Collection and Recording of Data For the Study and Improvement of Sky Diving and Formation forming

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Abstract

When skydiving the ability to record data of the jump is essential when jumping in formation. With the use of inertial measurement units (IMU) it is possible to gain a better understanding of the technique used and improve on form. With the use of sensing equipment such as ; Magnetometer, accelerometer, gyroscope it is possible to get accurate results of pitch, yaw and roll. The choice of a good micro-controller will determine the over all efficiency. Storing this data and being able to access it either between jumps or after a day of jumping is essential. Making this easy for the user to attain will be looked at in the form of SD cards and direct link. Blue-tooth will also be discussed. Making the device energy efficient and possibilities of scavenging energy from wind and sun will be discussed. During the project, the price of materials will be in the forefront of thought, ensuring that a good price to efficiency ratio will be met.

Contents

Chapter 1

Hardware Selection and Design

Choosing the correct hardware will define the overall practicality of the project. Several factors have to be taken into consideration when selecting hardware such as functionality, connections, power consumption and size with many more. These will be discussed in detail and compared to other products with indication why they were chosen over them. What storage is used for the device and the format in which it is stored in will be discussed Both prototyping and final design will be discussed in separate stages to provide a structured design to the final product. The three main sensing components that will be used will be a gyroscope, accelerometer and a magnetometer. Using all three allows for greater results. When combined together the accelerometer and gyroscope will work with each other to provide the pitch and roll. To receive the yaw result the manometer will be used.

1.1 Breakout Board Prototype

For the prototyping breakout board will be used. By creating the prototype using breakout boards it is possible to have a more practical and faster way to make the product. It will also be good to study the way that they are put together to then efficiently create the final product. A great advantage of using break out for the prototyping is that they include any resistors or capacitors that may be needed to reduce noise on the device. This will be considered when creating the final design, hopefully based on some ideas that the break out boards provide.

1.1.1 Micro-controller

The micro-controller is chosen due to the sensors that are needed. Available EEPROM memory is taken in to account to store system files. The micro controller that will be used for the prototype is PIC16F818.

- 128 bytes of EEPROM data memory
- 2 to 5.5 voltage
- i^2c

1.1.2 Gyroscope i^2c connector

The gyroscope that will be used in the prototype will be the Triple-Axis Digital-Output Gyro ITG-3200 breakout board. By using the inter-integrated This particular model has been chosen due to the completeness of the device and it flexible power consumption rate.

- voltage range of 2.1V to 3.6V
- Fast Mode I^2C (400kHz) serial interface

1.1.3 Accelerometer i^2c connector

The triple axis MMA8452Q break out board will be sourced for the prototype. One of the great features of this particular device is the ability to stay in low power mode until told otherwise. This will save power and can be incorporated with possibly another embedded device such as the barometer or a simple switch to swap between power modes.

- 2g/4g/8g dynamically selectable full-scale
- I2C digital output interface
- 1.6 V to 3.6 V interface voltage

1.1.4 Magnetometer i^2c connector

Triple Axis Magnetometer Breakout - MAG3110 will be sourced for the magnetometer. This particular board comes with its own voltage regulator opposed to its main competitor, HMC5883L, which does not. This allows for a wider spectrum of voltage control .

- 1.95V to 3.6V Supply Voltage
- 7-bit I2C address = 0x0E

1.1.5 Barometer i^2c connector

Barometric Pressure Sensor - BMP180 Breakout will be used to measure pressure. This will be used to measure the altitude of the device.

- Digital two wire (IC, TWI, "Wire")
- Ultra-low power consumption - Flexible supply voltage range (1.8V to 3.6V)

1.1.6 SD Card Reader

SD cards are non volatile storage. This allows information to be stored even when the device is not under direct power. The ability to remove the storage device will allow the user to retrieve the data collected and upgrade the devices storage. The component used for prototyping will be Breakout Board for microSD Transflash. This product will also be sourced out for the final design. To

1.1.7 Power

The aim goal for the power is small and rechargeable. With this in mind the ANSMANN 3.7V Wire lead terminal has been chosen.

- 3.7v nominal
- 2250mAh
- Lithium-Ion

1.2 Final Product Specification

1.2.1 Micro-controller

The micro controller that will be used for the prototype is PIC16F818. This is the same micro controller that was used in the prototype. For its capabilities and its price it seem the most efficient. With having 128Bytes EEPROM memory it is possible to store the code for the device on here. It will then export the information that is collected straight of the micro sd card ready for the user to transport to a computer for retrieval. The micro-controller also has bi-directional I/O ports which allow for multiple $I2^C$ connections. It allows for selectable selectable frequencies, including 31.25 kHz, 125 kHz,250 kHz, 500 kHz, 1 MHz, 2 MHz, 4 MHz and 8 MHz from the RC oscillator. This will enable the ability to select the most efficient frequency and will save power usage.

- 128 bytes of EEPROM data memory
- 2 to 5.5 voltage
- i^2c

Amount	Price W/O VAT	Price
1	1.58	1.90
10	1.33	1.60
100	1.22	1.46

1.2.2 Gyroscope and Accelerometer

STMICROELECTRONICS - LSM330DLC functionas as both gyroscope and accelerometer. As opposed to the prototype model this unit contains both. The advantage of this is the connections used will be less. It is also by far and large the cheapest that has been sought out and works well with the voltages needed and the micro controller. It does not have any extra features such as stand by mode or a sleep mode. Is supported by a 1^2C connector.

- 2.4 - 3.6 voltage
- Gyroscope - 250/s, 500/s, 2000/s
- Accelerometer - 2g, 4g, 8g, 16g
- SMT surface mount

- Triple axis both

Amount	Price W/O VAT	Price
1	4.69	5.63
10	3.81	4.75
100	3.28	3.94

1.2.3 Magnetometer

MEMSIC - MMC3280MS magnetometer has been selected. This particular device takes readings from the X, Y, and the Z axis as measured data. Being connected to the micro-processor directly from the i^2C bus, it eliminates the need for any A/D converters. Running at

- $accuracy^2$ min = +-2.0 / max +- 5.0 degrees
- voltage 1.6 - 3.7 volts. Typical 1.6
- -8/+8 gauss
- SMT surface mount

Amount	Price W/O VAT	Price with VAT
1	6.90	8.28
10	5.30	6.36
100	4.32	5.18

1.2.4 Barometer

MEMS-LPS331AP has been chosen. Due to its ability to operate at -40 degrees this particular model is better than some other that were looked at that would not operate below 0 degrees. It has a operating voltage of around 1.7 volts which matched nicely with the other sensing components. With both SPI and $I2^C$ I/O, makes it extremely practical for the micro-controller used. Its ability to work to 35,000 feet means that it has plenty of operating space for this product, which has been designed with 10,000 feet in mind.

- 1.71 V to 3.6 V
- Operating temperature -40 - +85 degrees
- 260 to 1260 mbar absolute pressure range

Amount	Price W/O VAT	Price with VAT
1	-	3.21
10	-	2.58
100	-	2.29

1.2.5 Power

ANSMANN 3.7V Wire lead terminal type has been chosen. As used in the prototype, Having researched further into the price and size this battery is most suitable. The advantages of lithium ion mean that this particular battery meqans that it will not need prolonged priming when bought One normal charge will suffice. This will help with sales of the device at the jump centres as they can be used when purchased.

- 3.7v nominal
- 2250mAh
- Lithium-Ion

Amount	Price W/O VAT	Price with VAT
1	-	16.96
20	-	15.94

Power Requirements

To work out the amount of power required and justify the correct choice of cell/battery the calculation seen in 1.1 will be used to convert microamp to micro amp hours. By doing this on each sensor and micro controller it is possible to get a better understanding of what batter is needed.

$$10^{-6} \times \mu Ah \times 60 \times 60 \tag{1.1}$$

The results for each were as follows;

- Micro-controller - 0.313 μAh
- Gyroscope and accelerometer 0.061 - μAh
- Magnetometer - 1.98 μAh
- Barometer 0.108 - μAh

1.2.6 Notification

To notify the user of the current state of the product a single LED will be used, TruOpto High Intensity LED White. The benefits using one LED will be shown in the state diagram. When the device is on the LED will show a solid color. When the device is recording data it will flash at periodic intervals. As the data is not transferred from the device, but rather through the medium of a removable SD card, there is no need to indicate to the user if the device is transferring. Solid color = on, flashing light = recording. This also allows the device not to have a LED constantly on. If the flash was to be every 5 seconds, on a days worth of jumping this would save battery life.

Amount	Price W/O VAT	Price with VAT
1	0.476	0.572
10	0.368	0.266
100	0.256	0.307

1.3 Description and Diagram of the Interconnections

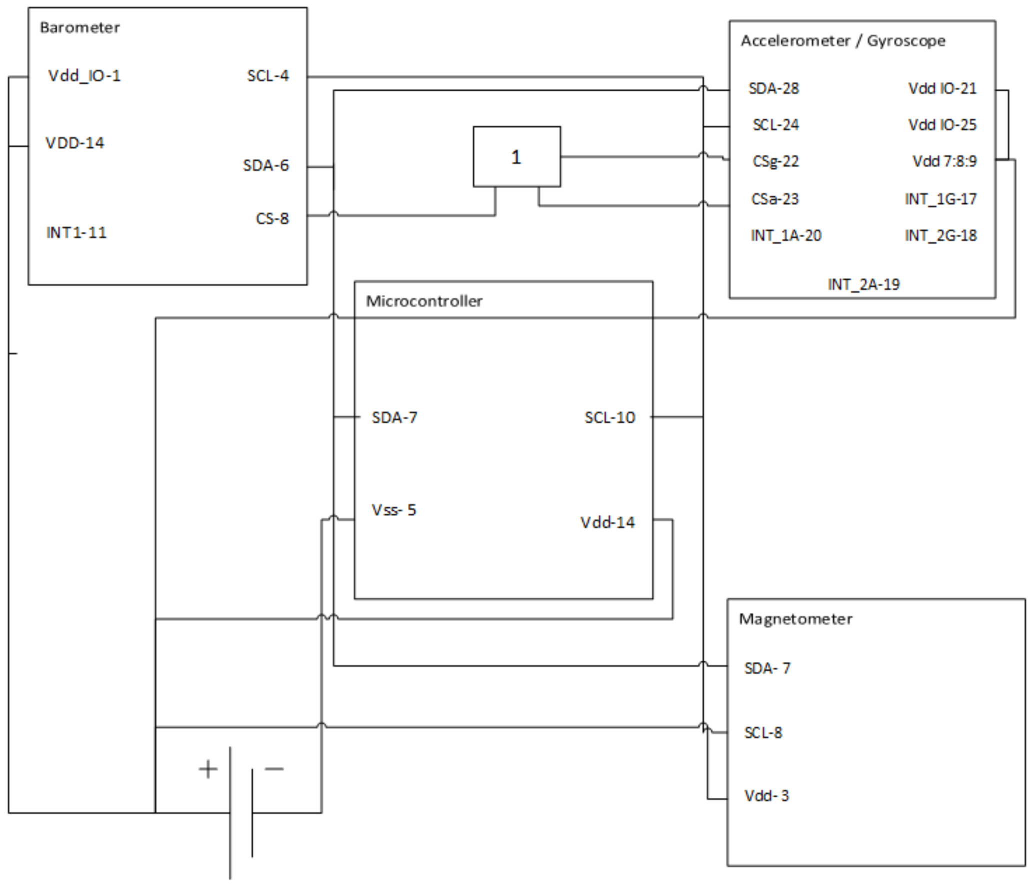

Figure 1.1: Diagram of the interconnections

1.3.1 Reasons of Choice

The reasons in choice for the type of serial bus was down to the flexibility and available parts. Building the project with $I2^C$ in mind allowed for a more straight forward approach in connecting to the micro-controller.

Chapter 2

Control Algorithm and Software

Bibliography

[1] exas Instruments, High speed CMOS logic analog multiplexers/demultiplexers, 74HC4051 datasheet, Nov. 1997 [Revised Sept. 2002].