# Experiment 4

# Half-Wave Rectifier Circuit

**1- Objects of the Experiment**

- Recording the output voltage for an Ohmic load resistance
- Representing the output voltage as a function of the charging capacitor.
- Representing the output voltage as a function of the load resistor.

**2- Principles**

Rectification is the process of converting an alternating (AC) voltage into one that is limited to one polarity. The diode is useful for this function because of its nonlinear characteristics, that is, current exists for one voltage polarity, but is essentially zero for the opposite polarity. Rectification is classified as half-wave or full-wave.

Figure 1 shows a power transformer with a diode and a resistor connected to the secondary of the transformer. We will use the piecewise linear approach in analysing this circuit, assuming the diode forward resistance $r_f = 0$ when the diode is "on".

The input signal, $v_I$, is, in general, a 220 V (rms), 60 Hz AC signal. Recall that the secondary voltage, $v_S$, and primary voltage, $v_I$, of an ideal transformer are related by

$$\frac{v_I}{v_S} = \frac{N_1}{N_2} \qquad \text{(Equation 1)}$$

where $N_1$ and $N_2$ are the number of primary and secondary turns, respectively.

The ratio $N_1/N_2$ is called the transformer turns ratio. The transformer turns ratio will be designed to provide a particular secondary voltage, $v_S$, which in turn will produce a particular output voltage $v_O$.

For $v_S < 0$, the diode is reverse biased, which means that the current is zero and the output voltage is zero. As long as $v_S < V_\gamma$, the diode will be nonconducting, so the output voltage will remain zero. When $v_S > V_\gamma$, the diode becomes forward biased and a current is induced in the circuit. In this case, we can write

$$i_D = \frac{v_S - V_\gamma}{R} \qquad \text{(for } v_s \rangle V_\gamma\text{)} \qquad \text{(Equation 2)}$$

$$v_O = R\,i_D = v_S - V_\gamma \qquad \text{(for } v_s \rangle V_\gamma\text{)} \qquad \text{(Equation 3)}$$

If a capacitor is added in parallel with the load resistor of a half-wave rectifier to form a simple filter circuit (Figure 2), we can begin to transform the half-wave sinusoidal output into a DC voltage. The voltage across the capacitor follows the initial portion of the signal voltage (the positive half of the output sine wave). When the signal voltage reaches its peak and begins to decrease, the voltage across the capacitor also starts to decrease, which means the capacitor starts to discharge. The only discharge current path is through the resistor. If the RC time constant is large, the voltage across the capacitor discharges exponentially with time. During this time period, the diode is cut off.

**3- Equipments**

| | |
|---|---|
| 1 resistor 100Ω / 2W | 577 32 |
| 1 resistor 1kΩ / 2W | 577 44 |
| 1 resistor 10kΩ / 0.5W | 577 56 |
| 1 electrolytic capacitor 10µF / 35V | 578 37 |
| 1 Electrolytic capacitor 47µF / 35V | 578 38 |
| 1 Electrolytic capacitor 100µF / 16V | 578 39 |
| 1 Si-diode 1N4007 | 578 51 |
| 1 Two-oscilloscope | |
| 1 Power supply unit | 726 961 |
| 1 Plug-in board 297X300 | 72650 |

| | |
|---|---|
| 1 Measuring cable BNC/4mm | 575 24 |
| 1 Set of bridging plugs 19mm | 501 48 |
| 1 Set of connecting leads | 501 532 |

**4- Setup**

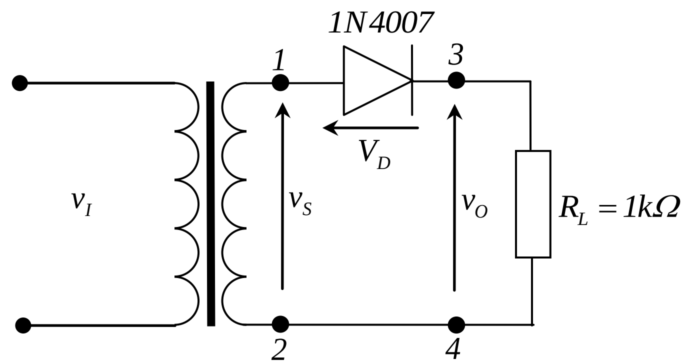


***Figure 1***. *Half-wave rectifier circuit*

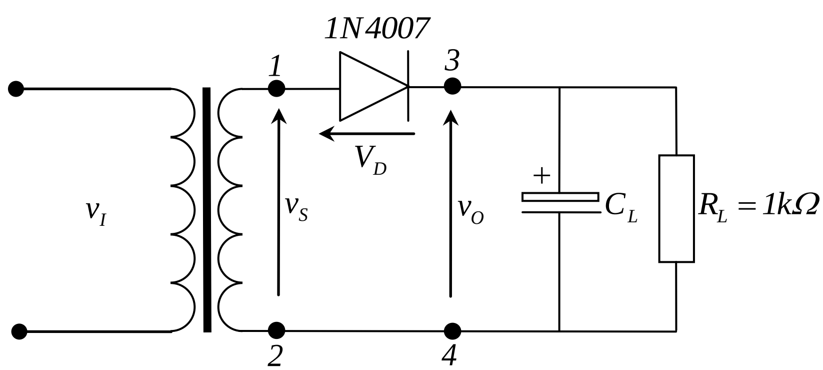


***Figure 2.*** *Half-wave rectifier with an RC filter*

**5- Carrying out the experiment**

**5-1- Representing the output voltage $v_O(t)$ for an Ohmic load resistance**

- Assemble the circuit as shown in Figure 1 and apply an AC voltage of $V_S$ = *6V* to terminals 1 and 2.

- Use channel 1 of the oscilloscope to measure the peak-to-peak value of the transformer voltage at terminals 1 and 2.

- Transfer the graph into a sheet of graph paper. Each axis should be labeled and appropriate units indicated.

- Determine the amplitude (peak value) $V_S$ and the frequency $f$ of the transformer voltage $v_S(t)$

- Use the second oscilloscope channel to measure the output voltage $v_O(t)$ and enter this into the same sheet of graph paper.

- Determine the amplitude (peak value) $V_O$ and the frequency $f$ of the output voltage $v_O(t)$

- Calculate the amplitude of the output voltage $V_O$ (from Equation 3) and compare the calculated value with the measured value. Give reasons for any deviations which may occur.

**5-2- Representing the output voltage as a function of the charging capacitor**

- Assemble the circuit without the capacitor as shown in Figure 2 and apply an AC voltage of $V_S = 6V$ to terminals 1 and 2.

- Without the capacitor, record the output voltage $v_O(t)$ on the oscilloscope.

- Transfer the graph into a sheet of graph paper.

- Connect the capacitors $C_{L1}$ = 10µF, $C_{L2}$ = 47µF and $C_{L3}$ = 100 µF (Polarity must be correct) to terminals 3 and 4 (parallel to the load resistor) as in Figure 2 one after the other.

- Record the output voltages $v_O(t)$ of the different capacitors on the oscilloscope.

- Transfer the graphs into the same sheet of graph paper. Each axis should be labeled and appropriate units indicated. Label the output voltages according to the appropriate capacitor.

- Comment on the relationship between the output voltage ripple and the capacitance value of the capacitor.

**5-3- Representing the output voltage as a function of the load resistor**

- Connect the capacitor $C_L$ = 47 µF between the terminals 3 and 4 shown in Figure 2.

- Connect the load resistors $R_{L1}$ = 100Ω, $R_{L2}$ = 1kΩ and $R_{L3}$ = 10kΩ parallel to the capacitor one after the other.

- Display the corresponding output voltage $v_O(t)$ on the oscilloscope.

- Transfer the graphs into a sheet of graph paper. Each axis should be labeled and appropriate units indicated. Label the output voltages according to the appropriate load resistor.

- Comment on the relationship between the output voltage ripple and the load resistor value. Give reasons for this.

**6- Conclusion**

Make a general conclusion about the experiments and the results obtained.