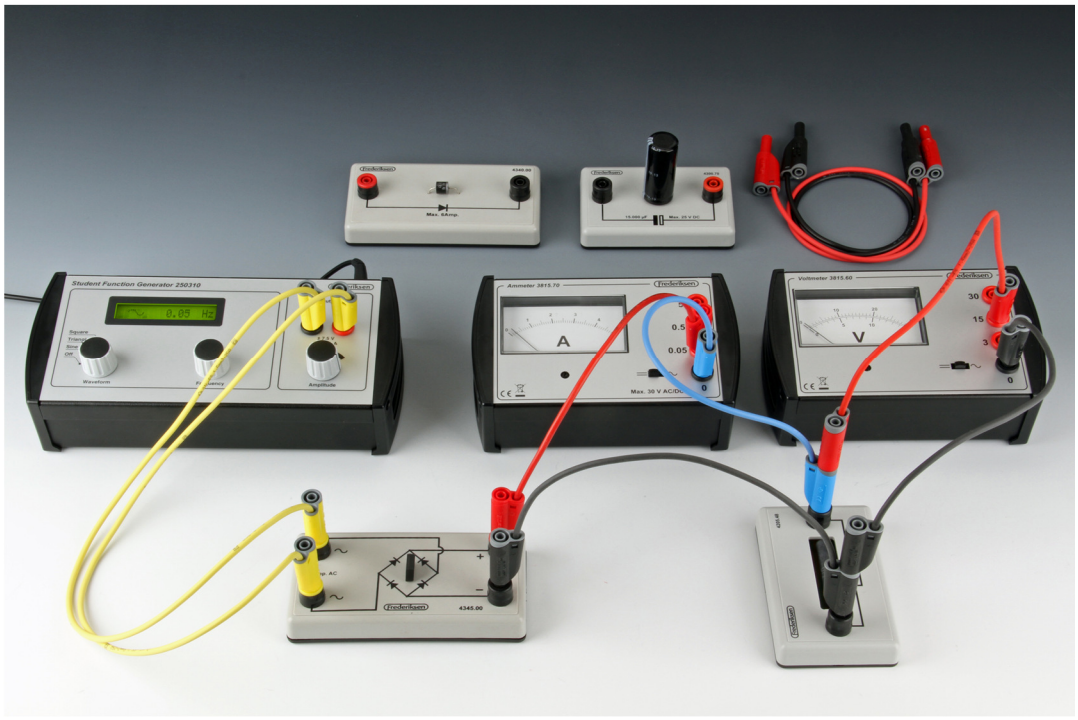
Rectifier circuits

Number	136210-EN	*Topic*	AC circuits, electricity			
Version	2017.03.24 / HS	*Type*	Student exercise	*Suggested for*	Grade 9-10	*p.* 1/4



Objective

We investigate how a diode and a bridge rectifier converts the alternating voltage to a direct voltage.
We also see how a capacitor can be used to smoot the pulsating direct current.

The rectifier circuit constitutes a very simple “power supply”. In this lab exercise we will use a resistor as “a device to be powered”.

Principle

Normally, the rectifier circuit is placed after a transformer that converts the AC mains voltage from the wall socket to a lower voltage.
But in order to be able to follow the variations in voltage and current, we don’t use 50 Hz (or 60 Hz) AC voltage here but instead a function generator adjusted to e.g. 0.1 Hz

With such a “slow motion” AC voltage, the variations can be observed with analog (needle) meters.

Equipment

(See Detailed List of Equipment at the last page)

Function generator
Analog voltmeter and ammeter
Rectifier diode
Bridge rectifier
Resistor
Electrolytic capacitor
Lab leads

About the instruments

The instruments used here are protected against over-load and will for instance tolerate swapping around plus and minus.

They can of course only indicate a little bit below zero but this is enough to indicate that the voltage (or the current) is negative.

Frederiksen Scientific A/S
Viaduktvej 35 · DK-6870 Ølgod
Tel. +45 7524 4966
Fax +45 7524 6282
info@frederiksen.eu
www.frederiksen.eu

Procedure

Adjust the function generator for sine wave, frequency 0.1 Hz, peak voltage (amplitude) approx. 7.5 V.

Both the instruments must be set for DC!
(The symbol "=")
We wish to measure instantaneous values with sign.

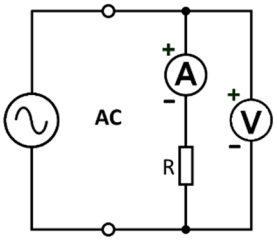
On the ammeter: Use the 0.05 A range. In this range, full scale "5" means 50 mA – "1" on the scale means 10 mA and so on.

On the voltmeter: Use the 15 V range. There is a scale specifically for this range.

Use a resistor R of 470 Ω as a load.

In the first 4 experiments, the instruments are connected the same:
The ammeter measures the current through the load resistor while the voltmeter measures the voltage at the output of our "power supply" (i.e. the rectifier circuit – except for experiment 1).

1 – Alternating voltage

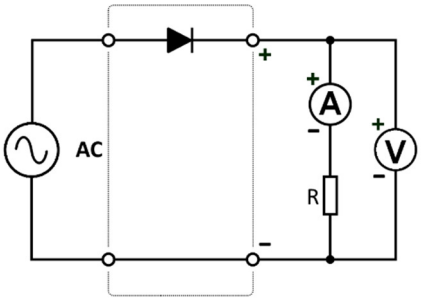


First, we will examine how the instruments behave when they are connected directly to the generator. Notice that the instruments are built to measure positive values – but they can also show a little bit below zero when the voltage or current is negative.

Do the needles on the instruments follow each other?
Are the deflections changing smoothly or jerky?
What are the maximum voltage and current?
Can you see when the voltage is negative? How?

Don't change the signal amplitude on the function generator from now on. (It is OK to change the frequency.)

2 – A diode as a rectifier

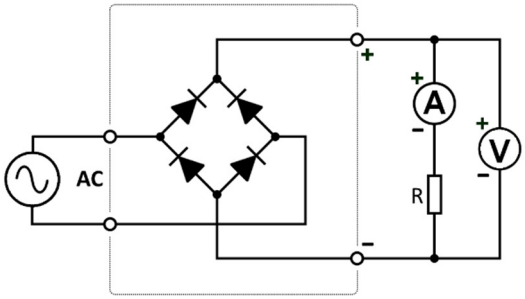


Insert a rectifier diode into one of the connections from the generator (the other is kept unchanged).

The current in a diode can only run in the direction of the arrow. The result is known as a half wave rectified DC voltage

Describe the behaviour of the instruments compared to experiment 1 – e.g. is current running all the time?
What are the maximum voltage and current now?
What is the minimum voltage?

3 – Full wave rectifier

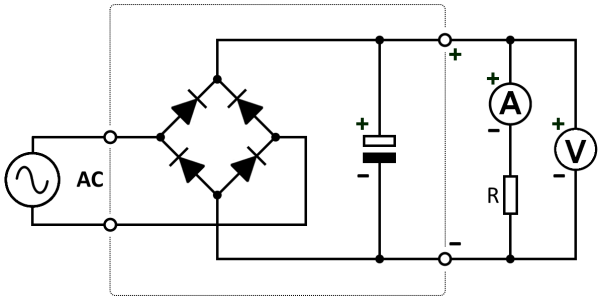


Exchange the diode with a bridge rectifier.

The result is called a full wave rectified DC voltage.

Describe as before the behaviour of the instruments in words. Note again the maximum voltage and current. Do the same for the minimum voltage.

4 – Smoothing with a capacitor

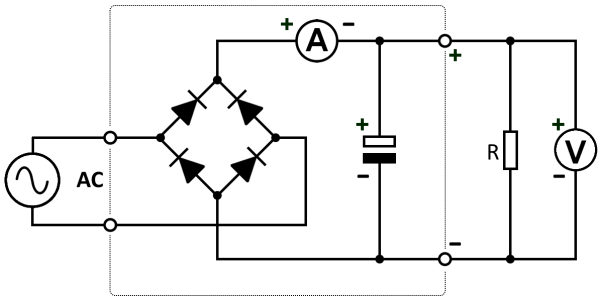


Now, the rectifier circuit is extended with a capacitor which is charged and stores the electric charge - which is given back again when the AC voltage is no longer big enough. Observe the polarity of the capacitor!

Now the voltage is called full wave rectified and smoothed.

Describe again the behaviour of the meters in words Note again maximum and minimum voltage and current.

5 – Optional: The charging current

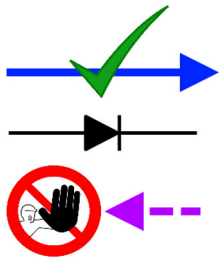


Instead of measuring the current through the resistor, this setup measures the capacitor's charging current.

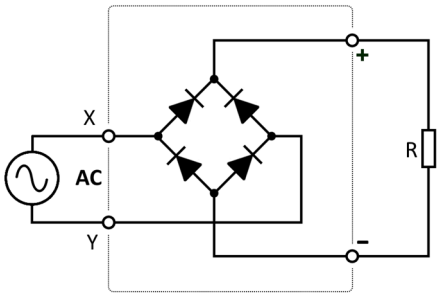
How does this current behave?

Theory and final considerations

The diode allows the current to pass in one direction – the other direction is blocked:



To understand how the bridge rectifier works, please draw a copy of the schematics below.



The AC voltage constantly changes sign, but we will study one instant where X is positive and Y negative. Take a colour pencil or marker and draw a line that follows the current through the rectifier and resistor *from X to Y* – take care to go only the right way through the diodes. You cannot go back to X – the current must go from X to Y. Draw arrows to show the direction of the current.

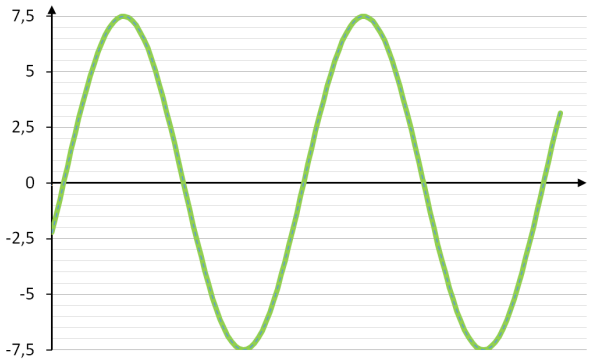
A short while later, Y is positive and X negative. Use a different coloured pencil and follow the current through the circuit *from Y to X* the same way again

What is the direction of the current through the resistor in the two situations?

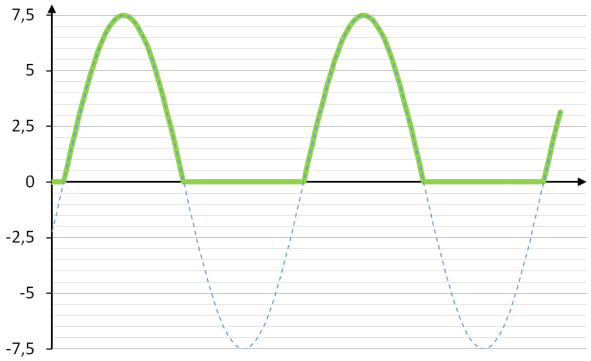
Often, graphs are used to describe the behaviour of the voltage when the AC voltage is rectified. Let's see if the drawings fit reality.

Draw your own version of the three last graphs to the right. Use your observations and notes from point 2, 3 and 4 in the measurements.

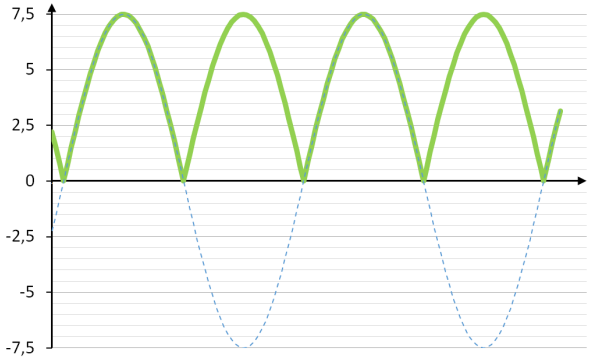
AC Voltage



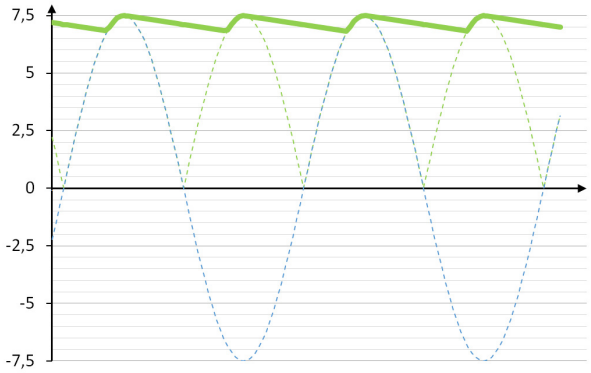
Half wave rectified



Full wave rectified



Full wave rectified, smoothed



Conclusion

Describe the advantages and disadvantages of the three rectifier circuits you have worked with.

Teacher's notes

Concepts used

Voltage
Current
Peak voltage
Diode
Rectifier
Capacitor

Mathematical skills

Graphs

About the equipment

The electrolytic capacitor must be oriented correctly!
The rest of the equipment cannot be damaged by the voltages and currents that the function generator is capable of.

Both the voltmeter and the ammeter are protected against wrong polarity

If another function generator is used, it must be able to deliver a sine wave with an amplitude of 7.5 V at 0.1 Hz. This corresponds to an RMS value of 5.3 V.

Silicon diodes are used both for the stand-alone diode and in the bridge rectifier. These diodes each have a voltage drop of approx. 0.7 V when current runs in the forward direction – rather independent of the size of the current.

Detailed equipment list

Specifically for the experiment

381560	Voltmeter
381570	Ammeter
434000	Rectifier diode
434500	Bridge rectifier
420548	Resistor, 470 Ω, 1%, 10 W
430070	Electrolytic capacitor, 15000 µF, 25 V

Larger equipment

250310	Student function generator

- or -

250350	Function generator

Standard lab equipment

105720	Safety cable, silicone, 50 cm, black (3 pcs.)
105721	Safety cable, silicone, 50 cm, red (3 pcs.)
105722	Safety cable, silicone, 50 cm,yellow (2 pcs.)
105723	Safety cable, silicone, 50 cm, blue (1 pcs.)