# Toturial:
# Hardware - Data Acquisition (DAQ)
# MEC100x-Lectures 10

Energy, Power and Intelligent Control
School of Electronics, Electrical Engineering and Computer Science
Ashby Building
Queen's University Belfast

# Aims

1. MQ-2 Gas Sensor Many type of DAS
2. PIR sensor
3. Steam Water Detection Sensor Module
4. USB-6009-Multifunction I/O Device

# Interfacing MQ-2 Gas Sensor with DAQ

## MQ-2 sensor working principle

### What is Gas sensor Module?

- Gas sensors are designed to measure the concentration of gases in the environment.
- MQ2 gas sensor is suitable for detecting H2, LPG, CH4, CO, Alcohol, Smoke or Propane.
- Due to its high sensitivity and fast response time, measurement can be taken as soon as possible.

# MQ-2 Gas Sensor

- **MQ series sensor** uses **a small heater inside** with **an electrochemical sensor in order to measure a different kind of gases combination.**
- The MQ2 Gas sensor has a **built-in variable resistor that changes its value according to the concentration of gas.**

**1- If the concentration is High, the resistance decreases,**

**2- If the concentration is low, the resistance increases.** Besides the built-in resistor, it is necessary to include load resistor, Load resistor serve to adjust sensor sensitivity and accuracy, it's value can range **from 2k ohm to 47 k ohm higher the value**, the more sensitive sensor becomes.

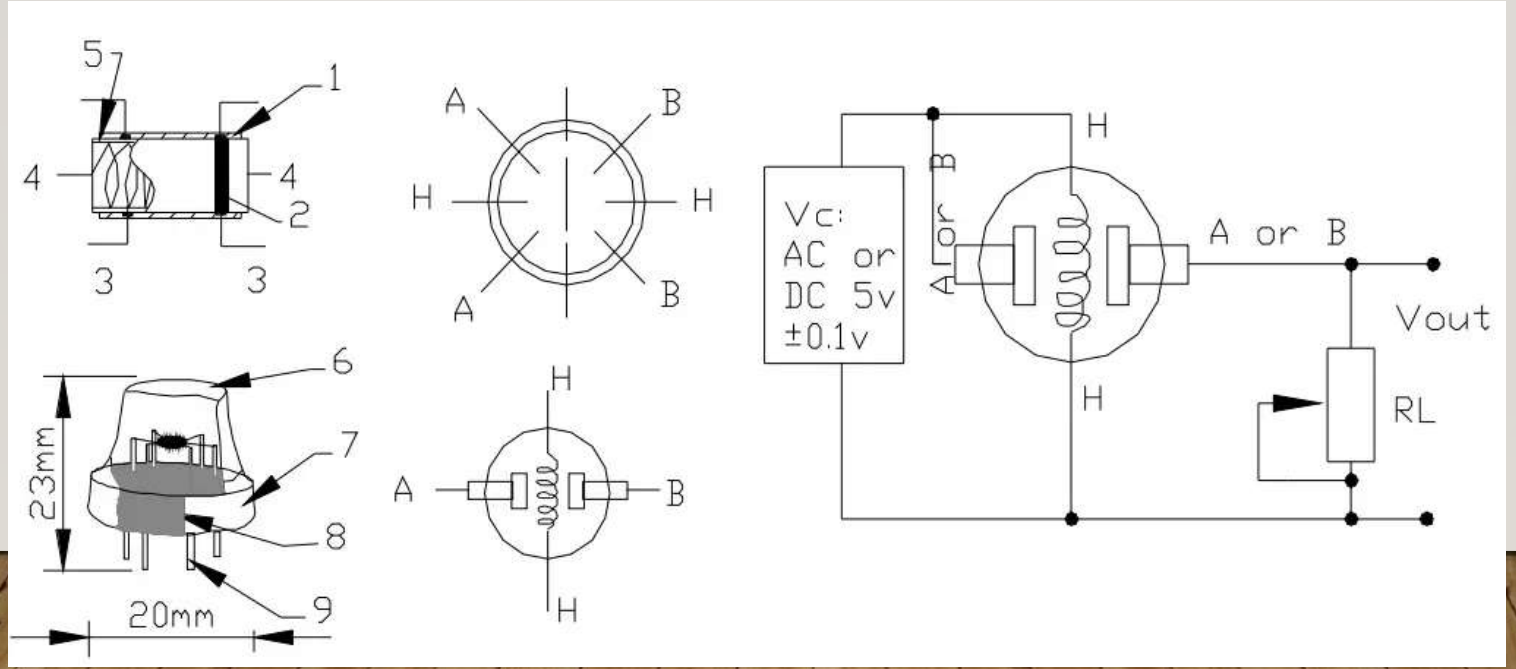
- They can be calibrated, but, in order to do that, a known concentration of measured gas or gases is needed.

# MQ-2 sensor working principle

The following picture shows the internal structure and configuration of MQ2 gas sensor.
It is composed of a micro AL2O3 ceramic tube (5 in picture), a SnO2 Tin Dioxide sensitive layer:

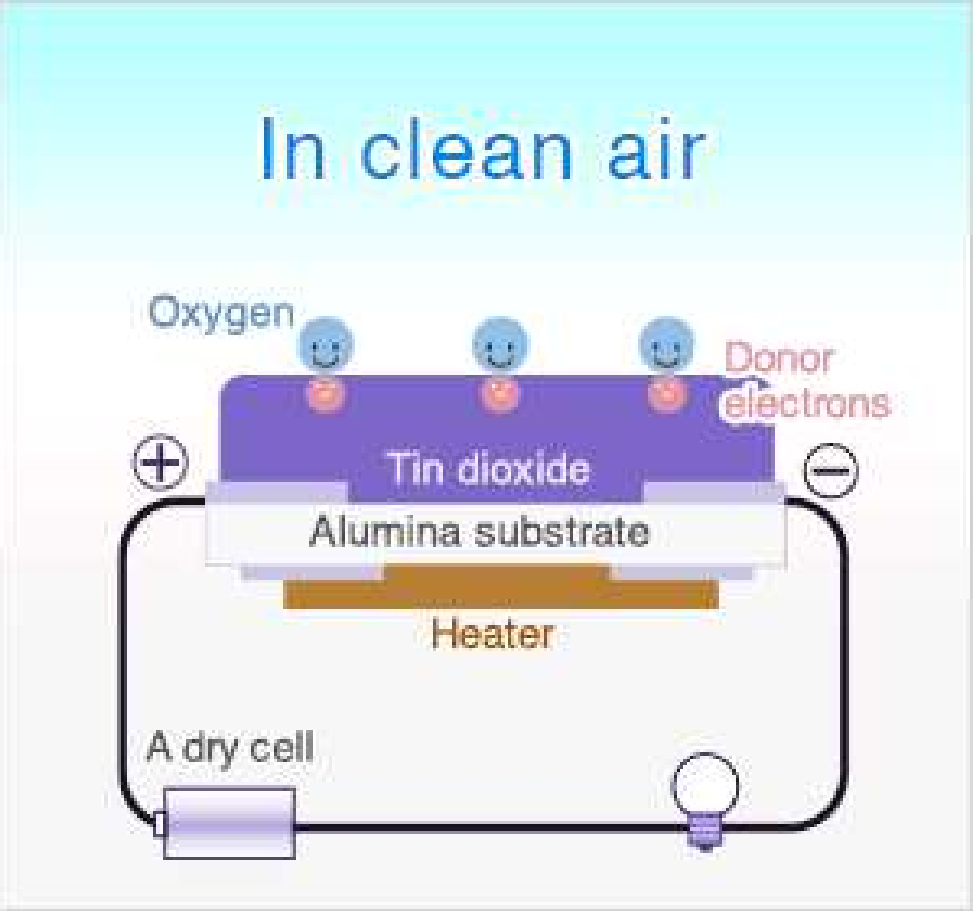
- A measuring electrode
- A heater
- **A potentiometer (RL) makes it possible to tune the sensor** in different temperature/humidity conditions.

The heater provides necessary work conditions for sensitive components. The enveloped MQ-2 have 6 pin, 4 of them are used to fetch signals, and the other 2 are used for providing heating current.



# MQ-2 sensor working principle

Mq-2 sensor working principle is described in a so nicely way from figaro.co.jp with the following gif:




https://www.figaro.co.jp/en/technicalinfo/principle/mos-type.html

# Pin description

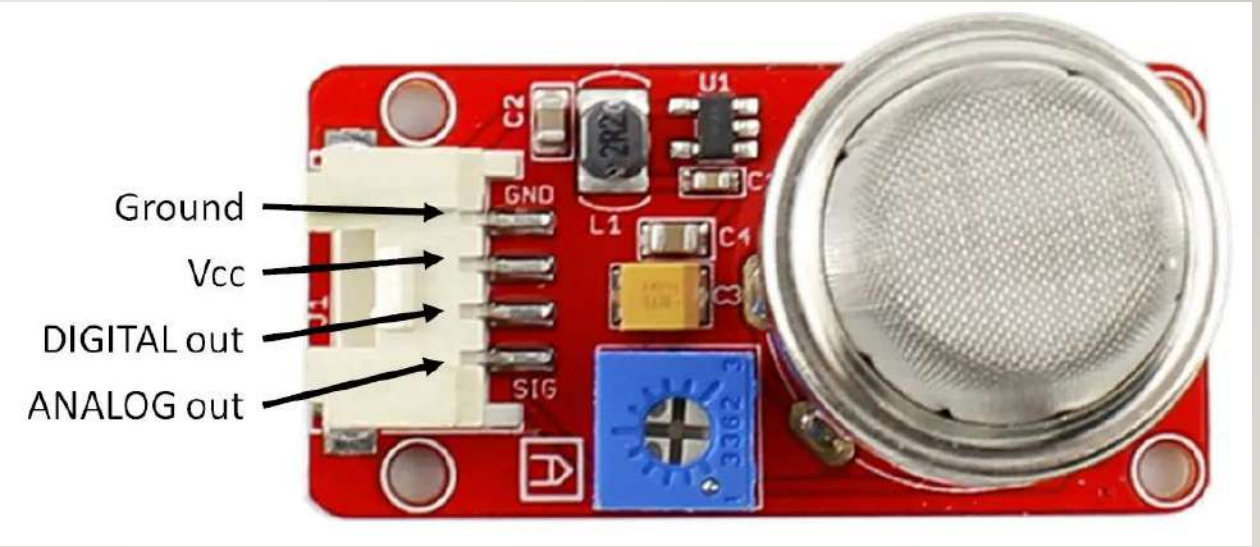
MQ2 Gas sensor has 4 pins:

- **VCC**
- **GND**
- **AOUT (Analog Output pin)**
- **DOUT (Digital Output pin)**

This PIN outputs a 0 or 1 when a threshold is reached.

You can leave this unconnected if you are going to use the analog

- **Connect "VCC" of the MQ2 gas sensor** with "VCC" of DAQ
- **Connect "GND" of MQ2 gas sensor** with "GND" of DAQ
- **Connect "Aout " pin of MQ2 gas sensor** with " A0" pin of DAQ




https://peppe8o.com/mq-2-with-raspberry-pi-pico-gas-sensor-wiring-and-micropython-code/

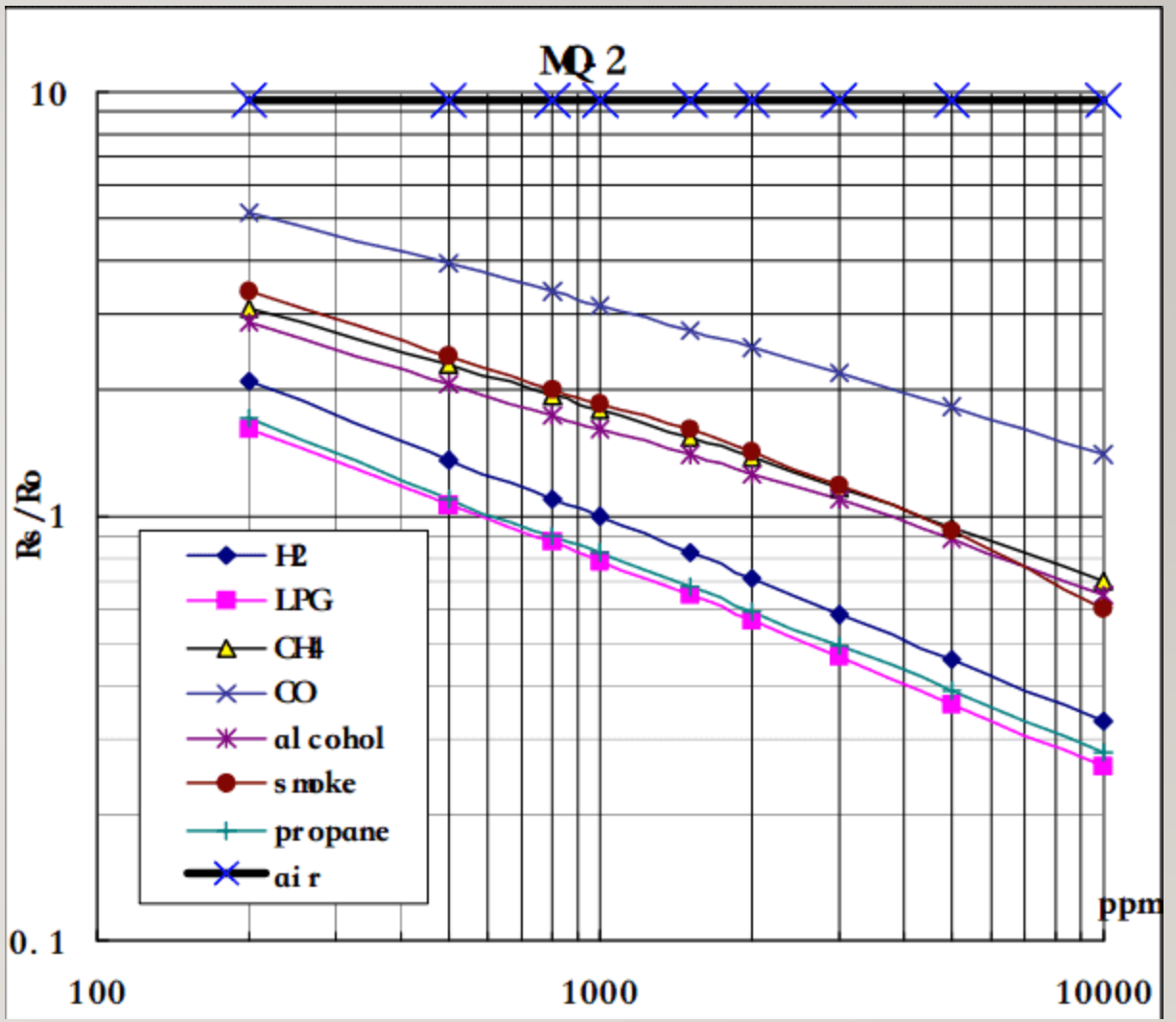
# Equations:

MQ-2 Gas Sensor Sensitivity Characteristics:

The graph tells us the concentration of a gas in part per million (ppm) according to the resistance ratio of the sensor (RS/R0).

**1.RS is the resistance of the sensor** that changes depending on the concentration of gas.

**2. R0 is the resistance of the sensor** at a known concentration **without the presence of other gases**, or in the fresh air.
For air, RS/R0 = 9.8 for MQ2 gas sensor.




https://thestempedia.com/tutorials/interfacing-mq-2-gas-sensor-with-evive/

# Calculation of R0 for the Sensor

**RS = [(Vin x RL) / Vout] - RL**

1. Vin is 5V in our case.
2. RL is 10 kOhm.
3. Vout is the analog voltage reading from the sensor

we can see that the **resistance ratio in fresh air** is a constant:

**RS / R0 = 9.8**

# Calculating PPM for a particular gas

- First of all, we will treat the lines as if they were linear. This way we can use one formula that linearly relates the ratio and the concentration.
- We can find the concentration of a gas at any ratio value even outside of the graph's boundaries.

$$y = mx + b$$

In the table given below, you can find the value of m and b for different gases.

| Gas | Value at 200 | Value at 10000 | Value at 5000 | m | b |
|---|---|---|---|---|---|
| H2 | 2.1 | 0.33 | 0.46 | -0.47305447 | 1.412572126 |
| LPG | 1.6 | 0.27 | 0.37 | -0.454838059 | 1.25063406 |
| Methane | 3 | 0.7 | 0.94 | -0.372003751 | 1.349158571 |
| CO | 5.1 | 1.35 | 1.8 | -0.33975668 | 1.512022272 |
| Alcohol | 2.8 | 0.65 | 0.85 | -0.373311285 | 1.310286169 |
| Smoke | 3.4 | 0.6 | 0.95 | -0.44340257 | 1.617856412 |

# Calculation of Vout for gas PPM

$m = \log(y/y0) / \log(x/x0)$

m = log(0.6/3.4) / log(10000/200)

m = -0.44

| Gas | Value at 200 | Value at 10000 | Value at 5000 | m | b |
|---|---|---|---|---|---|
| Smoke | 3.4 | 0.6 | 0.95 | -0.44340257 | 1.617856412 |

$b = \log(y) - m*\log(x)$

b = log(0.95) - (-0.443)*log(5000)

| Gas | Value at 200 | Value at 10000 | X= Value at 5000 | m | b |
|---|---|---|---|---|---|
| Smoke | 3.4 | 0.6 | Y= 0.95 | -0.44340257 | 1.617856412 |

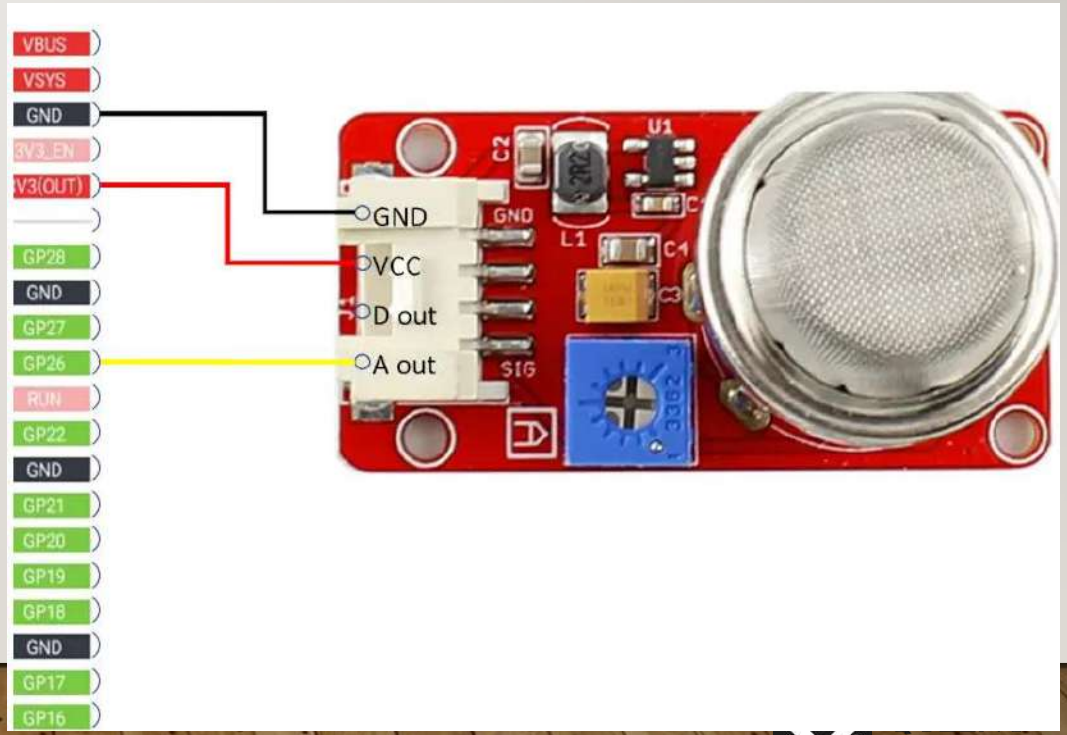
# Calculation of Vout for gas PPM

| Gas | Value at 200 | Value at 10000 | X= Value at 5000 | m | b |
|---|---|---|---|---|---|
| Smoke | 3.4 | 0.6 | Y= 0.95 | -0.44340257 | 1.617856412 |

$$\log(y) = m * \log(x) + b$$

X=
Value at 200-10000 ,…. Points PPM

$$1.3 < y=V < 4$$

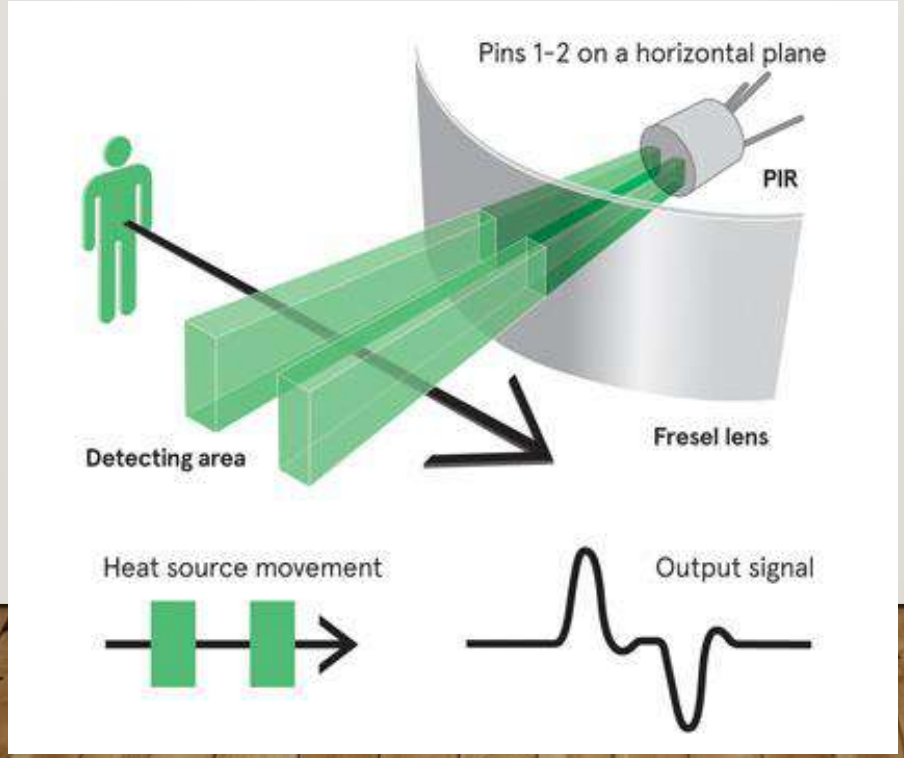


# Using a PIR sensor

- A PIR sensor is a simple but excellent device for detecting when motion has occurred. In older style security systems these sensors were used a lot.
- Humans and other animals emit radiation all the time. In fact, all objects at temperatures above absolute zero (-273.15C) emit infrared radiation.
- A PIR sensor detects changes in the amount of infrared radiation it receives. When there is a significant change in the amount of infrared radiation it detects, then a pulse is triggered.
- This means that a PIR sensor can detect when a human (or any animal) moves in front of it.
- **The PIR sensor is usually the first choice for home security systems**, as its ability to sense warm, moving objects such as people walking into a room is coupled with simplicity and cost effectiveness.

# How Does the PIR Sensor Work?

- This motion sensor consists of a fresnel lens, an infrared detector, and supporting detection circuitry.
- The lens on the sensor focuses any infrared radiation present around it toward the infrared detector.
- Our bodies generate infrared heat, and as a result, this heat is picked up by the motion sensor.
- The sensor outputs a 5V signal for a period of one minute as soon as it detects the presence of a person.
- It offers a tentative range of detection of about 6- 7 meters and is highly sensitive.
- When the PIR motion sensor detects a person, it outputs a 5V signal.



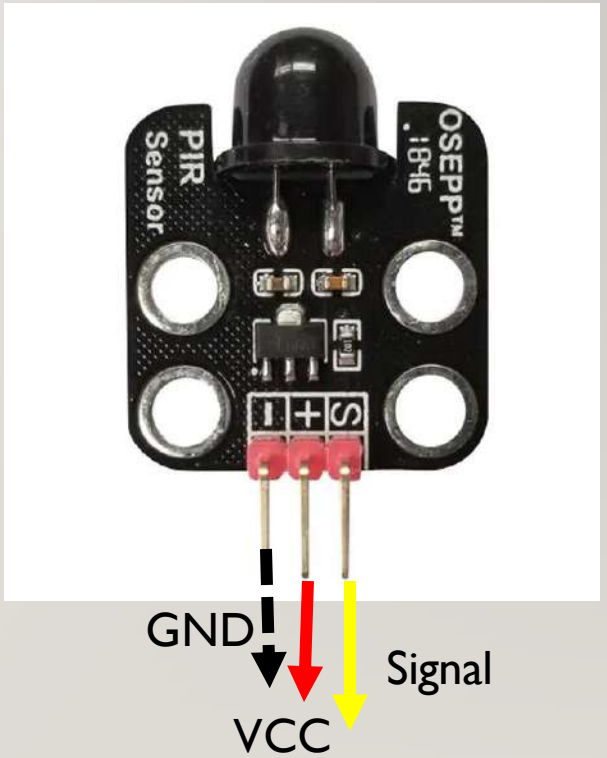
# PIR motion sensor

## Pinout

Looking at the bottom of the sensor with the pins at the top, the pins (from left to right) are:

- GND
- OUT
- VCC

**Passive infrared (PIR) sensors are straightforward, low cost motion sensors**




## Specifications

Input voltage: DC 3.3V ~ 18V

Working current: 15uA

Working temperature: -20 ~ 85 degrees Celsius

Output voltage: high 3 V, low 0 V

Output delay time (high level): about 2.3 to 3 seconds

Detection angle: about 100 ° Detection distance: 3-4 meters Output

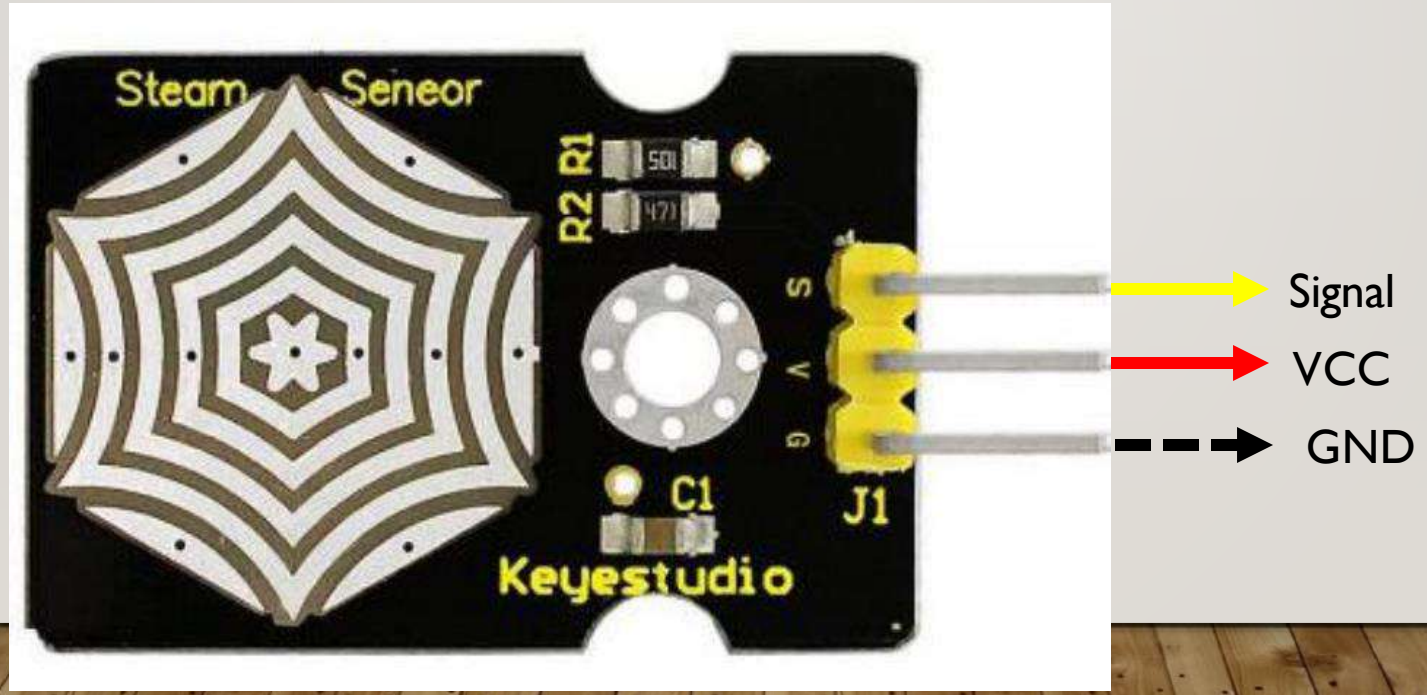
# Steam Water Detection Sensor Module

## DESCRIPTION

- This module is ideally suited to adding water/steam detection to your project.
- This is a sensor module which can detect water droplets and relay a signal to DAQ.
- This allows you to build in water detection, for your weather, watering or kettle monitoring project.

# Steam Water Detection Sensor Module

- Its principle is to detect the amount of water by bare printed parallel lines on the circuit board.
- As the conductive contact area increases, the output voltage will gradually rise. It can detect water vapor in the air as well.
- The steam sensor can be used as a rain water detector and level switch.
- When the humidity on the sensor surface surges, the output voltage will increase.



# TEMPERATURE AND HUMIDITY SENSOR WITH DAQ

## What is DTH?

- The DHT22 sensor is ideal for reading the temperature or humidity of your surroundings.
- The DHT22 is a Temperature and Humidity Sensor.
- The DHT22 is a basic, low-cost digital temperature and humidity sensor.
- It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed).
- Before you can use the DHT22 and its chip inside that does analogue to digital conversion, it is important to make the right connections.

# USB-6009
# Multifunction I/O Device

**8 AI (14-Bit, 48 kS/s), 2 AO (150 Hz), 13 DIO USB Multifunction I/O Device**

The USB-6009 is:

- **a low-cost,**
- **multifunction DAQ device**.

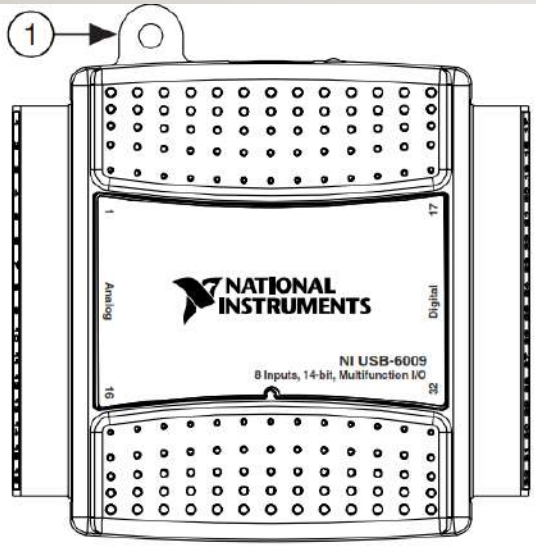
It offers:

- Analog I/O,
- Digital I/O,
- 32-bit counter.

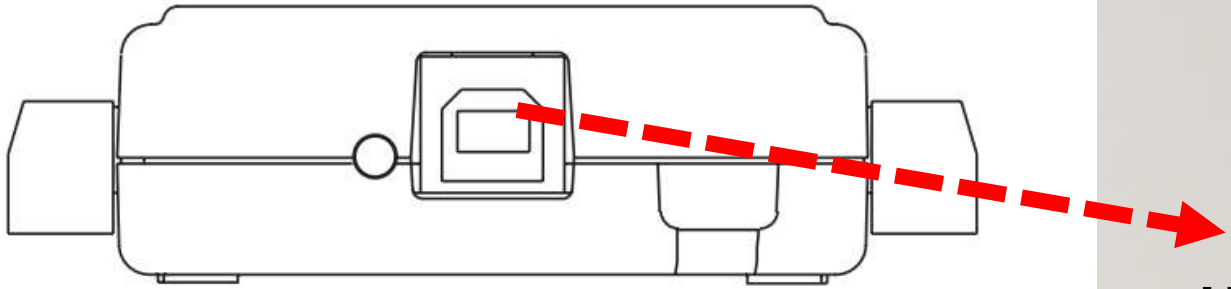
The USB-6009 provides basic functionality for applications such as simple data logging.

# Module specification

| Feature | USB-6009 |
|---|---|
| AI Resolution | 14 bits differential,<br>13 bits single-ended |
| Maximum AI Sample Rate,<br>Single Channel | 48 kS/s |
| DIO Configuration | Open collector or active drive |




1 USB Cable Strain Relief



USB connection

**Figure 2.** USB-6008/6009 Back View

https://courses.cit.cornell.edu/bionb442/labs/f2007/NI6008manual.pdf

# Module specification

| Signal Name | Direction | Description |
|---|---|---|
| AI <0..7> | Input | Analog Input Channels 0 to 7<br><br>Differential input channels:<br><AI 0 and AI 4> , <AI 1, AI 5>, <AI 2, AI 6>, and <AI3, AI7>. |
| AO 0 | Output | Analog Channel 0 Output—Supplies the voltage output of AO channel 0. |
| AO 1 | Output | Analog Channel 1 Output—Supplies the voltage output of AO channel 1. |
| P1.<0..3><br>P0.<0..7> | Input or Output | Digital I/O Signals—You can individually configure each signal as an<br>input or output. |
| +2.5 V | Output | +2.5 V External Reference—Provides a reference for wrap-back testing. |
| +5 V | Output | +5 V Power Source—Provides +5 V<br>power up to 200 mA. |

https://courses.cit.cornell.edu/bionb442/labs/f2007/NI6008manual.pdf

# Device pinout

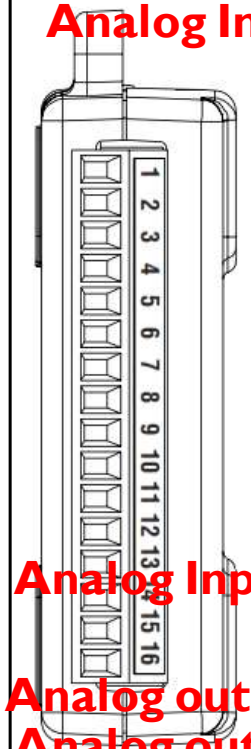
| Module | Terminal | Signal, Single-Ended Mode | Signal, Differential Mode |
|---|---|---|---|
| | 1 | GND | GND |
| | 2 | AI 0 | AI 0+ |
| | 3 | AI 4 | AI 0– |
| | 4 | GND | GND |
| | 5 | AI 1 | AI 1+ |
| | 6 | AI 5 | AI 1– |
| | 7 | GND | GND |
| | 8 | AI 2 | AI 2+ |
| | 9 | AI 6 | AI 2– |
| | 10 | GND | GND |
| | 11 | AI 3 | AI 3+ |
| | 12 | AI 7 | AI 3– |
| | 13 | GND | GND |
| | 14 | AO 0 | AO 0 |
| | 15 | AO 1 | AO 1 |
| | 16 | GND | GND |

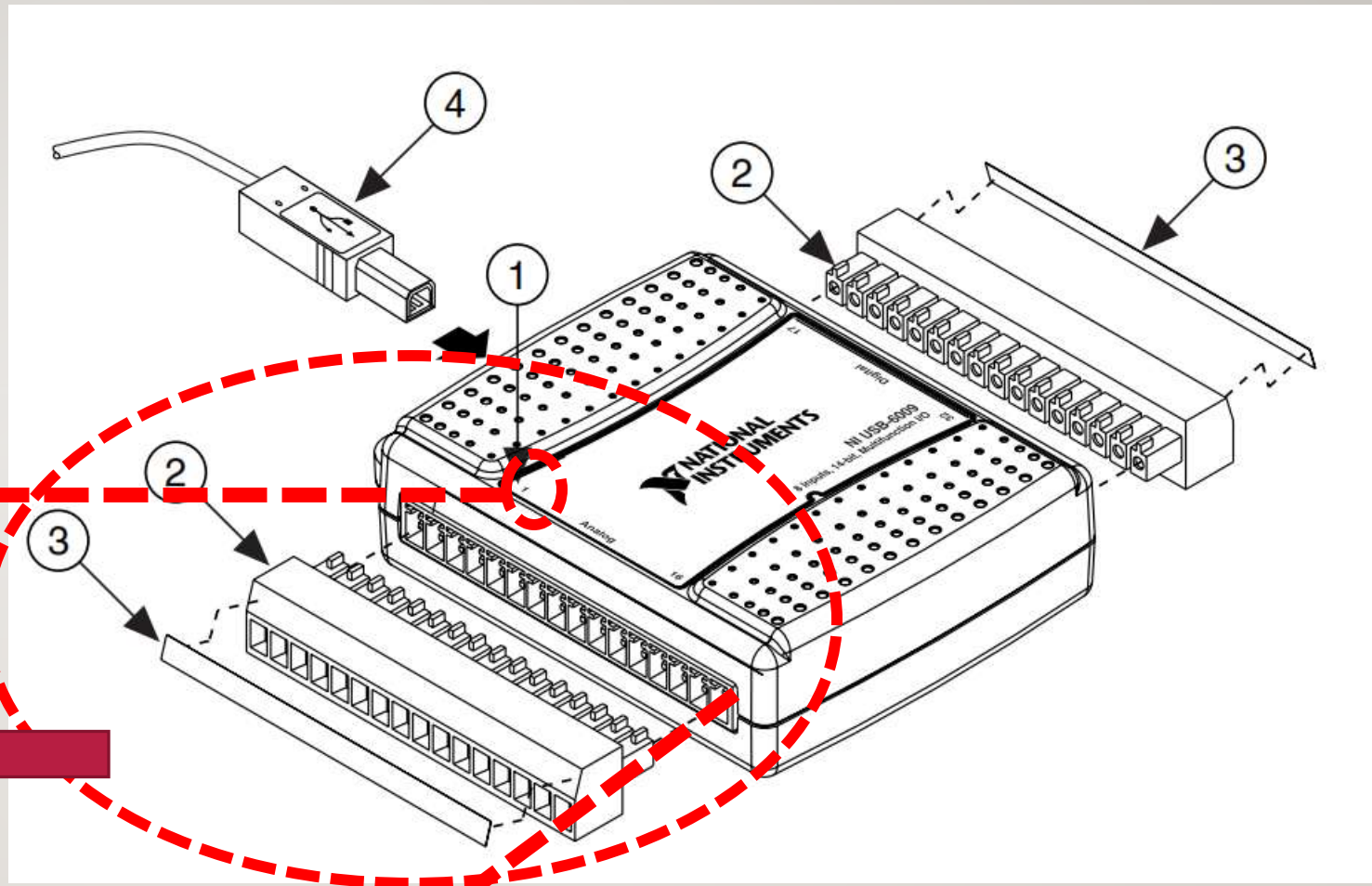
Analog Input 0

Analog Input 7

Analog output 0

Analog output 1

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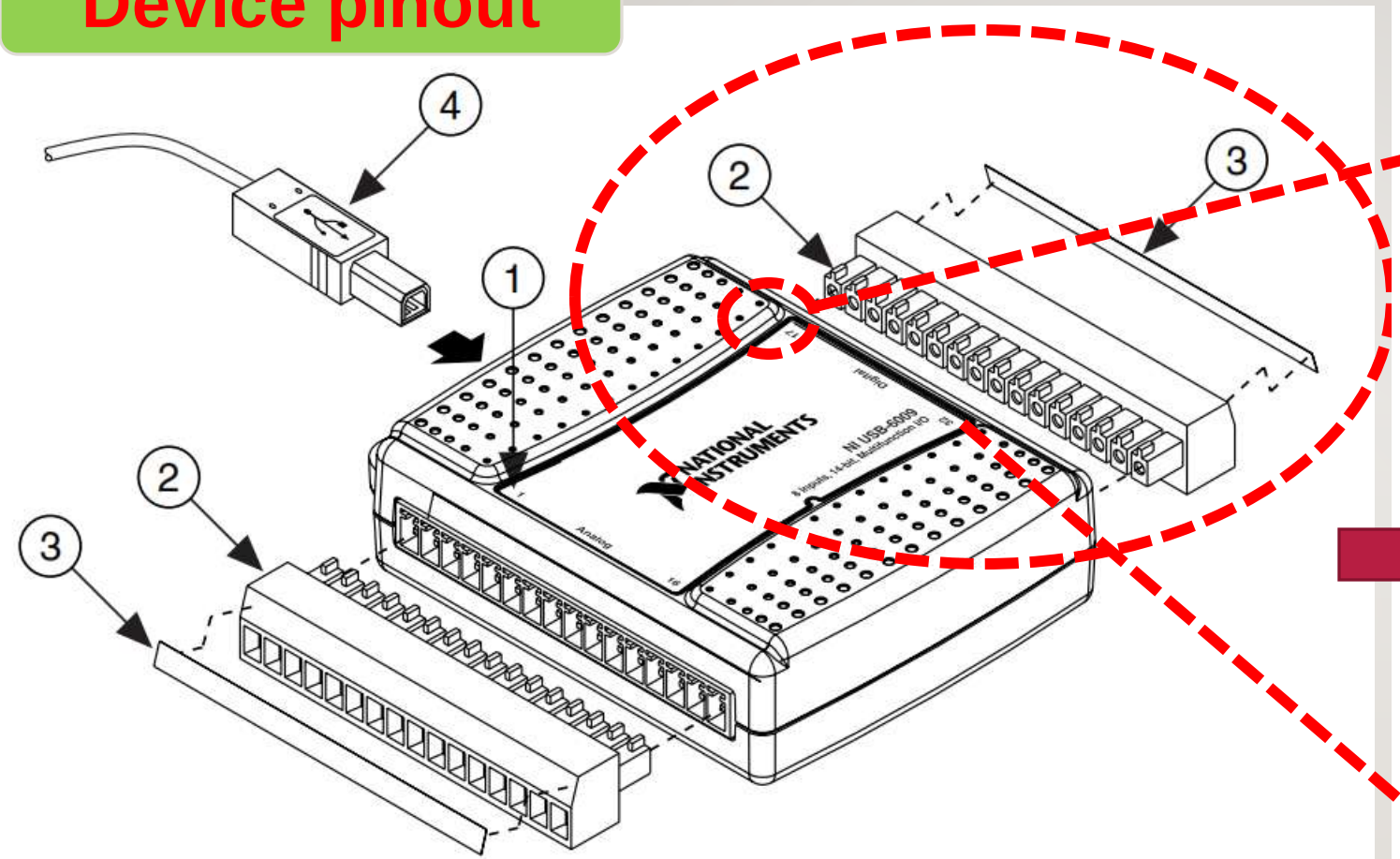
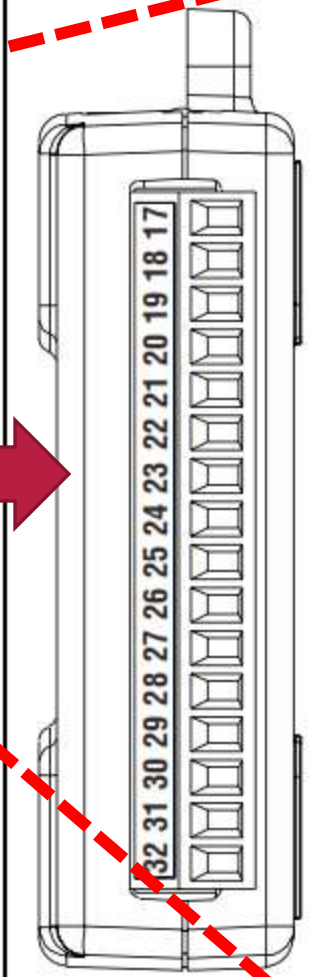
# Device pinout

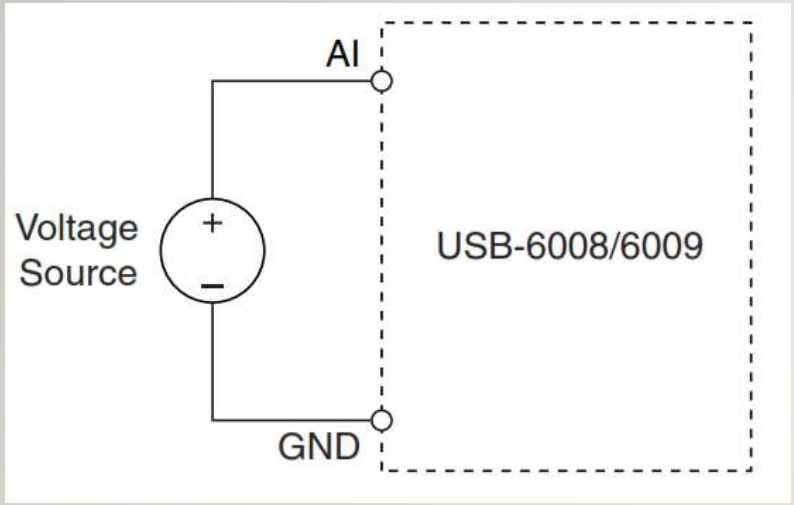



https://courses.cit.cornell.edu/bionb442/labs/f2007/NI6008manual.pdf

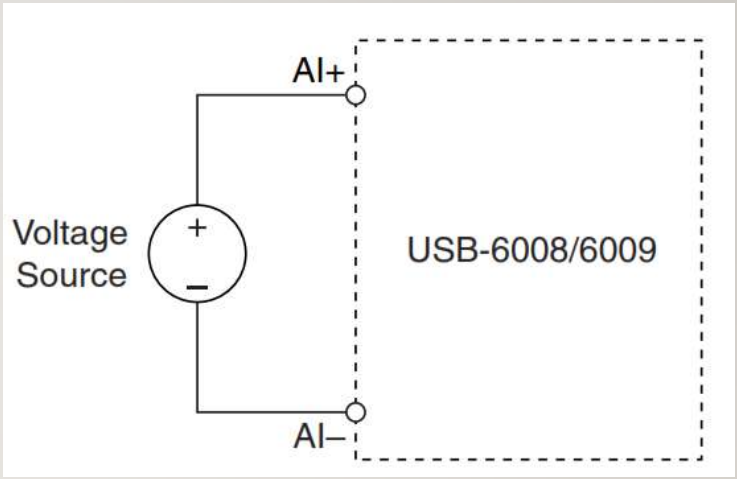



| Module | Terminal | Signal |
|---|---|---|
| | 17 | P0.0 |
| | 18 | P0.1 |
| | 19 | P0.2 |
| | 20 | P0.3 |
| | 21 | P0.4 |
| | 22 | P0.5 |
| | 23 | P0 6 |
| | 24 | P0.7 |
| | 25 | P1.0 |
| | 26 | P1.1 |
| | 27 | P1.2 |
| | 28 | P1.3 |
| | 29 | PFI 0 |
| | 30 | +2.5 V |
| | 31 | +5 V |
| | 32 | GND |

# Connecting Reference Single-Ended Voltage Signals




**AI connection:**
**Connecting a Reference Single-Ended Voltage Signal**

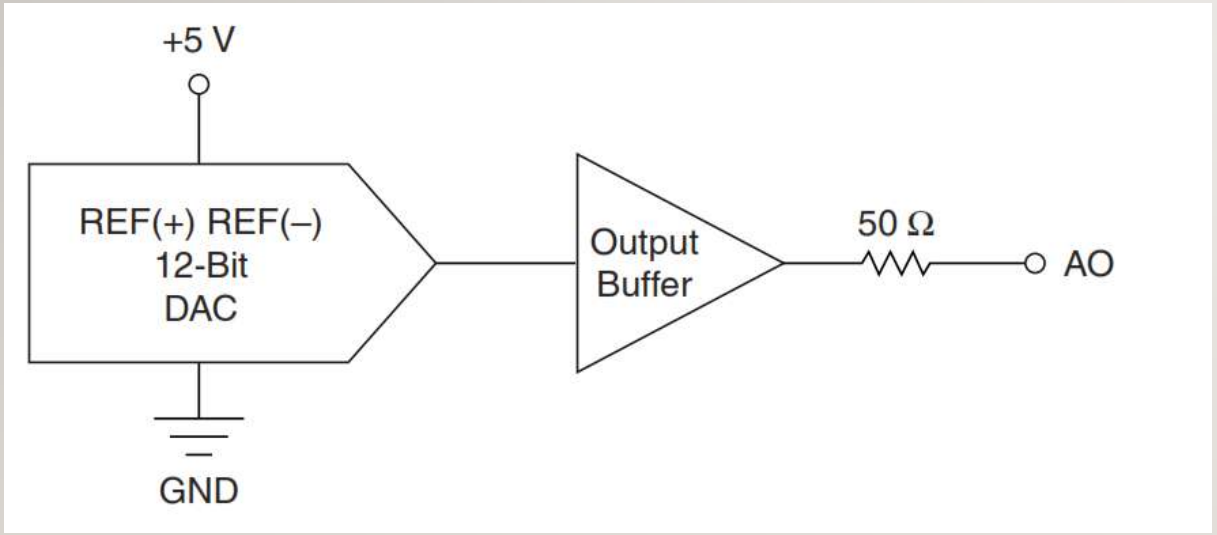


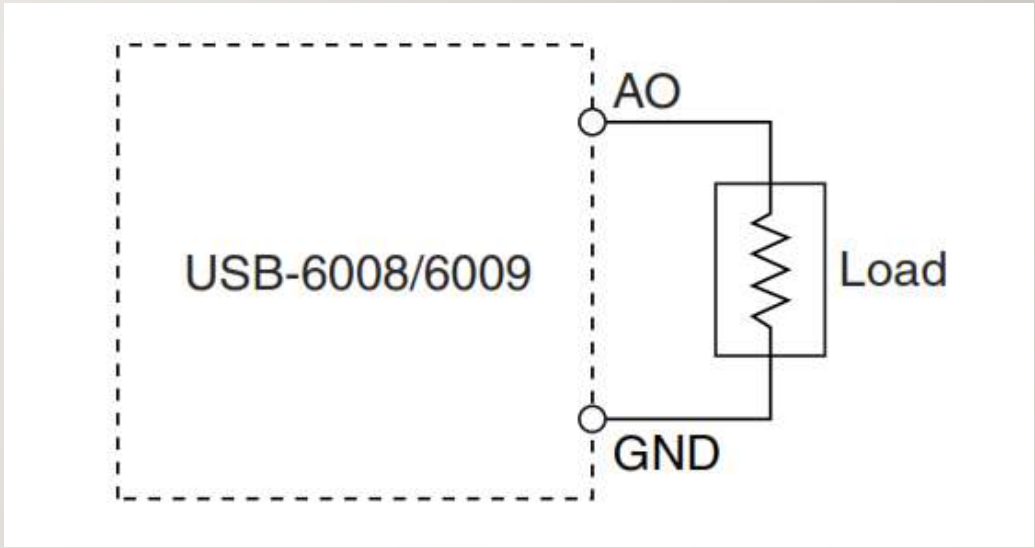

**AI connection:**
**Connecting a Differential Voltage Signal**

- For differential signals, connect the positive lead of the signal to the AI+ terminal, and the negative lead to the AI– terminal.

# Connecting Analog Output to a Load

To connect loads to the USB-6008/6009, connect the positive lead of the load to the AO terminal, and connect the ground of the load to a GND terminal.



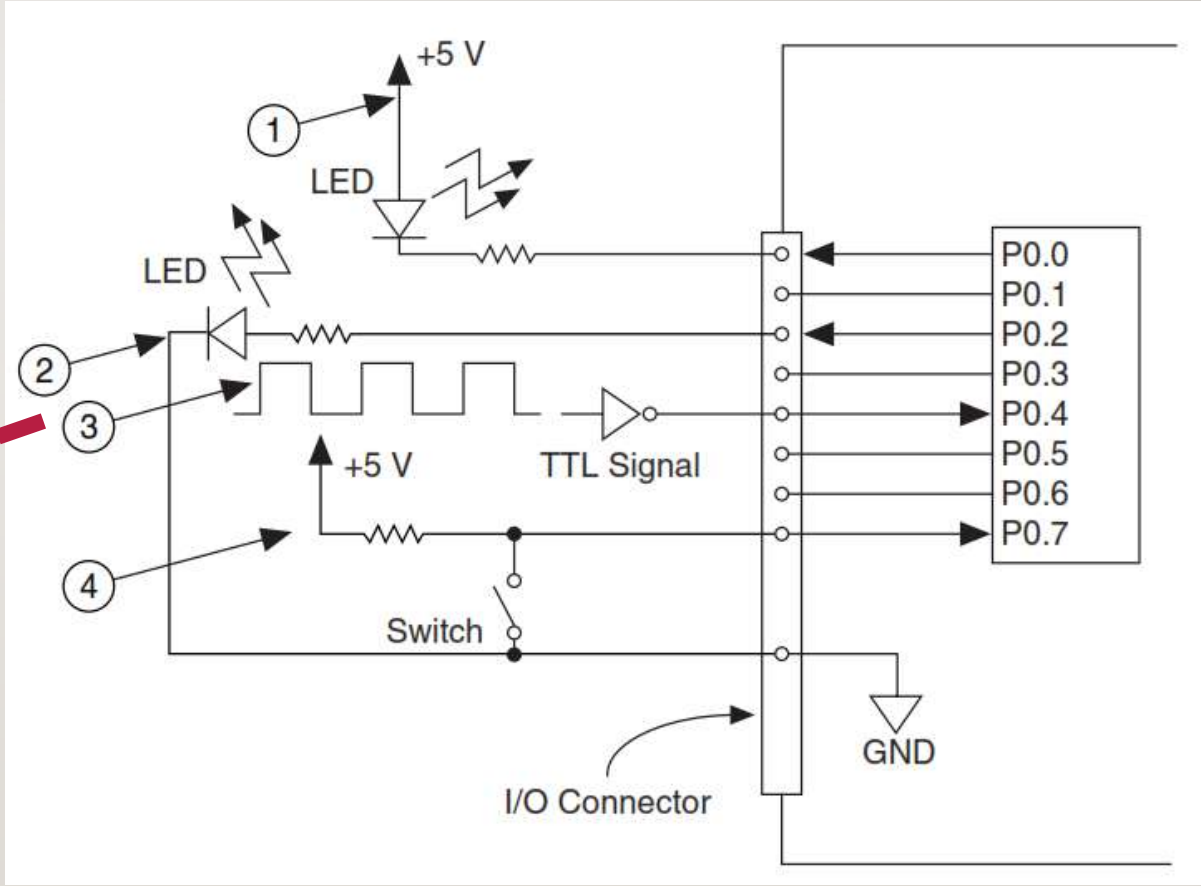

AO connection:
Connecting a Load

# Connecting Digital I/O

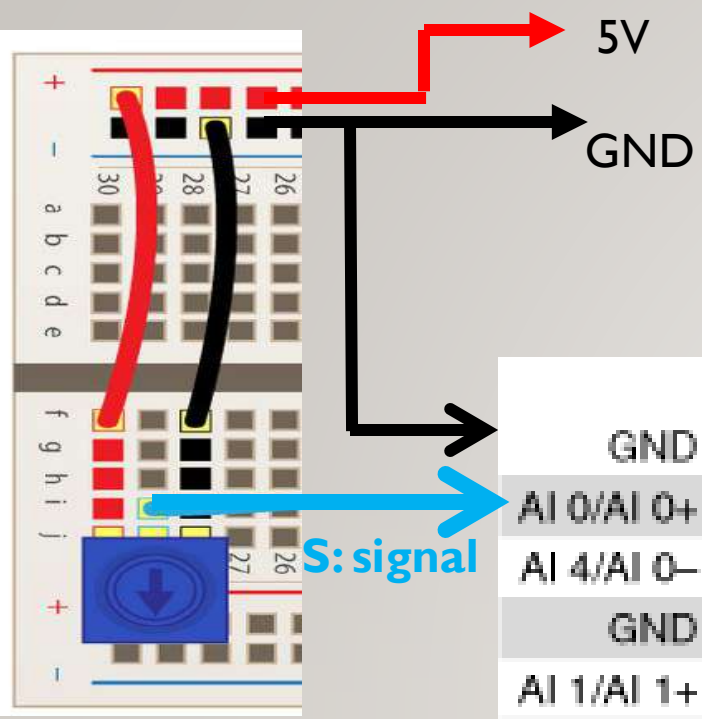
The USB-6009 has 12 digital lines, P0.<0..7> and P1.<0..3>, which comprise the DIO port.

1. P0.0 configured as an open collector digital output driving a LED.

3. P0.4 configured as a digital input receiving a TTL signal from a gated invertor.



# Hardware wiring




| | | | |
|---|---|---|---|
| GND | 1 | 17 | P0.0 |
| AI 0/AI 0+ | 2 | 18 | P0.1 |
| AI 4/AI 0– | 3 | 19 | P0.2 |
| GND | 4 | 20 | P0.3 |
| AI 1/AI 1+ | 5 | 21 | P0.4 |
| AI 5/AI 1– | 6 | 22 | P0.5 |
| GND | 7 | 23 | P0.6 |
| AI 2/AI 2+ | 8 | 24 | P0.7 |
| AI 6/AI 2– | 9 | 25 | P1.0 |
| GND | 10 | 26 | P1.1 |
| AI 3/AI 3+ | 11 | 27 | P1.2 |
| AI 7/AI 3– | 12 | 28 | P1.3 |
| GND | 13 | 29 | PFI 0 |
| AO 0 | 14 | 30 | +2.5 V |
| AO 1 | 15 | 31 | +5 V |
| GND | 16 | 32 | GND |

**Analog Input 0**

## Add a potentiometer


- A potentiometer's pins are ground, data, and 5V.
- This means you connect it to ground and a supply of 5V, and read the actual voltage from the middle pin.

# Wiring diagram MQ-2 gas sensor

- The following picture shows how to connect your DAQ with the MQ-2 gas sensor, according to DAQ pinout:

## Analog Input 1


S: signal

5V

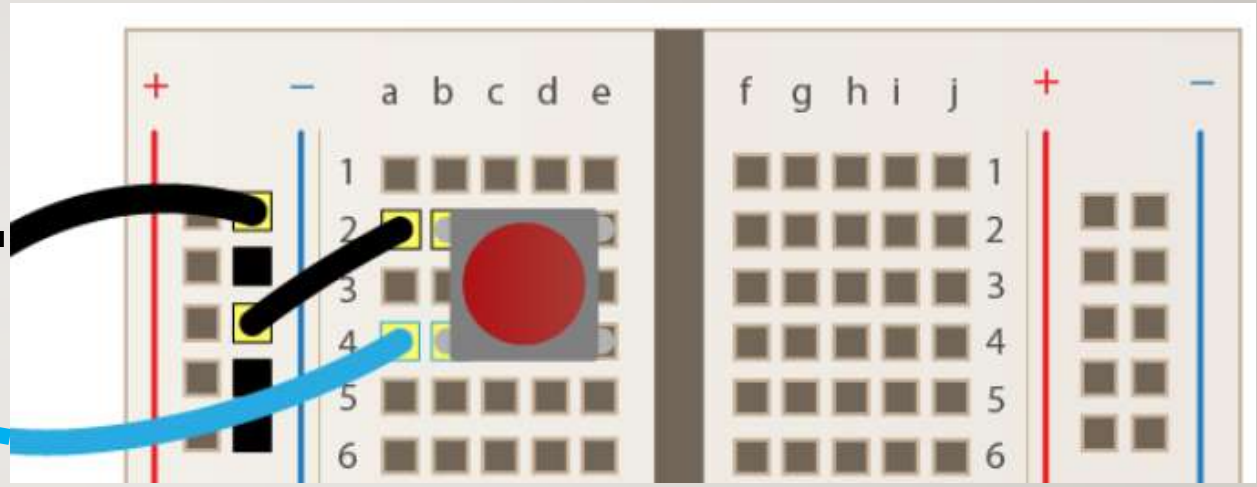
GND

| | | | |
|---|---|---|---|
| GND | 1 | 17 | P0.0 |
| AI 0/AI 0+ | 2 | 18 | P0.1 |
| AI 4/AI 0– | 3 | 19 | P0.2 |
| GND | 4 | 20 | P0.3 |
| AI 1/AI 1+ | 5 | 21 | P0.4 |
| AI 5/AI 1– | 6 | 22 | P0.5 |
| GND | 7 | 23 | P0.6 |
| AI 2/AI 2+ | 8 | 24 | P0.7 |
| AI 6/AI 2– | 9 | 25 | P1.0 |
| GND | 10 | 26 | P1.1 |
| AI 3/AI 3+ | 11 | 27 | P1.2 |
| AI 7/AI 3– | 12 | 28 | P1.3 |
| GND | 13 | 29 | PFI 0 |
| AO 0 | 14 | 30 | +2.5 V |
| AO 1 | 15 | 31 | +5 V |
| GND | 16 | 32 | GND |

# Wiring diagram for Push Bottom Switch

## Digital Input 2

| | | | |
|---|---|---|---|
| GND | 1 | 17 | P0.0 |
| AI 0/AI 0+ | 2 | 18 | P0.1 |
| AI 4/AI 0– | 3 | 19 | P0.2 |
| GND | 4 | 20 | P0.3 |
| AI 1/AI 1+ | 5 | 21 | P0.4 |
| AI 5/AI 1– | 6 | 22 | P0.5 |
| GND | 7 | 23 | P0.6 |
| AI 2/AI 2+ | 8 | 24 | P0.7 |
| AI 6/AI 2– | 9 | 25 | P1.0 |
| GND | 10 | 26 | P1.1 |
| AI 3/AI 3+ | 11 | 27 | P1.2 |
| AI 7/AI 3– | 12 | 28 | P1.3 |
| GND | 13 | 29 | PFI 0 |
| AO 0 | 14 | 30 | +2.5 V |
| AO 1 | 15 | 31 | +5 V |
| GND | 16 | 32 | GND |

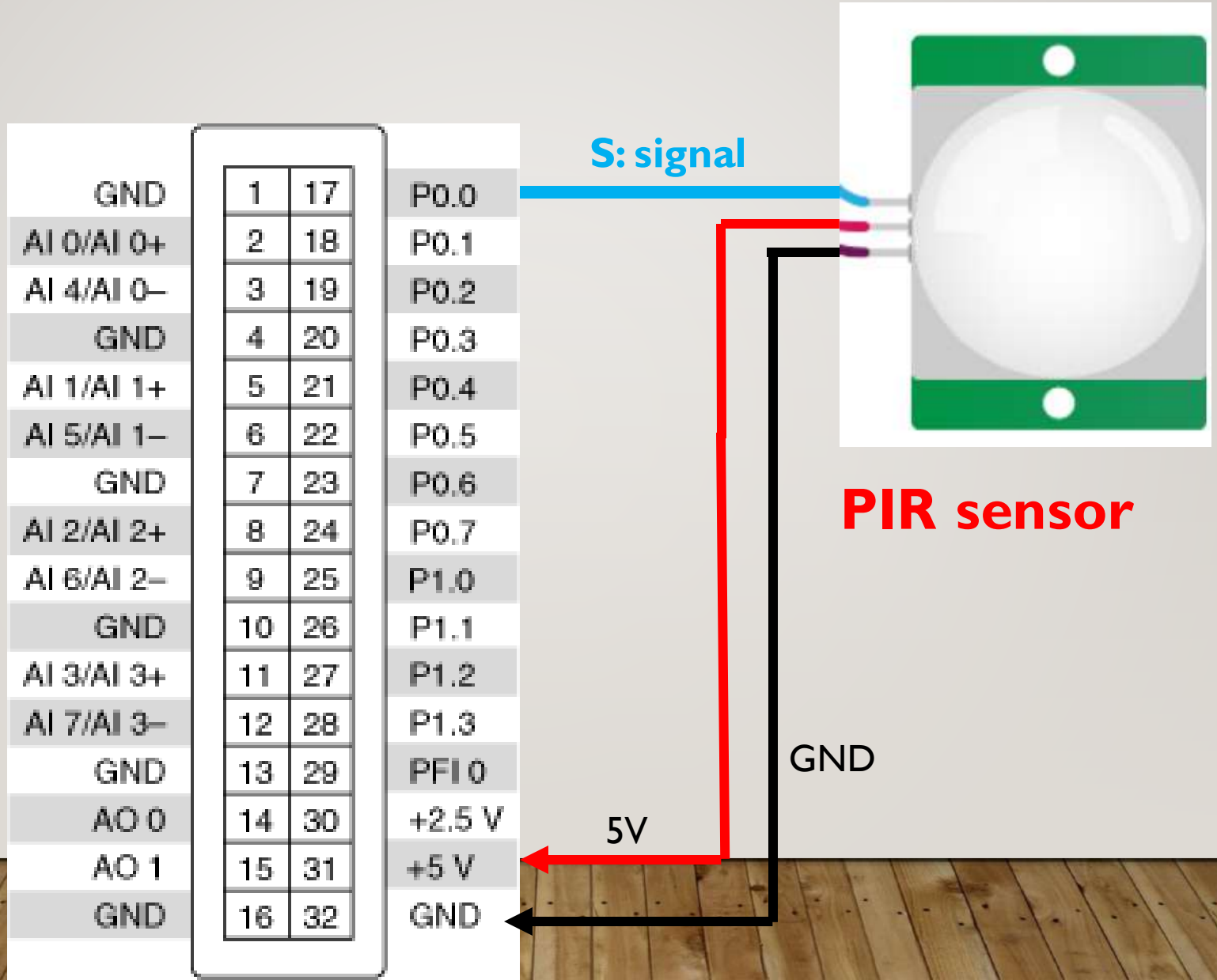



S: signal

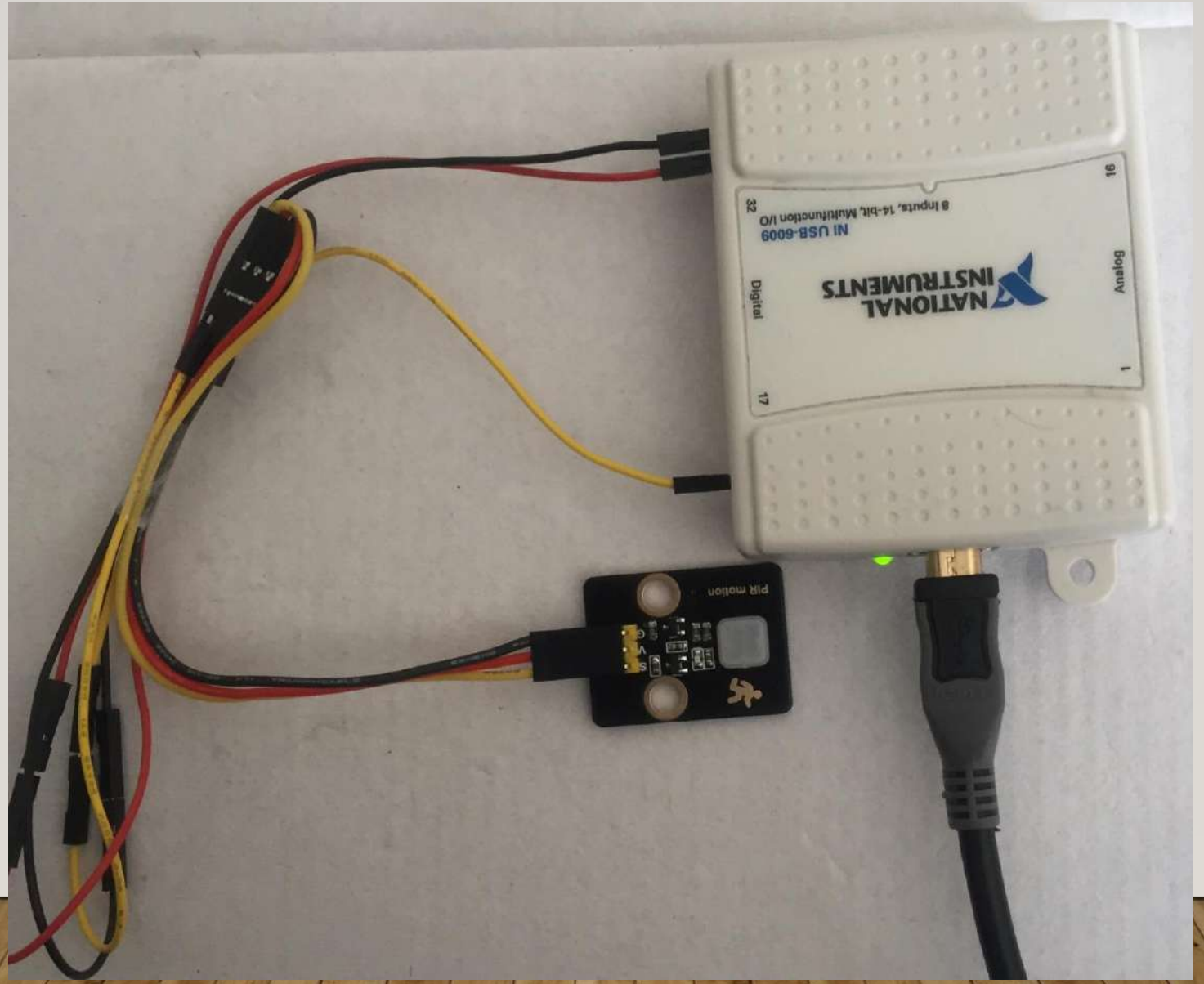
GND

# Wiring diagram PIR motion sensor

## Digital Input 0



# Wiring diagram PIR motion sensor



# Wiring diagram for Steam Water Detection

## Digital Input 1

| | | | |
|---|---|---|---|
| GND | 1 | 17 | P0.0 |
| AI 0/AI 0+ | 2 | 18 | P0.1 |
| AI 4/AI 0– | 3 | 19 | P0.2 |
| GND | 4 | 20 | P0.3 |
| AI 1/AI 1+ | 5 | 21 | P0.4 |
| AI 5/AI 1– | 6 | 22 | P0.5 |
| GND | 7 | 23 | P0.6 |
| AI 2/AI 2+ | 8 | 24 | P0.7 |
| AI 6/AI 2– | 9 | 25 | P1.0 |
| GND | 10 | 26 | P1.1 |
| AI 3/AI 3+ | 11 | 27 | P1.2 |
| AI 7/AI 3– | 12 | 28 | P1.3 |
| GND | 13 | 29 | PFI 0 |
| AO 0 | 14 | 30 | +2.5 V |
| AO 1 | 15 | 31 | +5 V |
| GND | 16 | 32 | GND |

S: signal

5V

GND


Steam Water Sensor

# Wiring diagram for Steam Water Detection

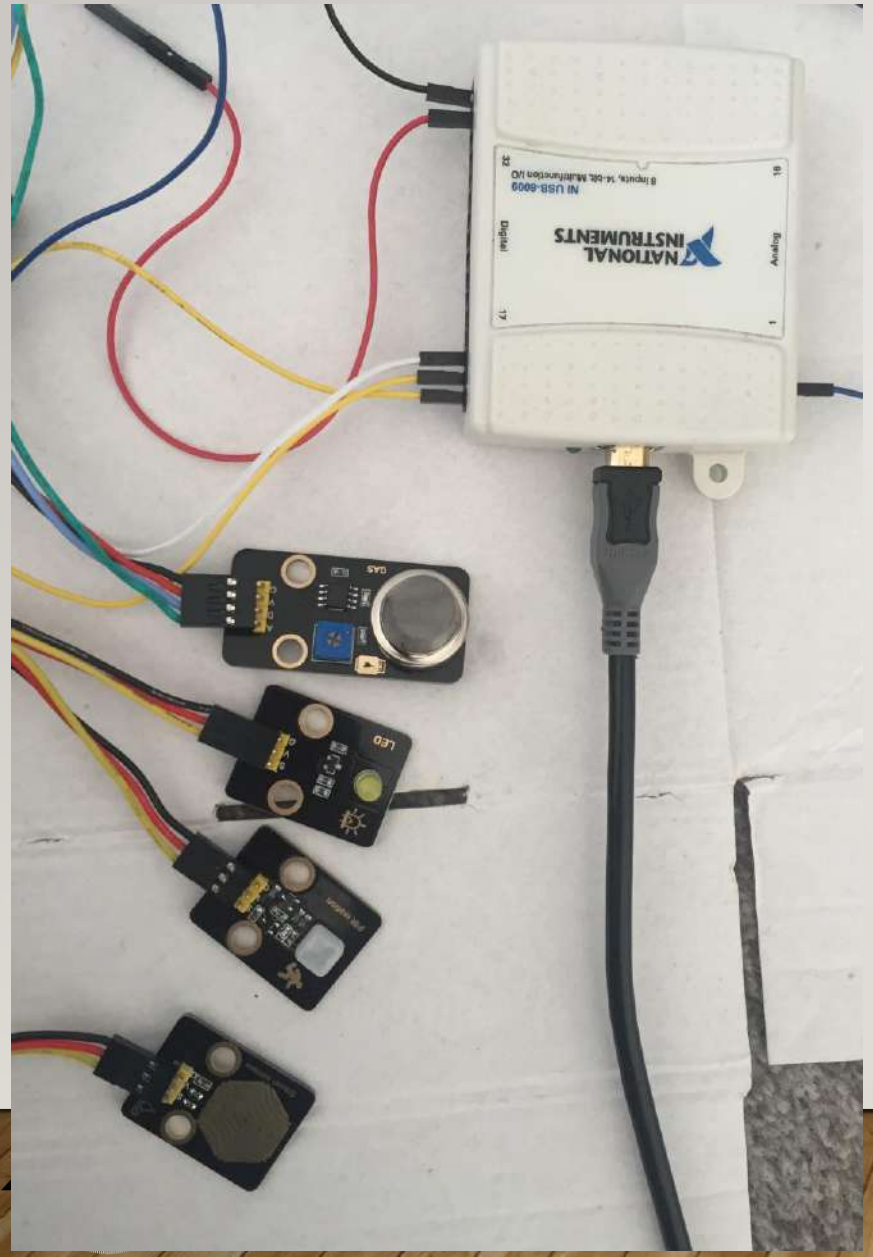
# Wiring diagram of LED lighting

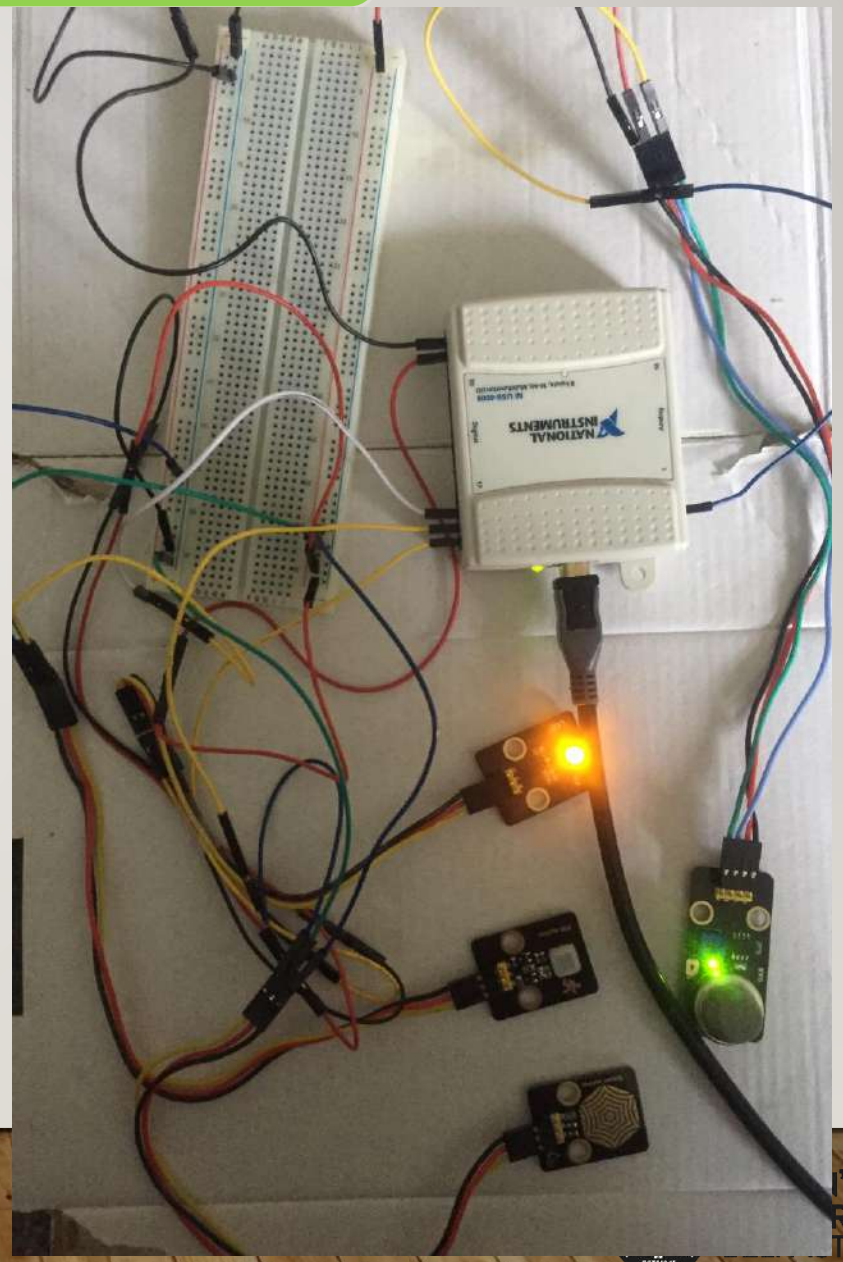
## Digital Input 1

| | | | |
|---|---|---|---|
| GND | 1 | 17 | P0.0 |
| AI 0/AI 0+ | 2 | 18 | P0.1 |
| AI 4/AI 0– | 3 | 19 | P0.2 |
| GND | 4 | 20 | P0.3 |
| AI 1/AI 1+ | 5 | 21 | P0.4 |
| AI 5/AI 1– | 6 | 22 | P0.5 |
| GND | 7 | 23 | P0.6 |
| AI 2/AI 2+ | 8 | 24 | P0.7 |
| AI 6/AI 2– | 9 | 25 | P1.0 |
| GND | 10 | 26 | P1.1 |
| AI 3/AI 3+ | 11 | 27 | P1.2 |
| AI 7/AI 3– | 12 | 28 | P1.3 |
| GND | 13 | 29 | PFI 0 |
| AO 0 | 14 | 30 | +2.5 V |
| AO 1 | 15 | 31 | +5 V |
| GND | 16 | 32 | GND |

# Wiring diagram for LED lighting

# All Parts Wiring diagram



# Thank You For Your Attention!

# Any Question?