Investigation on Half-wave Rectifiers with Capacitors CS1025

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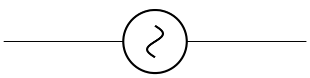
Lab Session:	Lab 3

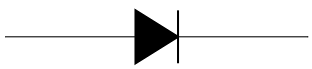
1 Objectives

The aim of this experiment is to investigate on the output waveform of a capacitor within an a.c. circuit. The typical applications of this is used in everyday circuits such as cellphone chargers, TV and PC cables, and power tools like electrical screw drivers.

2 Apparatus



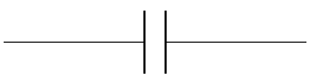
A.C. source x 1



Diode x 1

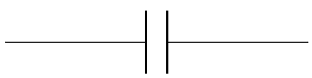
$10\,\text{k}\Omega$ Resistor x 1

$1\,\mu\text{F}$



$1\,\mu\text{F}$ Capacitor x 1

$10\,\mu\text{F}$



$10\,\mu\text{F}$ Capacitor x 1

- 1 x Kenwood CS-4125 Oscilloscope

3 Theory

A capacitor is a two terminal electrical component that stores electricity in an electric field. Its ability to store energy is described numerically by its 'capacitance' value. A capacitor is formed by two conductors which usually may be parallel connecting plates, with a dielectric placed between. The distance that the two plates are separated enhance the capacitance of the component. Therefore capacitance is defined by the formula:

$$C = \frac{q(t)}{v(t)}$$

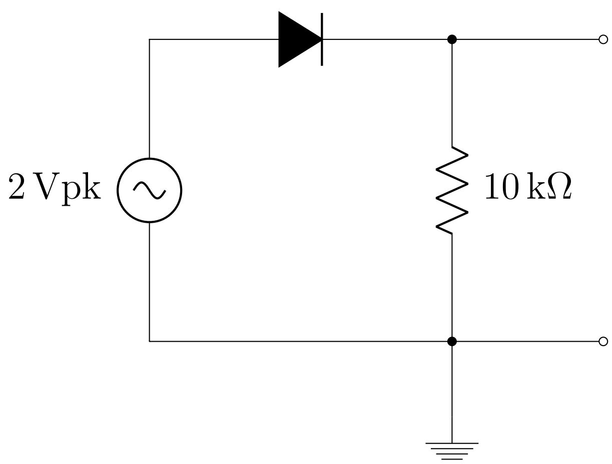
Capacitors can either be polarized(electrolytic), meaning that that its anode and cathode side are set; or non-polarized(ceramic) which can conduct either way and does not require for it to be in the right bias.

When a voltage is passed through a capacitor, positive charge would reside on the positive plate and negative charge would reside on the negative plate, thus storing the energy. The capacitor would be able to hold this charge indefinitely as long as the supply voltage is present during d.c. connection.
However, in an a.c. circuit, the capacitor would continuously charge and recharge due to the alternating current connection i.e. the voltage supplied increases and decreases at a same rate causing the capacitor to charge and recharge accordingly.

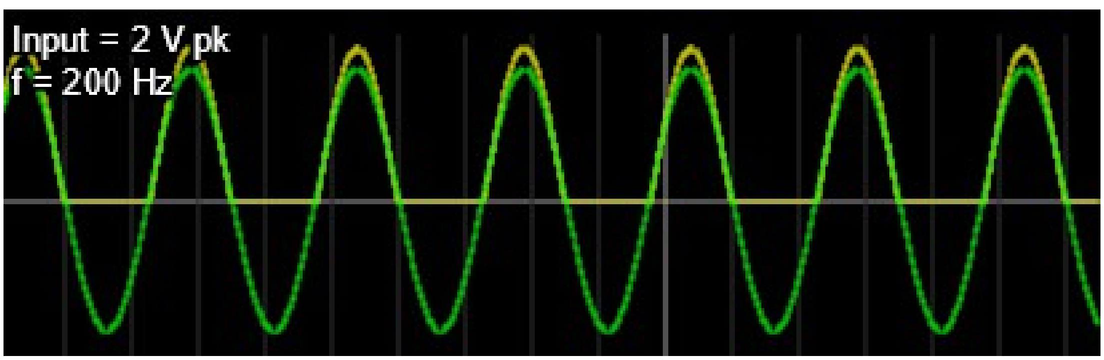
4 Procedure

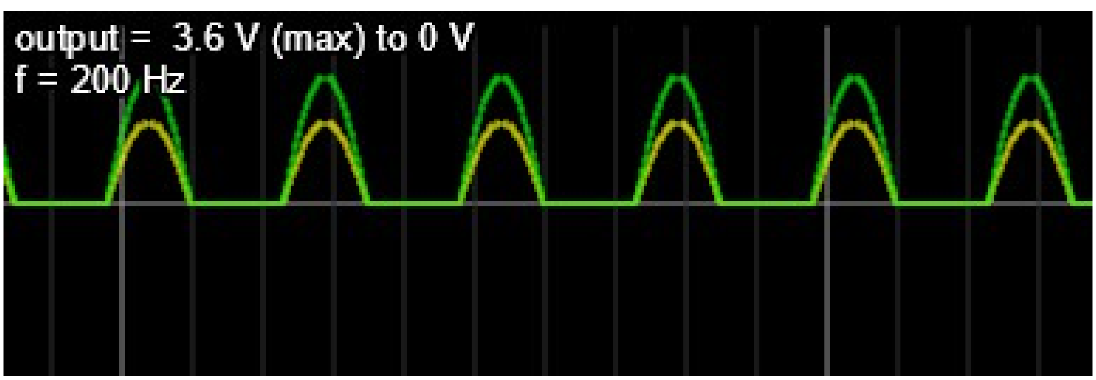
The circuits are connected according to the relevant circuit diagrams, choosing a point from the bottom part of the circuit to be ground. The oscilloscope is calibrated accordingly and is placed in the circuit to view the output waveform.

5 Observation and Data



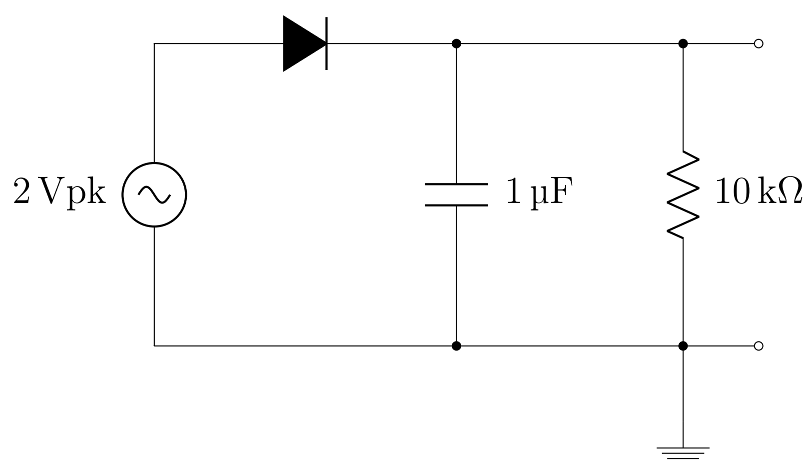
The First Circuit:



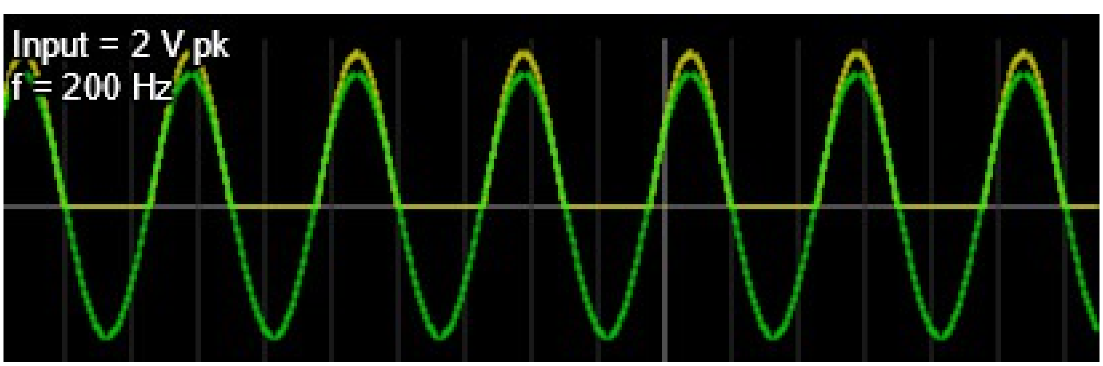


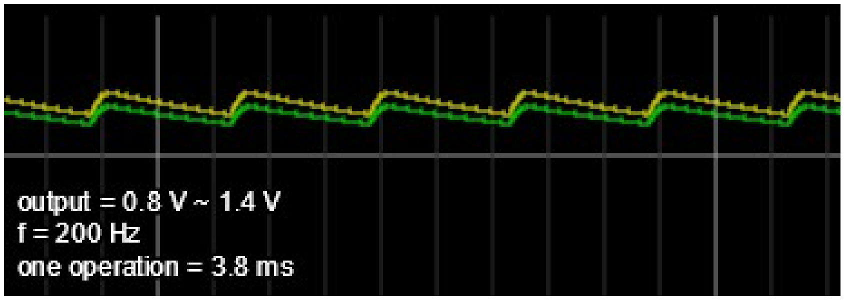
Where the green line on the graphs represents voltage and the yellow represents current. Comparing the input and output waveforms, it is observed that the the with the diode, the circuit acts as a rectifier. A rectifier is one that converts the alternating current input power to a direct current output power.

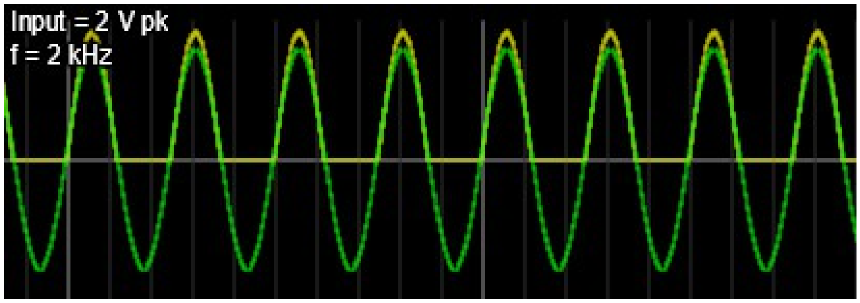
As observed from the output waveform, the diode only passes one half of the sine wave of the a.c supply to convert it into a d.c. supply. This circuit is thus called a "half wave" rectifier because it only passes one half of the incoming a.c. power. The diode is non-ideal and thus requires its cur-in voltage to conduct.

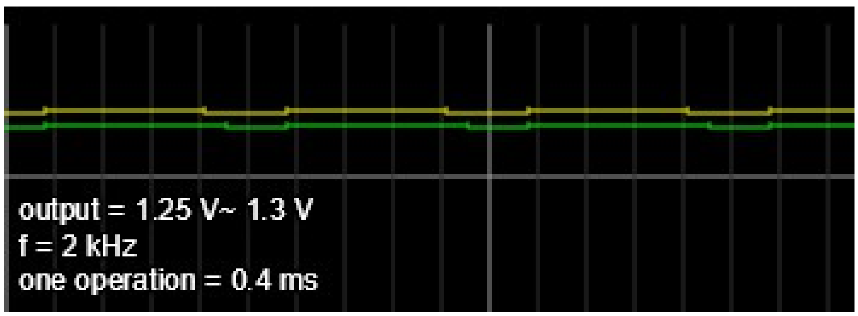


The Second Circuit:





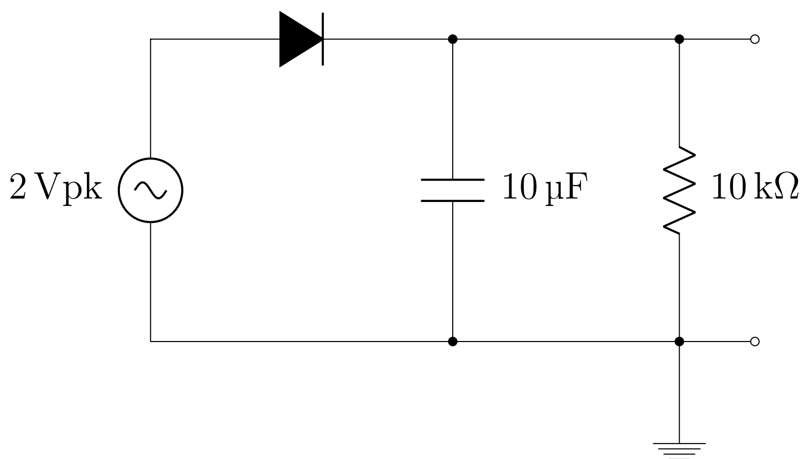




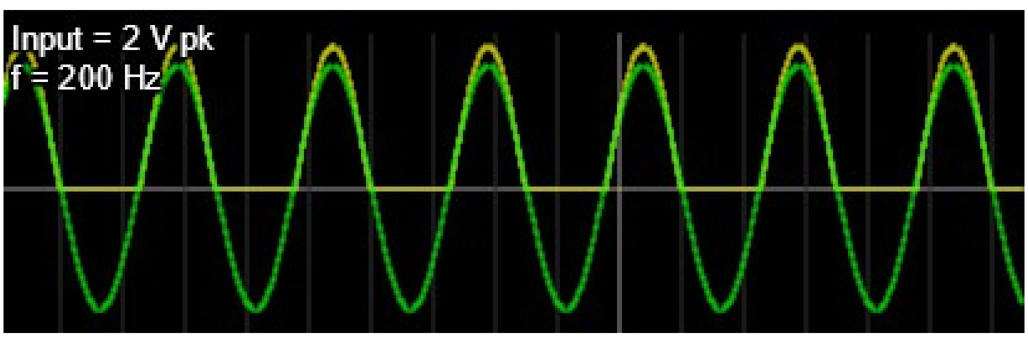
Where the green line on the graphs represents voltage and the yellow represents current. As observed from the output waveforms with different frequencies, the larger the frequency, the more closer the waveform is to a straight line. This is due to the diode(as per operation) does not allow current to pass through one half of the wave, the capacitor discharges during this and this helps to smooth out the output waveform during this process. As per operation, the diode(half wave rectifier) only passes half way of the sine wave of the a.c. supply whilst the capacitor is discharging ad in doing so helps smoothen the output d.c. waveform.

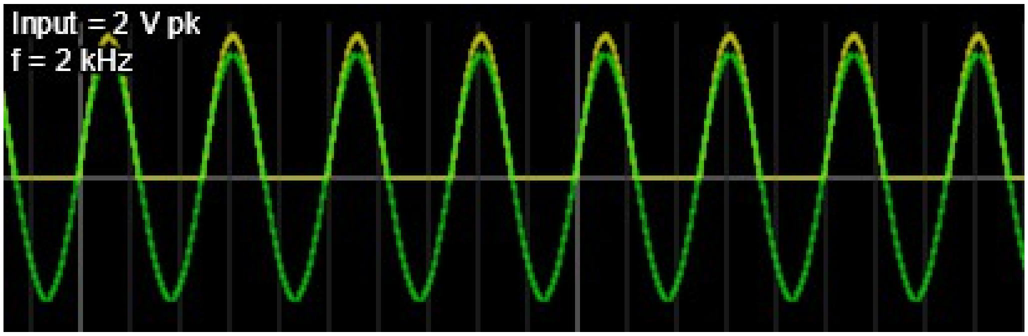
For a set frequency of 2 kHz, the duration for one operation of the capacitor charging and recharging is approxiately 3.8 s where the wave oscillates from approximately 1.4 V to 0.8 V.

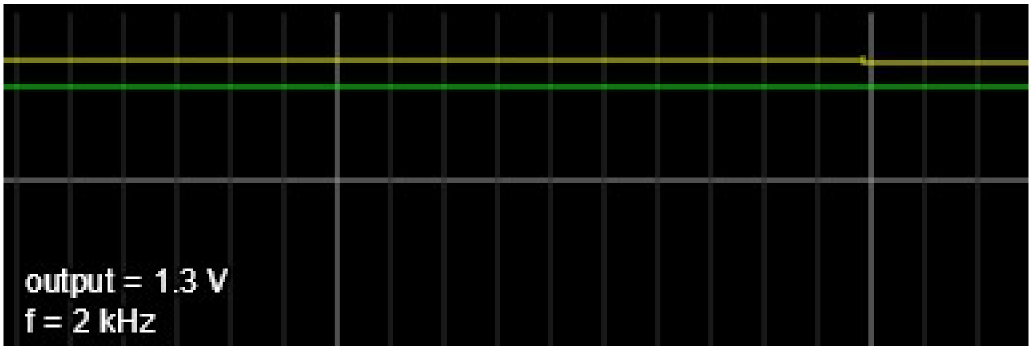
As observed for the waveform when the frequency is set to 2 kHz, the duration for one operation of the capacitor charging and discharging is approximately 0.4 s where the range of the wave oscillates from 1.25 V to 0.3 V. The output appears to be more of a straight line than when the set frequency is 200 Hz.



The Third Circuit:







Where the green line on the graphs represents voltage and the yellow represents current. In this circuit, the 1 µF capacitor is replaced with a 10 µF capacitor, having the output waveform when the frequency is set to 200 Hz and 2 kHz.

When the frequency is set to 200 Hz, the approximate time for one operation of the capacitor charging and discharging is approximately 1.9 s, where the waveform oscillated from appriximately 1.27 V to 1.3 V. Which is faster than the previous circuit with a capacitor of lower capacitance.

When the frequency is set to 2 kHz, the time for one operation of the capacitor charging and recharging is difficult to observe as it is too frequent. This results in a graph which is apprximately a straight line at 1.3 V. Which again, operates faster than the previous circuit with a capacitor of lower capacitance value.

6 Applications

A.c. to d.c. converters are used frequently in everyday living including applications such as:

- Power adapters and chargers for cell and mobile phones;
- Power supplies for LCD TVs and monitors;
- Power suppliers for fast charging mobile devices.

7 Conclusion

The diodes in the above circuits act as half wave rectifiers, which converts alternating current input power to direct current output power. The diode thus only passes through one half of the sine wave of the a.c. supply to convert to d.c.

A capacitor inserted into this circuit would soothen the wave into a ripple like wave. This is due to the diode(as per operation) blocking current for one half of the wave and at this time the capacitor discharges, thus smoothening the waveform.

The higher the frequency set for the wave, the quicker the capacitor charges and discharges, resulting in an output waveform which appears to be similar to a straight line. Similarly, the higher the capacitance value of the capacitor, the quicker it charges and discharges resulting in a more linear fashioned waveform.