WEBSITE: sparkfun.com

6175 LONGBOW DRIVE, SUITE 200
BOULDER, COLORADO   USA   ZIP CODE: 80301

[303]   284.0979 [GENERAL]
         443.0048   P
                     F

2008.02.21

IMU 6 Degrees of Freedom v2 Data Sheet

Overview

The original IMU 6-DOF unit was designed to provide a wireless 3 dimensional sensing platform development tool for a reasonable price. Combining a variety of pre-existing SparkFun devices, this unit has applications in guidance control, industrial sensing, and a host of other applications where the user just has to know "what's going on over there".

The IMU 6-DOF v2 uses the single IC triple axis accelerometer from Freescale MMA7260Q and combines it with three iMEMS gyroscopes, a motherboard with a PIC16F88 for control, a BlueSMiRF unit, a Bluetooth USB dongle, and a 4xAA Battery holder with polarized connector.

The IMU 6-DOF v2 unit provides:

- · Three gyro readings
- · Three tilt readings
- · Three temperature readings from ADXRS sensors
- · Three 2.5V outputs from the ADXRS sensors for error correction
- · One battery level voltage

These readings are accessible through a terminal program, or optionally with the IMU 6DOF Mixer v1.2 . Additionally, the unit may be connected to a serial port through the 4-pin debug header.

Caution: care must be taken to set the "RF/Debug" switch to "debug" before connecting to the debug header.

Hardware description

Here's a list of the stand-out items on the 6-DOF v2 motherboard:

1) Power Switch
2) RF/Debug switch, switches the uC UART from the Debug header to the Blue Tooth Module
3) Power connector
4) Debug connector, connects directly to the uC's UART (this is TTL, NOT RS-232)
5) uC Reset (does not reset the Blue SMiRF)
6) Status LEDs
7) Pitch Gyro
8) Yaw Gyro
9) Roll Gyro
10) Blue SMiRF Module
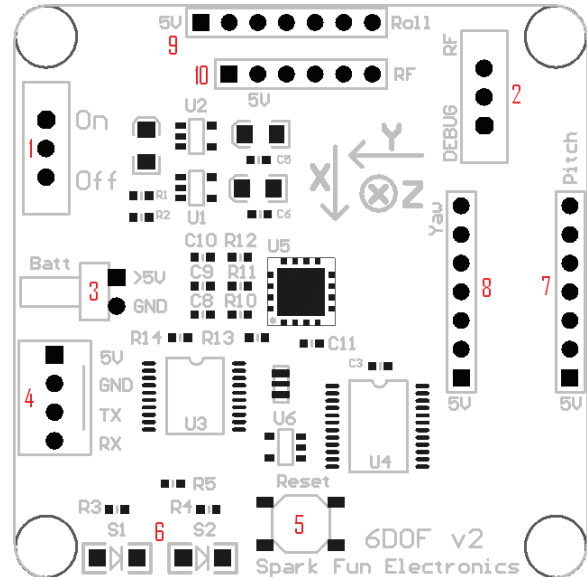
If the user desires, access to an ICSP port can be found on the underside of the motherboard. However, the PIC16F88 uC is equipped with a boot loader and programming can be more easily achieved through the debug header. Note: take care that you switch the RF/Debug switch to "debug" before attaching to the debug header or you will cause a hardware conflict with the Blue SMiRF.

The 6-DOF unit motherboard is 2"x2" and sits on .375" stand-offs. Two of the three gyro units stand vertically on the motherboard, and stand 3/4" high. The third gyro and the BlueSMiRF module sit horizontally above the motherboard, as seen in the photo in the header of this data sheet.

The kit also comes with a 4xAA battery holder and a set of stand-offs.

Installation and Configuration

The first thing that the user needs to do is to configure their local Bluetooth connection. Any Bluetooth device should work, provided it's configured as a serial port and running at 57600 bps or above.

Previous versions of the 6DOF v2 required the user to do remote Bluetooth configuration. The latest revision of the 6DOF v2 code now does that for you . From your computer (or whatever local Bluetooth platform you're using), the 6DOF v2 will show up in a Bluetooth discovery as either "SparkFun-BT" with a MAC of 5FE00006D0F2 if it has a SparkFun BlueSMiRF module, or as "FireFly" with a random MAC if it has a Roving Networks BlueSMiRF. In either case, initiate your Bluetooth connection, start up your terminal emulator of choice, and you're ready to go.

Optionally, the 6DOF v2 can operate over the debug connector at TTL levels (NOT RS-232). Just make sure that you set the "RF/debug" switch to "debug" before you power it up, otherwise you will create a UART conflict with the Bluetooth module, and that could be damaging.

When powering up for use with the hardline, several commands will display on the user's terminal screen before the 6DOF is ready. These commands are used to configure the Bluetooth module, and they take a few seconds to complete. Once the commands are done, hit the spacebar and the configuration menu will come up.

Configuration Menu

When the 6-DOF v2 powers up, the first thing you'll see is the configuration menu. You are presented with 3 options for configuration: Sensor range, output type and the active channel list. Just hit "1", "2" or "3" to enter the submenu of your choice, or hit "<ctrl>g" to start the unit sampling.

In the sensor range submenu, press "1" for +/-1.5g, "2" for +/-2g, "3" for +/-4g, "4" for +/-6g or "x" to exit without changing anything.

In the display mode submenu, you first choose between ASCII (by pressing "a") and binary (by pressing "b") output types. If you select ASCII, you'll then be asked if you'd like a scrolling output (by pressing "s") or a single over written line ("by pressing "o"). Note: all outputs are raw values from the analog to digital convertor. Nothing is calculated.

In the View/Change Active Channel List submenu you'll be given the full list of channels and their active status. Just press the corresponding number or letter to toggle a channel's active status, and press "x" to save and return to the main menu.

All settings are saved in EEPROM so you don't have to keep re-entering your preferences at each power up.

Once you have it configured the way you like, hit "<ctrl>g" to start. To stop sampling, hit the spacebar (ASCII 32).

Firmware and Output Format

The theory of the 6-DOF v2's operation is very simple. Three ADXRS units provide 3 measurements each, plus 3 acceleration readings from the Freescale MMA7260Q. These 12 measurements, plus battery voltage, are then multiplexed via a CD74HC4067 16-channel multiplexer to the 10-bit ADC on the PIC 16F88. The PIC then takes these measurements and sends them out its UART at 57,600 bps, either to a hard-wired serial port or to the included BlueSMiRF.

As mentioned, the current firmware runs the PIC16F88's UART at 57,600 bps. We've found that we can safely run at this speed without compromising the accuracy of the ADC.

The output of the data stream on the receiving end of the 6-DOF v2 varies in length depending on active channel selection. The data stream begins with the ASCII character 'A', followed by up to 13 measurements. The sequence of the measurements following the start character is:

Pitch, Rate Out (channel 0)

Pitch, 2.5V (channel 1)

Pitch, Temperature (channel 2)

Roll, Rate Out (channel 3)

Roll, 2.5V (channel 4)

Roll, Temperature (channel 5)

Yaw, Rate Out (channel 6)

Yaw, 2.5V (channel 7)

Yaw, Temperature (channel 8)

X acceleration (channel 9)

Y acceleration (channel 10)

Z acceleration (channel 11)

Battery Reference (VCC/2, channel 12)

Each measurement is two bytes in the data stream. Each two-byte segment utilizes the lowest ten bits for the measurement (the upper six bits will be read as 0), and they are sent MSB first.

The last byte in the data stream is an ASCII 'Z'. The first and last bytes were set to simple ASCII characters in an effort to simplify development and provide a simple way to sync to the data stream.

As stated earlier, data frames now vary in length according to which measurements are active. As an example, if you were to omit channels 1 and 2 from the list, all remaining channels above channel 0 would move their data slots up by two positions. And remember that one data slot represents two bytes.

Sampling rates vary between binary mode and ASCII mode. To save you time and confusion, please refer to Table 1 below for a list of active channels and sampling frequencies.

Number of Channels	Frequency	
	ASCII	Binary
1	657Hz	1457Hz
2	418Hz	948Hz
3	306Hz	695Hz
4	242Hz	553Hz
5	200Hz	460Hz
6	171Hz	393Hz
7	149Hz	343Hz
8	132Hz	305Hz
9	118Hz	274Hz
10	107Hz	249Hz
11	98Hz	228Hz
12	90Hz	210Hz
13	83Hz	195Hz

Raw ADC reading from the 3 gyros should been seen in the neighborhood of 512 at equilibrium. ADC reading from the Freescale accelerometer will be somewhat lower at equilibrium due to it being a 3.3V device operating within a 5V ADC window.

Bandwidth Considerations

The output bandwidth of the ADXRS gyros is set at 325Hz. The output bandwidth of the MMA7620Q accelerometer is 350Hz for X and Y axes, and 150Hz for the Z axis. Aliasing should be suppressed so long as the sampling frequency is somewhere above 233Hz.

Connecting via IMU 6DOF v1.2 Mixer

Note: All channels must be active for the 6-DOF IMU Mixer v1.2 to recognize the data frame properly, and it must be running in binary mode.

After configuration is completed, you can get a graphical representation of the data returned from the 6-DOF unit by starting up the IMU 6-DOF Mixer v1.2 application (this is without Hyperterminal running, of course). Once it's open, select the COM port you wish to connect to and hit "Connect to IMU." The port you select can either be the BlueTooth dongle port or a hardwired port to the debug header on the 6-DOF unit, provided that the port number is from 1 to 16 (sorry, it's a VB limitation). Again, if you use the debug header, you must set the "RF/debug" switch to "debug." Not doing so will cause a UART conflict.