

Rectifiers and Voltage Doublers

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Lab No. 3

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I. Introduction

The purpose of this part of the lab is to investigate the characteristics of a circuit using superposition principle with both dependent and independent voltage sources

II. Background Information

Rectification: The conversion of alternating current to direct current is called rectification. Rectification can be accomplished in different ways, but most commonly depends on the usage of diodes or commutators. Diodes are generally used for electronic-circuit rectification; commutators are used in motors and generators when direct current is needed. The diode conducts current in only one direction. Therefore, when a diode is placed in a circuit where alternating current flows, the output is pulsating direct current.

A **rectifier** is a two terminal junction diode that converts alternating current into direct current. As a class rectifiers are considered to be capable of conducting 1 A or more of current or dissipating 1 W or more of power. Most semiconductor rectifiers today are made from silicon.

The **Voltage Doubler** makes it possible to use a transformer with a lower step up ratio than would be needed if an ordinary full wave supply were used. Voltage doublers are sometimes used in radio-frequency-actuated circuits to obtain the control voltage. Voltage doubler circuits are not generally used when excellent regulation is needed, or when the current drain is high.

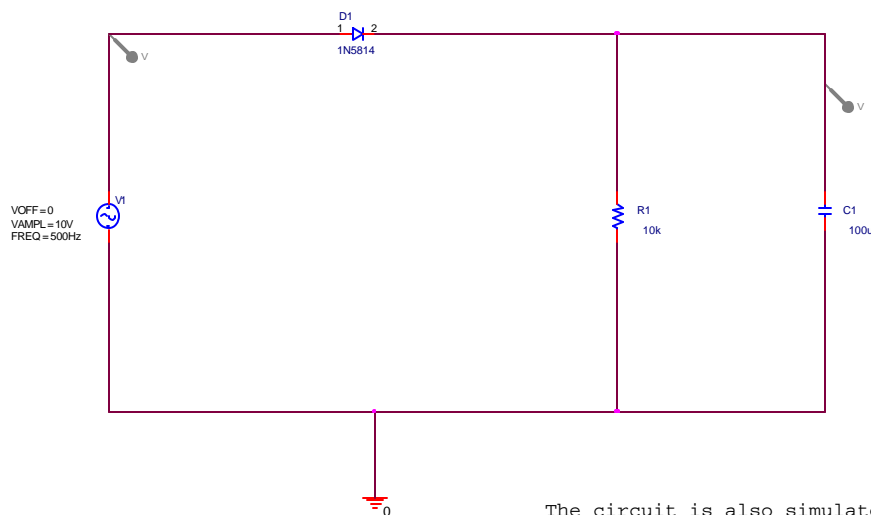
III. Materials Used

The following materials were used in this lab: resistors of 10 k Ω , 100 k Ω resistance, function generator, capacitor of value 100 μ F, 10 μ F, 1 μ F, oscilloscope, and the bread board on the Heathkit Trainer.

IV. Procedure

A. Half Wave Rectifier

1. Setup the following circuit with the capacitor value of 100 μ F:

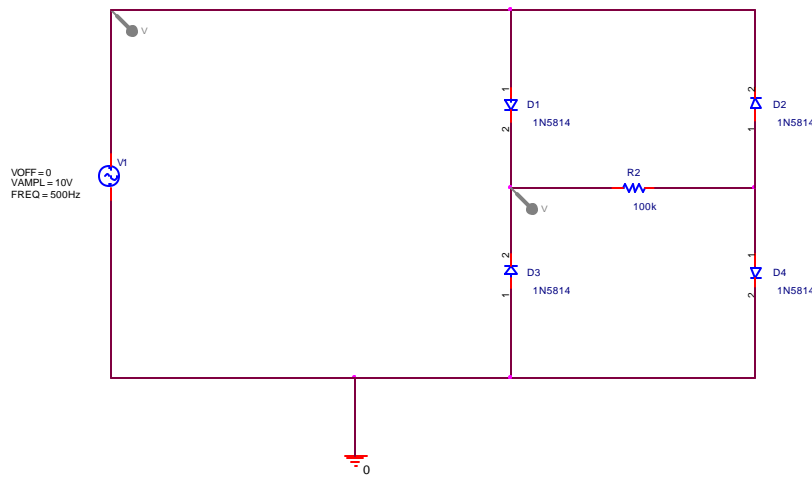


The circuit is also simulated with 10uF and 1uF capacitors

2. Connect the input to the function generator and supply a voltage of $10 V_{pp}$ and frequency of 500 Hz.
3. Connect the input of the circuit to the oscilloscope (ch1).
4. On the oscilloscope observe and measure the input waveform. The input should be $10 V_{pp}$.
5. Connect the second channel (ch2) of the oscilloscope to the V_o .
6. On the oscilloscope change the switch (AC GND DC) to AC.
7. Again on the oscilloscope (ch 2) observe and measure the waveform that is the ripple voltage and is in the shape of sawtooth waveform.
8. Repeat the process with capacitor values of $10 \mu F$ and $1 \mu F$.

B. Full Wave Rectifier

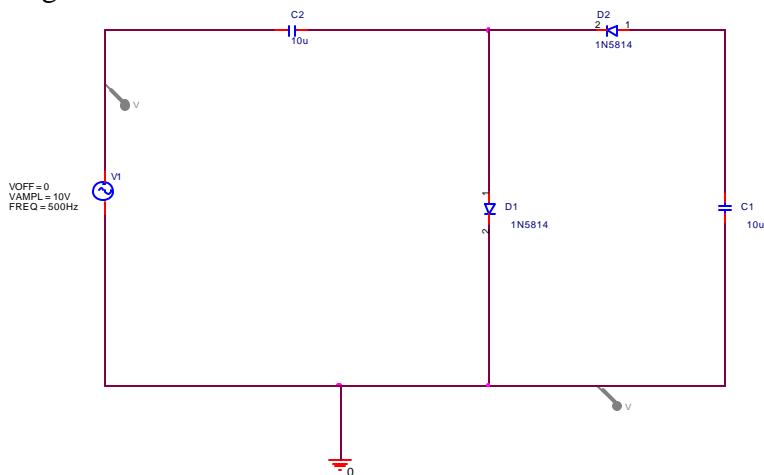
1. Setup the following circuit:



2. Connect the input to the function generator and supply a voltage of $10 V_{pp}$ and frequency of 500 Hz.
3. Connect the input of the circuit to the oscilloscope (ch1).
4. On the oscilloscope observe and measure the input waveform. The input should be $10 V_{pp}$.
5. Using probe connected to second channel (ch2) of the oscilloscope measure the voltage of the marked points with respect to the signal generator and ground.

C. Voltage doubler

1. Setup the following circuit:



2. Connect the input to the function generator and supply a voltage of 10 V_{pp} and frequency of 500 Hz.
3. Connect the input of the circuit to the oscilloscope (ch1).
4. On the oscilloscope observe and measure the input waveform. The input should be 10 V_{pp}.
5. Using probe connected to second channel (ch2) of the oscilloscope measure the voltage of the marked points with respect to the signal generator and ground.

V. Results

A. Half Wave Rectifier

Frequency (Hz)	V _{in} (V _{pp})	Resistance (KW)	Capacitance (mF)	Ripple Voltage (V)	Ripple factor
500	10	10	100 μF	0.0065	0.0013
500	10	10	10 μF	0.08	0.016
500	10	10	1 μF	0.8	0.16

The ripple factor above is calculated using the following formula:

$$\text{Ripple factor} = (\text{Ripple voltage}) / (\text{peak input voltage})$$

B. Full Wave Rectifier

Frequency (Hz)	V _{in} (V _{pp})	Resistance (KW)	Position	Voltage (V)
500	10	100	1, 2, 5	10
500	10	100	4, 7	0
500	10	100	3	5
500	10	100	6	5

C. Voltage doubler

Frequency (Hz)	V_{in} (V _{pp})	V_{out} (V _{pp})
500	10	

VI. Conclusion and Observations

A. Half Wave Rectifier

As was expected the half wave rectifier utilizes only half of the input signal. A look at the experimental data and graphs as well as the PSpice simulations will show that the theoretical and experimental values are in very good agreement. In both experimental and simulation we can observe that the ripple voltage decreases with increase in capacitance or vice versa. This is expected because the addition of the capacitor in the circuit serves to stabilize and reduce the ripple voltage. The higher the capacitance the lower the ripple voltage. The more the ripple voltage is reduced a better constant signal will be obtained. Whenever input voltage is higher than the capacitor voltage, the diode conducts and the capacitor charges. When voltage drops below the capacitor voltage, the capacitor tries to discharge through the diode, but is unable to do so. The diode becomes an open circuit and the capacitor discharges through the load resistor until the input voltage again becomes higher than the capacitor voltage. The difference between the maximum and minimum voltages across the load is called the ripple voltage.

B. Full Wave Rectifier

It can be clearly seen that in the half-wave rectifier, we lost half of the signal. To take advantage of the entire input signal we use the full-wave rectifier. The full-wave rectifier uses four diodes to ensure that current always flows the same way through a resistor. Unlike the half-wave rectifier (which cuts the current for half the cycle), the full-wave rectifier allows current flow for both positive and negative source voltages.

It can be observed that when the input voltage is in its positive cycle, the two diodes, D1 and D4, are on while the other two diodes, D2 and D3, are off and current flows in the direction through the resistor as indicated by the arrow in the figure 2. When the input voltage is in its negative cycle, D2 and D3 are on while D1 and D4 are off, and current flows in the same direction through the resistor as indicated by the arrow in the figure 2. So, during both halves of the cycle current flows through the load resistor in the same direction, and the entire signal is used.

C. Voltage doubler

As it can be observed in both experimental and PSpice simulation, the circuit of figure 3 acts as a voltage doubler. It has an AC input voltage but puts out a DC voltage equal to twice the peak value of its input. Once the diode D1 is on, the voltage across the capacitor C1 is just a constant DC voltage. In the same time when the input voltage is doubled the current is also reduces and there will be a time when no current flows.