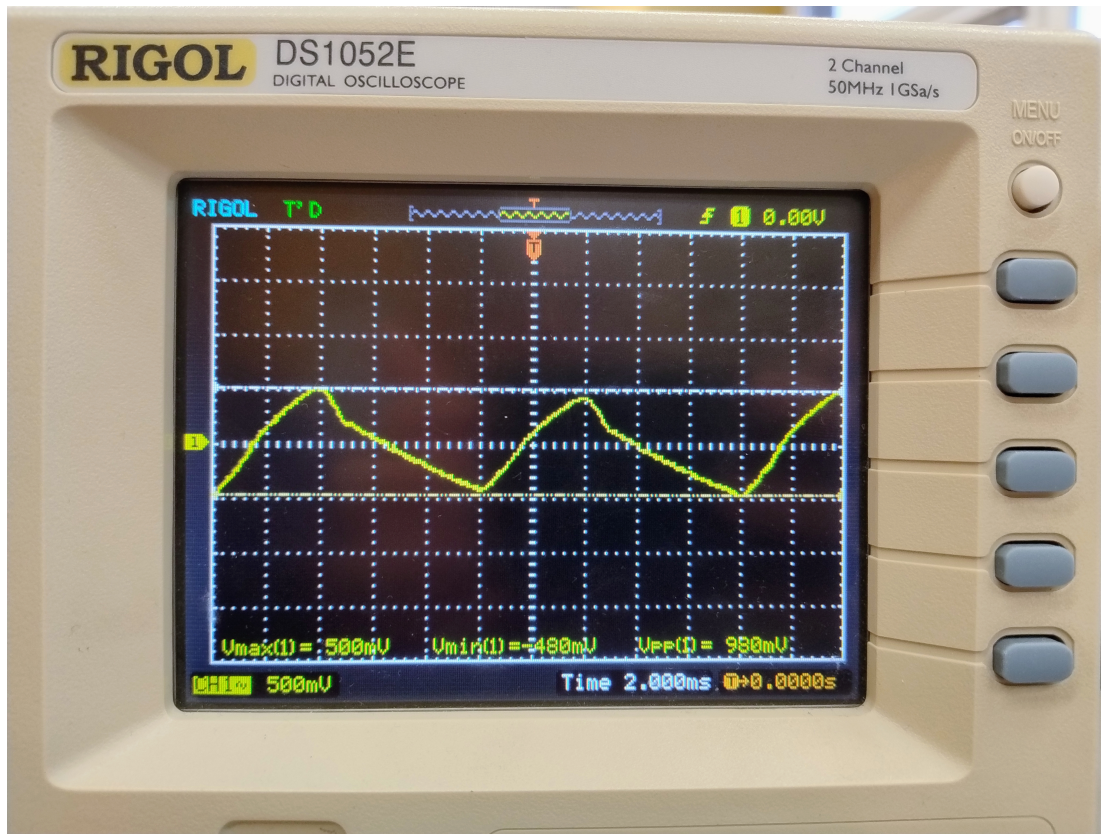


Figure 4 - Output voltage waveform for the half-wave rectifier with resistive load. It illustrates the rectified output, where only the positive half-cycles are retained, with a reduced amplitude due to diode forward voltage drop.

The waveform shows that only positive half-cycles of the input voltage are passed, while the negative cycles are blocked. This behavior aligns with theoretical expectations since the diode allows current flow in one direction only. The slightly reduced amplitude compared to the ideal value can be attributed to the forward voltage drop across the diode.

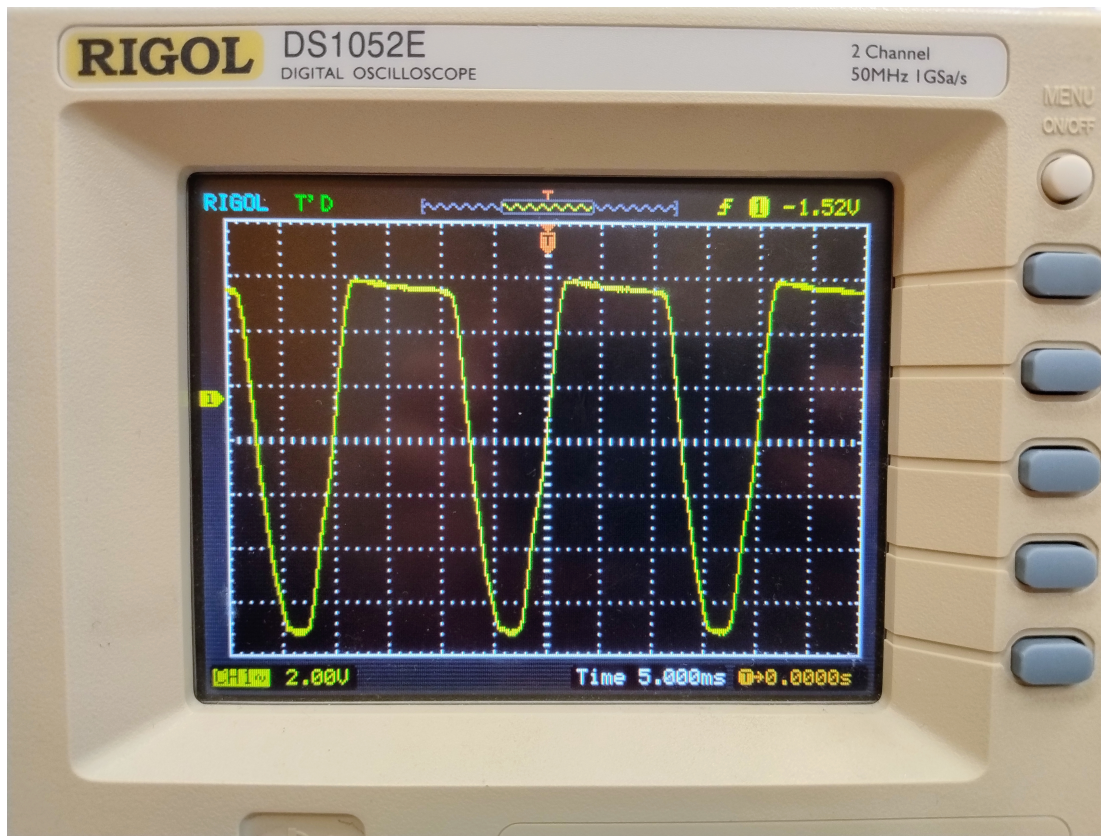


Figure 5 - Output voltage waveform for the half-wave rectifier with capacitive filter. It shows reduced ripple due to the smoothing action of the capacitor, with performance dependent on the filter's capacitance and load resistance.

The waveform demonstrates the smoothing effect of the capacitor. Instead of a pulsating DC output, the capacitor discharges slowly during non-conducting intervals, resulting in reduced ripple voltage. The effectiveness of filtering depends on the capacitance value and load resistance, as anticipated.

Measurements investigating voltage-current characteristics of the half-wave rectifier.

I_{OUT}^{DC}	U_{OUT}^{DC}
5 mA	-7.45 V
30 mA	-6.75 V
60 mA	-6.38 V

I_{OUT}^{DC}	U_{OUT}^{DC}
90 mA	-6.08 V
120 mA	-5.77 V

Table 1 - Static load characteristics of the half-wave rectifier. Voltage drop is observed with increasing current due to practical losses in circuit components.

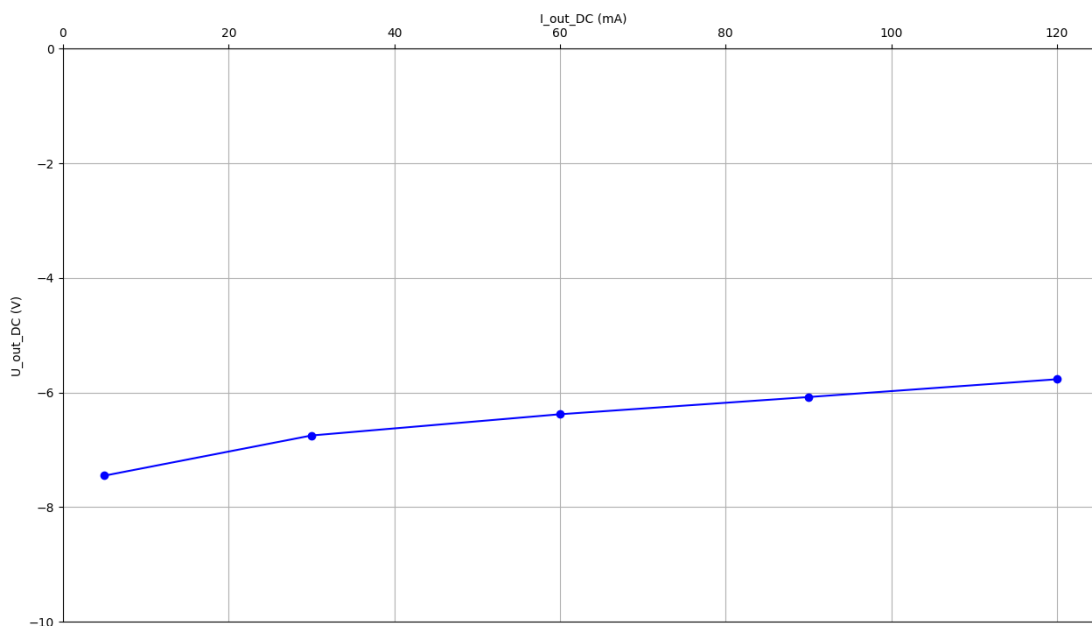


Figure 6 - Graphical representation of Table 1. It shows the relationship between load current and output voltage for the half-wave rectifier.

As current increases, the output voltage decreases slightly, indicating the impact of load resistance and the internal resistance of the circuit components. The deviation from ideal values arises due to practical factors like transformer resistance, diode forward voltage drop, and measurement inaccuracies.

Full-wave rectifier

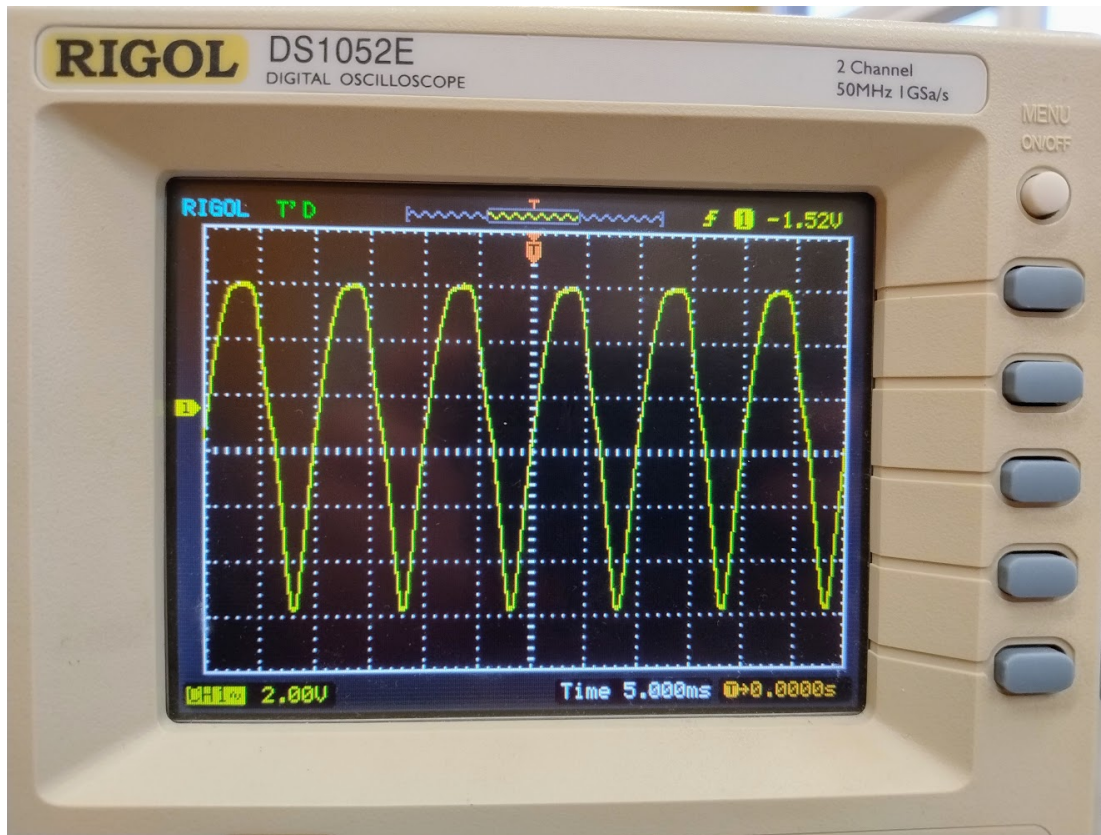


Figure 7 - Output voltage waveform for the full-wave rectifier with resistive load. The rectifier retains both positive and negative half-cycles, providing a more consistent output with reduced ripple compared to the half-wave rectifier.

The output voltage for the full-wave rectifier retains both positive and negative half-cycles of the input voltage, rectifying them into a unidirectional flow. The waveform demonstrates reduced ripple compared to the half-wave rectifier, as a charging pulse occurs every half-cycle. The slight reduction in amplitude compared to ideal values is due to the voltage drop across the diodes in the bridge.

I_{OUT}^{DC}	U_{OUT}^{DC}	U_{OUTPP}
3.8 mA	11.2 V	104 mV
30.5 mA	10.28 V	328 mV
60.9 mA	9.48 V	580 mV

I_{OUT}^{DC}	U_{OUT}^{DC}	U_{OUTPP}
90 mA	8.80 V	832 mV
120 mA	8.14 V	1 V

Table 2 - Static load characteristics of the full-wave rectifier. It shows the relationship between output voltage, load current, and ripple voltage, highlighting the impact of increased load on performance.

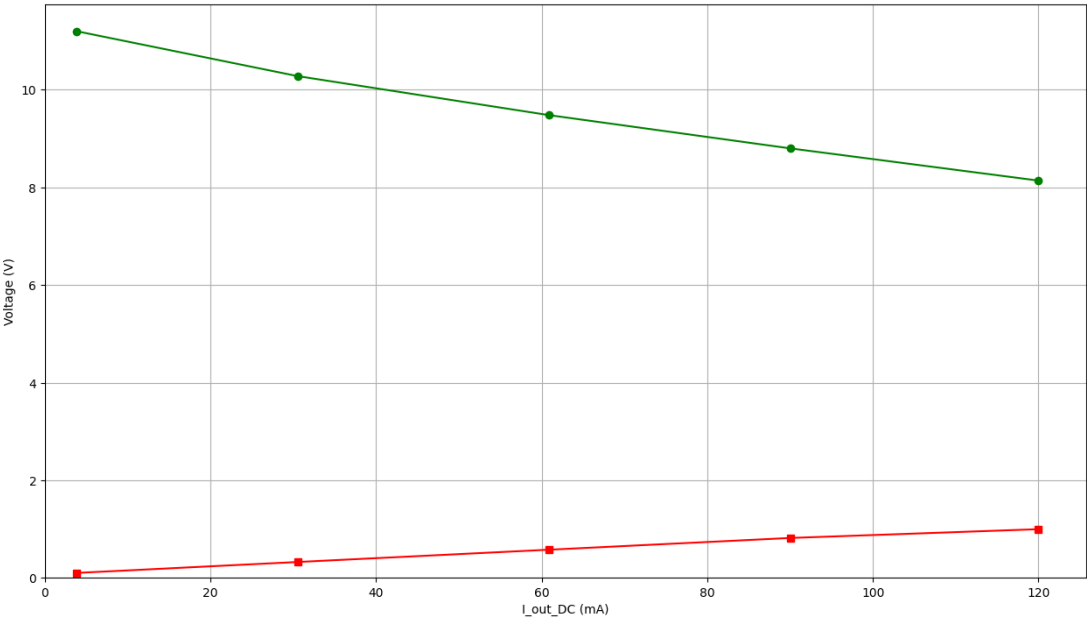


Figure 8 - Graphical representation of Table 2. It depicts the decreasing output voltage and increasing ripple voltage with higher load current in a full-wave rectifier.

The results confirm that as the load current increases, the output voltage decreases due to the voltage drops across the diodes and internal resistance of the transformer. The peak-to-peak ripple voltage (U_{OUTPP}) increases with load current, consistent with expectations since the capacitor discharges faster under higher loads.

Summary

In this experiment, the operation and characteristics of rectifier circuits were analyzed, providing a deeper understanding of their behavior and practical applications.

The study reinforced the importance of rectifiers in AC-to-DC conversion and highlighted the role of filters in improving the output quality. Full-wave rectifiers with capacitive filters were found to be the most effective configuration for providing a smooth and reliable DC output, making them ideal for power supply applications. The experiment successfully demonstrated the principles and applications of rectifier circuits, aligning theoretical knowledge with practical observations.