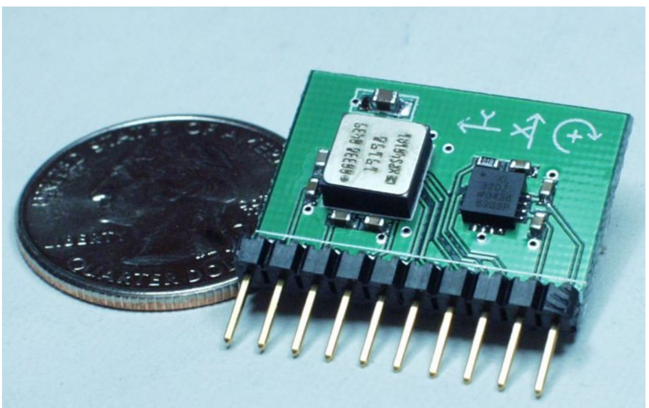
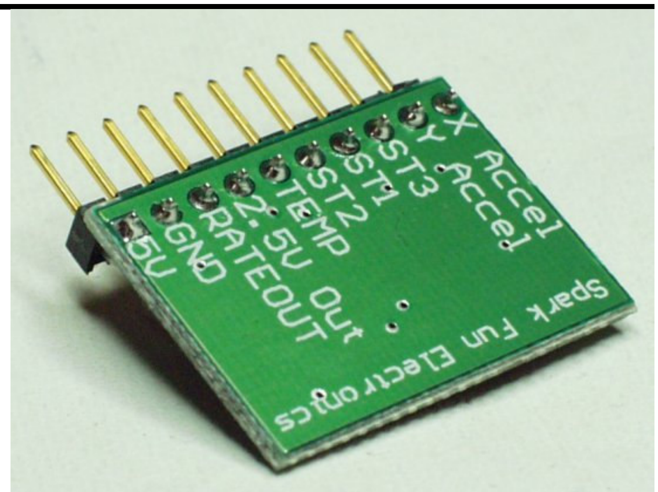
IMU Combo Board v1



2 Degree of Freedom Gyroscope/ Accelerometer Combination
11/13/2004

1 Overview

The new ADXRS401 Gyro and ADXL320 from Analog Devices are great new MEMs technology sensors. This module was developed to get these great sensors into the hands of hobbyists, engineers, and students. The footprint was made as small as possible, while retaining the most raw form of output from the sensors allowing the module to be used for any purpose the imagination can fathom. This module is ideal for reverse pendulum robots (the Segway is a perfect example) or with Unmanned Aerial Vehicle control (detect the roll of a plane for aileron correction).



2 Interface Specifications

Both sensors output an analog voltage representing the relative reading.

1. **5V** : 5 volt regulated power
2. **GND** : Ground Connection
3. **Rateout** : Gyro analog output
4. **2.5V Out** : Internal 2.5V precision output
5. **Temp** : Internal precision temperature
6. **ST2** : Self test 2 (Gyro)
7. **ST1** : Self test 1 (Gyro)
8. **ST3** : Self test 3 (Accelerometer)
9. **Y Accel** : Y axis acceleration output
10. **X Accel** : X axis acceleration output

3 Pin Definitions

Rateout : The ADXRS401 outputs 15mV/°/s or 15mV per degree per second. The ADXRS will output 2.5V on the Rateout pin while sitting still. When you rotate the module, this pin will fluctuate around 2.5V depending on how fast you rotate it. With a good ADC, you will be able to detect very small rotations/fluctuations.

2.5V Out : This pin connects to the internal precision 2.5V reference. Use this reference to compare it to you ADC readings to increase accuracy.

Temp : The ADXRS401 includes a precision temperature sensor for temperature compensation for increased accuracy. The Temp pin will output 2.5V at 27°C and will vary 8.4mV°/C.

ST2 : Used to internally self-test the gyro.

ST1 : Used to internally self-test the gyro.

ST3 : Used to internally self-test the accelerometer.

Y-Accel : This pin will output 2.5V when laying flat on a table - perpendicular to the earth's surface. The output will change 312mV/g change. That is, for every gravity of acceleration on the Y axis, you will see a 312mV change on the 2.5V output.

X-Accel : Identical to Y-Accel, but in the perpendicular X axis. When perpendicular to the earth's surface, the X Accel pin (or similarly the Y Accel pin) will output 2.188V or 2.812 depending on orientation (+/- 180 degrees of tilt). Based on these values and the performance of your ADC, you will be able to very accurately detect tilt to a fraction of a degree.

Of course you should read the datasheets for the ADXRS401 and ADXL320 themselves for information on the output specifications.

4 Increasing ADC Performance

The accuracy of your system will depend completely on your ADC. The higher the number of bits, the better resolution you can achieve. For instance, if you have a 10-bit ADC (common on most PICs/AVRs) you can detect

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5V / 1024 = 4.88mV per bit
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4.88mV changes. If you have a 12-bit ADC

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5V / 4096 = 1.22mV per bit
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or 1.22mV changes. Obviously you will be hindered greatly if your system is noisy or poorly decoupled. Use low noise regulators and lots of decoupling capacitors.

4.1 Decreasing the ADC Window

One common trick to increasing performance is by shrinking the window on which the Analog to Digital Converter operates. For instance, the PIC16F88 has two pins that serve as Vref- and Vref+. These are the upper and lower limits of the Voltage Reference on the ADC. You will need to read heavily into the datasheet for your specific micro, not all micros have both upper and lower Vref pins. The 16F88 can be set within specs to 1.5V and 3.5V. This gives us a *much* smaller window thus a more accurate measurement system:

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2V / 1024 = 1.95mV per bit
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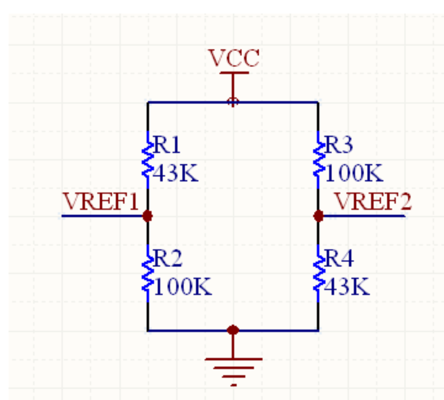
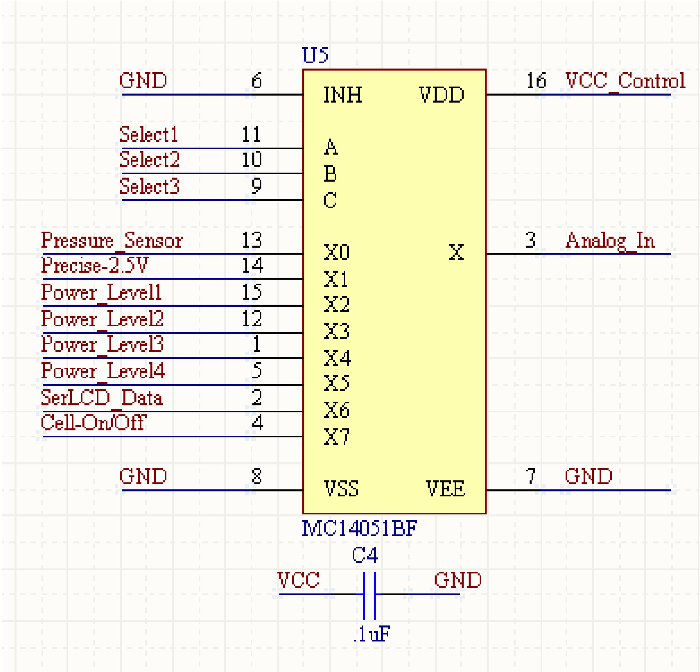
We effectively improved the performance of the ADC simply by decreasing the window in which we are measuring.

You will need to consider that you will saturate the ADC if you try to do an ADC on voltages that are less than 1.5V or greater than 3.5V, but just keep this in the back of your mind. Using the Gyro and Accelerometer for reverse pendulum or UAV applications, you will need to detect very minute changes many times a second. Therefore, the firmware should be able to take care of special cases where the ADC saturates (the 'uh-oh' function should be called).

To set the Vref+/- pins, a simple resistor divider circuit can be used:





4.2 Finding more ADC Channels

Many micros only have 3-4 ADC channels. Some PICs have as many as 8. But what do you do if you need more? There are devices called Analog Multiplexers that allow you to expand one ADC channel to 8 ADC channels. The 4051 IC (search Digikey "4051 dip mux") allows you to multiplex one ADC channel to 8 different sources using 3 control pins. You get to read 8 ADC devices while only needing 1 ADC pin and 3 control pins (8 for the price of 4!).

4.3 Amplifying the Outputs

The analog signals can be amplified using a simple, single-supply opamp. Search Digikey for "OPA340 DIP". It is a TI opamp that is sufficient for signal amplification and ADC interfacing.