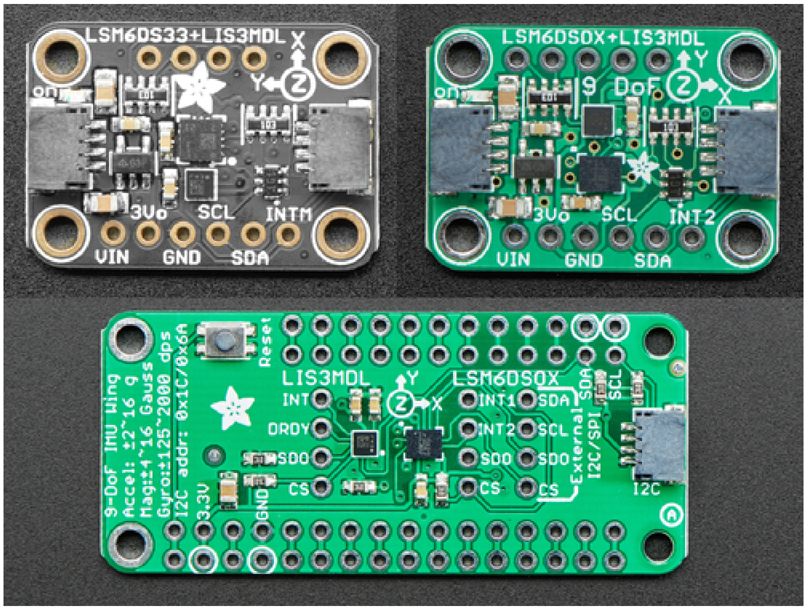
adafruit learning system

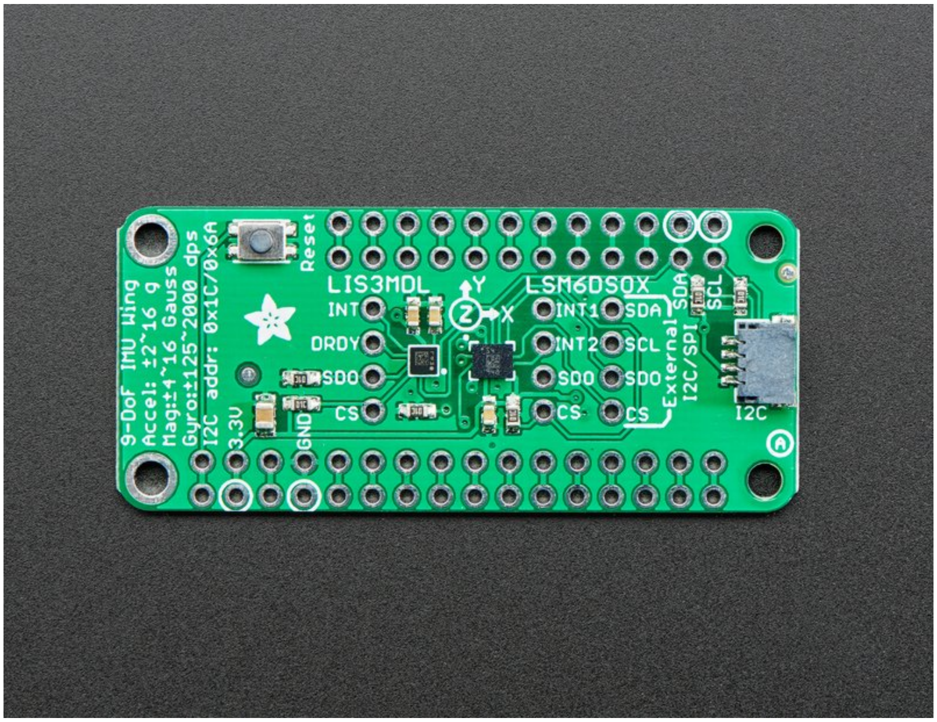
ST 9-DoF Combo Breakouts and Wings

Created by Kattni Rembor

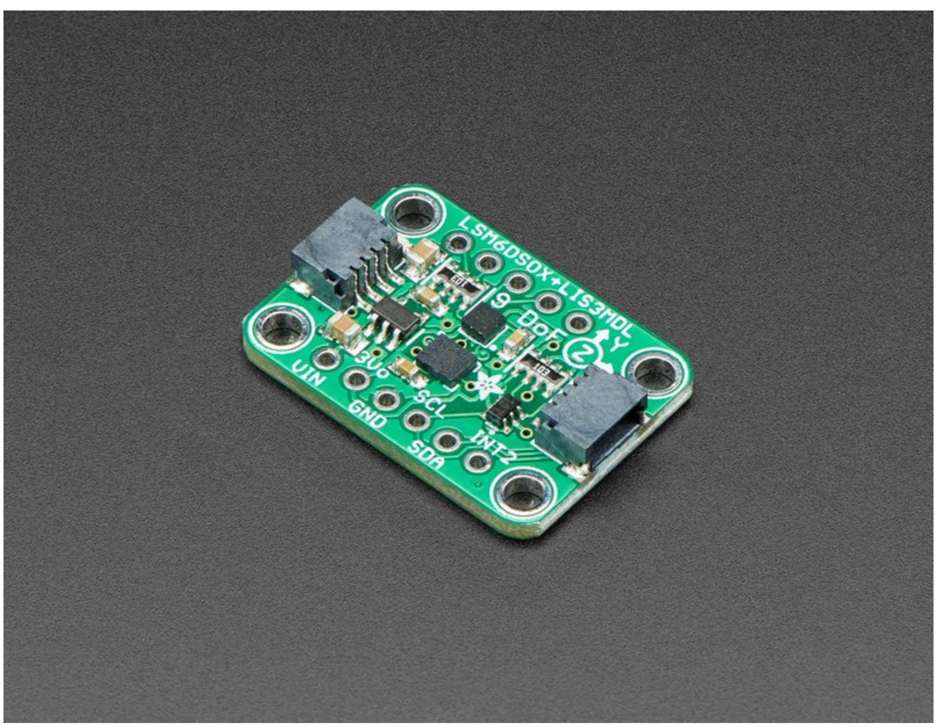


Last updated on 2020-07-02 04:38:45 PM EDT

Overview



Add high quality motion, direction and orientation sensing to your project with these all-in-one 9 Degree of Freedom (9-DoF) FeatherWings and breakouts with sensors from ST. This little breakout and FeatherWing contain two chips that sit side-by-side to provide 9 degrees of full-motion data.



The breakout and FeatherWings include an **LSM6DSOX**, **ISM330DHC**, **ISM330DHCX**, or **LSM6DS33**. These are 6-DoF IMUs with accelerometer + gyro. The 3-axis accelerometer, can tell you which direction is down towards the Earth (by measuring gravity) or how fast the board is accelerating in 3D space. The 3-axis gyroscope that can measure spin and twist. The three triple-axis sensors add up to 9 degrees of freedom.

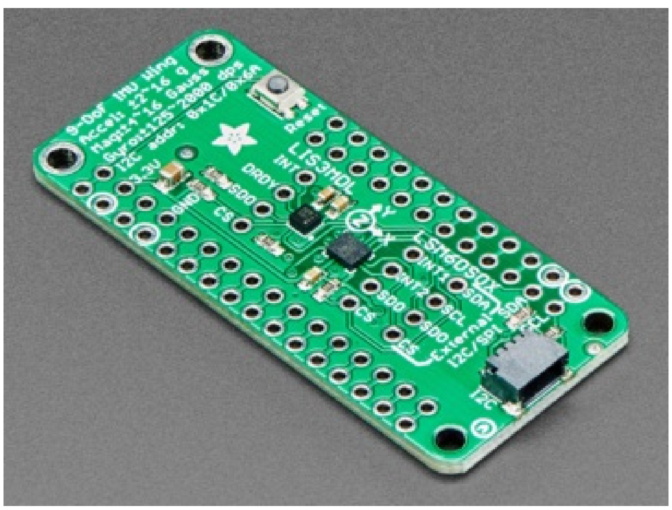
The LSM6DS33 is a lower cost IMU.

This LSM6DSOX is a mid-range cost IMU has very low gyro zero rate and noise(https://adafru.it/LGc) compared to the LSM6DS33, so it's excellent for orientation fusion usage: you'll get less drift and faster responses.

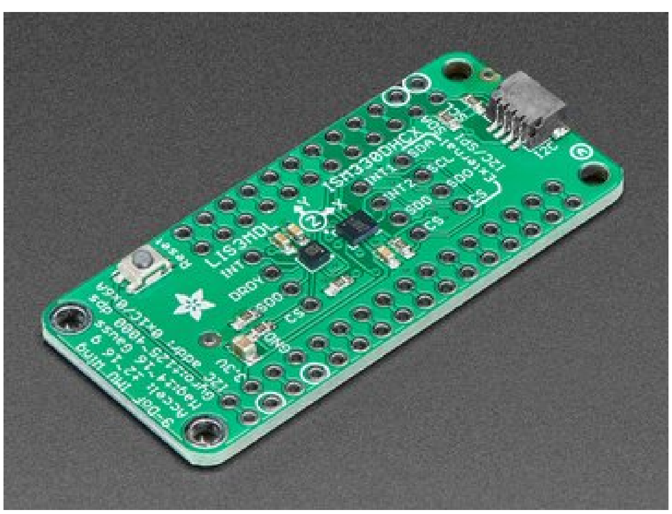
The LSM6DSOX and LSM6DS33 both have flexible data rates and ranges. For the accelerometer: **±2/±4/±8/±16 g** at 1.6 Hz to 6.7KHz update rate. For the gyroscope: **±125/±250/±500/±1000/±2000 dps** at 12.5 Hz to 6.7 KHz. There's also some nice extras, such as built-in tap detection, activity detection, and pedometer/step counter. The LSM6DSOX also has a programmable finite state machine / machine learning core that can perform some basic gesture recognition.

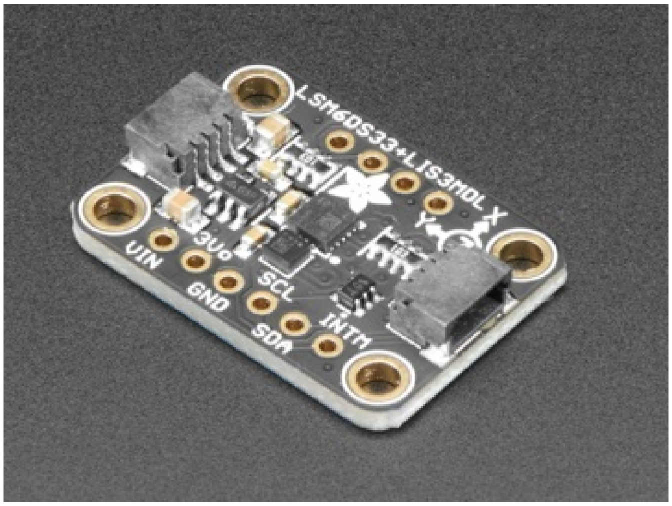
The ISM330DHCX also has flexible data rates and ranges. For the accelerometer: **±2/±4/±8/±16 g** at 1.6 Hz to 6.7KHz update rate. For the gyroscope: **±125/±250/±500/±1000/±2000/±4000 dps** at 12.5 Hz to 6.7 KHz. In particular, this is one of the few gyro's we stock with 4000 dps range, usually they top out at 2000. This sensor has extra calibration and compensation circuits to give it excellent performance in a wide environmental range from -40 to +105°C.

Also included is a **LIS3MDL** 3-axis magnetometer that can sense where the strongest magnetic force is coming from, generally used to detect magnetic north. The three triple-axis sensors add up to 9 degrees of freedom, by combining this data you can orient the board.

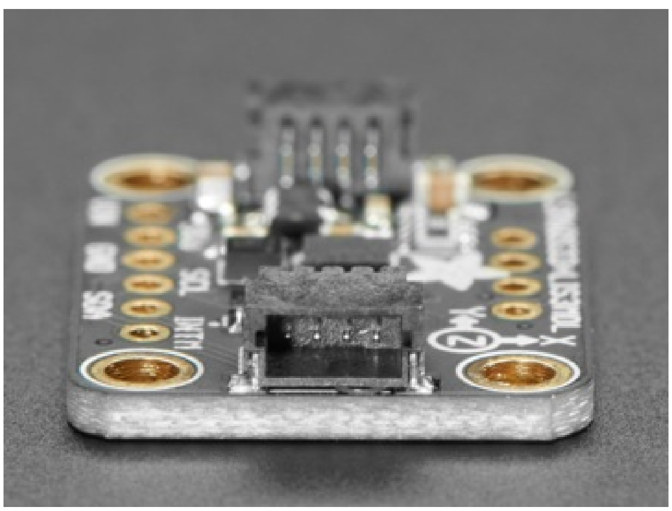


For the FeatherWings, both sensors are connected over the shared I2C bus, so you can use it with any and all Feathers! We also break out the interrupt pins and address-selection jumpers in case you want multiple Feathers or have I2C address conflicts. We've got both Arduino (C/C++) and CircuitPython libraries available so you can use it with any Feather board and get data readings in under 5 minutes. Four mounting holes make for a secure connection.



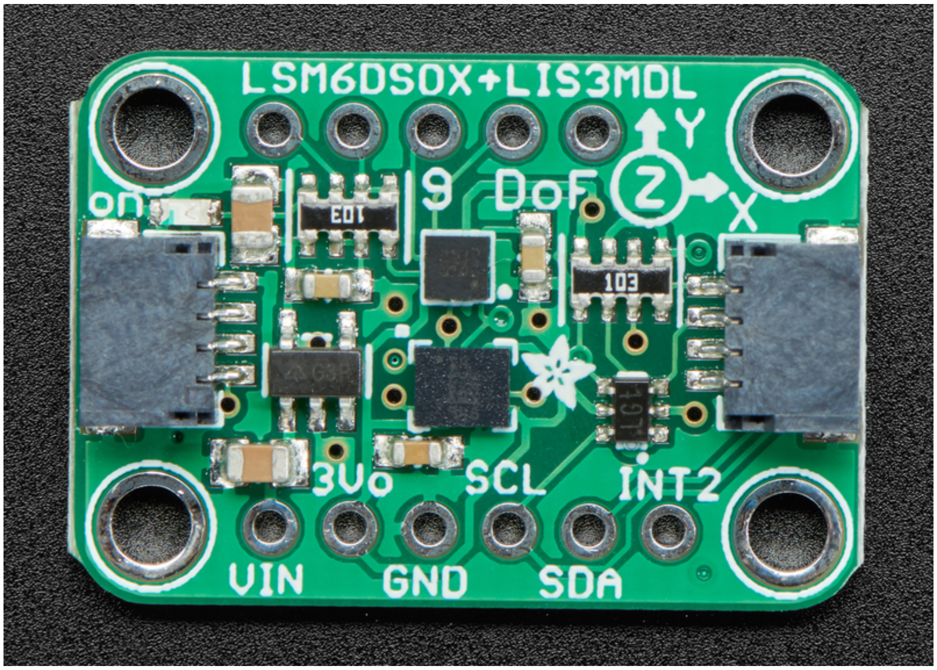


To make getting started fast and easy for non-Feather use, we placed the sensors on a compact breakout board with voltage regulation and level-shifted inputs. That way you can use them with 3V or 5V power/logic devices without worry. To make usage simple, we expose only the I2C interface and some interrupt pins from each chip. The breakout comes fully assembled and tested, with some extra header so you can use it on a breadboard. Four mounting holes make for a secure connection.



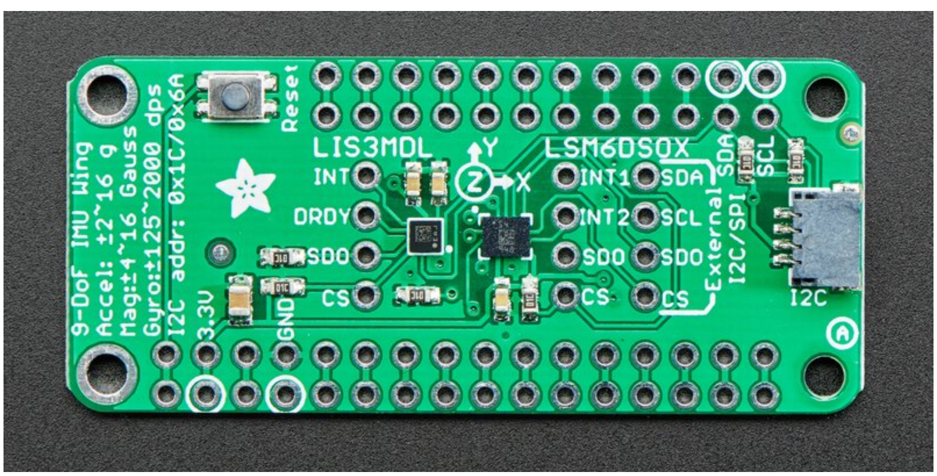
For the breakouts, since the sensors are wired together over I2C, you can easily connect it up with two wires (plus power and ground!). We've even included SparkFun qwiic (https://adafru.it/Fpw) compatible **STEMMA QT (https://adafru.it/Ft4)** connectors for the I2C bus so **you don't even need to solder!** Just wire up to your favorite micro like the STM32F405 Feather (https://adafru.it/Iqc) with a plug-and-play cable to get 9 DoF data ASAP. You can change the I2C addresses on the back using the solder jumpers to have two of these sensor boards on one bus.

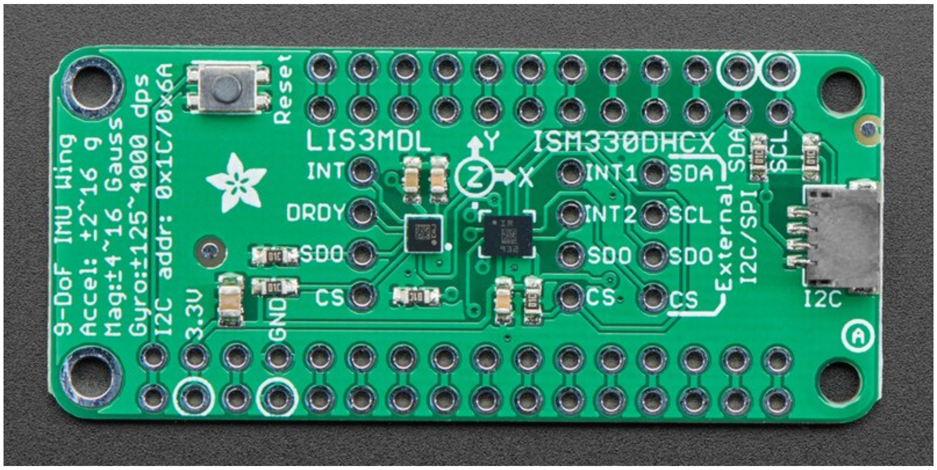
LSM6DSOX or ISM330DHCX + LIS3MDL Pinouts



Breakout Power Pins

- **Vin** - this is the power pin. Since the sensor chip uses 3 VDC, we have included a voltage regulator on board that will take 3-5VDC and safely convert it down. To power the board, give it the same power as the logic level of your microcontroller - e.g. for a 5V microcontroller like Arduino, use 5V
- **3Vo** - this is the 3.3V output from the voltage regulator, you can grab up to 100mA from this if you like
- **GND** - common ground for power and logic





FeatherWing Power Pins

- **3.3V** - this is the 3.3V input to the FeatherWing, we use the Feather's power regulator to generate the clean 3v power needed.
- **GND** - common ground for power and logic

> On the earlier versions of the FeatherWing, SCL and SDA are swapped on the silk. The pins themselves are accurate. The issue is only with the labels printed on the board.

I2C Logic Pins

- **SCL** - I2C clock pin, connect to your microcontroller's I2C clock line. On the breakouts, this pin is level shifted so you can use 3-5V logic. On the FeatherWing, there is no level shifter. There's a **10K pullup** on this pin.
- **SDA** - I2C data pin, connect to your microcontroller's I2C data line.
- On the breakouts, this pin is level shifted so you can use 3-5V logic. On the FeatherWing, there is no level shifter. There's a **10K pullup** on this pin.
- **STEMMA QT (https://adafru.it/Ft4) -** These connectors allow you to make I2C connections to dev boards with **STEMMA QT** connectors or to other things with various associated accessories (https://adafru.it/Ft6).

I2C Address Pins

- **ADM / Mag Addr** - LIS3MDL Magnetometer I2C address pin. Pulling this pin high or bridging the solder jumper on the back will change the I2C address from **0x1C** to **0x1E.**
- **ADAG / A/G Addr** - LSM6DSOX or ISM330DHCX Accel/Gyro I2C address pin. Pulling this pin high or bridging the solder jumper on the back will change the I2C address from **0x6A** to **0x6B.**

Other Pins

- **INT1** -This is the primary interrupt pin for the Accel/Gyro. You can setup the LSM6DSOX or ISM330DHCX to pull this low when certain conditions are met such as new measurement data being available. Consult the datasheet (https://adafru.it/HFU) for usage.
- **INT2** -This is the secondary interrupt pin for the Accel/Gyro. You can setup the LSM6DSOX or ISM330DHCX to pull this low when certain conditions are met such as new measurement data being available. Consult the datasheet (https://adafru.it/HFU) for usage.
- **INTM** - This is the primary interrupt pin for the Magnetometer. You can setup the LIS3MDL to pull this low when certain conditions are met such as a value exceeding a threshold. Consult the datasheet (https://adafru.it/IbR) for

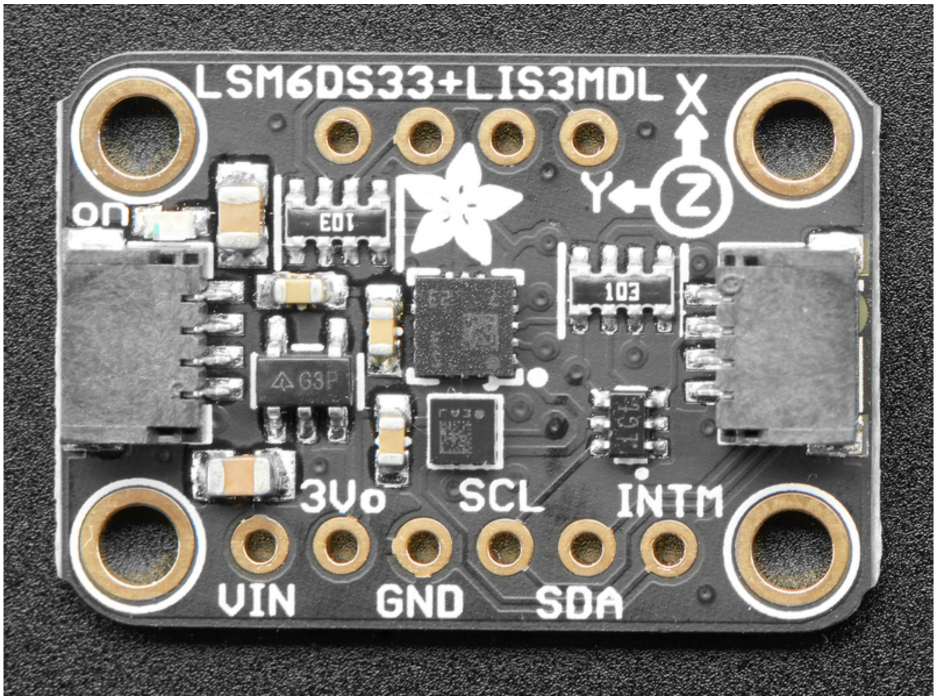
usage.

- **DRDY -** The data ready pin. When measurement data is available the sensor will pull this pin high low.

FeatherWing Pins

- **SPI Logic pins.** Located toward the center of the FeatherWing, these are the same for both the LIS3MDL and LSM6DSOX or ISM330DHCX. All pins going into the breakout have level shifting circuitry to make them 3-5V logic level safe. Use whatever logic level is on **Vin!**
  - **SCL** - This is *also* the **S**PI **C**loc**k** pin, it's an input to the chip.
  - **SDA** - this is *also* the **S**ensor **D**ata **I**n / **M**icrocontroller **O**ut **S**ensor **I**n pin, for data sent from your processor to the LIS3MDL or LSM6DSOX.
  - **SDO** - this is the **S**ensor **D**ata **O**ut / **M**icrocontroller **I**n **S**ensor **O**ut pin, for data sent from the LIS3MDL, ISM330DHCX, or LSM6DSOX to your processor.
  - **CS** - this is the **C**hip **S**elect pin, drop it low to start an SPI transaction. It's an input to the chip.
- **External I2C/SPI pins** - Control a separate sensor on a separate I2C/SPI bus.
  - **SCL** - I2C clock pin OR the **S**PI **C**lock pin.
  - **SDA** - I2C data pin OR the **S**ensor **D**ata **I**n / **M**icrocontroller **O**ut **S**ensor **I**n pin, for data sent from your processor to the LIS3MDL, ISM330DHCX, or LSM6DSOX.
  - **SDO** - this is the **S**ensor **D**ata **O**ut / **M**icrocontroller **I**n **S**ensor **O**ut pin, for data sent from the LIS3MDL, ISM330DHCX, or LSM6DSOX to your processor.
  - **CS** - this is the **C**hip **S**elect pin, drop it low to start an SPI transaction. Its an input to the chip.

LSM6DS33 + LIS3MDL Pinouts



Power Pins

- **Vin** - this is the power pin. Since the sensor chip uses 3 VDC, we have included a voltage regulator on board that will take 3-5VDC and safely convert it down. To power the board, give it the same power as the logic level of your microcontroller - e.g. for a 5V microcontroller like Arduino, use 5V.
- **3Vo** - this is the 3.3V output from the voltage regulator, you can grab up to 100mA from this if you like.
- **GND** - common ground for power and logic.

I2C Logic Pins

- **SCL** - I2C clock pin, connect to your microcontroller's I2C clock line. This pin is level shifted so you can use 3-5V logic, and there's a **10K pullup** on this pin.
- **SDA** - I2C data pin, connect to your microcontroller's I2C data line. This pin is level shifted so you can use 3-5V logic, and there's a **10K pullup** on this pin.
- STEMMA QT (https://adafru.it/Ft4) **-** These connectors allow you to make I2C connections to dev boards with **STEMMA QT** connectors or to other things with various associated accessories (https://adafru.it/Ft6).

I2C Address Pins

- **ADM** - LIS3MDL Magnetometer I2C address pin. Pulling this pin high or bridging the solder jumper on the back will change the I2C address from **0x1C** to **0x1E.**
- **AGAD** - LSM6DS33 Accel/Gyro I2C address pin. Pulling this pin high or bridging the solder jumper on the back will change the I2C address from **0x6A** to **0x6B.**

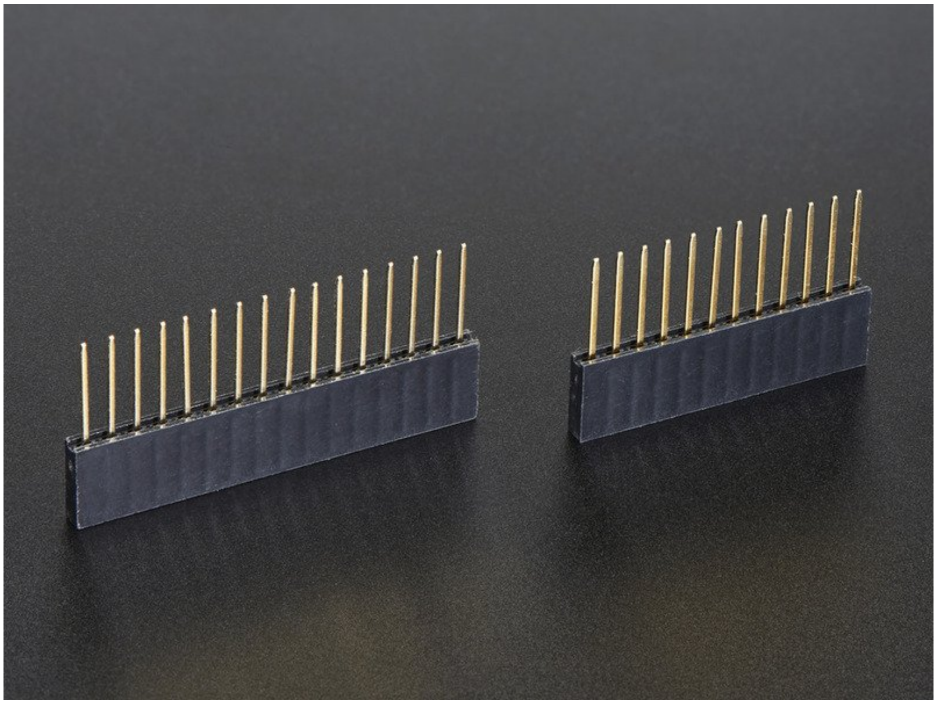
Other Pins

- **INT1** -This is the primary interrupt pin for the Accel/Gyro. You can setup the LSM6DS33 to pull this low when certain conditions are met such as new measurement data being available. Consult the datasheet (https://adafru.it/HFU) for usage.

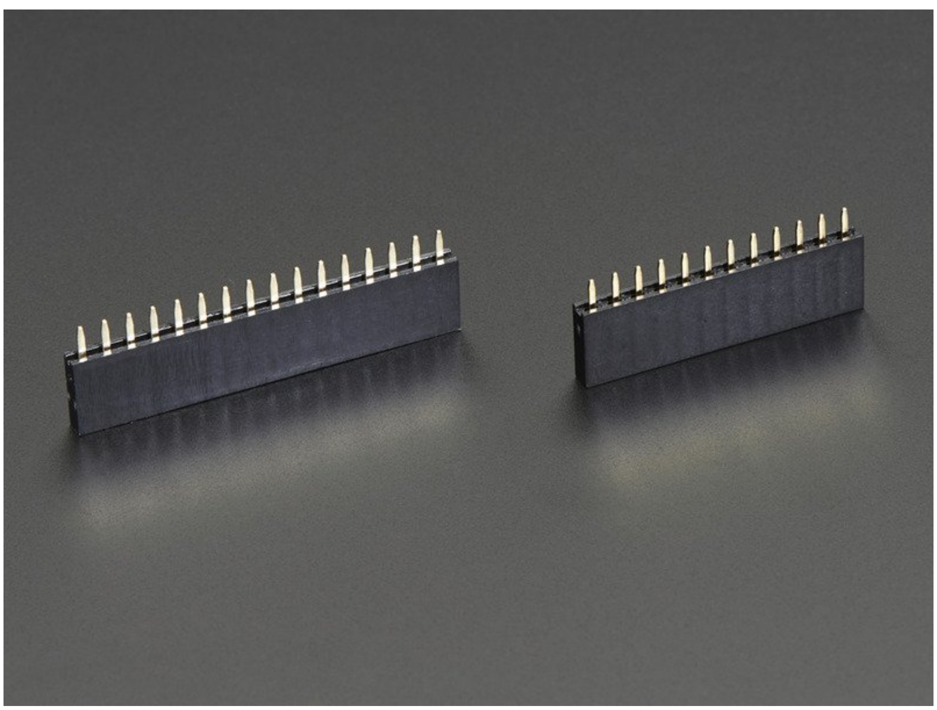
- **INTM -** This is the primary interrupt pin for the Magnetometer. You can setup the LIS3MDL to pull this low when certain conditions are met such as a value exceeding a threshold. Consult the datasheet (https://adafru.it/IbR) for usage.
- **DRDY -** The data ready pin. When measurement data is available the sensor will pull this pin high low.

Assembly

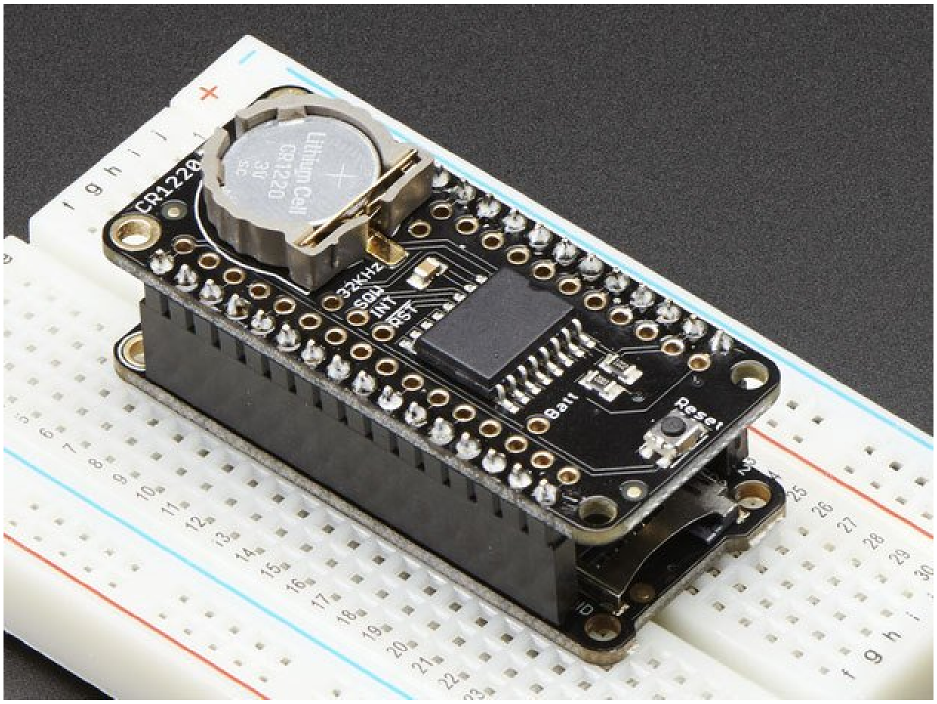
When putting together your Featherwings, think about how you want it to connect, you can use stacking headers:



Or plain female socket headers:



The most common method of attachment for the featherwing is putting stacking or female headers on the *Feather mainboard* and then putting the Wing on top:

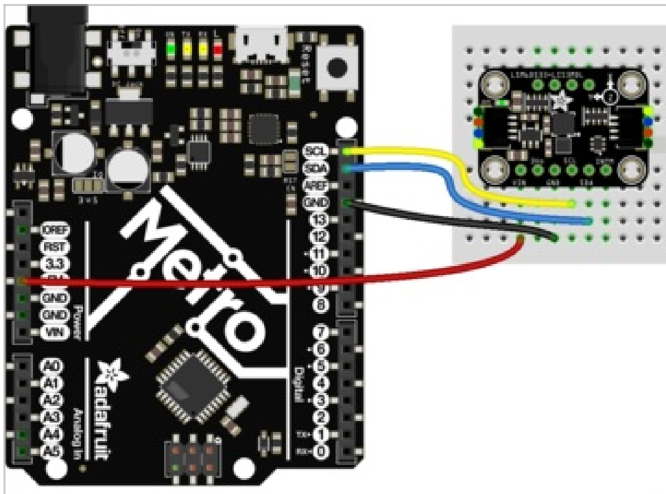


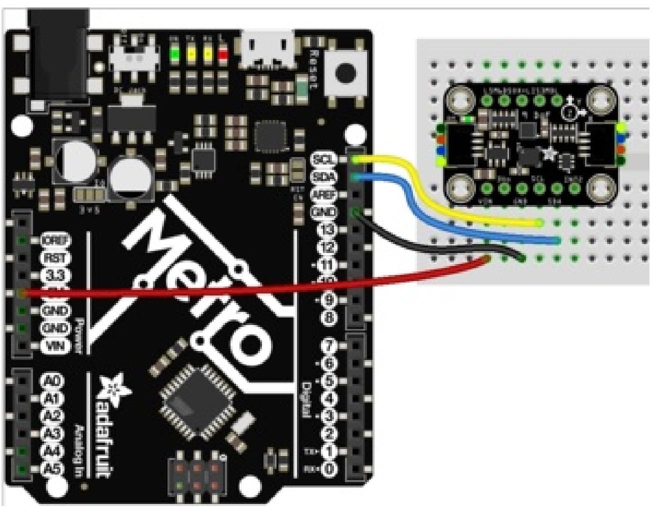
But don't forget, you can **also put the stacking headers on the wing and stack the Feather on top of it!**

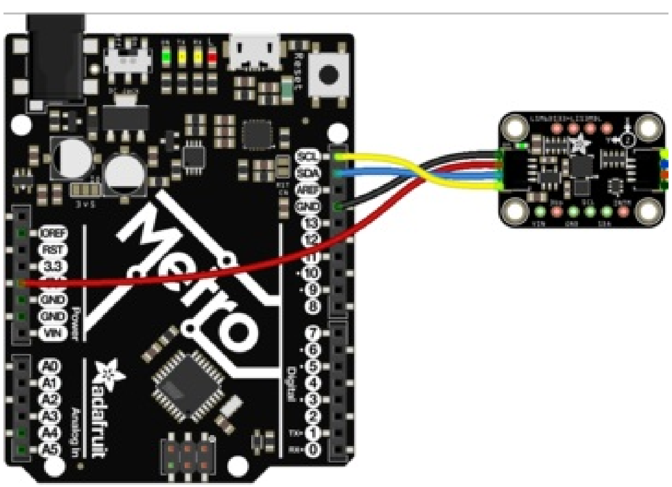
Arduino

Wiring

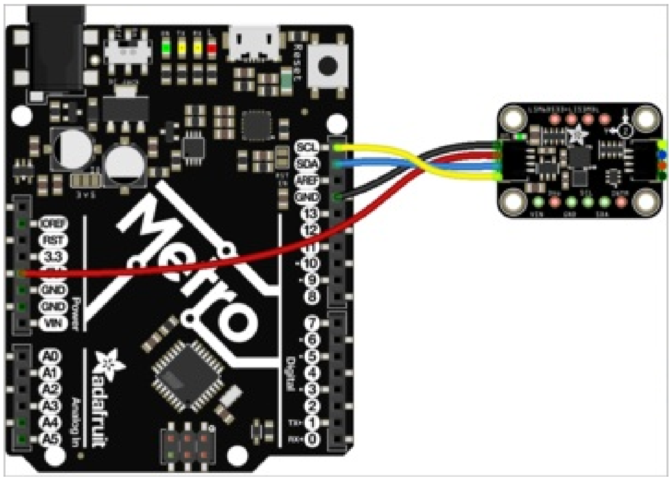
The following shows connecting to an Arduino using I2C.







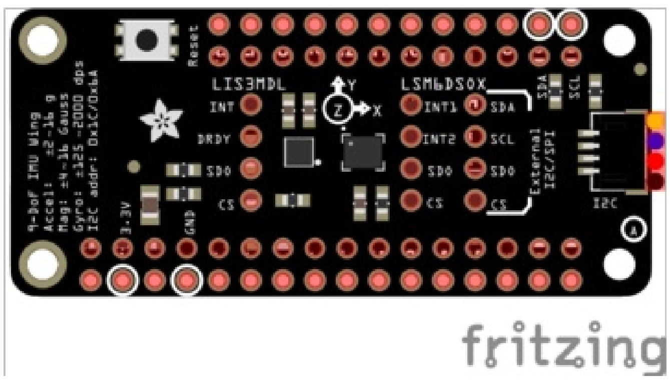
- Connect **board VIN (red wire)** to **Arduino 5V** if you are running a **5V** board Arduino (Uno, etc.). If your board is **3V,** connect to that instead.
- Connect **board GND (black wire)** to **Arduino GND**
- Connect **board SCL (yellow wire)** to **Arduino SCL**
- Connect **board SDA (blue wire)** to **Arduino SDA**



The final results should resemble the illustration above, showing an Adafruit Metro development board.

For the FeatherWing:

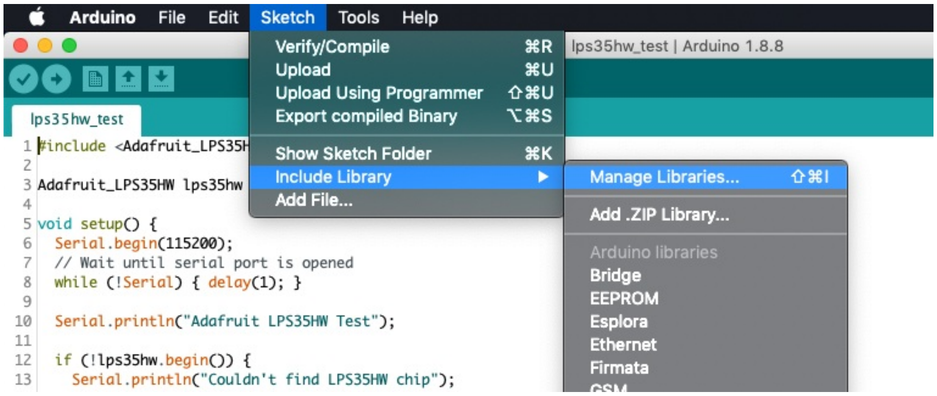
- **Plug the FeatherWing into a Feather**. This image is the Wing plugged into a Feather M4.



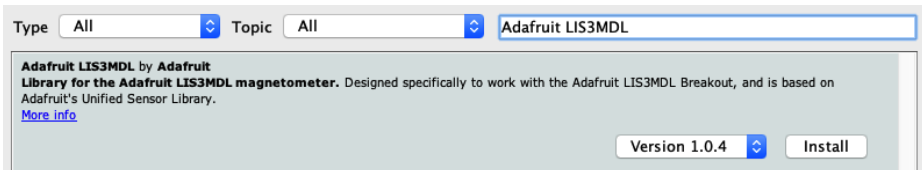
Both the breakouts and FeatherWing use I2C for communication only!

Library Installation

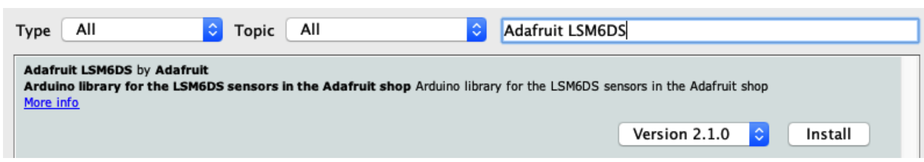
You can install the **Adafruit LIS3MDL Library** and the **Adafruit LSM6DS Library** for Arduino using the Library Manager in the Arduino IDE.



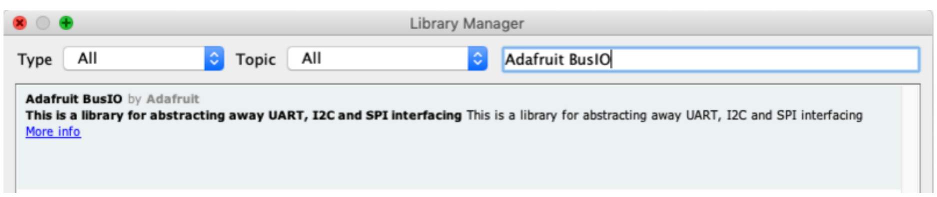
Click the **Manage Libraries ...** menu item, search for **Adafruit LIS3MDL**, and select the **Adafruit LIS3MDL** library:



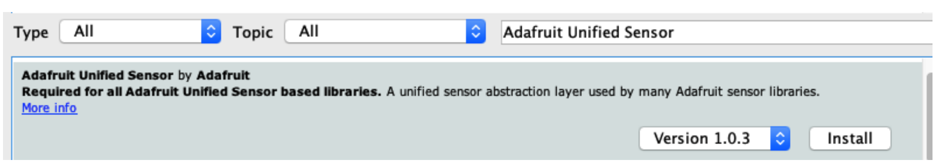
Follow the same process for the **Adafruit LSM6DS** library.



Then follow the same process for the **Adafruit BusIO** library.



Finally follow the same process for the **Adafruit Unified Sensor** library:



Load Example

Download the example below. Open up **File -> Open** and navigate to the downloaded **lis3mdl_lsm6ds_test** and upload to your Arduino wired up to the sensor.

The example is written to work with the LIS3MDL + LSM6DSOX. To use with the LIS3MDL + LSM6DS33, uncomment the following lines.

```
//#include <Adafruit_LSM6DS33.h>
//Adafruit_LSM6DS33 lsm6ds;
```

To use with the LIS3MDL + ISM330DHCX, uncomment the following lines.

```
//#include <Adafruit_ISM330DHCX.h>
//Adafruit_ISM330DHCX lsm6ds;
```

Once you upload the code and open the Serial Monitor (**Tools->Serial Monitor**) at **115200** baud, you will see the current configuration printed, followed by the accelerometer, gyro, and temperature measurements. You should see something similar to this:

```
LSM6DS and LIS3MDL Found!
Accelerometer range set to: +-2G
Accelerometer data rate set to: 104 Hz
Gyro range set to: 250 degrees/s
Gyro data rate set to: 104 Hz
Magnetometer data rate set to: 155 Hz
Range set to: +-4 gauss
Magnetometer performance mode set to: Medium
Magnetometer operation mode set to: Continuous
                Accel X: 9.2267        Y: 2.0369       Z: 2.7099       m/s^2
                Gyro  X: -0.0996       Y: 0.2494       Z: -0.7196      radians/s
                Mag   X: -61.8679      Y: -6.7378      Z: 20.1257      uTesla
                Temp   :                                      24.90    deg C

                Accel X: 9.2243        Y: 2.1320       Z: 2.6794       m/s^2
                Gyro  X: 0.0747        Y: -0.1168      Z: -0.1034      radians/s
                Mag   X: -61.8679      Y: -6.7378      Z: 20.1257      uTesla
                Temp   :                                      24.90    deg C

                Accel X: 9.3296        Y: 2.1870       Z: 2.6758       m/s^2
                Gyro  X: 0.0730        Y: -0.1327      Z: -0.0913      radians/s
                Mag   X: -61.8679      Y: -6.7378      Z: 20.1257      uTesla
                Temp   :                                      24.89    deg C
```

Example Code

```
Temporarily unable to load content:
```

LIS3MDL Arduino Docs

LIS3MDL Arduino Docs (https://adafru.it/LCr)

LSM6DS Arduino Docs

LSM6DS Arduino Docs (https://adafru.it/LCs)

Python & CircuitPython

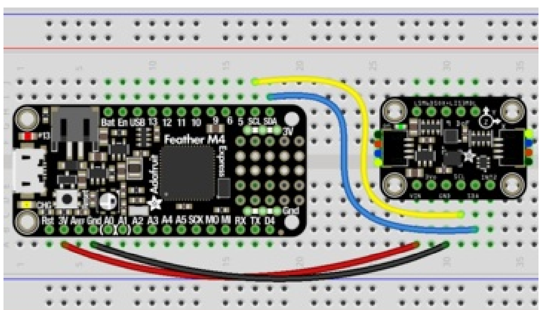
It's easy to use the LIS3MDL + LSM6DSOX and LSM6DS33 sensor combos with Python and CircuitPython, and the Adafruit CircuitPython LIS3MDL (https://adafru.it/IfJ) and Adafruit CircuitPython LSM6DS (https://adafru.it/Iec) libraries. These libraries allow you to easily write Python code that read measurements from the accelerometer, gyro, and magnetometer.

You can use this sensor with any CircuitPython microcontroller board or with a computer that has GPIO and Python thanks to Adafruit_Blinka, our CircuitPython-for-Python compatibility library (https://adafru.it/BSN).

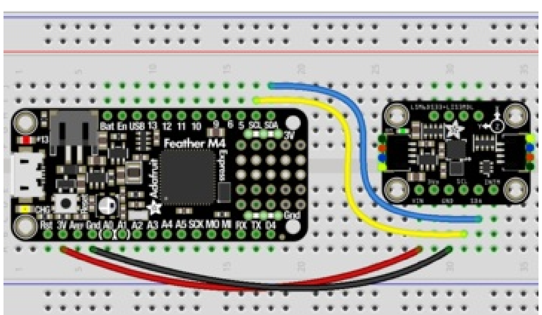
CircuitPython Microcontroller Wiring

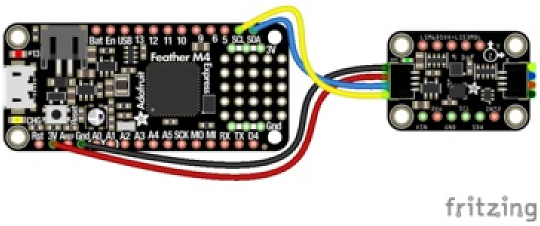
First, wire up the board to a microcontroller using I2C. The following shows wiring each board to a Feather M4 Express.

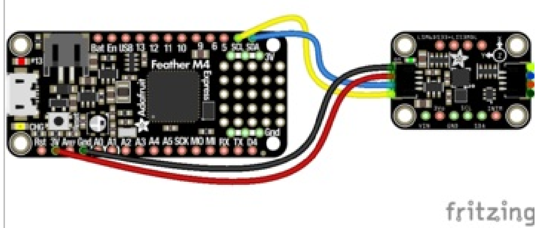
Breakout Board



- **Board 3V** to **sensor VIN (red wire)**
- **Board GND** to **sensor GND (black wire)**
- **Board SCL** to **sensor SCL (yellow wire)**
- **Board SDA** to **sensor SDA (blue wire)**

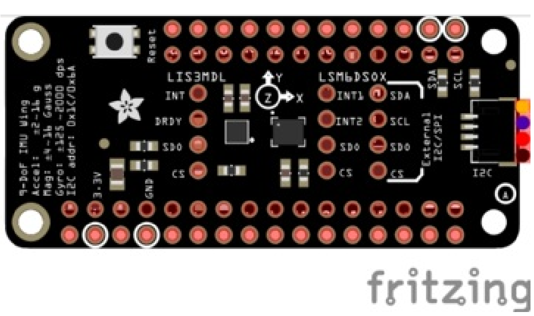






FeatherWing

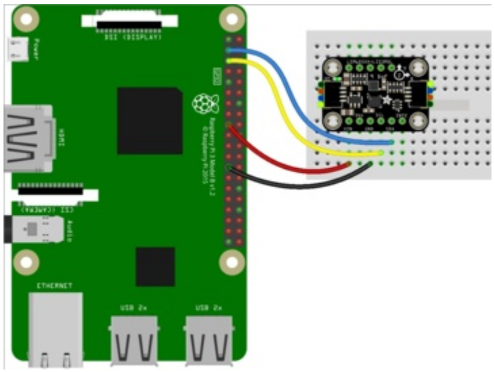
- Plug the FeatherWing into the Feather.

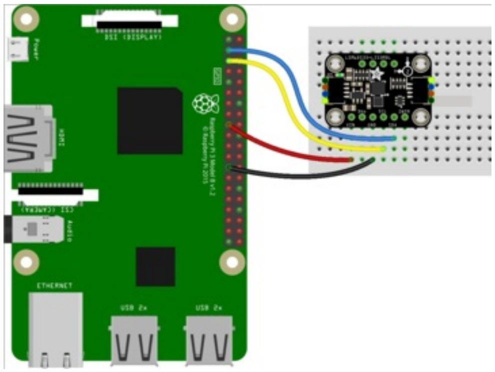


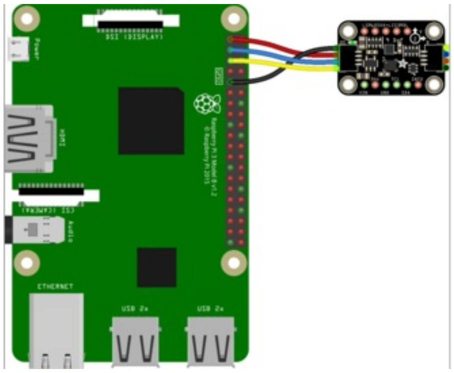
Python Computer Wiring

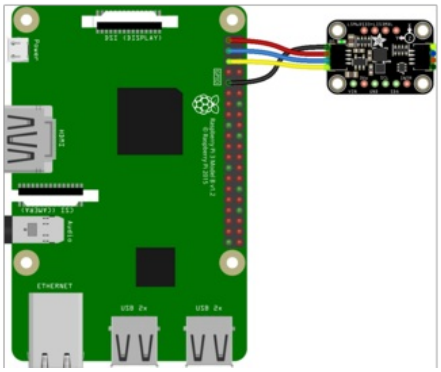
Since there's *dozens* of Linux computers/boards you can use we will show wiring for Raspberry Pi. For other platforms, please visit the guide for CircuitPython on Linux to see whether your platform is supported (https://adafru.it/BSN).

Here's the Raspberry Pi wired with I2C:









- **Pi 3V** to **sensor VCC (red wire)**
- **Pi GND** to **sensor GND (black wire)**
- **Pi SCL** to **sensor SCL (yellow wire)**
- **Pi SDA** to **sensor SDA (blue wire)**

CircuitPython Installation of LIS3MDL and LSM6DS Libraries

You'll need to install the Adafruit CircuitPython LIS3MDL (https://adafru.it/IfJ) and the Adafruit CircuitPython

LSM6DS (https://adafru.it/Iec) libraries on your CircuitPython board. **The LSM6DS library works with the LSM6DSOX and LSM6DS33.**

First make sure you are running the latest version of Adafruit CircuitPython (https://adafru.it/Amd) for your board.

Next you'll need to install the necessary libraries to use the hardware--carefully follow the steps to find and install these libraries from Adafruit's CircuitPython library bundle (https://adafru.it/ENC). Our CircuitPython starter guide has a great page on how to install the library bundle (https://adafru.it/ABU).

Copy the following files from the bundle to the **lib** folder on your **CIRCUITPY** drive:

- **adafruit_lismdl.mpy**
- **adafruit_lsm6ds.mpy**
- **adafruit_bus_device**
- **adafruit_register**

Before continuing make sure your board's **lib** folder or root filesystem has the **adafruit_lis3mdl.mpy, adafruit_lsm6ds.mpy, adafruit_bus_device**, and **adafruit_register** files and folders copied over.

Next connect to the board's serial REPL (https://adafru.it/Awz)so you are at the CircuitPython `>>>` prompt.

CircuitPython & Python Usage

To demonstrate the usage of the sensor we'll initialize it and read the acceleration, rotation and magnetic measurements from the board's Python REPL.

Run the following code to import the necessary modules and initialize the I2C connection with the sensor:

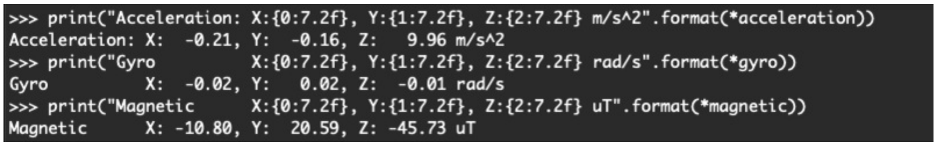
```
import time
import board
from adafruit_lsm6ds import LSM6DSOX as LSM6DS
# To use LSM6DS33, comment out the LSM6DSOX import line
# and uncomment the next line
# from adafruit_lsm6ds import LSM6DS33 as LSM6DS
# To use ISM330DHCX, comment out the LSM6DSOX import line
# and uncomment the next line
# from adafruit_lsm6ds import ISM330DHCX as LSM6DS
from adafruit_lis3mdl import LIS3MDL

accel_gyro = LSM6DS(board.I2C())
mag = LIS3MDL(board.I2C())
```

Now you're ready to read values from the sensor using these properties:

- **acceleration -** The acceleration forces in the X, Y, and Z axes in m/s^2
- **gyro** - The rotation measurement on the X, Y, and Z axes in degrees/sec
- **magnetic** - The magnetic forces on the X, Y, and Z axes in micro-Teslas (uT)

For example, to print out the acceleration, gyro and magnetic measurements use this code:

```
acceleration = accel_gyro.acceleration
    gyro = accel_gyro.gyro
    magnetic = mag.magnetic
    print("Acceleration: X:{0:7.2f}, Y:{1:7.2f}, Z:{2:7.2f} m/s^2".format(*acceleration))
    print("Gyro          X:{0:7.2f}, Y:{1:7.2f}, Z:{2:7.2f} rad/s".format(*gyro))
    print("Magnetic      X:{0:7.2f}, Y:{1:7.2f}, Z:{2:7.2f} uT".format(*magnetic))
```



Full Example Code

```
import time
import board
from adafruit_lsm6ds import LSM6DSOX as LSM6DS

# To use LSM6DS33, comment out the LSM6DSOX import line
# and uncomment the next line
# from adafruit_lsm6ds import LSM6DS33 as LSM6DS

# To use ISM330DHCX, comment out the LSM6DSOX import line
# and uncomment the next line
# from adafruit_lsm6ds import ISM330DHCX as LSM6DS

from adafruit_lis3mdl import LIS3MDL

accel_gyro = LSM6DS(board.I2C())
mag = LIS3MDL(board.I2C())

while True:
    acceleration = accel_gyro.acceleration
    gyro = accel_gyro.gyro
    magnetic = mag.magnetic
    print(
        "Acceleration: X:{0:7.2f}, Y:{1:7.2f}, Z:{2:7.2f} m/s^2".format(*acceleration)
    )
    print("Gyro          X:{0:7.2f}, Y:{1:7.2f}, Z:{2:7.2f} rad/s".format(*gyro))
    print("Magnetic      X:{0:7.2f}, Y:{1:7.2f}, Z:{2:7.2f} uT".format(*magnetic))
    print("")
    time.sleep(0.5)
```

LIS3MDL Python docs

LIS3MDL Python docs (https://adafru.it/LCt)

LSM6DS Python Docs

LSM6DS Python Docs (https://adafru.it/LCu)

AHRS Fusion of 9 DoF Sensors

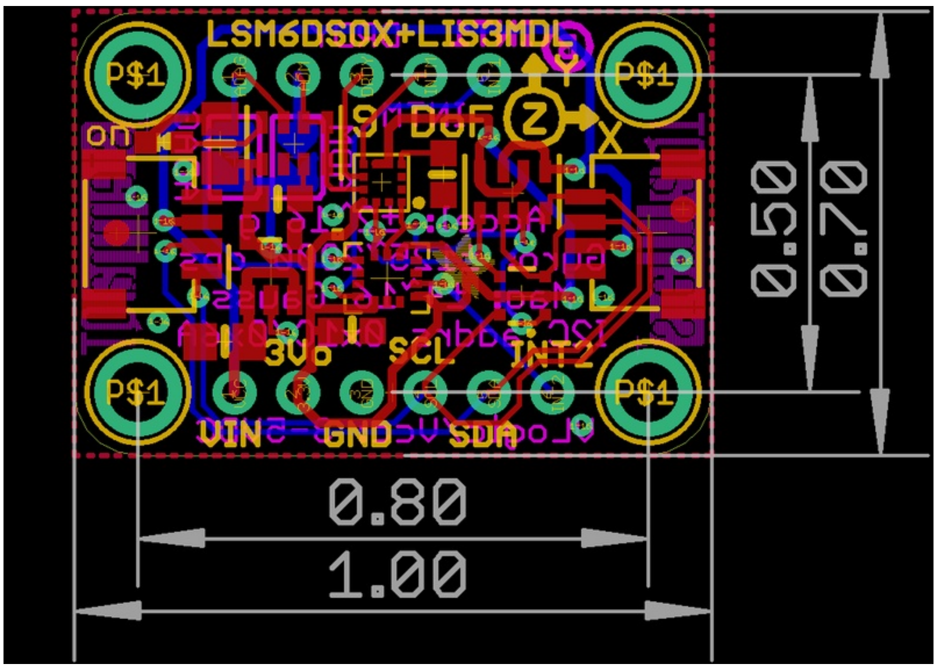
[AHRS Fusion of 9 DoF Sensors](https://adafru.it/LGC) (https://adafru.it/LGC)

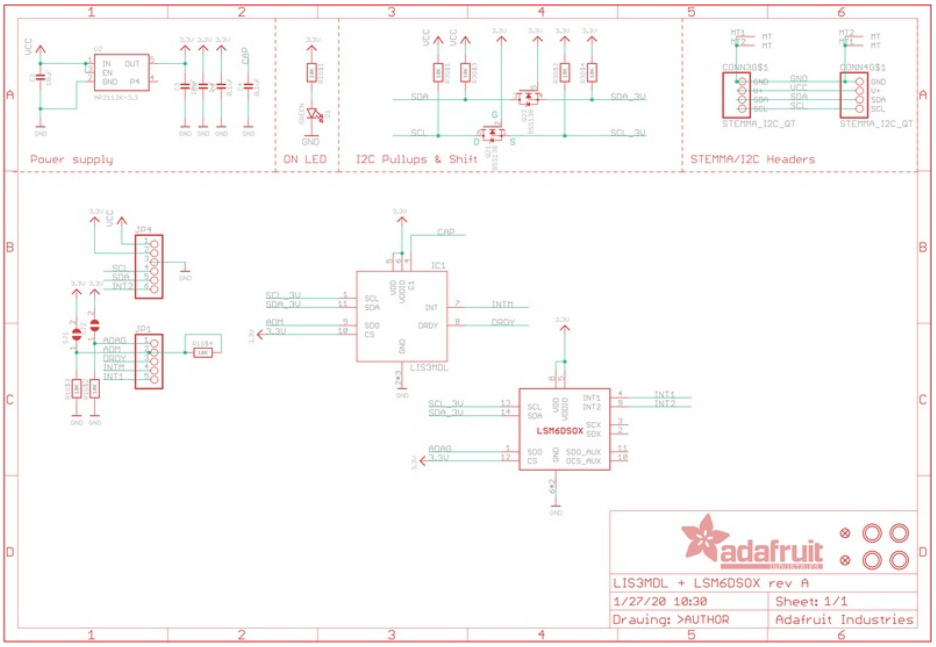
Downloads

Files

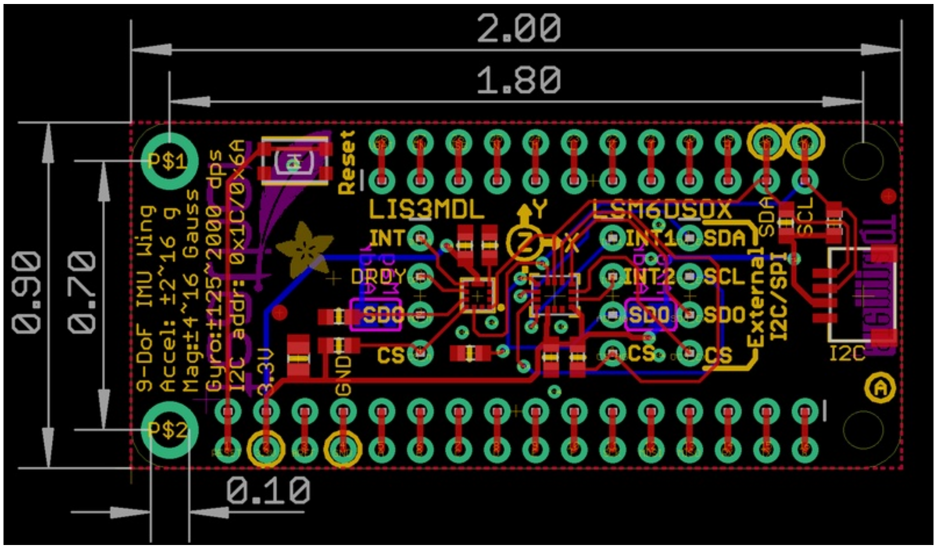
- LIS3MDL datasheet (https://adafru.it/IbR)
- LSM6DSOX datasheet (https://adafru.it/HFw)
- LSM6DS33 datasheet (https://adafru.it/HFw)
- ISM330DHCX datasheet (https://adafru.it/LXf)
- LSM6DS33 + LIS3MDL Fritzing object in the Adafruit Fritzing library (https://adafru.it/LGd)
- LSM6DSOX + LIS3MDL FeatherWing Fritzing object in the Adafruit Fritzing library (https://adafru.it/LGe)
- LSM6DSOX + LIS3MDL breakout Fritzing object in the Adafruit Fritzing library (https://adafru.it/LGf)
- ISM330DHCX + LIS3MDL FeatherWing Fritzing object in the Adafruit Fritzing library (https://adafru.it/LXA)
- LSM6DSOX + LIS3MDL EagleCAD files on GitHub (https://adafru.it/LGA)
- LSM6DS33 + LIS3MDL EagleCAD files on GitHub (https://adafru.it/LGB)
- ISM330DHCX + LIS3MDL EagleCAD files on GitHub (https://adafru.it/LXC)

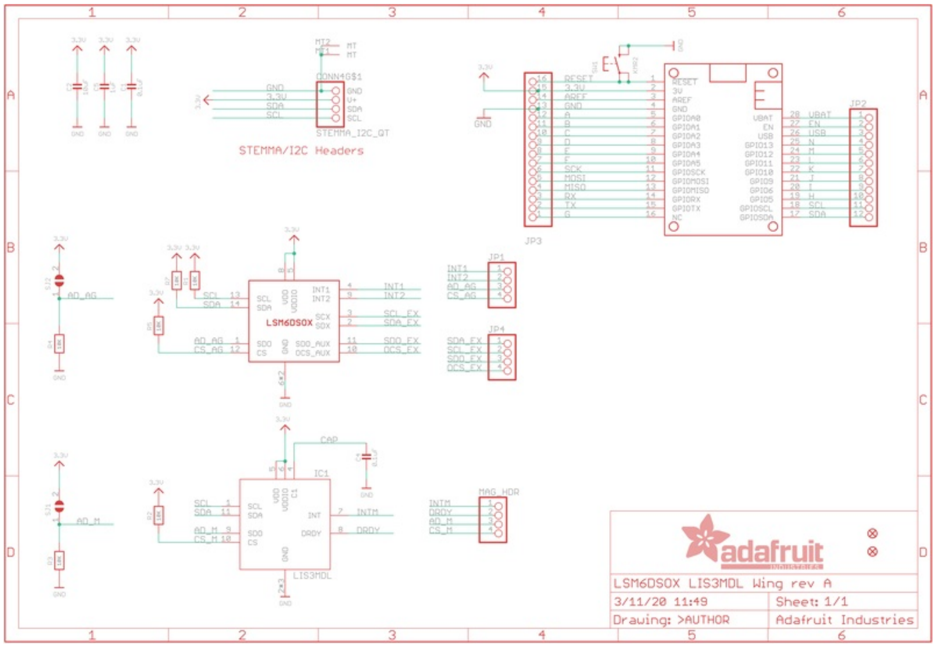
LSM6DSOX + LIS3MDL breakout Fab Print and Schematic



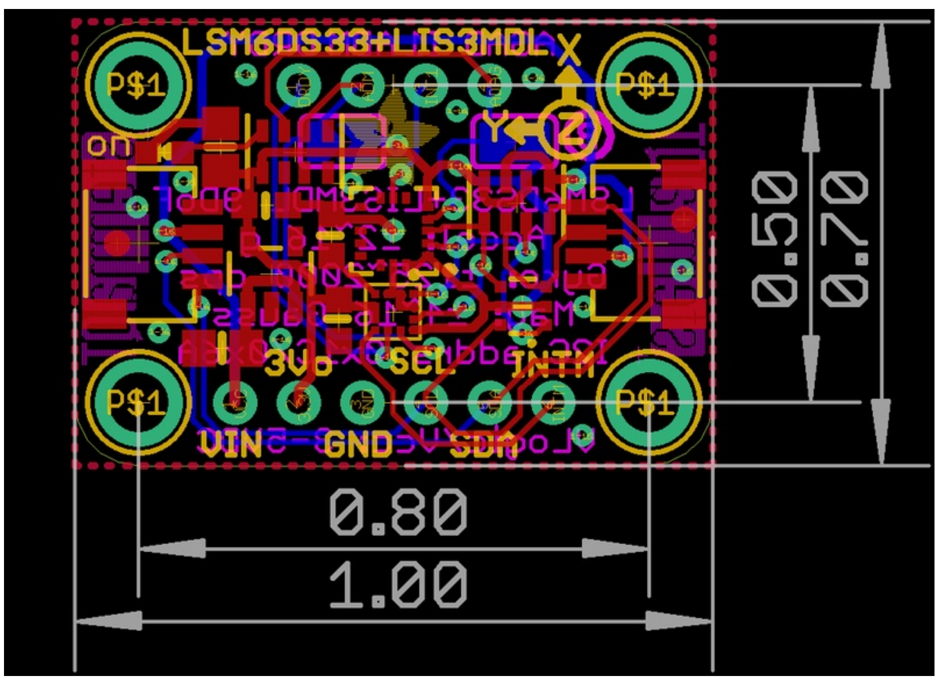


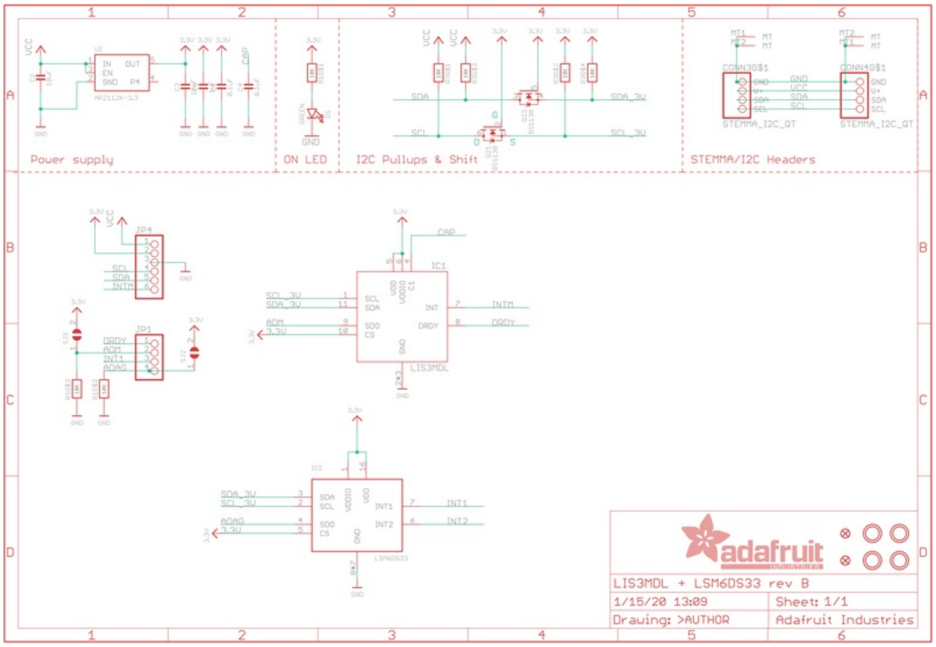
LSM6DSOX + LIS3MDL FeatherWing Fab Print and Schematic



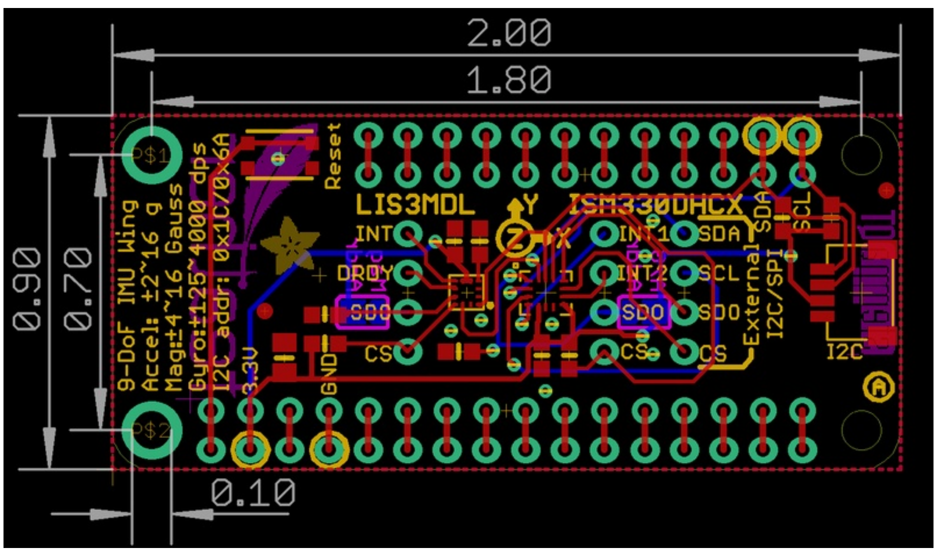


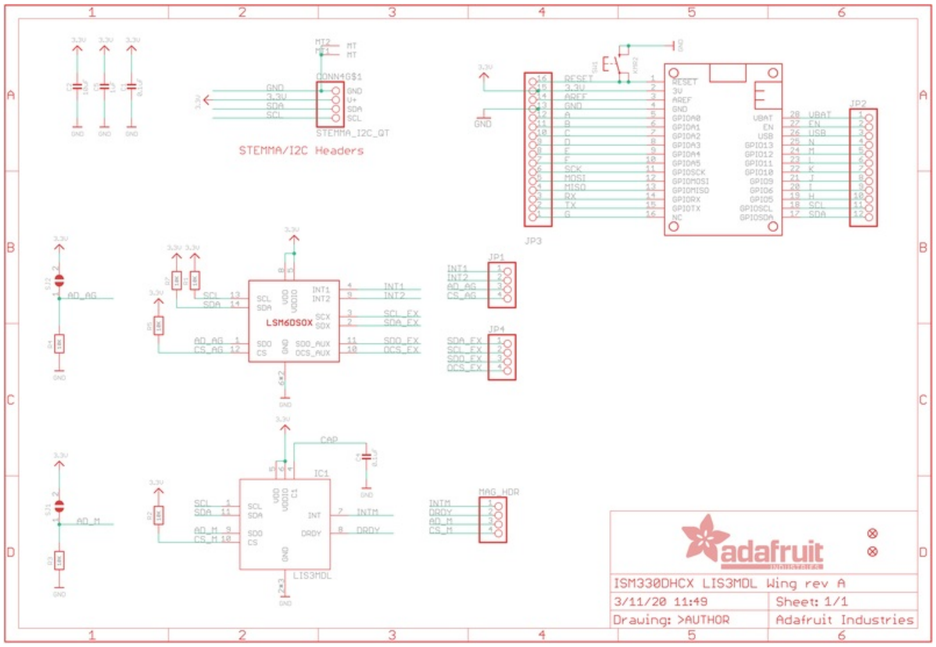
LSM6DS33 + LIS3MDL Fab Print and Schematic





ISM330DHCX + LIS3MDL Fab Print and Schematic




STEMMA/I2C Headers
LSM6DSOX
LIS3MDL
ISM330DHCX LIS3MDL Wing rev A
3/11/20 11:49
Sheet: 1/1
Drawing: >AUTHOR
Adafruit Industries