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Special Sensor Report

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Special Sensors

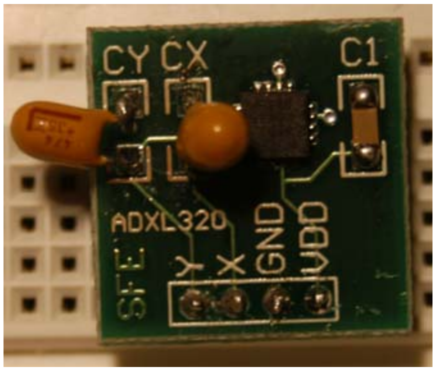
Accelerometer

Introduction

Accelerometer is a device that measure acceleration forces related to the Earth's gravity. The accelerometer used in this project is ADXL 320 from Analog Devices. The ADXL 320 is capable of measuring acceleration force from -5 g to +5 g over two parallel axes, X and Y. Moreover, it can measure both dynamic acceleration (vibration) and static acceleration (gravity). The sensor provides two analog outputs for x-axis and y-axis. I'm using accelerometer to measure the tilt of the helicopter so that the adjustment can be made to the rotor blades.

Specification

The sensor has been obtained from Sparkfun.com fully assembled. I don't want to assemble the sensor myself because of the very small and thin chip package, LFCSP. I would be next to impossible to solder it onto the PCB.



The input voltage of the sensor is in a wide range from 2.4V to 5.25V. For this project, I am using regulated 5V as a supply. The sensor also required a power supply decoupling to reduce the noise from power line. Sparkfun fixed the value of this capacitor, C1, to .1uF. Also, the ADXL320 required two low-pass capacitors, one for each axis. I have chosen 0.47uF for Cx and Cy. The capacitor will bypass everything over 10Hz. The very low pass helps reduce the sensitivity of the sensor for dynamic acceleration. This is good since I will be using the sensor for tilt sensing, static acceleration. The datasheet for the sensor can be downloaded from Analog Device at http://www.analog.com/UploadedFiles/Data_Sheets/84033828ADXL320_0.pdf.

Integration

The sensor will be integrated to the system by attaching it directly to the helicopter. The alignment of the board and helicopter is critical since an off-alignment will result in a wrong readout. A/D will be used to read the value from the output ports of the sensor. The output of voltage of the sensor ranges from 0V to 5V. With the sensor sits parallel to the ground, both outputs should read 2.5V. The A/D values will then be used to adjust servos for pitch and roll of the helicopter using PID.

Problem

The problem that I am having with this sensor which halted the project is that the sensor also measures vibration. Therefore, the output from the sensor also contains the vibration signal which overlay the tilt signal. In order to fix this problem, I have tried putting a moving average on the captured data. This helps reduce the swing in the waveform. Figure A1 shows the captured values of the accelerometer **without** the engine running. The inner texts show what the helicopter is doing relative to the ground.

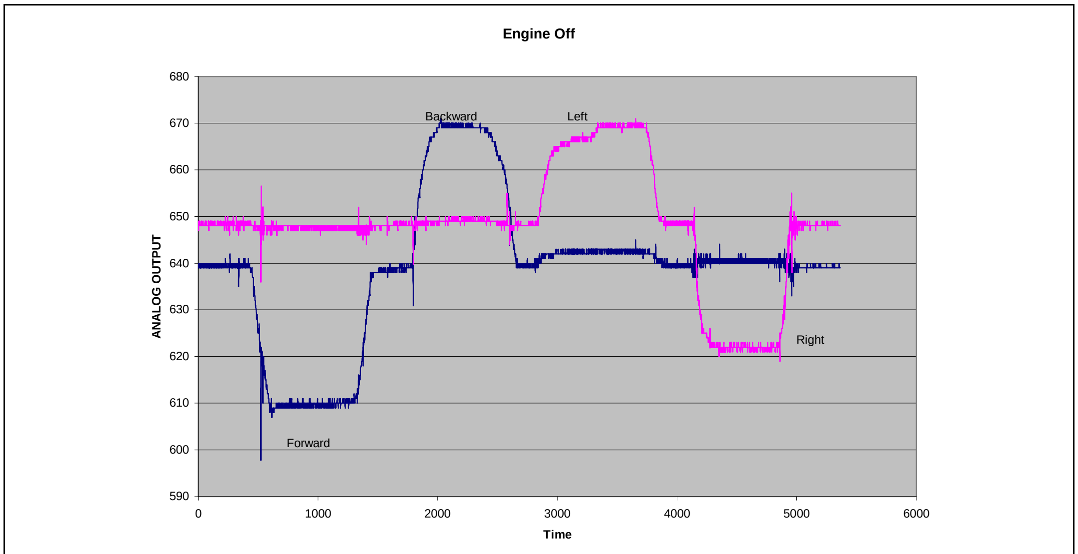


Figure A1 – Accelerometer Output – Engine Off – Partial Average

Each data points on the graph is taken with ten sample average. Figure A2 shows the captured values of the accelerometer **with** the engine running.

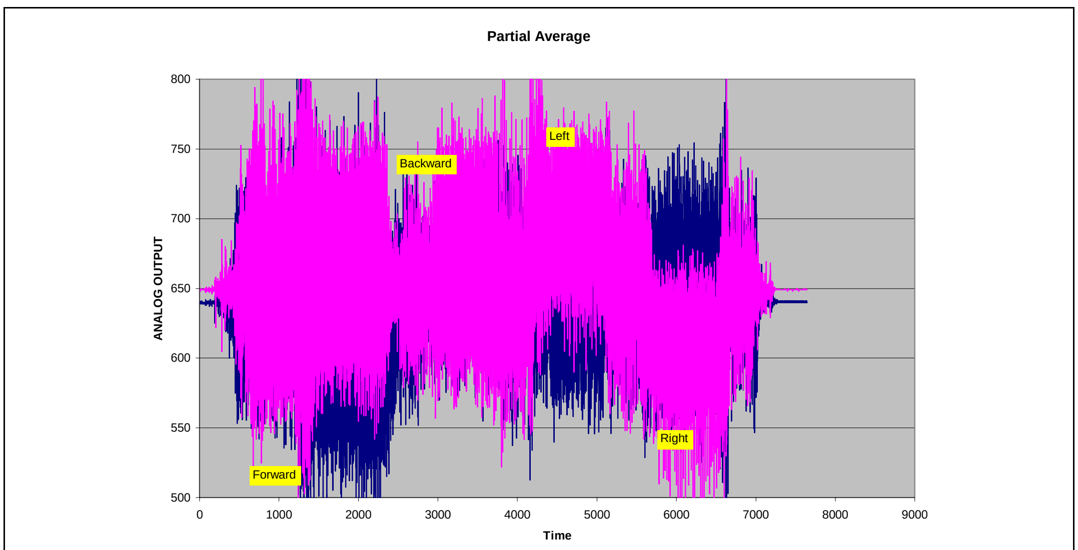


Figure A2 – Accelerometer Output – Engine On – Partial Average

After exploring for solution, I found that people add a moving average to the captured data. The moving average is done as follow:

$$Current = get(A/D)$$
$$x = \frac{Previous + Current}{2}$$
$$Previous = x$$

Figure A3 shows the result of the A/D using moving average.

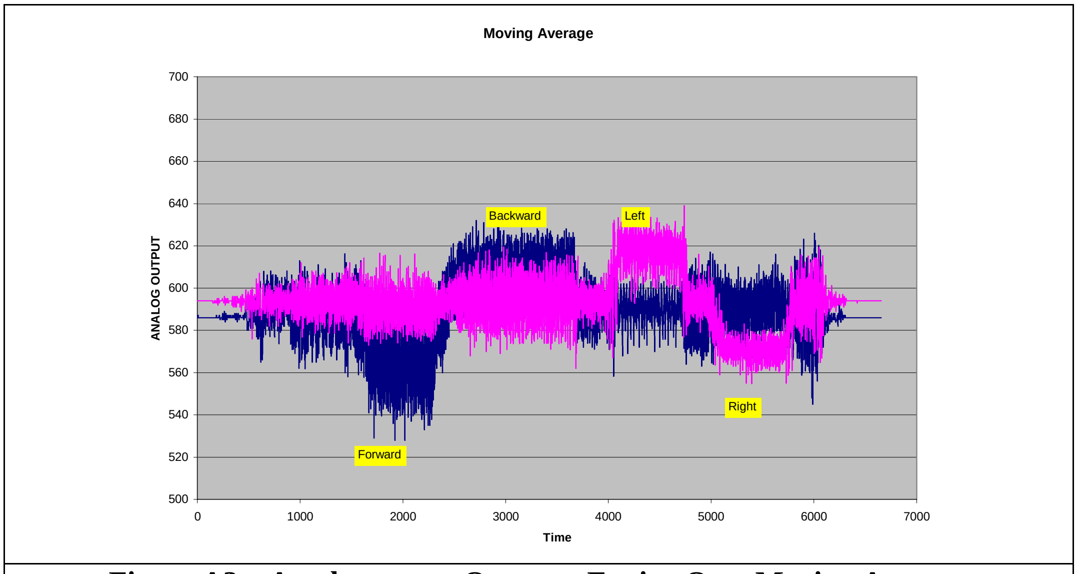


Figure A3 – Accelerometer Output – Engine On – Moving Average

By using moving average on the captured data, the swing in the signal reduced dramatically. However, this is still not good enough for the stabilization of the helicopter. I then changed the filter capacitor on the accelerometer board from 0.027uF that bypass samples above 200Hz to 0.47uF that bypass samples above 10Hz. The result is shown in Figure A4 which is a great improvement to the previous figure.

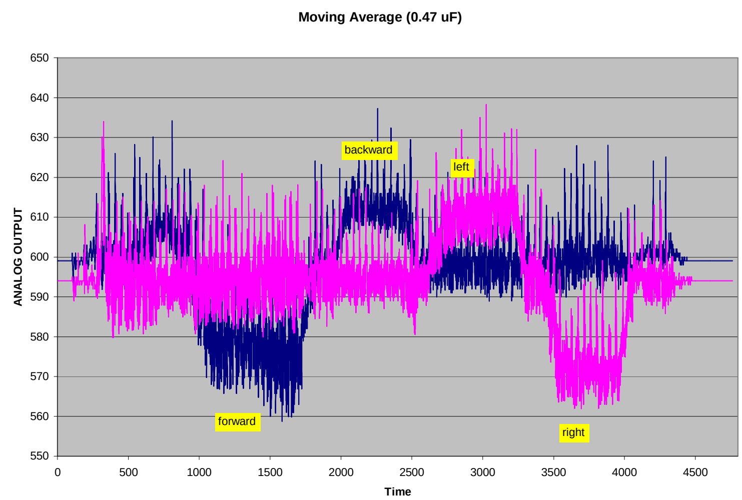


Figure A4 – Accelerometer Output – Engine On – Moving Average – 0.47uF Cap

I’m trying to achieve the result as close to Figure A1 as much as possible, and this is where PID comes in. I’m still experimenting on the PID on the sensor, and therefore I will not be able to present you the detail on the PID in this report.

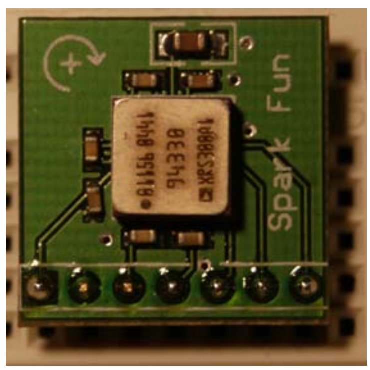
Gyroscope

Introduction

The gyroscope is used to sense the rate of turn per second. I'm using Analog Devices, ADXRS 300 gyroscope which can measure up to 300 degree/sec. The sensor has an analog output that can be read with A/D of the Atmega-128 processor. It will give out 2.5V output when the sensor is not turning. This sensor is very easy to use and integrated into the system. A fully assembled board has been purchased from Sparkfun with the same reason as the accelerometer board.

Specification

The ADXRS300 sensor from Analog Devices is a single axis angular rate sensor. It also provides a built-in temperature with it. The output from both sensors is in analog and can be use with the A/D of Atmega-128 directly to read the values. The datasheet of the device can be obtained from Analog Device at http://www.analog.com/UploadedFiles/Data_Sheets/732884779ADXRS300_b.pdf.



Integration

The sensor will be used to control the stabilizing tail-rotor of the helicopter. For example, if the helicopter starts turning when it supposed to go straight, the uP will adjust the tail-rotor's speed to stop the rotation on the z-axis of the helicopter.

Problem

There has been no problem using this sensor. Output and response time work pretty good for my application.

References

Analog Devices Datasheets:
http://www.analog.com/UploadedFiles/Data_Sheets/732884779ADXRS300_b.pdf
http://www.analog.com/UploadedFiles/Data_Sheets/84033828ADXL320_0.pdf

PID Tutorial, Carnegie Mellon University
http://www.engin.umich.edu/group/ctm/PID/PID.html