Modern CAD Technique to Design Gyrocompass for UAVs and Robot, Ships, Aircrafts Navigation Systems

M. S. Zaghloul

Arab Academy for Science, Technology, and Maritime Transport, Electronic, Communication Department[2], P.O.1029, Alex, Egypt

dr_mszaghloul@yahoo.com

Abstract

This paper concerns the practical design and implementation of gyrocompass required for operation of all installed navigation equipments on robot, aircrafts, ships, also for UAVs. Most navigation systems today use some type of compass to determine heading direction. Using the Earth Õs magnetic field, electronic compasses based on magneto-resistive (MR) sensors can electrically resolve better than 0.1 degree rotation and accuracy from 1 to 2 degree. Most of installed equipment on aircrafts, ships, and spaceship are form of computer-based navigation information system that complies with International regulations. These equipments can be Global position System (GPS), Radar, speed, direction, electronic chart display, height finder for aircrafts and spaceship, echo sounder for ships etc. In our design, Compass Module was utilized with Honeywell's HMC5883L 3-Axis Magnetometer, I²C, 2.7-6.5V, TTL-USB and microcontroller 16F877. For programming of the microcontroller, software PIC Basic pro was used, a window based Software. We are trying to use a cheap and good resolution within a small size Using Anisotropic Magneto resistive (AMR) technology that provides advantages over other magnetic sensor technologies. These anisotropic, directional sensors feature precision in-axis sensitivity and linearity. These sensors' solid-state construction with very low cross-axis sensitivity is designed to measure both the direction and the magnitude of Earth's magnetic fields, from milli-gauss to 8 gauss. The complete designed system has three outputs, the first one is USB port friendly user interface, the other two outputs are control logic state outputs. We used the designed gyro output to interface with Radar display so the targets direction can be measured in true mode instead of relative mode; as well, our designed module was employed in car protection in driver safety.

Keywords

Microprocessor; CAD; Ship Control, Radar; Signal Processing; Sensors

Introduction

From very long time, the magnetic compass has been used in navigation. It appears that Mediterranean seamen of the 12th century were the first to use a magnetic compass at sea

Today, the balanced needle compass is only a slight variation of this early discovery. In our design, we make use of advances in technology that have led to the solid state electronic compass based on MR magnetic sensors and acceleration based tilt sensors. In our design, he Honeywell HMC5883L is implemented which is a surface-mount, multi-chip module designed for low-field magnetic sensing with a digital interface for applications that enables 1° to 2° compass heading accuracy. Plus a friendly user interface USB which can be used with any equipment fitted with USB port; moreover, we use the micro controller 16 F877. The I²C serial buses for the gyro allows for easy interface. The gyro sensor converts any magnetic field into a differential voltage output on three axes. This voltage shift is the raw digital output value, which then can be used to calculate headings or sense magnetic fields coming from different directions. Output of the gyro compass is fed to the microcontroller that is programmed using Basic pro which allows accepting the data from the gyro module, then we have three outputs from the microcontroller, one output to the TTL-USB, and the other two outputs are fed to two transistors which will give control using two relays. Compasses are commonly used with accelerometers, where the data from both the compass and accelerometer can provide extended information to compensate for any tilt of the compass because the reading is affected if the compass is not level. The Memsic 2125 Dual-axis Accelerometer and MMA7455 3-Axis Accelerometer Module are available companion accelerometers for the 3-Axis Compass module. Newer solid state accelerometer tilts sensors that measure the earth Õs gravitational field by means of an electromechanical circuit.

The Compass Module with 3 –Axis HMC5883L

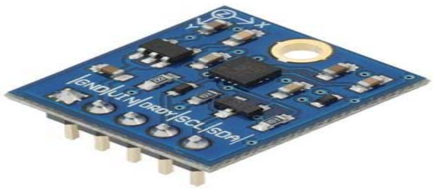

FIG.1 COMPASS MODULE WITH 3 –AXIS HMC5883L

This is a breakout board for Honeywell's HMC5883L, a 3-axis digital compass. Communication with the HMC5883L is simple and all done through an I²C interface. This model can measures the earth's magnetic field in three axes, with 1–2 degree accuracy, providing individual readings for each axis, which may be used separately or together for 3D calculations, and measures raw strength (gauss) of a nearby magnetic source. The 3-Axis Compass module measures magnetic fields in three directions–or axes, labelled X, Y, and Z. In its most simple form, the module can be used as a basic compass to find earth's magnetic north. The compass module can also sense the relative strength of a nearby magnetic source, such as those caused by magnets or electric fields. As the sensor detects magnetism in three dimensions, relative distance and direction to these sources can be determined. One application of adding an accelerometer is to compensate for any tilt of the compass. As with most compasses, the reading is affected if the compass is not level. The Mimic 2125 Dual-axis Accelerometer and MMA7455 3-Axis Accelerometer Module are good companion accelerometers for the 3-Axis Compass module. The International Geomagnetic Reference Field (IGRF) is a series of mathematical models describing the earth's field and its time variation

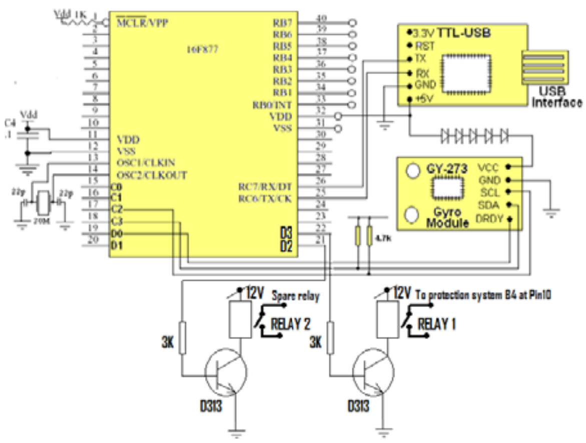

FIG. 2 GYRO COMPLETE CIRCUIT DIAGRAM

The System Design

The designed system is 3-axis digital compass. We are trying to use a cheap and good resolution with a small size. The Used Anisotropic Magneto-resistive (AMR) technology provides advantages over other magnetic sensor technologies. These anisotropic, directional sensors feature precision in-axis sensitivity and linearity. These sensors' solid-state construction with very low cross-axis sensitivity is designed to measure both the direction and the magnitude of Earth's magnetic fields, from milli-gauss to 8 gauss.

To get the data from the module, we need I²C interface so a micro controller chip 16F877 is applied to read this data. The design includes a small PCB with Micro Chip "Pic16F877" micro controller and the supporting hardware. We get the I²C data to C_2, C_3 and an interrupt pin to D_0 to indicate data ready. Still it is required to read the data on a PC. The microcontroller is connected to TTL-USB converter to read Data from Microcontroller. Then a small 5 v power is made. To supply the Module with 3.3 volts, we applied the 5 v to 4 diodes forward to have the required voltage drop. We made an external pull up resistor (4.7K) to the SCL & SDA. The I²C software is listed as S/W 2_6, From this gyro complete circuit, we get two outputs, the first of which is from the USB and this can be fed into computer or display system to give the three reading x, y, and z where x indicates the direction, y for roll, and z for beach; while the second output is taken from D_3 and used to be fed to another circuit to control and change status, in addition, we have spare output D_2 which can be used for any other application.

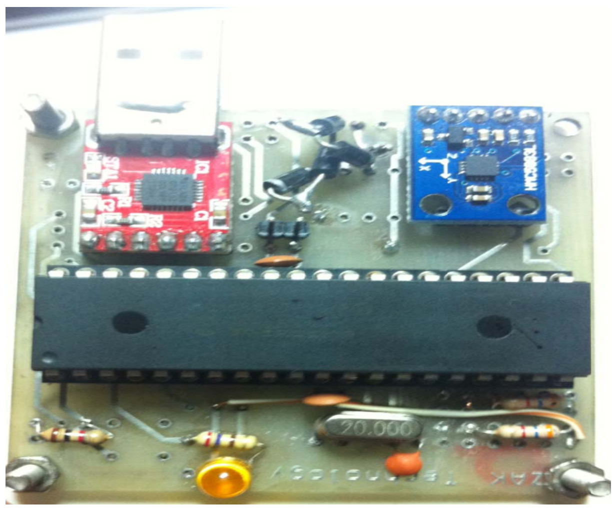

FIG. 3 FINISHED DESIGNED MODULE

The HOST Computer Software

We used a V Basic program as shown in appendix (A) or under request from the author which is mainly to read the data from module, 6 data bytes (2 for each word) which are x, y, z angles. The program has a given name COMVB and the given three outing angles in three boxes. The rate of reading the angles by computer is every 2 seconds with width of 1-2 degree accuracy, and the real reading of the computer is shown in figure 5. Moreover, figure 6 represents Radar display with the use of our gyrocompass input via USB.

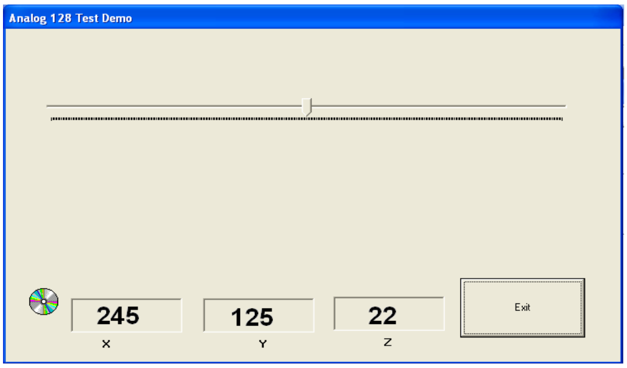

FIG. 4 READING OF 3 ANGLES X, Y AND Z ON COMPUTER DISPLAY

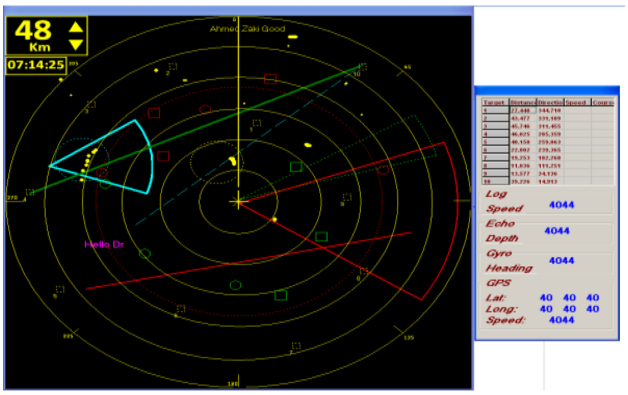

FIG. 5 RADAR DISPLAY USE GYROCOMPASS INPUT FROM USB

Our design was implemented in two application, the first of which is in design of open architecture system to reduce the likelihood of a vehicle getting stolen or carjacking and driver safety in which e the gyro is employed to detect the sleep of the driver, the second application is in Radar display which will be shown and explained in next part of the paper. By applying the gyro output from the USB port, all the target direction can be read with respect to the true north (north up), and when the this input is stopped, all our reading for the tracks direction will be in relative to ships heading (ships head up), and the target directions will be from 00 to 1800 right (green) or left (red).

Practical Implementation of the Gyrocompass Output to a Ship Navigation Radar.

We used to have a view of a relative motion display i.e. the ships heading is the zero angle for display as shown in Fig. 6.

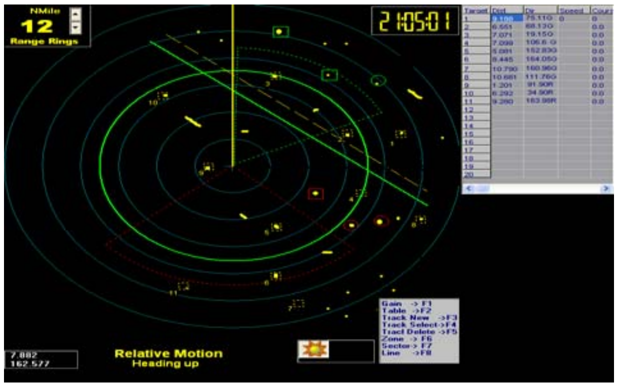

FIG. 6 RADAR DISPLAYNOT USE GYROCOMPASS INPUT

When gyro is implemented after 40 mints of operation as a hard ware and soft ware in the display program, a true motion display can be obtained in which North is taken as the zero angles for the display, which is more realistic and easier to identify true target angle and locations regardless of our ship heading. This is indicated in Fig. 7, and it is noticed that all targets and graphics are rotated by the gyro heading angle being 90 degrees, which is the gyro reading at that time.

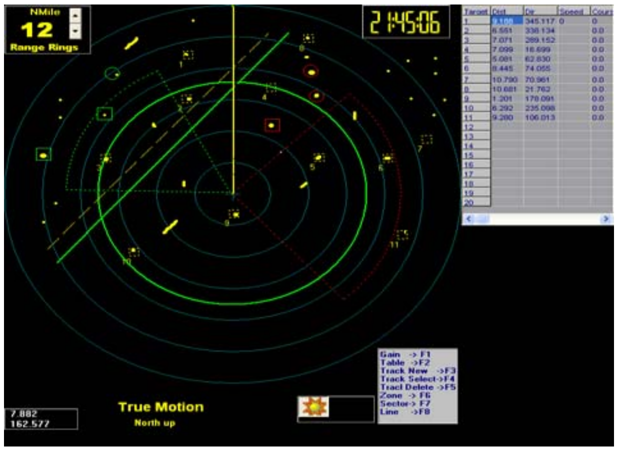

FIG. 7 RADAR DISPLAY WHEN GYROCOMPASS INPUT IMPLEMENTED

Conclusions

The designed system is friendly user with TTL USB interface, most sensitive, reliable low-field sensors in the industry, and low cost gyro having a one degree accuracy requirement due to the choice for the HMC5883L utilizing Honeywell's Anisotropic Magneto-resistive (AMR) technology that provides advantages over other magnetic sensor technologies. It is available to have directional sensors feature precision in-axis sensitivity and linearity. These sensors' solid-state construction with very low cross-axis sensitivity is designed to measure both the direction and the magnitude of Earth's magnetic fields, from milli-gauss to 8 gauss. We can electrically resolve better than 0.1 degree rotation and accuracy from 1 to

2 degree. Adding to that for tilt compensation, an accelerometer needs to be used along with this module. A low cost compass has been discussed here having a one degree accuracy requirement. At the heart of the compass is a three-axis MR magnetic sensor. If a compass system has a requirement higher than one degree of accuracy, then it is important to break down the error caused by the tilt sensor and the magnetic sensor and it is determined that the level of signal processing is required. [3] The designed compass can be used in car protection for driver safety and with Radar display where relative motion picture of the displayed tracks is obtained.

REFERENCES

A Dual Axis Tilt Sensor Based on Micro machined Accelerometers, Mike Horton, Charles Kitchin, Sensors Magazine, April, 1996.

Applications of Magneto resistive Sensors in Navigation Systems Michael J. Caruso, Honeywell Inc.

Applications of Magnetic Sensors for Low Cost Compass Systems Michael J. Caruso Honeywell, SSEC.

National Geomagnetic Information Centre, website URL http://geomag.usgs.gov/.

National Geophysical Data Centre, website URL http://www.ngdc.noaa.gov/.

Sensor Products Data Sheet, "1 and 2 Axis Magneto-resistive Microcircuits", Honeywell SSEC, 5/99, <www. magneticsensors.com>.

The Ship's Compass Grant, George A, and Klinkert, John. , 2d ed. (1970).

1st international conference on computer science and application (ICOCSA 2014). January 10 to 11, Indianapolis, Indiana, USA, 2014, M. S. Zaghloul .