Experiment 5

Full-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

The full-wave rectifier inverts the negative portions of the input sinusoid v_S so that a unipolar output signal is generated during both halves of v_S. One example of a full-wave rectifier circuit appears in Figure 1. The input to the rectifier consists of a power transformer, in which the input is normally a 220 V (rms), 60 Hz AC signal, and the two outputs are from a center-tapped secondary winding that provides equal voltages v_S, with the polarities shown. When the input line voltage is positive, both output signal voltages v_S are also positive.

The primary winding connected to the 220 V AC source has N_1 windings, and each half of the secondary winding has N_2 windings. The value of the v_S output voltage is $120(N_2/N_1)$ volts (rms). The **turns ratio** of the transformer (N_1/N_2) can be designed to "step down" the input line voltage to a value that will produce a particular DC output voltage from the rectifier.

During the positive half of the input voltage cycle, both output voltages v_S are positive, therefore, diode D_1 is forward biased and conducting and D_2 is reverse biased and cut off. The current through D_1 and the output resistance produce a positive output voltage. During the negative half cycle, D_1 is cut off and D_2 is forward biased, or "on", and the current through the output resistance again produces a positive output voltage.

For a sinusoidal input voltage, we can determine the output voltage versus time as follow:

- when v_S is positive, then for $v_S > v_\gamma$, D_1 is on and the output voltage is

$$v_O = v_S - V_\gamma \qquad \text{(Equation 1)}$$

where $V_\gamma = 0.7V$ the cut-in voltage

- when v_S is negative, then for $v_S < -v_\gamma$, or $-v_S > v_\gamma$, D_2 is on and the output voltage is

$$v_O = -v_S - V_\gamma \qquad \text{(Equation 2)}$$

Since a rectified output voltage occurs during both the positive and negative cycles of the input signal, this circuit is called a **full-wave rectifier**.

If a capacitor is added in parallel with the load resistor of a full-wave rectifier to form a simple filter circuit (Figure 2), we can begin to transform the full-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 88
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

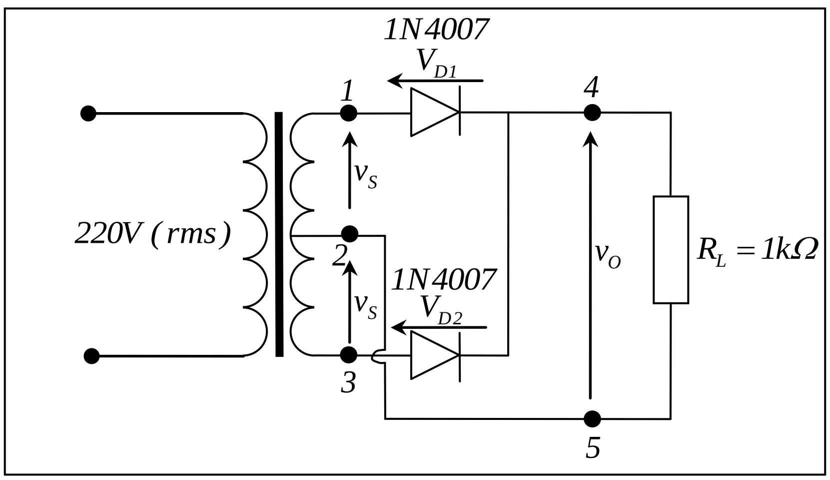

Figure 1. *Full-wave rectifier circuit with center-taped transformer*

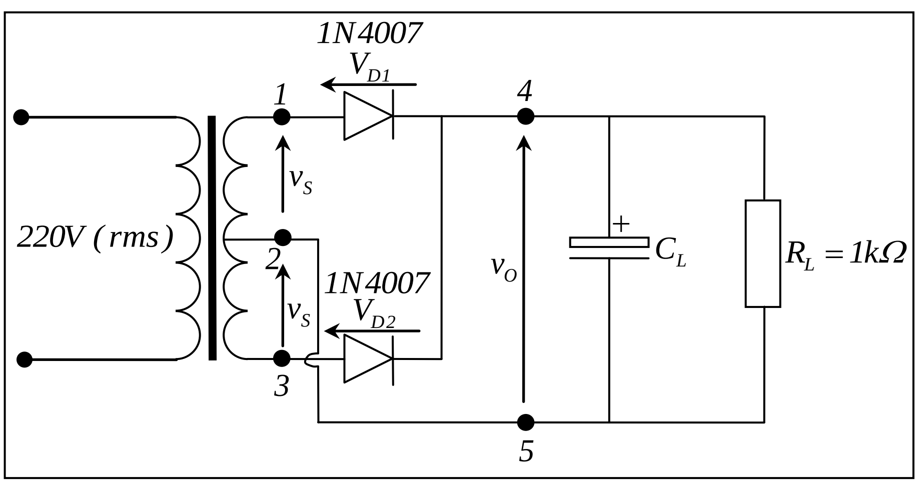

Figure 2. *Full-wave rectifier circuit with center-taped transformer and RC filter*

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 $v_S(max) = 2X6V$ to terminals 1 and 3.
- Use channel 1 of the oscilloscope to measure the peak-to-peak value of the transformer voltage at terminals 1 and 3.
- Transfer the graph into a sheet of graph paper. Each axis should be labeled and appropriate units indicated.
- Determine the amplitude (peak value) $v_S(max)$ 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) $v_O(max)$ and the frequency f of the output voltage $v_O(t)$
- Calculate the amplitude of the output voltage $v_O(max)$ and compare the calculated value (Equation 1) 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 $v_S(max) = 2X6V$ to terminals 1 and 3.
- 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 4 and 5 (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

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

- Transfer the graph into a sheet of graph paper.

- Connect the capacitor C_L = 47 µF between the terminals 4 and 5 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 the same 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.