RESEARCH OF MAGNETOMETER PLACEMENT ON BOARD OF MICROSATELLITE

S. Candraman, PhD student, N. Secrieru, PhD, assoc.Prof.
Technical University of Moldova.

1. INTRODUCTION

Currently the research area requires to determine the implementation and development vector of SATUM's satellite attitude system.

To solve this global problem, under research purpose were developed several algorithms of absolute position determination in tridimensional space using the theory of sensor fusion [3].

In previous works were presented models of software ,figure 1, and hardware, figure 2, which were realized during my research [1].

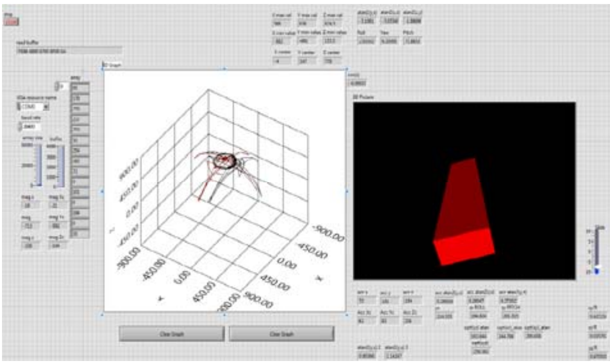

Figure 1. Graphical User Interface developed for IMU(Inertial Measurement Unit).

Software models mentioned above represent the algorithms already implemented in microcontrollers which allow us to adjust, fusion and solve the problem of attitude determination. Labview is used as GUI(Graphical User Interface) for visualizing every idea in short time. Hardware models represents the PCB (Printed Board Circuits) with all sensor mounted needed for solving the problem of attitude determination, PCBs with controllers which make the acquisition of data and prepare data for calculation inside the main microcontroller, and in the last are the PCBs which are controlling the moving our spacecraft, this means motors, reaction wheels and magnetorquers.

Learning and using the Labview software were developed the GUI which allowed to make a list of tests and experiments with the sensors of absolute position determination. And also allowed to another colleagues from our laboratory to make theirs tests with minimum time to get the result.

Figure 2. 3DOF(degree of freedom) Laboratory gyroscope.

Based on the tests made in Labview models and in real time systems such as quadcopter where determined the limits where the sensors works in best conditions, the main tests were made on the magnetometer HMC5883L, which is a sensor widely used as in commercial area as in cubesats or other flying crafts.

Figure 3. HMR2300 intelligent 3DOF magnetometer.

This work also rely on researches on other sensors, such HMR2300 which a ready to use sensor, Figure 3.

The HMR2300 sensor is a sensor realized from 3 one axis sensors, 3 ADCs and a microcontroller which is analyzing and then puts everything on the RS232 BUS. Also this module has an already programmed controller which cannot be reprogrammed by our needs. For tests the module were connected to a PC using a RS232 terminal and then connected to Labview, figure 4, also where made another diagram in labview which works with this sensor and puts the data on 3D graph in the same way which is makes the diagram for the HMC5883L sensor. All this were made on purpose to compare the data from both sensors.

Figure 4. The HMR2300 Module and its connection to PC.

2. ORIENTATION SYSTEM DEVELOPMENT

The HMC5883L sensor has a high sensibility as the HMR2300 sensor, and based on this, were made the conclusion that this is good sensor and then the decision to realize the attitude determination system on the HMC5883L magnetic sensor.

After installation works of housing satellite magnetic sensor was determined that there is an influence from the housing and from some active components inside the satellite on the magnetic field sensor, in this context was started the research area of housing the magnetic field sensor on board of the satellite.

The influence of the materials on the magnetic field sensors can be seen on the picture in the figure 5, which represents the distortion of the ideal magnetic field around the sensor, if the magnetic field is close to the ideal form then is possible to apply the algorithm of attitude determination.

If around the sensor is a piece of metal or some active components the sensor starts to draw an ellipsoid or an egg if we are making the map of the sensor. This map is made rotating the sensor by every axe by 360 degrees. Also the distortion of the magnetic field could be seen when the center of the sphere is not equal to the ideal center of the sensor.

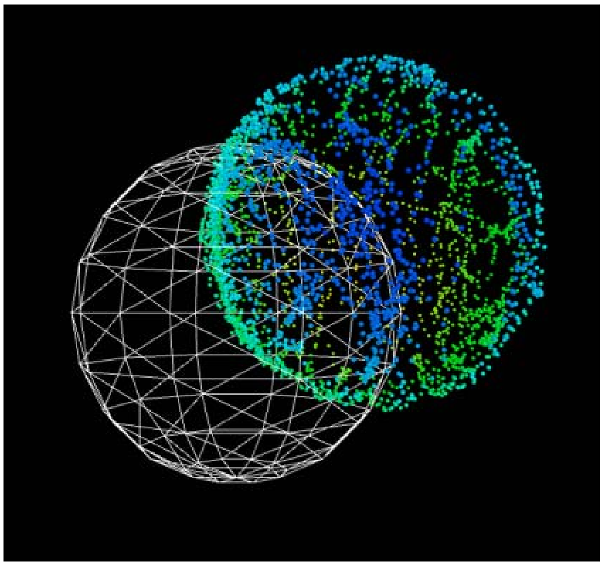

Figure 5. The distortion of the magnetic field around a metal body.

This work determined us to test different sensor locations in housing to reduce the maximum possible the influence of the metals and active components, based on this we made a conclusion that the sensor could be installed in two ways on the satellite.

The first variant and the most commonly used by manufacturers of satellites is to find a place within the satellite housing where the magnetic field is less polluted by reaction wheels and magnetorquers. The placement of the sensor inside the satellite could be in two ways:

- On the navigation system PCB, figure 6.

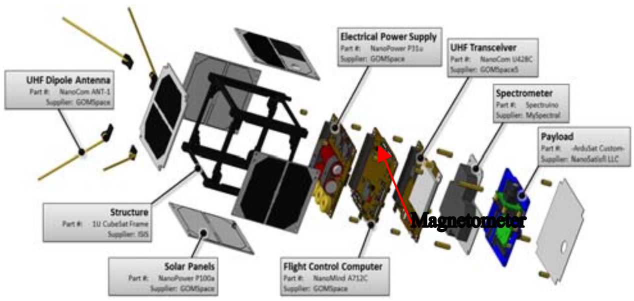

Figure 6. Placement of the magnetic sensor on the navigation system PCB.

- On an additional PCB connected with copper flexible wires which allows the placement at a specific distance from the active components on the satellite, figure 7.

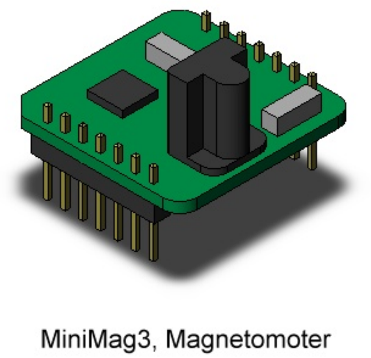

Figure 7. The magnetometer module prepared to be installed in a less polluted place.

In this research was proposed to find the minimum noise that the sensor does not use or cannot see [3].

The second option are the experiments result of the minimal noise determination of the magnetometer sensor. The experiments inside the research work showed that the sensors now are more intelligent and can compensate some fluctuations, this means that inside the sensor are a microcontroller that can apply some filters [5]. The final scope is to make a module that will be able to position the satellite with a high precision. And here appeared an idea to put the sensor outside the housing o the satellite at a distance of more than 30cm. When we were working on solving the problem we developed a device specially designed to see the magnetic field, we've named the device “MAGCAM” the tridimensional diagram is presented in figure 8 [7].

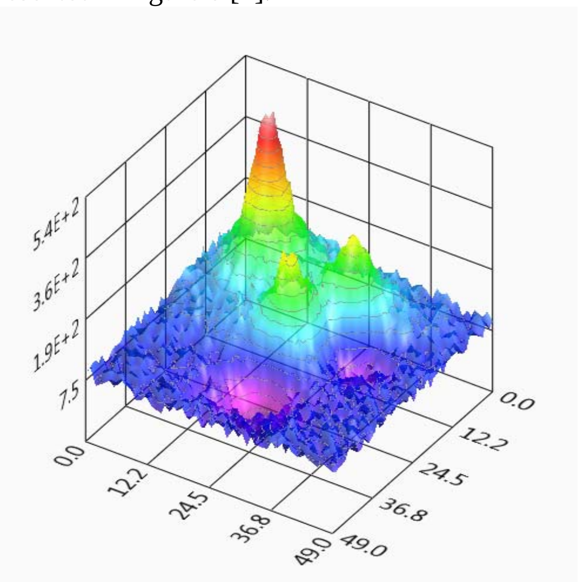

Figure 8. The magnetic fields around a step-down converter.

3. STUDY OF A COMPASS ON THE QUADCOPTER

The experiment on a quadcopter needed to make a module with all sensors on the PCB and that the sensors to be the same used in our research before in the lab [2]. Here the thoughts where to develop a brand new PCB or to find something ready on the market. On the marked we've found some modules based on Atmega 2560, which is a good choice because the first module we've used was based on a atmega 328, mainly is the same controller, the same program to upload, so the experiment was easy to make based on this [2].

The advantages of this selection is that this module could be programmed in two ways, by SPI port, or by USB using the bootloader which reduces the development time.

The selected module is presented in figure 9, is a complete flight module with the same magnetometer HMC5883L and 8PWMs available, the single difference is that the accelerometer and gyroscope is different, but this is not a problem because the algorithm is concentrated on the HMC5883L sensor [4].

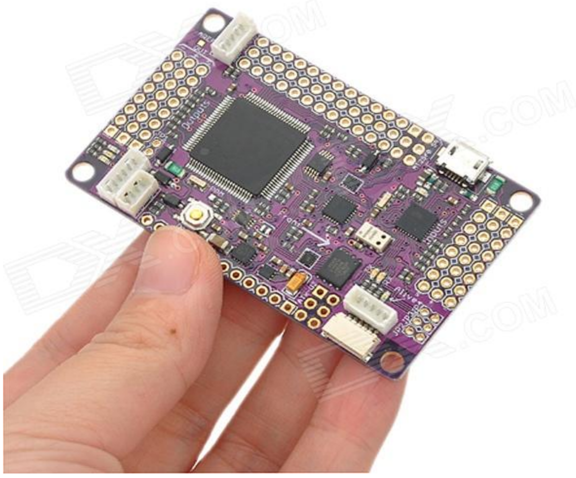

Figure 9. The selected module for tests on quadcopter

Another advantage of the selected module is that on the board of the PCB is available an I2C port where could be connected an external magnetometer, which represents exactly that we can test the external sensor, the main scope of this research, figure 10.

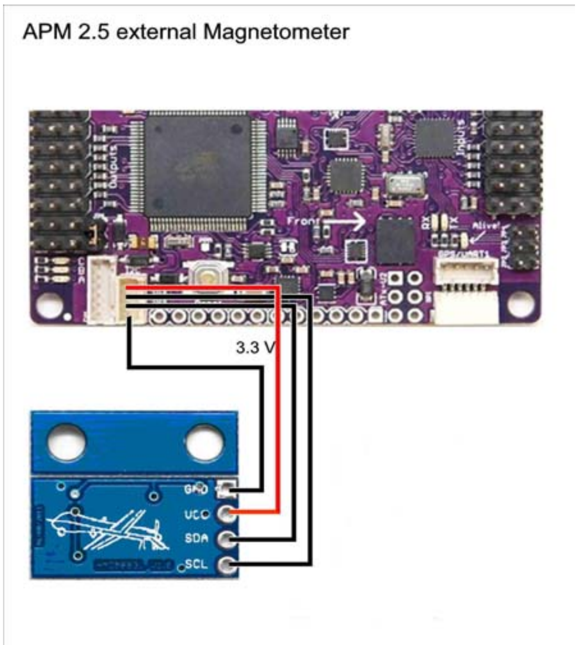

Figure 10. The external magnetometer on the quadcopter flight controller.

4. FEAUTURES OF ATTITUDE SYSTEMS

Were tested both versions, and in this context we have to put the advantages and disadvantages of each of the ideas.

The first option has the advantage of not requiring the installation of mobile modules in housing the satellite. But the disadvantage is that there may appear an error which will give a low resolution to the whole navigation system. The resolution here could be 1 to 5 degrees.

The second option is superior to the first option if we are looking at the quality of calculations made by navigation system. But here the main problem is the deployment system of the sensor, there is a possibility that the sensor will stick to the frame when the satellite will be launched and then the whole mission will be aborted, because the sensor will give wrong position [6].

5. STUDY OF THE COMPASS WHEN THE SATELLITE IS LAUNCHED

Study of the compass in space behavior at the moment is just an analysis of telemetry data from other educational satellites and a model of earths magnetic field on the LEO orbit. This could be done in several ways. Is modeled the magnetic field on the orbit according on the data posted on specialized sites or the orbit is modeled according to data posted from another educational satellites, which are uploading this data as a telemetry part of their communication.

For the second option were made calculation of the deployment system and the period of one cycle of the satellite, this is presented in figure 11 [5].

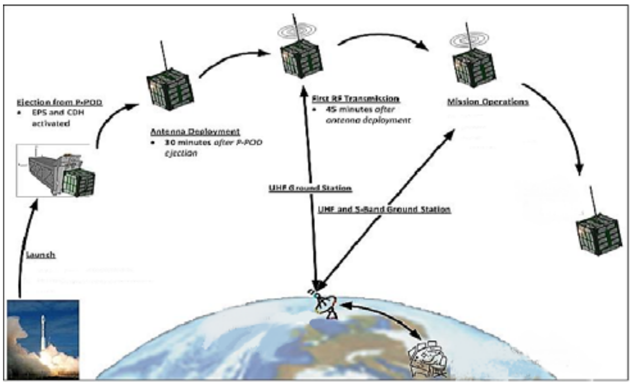

Figure 11. Deployment time of the antennas and magnetic sensor

Analysis of the compass deployment system is still in a nascent stage because of the main deployment structure. This could be a telescopic system opened by a spring or a motor that opens this module.

Another option is to place the sensor as do many manufacturers, figure 12.

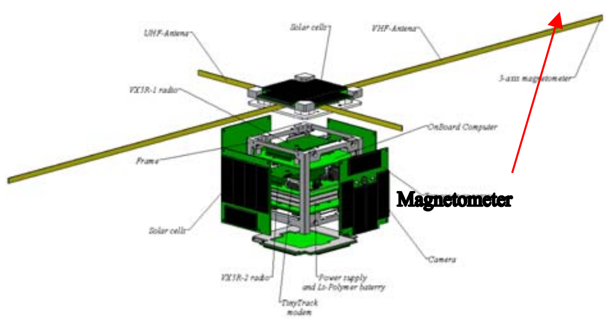

Figure 12. Installation of the magnetometer on the VHF antenna.

As is seen from the picture the HMC5883L module is located on the VHF antenna, the material is made from a elastic material which acts like a spring when the satellite is launched in space.

Some deployment systems are deploying at the time when the satellite is launched and some are held by an arm which could be controlled by a motor that is auctioned after some in order to be at a distance from another satellites, Figure 11.

6. CONCLUSION

The development in LabView of the graphical module for testing of different sensors is an important strategic step in this area for allowing to the whole team in the laboratory to investigate several areas such as modeling the behavior of magnetic field sensor on the orbit.

This work second scope was to design another GUI in another program such as Phyton or Processing which allows to make calculations faster and with less computational resources.

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