# Diode Rectifier Circuits

**Objectives:**

In this experiment you will learn how to:

- Measure and calculate all the characteristics of the half-wave rectifier.
- Measure, calculate, and compare the characteristics of full-wave rectifiers.
- Measure and calculate the characteristics of a rectifier with a capacitor filter.
- Design a rectifier circuit with a capacitor filter by proper choice of the transformer secondary voltage and the capacitance value.

## Circuit Diagrams

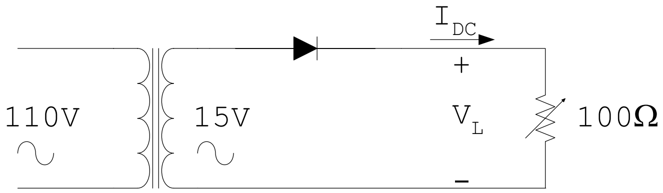


Fig. 1

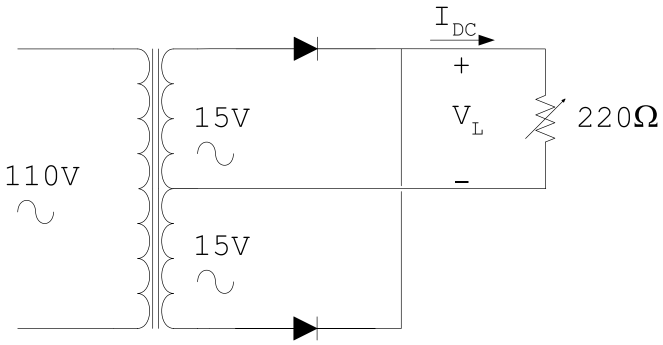


Fig. 2

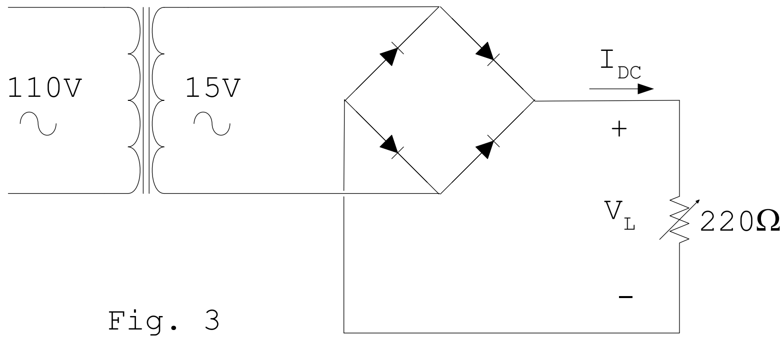


Fig. 3

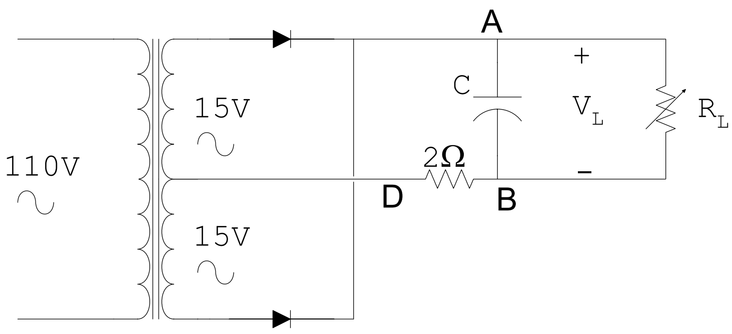


Fig. 4

## Theory

A rectifier circuit converts an alternating input to a unidirectional output. This may be accomplished by using unidirectional devices, which allow the passage of current in one direction through the device but not in the opposite direction. The most common type of unidirectional devices are semiconductor diodes. Ideally, a diode behaves as a perfect switch. In the forward direction it has a zero resistance and zero offset voltage. In the reverse direction, it behaves as an open circuit.

**Note** *The half-wave rectifier blocks the negative variations of the input; the output is approximately equal to the input when the input is positive, and is zero otherwise. In the full-wave rectifier, on the other hand, the output is approximately equal to the absolute value of the input.*

The most important characteristics which must be specified for a rectifier circuit are:

1. DC output voltage.
2. ripple-factor, defined as a ratio of the peak-to-peak ripple (voltage variation in the output) to the average voltage across the load.
3. average and peak currents in each diode.
4. peak inverse voltage (PIV) for each diode.
5. percent regulation, defined as $\frac{V_L - V_0}{V_0} \times 100$, where $V_0$ is the no-load voltage and $V_L$ is the full-load voltage.
6. transformer requirements, such as the secondary winding voltage and current ratings.

It should be carefully noted that these characteristics, depend, in general, upon the type of load connected to the rectifier output, i.e., whether it is resistive, capacitive or inductive.

A transformer is used for stepping-down the input AC voltage. It is a device that transmits AC power from one circuit to another through magnetic coupling, often with no conductive connection. The transformation process obeys the relationships: $\frac{V_2}{V_1} = \frac{N_2}{N_1}$ and $\frac{I_2}{I_1} = \frac{N_1}{N_2}$,

where subscripts 1 and 2 refer to the primary and secondary sides, respectively.

A capacitor can be connected at the output of the rectifier to smooth the voltage variations. An approximate analysis for a full-wave rectifier with a capacitor filter gives the following:

$$\text{PEAK-TO-PEAK RIPPLE VOLTAGE: } V_r \approx \frac{V_{2max}}{2fR_LC}$$

$$\text{DC VOLTAGE: } V_{DC} \approx V_{2max} - \frac{V_r}{2}$$

$$\text{DC CURRENT: } I_{DC} = \frac{V_{DC}}{R_L}.$$

where $V_{2max}$ is the peak AC input voltage (at the secondary of the transformer), $R_L$ is the load resistance, C is the filter capacitance, and f is the frequency of the AC voltage.

## Procedure

- For each of the circuits in Figs 1, 2, and 3 adjust the load resistor to get $I_{DC}$ = 50 mA. observe the output across the load on the oscilloscope and determine each of the quantities 1 to 4 mentioned in the Theory section above.

- For each of the circuits in Figs 1, 2, and 3, change the DC current from 50 mA to 0 by opening the load connection, and determine the percent regulation.

- Refer to the circuit shown in Fig. 4. Use the oscilloscope to read the AC voltages across AB and BD.

  With $R_L$ = 680 Ω, measure $V_{DC}$, $I_{DC}$, $V_r$, and $I_F$ (the peak diode current), for the following values of the capacitor: 1, 22, 100, and 1000 μF. Record your data in Table 1. Note the period during which diode conducts. Repeat for $R_L$ = 2.2 KΩ.

TABLE 1.

| C ($\mu$F) | $R_L$ = 680 Ω | | | | $R_L$ = 2.2 KΩ | | | |
|---|---|---|---|---|---|---|---|---|
| | $V_{DC}$ | $I_{DC}$ | $V_r$ | $I_F$ | $V_{DC}$ | $I_{DC}$ | $V_r$ | $I_F$ |
| 1 | | | | | | | | |
| 22 | | | | | | | | |
| 100 | | | | | | | | |
| 1000 | | | | | | | | |

Plot the following as a function of 10 log($2\pi f\, C\, R_L$):

i) $V_{DC} / V_{2max}$

ii) $V_r / V_{DC}$

iii) $I_F / I_{DC}$

Compare the measured values of $V_r$ and $V_{DC}$ with those calculated using the approximate relations in the Theory section above.

## Discussion

***For the circuits shown in Figs. 1, 2, and 3:***

**Q How is the current rating of the transformer secondary calculated?**

**Q Compare the three circuits for each of the characteristics 1 to 6 listed in the Theory section, and with respect to magnetic polarization of the transformer. What is the regulation mainly due to?**

**Q Under what conditions would each of the circuits be most advantageous?**

***For the circuit shown in Fig. 4:***

**Q Does $V_{DC}$ increase appreciably with C for all values of C?**

**Q** **Does $V_r$ decrease appreciably with C for the values of C used in the experiment?**

**Q** **Does the ratio $I_F/I_{DC}$ vary with C? Of what practical importance is this ratio?**

**Q** **Under what conditions are the approximate relations in the Theory section adequate for calculating $V_r$ and $V_{DC}$?**

**Q** **How does the presence of the capacitor affect the regulation of the circuit?**

**Q** **What additional current rating of diodes must be considered for the capacitor filter?**

**Q** **For a certain required ripple voltage and DC voltage/current at the load:**
**what should be the RMS voltage rating of the secondary of the transformer?**
**what should be the value of the capacitor?**