Electronic Circuits I – Laboratory 03

Rectifiers

#	Student ID	Student Name	Grade (10)	Instructor signature
1				
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Delivery Date	

Objectives

In this experiment, you will get to know a group of components and circuits known as rectifiers. The response of simple half-wave and bridge rectifiers is investigated and characterised by measuring under various loads.

Training contents

- Half-wave rectifiers
- Bridge rectifiers
- Smoothing and residual ripple
- Load resistance

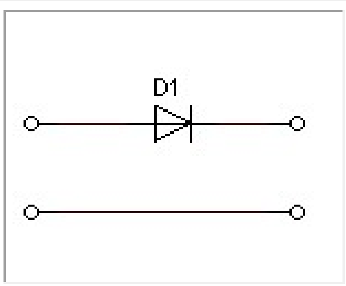
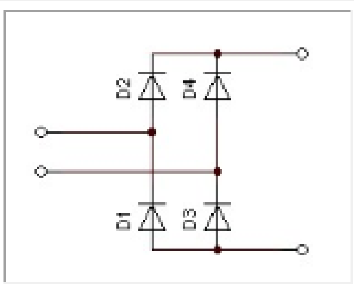
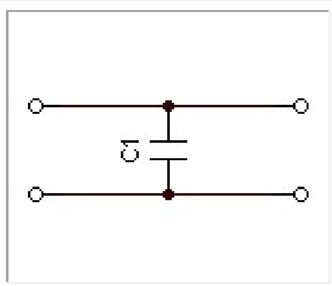
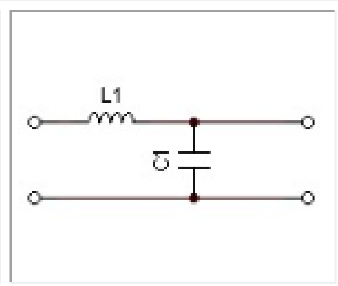
Introduction

Mains voltages (AC) are generally unsuitable for supplying electricity directly to electronic equipment. It is usually necessary to convert the mains into a suitable DC voltage, which needs rectification and smoothing. An additional voltage regulator maintains the voltage at a constant level irrespective of the load.

This description and the experiments that follow cover the rectifiers themselves and the accompanying smoothing circuits.

With the semiconductor diodes available nowadays, it has become particular easy to implement rectifiers for all ranges of power. Among the numerous types of rectifier circuits which may be conceived, two of them are of particular importance, half-wave and bridge rectifiers, since they are so widely used.

In addition to the actual rectifier circuit, it is nearly always necessary to have a separate smoothing network to smooth out "pulsating" voltage or suppress current peaks where necessary.

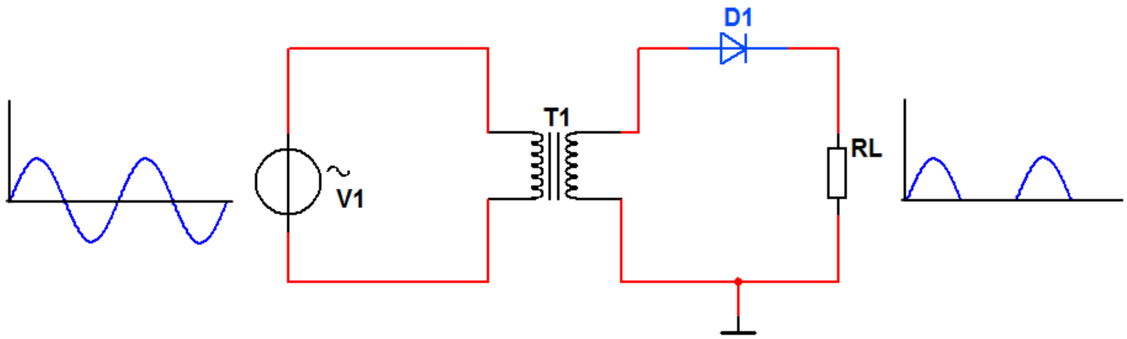
			
Half-wave rectifiers	Bridge rectifiers	Smoothing capacitors	Smoothing using both capacitors and inductors

Half-wave rectifiers

The following animation illustrates how a half-wave rectifier works. As long as the input voltage to the circuit shown is greater than the threshold voltage of the diode, the half-wave rectifier behaves as follows: only the positive half-waves of the alternating input signal arrive at the load, resulting in a pulsating DC output.

During the positive half-wave:
The voltage across the diode D1 is forward-biased, so that the diode allows the current to pass through to the load resistor. The voltage associated with this current has the same wave-form as the positive half wave of the input voltage, as shown in the following animation.

During the negative half-wave:
The voltage across the diode is reverse-biased, so that the diode allows no current to pass through to the load resistor. The output voltage, the voltage across the load, is 0 V.

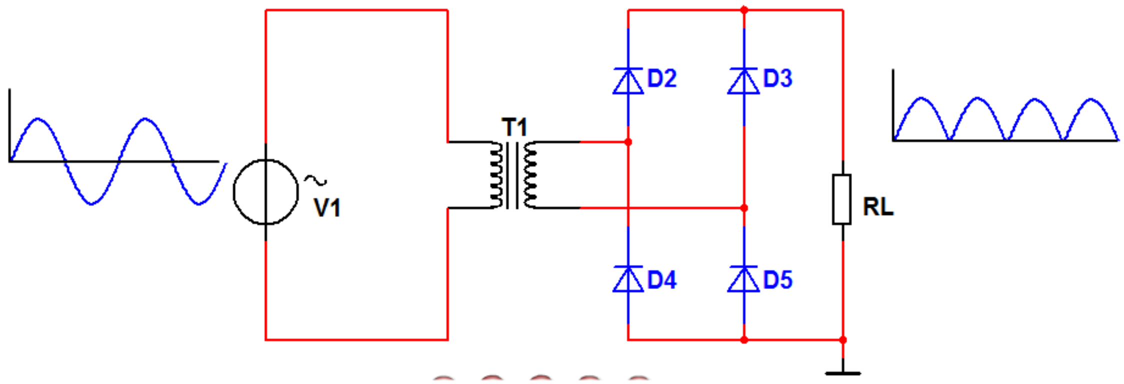


Bridge rectifiers

This rectifier circuit employs four diodes. A simplified illustration of its response is shown in the animation and is explained below:

During the positive half-wave:
Diodes D2 and D5 are forward-biased. Current flows from the transformer via the anode of diode D2 through the load resistor RL. After that, it flows through the anode of diode D5 to the negative terminal of the secondary winding. Throughout this period, diodes D4 and D3 are reverse-biased and conduct no current.

During the negative half-wave:
Diodes D4 and D3 are forward-biased. Current flows from the secondary winding terminal (which in the previous half-wave was seen to be negative but which now appears to be positive). Current flows through the anode of D3, the load resistor RL and then to the anode of D4.



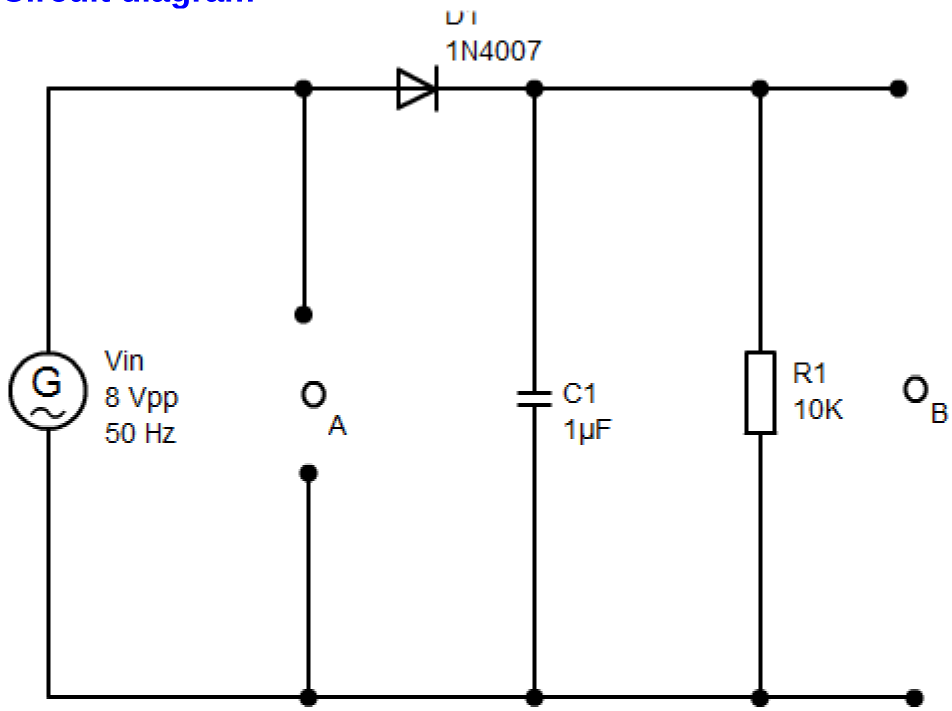
Residual ripple

Use of a capacitor in parallel with the load causes charge carriers to be temporarily stored. These can then be consumed by the load when the voltage level falls beneath a certain value in the course of the periodic rising and falling of the voltage. Once the voltage rises back above the value, the capacitor starts storing charge again. The difference between the maximum and minimum voltage across the capacitor is called the ripple voltage or AC component

The residual ripple (w) is expressed as a percentage stating the ratio between the AC and DC components. This is calculated by dividing the AC component by the DC component of the rectified voltage.

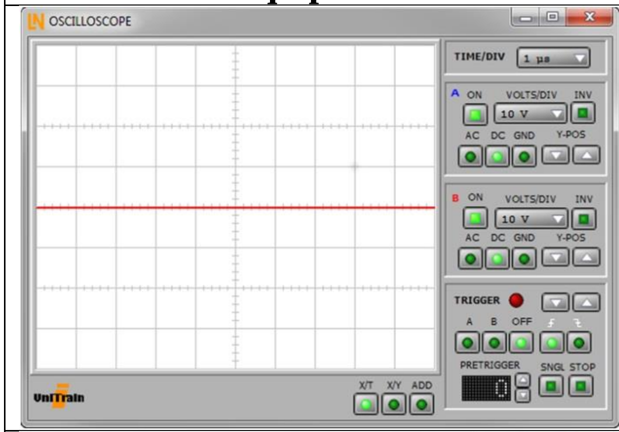
Part 1; Half-wave rectifiers

Circuit diagram



Equipment

The following equipment is needed for this experiment and should be configured as shown:

<table>
<tr><th>Equipment</th><th>Settings</th></tr>
<tr><td>
</td><td>
<table>
<tr><th></th><th>Channel A</th><th>Channel B</th></tr>
<tr><td>Sensitivity</td><td>2 V/div</td><td>2 V/div</td></tr>
<tr><td>Coupling</td><td>DC</td><td>DC</td></tr>
<tr><td>Polarity</td><td>Normal</td><td>Normal</td></tr>
<tr><td>Y position</td><td>0</td><td>0</td></tr>
<tr><td>Time base</td><td colspan="2">5 ms/div</td></tr>
<tr><td>Mode</td><td colspan="2">X/T</td></tr>
<tr><td>Trigger channel</td><td colspan="2">A</td></tr>
<tr><td>Trigger edge</td><td colspan="2">Pos</td></tr>
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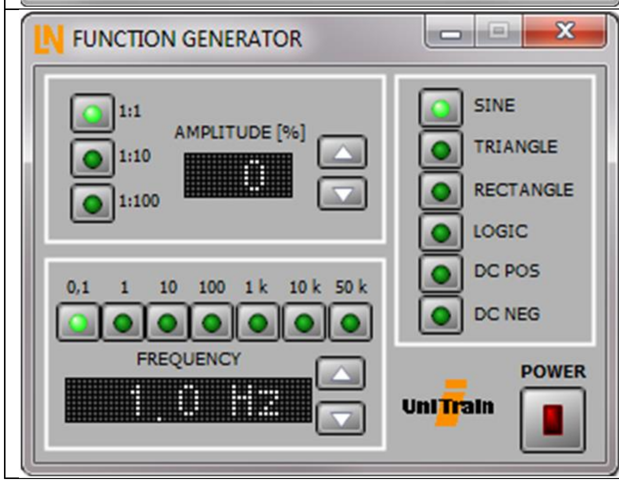
</td></tr>
<tr><td>
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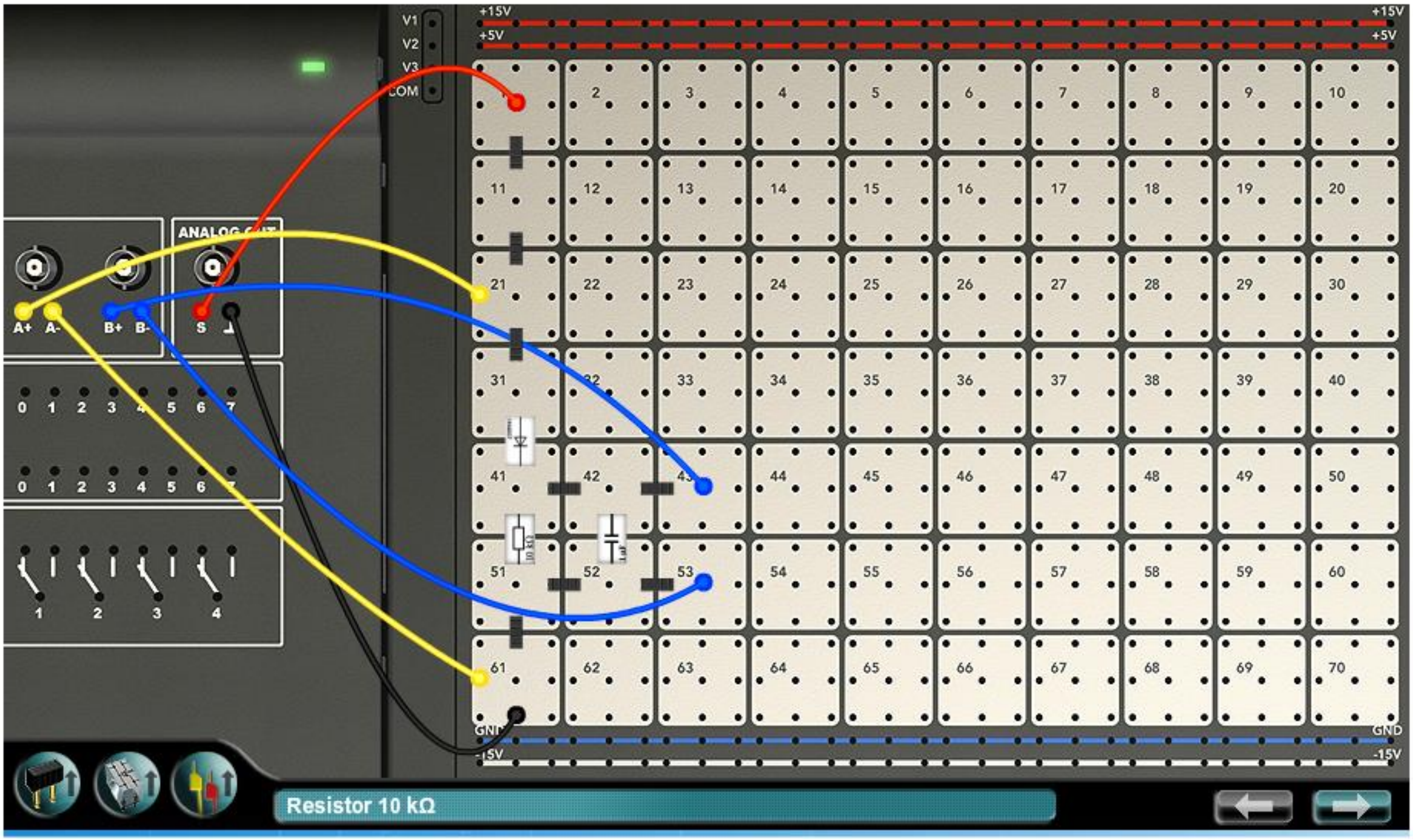
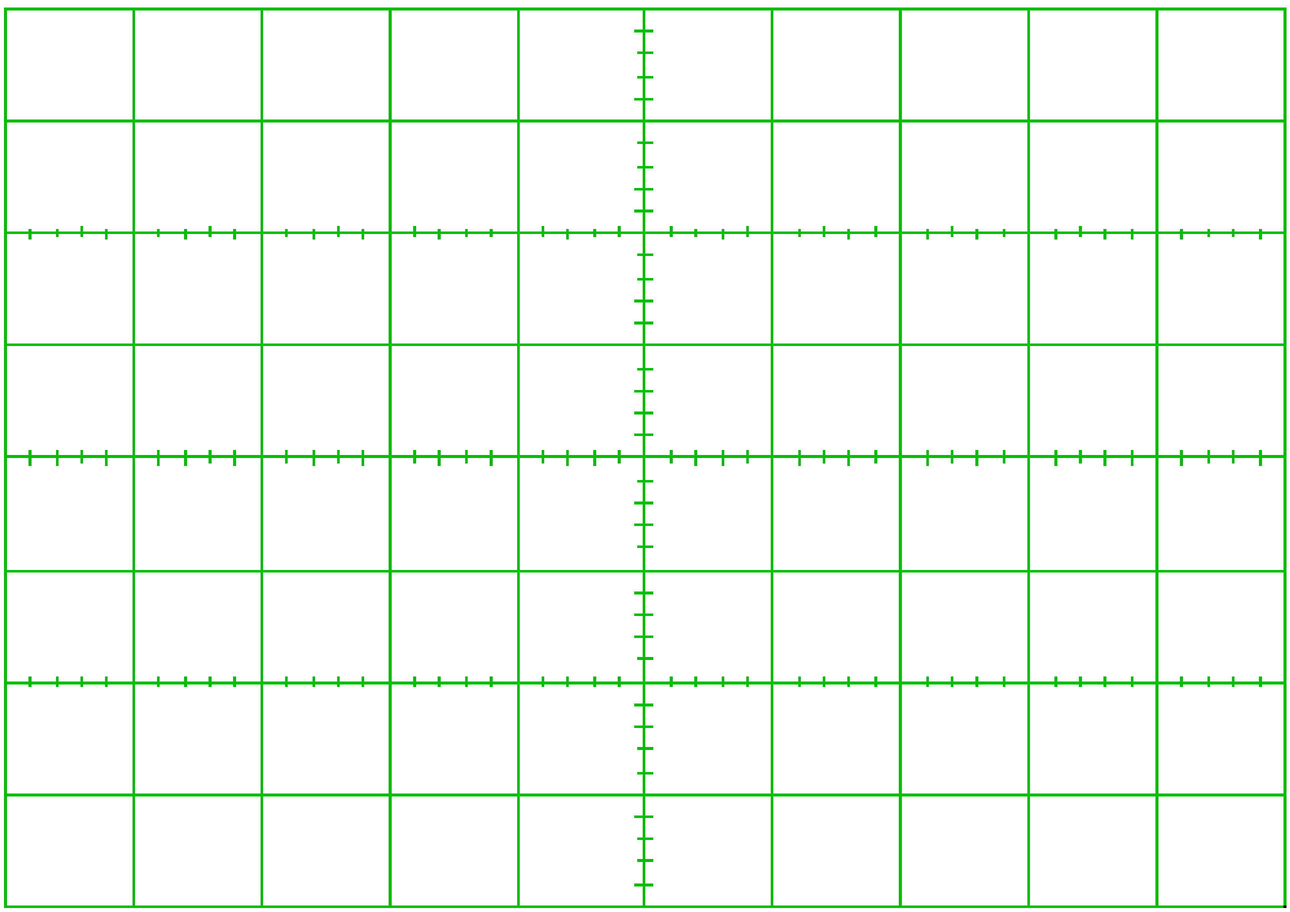
<table>
<tr><td>Waveform</td><td>Sine</td></tr>
<tr><td>Amplitude</td><td>8 Vpp (40%, 1:1)</td></tr>
<tr><td>Frequency factor</td><td>10</td></tr>
<tr><td>Frequency</td><td>50 Hz</td></tr>
</table>
</td></tr>
</table>

Experiment set-up



Experiment procedure and exercises

- Set up the oscilloscope as shown above. Copy the oscilloscope trace into the space below.



What is the maximum voltage across the resistor?

V_{Max} (volts)	

Set up the oscilloscope in such a way that you can best read off the value. You may need to change the time base to make sure that the positive half-wave is in the middle of the screen.

What then is the minimum voltage drop across the resistor?

V_{Min} (volts)	

Set up the oscilloscope in such a way that you can best read off the value. You may need to change the time base to make sure that the curve is in the middle of the oscilloscope screen.

- Change the frequency of the function generator to 200 Hz. Do not modify the time base for the frequency. Copy the oscilloscope trace into the space below.

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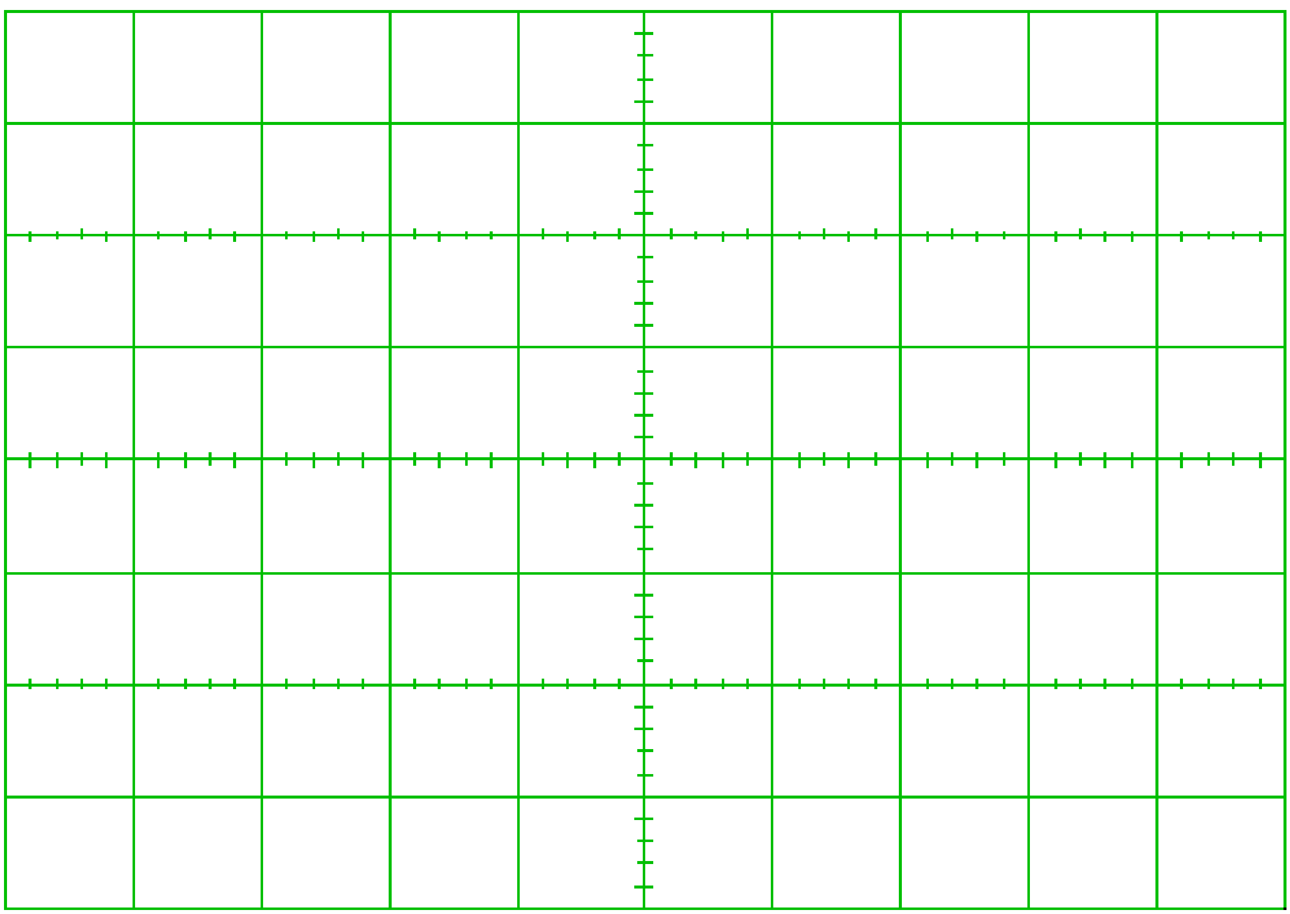


What is the maximum voltage across the resistor now?

V_{Max} (volts)	

What is the minimum voltage across the resistor?

V_{Min} (volts)	

Swap the 10-kΩ resistor for a 4.7-kΩ resistor and set the frequency to 50 Hz. What is the minimum voltage across the resistor?

V_{Max} (volts)	

Set the frequency back to 200 Hz. What is the minimum voltage across the resistor?

V_{Min} (volts)	

- Calculate the residual ripple. Measure both the AC and DC components of the output voltage.

$Ripple_{10k,50Hz}$ (%)	
$Ripple_{10k,200Hz}$(%)	
$Ripple_{4.7k,50Hz}$(%)	
$Ripple_{4.7k,200Hz}$(%)	

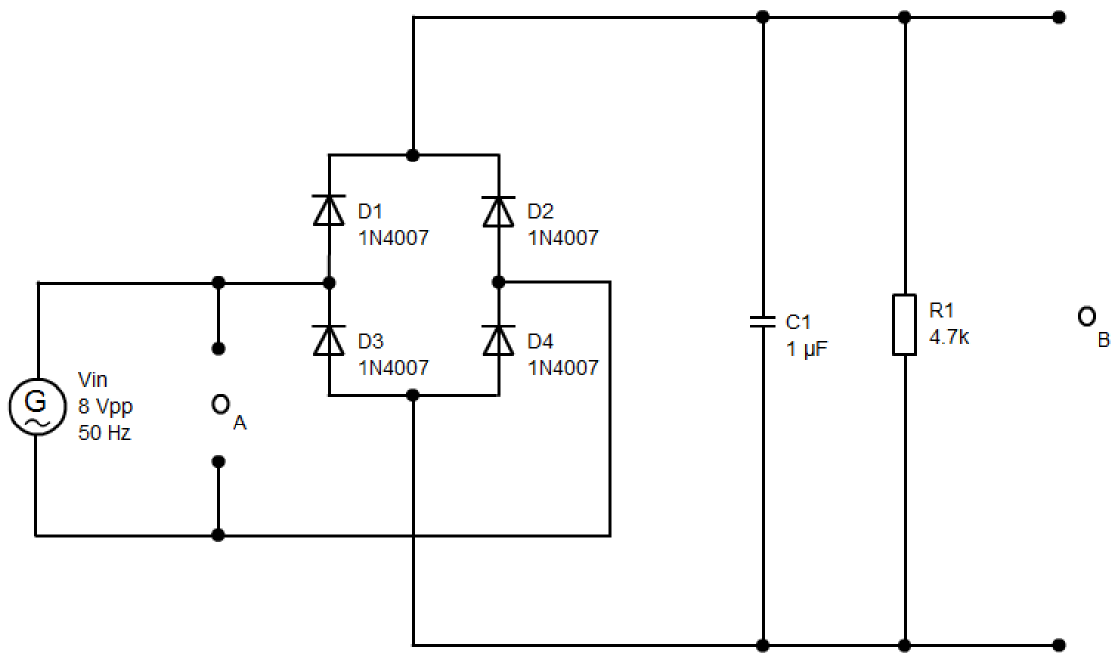
Which of the following statements is correct?

a) Residual ripple decreases with a larger load.
b) Residual ripple increases at higher frequency.
c) Residual ripple always remains constant.
d) Residual ripple decreases with a smaller load.
e) Residual ripple increases at lower frequency

Part 2; Bridge rectifier

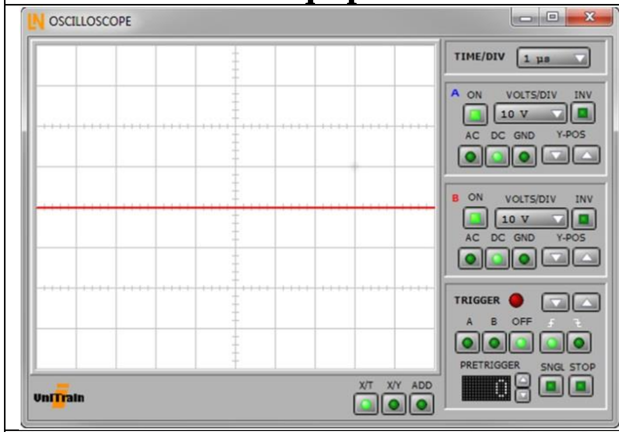
Circuit diagram

This experiment is based on the following circuit:

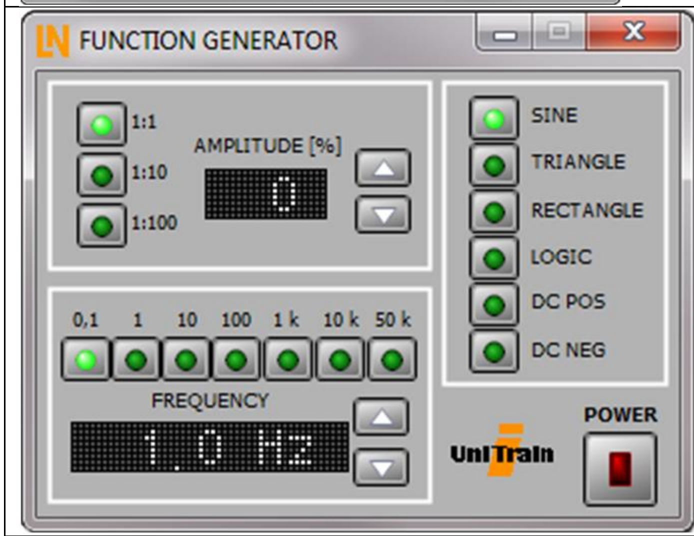


Equipment

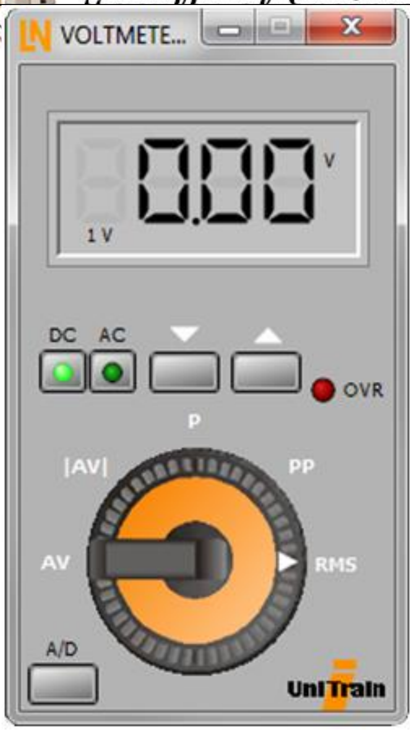
Equipment | **Settings**



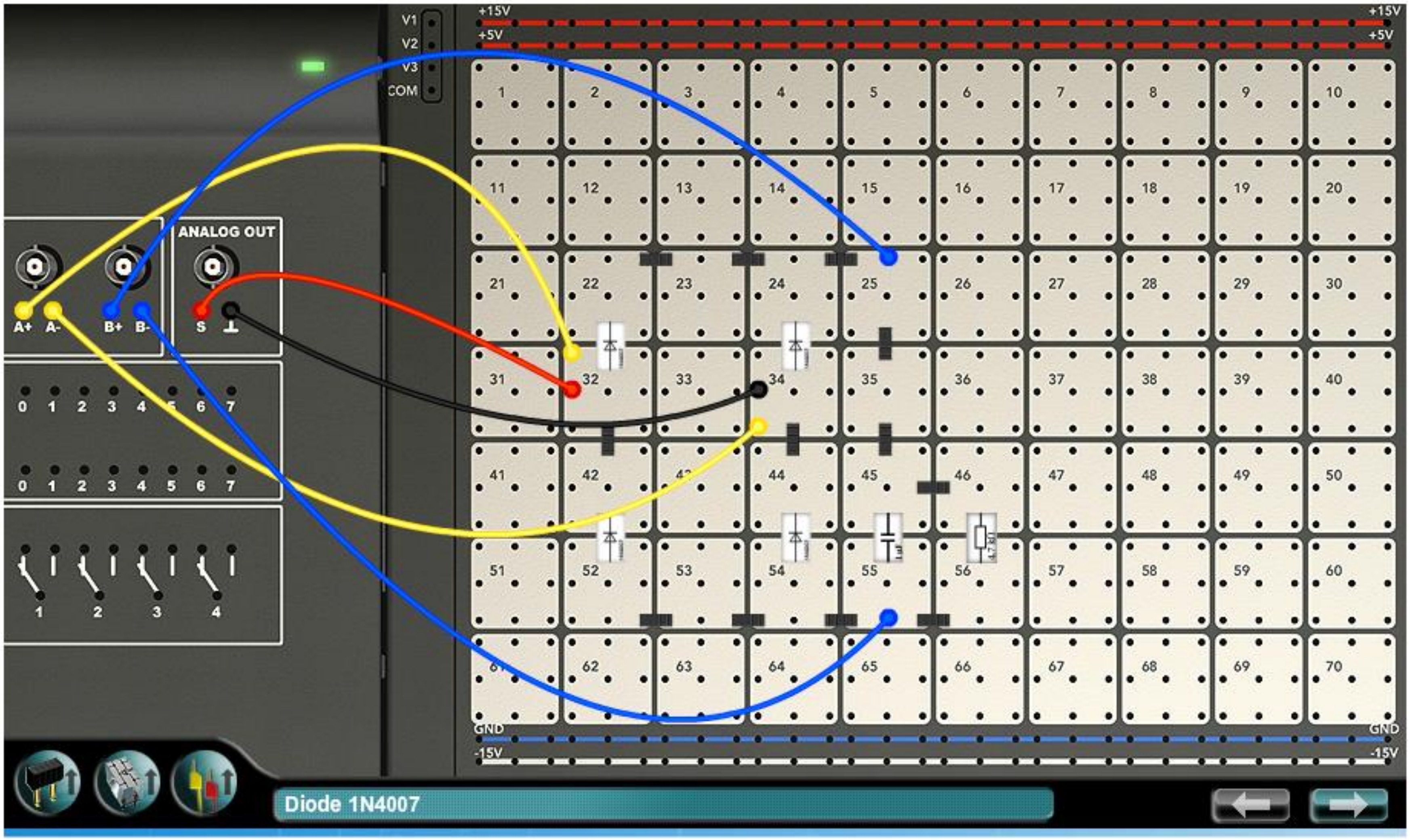
	Channel A	Channel B
Sensitivity	1 V/div	1 V/div
Coupling	DC	DC
Polarity	Normal	Normal
Y position	0	0
Time base	2 ms/div	
Mode	X/T	
Trigger channel	A	
Trigger edge	Pos	



Waveform	Sine
Amplitude	8 Vpp (40%, 1:1)
Frequency factor	10
Frequency	50 Hz

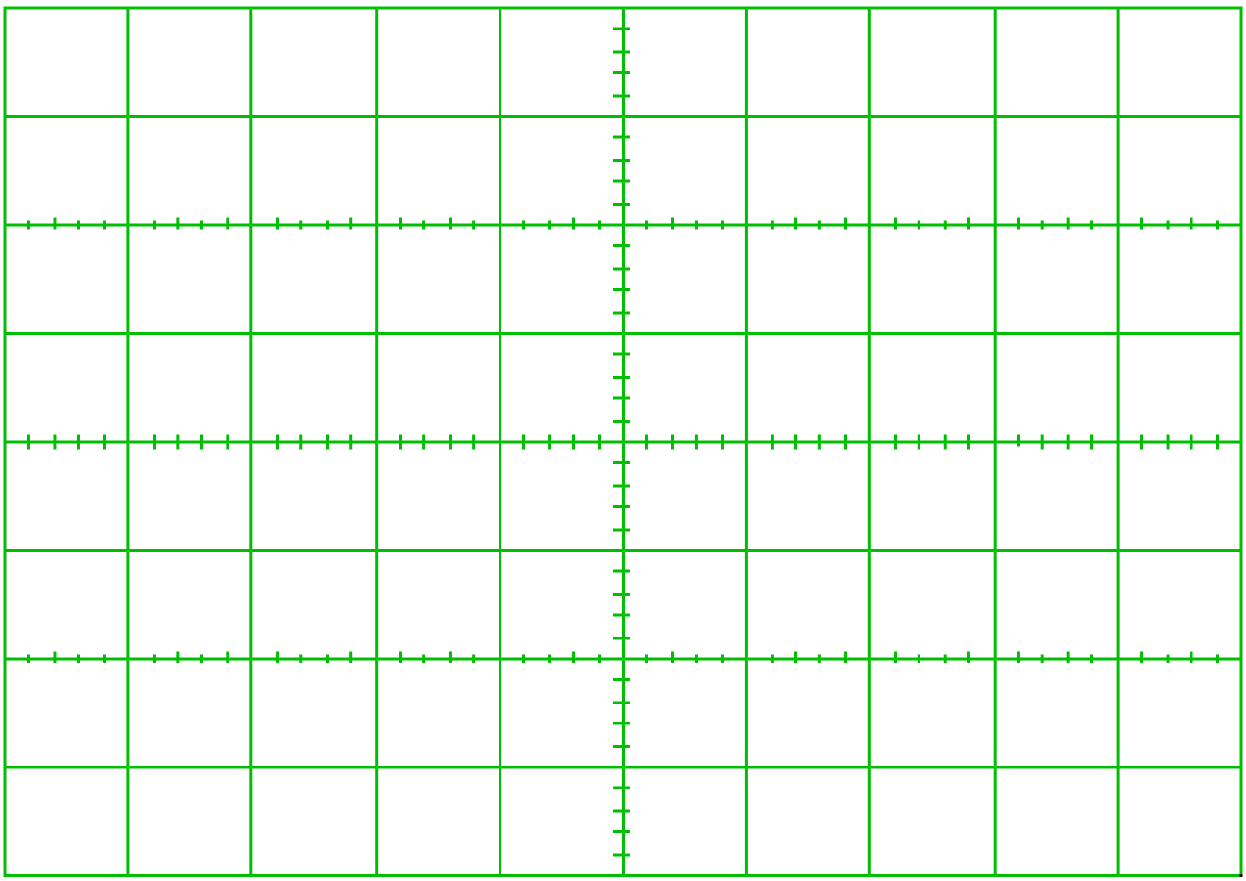


Positive input	B+
Negative input	B-
Selector knob	RMS (AC)


ANALOG OUT
Diode 1N4007

Experiment procedure and exercises

Set up the oscilloscope as shown above and remove the capacitor from the circuit. Copy the oscilloscope trace into the space below.



What is the peak voltage at the output side of the bridge rectifier?

V_p (Volts)	

Set up the oscilloscope in such a way that you can best read off the values.

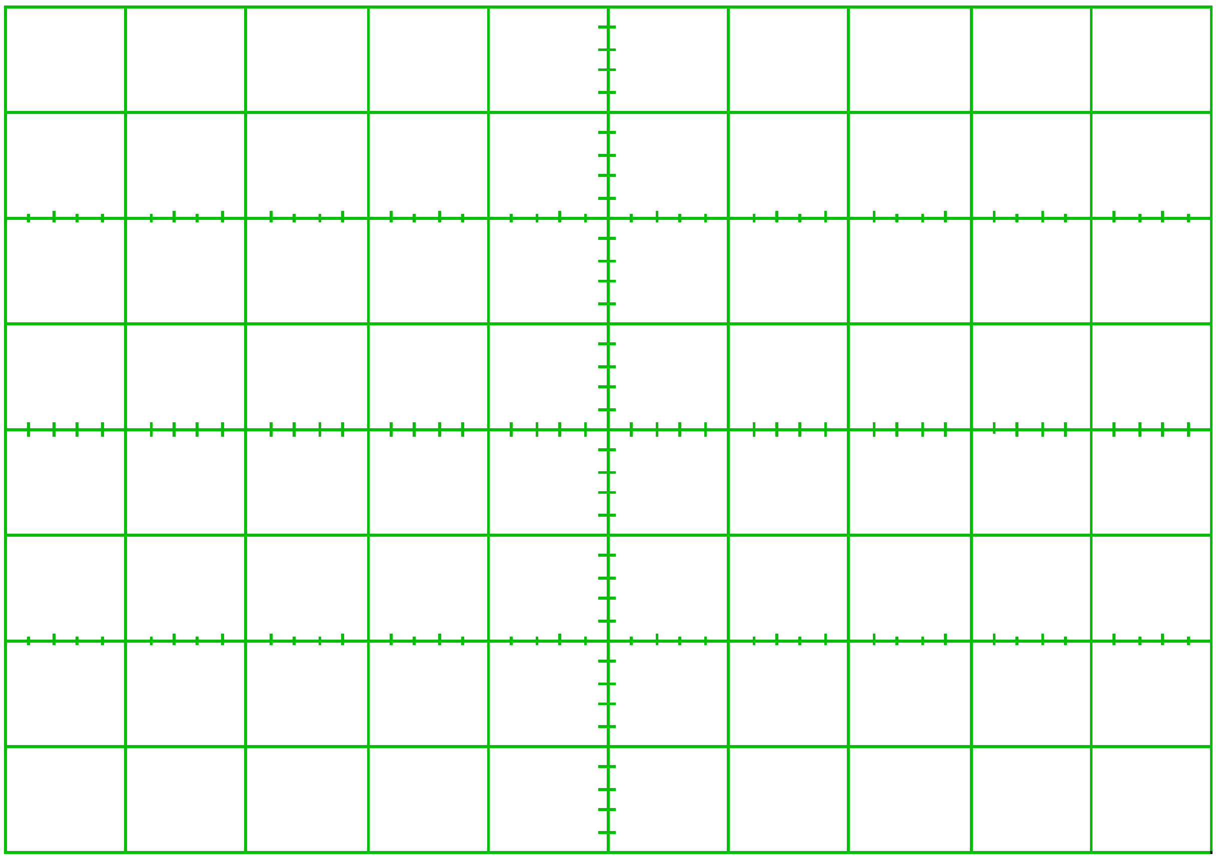
Why is the peak voltage at the output lower than the input voltage?

a) The voltage is smaller because the signal is shifted in time.
b) The voltage is smaller because there is a voltage drop of 0.7 volts across each of the diodes.
c) The voltage is smaller because it is closer to the load.

Why is the output voltage between the half-waves flat?

a) A voltage of 0.7 V falls across each of the diodes. That means that when the input voltage is lower than 1.4 V, there is no output voltage.
b) All of the voltage drops across the load.
c) The output voltage is affected by being measured with an oscilloscope.

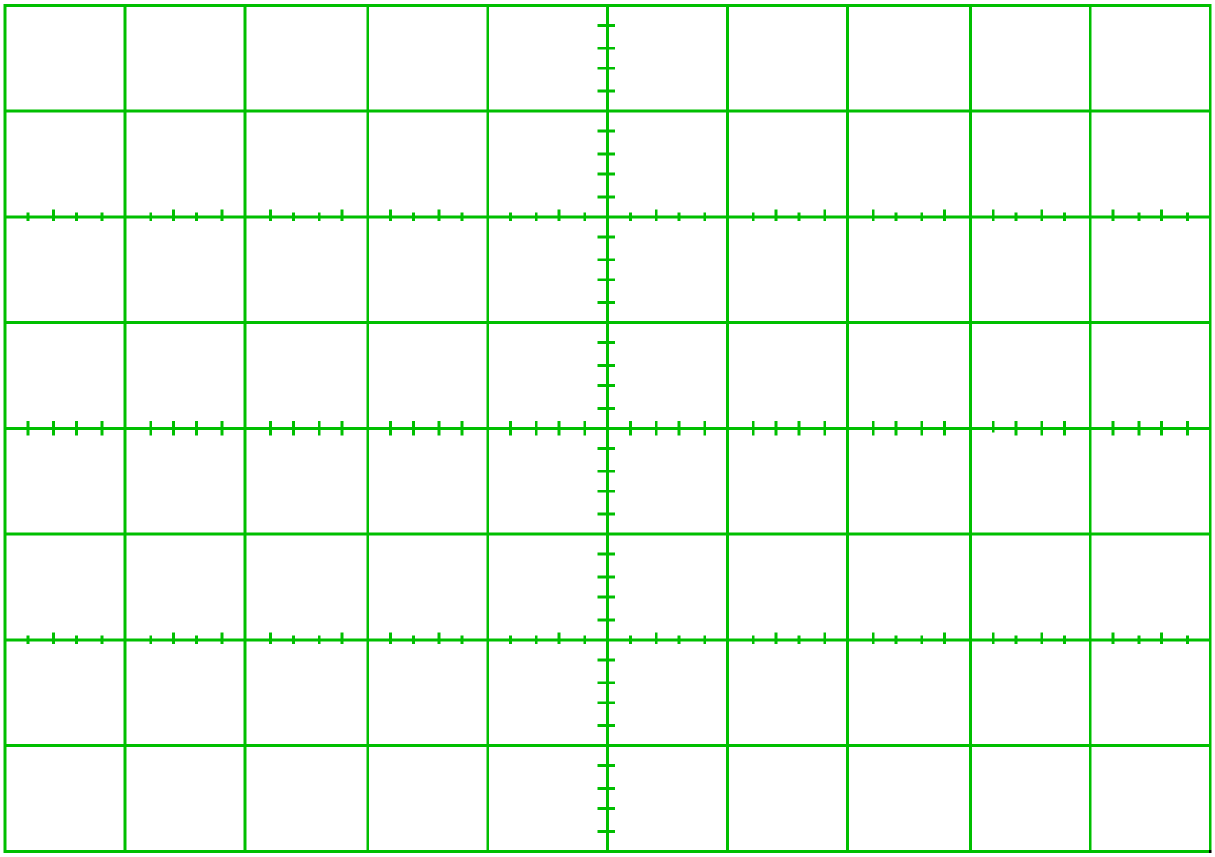
Now insert the capacitor at the correct position. Copy the oscilloscope trace into the space below.



Measure the residual ripple.

V_{br} (Volts)	

Remove the top left diode from the circuit. Copy the oscilloscope trace into the space below.



What can you observe from the oscilloscope trace?

a) The trace is unchanged.
b) The trace is exactly the same as that for a half-wave rectifier.
c) The trace is exactly the same as that for a half-wave rectifier except that the output voltage is another 0.7 V smaller, i.e. 1.4 less than with the half-wave rectifier.

*Removing the diode is comparable to the component burning out due to excessive load.