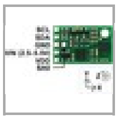
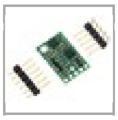
MinIMU-9 v3 Gyro, Accelerometer, and Compass (L3GD20H and LSM303D Carrier)



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The Pololu MinIMU-9 v3 is an inertial measurement unit (IMU) that packs an L3GD20H 3-axis gyro and an LSM303D 3-axis accelerometer and 3-axis magnetometer onto a tiny 0.8″ × 0.5″ board. An I²C interface accesses nine independent rotation, acceleration, and magnetic measurements that can be used to calculate the sensor's absolute orientation. The MinIMU-9 v3 board includes a voltage regulator and a level-shifting circuit that allows operation from 2.5 to 5.5 V, and the 0.1″ pin spacing makes it easy to use with standard solderless breadboards and 0.1″ perfboards.

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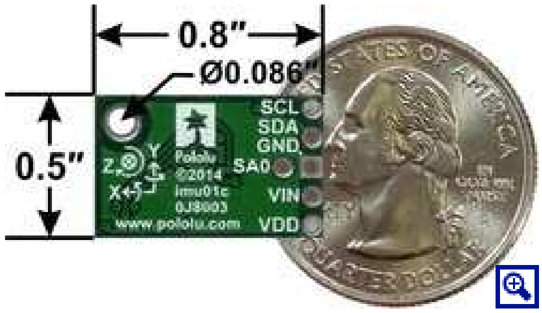
Description **Specs (8)** **Pictures (7)** **Resources (15)** **FAQs (1)** **On the blog (6)**

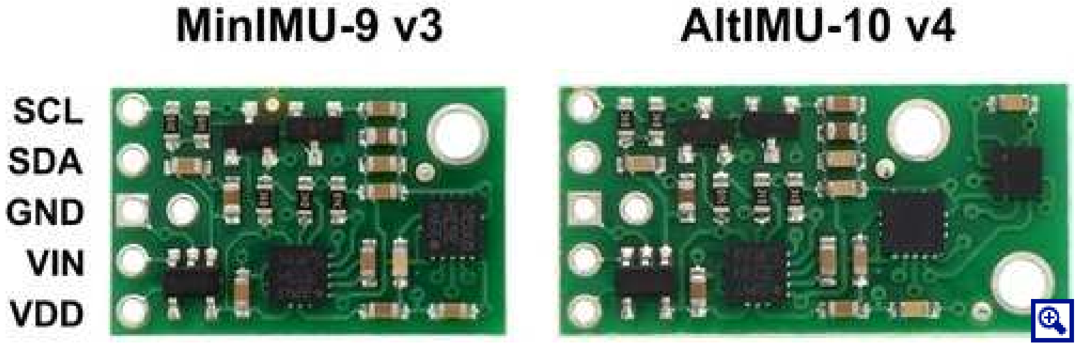
Overview



The Pololu MinIMU-9 v3 is a compact (0.8″ × 0.5″) board that combines ST's L3GD20H 3-axis gyroscope and LSM303D 3-axis accelerometer and 3-axis magnetometer to form an inertial measurement unit (IMU); we therefore recommend careful reading of the **L3GD20H datasheet** (3MB pdf) and **LSM303D datasheet** (1MB pdf) before using this product. These sensors are great ICs, but their small packages make them difficult for the typical student or hobbyist to use. They also operate at voltages below 3.6 V, which can make interfacing difficult for microcontrollers operating at 5 V. The MinIMU-9 v3 addresses these issues by incorporating additional electronics, including a voltage regulator and a level-shifting circuit, while keeping the overall size as compact as possible. The board ships fully populated with its SMD components, including the L3GD20H and LSM303D, as shown in the product picture.

Compared to the previous **MinIMU-9 v2**, the v3 version offers a number of improvements arising from the use of newer MEMS sensors, including a wider maximum magnetic sensing range and better gyroscopic accuracy and stability. This version also adds a pin for changing the sensor slave addresses, allowing two MinIMUs to be on the same I²C bus. The MinIMU-9 v3 is pin-compatible with the MinIMU-9 v2, but changes in I²C addresses and configuration registers might require some changes to software written for older versions (this should not be an issue if you are using our Arduino libraries).

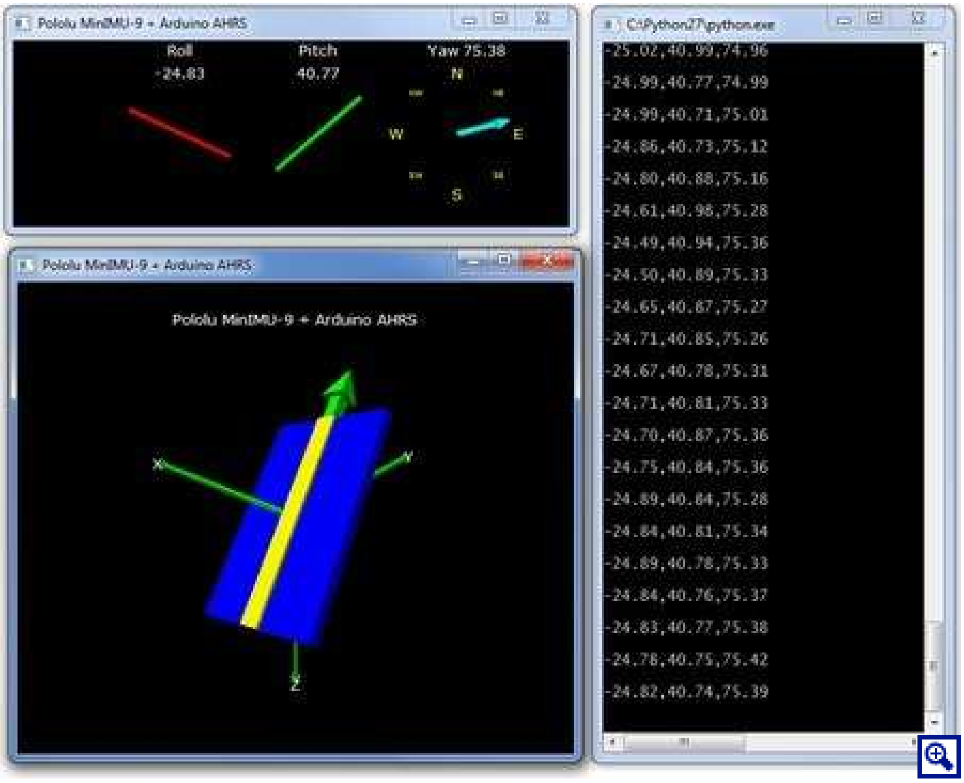
The MinIMU-9 v3 is pin-compatible with the **AltIMU-10 v4**, which offers the same functionality augmented by a digital barometer that can be used to obtain pressure and altitude measurements. The AltIMU includes a second mounting hole and is 0.2″ longer than the MinIMU. Any code written for the MinIMU-9 v3 should also work with the AltIMU-10 v4.



Side-by-side comparison of the MinIMU-9 v3 with the AltIMU-10 v4.

The L3GD20H and LSM303D have many configurable options, including dynamically selectable sensitivities for the gyro, accelerometer, and magnetometer. Each sensor also has a choice of output data rates. The two ICs can be accessed through a shared I²C/TWI interface, allowing the sensors to be addressed individually via a single clock line and a single data line. Additionally, the SA0 pin is accessible, allowing users to change the slave addresses and have two MinIMUs connected on the same I²C bus (For additional information, see the I²C Communication section below).

The nine independent rotation, acceleration, and magnetic readings (sometimes called 9DOF) provide all the data needed to make an attitude and heading reference system (AHRS). With an appropriate algorithm, a microcontroller or computer can use the data to calculate the orientation of the MinIMU board. The gyro can be used to very accurately track rotation on a short timescale, while the accelerometer and compass can help compensate for gyro drift over time by providing an absolute frame of reference. The respective axes of the two chips are aligned on the board to facilitate these sensor fusion calculations. (For an example of such a system using an **Arduino**, see the picture below and the Sample Code section at the bottom of this page.)



Visualization of AHRS orientation calculated from MinIMU-9 readings.

The carrier board includes a low-dropout linear voltage regulator that provides the 3.3 V required by the L3GD20H and LSM303D, allowing the module to be powered from a single 2.5 V to 5.5 V supply. The regulator output is available on the VDD pin and can supply almost 150 mA to external devices. The breakout board also includes a circuit that shifts the I²C clock and data lines to the same logic voltage level as the supplied VIN, making it simple to interface the board with 5 V systems. The board’s 0.1″ pin spacing makes it easy to use with standard **solderless breadboards** and 0.1″ perfboards.

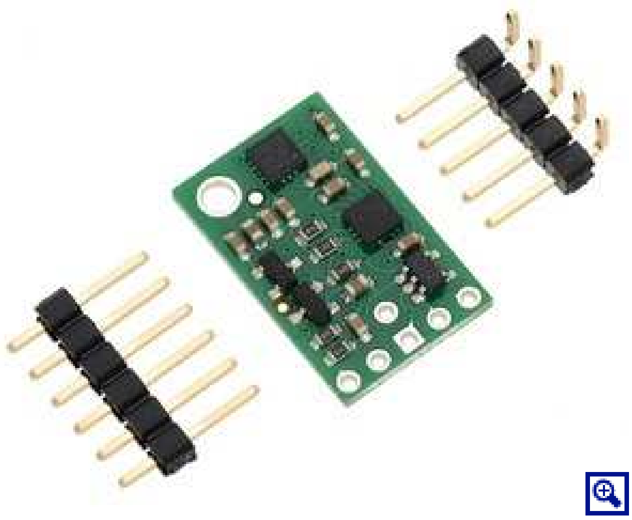
Specifications

- Dimensions: 0.8″ × 0.5″ × 0.1″ (20 mm × 13 mm × 3 mm)

- Weight without header pins: 0.7 g (0.02 oz)
- Operating voltage: 2.5 V to 5.5 V
- Supply current: 6 mA
- Output format (I²C):
  - Gyro: one 16-bit reading per axis
  - Accelerometer: one 16-bit reading per axis
  - Magnetometer: one 16-bit reading per axis
- Sensitivity range:
  - Gyro: ±245, ±500, or ±2000°/s
  - Accelerometer: ±2, ±4, ±6, ±8, or ±16 g
  - Magnetometer: ±2, ±4, ±8, or ±12 gauss

Included Components

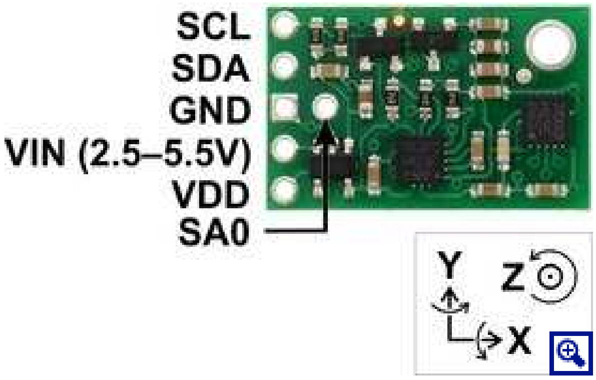
A 1×6 strip of **0.1″ header pins** and a 1×5 strip of **0.1″ right-angle header pins** are included, as shown in the picture below. You can solder the header strip of your choice to the board for use with **custom cables** or **solderless breadboards** or solder wires directly to the board itself for more compact installations. The board features two mounting holes that work with #2 or M2 **screws** (not included).



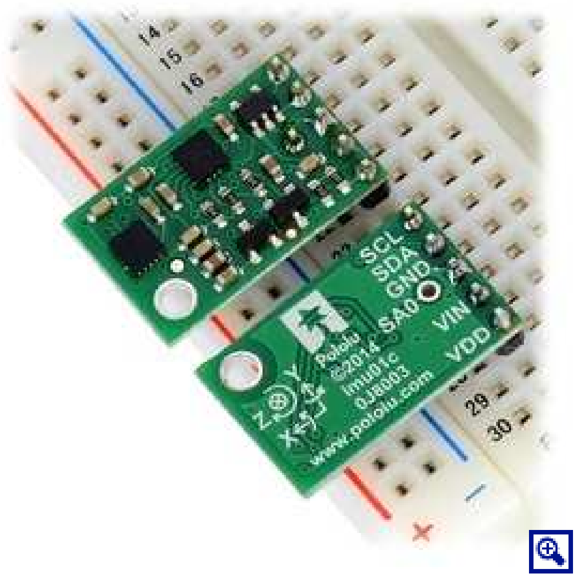
Using the MinIMU-9 v3

Connections

A minimum of four connections are necessary to use the MinIMU-9 v3: VIN, GND, SCL, and SDA. VIN should be connected to a 2.5 V to 5.5 V source, GND to 0 volts, and SCL and SDA should be connected to an I²C bus operating at the same logic level as VIN. (Alternatively, if you are using the board with a 3.3 V system, you can leave VIN disconnected and bypass the built-in regulator by connecting 3.3 V directly to VDD.)



Pololu MinIMU-9 v3 gyro, accelerometer, and compass pinout.



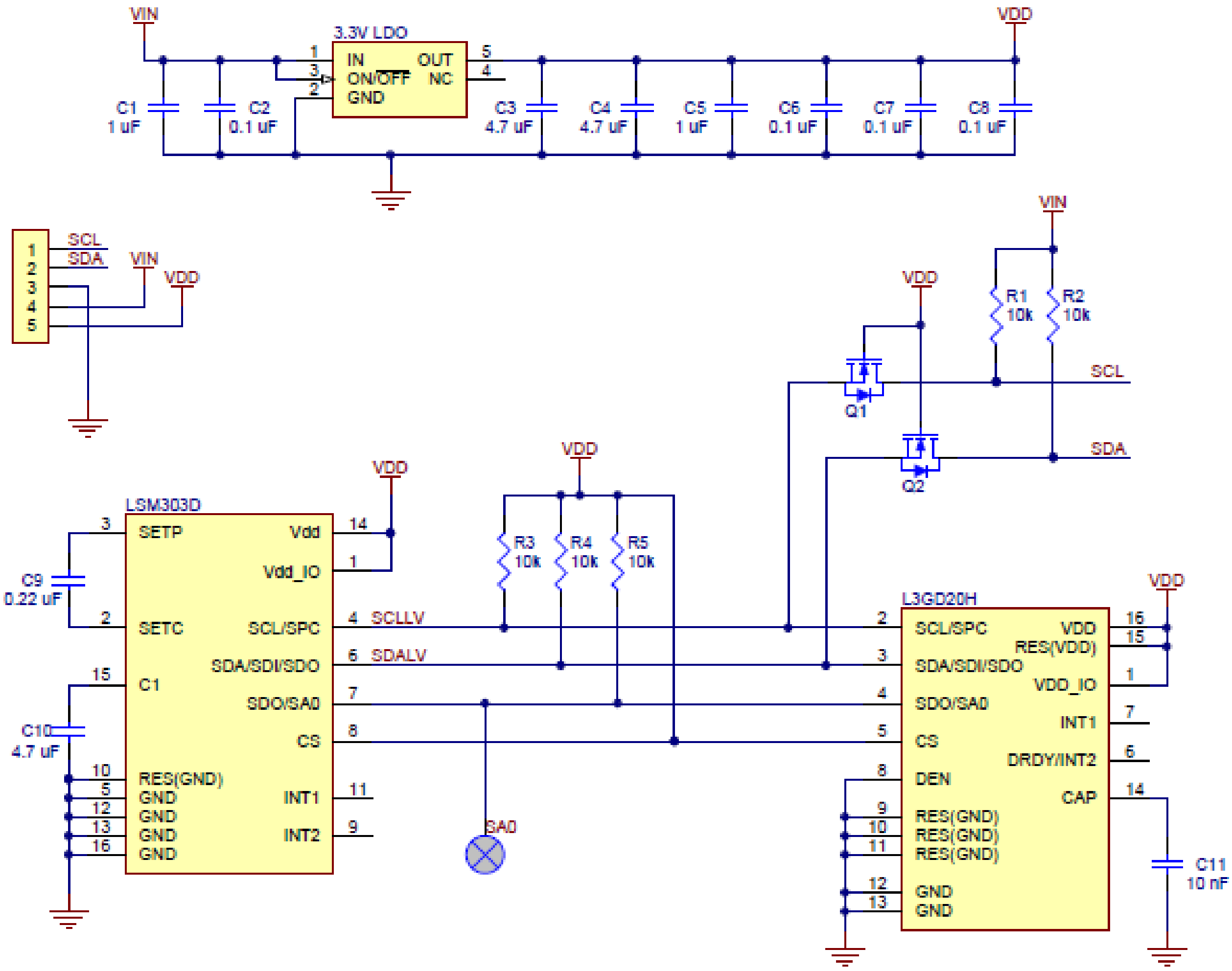
Two Pololu MinIMU-9 v3 modules in a breadboard.

Pinout

PIN	Description
SCL	Level-shifted I²C clock line: HIGH is VIN, LOW is 0 V
SDA	Level-shifted I²C data line: HIGH is VIN, LOW is 0 V
GND	The ground (0 V) connection for your power supply. Your I²C control source must also share a common ground with this board.
VIN	This is the main 2.5 V to 5.5 V power supply connection. The SCL and SDA level shifters pull the I²C bus high bits up to this level.
VDD	3.3 V regulator **output** or low-voltage logic power supply, depending on VIN. When VIN is supplied and greater than 3.3 V, VDD is a regulated 3.3 V output that can supply up to approximately 150 mA to external components. Alternatively, when interfacing with a 2.5 V to 3.3 V system, VIN can be left disconnected and power can be supplied directly to VDD. <u>Never supply voltage to VDD when VIN is connected, and never supply more than 3.6 V to VDD.</u>
SA0	3.3V-logic-level input to determine I²C slave addresses of the three ICs (see below). It is pulled high by default through 10 kΩ resistor. *This pin is not level-shifted and is not 5V-tolerant.*

The CS, DEN, data ready, and interrupt pins of the L3GD20H and LSM303D are not accessible on the MinIMU-9 v3. In particular, lack of the CS pin means that the optional SPI interface of these ICs is not available. If you want these features, consider using our **L3GD20H carrier** and **LSM303D carrier** boards.

Schematic Diagram



The above schematic shows the additional components the carrier board incorporates to make the L3GD20H and LSM303D easier to use, including the voltage regulator that allows the board to be powered from a single 2.5 V to 5.5 V supply and the level-shifter circuit that allows for I²C communication at the same logic voltage level as VIN. This schematic is also available as a downloadable pdf: **MinIMU-9 v3 schematic** (190k pdf).

I²C Communication

The L3GD20H's gyro and the LSM303D's accelerometer and magnetometer can be queried and configured through the I²C bus. Each of the three sensors acts as a slave device on the same I²C bus (i.e. their clock and data lines are tied together to ease communication). Additionally, level shifters on the I²C clock (SCL) and data lines (SDA) enable I²C communication with microcontrollers operating at the same voltage as VIN (2.5 V to 5.5 V). A detailed explanation of the protocols used by each device can be found in the **L3GD20H datasheet** (3MB pdf) and the **LSM303D datasheet** (1MB pdf). More detailed information about I²C in general can be found in **NXP's I²C-bus specification** (371k pdf).

The L3GD20H and LSM303D each have separate slave addresses on the I²C bus. The board connects SA0 pins of the two ICs together and pulls them all to VDD through a 10 kΩ resistor. You can drive the SA0 pin low to change the slave address. This allows you to have two MinIMUs (or an AltIMU v3 and a MinIMU v3) connected on the same I²C bus. The following table shows the slave addresses of the sensors:

Sensor	Slave Address (default)	Slave Address (SA0 driven low)
L3GD20H (gyro)	1101011b	1101010b
LSM303D (accelerometer and magnetometer)	0011101b	0011110b

Both chips on the MinIMU-9 v3 are compliant with fast mode (400 kHz) I²C standards as well as with the normal mode.

Sample Code

We have written a basic **[L3GD20 Arduino library]** and **[LSM303 Arduino library]** that make it easy to interface the MinIMU-9 v3 with an **[Arduino]** or Arduino-compatible board like an **[A-Star]**. They also make it simple to configure the sensors and read the raw gyro, accelerometer, and magnetometer data.

For a demonstration of what you can do with this data, you can turn an Arduino connected to a MinIMU-9 v3 into an attitude and heading reference system, or AHRS, with **[this Arduino program]**. It uses the data from the MinIMU-9 to calculate estimated roll, pitch, and yaw angles, and you can visualize the output of the AHRS with a 3D test program on your PC (as shown in a screenshot above). This software is based on the work of Jordi Munoz, William Premerlani, Jose Julio, and Doug Weibel.

Protocol Hints

The datasheets provide all the information you need to use the sensors on the MinIMU-9 v3, but picking out the important details can take some time. Here are some pointers for communicating with and configuring the L3GD20H and LSM303D that we hope will get you up and running a little bit faster:

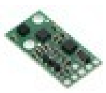
- The gyro, accelerometer, and magnetometer are all off by default. You have to turn them on by setting the correct configuration registers.
- You can read or write multiple gyro, or accelerometer registers in a single I²C command by asserting the most significant bit of the register address to enable address auto-increment.
- Compared with previous LSM303-series sensors, the register interface to the magnetometer in the LSM303D is much more consistent with the accelerometer interface, and its accelerometer and magnetometer share a common I²C address instead of acting as two separate slave devices on the same bus.
- The gyro, accelerometer, and magnetometer all output readings in a 16-bit reading (obtained by combining the values in two 8-bit registers for each axis).

Product Comparison

We carry several inertial measurement and orientation sensors. The table below compares their capabilities:

Product Name	Sensors				Estimation				Other
	Gyros (3x)	Accels (3x)	Mag (3x)	Altitude	Roll	Pitch	Yaw	Quaternion	Enclosure
[Pololu MinIMU-9 v3]	✓	✓	✓						
[Pololu AltIMU-10 v4]	✓	✓	✓	✓					
[CH Robotics UM7-LT Orientation Sensor]	✓	✓	✓		✓	✓	✓	✓	
[CH Robotics UM7 Orientation Sensor]	✓	✓	✓		✓	✓	✓	✓	✓

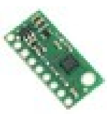
Related products



[AltIMU-10 v4 Gyro, Accelerometer, Compass, and Altimeter (L3GD20H, LSM303D, and LPS25H Carrier)]

[AltIMU-10 v3 Gyro, Accelerometer, Compass, and Altimeter (L3GD20H, LSM303D, and LPS331AP Carrier)]

[L3GD20H 3-Axis Gyro Carrier with Voltage Regulator]



[LSM303D 3D Compass and Accelerometer Carrier with Voltage Regulator]

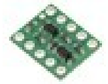

UM7 Orientation Sensor

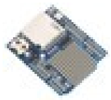

UM7-LT Orientation Sensor


LPS331AP Pressure/Altitude Sensor Carrier with Voltage Regulator


66-Channel LS20031 GPS Receiver Module (MT3339 Chipset)


I^{2}C Long-Distance Differential Extender


Logic Level Shifter, 4-Channel, Bidirectional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