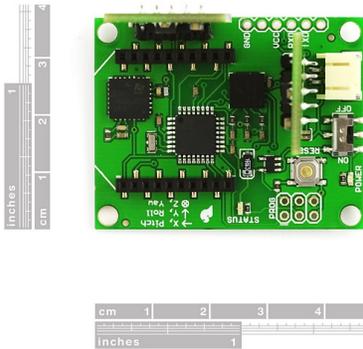# Atomic IMU - 6 Degrees of Freedom - XBee Ready
2009.3.25

Overview

Need a jump start on your robotics project, but strapped for cash? Is your junk food budget cutting into your autonomous monkey-shaving-robot plans? Is your quest for world domination constantly thwarted, week after week, because you always end up 25 bucks short of a 6DOF v4?

The 6DOF Atomic is a stripped-down IMU unit, designed to give good performance at a low price. The unit can run as a hard-wired UART interface (0-3.3V, 115200bps), or optionally with an XBee TM RF module, and is powered from a single LiPo (Lithium Polymer) cell.

The processor is an Atmel ATMega168TM running at 10MHz with 6 dedicated 10-bit ADC channels reading the sensors. Source code for the 6DOF Atomic is freely available and compiles with the free AVR GCC compiler.
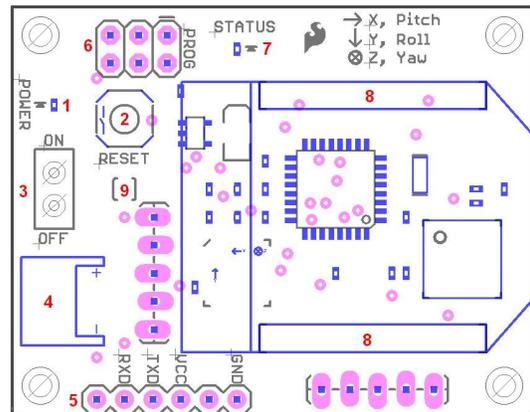
The 6-DOF Atomic uses these sensors:

- Freescale MMA7260Q TM triple-axis accelerometer, settable to 1.5g, 2g, 4g or 6g sensitivity
- 3 ST Microelectronics LISY300AL TM single-axis, 300°/s gyros

Electrical Specifications:

- Input voltage: 3.4V to 10V DC
- Current consumption: 24mA (75mA with XBee)
- Sensor bandwidth and resolution:

- LISY300AL Gyros: 88Hz, 0.977°/tick (ADC count)
- MMA7260Q Accelerometer:
- 350Hz, X and Y axes
- 150Hz, Z axis
- 0.00403g/tick @ 1.5g
- 0.00537g/tick @ 2g
- 0.0107g/tick @ 4g
- 0.0161g/tick @ 6g

The MMA7260Q accelerometer and the LISY300AL gyros have each been set up per their manufacturer's recommendations, i.e. internal clock suppression filters on their outputs.

These sensors are also internally temperature compensated. For a full description of the sensor specifications, please see the respective manufacturer's data sheets (available at http://www.sparkfun.com/).

Hardware Overview

1) Power indicator LED
2) Reset switch for the ATMega168
3) Power Switch
4) JST power connector for single Lipo cell
5) Serial port, 0-3.3V, 115200/8/1/N. The unit can optionally be powered with 3.4V to 10V from this port by closing the solder jumper marked "9" in Figure 1.
6) Programming port for ATMega168

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7) Status LED, blinks at the sample rate when unit is sampling, off otherwise
8) Sockets for optional XBee RF module
9) Solder jumper, connects VCC on the serial port to the battery input

Setup

When you first power up the 6DOF Atomic, you will see the power indicator LED light up and status LED blink 5 times quickly. During normal sampling operations, the status LED will toggle on or off every 64 sampling cycles. When in the configuration menu, the status LED will be on continuously. If the device is not in the configuration menu and not sampling, the 6DOF Atomic is in its idle state and the status LED will be off (see the section on the configuration menu auto run mode for more details on this).

The 6DOF Atomic can run either as a hard-wired device or optionally with a pair of XBee RF modules. The unit uses the same UART for both operations so no firmware configuration is required to run in either mode. However, care must be taken not to connect both a hard line and an XBee at the same time as that will result in a UART conflict and may possibly damage the unit.

Hard line connection

If the user chooses a hard-wired connection to the Atomic, the serial UART lines can be accessed on the serial port header (marked "5" in Figure 1). TX, RX and ground are all that's required. The logic is 0 – 3.3V, but the lines are 5V tolerant. DO NOT connect RS-232 to the UART lines as you will most likely damage the unit.

The serial port header is lined up to match the SparkFun FTDI Basic Breakout – 5V (sku: DEV-09115). It provides the quickest way to get up and running with the 6DOF Atomic. The user only needs to install a right-angled male header into the serial port and plug them together.

XBee connection

To establish a connection over XBee modules, the user must first purchase the necessary hardware, such as two XBee 1mW Chip Antenna modules and an XBee Explorer USB (sku: WRL-08664 and WRL-08687). Then you only need to follow the beginning part of the Wireless XBee/AVR Bootloading tutorial (setting up the XBee modules, http://www.sparkfun.com/commerce/tutorial_info.php?tutorials_id=122), substituting 115200 baud for 19200 baud. Once the setup is complete, the XBee modules will operate transparently.

It is worth noting, however, that stopping the 6DOF Atomic over the XBee link at frequencies over 150Hz can be problematic. With so much data streaming over the link it becomes difficult to get the stop signal back to the 6DOF. The only way to stop in this situation is to hit the reset button or cycle power.

6DOF Atomic Mixer demo application

For a demonstration of the 6DOF Atomic's operation, the user can run the 6DOF Atomic Mixer program. With the 6DOF powered up and connected in its idle state, close any terminal programs open the 6DOF's serial port and start the mixer application. Select the port number to which the 6DOF (or XBee base unit) is connected, set the frequency and sensitivity, hit the start button and you're off and running.

The mixer program requires that all channels are active. If you have any trouble getting the program to work correctly, check that all channels are active in the configuration menu.

Using a Terminal and the Configuration Menu

Once the initial novelty of the mixer program wears off, the user may want to do something slightly more useful with the Atomic, like attach it to something and log a file with a terminal program. What follows is a brief description of the configuration menu as well as a functional description of the 6DOF Atomic's operation.

Operation from the Idle State

Upon reset and in its default configuration, the Atomic will check to see if it has been configured for "auto run" mode (more on that later). If it's not in auto run mode, it goes into an idle state waiting for input. Normally this idle state serves as the start up state for the mixer application. In this state, the following inputs have the following effects:

1) "%", ASCII 37, sets the accelerometer to 1.5g sensitivity
2) "&", ASCII 38, sets the accelerometer sensitivity to 2g

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3) " ' " (apostrophe), ASCII 39, sets the accelerometer sensitivity to 4g
4) " (", ASCII 40, sets the accelerometer sensitivity to 6g
5) ") ", ASCII 41, sets the sample frequency to 50Hz
6) " * ", ASCII 42, sets the sample frequency to 100Hz
7) "+", ASCII 43, sets the sample frequency to 150Hz
8) " , ", ASCII 44, sets the sample frequency to 200Hz
9) " - ", ASCII 45, sets the sample frequency to 250Hz
10) "#", ASCII 35, starts the unit running in binary mode with all channels active
11) " " (space), ASCII 32, stops the unit and returns it to the idle state (issuing another ASCII 32 will bring up the configuration menu)

Operation from this idle state will always be in binary output mode, but the user may select which channels are active. Also, configuration from this state as done in the mixer application will not be saved in memory, whereas settings from the actual configuration menu will be saved to memory for future use. At the same time, all but the active channel settings saved in memory have no effect on operation from the idle state.

It should be noted that the primary purpose of this idle state and mode of operation is to more easily interact with the Atomic mixer demonstration application, but there's no reason that a user's own application couldn't use it for a quick setup.

Operation from the Configuration Menu

6DOF Atomic setup, version 1.0
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1) View/edit active channel list
2) Change output mode, currently binary
3) Set Auto run mode, currently off
4) Set accelerometer sensitivity, currently 1.5g
5) Set output frequency, currently 100
6) Save settings and run unit

Active Channel List

Pressing "1" will bring up the active channel list:

1) Accel X = on
2) Accel Y = on
3) Accel Z = on
4) Pitch = on
5) Roll = on
6) Yaw = on

Press the number of the channel you wish to change, or press x to exit

To change a channel from active to inactive (or the reverse), just press the number of the channel you wish to change. It's a toggling function; pressing a number will bring up the full list again, but with the channel you wished to change in its opposite state. Press a few numbers and get a feel for it. Pressing "x" gets you back to the main menu.

Output Mode

Pressing "2" from the main menu will toggle the output mode from binary to ASCII and back again. What are these output modes, you ask?
In both output modes, the data from all active channels is framed by an "A" (ASCII 65) at the start and a "Z" (ASCII 90) at the end. Also in both modes, each channel is reported in exactly the sequence shown in the active channel list, with the addition of a sample count that immediately follows the "A" and precedes the first active measurement, which is to say:

1) Count
2) Accel X
3) Accel Y
4) Accel Z
5) Pitch
6) Roll
7) Yaw

The count is two bytes that comes as MSB-LSB, and will range from 0 to 32767. If any of the channels are selected as inactive, that data is omitted from the frame and subsequent data moves up in the report sequence.

In binary mode, each active channel report comes as 2 bytes: MSB and LSB, in that sequence, and they will always be between 0 and 1023 because we're reading from 10-bit ADC's. The width of the data

frame in binary mode will be 4 bytes ("A", "Z", and count are always present) plus 2 bytes for each active measurement. So for all active channels the data frame will be 16 bytes wide.

In ASCII mode, the count and active measurements are reported in ASCII so it's easier to read with a terminal program, plus all measurements and the count are delimited with TAB characters (ASCII 9) as well as a carriage return and line feed at the end of the data frame. This makes data capture and importation into a spreadsheet a relatively simple matter.

Auto Run Mode

Pressing "3" from the main menu will toggle the auto run setting. If you intend to use the 6DOF Atomic in ASCII mode, set this to "on". If the auto run feature is off, the unit will always run from it's primary idle state, which means that it will always wait for a "#" to begin sampling and it will always run in binary mode.

One feature of auto run mode is that if the setting is active the Atomic will begin sampling immediately upon power up. Pressing the spacebar will bring up the configuration menu again.

Setting the Accelerometer Sensitivity

Pressing "4" from the main menu will bring up the following submenu:

Set to:
1) 1.5g
2) 2g
3) 4g
4) 6g

Just press the number which corresponds to your choice and the unit will revert to the main menu with the sensitivity changed.

Setting the Output Frequency

Pressing "5" from the main menu will allow you to change the sample frequency. Simply press "i" to increase or "d" to decrease, or "x" to revert to the main menu.

The minimum frequency setting is 10Hz, and there is no maximum setting. This allows the user to experiment with smaller data frames and higher sampling rates.

Save Settings and Run Unit

Pressing "9" from the main menu will save the current settings to flash and exit the configuration menu. If the auto run feature has been activated the unit will begin running immediately. If it has not been set, the unit will revert to the initial idle state and wait for additional input.

Bandwidth Considerations and Firmware

The 6DOF Atomic does not have any filtering in firmware, though there is enough memory left in the ATMega168 flash program space to implement filtering. The internally set output bandwidth of the MMA7260Q accelerometer is 350Hz for the X and Y axis, and 150Hz for the Z axis. There are also additional single-poll low-pass filters to reduce switching noise from the sensor with polls set at 1591Hz (recommended by Freescale). The internally set output bandwidth for the LISY300AL gyro sensors is 88Hz. Of course, it's a good idea for the user to consider these numbers when developing an application to ensure that the proper filtering is in place for whatever sampling rate is selected.

All source code and schematics for the 6DOF Atomic are freely available from the Atomic's product description page on http://www.sparkfun.com. Source code is compiled with GCC using WinAVR (http://winavr.sourceforge.net/). Programming is typically done with a AVR-PG1B (sku: PGM-00014, $12.95) along with our programming adapter (sku: BOB-08508).

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