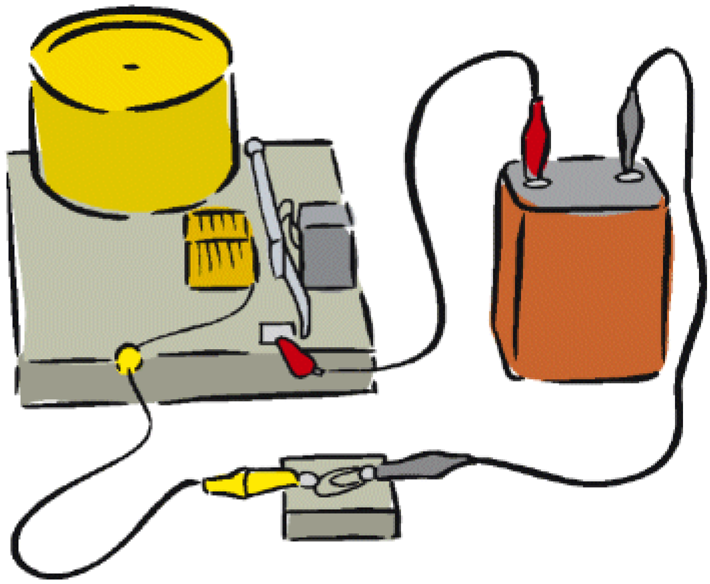
Light emitting diode



Training objectives and introduction

Light emitting diodes or LEDs are essential for many electronic circuits. On the following pages you will become familiar with various types and learn to characterise them on the basis of their threshold voltage.

In this experiment the threshold voltage of various light emitting diodes will be examined and compared to the threshold voltage of a silicon and germanium diode.

Introduction

Optoelectronics is a segment of electronics which involves the conversion of optical signals into electrical signals and viceversa. Optoelectronics also entails the coupling of optical and electronic signals. Knowledge of optoelectronics forms the foundation for its application in the area of communications engineering and in the transmission of optical signals via fibre optic waveguides.

Optical signals can be in located in the visible light range. In principle the range of optical radiation spans from infrared all the way into the ultraviolet range.

Standard light-emitting sources include:

- LEDs in diverse visible colours
- IR-LEDs
- Laser diodes

Standard light sensitive receivers include:

- Photoresistors
- Photodiodes
- Phototransistors
- Photothyristors
- Solar cells

LEDs

LEDs or light emitting diodes exist in various colours. The most common of these are red, green and yellow LEDs. In recent times blue LEDs have emerged thanks to requirements from the car industry (headlamp control lights). In addition to visible colours there are also LEDs which emit light which is invisible to the human eye, infrared light.

The current-voltage characteristics of LEDs differ only slightly from those of normal diodes. The break voltage of the characteristic depends on the colour of the LED.

Colour	*Threshold voltage*
IR	1.3 V
red	1.6 V - 1.8 V
orange	2.0 V
yellow	2.2 V
green	2.4 V
blue	4V - 4.5 V

The radiation strength is for all intents and purposes practically proportional to the diode current. However, LEDs possess limiting values which may not be exceeded as otherwise the component becomes damaged. The precise data on this can be taken from the manufacturer's data sheet.

Phototransistors

Like the photodiode the phototransistor is an optical signal detector. Various types of phototransistors have varing spectral sensitivity. For that reason they always have to be matched to the transmitter.
As in the case of a normal transistor, the phototransistor is equipped with an emitter and collector. But the base is not available to function as the third terminal. Instead the base-collector junction is designed with an expanded surface. When subject to light radiation a base current is evoked through photon absorption, which thanks to current amplification attracts an even larger collector-emitter current.

The family of output characteristics differ insignificantly from that of a standard transistor.
The rise and fall times of commercially available phototransistors are at a few µs, while the limiting frequency is correspondingly at a few hundred kHz.

The transistor is already supplied by a fixed power supply of 15 V having a series resistor R6 = 18 kOhm at the collector upstream and the emitter connected to ground.

Optocouplers

When the emitter and receiver are integrated in a self-contained unit, this is referred to as a n optocoupler. Optocouplers serve primarily to isolate electrical potential. As such people are able to operate and control life-threatening voltages without any problems using optocouplers and photothyristors because the couplers keep the hazardous electrical potential at a distance. In the area of digital technology the isolation of electrical potential using optocouplers is needed to avoid "hum" from feedback loops.

Fork light barriers

Light barriers are a typical application of optoelectronics. If receiver and emitter are in very close proximity and permanently attached to a U-shaped fork, this is called a fork light barrier. Fork light barriers are used, for example, to count the increments of a rotating disc or simply to test whether a tool is present or not.

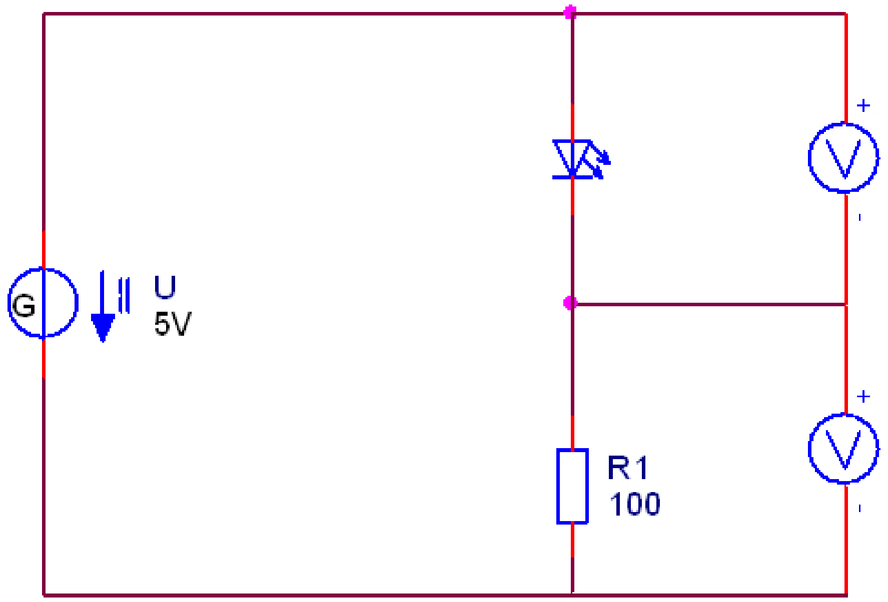
The fork light barrier found on the card OBP847 is equipped with both an

- IR-LED as well as a
- Phototransistor

Experiment procedure

Circuit diagram

The following circuit diagram is used for this experiment:



Components

The following components are used in this experiment:

Parts	Id no.	Designation
2	SO5126-5M	Cables
11	SO5124-6F	Bridge, small
1	PS4121-2N	R 100
1	PS4123-5E	LED green
1	PS4123-5B	LED red
1	PS4122-7C	Diode 1N4007
1	PS4122-7D	Diode Ge AA118
1	PS4122-8A	Z-Diode 4.7 V

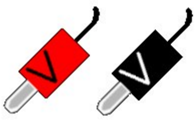
Cable connections

The following cable connections are used in this experiment:

Designation	Symbol	Equipment	Sockets
5V / 1A		DC Power Supply	
GND		MULTI POWER SUPPLY 60VA / 500KHz	

Equipment

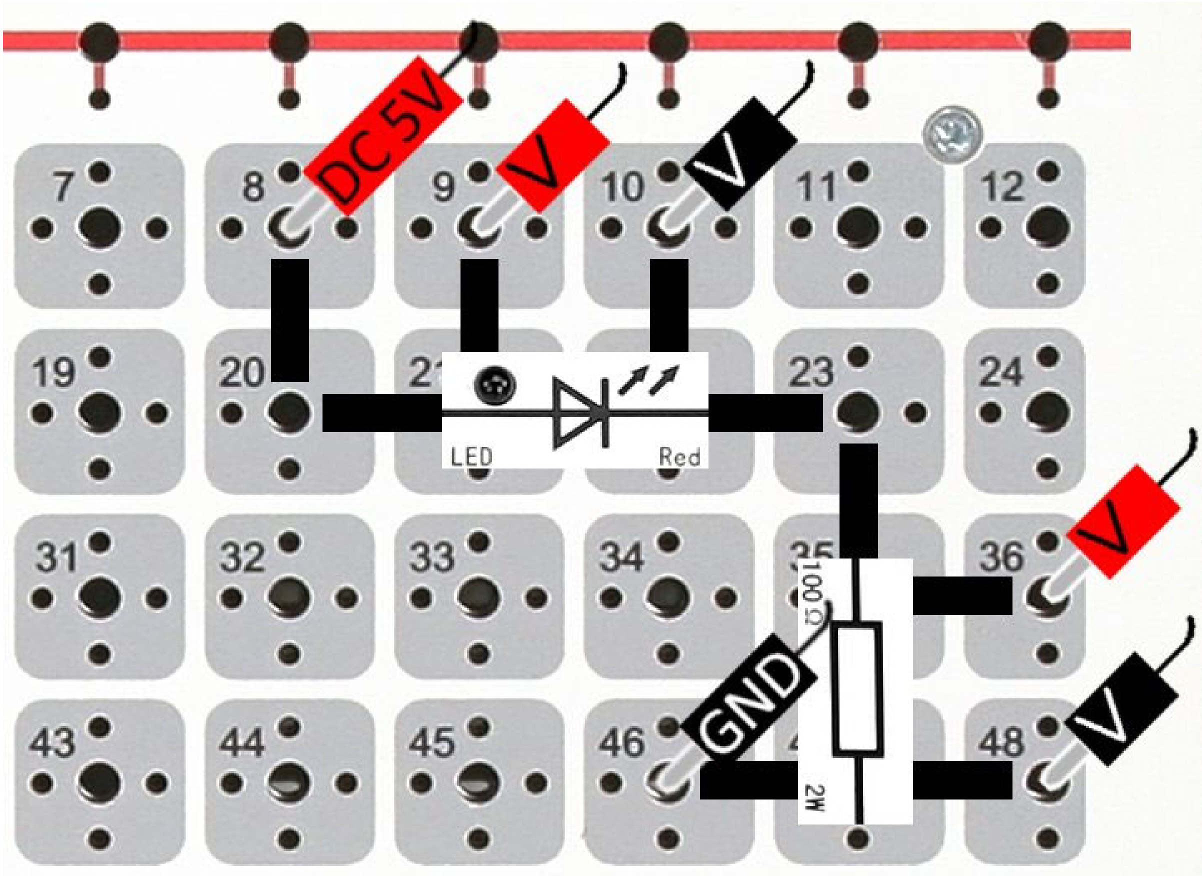
The following equipment with their corresponding settings are needed for the experiment:

Equipment	Settings	
	Black cable	Ground
	Red cable	V Ohm input
	Control knob	V DC
		Please plug in the red and black probes at the specified locations

Experiment set-up

Now please set up the experiment as a testing station in the upper right hand corner of the patch panel. Begin with the following:

- Bridging plugs
- Electronic components
- Measuring instruments and cables



Experiment procedure and exercises

Compute the currents based on the voltage across the resistor by applying Ohm's law.

Measure the threshold voltage at the various types of light emitting diodes or diodes. To do this connect the corresponding diode at the specified position and then please enter the voltage drop across the diode and the associated current. Begin with the red light emitting diode.

U_S = __________ V

I_S = __________ mA

Now connect the green to the location where the diode was. Measure the voltage and current and enter the values below.

U_S = __________ V

I_S = __________ mA

Now connect the germanium diode into the diode position. Measure the voltage and current and enter these values below.

U_S = __________ V

I_S = __________ mA

Now connect the silicon diode into the diode position. Measure the voltage and current and enter the values below.

U_S = __________ V

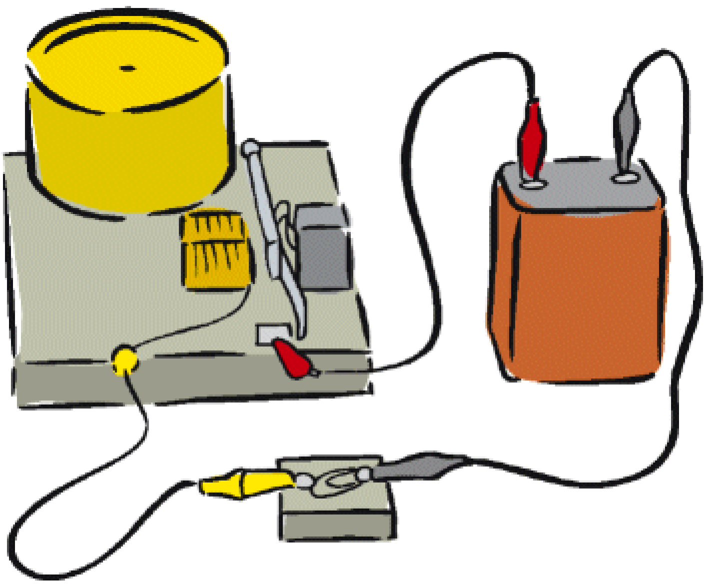
I_S = __________ mA

Now connect the zener diode into the diode position. Measure the voltage and current and enter the values below.

U_S = __________ V

I_S = __________ mA

Zener diode



Training objectives and introduction

The zener diode constitutes an essential component of many circuits. Since the diode's production process dictates that a certain constant voltage always drops across this component, this diode is often used to stabilise voltages.

Training content

Zener diodes or Z-diodes for short were named after the physicist C.M. Zener. In electronics Z-diodes have become so important thanks to their voltage limiting properties.

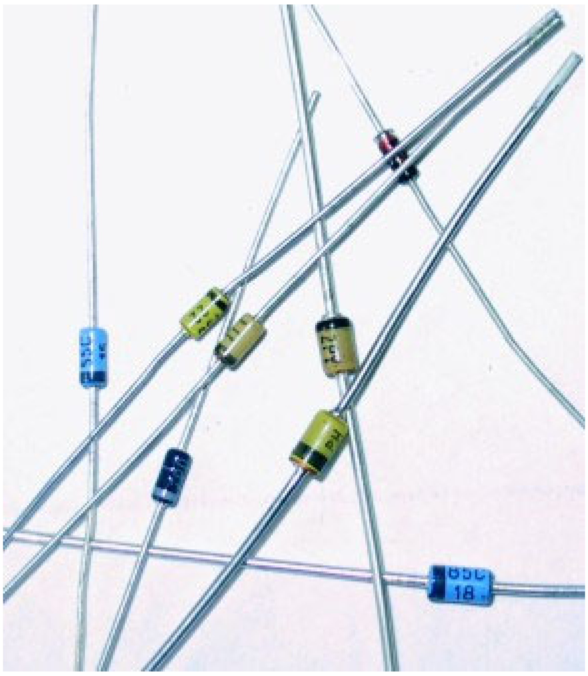


Figure 1:
Z-diodes with various Zener voltages and varying maximum levels of power loss.

Figure 2:
Normally the Zener voltage, here 18V, is printed on the component. As in the case of other diodes the cathode is labelled with a ring.

Anode Cathode

Figure 3:
Circuit symbol of the Zener diode.

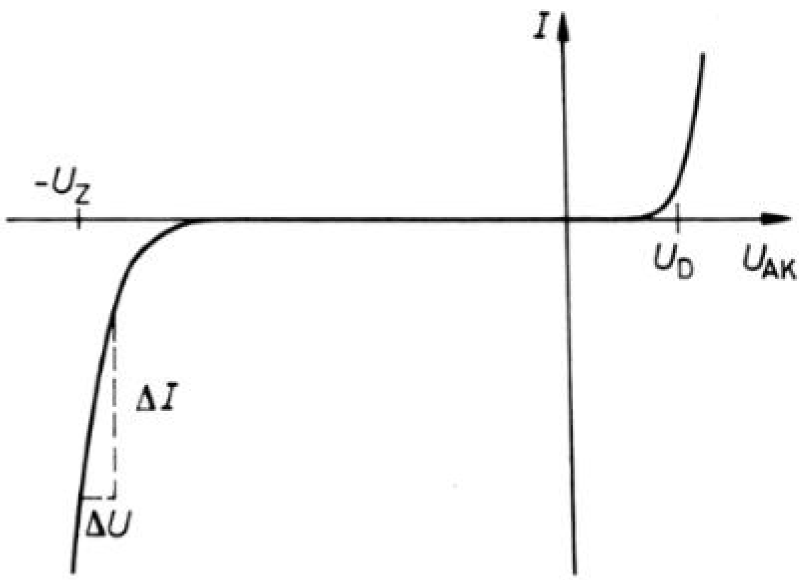


Figure 4:
Conducting and blocking characteristic of a Zener diode.

Functional description:
Zener diodes also act like a valve for electric current. They allow the current to pass in the forward or conducting direction, from anode to cathode and respond overall like normal silicon diodes here. In the reverse direction they block but only up to a specifically defined voltage, the so-called Zener voltage. When Zener voltage levels are reached the Zener diode conducts through.
The Zener voltage is predetermined during the production process. There are various types starting with low voltages, like e.g. 2.7V up to ranges exceeding 100 V. Zener diodes are normally operated in the blocking direction.

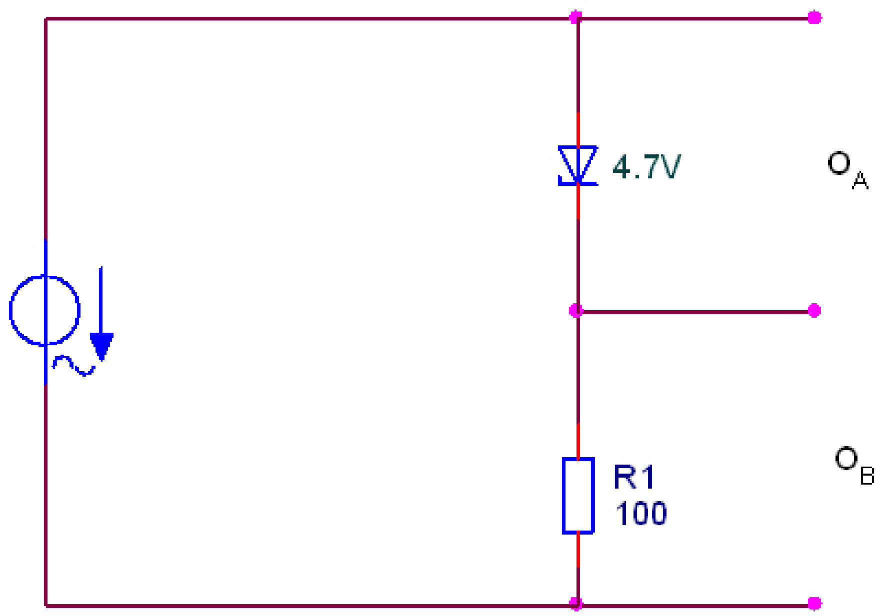
Real diodes:
A type designation is printed on real diodes (see Figures 1+2). The cathode is designated using a coloured ring. The breakdown voltage, i.e. Zener voltage is also printed on the diode (Fig. 2).
The properties of real diodes differ only slightly from ideal diodes having neither ideal forward conducting nor ideal blocking properties. These attributes are particularly obvious in the Z-diode characteristic (Fig. 4). At high frequencies even more disturbing effects can be seen which however will be ignored here.

- Conducting direction:
  Z-diodes possess a low conducting state voltage of approx. 0.7 V. The conducting state region is not of interest for typical applications.
- Blocking properties:
  Z-diodes become conductive starting at the Zener voltage. This means they have a low resistance, whose value can be determined from the slope of the blocking characteristic.
  Z- diodes have limiting data, e.g. maximum temperature or maximum power dissipation which may not be exceeded.

Experiment procedure

Circuit diagram

The following circuit diagram is used for this experiment:



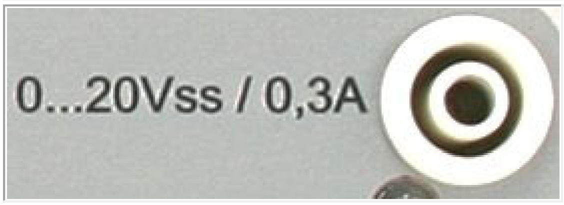
Components

The following components are used in this experiment:

Parts	Id no.	Designation
2	SO5126-5M	Cables
14	SO5124-6F	Bridges, small
1	PS4121-2N	R 100
1	PS4122-8A	Z-diode 4.7 V

Cable connections

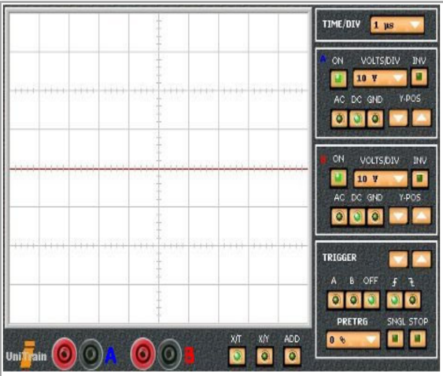
The following cable connections are used in this experiment:

Designation	Symbol	Equipment	Sockets
FG		FUNCTION GENERATOR	
GND		MULTI POWER SUPPLY 60 VA / 500 KHz	

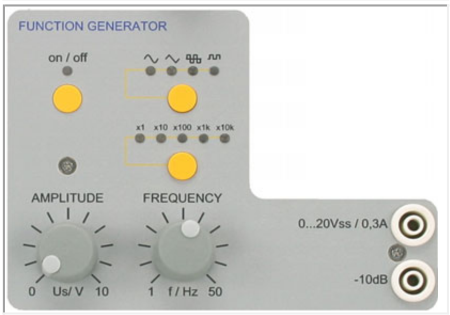
Connect the specified sockets to the plug-in position shown in the layout diagram.

Equipment

The following equipment is required including the corresponding settings for the experiment:

Equipment	Settings
	see table below

	Channel A	Channel B
Sensitivity	2 V/DIV	2 V/DIV
Coupling	DC	DC
Polarity	inv	norm
y-pos	0	0
Time base	2 msec/DIV	
Mode	X/Y	
Trigger channel	-	
Trigger edge	-	

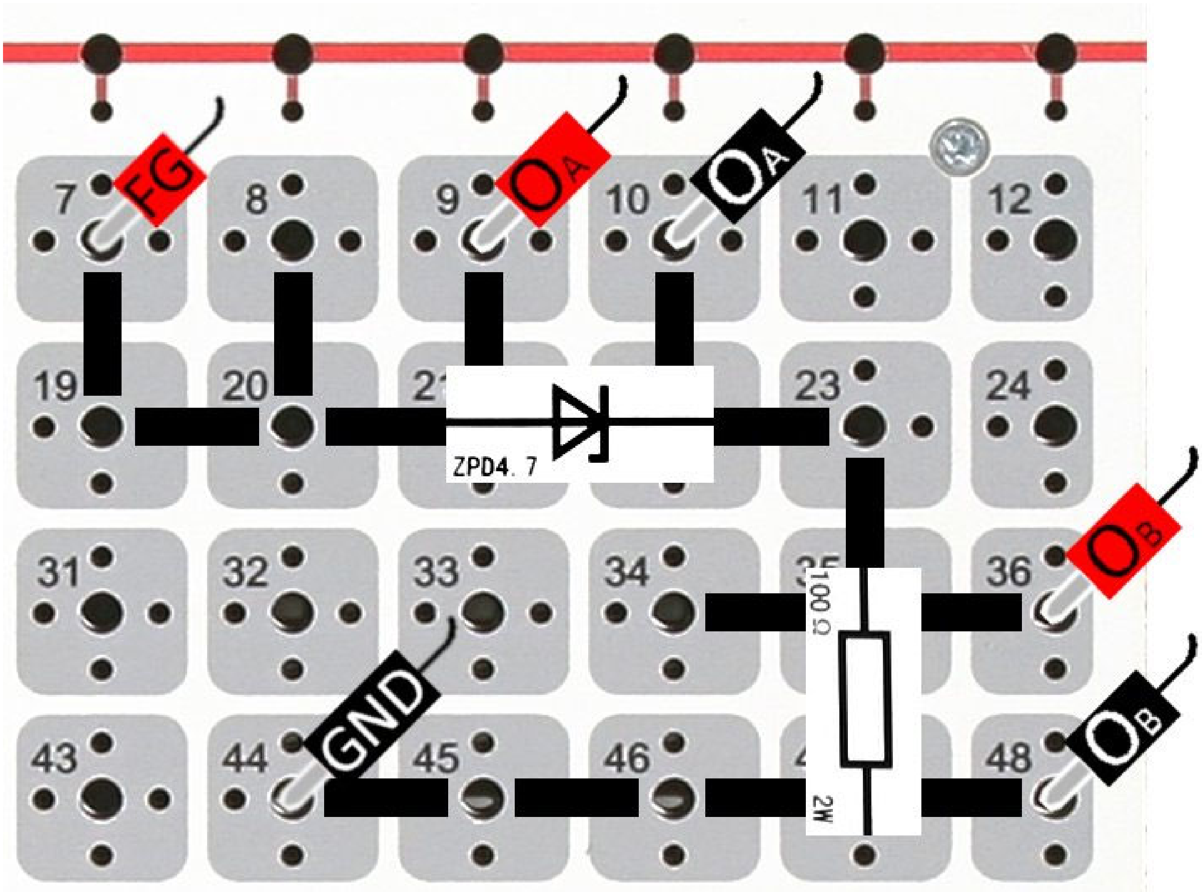


Curve shape	sinusoidal
Amplitude	8V
Frequency factor	x1
Frequency	50Hz

Experiment set-up

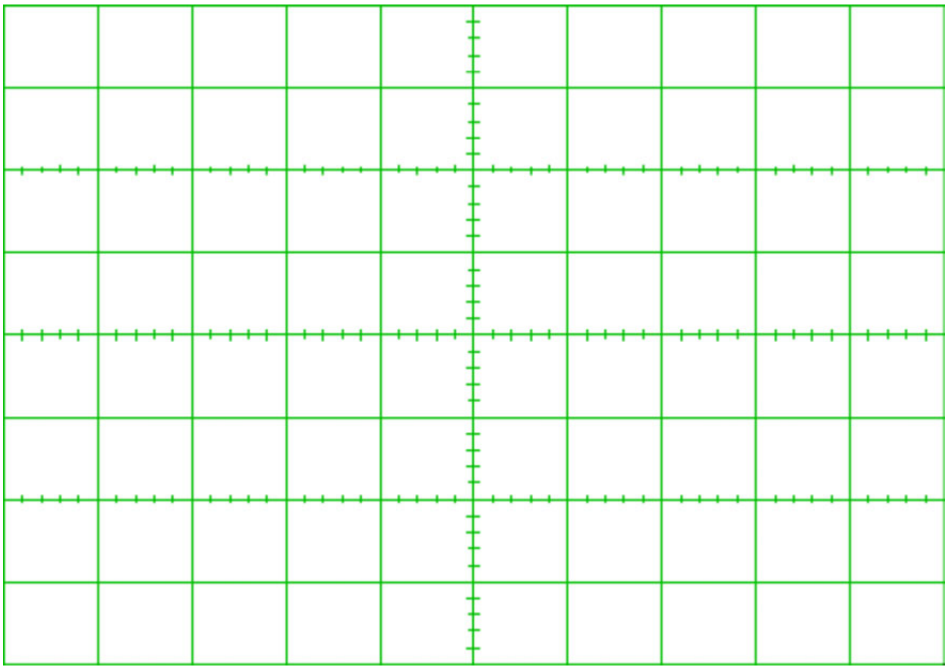
Please now set up the experiment as a testing station in the upper right hand corner of the patch panel. Begin as follows:

- Bridging plugs
- Electronic components
- Measuring instruments and cables



Experiment procedure and exercises

Set the oscilloscope and the function generator to the values specified above and enter the voltage-current characteristic of the Zener diode into the diagram below. Make sure that you obtain a good reading of the Zener diode's breakdown voltage.



The Zener diode begins conducting as of a certain voltage, the threshold voltage, and the amperage increases quite abruptly. In the normal forward (line) direction the voltage corresponds to that of a standard diode. How high is the low threshold voltage?

U_{Sw}=______________________________ V

How high is the higher threshold voltage in the reverse (line) direction?

U_{Sw}=______________________________ V