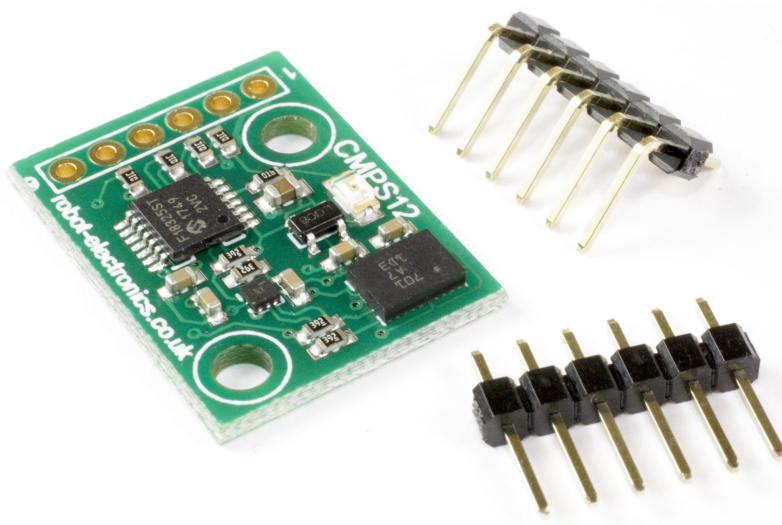


## CMPS12 – documentation



### Introduction

The CMPS12 is our 4th generation tilt compensated compass. Employing a 3-axis magnetometer, a 3-axis gyro and a 3-axis accelerometer. At the core of the module is the superb BNO055 running algorithms to remove the errors caused by tilting of the PCB.

Power supply requirements are flexible, you can feed between 3.3 - 5v and the module draws a nominal 18mA of current. A choice of serial or I2C interfaces can be used for communication.

### Overview of outputs

**Heading, 16 bit** – 2 outputs, one calculated by Bosch and one by us

**Heading, 8 bit** – 0-255 scaled for simpler requirements

**Pitch** – +/- 0-90° or +/- 0-180°

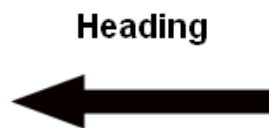
**Roll** – +/- 0-90°

**Temperature** – current temperature of the BNO055 in °c

**Raw sensor outputs** – 3 x 16 bit integers for each of the Magnetometer, accelerometer and gyro

### Mode selection

Serial or I2C mode is easily selected with the state of the mode pin. Note the CMPS12 looks at the mode selection pin at power-up only.



3.3v-5v  
SDA/TX  
SCL/RX  
Mode  
Factory use  
0v ground



For **I2C** the mode pin can be left open or pulled to the supply voltage, for **serial mode** the mode pin should be connected to 0v ground.

## I2C Mode

The compass has a 31 byte array of registers:

Register	Function
0x00	Command register (write) / Software version (read)
0x01	Compass Bearing 8 bit, i.e. 0-255 for a full circle
0x02, 0x03	Compass Bearing 16 bit, i.e. 0-3599, representing 0-359.9 degrees. register 2 being the high byte. This is calculated by the processor from quaternion outputs of the BNO055
0x04	Pitch angle - signed byte giving angle in degrees from the horizontal plane (+/- 90°)
0x05	Roll angle - signed byte giving angle in degrees from the horizontal plane (+/- 90°)
0x06, 0x07	Magnetometer X axis raw output, 16 bit signed integer (register 0x06 high byte)
0x08,0x09	Magnetometer Y axis raw output, 16 bit signed integer (register 0x08 high byte)
0x0A,0x0B	Magnetometer Z axis raw output, 16 bit signed integer (register 0x0A high byte)
0x0C, 0x0D	Accelerometer X axis raw output, 16 bit signed integer (register 0x0C high byte)
0x0E, 0x0F	Accelerometer Y axis raw output, 16 bit signed integer (register 0x0E high byte)
0x10, 0x11	Accelerometer Z axis raw output, 16 bit signed integer (register 0x10 high byte)
0x12, 0x13	Gyro X axis raw output, 16 bit signed integer (register 0x12 high byte)
0x14, 0x15	Gyro Y axis raw output, 16 bit signed integer (register 0x14 high byte)
0x16, 0x17	Gyro Z axis raw output, 16 bit signed integer (register 0x16 high byte)
0x18,0x19	Temperature of the BNO055 in degrees centigrade (register 0x18 high byte)
0x1A, 0x1B	Compass Bearing 16 bit This is the angle Bosch generate in the BNO055 (0-5759), divide by 16 for degrees
0x1C, 0x1D	Pitch angle 16 bit - signed byte giving angle in degrees from the horizontal plane (+/- 180°)
0x1E	Calibration state, bits 0 and 1 reflect the calibration status (0 un-calibrated, 3 fully calibrated)

Register 0x00 is a dual action register, in the event of a read the CMPS12 will reply with the software version, for a write it acts as the command register and is used to initiate storage/deletion of the calibration profile of the compass. There is also commands to change the I2C address that are sent here.

Register 0x01 is the bearing converted to a 0-255 value, this may be easier for some applications than 0-3599 which requires two bytes.

For those who require a bearing with better resolution registers 0x02 and 0x03 (high byte first) form a 16 bit unsigned integer in the range 0-3599. This represents 0-359.9°.

Registers 0x04 and 0x05 are the pitch and roll angles, giving an angle of 0 when the board is flat and up to +/- 90° at maximum tilt in either direction.

There is then an array of registers (0x06-0x17) providing all the raw sensor data from the magnetic and acceleration sensors.

Registers 0x18 (high byte) and 0x19 (low byte) form a 16 bit temperature that the BNO055 is currently measuring, this is provided in °C.

Bosch generate a compass bearing within the BNO055, so this is available in registers 0x1A (high byte) and 0x1B (low byte) and together they form a 16 bit unsigned integer in the range 0-5759, this number can be scaled to degrees by dividing by 16.

Registers 0x1C (high byte) and 0x1D (low byte) form a 16 bit pitch angle for +/- 180 from the horizontal plane.

Finally we have register 0x1E, this provides feedback on the degree of the calibration that the automatic calibration routines have achieved.

### Calibration of the CMPS12

The CMPS12 is automatically calibrated, the user is just required to perform simple movements to allow the CMPS12 to complete this.

Gyro – calibrated by the CMPS12 being in a stationary state.

Accelerometer – calibrated by tilting the module to roughly 45 and 90 degrees on one axis.

Magnetometer – a few random movements easily calibrates the CMPS12

The level to which the CMPS12 has been calibrated can be checked by reading register 0x1E, the gyro, accelerometer and magnetometer are allocated 2 bits each in the register. A value of 0 in the two bits reflects an uncalibrated state, when fully calibrated this will become 3 (both bits set). There is also a complete system calibration level.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Cal status	System calibration		Gyro calibration		Accelerometer calibration		Magnetometer calibration	

### Storing and erasing calibration profiles

After calibrating the compass the profile can be stored so it will be automatically reloaded when the module is ready for use again.

To **store a profile** write the following to the command register 0xF0, 0xF5, 0xF6 with a 20ms delay after each of the three bytes.

If you wish to **erase the stored profile** so your module powers into a default state write the following to the command register 0xE0, 0xE5, 0xE2 with a 20ms delay after each of the three bytes.

### Changing the I2C Bus Address

To change the I2C address of the CMPS12 you must have only one module on the bus. Write the 3 sequence commands in the correct order followed by the address with 20ms between writes. Example; to change the address of a compass currently at 0xC0 (the default shipped address) to 0xC2, write the following to the command register 0 at address 0xC0: (0xA0, 0xAA, 0xA5, 0xC2 ) with a 20ms delay after each of the first three bytes. These commands must be sent in the correct sequence to change the I2C address, additionally, No other command may be issued in the middle of the sequence. The sequence must be sent to the command register at location 0, which means 4 separate write transactions on the I2C bus. When the CMPS12 is re-powered will flash its address out on the LED.

Address		flashes
Decimal	Hex	
192	C0	1
194	C2	2
196	C4	3
198	C6	4
200	C8	5
202	CA	6
204	CC	7
206	CE	8

Take care not to set more than one device to the same address, there will be a bus collision and very unpredictable results.

## Serial mode

### Communication settings

The Serial mode operates over a link with a default baud rate of 9600 bps (no parity, 2 stop bits) and 3.3v-5v signal levels. This is not RS232. Do not connect RS232 to the module, the high RS232 voltages will irreversibly damage the module.

### Commands for Serial

Command	Name	Bytes returned	Returned data description
0x11	GET VERSION	1	Software version
0x12	GET BEARING 8 BIT	1	Bearing as a single byte 0-255
0x13	GET BEARING 16 BIT	2	Bearing (16 bit), high byte first 0-3599
0x14	GET PITCH	1	Pitch angle +/- 0-90°
0x15	GET ROLL	1	Roll angle +/- 0-90°
0x19	GET MAG RAW	6	Raw magnetic data, 16 bit signed: X high, X low, Y high, Y low, Z high, Z low
0x20	GET ACCEL RAW	6	Raw accelerometer data, 16 bit signed: X high, X low, Y high, Y low, Z high, Z low
0x21	GET GYRO RAW	6	Raw gyro data, 16 bit signed: X high, X low, Y high, Y low, Z high, Z low
0x22	GET TEMP	2	BNO055 reported temperature as two bytes, high byte first and scaled in °C
0x23	GET ALL	4	Angle high, angle low (0-3599), pitch (+/- 0-90), roll (+/- 0-90)
0x24	GET CALIBRATION STATE	1	Bits 0 and 1 reflect the calibration status (0 un-calibrated, 3 fully calibrated)
0x25	GET BOSCH BEARING 16 BIT	2	Bearing (16 bit), high byte first (0-5759), divide by 16 for degrees
0x26	GET PITCH 180	2	Pitch angle (16 bit) high bytes first +/- 0-180°
0xF0	STORE CALIBRATION BYTE 1	1	Returns ok (0x55)
0xF5	STORE CALIBRATION BYTE 2	1	Returns ok (0x55)
0xF6	STORE CALIBRATION BYTE 3	1	Returns ok (0x55)
0xE0	DELETE CALIBRATION BYTE 1	1	Returns ok (0x55)
0xE5	DELETE CALIBRATION BYTE 2	1	Returns ok (0x55)
0xE2	DELETE CALIBRATION BYTE 3	1	Returns ok (0x55)
0xA0	BAUD 19200	1	Returns ok (0x55)
0xA1	BAUD 38400	1	Returns ok (0x55)

## Calibration of the CMPS12

The CMPS12 is automatically calibrated, the user is just required to perform simple movements to allow the CMPS12 to complete this.

Gyro – calibrated by the CMPS12 being in a stationary state.

Accelerometer – calibrated by tilting the module to roughly 45 and 90 degrees on one axis.

Magnetometer – a few random movements easily calibrates the CMPS12

The level to which the CMPS12 has been calibrated can be checked by using command 0x24, the gyro, accelerometer and magnetometer are allocated 2 bits each in the register. A value of 0 in the two bits reflects an uncalibrated state, when fully calibrated this will become 3 (both bits set). There is also a complete system calibration level.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Cal status	System calibration		Gyro calibration		Accelerometer calibration		Magnetometer calibration	

## Storing and erasing calibration profiles

After calibrating the compass the profile can be stored so it will be automatically reloaded when the module is ready for use again. To do this we need to write a sequence of 3 commands sent in the correct order.

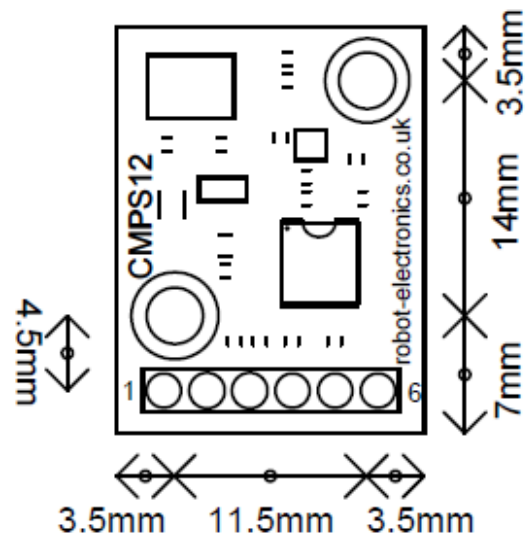
To **store a profile** send the sequence 0xF0, 0xF5, 0xF6 to the CMPS12, remembering to pick up the response byte ok (0x55) after each byte.

If you wish to **erase the stored profile** so your module powers into a default state send the sequence 0xE0, 0xE5, 0xE2 again each byte will return an ok (0x55).

## Changing the baud rate

The default serial baud rate of 9600 can be changed. There are two other baud rates that can be used, for 19200 just send 0xA0 or alternatively for 38400 send 0xA1. Please note that the CMPS12 will always default to its 9600 bps rate after power cycling and after setting a new baud rate the ok response (0x55) will be sent at the newly selected speed.

## Board dimensions



## Migration from the CMPS11

Every effort has been made to try and make the CMPS12 as compatible with its CMPS11 predecessor. Electronically it has been designed to drop in with pin compatibility. In I2C mode all data is in the same locations as it was found on the CMPS11 with some extra features in new registers, in serial mode the original command set is implemented and added to for some extra features. There are however a few differences:

Raw sensor data is now from a BNO055 sensor

Temperature is returned in °C

Pitch and roll values from the sensor are automatically filtered, so there is no longer pitch and roll with no Kalman filter values. This affects registers 0x1A and 0x1B in I2C and commands 0x16 and 0x17 in serial mode.

Calibration is fundamentally different, the CMPS12 is continually auto calibrating, there is commands to save the current calibration profile so it can be automatically restored if power is lost. There is also a command sequence to delete the profile if required.