

## MULTI-SENSOR

This project consists of a module that manages different sensors for home use. The idea is to be able to mix and match different sensors, according to the requirements of each area of the house, using a single PCB design and a configurable sketch, making it easier to setup and maintain a sensor network.

### Description

The sensor module is based on the MySensors library using an Arduino® Mini Pro, which has a good number of interface pins, it has a small footprint and is suited for running on batteries.

The radio module for wireless communication is the NRF24L01.

It supports the following sensors:

- Motion Sensor.
- 1 – 3 Door / Window sensors.
- Temperature and humidity sensor.
- Flame sensor.
- Light sensor.
- LUX Sensor (I2C).
- Smoke sensor.
- Gas sensor.
- CO sensor.
- 1 – 3 Moisture sensors.
- 1 – 3 Leak detectors.

It also includes the features:

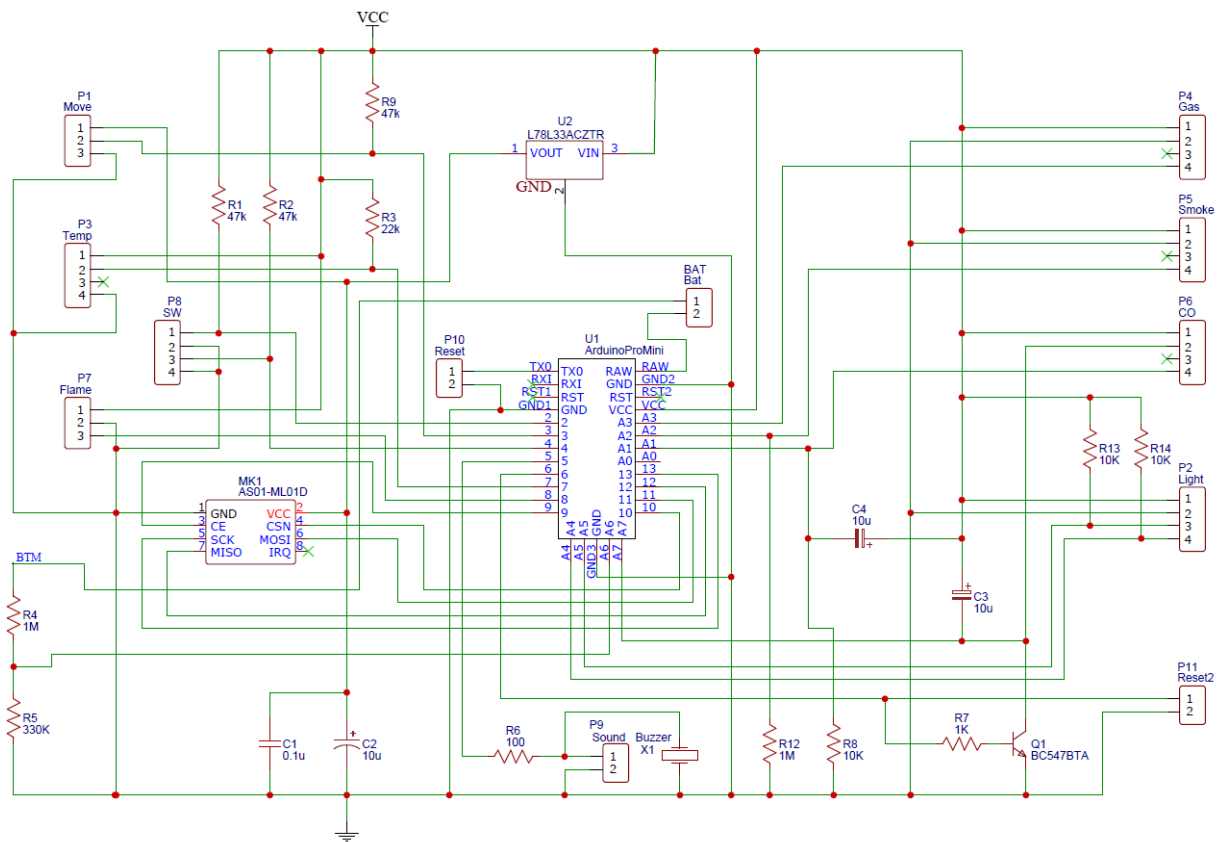
- Battery operation or battery backup
- Audible Alarm
- Reset / Test / Calibrate button

### Hardware

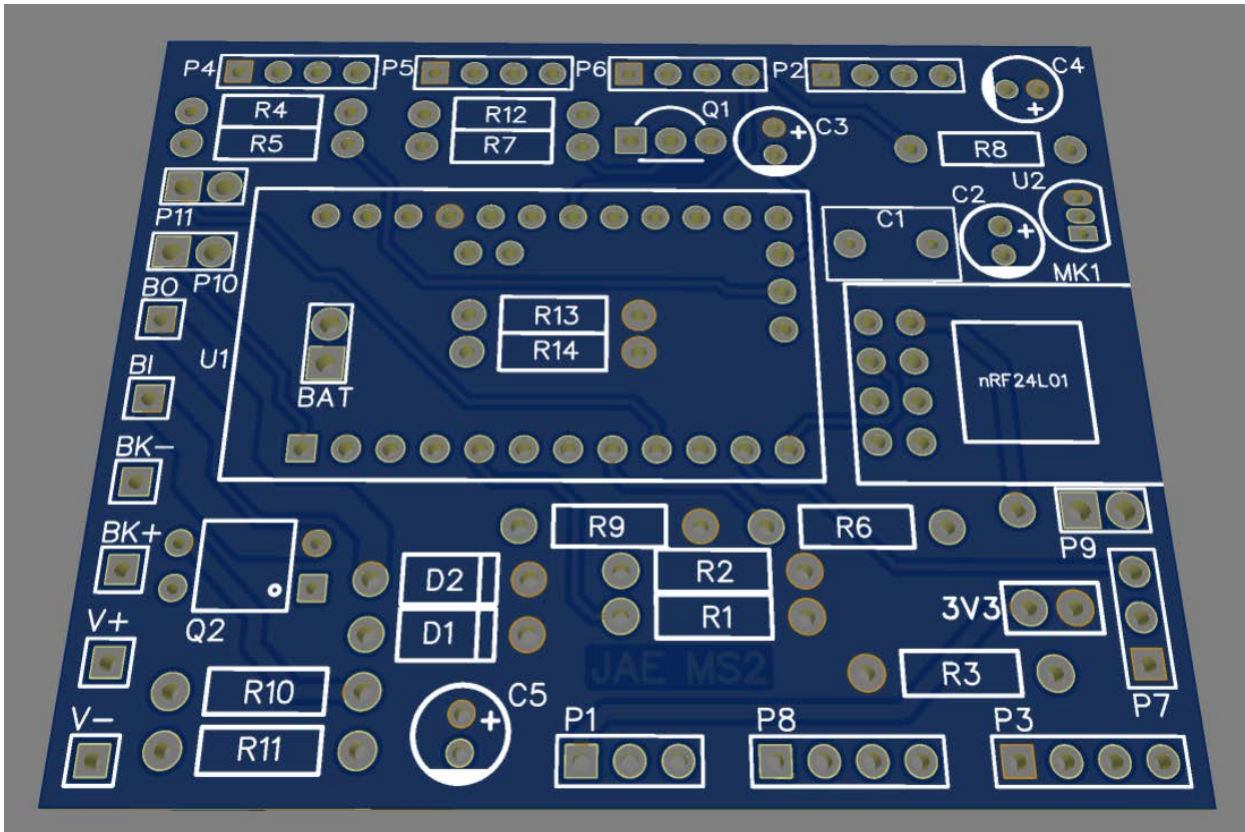
The module is based on the Arduino® Mini Pro and the NRF24L01 radio, using readily available sensor boards, connected through a PCB.

The sensor module can be powered using a small power supply, through batteries, or a combination of a power supply and rechargeable battery for backup.

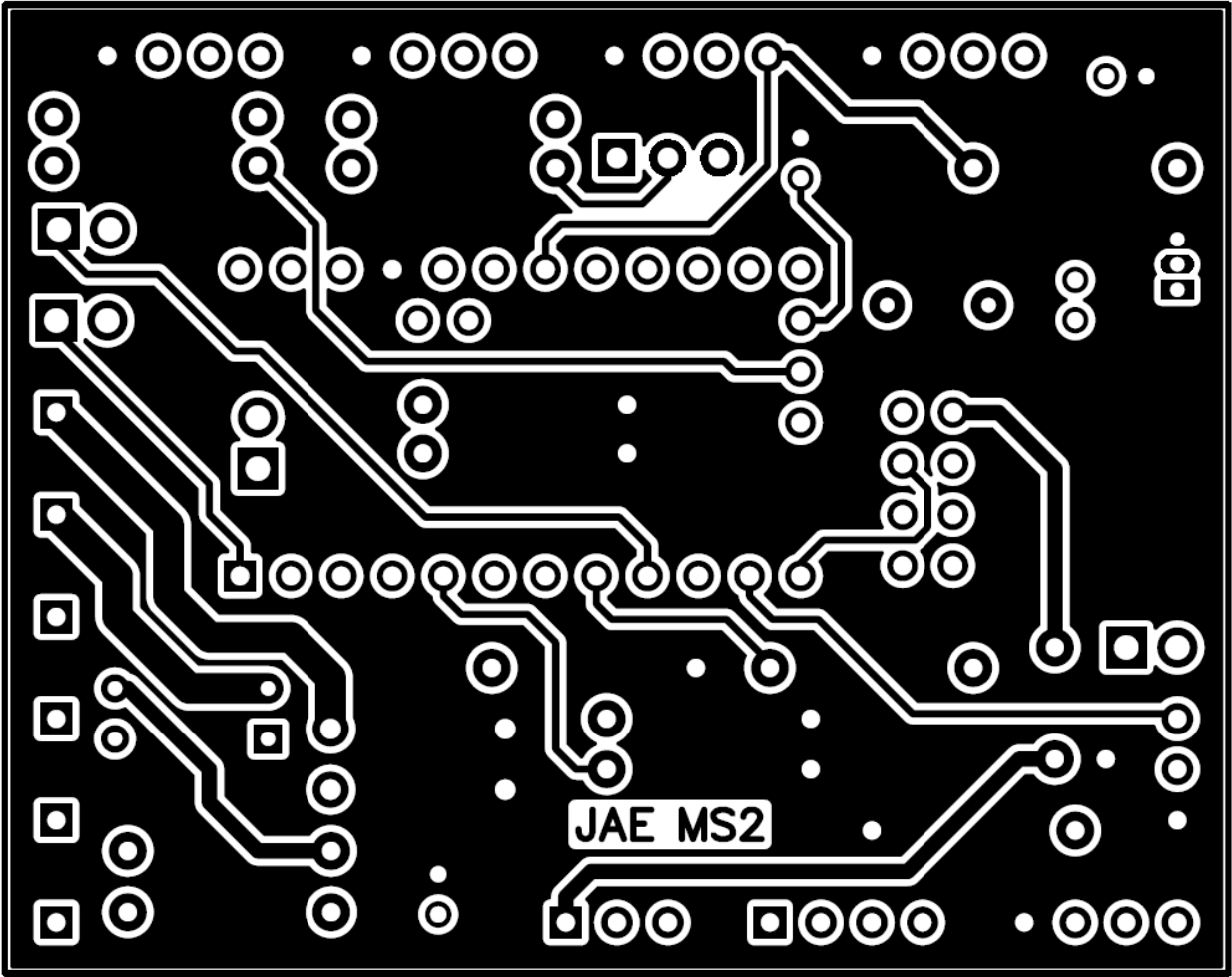
## Schematic Diagram



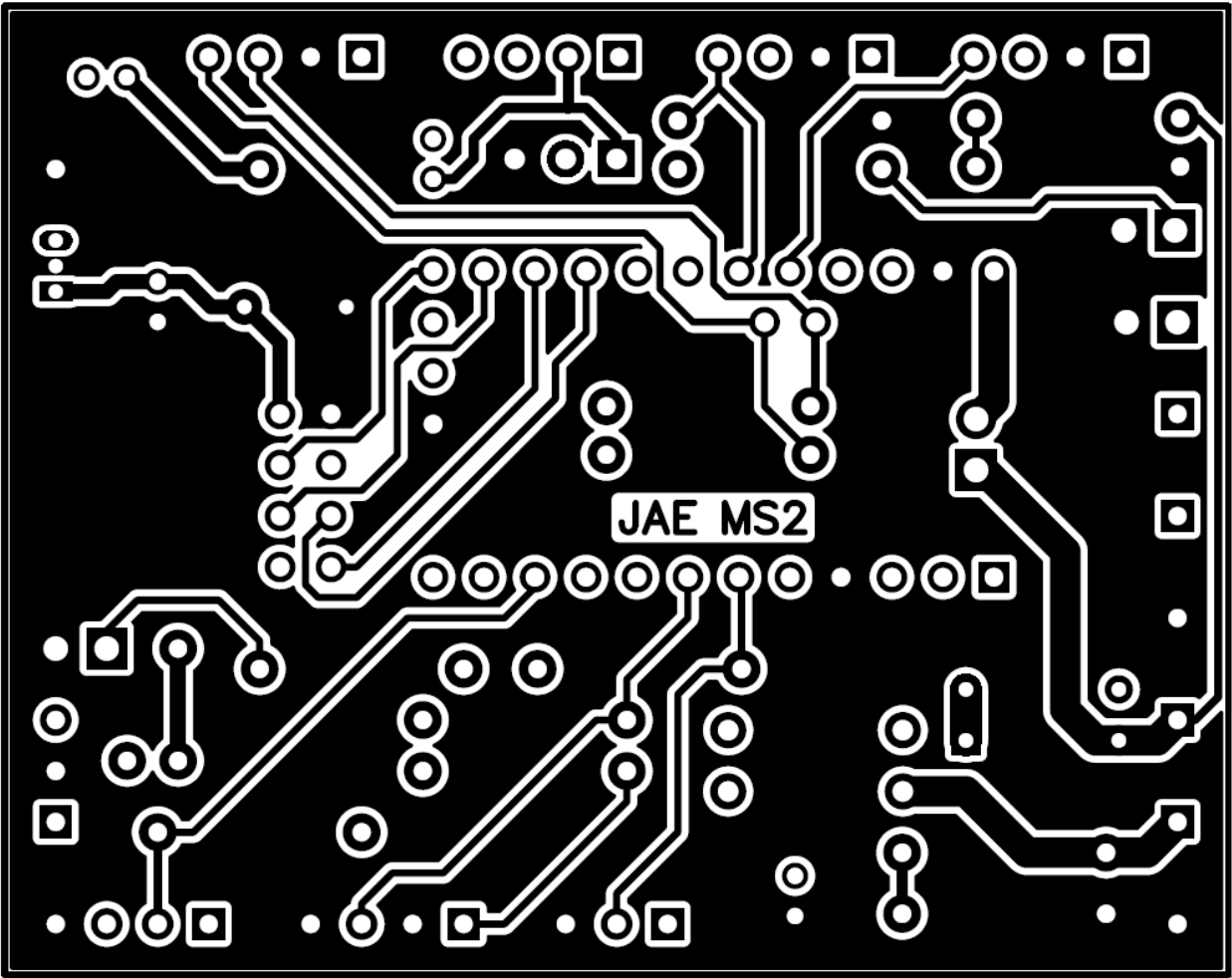
## PCB



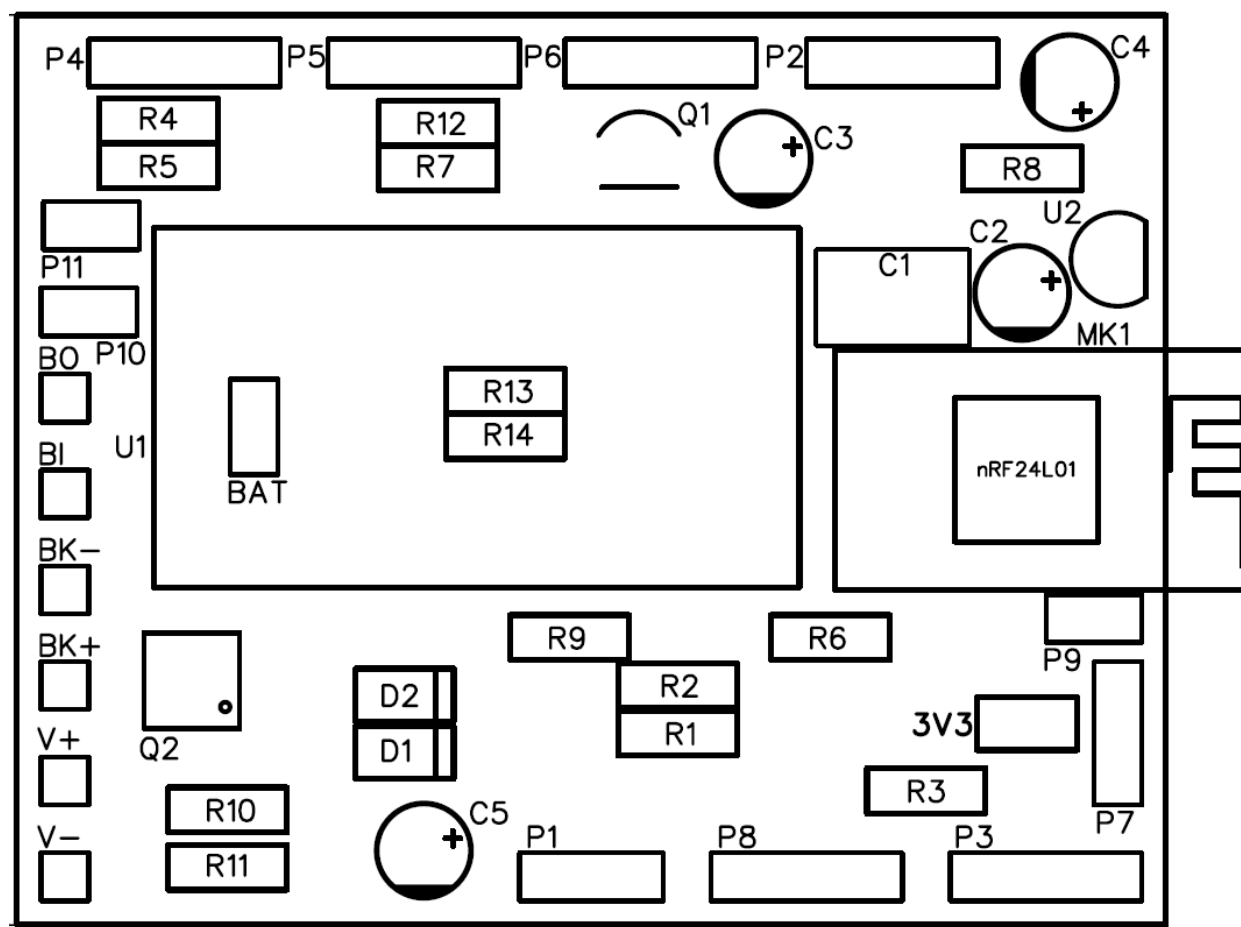
Top Layer



Bottom Layer



## Component Silk Mask



## Microcontroller

The module can be configured with a 5V or 3.3V Arduino Pro Mini microcontroller module.

In the case of battery operation, it is recommended to use the 3.3V microcontroller. In this case, all sensors must be rated to operate at 3.3V.

In the case of a 5V microcontroller you can use 5V and 3.3V sensors in combination.

The NRF24L01 radio module requires 3.3V, so a regulator (U2) for the radio (and the motion sensor) is included in the circuit, in case of using a 5V microcontroller.

If the controller is 3.3V, the U2 regulator is not required, but it is necessary to put a jumper between terminals 1 and 3 of U2.

## Sensors

Some of the sensors use the same pins in the microcontroller, so a combination of sensors can be chosen according to the following table:

Arduino Pins	Sensors			Features	Sleep
1				Button	N/A
2	Door 1			Button	
3	Door 2	PIR Motion		Button	

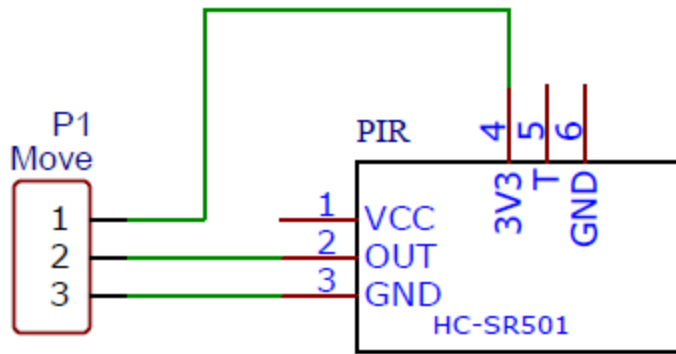
4	Door 3				Optional
5				Alarm	
7	Temp. / Hum.				
8	Flame				
6, A1, A7	MQ-7	Moist 3	Leak 3	Button	Optional
A2	MQ-2	Moist 2	Leak 2		
A3	MQ-5	Moist 1			
A4, A5	Light	Lux			
A6				Battery monitor	

The sensors that require it, have been configured with external Pull Up resistors to improve energy consumption and to be able to operate with batteries.

Sensor	VCC	Reference
PIR Motion Sensor	3.3V, 5V	<a href="https://www.adafruit.com/product/189">https://www.adafruit.com/product/189</a>
Door Sensor	3.3V, 5V	<a href="https://www.sparkfun.com/products/8642">https://www.sparkfun.com/products/8642</a>
	3.3V, 5V	<a href="https://www.sparkfun.com/products/13247">https://www.sparkfun.com/products/13247</a>
	3.3V, 5V	<a href="https://www.sparkfun.com/products/13014">https://www.sparkfun.com/products/13014</a>
Temp / Humidity sensor	3.3V, 5V	<a href="https://learn.adafruit.com/dht">https://learn.adafruit.com/dht</a>
Light Sensor	5V	<a href="https://www.makerfabs.com/light-sensor-module.html">https://www.makerfabs.com/light-sensor-module.html</a>
	3.3V, 5V	<a href="https://www.adafruit.com/product/2748">https://www.adafruit.com/product/2748</a>
	3.3V, 5V	<a href="http://arduinolearning.com/code/arduino-lx1972-light-sensor-example.php">http://arduinolearning.com/code/arduino-lx1972-light-sensor-example.php</a>
LUX Sensor	3.3V, 5V	<a href="https://www.adafruit.com/product/4162">https://www.adafruit.com/product/4162</a>
	3.3V, 5V	<a href="https://www.adafruit.com/product/439">https://www.adafruit.com/product/439</a>
	3.3V, 5V	<a href="https://www.adafruit.com/product/4681">https://www.adafruit.com/product/4681</a>
Flame Sensor	3.3V, 5V	<a href="https://www.pcboard.ca/flame-sensor-module">https://www.pcboard.ca/flame-sensor-module</a>
Smoke Sensor	5V	<a href="https://www.smart-prototyping.com/MQ2-gas-sensors-module.html">https://www.smart-prototyping.com/MQ2-gas-sensors-module.html</a>
Gas Sensor	5V	<a href="https://www.smart-prototyping.com/MQ-5-Methane-Gas-Sensor-Module.html?search=mq-5">https://www.smart-prototyping.com/MQ-5-Methane-Gas-Sensor-Module.html?search=mq-5</a>
CO Sensor	5V	<a href="https://www.waveshare.com/mq-7-gas-sensor.htm">https://www.waveshare.com/mq-7-gas-sensor.htm</a>
Moisture sensor	3.3V, 5V	<a href="https://www.seeedstudio.com/Grove-Capacitive-Moisture-Sensor-Corrosion-Resistant.html?utm_source=blog&amp;utm_medium=blog">https://www.seeedstudio.com/Grove-Capacitive-Moisture-Sensor-Corrosion-Resistant.html?utm_source=blog&amp;utm_medium=blog</a>
	3.3V, 5V	<a href="https://www.seeedstudio.com/Grove-Moisture-Sensor.html">https://www.seeedstudio.com/Grove-Moisture-Sensor.html</a>
Leak Sensor	3.3V, 5V	<a href="https://www.aartech.ca/vip1000-h2o/flair-waterguard-water-detector-5-24vdc-white.html">https://www.aartech.ca/vip1000-h2o/flair-waterguard-water-detector-5-24vdc-white.html</a>

## Wiring

### a) Motion sensor



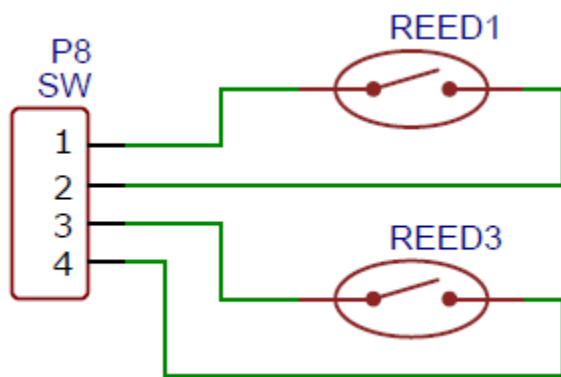
Install 47 KOhms resistor **R9**.

The motion sensor is connected to the 3.3V source, which is more efficient in power consumption. Consider the next articles for details on how to connect the PIR sensor:

<https://screenzone.eu/modify-hc-sr501-pir-sensor-to-work-with-3-3v/>

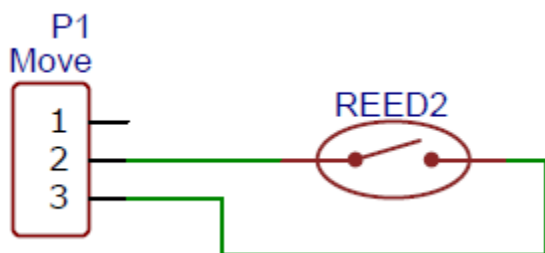
<https://gndtovcc.home.blog/2020/04/23/modifying-cheap-pir-motion-sensor-to-work-at-3-3v/>

#### b) Door sensors 1 and 3



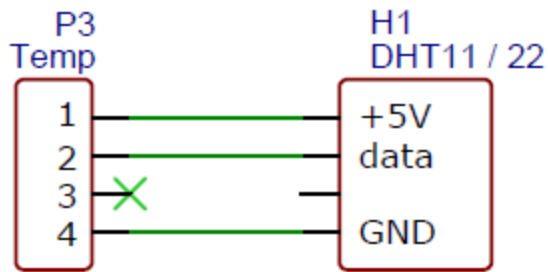
Install 47 KOhms resistors **R1** (Door 1) and **R2** (Door 2).

#### c) Door sensor 2



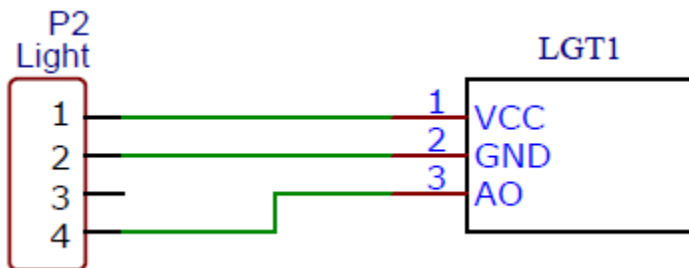
Install 47 KOhms resistor **R9**.

#### d) Temperature / Humidity sensor



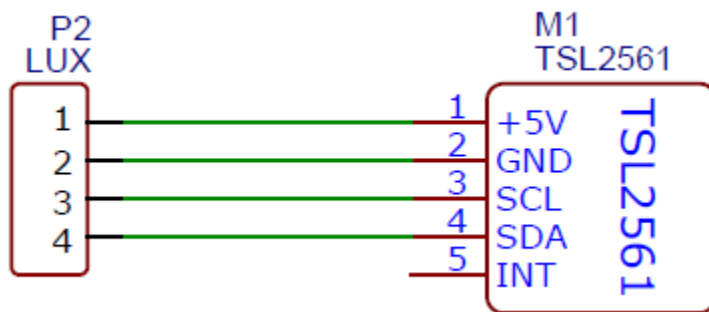
Install 22 KOhms resistor **R3**.

#### e) Light sensor



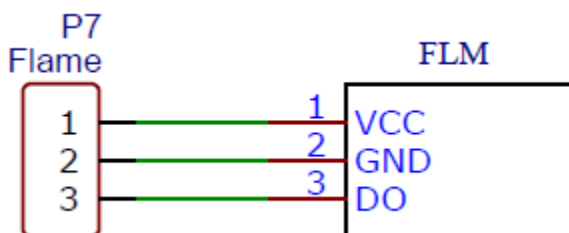
#### f) LUX Sensor

This sensor connects using two data pins with the I2C protocol. Any other I2C compatible sensor can be used instead or in parallel, but the sketch must be modified and the corresponding libraries installed.



Install 10 KOhms resistors R13 and R14.

#### g) Flame sensor





## Air Quality Sensors

The module supports 3 air quality sensors. MQ-2, MQ-5 and MQ-7. It is possible to replace the MQ-2 and MQ-5 with others similar sensors to detect specific gases, but the curves for the calculation of PPMs must be adjusted in the sketch.

These MQ sensors have different sensitivities to different gases, however it is not possible to differentiate between one specific gas, for this reason the module has been equipped with a sensor for general air quality detection (MQ-2) and other more specific ones in order to have an accurate reading of the type of gas present, if required.

These sensors can consume up to 900mA, so it is not suitable for battery operation, so it is recommended to have a power supply with backup batteries, especially if using more than one sensor simultaneously.

For a simple, general use sensor and triggering an alarm, a single MQ-2 sensor is enough. If a more accurate reading of flammable gases is required, the MQ-5 can be used and MQ-7 can be used to detect Carbon Monoxide more accurately.

The MQ-2 is a general-purpose sensor that can detect:

- Smoke
- Liquefied Petroleum Gas (LPG)
- Natural Gas (CH<sub>4</sub>)
- Carbon Monoxide (CO)

The MQ-5 is sensor focused on flammable gases and can detect:

- Liquefied Petroleum Gas (LPG)
- Natural Gas (CH<sub>4</sub>)

The MQ-7 sensor is specific for Carbon Monoxide. This sensor requires the application of two voltage levels alternately, so it requires constant operation of the microprocessor, so if this sensor is activated, the sleep mode is deactivated.

The air quality sensors can be used to trigger an alarm or exclusively for monitoring.

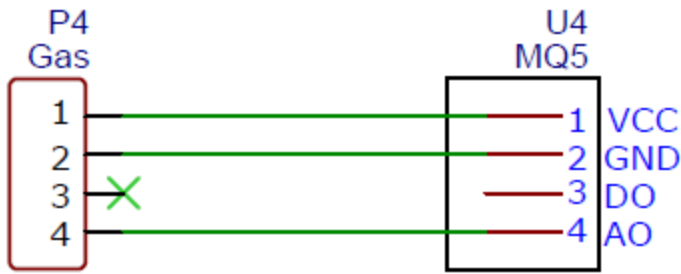
When any of the air quality sensors is enabled in the module, the calibration button is automatically enabled. See below on the BUTTON and INTERRUPTIONS sections for more details.

If the alarm feature is enabled, it will be trigger if certain levels are reached in the monitored gases. The button is also used to reset / test the alarm.

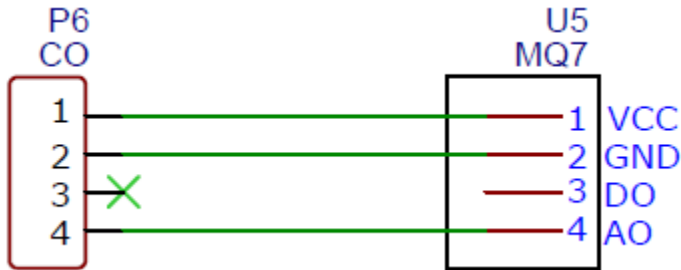
### h) Smoke sensor



### i) Gas sensor



#### j) Carbon Monoxide sensor



Install 1 KOhms resistor **R7**, 10 KOhms resistor **R8**, 10uF tantalum capacitors **C3** and **C4**, and transistor **Q1** (BC547B).

#### Moisture / Leak Sensors

Moisture sensors are used to measure humidity in media such as soil, but can also be used as water leak detectors, setting a humidity threshold.

The type of sensors supported are:

- [https://www.seeedstudio.com/Grove-Capacitive-Moisture-Sensor-Corrosion-Resistant.html?utm\\_source=blog&utm\\_medium=blog](https://www.seeedstudio.com/Grove-Capacitive-Moisture-Sensor-Corrosion-Resistant.html?utm_source=blog&utm_medium=blog)
- <https://www.seeedstudio.com/Grove-Moisture-Sensor.html>

For the humidity in the soil it is recommended to use the capacitive type, since they are more durable and do not release harmful residues that can affect the chemistry of the soil.

There are other types of sensors that are used specifically to detect leaks:

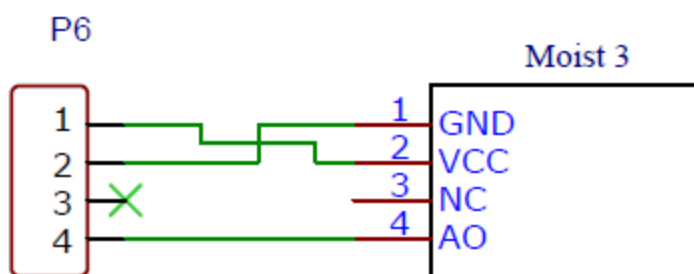
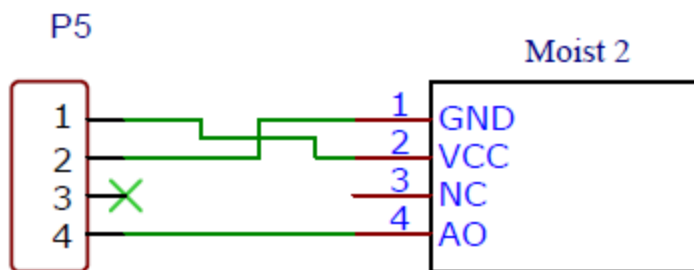
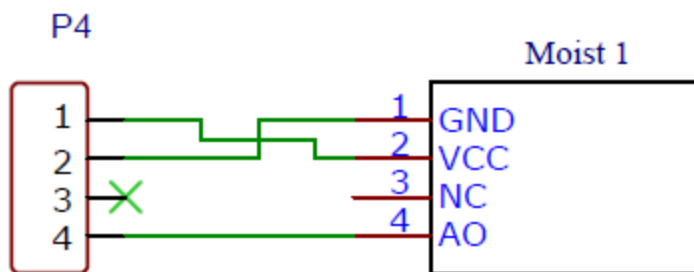
- <https://www.aartech.ca/vip1000-h2o/flair-waterguard-water-detector-5-24vdc-white.html>

These sensors require a Pull Up resistor. The module supports two of these sensors in positions 2 and 3.

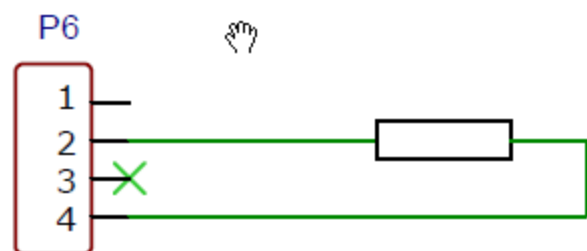
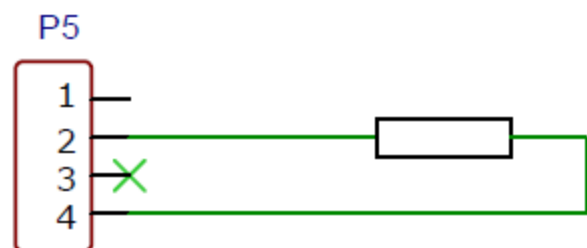
Moisture sensors use the same analog inputs as gas sensors.

- Moisture 1 uses the same Analog Pin as the MQ-5 Air quality sensor.
- Moisture 2 uses the same Analog Pin as the MQ-2 Air quality sensor.
- Moisture 3 uses the same Analog Pin as the MQ-7 Air quality sensor.

#### k) Moisture sensors 1 – 3



## I) Water Leak Sensors

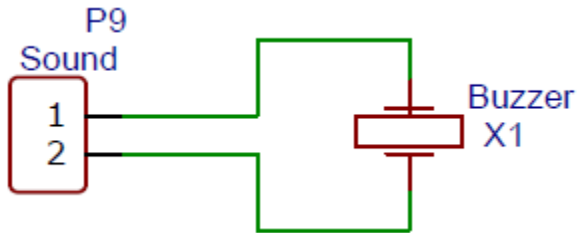


Install 1 MOhm resistors **R12** and **R8**.

## Features

### Alarm

The alarm is based on a simple piezoelectric transducer, which can produce sounds at an acceptable volume.



Install 100 Ohm resistors **R6**.

### Alarm Triggers

The alarm can be triggered by various gas measurements or moisture sensors.

- Flame On/Off (The threshold is calibrated in the sensor module)
- Smoke 300ppm
- LPG 300ppm
- Natural gas 300ppm
- CO 40ppm
- Leak/Flood 1 10%
- Leak/Flood 2 10%
- Leak/Flood 3 10%

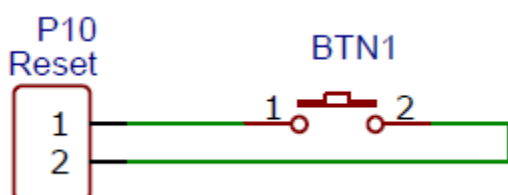
### Button

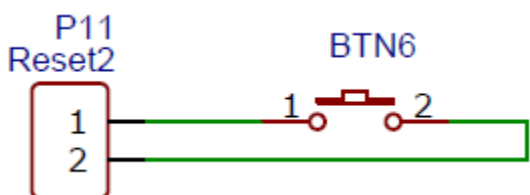
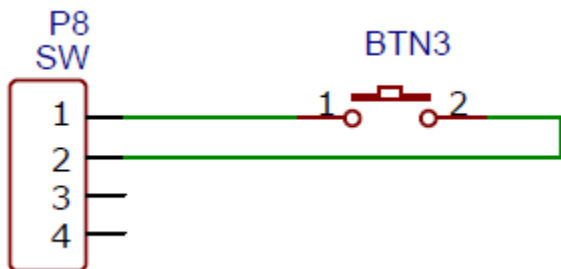
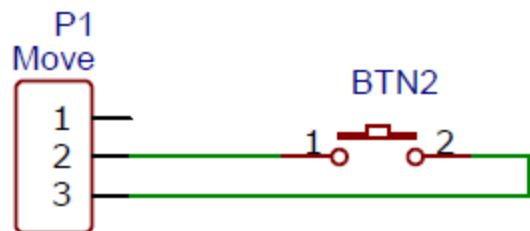
The button is used to Reset and Test the alarm, as well as to Calibrate the Air Quality sensors.

- Short press; Less than 3 seconds. Resets the alarm (it will stay off for at least 30 seconds; see ALARM\_RETRIGGER in the sketch).
- Long press; 3-5 seconds. Starts an alarm test for 10 seconds (See ALARM\_TEST in the sketch).
- Very long press; Longer than 6 seconds. Starts a calibration for the Air Quality sensors. The sensors need to be in clean air for the calibration to be effective.

The button can be installed on pins 2 (default) or 3, depending on the other sensors present. If the button is installed in these positions, an interruption is assigned to the button and the microcontroller can enter sleep mode.

If these pins are not available, it can be installed on pin 6 or on pin 1. In these cases the sleep cycle is suspended and for pin 1 the debugging for the serial port is deactivated.





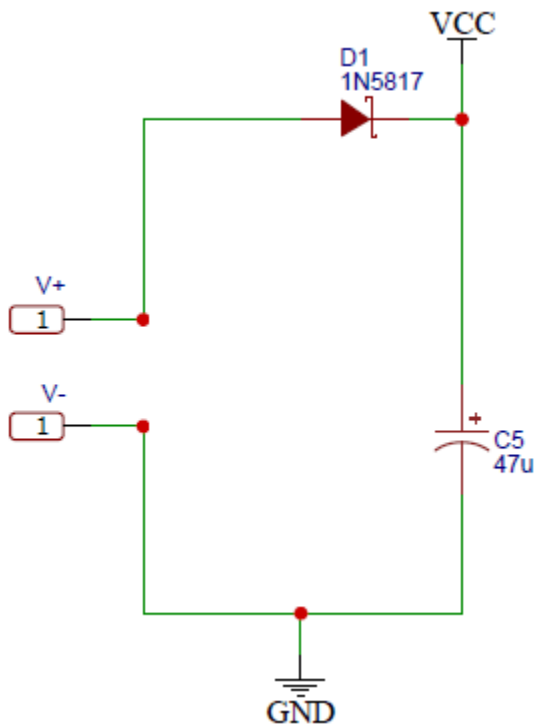
## Power

The module can be powered in several ways:

- Using a 5V power supply. I have used small USB chargers successfully.
- Using batteries. In this case I have tested 2 configurations.
  - Using 2 1.5V cells and a voltage booster or buck converter
  - Using 3 1.5V cells directly.
- Using a 5V power supply and a rechargeable LiPo cell for backup.

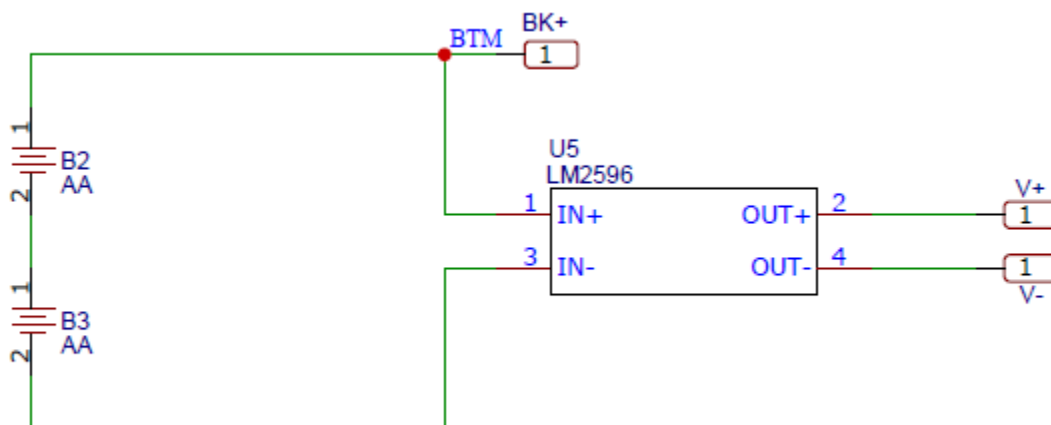
Power mode	VCC	Arduino 5V	Arduino 3.3V	Jumpers
5V Power Supply	5V	X		D1
5V Power Supply + Battery Backup	5V	X		
3V (2 AA batteries)	3.3V		X	D1, U2 (Pins 1 and 3)
4.5V (2 AA batteries)	3.3V		X	BAT, U2 (Pins 1 and 3)

## Power Supply



The use of diode D1 is optional and can be replaced by a jumper.

## 2 Cells



Set a jumper cable in the position of D1 and other between pins 1 and 3 of U2 (3.3V Regulator). The regulator U2 is not required.

## 3 Cells

-

- Door sensor 2 (IRQ3)
- Reset / Test / Calibrate button (IRQ2)

The button is required to operate the alarm and is also used to calibrate the air quality sensors.

The Door Sensor 1 and Button share the same interrupt by default, so you have to select between these two features, also the Motion Sensor and the Door Sensor 2 use the same pin, so you have to configure one or the other.

## Sleep Cycle

During normal operation, the microcontroller reads the status of all sensors, then goes into a sleep cycle for one minute, to minimize power consumption. The controller can wake up after the time has elapsed or if activity is detected in the sensors that have hardware interruptions.

The sleep cycle can be disabled temporarily if:

- Alarm is On
- The button is pressed
- MQ-7 sensor is enabled
- Wait for child initial presentation to occur

And it is permanently disabled if:

- The button is set in pins 1 or 6
- MQ-7 sensor is permanently enabled
- The module is configured as a repeater for the MySensors network

## Bill of material

Name	Designator	Quantity	Description	Link
nRF24L01+	MK1	1	Radio Module	<a href="https://www.aliexpress.com/item/10000372208801.html">https://www.aliexpress.com/item/10000372208801.html</a>
ArduinoPro Mini	U1	1	Microcontroller	<a href="https://www.arduino.cc/en/pmwiki.php?n=Main/ArduinoBoardProMini">https://www.arduino.cc/en/pmwiki.php?n=Main/ArduinoBoardProMini</a>
L78L33ACZTR	U2	1	3.3 V Linear regulator	<a href="https://www.digikey.com/en/products/detail/stmicroelectronics/L78L33ACZTR/1038305?s=N4lgTCBcDaIDIHYAccDMqCC8hAWgFQCUQ8dAXyA">https://www.digikey.com/en/products/detail/stmicroelectronics/L78L33ACZTR/1038305?s=N4lgTCBcDaIDIHYAccDMqCC8hAWgFQCUQ8dAXyA</a>
03962A	U4	1	LiPo Battery charger	<a href="https://www.addicore.com/TP4056-Charger-and-Protection-Module-p/ad310.htm">https://www.addicore.com/TP4056-Charger-and-Protection-Module-p/ad310.htm</a>
LM2596	U3,U5	1	DC-DC Boost Converter Step-Up. NOTE: Make sure to get a Step-Up converter and not a Step-Down.	<a href="https://www.itead.cc/power/dc-dc.html">https://www.itead.cc/power/dc-dc.html</a>
0.1u	C1	1	Ceramic Capacitor	<a href="https://www.digikey.com/en/products/detail/kemet/C326C104K3G5TA7301/6671327">https://www.digikey.com/en/products/detail/kemet/C326C104K3G5TA7301/6671327</a>
10u	C2,C3,C4	3	Electrolytic Capacitor	<a href="https://www.digikey.com/en/products/detail/panasonic-electronic-components/ECA-1EM100/2688677">https://www.digikey.com/en/products/detail/panasonic-electronic-components/ECA-1EM100/2688677</a>
47u	C5	1	Electrolytic Capacitor	<a href="https://www.mouser.com/ProductDetail/Nichicon/UVR1E470MDD1TA?qs=nd5JBRjZIXgOh2LQ2cd6pg%3D%3D">https://www.mouser.com/ProductDetail/Nichicon/UVR1E470MDD1TA?qs=nd5JBRjZIXgOh2LQ2cd6pg%3D%3D</a>
1N5817	D1,D2	2	Schottky Rectifier	<a href="https://www.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/1N5817?qs=Ro3gc6G1sTm8wr1Du93jFw%3D%3D">https://www.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/1N5817?qs=Ro3gc6G1sTm8wr1Du93jFw%3D%3D</a>
BC547BTA	Q1	1	NPN Transistor	<a href="https://www.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/BC547BTA?qs=TA8iY4F6Vcf01oKZdNLa0w%3D%3D">https://www.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/BC547BTA?qs=TA8iY4F6Vcf01oKZdNLa0w%3D%3D</a>
IRFD9120	Q2	1	MOSFET	<a href="https://www.mouser.com/Search/Refine?Keyword=IRFD9120">https://www.mouser.com/Search/Refine?Keyword=IRFD9120</a>
22k	R3	1	Resistor 1/4W	<a href="https://www.mouser.com/ProductDetail/TE-Connectivity-Holsworthy/CBT25J22K?qs=VHc52MTj4gYx622ynmvRcg%3D%3D">https://www.mouser.com/ProductDetail/TE-Connectivity-Holsworthy/CBT25J22K?qs=VHc52MTj4gYx622ynmvRcg%3D%3D</a>
1M	R4, R12, (R8)	2	Resistor 1/4W	<a href="https://www.mouser.com/ProductDetail/TE-Connectivity-Holsworthy/CBT25K1M0?qs=vLWxofP3U2yRkXFov3WQ%3D%3D">https://www.mouser.com/ProductDetail/TE-Connectivity-Holsworthy/CBT25K1M0?qs=vLWxofP3U2yRkXFov3WQ%3D%3D</a>
330K	R5	1	Resistor 1/4W	<a href="https://www.mouser.com/ProductDetail/Kamaya/RC1-4334KTb?qs=F5EMLAvA7IBvU3lvZkWPQ%3D%3D">https://www.mouser.com/ProductDetail/Kamaya/RC1-4334KTb?qs=F5EMLAvA7IBvU3lvZkWPQ%3D%3D</a>
100 Ohm	R6	1	Resistor 1/4W	<a href="https://www.mouser.com/ProductDetail/TE-Connectivity-Holsworthy/CBT25J100R?qs=VHc52MTj4gan3wTTNkvgnA%3D%3D">https://www.mouser.com/ProductDetail/TE-Connectivity-Holsworthy/CBT25J100R?qs=VHc52MTj4gan3wTTNkvgnA%3D%3D</a>

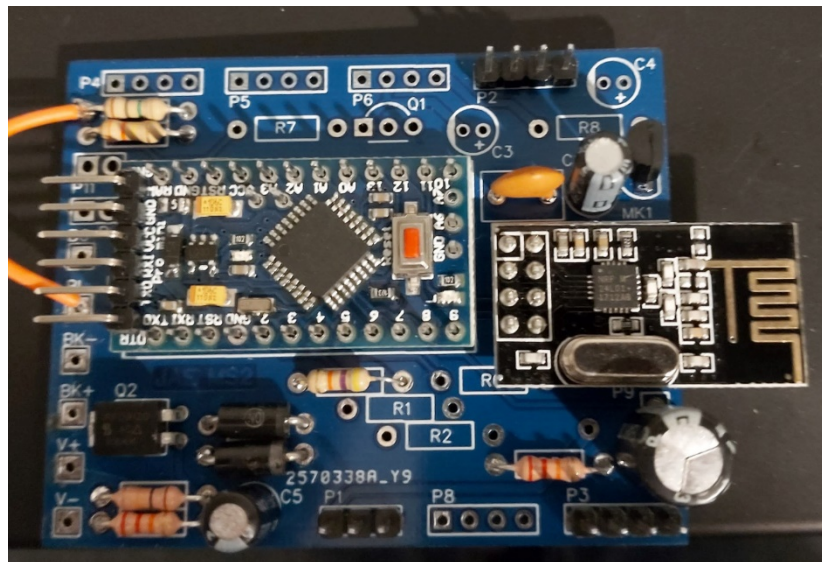


1K	R7	1	Resistor 1/4W	<a href="https://www.mouser.com/ProductDetail/TE-Connectivity-Neohm/CBT25J1K0?qs=VHc52MTj4gbgcyA0qV722Q%3D%3D">https://www.mouser.com/ProductDetail/TE-Connectivity-Neohm/CBT25J1K0?qs=VHc52MTj4gbgcyA0qV722Q%3D%3D</a>
10K	(R8), R10, R11, R13, R14	5	Resistor 1/4W	<a href="https://www.mouser.com/ProductDetail/TE-Connectivity-Holsworthy/CBT25J10K?qs=VHc52MTj4gYWJg5s4QtMBw%3D%3D">https://www.mouser.com/ProductDetail/TE-Connectivity-Holsworthy/CBT25J10K?qs=VHc52MTj4gYWJg5s4QtMBw%3D%3D</a>
47k	R1, R2, R9	3	Resistor 1/4W	<a href="https://www.mouser.com/ProductDetail/TE-Connectivity-Neohm/CBT25J47K?qs=VHc52MTj4gbt9aO8l9ysw%3D%3D">https://www.mouser.com/ProductDetail/TE-Connectivity-Neohm/CBT25J47K?qs=VHc52MTj4gbt9aO8l9ysw%3D%3D</a>
Buzzer	X1	1	Piezo Trasnducer	<a href="https://www.digikey.com/en/products/detail/murata-electronics/7BB-20-6L0/4358152">https://www.digikey.com/en/products/detail/murata-electronics/7BB-20-6L0/4358152</a>
LiPo	B1	1	LiPo cell	<a href="https://www.digikey.com/en/products/detail/mikroelektronika/MIKROE-4471/13679389">https://www.digikey.com/en/products/detail/mikroelektronika/MIKROE-4471/13679389</a>
AA Battery	B2,B3,B4,B5, B6	2 - 3	AA Rechargeable Battery	<a href="https://www.mouser.com/ProductDetail/Panasonic-Battery/HHR-70AAB7?qs=1VjY50kO94REvXlpJrz3gA%3D%3D">https://www.mouser.com/ProductDetail/Panasonic-Battery/HHR-70AAB7?qs=1VjY50kO94REvXlpJrz3gA%3D%3D</a>
BI	BI,BK+,BK- ,BO,V+,V-	1	2.54mm Header	<a href="https://www.mouser.com/ProductDetail/TE-Connectivity-AMP/5-826938-0?qs=xF5SkmKSM747%252BA1%2FGulWHw%3D%3D">https://www.mouser.com/ProductDetail/TE-Connectivity-AMP/5-826938-0?qs=xF5SkmKSM747%252BA1%2FGulWHw%3D%3D</a>
BK+	P1, P2, P3, P4, P4, P5, P6, P7, P8, P9, P10, P11	1	2.54mm Header	
Push Button				
Dupont Cables				

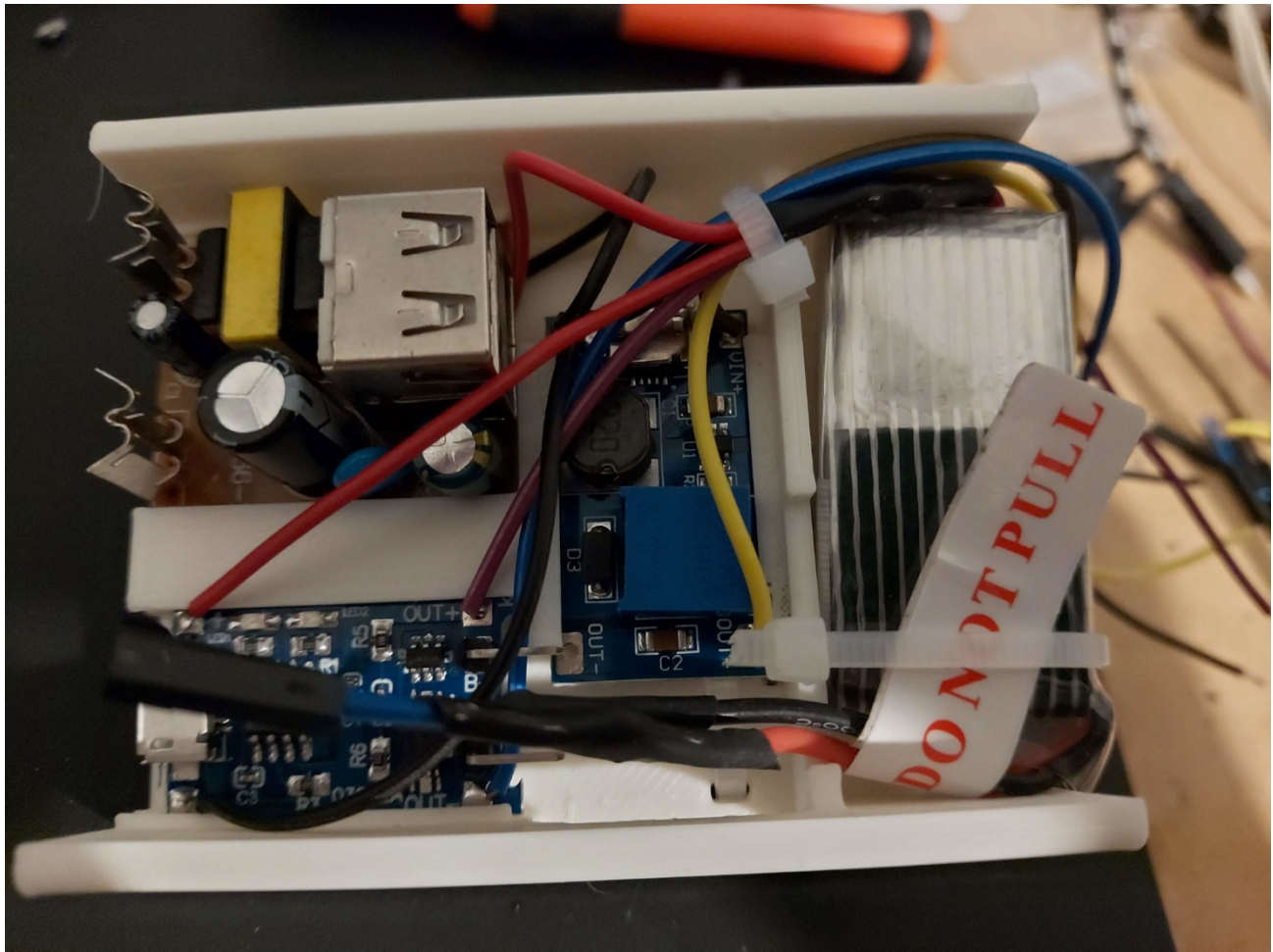
## Motion / Light / Temperature module

Below are the images of the module assembly with motion, temperature / humidity and light level sensors.

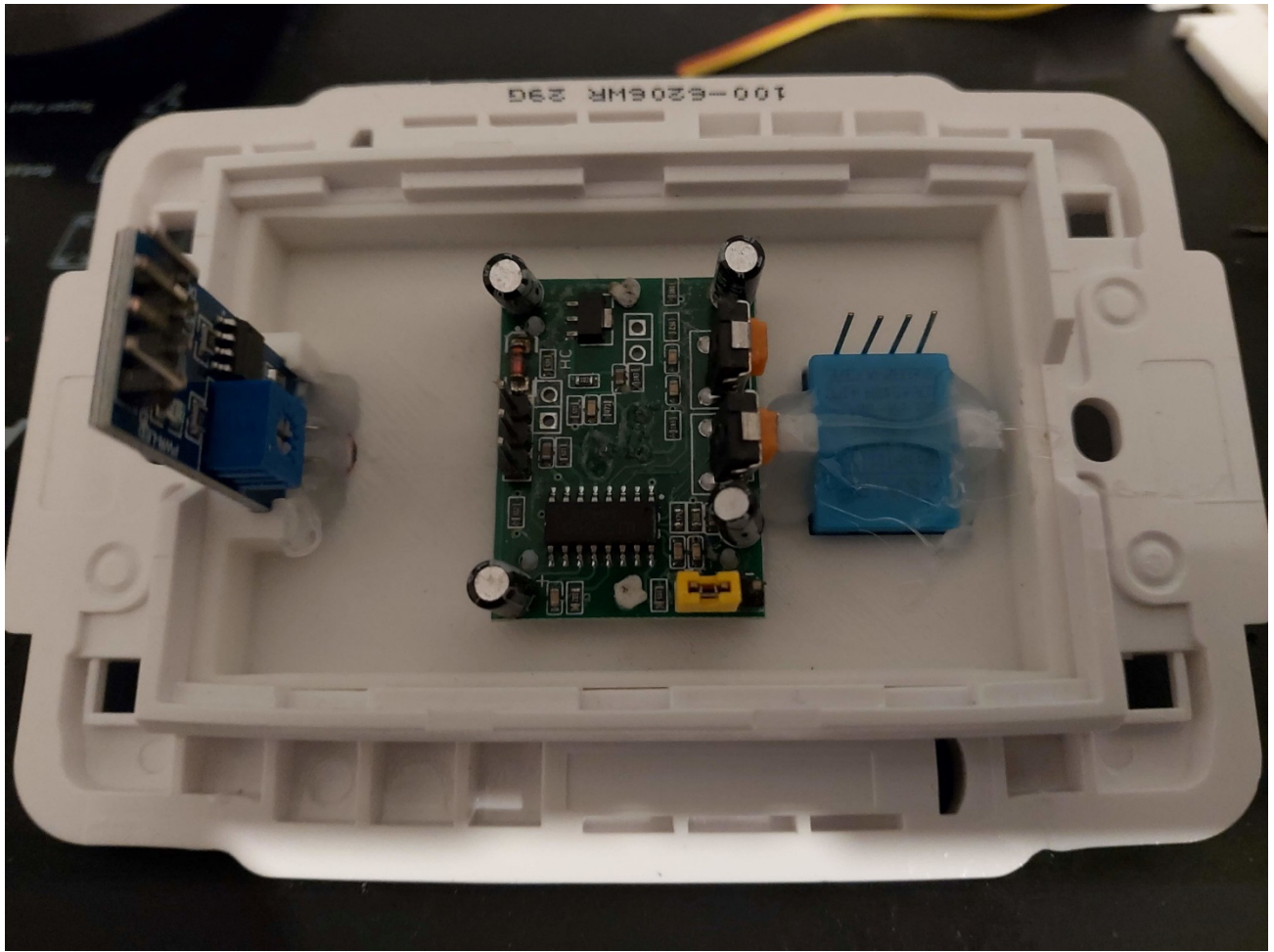
The module is powered by 120V using a 5V USB charger and battery backup.

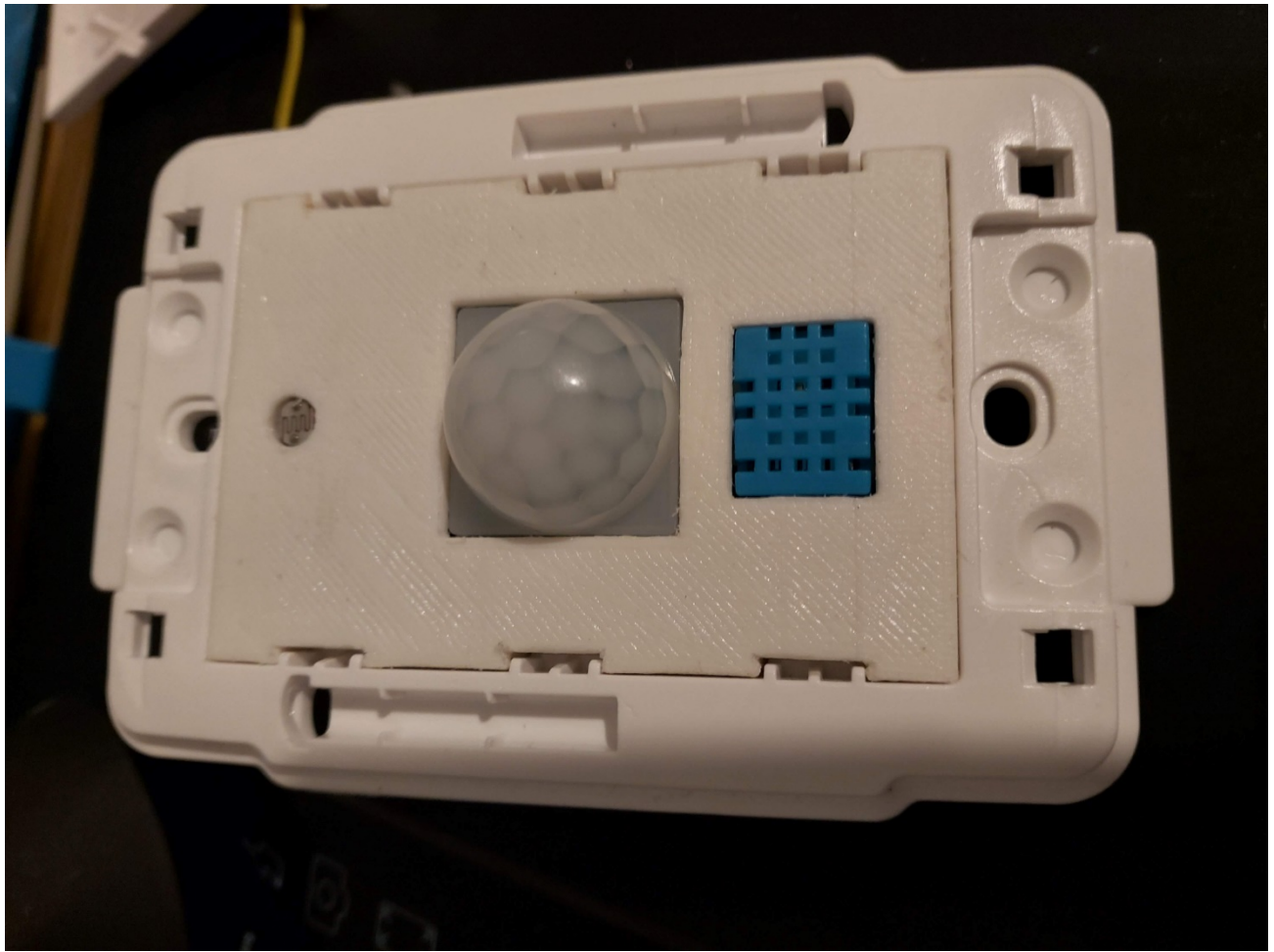


PCB Asselmbly



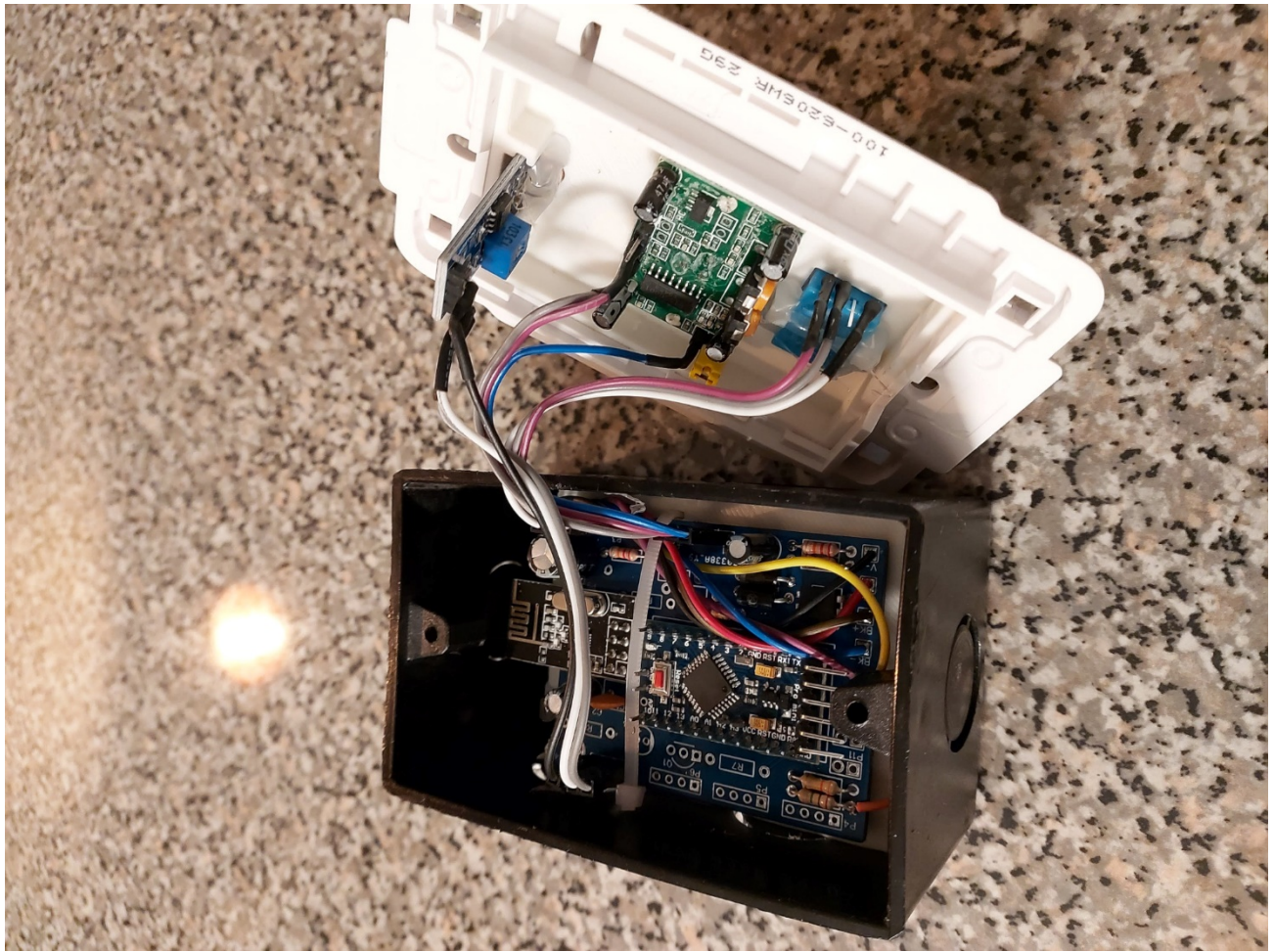
Power elements. USB Charger, Battery charger, Buck converter and LiPo battery.





Left to right: Light, Motion and temperature sensors.





Full assembly.



Module mounted on the ceiling drywall.