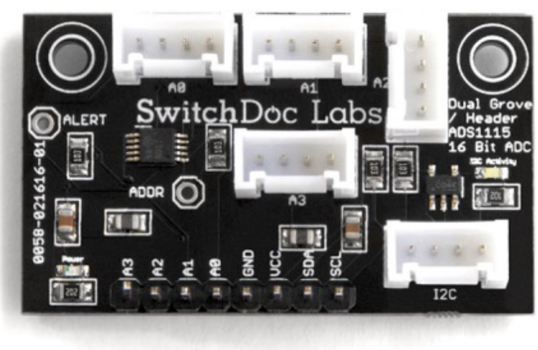
The Grove 4 Channel 16 bit Analog to Digital Converter has 4 Grove Analog ports and one I2C port and operates at 3.3V or 5V. It uses the industry standard ADS1115.



Features and Benefits:

- The Missing Board for the Raspberry Pi
- 4 Channels with Grove Connectors
- Grove I2C connector provided
- Headers provided for non Grove usage
- Supports both 3.3V and 5V I2C
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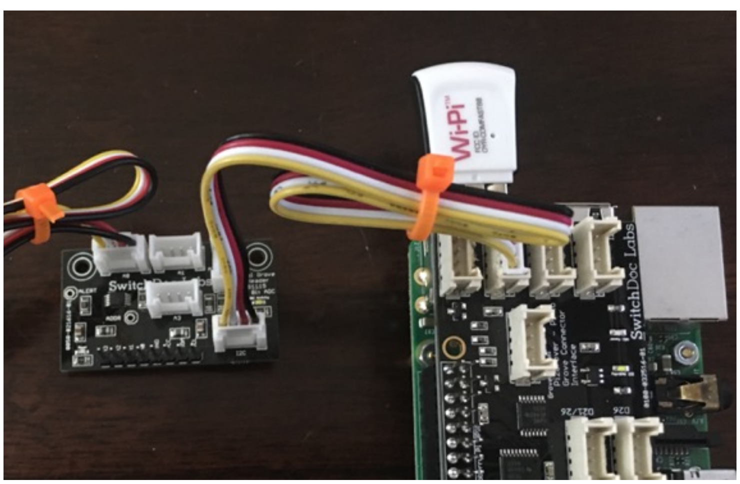
- Quantity Discounts Available
- Immediate Availability

Introduction



No question about it. The lack of an Analog to Digital Converter is a pain on the Raspberry Pi. We want to read those real world signals all the time and we didn't have a good way of doing it. And not one really workable ADC for the Grove either. So, we designed the board above. 4 channels of 16 bit Analog to Digital nirvana.

The Grove 4 Ch 16bit ADC connects to a Grove I2C connector and supplies 4 channels of Grove Analog plugs for your projects.

What are Grove Connectors?

A Grove connector is a four pin standardized size connector used to plug into the Pi2Grover base unit and Grove devices and modules. These standardized connectors (common to all types of Grove Connectors) are the key to making this system work. They are keyed to prevent plugging them in backwards, and the four types of connectors (see below) are all designed so that if you plug the wrong type of device into the wrong type of base unit, there is no problem. They just won't work. This is a good thing. Less smoke, more prototyping!

The Four Types of Grove Connectors

Below are some of the specifics of each of the four types of connectors. First of all, physically all of them are the same. Exactly. The differences are in the signal types that are provided. Now, note. You will never short out power and ground by mis-plugging one type of Grove connector in the other. **However, it is possible to plug a 3.3V Grove Module into a 5.0V Grove connector and damage the device**. The same could happen with an output coming back from a Grove button or switch for example into another output. While you do need to be careful and think about what you are doing, it is a lot less risky than soldering or using just jumpers to wire up devices to your Pi or Arduino.

Generically, all of the Grove connectors are wired the same: Signal 1, Signal 2, Power, Ground.

Grove Digital (Note: The Grove 4Ch 16bit ADC has no Grove Digital Ports)

A digital Grove connector consists of the standard four lines coming into the Grove plug. The two signal lines are generically called D0 and D1. Most modules only use D0, but some do (like the LED Bar Grove display) use both. Often base units will have the first connector called D0 and the second called D1 and they will be wired D0/D1 and then D1/D2, etc.

Grove Digital		
Pin 1	D0	Primary Digital Input/Output
Pin 2	D1	Secondary Digital Input/Output
Pin 3	VCC	Power for Grove Module (5V or 3.3V)
Pin 4	GND	Ground

Examples of Grove Digital modules are: Switch Modules, the Fan Module, and the LED Module.

Grove Analog

An Grove Analog connector consists of the standard four lines coming into the Grove plug. The two signal lines are generically called A0 and D0. Most modules only use A0. Often base units will have the first connector called A0 and the second called A1 and they will be wired A0/A1 and then A1/A2, etc.

Grove Analog		
Pin 1	A0	Primary Analog Input
Pin 2	A1	Secondary Analog Input
Pin 3	VCC	Power for Grove Module (5V or 3.3V)
Pin 4	GND	Ground

Examples of Grove Analog modules are: Potentiometer, Voltage Divider and the Grove Air Quality Sensor.

Grove UART ((Note: The Grove 4Ch 16bit ADC has no Grove UART Ports))

The Grove UART module is a specialized version of a Grove Digital Module. It uses both Pin 1 and Pin 2 for the serial input and transmit. The Grove UART plug is labeled from the base unit point of view. In other words, Pin 1 is the RX line (which the base unit uses to receive data, so it is an input) where Pin 2 is the TX line (which the base unit uses to transmit data to the Grove module).

Grove UART		
Pin 1	RX	Serial Receive (from base point of view)
Pin 2	TX	Serial Transmit (from base point of view)
Pin 3	VCC	Power for Grove Module (5V or 3.3V)
Pin 4	GND	Ground

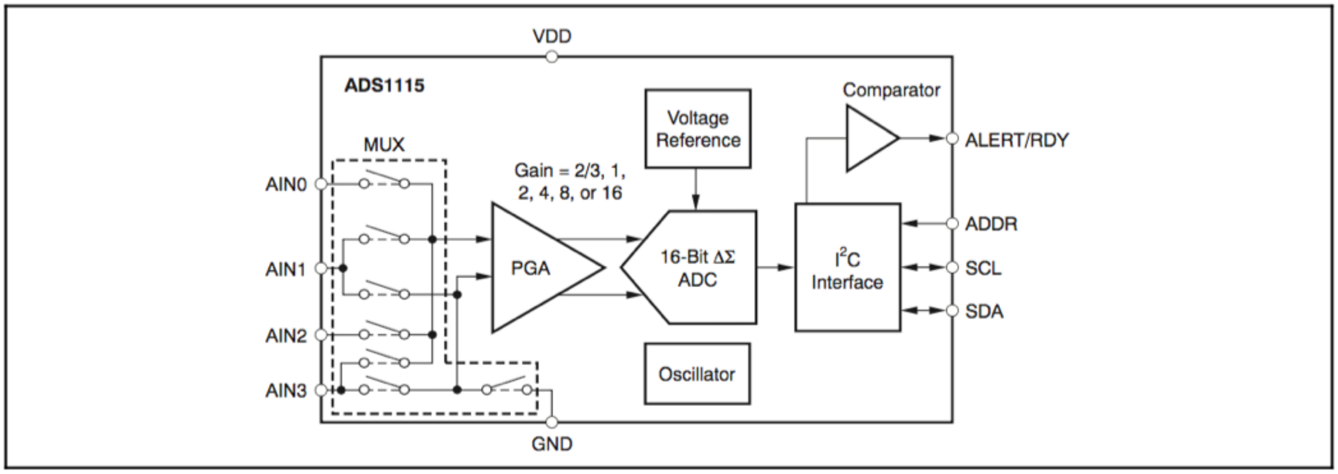
Examples of Grove UART modules are: XBee Wireless Sockets, 125KHz RFID Reader

Grove I2C

The Grove I2C connector has the standard layout. Pin 1 is the SCL signal and Pin 2 is the SDA signal. Power and Ground are the same as the other connectors. This is another special version of the Grove Digital Connector. In fact, often the I2C bus on a controller (like the ESP8266, Raspberry Pi and the Arduino) just uses Digital I/O pins to implement the I2C bus. The pins on the Raspberry Pi and Arduino are special with hardware support for the I2C bus. The ESP8266 is purely software.

Grove I2C		
Pin 1	SCL	I2C Clock
Pin 2	SDA	I2C Data
Pin 3	VCC	Power for Grove Module (5V or 3.3V)
Pin 4	GND	Ground

Theory of Operation



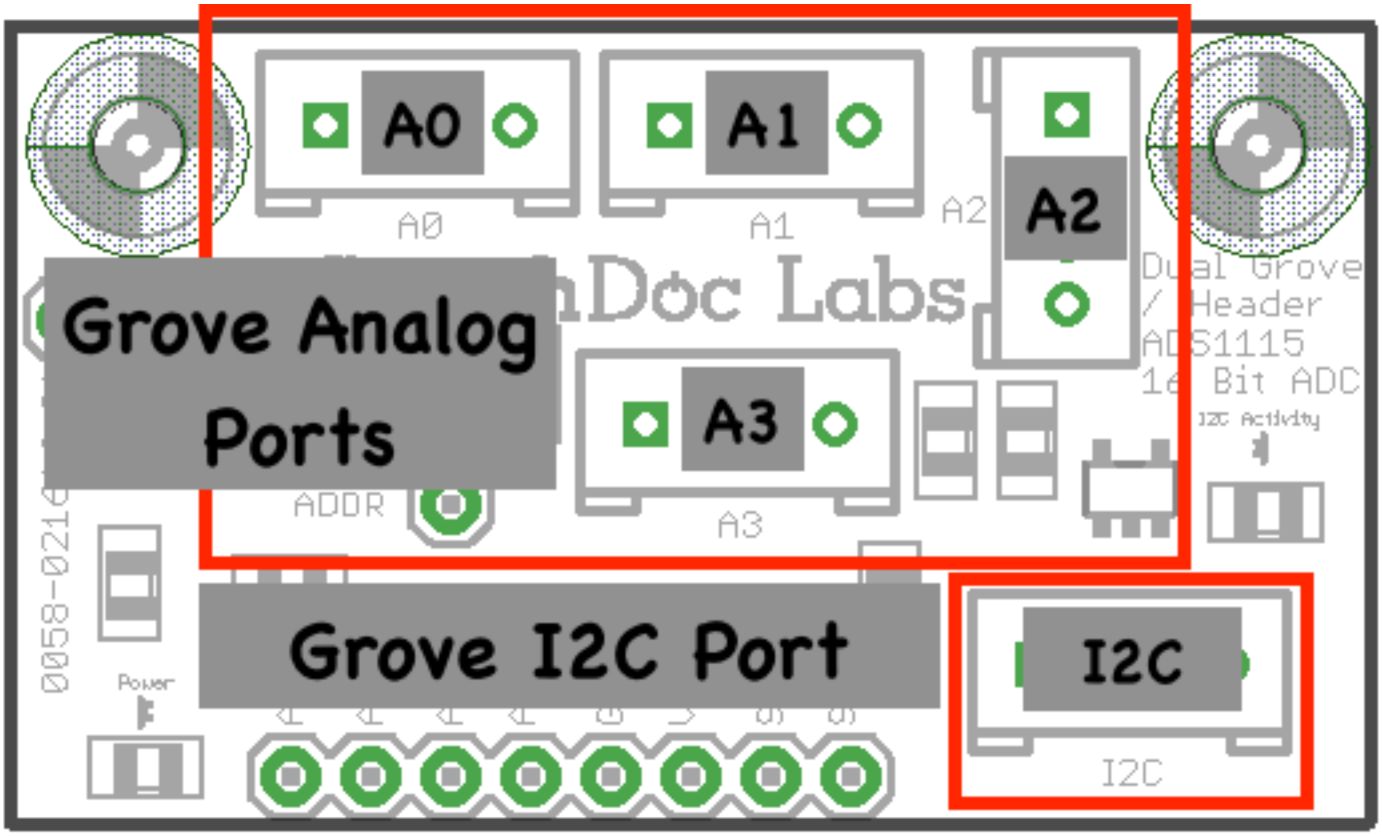
The ADS1115 is a very small, low-power, 16-bit, delta-sigma (ΔΣ) analog-to-digital converter (ADC). The ADS111/5 are extremely easy to configure and design into a wide variety of applications, and allow precise measurements to be obtained with very little effort. Both experienced and novice users of data converters find designing with the ADS1115 to be intuitive and problem-free.

The ADS111/5 consists of a ΔΣ analog-to-digital (A/D) core with adjustable gain, an internal voltage reference, a clock oscillator, and an I^2C interface. An additional feature available on the ADS1115 is a programmable digital comparator that provides an alert on a dedicated pin. All of these features are intended to reduce required external circuitry and improve performance. The ADS1115 functional block diagram is shown above.

The ADS1115 A/D core measures a differential signal, V_{IN}, that is the difference of AIN_P and AIN_N. A MUX is available on the ADS1115. This architecture results in a very strong attenuation in any common-mode signals. The converter core consists of a differential, switched-capacitor ΔΣ modulator followed by a digital filter. Input signals are compared to the internal voltage reference. The digital filter receives a high-speed bitstream from the modulator and outputs a code proportional to the input voltage.

The ADS1115 has two available conversion modes: single-shot mode and continuous conversion mode. In single-shot mode, the ADC performs one conversion of the input signal upon request and stores the value to an internal result register. The device then enters a low-power shutdown mode. This mode is intended to provide significant power savings in systems that only require periodic conversions or when there are long idle periods between conversions. In continuous conversion mode, the ADC automatically begins a conversion of the input signal as soon as the previous conversion is completed. The rate of continuous conversion is equal to the programmed data rate. Data can be read at any time and always reflect the most recent completed conversion.

Grove 4Ch/16Bit ADC Pinout



Physical dimensions of board: 43mm x 37 mm x 10mm(max). Two mounting holes are provided.

Key:

A - Analog Pin
I - Digital Input
O - Digital Output
I/O - Bi-directional Input/Output

JP1 - Pin Header

The ADS1115 is a precision analog-to-digital converter (ADC) with 16 bits of resolution. The ADS1115 is designed with precision, power, and ease of implementation in mind. Data are transferred via an I2C-compatible serial interface; four I2C slave addresses can be selected. See JP2 - ADDR Pin.

NAME	PIN	I/O	DESCRIPTION
A3	JP1 / 1	A	Differential channel 2: Negative Input or single-ended channel 4 input
A2	JP1 / 2	A	Differential channel 2: Positive Input or single-ended channel 3 input.
A1	JP1 / 3	A	Differential channel 1: Negative Input or single-ended channel 2 input.
A0	JP1 / 4	A	Differential channel 1: Positive Input or single-ended channel 1 input
GND	JP1 / 5	A	GND
3V3	JP1 / 6	A	VDD - 3.3V or 5V
SDA	JP1 / 7	I/O	Serial bus data line; open-drain input/output. 10K Pullup on line to VDD
SCL	JP1 / 8	I	Serial bus clock line; open-drain input. 10K Pullup on line to VDD

JP2 - ADDR

The ADDR pin can be connected to various pins to change the I2C address of the Grove 4 Ch 16 Bit ADC Board.

The ADS1115 chips have a base 7-bit I2C address of 0x48 and an addressing scheme that allows four different addresses using just one address pin. To program the address, connect the address pin as follows:

- 0x48 (1001000) ADDR -> GND
- 0x49 (1001001) ADDR -> VDD
- 0x4A (1001010) ADDR -> SDA
- 0x4B (1001011) ADDR -> SCL

The ADDR pin comes with a 10K pullup to GND on board. This means the default address is 0x48.

NAME	PIN	I/O	DESCRIPTION
ADDR	JP2 / 1	I	I2C slave address select. Connected internally by a 10K Ohm Pulldown to GND.

JP3 - ALERT

The ADS1115 is equipped with a customizable comparator that can issue an alert on the ALERT/RDY pin. This feature can significantly reduce external circuitry for many applications. The comparator can be implemented as either a traditional comparator or a window comparator via the COMP_MODE bit in the Config register.

The ALERT/RDY pin can also be configured as a conversion ready pin. See the ADS1115 specification (http://www.switchdoc.com/wp-content/uploads/2016/05/ads1115.pdf) for details.

NAME	PIN	I/O	DESCRIPTION
ALERT	JP3 / 1	O	Digital comparator output or conversion ready

How To Use the Board

Warning: Always turn off the power before you remove or replace any Grove devices or wires on board. You may damage your devices or your computer!

Basically, there are two steps to using this board.

1) Download the software drivers for the Grove4Ch16BitADC
2) Install a Grove Connector from your computer I2C port to the Grove4Ch16BitADC I2C Port
3) Connect up the Grove device producing an analog voltage (Grove Analog) to your chosen A0-A4 port on the Grove4Ch16BitADC device

Or you can use the provided JP1 Header to hook up this device to your I2C bus or the voltages to be measured. Remember a common ground!

All of the Grove 4Ch/16Bit ADC channels can perform conversions at rates up to 860 samples per second (SPS) and can measure signals from 0 - VDD. ***Note: If you want to measure voltages higher than VDD (3.3V or 5V), you must use a voltage divider to reduce the voltage below VDD.***

See the Arduino and Raspberry Pi Drivers for software examples.

Operating Values

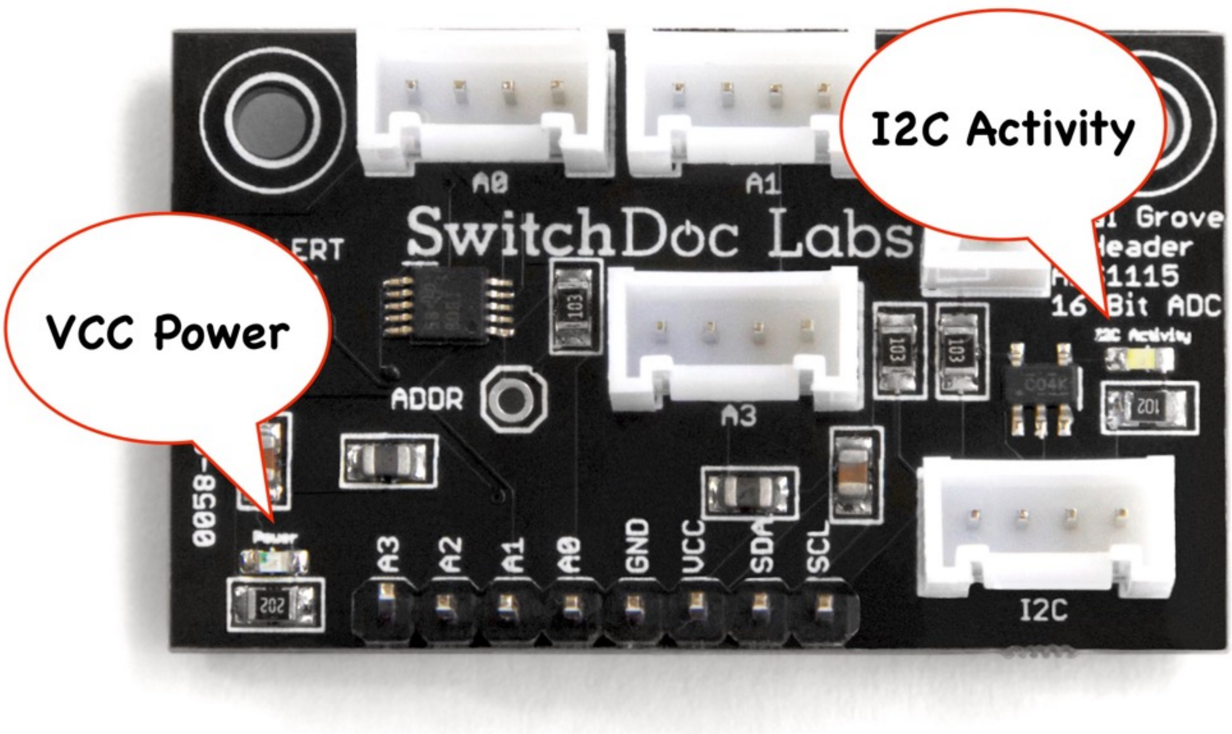
	Min	Normal	Max	Unit
VDD	2.0V		5.5	V
Analog Input Voltage to GND	GND		VDD	V
SDA, SCL, ADDR, ALERT/RDY voltage to GND	GND		5.0	V

LEDs on Grove 4Ch/16Bit ADC

There are two LEDs on Grove 4Ch/16Bit ADC Board.

LED1 (Power) - On if Raspberry Pi is supplying 5V to the Grove 4Ch/16Bit ADC r Board

LED2 (I2C Activity) - Flashes when there is activity on the I2C bus.



Software Drivers for Arduino and Raspberry Pi

Raspberry Pi Pure Python Software is at: https://github.com/switchdoclabs/SDL_Pi_Grove4Ch16BitADC

Arduino Software is at: https://github.com/switchdoclabs/SDL_Arduino_Grove4Ch16BitADC

Raspberry Pi Test Output

```
pi@RPi3:~/SDL_Pi_Grove4Ch16BitADC $ sudo python TestGrove4Ch16BitADC.py
--------------------
Channel 0 =0.323875V raw=0x A1D
Channel 1 =0.642375V raw=0x1020
Channel 2 =1.617125V raw=0x3288
Channel 3 =0.566750V raw=0x116D
--------------------
--------------------
Channel 0 =0.323750V raw=0x A1D
Channel 1 =0.553125V raw=0x147F
Channel 2 =1.612750V raw=0x3260
Channel 3 =0.584625V raw=0x1240
--------------------
--------------------
Channel 0 =0.323625V raw=0x A1E
Channel 1 =0.630875V raw=0x1005
Channel 2 =1.610125V raw=0x3277
Channel 3 =0.557750V raw=0x121C
--------------------
```

Arduino Test Output

```
------------------------------
------------------------------
Grove4Ch16BitADC Test
------------------------------
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------------------------------
Channel 0 Voltage =0.23V ad0=0x4C7
Channel 1 Voltage =0.58V ad0=0xC0A
Channel 2 Voltage =0.48V ad2=0xA04
Channel 3 Voltage =0.58V ad3=0xBFB
```

```
------------------------------
------------------------------
Channel 0 Voltage =0.23V ad0=0x4C7
Channel 1 Voltage =0.58V ad0=0xC1F
Channel 2 Voltage =0.48V ad2=0xA04
Channel 3 Voltage =0.58V ad3=0xC11
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```
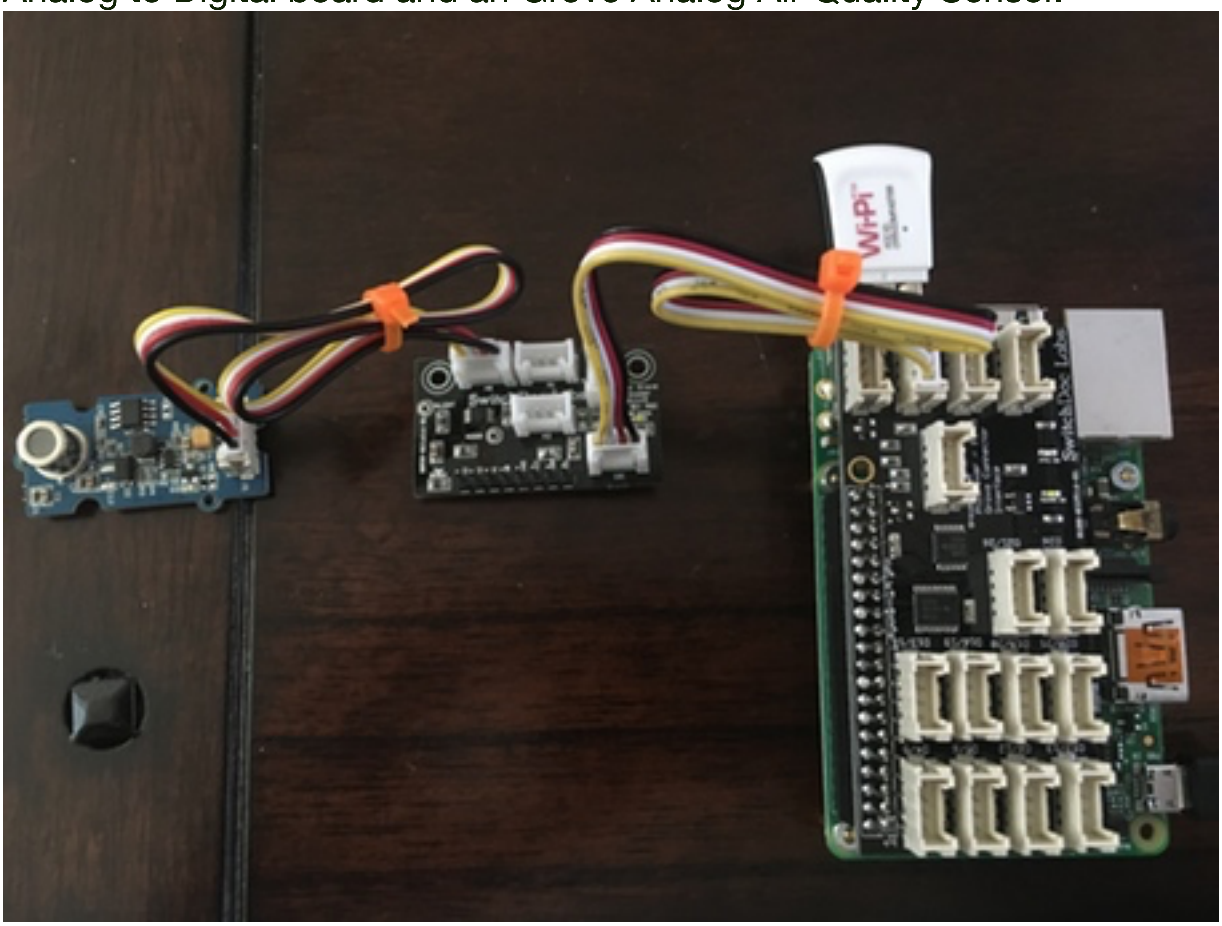

Example Project

Here is a simple IOT project on the Raspberry Pi using the Pi2Grover board, Grove Analog to Digital board and an Grove Analog Air Quality Sensor.



Air Quality Sensor Project

We built this in a matter of minutes. Plugged the Pi2Grover into the Raspberry Pi, the Grove Analog to Digital to a Grove I2C connector and the Grove Air Quality Sensor into the Grove Analog A0 input on the Grove Analog to Digital board. Done. We installed the software and here are the results. For your information, we caused the air pollution alert with a can of hairspray.

```
------------------------------
------------------------------
OurWeather - Air Quality Sensor Test
------------------------------
------------------------------
Completed Setup
Sensor_Value=78--->Fresh Air
Sensor_Value=78--->Fresh Air
Sensor_Value=79--->Fresh Air
Sensor_Value=81--->Fresh Air
Sensor_Value=832--->Very High Pollution Detected
Sensor_Value=847--->Very High Pollution Detected
Sensor_Value=821--->Very High Pollution Detected
Sensor_Value=826--->Very High Pollution Detected
Sensor_Value=839--->Very High Pollution Detected
Sensor_Value=834--->Very High Pollution Detected
Sensor_Value=811--->Very High Pollution Detected
Sensor_Value=788--->Very High Pollution Detected
Sensor_Value=779--->Very High Pollution Detected
Sensor_Value=768--->Very High Pollution Detected
Sensor_Value=758--->Very High Pollution Detected
Sensor_Value=717--->Very High Pollution Detected
Sensor_Value=638--->High Pollution
Sensor_Value=544--->High Pollution
Sensor_Value=457--->High Pollution
Sensor_Value=399--->Low Pollution
Sensor_Value=352--->Low Pollution
Sensor_Value=309--->Low Pollution
Sensor_Value=281--->Low Pollution
Sensor_Value=260--->Low Pollution
Sensor_Value=238--->Low Pollution
Sensor_Value=221--->Low Pollution
Sensor_Value=210--->Low Pollution
Sensor_Value=205--->Low Pollution
Sensor_Value=189--->Fresh Air
Sensor_Value=174--->Fresh Air
```

Hairspray Air Pollution Detected!