IMU6410 9/10 Degree of Freedom Processing Platform

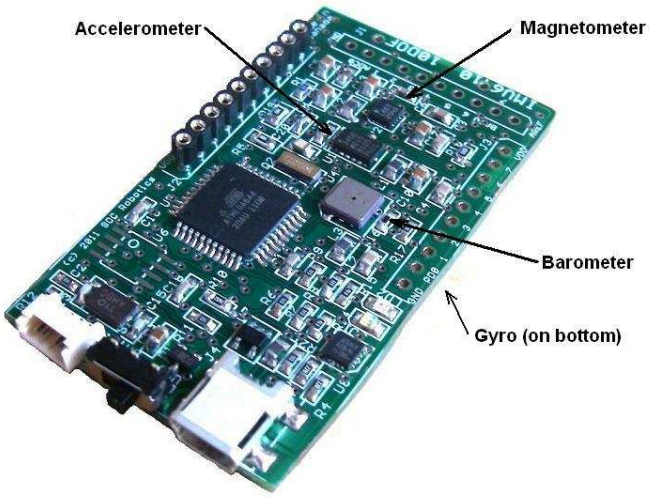
+-16G, +-2000 dps, +-8Gauss, 350-700hPa

IMU6410-9
IMU6410-10

Hardware Reference Guide

PCB Rev 1.0

IMU6410 Sensors



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1935A–08/00/5M

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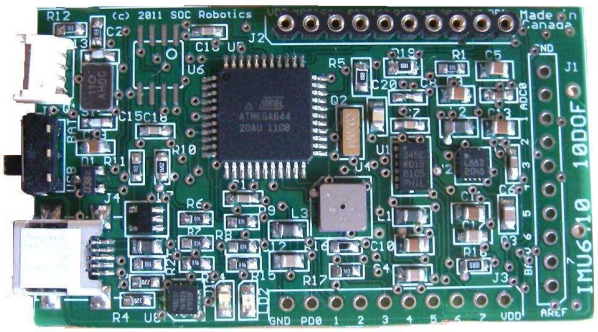
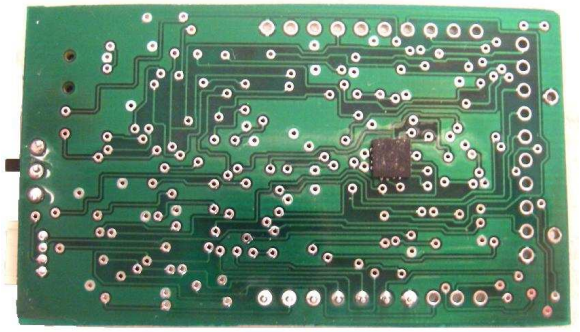
Introduction





Features:

- 8bit RISC AVR Processor (ATmega1284P)
- 11.0592MHz External crystal oscillator
- 4 Sensors integrated onto one PCB
- 3-Axis Accelerometer +-16G
- 3-Axis Rate Gyro 250/500/2000 deg/sec
- 3-Axis Magnetometer eight ranges from 0.88 – 8.1 gauss
- Barometer with 8m accuracy and 0.8m sensitivity
- All digital sensors – no analog interface required
- 8ch 10 bit A/D
- 15 Digital IO
- SPI Port
- TWI I2C Port
- 128K Internal Program Flash
- 4K EEPROM, 16K SRAM
- USB 2.0 Interface
- 1M or 8Mbyte External Serial Flash
- ISP Programming Port
- 32.756KHz External Clock crystal
- GNU C Compiler, Third Party Commercial C Compiler
- 3-3.3V DC operation
- Small form factor (1.34x2.34in) - 0.88in height with battery
- 9 DOF version available
- Sample programs included in IMU6410 Application Code
- Desktop Data Acquisition Device (DAD) for real time display

Hardware

The IMU6410 is an extremely compact embedded processor for mobile data acquisition, control and remote monitoring applications. The IMU6410 by default is shipped with an ATmega61284P processor. The ATmega61284P has the added benefit of being able to generate an interrupt on any pin transition (low to high or high to low). The processor has internal Flash, SRAM, EEPROM, SPI, TWI (I2C), UART, 8 channel 10bit A/D and general purpose IO. The IMU6410 has an internal 8MHz oscillator but is shipped with an external 11.0592MHz crystal. An external 32.756KHz crystal is also on the board to provide an accurate real time clock active during power down modes.

The IMU6410 consumes about 25ma in the active state (not including losses through the USB voltage regulator - not present with battery operation) and about 1.5ma in standby. By changing the internal clock and reducing power to certain peripherals it is possible for the IMU6410 to operate with very low power consumption. The IMU6410 is programming using an ISP Programming Adapter such as the ISP10 or via the Arduino Development Environment using the on chip Arduino bootloader.

The Rev 1.0 PCB has connectors J1, J2 and J3 on 0.1" pin spacing so prototype daughter cards can easily be attached to the top or bottom of the board making custom circuit design possible without the need for a custom PCB. An Eagle CAD layout template of the connectors to facilitate the development of custom circuits can be downloaded from the SOC Robotics web site.

The IMU6410 can be power via the USB port or by two double AA batteries (with the optional battery holder installed) with power source selected by a slide switch.

Software

The IMU6410 can be programmed with the Arduino Development Environment. An Arduino compatible bootloader is preloaded into the ATmega1284P's internal Flash. On power up the Arduino bootloader starts and runs for the first five seconds waiting for programming commands. If no commands are received the data logging application also loaded into flash starts automatically. Complete source code for the application and bootloader are provided. Currently the application program is written in C using the ImageCraft ICCAVR development environment. An Arduino version of the data logging application is underdevelopment and will be provided shortly.

The IMU6410 can also be programmed in C using either a GNU C Compiler, AVR Studio V4 or V5 or a third party IDE such as ICCAVR from ImageCraft. Check the SOC Robotics web site www.soc-robotics.com for program examples and ICCAVR project files. Example code is provided to read the accelerometer, communicate on the I2C port, how to use the UART and configure all the MEMs sensors.

Configurations

The IMU6410 is available in two different configurations – a 9DOF or 10DOF. The difference between the two is the installation of a barometric pressure sensor.

MEMs Configuration	Model Designation
9 DOF	IMU6410-9
10 DOF	IMU6410-10

Two different external flash configurations are available – 1Mx8 and 8Mx8. Configurations with Serial Flash have a choice of Flash size – see the table below. The default configuration is 1Mx8.

Flash Size (bytes)	Chip Designation
1M	AT45DB081D
8M	AT45DB642D

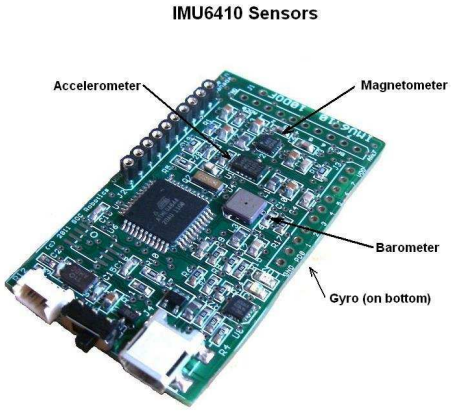
A double AA battery holder attaches to the bottom of the PCB. A power switch selects either USB 2.0 port power or battery power. Nominal operating voltage of the board is 3.080V. The battery holder is ordered separately.

A number of daughter cards are in the works the first of which is a microSD adapter that attaches to the top of the PCB. The microSD accepts various card sizes ranging from 1G to 16G (with suitable software drivers).

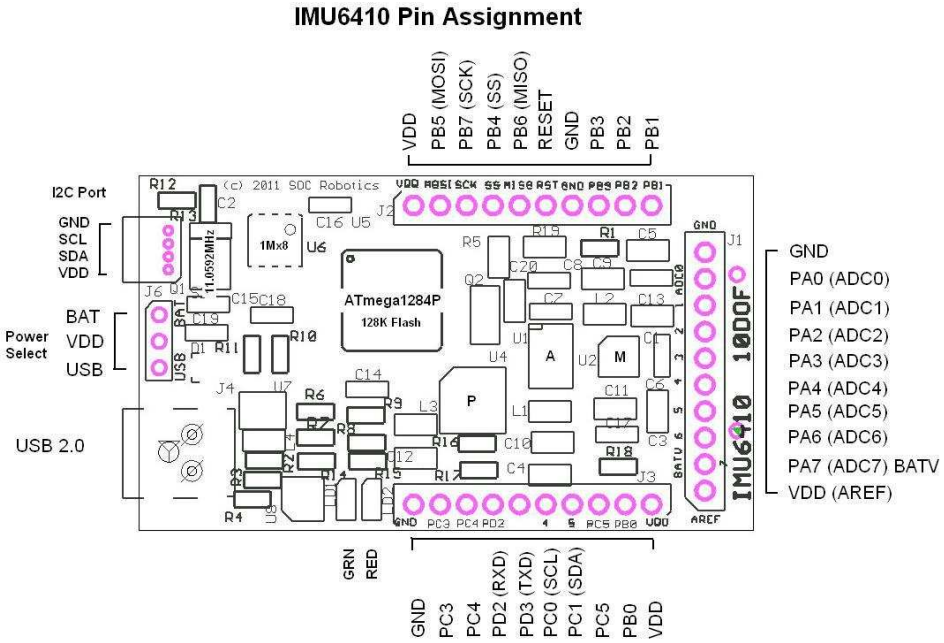
2.0 Feature Summary

2.1 Introduction

The IMU6410 is a 10 degree of freedom (DOF) all digital sensor that brings a new level of integration and sensing. The IMU6410 has a 3-axis accelerometer, 3-axis rate gyro, 3-axis magnetometer and a barometric pressure sensor. The accelerometer is the Analog Devices ADXL345 with several acceleration range settings with a maximum of +-16G and a sensitivity of 4mG. The rate gyro is the STMicroelectronics L3G4200D with three range settings of 250, 500 and 2000 deg/sec. The magnetometer is a Honeywell HMC5883 with eight range settings from 0.88Gauss to 8.1Gauss. The barometer is a Bosch BMP085 with an absolute accuracy of 8M and a sensitivity of 80cm.



The picture below shows the IMU6410 pin assignment. The accelerometer and rate gyro use an SPI interface while the magnetometer and barometer are I2C devices. Software to program and configure each of the four sensors is provided.



The IMU6410 has three expansion ports with a mix of digital IO and analog input.

1.2 Theory of Operation

Circuit Description

The IMU6410 uses sensors with digital interfaces so no A/D conversion interface logic is required. See the individual sensor datasheets for detailed operational and programming information.

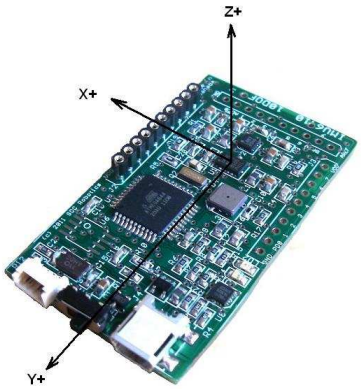
The Accelerometer and Rate Gyro have a high speed SPI interface. The Magnetometer and Barometric pressure sensor have an I2C interface. The IMU6410 is easily interfaced to other processors via the I2C and SPI interfaces.

The output from each sensor is in binary format and is easily converted to engineering units. The pressure sensor, however, requires a more sophisticated conversion formula and the source code for this conversion is provided in the sample application IMU6410 Datalogger V0.95 available for download from our web site.

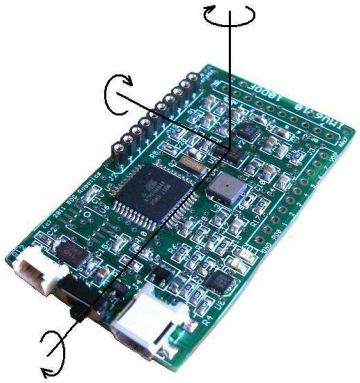
Polarity of Measurement

The IMU6410 outputs sensor data with 9 degrees of freedom. The pictures below show the output orientation of each sensor. The barometric pressure sensor is not affected by orientation.

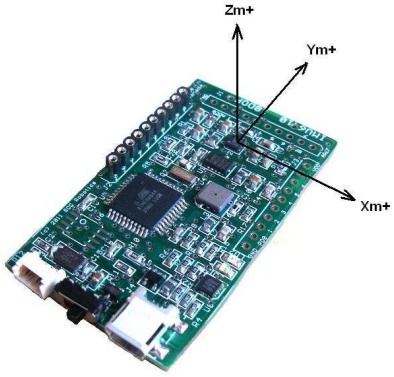
IMU6410 3-Axis Accelerometer Orientation +-16G



IMU6410 3-Axis Rate Gyro Orientation 2000dps



IMU6410 3-Axis Magnetometer Orientation +- 8Gauss



Calibration

Although each sensor has a digital interface sensor output may vary slightly due to sensor mounting skew – this should be taken into account before use.

1.3 Software Overview

A sample application IMU6410 DataLogger V0.95 ATmega1284P processor (with full source code) configures each of the sensors on the IMU6410 and outputs the sensor data to the USB port. This application can be downloaded from the SOC Robotics web site.

The IMU6410 DataLogger is a complete data logging application designed to simplify the setup and configuration of the sensors. The application was developed using ImageCraft's ICCAVR IDE. ICCAVR is available as a time limited free download. The application is being converted to AVR Studio 4 and the Arduino Development Environmant. Users can easily modify the source code to add additional functions such as AHRS or additional processing tasks. The Data Logger application requires approximately half of the available program flash leaving plenty of room for custom enhancements.

A desktop GUI application called DAD is under development and should be released in late 2011. DAD is a graphical real time display application that shows sensor data in graphical form on the desktop. The application relies on a small real time kernel executing on the ATmega1284P processor that communicates via the USB channel. Sensor data is sampled at a user defined data rate.

A Kalman Filter sensor fusion application is under development with a local university research team. More information about this application is available upon request.

1.4 MEMs Specifications

The IMU6410 uses the STMicroelectronics L3G4200D digital 3-axis rate gyro, the Analog Devices ADXL345 3-axis accelerometer, Honeywell HMC5883 3-axis magnetometer and the Bosch BMP085 barometric pressure sensor. Several of the sensors also include an on chip temperature sensor.

Accelerometer Specifications

Parameter	Value
Power Source	3.0V-+0.3VDC
Temperature Range	-20 to +80 deg C
Resolution	4mG
Gain	2,4,8,16g
Rate Range	-+100 deg/sec
Interface	SPI
Frequency Response	200Hz (90 deg delay)
Power Consumption	140uA

Rate Gyro Specifications

Parameter	Value
Power Source	3.0V-+0.6VDC
Temperature Range	-20 to +80 deg C
Resolution	8.7/17/70mdps
Gain	3 settings
Rate Range	250/500/2000dps
Interface	SPI
Frequency Response	200Hz (90 deg delay)
Power Consumption	2.9ma

Magnetometer Specifications

Parameter	Value
Power Source	3.0V-+0.3VDC
Temperature Range	-20 to +80 deg C
Resolution	5mGauss
Gain	8 settings
Rate Range	0.88,1.3,8.1Gauss
Interface	I2C
Frequency Response	200Hz (90 deg delay)
Power Consumption	2.9ma

Barometer Specifications

Parameter	Value
Power Source	3.0V-+0.3VDC
Temperature Range	-20 to +80 deg C
Resolution	0.01hPa (0.00041psi)
Gain	8 settings
Rate Range	350-700hPa
Interface	I2C
Frequency Response	200Hz (90 deg delay)
Power Consumption	2.9ma

3.0 IMU6410 Detailed Description

3.1 Introduction

The IMU6410 is an extremely compact embedded processor for mobile data acquisition, control and monitoring applications. Programmed in C and powered by a coin cell the IMU6410 is an excellent embedded processor platform for small mobile applications.

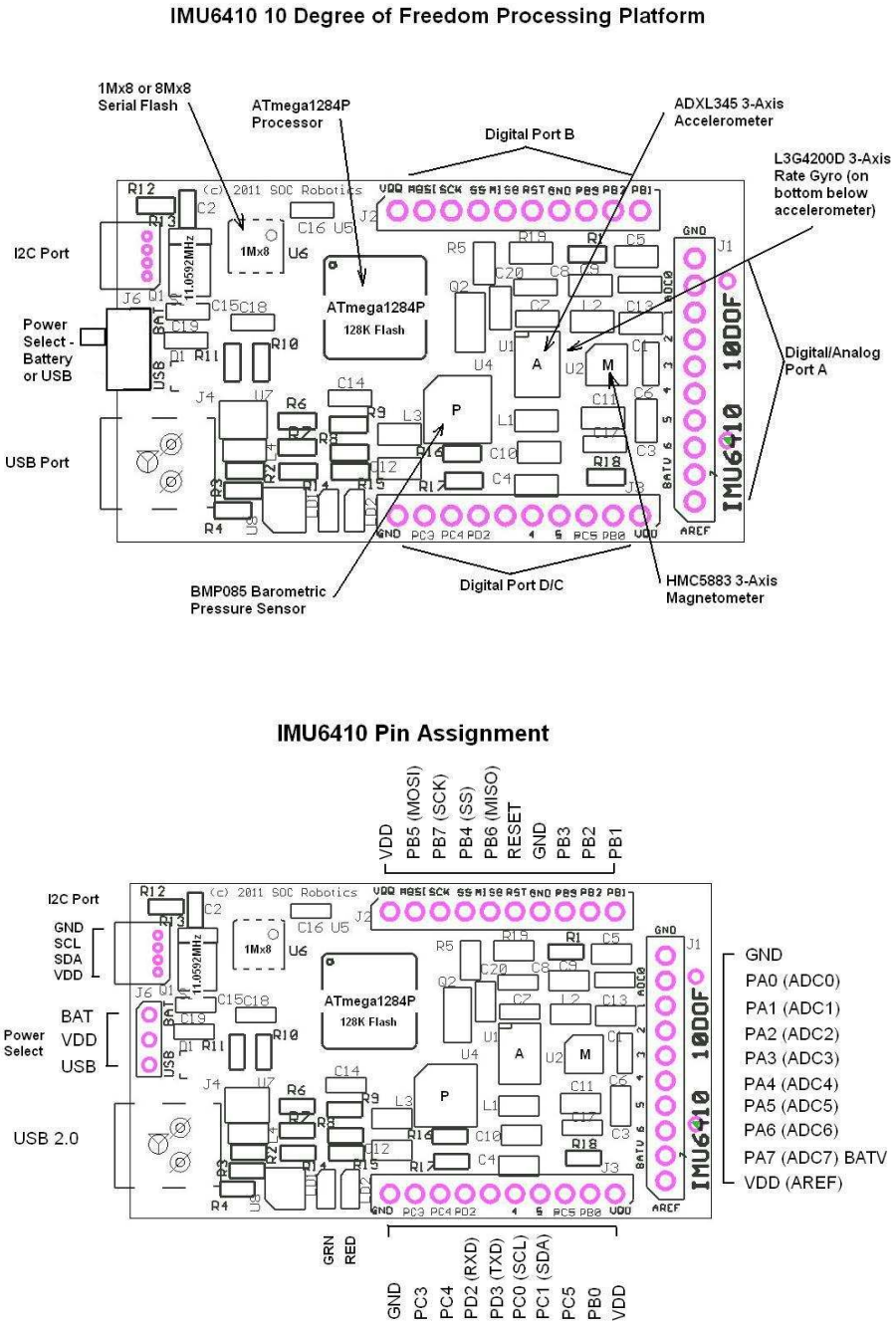


Figure 2-1. **Primary Components on top and bottom sides of PCB.**

3.2 Processor
The IMU6410 has an 8bit RISC AVR ATmega1284P processor. The processor has a UART, SPI port, TWI I2C, 8 Channel 10 bit A/D, digital IO ports, interrupts and timer/counter pins. A detailed device datasheet is available from the Atmel's web site providing detailed information on the internal peripherals.

The ATmega1284P has an external 11.0592MHz crystal and the board runs at 3.08V when powered by the USB port and 3.00 volts when powered by a battery pack.

Nominal power consumption of the board is 24ma. If internal peripherals are turned off and the processor placed in a sleep state power drops below 1ma.

3.3 Real Time Clock
A 32.756KHz clock crystal is connected to pins PC6/7 driving internal Timer 2. By setting up an interrupt routine on TIMER2 it is possible to create a time of day real time clock or to calibrate the internal 8MHz oscillator. The real time clock can be configured to wake the processor from a sleep state to reduce power consumption dramatically.

3.4 External Serial Flash
The IMU6410 has an ATDB45081D 1Mbyte external Serial Flash. The AVR communicates with the Serial Flash using the SPI lines. The IMU6410 is compatible with the AT45DB161 (2M), AT45DB321 (4M) and AT45DB642 (8M) so higher capacity Flash can be mounted in place of the AT45DB081D.

3.5 USB Port
The IMU6410 has a USB 2.0 port configured as a serial communication device. Baud rates up to 2Mbits/second are supported. The IMU6410 USB interface chip is the XR21V1410 chip.

3.6 TWI Port
The IMU6410 has a TWI I2C port for communicating with smart peripherals or other I2C peripherals. The TWI port uses a 4 pin Molex connector with power and ground so the IMU6410 can power other peripherals or be powered itself via this connector.

3.7 Expansion Ports
The IMU6410 has three expansion ports. PORTA, PORTB and PORTC - PORTA has analog inputs, digital IO, PORTB has SPI and PORTD has UART and TWI.

3.8 MEMs sensors
The IMU6410 uses the STMicroelectronics L3G4200D digital 3-axis rate gyro, the Analog Devices ADXL345 3-axis accelerometer, Honeywell HMC5883 3-axis magnetometer and the Bosch BMP085 barometric pressure sensor. See the respective vendor datasheets for detail specifications and programming information.

3.9 Battery Holder
The IMU6410 can be powered by an optional two AA batteries. Power from the USB Port or Battery is selected by a slide switch.

2.10 Programming
The ATmega1284P can be programmed using either the ISP programming port or via the USB interface using the on chip Arduino bootloader.

Arduino BootLoader

The ATmega1284P has an on chip Arduino compatible bootloader running at 38,400 baud. Arduino development software can be used to load new applications into the ATmega1284P. A data logging application is also programmed into the ATmega1284P. On power up the Arduino Bootloader starts first and waits for programming commands for the first 5 seconds after which the data logging application is started.

ISP Programming

The IMU6410 is programmed using an ISP10 Parallel Port programming adapter or any 10pin Atmel ISP compatible programming adapter. An optional CISP programming adapter is available that converts the IMU6410 7 pin ISP programming port into an Atmel compatible 10 pin ISP programming port. The CISP attaches to connector J2 located on the top edge of the board – attach as shown in the picture below.

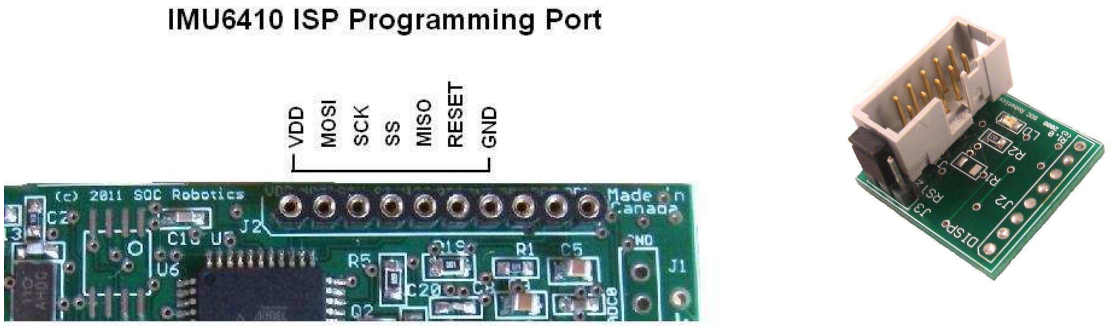


Figure 2-4. **CISP ISP Adapter and correct attachment to the IMU6410 .**

2.11 Molex Connector

The IMU6410 uses one small Molex picoBlade 4 pin connector with 1.25mm pin spacing (4 pin Molex Part No. 53048-0410 - Digikey Part No. WM1744-ND). The connectors mate with a female Molex 4 housing connector (4 pin housing Molex Part No. 51021-0400 - Digikey Part No. WM1722-ND).

The housing connector has two different crimp terminal types: 26-28AWG (Molex Part No. 50079-8000 - Digikey Part No. WM1722-ND – Crimp tool 63811-0300) and 28-32AWG (Molex Part No. 50058-8000 - Digikey Part No. WM1775-ND - Crimp tool 63811-0200).

2.12 Applications

The IMU6410 is a small, battery powered, low power, Inertial Measurement Unit with embedded processor with up to 8Mbytes of serial flash for storage of data measurement data, 8 10 bit analog input channels and up to 14 digital IO channels.

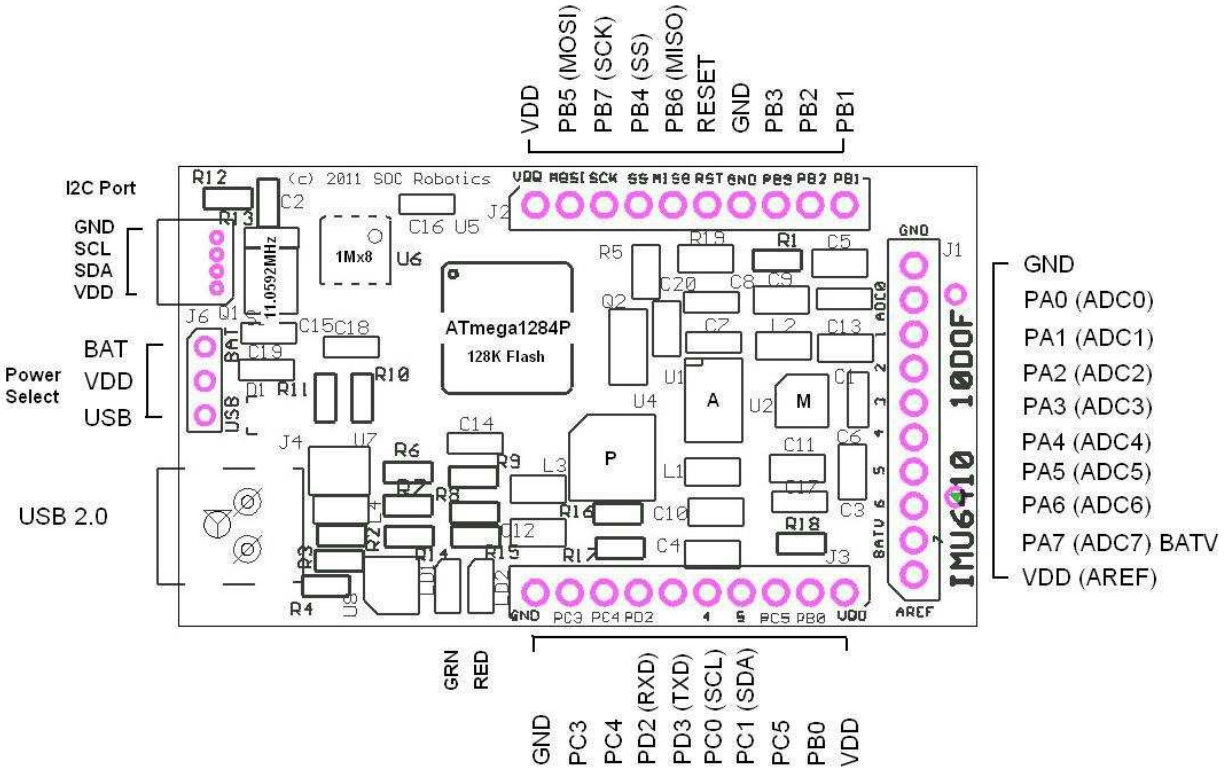
A sample data logging application is preloaded into the ATmega1284P processor and automatically configures all the MEMs sensors when activated. See the DataLogger V0.95 Application Note for more information.

4.0 IMU6410 Hardware Expansion Port Summary

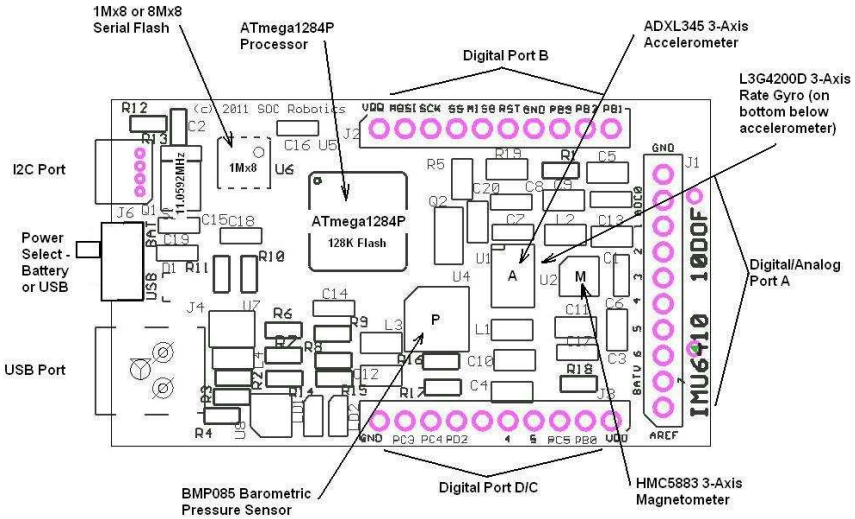
4.1 Introduction

The IMU6410 has three I/O expansion ports, a power port and I2C as shown in the connector layout diagram below.

IMU6410 Pin Assignment



IMU6410 10 Degree of Freedom Processing Platform



4.2 Expansion PORT A

AVR PORTA is routed to connector J1.

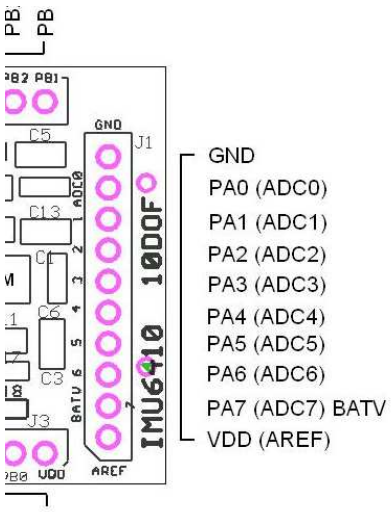


Figure 3-3. **PORTA Pin Assignment J1.**

Note that PA7 is connected to an on board resistive voltage divider network that can be used to measure battery voltage level by selecting either the 2.56 or 1.1 volt internal reference. The difference between the internal reference voltage and the measured voltage gives current battery voltage level.

Each PORTA pin can be configured either as an Analog input, digital output or digital input.

4.3 Expansion PORT B

AVR PORTB is routed to connector J2.

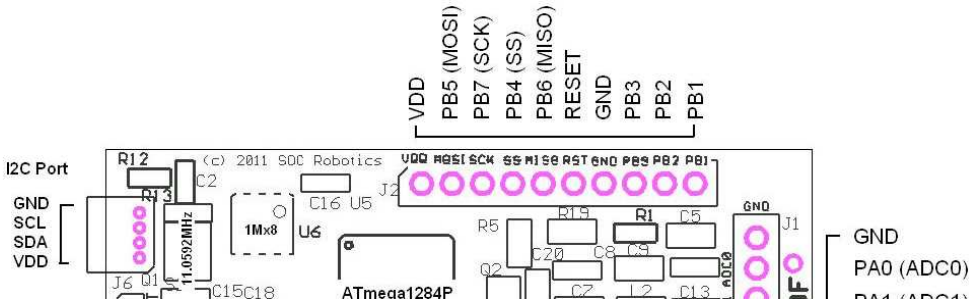


Figure 3-4. **PORTB Pin Assignment J2.**

Port B has an SPI port, general IO and is also the ISP programming port.

4.4 Expansion PORT B/C/D

Partial AVR PORTS B/C/D are routed to connector J3.

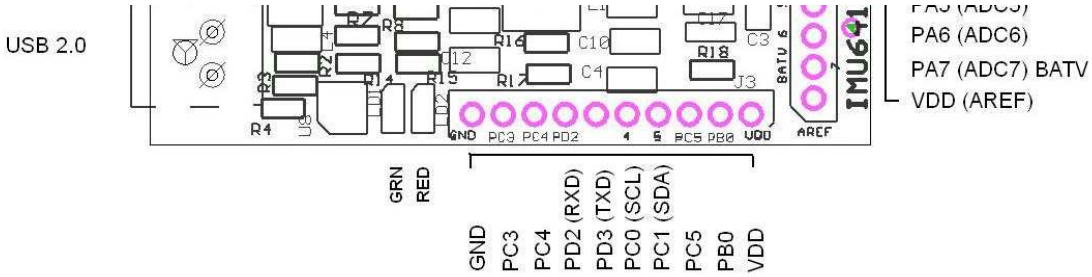


Figure 3-5. **PORTC/D/B Pin Assignment J3.**

Expansion Port J3 combines PORT pins from B, C and D. Note that PD2 and PD3 is USART1 RXD1 and TXD1 respectively. USART0 is connected to the on board USB interface chip and is not available.

4.5 TWI I2C Expansion Port

The TWI I2C lines are routed to connector J3 and a separate 4 pin Molex connector J5 (4 pin Molex picoBlade connector). J5 is compatible with the SOC Robotics Smart Peripheral family of motor controllers, LCD displays and data acquisition modules.

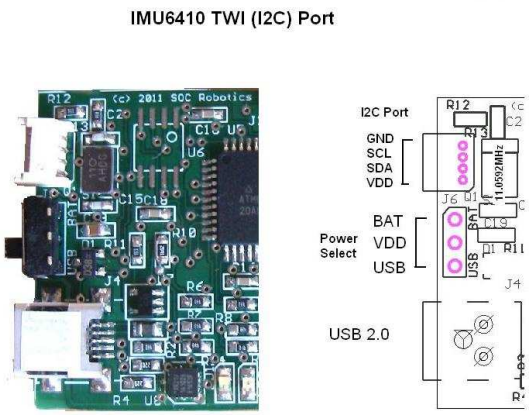


Figure 3-6. **TWI I2C Port with 4 Pin Molex picoBlade Connector.**

4.6 Board Power Connector and Battery Holder

IMU6410 power may range from 1.8 to 3.3VDC. Power is supplied either by the USB port or an optional battery pack. The USB port supplies 5V to the board that is regulated to 3.08V. The optional battery pack holds two AA batteries that supply a nominal 3.00V to the board. A switch selects either the battery pack or USB port as the primary power source. A protection diode on the USB power subsystems protects the USB logic. Power from the USB port and batter pack can not be applied at the same time.

Two standard AA batteries can power the IMU6410 at full operation for up to 8 hours.

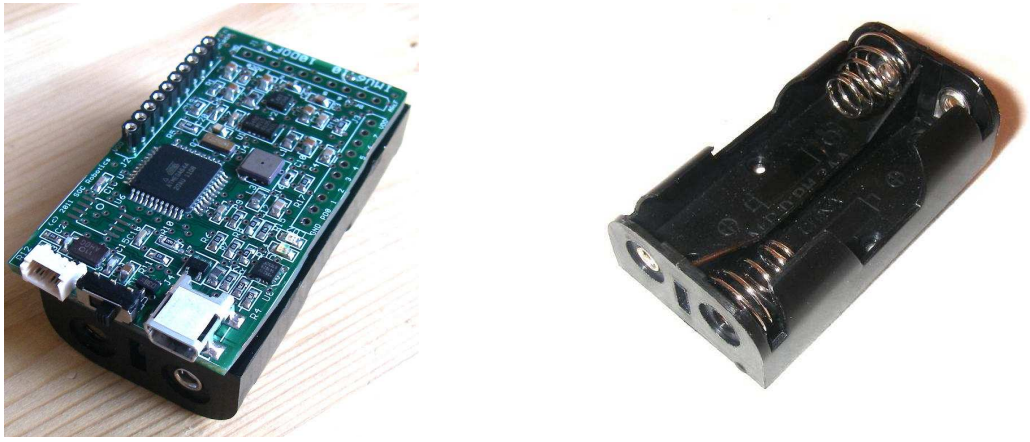


Figure 3-7. **IMU6410 attached to two AA battery cell holder shown on left.**

4.7 ISP Programming Port

The ISP Programming port is on connector J2. See the Atmel ISP programming specification for detailed ATmega1284Pprogramming procedures. The CISP converts the 7 pin ISP signals to a standard 10 pin Atmel ISP header. The ISP10 parallel port ISP programmer (Figure 3-9) is used to program the IMU6410 using anyone of the following software utilities - ISProg.exe (SOC Robotics, Inc utility), AVRDude, ICCAVR IDE or PonyProg. The USB10 can also be used to program the IMU6410.

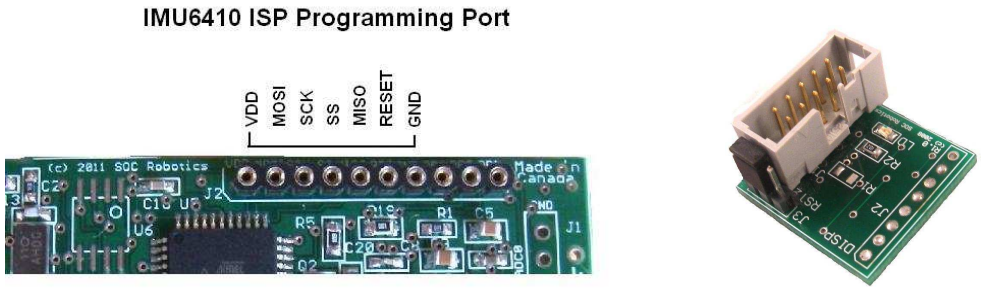


Figure 3-8. **ISP Programming Port and CISP Adapter Connection.**

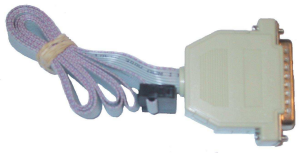
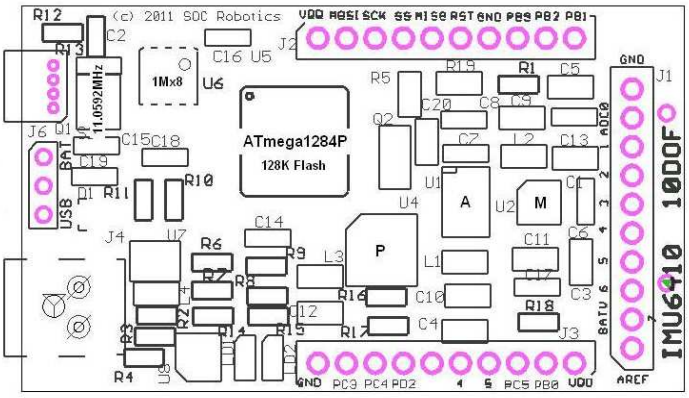


Figure 3-9. **ISP10 Parallel Port programming adapter.**

5.0 Electrical and Mechanical Description

5.1 Component Layout

Components are mounted on both sides of the board. Not all components may be mounted. See the section on optional components for more information.



5.2 Electrical Specifications

Electrical

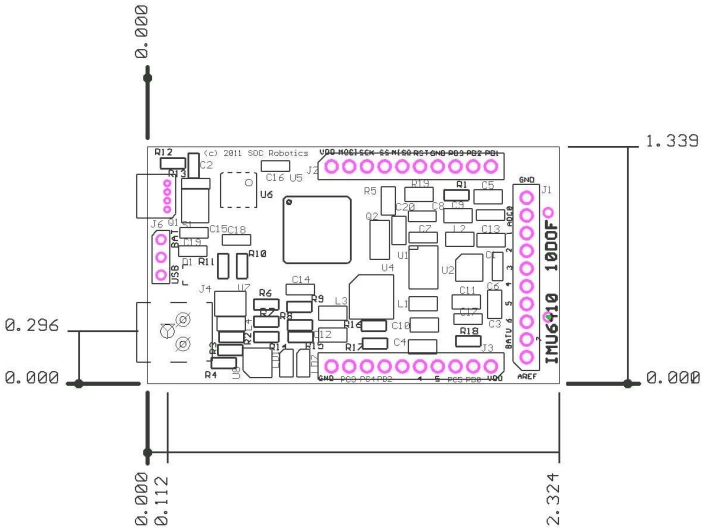
Input power: 1.8-3.3VDC @ 25ma
Sleep Mode: 1.5ma

Mechanical

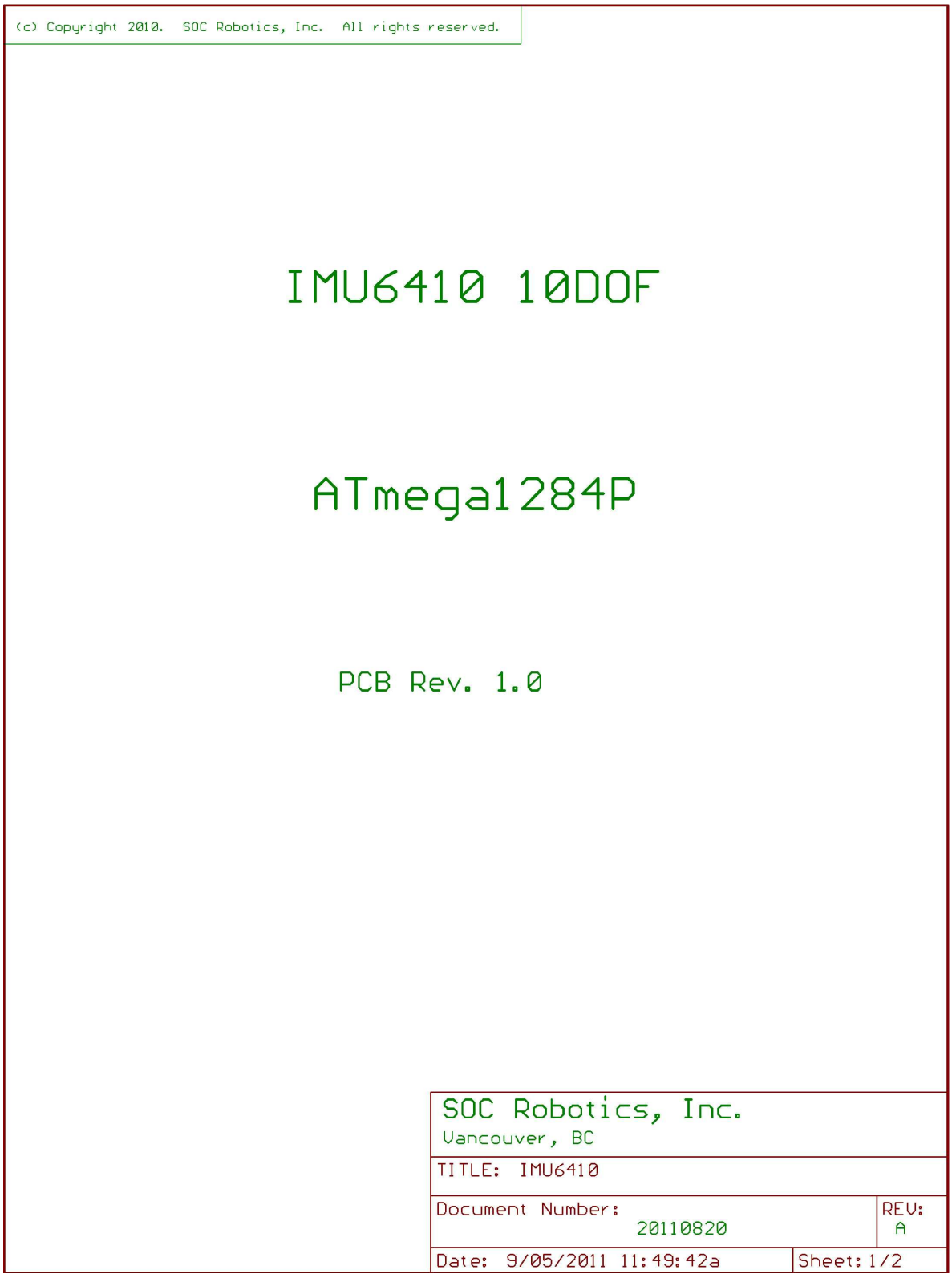
Dimensions: 1.34x2.34 in (one mounting hole)
Weight: 6 grams

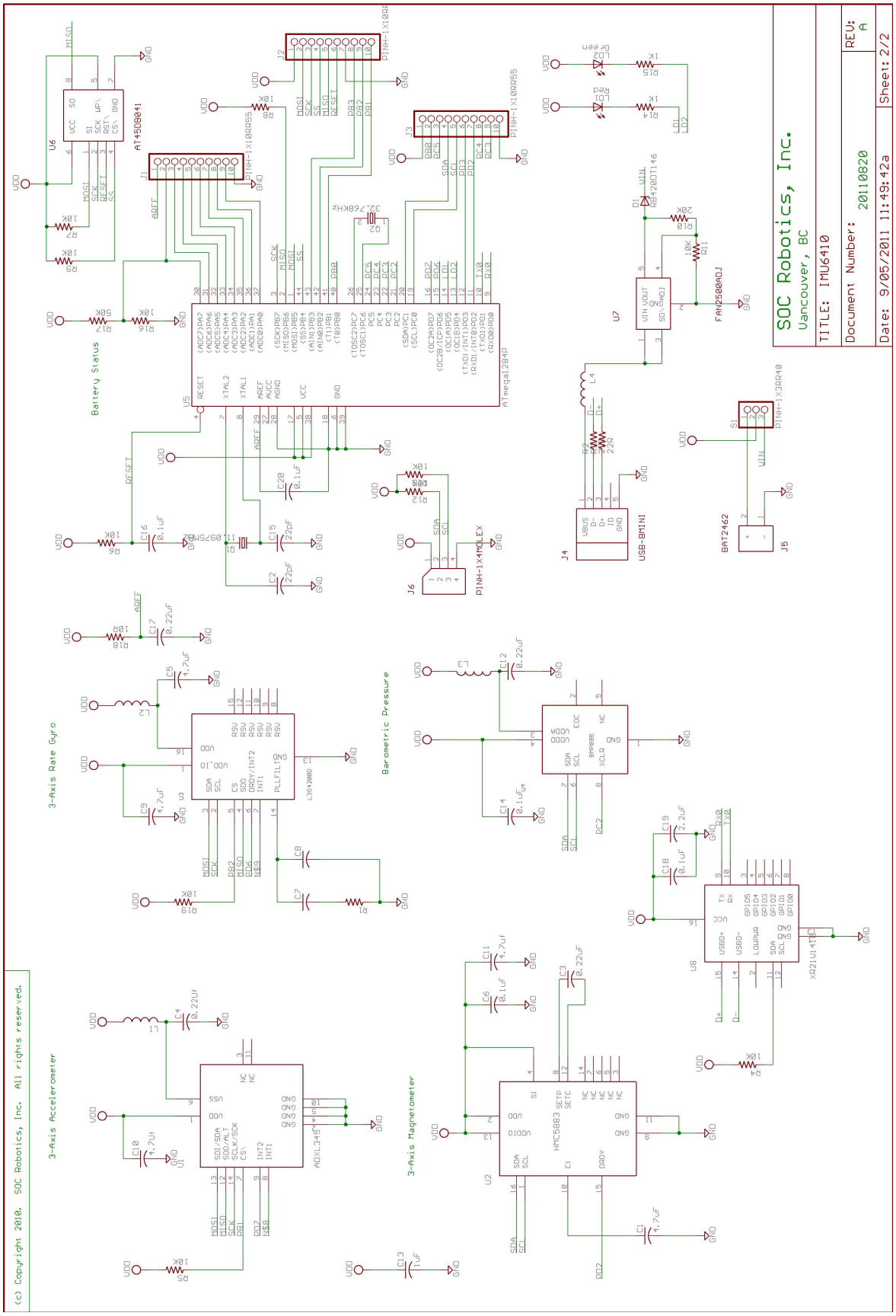
5.3 Mechanical Dimensions

Board dimensions are stated in inches. Connectors J1, J2 and J3 are positioned on 0.1″ pin spacing so the IMU6410 is easily mounted directly on any standard 0.1″ prototyping board.



6.0 IMU6410 Rev 1.0 Schematics

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Vancouver, BC
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Battery Status
3-Axis Rate Gyro
Barometric Pressure
3-Axis Accelerometer
3-Axis Magnetometer
ATmega128-16P
AT45DB041
USB-BMINI
FAN2500AOJ
BAT2462
XR21V1410
HMC5883
ADXL345
BMP085
L3G4200D
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Notes: