EE 318
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VARIOMETER

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Abstract

The variation of atmospheric pressure with height is the main principle underlying the working of our instrument. This principle is used to measure height with respect to a reference point and which in turn is used to calculate the rate of ascent/descent of the body to which the Variometer is attached.

Introduction

Although human beings could readily detect abrupt changes in vertical speed, their senses do not allow them to distinguish lift from sink, or strong lift from weak lift. The actual climb/sink rate could not even be gauged.

During daylight, the solar rays heat the earth's surface which in turn heats up the air close to it. As hot air has low density it starts to rise up. This is called a thermal.
Para glider pilots use this rising thermal to gain height. The speed can be of the order of 1-5 m/s, however it may reach up to 15m/s. With the help of these thermals they can go up to the height of 10000-12000ft. When a para glider enters into a thermal he is lifted up.

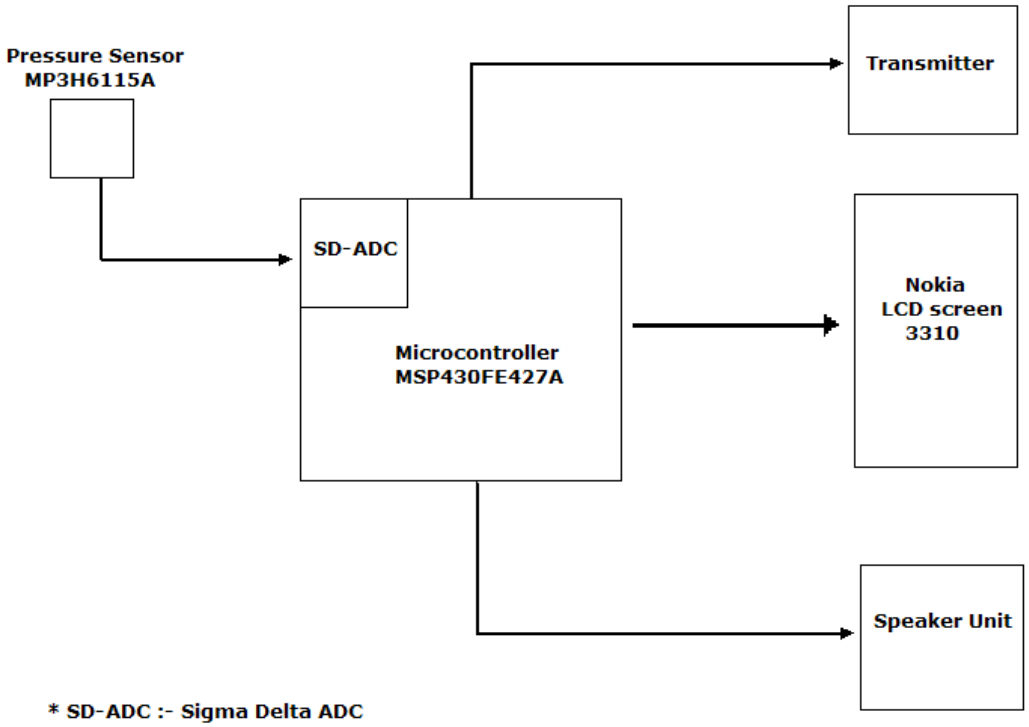
The invention of the variometer (by Max Kronfeld) moved the sport of gliding into a whole new realm.

Variometer measures the rate of change of altitude by detecting the change in static pressure as altitude changes.

Design Approach

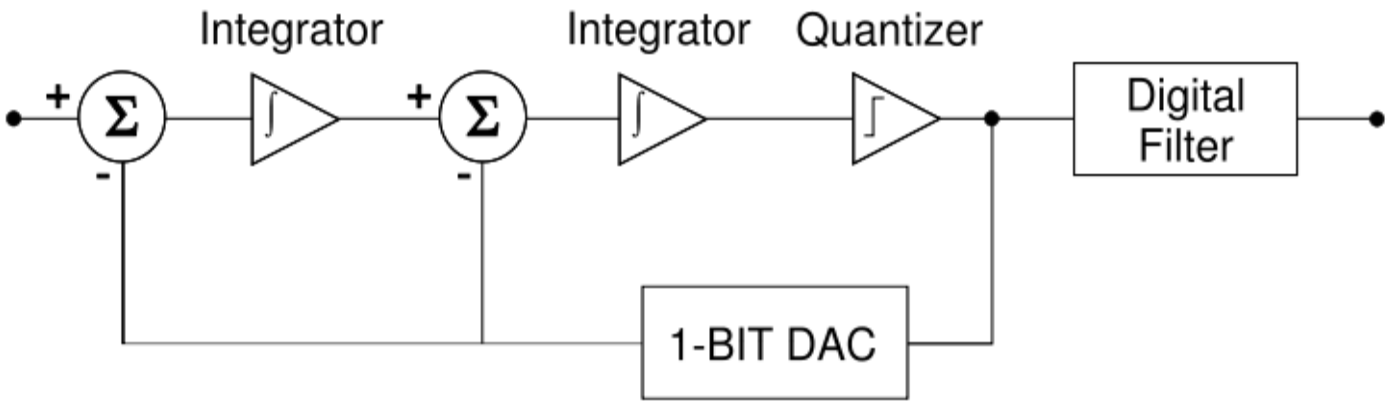
The basic and the foremost objective was to implement a complete product which is accurate, portable, user-friendly but at an affordable price. Though there were constraints that include the following:-
Output from the pressure sensor has a noise in frequency of 1/f type. Also as height increases, the rate of change of pressure with altitude decreases and there are small changes in altitude before increasingly difficult to detect.

Block Diagram



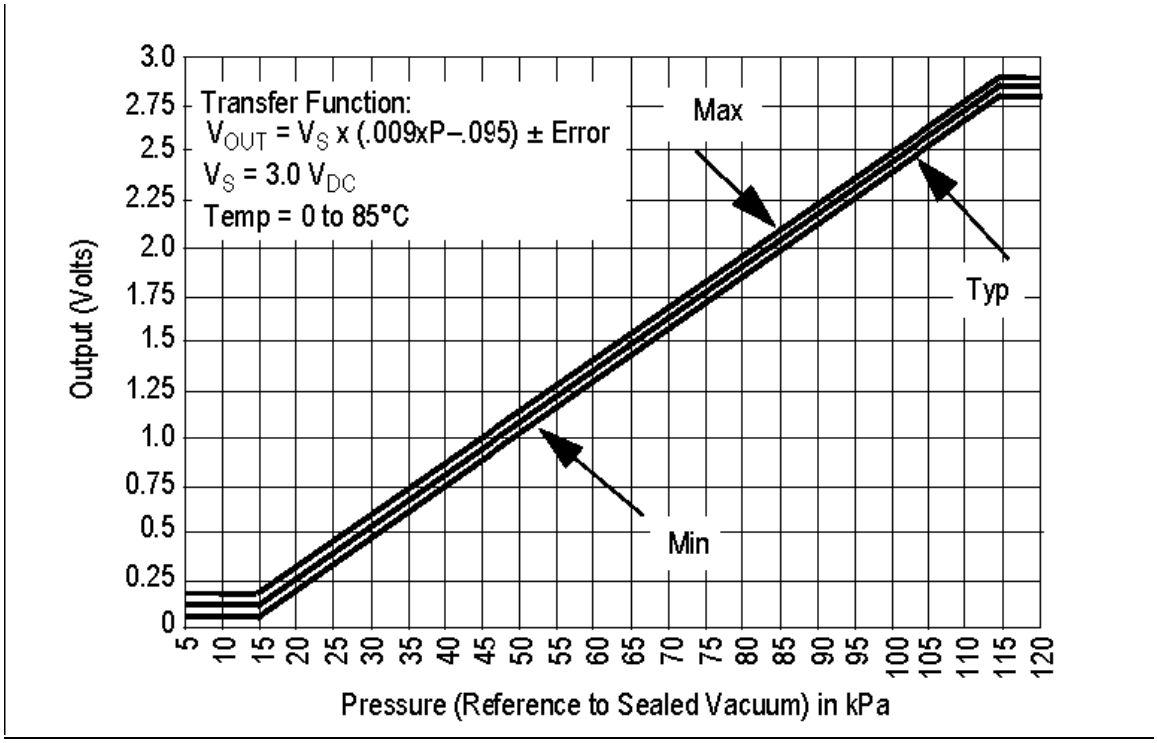
Components

- Microprocessor
  MSP430427FEA from T.I. was used as the microprocessor for its following characteristics:-
  1. It had an inbuilt Sigma Delta ADC. A **Sigma-Delta** over samples the desired signal by a large factor and filters the desired signal band. Generally a smaller number of bits than required are converted using a Flash ADC after the Filter. The resulting signal, along with the error generated by the discrete levels of the Flash, is fed back and subtracted from the input to the filter. This negative feedback has the effect of noise shaping the error due to the Flash so that it does not appear in the desired signal frequencies. A digital filter (decimation filter) follows the ADC which reduces the sampling rate, filters off unwanted noise signal and increases the resolution of the output.



2. It also has an USART for interfacing with the RF unit.
3. It is also a low power micro controller.

- Pressure Sensor
  MP3H6115A, pressure sensor from freescale was used, which has a voltage rating of 3.3 volts. Following is its variation with pressure:-



This graph shows that a voltage variation of .25 volts to 2.75 volts over a pressure range of 15 kPa to 115kPa. Although, it seems theoretically possible to measure great heights, many constraints prevent us from achieving this.

The advantage of using pressure sensor of 3.3 volts rating is that we are able to avoid using voltage boosters which would otherwise be needed to amplify voltage from 3.3 volts to 5 volts, thus reducing noise. However, using a pressure sensor with lower voltage rating leads to the problem of lower voltage difference due to pressure change.

- Display Unit
  The Nokia 3310 LCD screen has been chosen because of the following features:
  1. Low Power Consumption
  2. Supply Range: 2.7–3.3V and hence compatible with the microcontroller power supply.

- Power Supply
  We used a Li-Ion battery (rechargeable battery) to power the unit. It supplies a voltage of about 3.78 volts. The microprocessor, the LCD and the pressure sensor requires a voltage of 3.3volts. This is generated by a LDO - TPS73330.

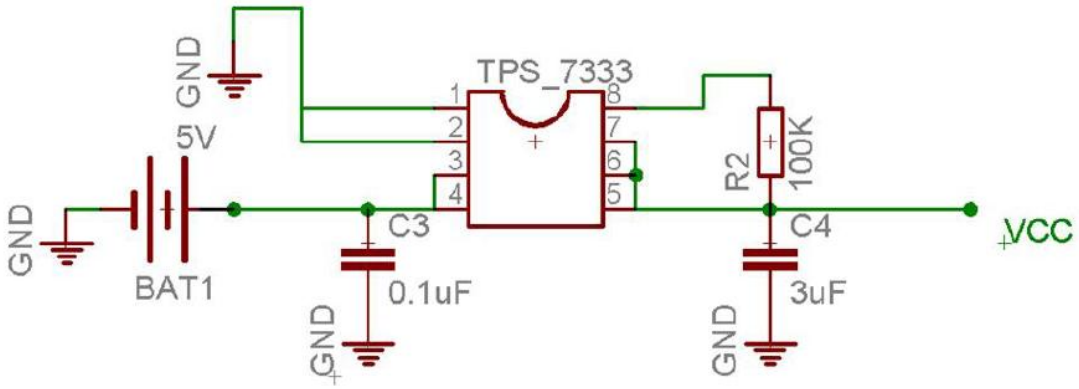
- RF Unit
  We had initially decided to work with Xbee pro but due to its high cost, it made the product very expensive, after which we switched over to CC1000, but due to time limitations and complexity attached we could not successfully run CC1000.

- Buzzer circuit
  This speaker in this circuit produces a buzzing sound whose frequency changes with the rate of ascent/descent of the person acting as a sort of warning signal for paragliders.

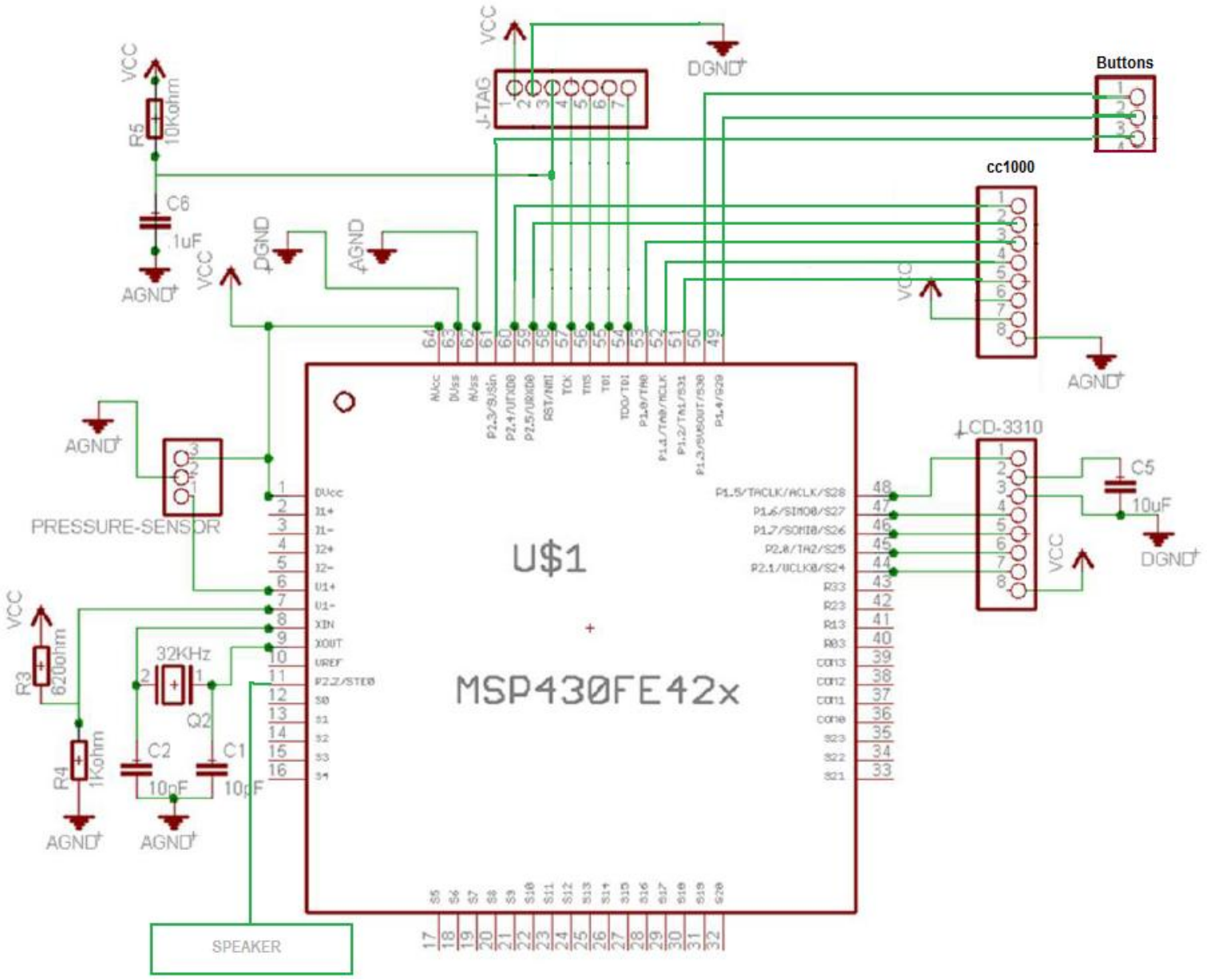
- Battery Life indicator
  The amount of battery life left is displayed on the LCD screen making it more user friendly. For this voltage across the battery is continuously monitored.

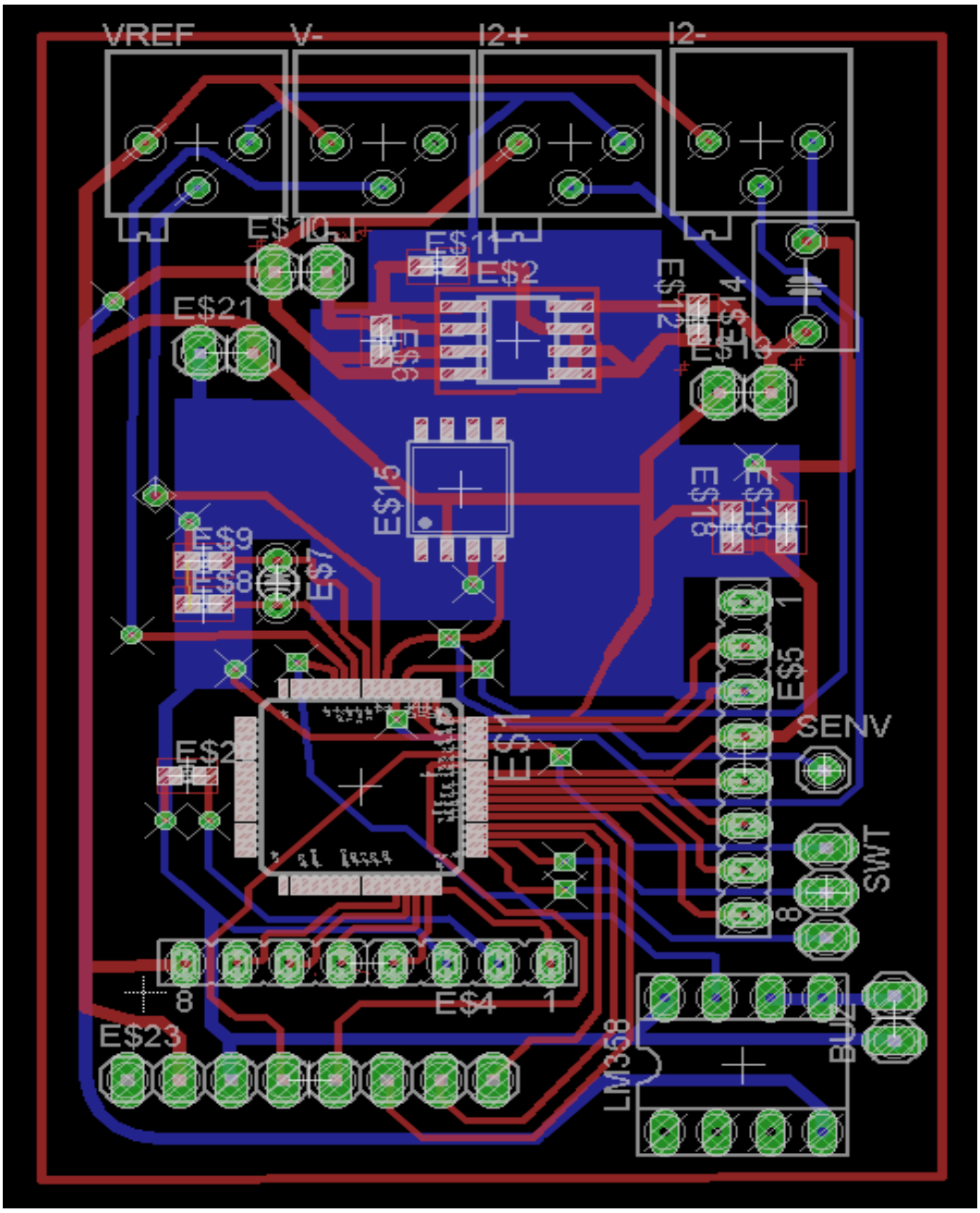
- Button Functionalities
  There are 4 buttons:
  1. On/Off the Variometer
  2. Calibrate the Height.
  3. RF On/OFF.
  4. Start/Stop Flight Time Log

- Accuracy
  Variometer built was quite accurate with an error of about 30 cm and a better derivative for velocity could be used to make velocity more dynamic.



Schematic for generating 3.3 Volt Power Supply


VCC
R5
10Kohm
C6
.1uF
AGND
DGND
AGND
VCC
J-TAG
VCC
DGND
Buttons
cc1000
VCC
AGND
AGND
PRESSURE-SENSOR
LCD-3310
C5
10uF
DGND
VCC
U$1
MSP430FE42x
VCC
R3
620ohm
32KHz
Q2
C2
10pF
C1
10pF
R4
1Kohm
AGND
AGND
SPEAKER



Board Design

Scope for Improvement:-

1. Could be run on solar power.
2. GPS could be fitted to the Variometer, so that its position is continuously sent to the control center to monitor its path and to predict its path trajectory.
3. Colored LCD screen display can be used and it can be made more user friendly.
4. A better transceiver can be used to facilitate communication between Paraglider and control center, So that Paraglider can be warned of any upcoming collision or any other danger.

References:-

[1] MP3A6115A Integrated Pressure Sensor datasheet, Freescale
[2] www.ti.com
[3] www.freescle.com
[4]MSP4304xxfx User guide
[5] www.wikipedia.com
[6] www.iar.com