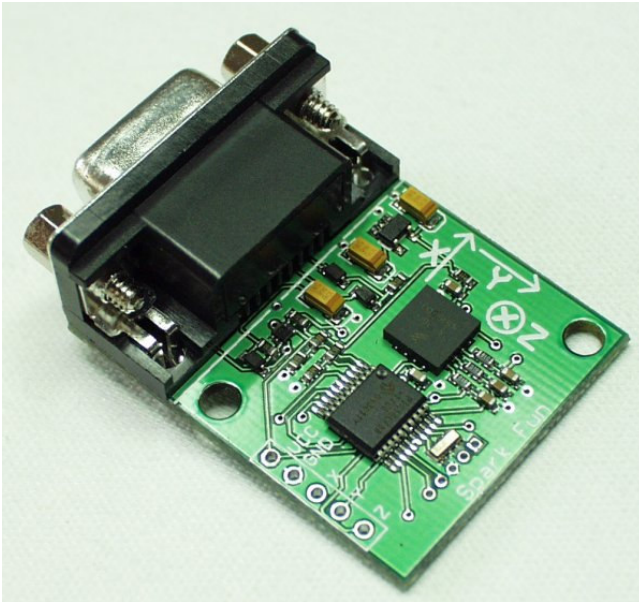




SerAccel v5

A Self Contained Triple-Axis Accelerometer

6/26/2005



1 Overview

The SerAccel v5 is a 3 axis accelerometer up to +/-6g with a serial interface. Power is gained from any RS232 port (including USB-to-RS232 converters) so no external power supply is needed. The onboard PIC (16LF88) runs at 10MHz and outputs three different types of outputs including calculated, binary, and raw outputs. The SerAccel v5 has software configurable settings to select between sensing ranges (+/- 1.5g, 2g, 4g, 6g), as well as a software selectable measurement frequency (0-

590Hz).

The SerAccel is a 'plug and go' device. It inserts into a DB9 male serial header and takes power from the RTS and DTR signals present on the serial lines. No external connections, other than the serial connection, are required for use. This allows for much 'freer' readings. How can you accurately track the vibrations of an 8 man Resolute racing shell in the middle of a river if you are looking for a wall outlet? All you need to get going with the SerAccel is a computer and a serial cable.

1.1 New Features on Version 5

The SerAccel v5 has many improvements over previous versions. The SerAccel now incorporates the newly released triple axis accelerometer from Freescale Semiconductor (formerly Motorola). This sensor uses the same MEMs techniques as in past SerAccel devices, with many added features such as range selection, low power sleep mode, and of course the MMA7260Q is the first readily available sensor to offer all three axis sensing on a single IC!

The SerAccel device itself had to be significantly changed to utilize this new sensor:

A low-voltage PIC 16LF88 running at 10MHz is used.

Serial communication is now done through RS232 conversion hardware instead of bit-banged firmware in past SerAccel models.

The new serial hardware allows the baud rate to be changed through the user interface. Users may choose from 9600bps to 57600bps.

Because the variable baud rate allows the unit to fall into a potentially unknown baud rate, a safety reset mechanism has been built into the firmware.

The new serial interface has allowed the return of the SFE boot loader.

A new sensor is used - the MMA7260Q. The MMA7260Q is the first of its kind to have sensitive outputs (800mV/g), multiple range selections, and the ability to sense all three axis in a single chip.

Because of the range selection, the firmware was changed to implement four detection ranges: +/-1.5g, +/-2g, +/-4g, and +/-6g.

2 Interface Specifications

2.1 How To Talk

All transmissions occur with 8 bits of data, 1 start bit, 1 stop bit, and no parity. The default baud rate is 9600bps.

The SerAccel is controlled using RS232 visible ASCII commands. This means that the SerAccel outputs and responds to actual ASCII characters within the terminal program. We use HyperTerminal provided with Windows, but your favorite terminal should work fine. Be sure to set the communication speed to 9600 8-N-1 and **disable** Flow Control. Plug the SerAccel onto the serial cable, open the port to provide power to the unit, and you will get calculated acceleration readings:

```
X=-0.983 Y= 1.227 Z=-0.007
X=-0.987 Y= 1.223 Z=-0.013
X=-0.984 Y= 1.229 Z=-0.013
...
```

If your SerAccel is outputting non-sensible values, it probably needs to be calibrated. (See the Section on Calibration). If you attached the unit, opened the power, and still get no response, double check that Flow Control has been turned off or set to **None**.

3 Configuration

The SerAccel has a very simple configuration system built in. To access it, press Ctrl-S (XOff, ASCII code 0x13) in the terminal window. You should see the following menu:

```
Shizzle Build 5.0 w/MMA7260Q
```

```
Configuration Menu:
```

```
[1] Calibrate
[2] Display Mode (Gravity)
[3] Output Frequency (50Hz)
[4] Sensor Range (+/-1.5g)
[5] Baud Rate (9600bps)
[x] Exit
```

```
:
```

To return to the general reading output, press **x**. To Calibrate the ADXL press **1**. To change the Display Options press **2**. To change the measurement frequency press **3**. To change the sensor range press **4**. To change the interface baud rate press **5**.

3.1 Calibration

The SerAccel ships with calibration values programmed within the on board non-volatile memory on the PIC16LF88. For greatest accuracy it is recommended the SerAccel be recalibrated upon arrival.

Pressing **1** from the Configuration Menu will start the calibration routine. Calibration is done using the force of gravity as a reference. You should see on screen commands to help you along:

```
Rotate on X Axis
Press return at Maximum
X=479
```

Rotate the SerAccel. You should see the various values increase or decrease. Turn the SerAccel so that the board is perpendicular to the earth's surface and the on-screen value is a maximum. Don't worry about getting the absolute maximum, the jitter the surrounding environment will prevent this from happening - the Calibration routine takes this into account. Press return when you are satisfied with the value. You will then be instructed to find the Minimum X. Repeat for the Y and Z axis

as well.

These calibration values are recorded to the non-volatile EEPROM on board the PIC microcontroller. Every time you plug in the SerAccel, these calibration values are read from memory and used within the main calculation routine. **You will not need to re-calibrate the SerAccel every time you turn it on.** Since the ADXL is sensitive to temperature variants, calibration is recommended in sensitive applications if the temperature changes more than 5 degrees Celsius (approx. 9 degrees Fahrenheit) since the previous calibration.

3.2 Display Modes

Pressing **2** from the Configuration Menu will open the Display Mode Options.

Change Display Mode to:

```
[1] Calculate Gravity Values
[2] Raw Values
[3] Binary Mode
[x] Exit
```

:

Pressing **x** will return you to the main menu. Selecting **1** will enable the calculated Gravity values. Selecting **2** will enable the Raw Output mode. Selecting **3** will enable the Binary Output mode.

3.2.1 Calculated Gravity Values

Example Calculate Gravity Values Output:

```
X=-0.589 Y=-0.101 Z= 0.820
X=-0.600 Y=-0.104 Z= 0.812
X=-0.582 Y=-0.091 Z= 0.812
...
```

The ADXL has the benefit of reading both Static Acceleration (Gravity) and Dynamic Acceleration (vibrations, movements, etc). As you tip

the SerAccel on one axis you should see the readings change for one direction. If the board is perpendicular to the earth's surface, you should see approximately +/-1.000 because earth's 1 gravity is pulling on the accelerometer. If your SerAccel is not doing this correctly, it probably needs to be calibrated (see the Section on Calibration).

3.2.2 Raw Values

The SerAccel also has the feature of 'Raw Values' output. In Raw Output mode, the SerAccel will output the raw timer values (for the PWM version) or raw analog to digital conversion values (for the Analog output version). This can be beneficial if you are going to be doing the computations on the host computer.

Example Raw Output:

```
X=0x01A2 Y=0x0255 Z=0x0340
X=0x01A6 Y=0x0252 Z=0x033B
X=0x01A9 Y=0x0252 Z=0x033C
...
```

3.2.3 Binary Mode

The SerAccel has a new 'Binary Mode' feature. In Binary mode, the SerAccel will act very differently. Once attached to a computer, the SerAccel in Binary mode will broadcast the 'Ready' string (**#R\$**) and wait for one of three commands from the host:

- 1) **Ready:** Sending a capital 'R' character (**0x52**) at any time will cause the SerAccel to respond with the 'Ready' string: **#R\$** once it has completed all current measurements.
- 2) **Abort:** Sending an 'A' character (**0x41**) will cause the SerAccel to stop any data output and respond with the 'Ready' string: **#R\$**
- 3) **Start:** Sending an 'S' character (**0x53**) will cause the SerAccel to respond with the 'Ready' string (**#R\$**) and then begin to transmit the following data string:

The *Sample Number* increases with every output and will roll-over at 65535. The *X*, *Y*, and *Z Axis* are in 16 bit binary form. They are numbers directly returned from the analog-to-digital conversion.

Binary Output Format	
Byte	Description
0	Start Character - always #
1	Data Output Designator - always @
2	Sample Number High Byte
3	Sample Number Low Byte
4	X Axis High Byte
5	X Axis Low Byte
6	Y Axis High Byte
7	Y Axis Low Byte
8	Z Axis High Byte
9	Z Axis Low Byte
10	End Character - always \$

3.3 Output Frequency

Pressing **3** from the Configuration Menu will open the Change Display Frequency Menu.

```
Change Display Frequency:
[+] Increase
[-] Decrease
[x] Exit
: = 100Hz
```

Pressing **x** will return you to the main menu. Pressing **+** will increase the frequency, **-** will decrease the frequency. The maximum frequency is different for the three types of output and is also significantly effected by the interface baud rate. The maximum frequencies at the fastest interface (57600bps) are as follows:

- Calculated Gravity output = 125Hz
- Raw output = 195Hz

- Binary output = 595Hz

The default shipped value is 100Hz.

3.4 Sensor Range

The new MMA7260Q has the added benefit of having software selectable ranges. The SerAccel firmware allows the user to select between the four different ranges.

Pressing **4** from the Configuration menu will open the Sensor Range Menu.

```
Change Range Mode to:
[1] 1.5g range
[2] 2g range
[3] 4g range
[4] 6g range
[x] Exit
:
```

Each range is positive and negative. That is to say, the 2g range can sense a maximum of +2g in the forward direction and -2g in the reverse direction.

By selecting a lower range (+/-1.5g for example), the resolution will increase. This means the sensor will be able to report the difference between 0.007mg and 0.015mg. Choosing a higher range (like 6g) will allow for higher acceleration readings without saturating the ADC. You can view what these means by shaking the accelerometer and watching the output peg at a certain value. You cannot damage the sensor by forcefully shaking it (don't drop it!) but the sensor *will* plateau, reporting a maximum value. If you are in the 1.5g range, the maximum value will be just over 1.5g. If you are in the 6g range, the maximum reported value will be just over 6g.

3.5 Baud Rate Selection

The SerAccel v5 uses onboard RS232 conversion hardware allowing the PIC to use its onboard UART which can be reconfigured via firm-

SerAccel v5

ware. Pressing **5** from the Configuration menu will open the Baud Rate selection menu:

Change Baud Rate to:

- [1] 9600bps
- [2] 19200bps
- [3] 38400bps
- [4] 57600bps
- [x] Exit

:

Once a new baud rate has been chosen, the following message will be displayed:

Please Detach SerAccel, Adjust Port Settings, and Re-Attach SerAccel

The SerAccel must be powered down and the terminal program must be reconfigured to the new baud rate. The port can then be re-opened powering the SerAccel and communication will begin at the new baud rate.

The faster the baud rate, the higher the maximum measurement output frequency. This is because the PIC spends most of the time outputting ASCII characters. The binary output at 57600bps is the fastest output format.

3.5.1 Emergency Baud Reset

Because the SerAccel has the ability to use a few different baud rates, it is entirely possible to configure the system to an unknown state. In the past, the only way to recover the system was to try many different combinations of baud rates in hopes of reestablishing communication. Now there is a better way!

Upon powering up the SerAccel v5, the unit will go into 9600bps mode for 100ms and scan for a single control character - ctrl+'t' or **0x14**. If this character is received (at 9600bps) the unit will reset to 9600bps interface, and report the following:

Baud rate reset to 9600bps - Please power cycle SerAccel

This message will be repeated until the unit is pow-

ered down. The SerAccel baud rate will be 9600bps upon the next power up.

If you've configured the SerAccel into an unknown baud rate, open Hyperterminal and close the port - this will power down the SerAccel. Configure the port to 9600bps with 8-N-1 settings. Hyperterminal will automatically open the port when a character is received. Thus, all you need to do is hold the control key, and press the 't' key a few times. This will open the port (powering up the SerAccel) and will send the ctrl+'t' command to the SerAccel. You should receive the 'Baud rate reset' statement - the unit is now reset to 9600bps!

If the ctrl+'t' command is sent at any other baud rate, or if the command is not received in the first 100ms after power up, the unit will boot as normal, loading all previous configuration settings (baud rate, range, output format, and output frequency) from non-volatile memory.

4 Precision and Accuracy

4.1 ADCs and the MMA7260Q

The MMA7260Q has a 800mV per gravity swing when powered by 3.3V and 1.65V output at 0g detection. The PIC 16LF88 was chosen as the controller because it has both an onboard 10-bit A/D converter as well as the ability to set the A/D reference points. Vref+ has been set to 2.85V. Vref- has been set to 0.45V. This grants a 2.4V window divided into 1024 parts (10-bit resolution).

$$2.4V / 1024 = 2.34mV \text{ resolution}$$

If 1 gravity is seen over 800mV, the SerAccel version 5, in +/-1.5g mode, can effectively detect

$$1g/800mV * 2.34mV/1 \text{ bit} = 2.925mg/1 \text{ bit}$$

The MMA7260Q has been shown to accurately measure within ±6mg in 1.5g range.

If 1 gravity is seen over 200mV, the SerAccel version 5, in +/-6g mode, can effectively detect

$$1g/200mV * 2.34mV/1 \text{ bit} = 11.7mg/1 \text{ bit}$$

The MMA7260Q has been shown to accurately measure within ±12mg over the full 6g range.

5 Hardware Layout

5.1 Physical Dimensions

The SerAccel Dongle version is 1.25" by 1.75" (4.5cm by 3.2cm) with a maximum depth of 0.60" (1.5cm). The SerAccel uses a double sided PCB with surface mount components on the top side only. Two mounting holes are available - spacing 0.775x0.970". Weight: 14g.

The SerAccel Enclosed version is 2.2"x1.75"x0.96" with approximately 6' serial cable protruding from one end of the enclosure. Weight: 86g including cable.



5.2 Power Connection

Power is regulated by a Low-Noise, Low Drop Out Voltage Regulator. The regulator provides power from the DTS and RTS signals from the serial connection. This is limited by a 100 resistor (33mA) to protect the computer in case of a short on the SerAccel. Current noise on the board (Vcc-GND) has been measured to be ~40mV.

5.3 ICSP Port

The In Circuit Serial Programming (ICSP) port is used to program the PIC in-circuit. Any of the popular Olimex Programmers (PG1, PG2C, PG3B, and MCP) are capable of loading new firm-

ware onto the SerAccel in combination with a 5-Pin polarized Molex Connector.

5.4 External Interface Port

A five pin .1" footprint is built into the board. This header is label with power connections and the three accelerometer axis. The SerAccel v5 can be externally powered with 3.3V and analog readings can be taken directly off the three axis.

6 Firmware

The firmware for the PIC 16LF88 was re-written to incorporate the new features associated with the MMA7260Q. The new firmware runs at 10MHz +/-0.50%. Because the SerAccel v5 uses a true RS232 interface, the SerAccel can be boot loaded quickly and easily with custom firmware revisions. If you have any recommendations or requests, please let us know. We are happy to help customers with code revisions for their particular application. The current version of the SerAccel firmware can be found at www.sparkfun.com.