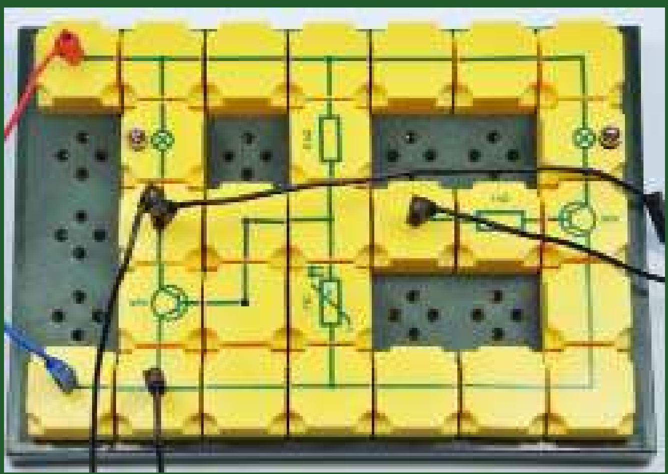
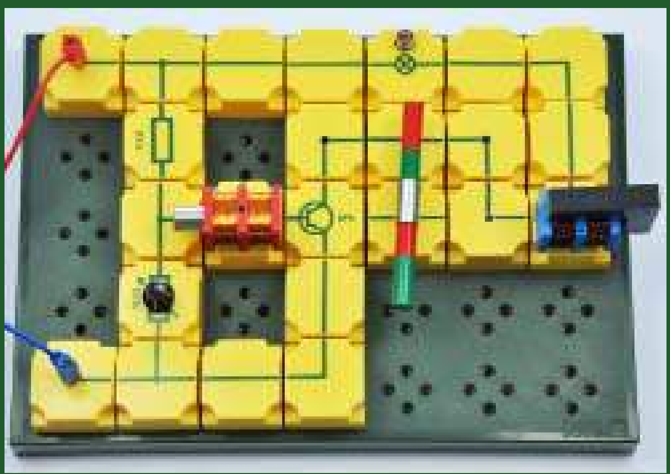
Student Experiments

Manual

ELECTRONICS

P9160-4F





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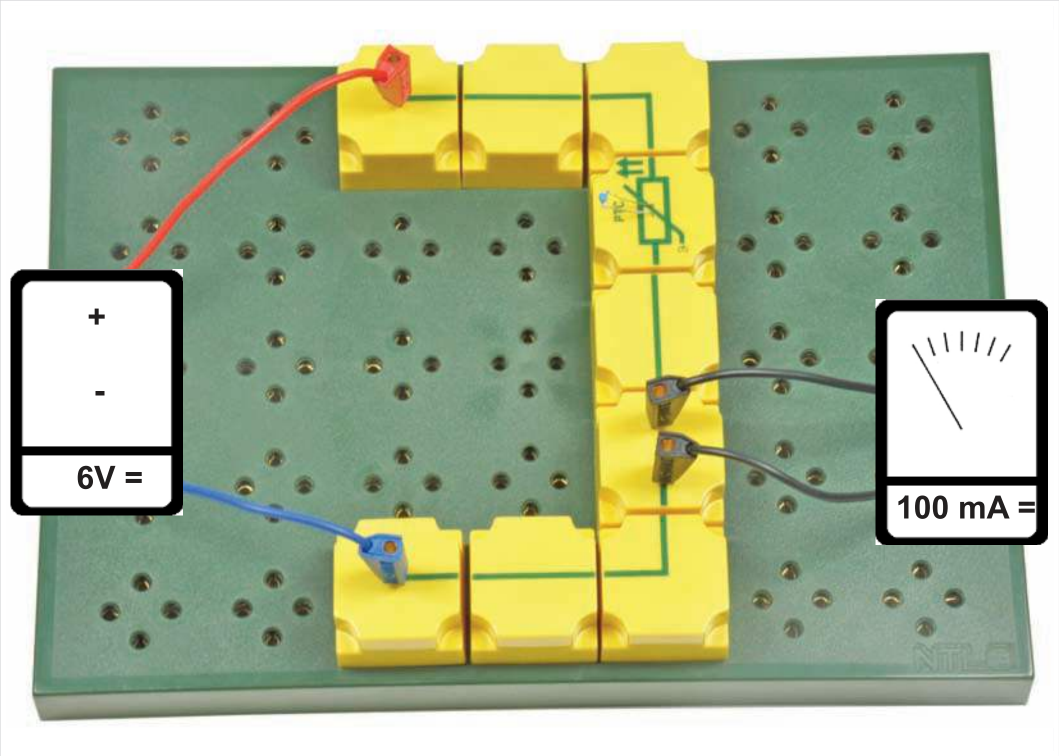
INDEX

INDEX

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
2x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB PTC Resistor

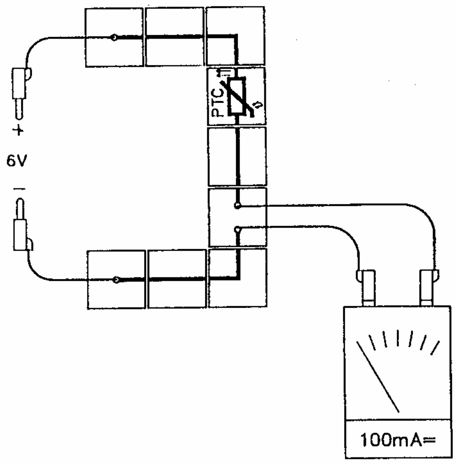
Additionally required:
1x Meter
1x Voltage supply

PTC RESISTOR

EOS 1.1

An incandescent lamp is no Ohmic resistor. The amount of resistance of a lamp increases when its spiral-wound filament is getting hot.
There are also semiconductor components whose amount of resistance increases with rising temperature.

Wiring:



Arrange the wiring according to the illustration.

A PTC-resistor and an ammeter (measuring range of 100 mA =) are connected in series.

A D.C. of 6 Volt is applied.

Experiment:

The current intensity is measured at different temperatures.

The amount of resistance is calculated from the amount of the applied voltage and the measured results by means of Ohm's Law.

<u>1.The current intensity is measured at room temperature:</u>

I = …….mA = ……..A

Resistance R = $\dfrac{6\ \text{Volt}}{\dots\dots\dots\ \text{Ampere}}$ = …….Ohm

<u>2. The PTC-resistor is heated by means of a burning match. The current intensity is measured:</u>

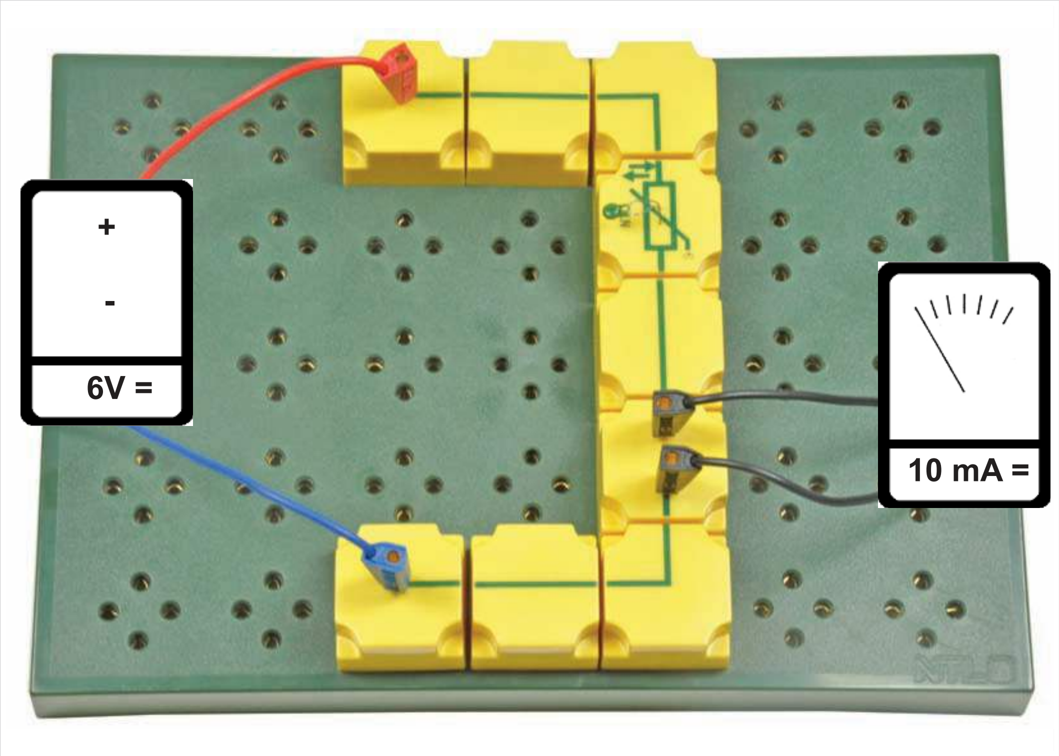
I = …….mA = ……..A

Resistance R = $\dfrac{6\ \text{Volt}}{\dots\dots\dots\ \text{Ampere}}$ = …….Ohm

Conclusion:
The amount of resistance of a PTC-resistor increases with risiang temperatures.
„PTC" means „positive temperature coefficient".

NTC RESISTOR

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



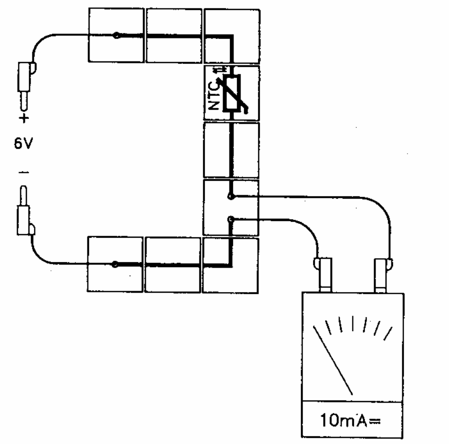
Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
2x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB NTC Resistor

Additionally required:
1x Meter
1x Voltage supply

NTC RESISTOR

EOS 1.2

There are electronic components whose amount of resistance decreases with rising temperatures.
The resistance of such a component is calculated for different temperatures.



Wiring:

Arrange according to the illustration.

An NTC-resistor and an ammeter (range of 10 mA =) are connected in series

A D.C source of 6 Volt is applied.

Experiment:

The current is measured at different temperatures.
The amount of resistance is calculated from the amount of the applied voltage and the measuring results.

1.The current is measured at room temperature:

I = ... mA = ... A

Resistance R = $\dfrac{\text{6 Volt}}{\text{........ Ampere}}$ = ... Ohm

2.The current intensity is measured at rising temperature.
To do so a match is held near the NTC.

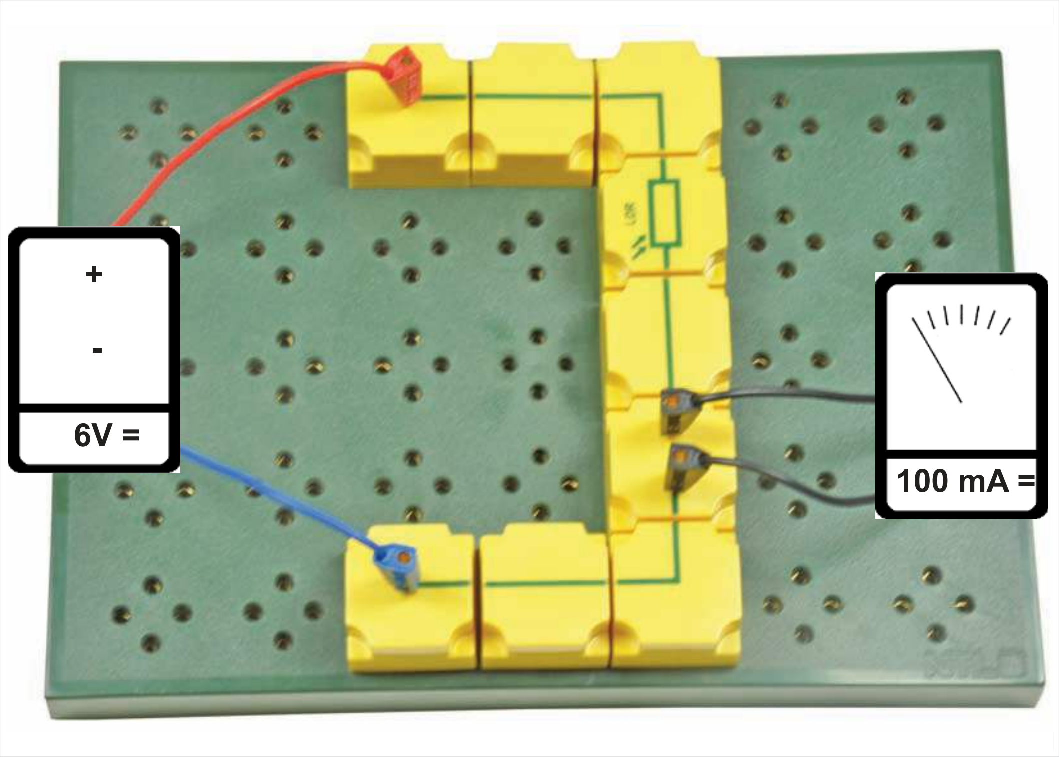
I = ... mA = ... A

Resistance R = $\dfrac{\text{6 Volt}}{\text{........ Ampere}}$ = ... Ohm

Conclusion:
The amount of resistance of an NTC-resistor decreases with rising temperatures.
„NTC" means „negative temperature coefficient".

LIGHT-DEPENDENT RESISTOR (LDR) EOS 1.3

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement

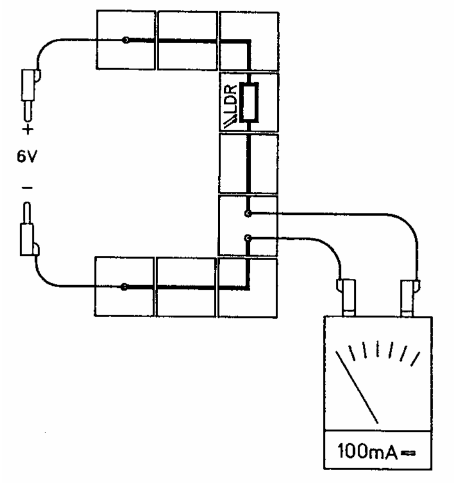


Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
2x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB photo resistor (LDR)

Additionally required:
1x Meter
1x Voltage supply

LIGHT-DEPENDENT RESISTOR (LDR) EOS 1.3

A component whose amount of resistance depends on light is introduced.



Wiring:

Arrange according to the illustration.

An LDR and an ammeter (range according to luminous intensity, first 100 mA =) are connected in series.

A D.C. source of 6 Volt is applied.

1. Experiment:

The LDR is exposed to light (daylight or artificial light):

Measured current I: .... mA = ... A

2. Experiment:

The LDR is darkened (e.g. by means of a book). The range of the ammeter is adjusted to 30 mA.

Measured current I: .... mA = ... A

Result:

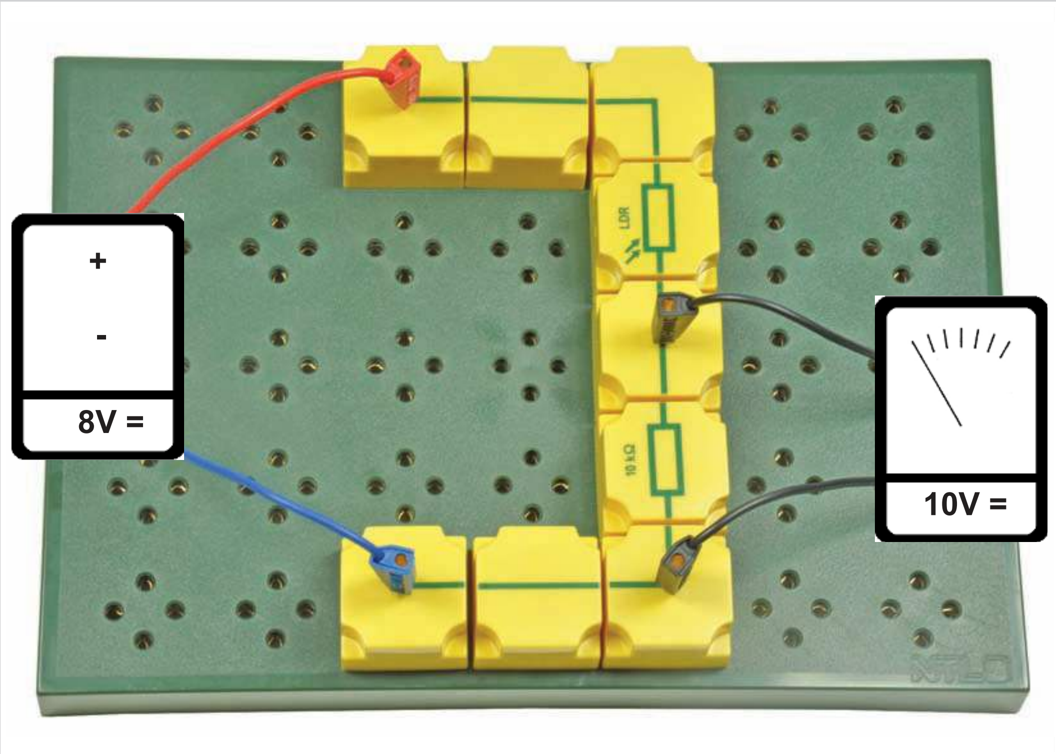
Amount of resistance with light: $R = \frac{6 \text{ Volt}}{\text{........ Ampere}} = \text{........ Ohm}$

Amount of resistance with darkening: $R = \frac{6 \text{ Volt}}{\text{........ Ampere}} = \text{........ Ohm}$

Conclusion:
The amount of resistance of an LDR decreases with light.
„LDR“ means „light dependent resistor“.

MEASURING LUMINOUS INTENSITY EOS 1.4

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



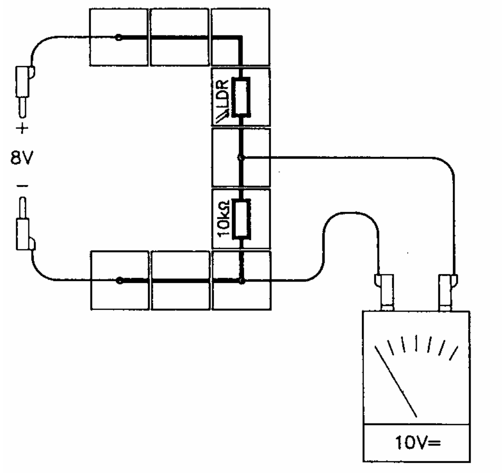
Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
2x PIB wire, straight
1x PIB wire, straight, with socket
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB resistor 10 kOhm
1x PIB photo resistor (LDR)

Additionally required:
1x Meter
1x Voltage supply

MEASURING LUMINOUS INTENSITY

EOS 1.4

Can the illumination of a place of work be checked by a voltmeter?
The experiment shows how changing illuminations of an LDR can be transformed into changing voltage.



Wiring:

An LDR and a resistor 10 kΩ are connected in series and a D.C. source of 8 Volt is applied.

The component voltage at the Ohmic resistor is measured by the voltmeter (range of 10 V =).

The component voltage at the LDR is received by substracting the component voltage at the Ohmic resistor from the total voltage.

Experiment:

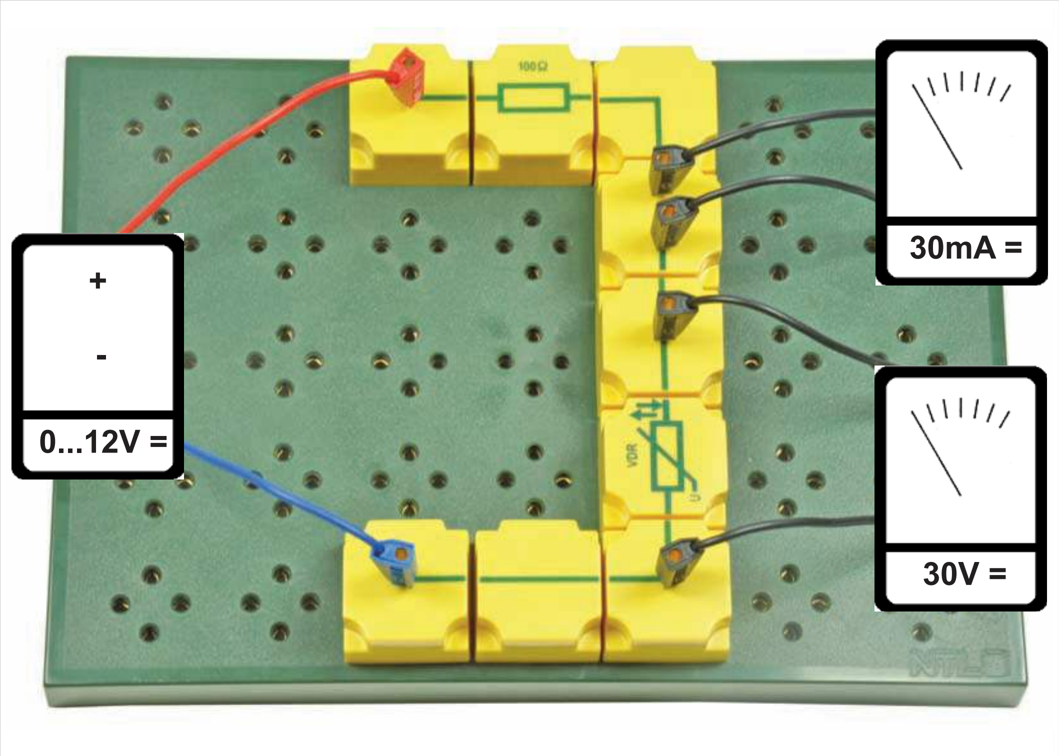
The illumination of the LDR is changed.

It is to be investigated if the voltmeter indicates a lower voltage with darkness and a highter voltage with illumintion.

Result:

	with darkness	with illumination
component voltage at resistor 10 kΩ		
(high/low)	....	....
component voltage at the LDR	....	....
amount of resistance of the LDR	....	....

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
1x PIB wire, straight
1x PIB wire, straight, with socket
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB resistor 100 Ohm
1x PIB varistor (VDR)

Additionally required:
2x Meter
1x Voltage supply

VDR RESISTOR

EOS 1.5

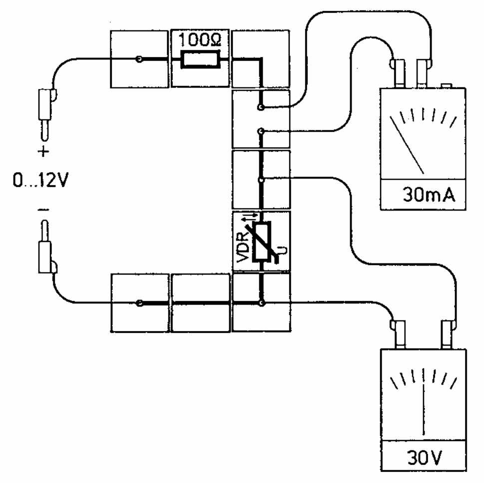
There are not only resistors depending on temperature and illumination but also components whose amount of resistance depends on the applied voltage.

Wiring:

Arrange according to the illustration.

A resistor 100 Ω, an ammeter (range of 30 mA =) and a VDR are connected in series and an adjustable D.C. source is applied.

The voltmeter (first use a measuring range of 10 V =, when increasing the applied voltage above 8 V use the 30 V = range) measures the voltage applied to the VDR.



Experiment:

The voltage at the VDR is gradually increased. The amount of the VDR is calculated individually from the voltage and the current intensity.

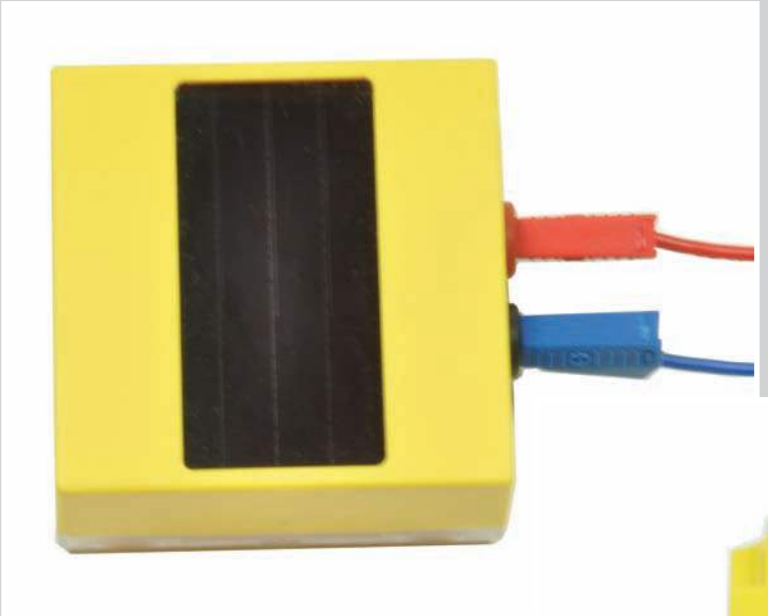
Voltage U	Current I	Resistance $R = \frac{U}{I}$ $\left(\frac{\text{Volt}}{\text{Ampere}}\right)$
1 V	.... mA = ... A	.... Ω
2 V	.... mA = ... A	.... Ω
5 V	.... mA = ... A	.... Ω
10 V	.... mA = ... A	.... Ω

Conclusion:
The amount of resistance of the VDR decreases with rising voltage.
„VDR“ means „voltage depend resistor“.

SOLAR CELL

EOS 1.6

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism



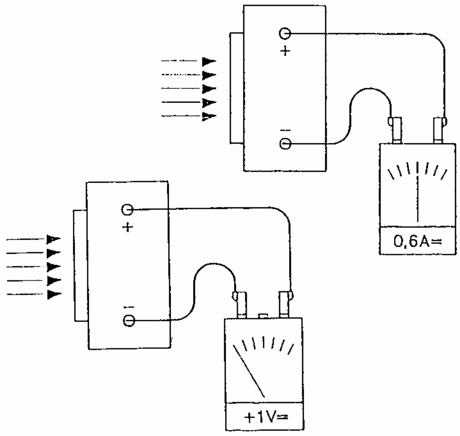
Material:
1x Connecting lead, red
1x Connecting lead, blue
1x Solar cell, in plastic housing
1x PIB motor

Additionally required:
1x Meter

SOLAR CELL

EOS 1.6

Radiation energy can be converted into electric energy by means of solar cells.



Preparation:

The voltmeter with the 1 V = range is connected to the solar cell in block.

1.Experiment:

First the voltage which is emitted from a solar cell is measured when the cell is not illuminted by the sun or an incandescent lamp. Then the solar cell is exposed to light. First the voltage is measured with half-concealed surface, then with fully exposed surface of the solar cell.

Voltage in shade: V

Voltage with half exposed surface: V

Voltage with fully exposed surface: V

2.Experiment:

Now the current which is provided by the solar cell is measured. The ammeter with the 300 mA = range is used. The measurement is carried out in the same way as in the first experiment with different illumination and illuminated surface.

Current intensity in shade: .... mA

Current intensity with half illumination: .... mA

Current intensity, fully illuminated surface: .... mA

3.Experiment:

Application of solar energy: The experimental motor is connected to the solar cell which is illuminated by the sun (or by the light from ans incadescent lamp).

Note: If the illumination is not sufficient for starting the motor on its own, try to start it by pushing it.

Conclusion:
The voltage emitted by the solar cell is about 0,4 – 0,5 Volt. It depends on the intensity of radiation and on the illuminated surface of the solar cell.
The correlation between voltage and illuminted surface is not a linear one.

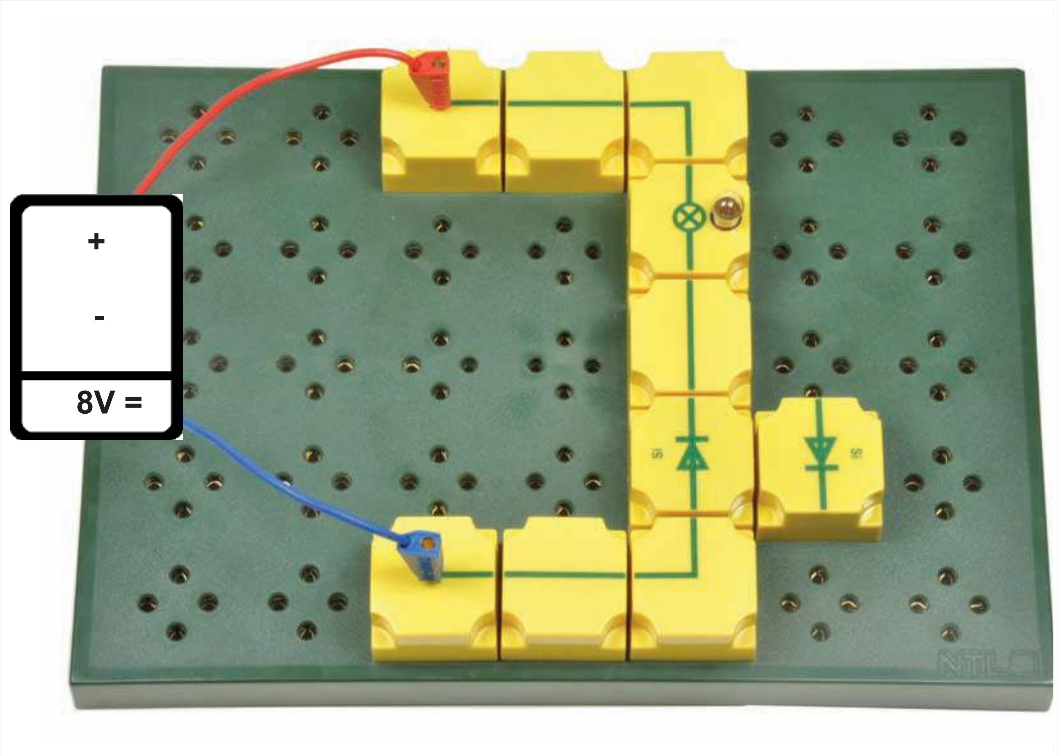
The current intensity delivered by the solar cell depends on the intensity of radiation and is proportional to the illuminate surface.

An electric motor can be run by solar energy.

SILICON DIODE

EOS 2.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb, 10V/50mA
1x PIB Si diode

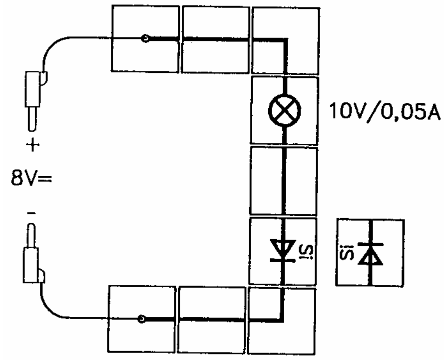
Additionally required:
1x Voltage supply

SILICON DIODE

EOS 2.1

It does not matter in which direction the electric current passes through incandescent lamps and Ohmic resistors.
Does this apply to all components? The behavior of a diode is to be investigated.

Wiring:



Arrange the wiring according to the illustration.

The Si-diode is inserted according to the connection diagram; that is the direction of arrow from plus to minus (technical direction of the electric current).

Experiment:

Check whether the lamp glows!
This direction is called „conducting direction".

Now the diode is inserted in the opposite direction. The arrow now points from minus to plus.
Does the lamp glow now?

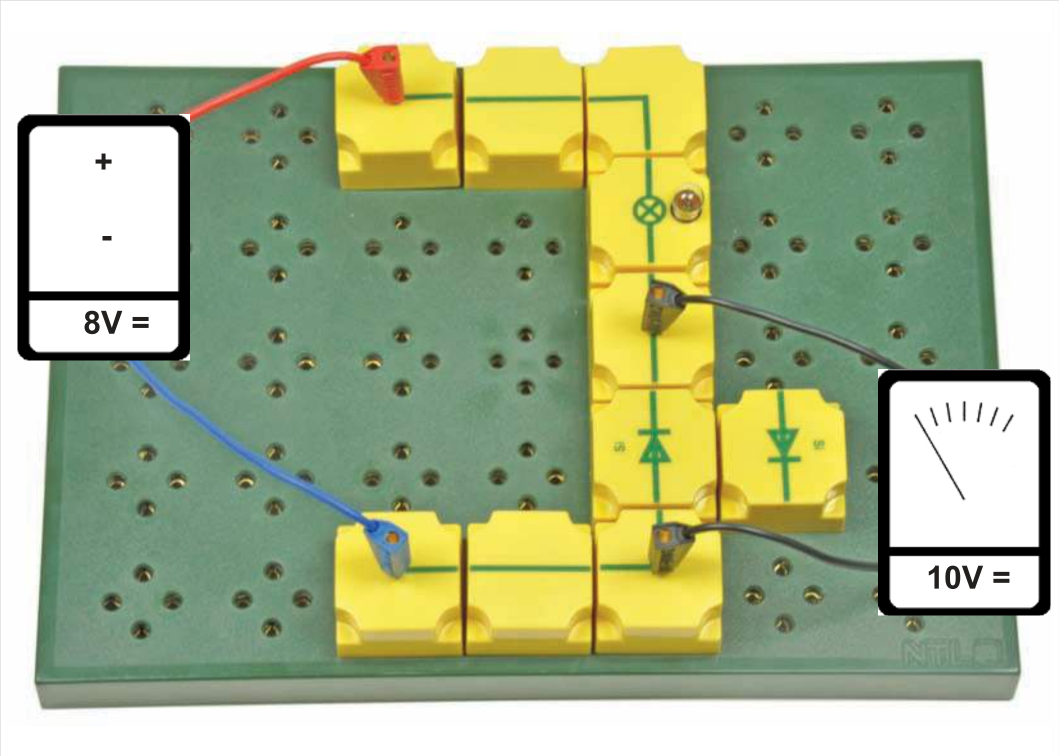
This direction is called „non-conducting direction".

Conclusion:
A diode allows the electric current to flow only in one direction. It serves as a „valve".
The direction of the arrow in the circuit symbol indicates the conducting direction.

FORWARD VOLTAGE OF A SILICON DIODE

EOS 2.2

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



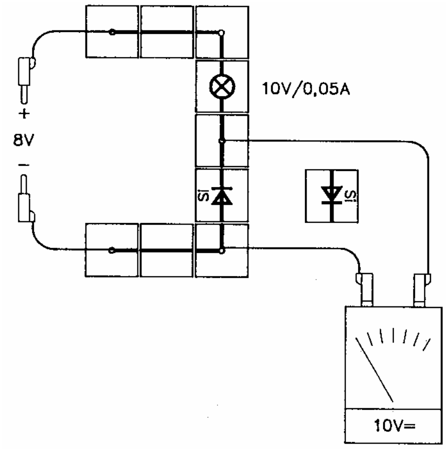
Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
2x PIB wire, straight
1x PIB wire, straight, with socket
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb, 10V/50mA
1x PIB Si diode

Additionally required:
1x Meter
1x Voltage supply

FORWARD VOLTAGE OF A SILICON DIODE

EOS 2.2

To investigate if a diode completely blocks when in non-conducting direction and whether it completely conducts (i.e. without a voltage drop) in conducting direction.



Wiring:

Arrange the wiring accoring to the illustration.

The diode is connected in series with an incandescent lamp (E 10, 10 V/0,05 A).

The voltmeter (range of 10 V =) measures the voltage at the diode.

1.Experiment:

The diode is inserted in the non-conducting direction.

The voltmeter indicates .... Volt.
The applied voltage is measured for a comparison.

The total voltage lies at the diode. There is no drop of voltage at the lamp, because there is no flow of electric current (if I = 0 then U = R*I = 0).

2.Experiment:

The diode is inserted in the conducting direction.

The voltmeter indicates .... Volt:
This diode admits a „conducting-state voltage".

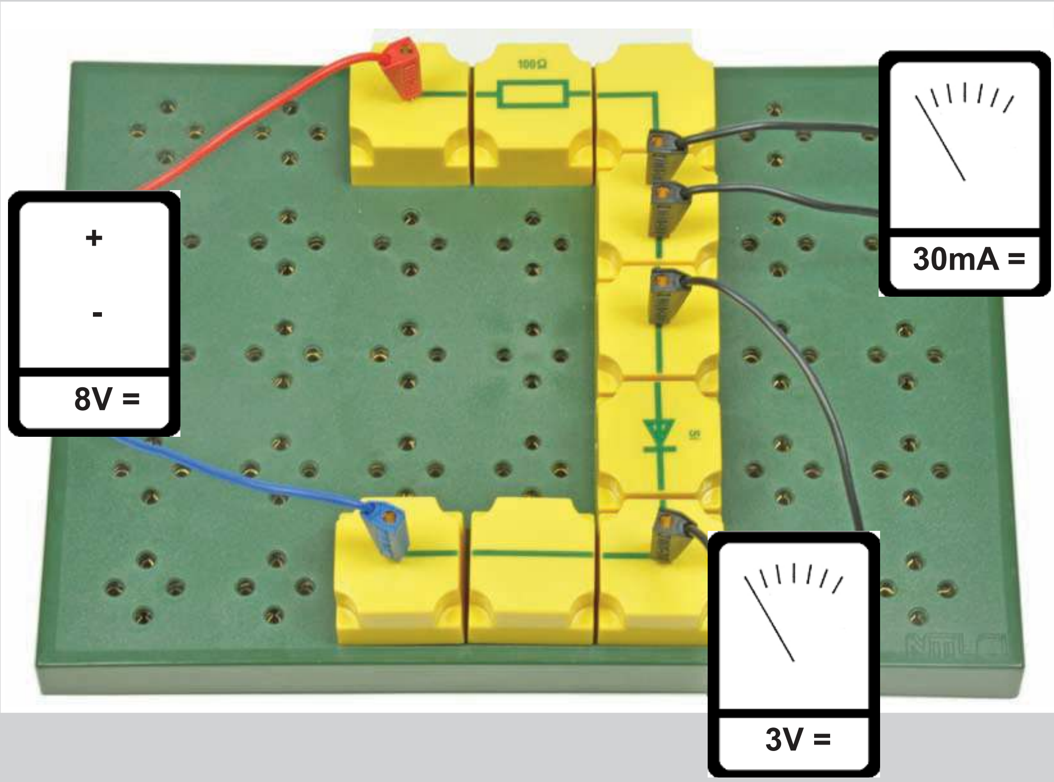
That is to say it is not completely conducting.

Conclusion:
The total voltage stops at the diode in non-conducting direction.
The conducting-state voltage stops at the diode (with silicon: 0,7 Volt) in conducting direction.

CHARACTERISTIC LINES OF SEMICONDUCTOR DIODES

EOS 2.2.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
1x PIB wire, straight
1x PIB wire, straight, with socket
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB wire, interrupted, with socket
1x PIB resistor 100 Ohm
1x PIB Si diode

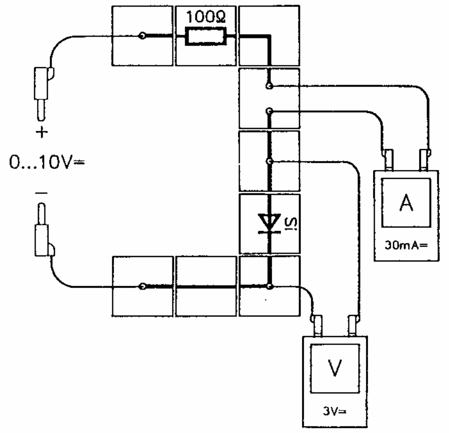
Additionally required:
2x Meter
1x Voltage supply

CHARACTERISTIC LINES OF SEMICONDUCTOR DIODES

EOS 2.2.1

The correlation between applied voltage and current intensity for an Si-diode and a Ge-diode is to be found out in the following experiment.

Wiring:
Arrange the wiring according to the illustration.



First the behavior of the Si-diode is to be investigated.
It is inserted in conducting direction.
The resistor 100 Ω serves as a protection for the diode.

The voltage applied at the diode is measured by the voltmeter which is switched to the 3 V = range.

The ammeter is set at the 30 mA = range.

1.Experiment:

A D.C. voltage is applied and slowly increased. The voltage at the Si-diode indicated by the voltmeter is to show the amounts listed in the chart one after the other. The corresponding current intensity is listed in the chart.

Voltage (in V)	0,1	0,2	0,3	0,4	0,5	0,6	0,7
Current intensity (in mA)	….	…..	…..	…..	…..	….	….

The measured results are traced in a diagram and the individual reference points are connected.

2.Experiment:

The Si-diode is replaced by the Ge-diode and the resistor 100 Ω is replaced by the resistor 500 Ω. The Ge-diode is also inserted in conducting direction. The applied voltages are adjusted one after the other in such a way that the voltmeter indicates the amounts given in the chart. The measured current is marked on the chart.

Voltage (in V)	0,1	0,2	0,4	0,8	1,0	1,2	1,4	1,6
Current intensity (in mA)	….	…..	…..	…..	…..	….	….	….

The measured results are also traced in the diagram and the reference points are connected.

3.Experiment:

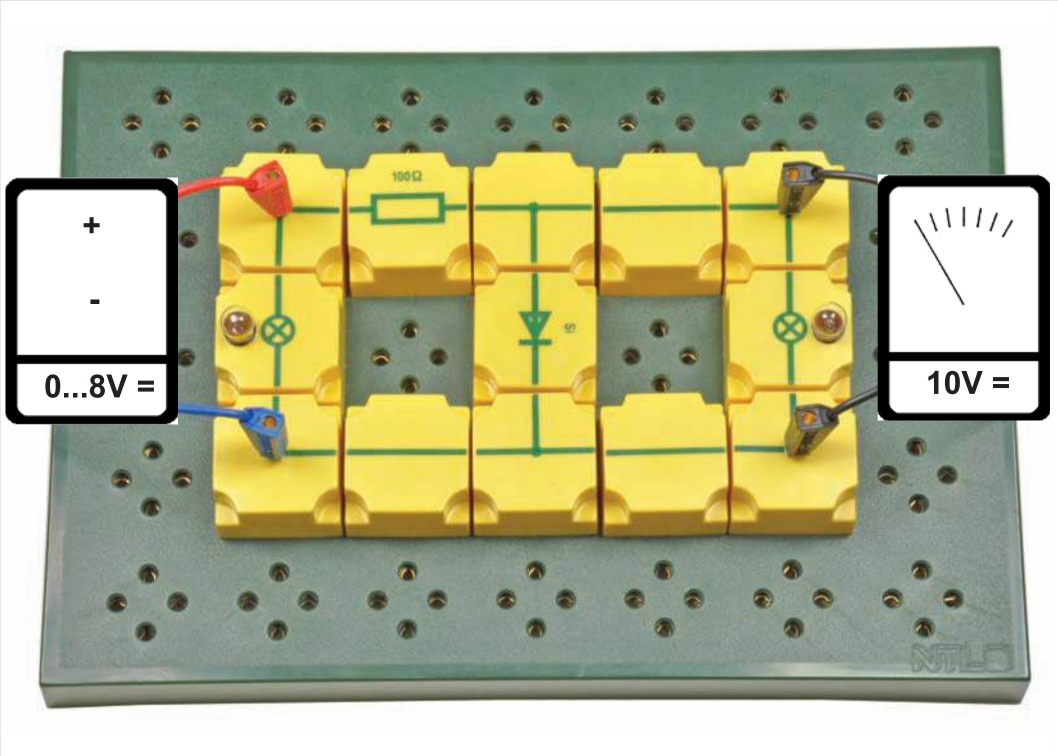
The Ge-diode and then the Di-diode are inserted in non-conducting direction and a D.C. source of 10 volt is applied.
The voltmeter now indicates a much higher voltage than in the first two experiments.
If these measured results are also traced on the diagram a different scale must be chosen for non-conducting direction.

Conclusion:
The current output of different diodes depends on different ways the voltage is applied.
If the current is dependent on the voltage applied at the diode is traced on a diagram, the characteristic line of a diode can be found out.
With a semicircular diode only a small current, the so called off-state current, flows in non-conducting direction.

DIODES PROTECT METERS

EOS 2.3

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
3x PIB wire, straight
2x PIB wire, T-shaped
4x PIB wire, angled, with socket
1x PIB resistor 100 Ohm
2x PIB lamp socket E10
2x Light bulb 10V/50mA
1x PIB Si diode

Additionally required:
1x Meter
1x Voltage supply

DIODES PROTECT METERS

EOS 2.3

Si-diodes cause only a drop of voltage of 0,7 V in conducting direction.
This can be used in practice.

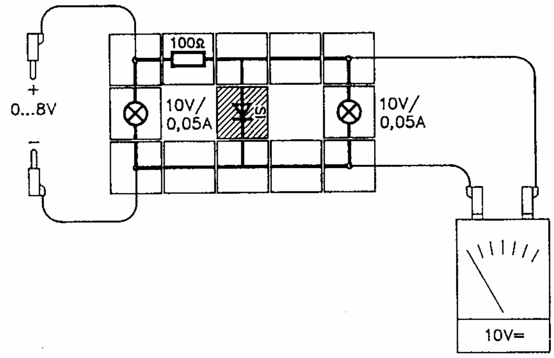
Wiring:

Arrange the wiring according to the illustration.

The Si-diode is not yet inserted.

The glowing left lamp shows the proportion of the applied voltage.
The right lamp serves as a meter and indicates the applied voltage.

In addition to that the voltage is measured by a votmeter (range of 10 V =).



1.Experiment:

The applied D.C. source is increased from 0 to 8 Volt.
In this case a meter might be damaged, because the voltage would be in excess of the meters range.

2.Experiment:

Again the initial voltage is 0.
Now the Si-diode is inserted as shown in the diagram.
Again the voltage is increased to 8 Volt.

This time the meter is not supplied with a higher voltage than 0,7 Volt (conducting-state voltage of the diode).

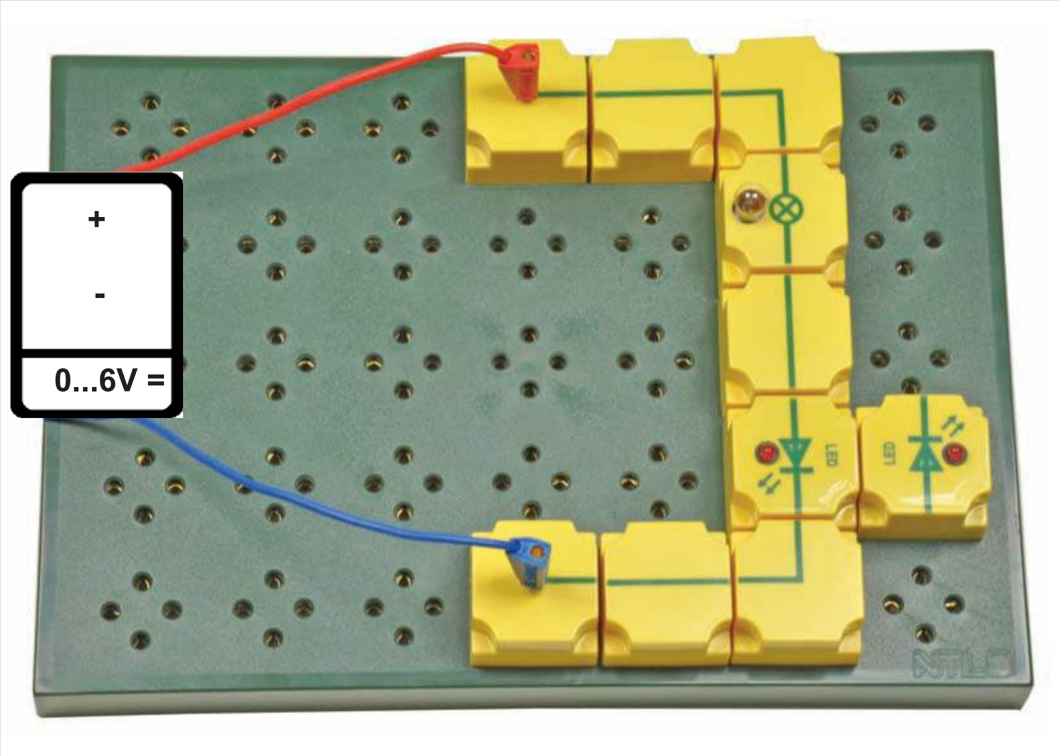
Conclusion:
A sensitive meter can be protected from higher voltages by means of a Si-diode connected in conducting direction.

Note:
Pairs of diodes can be used as protection against too high voltages by connecting them anode to cathode.

LIGHT-EMITTING DIODE (LED)

EOS 2.4

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



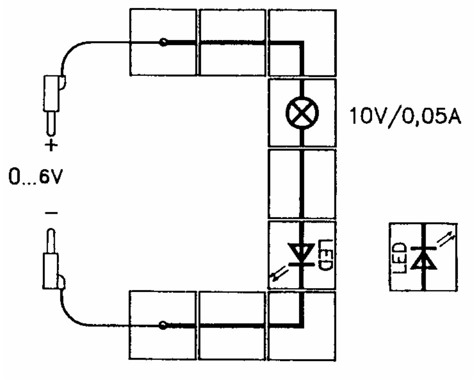
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb, 10V/50mA
1x PIB LED red

Additionally required:
1x Voltage supply

LIGHT-EMITTING DIODE (LED)

EOS 2.4

The behaviour of a light-emittng diode is to be investigated.



Wiring:

Arrange the wiring according to the illustration.

A lamp E 10, 10 V/0,05 A and a light-emitting diode (LED) are connected in series.

1.Experiment:

The LED is inserted in conducting direction.
The lamp and the LED glow as soon as the applied voltage has reached 4 Volt.

2.Experiment:

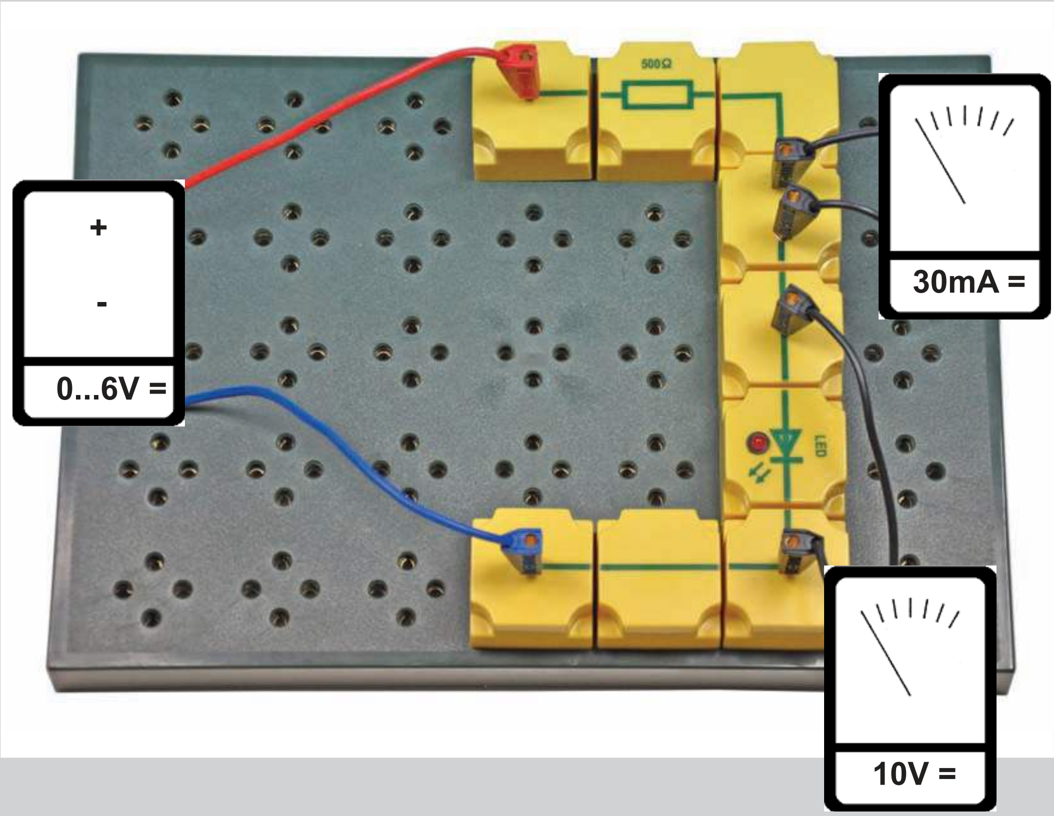
The LED is inserted in non-conducting direction.
Neither the lamp nor the LED emit light.

Conclusion:
A light-emitting diode glows if it is connected in conducting direction and if electric current is passed through.
„LED“ is the abbreviation for „light-emitting diode“.

Note:
Attention! LEDs may only be used in connection with drop resistors (the lamp in the experiment) because the current intensity should not exceed 20 mA in continous operation.

FORWARD VOLTAGE OF AN LED

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



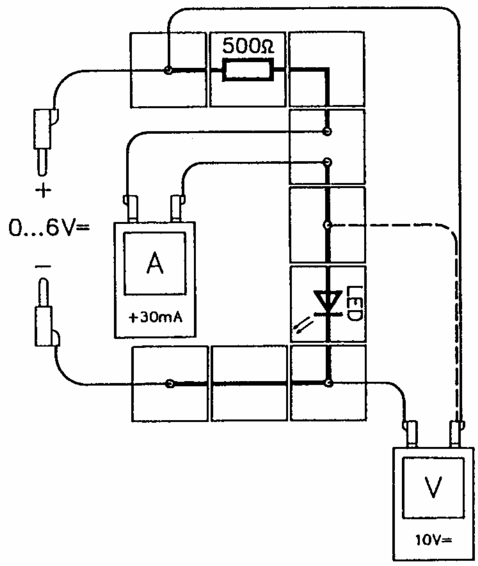
Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
1x PIB wire, straight
1x PIB wire, straight, with socket
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB wire, interrupted, with socket
1x PIB resistor 500 Ohm
1x PIB LED red

Additionally required:
2x Meter
1x Voltage supply

FORWARD VOLTAGE OF AN LED

EOS 2.4.1

The forward voltage of the light-emitting diode is to be investigated.



Wiring:

Arrange the wiring according to the illustration.

The light-emitting diode is connected in series with an incandescent lamp E 10, 10 V/0,05 A.

The voltmeter with the range of 10 V = measures the voltage at the light-emittng diode.

The ammeter is used with the range of 30 mA=.

1.Experiment:

The light-emitting diode is inserted in non-conducting direction.

The voltmeter indicates .... Volt.

The applied voltage is measured for comparison. The total voltage is at the light-emitting diode. There is nodrop of voltage at the incandescent lamp because no current flows (if I = 0 then U = R*I = 0 as well).

2.Experiment:

The light-emitting diode is inserted in conducting direction.

The voltmeter indicates .... Volt.

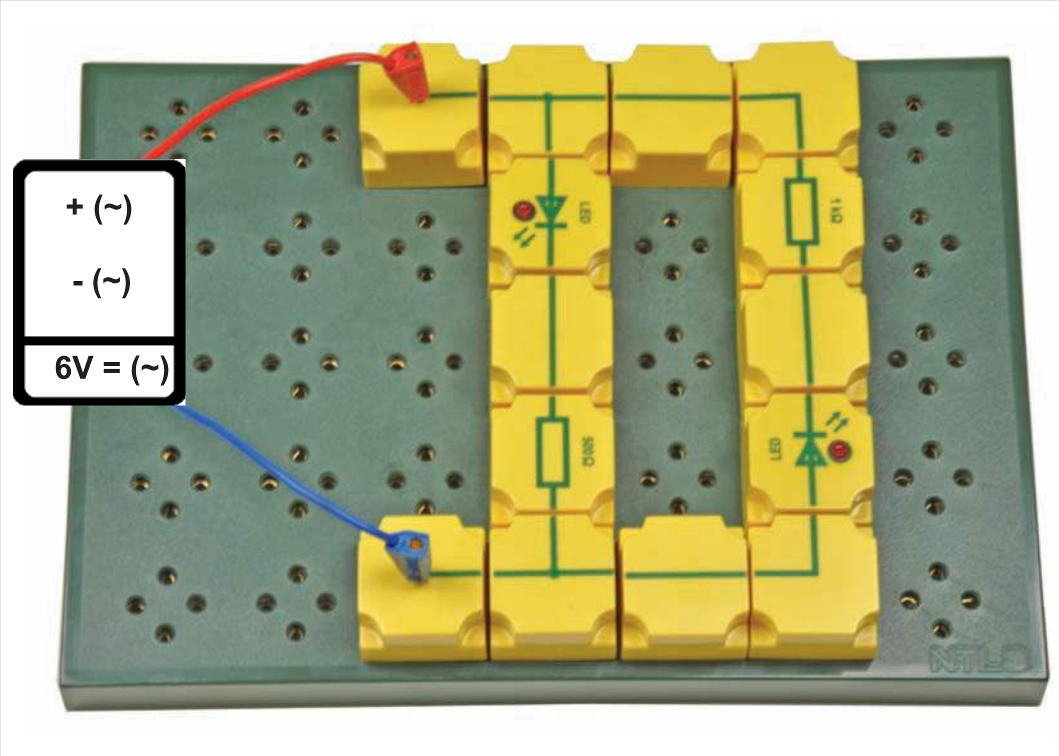
There is a „conducting-state voltage" at the light-emititng diode.

Conclusion:
The total voltage is at the light-emitting diode in non-conducting direction.
A conducting-state voltage of 1,5 to 1,6 volt is a the light-emittng diode (depending on the kind of LED that is used) in conducting direction.

POLARITY INDICATORS

EOS 2.5

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



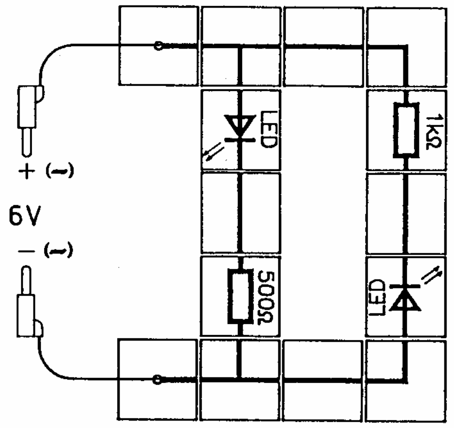
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
4x PIB wire, straight
2x PIB wire, T-shaped
2x PIB wire, angled
1x PIB resistor 500 Ohm
1x PIB resistor 1 kOhm
2x PIB LED red

Additionally required:
1x Voltage supply

POLARITY INDICATORS

EOS 2.5

A simple indicator of polarity can be assembled with two LEDs and two drop resistors.
Thus the poles of a D.C. voltage source may be indentified.



Wiring:

Arrange the wiring according to the illustration.

The two LEDs are inserted in opposite directions.

Each of them is connected in series with one resistor.

1.Experiment:

A D.C source of 6 Volt is applied and the poles are changed several times by exchanging th connections at the voltage source.

Each time the LED glows whose wiring symbol points towards the negative pole of the D.C.

2.Experiment:

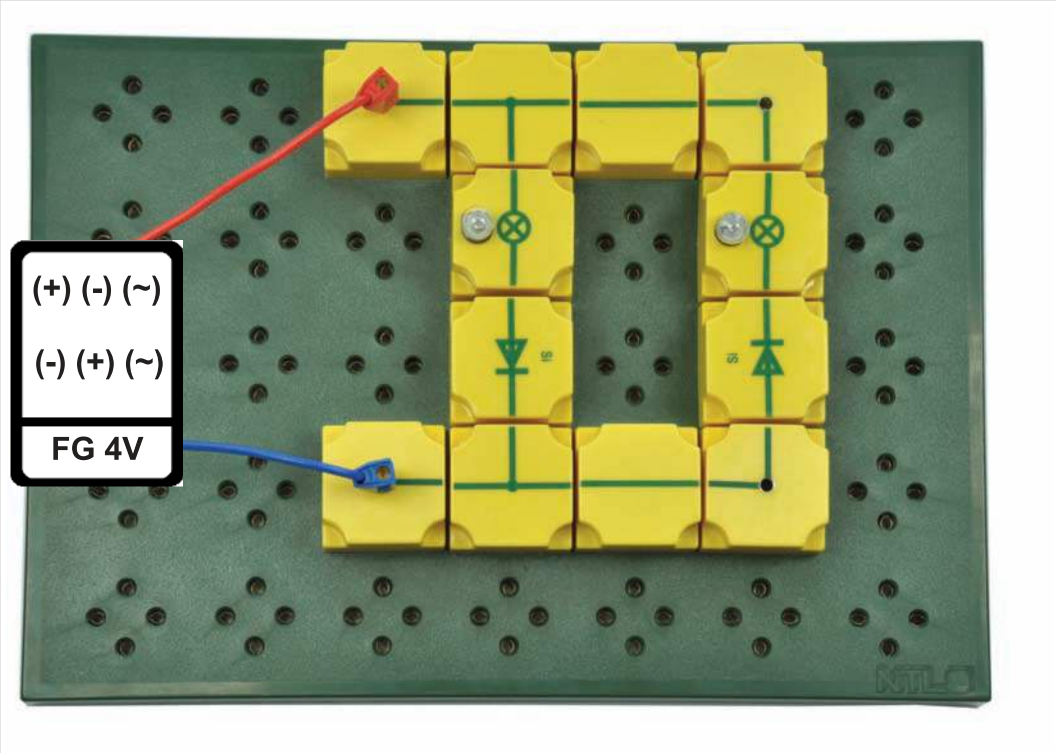
An A.C. source of 6 volt is applied. Why do both LEDs glow now?

Conclusion:
Indicators of polarity make use of th characteristic feature of the LED to emit light in conducting direction.
With A.C. voltage the poles are changed a 100 times per second so that each LED glows 50 times.
This cannot be reconized because of the inertia of our eyes.

POLARITY INDICATORS UNDER VARIBABLE FREQUENCY AC

EOS 2.5.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



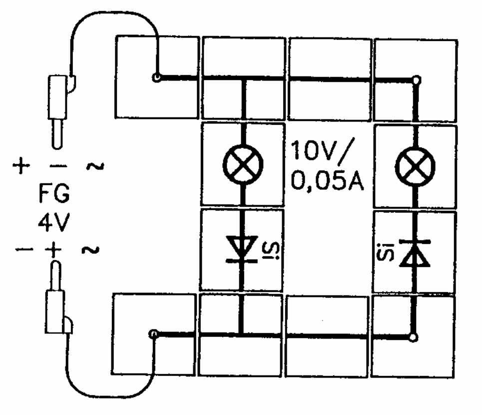
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
2x PIB wire, straight
2x PIB wire, T-shaped
2x PIB wire, angled
2x PIB lamp socket E10
2x Light bulb 10V/50mA
2x PIB Si diode

Additionally required:
1x Function generator
1x Voltage supply

POLARITY INDICATORS UNDER VARIABLE FREQUENCY AC

EOS 2.5.1

A simple indicator of polarity can be assembled with two LEDs and two drop resistors.
By applying by means of the light-emitting diodes a square wave voltage it is possible to find out which pole of the terminal point is the positive pole, using LEDs.



Wiring:
Arrange the wiring according to the illustration.

The two LEDs are inserted in different direction each of them is connected in series with a restistor.

An A.C. source of 12 Volt is applied to the signal generator.

The signal generator is used as a sine-wave generator and serves as the voltage source for the circuit.

1.Experiment:

First a low frequency (1 Hz) and a maximum output voltage are chosen. Only one LED glows each time. The point of its wiring symbol faces the negative pole of the voltage source.

2.Experiment:

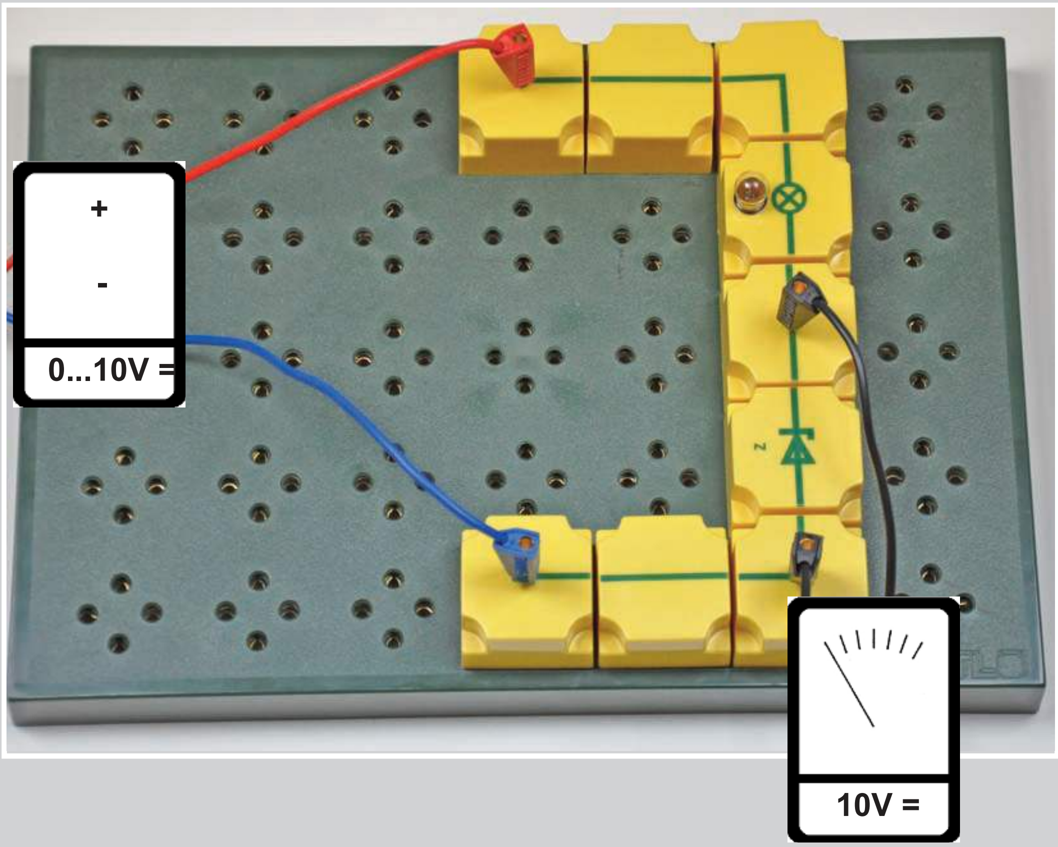
The frequency of the applied voltage is increased.
The two LEDs flash more quickly one after the other.

Try to find out at which frequency the flashes can no longer be observed.
It seems as if both LEDs constantly glow. The same impression is given if an A.C. source with a frequency of 50 Hz is applied.

Conclusion:
Indicators of polarity make use of the characteristic of LEDs to emit light in conducting-direction.
The polarity can be found out each time by the flashing of the LEDs with A.C. source of low frequency.
From a frequency of about 20 Hz the flashing up of the individual LEDs can no longer be recognized because of the speed of reaction of the human eye and one can see both LEDs glowing at the same time.

ZENERDIODES

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



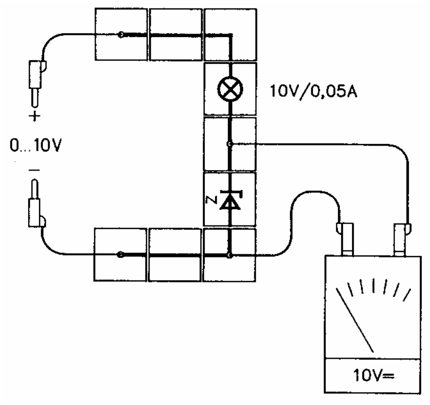
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb, 10V/50mA
1x PIB Zener diode

Additionally required:
1x Voltage supply

ZENERDIODES

EOS 2.6

Zener diodes behave like Si-diodes in conducting direction.
They show a different behavior in non-conducting direction.



Wiring:

Arrange the wiring according to the illustration.

The lamp and the Z-diode (in non-conducting direction) are connected in series.

The voltmeter measures the „off-state voltage" at the Z-diode.

Experiment:

The D.C. source is slowly increased from 0 to 10 Volt.

The voltmeter and the lamp are observed.

Result:

The voltage at the Z-diode rises only to about 4,7 Volt.
Then it remains almost constant in spite of the increased applied voltage.

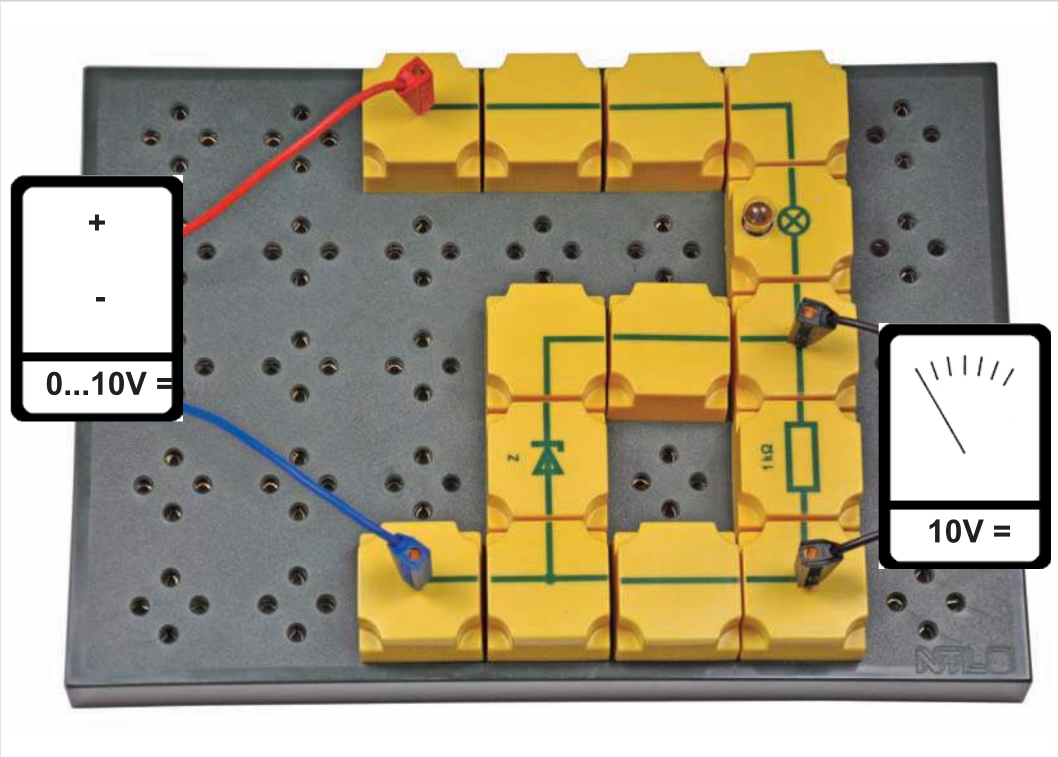
The lamp indicates a flow of electricity (in spite of non-conducting direction!)

Conclusion:
If Z-diodes are connected in non-conducting directions, electric current breaks through at a certain voltage (the „break-through voltage" of the diode).
When the applied voltage is increased the voltage which is at the Z-diode remains almost constant.

STABLILIZING VOLTAGE

EOS 2.7

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



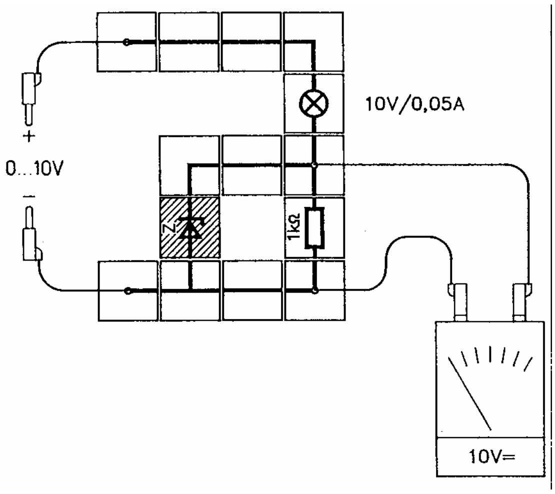
Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
4x PIB wire, straight
1x PIB wire, T-shaped, with socket
1x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 1 kOhm
1x PIB lamp socket E10
1x Light bulb, 10V/50mA
1x PIB Zener diode

Additionally required:
1x Meter
1x Voltage supply

STABILIZING VOLTAGE

EOS 2.7

If a constant voltage remains at a component in spite of fluctuating input voltage this is called stabilizing of voltage.



Wiring:

Arrange the wiring according to the illustration.

The Z-diode is not yet inserted.

The lamp serves as a drop resistor for the Z-diode and indicates whether electric current flows.

1.Experiment:

The input voltage is increased from 0 to 10 Volt.
The voltmeter indicates that the voltage at the resistor 1 kΩ rises to almost 10 Volt as well.

The lamp does not glow.

2.Experiment:

Start again with 0 Volt.
The Z-diode is inserted according to the circuit diagram.

Again the voltage is gradually increased to 10 Volt.

Result:

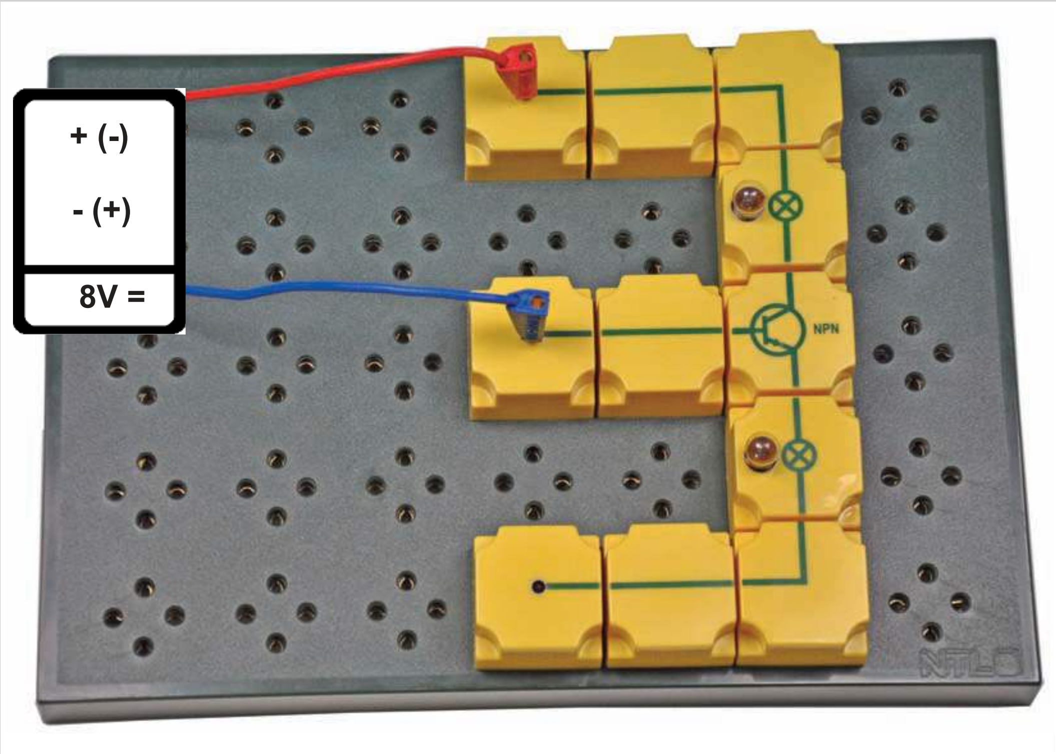
The voltmeter indicates a maximum voltage of 4,7 Volt now.
The lamp indicates the „break-through voltage" via the Z-diode by glowing.

Conclusion:
Stabilizing circuits are based on the „break-through voltage" of a Z-diode.

DOES A TRANSISTOR CONSIST OF TWO DIODES?

EOS 3.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



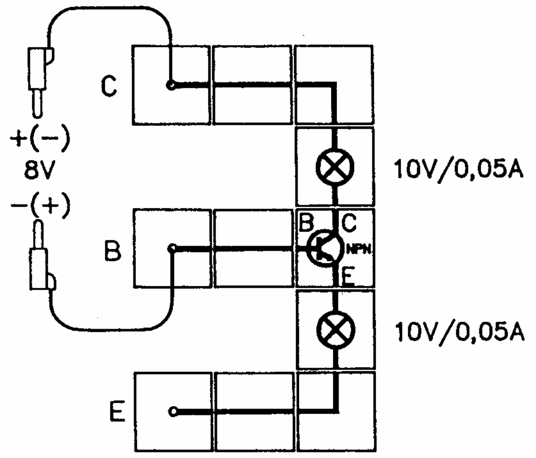
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
3x PIB connector
3x PIB wire, straight
2x PIB wire, angled
2x PIB lamp socket
2x Light bulb 10V/50mA
1x PIB transistor NPN, base left

Additionally required:
1x Voltage supply

DOES A TRANSISTOR CONSIST OF TWO DIODES

EOS 3.1

A transistor consits of three layers.
First to be investigated is the polarity of the current which can flow through two neighbouring layers.



Wiring:

Arrange the wiring according to the illustration.

The transistor and two lamps are connected in series.

In the first experiment the voltage is applied to the connections C and B, in the second expriment to the connctions B and E.

1. Experiment:

The junction collector – base is checked by connecting the positive pole to the collector (C) first and then to the base (B) .
At which pole does electric current flow?

Positive pole at ....

2. Experiment:

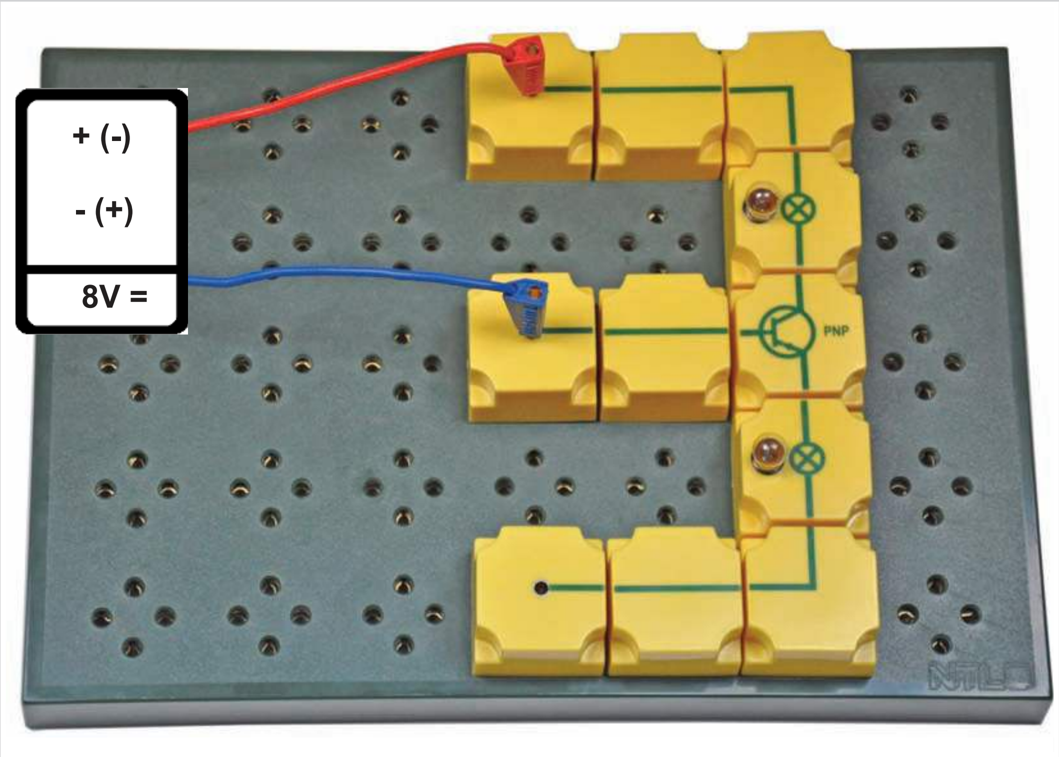
The junction base – emittor is checked by connecting the positive pole to the base (B) first and the to the emittor (E).
At which pole does electric current flow?

Positive pole at ....

Conclusion:
The transistor behaves as if consisting of two diodes.
The results of the experiments show that the diodes must be connected according to the illustration.

RESPONSE OF A PNP TRANSISTOR EOS 3.1.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



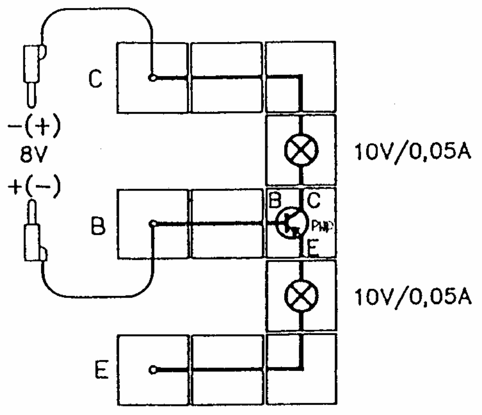
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
3x PIB connector
3x PIB wire, straight
2x PIB wire, angled
2x PIB lamp socket
2x Light bulb 10V/50mA
1x PIB transistor PNP, base left

Additionally required:
1x Voltage supply

RESPONSE OF A PNP TRANSISTOR

EOS 3.1.1

An NPN-transistor conducts the electric current only if ist base is positive.
Now investigate how a PNP-transistor behaves.



Wiring:

Arrange the wiring according to theillustration.

The transistor and two lamps are connected in series.

In the first experiment the voltage is applied to the connections C and B.

In the second experiment it is applied to the connections B and E.

1.Experiment:

The junction collector – base is checked by connecting the positive pole to the collector (C) first and then to the base (B) .
At which pole does electric current flow?

Positive pole at ....

2. Experiment:

The junction base – emittor is checked by connecting the positive pole to the base (B) first and the to the emittor (E).
At which pole does electric current flow?

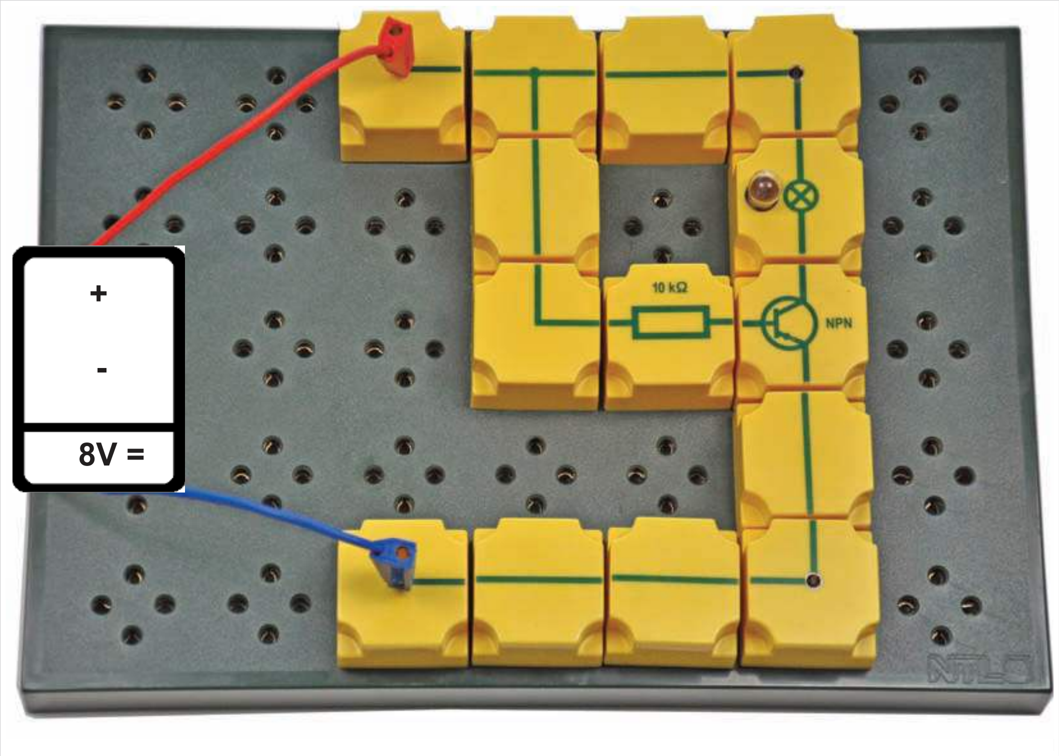
Positive pole at ....

Conclusion:
The transistor behaves as if consisting of two diodes.
The results of the experiments show that the diodes must be connected according to the illustration.

BASE CURRENT ENABLES COLLECTOR CURRENT (NPN TRANSISTOR)

EOS 3.2

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



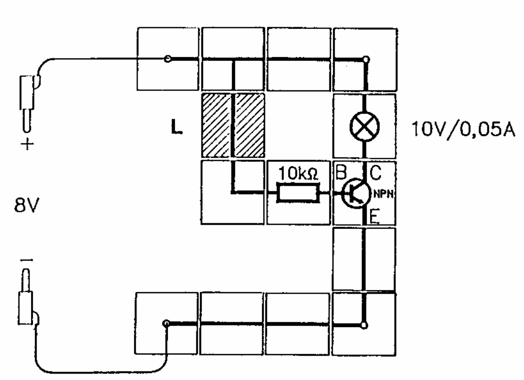
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
5x PIB wire, straight
1x PIB wire, T-shaped
2x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB lamp socket
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB transistor NPN, base left

Additionally required:
1x Voltage supply

BASE CURRENT ENABLES COLLECTOR CURRENT (NPN TRANSITOR)

EOS 3.2

According to the model of the transistor as a double diode it should be impossible for a collector – emittor – current to flow, since one diode blocks at each possible pole at collector and emittor.



Schaltung:

Arrange the wiring according to the illustration. An elelctric circut (8 Volt D.C., positive pole at the collector) leads to the emittor of the transistor via lamp and collector.

The PIB-lead L is not yet inserted.

Experiment:

The lamp does not glow without base – emittor – current.
The double diode blocks as expected.

Now the connection L is inserted.
Thus the positive pole is connected with the base via the resistor 10 kΩ.
The lamp glows.

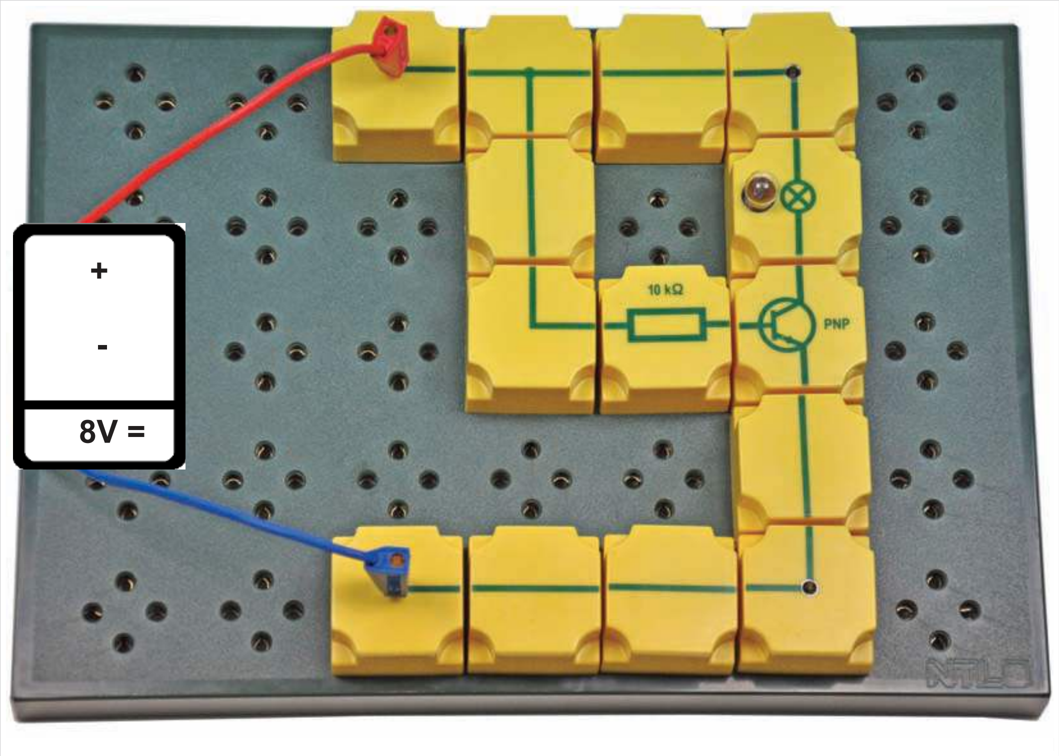
Thus the base – emittor – current effects that the transistor becomes conducting and that a collector – emittor – current comes into existence.

Conclusion:
The model of the transistor as a double diode is not sufficient.
Base current makes collector current possible.

BASE CURRENT ENABLES COLLECTOR CURRENT (PNP TRANSISTOR)

EOS 3.2.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



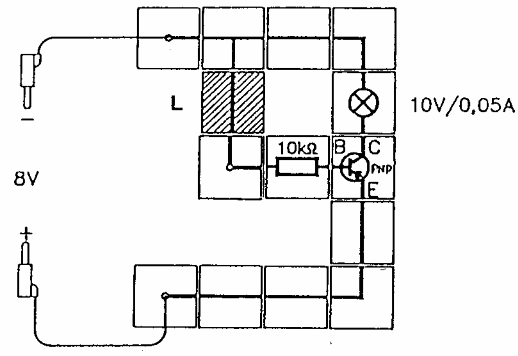
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
5x PIB wire, straight
1x PIB wire, T-shaped
2x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB lamp socket
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB transistor PNP, base left

Additionally required:
1x Voltage supply

BASE CURRENT ENABLES COLLECTOR CURRENT (PNP TRANSISTOR)

EOS 3.2.1

The behaviour of a PNP-trasistor is introduced.



Wiring:

Arrange the wiring according to the illustration.

An electric circuit (D.C. source of 8 Volt, positive pole at the collector) leads to the emittor of the transistor via the lamp and the collector.

The PIB-lead L marked by hatching is not yet inserted.

Experiment:

The lamp does not glow without electric current base-emittor.
The double diode blocks as expected.

Now the connection L is inserted. In this way the negative pole is connected to the base via the resistor 10 kΩ.
The lamp glows.

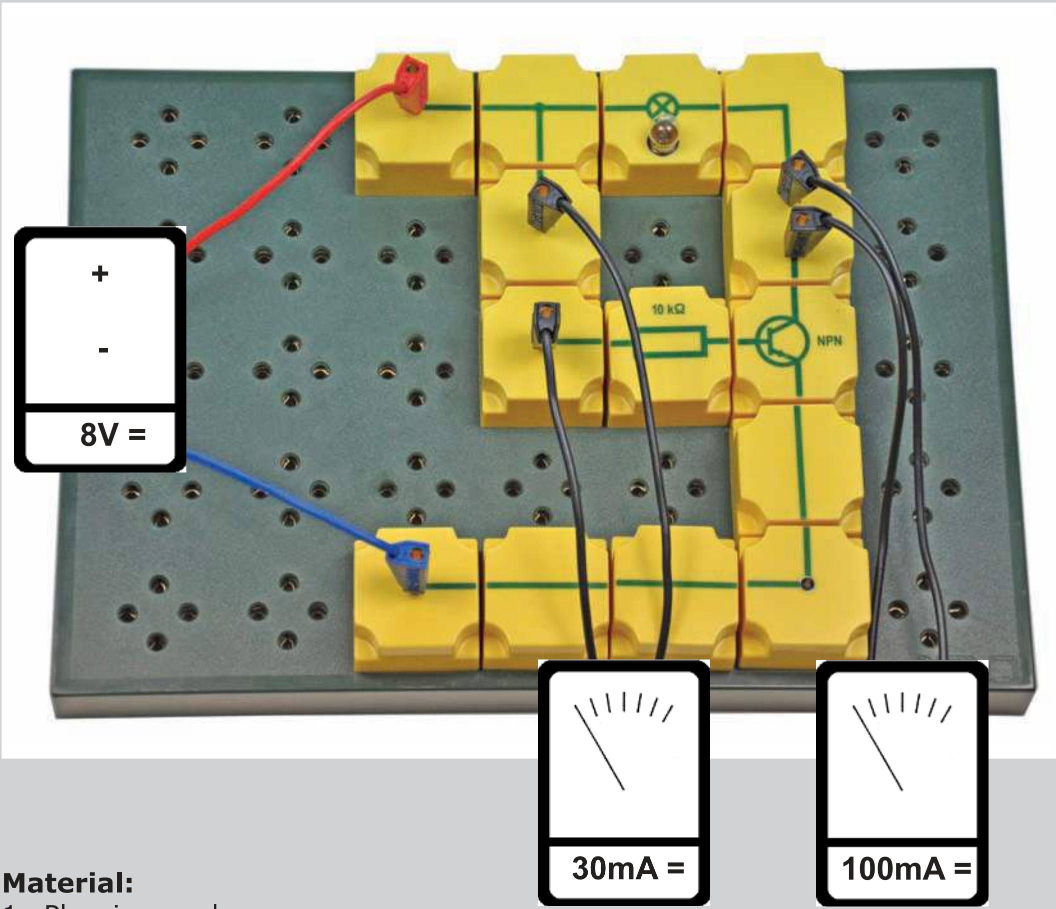
The base – emittor – current effects that the transistor becomes conducting and that the collector – emittor – current comes into existence.

Conclusion:
The model of the transistor as a double diode is not sufficient.
A base current makes a collector current possible.

THE TRANSISTOR AS AN AMPLIFIER

EOS 3.3

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
4x PIB connector
4x PIB wire, straight
1x PIB wire, T-shaped
2x PIB wire, angled, with socket
1x PIB lamp socket
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB resistor 47 kOhm
1x PIB transistor NPN, base left

Additionally required:
2x Meter
1x Voltage supply

THE TRANSISTOR AS AN AMPLIFIER

EOS 3.3

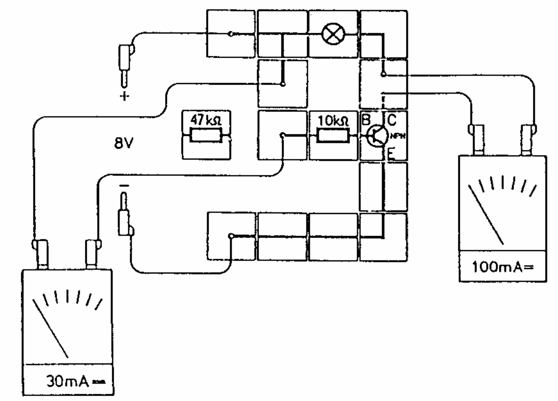
Small changes of the base current result in much greater changes of the collector current of a transistor.
The amplifying effect of a transistor is based on this fact.

Wiring:

Arrange the wiring according to the illustration.

The base current is measured by means of the ammeter (range of 30 mA =).

The collector current is measured as well, but with a different measuring range (100 mA =).



Experiment:

The collector current and the base current are first measured by means of the base resistor 10 kΩ and then by means of the base resistor 47 kΩ. The measuring results are noted on the chart. The change of electric current is calculated individually.

Collector current at 47 kΩ: .... mA

Collector current at 10 kΩ: .... mA

Change of collector current: ....mA

Base current at 47 kΩ: ....mA

Base current at 10 kΩ: ....mA

Change of base current: ....mA

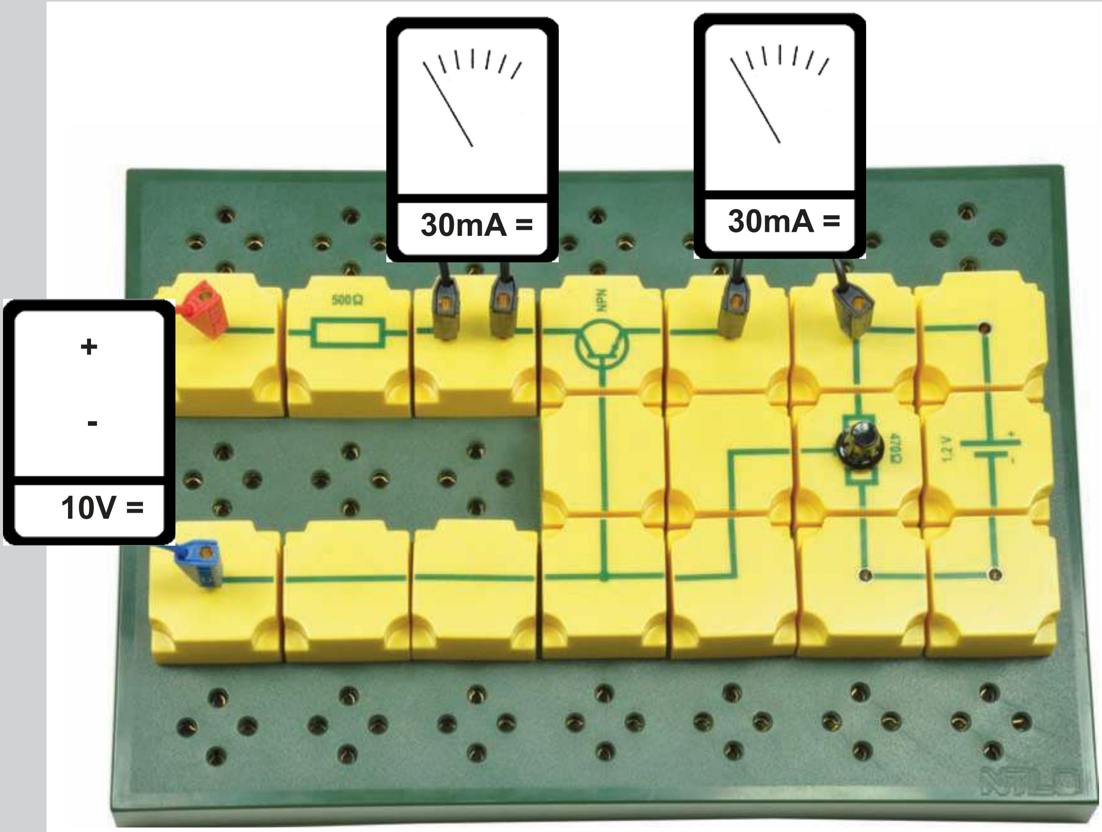
The change of the collector current is divided by the change of the base current.

Conclusion:
The change of the collector current is about 40 times greater compared to the change of the base current.
The transistor used indicates the current amplification factor of 40.

BASE CIRCUIT (CURRENT AMPLIFICATION)

EOS 3.3.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
3x PIB connector
3x PIB wire, straight
1x PIB wire, T-shaped
4x PIB wire, angled, with scoket
2x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB resistor 500 Ohm
1x PIB battery 1.2V
1x PIB potentiometer 470 Ohm
1x PIB transistor NPN, base left

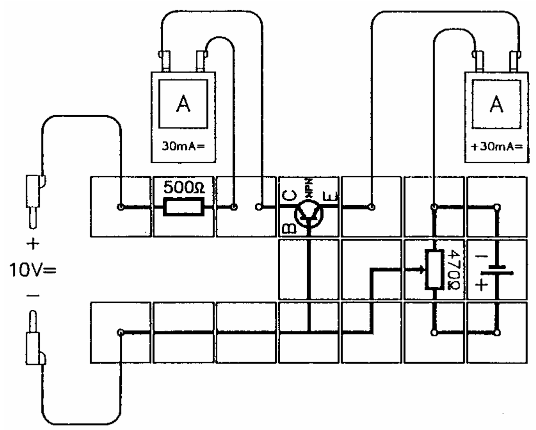
Additionally required:
2x Meter
1x Voltage supply

BASE CIRCUIT (CURRENT AMPLIFICATION)

EOS 3.3.1

The base (one of the three connections of the transistor) is used as a point of reference for the two currents.

Wiring:



Arrange the wiring according to the illustration.

Base connection means that the base is the common connection for both voltage sources.

The emitter current is measured by means of the ammeter with the range of 30 mA =, the collector current by means of the second ammeter with the range of 30 mA=.

The emitter current I_E can be adjusted by means of the potentiometer.
The corresponding collector current I_C is measured as well.

The ratio of the change of the collector current and the change of the emitter current provides the current amplification factor for base connection.

Experiment:

The emitter current is first adjusted to 2 mA and then to 10 mA and the individual amounts of the collector current are taken down.

Then the current amplification factor for base connection is calculated.

Emitter current I_E	2 mA	10 mA	Change: 0,008 A
Collector current I_C	.... mA	.... mA	Change: .... A

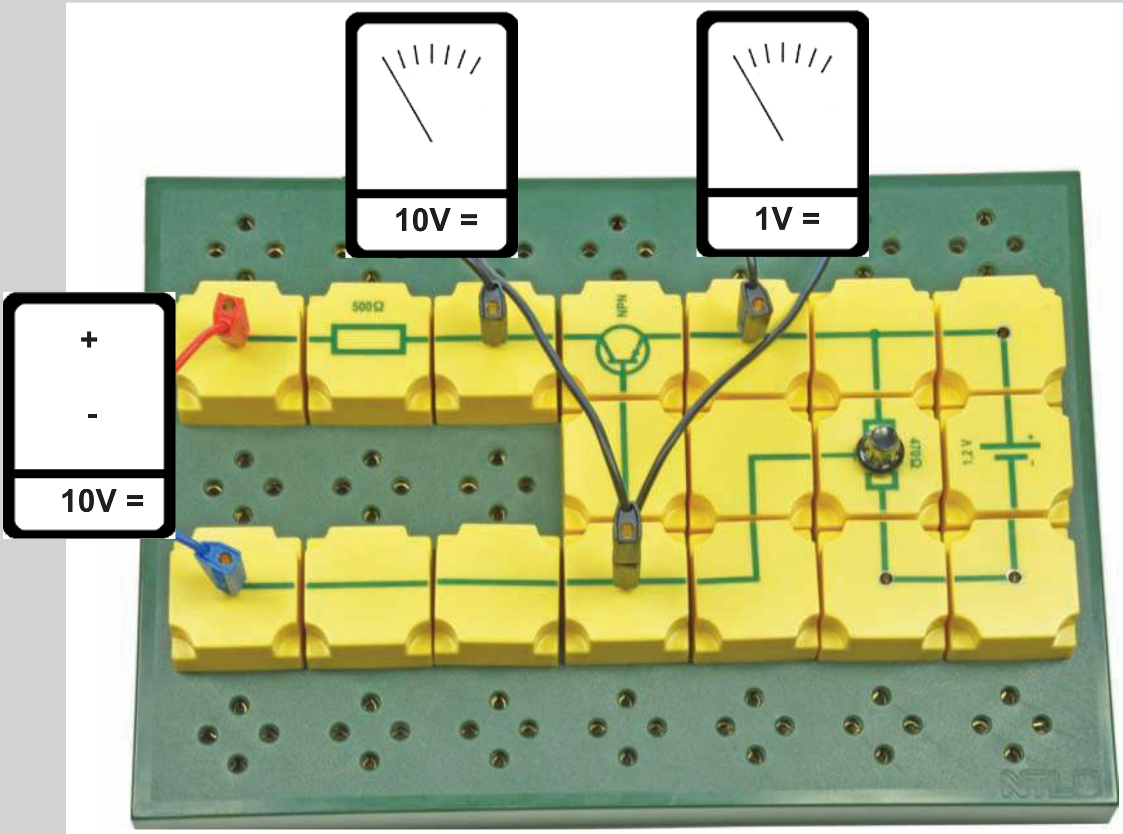
Current amplification: $\frac{dI_C}{dI_E}$ = ...

Conclusion:
The base connection provides a current amplification factor which is smaller than 1.

BASE CIRCUIT (VOLTAGE AMPLIFICATION)

EOS 3.3.2

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
2x PIB wire, straight, with socket
1x PIB wire, T-shaped, with socket
1x PIB wire, T-shaped
3x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB resistor 500 Ohm
1x PIB battery 1.2V
1x PIB potentiometer 470 Ohm
1x PIB transistor, NPN, base left

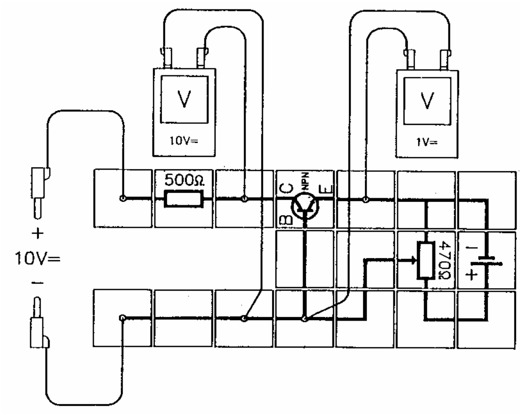
Additionally required:
2x Meter
1x Voltage supply

BASE CIRCUIT (VOLTAGE AMPLIFICATION)

EOS 3.3.2

The base (one of the three connections of the transistor) is used as a point of reference for the two currents.

Wiring:



Arrange the wiring according to the illustration.

Base connection means that the base is the common connection for both voltage sources.

The collector-base voltage U_{CB} is measured by the voltmeter with the range of 10 V =, the base-emittor voltage by the voltmeter with the range of 1 V =.

The collector-base voltage can be adjusted by means of the potentiometer.

The ratio of the change of the collector-base voltage and the change of the base-emittor voltage is the voltage amplification.

Experiment:

The base-emittor voltages which correspond to the collector-base voltge 8 Volt and 0 Volt (provided that 0 Volt is nearly reached) are measured.

Collector-base voltage U_{CB}	8 V	0 V	Change: 8 V
Base-emittor voltage U_{EB}........ V		 V	Change: V

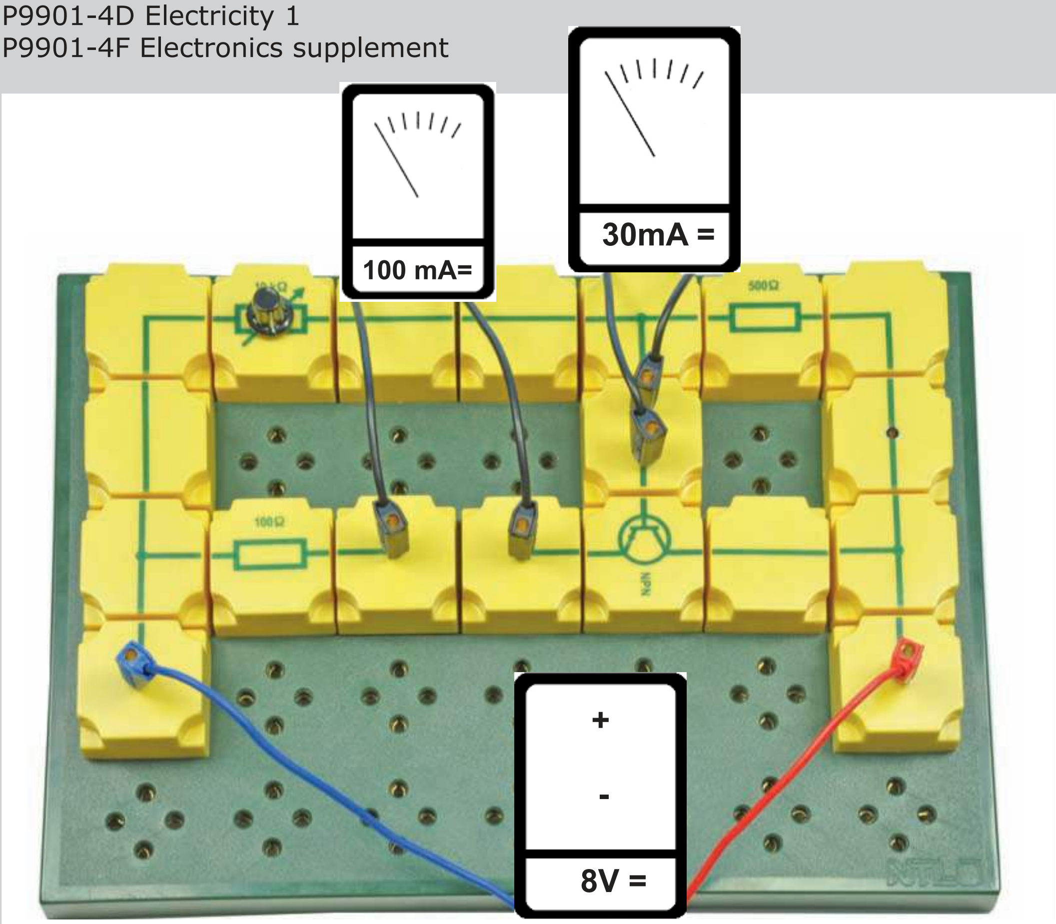
Voltage amplification: $\frac{dU_{CB}}{dU_{BE}} =$ ....

Conclusion:
The base connection provides a voltage amplification between 100 and 1000.

COLLECTOR CIRCUIT (CURRENT AMPLIFICATION)

EOS 3.3.3

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
4x PIB connector
4x PIB wire, straight
1x PIB wire, straight, with socket
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB wire, interrupted, with socket
1x PIB resistor 100 Ohm
1x PIB resistor 500 Ohm
1x PIB rheostat 10 kOhm
1x PIB transistor, NPN, base left

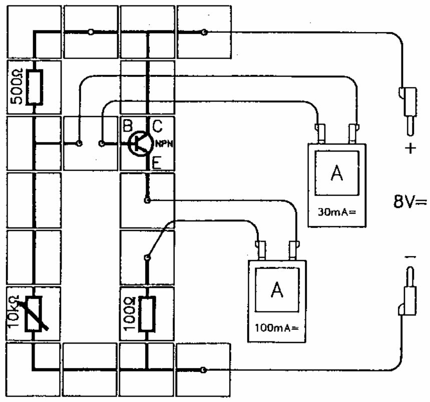
Additionally required:
2x Meter
1x Voltage supply

COLLECTOR CIRCUIT (CURRENT AMPLIFICATION)

EOS 3.3.3

The collector (one of the three connections of the transistor) is used as a reference point for the two currents.

Wiring:



Arrange the wiring according to the illustration.

Collector connection means that the collector is the common connection for both voltage sources.

The collector-base current is measured by the ammeter with the range of 30 mA =, the collector-emittor current by the ammeter with the range of 100 mA =.

The collector-base current I_{CB} can be adjusted to the given amounts by means of the variable resistor.

The corresponding collector-emittor current I_{CE} is measured as well.

The ratio of the two changes of the current provides the current amplification factor for collector connection.

Experiment:

The collector-base current is adjusted to 0,1 mA and then to 0,3 mA and the corresponding amounts of the collector-emittor current are takend down. Then the current amplification factor for collector connection is calculated.

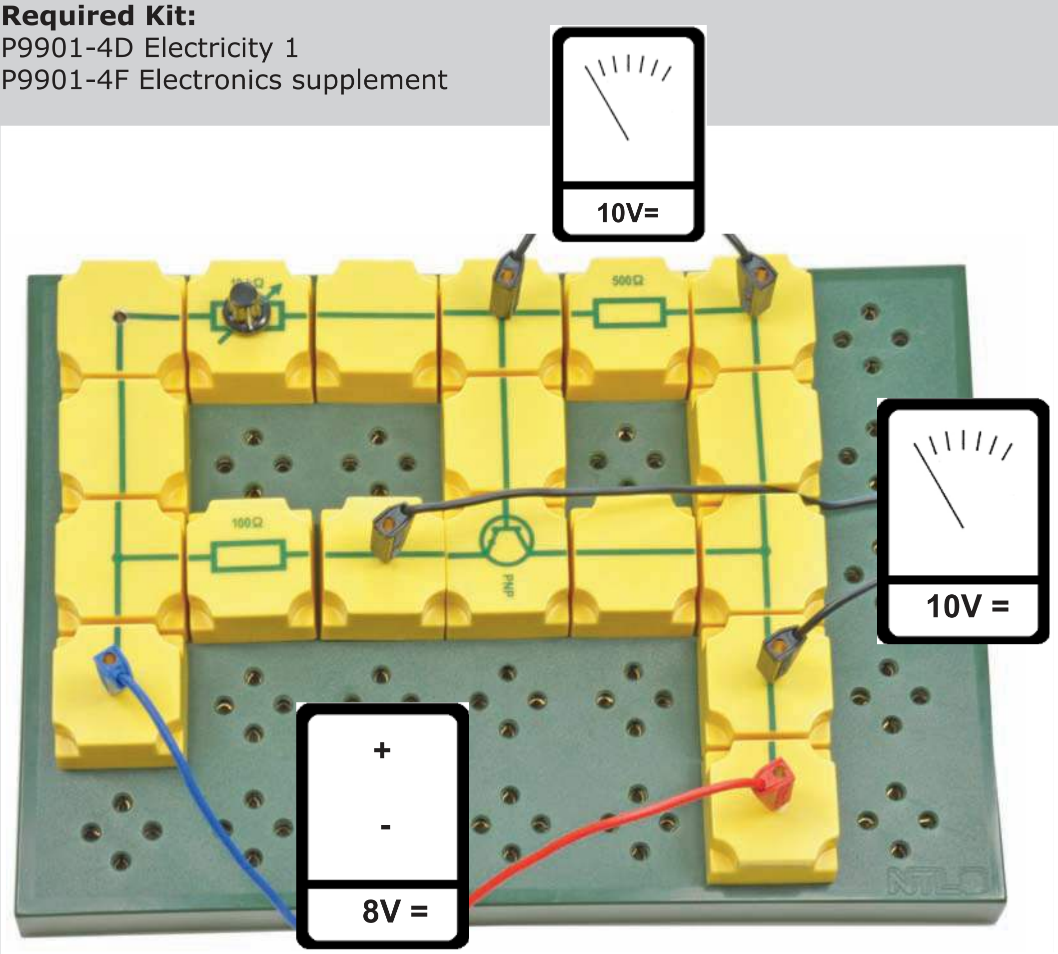
Collector-base current I_{CB}	0,1 mA	0,3 mA	Change: 0,0002 A
Base-emittor current I_{CE}	.... mA	.... mA	Change: .... A

Current amplification: $$\frac{dI_{CE}}{dI_{CB}} = \text{........}$$

Conclusion: The collector current provides a current amplification from 50 to 500.

COLLECTOR CIRCUIT (VOLTAGE AMPLIFICATION)

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
4x PIB wire, straight, with socket
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB resistor 100 Ohm
1x PIB resistor 500 Ohm
1x PIB rheostat 10 kOhm
1x PIB transistor, NPN, base left

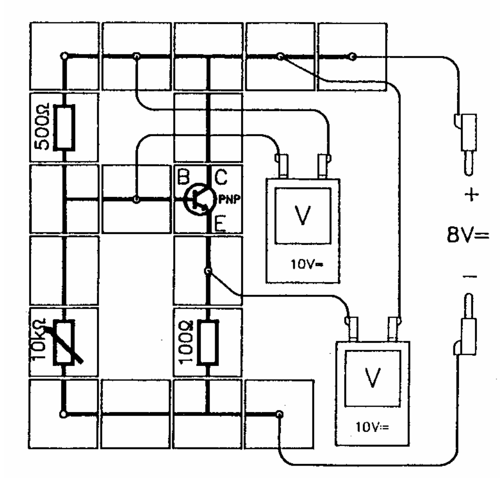
Additionally required:
2x Meter
1x Voltage supply

COLLECTOR CIRCUIT (VOLTAGE AMPLIFICATION)

EOS 3.3.4

The collector (one of the three connections of the transistor) is used as a point of reference for the two voltages.

Wiring:



Arrange the wiring according to the illustration.

Collector connection means that the collector is the common connection.

The collector-base voltage U_{CB} is measured by the voltmeter with the range of 10 V =, the collector-emittor voltage by the second voltmeter with the range of 10 V =.

The collector-base voltage can be adjusted by means of the variable resistor.

The ratio of the change of the collector-base voltage and the change of the collector-emittor voltage is the voltage amplification.

Experiment:

The collector-emittor voltages which correspond to the collector-base voltage 2 Volt and 7 Volt are measured.

Collector-base voltage U_{CB}	2 V	7 V	Change: 5 V
Collector-emittor voltage U_{CE}	 V	 V	Change: V

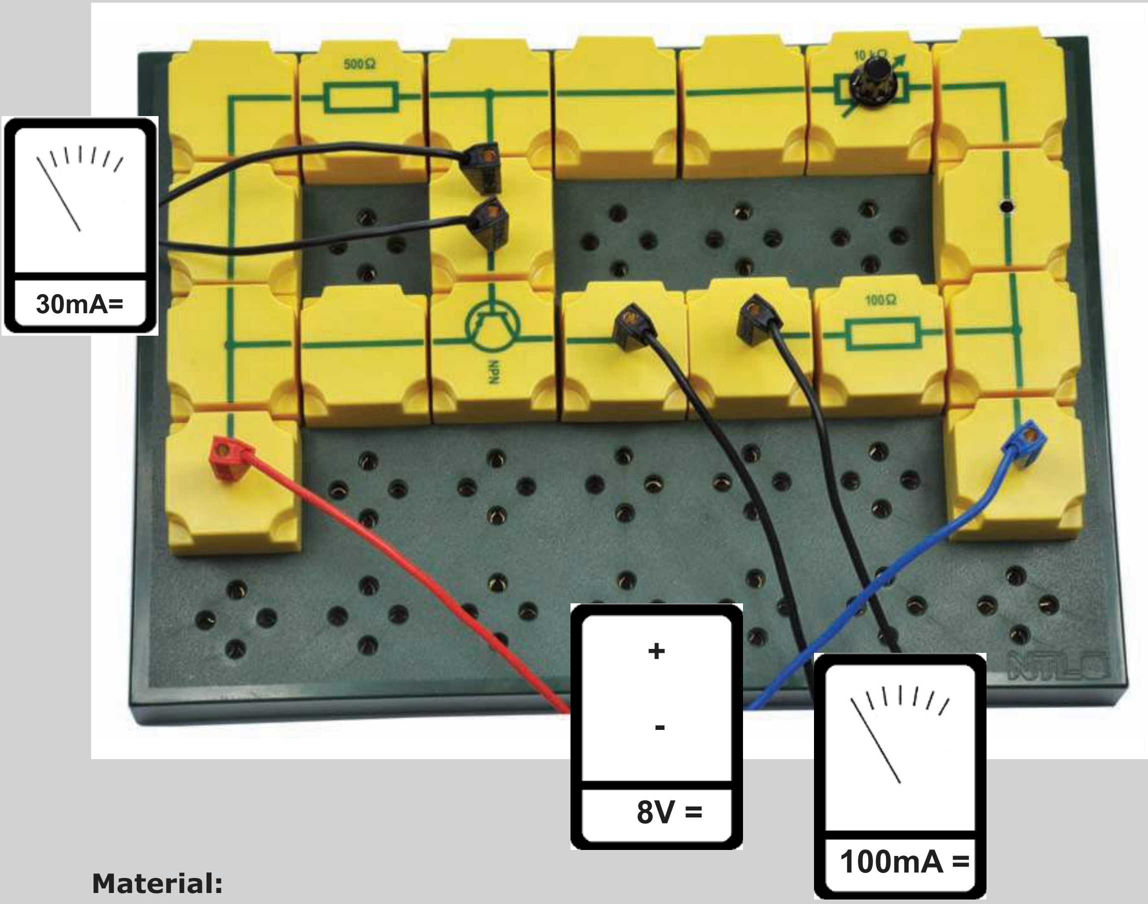
Voltage amplification: $\frac{dU_{CB}}{dU_{CE}} =$ ....

Conclusion:
The collector connection provides a voltage amplification which is smaller than 1.

EMITTER CIRCUIT (CURRENT AMPLIFICATION)

EOS 3.3.5

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



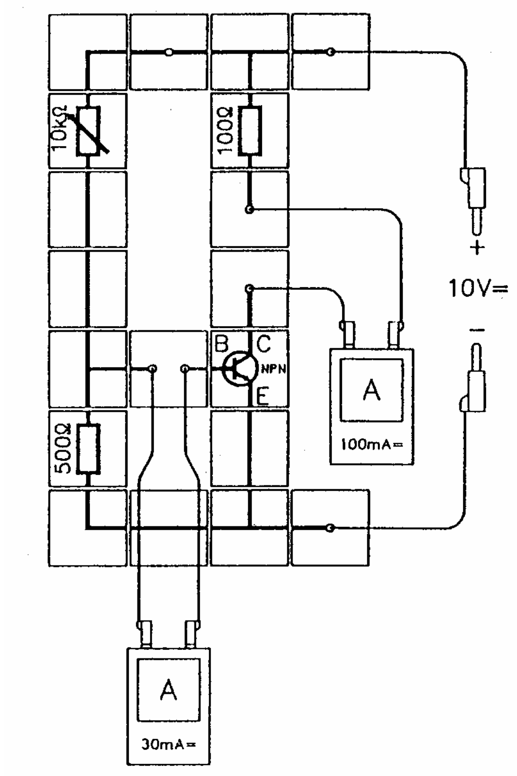
Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
4x PIB connector
4x PIB wire, straight
1x PIB wire, straight, with socket
3x PIB wire, T-shaped
1x PIB wire, interrupted, with sockets
2x PIB wire, angled
1x PIB resistor 100 Ohm
1x PIB resistor 500 Ohm
1x PIB rheostat 10 kOhm
1x PIB transistor, NPN, base left

Additionally required:
2x Meter
1x Voltage supply

EMITTER CIRCUIT (CURRENT AMPLIFICATION)

EOS 3.3.5

The emittor (one of the three connections of the transistor) is used as a point of reference for the two currents.



Wiring:

Arrange the wiring according to the illustration.

Emitter connection means that the emittor is the common connection for the base current I_B and the collector current I_C.

The base current is measured by the ammter with the range of 30 mA =, the collector current by the ammeter with the range of 100 mA =.

The base current I_B can be adjusted by means of the variable resistor.

The corresponding collector current I_C is measured as well.

The ratio of the change of the collector current and the change of the base current is the current amplification factor for emittor connection.

Experiment:

The base current is first adjusted to 0,1 mA and then to 0,3 mA and the individual amounts of the collector current are taken down. Then the current amplification factor is calculated.

Base current I_B	0,1 mA	0,3 mA	Change: 0,002 A
Collector current I_C	.... mA	.... mA	Change: .... A

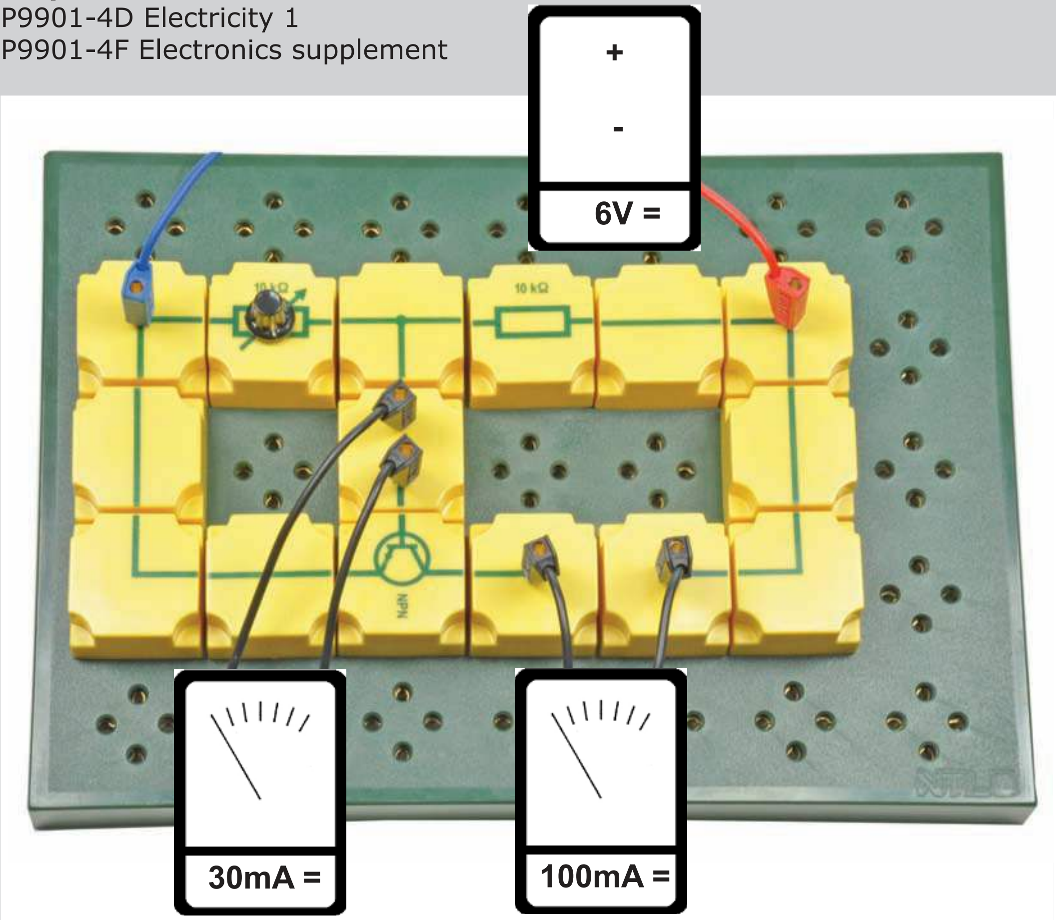
Current amplification: $\frac{dI_C}{dI_B}$ = ...

Conclusion:
The emitter connection provides a current amplification factor from 50 to 500.

TRANSFER CHARACTERISTIC OF A NPN TRANSISTOR

EOS 3.3.6

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



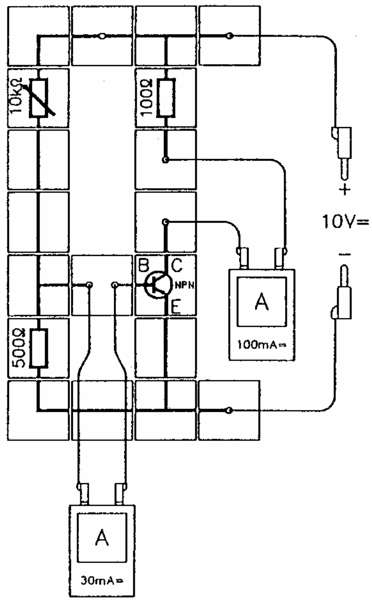
Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
4x PIB wire, straight
1x PIB wire, T-shaped
1x PIB wire, interrupted, with sockets
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 10 kOhm
1x PIB rheostat 10 kOhm
1x PIB transistor, NPN, base left

Additionally required:
2x Meter
1x Voltage supply

TRANSFER CHARACTERISTIC OF AN NPN TRANSISTOR

EOS 3.3.6

The dependence of the collector current on the base current without load resistance is to be measured at an NPN-transistor.



Wiring:

Arrange the wiring according to the illustration.

The ammeter which measures the base curent I_B is used in the 30 mA = range, the ammeter which measures the collector current I_C is used with the range of 100 mA =.

Experiment:

A D.C. source of 6 Volt is applied and the base current is adjusted by means of the variable resistor.

The amounts of the base current listed on the chart are adjusted one after the other, the corresponding collector current is measured and listed in the chart.

Base current I_B (in mA)	0,05	0,1	0,15	0,2	0,25
Collector current I_C (in mA)	....	....	....	....	....

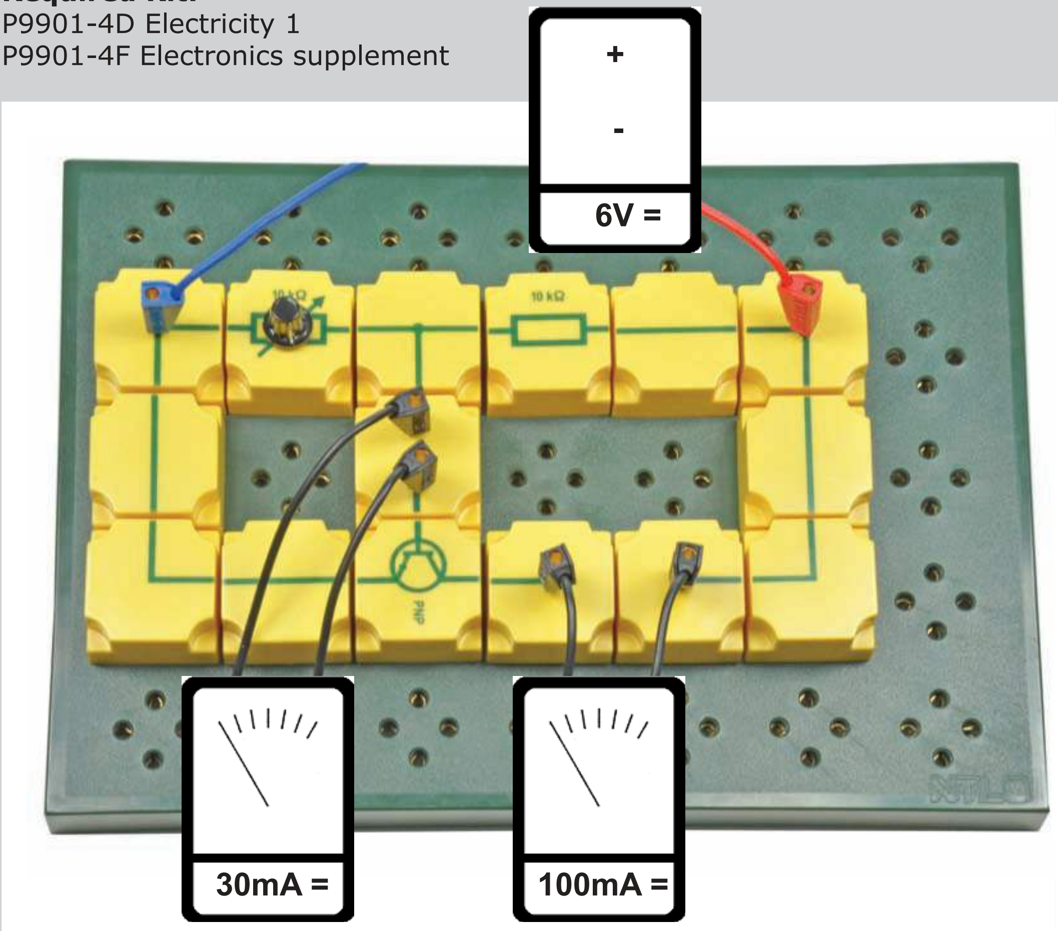
The measurements are shown graphically in an I_C-I_B diagram.

Conclusion:
The correlation between the base current I_B and the collector current I_C is almost a linear one.

TRANSFER CHARACTERISTIC OF A PNP TRANSISTOR

EOS 3.3.7

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



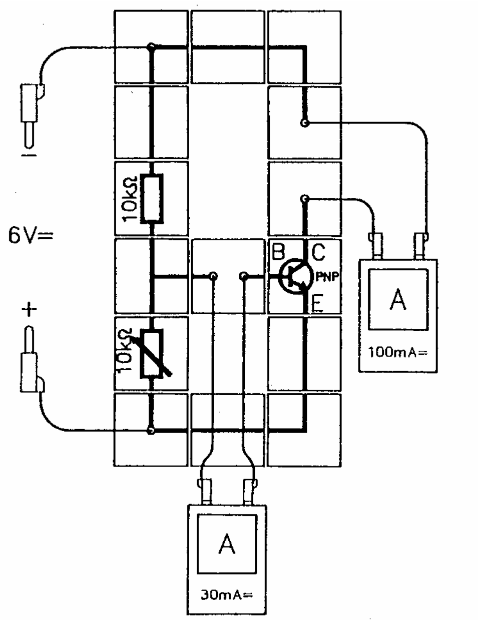
Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
4x PIB wire, straight
1x PIB wire, T-shaped
1x PIB wire, interrupted, with sockets
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 10 kOhm
1x PIB rheostat 10 kOhm
1x PIB transistor, PNP, base left

Additionally required:
2x Meter
1x Voltage supply

TRANSFER CHARACTERISTIC OF AN PNP TRANSISTOR

EOS 3.3.7

The dependence of the collector current on the base current without load resistance is to be measured at a PNP-transistor.



Wiring:

Arrange the wiring according to the illustration.

The polarity of the applied voltage has to be changed contrary the connection of an NPN-transistor.

The positive pole of the voltage source is at the emittor, the negative pole at the collector.

The ammeter which measures the base current I_B is used in the 30 mA = range, the ammeter which measures the collector current I_C is used with the range of 100 mA =.

Experiment:

A D.C. of 6 Volt is applied and the base current is adjusted by means of the variable resistor. The amounts of the base current listed on the chart are adjusted one after the other.
The corresponding collector current is measured and listed on the chart.

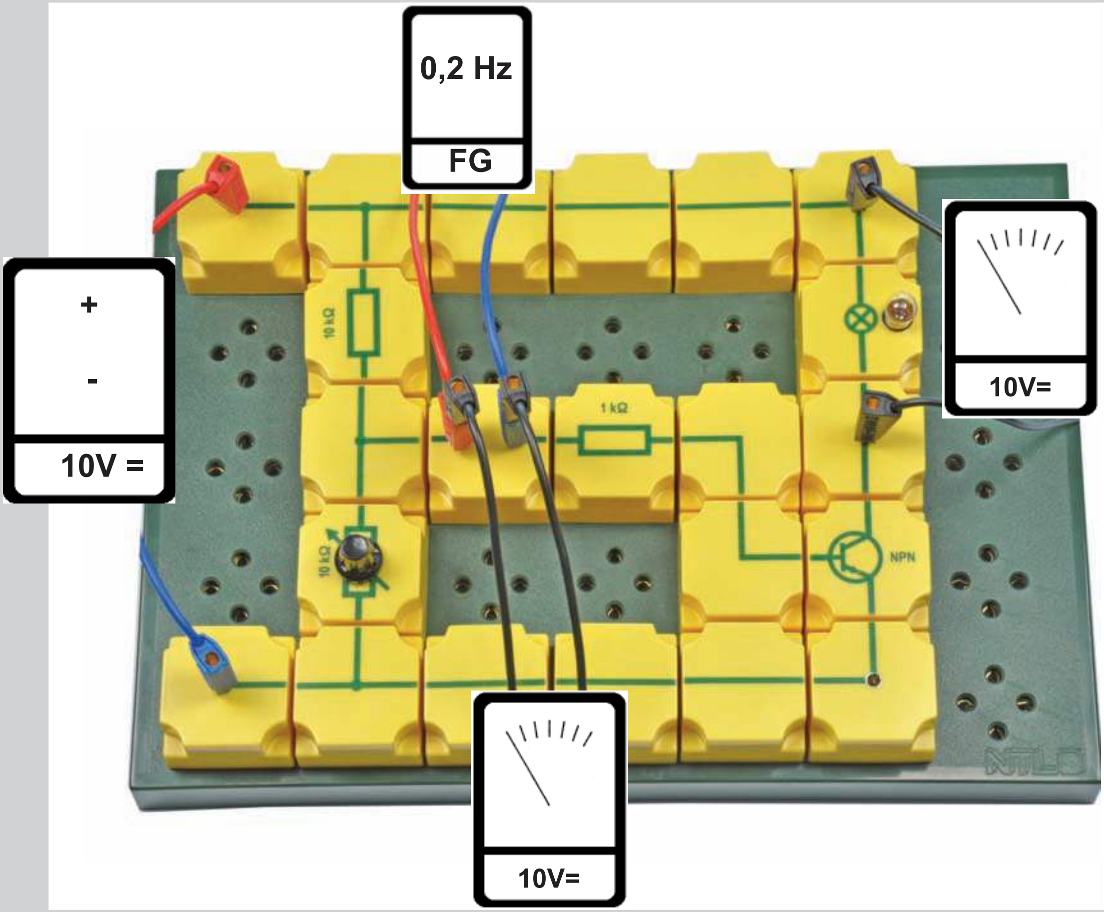
Base current I_B (in mA)	0,05	0,1	0,15	0,2	0,25
Collector current I_C (in mA)	....	....	....	....	....

The measured results are shown graphically in an I_C-I_B diagram.

Conclusion:
The correlation between the base current I_B and the collector current I_C is almost linear.

ADJUSTING THE OPERATING POINT EOS 3.3.8

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



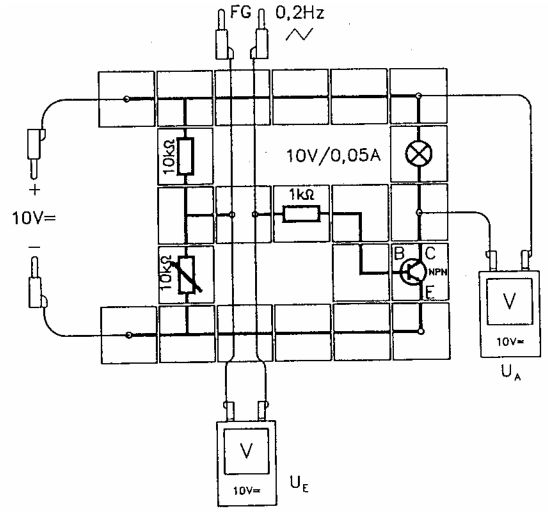
Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
6x PIB wire, straight
1x PIB wire, straight, with socket
3x PIB wire, T-shaped
1x PIB wire, interrupted, with sockets
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 1 kOhm
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB rheostat 10 kOhm
1x PIB transistor, NPN, base left

Additionally required:
2x Meter
1x Voltage supply

ADJUSTING THE OPERATION POINT

EOS 3.3.8

A base current at an NPN-transistor can only effect an amplification if it flows in the direction of the base-emittor.
A current cannot flow in the opposite direction because the base-emittor path functions as a diode. If an A.C. is applied to the base and the emittor, only half a period can result in a base current and thus in an amlified collector current.
The other half period remains completely ineffective.
In the second experiment the possiblity of how this half period and thus the complete period of the A.C. can be amplified is introduced.



Wiring:

Wir bauen die Schaltung gemäß der Abbildung auf.

Die beiden Voltmeter werden mit dem Messbereich 10 V = verwendet.

Nach Anlegen von 10 Volt Gleichspannung entfernen wir den Widerstand 10 kΩ und drehen den Regelknopf des Drehwiderstandes ganz im Uhrzeigersinn (maximaler Widerstandswert).

1. Experiment:

The signal generator is adjusted to 0,2 Hz triangular. The voltage U_E should be 2 Volt. The two measuring devices are watched.

During the positive half period the incandescent lamp glows. The voltage U_A at the load resistor (incandescent lamp) is proportional to U_E during this half period.
During the negative half period the voltage at the incandescent lamp remains 0, this half period remains ineffective.

2. Experiment:

The output voltage of the signal generator is adjusted to 0. The resistor 10 kΩ is inserted and the adjustment knob of the variable resistor is turned in such a way that the voltmeter which measures the voltage at the load resistor (incandescent lamp) indicates a voltage U_A of 5 Volt.

Now the generator is adjusted to 1 Volt.

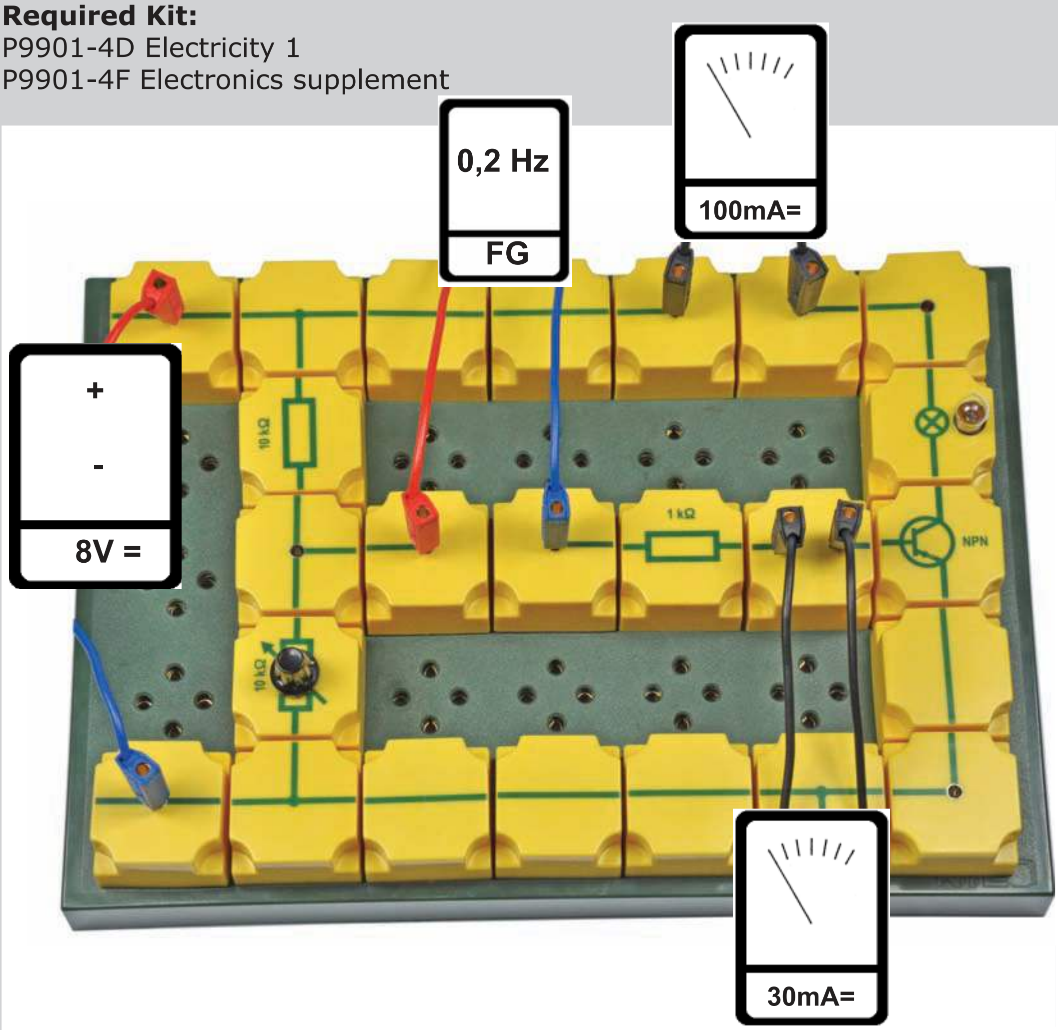
The voltage U_A is proportional to U_E during the complete period.

Conclusion:
If the operating point is at base current 0 half a period of the base A.C. remains ineffective.
If a base D.C. is produced by remains of a base voltage divider and A.C. is interfered with it, the operating point is differnt.
Thus it can achieve that the output voltage U_A of the transistor circuit is proportional input voltage U_E (A.C.).

DISTORTION-FREE AMPLIFICATION THROUGH QUIESCENT BASE CURRENT

EOS 3.3.9

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
4x PIB connector
6x PIB wire, straight
2x PIB wire, straight, with socket
1x PIB wire, T-shaped, with socket
2x PIB wire, T-shaped
1x PIB wire, interrupted, with sockets
2x PIB wire, angled, with socket
1x PIB resistor 1 kOhm
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB rheostat 10 kOhm
1x PIB transistor, NPN, base left

Additionally required:
2x Meter
1x Function generator
1x Voltage supply

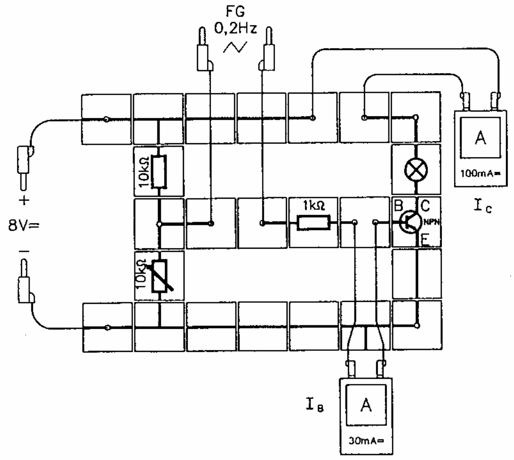
DISTORTION-FREE AMPLIFICATION THROUGH QUIESCENT BASE CURRENT

EOS 3.3.9

A proportional amplification is only possible by means of a base D.C. This zero signal current is to be investigated.

Wiring:

Arrange the wiring according to the illustration.



The ammeter which measures the base current is used in the range of 30 mA =, the ammeter which measures the current is the load circuit (collector current) is used in the range of 100 mA =.
First the resistor 10 kΩ is not inserted and the adjustment knob of the variable resistor is completely turned clockwise (maximum amount of resistance).

1. Experiment:

The signal generator is adjusted to 0,2 Hz Sine or triangular. Its output voltage is increased until the peak amount of the collector current I_C reaches about 25 – 30 mA. The two measuring devices are watched.

Both currents only flow during one half period. With negative voltage at the base neither base current nor collector current can flow. This is a complete disortion with regard to the the voltage.

2.Experiment:

The resistor 10 kΩ is inserted and the adjustment knob of the variable resistor is turned counter-clockwise until both indicators of the measuring devices carry out full oscillations.

The base current I_B deviates from .... mA to .... mA.

The collector current I_C deviates from .... mA to .... mA.

The output voltage of the signal generator is adjusted t 0 in order to measure the zero signal currents.

Zero signal base current: .... mA

Zero signal collector current: .... mA

3.Experiment:

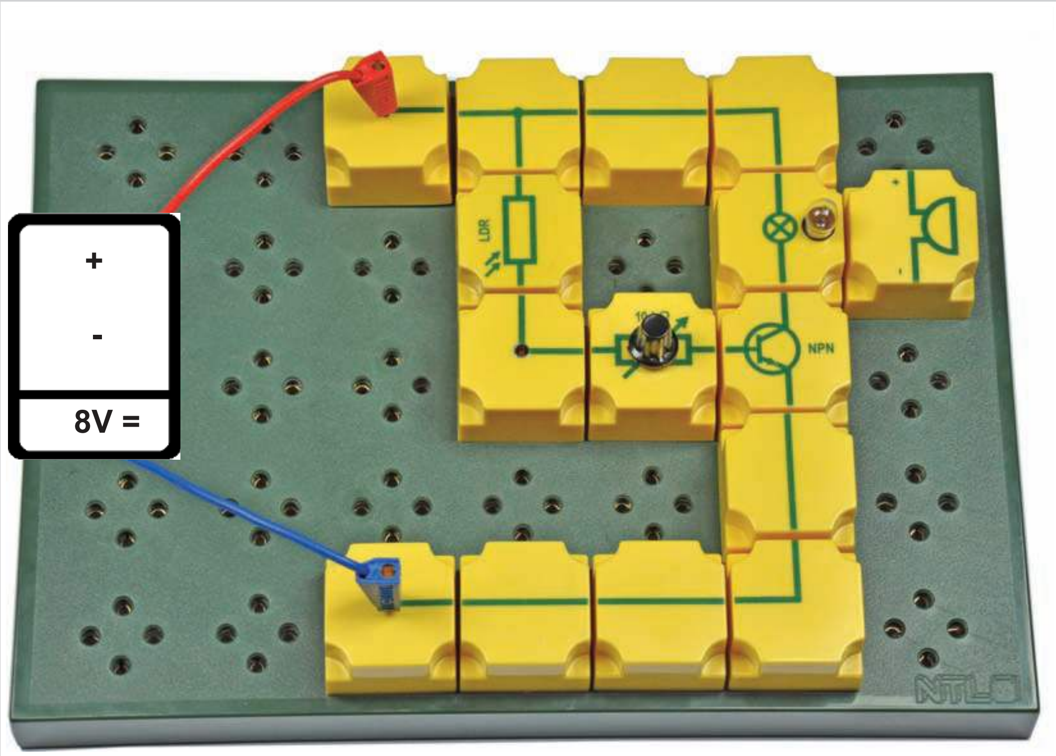
The output voltage of the signal generator is increased until the indicators of the measuring devices remain in their final positions. The gate voltage is distorted again.

Conclusion:
A zero signal base current and a zero signal collector current must be adjusted for the distortion of free amplification. The voltage which is to be amplified (gate voltage) must not be too high. The interference of zero signal base current and the gate current must not drop below 0 an the one and and must not reach the range in which the trasistor is already in saturation on the other hand.
If these limits are crossed, distortions arise because the peaks of tha gate voltage do no longer result in proportional currents, but are „cut off" in their effects.

LIGHT-TRIGGERED ALARM

EOS 3.4

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
4x PIB wire, straight
1x PIB wire, T-shaped
1x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB lamp socket
1x Light bulb 10V/50mA
1x PIB rheostat10 kOhm
1x PIB photo resistor (LDR)
1x PIB buzzer
1x PIB transistor PNP, base left

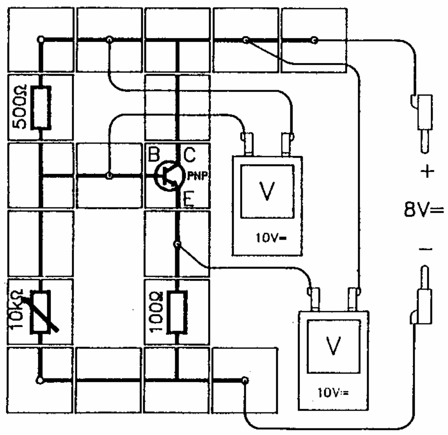
Additionally required:
1x Voltage supply

LIGHT-TRIGGERED ALARM

EOS 3.4

An LDR-resistor controls the base current of a transistor by its light-dependent amount of resistance.
If it is dark there is not sufficient base current to make the transistor conducting.
If light falls on the LDR-resistor, base current and collector current of the transistor increase.

Wiring:



Arrange the wiring according to the illustration.

First a lamp is inserted in front of the trasistor to check how it works.

The base current flows from the positive pole via the LDR-resistor and the variable resistor 10 kΩ, which makes an adaptation to the desired luminous intensity starting the alarm possible.

Furthermore the applied voltage can be adjusted accordingly.

1.Experiment:

The LDR is darkened.
Therefore the lam does not glow.

If light falls on the LDR the lamp should glow because the higher base current „switches the transistor through".

2.Experiment:

The lamp is replaced by the buzzer.
The amount of resistance and the applied voltage may possibly have to be adjusted again.

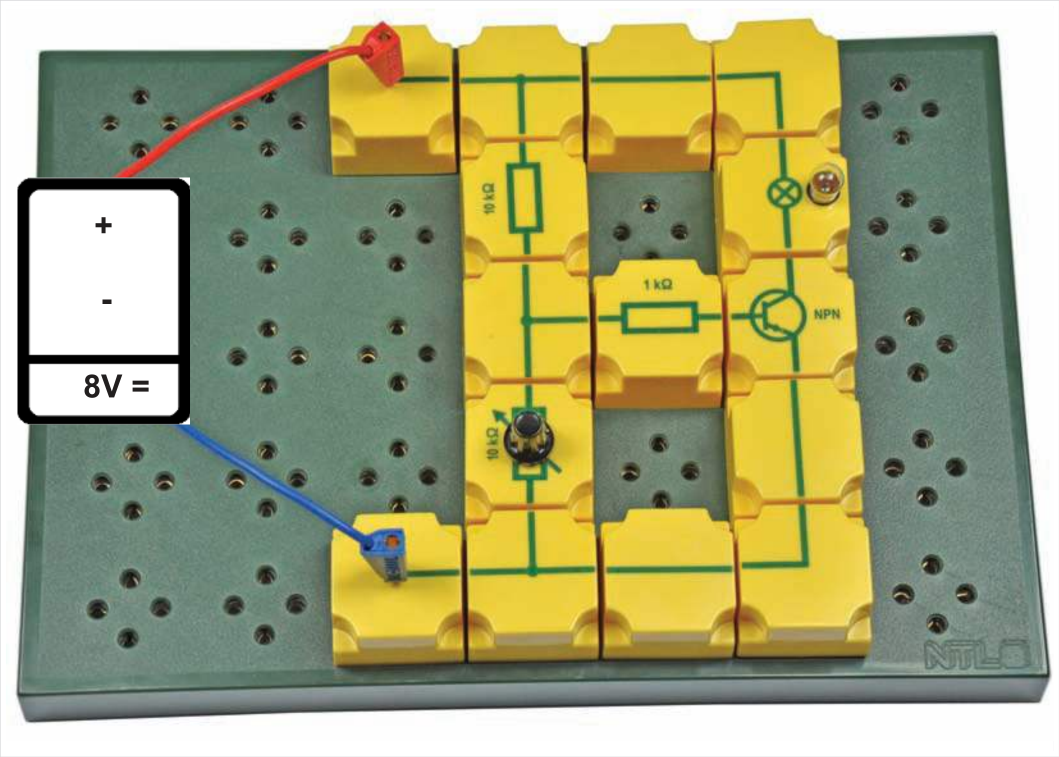
If light falls on the LDR now, the alarm is started.

Conclusion:
The LDR changes its amount of resistance between darkness and light to such an extent that the transistor blcks at darkness and is „switched through" at light.

BASE VOLTAGE DIVIDER

EOS 3.5

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB resistor 1 kOhm
1x PIB lamp socket
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB rheostat10 kOhm
1x PIB transistor PNP, base left

Additionally required:
1x Voltage supply

BASE VOLTAGE DIVIDER

EOS 3.5

A base voltage divider makes a precise adjustment of the base current possible.

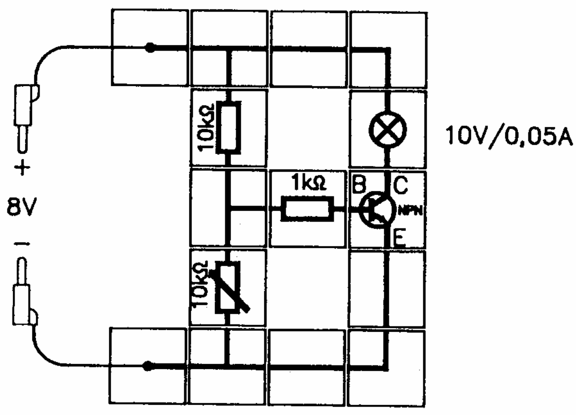
Wiring:

Arrange the wiring according to the illustration.

The total voltage of 8 volt is divided by a voltage divider.

The component voltage at the vriable resistor effects base and emittor and causes a base current.

The resistor 1 kΩ protects the base from wrong connections.



1. Experiment

The knob of the variable resistor is completely turned counter-clockwise.
Its amount of resistance is 0, therefore its component voltage is 0 as well.

Neither base current nor collector current are produced.

2. Experiment

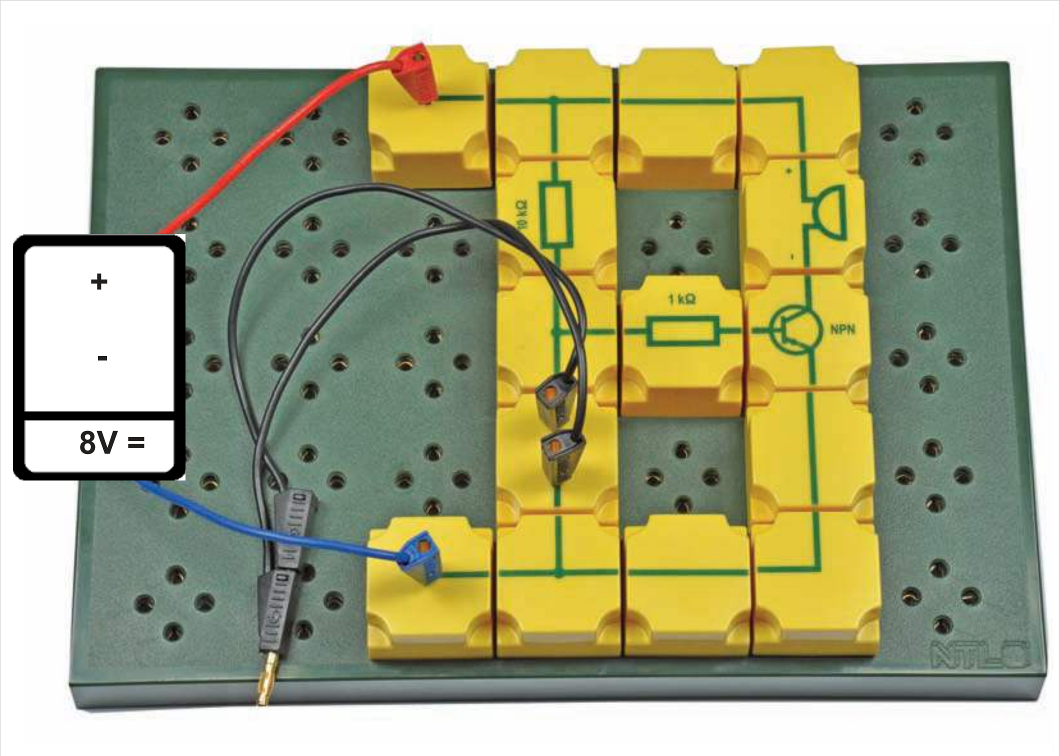
The knob of the variable resistor is turned clockwise.
Its amount of resistance and consequently its component voltage increase.

Thus the base current increases, leading to an increase of the collector current.

Conclusion:
Each collector current can be adjusted between 0 and maximum by an appropriate base voltage divider.

BURGLAR ALARM USING TRIP WIRE EOS 3.6

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB resistor 1 kOhm
1x PIB resistor 10 kOhm
1x PIB buzzer
1x PIB transistor PNP, base left

Additionally required:
1x Voltage supply

BURGLAR ALARM USING TRIP WIRE

EOS 3.6

A very simple device against burglary can be effected by thin wires connected with each other (cabled). If the connection is interrupted, an alarm starts.

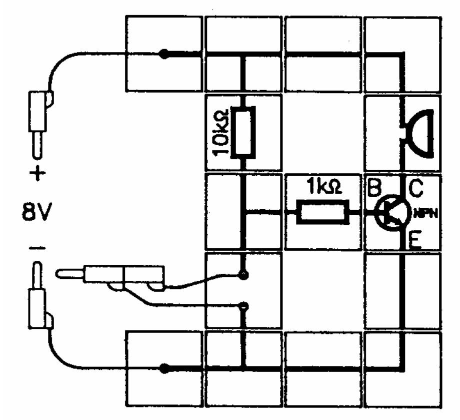
Wiring:

Arrange the wiring according to the illustration.

The part of the voltage divider effective on the base current now consists of „trip wires‟, for which two joint connecting leads are used in the experiment.

Since the amount of resistance is almost 0, no base current is produced.

Connect „trip wires‟ before applying voltage!



Experiment:

The „trip wires‟ are interrupted.
Thus the amount of resistance (theoretically) increases to infinity.
The total voltage lies at the lower part of the voltage divider between base and emittor.

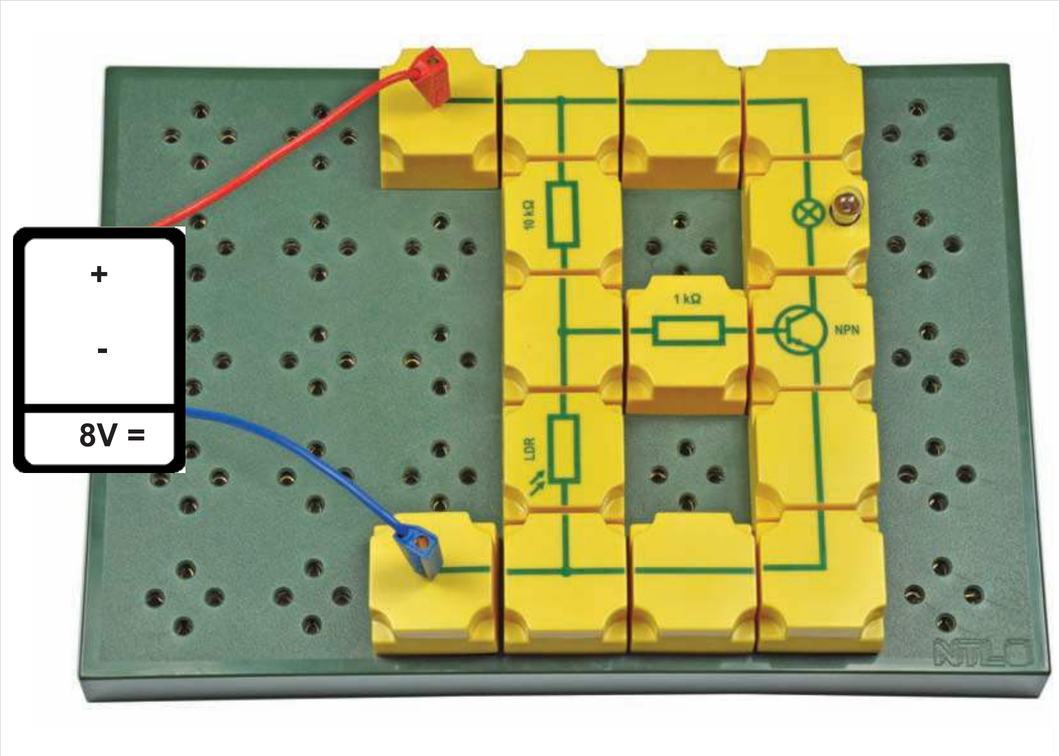
Thus the transistor is switched through and the buzzer sounds the alarm.

Conclusion:
„Trip wires‟ change the amount of resistance of the voltage divider resistor at the emittor from 0 to infinity.
Thus the transistor is switched from blocking to connecting.

AUTOMATIC LIGHTING

EOS 3.7

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB resistor 1 kOhm
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB photo resistor (LDR)
1x PIB transistor PNP, base left

Additionally required:
1x Voltage supply

AUTOMATIC LIGHTING

EOS 3.7

The base current of a transistor is controlled by means of a LDR. Thus the transistor is switched through in dependence on the illumination.

Wiring:

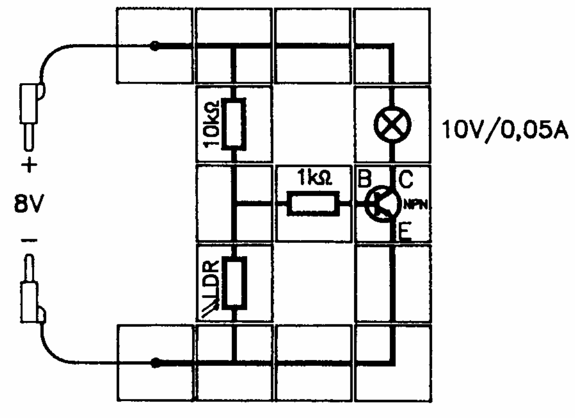
Arrange the wiring according to the illustration.

The voltage divider consists of a resistor 10 kΩ and the LDR.

The amount of resistance of the LDR is high at darkness.

The major part of the voltage lies at the LDR.

Thus base current flows and the lamp glows.



Experiment:

The amount of resistance of the LDR is darkened and illumined alternately.

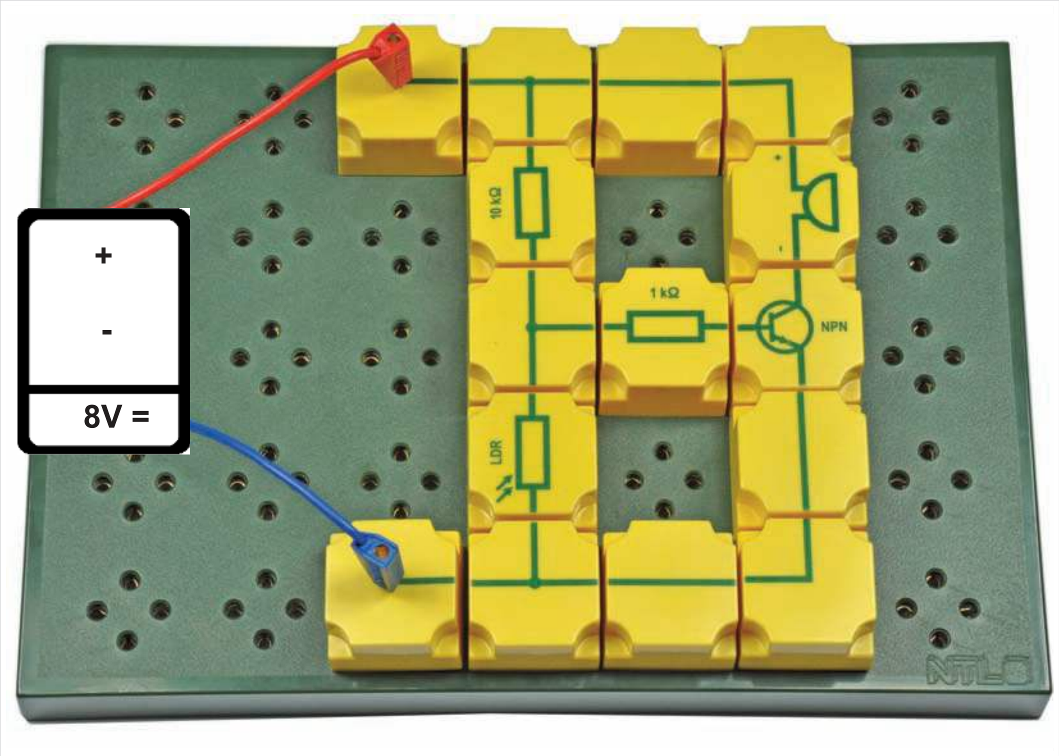
The lamp should glow at darkening, the lamp does not glow when the LDR is illumined.

Conclusion:
The wiring (by means of an LDR which serves as a resistor at the emittor) is such that the light is automatically switched on at darkness and switched off at daylight.

ALARM TRIGGERED BY A LIGHT BARRIER

EOS 3.8

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB resistor 1 kOhm
1x PIB resistor 10 kOhm
1x PIB photo resistor (LDR)
1x PIB buzzer
1x PIB transistor PNP, base left

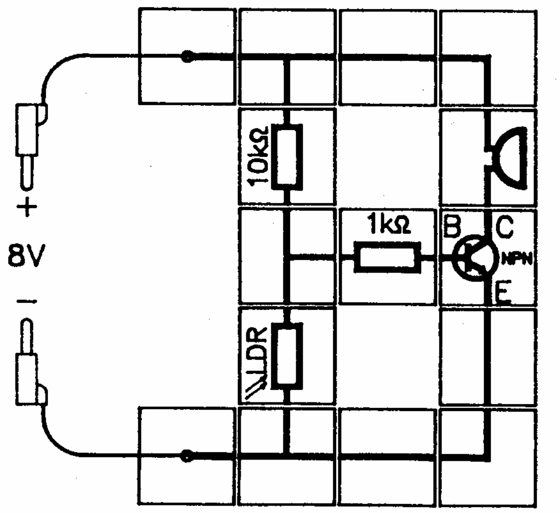
Additionally required:
1x Voltage supply

ALARM TRIGGERED BY A LIGHT BARRIER

EOS 3.8

The task of light barriers is to trigger signals or automatic counting when a beam of light is interrupted.
Infrared light which is invisible for men is frequently used as a source ol light.
In this experiment daylight or an experimental lamp is used as the source of light.

Wiring:



Arrange the wiring according to the illustration.

The voltage divider consists of the resistor 10 kΩ and the LDR.

The amount of resistance of the LDR is high at darkness.

The major part of the voltage stops at the LDR.

Thus base current flows.

The amount of resistance is low with sufficient light on the LDR.

The component voltage is low as well. There is little base current and little collector current.

If an experimental lamp is used as the source of light, it must be switched on at the beginning of the experiment.

Experiment:

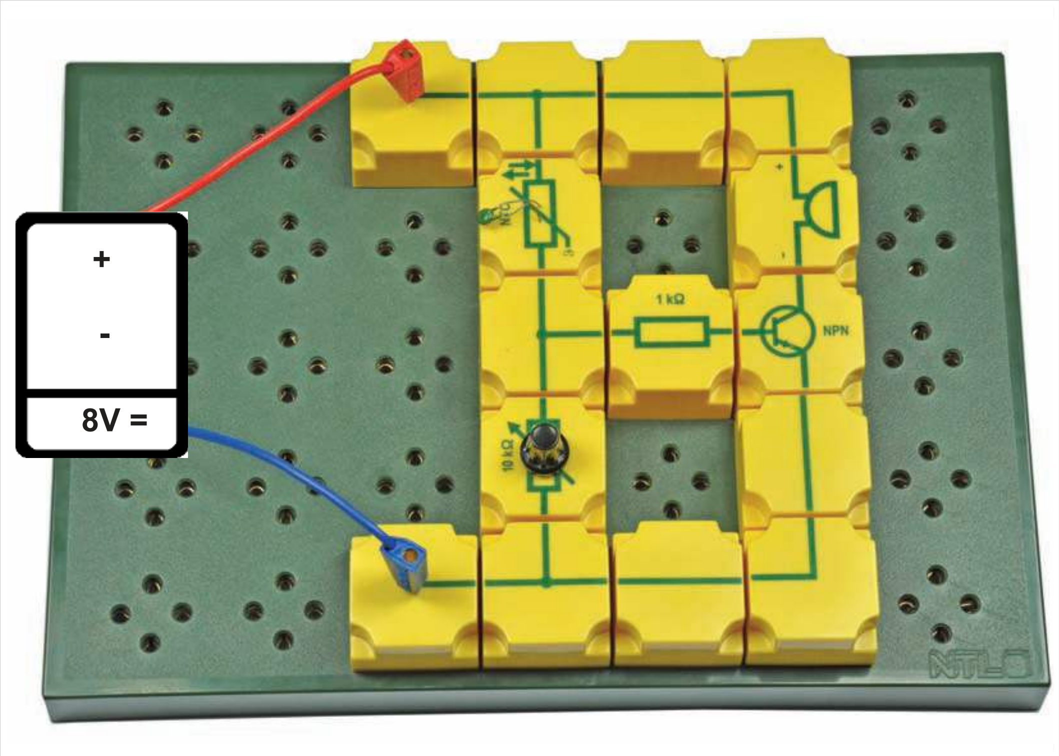
If the beams of light falling on the LDR are interrupted, the buzzer sounds the „alarm".

Conclusion:
An interruption of the light beams of the LDR leads to an increase of the amount of resistance of the LDR with light barriers.
The LDR serves as a resistor of the voltage divider at the emittor.
In this way processes can be triggered (alarm, automatic counting).

FIRE ALARM

EOS 3.9

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB resistor 1 kOhm
1x PIB potentiometer 10 kOhm
1x PIB NTC resistor
1x PIB buzzer
1x PIB transistor PNP, base left

Additionally required:
1x Voltage supply

FIRE ALARM

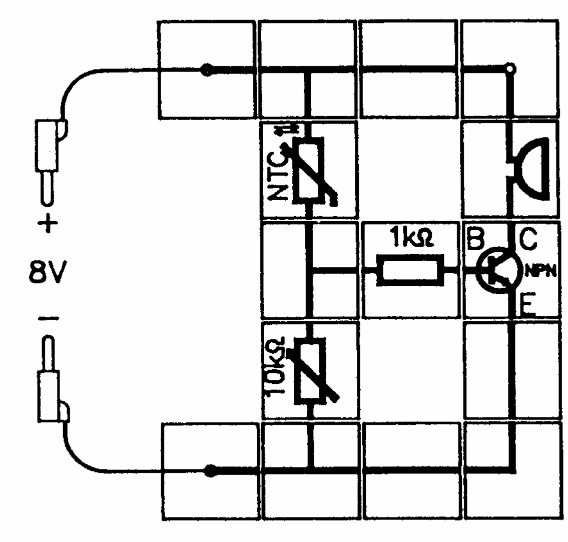
EOS 3.9

The amount of resistance decreases at rising temperatures with NTC-resistors.

Wiring:

Arrange the wiring according to the illustration.

The variable resistor 10 kΩ is adjusted in such a way that the buzzer almost sounds.



Experiment:

The NTC is warmed by the fingers.

Result:

After a few seconds the „alarm" sounds.
The amount of resistance of the NTC has decreased.

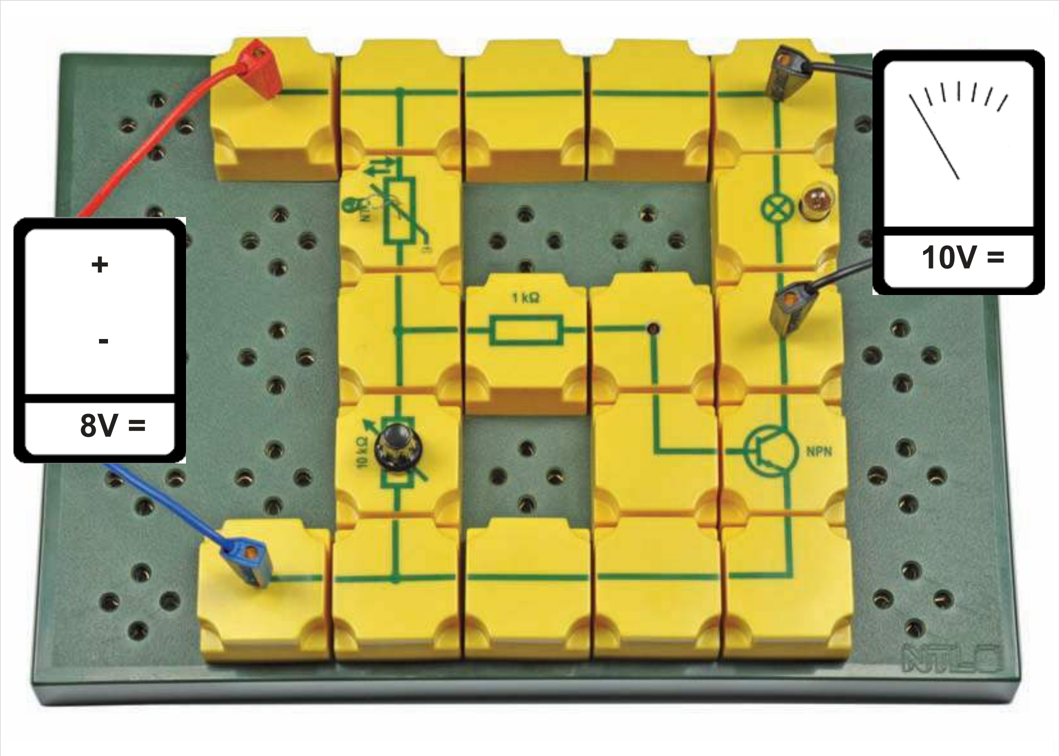
Thus the voltage rises at the variable resistor and the transistor is switched through.

Conclusion:
The decrease of resistance of a NTC by warming can be used with fire-alarms.

ELECTRIC THERMOMETER

EOS 3.10

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



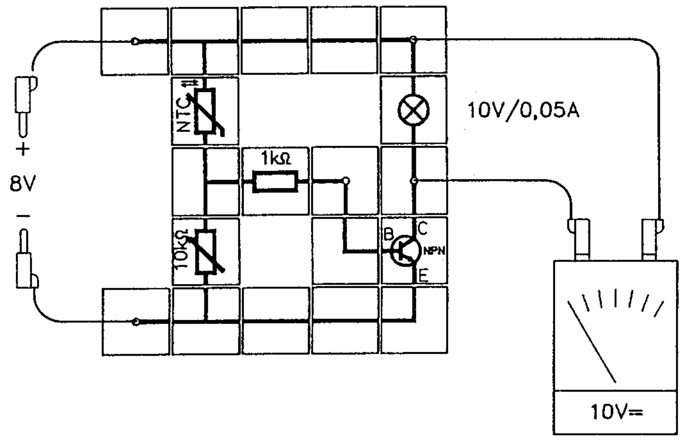
Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
4x PIB wire, straight
1x PIB wire, straight, with socket
3x PIB wire, T-shaped
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 1 kOhm
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB potentiometer 10 kOhm
1x PIB NTC resistor
1x PIB buzzer
1x PIB transistor PNP, base left

Additionally required:
1x Meter
1x Voltage supply

ELECTRIC THERMOMETER

EOS 3.10

Changes in temperature must be converted into changes of voltage for metering temperatures by means of voltmeter.
This can be achieved by means of NTC-resistors and transistors.



Wiring:

Arrange the wiring according to the illustration.

An NTC-resistor and a variable resistor serve as the base voltage divider.

The amount of resistance and thus the component voltage of the NTC decrease at rising temperature.

Base current and collector current rise.

Therefore a great drop of voltage is caused at the lamp.

Experiment:

The variable resistor is adjusted in such a way that the voltmeter indicates a voltage of 4 Volt.

Then the NTC is warmed by the fingers.

Result:

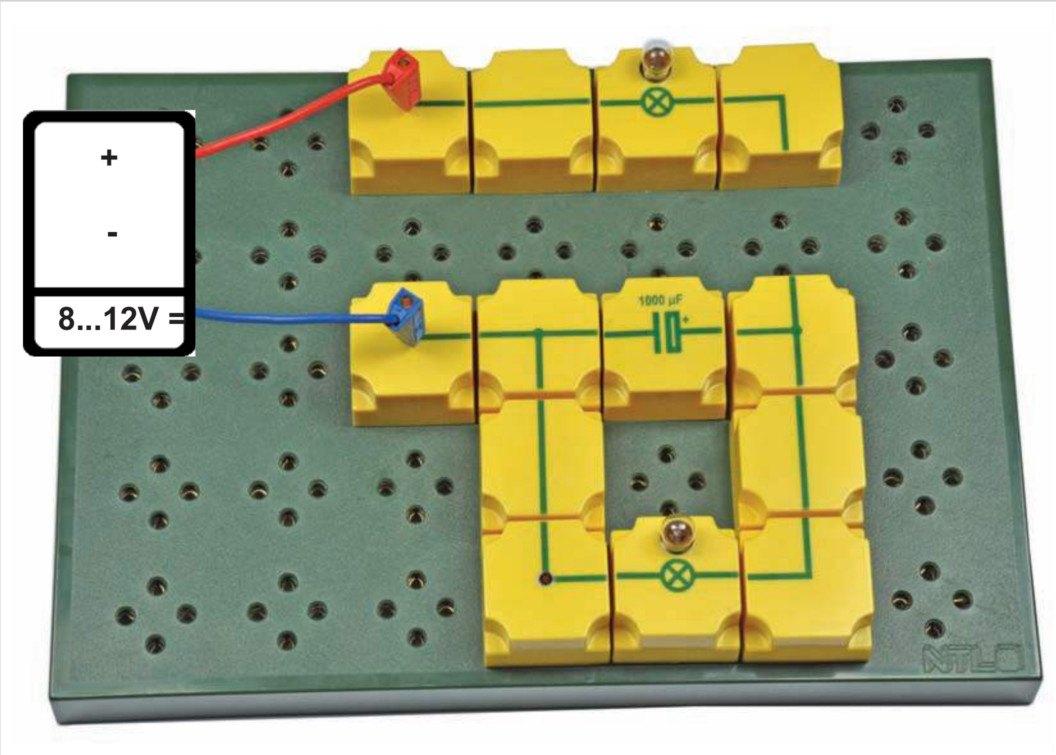
The voltmeter indicates a higher voltage.

Conclusion:
Higher temperatures can be converted into higher voltages by means of resistors depending on temperature.

ELECTRIC CHARGE STORAGE

EOS 4.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



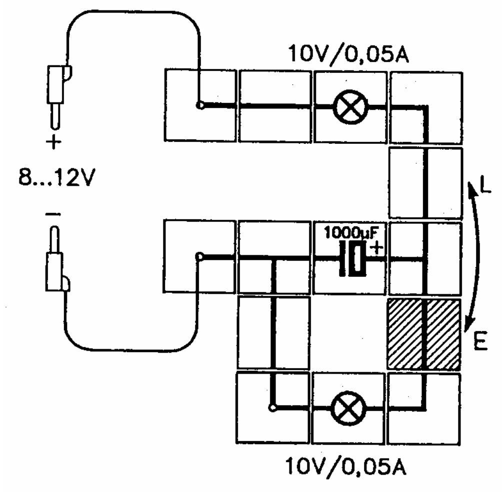
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
2x PIB wire, T-shaped
1x PIB wire, angled, with socket
2x PIB wire, angled
2x PIB lamp socket E10
2x Light bulb 10V/50mA
1x PIB capacitor 1000 µF

Additionally required:
1x Voltage supply

ELECTRIC CHARGE STORAGE

EOS 4.1

Electric charges can be stored in a condenser.
The „charged" condenser can cause the glowing of a lamp for a short time.



Wiring:

Arrange the wiring according to the illustration.

A PIB-lead is set from E to L (charging of the condenser) and then reset to E (discharging of the condenser).

Experiment:

The circuit is closed for the applied voltage of 8 Volt at L and the condenser is charged.

If the PIB-lead straight is moved from L to E, the voltage source is disconnected. Now the condenser can be discharged via the closed lower circuit.

The PIB-lead is moved from E to L several times and then removed to E. The lamps are watched.

The surge which charges the condenser is indicated by the upper lamp. The lower lamp indicates the pulsating discharge of the condenser.

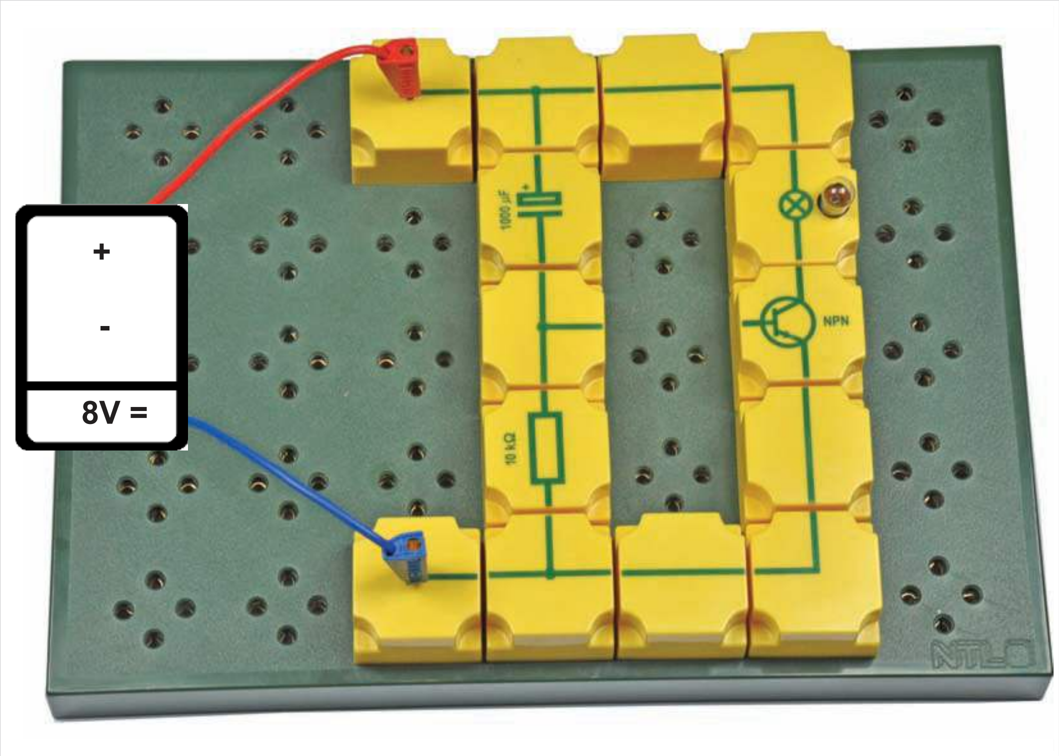
Conclusion: Condensers are storages for electric charges.

Note: The lead can also be assembled with an alteration switch.

A CAPACITOR SUPPLIES BASE CURRENT

EOS 4.2

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB capacitor 1000 µF
1x PIB transistor NPN, Base left

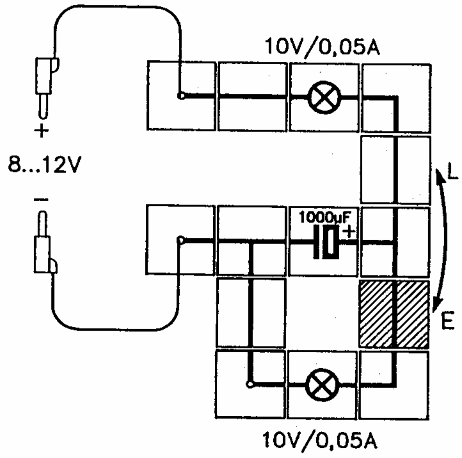
Additionally required:
1x Voltage supply

A CAPACITOR SUPPLIES BASE CURRENT

A charged condenser can be used as a source of base current.

Wiring:

Arrange the wiring according to the illustration.



The condenser is charged in position L (charging) by the voltage source via the resistor 10 kΩ (check the polarity!).

After a charging time of 10 seconds it can be moved to position E (discharging; check the correct polarity!).

There the condenser discharges via the base-emittor-path of the transistor and the resistor 10 kΩ.

This resistor limits the discharging current to a very low current intensity.

In this way the condenser can supply base current for a very long time.

The lamp glows comparatively long.

Experiment:

The condenser is moved under strict adherence to the polarity from E to L several times and then removed to E after at least 1 seconds.

Result:

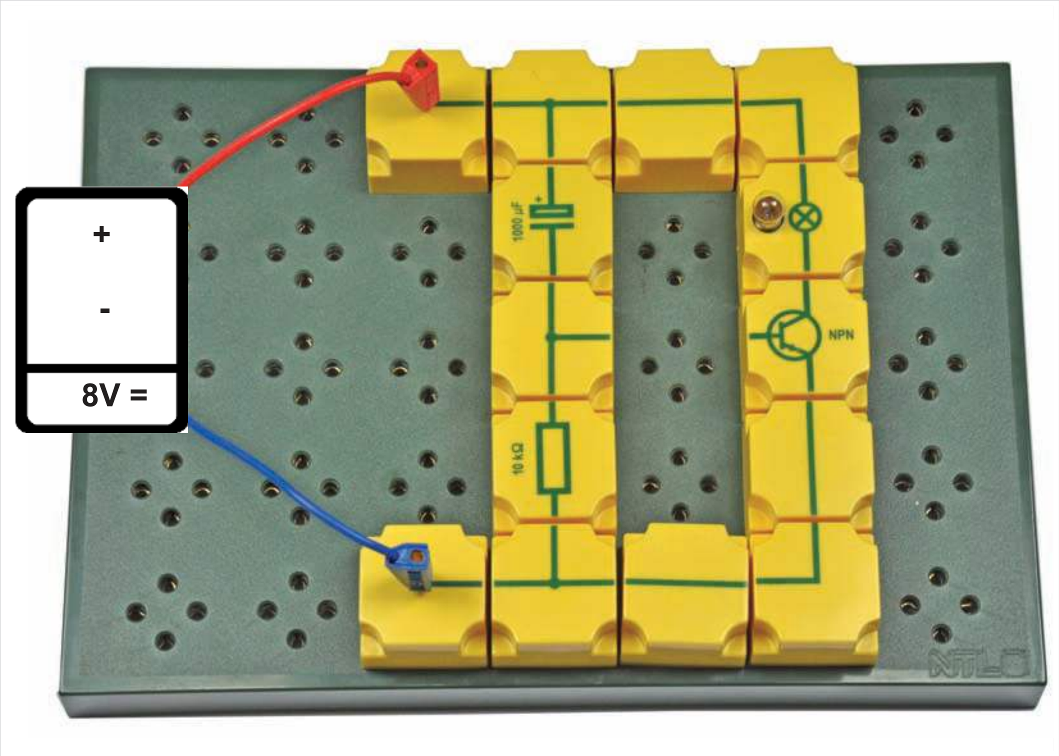
The lamp glows for quite a while.

But do not get deceived: The energy for the lamp is supplied by the voltage source. The condenser only effects the flow of the collector current by the base current which is supplied by it.

CAPACITANCE

EOS 4.3

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB capacitor 100 µF
1x PIB capacitor 1000 µF
1x PIB transistor NPN, Base left

Additionally required:
1x Voltage supply

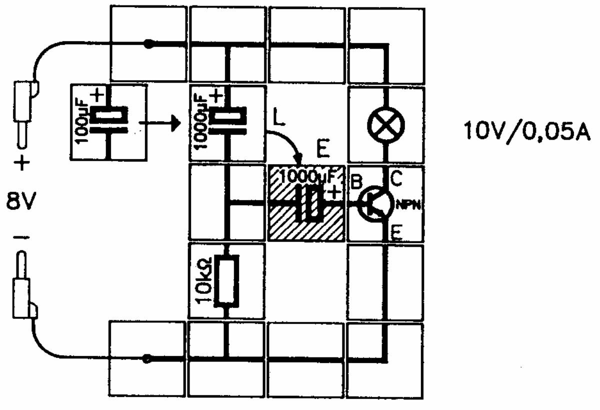
CAPACITANCE

EOS 4.3

The „capacitance" of a condenser is the measurable variable of the storage capacity. The experiment presents a simple possibility to estimate the storage capacity.

Wiring:

Arrange the wiring according to the illustration.



The condenser is charged in position L (charging) via the resistor 10 kΩ by the voltage source (check the polarity!).

After a charging period of 10 seconds it can be moved to position E (discharging; check the correct polarity!).

It discharges via the base-emittor-path of the transistor and the resistor 10 kΩ.

This resistor limits the discharging current to a very low current intensity.

In this way the condenser provides base current for quite a long time.

A D.C. source of 8 Volt is applied.

Experiment:

The condenser is inserted in L and charged.
After at least 10 seconds it is inserted in E and discharged (check the correct polarity in each case!).

The experiment is first carried out with the condenser 1000 µF, then with the condenser 100 µF.
Each time it is to be found out how long the lamp glows.

Period of glowing at 1000 µF: .... seconds

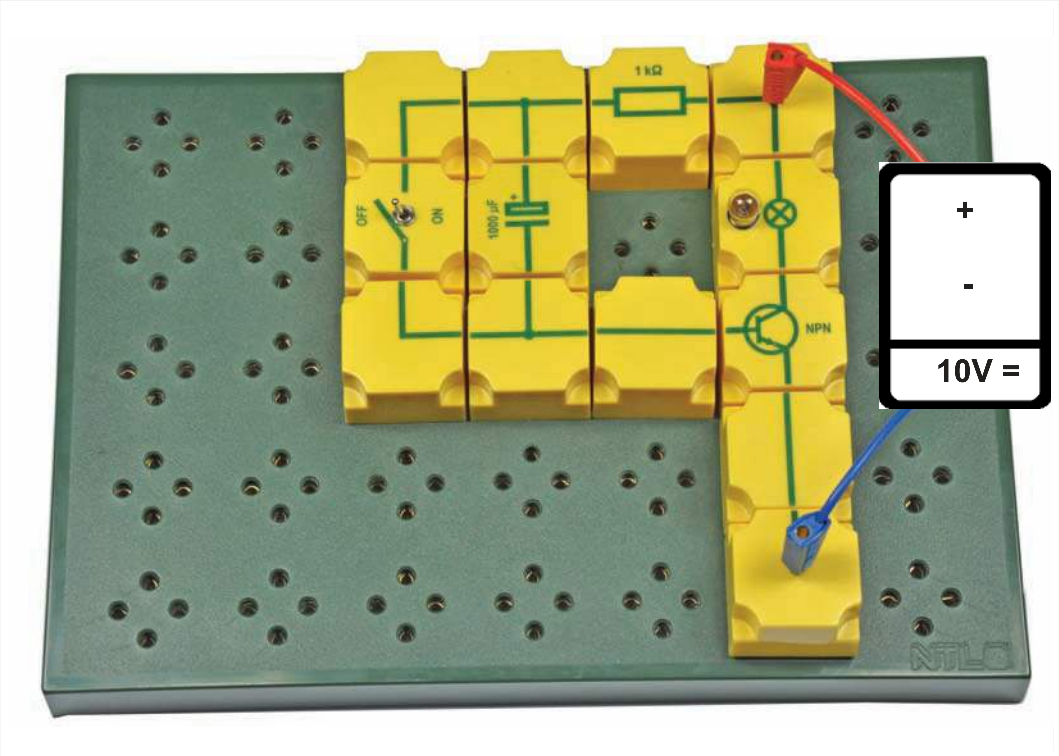
Period of glowing at 100 µF: .... seconds

Conclusion:
If a condenser is used for the production of base current a simple wiring for the estimation of capacitances is achieved.

TIME SWITCH

EOS 4.3.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
1x PIB connector
2x PIB wire, straight
2x PIB wire, T-shaped
1x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB switch ON/OFF
1x PIB resistor 1 kOhm
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB capacitor 10 µF
1x PIB capacitor 1000 µF
1x PIB transistor NPN, Base left

Additionally required:
1x Voltage supply

TIME SWITCH

EOS 4.3.1

A time switch is to be prodced by means of a condenser and a transistor.

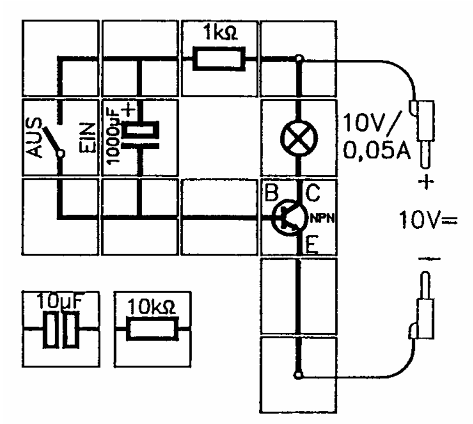
Wiring:

Arrange the wiring according to the illustration.

First the switch is open.

Check the polarity of the condenser.

First the resistor 1 kΩ and the condenser 1000 µF are used.



Experiment:

The switch is closed and the lamp glows.
After some seconds the switch is reopened and the time is measured.

Determine how much time passes till the lamp goes out.

The resistor 1 kΩ is replaced by the resistor 10 kΩ and the experiment is repeated.
Then the condenser 1000 µF is replaced by the resistor 10 kΩ and the time for both resistors is measured.

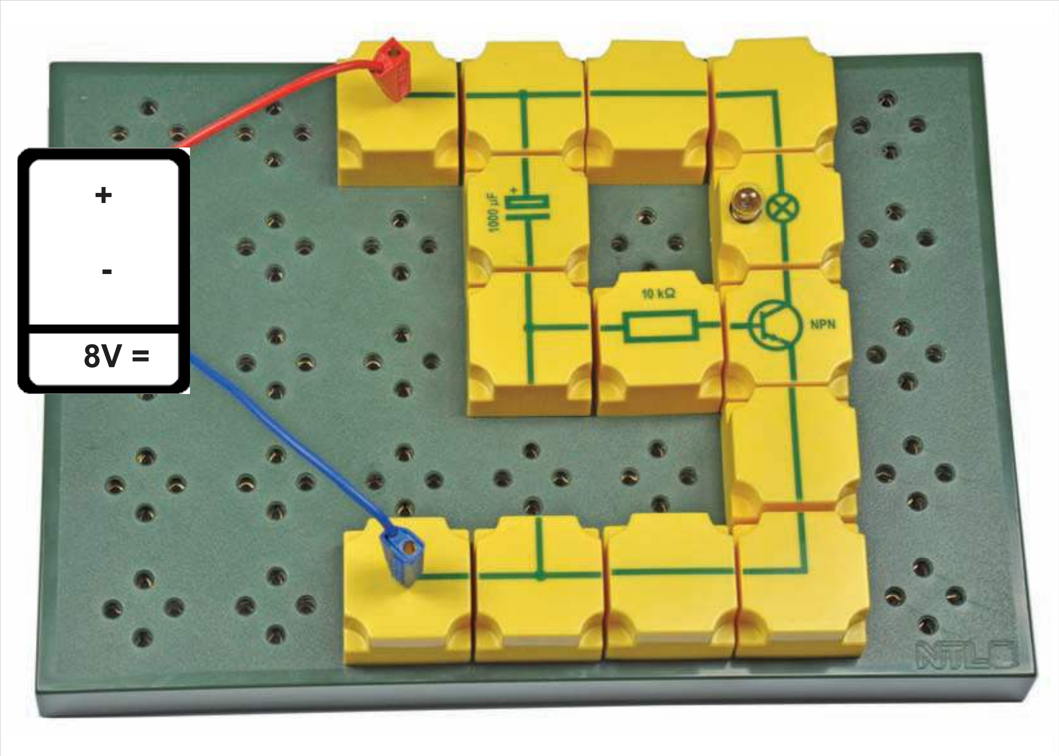
The results are listed in the chart.

C	= 1000 µF and R =	1 kΩ:	Time t	=	.... seconds
C	= 1000 µF and R =	10 kΩ:	Time t	=	.... seconds
C	= 100 µF and R =	1 kΩ:	Time t	=	.... seconds
C	= 100 µF and R =	10 kΩ:	Time t	=	.... seconds

Conclusion:
The time switch makes it possible for the lamp to glow for a certain period of time when the switch is closed and reopened.
The period of time if defined by the product of R x C.
The lamp can only glow if base current flows.

A CAPACITOR BLOCKS DC

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB capacitor 1000 µF
1x PIB transistor NPN, Base left

Additionally required:
1x Voltage supply

A CAPACITOR BLOCKS DC

EOS 4.4

Condensers can also be used to prevent a flow of D.C. through a part of a wiring.
After being fully charged the condenser blocks the D.C.

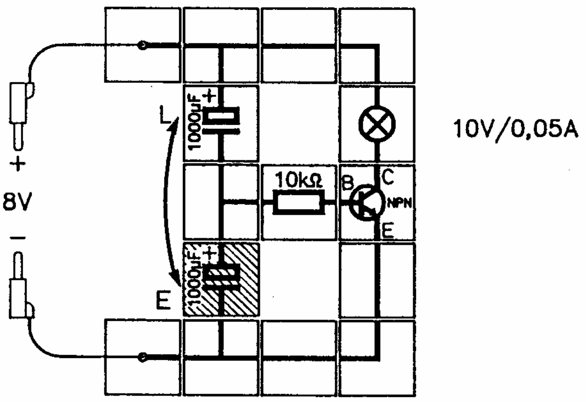
Wiring:

Arrange the wiring according to the illustration.

The condenser (1000 µF or 100 µF) is inserted in L in correct polarity.

Thus the charging current switches the transistor through as base current.

The lamp glows.



Experiment:

After charging the condenser the D.C. is blocked.
There is no flow of base current and the light of the lamp goes out.

Now the charged condenser is removed to E where it provides base current via the transistor till it is discharged.

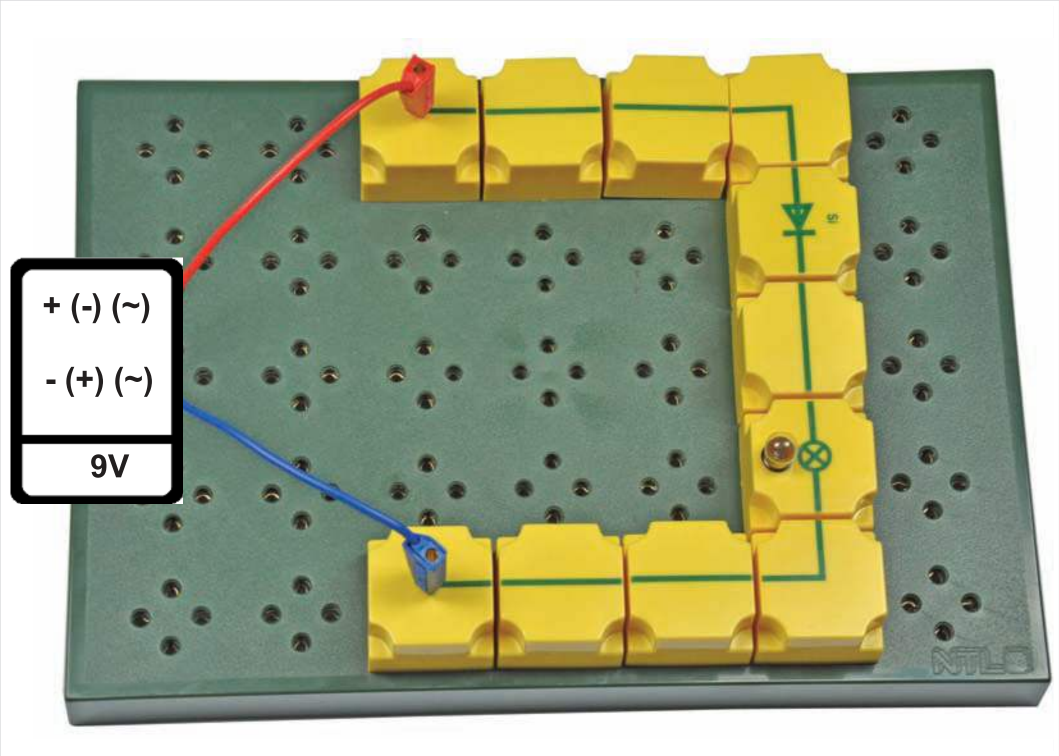
The lamp glows.

Conclusion: A condenser blocks D.C. after its charging.

HALF-WAVE RECTIFICATION

EOS 4.5

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
5x PIB wire, straight
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB Si diode

Additionally required:
1x Voltage supply

HALF-WAVE RECTIFICATION

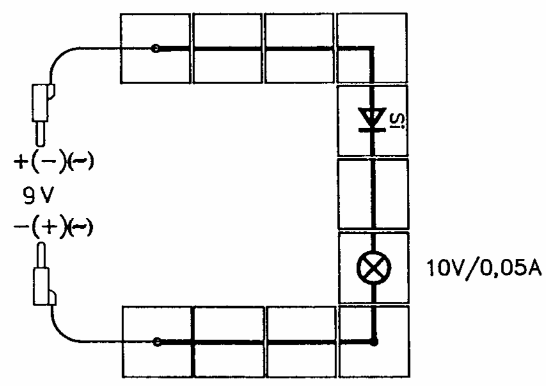
EOS 4.5

If only A.C. is available, but D.C. is required, the required D.C. can be provided by means of a diode.
Only each half period of the 50 cycles per second of A.C. leads to a flow of electric current.
This results in 50 half periods per second with a flow of electric current in the same direction.

Wiring:

Arrange the wiring according to the illustration.

The first experiment illustrates this process by changing poles of D.C. instead of using A.C.



1. Experiment:

The poles of the applied voltage are changed several times by exchanging the connections at the voltage source.

The glowing of the lamp can be seen whenever the diode is in conducting direction.

2. Experiment:

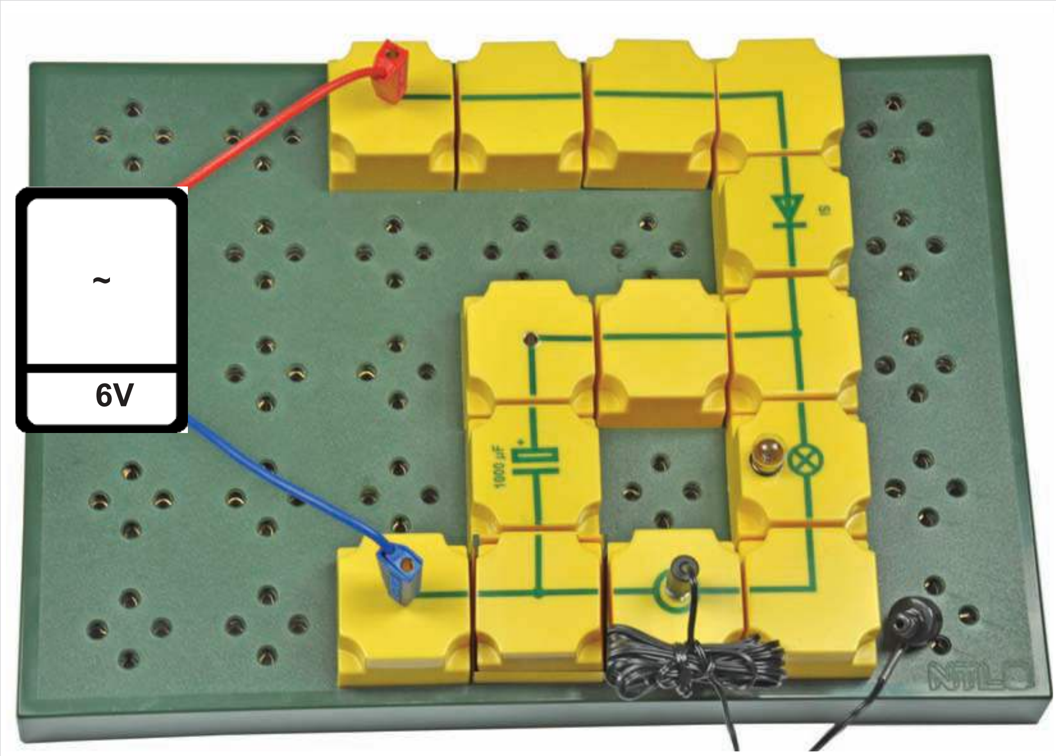
Now an A.C. source of 9 Volt is applied. The lamp glows constantly.

Conclusion:
Half-wave rectification by means of a diode leads to 50 surges per second at an A.C. of 50 Hz.
Each surge lasts one hundredth of a second and is followed by an interval of the same length.
These surges cannot be seen because of the inertia of our eyes.

SMOOTHING RECTIFIED VOLTAGE

EOS 4.6

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



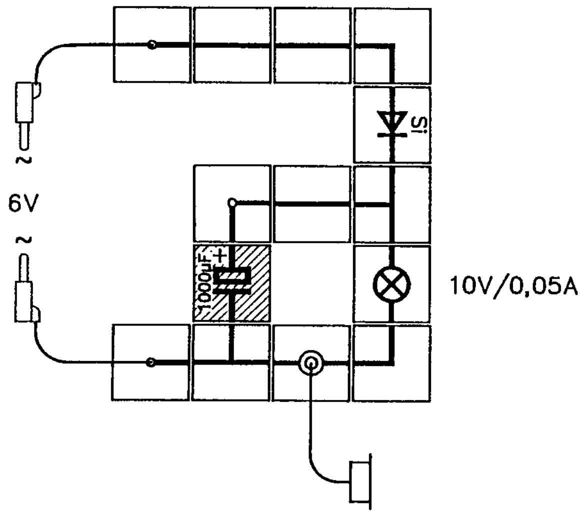
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
2x PIB wire, T-shaped
1x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x Earphone
1x PIB capacitor 1000 µF
1x PIB wire with jack bush
1x PIB Si diode

Additionally required:
1x Voltage supply

SMOOTHING RECTIFIED VOLTAGE

EOS 4.6

Rectification by means of a diode results in an A.C. with 50 half periods of rectified electric current.
This A.C. can be converted into D.C. by means of a filter condenser.



Wiring:

Arrange the wiring according to the illustration.

The condenser is not yet inserted.

Experiment:

After applying A.C. the deep buzzing sound of the 50 half periods of the rectified electric current can be heard in the earphone.

The lamp glows weakly.

Now the condenser 1000 µF is inserted (check correct polarity!).

Result:
The buzzing noise has disappeared, because now there is a flow of a temporally constant D.C.

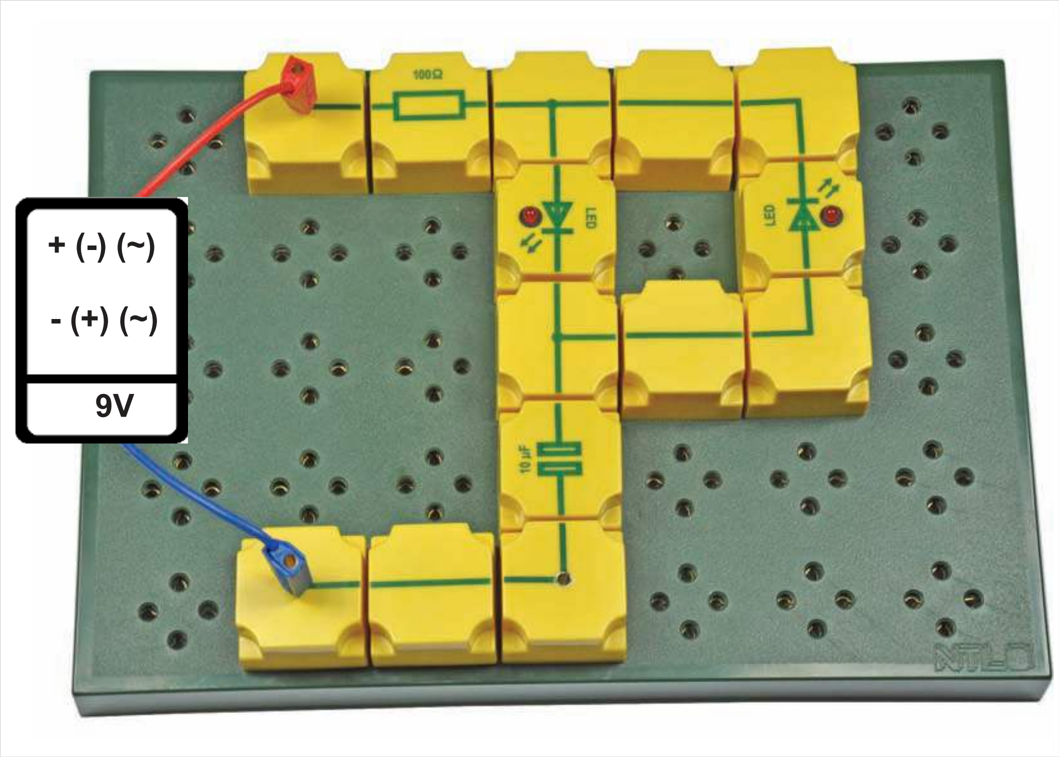
Conclusion:
An (almost) temporally constant D.C. can be generated from A.C. by means of a diode and a filter condenser.

Note: The lamp glows stronger, because the condenser is charged to the peak value of the half periods.

CAPACITORS AS AC RESISTORS

EOS 4.7

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
2x PIB wire, T-shaped
1x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 100 Ohm
1x PIB capacitor 10 µF
2x PIB LED red

Additionally required:
1x Voltage supply

CAPACITORS AS AC RESISTORS

EOS 4.7

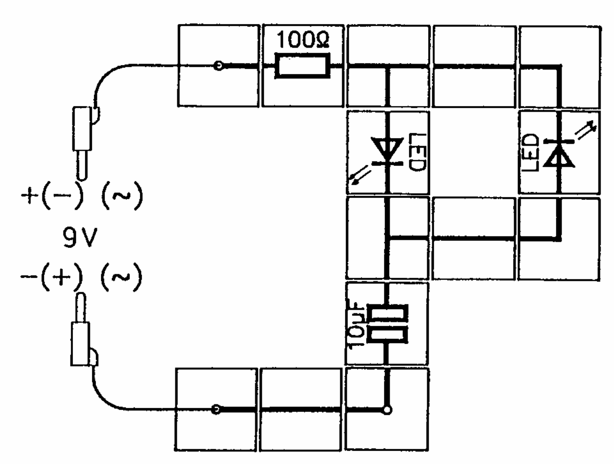
A condenser blocks D.C. How does it behave with A.C.?

Wiring:

Arrange the wiring according to the illustration.

First D.C. is applied and the poles are changed several times by exchanging the connections at the voltage source.

It is to be seen why a permanent flow of electric current is caused with A.C.



1.Experiment:

D.C. is applied and the poles are changed several times by exchanging the connections at the voltage source.
The LEDs indicate in which direction the electric current flows.

Upper positive pole: .... LED glows for a short time.

Lower positive pole: .... LED glows for a short time.

2.Experiment:

A.C. is applied.

Result:
Both LEDs seem to glow all the time.
In reality each LED glows only 50 times per second.
This cannot be distinguished because of the inertia of our eyes.

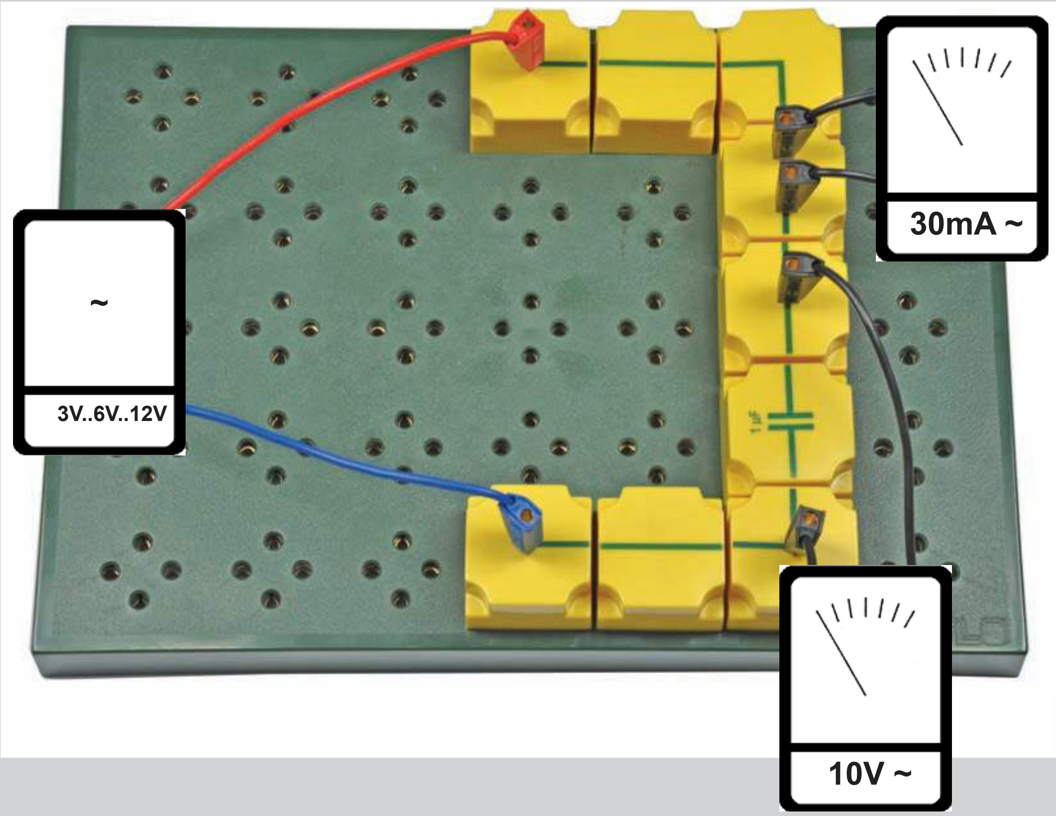
The glowing of the LEDs indicates that there is a flow of A.C.

Conclusion: A condenser behaves similar to a resistor at A.C. voltage.

CAPACITIVE RESISTANCE AT 50 Hz AC

EOS 4.7.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
2x PIB wire, straight
1x PIB wire, straight, with socket
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB capacitor 1 µF

Additionally required:
2x Meter
1x Voltage supply

CAPACITIVE RESISTANCE AT 50 Hz AC

EOS 4.7.1

A steady alternating current flows through a condenser with A.C.
The condenser reacts lide a resistor.

The next experiment will find out which amount of resistance a condenser has if an A.C. source of 50 Hz is applied to it.

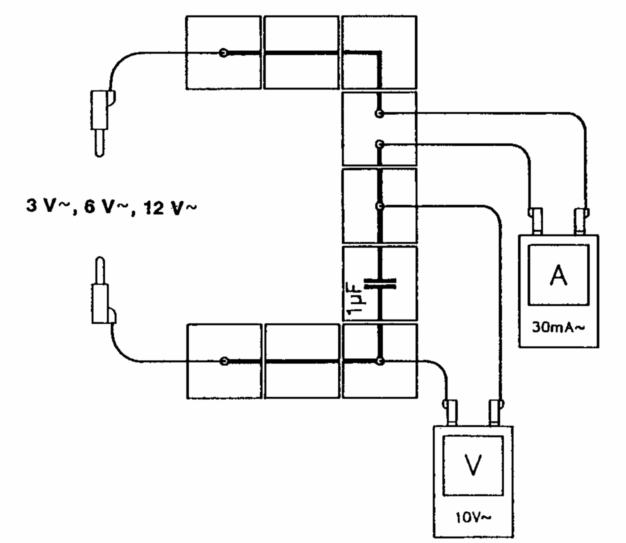
Wiring:

Arrange the wiring according to the illustration.

The voltmeter measures the voltage at the condenser and is used in the 10 V ~ range.

The ammeter is used in the 30 mA ~ range.

If the applied voltage is 12 V, the voltmeter is used in the 30 V ~ range.



Experiment:

The current flowing through the condenser is measured for three different A.C. voltages between 3 Volt and 12 Volt and then its amount of resistance is defined.

Voltage U (in V)	3	6	12
Current intensity (in mA)	……..	……..	……..
Current intensity (in A)	……..	……..	……..
Amount of resistance R (in Ω)	……..	……..	……..

The condenser 1 µF is replaced by the condenser 2 µF and the experiment is repeated.

Voltage U (in V)	3	6	12
Current intensity (in mA)	……..	……..	……..
Current intensity (in A)	……..	……..	……..
Amount of resistance R (in Ω)	……..	……..	……..

CAPACITIVE RESISTANCE AT 50 Hz AC

EOS 4.7.1

Conclusion:
The condenser behaves like a resistor at A.C. voltage. There is a permanent flow of A.C. which is proportional to the applied voltage and to the capacitance of the condenser at a certain frequency of the A.C. (e.g. 50 Hz). The resistance of the condenser is indirectly proportional to the capacitance.

The following formula holds true for 50 Hz:

$$C = \frac{3200}{R} = \frac{3200*I}{U} \qquad C \text{ in } \mu F$$

1. Advice: The voltage provided by the unit may deviate from the nominal voltage (no-load voltage) with power units with a fixed voltage.

2. Advice: For explaining the factor 3200 in the formula:

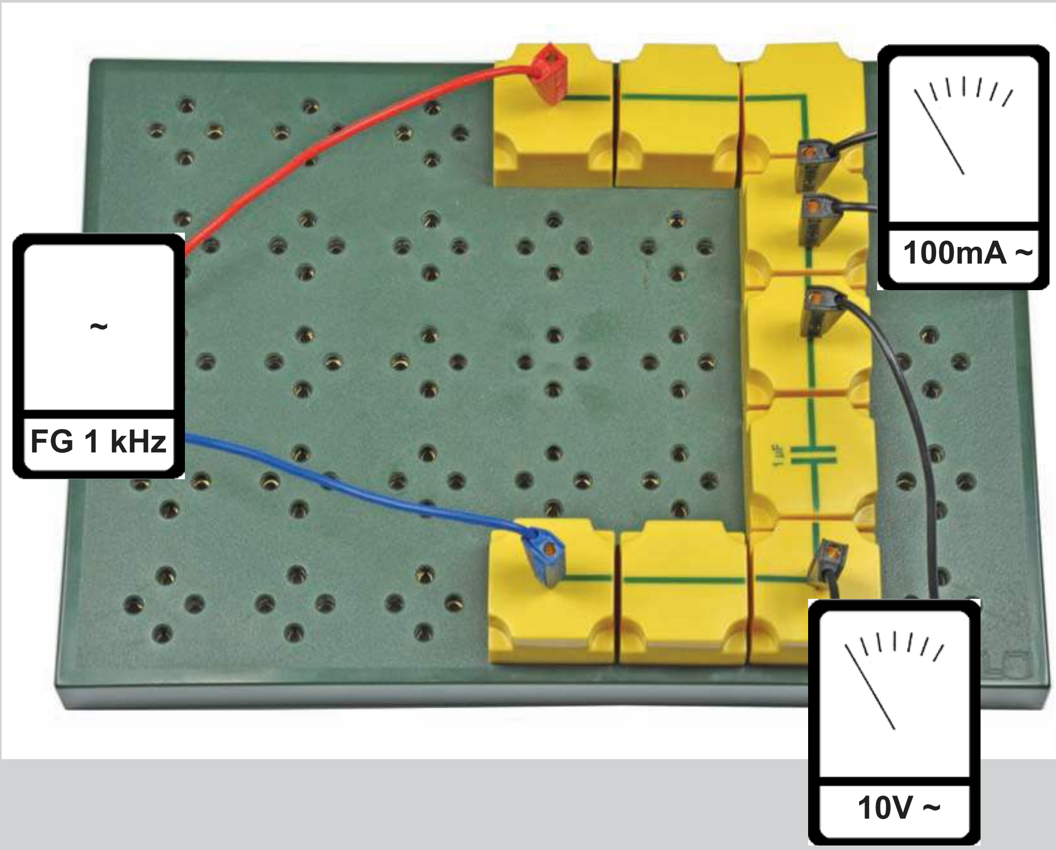
$$R_C = \frac{1}{\omega C} = \frac{1}{2\pi f*C}$$

For 50 Hz and C in μF holds: $R_C = \frac{1}{100*\pi*10^{-6}*C} = 3*2*10^3* \quad \frac{1}{C}$

CAPACITIVE RESISTANCE

EOS 4.7.2

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



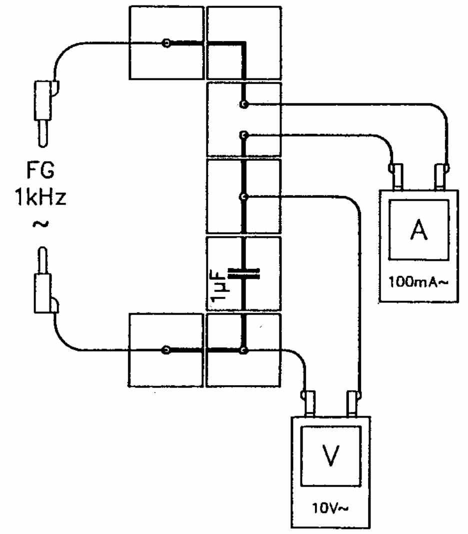
Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
1x PIB wire, straight, with socket
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB capacitor 1 µF
1x PIB capacitor 2 µF

Additionally required:
2x Meter
1x Function generator
1x Voltage supply

CAPACITIVE RESISTANCE

EOS 4.7.2

To investigate the way in which way the capactive resistance depends on the frequency of the applied sinusoidal A.C. and the capacitance of the condenser.



Wiring:
Arrange the wiring according to the illustration.
The voltmeter measures the voltage at the condenser and is used in the 10 V ~ range.

The ammeter is used in the 100 mA ~ range.
The frequency 1000 Hz Sine wave is adjusted on the signal generator.

Use an amplitude that the ammeter indicates a current intensity of 10 mA.

This amplitude should not be changed during the experiment.

1.Experiment:

The current at a frequency of 1000 Hz (1 kHz) is measured. Now the frequency is increased to 2000 Hz and the current is measured.
Then the frequency is increased to 4000 Hz and again the current intensity is measured.

Capacitance 1 µF

Voltage at the condenser : U = ... V

Frequency (in kHz)	1	2	4
Current intensity (in mA)	10	....	......

2.Experiment:

The amplitude is not changed. The condenser 1 µF is replaced by the condenser 2 µF. As in the first experiment the frequency is first ajusted to 1 kHz, then to 2 kHz and 4 kHz. The corresponding current intensities are listed in the chart and the results are compared with the results of the first experiment.

Capacitance 2 µF

Voltage at the condenser : U = ... V

Frequency (in kHz)	1	2	4
Current intensity (in mA)	....	....	....

CAPACITIVE RESISTANCE

Conclusion:
The current intensity is directly proportional to the frequency of the applied A.C. and to the capacitance of the condenser.
Thus the A.C. resistance is indirectly proportional to the frequency and to the capacitance.
The following formula holds true:

$$C = \frac{160\,000 * I}{f * U} \qquad \text{and for } R = \frac{160\,000}{f * C}$$

Capacitance C in µF
Resistance R in Ω
Current intensity in A
Voltage U in V

The amount of resistance can be obtained from ω and C according to the formula

$$R_C = \frac{1}{\omega * C}$$

by means of the calculation $\omega = 2 * \pi * f$

Note: For explaining the factor 160 000 in the formula:

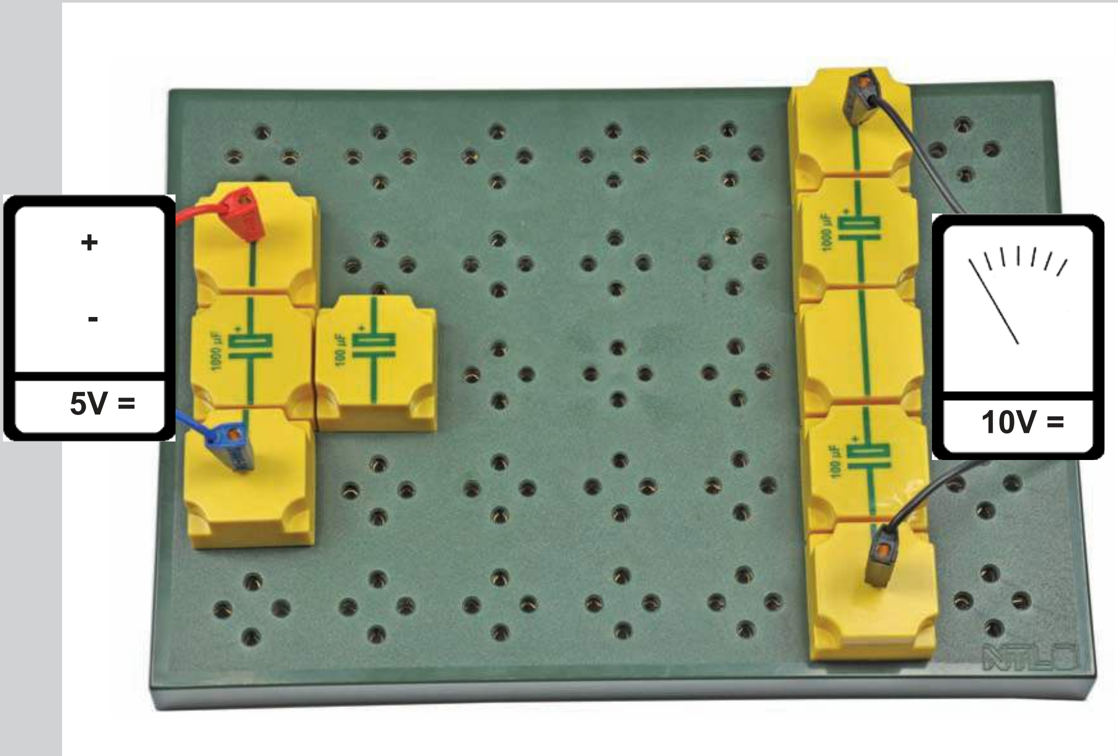
$$R_C = \frac{1}{\omega C} = \frac{1}{2\pi f * C}$$

For C in µF holds: $R_C = \frac{1}{2\pi f * 10^{-6} * C} = 0{,}16 * 10^{6} * \frac{1}{C}$

CHARGED CONDENSERS CONNECTED IN SERIES

EOS 4.8

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
4x PIB connector
1x PIB wire, straigh
1x PIB capacitor 100 µF
1x PIB capacitor 1000 µF

Additionally required:
1x Meter
1x Voltage supply

CHARGED CONDENSERS CONNECTED IN SERIES

EOS 4.8

If voltage sources are connected in series the total voltage equals the sum of the component voltages. Does this also hold true for charged condensers?

Wiring:

Arrange the wiring according to the illustrations 1 and 2.

The D.C. is adjusted to 5 Volt and connected to A and B.

The two condensers (100 µF and 1000 µF) are charged one after the other according to illustration 1.

Arrange the serial connection according to illustration 2.

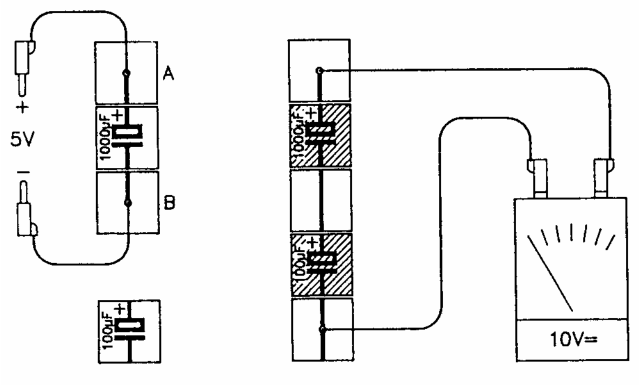


Abb. 1 Abb. 2

Experiment:

First the voltmeter is connected to A and B, in order to adjust a voltage of 5 Volt. Then the volmeter is connected to the serial connection according to illustration 2. This makes a later metering of the total voltage possible.

Immediately after charging between A and B the condensers are inserted in the positions marked by hatching according to illustration 2 and thus are connected in series.
The reading from the voltmeter is to be carried out quickly since the condensers discharge slowly via the measuring device

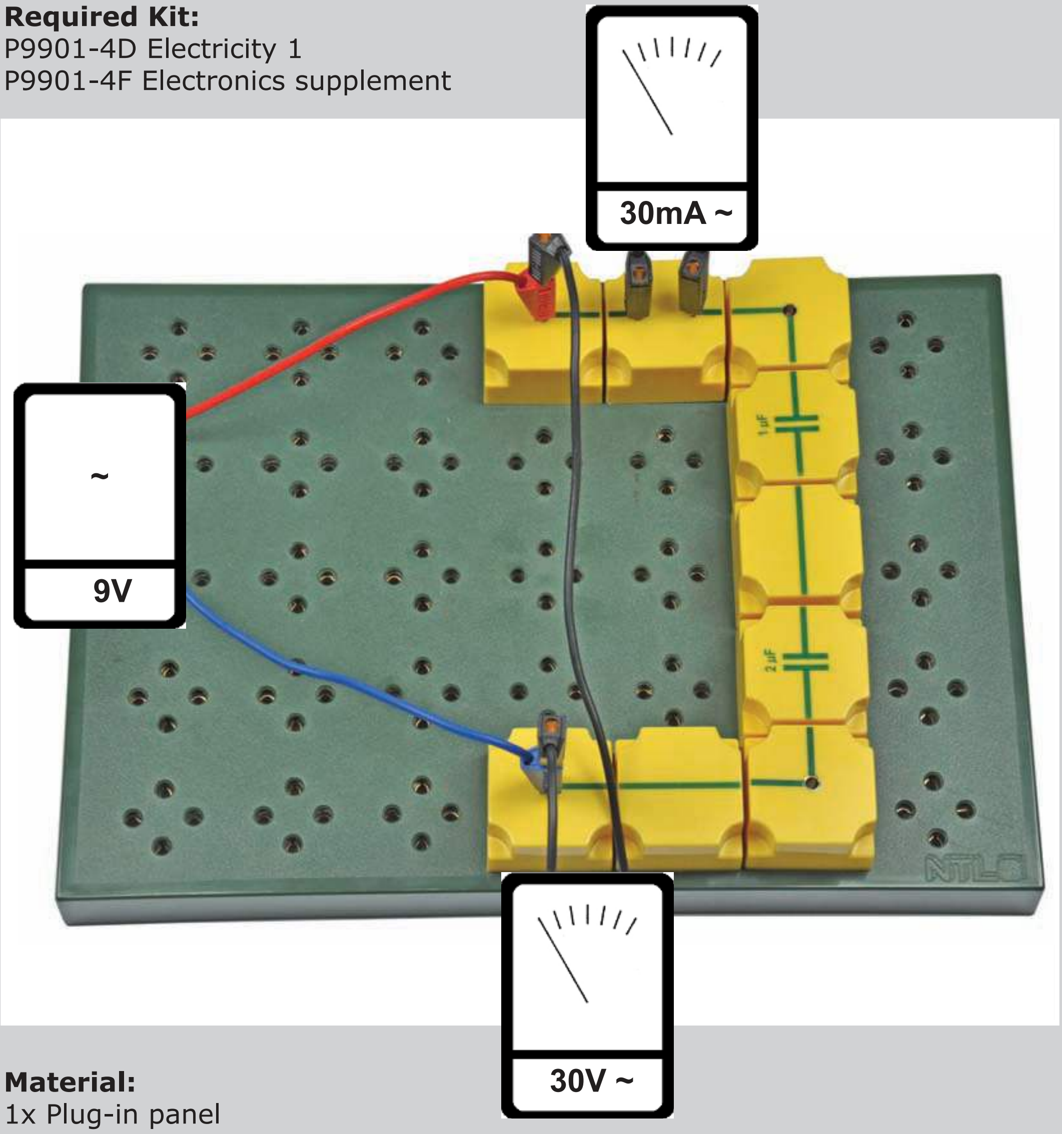
Result: Total voltage: .... Volt

Conclusion:
The total voltage of condensers connected in series equals the sum of the component voltages at both condensers.

CAPACITORS CONNECTED IN SERIES (DETERMINING CAPACITANCE)

EOS 4.9

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



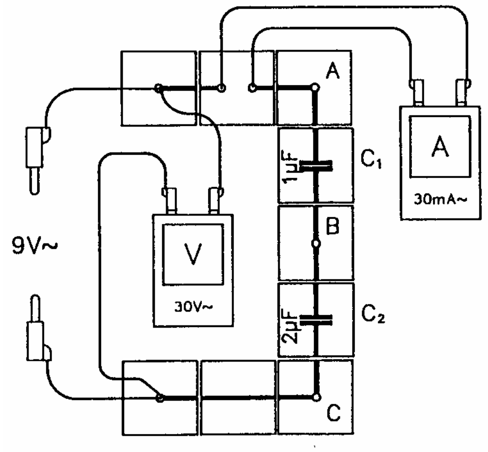
Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
1x PIB wire, straight
1x PIB wire, straight, with socket
2x PIB wire, angled, with socket
1x PIB wire, interrupted, with sockets
1x PIB capacitor 1 µF
1x PIB capacitor 2 µF

Additionally required:
2x Meter
1x Voltage supply

CAPACITORS CONNECTED IN SERIES (DETERMINING CAPACITANCE)

EOS 4.9

The complete capacitance of two condensers connected in series is to be determined.



Wiring:
Arrange the wiring according to the illustration.
The condensers are of a capacitance C_1 = 1 µF and of a capacitance C_2 = 2 µF.
The voltmeter measures the applied voltage and is used in the 30 V ~ range.
The ammeter is used in the 30 mA ~ range. An A.C. of 9 volt is applied and the applied voltage is checked by means of the voltmeter.

1.Experiment:

The current is measured and the total capacitance of the two condensers is calculated by means of the given formula for 50 Hz A.C.

Voltage U = ... V
Current intensity I = ... mA = ... A

Capacitance $C = \frac{3200 * I}{U}$ = ... µF

Check whether the following formula holds true.

$$C = \frac{C_1 * C_2}{C_1 + C_2}$$

2.Experiment

To investigate how the total voltage is distributed to the two condensers.
The measuring device which was used as an ammeter in the first experiment is now used as a voltmeter in the 10 V ~ range.
The two component voltages at the condensers are measured by means of the second voltmeter.
Voltage at both condensers measured between A and C: V
Voltage at condenser 1 µF measured between A and C : V
Voltage at condenser 2 µF measured between B and C : V

Conclusions:

1. The total capacitance of a series connection of condensers is smaller than the smaller component capacitance.

It holds true:

$$C = \frac{C_1 * C_2}{C_1 + C_2}$$

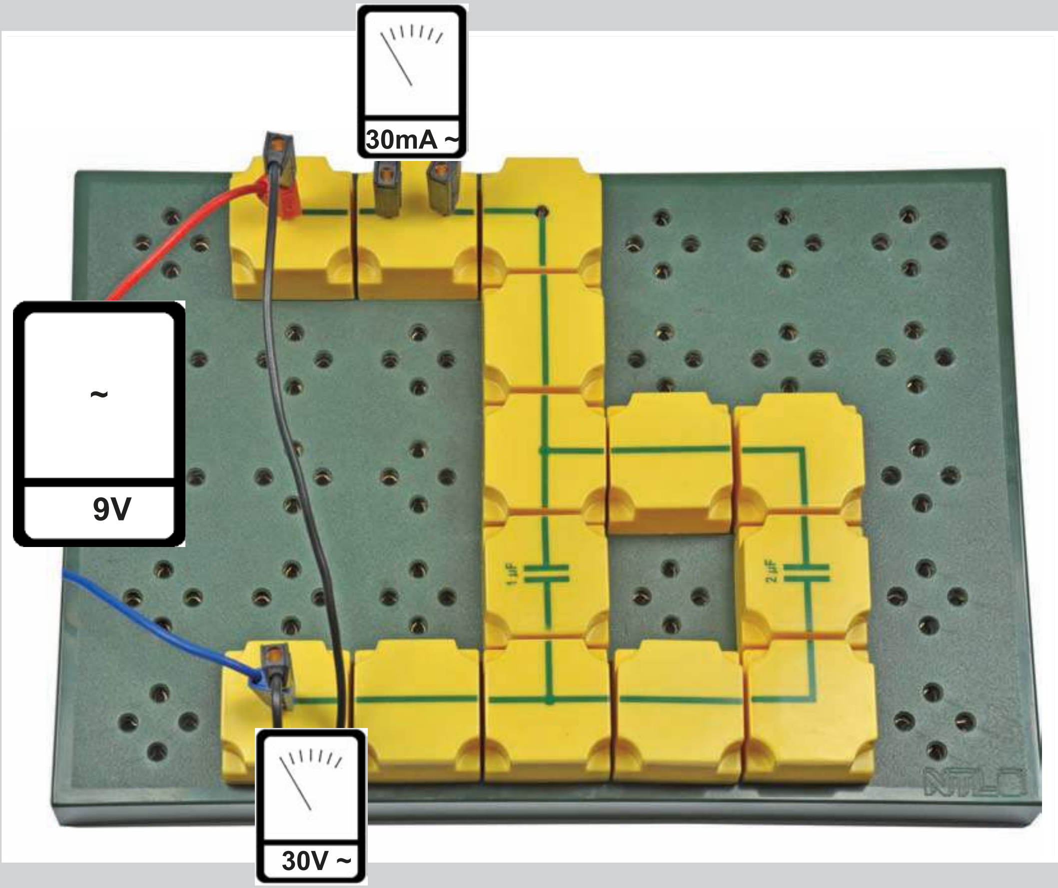
2. At each condenser in a series connection lies a component voltage. The component voltages behave in reverse proportion to the capacitances. It holds true:

$$U_1 : U_2 = \frac{1}{C_1} : \frac{1}{C_2} \qquad \text{or } U_1 : U_2 = C_2 : C_1$$

CAPACITORS CONNECTED IN PARALLEL

EOS 4.10

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



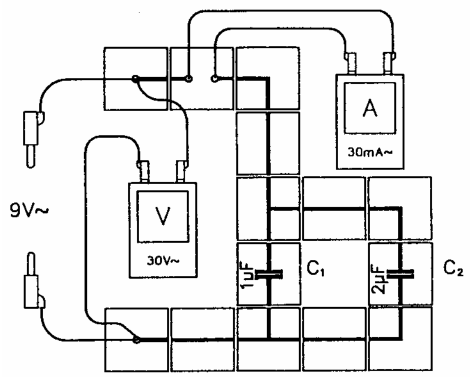
Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
4x PIB wire, straight
2x PIB wire, T-shaped
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB capacitor 1 µF
1x PIB capacitor 2 µF

Additionally required:
2x Meter
1x Voltage supply

CAPACITORS CONNECTED IN PARALLEL

EOS 4.10

The total capacitance of two condensers in parallel connection is to be defined.



Wiring:
Arrange the wiring according to the illustration.

The condensers are of the capacitance C_1 = 1 µF and of a capacitance C_2 = 2 µF.

The voltmeter measures the applied voltage and is used in the 30 V ~ range.

The ammeter is used in the 30 mA ~ range.

The two condensers are not yet inserted. An A.C. source of 9 Volt is applied and the applied voltage is checked by means of the voltmeter.

1.Experiment:

The condenser with C_1 = 1 µF is inserted and the current intensity is measured.

Voltage U = ...
Current intensity I = ... mA = ... A

Make sure that the two measured results coincide by means of the formula for an A.C. of 50 Hz:

Capacitance $C = \frac{3200 * I}{U}$ C in µF, I in Ampere, U in Volt

2.Experiment:

The prallel connection is arranged according to the illustration.

Voltage U = ...
Current intensity I = ... mA = ... A

The total capacitance for the parallel connection can be determined means of the formula for the capacitance.

Capacitance $C = \frac{3200 * I}{U}$ = ... µF

Conclusion:
The total capacitance equals the sum of the two component capacitances with parallel connection of condensers.

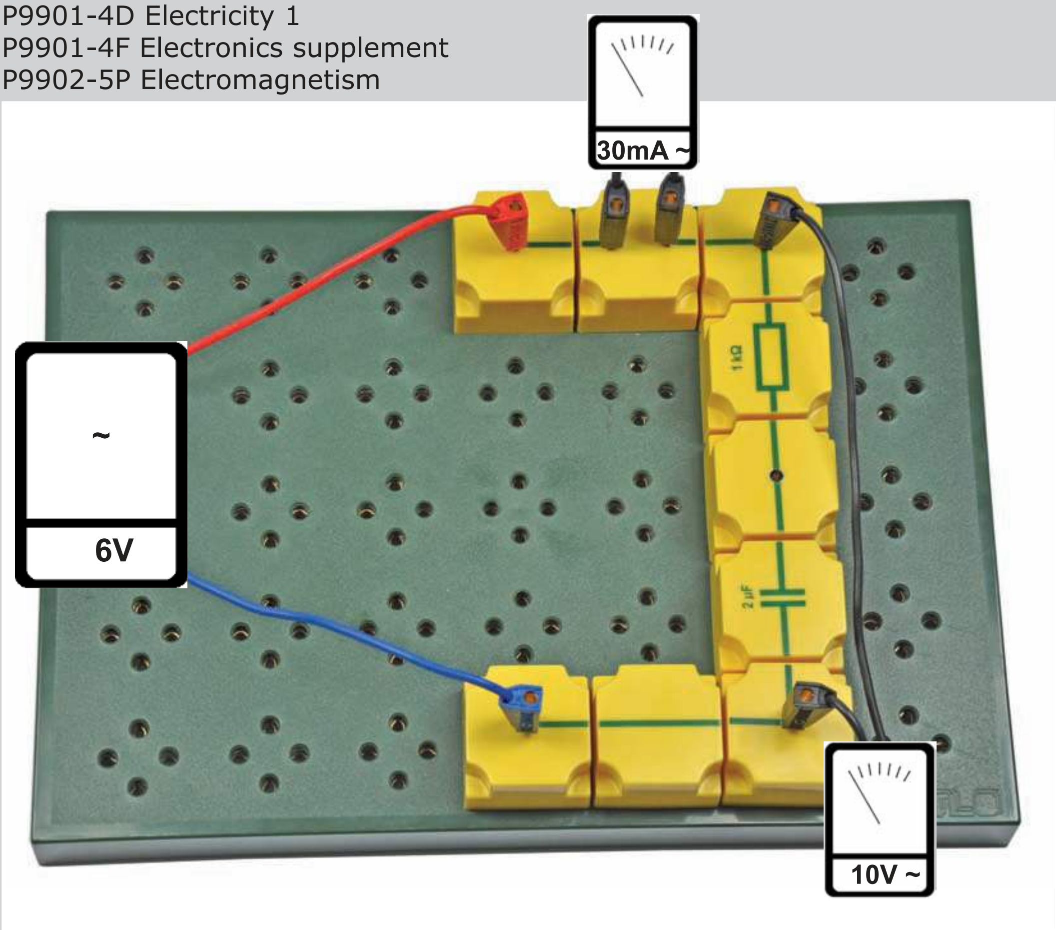
Following holds true: C = C1 + C2

Note: The voltage provided by the unit may deviate from the nominal voltage (no-load voltage!) with power units with a fixed voltage.

AC RESISTORS CONNECTED IN SERIES

EOS 4.11

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
1x PIB wire, straight
1x PIB wire, straight, with socket
2x PIB wire, angled, with socket
1x PIB wire, interrupted, with sockets
1x PIB resistor 1 kOhm
1x PIB capacitor 2 µF
1x PIB for coil with 800 turns
1x Coil with 800 turns, blue
1x Iron core, U- and I-shaped core with clamp strap

Additionally required:
2x Meter
1x Voltage supply

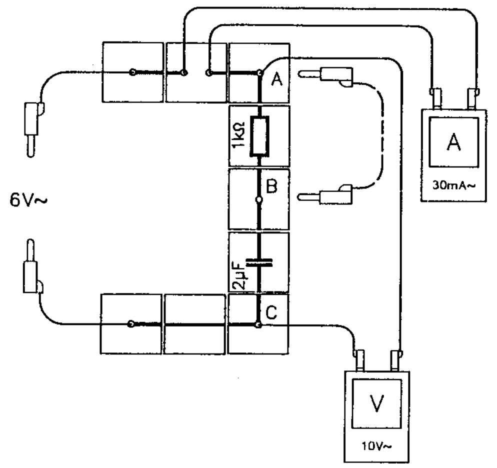
AC RESISTORS CONNECTED IN SERIES

EOS 4.11

The following holds true for the series connection of Ohmic resistors: the total resistance equals the sum of the component resistances, the total voltage equals the sum of the component voltages.
In this experiment the more complicated rules for A.C. resistors are to be introduced.

Wiring:

Arrange the wiring according to the illustration.



The voltmetermeasures the voltage at the A.C. resistors and is used in the 10 V ~ range.

The ammeter is used in the 30 mA ~ range.

An A.C. source of 6 Volt is applied.

Pre-Experiment:

First the A.C. resistance of the condenser 2 µF at 50 Hz is defined by experiment.
To do so the Ohmic resistor 1 kΩ (insert conncting lead in A and B) is bridged and the voltage at the condenser as well as the current intensity are measured.

The ratio is formed for calculating the Ohmic resistance.

Voltage U = ... V

Current intensity I = ... mA = ... A

Amount of resistance $R_C = \frac{U}{I}$ = ... Ω

1.Experiment:

The bridge at the Ohmic resistor is removed. The component voltages at the Ohmic resistor and at the condenser are measured by means of the voltmeter.

Applied A.C. voltage: V
Component voltage at Ohmic resistor (voltmeter at A and B): U_R = ... V
Component voltage at condenser (voltmeter at B and C): U_C = ... V

The sum of the component voltages is larger than the total voltage.

The result is compared with the formula:

$$U_{tot} = \sqrt{U_R^2 + U_C^2}$$

AC RESISTORS CONNECTED IN SERIES

EOS 4.11

2.Experiment:

The current intensity is measured.

Current intensity I = ... mA = ... A
Total voltage U = ... V

The total resistance of the series connection is calculated by means of the current intensity.

$$R_{tot} = \frac{U}{I} = \ldots\ldots\ldots\ \Omega$$

It can be seen that the total resistance cannot be calculated as the sum of the component resistances. Compare the result with the formula

$$R_{tot} = \sqrt{R_R^2 + R_C^2}$$

3. Experiment:

The condenser is replaced by the PI-coil with 800 turns with closed iron core (U-shaped core with yoke held by camp strap) and the experiments are repeated.

The results are similar to the experiments with the condenser, but the deviations from the formula are considerable.
The reason for the deviation is the Ohmic resistor of the coil which is not taken into account.

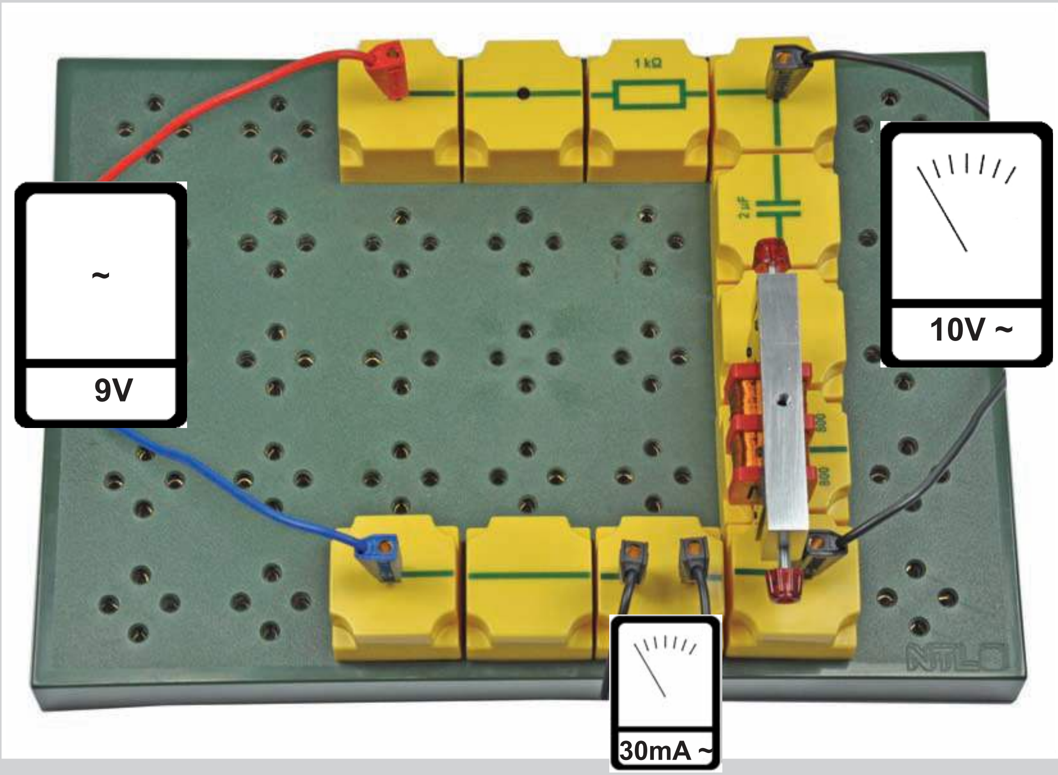
Conclusion:
The total resistance cannot be calculated as the sum of the component resistances with a series connection of A.C. resistors like condenser or coil.
The sum of the component resistances does not equal the total resistance either.

Note: The voltage provided by the unit may deviate from the nominal voltage (no-load voltage!) with power units with a fixed voltage.

OHMIC RESISTORS, COIL AND CAPACITOR IN AN AC CIRCUIT

EOS 4.12

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism



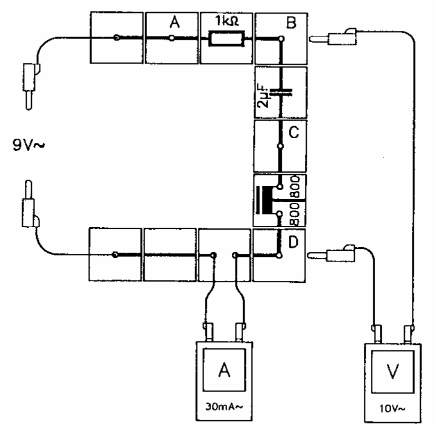
Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
1x PIB wire, straight
2x PIB wire, straight, with socket
2x PIB wire, angled, with socket
1x PIB wire, interrupted, with sockets
1x PIB resistor 1 kOhm
1x PIB capacitor 2 µF
1x PIB for coil with 2x 800 turns
1x Coil with 2x 800 turns, red
1x Iron core, U- and I-shaped core with clamp strap

Additionally required:
2x Meter
1x Voltage supply

OHMIC RESISTORS, COIL AND CAPACITOR IN AN AC CIRCUIT

EOS 4.12

The total resistance of a series connection of an Ohmic resistor, a condenser and a coil is to be determined.



Wiring:
Arrange the wiring according tot he illustration.

The PI-coil with 2 x 800 turns is provided with the closed iron core (U-shaped core with yoke held by clamp strap).

The voltmeter is used in the 10 V ~ range and measures the individual component voltages as well as the total voltage.
The ammeter is used in the 30 mA ~ range. An A.C. source of 9 Volt is applied.

1.Experiment:

The component voltages and the total voltage are metered.
Component voltage at Ohmic resistor (voltmeter at A and B) : U_R = ... V
Component voltage at condenser (voltmeter at B and C) : U_C = ... V
Component voltage at the coil (voltmeter at C and D): U_L = ... V
Total voltage (voltmeter at A and D): U_{tot} = ... V

The sum of the component voltages is calculated and compared with the total voltage.
The sum of the component voltage is larger!

2.Experiment:

The resistances are determined. For that purpose the current intensity in the series connection must be measured. The ratios U/I are the amounts of resistance.
Current intensity I = ... mA = ... A
Ohmic resistance $R = U_R/L$ = ... Ω
Resistance of the condenser $R_C = U_C/I$ = ... Ω
Resistance of the coil $R_L = U_L/I$ = ... Ω
Total resistance $R_{tot} = U_{tot}/I$ = ... Ω

The sum of the resistances does not equal the total resistance either.

Conclusion:
The total resistance of A.C. resistors connected in series cannot be calculated as the sum of the component resistances. The phase displacement occuring at A.C. requires a much more complicated calculation of the total resistance.

The total resistance can be calculated by means of complex numbers (the Ohmic resistance of the coil is not taken into account in this case).

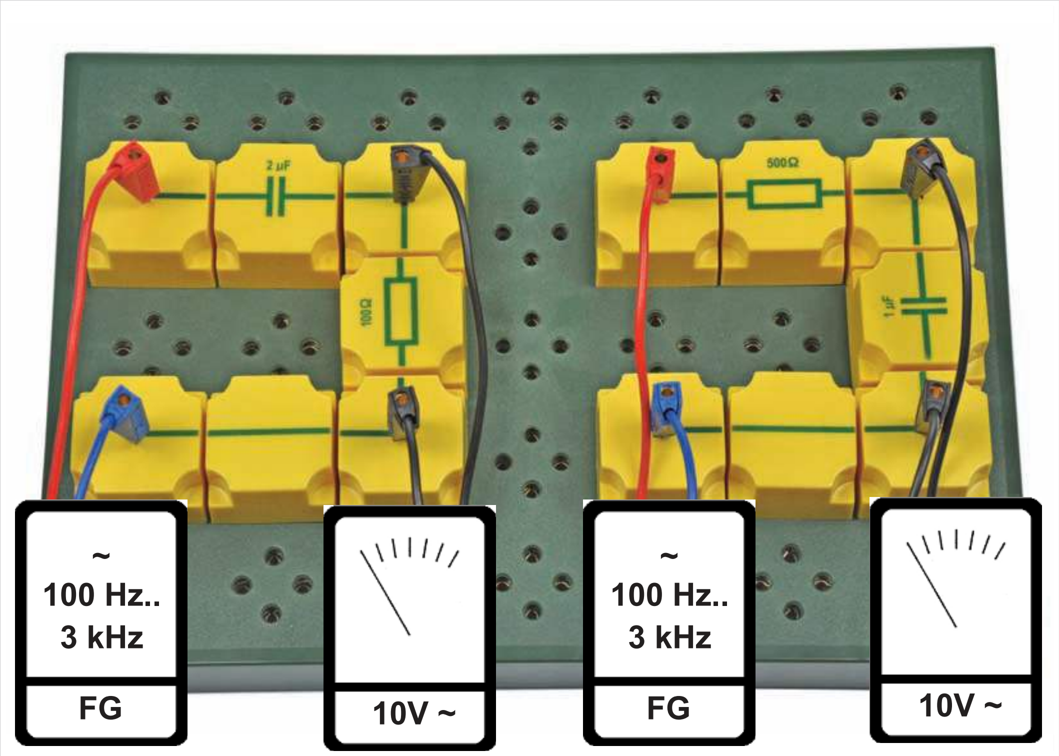
$$Z_{tot} = R + i\omega L + \frac{i}{\omega C}$$

The amount Z of the resistance then is

$$Z = \sqrt{R^2 + \left(\omega L + \frac{i}{\omega C}\right)^2}$$

Note: The voltage provided by the unit may deviate from the nominal voltage (no-load voltage!) with power units with a fixed voltage.

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
1x PIB wire, straight
2x PIB wire, angled, with socket
1x PIB resistor 100 Ohm
1x PIB resistor 500 Ohm
1x PIB capacitor 1 µF
1x PIB capacitor 2 µF

Additionally required:
1x Meter
1x Function generator
1x Voltage supply

FILTER

EOS 4.13

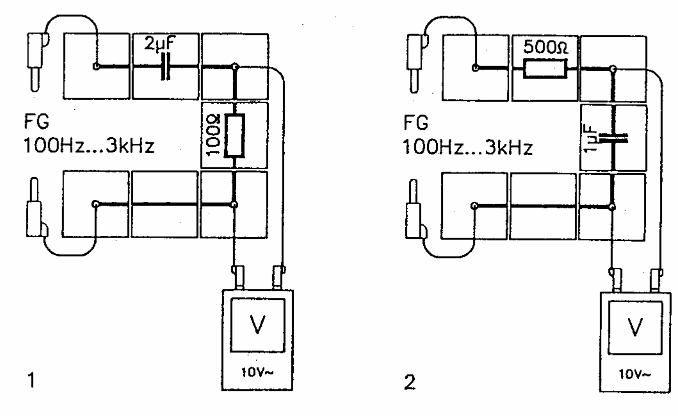
In electronics it is the task of the filters to emphasize certain ranges of frequency or to suppress them. A high pass and a low pass are to be investigated.

Wiring:

Arrange the wiring according to illustration 1.

The voltmeter measures the voltage at the Ohmic resistor and is used in the 10 V ~ range.

The signal generator is to provide a sinusoidal A.C. The frequency is first adjusted to 3000 Hz.



The output voltage of the signal generator is adjusted in such a way that there is a voltage of 4 Volt at the Ohmic resistor.

1.Experiment:

The frequency of the signal generator is changed from 3000 Hz to 100 Hz and the voltmeter is observed.

The condenser has a high resistance with low frequencies, there is a low voltage at the Ohmic resistor. The voltage at the Ohmic resistor is higher with high frequencies. The circuit is called „high pass", because high frequencies can pass through.

2.Experiment:

The wiring is changed according to illustration 2.
The applied voltage remains unchanged. Again the measurings are started with a frequency of 3000 Hz which is slowly reduced to 100 Hz.

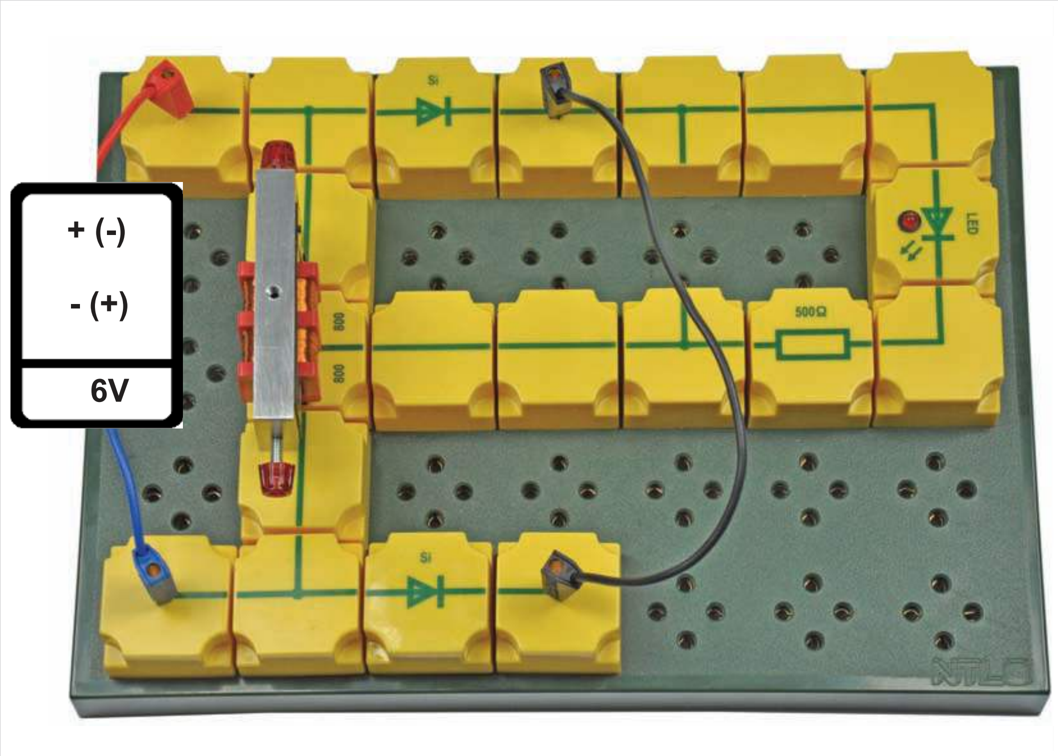
In doing so the voltmeter is watched. Lower frequencies can pass through more easily with this circuit, therefore the circuit is called „low pass".

Conclusion:
The condenser has a high A.C. resistance and causes a high drop of voltage with low frequencies, whereas the drop of voltage at the Ohmic resistor is low.
It is the other way round with high frequencies.

PRINCIPLE OF FULL-WAVE RECTIFICATION (MID-POINT TAPPING

EOS 5.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism



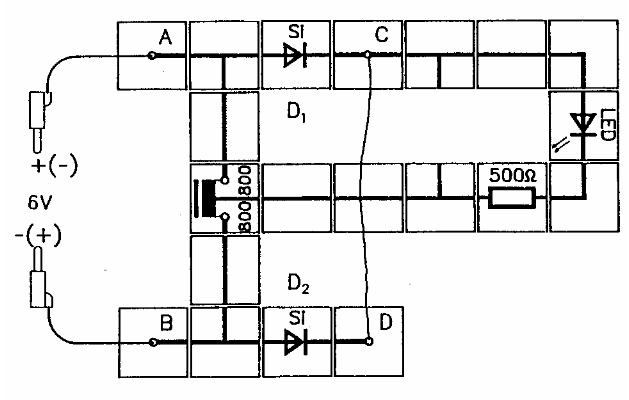
Material:
1x Plug-in panel
1x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
3x PIB connector
5x PIB wire, straight
1x PIB wire, straight, with socket
4x PIB wire, T-shaped
2x PIB wire, angled
1x PIB resistor 500 Ohm
2x PIB Si diode
1x PIB LED red
1x PIB for coil with 800 turns
1x Coil with 800 turns, blue
1x Iron core, U- and I-shaped core with clamp strap

Additionally required:
1x Voltage supply

PRINCIPLE OF FULL-WAVE RECTIFICATION (MID-POINT TAPPING)

EOS 5.1

With full-wave rectifying both possibilities of A.C. polarity for electric current in the same direction through the consumer are used.



Wiring:
Arrange the wiring according to the illustration.

A light emitting diode with a 500 Ω drop resistor serves as a consumer.

The diode allows the electric current to flow in one direction only and thus proves the rectification.

The red PI-coil with 2 x 800 turns need not have an iron core.
A D.C. of 6 Volt is used.

Experiment:

The positive pole of the voltage source is connected to A, the negative pole to B.
The connecting lead from C to D is not used.

The diode D_2 is removed and the direction of the electric current via the connecting lead and the consumer (LED) is observed.

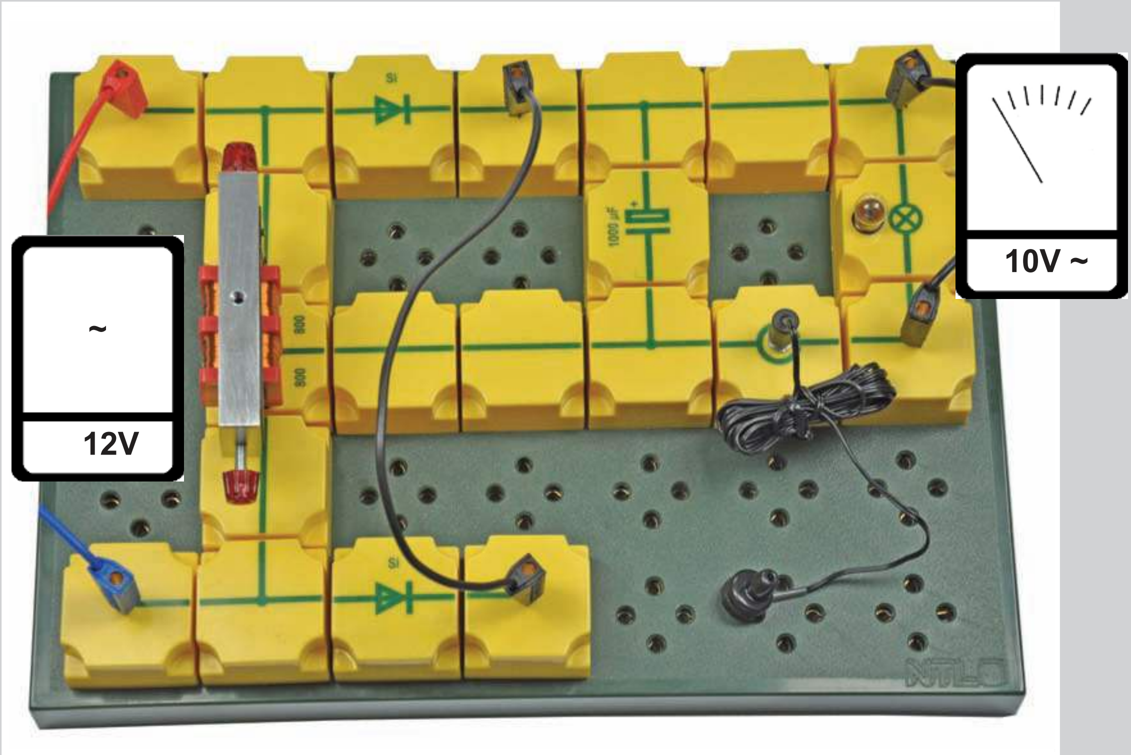
Conclusion:
Both possibilities of polarity lead to a flow of electric current in the same direction through the consumer.

Note: The applied voltage must be double the amout of the voltage desired at the consumer because of centre tapping at the coil.

APPLICATION OF FULL-WAVE RECTIFICATION

EOS 5.2

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electomagnetism



Material:
1x Plug-in panel
1x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
3x PIB connector
5x PIB wire, straight
1x PIB wire, straight, with socket
4x PIB wire, T-shaped
2x PIB wire, angled, with socket
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x Earphone
1x PIB capacitor 1000 µF
1x PIB wire with jack bush
2x PIB Si diode
1x PIB for coil with 800 turns
1x Coil with 800 turns, blue
1x Iron core, U- and I-shaped core with clamp strap

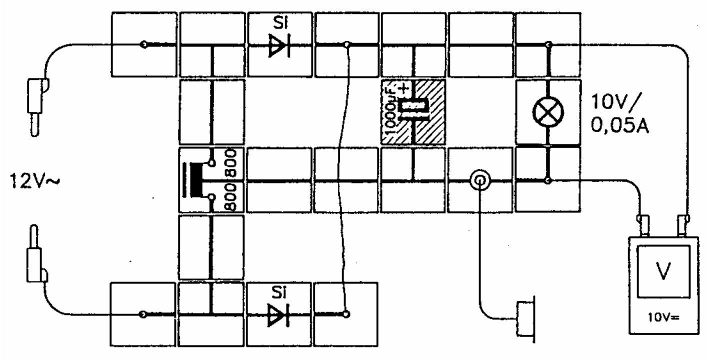
Additionally required:
1x Meter
1x Voltage supply

APPLICATION OF FULL-WAVE RECTIFICATION

EOS 5.2

The experiment is to show the practical application of A.C. mid-point tapping.

Wiring:



Arrange the wiring according to the illstration.

The PI-coil with 2 x 800 turns, red is provided with the closed iron core (U-shaped core with yoke and clamp strap).

The condenser (1000 µF) is not yet inserted.

The voltmeter indicates the voltage at the consumer.

1. Experiment:

The earphone indicates the hundred half periods per second by buzzing sound.

When removing one diode, the drop of the pitch to the lower octave can be heard, because then only 50 cycles per second flow.

Voltage with only one diode: .... Volt

Voltage with both diodes: .... Volt

2.Experiment:

The condenser is inserted (mind correct polarity!).
The sound in the earhone has disappeared.

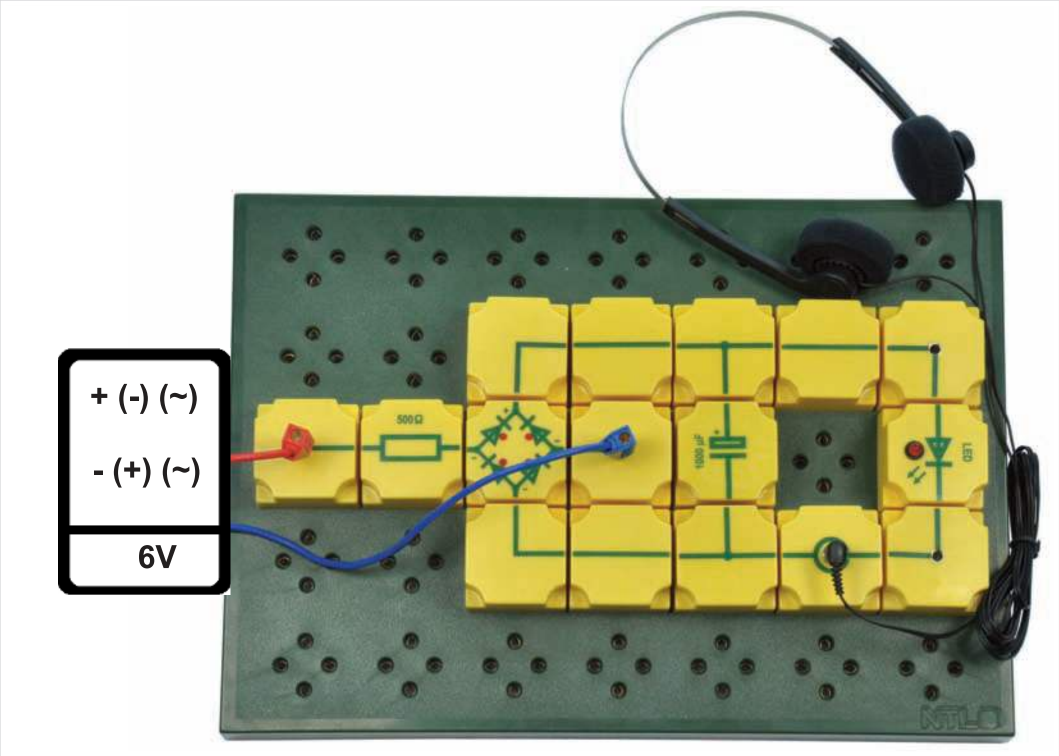
Voltage at the consumer: .... Volt

Conclusion:
The voltage at the consumer is twice as high as when using only one diode with full-wave rectifying.
The voltage at the consumer increases to the peak amount of the applied voltage at smoothing by means of a condenser.

BRIDGE CIRCUIT

EOS 5.3

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



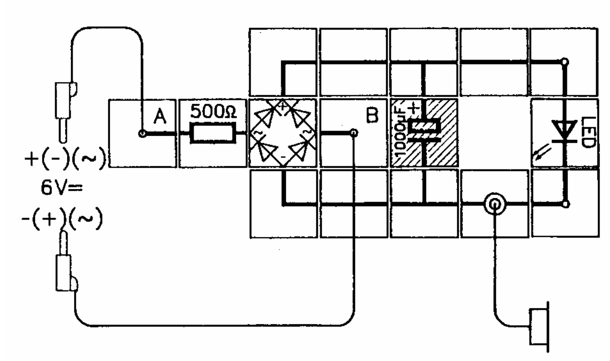
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
1x PIB connector
3x PIB wire, straight
2x PIB wire, T-shaped
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 500 Ohm
1x Earphones
1x PIB capacitor 1000 µF
1x PIB Bridge rectifier
1x PIB wire with jack bush
1x PIB LED red

Additionally required:
1x Voltage supply

BRIDGE CIRCUIT

EOS 5.3

Wiring:



Arrange the wiring according to the illustration.

The condenser 1000 µF is not yet inserted.

Check the correct insertion of the bridge rectifier (all arrows must point upwards)!

1.Experiment:

The positive pole of the voltage source is connected to A, the negative pole to B.
The flow of the electric current from the positive pole via the consumer (LED) to the negative pole is observed.
The LED used as a consumer glows.
The LEDs on the PIB-bridge rectifier indicate the direction of the electric current.
Two LEDs glow.

2.Experiment:

The positive pole of the voltage source is connected to B, the negative pole to A.
The flow of the electric current from the positive pole via the consumer (LED) to the negative pole is observed.
The consumer is again passed by electric current.
Now the two other LEDs glow on the PIB-bridge rectifier.

3.Experiment:

A.C. is applied. All LEDs of the PIB-bridge rectifier glow. A buzzing sound can be heard in the earphone. Where does it come from?

The buzzing sound is caused by the hundred half periods per second passing through the consumer.
The current intensity rises to the peak level, a hundred times per second, and decreases to.
These flucations can be heard in the earphone.

4.Experiment:

The condenser is inserted (check correct polarity!).
Why has the buzzing sound disappeared?

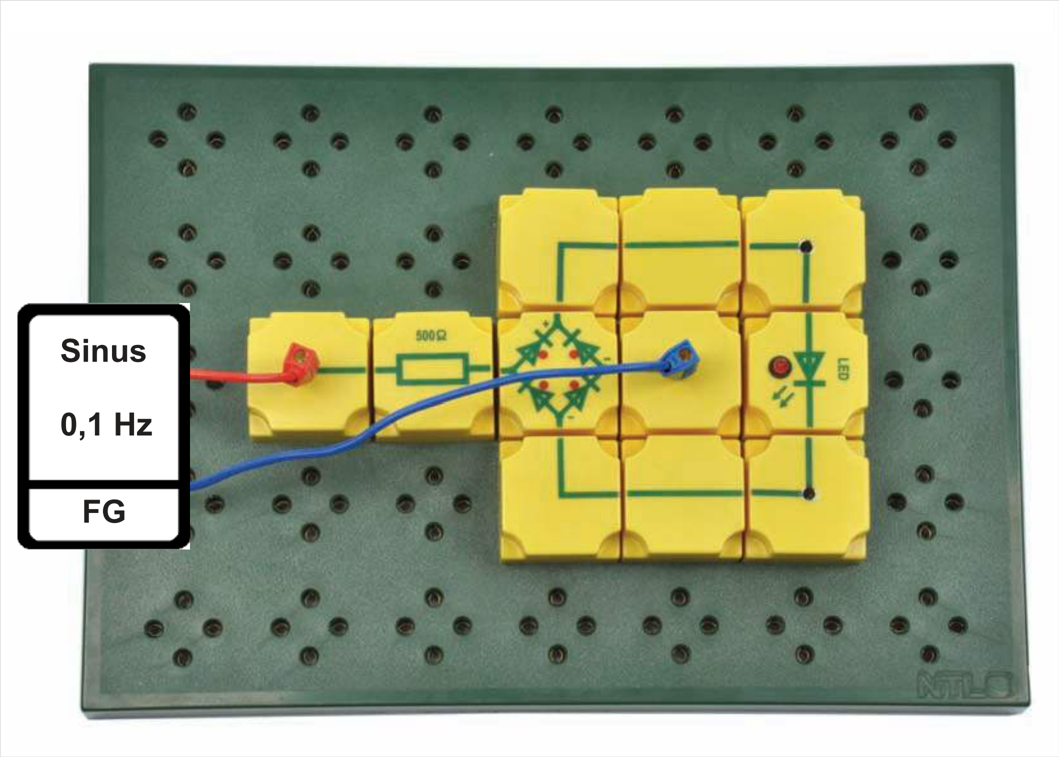
The D.C. is smoothened by the condenser.

Conclusion:
The bridge connection does not need a double amount of voltage (like the mid-point tapping), but it needs four instead of two rectifying componentes (diodes).

AC BRIDGE CIRCUIT (VARIABLE FREQUENCY)

EOS 5.3.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



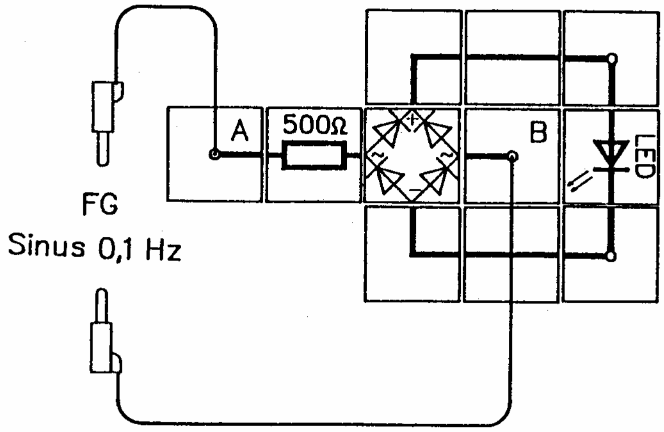
Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
2x PIB wire, straight
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 500 Ohm
1x PIB Bridge rectifier
1x PIB LED red

Additionally required:
1x Function generator
1x Voltage supply

AC BRIDGE CIRCUIT (VARIABLE FREQUENCY)

EOS 5.3.1

Wiring:



Arrange the wiring according to the illustration.

Check the correct insertion of the bridge rectifier (all arrows must point upwards).

The signal generator is used as voltage source.

The generator is provided with an A.C. of 12 Volt.

The amplitude is adjusted to maximum voltage. The form of the oscillation is sinusoidal.

1.Experiment:

The signal generator is first adjusted to its lowest frequency (0,1 Hz).
The direction of the current from the positive pole via the consumer (LED) to the negative pole is watched.
The LED used as a consumer glows.
The LEDs at the PIB-bridge rectifier indicate the direction of the current.
Two LEDs glow.

After the first half period the direction of the current changes.
Again the direction of the current from the positive pole to the negative pole is watched.
The consumer is again passed by the current.
Now the two other LEDs at the PIB-bridge rectifier glow.

2.Experiment:

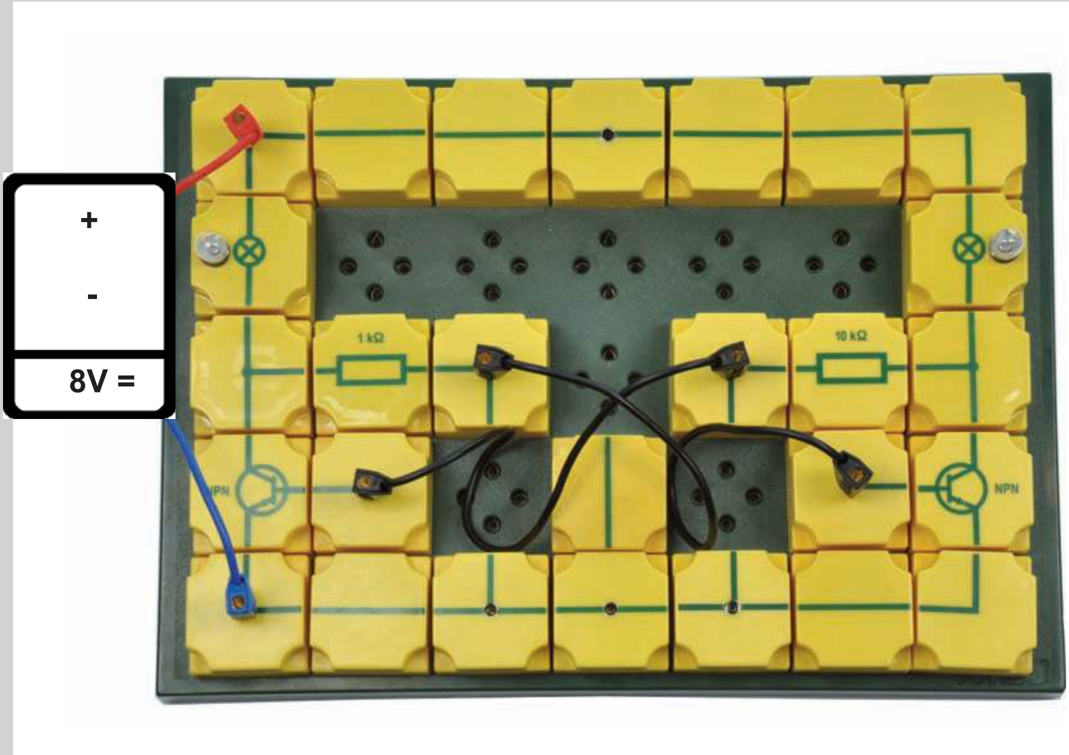
Now the frequency is slowly increased and it is found out a which frequency the LEDs no longer glow.
Both LEDs seem to be permanently lit because of the inertia of the human eye.

Conclusion:
The function of the bridge rectifier with different frequencies can be observed by means of the signal generator.
The limit frequency at which the LEDs no longer glow can be determined as well.
This limit frequency for the individual LED is about half the limit frequency for two LEDs at a time in bridge connection.

BISTABLE MULTIVIBRATOR

EOS 6.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Conencting lead, blue
2x PIB connector
7x PIB wire, straight
2x PIB wire, straight, with socket
4x PIB wire, T-shaped+
4x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 1 kOhm
2x PIB lamp socket E10
2x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additionally required:
1x Voltage supply

BISTABLE MULTIVIBRATOR

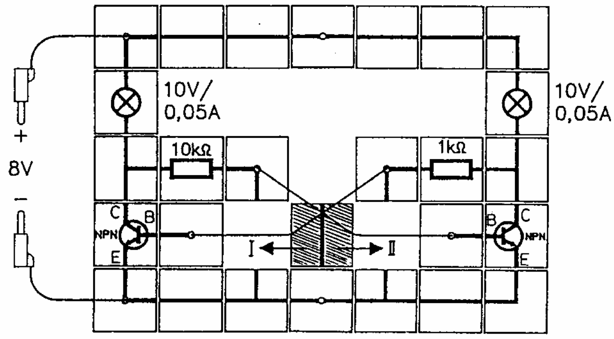
EOS 6.1

Electronic storage elements must have two permanent conditions.

Wiring:

Arrange the wiring according to the illustration.

The PIB-lead straight marked by hatching in the middle of the wiring is not inserted but it is inserted during the experiment in position I or II (this is marked by arrows!).



Experiment:

After applying the voltage, one of the lamps glows, the other one does not glow.

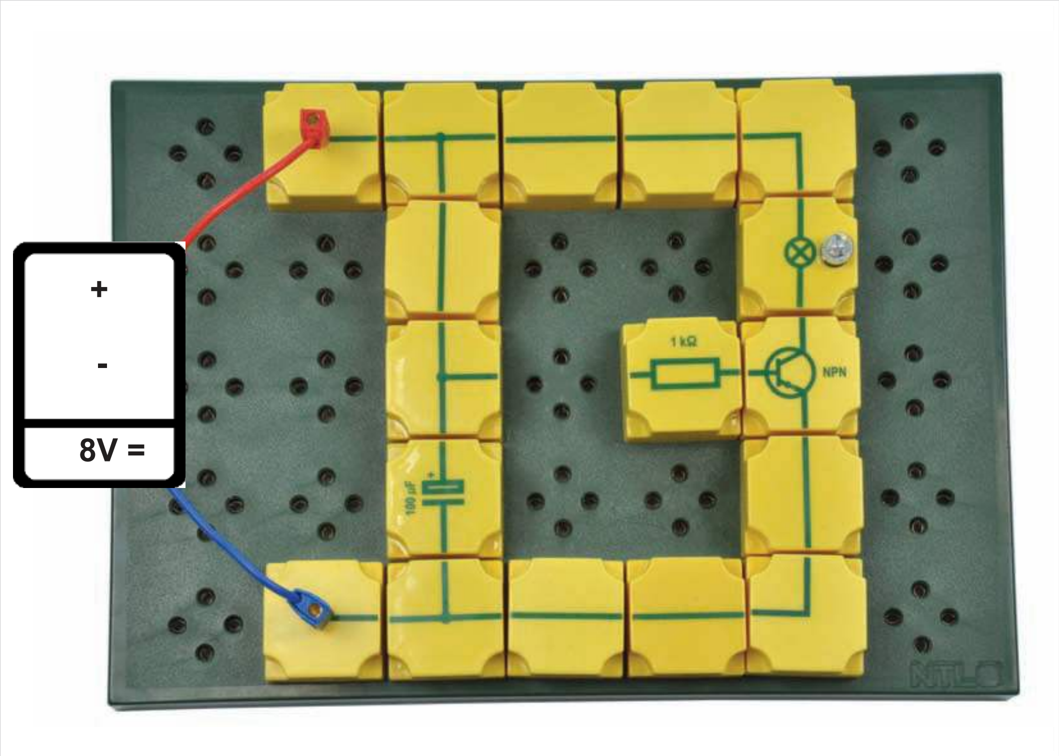
The straight lead is always inserted on the side of the non-glowing lamp.

Thus the wiring „sweeps" to the other stable condition.
The lamp glowing first is switched off, the other lamp glows.

Conclusion:
The wiring has two stable conditions.
Either only the right lamp or only the left lamp glows.
This is why it is called „bistable" multivibrator.

CAPACITOR DISCHARGE

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
6x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 1 kOhm
1x PIB resistor 10 kOhm
1x PIB capacitor 100 µF
1x PIB capacitor 1000 µF
1x PIB transistor NPN, base left

Additionally required:
1x Voltage supply

CAPACITOR DISCHARGE

If a condenser is discharged via a resistor, it is to be assumed that its time of discharging increases with its capacitance (a higher amount of electricity must be discharged with a higher capacitance) and its amount of resistance (a lower capacitance can be discharged per second with a higher amount of resistance).

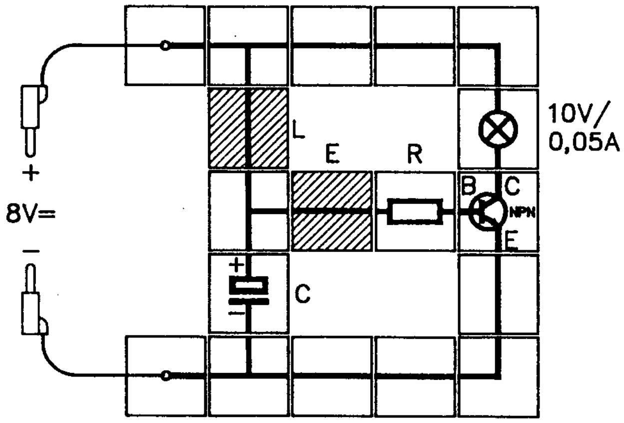
Wiring:

If the straight lead (marked by hatching) is inserted in L the condenser is charged.

Then this straight lead is moved to E.

Thus the condenser is discharged via R and the base-emitter diode.

The lamp glows.



Experiment:

The time that passes from the glowing of the lamp (when moving the lead from L to E) until it is comletely extinguished is metered in each case.

C = 100 µF,R = 10 kΩ t = ... seconds

C = 1000 µF,R = 1 kΩ t = ... seconds

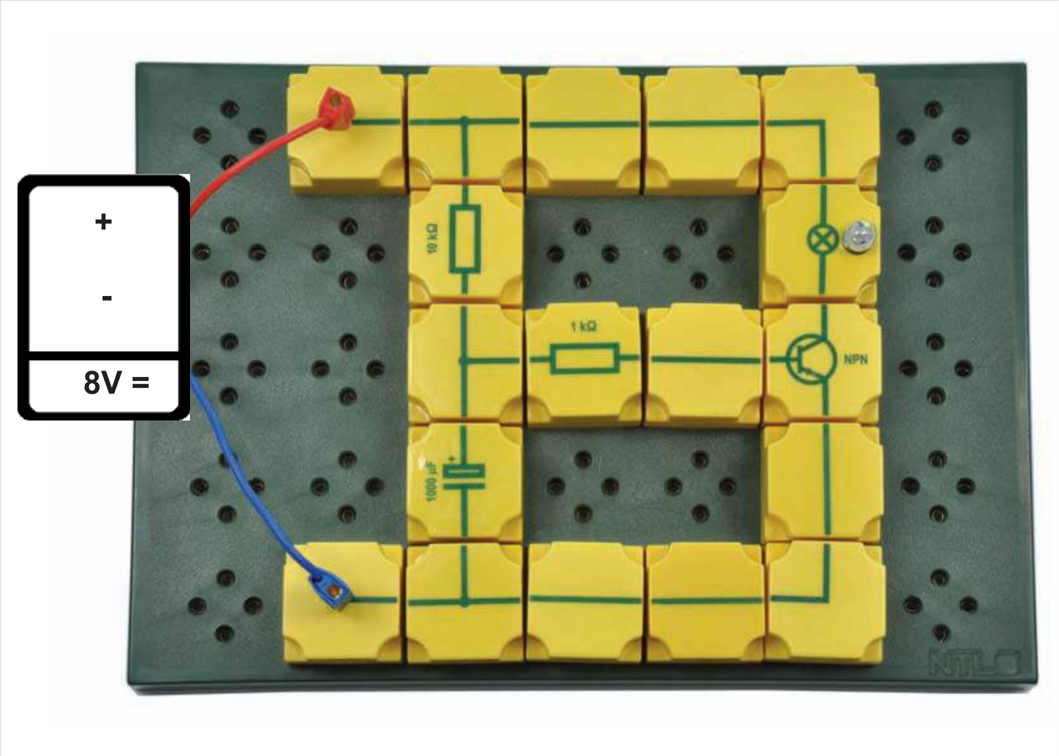
C = 1000 µF,R = 10 kΩ t = ... seconds

Conclusion: The time of discharging increases with C and R.

A CAPACITOR PREVENTS BASE CURRENT

EOS 6.3

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
6x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 1 kOhm
1x PIB resistor 10 kOhm
1x PIB capacitor 1000 µF
1x PIB transistor NPN, base left

Additionally required:
1x Voltage supply

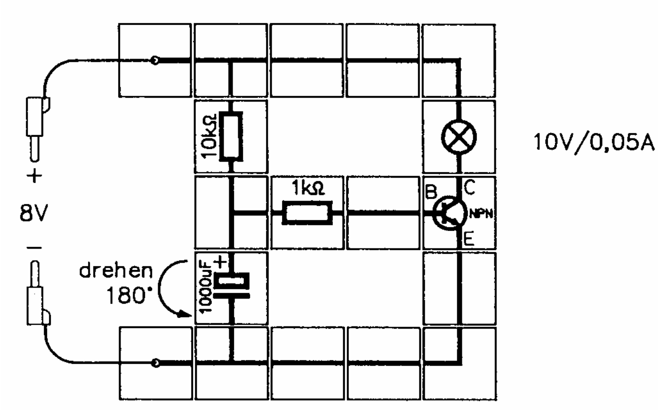
A CAPACITOR PREVENTS BASE CURRENT

EOS 6.3

An „invertedly" charged condenser may block a transistor till it is discharged.

Wiring:

Arrange the wiring according to the illustration.



After supplying the voltage (8 V D.C.) the condenser is charged.

There is a flow of base current and the lamp glows.

If the condenser is turned at an angle of 180 degrees its negatively charged side lies at the base.

It hinders base current till the negative voltage is reduced by discharging the condenser via the resistor 10 kΩ.

Experiment:

First the condenser is inserted according to the circuit diagram.
Then it is turned at an angle of 180 degrees till the lamp glows again.

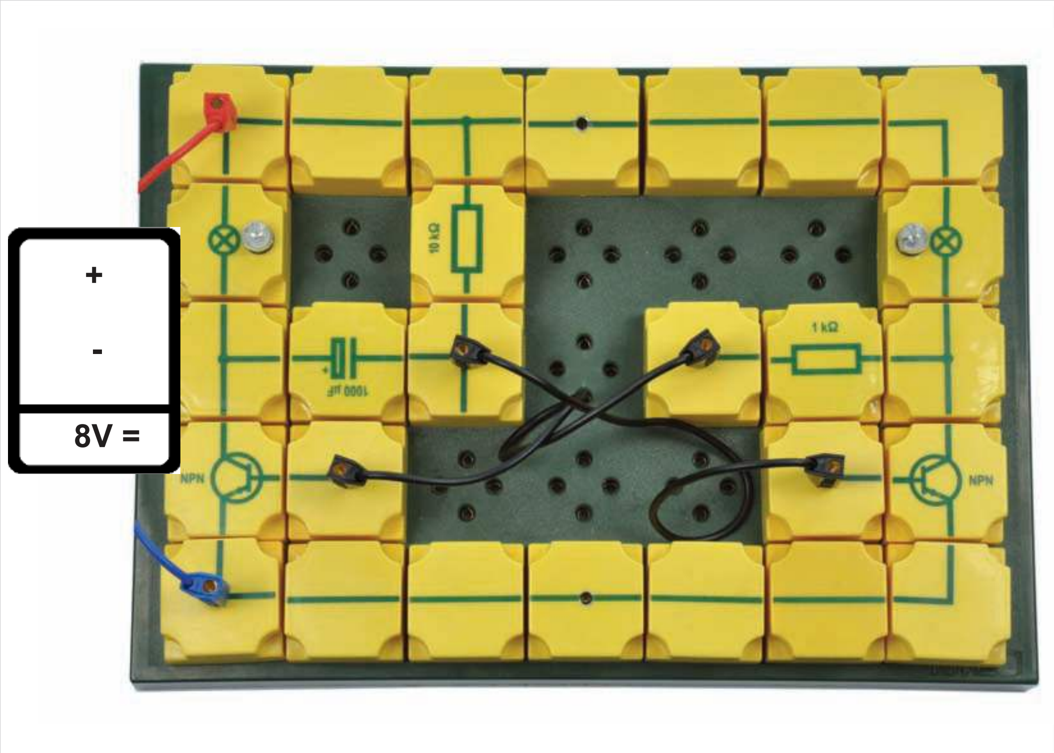
The condenser should not remain unnecessarily long in reversed polarity (it may get harmed!).

Conclusion:
If the negatively charged side of a condenser lies at the base the transistor is blocked till the condenser is discharged.

MONOSTABLE MULTIVIBRATOR

EOS 6.4

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Conencting lead, blue
3x PIB connector
7x PIB wire, straight
2x PIB wire, straight, with socket
4x PIB wire, T-shaped
1x PIB wire, T-shaped, with socket
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 1 kOhm
2x PIB lamp socket E10
2x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB capacitor 1000 µF
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additionally required:
1x Voltage supply

MONOSTABLE MULTIVIBRATOR

EOS 6.4

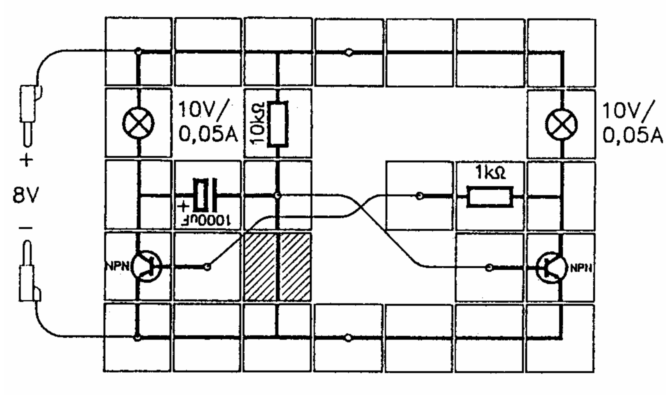
Monostable means that there is only one permanent condition.
If the wiring is brought from this condition to a different condition it flops back on its own.

Wiring:

Arrange the wiring according to the illustration.

Each time the straight lead (marked) is inserted during the experiment only for a very short time.

Check the correct polarity of the condenser!



Experiment:

After applying the voltage the right lamp glows. This is the stable condition.

By inserting the straight lead (marked) for a short time the right lamp is extinguished and the left one glows.

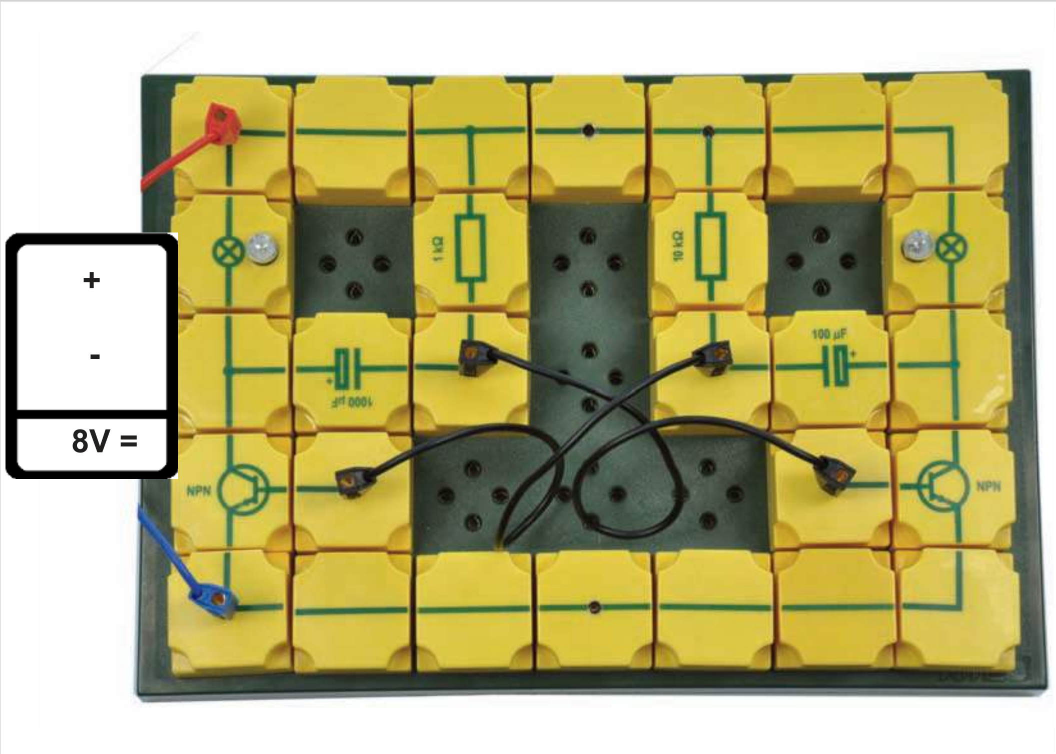
After removing the straight lead the wiring, however, soon flops back into stable condition.

Conclusion:
The monostable multivibrator has two switching conditions as well, but is only stable in one condition.

FLASHING CIRCUIT

EOS 6.5

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Conencting lead, blue
2x PIB connector
7x PIB wire, straight
1x PIB wire, straight, with socket
4x PIB wire, T-shaped
4x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 1 kOhm
2x PIB lamp socket E10
2x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB capacitor 100 µF
1x PIB capacitor 1000 µF
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additionally required:
1x Voltage supply

FLASHING CIRCUIT

EOS 6.5

This wiring should actually be called „astable multivibrator". It does not remain stable in any of the two conditions, but flips to and fro. This can be used for a flashing circuit.

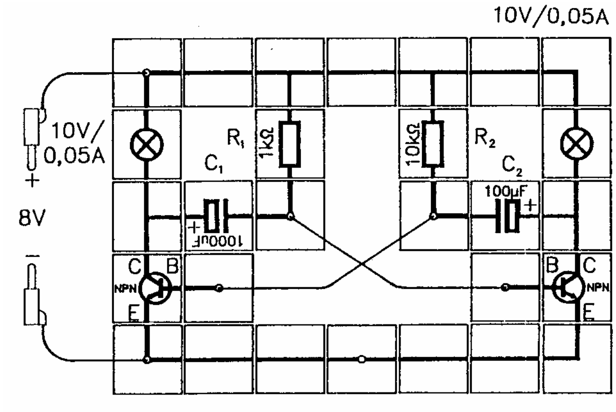
Wiring:

Arrange the wiring according to the illustration.

Two RC-modules are used whose product is the same: R_1 = 1 kΩ, C_1 = 1000 µF and R_2 = 10 kΩ, C_2 = 100 µF.

The product of R and C is 1000 each time.

Mind the correct polarities of the condensers!



Experiment:

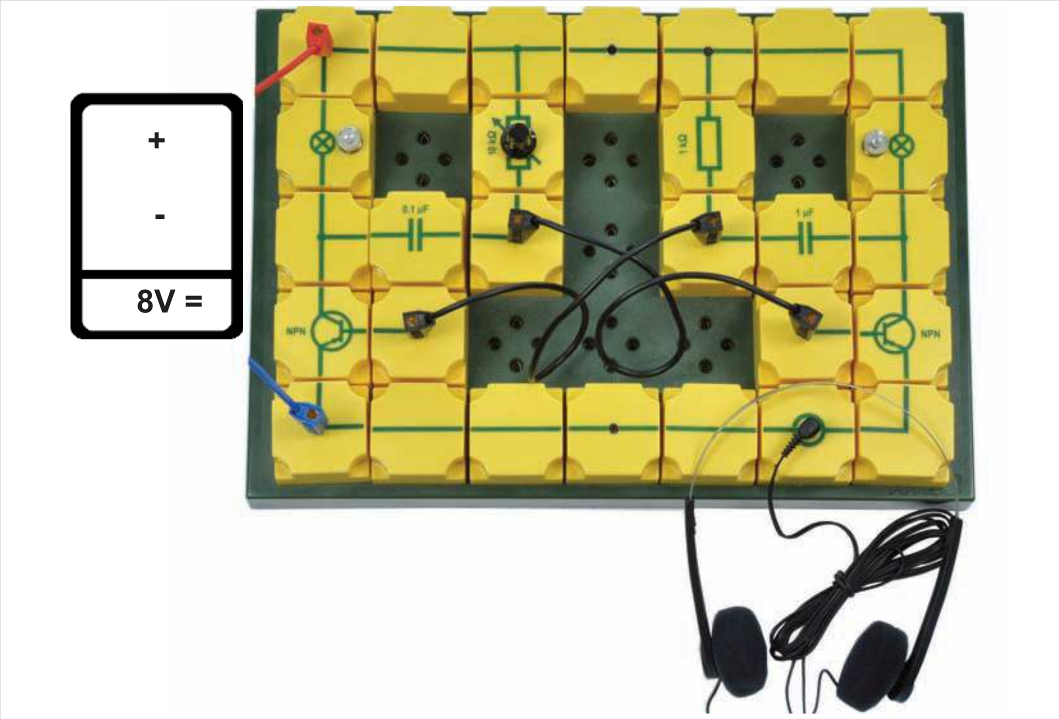
After applying a D.C. source of 8 Volt both lamps flash alternately.

Conclusion:
One transistor is alternately blocked and the other one becomes conducting (and vice versa) becase of the interplay of the two RC-modules.

Expansion:
Try to change the flash period! It depends on the amount of resistance of the Ohmic resistor and on the capacitance of the condenser.
By using a variable resistor instead of a resistor 10 kΩ the product of R anc C can be easily changed.

MULTIVIBRATOR MUSIC

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Conencting lead, blue
2x PIB connector
7x PIB wire, straight
4x PIB wire, T-shaped
4x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 1 kOhm
2x PIB lamp socket E10
2x Light bulb 10V/50mA
1x PIB rheostat 10 kOhm
1x Earphones
1x PIB capacitor 0.1 µF
1x PIB capacitor 1 µF
1x PIB wire with jack bush
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additionally required:
1x Voltage supply

MULTIVIBRATOR MUSIC

EOS 6.6

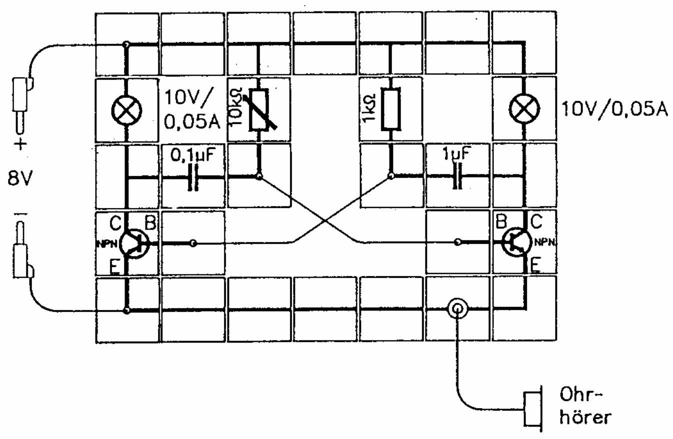
If the process of flipping with the astable multivibrator is accelerated (by using smaller RC-modules) the range of acoustic frequencies is reached.

Wiring:

Arrange the wiring according to the illustration.

The variable resistor in the left RC-module must first be turned completely clockwise (highest amount of resistance).

A D.C. of 8 Volt is applied.



Experiment:

A sound can be heard in the earphone. This sound can be modulated by changing the varible resistor.

Try to „play" a scale and a simple melody.

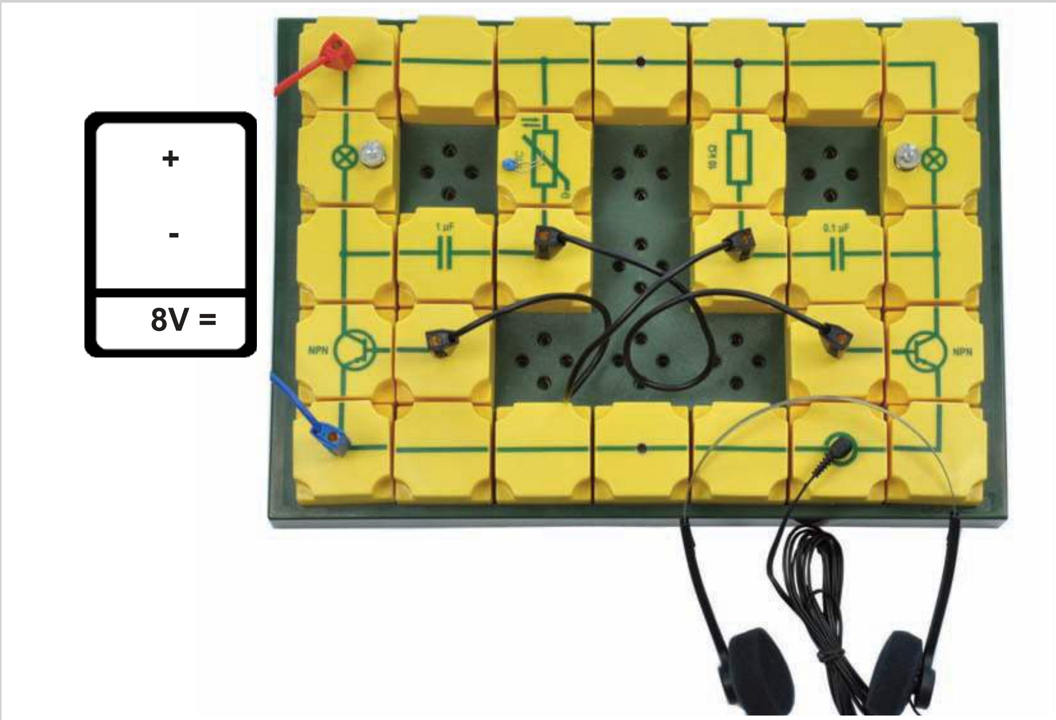
Conclusion:
If the product of R and C gets smaller, the frequency rises and sounds can be generated.

Note: If the sound suddenly stops and both lamps glow, the circuit is interrupted for a short time (switch of the voltage source is to be turned) and then closed again.

MUSIC CONTROLLED BY LIGHT

EOS 6.7

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Conencting lead, blue
2x PIB connector
7x PIB wire, straight
4x PIB wire, T-shaped
4x PIB wire, angled, with socket
2x PIB wire, angled
2x PIB lamp socket E10
2x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB photo resistor (LDR)
1x Earphones
1x PIB capacitor 0.1 µF
1x PIB capacitor 1 µF
1x PIB wire with jack bush
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additionally required:
1x Voltage supply

MUSIC CONTROLLED BY LIGHT

EOS 6.7

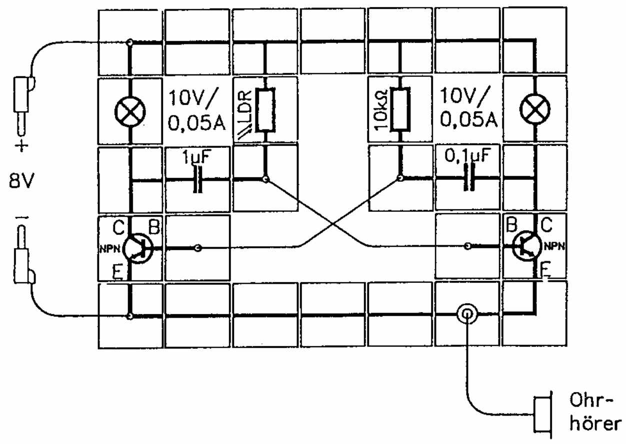
Pitch is controlled by light with this new „musical instrument“.

Wiring:

Arrange the wiring according to the illustration.

To facilitate a change of illumination of the LDR it is of advantage to connect the LDR to a PIB-lead interrupted via connecting leads.

A D.C. of 8 Volt is applied.



Experiment:

According to the illumination of the LDR, higher or deeper sounds can be produced.

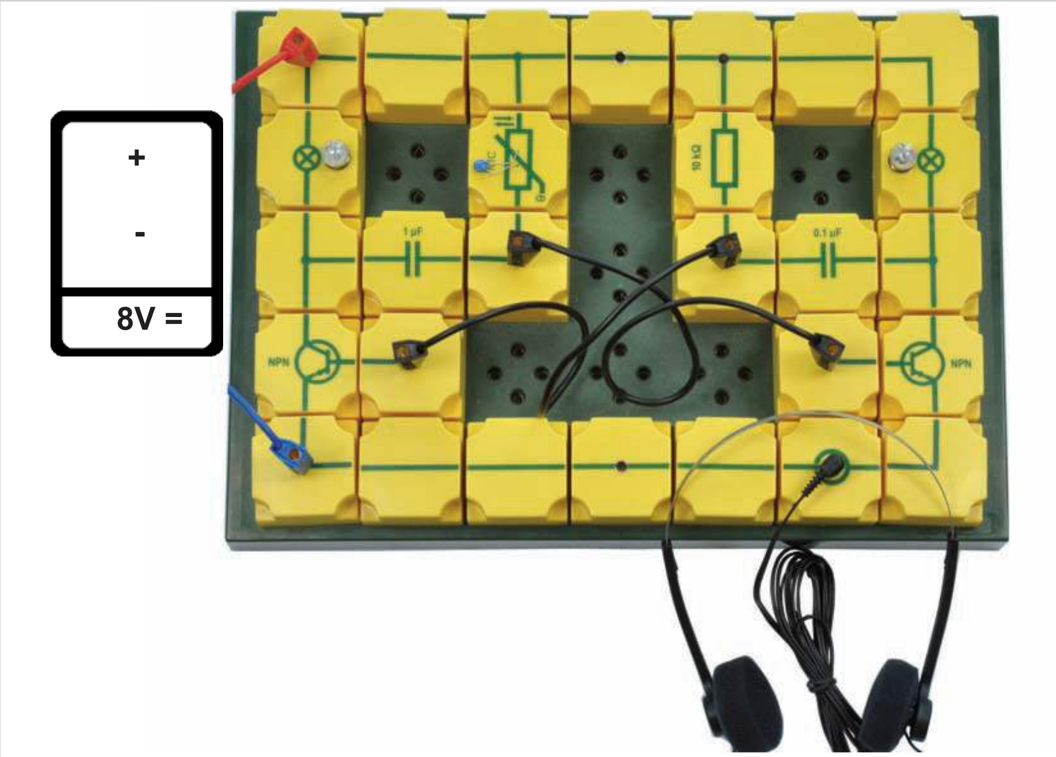
Melodies can be produced with skilled darkening by the hands. Why?

Note: Whenever the sound breaks off (because the amount of resistance of the LDR is too small) the D.C. must be switched off for a short time and then switched on again.

MUSIC CONTROLLED BY TEMPERATURE

EOS 6.7.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Conencting lead, blue
2x PIB connector
7x PIB wire, straight
4x PIB wire, T-shaped
4x PIB wire, angled, with socket
2x PIB wire, angled
2x PIB lamp socket E10
2x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB NTC resistor
1x Earphones
1x PIB capacitor 0.1 µF
1x PIB capacitor 1 µF
1x PIB wire with jack bush
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additionally required:
1x Voltage supply

MUSIC CONTROLLED BY TEMPERATURE

EOS 6.7.1

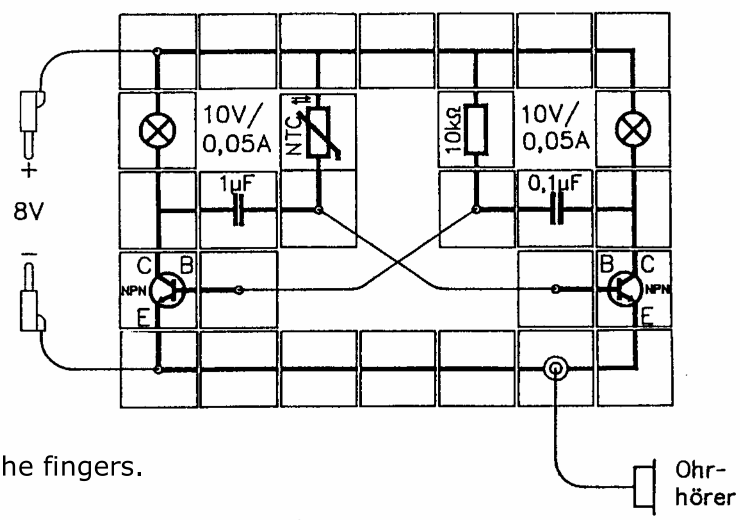
Pitch is controlled by warming a component with this new „mucical instrument".

Wiring:

Arrange the wiring according to the illustration.

The NTC-resistor has room temperature first.

A D.C. source of 8 Volt is applied.



Experiment:

The NTC-resistor is warmed by the fingers.

According to the warmth of the NTC-resistor, higher of deeper sounds can be produced.
Now the NTC-resistor is warmed by a match.

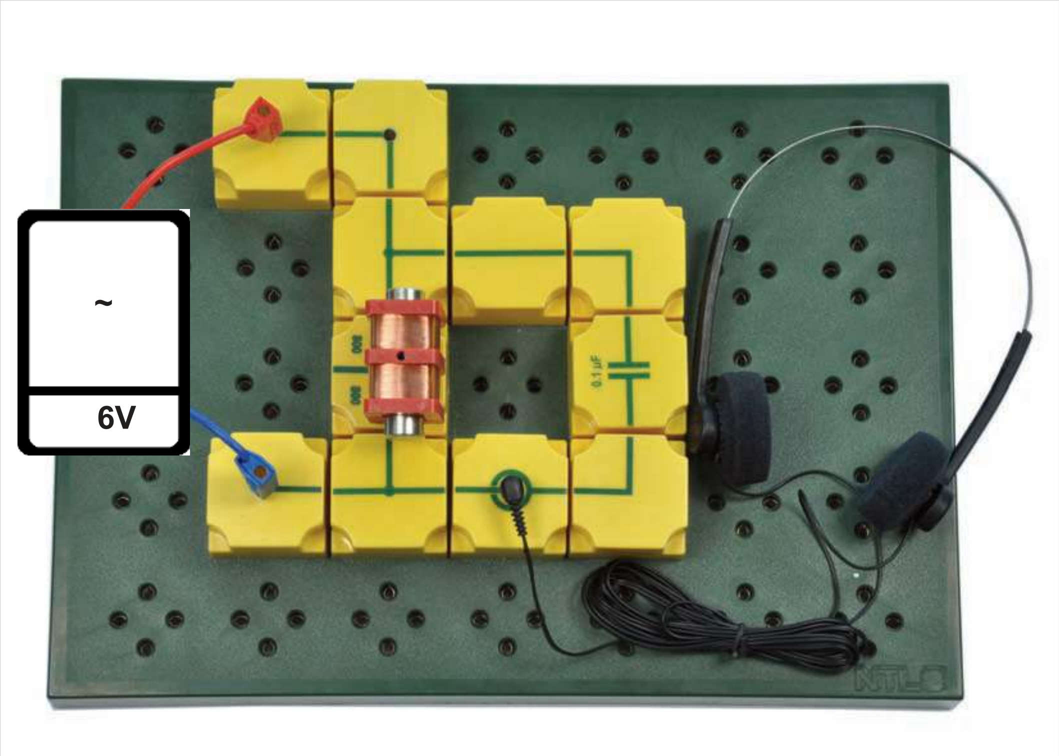
Is a high or a deep sound produced?

Note: Whenever the sound breaks off (because the amount of resistance of the NTC-resistor gets too small) the D.C. must be switched off for a short time and then switched on again.

PRINCIPLE OF A RESONANT CIRCUIT

EOS 7.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
1x PIB wire, straight
2x PIB wire, T-shaped
1x PIB wire, angled, with socket
2x PIB wire, angled
1x Earphones
1x PIB capacitor 0.1 µF
1x PIB wire with jack bush
1x PIB Si diode
1x PIB for coil 2x 800 turns
1x Coil with 2x 800 turns, red
1x Iron core solid

Additionally required:
1x Voltage supply

PRINCIPLE OF A RESONANT CIRCUIT

EOS 7.1

A resonant circuit consists of a coil and a condenser.
Its name originates in the fact that an electric charge can flop from one condenser board to the other.
This exeriment shows in a simple way that such a vibration is actually produced.

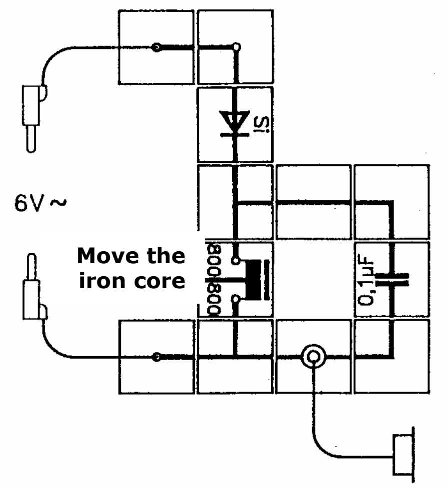
Wiring:

Arrange the wiring according to the illustration.

The condenser is charged by the A.C. source via the diode 50 times per second.

But during the intervals (of one hundredth of a second during the blocked half periods) the charge quickly flaps.

An A.C. of 6 Volt is applied.



Experiment:

The straight iron core is slowly moved in the coil and a noise can be heard in the earphone which is much higher than the already known buzzing produced by the A.C. of 50 Hz.

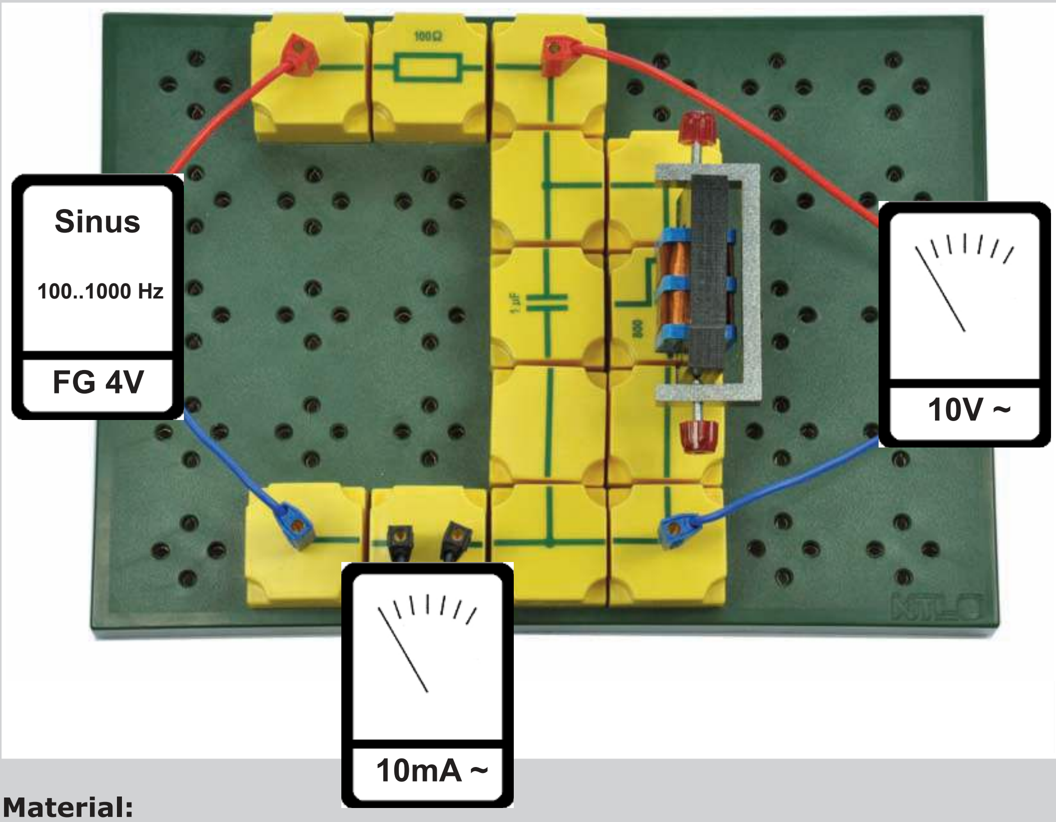
The pitch can be changed by moving the iron core.

Conclusion:
Electric charges flip in a resonant circuit. If the iron core is farhter inserted in the coil („higher inductance") the frequency of the vibration decreases.

PARALLEL RESONANT CIRCUIT

EOS 7.1.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
2x PIB wire, straight
2x PIB wire, T-shaped
2x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB resistor 100 Ohm
1x PIB capacitor 100 µF
1x PIB for coil 2x 800 turns
1x Coil with 2x 800 turns, red
1x Iron core, U- and I-shaped core with clamp strap

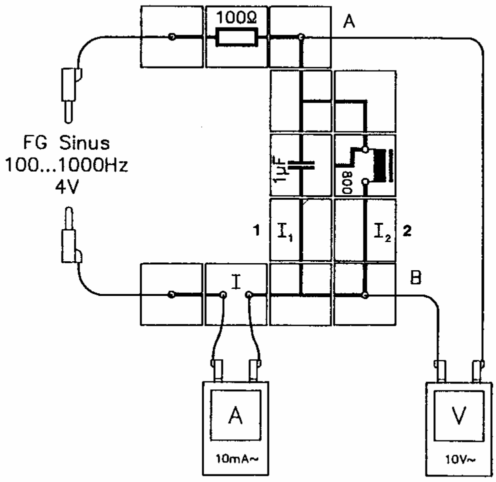
Additionally required:
2x Meter
1x Function generator
1x Voltage supply

PARALLEL RESONANT CIRCUIT

EOS 7.1.1

The inductance and capacitance of a parallel connection are to be investigated.

Wiring:
Arrange the wiring according to the illustration.



The PI-coil with 800 turns is provided with the closed iron core (U-shaped core with yoke held by clamp strap).
The ammeter measures the total current intensity I or the component current intensities I_1 and I_2 at the points 1 and 2.
To do so the PIB-lead straight must be exchanged for the PIB-lead interrupted to which the ammeter is connected.
The ammeter is used in the 100 mA ~ range.
The voltmeter is connected to the points A and B and is used in the 10 V ~ range.
The signal generator is provided with an A.C. of 12 Volt.It should produce a sinusoidal oscillation with a frequency of 100 Hz first.

The amplitude is adjusted to maximum voltage.

1.Experiment:

The frequency is slowly increased starting from 100 Hz and the ammeter which measures the total current intensity is watched.
There is a minimum current intensity at a certain frequency. This frequency is called „resonant frequency".

Minimum of current intensity at about .... Hz.
Minimal current intensity: I = ... mA

2.Experiment:

Check whether a maximum of voltage occurs together with a minimm of current intensity.

3.Experiment:

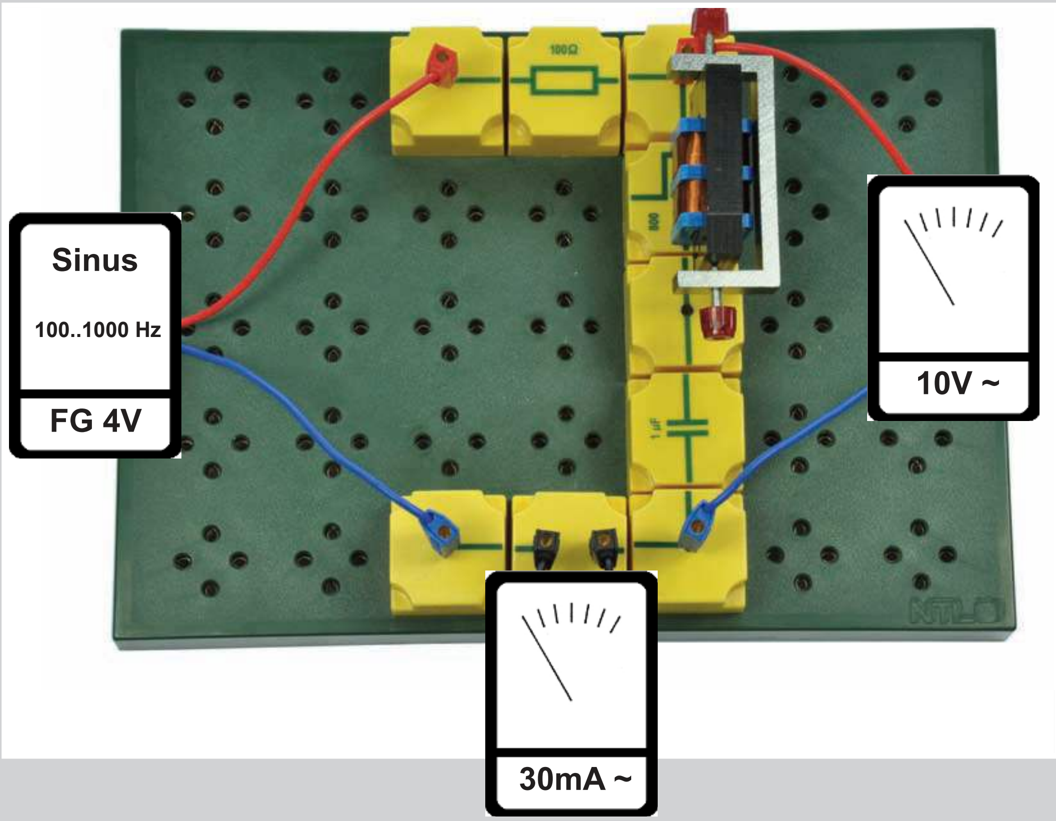
Now the component current intensities at resonant frequency are measured. To do so the PIB-lead straight is exchanged for the PIB-lead interrupted to which the ammeter is connected.
Component current intensity at condenser branch: I_1 = ... mA
Component current intensity at coil branch: I_2 = ... mA

The component current intensities are larger than the total current intensity!

Conclusion:
The A.C. resistance of a parallel connection is largest and the total current intensity therefore is smallest at a certain frequency.
The component current intensities can only be larger than the total current intensity because the currents in the two branches always flow in opposite direction.

ACCEPTOR CIRCUIT

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
2x PIB connector
1x PIB wire, straight, with socket
2x PIB wire, angled, with socket
1x PIB wire, interrupted, with sockets
1x PIB resistor 100 Ohm
1x PIB capacitor 1 µF
1x PIB for coil 800 turns
1x Coil with 800 turns, blue
1x Iron core, U- and I-shaped core with clamp strap

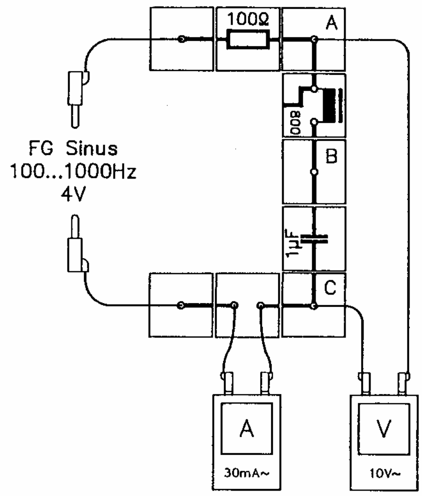
Additionally required:
2x Meter
1x Function generator
1x Voltage supply

ACCEPTOR CIRCUIT

EOS 7.1.2

The inductance and capacitance of a series connection are to be investigated.

Wiring:



Arrange the wiring according to the illustration.

The PI-coil with 800 turns is provided with the closed iron core (U-shaped core with yoke held by clamp strap).

The signal generator is suplied with an A.C. source of 12 Volt.
It should produce a sinusoidal oscillation with the frequency of 100 Hz first.
The amplitude is adjusted to maximum voltage.
The voltmeter measures the voltage at the acceptor circuit (connections A and C) and is used in the 10 Volt ~ range.

The ammeter is used with the measuring range of 30 mA ~.

1.Experiment:

The frequency is slowly increased starting from 100 Hz and the ammeter is watched. There is a maximum current intensity at a certain frequency.

Maximum of current intensity at about .... Hz

The resonance current intensity is .... mA = ... A.

2.Experiment:

The component voltages at coil and condenser are measured at resonant frequency.

Component voltage at the coil (connections A and B): U_L = ... V

Component voltage at condenser (connections B and C): U_C = ... V

The two component voltages are larger than the total voltage.

Conclusion:
The total resistance is smallest and thus the current intensity largest at a certain frequency.

CONTINUOUS OSCILLATION

EOS 7.2

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism

Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
5x PIB wire, straight
5x PIB wire, T-shaped
4x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB rheostat 10 kOhm
1x Earphones
1x PIB capacitor 100 µF
1x PIB transistor NPN, base left
1x PIB wire with jack bush
1x PIB for coil 800 turns
1x PIB for coil 2x 800 turns
1x Coil with 800 turns, blue
1x Coil with 2x 800 turns, red
1x Iron core, U- and I-shaped core with clamp strap

Additionally required:
1x Meter
1x Voltage supply

CONTINUOUS OSCILLATION

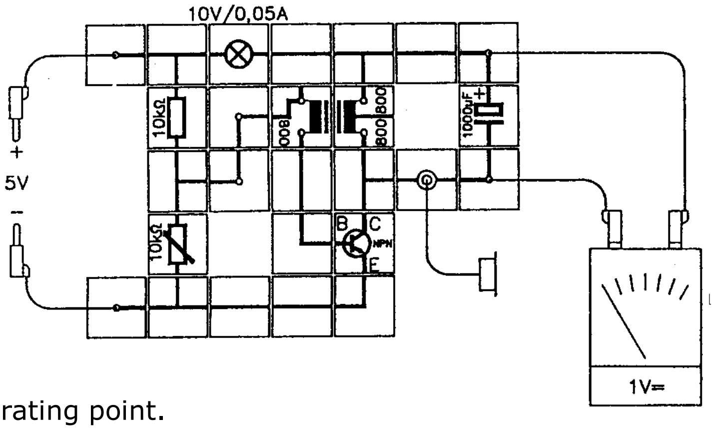
EOS 7.2

Continuous oscillations can be produced if the loss of energy is supplied after each oscillation. An inductive back coupling which is used here is based on the principle that the transistor gets conducting in the right moment and thus the loss of charge of the condenser after each oscillation is supplied.

Wiring:

The resonant circuit consists of a PI-coil with 2 x 800 turns and of the condenser.

The back coupling-coil with 800 turns supplies the voltage controlling the transistor, to the base and the emittor.



A voltage divider provides the correct operating point.

The two coils are provided with the closed iron core (U-shaped core with yoke fixed by clamp strap!).
A D.C. of 5 volt is applied.

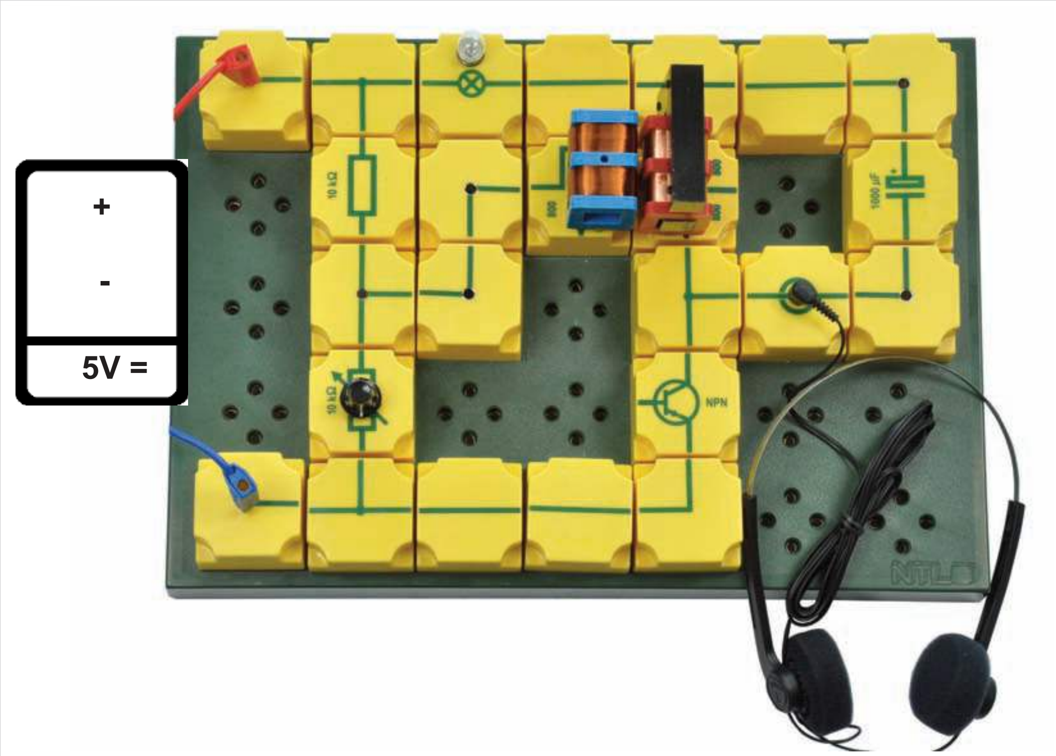
Experiment:

First the variable resistor is completely turned clockwise till the oscillations start.
The lamp indicates the surges of recharging towards the condenser.

The measuring device indicates the periodically oscillating voltage at the condenser.

Conclusion:
A condenser with high capacitance C and a coil with closed iron core (high inductance L) result in a comparatively slow oscillation.

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
5x PIB wire, straight
5x PIB wire, T-shaped
4x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB rheostat 10 kOhm
1x Earphones
1x PIB capacitor 0.1 µF
1x PIB capacitor 1 µF
1x PIB transistor NPN, base left
1x PIB wire with jack bush
1x PIB for coil 800 turns
1x PIB for coil 2x 800 turns
1x Coil with 800 turns, blue
1x Coil with 2x 800 turns, red
1x Iron core, U- and I-shaped core with clamp strap

Additionally required:
1x Meter
1x Voltage supply

LC MUSIC

EOS 7.3

The frequency of the oscillation depends on the product of the inductance L of the coil and the capacitance C of the condenser.

Wiring:

Arrange the wiring according to the illustration.

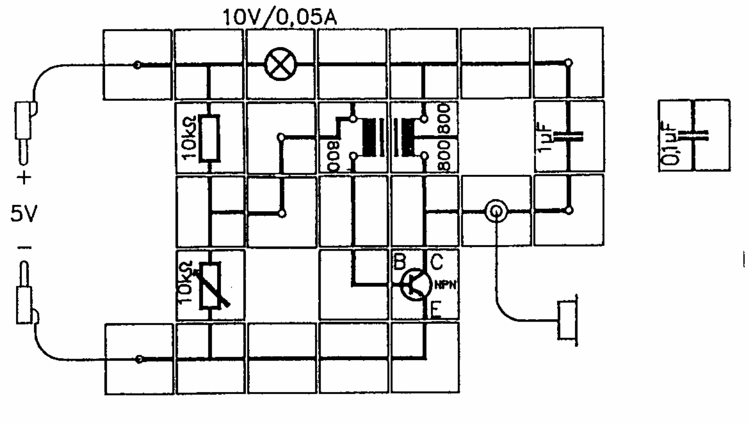
The coil is used without closed iron core.

Thus its inductance is lower.

The yoke is inserted in the PI-coil with 2 x 800 turns.

The condenser 1 µF (then 0,1 µF) is inserted.

A D.C. of 5 Volt is applied.



Experiment:

The variable resistor is first completely turned clockwise, then it is slowly turned counter-clockwise till a sound can be heard in the earphone.

The straight iron core is jerkily moved in the coil so that a scale is produced.

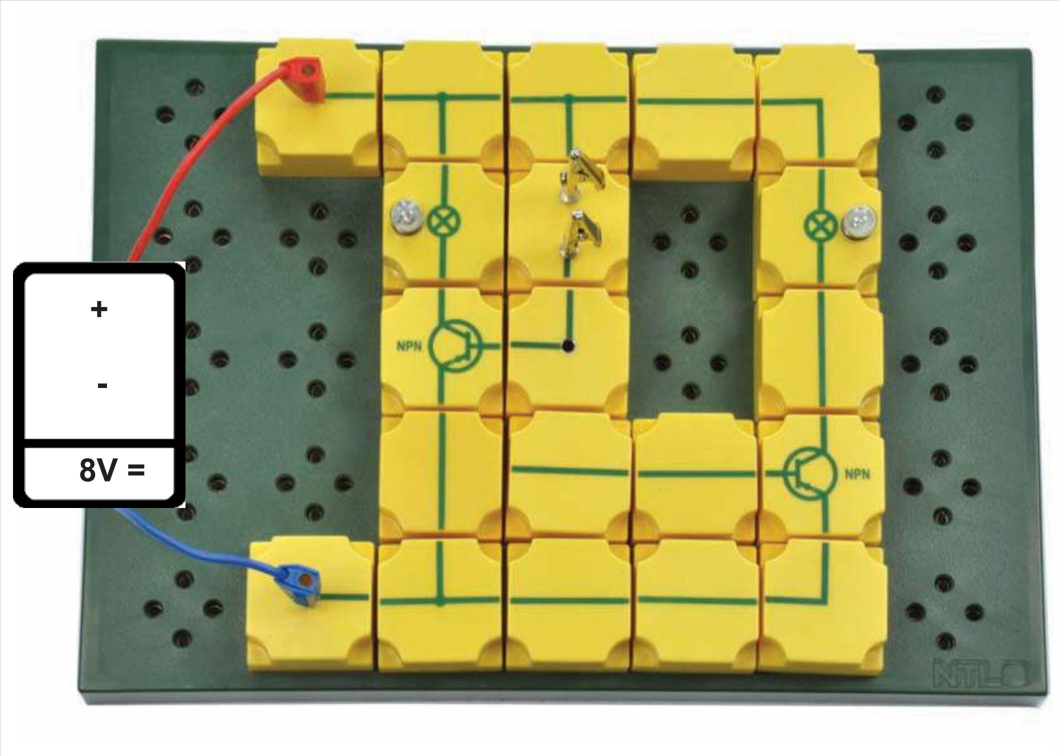
The pitch (frequency) rises considerably with the condenser 0,1 µF.

Conclusion: A generator for sound is obtained at the suitable product of L and C.

THE RESISTANCE IN THE HUMAN BODY

EOS 8.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Conencting lead, blue
2x PIB connector
7x PIB wire, straight
2x PIB wire, T-shaped
2x PIB wire, angled with socket
2x PIB wire, angled
1x PIB wire, interrupted, with sockets
2x PIB lamp socket E10
2x Light bulb 10V/50mA
2x Crocodile clip with plug
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additonally required:
1x Voltage supply

THE RESISTANCE IN THE HUMAN BODY

EOS 8.1

The human body has an amount of resistance of some hundred kΩ with low voltages. Thus it does not supply enough base current as a base resistor to switch through the transistor.

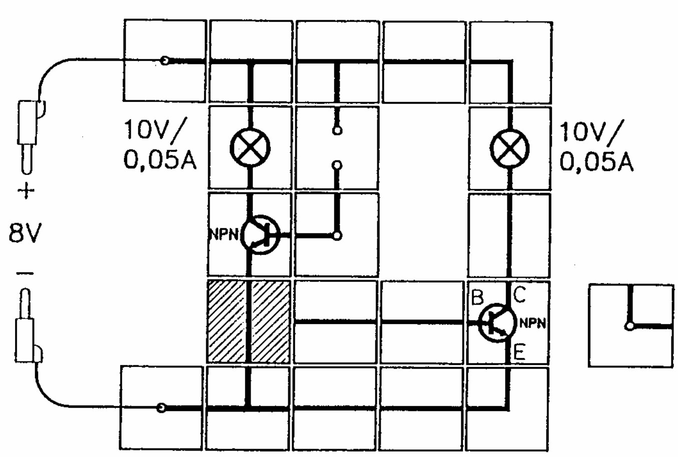
The Darlington-arrangement uses the low collector current of the first transistor as base current for a second transistor. Thus a higher amplification is produced.

Wiring:

Arrange the wiring according to the illustration.

The right transistor is not working condition first.

Two crocodile clips with plug pin are inserted in the sockets of the PIB-lead interrupted.



1.Experiment:

Each crocodile clip is touched with dry fingers of one hand each.
The base current is not high enough, the lamp does not glow.

2.Experiment:

The PIB-lead straight marked by hatching is replaced by an angled lead. The Darlington-arrangement is achieved in this way. The collector-emitter current of the first transistor flows via the base of the second transistor.

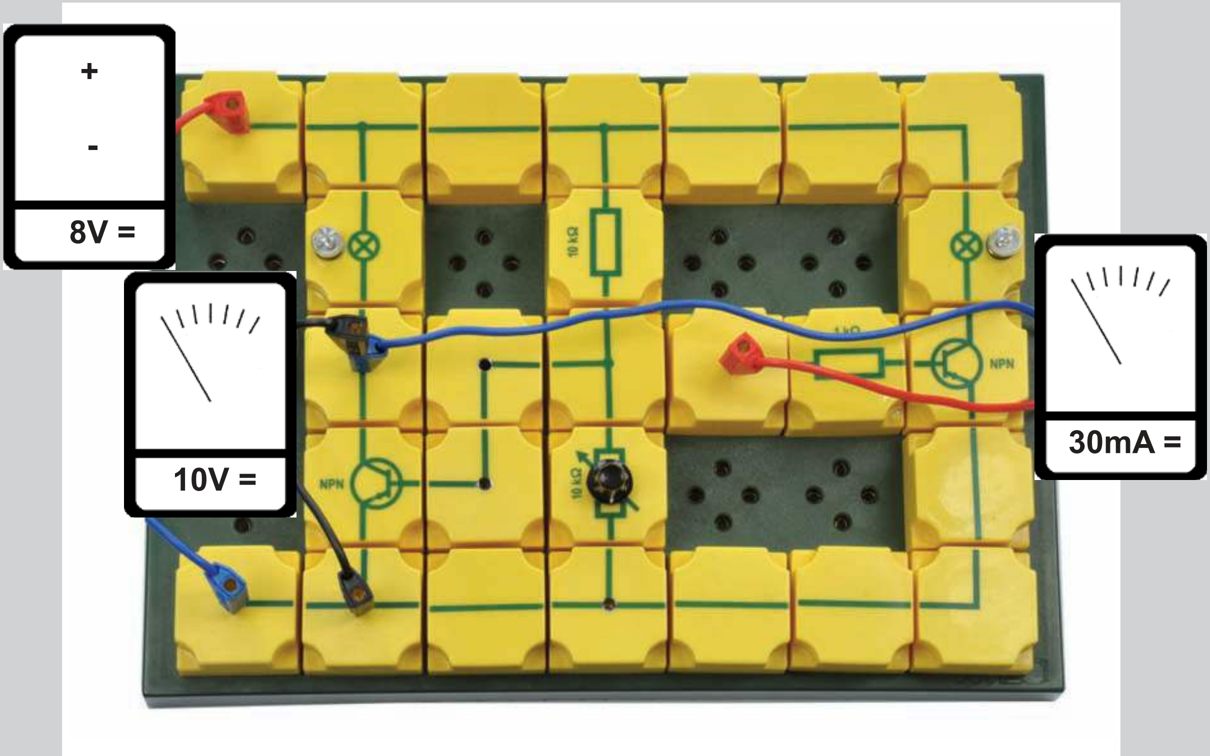
The right lamp glows when the crocodile clips are touched.

Conclusion:
A high current amplification can be achieved by means of a Darlington-arrangement.

A TRANSISTOR STEP CONTROLS A SECOND STEP

EOS 8.1.1

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Conencting lead, blue
3x PIB connector
7x PIB wire, straight
1x PIB wire, straight, with socket
4x PIB wire, T-shaped
1x PIB wire, T-shaped, with socket
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 1 kOhm
2x PIB lamp socket E10
2x Light bulb 10V/50mA
2x Crocodile clip with plug

1x PIB resistor 10 kOhm
1x PIB rheostat 10 kOhm
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additionally required:
2x Meter
1x Voltage supply

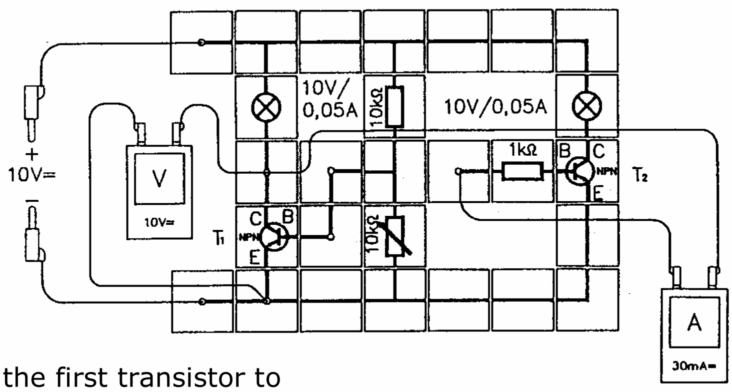
A TRANSISTOR STEP CONTROLS A SECOND STEP

EOS 8.1.1

There are several possibilities how two transistors may co-operate.
In this experiment the second step of the collector voltage is cotrolled by the first step.

Wiring:

Arrange the wiring according to the illustration.



The first step shows a normal transistor circuit with base voltage divider (resistor 10 kΩ and variable resistor 10 kΩ).

The trip line leads from the collector of the first transistor to the base resistor of the second transistor via the ammeter (30 mA = range).

The voltmeter measures the collector voltage of the first transistor and is used in the 10 V = range A D.C. of 10 Volt is applied.

1. Experiment:

The adjustment knob of the variable resistor 10 kΩ is completely turned clockwise (maximum amount of resistance). The left lamp glows, the second one does not glow.

Collector voltage of the first transistor: V

Base current to the second transistor:........ mA

2. Experiment:

The adjustment knob of the variable resistor is now turned counter-clockwise until the left lamp goes out and the right lamp glows.
The two steps of the transistor switch over.

Collector voltage of the first transistor: V

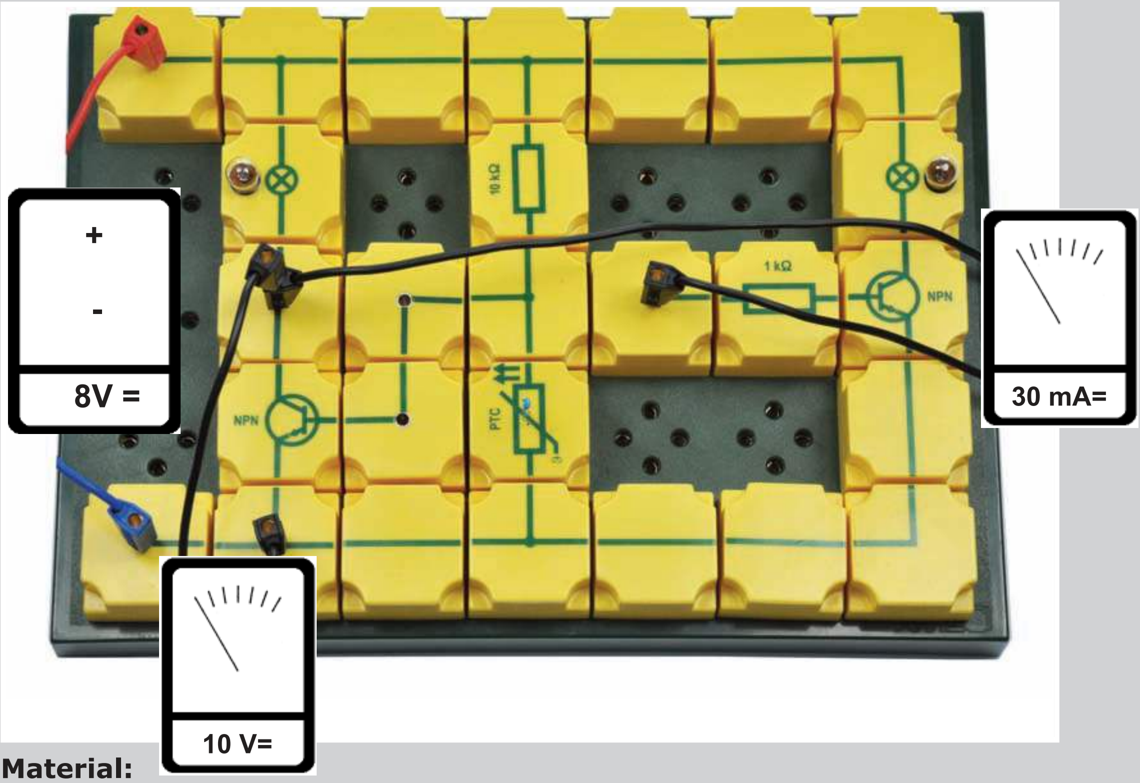
Base current to the second transistor:........ mA

Conclusion:
If the first transistor T_1 conducts, the total voltage is at the incandescent lamp passed by the electric current.
The collector voltage therefore is low.
That is the reason why no base current can flow to the second transistor which is blocked.
If the first transistor is blocked, the incandescent lamp does not cause a drop of voltage (because of I = 0, U = R x I = 0 as well).
The collector voltage is high, base current flows to the second transistor which is conducting.

ALARM ON HEATING FAILURE

EOS 8.1.2

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Conencting lead, blue
3x PIB connector
7x PIB wire, straight
1x PIB wire, straight, with socket
4x PIB wire, T-shaped
1x PIB wire, T-shaped, with socket
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB resistor 1 kOhm
2x PIB lamp socket E10
2x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB PTC resistor
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

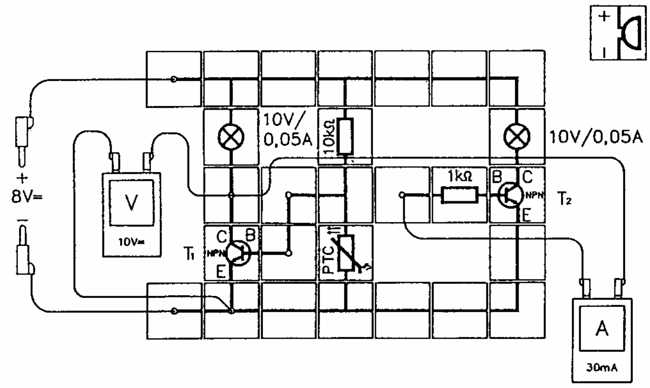
Additionally required:
2x Meter
1x Voltage supply

ALARM ON HEATING FAILURE

EOS 8.1.2

As an example of the control of a second step of a transistor by means of the collector voltage of the first step and alarm circuit effective at failure of a heating is investigated.

Wiring:



Arrange the wiring according to the illustration.

The base voltage divider consists of the PTC-resistor and the resistor 10 kΩ.

The voltmeter measures the collector voltage of the first transistor and is used with the measuring range of 10 V =.

The ammeter is used with the measuring range of 30 mA =. A D.C. of 8 Volt is applied.

Experiment:

The cold PTC-resistor has a relatively low amount of resistance. Thus the left transistor T_1 blocks and the right transistor T_2 conducts.

The PTC-resistor is warmed by means of a match.
Thus its amount of resistance increases, the transistor T_1 gets conducting and T_2 thus blocks. The right incandescent lamp does not glow.

The right lamp is replaced by the buzzer.

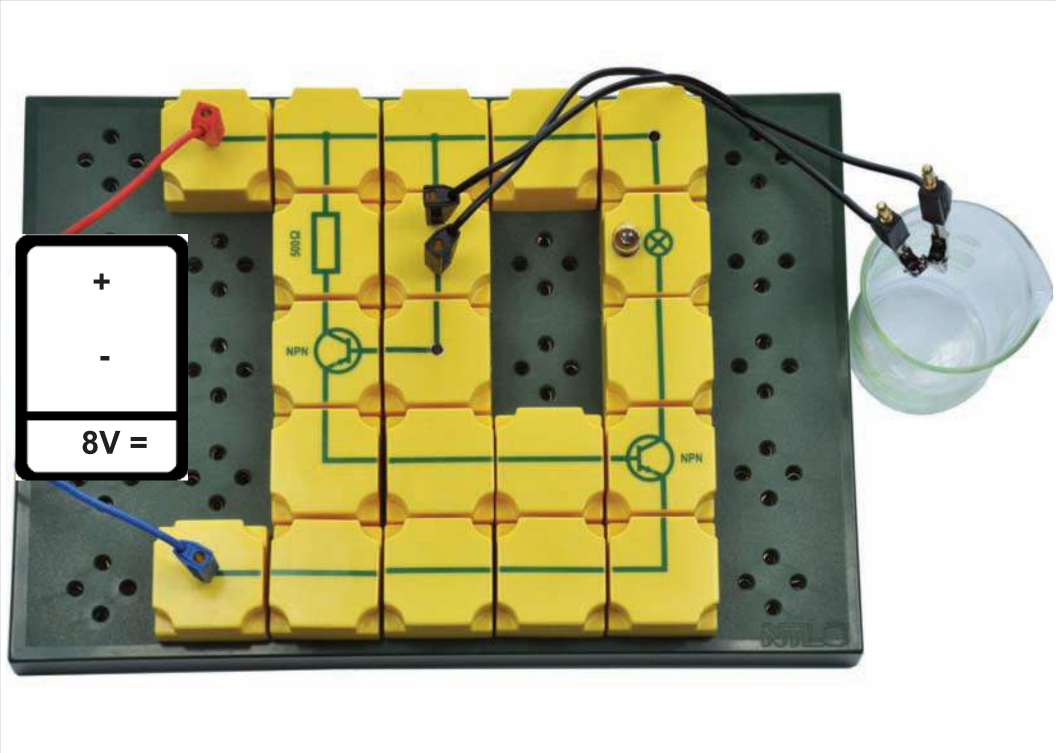
The PTC-resistor cools down without heating, thus its original state is reached. The transistor T_2 conducts and the alarm sounds.

Conclusion:
The small amount of resistance of a cold PTC-resistor can be used for sounding a buzzer. If the heating fails the temperature of the PTC is too low thus causing the alarm.

AUTOMATIC LEVEL MEASUREMENT

EOS 8.2

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
7x PIB wire, straight
2x PIB wire, T-shaped
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB resistor 500 Ohm
1x PIB lamp socket E10
1x Light bulb 10V/50mA
2x Crocodile clip with plug
1x PIB Buzzer
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additionally required:
1x Beaker
1x Voltage supply

AUTOMATIC LEVEL MEASUREMENT

EOS 8.2

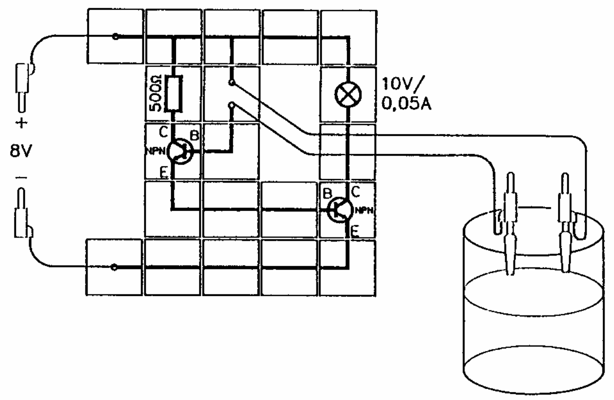
If a vessel is filled with liquid an indication when reaching a certain filling height is often desired.

Wiring:

Arrange the wiring according to the illustration.

The circuit is the Darlington-arrangement. Two connecting leads are inserted in a PIB-lead interrupted.

The crocodile clips with plug pin are attached to the other end and clamped to the empty beaker.



Experiment:

Water is filled into the beaker by means of the measuring cylinder.

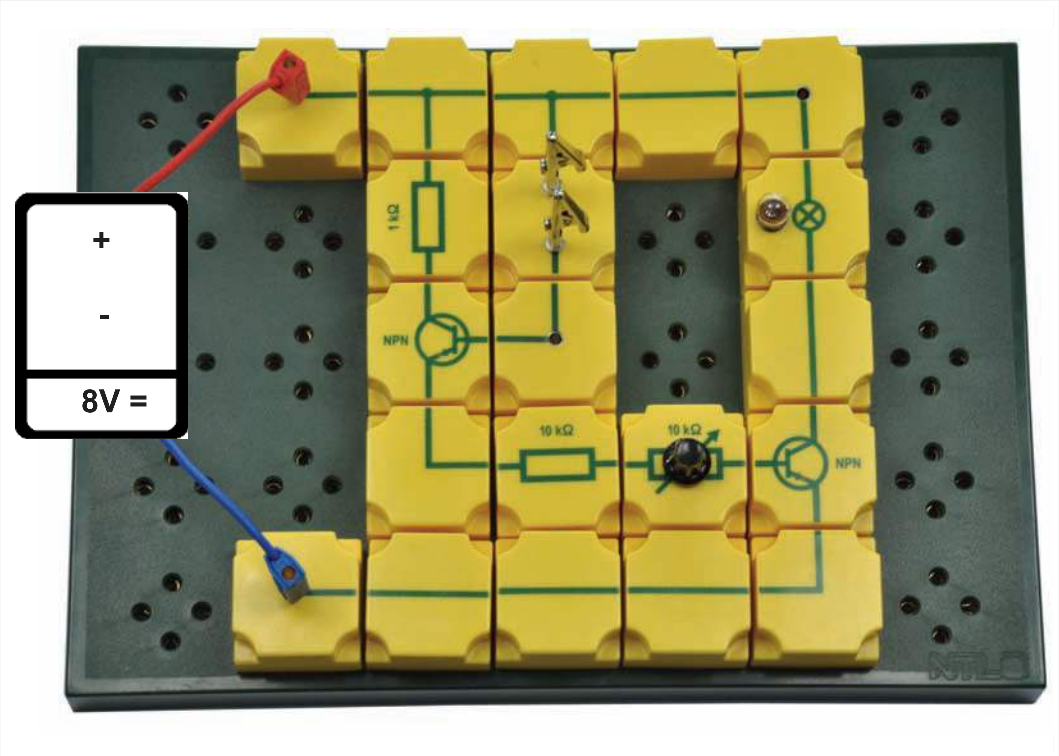
When the water reaches the two electrodes (pins of the connecting leads) the lamp glows.
The lamp can also be replaced by the buzzer.

Conclusion:
The Darlington-arrangement makes an indication of levels possible, even with poorly conducting liquids.

LIE DETECTOR

EOS 8.3

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
5x PIB wire, straight
2x PIB wire, T-shaped
2x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB resistor 1 kOhm
1x PIB lamp socket E10
1x Light bulb 10V/50mA
2x Crocodile clip with plug
1x PIB resistor 10 kOhm
1x PIB rheostat 10 kOhm
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additionally required:
1x Voltage supply

LIE DETECTOR

EOS 8.3

A lie detector is based on the principle that the moisture of the skin increases with excitement. Thus a person's amount of resistance decreases.

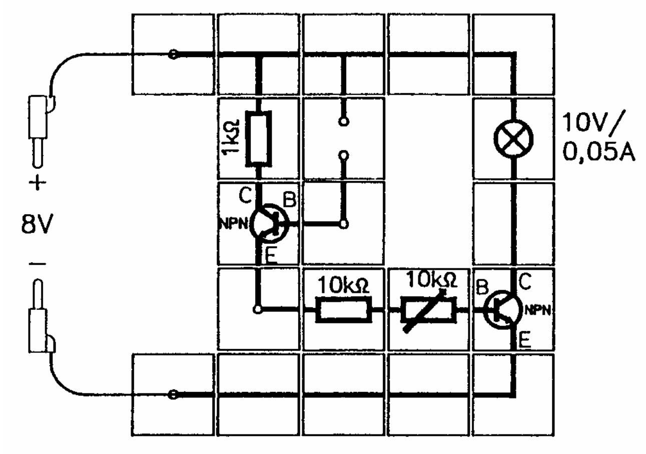
Wiring:

Arrange the wiring according to the illustration.

Additional resistors are inserted in the Darlington-arrangement.

Two crocodile clips with plug pin are inserted in the PIB-lead interrupted.

The adjustment by means of the variable resistor is done in such a way that when the crocodile clips are touched with dry fingers no glowing of the lamp is caused.



A D.C. source of 8 Volt is applied.
The crocodile clips ought to be touched, but must not be pressed too strongley.

Experiment:

If the touching of the crocodile clips causes no or only a very weak glowing of the lamp, the fingers are moistened and the crocodile clips are touched again.

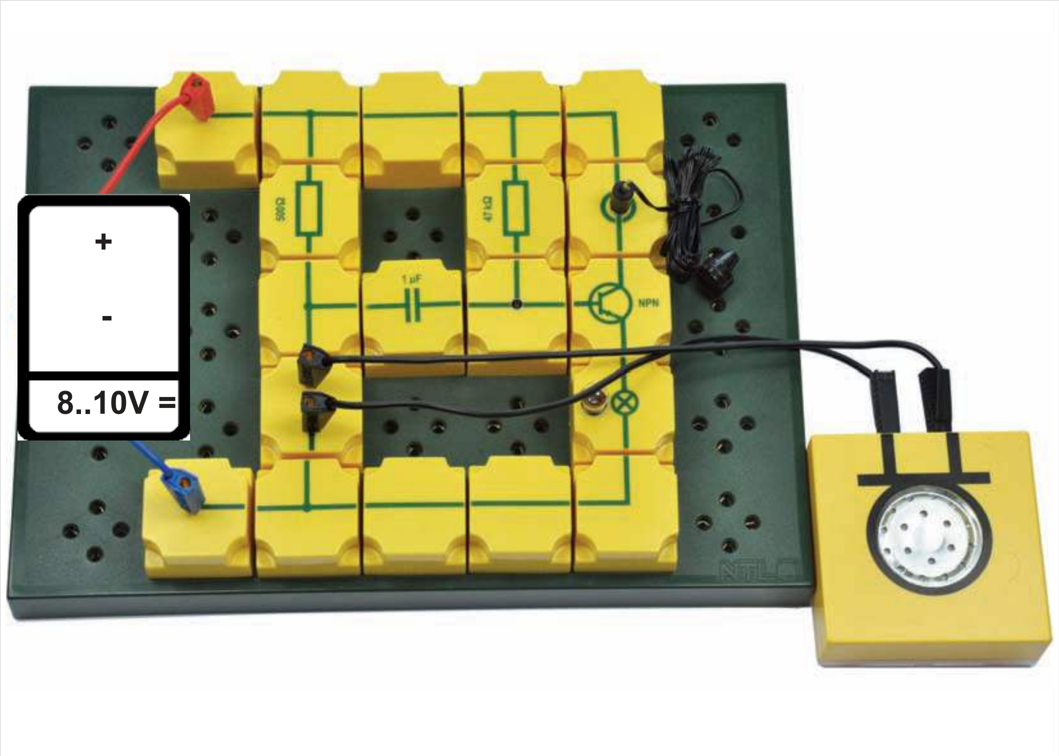
Now the lamp glows.

Conclusion:
Moistening of the skin can be proved by means of a Darlington-arrangement.
This is the principle of a lie detector.

MICROPHONE AMPLIFIER

EOS 8.4

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



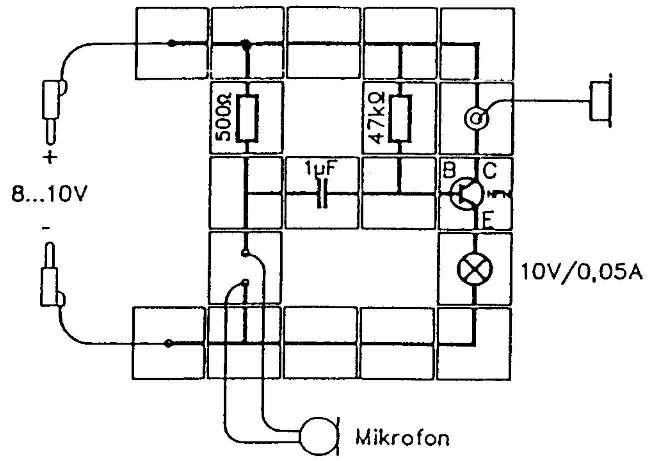
Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
5x PIB wire, T-shaped
2x PIB wire, angled
1x PIB wire, interrupted, with sockets
1x PIB resistor 500 Ohm
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 47 kOhm
1x Earphones
1x PIB capacitor 1 µF
1x PIB wire with jack bush
1x PIB transistor NPN, base left
1x MBC microphone

Additionally required:
1x Voltage supply

MICROPHONE AMPLIFIER

EOS 8.4

A simple wiring for the amplification of speaking oscillations is to be investigated.



Wiring:

Arrange the wiring according to the illustration.

The carbon microphone is connected in series with the resistor 500 Ω at the operating voltage (8 V – 10 V).

The voltage fluctuations caused by the peaking oscillations are led to the base via the condenser.

The base supplied with D.C. for adjusting the operating point via the resistor 47 kΩ.

The earphone is connected to the collector circuit by means of the PIB with jack bush. The base. D.C. is kept away from the signal which is to be amplified by the condenser.

The earphone should not be used by the same person speaking into the microphone.

Experiment:

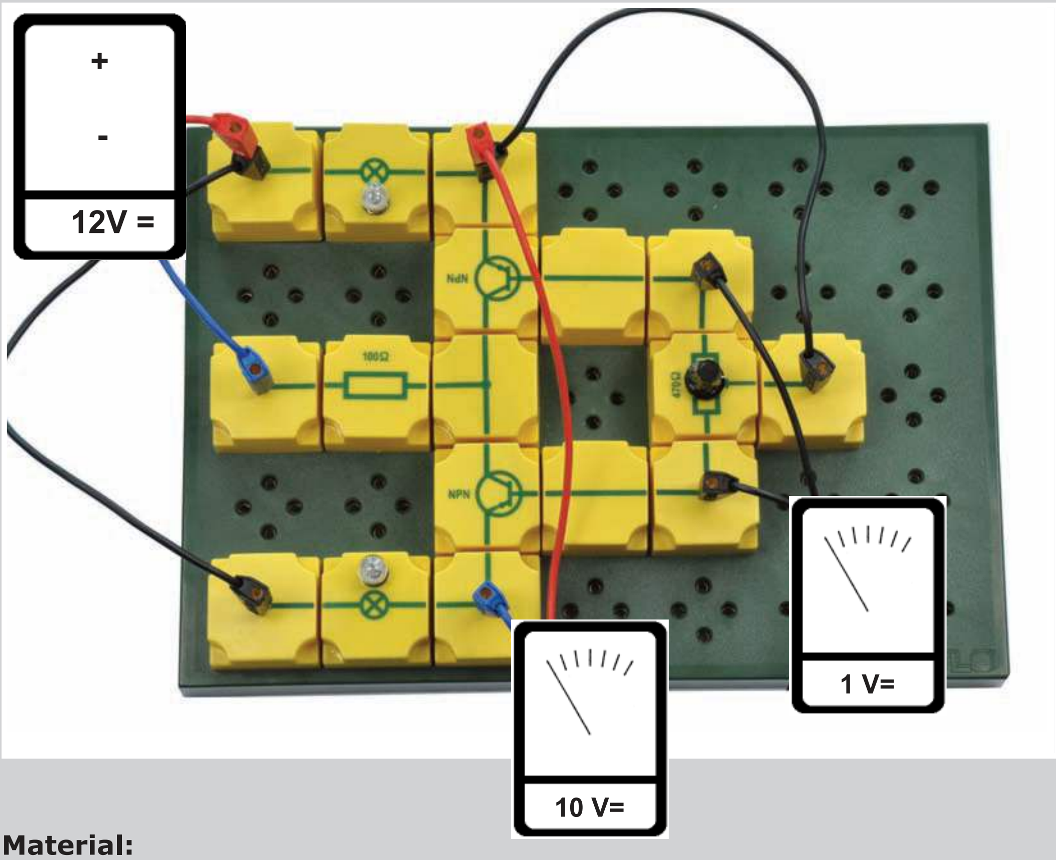
Either the fingers tap at the microphone or something is spoken into it. The earphone makes the amplified oscillations audible.

Conclusion:
The voltage which is to be amplified is led to the base and to the emittor of a transistor via the condenser for the amplification of voice.
The amlified signal can be tapped at the collector contact.

SUM AND DIFFERENCE AMPLIFIER

EOS 8.5

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



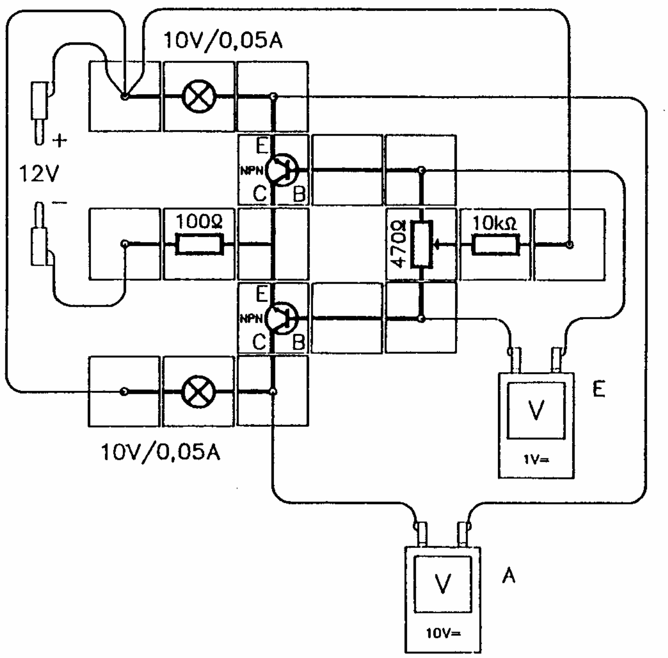
Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
4x PIB connector
2x PIB wire, straight
1x PIB wire, T-shaped
4x PIB wire, angledm with socket
1x PIB resistor 100 Ohm
2x PIB lamp socket E10
2x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB potentiometer 47 kOhm
1x PIB transistor NPN, base left
1x PIB transistor NPN, base right

Additionally required:
2x Meter
1x Voltage supply

SUM AND DIFFERENCE AMPLIFIER

EOS 8.5

The sum and difference-amplifier is the basis for many different types of operational amplifiers which are used in electronics today.



Wiring:

Arrange the wiring according to the illustration.

The positive pole of the voltage source is connected with the three points of the connection: with the collector connectors via the lamp and with the center tapping of the potentiometer via the resistor 10 kΩ.
The two emitters are at the negative pole above the resistor 100 Ω.
If the tapping of the potentionmeter is exactly in its middle there is the same input voltage at both base connections.

A difference of voltage can be adjusted at the base connections by turning the tapping.
The output voltage is tapped at the two collector connections of the transistors.
A D.C. of 12 Volt is applied.

1.Experiment:

The potentiometer is adjusted in such a way that the voltmeter A (measuring range of 10 V =) which indicates the „output voltage" between the collector connections has the voltage 0.
The „input voltage" between the base connections is measured by means of the voltmeter E (measuring range of 0,3 V =) as well.

Input voltage : V

2.Experiment:

The turning knob of the potentiometer is turned in both directions.
If it is turned to the right the upper incandescent lamp gets brighter the lower one darker.
If it is turned to the left the lower incandescent lamp gets brighter and the upper one darker.

The voltmeter A indicates the corresonding positive and negative voltage.

3.Experiment:

The amplification factor is to be defined.
The voltmeter A is switched over to the 3 V = range.
The output voltage is adjusted to exactly 1 Volt by means of the potentiometer.

The input voltage is read at the voltmeter E:

Input voltage U_{E1} = ... mV

Then the output voltage is adjusted to 3 Volt and the input voltage is read again:

Input voltage U_{E2} = ... mV

The difference between the output voltages and the difference between the input voltages are calculated. The ratio of the two differences is the amplification factor.

Difference of the output voltages: 2 V

Difference of the input voltages: $U_{E2} - U_{E1}$ = ... mV

Ratio: ....

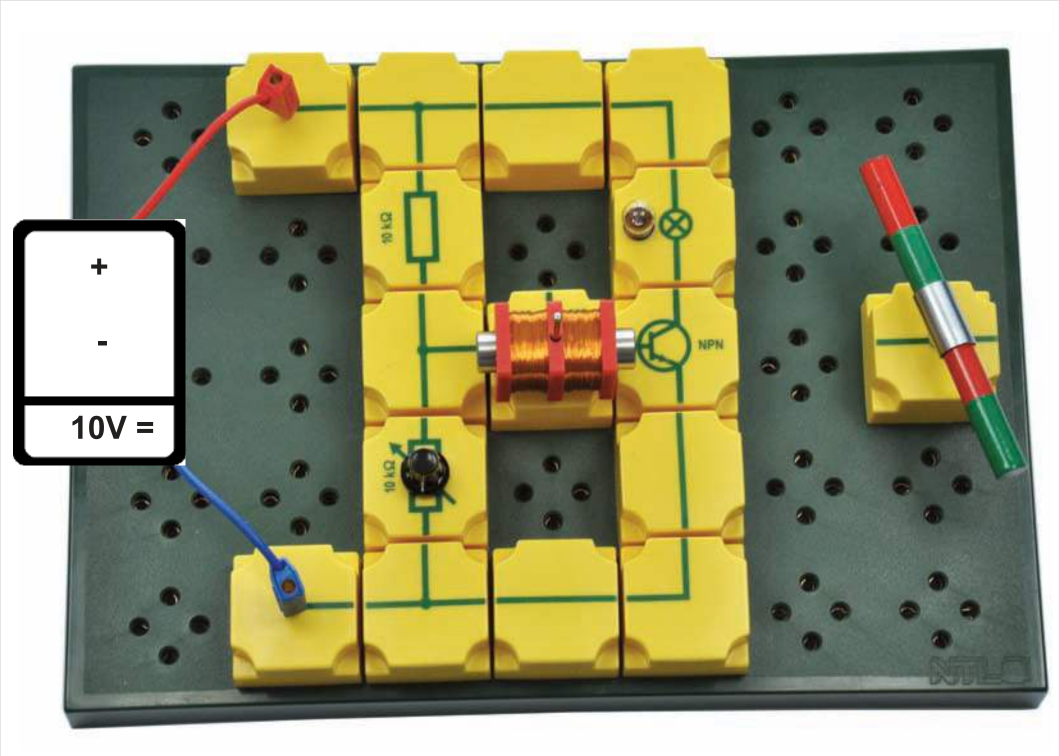
The ratio is named „low-loading amplification".

Conclusion:
A sum and difference-amplifier amplifies the difference between the voltages at the base connections of two transistors.

A MOTOR ARMATURE SIGNALS ITS POSITION

EOS 8.6

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism
P9110-5M Magnetism



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
3x PIB wire, straight
3x PIB wire, T-shaped
2x PIB wire, angled
1x PIB resistor 10 kOhm
1x PIB rheostat 10 kOhm
1x PIB transistor NPN, base left
1x Iron core solid
1x PIB for coil with 2x 800 turns
1x Coil with 2x 800 turns, red
2x Bar magnet
1x Plug-in pin with needle
1x Insulating block with socket
1x Bearing bush

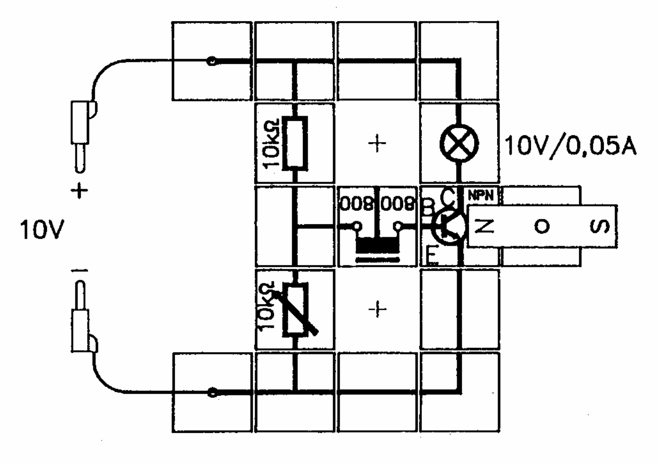
Additionally required:
1x Voltage supply

A MOTOR ARMATURE SIGNALS ITS POSITION

EOS 8.6

This experiment is to show how the armature of a motor can signal its position.

Wiring:



Arrange the wiring according to the illustration.

The PI-coil with 2 x 800 turns is provided with the iron core and connected in front of the transistor base.

The cylindrical magnet which is assembled from the two cylindrical magnets by means of the bearing bush and placed on the plug pin with needle rotates in front of the iron core.

The plug pin with needle is in a PIB-lead straight with socket which is inserted in the circuit board.

A D.C. source of 10 Volt is applied.

Experiment:

The cylindrical magnet does not move first.
The variable transistor is adjusted in such a way that the lamp glows with about half its strength.
Then the cylindrical magnet is set in rotation.
When the north pole comes near the collector current decreases, when the south pole comes near the collector current increases.

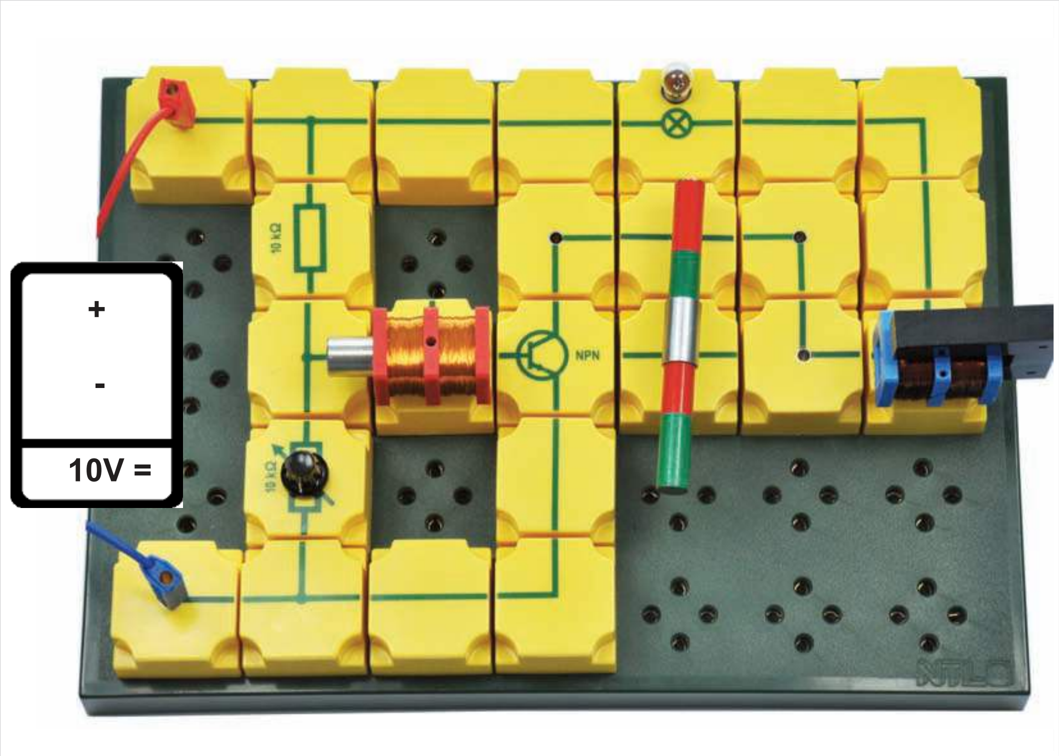
The reason for this is the induction in the coil.

Conclusion:
The transistor circuit is informed about the momentary position of the rotating armature (cylindrical magnet) by induction.

DIRECT CURRENT MOTOR WITHOUT COMMUTATOR

EOS 8.7

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism
P9110-5M Magnetism



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
6x PIB wire, straight
1x PIB wire, straight, with scoket
3x PIB wire, T-shaped
3x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB resistor 10 kOhm
1x PIB rheostat 10 kOhm
1x PIB transistor NPN, base left
1x Iron core solid
1x PIB for coil with 800 turns
1x PIB for coil with 2x 800 turns
1x Coil with 800 turns, blue
1x Coil with 2x 800 turns, red
2x Bar magnet
1x Plug-in pin with needle
1x Insulating block with socket
1x Bearing bush

Additionally required:
1x Voltage supply

DIRECT CURRENT MOTOR WITHOUT COMMUTATOR

EOS 8.7

A transistor amplifying circuit takes over the task of the collector in a D.C. motor without collector.

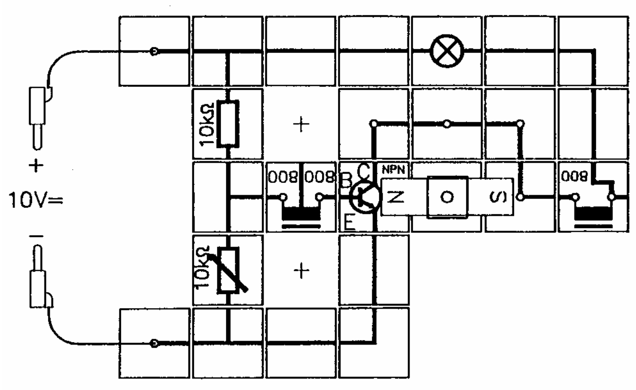
The signalling of the position of the armature is used in order to control the current in the field coil in such a way that one magnetic pole of the armature (rotor) is attracted when approaching, while the current is switched off when this pole withdraws.

Wiring:

Arrange the wiring according to the illustration.

The coil with 2 x 800 turns is provided with the solid iron core and connected in front of the base of the transistor.

The U-shaped core is shoved in the coil with 800 turns.



The cylindrical magnet which is assembled from the two cylindrical magnets by means of the bearing bush and which is placed on the plug pin with needle rotates between the two iron cores.
The plug pin with needle is in a PIB-lead straight with socked which is inserted in the circuit board.
The variable resistor 10 kΩ is adjusted when the cylindrical magnet does not move in such a way that the lamp glows with about half its strength.
This adjustment of the variable resistor is not changed any more.

Experiment:

The cylindrical magnet is set in rotation.
It can be seen that the incandescent lamp glows with different brightness depending on how the base current is changed by the inductive voltage in the coil with 2 x 800 turns.

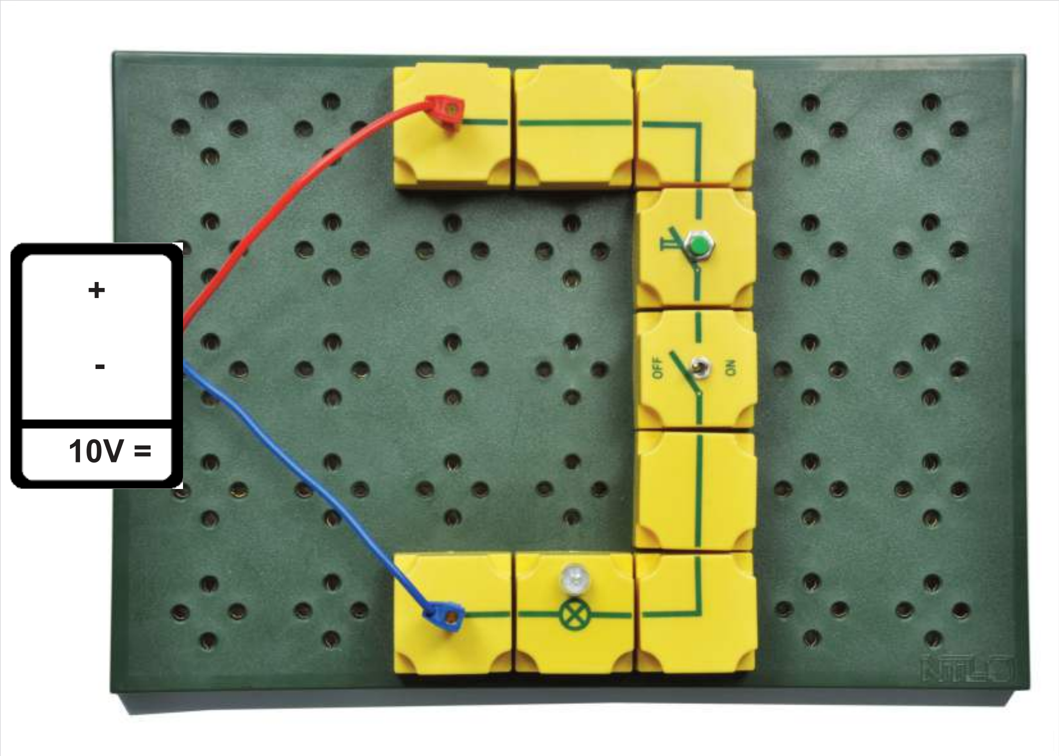
The cylindrical magnet rotates on its own with correct adjustment of the operating point and correct polarity of the coil.

Conclusion:
This circuit is a simple feedback system.
The rotating armature controls its drive on its own by means of the amplification circuit.

Note: The lamp is not only used for indicating the changing collector current but also for current limitation and thus for speed limitation in order to keep the rotor magnets in the bearing bush.

LOGICAL AND

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
2x PIB wire, straight
2x PIB wire, angled
2x PIB switch ON/OFF
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB pushbutton

Additionally required:
1x Voltage supply

LOGICAL AND

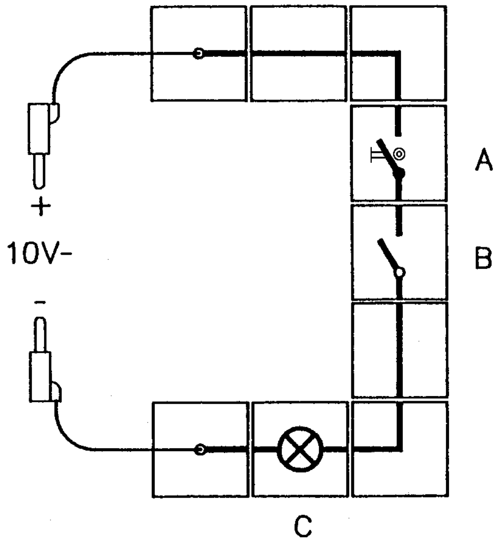
EOS 9.1

Logic circuits connect bivalent input quantities with a bivalent output quantity.
The input quantities are two switches (or PIB pushbutton) A and B in this experiment.

These switches can have two conditions:

1. Switch closed, corresponds to HIGH
2. Switch open, corresponds to LOW.

The output quantity C is represented by the glowing (HIGH) or non-glowing (LOW) of the lamp C.



Wiring:

Arrange the wiring according to the illustration.

The switch is open first.

A D.C. source of 10 Volt is applied.

The lamp does not glow yet.

Experiment:

Each time only one switch (or PIB pushbutton) is closed and the lamp is watched.
It does not glow because the circuit is open.
Then both switches (or PIB pushbutton) are closed. The lamp glows.

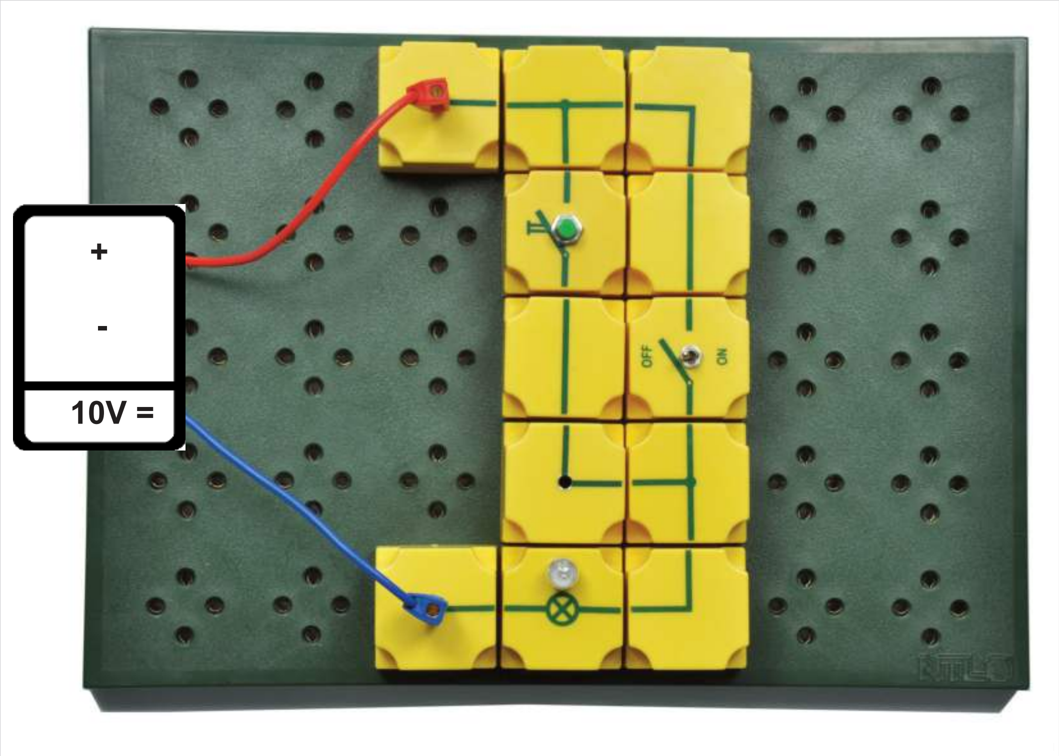
The results are listed in the chart. H stands for HIGH and L for LOW:

A	H	H	L	L
B	H	L	H	L
C	…	….	….	…..

Conclusion:
The output quantity is only in HIGH-condition in the AND-circuit if both input quantities are HIGH.

LOGICAL OR

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement
P9902-5P Electromagnetism



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
2x PIB wire, straight
2x PIB wire, T-shaped
1x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB switch ON/OFF
1x PIB lamp socket E10
1x Light bulb 10V/50mA
1x PIB pushbutton

Additionally required:
1x Voltage supply

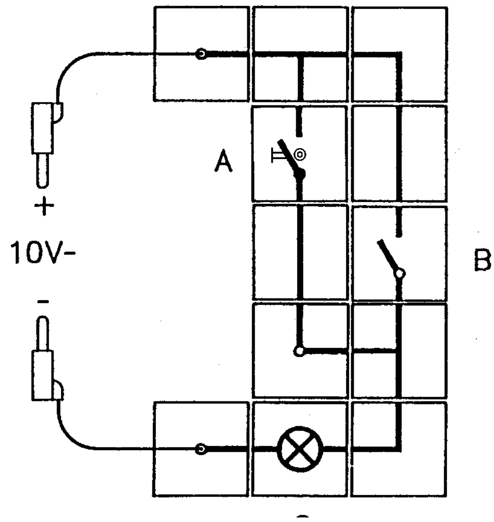
LOGICAL OR

EOS 9.2

Logic circuits connect bivalent input quantities with a bivalent output quantity.
In this experiment the input quantities are two switches (or PIB pushbutton) A and B which can have two different conditions.

1. Switch closed, corresponds to HIGH
2. Switch open, corresponds to LOW.

The output quantity C is represented by the glowing (HIGH) or non-glowing (LOW) of the lamp C.



Wiring:

Arrange the wiring according to the illustration.

The switch is open first.

A D.C. source of 10 Volt is applied.

The lamp does not glow yet.

Experiment:

Each time only one switch (or PIB pushbutton) is closed and the lamp is watched.
It glows as soon as a switch (or PIB pushbutton) is closed.
If both switches (or PIB pushbutton) are closed at the same time the lamp glows as well.

The results are listed in the chart. H stands for HIGH and L for LOW.

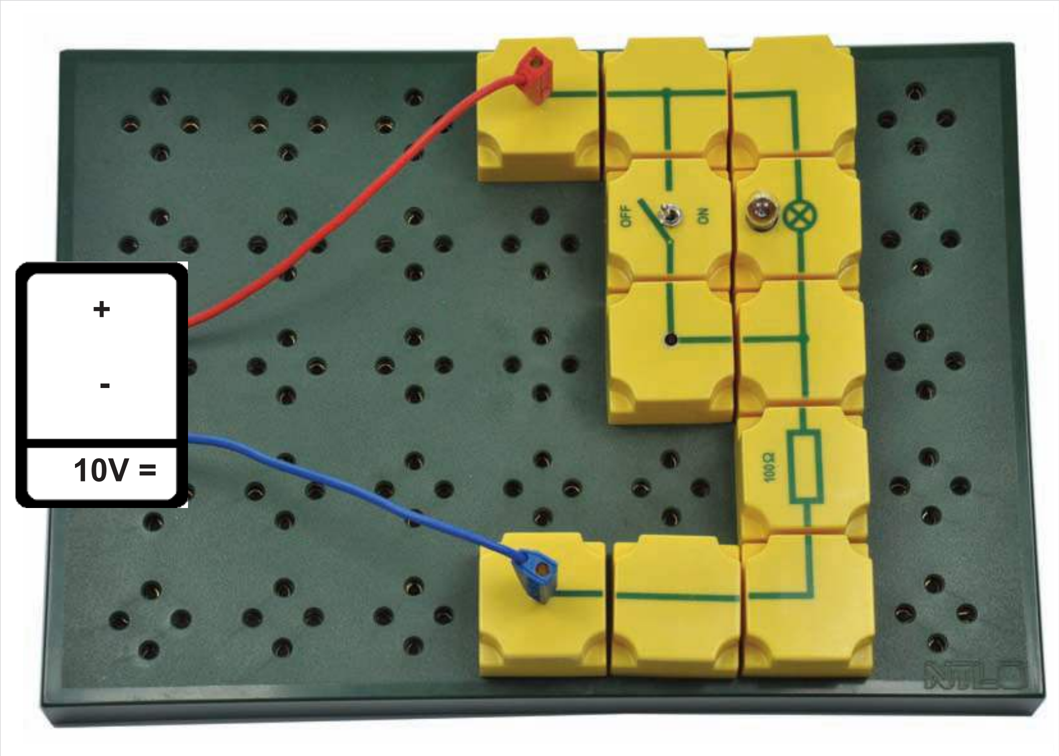
A	H	H	L	L
B	H	L	H	L
C	...	....	....	.....

Conclusion:
The output quantity is in condition HIGH in an OR-circuit if at least one of the two input quantities is HIGH.

LOGICAL NOT

EOS 9.3

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
1x Connecting lead, red
1x Connecting lead, blue
2x PIB connector
1x PIB wire, straight
2x PIB wire, T-shaped
1x PIB wire, angled, with socket
2x PIB wire, angled
1x PIB switch ON/OFF
1x PIB resistor 100 Ohm
1x PIB lamp socket E10
1x Light bulb 10V/50mA

Additionally required:
1x Voltage supply

LOGICAL NOT

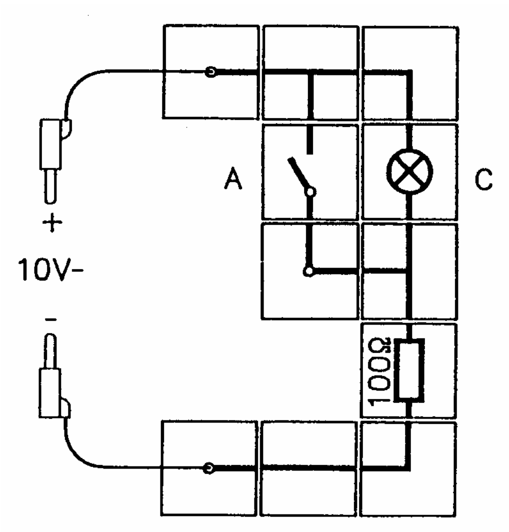
EOS 9.3

Logic circuits connect bivalent input quantities with a bivalent output quantity.
In this experiment the input quantity is a switch A which can have two different conditions.

1. Switch closed, corresponds to HIGH
2. Switch open, corresponds to LOW.

The output quantity is represented by the glowing (HIGH) or non-glowing (LOW) of the lamp C.

Wiring:



Arrange the wiring according to the illustration.

The switch is connected in parallel to the lamp and is open first.

The resistor 100 Ohm is connected in series to the parallel connection of switch and lamp.

A D.C. source of 10 Volt is applied.

The lamp glows.

Experiment:

The switch is closed and the lamp is watched.
It does not glow because the closed switch serves as a short-circuit.
The switch is reopened. The lamp glows.

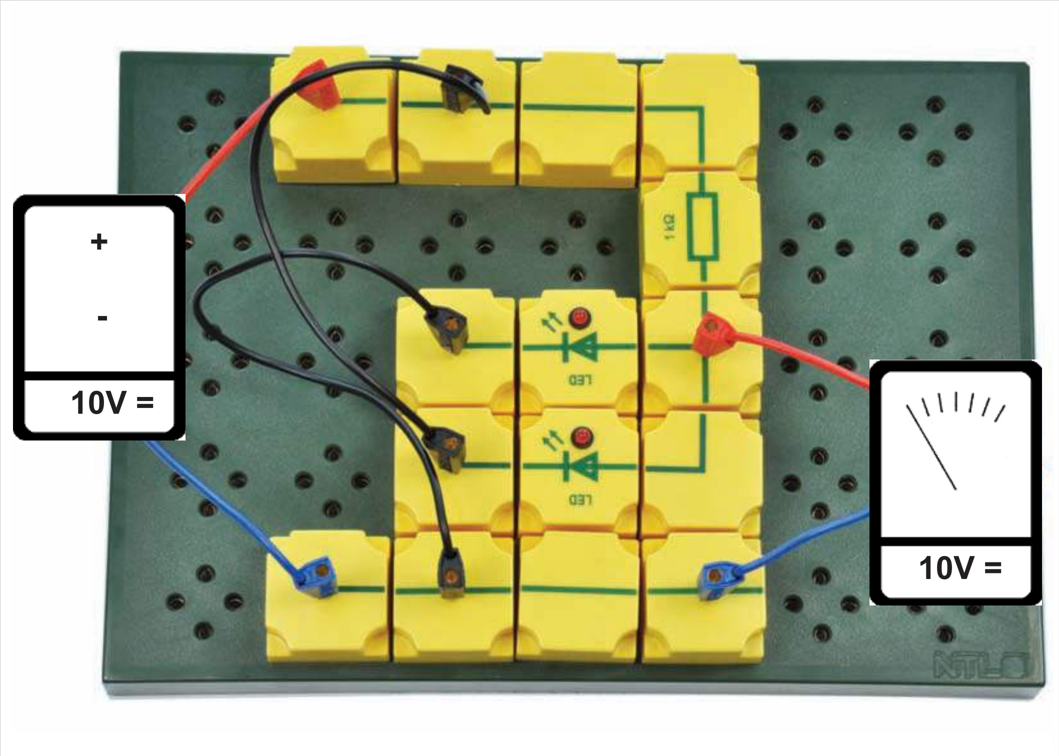
The results are listed in a chart. H stands for HIGH and L for LOW.

A	H	L
C	….	…..

Conclusion:
The output quantity is in HIGH-condition in NOT-circuits if the input quantity is LOW.

AND CIRCUIT

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
4x PIB connector
2x PIB wire, straight
3x PIB wire, straight, with socket
1x PIB wire, T-shaped, with socket
2x PIB wire, angled
1x PIB resistor 1 kOhm
2x PIB LED red or Si diode

Additionally required:
1x Meter
1x Voltage supply

AND CIRCUIT

Logic circuits connect binary conditions at inputs to binary conditions at an output.

The binary conditions are HIGH (voltage 8 –10 Volt, referred to as H) and LOW (voltage 0 –2 Volt, referred to as L).

Wiring:

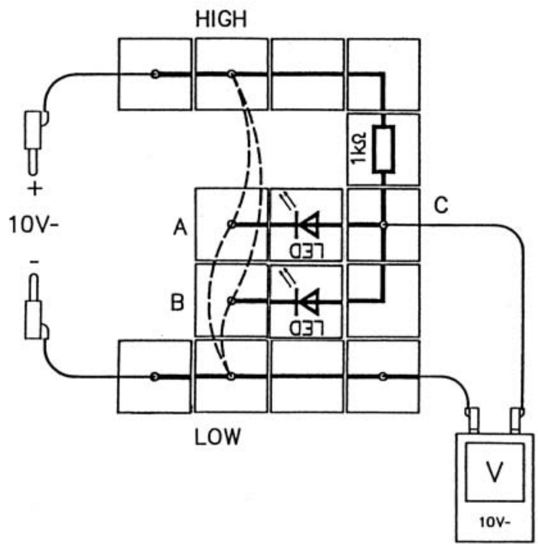
Arrange the wiring according to the illustration.

The inputs A and B are put near HIGH by connection with the positive lead or near LOW by connection with the negative lead to which all voltages are referred to.

The voltmeter with the measuring range of 10 V = is used.

It indicates the condition at the output C.

The two inputs must always be HIGH of LOW, which means that the connecting leads must always be plugged in.



Experiment:

All four possibilities of the condition of the two inputs are tried one after the other.

The results are listed in the chart. H stands for HIGH and L for LOW.

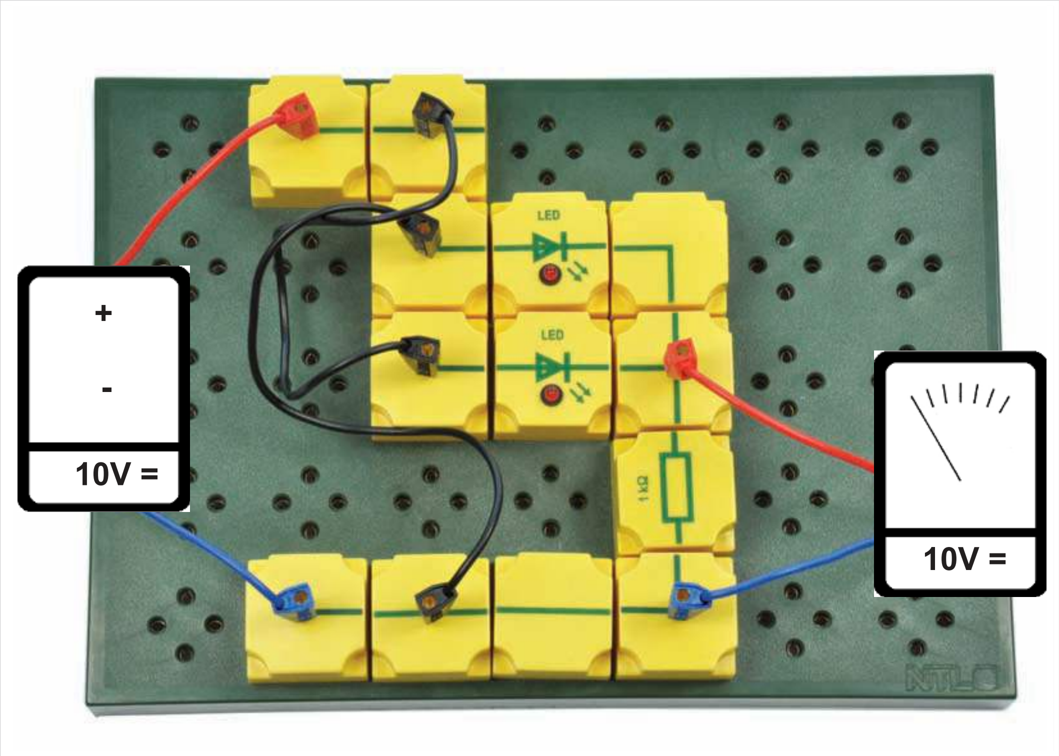
A	H	H	L	L
B	H	L	H	L
C	….	….	….	…..

Conclusion:
The output is HIGH in an AND-circuit only if A as well as B are in HIGH-condition.

OR CIRCUIT

EOS 9.5

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
1x Connecting lead, red
1x Connecting lead, blue
4x PIB connector
1x PIB wire, straight
2x PIB wire, straight, with socket
1x PIB wire, T-shaped, with socket
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB resistor 1 kOhm
2x PIB LED red or Si diode

Additionally required:
1x Meter
1x Voltage supply

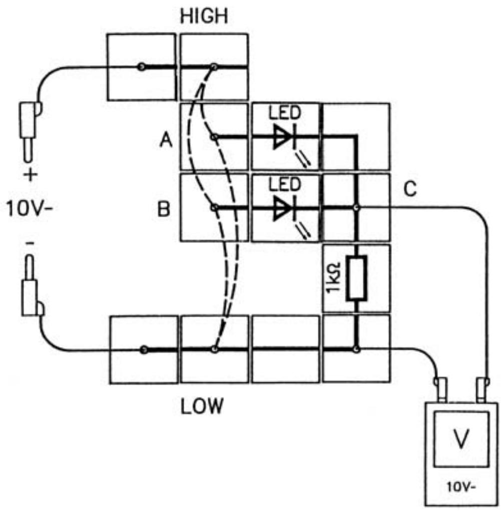
OR CIRCUIT

EOS 9.5

Logic circuits connect binary conditions at inputs to binary conditions at an output.
The binary conditions are HIGH (voltage 8 – 10 volt, referred to as H) and LOW (voltage 0 – 2 Volt, referred to as L).

Wiring:

Arrange the wiring according to the illustration.



The inputs A and B are put near HIGH by connection with the positive lead or near LOW by connection with the negative lead to which all voltages are referred to.

The voltmeter is used in the 10 V = range.

It indicates the condition at output C.

The two inputs must always be HIGH or LOW which means that the connecting leads must alwys be plugged in.

Experiment:

All four possibilities of the condition of the two inputs are tried one after the other.

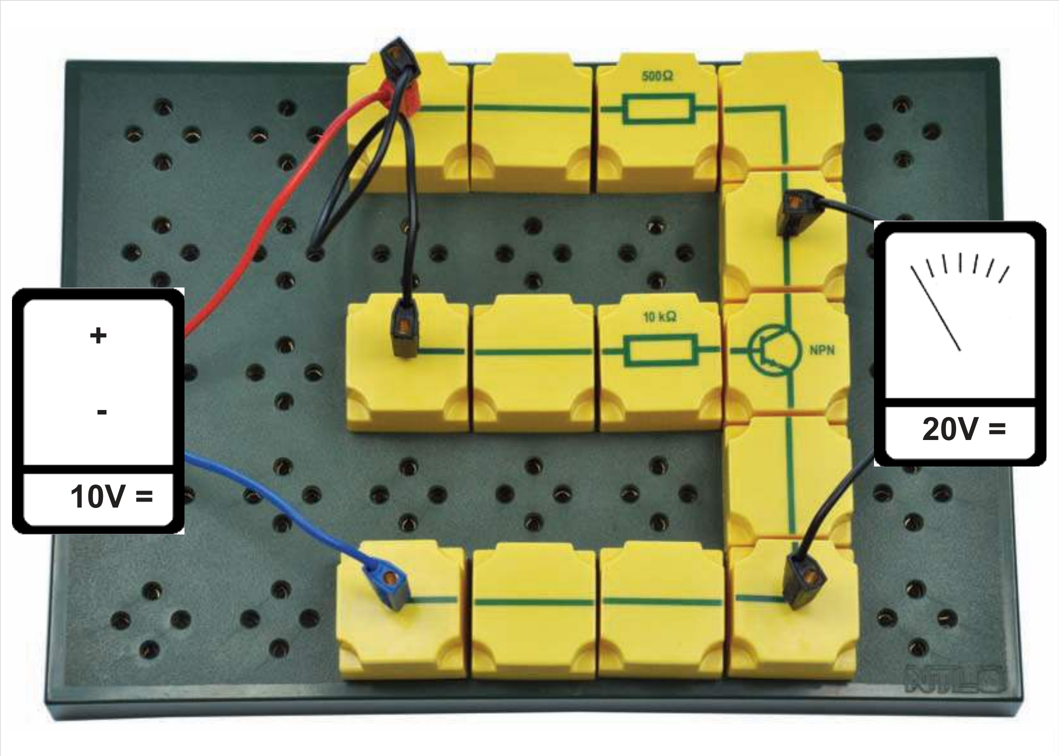
The results are listed in the chart. H stands for HIGH and L for LOW.

A	H	H	L	L
B	H	L	H	L
C	….	….	….	….

Conclusion:
The output is HIGH in OR-circuits only if at least one of the inputs is HIGH.

NOT CIRCUIT

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
3x PIB connector
5x PIB wire, straight
1x PIB wire, straight, with socket
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB resistor 500 Ohm
1x PIB resistor 10 kOhm
1x PIB transistor NPN, base left

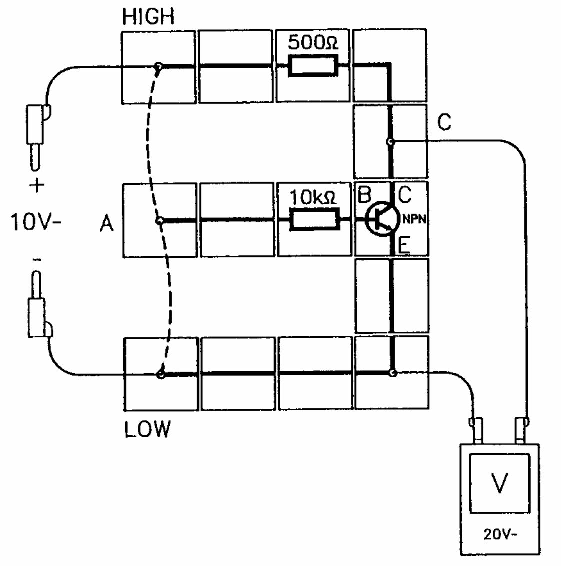
Additionally required:
1x Meter
1x Voltage supply

NOT CIRCUIT

EOS 9.6

The NOT-circuit is supposed to effect that the output C always is of opposite condition to the input.

Wiring:



Arrange the wiring according to the illustration.

The input A is put near HIGH by connection with the positive lead or near LOW by connection with the negative lead to which all voltages are referred to.

The voltmeter indicates the condition at output C.

The input must always be HIGH or LOW, which means that the connecting leads must always be plugged in.

Experiment:

The two possibilities of the condition at input A are tried.
The results are listed in a chart. H stands for HIGH and L for LOW.

A	H	L
C	….	……

Explanation:

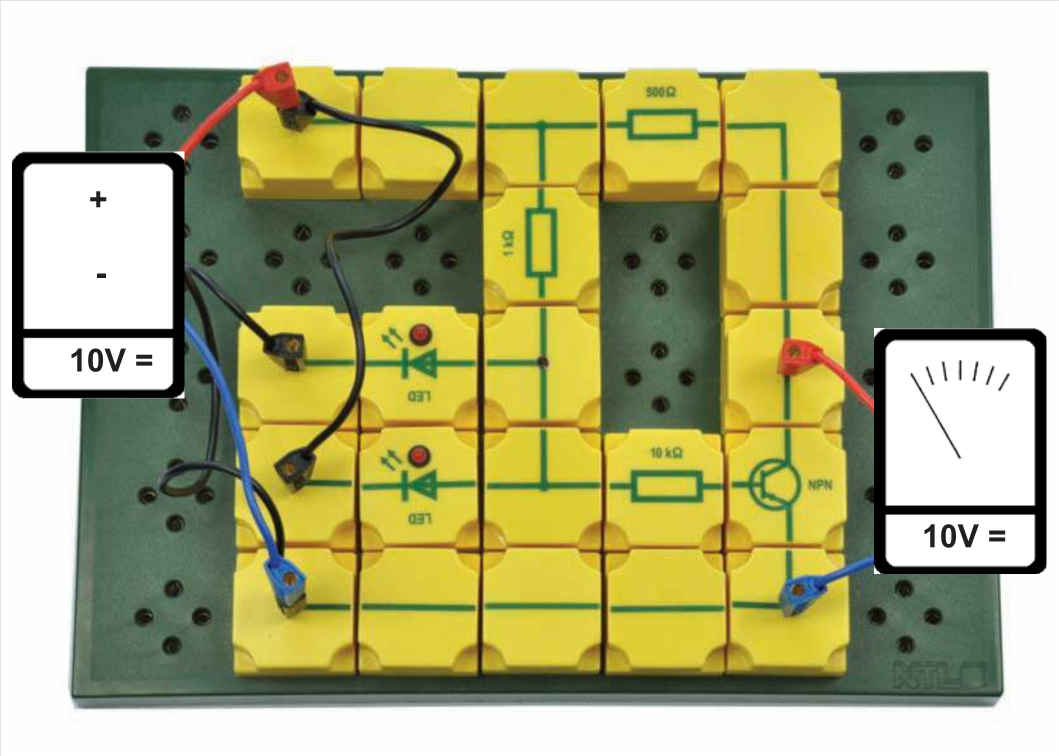
If A is put in HIGH-conduction base current flows and the transistor gets conducting.

The conducting transistor functions as a closed switch.
No drop of voltage is noticed at this switch (C is LOW).
If the transistor blocks (A is LOW) the total voltage lies a the transistor (C is HIGH) like at an open switch.

Conclusion:
The output is always in opposite direction to the input in NOT-circuits.
This can be achieved by an appropriate transistor-circuit.

NAND CIRCUIT

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
4x PIB connector
5x PIB wire, straight
1x PIB wire, straight, with socket
2x PIB wire, T-shaped
1x PIB wire, T-shaped, with socket
1x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB resistor 500 Ohm
1x PIB resistor 1 kOhm
1x PIB resistor 10 kOhm
1x PIB transistor NPN, base left
2x PIB LED red or Si diode

Additionally required:
1x Meter
1x Voltage supply

NAND CIRCUIT

EOS 9.7

The NAND-circuit is a combination of AND and NOT-circuit.

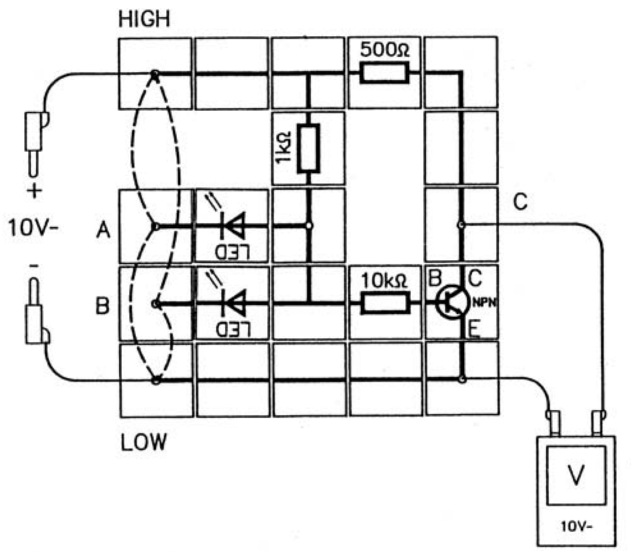
Wiring:

Arrange the wiring according to the illustration.

The inputs A and B are put near HIGH by connection with the positive lead or near LOW by connection with the negative lead to which all voltages are referred to.

The voltmeter indicates the condition at output C.

The two inputs must always be HIGH or LOW which means that the connecting leads must always be plugged in.



Experiment:

The four possibilities of the condition of the two quantities of input are tried one after the other.
The results are listed in a chart. H stands for HIGH and L for LOW.

The results are compared with the results of an AND-circuit.

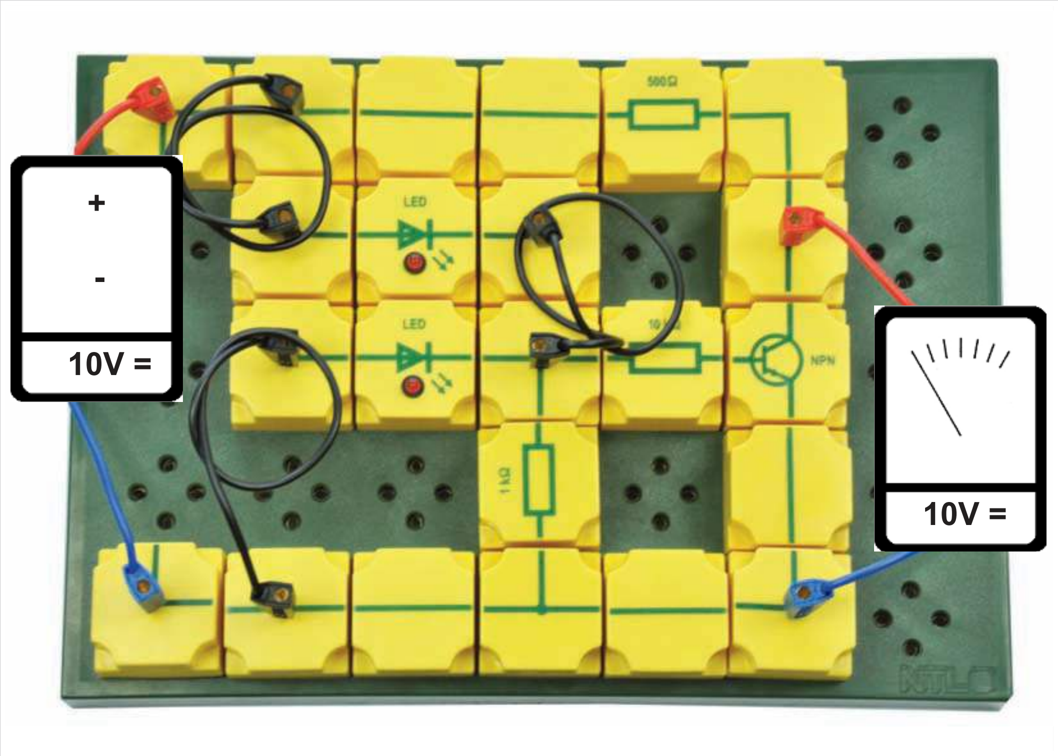
A	H	H	L	L
B	H	L	H	L
C	…	….	….	…..
A and B	H	L	L	L

Conclusion:
The NAND-circuit is the inversion of an AND-circuit (negation).
NOT AND is abbreviated to NAND.
The output is HIGH if only one or none of the inputs is HIGH.
If both inputs are HIGH, the output is LOW.

NOR CIRCUIT

EOS 9.8

Required Kit:
P9901-4D Electricity 1
P9901-4F Electronics supplement



Material:
1x Plug-in panel
2x Connecting lead, black
2x Connecting lead, red
2x Connecting lead, blue
3x PIB connector
5x PIB wire, straight
3x PIB wire, straight, with socket
1x PIB wire, T-shaped
1x PIB wire, T-shaped, with socket
3x PIB wire, angled, with socket
1x PIB wire, angled
1x PIB resistor 500 Ohm
1x PIB resistor 1 kOhm
1x PIB resistor 10 kOhm
1x PIB transistor NPN, base left
2x PIB LED red or Si diode

Additionally required:
1x Meter
1x Voltage supply

NOR CIRCUIT

EOS 9.8

The NOR-circuit is a combination of an OR-circuit and a NOT-circuit.

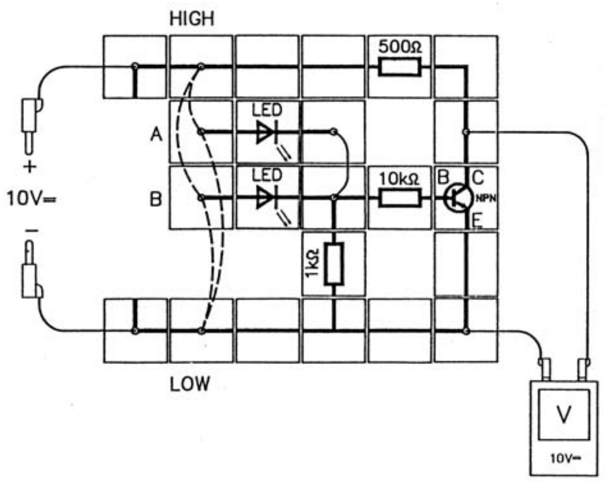
Wiring:

Arrange the wiring according to the illustration.

The inputs A and B are put near HIGH by connection with the positive lead or near LOW by connection with the negative lead to which all voltages are referred to.

The voltmeter indicates the condition at output C.

The two inputs must always be HIGH or LOW which means that the connecting leads must always be plugged in.



Experiment:

All four possibilities of the condition of the two input quantities are tried one after the other.
The results are listed in a chart. H stands for HIGH and L for LOW.

The results are compared with the results of an OR-circuit.

A	H	H	L	L
B	H	L	H	L
C	….	….	….	….
A OR B	H	H	H	L

Conclusion:
The NOR-circuit is the inversion of the OR-circuit. NOT OR is abbreviated to NOR.
The output is HIGH only if both inputs are LOW.

Student Experiments

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Austria

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