AUTOPILOT CONTROL SYSTEM - III

Determination of Orientation from acceleration data

When there is no other acceleration other than normal g-force, it is easy to determine the orientation from the acceleration data since the acceleration measured along each axis would be a component of this acceleration. The various required angles can be then calculated as:

$$\text{Pitch} = \tan^{-1}\left(\frac{A_x}{\sqrt{A_y^2 + A_z^2}}\right)$$

$$\text{Roll} = \tan^{-1}\left(\frac{A_y}{\sqrt{A_x^2 + A_z^2}}\right)$$

$$\text{Theta} = \tan^{-1}\left(\frac{\sqrt{A_x^2 + A_y^2}}{A_z}\right)$$

Algorithms for division, determination of square root and calculation of $\tan^{-1}x$ were implemented. The resultant angles were calculated.

The accelerometers generally give high precision measurements. But these are significantly noisy. The angle tilts which obtained from the acceleration values are not very reliable. So in conjunction with these accelerometers, gyroscopes is also used which gives much smoother values.

Gyroscope

A gyroscope is a device for measuring or maintaining orientation, based on the principles of angular momentum. The traditional form of a gyroscope is a spinning wheel or disk whose axle is free to take any orientation. This orientation changes much less in response to a given external torque than it would without the large angular momentum associated with the gyroscope's high rate of spin. Since external torque is minimized by mounting the device in gimbals, its orientation remains nearly fixed, regardless of any motion of the platform on which it is mounted.

We used MEMS gyroscopes available in the form of microchips for angular measurements. Since we require measurements in all 3 axes and with the gyroscopes being single axis, we used 3 such devices. The analog outputs from these were taken into the microcontroller for sampling. The following is an account on the single-axis gyroscope which we used in our project.

The gyro used is a low power single axis one from ST Microelectronics with a 300 degree per second maximum range. A low-pass filter is integrated into the board along with a power down feature. The gyroscope (LISY300AL) outputs an analog voltage in proportion to the angular rate.

Features

- 2.7V To 3.6V DC supply
- +/-300 degree/second output
- Analog rate out
- High shock survivability
- Embedded power-down feature

Fig 3.2 is the breakout board of the gyroscope used.

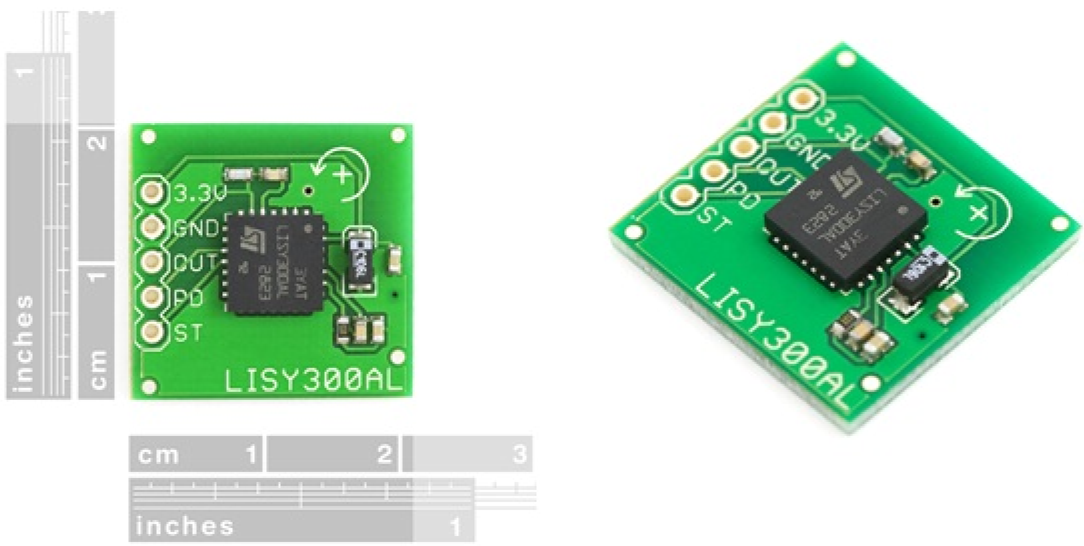

Fig 3.2 - Gyroscope with evaluation board

One main disadvantage of these gyroscopes is the drifting of measurement values. Even at static conditions after a period of time these gyroscopes give drifted values causing the system to interpret its position and orientation in the incorrect manner. The significant advantage with these gyroscopes is the smoothness in the values it shows. In accelerometers we obtain rough output values with a lot of noisy fluctuations.

Calibration of input devices

Accelerometer and gyroscopes were calibrated. The data from the accelerometer for various orientations were recorded into the memory card. About 170 samples were recorded for each orientation. This data was analyzed on the PC using a visual basic program. The mean and variance (as a measure of noise) of each accelerometer reading was determined. Few screenshots of these readings are given in Fig 3.3(a) and Fig 3.3(b).

These readings were then used to determine the offset for each axis.

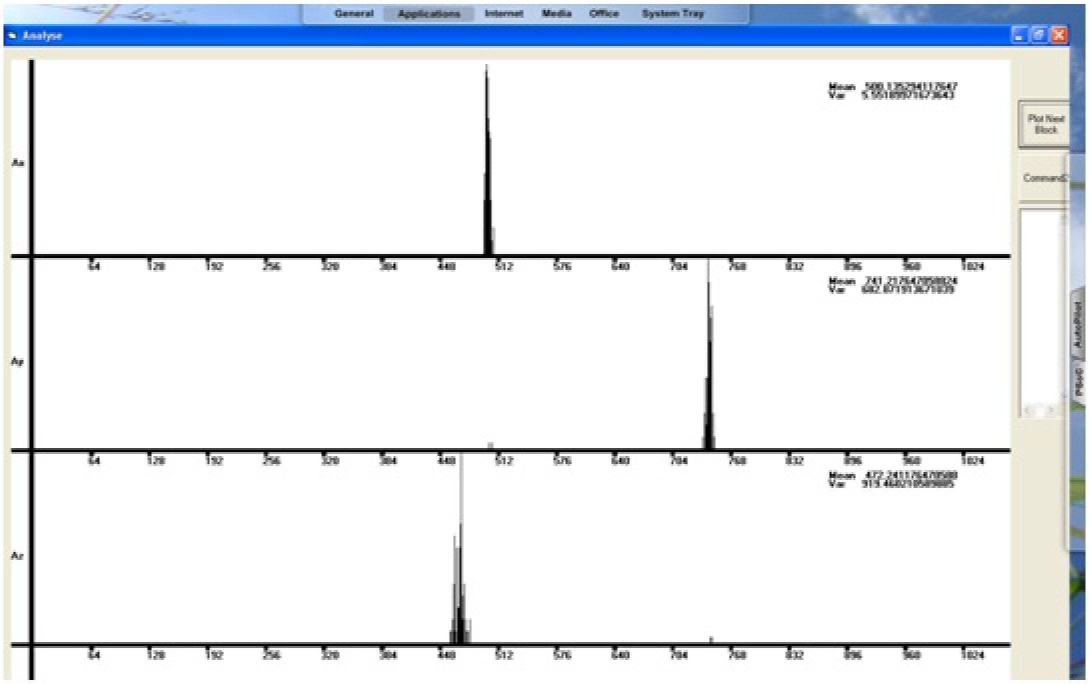

Fig 3.3(a)

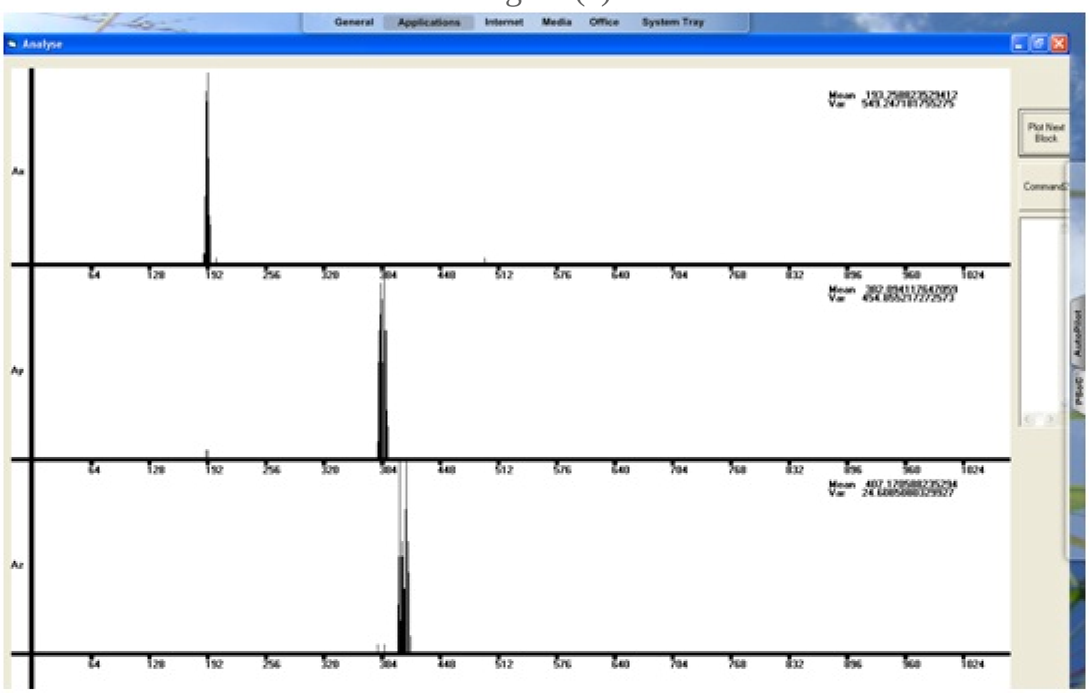

Fig 3.3(b)

The following screenshot shows the data logged in from the gyroscope for calibration purposes:

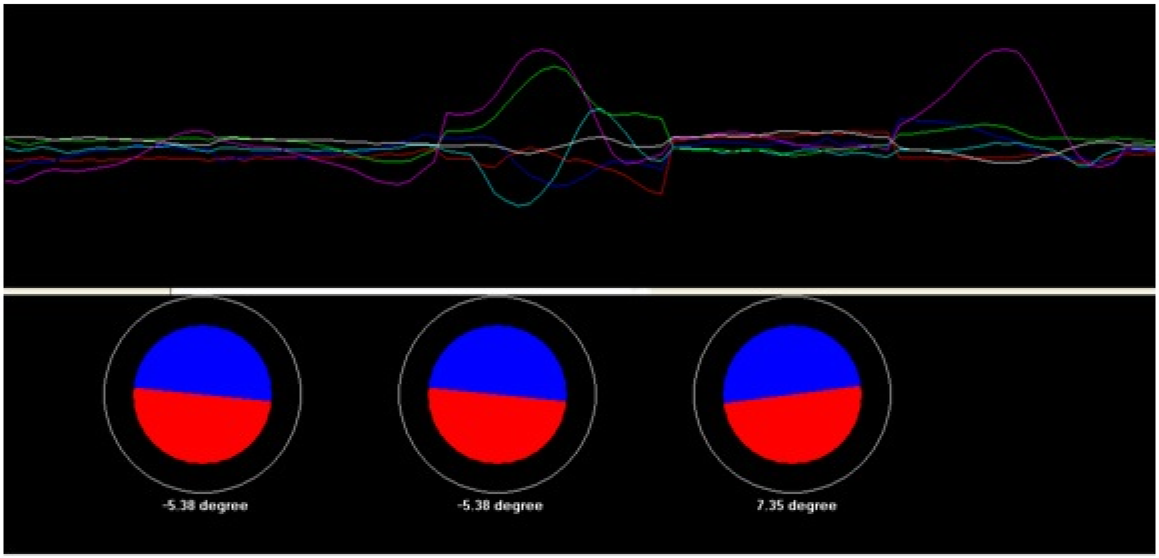

Fig 3.3(c)

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