

Experiment No. 5

Full Wave Bridge Rectifier with and without Filter

1. OBJECTIVES

- ❖ To construct a full-wave bridge rectifier circuit and analyze its output.
- ❖ To analyze the rectifier output using a capacitor in shunt as a filter.

2. COMPONENTS REQUIRED

- ❖ DSO1052B Digital Oscilloscope and Probes.
- ❖ Function Generator.
- ❖ Capacitor 10 μ f.
- ❖ Bread Board.
- ❖ Connecting wires.
- ❖ Diode 1N4007.
- ❖ Digital Voltmeter (0 - 20V).
- ❖ Resistors 1k Ω , 10 k Ω .

3. THEORY

As you have seen already a half-wave rectifier circuit is unsuitable to applications which need a "steady and smooth" DC supply voltage. One method to improve on this is to use every half-cycle of the input voltage instead of every other half-cycle. The circuit which allows us to do this is called a Full-wave Rectifier. Full wave rectifiers have some fundamental advantages over their half wave rectifier counterparts. The average (DC) output voltage is higher than for half wave rectifier, the output of the full wave rectifier has much less ripple than that of the half wave rectifier producing a smoother output waveform.

The Bridge rectifier is a circuit, which converts an AC voltage to DC voltage using both half cycles of the input AC voltage. The Bridge rectifier has four diodes connected to form a Bridge. The load resistance is connected between the other two ends of the bridge

Basic Circuit Operation

Fig. 1 shows the circuit of diode bridge rectifier. The circuit uses four diodes D1, D2, D3 and D4 connected in the form of bridge.

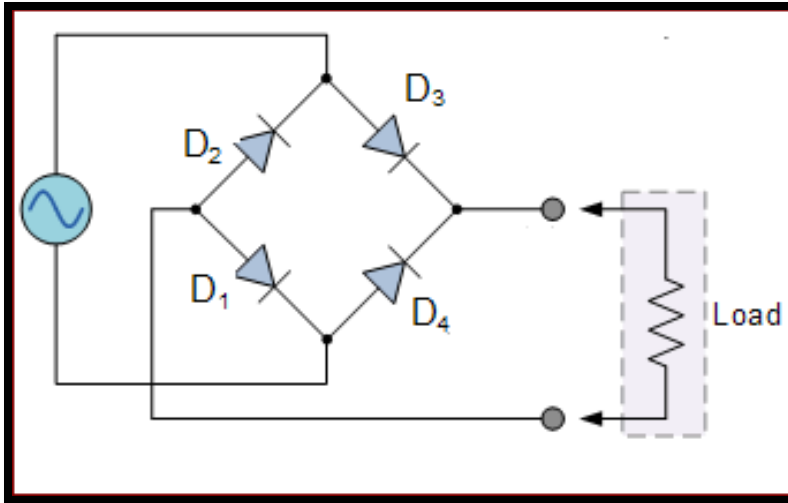


Fig. 1: Full wave bridge rectifier circuit.

During the positive half cycle (Figure 2), both D3 and D1 are forward biased. At the same time, both D2 and D4 are reverse biased. Note the direction of current flow through the load.

During the negative half cycle (Figure 3), both D2 and D4 are forward biased and D1 and D3 are reverse biased. Again note that current through the load is in the same direction although the secondary winding polarity has reversed.

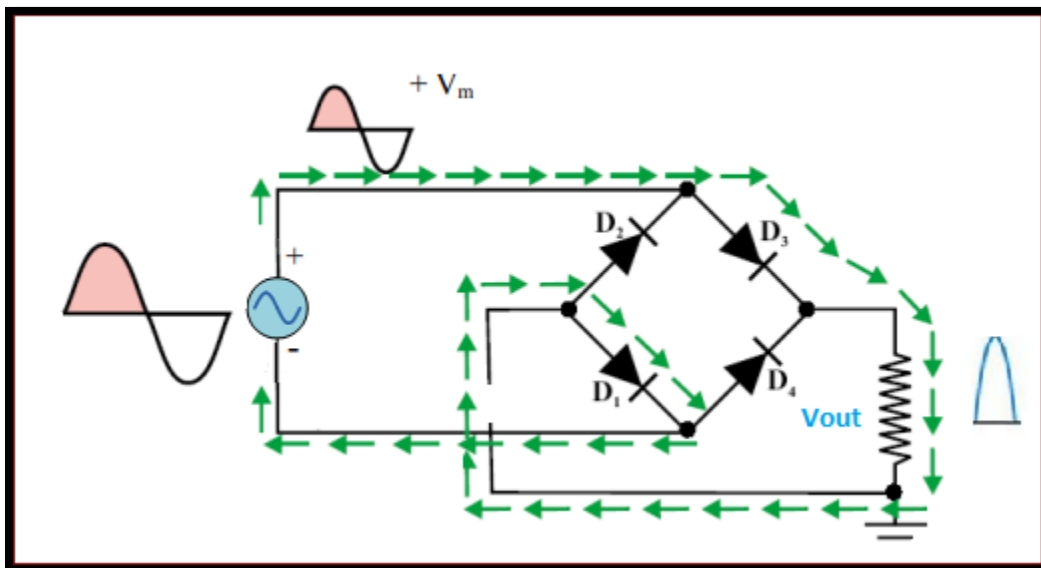


Fig. 2: Operation during positive half cycle.

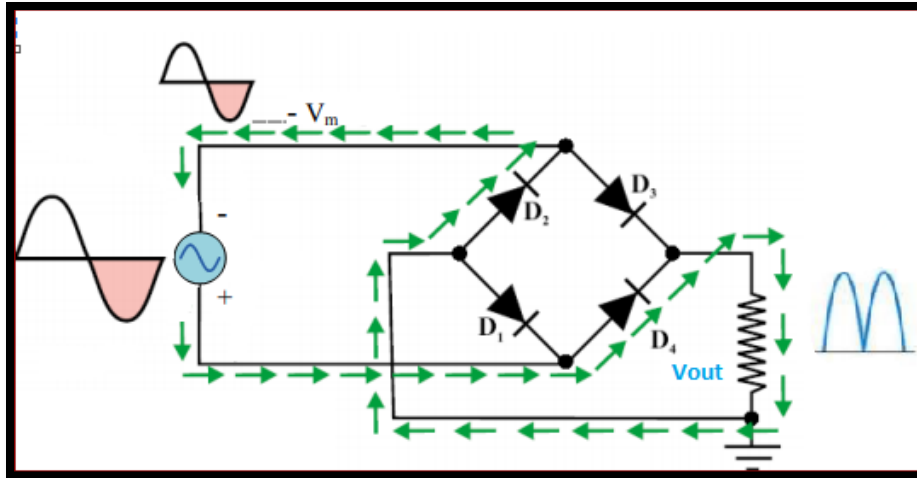


Fig. 3: Operation during negative half cycle.

During each half cycle, the current flows through two diodes instead of just one so the amplitude of the output voltage is two voltage drops ($2 \times 0.7 = 1.4\text{V}$) less than the input V_{MAX} amplitude. The ripple frequency is now twice the supply frequency.

$$V_m(out) = V_m(in) - 1.4$$

$$f(out) = 2 * f(in)$$

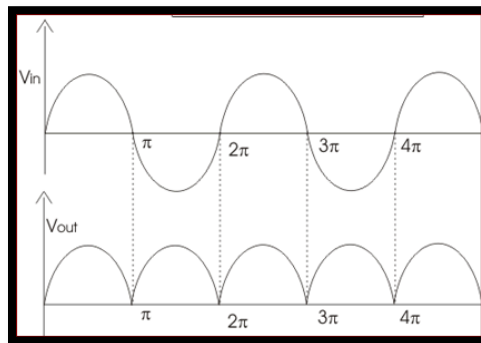


Fig. 4: Source and output voltages of Full wave bridge rectifier .

Average load voltage

If a DC voltmeter is connected to measure the output voltage of the full-wave bridge rectifier (across the load resistance), the reading obtained would be the average load voltage V_{avg} , also called the DC output voltage.

For a complete input sinusoidal cycle, the output of the full-wave bridge rectifier repeat twice. In other words, the voltage developed across the load resistor is double that of a half rectifier circuit.

Average or mean value(dc value) = $\frac{\text{area under the curve}}{\text{length of base}}$

$$V_{av} = \frac{2 \int_0^{\pi} V_m \sin(\theta)}{2\pi} = \frac{V_m}{\pi} (-\cos(\theta)) \Big|_0^{\pi} = \frac{2V_m}{\pi}$$

Root mean square (RMS) value of output load voltage V_{RMS}

The root mean square (RMS) value of output load voltage in a full-wave bridge rectifier is:

$$\begin{aligned} \text{RMS Value} &= \sqrt{\left(\frac{1}{2\pi}\right) \int_0^{\pi} (V_m \sin \omega t)^2 d(\omega t) + \left(\frac{1}{2\pi}\right) \int_{\pi}^{2\pi} (V_m \sin \omega t)^2 d(\omega t)} \\ &= \sqrt{\left(\frac{V_m^2}{2\pi}\right) \int_0^{\pi} 2(\sin \omega t)^2 d(\omega t)} \\ &= V_m \sqrt{\left(\frac{1}{2\pi}\right) \int_0^{\pi} 2(\sin \omega t)^2 d(\omega t)} \\ &= V_m \sqrt{\left(\frac{1}{2\pi}\right) \int_0^{\pi} (1 - \cos \omega t) d(\omega t)} \\ &= V_m \sqrt{\left(\frac{1}{2\pi}\right) \int_0^{\pi} 1 d(\omega t)} \\ &= V_m \sqrt{\left(\frac{1}{2\pi}\right) [\pi - 0]} \\ &= \frac{V_m}{\sqrt{2}} \end{aligned}$$

Peak inverse voltage

Peak inverse voltage is the maximum voltage that a diode can withstand in the reverse direction without breaking down or [avalanching](#). If this voltage is exceeded the diode may be destroyed.

Consider a positive half cycle, where D1 and D3 are forward biased and D2 and D4 are reversed biased. Peak inverse voltage appears across the diode D2 and D4. The inverse voltage across the diode D4 can be determined by applying KVL at the loop:

$$V_m(in) - PIV - 0.7v = 0$$

$$PIV = V_m(in) + 0.7v$$

Ripple Factor of full-wave bridge rectifier

As mentioned in the previous lab the ripple factor is a measure of purity of the DC output of a rectifier and is defined as:

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

This is a significant improvement in the ripple factor compared to that of a Half wave rectifier ($r = 1.21$). However, this pulsating DC is not useful to power electronic circuits as it still has a large AC component. The output can be made smooth by using capacitor filter as described in Half Wave rectifier.

Full-wave bridge rectifier with Capacitor Filter

The full-wave rectifier circuit with capacitor filter is shown in Fig. 5. The smoothing capacitor converts the full-wave rippled output of the rectifier into a smooth DC output voltage. The detailed description of its filtering action is already explained in half-wave rectifier handout. Two important parameters to consider when choosing a suitable a capacitor are its working voltage, which must be higher than the no-load output value of the rectifier and its capacitance value, which determines the amount of ripple that will appear on top of the DC voltage.

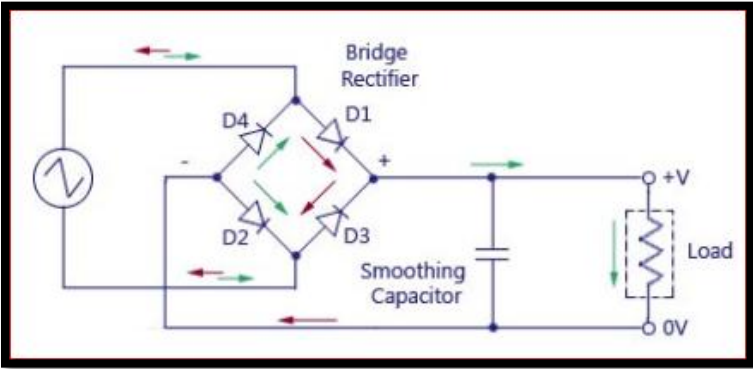


Fig. 5: Full Wave Bridge Rectifier – with Capacitor Filter

Apart from rectification efficiency, the main advantages of a full-wave bridge rectifier is that it has a smaller AC ripple value for a given load and a smaller smoothing capacitor than an equivalent half-wave rectifier.

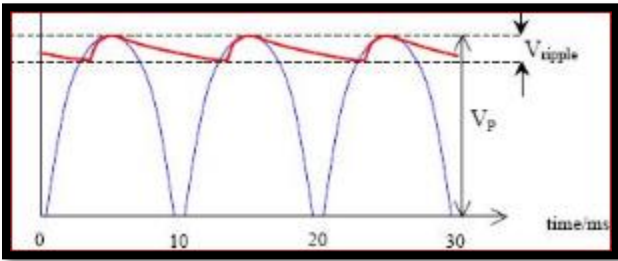


Fig. 6: Output voltage waveform of Full Wave bridge Rectifier with capacitor filter.

The ripple factor can be significantly reduced using a filter capacitor. For a Full Wave bridge Rectifier with filter capacitor, ripple factor is given by,

$$r = \frac{1}{4\sqrt{3}fR_L C}$$

Where f is the frequency of the input signal.

Also,

$$V_{dc} = V_m - \frac{V_r}{2}$$
$$V_r = \frac{V_m}{4\sqrt{3}fR_L C}$$

4. PROCEDURE

❖ Without Filter

- 1- Configure the Full Wave bridge Rectifier circuit as shown in Figure 1 and apply an AC voltage of $V_{pp} = 6V$.
- 2- Use channel 1 of the oscilloscope to measure the V_{pp} of the input signal.
- 3- **Transfer the graph into a sheet of graph paper. Each axis should be labeled and appropriate units indicated.**
- 4- Determine the amplitude (peak value) and the frequency f of the input voltage.
- 5- Use the second oscilloscope channel to measure the output voltage and enter this into the same sheet of graph paper.
- 6- Determine the amplitude (peak value) and the frequency f of the output voltage.
- 7- Measure the input AC voltage and the output AC and DC voltages using multimeter for at least 2 values of load resistor (Be careful to choose proper settings of multimeter for AC and DC measurement).
- 8- Multiply the V_{ac} at the input by $\sqrt{2}$ to get the peak value and calculate V_{dc} Using the formula $V_{dc} = 2V_m / \pi$. Compare this value with the measured V_{dc} at the output.
- 9- Calculate the ripple factor.

Table (I): Data and results for Full-wave bridge rectifier with no filter, $R=1\text{ k}\Omega$

| $R=1\text{ k}\Omega$ | | | |
|---|--|-------------------------------------|--|
| Input | | output | |
| V_{pp} | | V_m (measured from CRO) | |
| V_m | | V_m (calculated) | |
| V_{ac} (measured using voltmeter) | | $V_m\%$ | |
| V_{ac} (calculated) | | V_{dc} (measured using voltmeter) | |
| $V_{ac}\%$ | | V_{dc} (calculated) | |
| Frequency f | | $V_{dc}\%$ | |
| | | V_{ac} (measured using voltmeter) | |
| | | V_{ac} (calculated) | |
| | | $V_{ac}\%$ | |
| | | Frequency f | |
| Ripple factor(measured and calculated) | | | |

❖ **With Filter**

Connect the capacitor across the output for each load resistor as shown in figure 4 and measure the output AC and DC voltages once again and calculate the ripple factor. (If time permits you could also use different values of capacitors and study the output)

Table (2): Data and result for Full-wave bridge rectifier with filter,, $R=1\text{ k}\Omega$,, $C=10\text{ }\mu\text{F}$

| output | |
|--|--|
| V_m(measured from CRO) | |
| V_m(calculated) | |
| $V_m\%$ | |
| V_{dc}(measured using voltmeter) | |
| V_{dc}(measured from CRO) | |
| V_{dc}(calculated) | |
| $V_{dc}\%$ | |
| V_r(measured from CRO) | |
| V_r(calculated) | |
| $V_r\%$ | |
| Ripple factor | |

Table (3): Data and result for Full-wave bridge rectifier with filter,, $R=10\text{ k}\Omega$, $C=10\text{ }\mu\text{F}$.

| output | |
|--|--|
| V_m(measured from CRO) | |
| V_m(calculated) | |
| $V_m\%$ | |
| V_{dc}(measured using voltmeter) | |
| V_{dc}(measured from CRO) | |
| V_{dc}(calculated) | |
| $V_{dc}\%$ | |
| V_r(measured from CRO) | |
| V_r(calculated) | |
| $V_r\%$ | |
| Ripple factor | |