



What is AbsoluteIMU

AbsoluteIMU device has various models:

AbsoluteIMU-A - Accelerometer

AbsoluteIMU-C - Compass and Magnetic Field sensor

AbsoluteIMU-AC - Accelerometer, Compass and Magnetic Field Sensor

AbsoluteIMU-ACG - Accelerometer, Compass, Magnetic Field Sensor and Gyro

Sensors mentioned above from the respective devices are available to you to read from.

Connections

AbsoluteIMU can be connected to any of the four sensor ports of NXT.

Values returned by sensor

The arrows marked on the sensor show the axes. Acceleration registers are signed integers and reads the acceleration value in milli-**g**, where **g** is acceleration due to gravity = 9.81m/S^2 .

i.e. A stationary sensor will report component of gravitational acceleration acting on that axis. (The axis pointing towards center of earth will show 1000 milli-**G**).

Gyro data has a unit of 8.75 milli-degree/second. i.e. if you get a reading of 100, it means the Gyro is turning at 0.875 degree/second rate **.

**** Note:** The rate mentioned above is at the sensitivity level of 250 degree/second. If you change the sensitivity level of Gyro, refer to 'Gyro Readings and Noise Level' section below for changes to units of this data.

Tilt data provided in tilt registers ranges from -127 to +128, where it shows 0 when that axis is level. (i.e. When sensor is stationary and leveled in horizontal plane, the tilt readings are 0).



TIP

There is a Trigonometric relation between the tilt readings and tilt angle of the sensor. As follows:

$$\text{angle} = \sin^{-1} (\text{tilt reading}/128)$$

where tilt-reading is from Accelerometer at Sensitivity 2G.

also as a alternative to \sin^{-1} , you can use:

$$\text{angle} = 2 * \arctan(t / (1 + \sqrt{1-t^2})),$$

where $t \equiv \text{tilt_reading} / 128$ to avoid a negative $\sqrt{()}$ operand when $\text{tilt_reading} = 128$.

Sensitivity of the Device

The device is very sensitive, and as a result it will show fluctuating values for a seemingly stationary device. If you don't want fluctuations in your readings, divide the resulting value by 10 or 100, there by reducing it's sensitivity.

Programming Techniques for reading sensor

EV3:

To use capabilities of the sensor, please download the EV3 block available at the following URL:

http://www.mindsensors.com/index.php?controller=attachment&id_attachment=144



Installation instructions for the EV3 block are available at:

<http://www.mindsensors.com/content/13-how-to-install-blocks-in-ev3>

Download the EV3 sample program from the following URL and modify it to suit your needs.

http://www.mindsensors.com/index.php?controller=attachment&id_attachment=146

NXT-G:

To use capabilities of the sensor, please download NXT blocks available at following URL:

http://www.mindsensors.com/index.php?controller=attachment&id_attachment=150



Installation instructions for the NXT block are available at:

<http://www.mindsensors.com/content/21-nxt-g-blocks-how-to-install-blocks>

Download NXT-G sample program from following URL and modify it to suit your needs.

http://www.mindsensors.com/index.php?controller=attachment&id_attachment=151

RobotC:

The driver implementation is available in Xander's driver suite at following url:



<https://github.com/botbench/robotcdriversuite>

the header file for the driver is: mindsensors-imu.h

NXC:

Download the library file and sample programs from following URL, and modify the sample program to suit your needs.

http://www.mindsensors.com/index.php?controller=attachment&id_attachment=149

If you need to use AbsoluteIMU in your existing program, at the top of your NXC program file, include it with following directive:

```
#include "IMU-lib.nxc"
```

Calibration

The Compass in AbsoluteIMU is calibrated for factory environment. However your environment will be different. For better performance, you should calibrate it for your environment.

Calibration for use of EV3 and NXT in the EV3 programming environment are included in the EV3 sample programs. Link provided in the previous section under EV3..

Download calibration programs for NXC from following url:

http://www.mindsensors.com/index.php?controller=attachment&id_attachment=148

To calibrate Compass, mount it on your robot where it will be used and issue 'Begin Compass Calibration' command and then rotate AbsoluteIMU slowly along all three axes. (The Compass in AbsoluteIMU is a 3 axis compass, and hence needs to be turned along all three axes, and if it's mounted on your robot, the whole robot needs to rotate).

Rotate one axis at a time, turn once in clock-wise direction completing at-least 360 degrees, and then turn it in anti-clock-wise direction, then go to next axis. Upon finishing turning along all axes, issue 'End Compass Calibration' command.

You can download calibration program from mindsensors.com website and run it on your NXT while the sensor is connected to Port 1. While running, follow on-screen instructions to calibrate.

All the calibration constants are stored in internal nonvolatile memory. i.e. the data is retained while it is powered off.

The Accelerometer and Gyro in AbsoluteIMU is pre-calibrated and does not need re-calibration.

Mounting AbsoluteIMU using Lego Technic Parts

The holes on AbsoluteIMU enclosure are designed for a tight fit of Technic pins (or axles) with '+' cross section. The holes however are not designed for repeated insertions/removals of these pins.



To mount AbsoluteIMU on your contraption we suggest that you use two dark gray 'Technic Axle 3 with Stud' as shown.

Insert axles from the top of the AbsoluteIMU and secure with a bushing on the back or mount it on your contraption directly.

Advanced Information

I2C commands and operations

Following table lists the Tilt and Acceleration calculations, calibration and setup commands:

Commands		Action
ASCII	Hex	
C	0x43	Begin Compass Calibration
c	0x63	End Compass Calibration
1	0x31	Change Accelerometer Sensitivity to 2G ** Change sensitivity of Gyro to 250 degrees/sec
2	0x32	Change Accelerometer Sensitivity to 4G ** Change sensitivity of Gyro to 500 degrees/sec
3	0x33	Change Accelerometer Sensitivity to 8G ** Change sensitivity of Gyro to 2000 degrees/sec
4	0x34	Change Accelerometer Sensitivity to 16G ** Change sensitivity of Gyro to 2000 degrees/sec

** After issuing command, allow 50 milliseconds for the sensor to reconfigure itself.

I2C Registers:

The AbsoluteIMU appears as a set of registers with following interpretation and operations.

Register	Read	Write
0x00-0x07	Software version - <i>Vx.nn</i>	-
0x08-0x0f	Vendor Id - <i>mndsnsrs</i>	-
0x10-0x17	Device ID - <i>AbsIMU</i>	-
0x41	-	Command Register
Accelerometer		
0x42	X Tilt data	-
0x43	Y Tilt data	-
0x44	Z Tilt data	-
0x45	X accel data LSB ¹	-
0x46	X accel data MSB	-
0x47	Y accel data LSB	-
0x48	Y accel data MSB	-
0x49	Z accel data LSB	-
0x4A	Z accel data MSB	-

Compass		
0x4B	Compass heading LSB ²	-
0x4C	Compass heading MSB	-
0x4D	Raw Magnetic field along X axis (LSB)	-
0x4E	Raw Magnetic field along X axis (MSB)	-
0x4F	Raw Magnetic field along Y axis (LSB)	-
0x50	Raw Magnetic field along Y axis (MSB)	
0x51	Raw Magnetic field along Z axis (LSB)	-
0x52	Raw Magnetic field along Z axis (MSB)	-
Gyro		
0x53	X Gyro data LSB ³	-
0x54	X Gyro data MSB	-
0x55	Y Gyro data LSB	-
0x56	Y Gyro data MSB	-
0x57	Z Gyro data LSB	-
0x58	Z Gyro data MSB	-
0x5A	Current filter value **	Gyro Filter Range: 0-7 0 no filter 7 is high filter Default value: 4

1 Accelerometer Data is available on devices equipped with Accelerometer sensor (AbsoluteIMU-AC/AbsoluteIMU-A).

2 Compass Data is available on devices equipped with Compass sensor (AbsoluteIMU-C/AbsoluteIMU-AC/AbsoluteIMU-ACG).

3 Gyro Data is available on devices equipped with Gyro sensor (AbsoluteIMU-ACG).

** Filter: The Gyro readings are filtered with n'th order finite impulse response filter, (where n ranges from 0 to 7)

value 0 will apply no filter, resulting in faster reading, but noisier values.

value 7 will apply stronger filter resulting in slower read (about 10 milli-seconds slower) but less noise.

Current Consumption

Average measured current profile is as follows:

Current Consumption	Duration
2.1mA	Continuous

Accelerometer Readings and Noise Level

The noise level of Accelerometer in AbsoluteIMU is about 4 to 6 milli-g.

Gyro Readings and Noise Level

The noise level of Gyro in AbsoluteIMU is about 70 to 100 milli-degrees/second.

Sensitivity Level	Reading Units
250 degrees/sec	8.75 milli-degrees/second
500 degrees/second	17.5 milli-degrees/second
2000 degrees/second	70 milli-degrees/second



NOTE

The noise levels are determined under ideal conditions. In normal use, even when the device is seemingly stationary, there are vibrations which are not noticeable to human senses and those will cause a reading change in the device.

Also, note that Gyro readings are rate of change of angle, which is generally a non-zero value at seemingly stationary state (due to these sensitivity to vibrations).

I2C address

Factory Default Address: 0x22

Changing the I2C Address:

The I2C address of AbsoluteIMU can be changed. For more information, please read:

<http://www.mindsensors.com/blog/how-to/change-i2c-device-address>

Upgrading Firmware

Current latest version: 1.20

To avail latest features and bug fixes, it is recommended to upgrade the firmware of AbsoluteIMU to the latest version.

To find current version of your AbsoluteIMU, use Explorer program from following url:

NXT:

http://www.mindsensors.com/index.php?controller=attachment&id_attachment=246

EV3:

http://www.mindsensors.com/index.php?controller=attachment&id_attachment=276

Attach sensor to Port 1 and run the program, the sensor information will be displayed on NXT or EV3 screen.

If your firmware version is older than the one mentioned above, please send e-mail to: support@mindsensors.com for assistance in upgrading.