Collecting Data with the LSM9DS1

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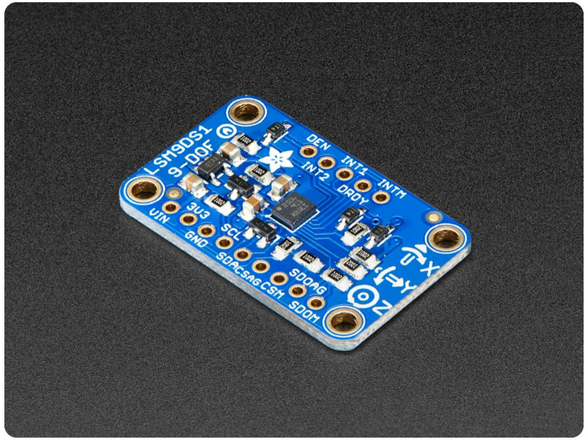
Specifications

The LSM9DS1 is not the same set of sensors as the LSM9DS0. Here are some of the differences:

- LSM9DS0 accelerometer has ±2/±4/±6/±8/±16 *g* ranges. The LSM9DS1 has ±2/±4/±8/±16 *g* (no ±6 *g* range).
- LSM9DS0 magnetometer has ±2/±4/±8/±12 gauss ranges. The LSM9DS1 has ±4/±8/±12/±16 gauss ranges. So the LSM9DS0 has ±2 gauss low range where-as the LSM9DS1 has ±16 gauss high range.
- LSM9DS0 and LSM9DS1 gyros *both* have the same ±245/±500/±2000 dps ranges.

There are other differences, for example we noticed the LSM9DS1 has slightly worse accuracy. The gyro angular zero-rate (±25 for the LSM9DS0 and ±30 for the LSM9DS1 at the highest sensing range). The accelerometer offset accuracy is ±90 m*g* for the LSM9DS1 and ±60 m*g* for the LSM9DS0.



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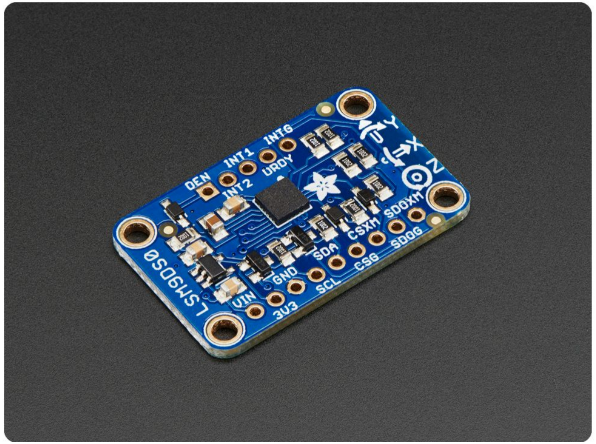
Description



Adafruit 9-DOF Accel/Mag/Gyro+Temp Breakout Board - LSM9DS0

Product ID: 2021

$24.95

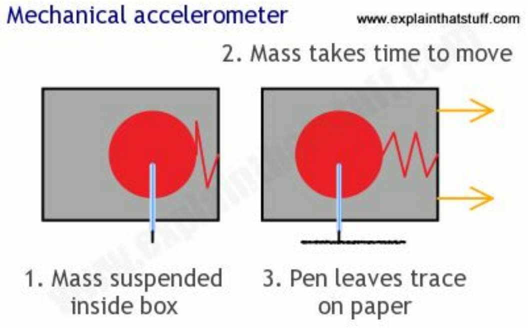
Discontinued

You can grab the Adafruit 9-DOF Accel/Mag/Gyro+Temp Breakout Board instead!

Description

Technical Details

What is an Accelerometer?



All do the same thing -measure acceleration

Different types

- Mechanical (mass on a spring)
- Piezoresistive (mass on a spring + potentiometer)
- Piezoelectric (mass on spring + crystal)
- Hall-effect (magnetic field)
- Micro Electro Mechanical System (MEMS) ← this is the one we care about

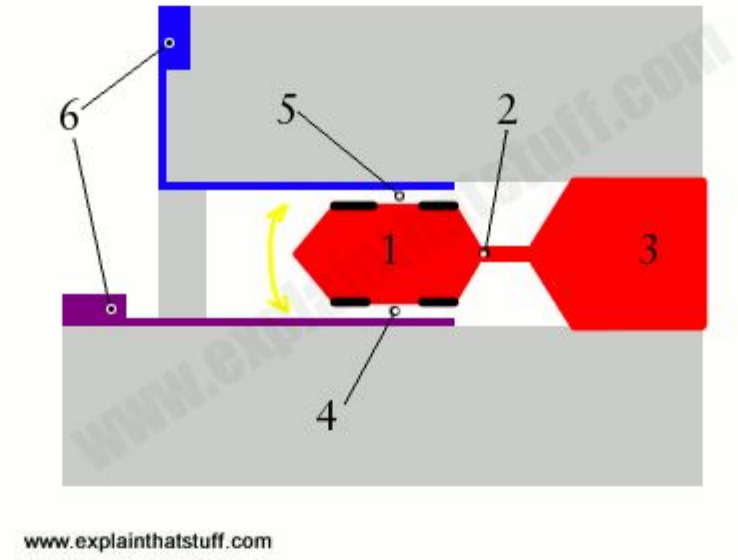
How does the MEMS work?

Simplified version- measures vibrations

1. Electrode
2. Cantilever
3. Electrical connections
4. 2nd electrode
5. 3rd electrode
6. Terminals

Our LSM9DS1 measures in units of *g* in increments of ±2 excluding 6*g*

3-axis

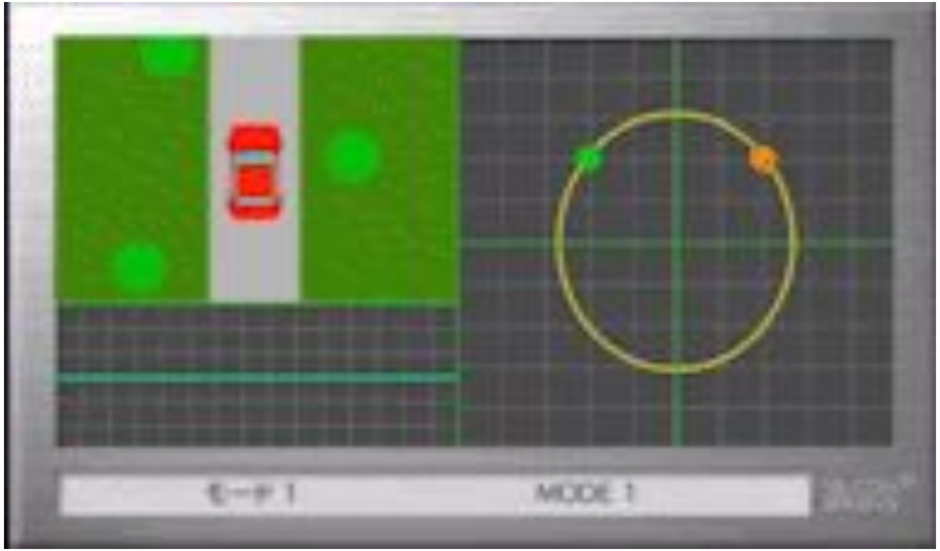


What is a Gyroscope?

- While an accelerometer measures movement along x, y, and z axis, gyroscope measures rotational movement along x, y, and z axis.
- Used to measure:
    - Angular velocity
    - Orientation
- Used on objects not rotating very fast.

How Does Our Gyroscope Work?

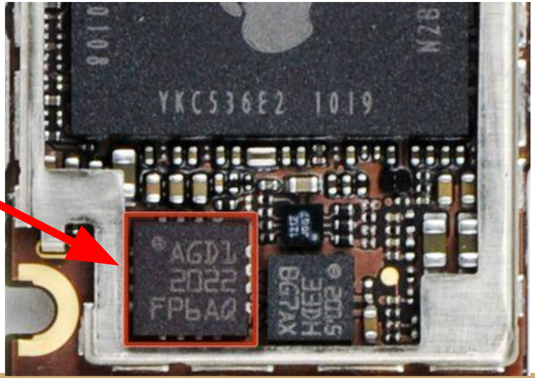
- LSM9DS1 has a MEMS Gyroscope
  - Small vibrating filament
  - When rotated, the coriolis force pushes on the filament
    - read and translated into information about rotational properties of the object.



Gyroscope Applications

- Navigation systems
  - Boats
  - Airplane stabilizers
- Virtual Reality
- Optical Image Stabilization
- Smartphones, tablets, and various controllers

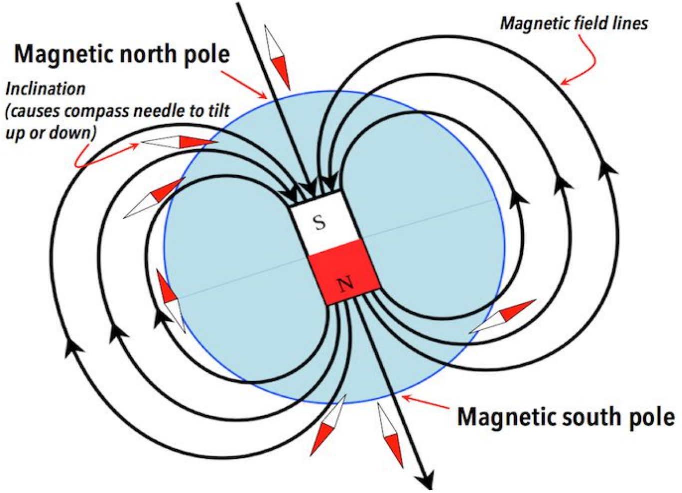
iPhone 4
MEMS Gyroscope



What is a magnetometer?

- A magnetometer is a device that measures the strength and sometimes the direction of a magnetic field.
- The LSM9DS1 can sense where the strongest magnetic force is coming from and use that to approximate your heading
- Units of gauss and can be set to

  measurement scale of +/- 4, 8, 12 or 16 Gs

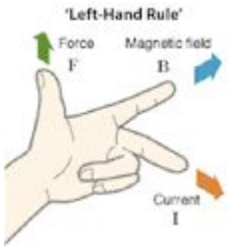


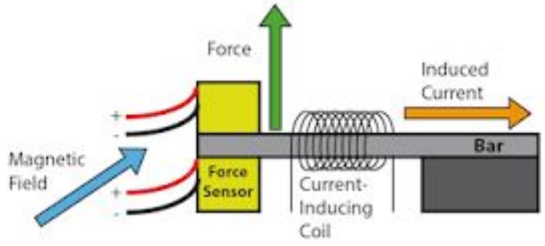
How do magnetometers work?

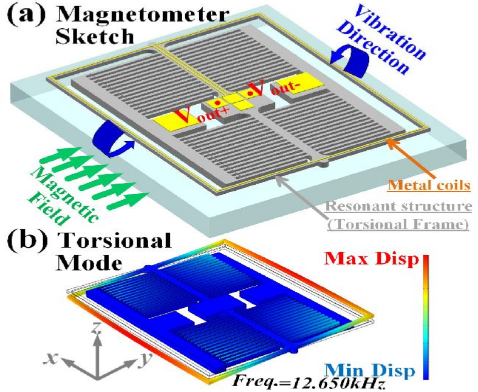
- Earth is surrounded by lines of flux which vibrate at different frequencies
- Our MEMS magnetometer measures resonant frequency

Types of magnetometers:

- Scalar magnetometers: Focus on accurately measuring the magnitude
- Vector: Measure both magnitude and direction



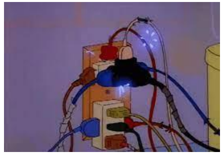




Magnetometer Applications

- Plasma flows: Studying solar winds and planetary bodies
- Archaeology
- Coal exploration and metal detection
- MRI: nuclear magnetic resonance
- Navigation of aircraft and ships
- Submarine detection

Wiring to Arduino

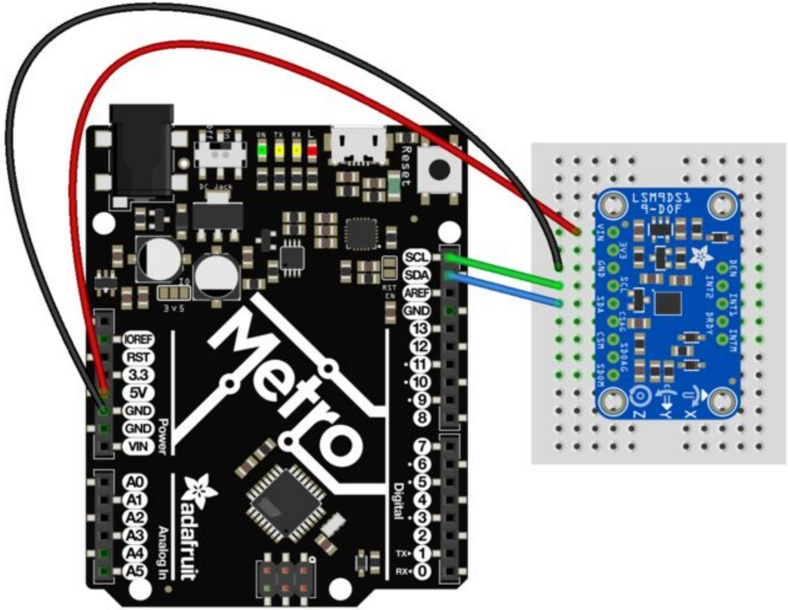


Vin - this is the power pin. Since the chip uses 3 VDC, we have included a voltage regulator on board that will take 3-5VDC and safely convert it down. The Arduino uses the 5V pin.

GND - common ground for power and logic

SCL - I2C clock pin, connect to your microcontrollers I2C clock line. This pin is level shifted so you can use 3-5V logic, and there's a 10K pullup on this pin. (*This connects to* **D20** *on the Arduino Mega)*

SDA - I2C data pin, connect to your microcontrollers I2C data line. This pin is level shifted so you can use 3-5V logic, and there's a 10K pullup on this pin. (*This connects to* **D21** *on the Arduino Mega)*



Other Pinouts

Power Pins:

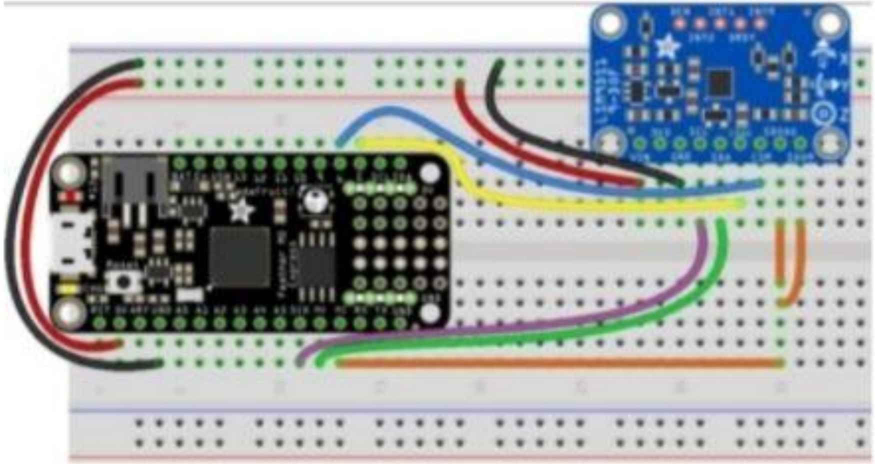
- **3V3** - this is the 3.3V output from the voltage regulator, you can grab up to 100mA from this if you like

Interrupt & Misc Pins:

- **DEN** - this is a pin that supposedly could be used to dynamically enable/disable the Gyro. There's actually no documentation on it but we break it out for you anyways.
- **INT1** & **INT2** - These are interrupts from the accelerometer/gyro subchip. We don't have specific library support for these so check the datasheet for what you can make these indicate. They are 3V-logic outputs
- **DRDY** - this is the accelerometer/gyro subchip data ready output. We don't have specific library support for these so check the datasheet for how you can set the registers to enable this pin. It is a 3V-logic output.
- **INTM** - This is the interrupt from the magnetometer subchip. We don't have specific library support for it so check the datasheet for what you can make it indicate. It is a 3V-logic output.

SPI Pins:

- **SCL** - this is also the SPI clock pin, it's level shifted so you can use 3-5V logic input
- **SDA** - this is also the SPI MOSI pin, it's level shifted so you can use 3-5V logic input
- **CSAG** - this is the Accelerometer+Gyro subchip Chip Select, it's level shifted so you can use 3-5V logic input
- **CSM** - this is the Magnetometer subchip Select, it's level shifted so you can use 3-5V logic input
- **SDOAG** - this is the Accelerometer+Gyro subchip MISO pin - it's 3V logic out, but can be read properly by 5V logic chips.
- **SDOM/DOM**- this is the Magnetometer subchip MISO pin - it's 3V logic out, but can be read properly by 5V logic chips.



- **Board 3V** to **sensor VIN (Red)**
- **Board GND** to **sensor GND (Black)**
- **Board SCK** to **sensor SCL (Purple)**
- **Board MOSI** to **sensor SDA (Green)**
- **Board MISO to sensor SDOAG** AND **sensor SDOM (Orange)**
- **Board D5** to **sensor CSAG (Yellow)**
- **Board D6** to **sensor CSM (Blue)**

How the code works

```
#include <Wire.h>
[redacted]
#include <Adafruit_LSM9DS1.h>
#include <Adafruit_Sensor.h>  // not used in this demo but required!

// i2c
Adafruit_LSM9DS1 lsm = Adafruit_LSM9DS1();

void setup()
{
  Serial.begin(115200);

  while (!Serial) {
    delay(1); // will pause Zero, Leonardo, etc until serial console opens
  }
  Serial.println("LSM9DS1 data read demo");

  // Try to initialise and warn if we couldn't detect the chip
  if (!lsm.begin())
  {
    Serial.println("Oops ... unable to initialize the LSM9DS1. Check your wiring!");
    while (1);
  }
  Serial.println("Found LSM9DS1 9DOF");

  // 1.) Set the accelerometer range
  lsm.setupAccel(lsm.LSM9DS1_ACCELRANGE_2G); //Can be 4G, 8G, 16G

  // 2.) Set the magnetometer sensitivity
  lsm.setupMag(lsm.LSM9DS1_MAGGAIN_4GAUSS); //8GAUSS, 12GAUSS, 16GAUSS

  // 3.) Setup the gyroscope
  lsm.setupGyro(lsm.LSM9DS1_GYROSCALE_245DPS); //500DPS, 2000DPS
}
```

Libraries to download

LSM object

We can set the measurement range for each sensor

```
void loop()
{
  lsm.read();  /* ask it to read in the data */

  /* Get a new sensor event */
  sensors_event_t a, m, g, temp;

  lsm.getEvent(&a, &m, &g, &temp);

  Serial.print("Accel X: "); Serial.print(a.acceleration.x); Serial.print(" m/s^2");
  Serial.print("\tY: "); Serial.print(a.acceleration.y);     Serial.print(" m/s^2 ");
  Serial.print("\tZ: "); Serial.print(a.acceleration.z);     Serial.println(" m/s^2 ");

  Serial.print("Mag X: "); Serial.print(m.magnetic.x);   Serial.print(" uT");
  Serial.print("\tY: "); Serial.print(m.magnetic.y);     Serial.print(" uT");
  Serial.print("\tZ: "); Serial.print(m.magnetic.z);     Serial.println(" uT");

  Serial.print("Gyro X: "); Serial.print(g.gyro.x);   Serial.print(" rad/s");
  Serial.print("\tY: "); Serial.print(g.gyro.y);      Serial.print(" rad/s");
  Serial.print("\tZ: "); Serial.print(g.gyro.z);      Serial.println(" rad/s");

  Serial.println();
  delay(200);
}
```

Each subsensor can print the data in each degree of freedom (dimension)

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