EXPERIMENT NO 2

FULL WAVE RECTIFIER WITH FILTER

February 1, 2024

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Objective

To examine the input and output waveforms of a full-wave rectifier with a filter and also calculate its ripple factor.

Apparatus

S.NO	Apparatus	Specification	Quantities
1	P-N Diode	IN4007	1
2	Resistor	1KΩ, 10KΩ	2
3	Digital Multimeter		1
4	Transformer	(6V-0-6V)	
5	Capacitor	100 $\mu F/4.7\mu F$	
6	CRO and CRO probes		3
7	Breadboard		1
8	Connecting wires		
9	Function Generator		1

THEORY

Another variant of a circuit generating a comparable output to a full-wave rectifier is the Bridge Rectifier (depicted in Figure 1). This single-phase rectifier employs four separate rectifying diodes arranged in a "bridged" configuration to achieve the desired output, eliminating the need for a specialized center-tapped transformer, thereby reducing both size and cost. The single secondary winding connects to one side of the diode bridge network, with the load connected to the other side, as illustrated in the figure. The four diodes, labeled D1 to D4, are organized in "series pairs," with only two diodes conducting current during each half cycle.

During the positive half cycle of the supply, diodes D1 and D2 conduct in series, while diodes D3 and D4 remain reverse biased, allowing current to flow through the load (refer to Figure 2). Conversely, during the negative half cycle of the supply, diodes D3 and D4 conduct in series, while diodes D1 and D2 turn off as they become reverse biased. The current flowing through the load maintains the same direction.

Since the current flowing through the load is unidirectional, the voltage developed across the load is also unidirectional during both half cycles. Consequently, the average DC output voltage across the load resistor is twice that of a half-wave rectifier circuit, assuming no losses.

$$V_{DC} = \frac{2 \cdot V_{\max}}{\pi} = 0.637 \cdot V_{\max}$$

Full-Wave Rectifier with Capacitor Filter

The full-wave rectifier circuit with a capacitor filter is illustrated in Figure 3. In this configuration, the smoothing capacitor transforms the full-wave rippled output of the rectifier into a continuous DC output voltage. A detailed explanation of its filtering action can be found in the half-wave rectifier handout.

When selecting an appropriate capacitor for this setup, two crucial parameters must be considered. Firstly, the working voltage of the capacitor should exceed the no-load output value of the rectifier. Secondly, the capacitance value plays a vital role in determining the extent of ripple that will be superimposed on the DC voltage.

The ripple voltage (V_{rpp}) is given by:

$$V_{rpp} = V_m - V_{dc} = V_m - \frac{V_m}{\pi}$$

In addition to its rectification efficiency, the full-wave bridge rectifier boasts significant advantages. It exhibits a smaller AC ripple value for a given load and requires a smaller smoothing capacitor compared to an equivalent half-wave rectifier. The diodes' introduction of ripple voltage onto the DC supply voltage can be nearly eliminated by incorporating enhanced filters such as a pi-filter.

$$r = \frac{V_{\mathrm{ac}}\,(\text{output})}{V_{\mathrm{dc}}\,(\text{output})} = \sqrt{\frac{V_{\mathrm{rms}}^2 - V_{\mathrm{dc}}^2}{V_{\mathrm{dc}}^2}} = \sqrt{\left(\frac{V_{\mathrm{rms}}}{V_{\mathrm{dc}}}\right)^2 - 1} = \sqrt{\left(\frac{0.707}{0.637}\right)^2 - 1} = 0.48$$

$$\eta = d.c.\,power\ delivered\ to\ load / a.c.\,power\ at\ input$$
$$= V_{dc} I_{dc} / V_{ac} I_{ac}$$
$$= \frac{V_{dc}^{\ 2}/R_L}{V_s^{\ 2}/(r_d + R_L)} = \frac{(0.637V_{\max})^2}{(0.707V_{\max})^2\left(1+\frac{r_d}{R_L}\right)} = \frac{0.811}{\left(1+\frac{r_d}{R_L}\right)}$$

Rectification Efficiency

CIRCUIT DIAGRAM

Full-Wave Rectifier With Filter:

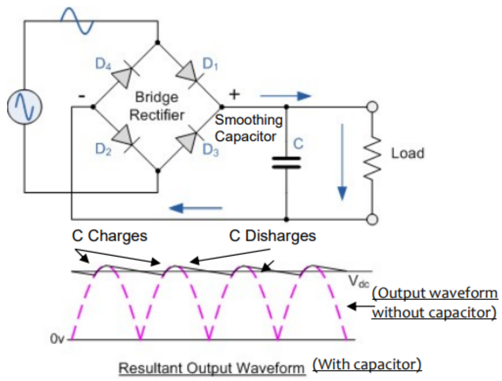

Fig.3: Full-wave rectifier circuit with capacitor filter

Figure: Full-Wave Rectifier with capacitor filter waveform

PROCEDURE

1. Connections are made as per the circuit diagram.
2. We will use functional generator as AC input as required per the experiment.
3. Measure the ac voltage at the input side of the rectifier.
4. Measure both ac and dc voltages at the output side of the rectifier.
5. Find the theoretical value of the dc voltage by using the formula $V_{dc} = \frac{2V_m}{\pi}$.
6. Connect the filter capacitor across the load resistor and measure the values of V_{ac} and V_{dc} at the output.

7. The theoretical values of Ripple factors with capacitor are calculated.
8. From the values of V_{ac} and V_{dc}, practical values of Ripple factors are calculated. The practical values are compared with theoretical values.

OBSERVATIONS AND CALCULATIONS

Full wave rectifier (with filter)

Vp-p (input voltage) (V)	Vrp-p (peak to peak ripple voltage) (V)	Vm (Peak voltage) =Vp-p/2 (V)	Vdc= Vm/π (V)	Vrms = Vrpp/4$\sqrt{3}$ (V)	Ripple factor	
					Theoretical	Experimental

Theoretical calculation (with filter):

$$\text{Ripple factor} = \frac{1}{4\sqrt{3} f R_L C}$$

Experimental calculation (with filter):

$$\text{Ripple factor} = \frac{V_{rms}}{V_{dc}}$$

MODEL WAVEFORMS

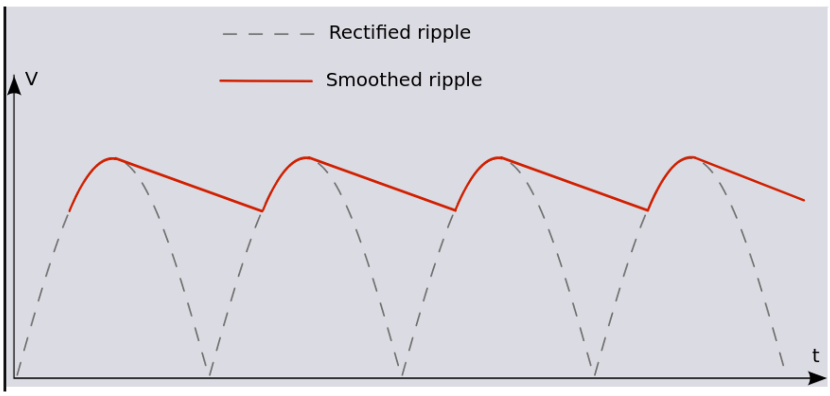

Figure: Full-Wave Rectifier with capacitor filter waveform

PRECAUTIONS

1. The primary and secondary side of the transformer should be carefully identified.
2. The polarities of all the diodes should be carefully identified.

Results

We have observed the Input and Output waveform of a full-wave rectifier with capacitor filter in DSO and also calculated the experimental value of the ripple factor of the full-wave rectifier with a filter.