CMPS10 Sensor Manual

Written by Neil Dhar
Adapted from http://www.robot-electronics.co.uk/htm/cmps10doc.htm

The CMPS10 module is a tilt compensated compass. The module requires a power supply at 3.6 - 5V and draws a nominal 25mA of current. There are three ways of getting the bearing from the module, serial interface, I2C interface and PWM.

New data on the heading of the compass is updated every 13.3ms (75Hz). Note also that when calibrating, the sensor must be pointed to actual north instead of some arbitrary north. The angle can be adjusted to point towards the goal by introducing an offset in the code.

Use Of Raw Magnetometer Values To Find Angle

If the raw magnetometer values are to be used, the values should be appropriately normalised to be within 1 and -1 so that the x and y reading ratio is accurate. Not doing so will affect the accuracy of the atan function.

For a given axis, the minimum and maximum possible magnetometer values are to be taken and averaged. This creates an offset that can be deducted from future readings such that the mean reading is 0. After the offset, the new maximum value is now half the difference between the original maximum and minimum values. So to normalise the values, simply divide by the new maximum value to obtain the final normalised value on each axis.

Expressed mathematically for the x axis:

$$x_{offset} = -(x_{min} + x_{max})/2$$

$$x_{scale} = (x_{max} - x_{min})/2$$

$$x_{final} = (x_{reading} + x_{offset})/x_{scale}$$

The same formulae apply to the y axis. Subsequently, use the inverse tangent to find the angle:

$$\theta = tan^{-1}(\frac{x_{final}}{y_{final}})$$

I2C Mode

To enter the I2C mode of operation leave the mode pin unconnected. The address set to the sensor must be bitshifted to the right by 1 when sending commands. The default address is 0xC0.

Communicating In I2C Mode

In I2C mode, the device is treated as containing 23 registers. To set the internal pointer to a certain address, simply send the register code via I2C. Subsequently, request an appropriate number of bytes to receive data for the selected register. The internal pointer will then shift to the next register and automatically return a byte from it until the requested number of bytes are returned.

Register	Function
0	Software version
1	Compass Bearing as a byte, i.e. 0-255 for a full circle
2,3	Compass Bearing as a word, i.e. 0-3599 for a full circle, representing 0-359.9 degrees.
4	Pitch angle - signed byte giving angle in degrees from the horizontal plane
5	Roll angle - signed byte giving angle in degrees from the horizontal plane
6	Unused
7	Unused
8	Unused
9	Unused
10,11	Magnetometer X axis raw output, 16 bit signed integer with register 10 being the upper 8 bits
12,13	Magnetometer Y axis raw output, 16 bit signed integer with register 12 being the upper 8 bits
14,15	Magnetometer Z axis raw output, 16 bit signed integer with register 14 being the upper 8 bits
16,17	Accelerometer X axis raw output, 16 bit signed integer with register 16 being the upper 8 bits
18,19	Accelerometer Y axis raw output, 16 bit signed integer with register 18 being the upper 8 bits
20,21	Accelerometer Z axis raw output, 16 bit signed integer with register 20 being the upper 8 bits
22	Command register

List of registers for I2C Mode

Reading Tilt Compensated Angle

To read the full 2-byte angle, set the internal pointer to register 2 by sending 0x02. Then request 2 bytes from the sensor. The high byte is returned first.

Calibrate Sensor

First, ensure that the CMPS10 is not located near ferrous objects as they will distort the magnetic field and induce errors in future readings. Then align the sensor with north. then enter the calibration mode by writing 0xF0 to the command register (22). Then calibrate the first point by sending 0xF5 to the command register. The LED should light up. Rotate the sensor 90° and send 0xF5 to the command register again. Repeat for two further 90° rotations to complete the calibration and the LED will turn off.

To reset to factory calibration, send the command sequence 0x20, 0x2A, 0x60 to the command register with ~100ms delay between them. This should be done in separate I2C transactions.

Note that for both of the above operations, the pointer must be reset to the command register after each command is set.

Set I2C Address

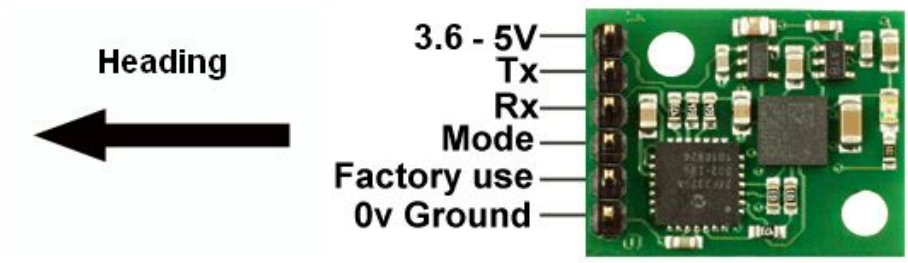
To change the I2C address of the CMPS10 there must be only 1 CMPS10 on the bus. Write the sequence 0xA0, 0xAA, 0xA5 in the correct order with a 100ms delay between them followed by the desired address. The sequence must be sent to the command register at location 22, and must be in 4 separate write transactions on the I2C bus. This is very similar to the process used for the SRF10 rangefinder. Note that the only allowable addresses are in the table below.

If the address is lost, power it up without sending any commands. The CMPS10 will flash its address out on the LED. One long flash followed by a number of shorter flashes indicating its address.

Address		Long Flash	Short flashes
Decimal	Hex		
192	C0	1	0
194	C2	1	1
196	C4	1	2
198	C6	1	3
200	C8	1	4
202	CA	1	5
204	CC	1	6
206	CE	1	7

Table of addresses corresponding to the number of flashes

Serial Mode



To use the serial mode of operation the mode pin must be connected to ground. The serial mode operates at a default baud rate of 9600 on 3.3 - 5V signal levels.

Communicating In Serial Mode

The commands in the table may be used to communicate with the sensor. Some of these are described in greater depth.

Command	Name	Bytes returned	Returned data description
0x11	GET VERSION	1	Software version
0x12	GET ANGLE 8 BIT	1	Angle as a single byte 0-255
0x13	GET ANGLE 16 BIT	2	Angle as two bytes, high byte first 0-3600
0x14	GET PITCH	1	Pitch angle +/- 0-85°
0x15	GET ROLL	1	Roll angle +/- 0-85°
0x21	GET MAG RAW	6	Raw magnetic data, 16 bit signed: X high, X low, Y high, Y low, Z high, Z low
0x22	GET ACCEL RAW	6	Raw accelerometer data, 16 bit signed: X high, X low, Y high, Y low, Z high, Z low
0x23	GET ALL	4	angle high, angle low (0-3600), pitch (+/- 0-85), roll (+/- 0-85)
0x31	CALIBRATE EN1	1	returns ok (0x55)
0x45	CALIBRATE EN2	1	returns ok (0x55)
0x5A	CALIBRATE EN3	1	returns ok (0x55)
0x5E	CALIBRATE	1	returns ok (0x55)
0x6A	RESTORE 1	1	returns ok (0x55)
0x7C	RESTORE 2	1	returns ok (0x55)
0x81	RESTORE 3	1	returns ok (0x55)
0xA0	BAUD 19200	1	returns ok (0x55)
0xA1	BAUD 38400	1	returns ok (0x55)

List of commands for serial mode

Read Tilt Compensated Angle

Generally, send the command 0x13 to receive a 2 byte value for the angle between 0-3599. Divide this by 10 to get the angle to one decimal place.

Change Baud Rate

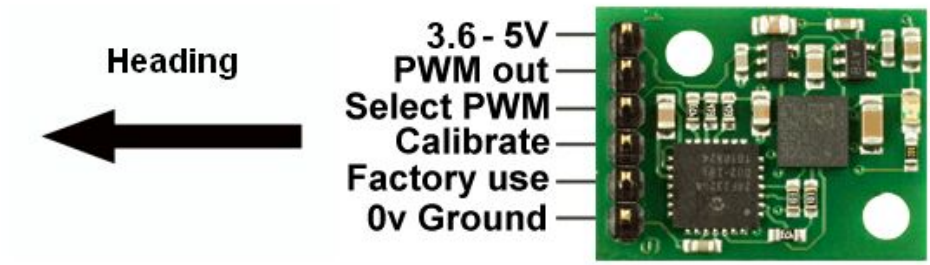
The baud rate can be changed if required to 19200 or 38400. See the table for the appropriate command. The changed rate is not persistent and so must be set on each boot.

Calibrate

First, ensure that the CMPS10 is not located near ferrous objects as they will distort the magnetic field and induce errors in future readings. Then align the sensor with north. Then write a sequence of 3 commands in the correct order with a small delay between bytes of ~100ms. The sequence to enter calibration mode is 0x31,0x45,0x5A. Then calibrate the first point by sending 0x5E to the sensor. The LED should light up. Rotate the sensor 90° and send 0x5E again. Repeat for two further 90° rotations to complete the calibration and the LED will turn off.

To reset to factory calibration, send the command sequence 0x6A, 0x7C, 0x81 with ~100ms delay between them.

PWM Mode



To enter the PWM mode of operation you are required to connect the Select PWM pin to ground.

Read Tilt Compensated Angle

Monitor the PWM output and record the length of the pulse *t*. The angle that the sensor makes to north is simply *(t-1)*10*.

Calibration

Calibration is the most trivial in the PWM mode. First, ensure that the CMPS10 is not located near ferrous objects as they will distort the magnetic field and induce errors in future readings. Subsequently, a normally open switch must be wired between the calibrate pin and ground. The first step is to line the compass up with north, then press the switch and the LED will light up. Then rotate the module by 90° and press the switch again. Repeat this 2 more times, the LED should now go out and the module will be recalibrated.

To restore the factory calibration, press and hold the switch for at least 5 seconds before releasing.