

ELECTRONIC COMPASS MODULE (LSM303DLHC) – BM004
OPEN SOURCE HARDWARE MODULE



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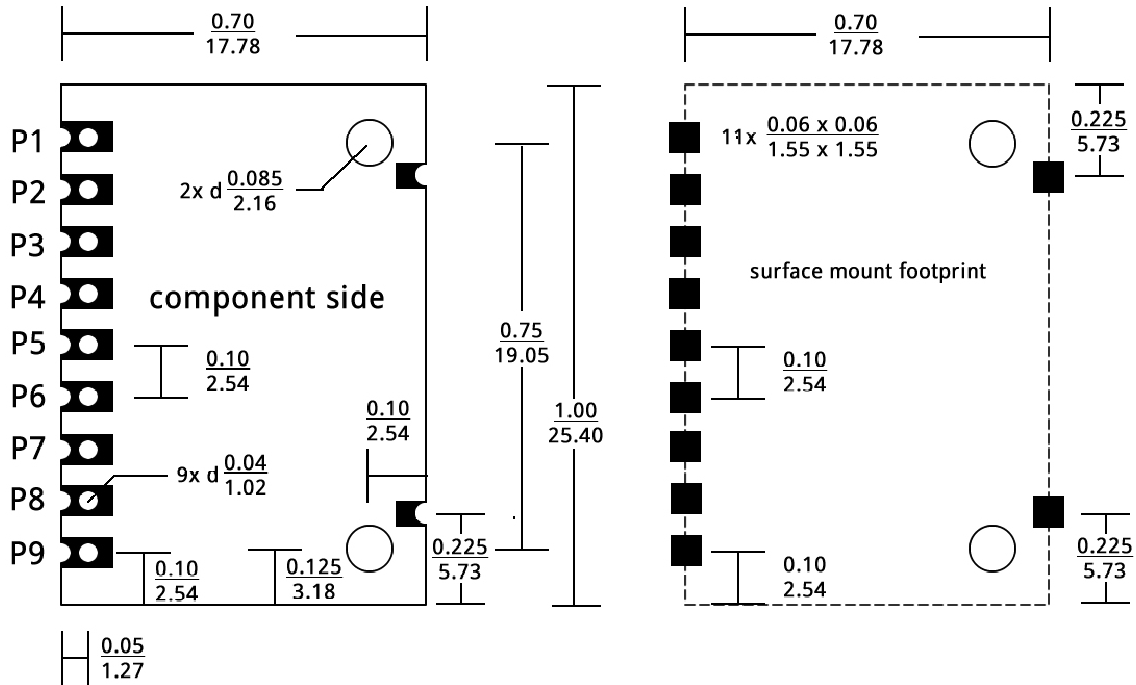
Product Description:

This breakout board carries a single ST Micro LSM303DLHC 3D accelerometer and 3D magnetometer. The module may be used to create an electronic compass.

- I²C™ serial interface
- Compatible with 3.3V or 5V inputs/outputs
- 3 magnetic field and 3 accelerometer channels, 16-bit data
- Embedded temperature sensor
- Forms core of compensated compass design
- Useful for motion activation, free-fall detection, pedometer, virtual reality

Dimensions:

9-pin SIP Mechanical Dimensions inches
mm



Specifications:

| Characteristic | Min | Typ | Max | Unit | Notes |
|-----------------------|-----|-----|-----|------|--|
| VIN operating voltage | 5 | | 24 | V | Onboard regulator provides 3.3V |
| Operating current | | 1.5 | | mA | Removing LED D1 can reduce this significantly. |
| Operating temperature | -40 | | 85 | °C | |

Pin Functions and Notes

| # | Name | Maximum Voltage | Notes |
|---|--------|-----------------|---|
| 1 | VIN | 24V | Voltage supply. 5-24VDC supplies onboard 3.3V regulator |
| 2 | GND | 0V | Ground return. |
| 3 | VDD | N/A | Voltage output. 3.3V should not draw more than 25mA from this connection. |
| 4 | VDD_IO | 5V | Voltage input. Sets operating voltage for SCL, SDA, INT. This pin must be connected to a voltage, even if you have pull-up resistors external to the board. |
| 5 | SCL | VDD_IO | Logic input. Serial data clock line. This pin is pulled to VDD_IO by a 4.7K Ω resistor. |
| 6 | SDA | VDD_IO | Logic input output. Serial data input and output to the IC. This pin is pulled to VDD_IO by a 4.7K Ω resistor. |
| 7 | INT2 | VDD | Logic output. Interrupt driven output pin. |
| 8 | INT1 | VDD | Logic output. Interrupt driven output pin. |
| 9 | DRDY | N/A | Logic output. Data ready output pin. |

User Notes/Tips

- Operation near magnetic fields or large conductors can cause measurement errors in the magnetometer. The device is most accurate if kept away from other electronics.
- The magnetometer axes registers are sequentially x,z,y not x,y,z. See LSM303DLHC datasheet for details.
- For accurate heading readings you should use a tilt compensated and calibrated method for calculating headings. See our Arduino code examples at www.solutions-cubed.com for methods to do this.
- VDD_IO must be connected to a voltage source, not left floating if you are using external pull-up resistors.
- For additional information on the accelerometer/magnetometer commands or timing of the I²C™ bus please review the ST Micro LSM303DLHC datasheet. The LSM303DLHC has a large command set detailed in the device datasheet.
- INT1 and INT2 functionality is highly configurable via the I²C™ communication protocol.
- Visit www.solutions-cubed.com for application notes related to this module.
- When operating at 5V you should provide 5V at the VIN and VDD_IO pins. This powers the on-board regulator and sets the voltage bus of the I²C™ pins. 3.3V will be present at the VDD pin. DRDY, INT1, and INT2 will be at 3.3V levels in this configuration.
- When operating at 3.3V you can provide 5V at VIN and use the on-board regulator output at VDD to power the VDD_IO pin. Alternatively you may tie VIN to ground and connect 3.3V to both VDD and VDD_IO if the on-board regulator is not needed to provide 3.3V.
- Keeping the module away from high currents and large metallic objects will reduce errors in measurement.

Calculating Heading, Pitch, and Roll:

For a more detailed discussion of using the LSM303DLHC as a compass see ST Micro's AN3192. A copy is maintained at the BM004 application note page at www.solutions-cubed.com.

We've provided example code for the Arduino in C. Using that code as a reference is the most efficient way to see how to implement heading readings.

Basic Heading:

Heading = $180^\circ * \text{atan}(M_{y_h}/M_{x_h})/\pi$ where $M_{y_h} = M_y$ and $M_{x_h} = M_x \Rightarrow$ the magnetometer register values.

However this equation is only valid with the tilt of the IC or module is equal to 0° . For tilt compensation you need the pitch and roll and other more detailed calculations.

Pitch and Roll:

You need the normalized acceleration values for the x and y axes, A_x and A_y , to calculate pitch and roll.

$$A_{x_n} = A_x / \sqrt{A_x^2 + A_y^2 + A_z^2}$$

$$A_{y_n} = A_y / \sqrt{A_x^2 + A_y^2 + A_z^2}$$

$$\text{Pitch} = \arcsin(-A_{x_n})$$

$$\text{Roll} = \arcsin(A_{y_n} / \cos(\text{Pitch}))$$

Tilt Compensated Heading:

To provide accurate heading information you'll need to calibrate the magnetometer values for your specific sensor. One simple method to do this is to capture the min and max values for each axes M_x , M_y , and M_z . Rotate the sensor around all axes and write down the max and min values for each axis. Then adjust then offset and scale your magnetic field values as shown below.

$$M_{x_c} = (M_x - M_{min_x}) / (M_{max_x} - M_{min_x}) * 2 - 1;$$

$$M_{y_c} = (M_y - M_{min_y}) / (M_{max_y} - M_{min_y}) * 2 - 1;$$

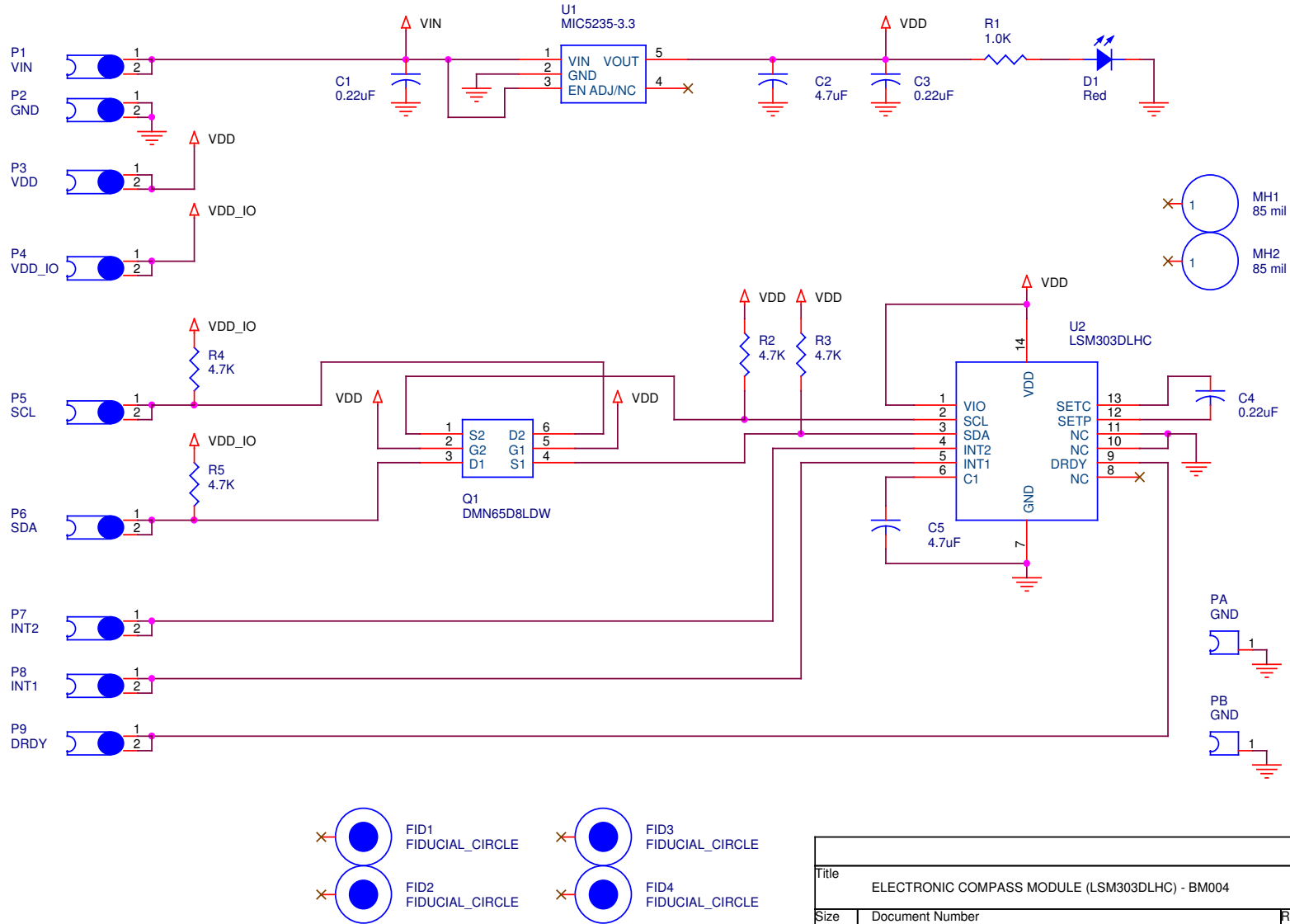
$$M_{z_c} = (M_z - M_{min_z}) / (M_{max_z} - M_{min_z}) * 2 - 1;$$

Then calculate M_{x_h} and M_{y_h} with these values.

$$M_{x_h} = M_{x_c} * \cos(\text{Pitch}) + M_{z_c} * \sin(\text{Pitch});$$

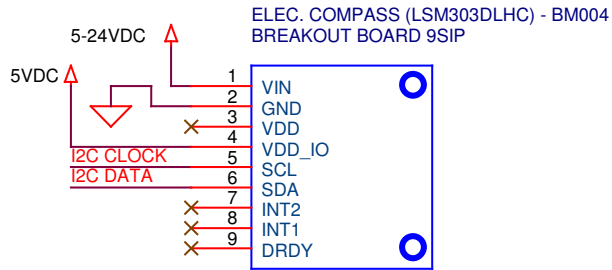
$$M_{y_h} = M_{x_c} * \sin(\text{Roll}) * \sin(\text{Pitch}) + M_{y_c} * \cos(\text{Roll}) - M_{z_c} * \sin(\text{Roll}) * \cos(\text{Pitch});$$

$$\text{Heading} = 180^\circ * \text{atan}(M_{y_h}/M_{x_h})/\pi$$

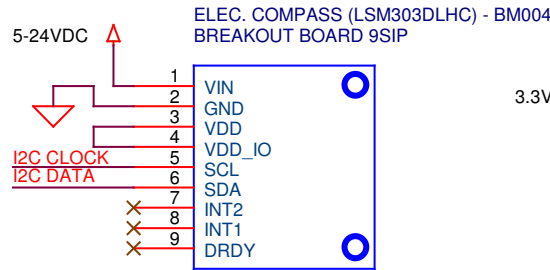


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| Title | | |
| ELECTRONIC COMPASS MODULE (LSM303DLHC) - BM004 | | |
| Size | Document Number | Rev |
| A | NA | 2 |
| Date: | Tuesday, April 16, 2013 | Sheet 1 of 1 |

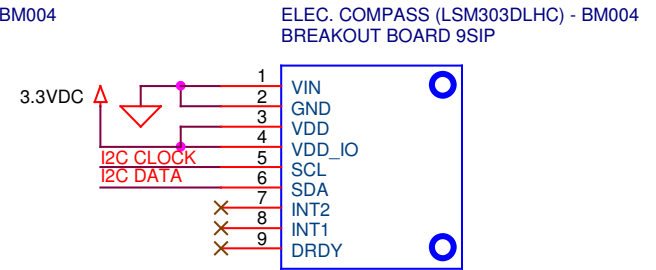
BASIC CONNECTIONS 5V SYSTEM



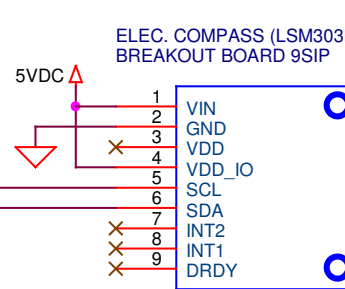
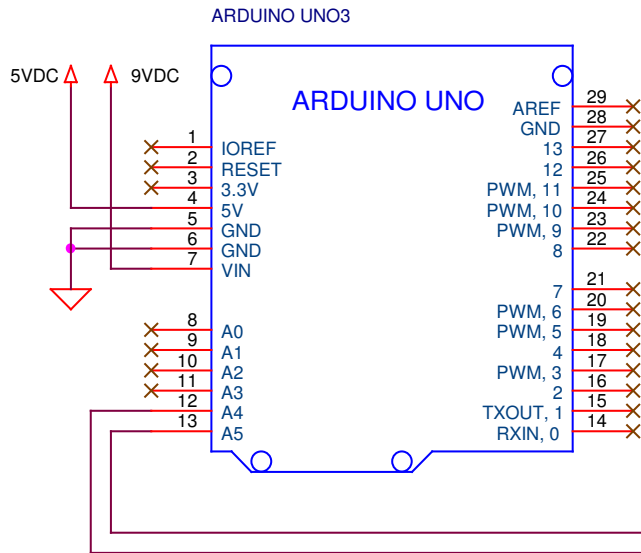
BASIC CONNECTIONS 3.3V SYSTEM



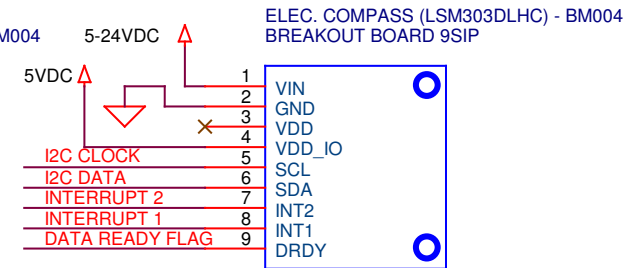
ALTERNATE CONNECTIONS 3.3V SYSTEM



ARDUINO CONNECTIONS



INTERRUPT AND DATA READY OUTPUTS



INTERRUPT AND DATA READY OUTPUTS WILL BE AT 3.3V LEVELS REGARDLESS OF THE VOLTAGE APPLIED TO VDD_IO

REVIEW THE LSM303DLHC COMMUNICATION PROTOCOL IN THE IC'S DATASHEET FOR MORE INFO ON INTERRUPTS