JOY-PI

Experimental and education case

1. TABLE OF CONTENT

The login data is:
Username : **pi**
Password : **12345**

2. GENERAL INFORMATION & SAFETY INSTRUCTIONS

Dear customer,

Thank you very much for choosing our product. In the following, we will show you what has to be observed during commissioning and use. Should you encounter any unexpected problems during use, please feel free to contact us.

The following lessons are designed so that, regardless of how much prior knowledge you already have, you can complete all lessons without any problems. For the different lessons, you have to download sample files and run them on the Joy-Pi. How to do this can also be found in this manual.

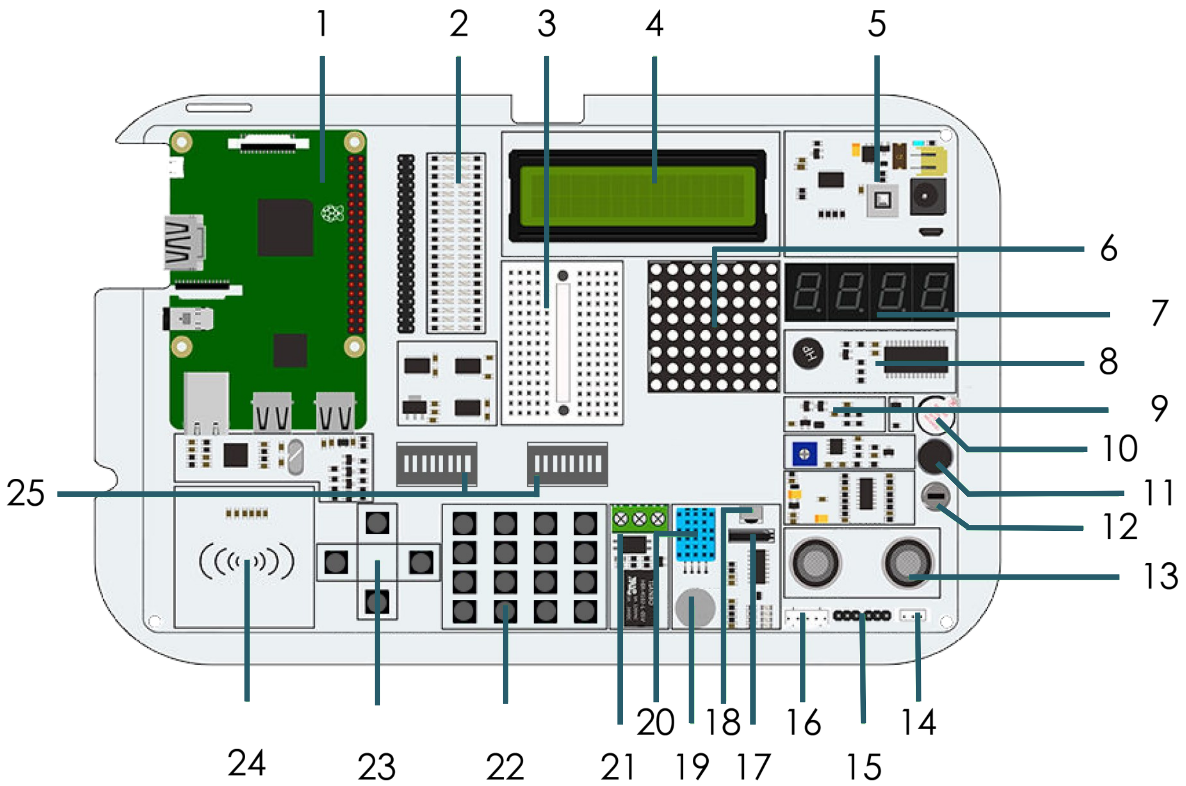
But these tutorials are only the beginning you can use your Joy-Pi for a variety of projects.

We are looking forward to see what you will do with our Joy-Pi.

Safety instructions

1. This device is intended for use in dry indoor areas. It must not become wet or damp! Also do not touch the device with wet hands!
2. The permissible ambient temperature is : 5 - 40 °C
3. Do not expose the device to direct sunlight, as the Joy-Pi could heat up by this.
4. If the unit is damaged or has faults, do not longer use it and contact our service for further instructions
5. Unplug the power supply from the power outlet if you are not going to use it for a longer period of time.
6. Handle this product with care. It must not contain high exposed to temperature, humidity or pressure. It may not be short-circuit either.

3. DETAILS



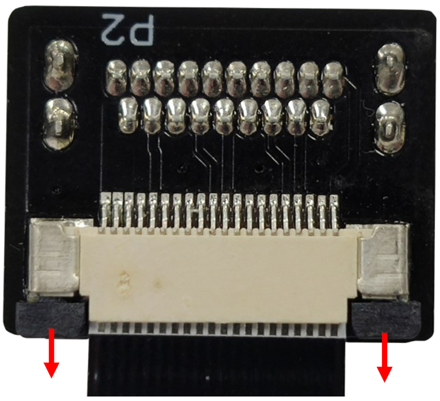
1	Raspberry Pi
2	GPIO LED display
3	Breadboard
4	16 x 2 LCD module (MCP23008)
5	Power supply
6	8 x 8 LED matrix (MAX7219)
7	7 segment LED display(HT16K33)
8	Vibration module
9	Light sensor (BH1750)
10	Buzzer
11	Sound sensor
12	Motion sensor (LH1778)
13	Ultrasonic distance sensor
14 / 15	Servo interfaces

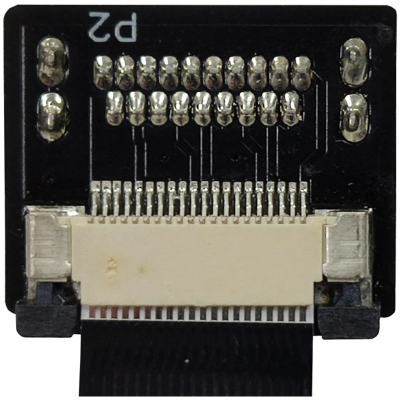
16	Stepper motor interface
17	Tilt sensor (SW-200D)
18	Infrared sensor
19	Touch sensor
20	DHT11 temperature and humidity sensor
21	Relay
22	Key matrix
23	Independent keys
24	RFID module (MFRC522)
25	Switch

4. COMMISSIONING & OPERATION

First you must insert your microSD card into the slot provided by the Raspberry Pi. If you do not want to use our image, please read **chapter 5.3** and **chapter 6.1** to create your own image.
Now you can wire the Raspberry Pi to the Joy-Pi. For this purpose plug the AUX adapter into the AUX port and the USB cable into one of the USB ports. Then connect both GPIO bars, one from the Raspberry Pi and one from the Joy-Pi with the supplied cable.
With the HDMI cable, please note that you may need to replace the HDMI adapter depending on the Raspberry Pi you are using. For the Raspbbery Pi 4 you need the small micro HDMI adapter, for all older Raspberry Pi models you need the big HDMI adapter.

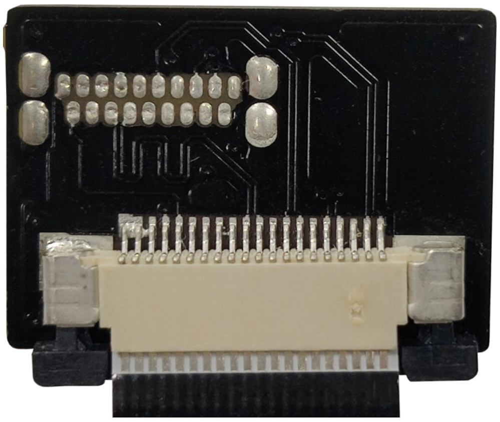
Changing the adapter is done quickly.
Pull the plastic lock of the connector carefully downwards to release the HDMI cable, as shown by the arrows in the picture below. Now you can simply pull the cable out of the adapter.



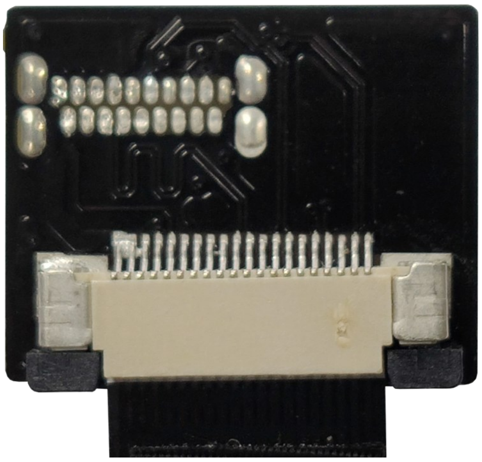


Now take the other HDMI adapter and, as in the previous step, carefully pull the plastic latch of the connector downwards to release the lock.

Now you can plug the HDMI cable into the connector. Make sure that the side of the cable with the silver contacts, as shown in the picture below, points away from the adapter.

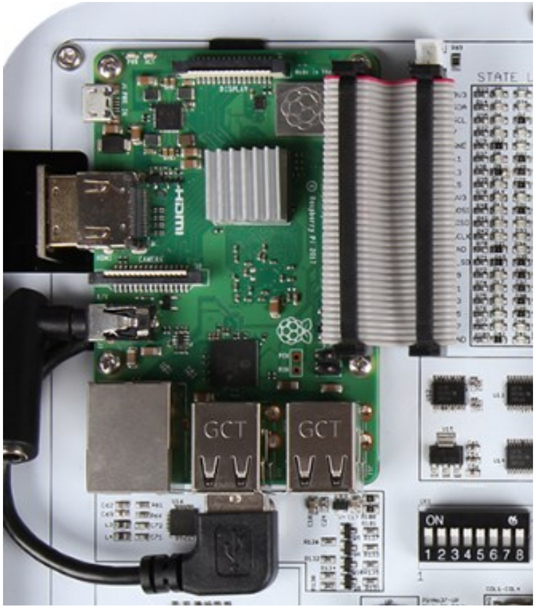


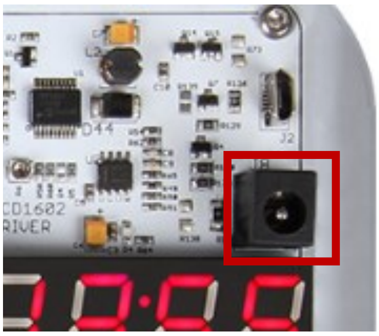
When the cable is fully inserted into the connector, you can close the lock by carefully pushing the plastic latch of the connector upwards.



Now you can plug the HDMI cable into your Raspberry Pi and screw the Raspberry Pi firmly onto the board of the Joy-Pis.

To start the Joy-Pi, all you have to do is to supply it with power. The power cable which is included, should be connected on the right side of the board. The Joy-Pi should now start as soon as you flip the switch on the power cord.





You have various possibilities to operate your Joy-Pi. One is via the wireless keyboard, which can be used in combination with the touch display, or you can provide a connection to your computer using VNC or SSH.

Wireless keyboard

First, connect the USB stick of the keyboard to one of your USB ports of the Raspberry Pi. Now you can switch it on at the right side of the keyboard and with the help of the key combination Fn+RF it will connect to the Joy-Pi. In order to make the key assignment match the German keyboard layout of the keyboard, German must be selected as language in the system preferences.

To do this, open the terminal and enter the following command to open the system settings:

```
sudo raspi-config
```

There you select ***4 Localisation Options → I1 Change Locale*** to select German as language. There is also a touchpad on the keyboard that you can use to move the cursor. Further functions are described in the enclosed instructions. The enclosed microUSB cable is intended for charging the keyboard.

VNC

With the help of the program VNC Viewer, which you can download **here**. With this program, you can see the desktop of your Joy-Pi on your computer and you can operate it completely.
To use this function you must first allow a VNC connection. You enable this in the system settings. To do this, execute the following command:

```
sudo raspi-config
```

There you activate VNC in ***5 Interfacing Options → P3 VNC***. Now you can connect to the Raspberry Pi via your network. To do so, enter the IP address of the Joy-Pi. You can see the IP address of the Joy-Pi by clicking on the VNC sign in the upper right corner. Now you only have to login with the login data and then you have fully access from your computer to your Joy-Pi.

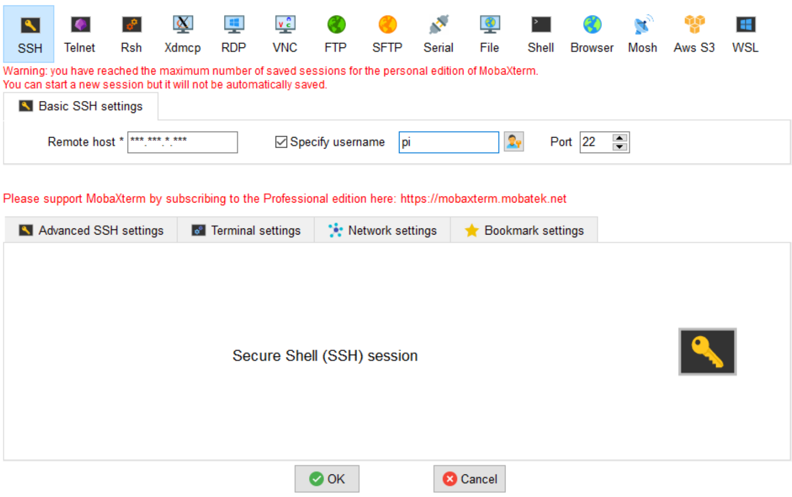
user name : **pi**
password : **12345**

SSH

SSH is a different connection path than VNC to connect wirelessly to your Joy-Pi from a PC. You can use for example MobaXTerm, which you can download **here**. To be able to establish an SSH connection, you must enable SSH and your Joy-Pi must be connected to your network. Enable SSH in system preferences ***5 Interfacing Options*** → ***P2 SSH***.
Open system preferences with:

```
sudo raspi-config
```

Now click on **Session** in MobaXTerm to establish a new connection. There you enter the IP address and the user name. The IP address can be displayed by clicking on the VNC icon in the upper right corner.

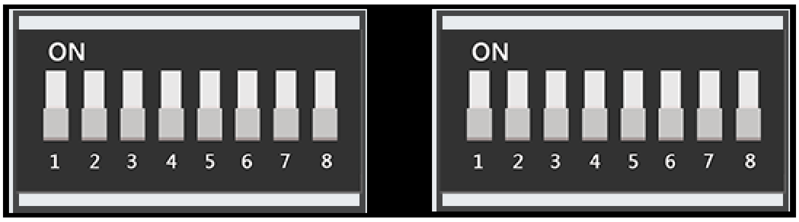


user name : **pi**
password : **12345**

You must then enter the password. Attention! It is possible that the keystrokes are not displayed when entering the password. Now, you can see a terminal which can control the Joy-Pi.

5. CHANGING MODULES AND USING THE GPIOS

5.1 Change of modules



On the Joy-Pi board there are two switching units with 8 switches each. The switches make it possible to switch between different sensors and modules. Since the Raspberry Pi has only a limited number of GPIO pins, these switches are needed to use more sensors and modules than GPIO pins are available.

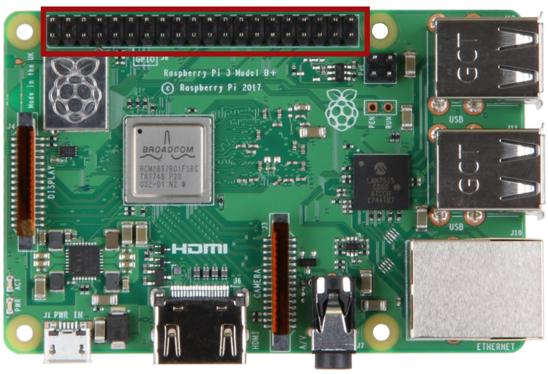
Using these switches is quite simple and will be needed in some of the following lessons.

In the table you can see which switch switches which sensor or module.

Sensors / modules	Switching unit	Keys
Key matrix	Left	1 - 8
Independent keys	Left	5 - 8
Vibration module	Right	1
Tilt sensor	Right	2
Stepper motor	Right	3, 4, 5, 6
Servo motor	Right	7, 8

5.2 Usage of GPIOs

In the following we will explain in more detail what GPIO's are, how they work and how they are controlled.



GPIO stands for: *General - purpose input / output (universal input / output).*
GPIO pins do not have a specific purpose. They can be configured as either input or output and have a general purpose. This depends on what you want to achieve.

Example input pin: Button
If the button is pressed, the signal will be transferred through the input pin of the Raspberry Pi.

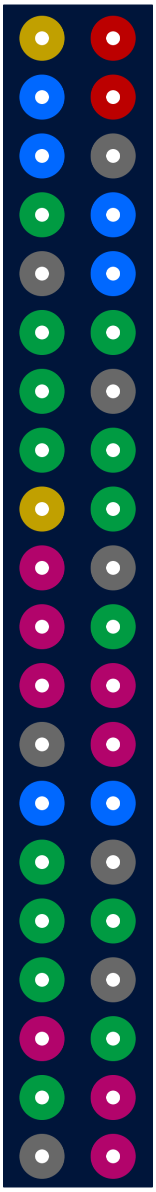
Example output pin: Buzzer
A signal will be sent via the output pin of the Raspberry Pi to the buzzer to control it.

If you look on the opened Joy-Pi from the front, the GPIO pins will be on the right side of the Raspberry Pi.

There are 2 possible schemata of the Raspberry Pi GPIO:
GPIO - BOARD and **GPIO - BCM**.
The GPIO - BOARD schemata that reference pins via the actual pin number. That means that the pin numbers of the following picture is used.

The schemata GPIO - BCM means that the pins reference *Broadcom SOC Channel.* These are the numbers after GPIO:

1	3.3 V DC	**2**	5 V DC
3	GPIO 2 (SDA1, I2C)	**4**	5 V DC
5	GPIO 3 (SCL1, I2C)	**6**	Ground
7	GPIO 4	**8**	GPIO 14 (TXD0)
9	Ground	**10**	GPIO 15 (RXD0)
11	GPIO 17	**12**	GPIO 18
13	GPIO 27	**14**	Ground
15	GPIO 22	**16**	GPIO 23
17	3.3 V	**18**	GPIO 24
19	GPIO 10 (SPI, MOSI)	**20**	Ground
21	GPIO 9 (SPI, MISO)	**22**	GPIO 25
23	GPIO 11 (SPI, CLK)	**24**	GPIO 8 (SPI)
25	Ground	**26**	GPIO 7 (SPI)
27	ID_SD (I2C, EEPROM)	**28**	ID_SC
29	GPIO 5	**30**	Ground
31	GPIO 6	**32**	GPIO 12
33	GPIO 13	**34**	Ground
35	GPIO 19	**36**	GPIO 16
37	GPIO 26	**38**	GPIO 20
39	Ground	**40**	GPIO 21



GPIO - BOARD	Sensors and modules
1	3.3 V
2	5.0 V
3	I2C, SDA1 (Light sensor, LCD display, 7 segment display)
4	5.0 V
5	I2C. SCL1 (Light sensor, LCD display, 7 segment display)
6	Ground
7	DHT11 sensor
8	TXD0
9	Ground
10	RXD0
11	Touch sensor
12	Buzzer
13	Button matrix(ROW1), vibration motor
14	Ground
15	Button matrix (ROW2), tilt sensor
16	Motion sensor
17	3.3 V
18	Sonic sensor
19	SPI
20	Ground
21	SPI
22	Servo2, Button matrix (COL1), left button
23	SPI
24	RFID module
25	Ground
26	LED matrix
27	ID_SD (I2C, EEPROM (Electrically Erasable Programmable Read - only Memory))
28	ID_SC
29	Stepper motor (STEP1), button matrix (ROW3)
30	Ground
31	Stepper motor (STEP2), button matrix (ROW4)
32	Ultrasonic sensor (Echo)
33	Stepper motor (STEP3), button matrix(COL4), down button
34	Ground
35	Stepper motor (STEP4), button matrix (COL3), right button
36	Ultrasonic sensor (TRIG)
37	Servo1, button matrix (COL2), up button
38	Infrared sensor
39	Ground
40	Relay

In our examples, we use the programming language *Python* to control the GPIO pins. In Python exists a library which is known as RPi.GPIO. This library is necessary to control the pins with Python.

The following example and comments in the code should help you to understand the program.

First, you have to import the required library with the **import** command. The variable **TOUCH** and **BUZZER** references to the pins of the touch sensor and the buzzer. Afterwards, you define the connection with *GPIO.setmode(GPIO.BOARD)* as the used GPIO schemata. As the next step, you configurate the earlier set variables with the command *GPIO.setup()* as input or rather output. Pin 11 (TOUCH) is set as input and pin 12 (BUZZER) as output.
The **main** function queries if a touch has been detected by the touch sensor. If this is the case, the function **do_smth** will be executed.
This function prints the text *Touch detected* and sets the buzzer ***HIGH*** and one second later ***LOW*** again(buzzer will sum one second):

```
import RPi.GPIO as GPIO
import time #import libraries
import signal

TOUCH = 11 #declaring variables
BUZZER = 12

def setup_gpio(): #definition of inputs and outputs
    GPIO.setmode(GPIO.BOARD)
    GPIO.setup(TOUCH, GPIO.IN, pull_up_down=GPIO.PUD_UP)
    GPIO.setup(BUZZER, GPIO.OUT)

def do_smt(channel): #function for the output if touch was dected
    print(“Touch detected“) #and output that touch was detected
    GPIO.output(BUZZER, GPIO.HIGH) #signal output
    time.sleep (1) #wait 1 second
    GPIO.output(BUZZER, GPIO.LOW) #stop signal output

def main():
    setup_gpio()
    try: #checking if touch is detected
        GPIO.add_event_detect(TOUCH,GPIO.FALLING,callback=do_smt,bouncetime=200)
    except KeyboardInterrupt: #CTRL + C exists the script
        pass
    finally:
        GPIO.cleanup()
if _name_==‘_main_‘:
    main()
```

To learn more about the purpose and usage of GPIO, we recommend that you read the official documentation on that topic of GPIO pins which is written by the Raspberry Pi Foundation.

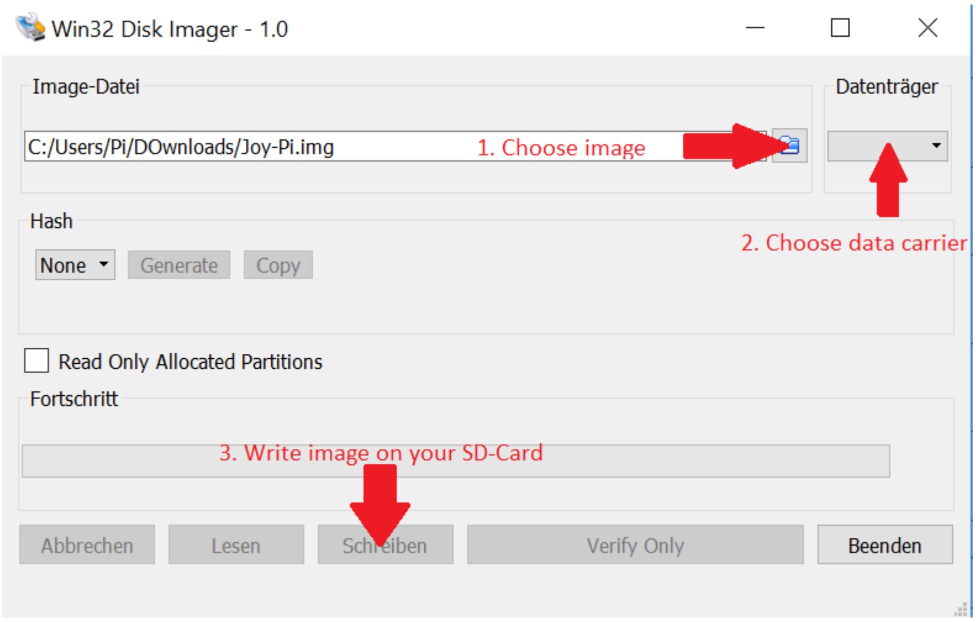
https://www.raspberrypi.org/documentation/usage/gpio/

5.3 Software installation for the Joy-Pi

On the included microSD card is a preinstalled operating system already installed. If you want to rewrite the card, you can do it like described in the following:

First of all, you should download the latest image file for the Joy-Pi from our website www.joy-pi.net.

1. Download the image file (.zip format). After unzipping the file, you get a file that ends with .img.
2. Connect your microSD card to your computer and format it with the program SD formatter. A microSD card reader is included in the scope of delivery.
3. Start the program Win32-Disk-Imager and choose
   ① the downloaded image file.
   ② the device which is to be written.
4. Now the card is written with the operating system and you can insert it into the microSD card slot of the Raspberry Pi.



5. At the end, you have to edit the image to the size of your SD card. Therefore, start the Raspberry Pi, open the terminal and enter **`sudo raspi-config`**.
   Click now on ***Advanced Options*** and after that ***Expand Filesystem***.
   After a restart, the size of the image will be adjusted to your SD card.

6. USAGE OF PYTHON AND LINUX

6.1 Download of code examples

This step is optional but it makes it easier to execute scripts without having to create them individually. On our prepared image for the Joy-Pi all code examples are already downloaded. So all scripts are already on the desktop.
The scripts which are used in this guide can be downloaded directly from a package. Therefore, follow the following instructions:

1. Open the **Terminal**. We will need this to perform most of our Python scripts and to download scripts and expansions.

2. After we have successfully opened the terminal, we need to download the script archive to the desktop (included on the image) using the following command

```
cd Desktop/
wget https://joy-pi.net/wp-content/uploads/2020/09/Joy-Pi.zip
```

3. Press **Enter** on your keyboard. Now you have to unzip the archive:

```
unzip Joy-Pi.zip
```

4. Press **Enter** again on your keyboard and wait until the process succeeded.
5. With the command **cd**, you can change to the right folder to be able to use the scripts which are placed there:

```
cd Joy-Pi
```

Attention! Every time you shut down your Joy-Pi, you must repeat these steps to change the folder.

The login data is:
Username : **pi**
Password : **12345**

6.2 Installation of the required libraries

If you are not using our prepared image, you can install the required libraries as follows:

16x2 LCD

For the 16x2 LCD the library Adafruit_CircuitPython_CharLCD from adafruit is used. Enter the following command into the terminal for the installation:

```
sudo pip3 install adafruit-circuitpython-charlcd
```

Segment Anzeige

For the segment display the library Adafruit_CircuitPython_HT16K33 from adafruitis used. Enter the following commands into the terminal for the installation:

```
sudo apt-get install python3-pip
```

```
sudo apt-get install python3-pil
```

```
sudo pip3 install adafruit-circuitpython-ht16k33
```

LED-Matrix

For the LED matrix the library luma.led_matrix from rm-hull is used. Enter the following command into the terminal for the installation:

```
sudo wget https://github.com/rm-hull/luma.led_matrix/
archive/refs/heads/master.zip
```

Now extract the downloaded archive:

```
sudo unzip master.zip
```

Now navigate to the library folder and edit the setup.cfg file with the following commands:

```
cd luma.led_matrix-master
```

```
sudo nano setup.cfg
```

Now remove the following line from the file:

ws2812; platform_machine=="armv7l" and platform_system=="Linux"

Save the changes with **Ctrl + O** and close the file with **Ctrl + X**. After that you can install the library with the following command:

```
sudo pip3 install -e .
```

RFID-MFRC522

For the RFID Module the library MFRC522-python from lucassarcanjo is used. Furthermore the library SPI-Py from lthiery is required. Enter the following commands into the terminal for the installation:

```
sudo git clone https://github.com/lthiery/SPI-Py.git
```

```
cd SPI-Py/
```

```
sudo python3 setup.py install
```

```
sudo git clone --single-branch --branch python3-spi-updates https://
github.com/lucassarcanjo/MFRC522-python.git
```

Note that also the last command must be entered as just one line.

IR-Sensor

For the IR-Sensor the library IR-Remote-Receiver-Python-Module from owainm713 is used. Enter the following commands into the terminal for the installation:

```
sudo git clone https://github.com/owainm713/IR-Remote-
Receiver-Python-Module.git
```

You can save the file IRModule.py in your library folder under "/usr/lib/python3.7/IRModule.py". This allows you to run the sample script from any folder. You can use this command to do this:

```
sudo mv /home/pi/IR-Remote-Receiver-Python-Module/
IRModule.py /usr/lib/python3.9/IRModule.py
```

DHT11

For the DHT11 the library DHT11_Python from szazo is used. Enter the following command into the terminal for the installation:

```
sudo pip3 install Adafruit_DHT
```

6.3 Performing Python scripts

After we successfully downloaded our script, we would like to execute it. Open the terminal again and follow the instructions below to run the script:

1. Enter the command **`sudo python3 <script name>`** to perform a Python script like for example:

```
sudo python3 buzzer.py
```

This command consist of 3 parts. Because of the command **`sudo`** , the following part of the command line will be performed with root right (admin rights).**`python3`** is the command of the programming language with the same name, in which the scripts are written in. At the end of the command, the name of the script is stated. Therefore, you should note that you must be in the right folder in which the script is saved or the indicated path (e.g. **`~/Joy-Pi/buzzer.py`**).

Lesson 1 : Using the buzzer for warning sounds

In the previous explanation, we learned how to use the GPIO pin both as output and input. To test this now, we go ahead with a real example and apply our knowledge from the previous lesson. The module we will use is the Buzzer.

We will use the GPIO output to send a signal to the buzzer and to close the circuit, to generate a loud buzz. Then we will send another signal to turn it off.

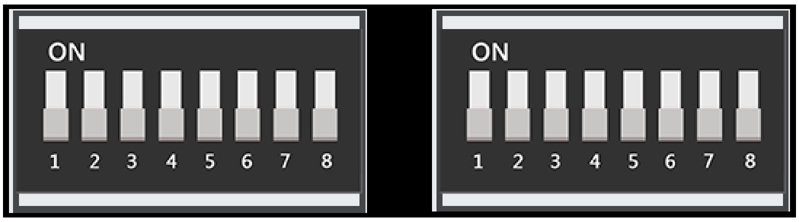
The buzzer is located on the right side of the Joy-Pi-Board and is easily recognized by the loud noise that it will make when activated. When you use your Joy-Pi for the first time, the buzzer may have a protective sticker on it. Make sure this sticker has been removed before using the Buzzer.

Just like in the previous example, we have prepared a special script with detailed comments that will explain how the whole buzzer process works, and how we can control the buzzer with the GPIOs.

First, we import the **RPi.GPIO library** and the **time library**. Then we configure the buzzer. At **pin 12** we set the GPIO mode to **GPIO BOARD** and the pin as **OUTPUT**.

We output a signal for 0.5 seconds and then turn it off.

Attention! In this example, you have to switch all switches on the left as well as on the right **OFF**.



```
#!/usr/bin/python

import RPI.GPIO as GPIO   #import the required librarys
import time

buzzer_pin = 12           #define buzzer pin

GPIO.setmode(GPIO.BOARD)
GPIO.setup(buzzer_pin, GPIO.OUT)

GPIO.output(buzzer_pin, GPIO.HIGH)     #make buzzer sound

time.sleep(0.5)           #wait 0.5 seconds

GPIO.output(buzzer_pin, GPIO.LOW) #stop buzzer sound

GPIO.cleanup()
```

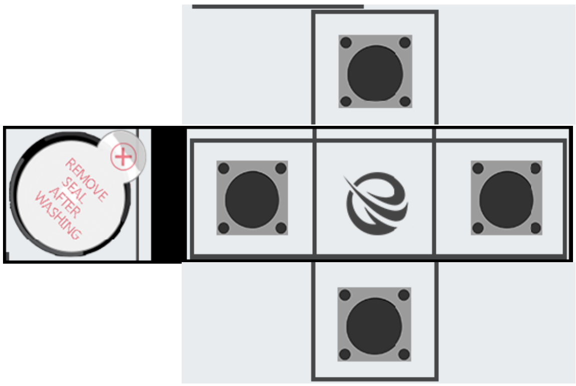
Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 buzzer.py
```

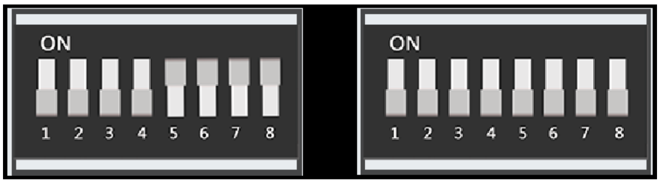
Lesson 2 : Controlling the buzzer with key inputs

After successfully demonstrating how to turn the buzzer on and off, it is time to make things a little more exciting. In this lesson, we will combine a button with the buzzer so that the buzzer is only turned on by pressing the button.

This time we will use 2 GPIO setups. One will be the GPIO.INPUT, which takes the button as an input, another will be the GPIO.OUTPUT, which sends a signal to the buzzer to output a sound.



Attention! For this example, you have to switch between the modules. Turn switch numbers 5, 6, 7 and 8 on the left switching unit **ON**. All the other switches should be turned **OFF**.



In our example we use the upper of the 4 keys on the lower left side. Theoretically, however, any of the 4 keys can be used. If you still want to use another key, you have to change the pin assignment accordingly.

GPIO37	Upper button
GPIO33	Lower button
GPIO22	Left button
GPIO35	Right button

For this part of our tutorial we need to use 2 GPIO settings. One input and one output. The GPIO input is used to determine when a key was pressed and the GPIO output is used to activate the buzzer when that key is pressed.

If you press the button on your Joy-Pi, the buzzer does a sound! Release the key and the buzzer will stops. The programm will be performed as long as **CTRL + C** is not beeing pressed.

Code example:

```
#!/usr/bin/python

import RPI.GPIO as GPIO   #import necessary libraries
import time

#define pins
button_pin = 37
buzzer_pin = 12

#set board mode to GPIO.BOARD
GPIO.setmode(GPIO.BOARD)

#setup button_pin as input and buzzer_pin as output
GPIO.setup(button_pin, GPIO.IN, pull_up_down=GPIO.PUD_UP)
GPIO.setup(buzzer_pin, GPIO.OUT)

try:
    while True:
        #check if button pressed
        if (GPIO.input(button_pin) == 0):
            #set buzzer on
            GPIO.output(buzzer_pin, GPIO.LOW)
        else:
            #button is not pressed, set buzzer off
            GPIO.output(buzzer_pin, GPIO.LOW)

except KeyboardInterrupt:
    GPIO.cleanup()
```

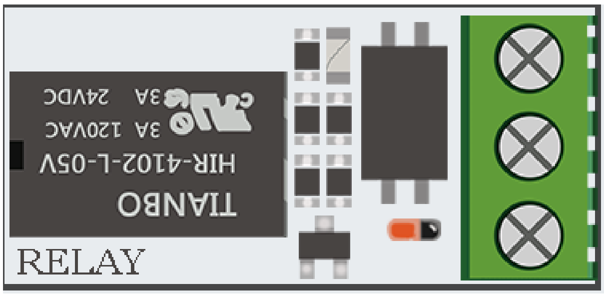
Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 button_buzzer.py
```

Lesson 3 : How a relay is working and how to control it

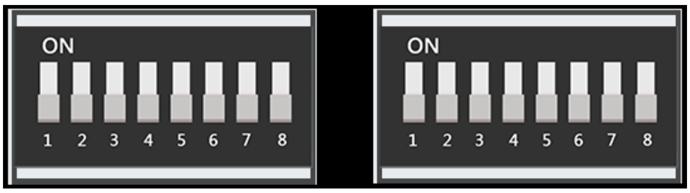
Now that we know everything we need to know about the buzzer, it is time for the next lesson. Now we will learn how to use the relay, what the function of the relay is and how to control it.

Simplified a relay is a switch that can be turned on and off with the help of GPIO pins. Relays are used to control a circuit through a separate low power signal or in case that more than circuit must be controlled through one signal. In our example, we show you how a GPIO signal is sent to close the relay to activate an individual circuit and how to sent another signal, to open the relay and to deactivate the circuit.



The relay is located in the middle, lower part of the board, next to the key matrix. It has 3 inputs of which we will use 2 in this example. **NC** means *normally closed*, **NO** means *normally open* and **COM** means *common*. *Common* means, in this case, the **common** ground.
If a circuit is connected to **NC** and **COM**, the circuit is closed if the control current circuit has not any voltage (GPIO.LOW). If the control current has a voltage (GPIO.HIGH), the relay opens the connection of the operating current circuit and the current flow will be stopped
The usage of **NO** and **COM** is exactly the opposite. If the control current circuit has no current (GPIO.LOW), the relay is opened and the operating current circuit is interrupted. If the control current circuit is supported by current (GPIO.HIGH), the relay closes the operating current and the current flows.

Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.



Attention! It is essential that you do not try to connect high voltage devices to the relay (e.g. table lamp, coffee machine, etc.) This could cause electric shocks and serious injuries.

```
#!/usr/bin/python

import RPI.GPIO as GPIO
import time

#define relay pin
relay_pin = 40

#set GPIO mode as GPIO.BOARD
GPIO.setmode(GPIO.BOARD)
#setup relay_pin as OUTPUT
GPIO.setup(relay_pin, GPIO.OUT)

#open relay
GPIO.output(relay_pin, GPIO.LOW)
#wait haf a second
time.sleep(0.5)
#close relay
GPIO.output(relay_pin, GPIO.HIGH)
GPIO.cleanup()
```

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 relay.py
```

Lesson 4 : Sending a vibration signal

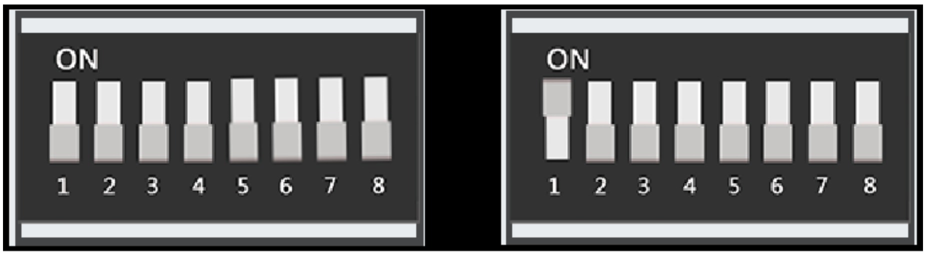
Have you ever wondered how your phone vibrates when someone calls you or when you receive a message? We built exactly the same module into our Joy-Pi and now we will learn how to use it.

The vibration module is located on the right side of the LED matrix and below the segment LED. If it is on, it is difficult to tell where the vibration is coming from because it feels like the whole Joy-Pi board is vibrating.

The vibration module uses a **GPIO.OUTPUT** signal just like the Buzzer and other modules previously used. If you send an output signal, the module will start vibrating. If you stop the signal with **GPIO.LOW**, the vibration will stop.

You can adjust the vibration length with different time.sleep() intervals. Try it yourself and maybe you can expand this example.

Attention! For this example you have to switch between the modules. Turn switch number 1 on the right switching unit **ON**. All the other switches should be turned **OFF**.



Code example:

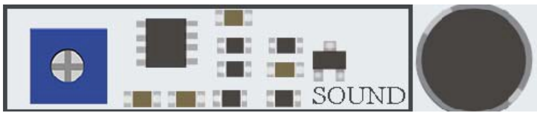
```
#!/usr/bin/python

import RPI.GPIO as GPIO
import time

#define vibration pin
vibration_pin = 13

#set board mode to GPIO.BOARD
GPIO.setmode(GPIO.BOARD)

#setup vibration pin to OUTPUT
GPIO.setup(vibration_pin, GPIO.OUT)

#turn on vibration
GPIO.output(vibration_pin, GPIO.HIGH)
#wait one second
time.sleep(1)
#clean up GPIO
GPIO.output(vibration_pin, GPIO.LOW)

GPIO.cleanup()
```

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 vibration.py
```

Lesson 5 : Detecting noises with sound sensor

In this lesson, we will learn how to use the sound sensor to make inputs, detect loud noises and react accordingly. So you can build your own alarm system that detects loud noises or turn on an LED by clapping!



The sound sensor consists of two parts: a blue potentiometer, which regulates the sensitivity, and the sensor itself, which detects the input of sounds. The sound sensor can be easily recognized by the blue potentiometer and the sensor itself is located on the right under the buzzer.

With the help of the potentiometer we can regulate the sensitivity of the sensor. For our script to work, we must first learn how to control the sensitivity. To adjust the sensitivity you have to turn the small screw on the potentiometer with a screwdriver to the left or right. The best way to test the sensitivity is to run the script. Clap your hands and see if the device is receiving a signal. If no signal is received this means that the sensitivity of the sensor is not set high enough. This can be easily corrected by turning the potentiometer.

```
#!/usr/bin/python

import RPI.GPIO as GPIO
import time

#define sound_pin
sound_pin = 18

#set GPIO mode to GPIO.BOARD
GPIO.setmode(GPIO.BOARD)

#setup sound_pin as INPUT
GPIO.setup(sound_pin, GPIO.IN, pull_up_down=GPIO.PUD_UP)

try:
    while True:
        #check if sound detected or not
        if(GPIO.input(sound_pin)==GPIO.LOW):
            print('Sound detected')
            time.sleep(0.1)
except KeyboardInterrupt:
    #CTRL+C detected, cleanning and quitting the script
    GPIO.cleanup()
```

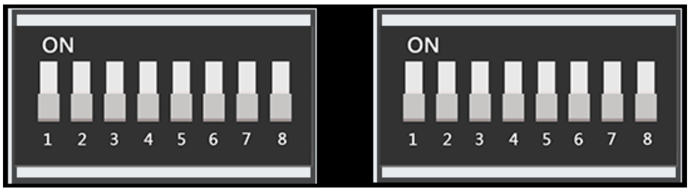
Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 sound.py
```

First, we define our pin **GPIO 18**. Afterwards, we set a **while loop** to run this script permanently. We check if we have received an input from the sound sensor indicating that loud noises have been detected and then we print *Sound detected*.

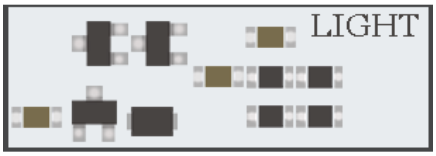
If you press **CTRL + C**, the programm will be closed.

Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.



Lesson 6 : Detecting brightness with the light sensor

The light sensor is one of our favorites. It is extremely useful in many projects and situations, e.g. with lamps that switch on automatically as soon as it gets dark. With the light sensor we can see how bright the module surface is.



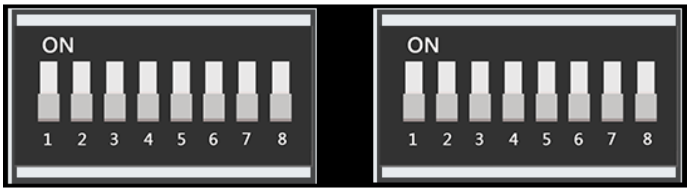
The light sensor is difficult to detect because it consists of very small parts. The sensor is to the left of the buzzer. If you cover it with your finger, the output of the light sensor should be close to zero, as no light can reach it.

It is time to test it in real time and see how it works. However, the light sensor is a little different from other sensors because it works with I2C and not with the normal GPIOs as we learned in the lessons before.

In this script we use a function to communicate with the sensor, this way we can get the wished output with the brightness. The higher the displayed number, the brighter is the surrounding.

```python
#!/usr/bin/python
# -*- coding: utf-8 -*-
# Author: Matt Hawkins
# Author's Git: https://bitbucket.org/MattHawkinsUK/
# Author's website: https://www.raspberrypi-spy.co.uk
import RPi.GPIO as GPIO
import smbus
import time

if(GPIO.RPI_REVISION == 1):
    bus = smbus.SMBus(0)
else:
    bus = smbus.SMBus(1)

class LightSensor():
    def __init__(self):
        #define some constants from the datasheet
        self.DEVICE = 0x5c #default device I2C address
        self.POWER_DOWN = 0x00 #no active state
        self.POWER_ON = 0x01 #power on
        self.RESET = 0x07 #reset data register value
        #start measurement at 4 Lux
        self.CONTINUOUS_LOW_RES_MODE = 0x13
        #start measurement at 1 Lux
        self.CONTINUOUS_HIGH_RES_MODE_1 = 0x10
        #start measurement at 0.5 Lux
        self.CONTINUOUS_HIGH_RES_MODE_2 = 0x11
        #start measurement at 1 Lux
        #device is automatically set to power down mode after measurement
        self.ONE_TIME_HIGH_RES_MODE_1 = 0x20
        #start measurement at 0.5 Lux
        #device is automatically set to power down mode after measurement
        self.ONE_TIME_HIGH_RES_MODE_2 = 0x21
        #start measurement at 4 Lux
        #device is automatically set to power down mode after measurement
        self.ONE_TIME_LOW_RES_MODE = 0x23

     def convertToNumber(self, data):
        #Simple function to convert 2 Bytes of data
        #into a decimal number
        return ((data[1] + (256 * data[0])) / 1.2)

    def readLight(self):
        data = bus.read_i2c_block_data(self.DEVICE,self.ONE_TIME_HIGH_RES_MODE_1)
        return self.convertToNumber(data)

def main():
    sensor = LightSensor()
    try:
        while True:
            print("Light Level : " + str(sensor.readLight()) + " lx")
            time.sleep(0.5)
    except KeyboardInterrupt:
        pass

if __name__ == "__main__":
    main()
```

Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.

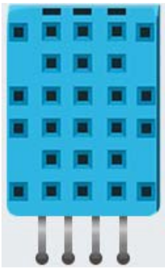


Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 light_sensor.py
```

Lesson 7 : Detecting the temperature and the humidity

The DHT11 is a very interesting sensor, because it has not only one function, but two! It contains both a humidity sensor and a temperature sensor, both of which are very accurate. Ideal for any weather station project, or if you want to check the temperature and humidity in the room!



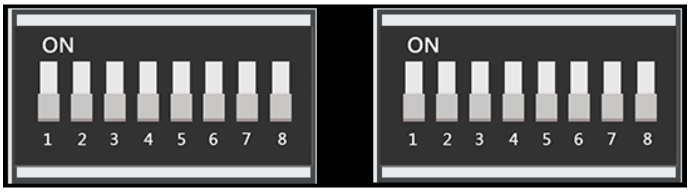
The DHT11 sensor is very easy to recognize. A small blue sensor with many small holes. It is located to the right of the relay and above the touch sensor. As specially accessible, we recommend the Python DHT Sensor Library which was published on https://github.com/coding-world/Python_DHT .
The library is used to display the values for the temperature and humidity

```
import RPi.GPIO as GPIO
import dht11

# initialize GPIO
GPIO.setwarnings(False)
GPIO.setmode(GPIO.BCM)
GPIO.cleanup()

# read data using pin 14
instance = dht11.DHT11(pin = 4)
result = instance.read()

while not result.is_valid():  # read until valid values
    result = instance.read()

print("Temperature: %-3.1f C" % result.temperature)
print("Humidity: %-3.1f %%" % result.humidity)
```

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 dht_11.py
```

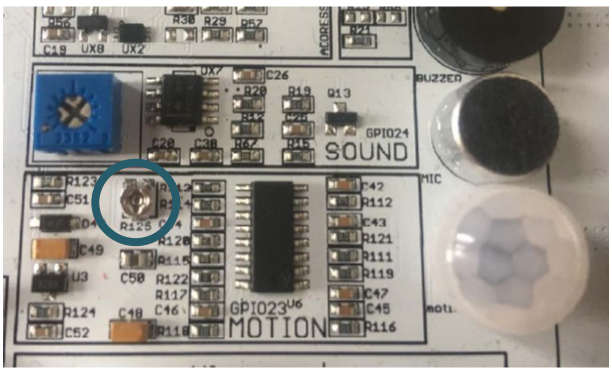
Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.



Lesson 8 : Detecting movements

The motion sensor is one of the most useful and frequently used sensors. It can be used, for example, to build an alarm system. When the sensor detects a movement, it can send a signal to the buzzer, which then makes a loud alarm.

The motion sensor is located directly under the sound sensor and is covered by a small, transparent cap. The cap helps the sensor to detect more movements by refracting the infrared light of the environment. The sensitivity of the motion sensor, like that of the sound sensor, is controlled with a potentiometer. This is located below the potentiometer of the sound sensor, but is much smaller. By using a screwdriver, you can set the distances, over which the motion sensor should react. By turning it clockwise the sensitivity decreases and counter-clockwise it increases.



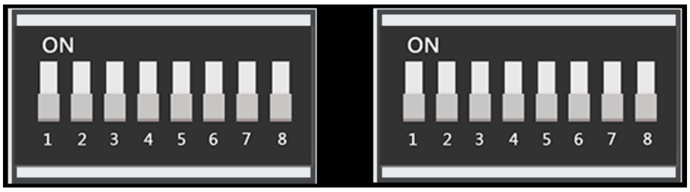
The motion sensor is controlled by the GPIO pins. When a motion is detected, the motion sensor will send a signal. This will stop for some time and then start again until the sensor detects the next movement.

```
#!/usr/bin/python
# -*- coding: utf-8 -*-

import RPi.GPIO as GPIO
import time #import of the libraries

motion_pin = 16 #define motion pin

GPIO.setmode(GPIO.BOARD) #set GPIO as GPIO.BOARD
GPIO.setup(motion_pin, GPIO.IN) #set motion pin as INPUT

try:      # beginning of loop
     while True:
          if(GPIO.input(motion_pin) == 0): #If sensor input = 0
               print("No movement ...") # print-command will be executed
          elif(GPIO.input(motion_pin) == 1): #If sensor input = 1
               print("Motion detected!") #print-command will be executed
          time.sleep(0.1) #wait 0.1 seconds
except KeyboardInterrupt:
     GPIO.cleanup() #enable GPIO ports again
```

Execute the following commands and try it yourself:

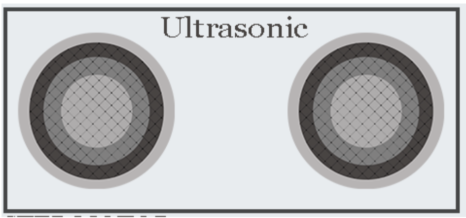
```
cd /home/pi/Desktop/Joy-Pi
sudo python3 motion.py
```

Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.



Lesson 9 : Measuring distances with the ultrasonic sensor

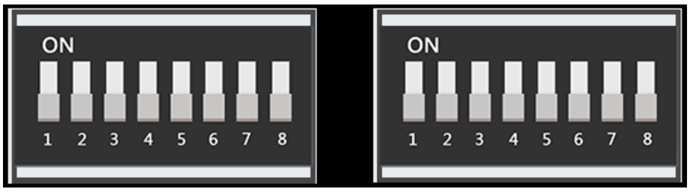
Now we will learn how to use the ultrasonic sensor to measure distances and display them on the Joy-Pi screen. By the way, cars use the same method to measure distances.



The ultrasonic sensor is located at the bottom right of the Joy-Pi board, directly above the stepper motor and servo interfaces. It is easily recognizable by the two large circles. We will move our hands over the distance sensor to measure the distance between our hands and the Joy-Pi.

The distance sensor works with **GPIO INPUT**, but it is slightly different from what we used in our previous lessons. The sensor needs a certain interval to be able to detect the distance in an accurate way. It sends an ultrasonic signal and with a built-in sensor it receives the echo reflected by an obstacle. From the time difference between sending the signal and receiving the echo, the distance is calculated.

Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.




```
#!/usr/bin/python
# -*- coding: utf-8 -*-
#Author : www.modmypi.com
#Link: https://www.modmypi.com/blog/hc-sr04-ultrasonic-range-sensor-on-the-raspberry-pi

import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BOARD) #set GPIO board configuration

TRIG = 36    #declaration of variable
ECHO = 32    #declaration of variable

print ("Distance measurement in progress.") #issues text in console

GPIO.setup(TRIG,GPIO.OUT) #set variable TRIG as output
GPIO.setup(ECHO,GPIO.IN)  #set variable ECHO as input

GPIO.output(TRIG, False)
print ("Warte auf den Sensor.")
time.sleep(2) #wait 2 seconds

GPIO.output(TRIG, True)  #start sending ultrasonic signal
time.sleep(0.00001)      #waits 0.00001 seconds
GPIO.output(TRIG, False) #stops sending a signal

while GPIO.input(ECHO)==0:
  pulse_start = time.time()

while GPIO.input(ECHO)==1:
  pulse_end = time.time()
```

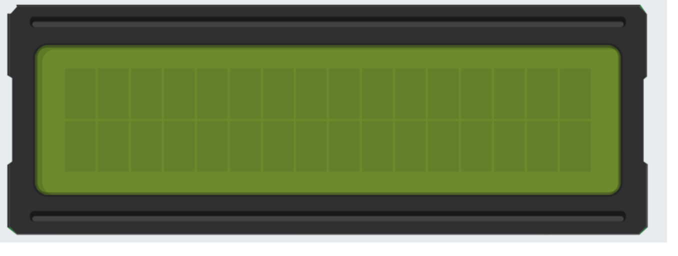
```
pulse_duration = pulse_end - pulse_start #calculation for duration of pulse

distance = pulse_duration * 17150  #calculation for determining distance

distance = round(distance, 2)      #solution is rounded to 2 decimal place

print ("Distance:",distance,"cm")    #output in console of distance in cm

GPIO.cleanup() #enable GPIO ports again
```

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 distance.py
```

Lesson 10 : Controlling the LCD display

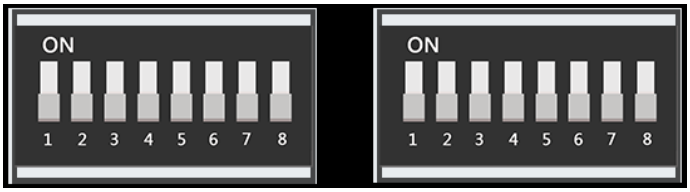
With the Joy-Pi you can display the LCD data that you collect with your sensors and update it in real time depending on the changes that the modules go through. For example, in conjunction with the temperature sensor - always display the current temperature and humidity on the LCD.



The LCD screen takes up a large part of the Joy-Pi board - it is located at the top center of the Joy-Pi, to the right of the GPIO LED display. As soon as the demo script and the examples are executed, the display turns on. Thanks to the integrated backlight you can read data on the display even in complete darkness.

Like the sound and motion sensors, the LCD also has an associated potentiometer. With this potentiometer, you can adjust the brightness of the backlight of the display. If you turn it counterclockwise the brightness gets higher and if you turn it clockwise it will get lowered.
Rotate the potentiometer counterclockwise to increase the contrast, rotate it clockwise to decrease the contrast.

Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.




```
#!/usr/bin/python
# -*- coding: utf-8 -*-

import time
import board
import busio
import adafruit_character_lcd.character_lcd_i2c as character_lcd

#define amount of lines and columns from LCD
lcd_columns = 16
lcd_rows    = 2

#initialization of I2C Bus
i2c = busio.I2C(board.SCL, board.SDA)

#set the LCD in the variable LCD
lcd = character_lcd.Character_LCD_I2C(i2c, lcd_columns, lcd_rows, 0x21)

try:
    #turn on the background
    lcd.backlight = True

    #issues 2 words with line break
    lcd.message = "Hello\nWorld!"

    #wait 5 seconds
    time.sleep(5.0)

    #show cursor
    lcd.clear()
    lcd.cursor = True
    lcd.message = "Show Cursor!"

    #wait 5 seconds
    time.sleep(5.0)

    #let cursor blink
    lcd.clear()
    lcd.blink = True
    lcd.message = "Blinky Cursor!"

    #wait 5 seconds, stop nlinking cursor and hide cursor
    time.sleep(5)
    lcd.blink = False
    lcd.clear()
```

```
    # scroll message from right to left
    lcd.clear()
    scroll_msg = "<-- Scroll -->"
    lcd.message = scroll_msg
    for i in range(len(scroll_msg)):
        time.sleep(0.5)
        lcd.move_right()
    for i in range(len(scroll_msg)):
        time.sleep(0.5)
        lcd.move_left()

    #turn no and off background lightning
    lcd.clear()
    lcd.message = "Flash backlight\nin 5 seconds..."
    time.sleep(5.0)
    #turn off background lightning
    lcd.backlight = False
    time.sleep(1.0)
    lcd.backlight = True
    time.sleep(1.0)
    lcd.backlight = False
    #change message
    lcd.clear()
    lcd.message = "Goodbye"
    #turn on background lightning
    lcd.backlight = True
    #turn off background lightning
    time.sleep(2.0)
    lcd.clear()
    lcd.backlight = False

except KeyboardInterrupt:
    #turn off LCD
    lcd.clear()
    lcd.backlight = False
```

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 lcd.py
```

Lesson 11 : Reading and writing RFID cards

In this lesson, you will learn how to control the RFID module. The RFID module is a very interesting and useful module. It is used worldwide in a variety of solutions such as Intelligent door locks, employee IDs, business cards and even dog collars.

The RFID module is located directly under the Raspberry Pi and looks like a small Wifi symbol. This symbol means wireless connectivity. To use it, we need to take the chip, or card, that comes with the Joy-Pi and hold it over the Joy-Pi RFID chip area. It must be close enough for our script to be recognized. 2-4cm should be close enough. Just try it out!

To use the RFID RC522 Shield we need the SPI Bus. We have to modify the config.txt file otherwise the kernel could not start. To get access to the config.txt, we use the following command:

```
sudo nano /boot/config.txt
```

The following lines have to be attached to the end of the file:

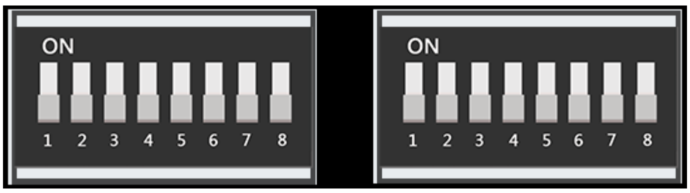
```
device_tree_param=spi=on
dtoverlay=spi-bcm2708
```

Save and exit the file with the keys **CTRL + O** and **CTRL + X**.
Afterwards, activate SPI:

```
sudo raspi-config
```

Activate in ***Interfacing Options*** → ***SPI*** and restart the Raspberry Pi afterwards.

Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.



To navigate to the folder for the RFID scripts you have to use the following command:

```
cd /home/pi/Desktop/Joy-Pi/MFRC522-python
```

If you want to write on the chip or card you can use the following command:

```
sudo python3 Write.py
```

To edit the files which are saved on the catd or the chip, you must modify the programm:

```
# Select the scanned tag
MIFAREReader.MFRC522_SelectTag(uid)

# Authenticate
status = MIFAREReader.MFRC522_Auth(MIFAREReader.PICC_AUTHENT1A, 8, key, uid)
print "\n"

# Check if authenticated
if status == MIFAREReader.MI_OK:

    # Variable for the data to write
    data = [99, 11, 55, 66, 44, 111, 222, 210, 125, 153, 136, 199, 144, 177, 166, 188]

    # Fill the data with 0xFF
    for x in range(0,16):
        data.append(0xFF)
```

To modify the data you have to change the numbers in the square brackets, but the numbers must be higher than 0 and smaller than 255.

If you want to read out the number sequence you have to use the following command:

```
sudo python3 Read.py
```

If you now apply the card or chip onto the reader, the saved number sequence will be shown in the console.

```
Card detected
Card read UID: 107,144,78,115
Size: 8
Sector 8 [99, 11, 55, 66, 44, 111, 222, 210, 125, 153, 136, 199, 144, 177, 166,
188]
```

Code example RFID-Read:

```
#!/usr/bin/env python
# -*- coding: utf8 -*-
#
#    Copyright 2014,2018 Mario Gomez <mario.gomez@teubi.co>
#    This file is part of MFRC522-Python
#    MFRC522-Python is a simple Python implementation for
#    the MFRC522 NFC Card Reader for the Raspberry Pi.
#    MFRC522-Python is free software: you can redistribute it and/or modify
#    it under the terms of the GNU Lesser General Public License as published by
#    the Free Software Foundation, either version 3 of the License, or
#    (at your option) any later version.
#    MFRC522-Python is distributed in the hope that it will be useful,
#    but WITHOUT ANY WARRANTY; without even the implied warranty of
#    MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
#    GNU Lesser General Public License for more details.
#    You should have received a copy of the GNU Lesser General Public License
#    along with MFRC522-Python.  If not, see <http://www.gnu.org/licenses/>.
import RPi.GPIO as GPIO
import MFRC522
import signal

continue_reading = True

# Capture SIGINT for cleanup when the script is aborted
def end_read(signal,frame):
    global continue_reading
    print("Ctrl+C captured, ending read.")
    continue_reading = False
    GPIO.cleanup()

# Hook the SIGINT
signal.signal(signal.SIGINT, end_read)

# Create an object of the class MFRC522
MIFAREReader = MFRC522.MFRC522()

# Welcome message
print("Welcome to the MFRC522 data read example")
print("Press Ctrl-C to stop.")

# This loop keeps checking for chips. If one is near it will get the UID and authenti-
cate
while continue_reading:

    # Scan for cards
    (status,TagType) = MIFAREReader.MFRC522_Request(MIFAREReader.PICC_REQIDL)

    # If a card is found
    if status == MIFAREReader.MI_OK:
        print("Card detected")

    # Get the UID of the card
    (status,uid) = MIFAREReader.MFRC522_Anticoll()
```

```
        # Print UID
        print("Card read UID: %s,%s,%s,%s".format(uid[0], uid[1], uid[2], uid[3]))

        # This is the default key for authentication
        key = [0xFF,0xFF,0xFF,0xFF,0xFF,0xFF]

        # Select the scanned tag
        MIFAREReader.MFRC522_SelectTag(uid)

        # Authenticate
        status = MIFAREReader.MFRC522_Auth(MIFAREReader.PICC_AUTHENT1A, 8, key, uid)

        # Check if authenticated
        if status == MIFAREReader.MI_OK:
            MIFAREReader.MFRC522_Read(8)
            MIFAREReader.MFRC522_StopCrypto1()
        else:
            print("Authentication error")
```

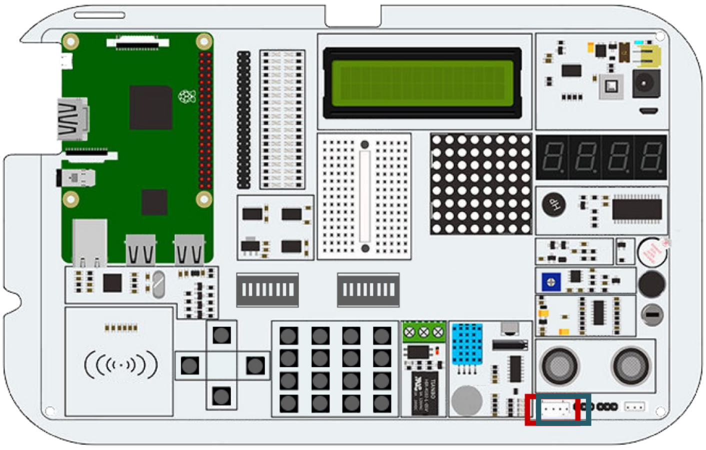
Code example RFID-Write:

```
#!/usr/bin/env python
# -*- coding: utf8 -*-
import RPi.GPIO as GPIO
import MFRC522
import signal

continue_reading = True

#function to perform cleanup functions if the script is aborted
def end_read(signal,frame):
    global continue_reading
    print ("Ctrl+C captured, ending read.")
    continue_reading = False
    GPIO.cleanup()

signal.signal(signal.SIGINT, end_read)

#create an object from the class MFR522
MIFAREReader = MFRC522.MFRC522()

#this loop searches permanently for chips or cards. If one is near, it gets the UID
and identifies itself
while continue_reading:

    # SUcht Karten
    (status,TagType) = MIFAREReader.MFRC522_Request(MIFAREReader.PICC_REQIDL)

    # Wenn Karte gefunden
    if status == MIFAREReader.MI_OK:
        print ("Card detected")
    # UID der Karte erhalten
    (status,uid) = MIFAREReader.MFRC522_Anticoll()
```

```
    #if UID is found, continue
    if status == MIFAREReader.MI_OK:

        #issues UID in console
        print ("Card read UID: %s,%s,%s,%s" % (uid[0], uid[1], uid[2], uid[3]))

        #standard key for authentication
        key = [0xFF,0xFF,0xFF,0xFF,0xFF,0xFF]


        MIFAREReader.MFRC522_SelectTag(uid)

        #authenticating
        status = MIFAREReader.MFRC522_Auth(MIFAREReader.PICC_AUTHENT1A, 8, key, uid)
        print ("\n")

        #Ensure if authenticated
        if status == MIFAREReader.MI_OK:

            #variables of values which should be saved on card
            data = [99, 11, 55, 66, 44, 111, 222, 210, 125, 153, 136, 199, 144, 177, 166, 188]

            for x in range(0,16):
                data.append(0xFF)

            print ("Sector 8 looked like this:")
            #read block 8
            MIFAREReader.MFRC522_Read(8)
            print ("\n")

            print ("Sector 8 will now be filled with 0xFF:")
            #write files
            MIFAREReader.MFRC522_Write(8, data)
            print ("\n")

            print ("It now looks like this:")
            #Checking if written
            MIFAREReader.MFRC522_Read(8)
            print ("\n")

            MIFAREReader.MFRC522_StopCrypto1()

            #Ensure to stop reading for cards
            continue_reading = False
        else:
            print ("Authentification error")
```

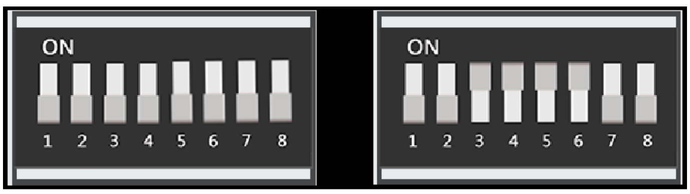
Lesson 12 : Using stepper motors

The stepper motor is an independent module that you will have to connect to the board. We need to take the stepper motor that came with the kit and connect it to your Joy-Pi.
Simply connect the stepper motor to the following connector on the Joy-Pi board:



The module may heat up during use. This is due to technical reasons and is not unusual.
The stepper motor is connected to 4 GPIO pins, which are switched on quickly one after the other. This causes the stepper motor to "push" forward and take one step. Any number of steps can be executed with the **turnSteps** function. The **turnDegrees** function rotates the motor by a certain angle.

Attention! For this example you have to switch between the modules. Turn switch number 3, 4, 5 and 6 on the right switching unit **ON**. All the other switches should be turned **OFF**.



Code example stepper motor

```
#!/usr/bin/python
# -*- coding: utf-8 -*-
# Author : Original author ludwigschuster
# Original Author Github: https://github.com/ludwigschuster/RasPi-GPIO-Stepmotor

import time
import RPi.GPIO as GPIO
import math

class Stepmotor:

    def __init__(self):
        #set GPIO mode
        GPIO.setmode(GPIO.BOARD)
        #the pins of your Raspberry Pi which are used
        self.pin_A = 29
        self.pin_B = 31
        self.pin_C = 33
        self.pin_D = 35
        self.interval = 0.010

        #declare pins as output
        GPIO.setup(self.pin_A,GPIO.OUT)
        GPIO.setup(self.pin_B,GPIO.OUT)
        GPIO.setup(self.pin_C,GPIO.OUT)
        GPIO.setup(self.pin_D,GPIO.OUT)
        GPIO.output(self.pin_A, False)
        GPIO.output(self.pin_B, False)
        GPIO.output(self.pin_C, False)
        GPIO.output(self.pin_D, False)

    def Step1(self):

        GPIO.output(self.pin_D, True)
        time.sleep(self.interval)
        GPIO.output(self.pin_D, False)

    def Step2(self):

        GPIO.output(self.pin_D, True)
        GPIO.output(self.pin_C, True)
        time.sleep(self.interval)
        GPIO.output(self.pin_D, False)
        GPIO.output(self.pin_C, False)

    def Step3(self):

        GPIO.output(self.pin_C, True)
        time.sleep(self.interval)
        GPIO.output(self.pin_C, False)

    def Step4(self):
        GPIO.output(self.pin_B, True)
        GPIO.output(self.pin_C, True)
        time.sleep(self.interval)
        GPIO.output(self.pin_B, False)
        GPIO.output(self.pin_C, False)

    def Step5(self):
        GPIO.output(self.pin_B, True)
        time.sleep(self.interval)
        GPIO.output(self.pin_B, False)
```

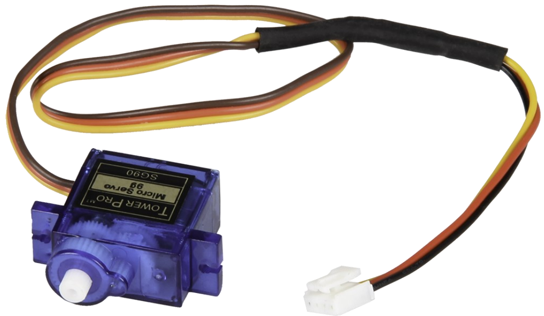
```
    def Step6(self):

        GPIO.output(self.pin_A, True)
        GPIO.output(self.pin_B, True)
        time.sleep(self.interval)
        GPIO.output(self.pin_A, False)
        GPIO.output(self.pin_B, False)

    def Step7(self):

        GPIO.output(self.pin_A, True)
        time.sleep(self.interval)
        GPIO.output(self.pin_A, False)

    def Step8(self):

        GPIO.output(self.pin_D, True)
        GPIO.output(self.pin_A, True)
        time.sleep(self.interval)
        GPIO.output(self.pin_D, False)
        GPIO.output(self.pin_A, False)

    def turn(self,count):
        for i in range (int(count)):
            self.Step1()
            self.Step2()
            self.Step3()
            self.Step4()
            self.Step5()
            self.Step6()
            self.Step7()
            self.Step8()

    def close(self):
        #release GPIOs for other activities
        GPIO.cleanup()

    def turnSteps(self, count):
        #Move n steps
        # (n will be set by yourself)
        for i in range (count):
            self.turn(1)

    def turnDegrees(self, count):
        #Turn n degrees (small values can cause inaccuracy)
        # (n degree from which will be turned)
        self.turn(round(count*512/360,0))

    def turnDistance(self, dist, rad):
        self.turn(round(512*dist/(2*math.pi*rad),0))

def main():

    print("Movement started.")
    motor = Stepmotor()
    print("One step")
    motor.turnSteps(1)
    time.sleep(0.5)
    print("20 steps")
    motor.turnSteps(20)
    time.sleep(0.5)
```

```
    print("quarter of a rotation")
    motor.turnDegrees(90)
    print("Movement stopped.")
    motor.close()

if __name__ == "__main__":
    main()
```

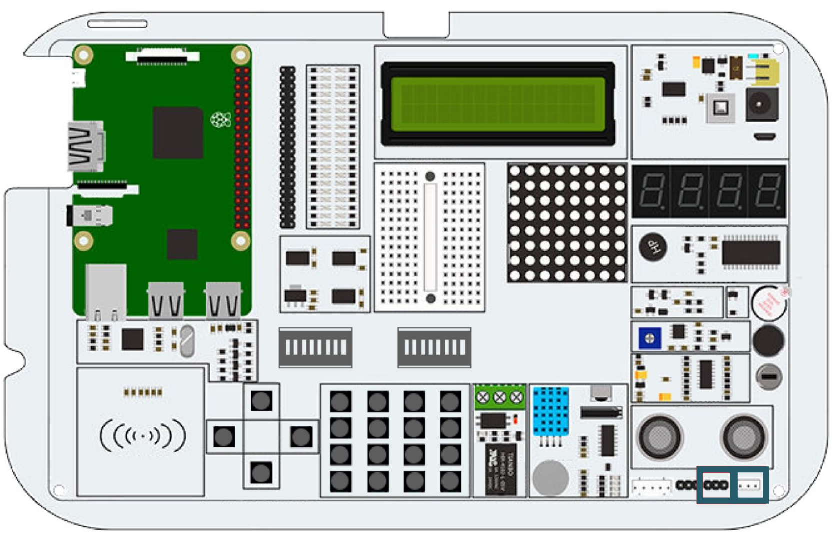
Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 stepmotor.py
```

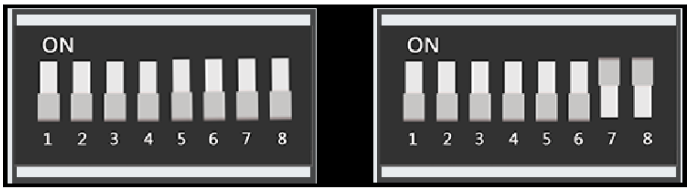
Lesson 13 : Controlling servo motors



With the help of the servo motor, devices can be mechanically controlled and parts can be moved. For example, intelligent waste bins, a box with an intelligent opening and closing door and many other interesting projects can be created.
The Joy-Pi has two servo interfaces, both of which can be used to control servo motors. In this tutorial, we will use interface number two, which is marked as *Servo2*. Of course, you can also use the other servo interface, but you have to adapt the script to the correct GPIOs for this.
The servomotor needs three pins: positive, negative, and the data pin. The positive pin is the red cable, the negative pin is the black cable (also called ground) and the data cable is yellow.



Attention! For this example you have to switch between the modules. Turn switch number 7 and 8 on the right switching unit **ON**. All the other switches should be turned **OFF**.



Cable	Pin
Brown	Left pin of Ser-vo2
Red	Middle pin of Servo2
Orange	Right pin of Servo2

Let's take a look at our example code to understand it better:

The servo uses the GPIO.Board pin number 22. Each time the script will set the direction of the servo motor to rotate. We can use positive degrees to rotate left and negative degrees to rotate right. Just change the degrees and see how the rotation of the motor changes.

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 servo.py
```

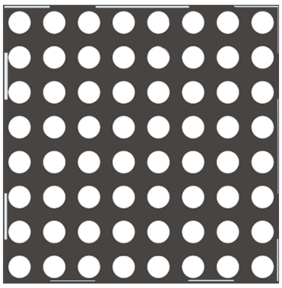
Code example servomotor:

```
#!/usr/bin/python
# -*- coding: utf-8 -*-
# Author : Original author WindVoiceVox
# Original Author Github: https://github.com/WindVoiceVox/Raspi_SG90
import RPi.GPIO as GPIO
import time
import sys

class sg90:

  def __init__( self, pin, direction ):
    GPIO.setmode( GPIO.BOARD )
    GPIO.setup( pin, GPIO.OUT )
    self.pin = int( pin )
    self.direction = int( direction )
    self.servo = GPIO.PWM( self.pin, 50 )
    self.servo.start(0.0)

  def cleanup( self ): #function to stop and to release used GPIOs
    self.servo.ChangeDutyCycle(self._henkan(0))
    time.sleep(0.3)
    self.servo.stop()
    GPIO.cleanup()
```

Code example continued:

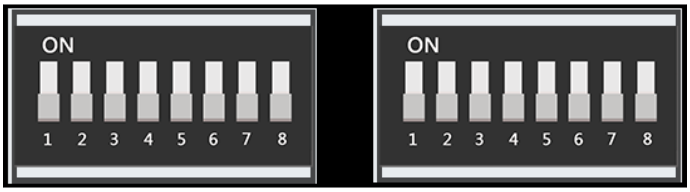
```
  def currentdirection( self ): #function which set the current position
    return self.direction

  def _henkan( self, value ):
    return 0.05 * value + 7.0

  def setdirection( self, direction, speed ): #function to indicate direction
    for d in range( self.direction, direction, int(speed) ):
      self.servo.ChangeDutyCycle( self._henkan( d ) )
      self.direction = d
      time.sleep(0.1)
    self.servo.ChangeDutyCycle( self._henkan( direction ) )
    self.direction = direction

def main():
    servo_pin = 22
    s = sg90(servo_pin,0) #declaration of pin and motor
    try:
        while True:
            print ("Turn left ...")
            s.setdirection( 100, 10 )   #rotate around left
            time.sleep(0.5)             #wait 0.5 seconds
            print ("Turn right ...")
            s.setdirection( -100, -10 ) #rotate around right
            time.sleep(0.5)             #wait 0.5 seconds
    except KeyboardInterrupt:
        s.cleanup()

if __name__ == "__main__":
    main()
```

Lesson 14 : Controlling the 8 x 8 LED matrix



The LED matrix plays an important role in many flashing LED projects. Even if you don't see it at first glance, the LED matrix can do much more than just blink red. It can be used to display small symbols and you can even play Snake on it.
The LED matrix module is a large square module located on the left side of the segment LED and just below the LCD. It can easily be recognized by the small white dots that are the LEDs.
In this example, we display a short text on the LED matrix. In the script, we create a string with a message and use therefore **show_message()**, to display it on the matrix.
We can control properties, such as delays, that make the message faster or slower. The Matrix LED, unlike other modules, uses an SPI interface from which it can be controlled. Try this example and modify it to see how you influence the displayed information.

Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.



Code example LED matrix

```
#!/usr/bin/env python
# -*- coding: utf-8 -*-
# Copyright (c) 2017-18 Richard Hull and contributors
# License: https://github.com/rm-hull/luma.led_matrix/blob/master/LICENSE.rst
# Github link: https://github.com/rm-hull/luma.led_matrix/

#download all required modules
import re
import time
from luma.led_matrix.device import max7219
from luma.core.interface.serial import spi, noop
from luma.core.render import canvas
from luma.core.virtual import viewport
from luma.core.legacy import text, show_message
from luma.core.legacy.font import proportional, CP437_FONT, TINY_FONT, SINCLAIR_FONT, LCD_FONT


def main(cascaded, block_orientation, rotate):

    #create and set matrix device
    serial = spi(port=0, device=1, gpio=noop())
    device = max7219(serial, cascaded=cascaded or 1, block_orientation=block_orientation,
    rotate=rotate or 0)
    #display initilisation of matrix in console
    print("[-] Matrix initialized")

    #show Hello World on matrix
    msg = "Hello World"
    #show issued text in console
    print("[-] Printing: %s" % msg)
    show_message(device, msg, fill="white", font=proportional(CP437_FONT), scroll_delay=0.1)


if __name__ == "__main__":

    # cascaded = Number of cascaded MAX7219 LED matrices, default = 1
    # block_orientation = choices 0, 90, -90, default = 0
    # rotate = choices 0, 1, 2, 3, Rotate display 0=0°, 1=90°, 2=180°, 3=270°, default = 0

    try:
        main(cascaded=1, block_orientation=90, rotate=0)
    except KeyboardInterrupt:
        pass
```

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 matrix_demo.py
```

Lesson 15 : Controlling the 7 segment display

The segment LED is a very useful display when it comes to numbers and data. It can show us the time and can count how many times we have done certain things. The segment display is also used in many industrial solutions, such as elevators.

The segment display is located directly above the vibration sensor and next to the LED matrix. When it is turned off, 4 eights are visible. As soon as you have activated the segment display module the dark colour becomes a shiny, bright red.

In our example, we demonstrate a clock. We will use the time and date modules to get the Raspberry Pi system time, which we display using the **segment.write_display()** function. The **set_digit()** function, in combination with the numbers 0,1,2 and 3, sets the position on the display where the number should be shown.

Since the current system time is retrieved in this example, it is necessary to configure the Raspberry Pi to the correct time zone first. Open a terminal window and enter the following command:

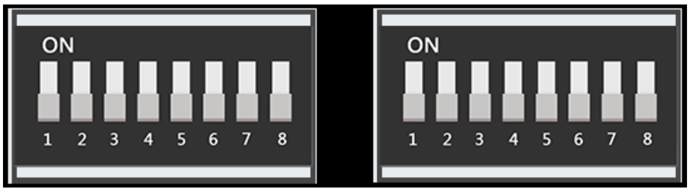
```
sudo dpkg-reconfigure tzdata
```

A window opens in which you can select your current time zone. After you have selected the correct time zone, confirm with the **OK** button and press **Enter** again to confirm.

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 segment.py
```

Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.



Code example segment display

```
#!/usr/bin/python
# -*- coding: utf-8 -*-

import time
import datetime
import board

from adafruit_ht16k33.segments import Seg7x4

i2c = board.I2C()
segment = Seg7x4(i2c, address=0x70)
# segment of I2C address 0x70 and assign the display definition

segment.fill(0)
# intialisation of the display,
# must be performed once before the display can be used

print ("STRG+C Druecken zum beenden.")
# print command for output to end the script

# loop which permanently updates the time and shows on the display
try:
  while(True):
    now = datetime.datetime.now()
    hour = now.hour
    minute = now.minute
    second = now.second

    segment.fill(0)

    # display for the hours
    segment[0] =  str(int(hour / 10))      # tens
    segment[1] =   str(hour % 10)          # single - figure numerals
    # display for the minutes
    segment[2] =   str(int(minute / 10))   # tens
    segment[3] =   str(minute % 10)        # single - figure numerals

    if second % 2  == 0:
        segment.colon = True
    else:
        segment.colon = False

    segment.show() # is needed to update LEDs

    time.sleep(1) # wait one second
except KeyboardInterrupt:
    segment.fill(0)
```

Lesson 16 : Detecting touches

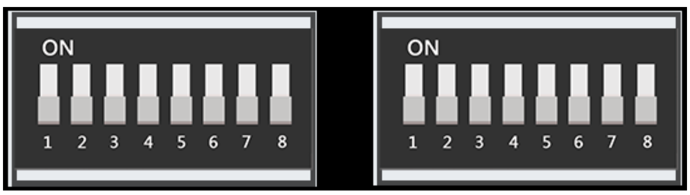
The touch sensor is very useful when it comes to key functions. Many products on the market use touch instead of pressing a button, such as smartphones and tablets. The touch sensor is located directly below the DHT11 sensor and to the right of the relay. The easily accessible positioning on the Joy-Pi allows easy operation.

The touch sensor works like any other key module. The only difference is that it only needs to be touched instead of pressed. By touching the touch sensor, the module closes a circuit because the computer detects that the sensor has been touched. The touch sensor uses GPIO board pin 11.

Code examples touch sensor:

```
#!/usr/bin/env python
# -*- coding: utf-8 -*-

from RPi import GPIO     #add libraries
import signal

TOUCH = 11                      #set TOUCH pin 11 (declaration of variables).

def setup_gpio():        #create function setup_gpio
    GPIO.setmode(GPIO.BOARD)  #use GPIO pins like in the GPIO board schemata
    GPIO.setup(TOUCH, GPIO.IN, pull_up_down=GPIO.PUD_UP)

def do_smt(channel):
    print("Touch detected")

def main():
    setup_gpio()
    try:
        GPIO.add_event_detect(TOUCH, GPIO.FALLING, callback=do_smt, bouncetime=200)
        signal.pause()
    except KeyboardInterrupt:
        pass
    finally:
        GPIO.cleanup()

if __name__ == '__main__':
    main()
```

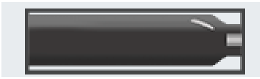
Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.



Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 touch.py
```

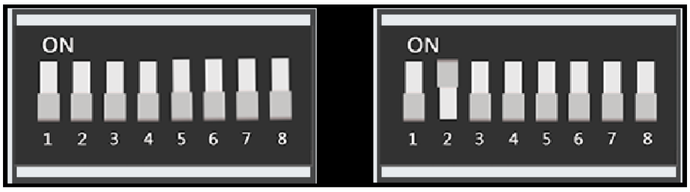
Lesson 17 : Detecting tilts with the tilt sensor



The tilt sensor allows us to detect an inclination to the right or left. It is used in robotics and other industries to ensure that things are held straight. It is a small, elongated, black sensor that lies between the DHT11 sensor and the ultrasonic sensor and can easily be detected by the sound it makes when you tilt the board a little.

If the tilt sensor is tilted to the left, the circuit is activated and a ***GPIO HIGH*** signal is sent. If the tilt sensor is tilted to the right, the circuit is deactivated and a ***GPIO LOW*** signal is sent.

Attention! For this example you have to switch between the modules. Turn switch number 2 on the right switching unit **ON**. All the other switches should be turned **OFF**.



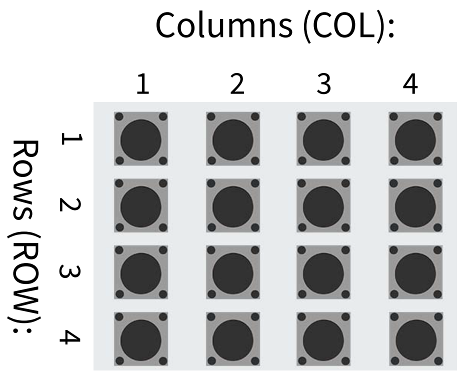
Code example tilt sensor:

```
#!/usr/bin/python

import time
import RPi.GPIO as GPIO

#define tilt_pin
tilt_pin = 15

#set GPIO mode to GPIO.BOARD
GPIO.setmode(GPIO.BOARD)

# set pin as INPUT
GPIO.setup(tilt_pin, GPIO.IN)

try:
     while True:
          #positive is tilt to the left / negative is tilt to the right
          if GPIO.input(tilt_pin):
               print ("[-] Left Tilt")
          else:
               print ("[-] Right Tilt")
          time.sleep(1)
except KeyboardInterrupt:
     #CTRL+C exists programm
     GPIO.cleanup()
```

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 tilt.py
```

Lesson 18 : Using the button matrix



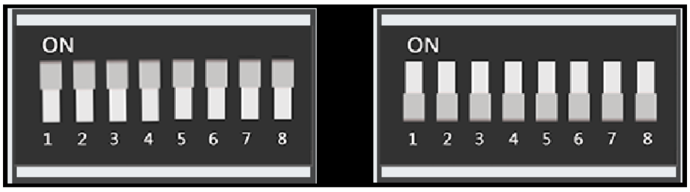
The button matrix is a module with 16 independent buttons that can be used for many projects such as a keyboard or a memory game.

The button matrix is located at the bottom center of the Joy-Pi board, to the right of the relay. It is easily recognizable by the 16 individual buttons. The excellent positioning on the board allows easy operation of the keys while still providing a good overview of all other sensors.

The button matrix consists of four columns and rows. We configure the matrix rows and columns with their GPIO pins and initialize the object **ButtonMatrix()** as a variable for buttons. Then we can press any button of the matrix and see which one has been pressed.

In our example, after recognizing a keystroke, we activate the function **activateButton()**, which displays the number of the pressed button. You can, of course, edit this module to do anything you can imagine.

Attention! For this example you have to switch between the modules. Turn **ALL** switches on the left switching unit **ON**. All the other switches should be turned **OFF**.

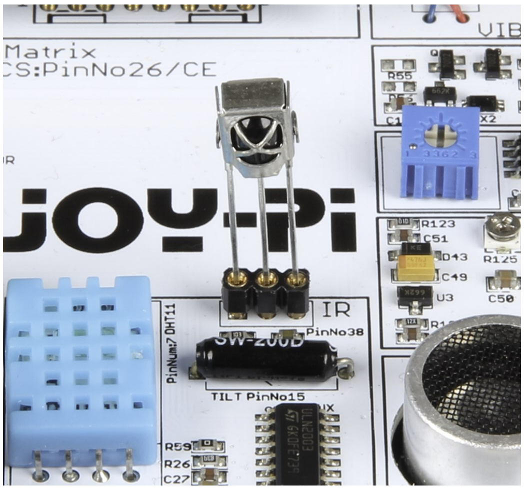


```python
#!/usr/bin/python
# -*- coding: utf-8 -*-
# Author : original author stenobot
# Original Author Github: https://github.com/stenobot/SoundMatrixPi

import RPi.GPIO as GPIO
import time

class ButtonMatrix():

    def __init__(self):

        GPIO.setmode(GPIO.BOARD)

        #set IDs of the buttons
        self.buttonIDs = [[4,3,2,1],[8,7,6,5],[12,11,10,9],[16,15,14,13]]
        #declarate GPIO pins for the lines
        self.rowPins = [13,15,29,31]
        #declarate GPIO pins for the columns
        self.columnPins = [33,35,37,22]

        #define 4 inputs with pull up resistors
        for i in range(len(self.rowPins)):
            GPIO.setup(self.rowPins[i], GPIO.IN, pull_up_down = GPIO.PUD_UP)

        #define 4 outputs ans set them on high
        for j in range(len(self.columnPins)):
            GPIO.setup(self.columnPins[j], GPIO.OUT)
            GPIO.output(self.columnPins[j], 1)

    def activateButton(self, rowPin, colPin):
        #get button number
        btnIndex = self.buttonIDs[rowPin][colPin] - 1
        print("button " + str(btnIndex + 1) + " pressed")
        #prevent several presses on a button in a short time
        time.sleep(.3)

    def buttonHeldDown(self,pin):
        if(GPIO.input(self.rowPins[pin]) == 0):
            return True
        return False

def main():

    #initialisation of button matrix
    buttons = ButtonMatrix()
    try:
        while(True):
            for j in range(len(buttons.columnPins)):
                #every output pin is set on low
                GPIO.output(buttons.columnPins[j],0)
                for i in range(len(buttons.rowPins)):
                    if GPIO.input(buttons.rowPins[i]) == 0:
                        buttons.activateButton(i,j)
                        #do nothing as long as teh button is pressed
                        while(buttons.buttonHeldDown(i)):
                            pass
                GPIO.output(buttons.columnPins[j],1)
    except KeyboardInterrupt:
        GPIO.cleanup()

if __name__ == "__main__":
    main()
```

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 button_matrix.py
```

Lesson 19 : Controlling and using the IR sensor

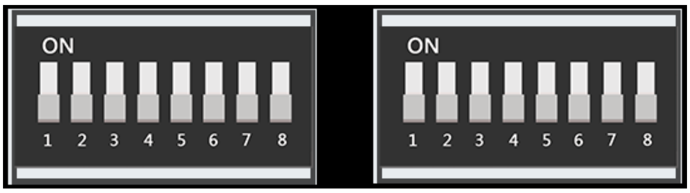


In this lesson, we will learn how to use the infrared receiver and how to receive IR codes from a remote control. The use of this method is extremely useful because we can use different define actions for different buttons. With a remote control, we can switch on different LEDs or control the servo motor each time the button is pressed.

The IR sensor will be delivered with the Joy-Pi but is not pre-installed. You have to plug it in the slot as shown in the picture above. The IR sensor is located to the right of the DHT11 sensor and above the tilt sensor. It looks like a small LED with 3 pins. We also need the IR remote control, which is included in the Joy-Pi-Kit.

Important! Remove the IR-sensor before you close the Joy-Pi case.

Attention! In this example you have to switch all switching units on the left as well as all on the right **OFF**.



Code example IR receiver:

```
#!/usr/bin/env python3
"""IRModuleExample1, program to practice using the IRModule
Created Apr 30, 2018"""

"""
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"""

import RPi.GPIO as GPIO
import IRModule
import time

def remote_callback(code):

    # Codes listed below are for the
    # Sparkfun 9 button remote

    if code == 0xffa25d:
        print("KEY_CH-")
    elif code == 0xff629d:
        print('KEY_CH')
    elif code == 0xffe21d:
        print('KEY_CH+')
    elif code == 0xff22dd:
        print('KEY_PREV')
    elif code == 0xff02fd:
        print('KEY_NEXT')
    elif code == 0xffc23d:
        print('KEY_PLAY/PAUSE')
    elif code == 0xffe01f:
        print('KEY_VOL-')
    elif code == 0xffa857:
        print('KEY_VOL+')
    elif code == 0xff906f:
        print('KEY_EQ')
    elif code == 0xff6897:
        print('KEY_0')
    elif code == 0xff9867:
        print('KEY_100+')
```

Code example IR receiver:

```
    elif code == 0xffb04f:
        print('KEY_200+')
    elif code == 0xff30cf:
        print('KEY_1')
    elif code == 0xff18e7:
        print('KEY_2')
    elif code == 0xff7a85:
        print('KEY_3')
    elif code == 0xff10ef:
        print('KEY_4')
    elif code == 0xff38c7:
        print('KEY_5')
    elif code == 0xff5aa5:
        print('KEY_6')
    elif code == 0xff42bd:
        print('KEY_7')
    elif code == 0xff4ab5:
        print('KEY_8')
    elif code == 0xff52ad:
        print('KEY_9')
    else:
        print('UNKNOWN')  # unknown code

    return

# set up IR pi pin and IR remote object
irPin = 20
ir = IRModule.IRRemote(callback='DECODE')
# using 'DECODE' option for callback will print out
# the IR code received in hexadecimal
# this can used to get the codes for whichever NEC
# compatable remote you are using

# set up GPIO options and set callback function required
# by the IR remote module (ir.pWidth)
GPIO.setwarnings(False)
GPIO.setmode(GPIO.BCM)      # uses numbering outside circles
GPIO.setup(irPin,GPIO.IN)   # set irPin to input
GPIO.add_event_detect(irPin,GPIO.BOTH,callback=ir.pWidth)

ir.set_verbose() # verbose option prints outs high and low width durati-
ons (ms)
print('Starting IR remote')
print('Use ctrl-c to exit program')
```

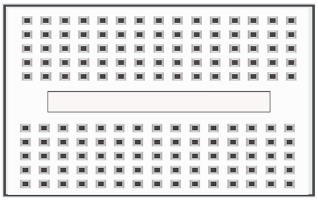
Code example IR receiver:

```
try:
    #time.sleep(5)

    # turn off verbose option and change callback function
    # to the function created above - remote_callback()
    print('Turning off verbose setting and setting up callback')
    ir.set_verbose(False)
    ir.set_callback(remote_callback)

    # This is where you could do other stuff
    # Blink a light, turn a motor, run a webserver
    # count sheep or mine bitcoin

    while True:
        time.sleep(1)

except:
    print('Removing callback and cleaning up GPIO')
    ir.remove_callback()
    GPIO.cleanup(irPin)
```

Execute the following commands and try it yourself:

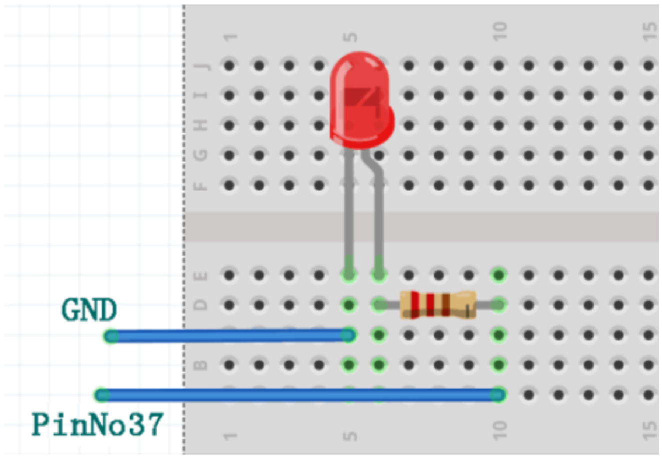
```
cd /home/pi/Desktop/Joy-Pi
sudo python3 IR.py
```

Lesson 20: Own circuits with the breadboard



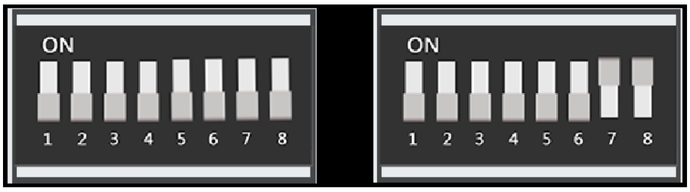
The breadboard is an extremely useful part of the Joy-Pi that allows us to create our own circuits and functions. Now that we've learned how to use all the sensors, it's time to create our own. In this lesson, you will create your first custom circuit using a flashing LED example. The breadboard is located in the middle of the Joy-Pi board. It is a small, white, board with many small holes.

We will create a custom circuit with the function to make an LED blink. To do this, we need to use GPIO as output and GND, as we already did in earlier lessons. We will connect the **servo interface** (SERVO1 interface) to **GPIO 37**.

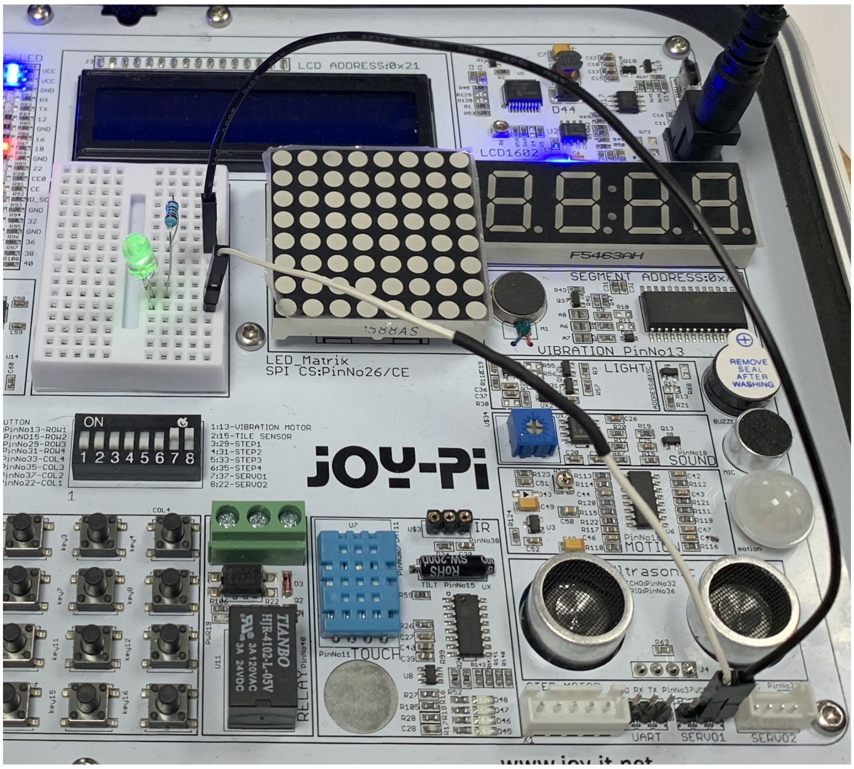


You can use this picture as a guide to create your circuit on the plug-in board. Remember that pin number 37 is on the GPIO port and GND is on the GND port of the SERVO1 interface.

Attention! For this example you have to switch between the modules because the servo pins are used. Turn switch number 7 and 8 on the right switching unit **ON**. All the other switches should be turned **OFF**.



We must use a resistor and connect it to the negative side of the LED (the negative side of the LED is the one with the shorter leg). We will connect the other side of the resistor directly to the GND pin on the SERVO1 interface using the cable. Connect the positive side of the LED to the GPIO37 pin of the SERVO1 interface.



After you build the circuit ist time to write the code that will control the LED. The plan is to send **GPIO.HIGH** to the GPIO37 Pin then wait for 0.2 seconds and cut the signal with **GPIO.LOW**. This will be looped and the LED will start blinking.
You can stop the program by clicking **CTRL+C**.

Important! The LED, the resistor and the cable are not included in the scope of delivery.

Code example:

```
#!/usr/bin/python
import time
import RPi.GPIO as GPIO

#define LED pin
led_pin = 37
#set GPIO mode to GPIO.BOARD
GPIO.setmode(GPIO.BOARD)
#set pin as output
GPIO.setup(led_pin, GPIO.OUT)

try:
    while True:
        #turn on LED
        GPIO.output(led_pin, GPIO.HIGH)
        #wait 0.2 seconds
        time.sleep(0.2)
        #turn off LED
        GPIO.output(led_pin, GPIO.LOW)
        #wait 0.2 seconds
        time.sleep(0.2)

except KeyboardInterrupt:
    #CTRL+C to exit the programm
    GPIO.cleanup()
```

Execute the following commands and try it yourself:

```
cd /home/pi/Desktop/Joy-Pi
sudo python3 blinking_led.py
```

Lesson 21 : Photographing with the Raspberry Pi camera

The Raspberry Pi camera is extremely useful and can be used for a variety of projects. For example for security cameras, face recognition and much more. In the following lesson, we will introduce you to the basics of using the Raspberry Pi camera. This will teach you how to take a picture.
The camera is located centrally above the Joy-Pi's screen and is connected directly to the Raspberry Pi with a USB cable.

First, after you ensured that the camera is connected, install the *fswebcam* package with the following command
(the package is in the prepared image already installed):

```
sudo apt-get install fswebcam
```

Enter the command *fswebcam* followed by the name of the file. The webcam will take a picture and will save it with the entered filename in the current directory:

```
sudo fswebcam image.jpg
```

You can take a picture with the resolution of 1280 x 1024 like that:

```
sudo fswebcam -r 1280-1024 image2.jpg
```

If you add now the command ***--no-banner*** , you remove the time and date stamp:

```
sudo fswebcam -r 1280-1024 --no-banner image3.jpg
```

To capture a video, we use the following command whereby the resolution can be modified:

```
sudo ffmpeg -f v412 -r 25 -s 780x480 -i /dev/video0 Beispiel.avi
```

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