THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Implementation of Mpu6050 6 DOF Gyro Accelerometer IMU as Auto Correction Direction in Ship Weapon System

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Abstract:
The stability of gun shots on warships has a very important role in the accuracy of the shooting results to support the operations of the Warship. The problem that often arises is the lack of stability in gun shooting on ships. At present one of the data sources to maintain stability in gun shooting is from the gyro compass so that it can overcome ship shocks by waves either shaking or bobbing. However, because the gyro compas works on a mechanical system, there is often wear and tear on the gyro compas component as the rotating clock increases. Besides that the cost of maintenance and maintenance of the gyro compass is quite expensive, if the tool will be reconditioned to restore its optimal capabilities.
Accuracy enhancements are needed in addition to streamlining the cost of maintenance and maintenance of the system (Gyro Compass). The purpose of this study is to make the implementation concept of the IMU MPU 6050 6 DOF Accelerometer as an Auto Correction Direction on the Ship Armament System to obtain better stability, more efficient and effective.

Keywords: *MPU 6050, Gyro accelerometer, IMU, auto correction*

1. Introduction

The stability of gun shots on warships has a very important role in the accuracy of the shooting results to support the operations of the warship. Changes in the position of a very small shot will affect the results of the shooting that changed very large. Therefore the weapon stability system must be able to deal with external disturbances such as waves, both shaking and nodding, so that the direction of shooting can remain stable so that satisfying shootings can be obtained.

The problem that often arises is the lack of stability in gun shooting on ships. At present one of the data sources to maintain stability in gun shooting is from the gyro compass so that it can overcome ship shocks by waves either shaking or bobbing. However, because the gyro compas works on a mechanical system, there is often wear and tear on the gyro compas component as the rotating clock increases. Besides that the cost of maintenance and maintenance of the gyro compass is quite expensive, if the tool will be reconditioned to restore its optimal capabilities. In this project, an IMU sensor (Inertia Measurement Unit) or better known as a gyroscope which is a standard sensor that has been widely applied to the UUV balance system (Unmanned Underwater Vehicle), ROV (Remote Operated Vehicle), UAV (Unmanned Aerial Vehicle), and in other applications. This sensor is used in making auto balance systems in the weapons on the ship so that the weapon is able to maintain its position from wave shocks by controlling the moving weapons platform based on sensor readings. From this project it is expected to produce an auto balance system that can maintain the position of the weapon on the ship with a slope tolerance of 0.5%, so that the shooting system will be much easier to do.

2. Material and Methods

2.1. MPU 6050 6 DOF Gyro Accelerometer IMU

IMU Sensor (Inertia Measurement Unit) MPU 6050 6 DOF or better known as gyroscope which is a standard sensor which is a 6 axis Motion Processing Unit with the addition of a voltage regulator and several other complementary components that make this module ready to use with a supply voltage of 3-5VDC . This module has an I2C interface that can be connected directly to the MCU that has an I2C facility. This sensor has been widely applied to the UUV balance system (Unmanned Underwater Vehicle), ROV (Remote Operated Vehicle), UAV (Unmanned Aerial Vehicle), and in other applications. One of the advantages of this sensor is IP67 or waterproof, and shock resistance is its own advantages that make this sensor feasible in the manufacture of auto balance systems in the weapons on the ship so that the weapon is able to maintain its position by utilizing a servo motor that moves based on reading the position of the weapon affected by waves.

From this project, it is expected to produce an auto balance system that can maintain the position of the weapon on the ship with a slope tolerance of 0.5%, so that the shooting system will be much easier to do.

This sensor contains a Micro Electromechanical Systems (MEMS) accelerometer and a MEMS Gyro that are integrated with each other. This sensor is very accurate with 16 bit ADC internal hardware facilities for each channel. This sensor will capture the value of channel X, Y and Z at the same time. Following are the specifications of this module:

- Based on MPU-6050 Chip.
- Voltage supply range: 3-5V.
- Gyroscope Range + 250 500 1000 2000 ° / s.
- Acceleration Range: ± 2 ± 4 ± 8 ± 16 g.
- Communication standar I2C.
- Chip built-in 16 bit AD converter, 16bits data output.
- Header pin range: 2.54 mm

2.2. Arduino

Arduino is an open-source single-board microcontroller, which is produced by the wiring platform, designed to facilitate the use and design of electronic devices in various fields. The hardware used uses an Atmel AVR processor and has software with its own programming language.

In this study the microcontroller used is Arduino Nano because this type of Arduino has a small size. As it is known that component size is something that must be considered because of the limited dimensions of HMD. Arduino Nano also has several advantages, it is supported by Arduino IDE with a library of programming languages that are quite complete.

The Arduino (sketch) software used as an Arduino IDE is also equipped with a serial monitor that allows programmers to display simple serial data that can be sent or received from the Arduino Nano board. The RX and TX LEDs installed on the Arduino Nano board will blink in the event of serial data communication between the PC and Arduino Nano.

2.3. CMPS10

CMPS10 is a module that is equipped with a 2-axis accelerometer and magnetometer, uses a 16-bit processor, and is designed to eliminate errors caused by PCB slope. The output of the sensor measures the direction of the magnetic field, as well as the pitch and roll of the accelerometer sensor. CMPS10 requires a 3.6 - 5v power supply with 25mA current. This module has several ways to access data, namely using serial interfaces, I2C interfaces, and PWM output.

2.4. Dc Motor Servo

DC Motor Servo is used in this project as a closed loop control system. The use of a closed loop control system on a servo motor is useful for controlling the movement and final position of the servo motor shaft. The simple explanation is this, the output shaft position will be in the sensor to find out the position of the shaft exactly as desired or not, and if not, then the input control will send a control signal to make the position of the shaft right at the desired position. For more details about closed loop control systems, consider a simple example of several other applications of closed loop control systems, such as temperature settings in air conditioners, refrigerators, irons and so on.

2.5. I2C

I2C (Inter Integrated Circuit), is a protocol for serial communication between ICs, and is often called the Two Wire Interface (TWI). Buses are used for communication between microcontrollers and peripheral devices such as memory, temperature sensors and I / O expander.

In I2C, Communication is carried out through two lines: SDA (serial data) and SCL (serial clock). Each I2C device has a unique 7-bit address. MSB is a fix and is intended for device categories. For example, 1010 binary is intended for serial EEPROM. The next three bits allow 8 I2C address combinations, which means that it is possible for 8 devices of the same type to operate on the same I2C bus. Data transmission can only be started when the channel is not busy, it is characterized by a long HIGH condition on the SCL and SDA pins.

During data transmission, serial data (SDA) must be stable when serial clock (SCL) is high. Changes in SDA conditions when high SCL will be considered as control signals, such as: START signal (LOW to HIGH) or STOP signal (HIGH to LOW).

2.6. Amplifier and Op Amp

Amplifiers are electronic components used to strengthen power. The amount of reinforcement is often known as the gain. The value of the gain expressed as a function of frequency is called the transfer function. The power amplifier serves as the final amplifier from the preamplifier to the transformer input. Amplifiers are generally divided into two namely Power Amplifier and Integrated Amplifier.Operational amplifier (Op-Amp) is a high-strength amplifier integrated in an IC chip that has two inverting and non-inverting inputs with an output terminal, where a feedback circuit can be added to control the overall response characteristics of the amplifier operations (Op-Amp) The amps consist of several parts, including differential amplifier, gain stage, level slider and final amplifier.

The op-amp symbol as in Figure 1, with 2 inputs, namely non-inverting (+) and inverting (-). Generally op-amps work with dual supply (+ Vcc and –Vee), but many op-amps are made with single supply (+ Vcc and Ground). The circuit symbol in Figure 1, is a general parameter of an op-amp. Rin is an input resistance whose value is infinite. Rout is the output resistance and the ideal amount of resistance is zero. Whereas AOL is an open loop reinforcement value and the ideal value is infinite..

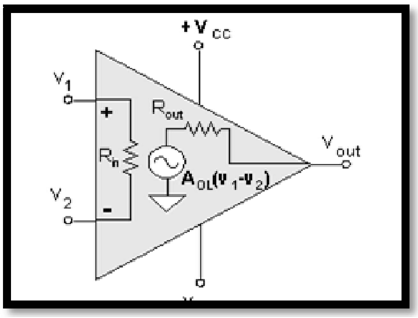

Figure 1: Operational Amplifier

The basic principle of an operational amplifier (Op-Amp) is to compare the values of both inputs (inverting input and non-inverting input), if the two inputs are equal then the Op-amp output is zero (if there are differences in the input values), than the op amp will provide output voltage. Operational amplifier (Op-Amp) is made from a differential amplifier with 2 inputs. As an ideal operational amplifier, operational amplifiers (Op-Amp) have the following characteristics:

- Input (Zi) besar = ∞
- Output Impedance(Z0) kecil= 0
- Voltage Amplifying (Av) tinggi = ∞
- Wide Frequency Response Band Width = ∞
- $V_0 = 0$ and if $V_1 = V_2$, independent of V_1.

3. Result and Discussion

3.1. System Principle

The design of this system consists of designing hardware and designing software. Figure 2 shows a system diagram block of MPU 6050 6 DOF IMU Gyro Accelerator Implementation as an Auto Correction Direction on a Ship Armament System. The MPU 6050 6 DOF has an embedded 3-axis MEMS gyroscope, a 3-axis MEMS accelerometer, and a Digital Motion Processor ™ (DMP ™) hardware accelerator machine with an additional I2C port that connects to digital sensor devices such as magnetometers. When connected to a 3-axis magnetometer, MPU-60X0 provides a Motion Fusion 9-axis output to the primary I2C or SPI port. MPU-60X0 combines acceleration and rotational motion plus heading information into a single data stream on the application used. MPU-60X0 is also designed to interface with several non-inertia digital sensors, such as pressure sensors, in additional I2C ports. MPU-60X0 is a 2nd generation motion processor and is compatible with MPU-30X0 family.

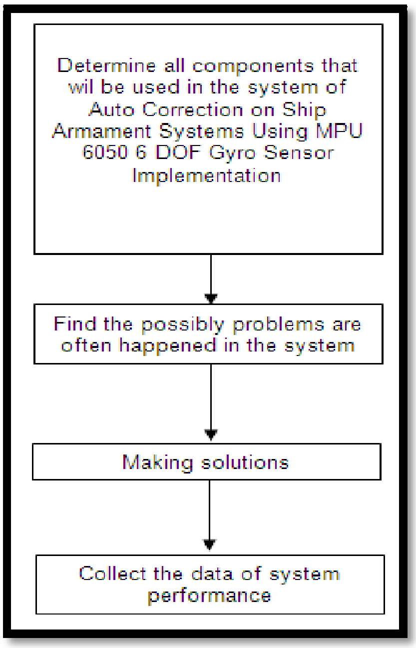

Figure 2: Block Diagram of System Design

Figure 3 shows, the system principle, start from reference position, Arduino Nano, Driver Motor, Platform, Servo, MPU 6050 6 DOF, and Driver Sensor in Block Diagram:

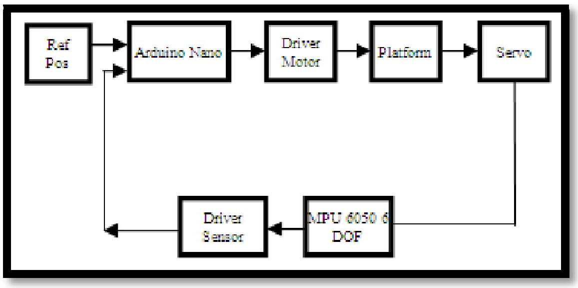

Figure 3: Block Diagram of System Principle

In the block diagram (Figure 3) illustrated that the balance system input is obtained from the starting point reference. This point is used to multiply the balanced position of the platform. Then the input will be processed by the Nano microcontroller. The microcontroller produces an output that will be used to signal to the linear motor driver which will then move the six linear motors which function as the main component in controlling the balance of weapons in this system. The conditions achieved will then be read by the gyro sensor which serves to read the slope of the platform. This sensor reading will be compared with the reference expected by the microcontroller, so that the control signal is in accordance with the expected conditions will be achieved.

In making this platform, a number of circuits are needed, namely the main divider circuit and the h-bridge circuit.

The voltage divider circuit is needed in collecting motor position data. This is because the output from the motor position will be read as resistance. The following is a voltage divider circuit:

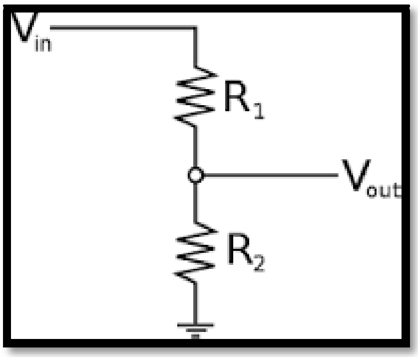

Figure 4.Voltage Divider Circuit

Output Voltage:

$$Vout = \frac{R2}{R1 + R2} . Vin$$

As the motor datasheet, it is known that the maximum value of the potentiometer is 10KΩ. Therefore, if the output potentiometer is placed in the R_2 position and the header resistor with the same value as the R_2 max value placed at position R_1, the maximum output value is 2.5 V, and at least 0 V. Because the Arduino Nano has 10 bits of ADC (analog to digital converter), so it is designed as the resolution obtained from the output signal is 512 data, ranging from 0 to 511.

The H-Bridge circuit in this project is used to reverse the position of the connection between the red and black cables, so that the motor can be controlled easily as can be seen at Figure 5.

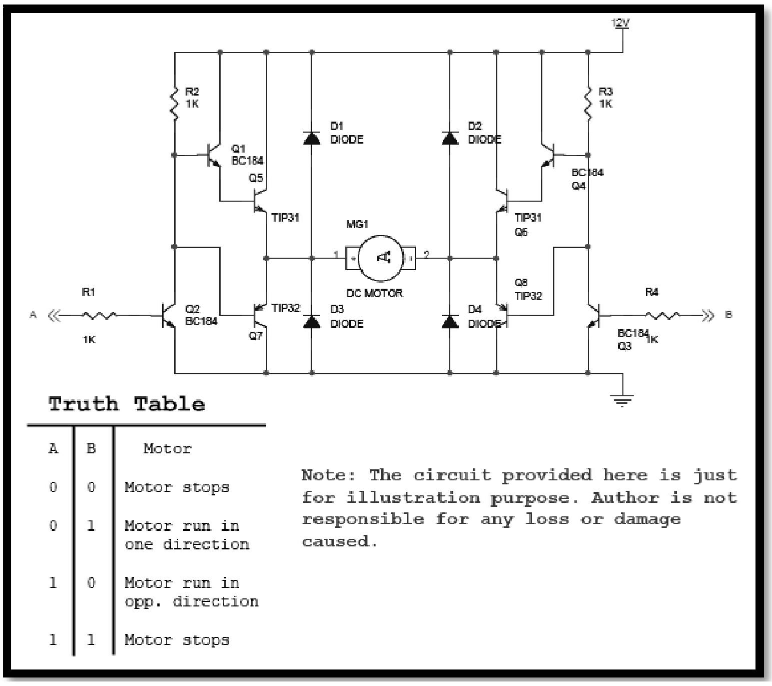

Figure 5: Circuit Scheme of H-Bridge and Truth Table Input

From the truth table in Figure 4, it can be concluded that to reverse the rotation only requires the opposite signal between the inputs at points A and B. Where as to stop the motor, points A and B are given input with the same logic. The motor speed can be adjusted by adding the MOSFET component to the source line of the motor. But in this project the maximum speed is needed to improve the response, so that only the H-Bridge range is needed to control the motor.

The process of comparison between the conditions of the input from the reference and the position sensor. The reference is obtained from the reading of the gyro sensor to adjust the slope conditions so that the system is stable. From the results of the comparison then the microcontroller will perform calculations to determine each height in the linear motor whose results will be compared again with the reference. This condition will continue to be carried out until the position sensor readings are in accordance with the reference, so that the system reaches an idle or stable state. After the system reaches a stable condition, position sensor readings will still be carried out to ensure the system's condition remains stable. This condition will continue to repeat, so that the system will continue to maintain the stability of the platform.

4. Conclusion

After conducting the process of testing and analysis of the system that has been made, it can be concluded that:

- The system can provide auto correction in the weapon system to deal with outside interference, such as wave shock, shaking or nodding.
- The error value of the weapon slope that appears on the system equates to a maximum error tolerance of 0.5% of the reference.
- Delay obtained from the system to achieve balance, with 100 ms delay tolerance
- To correct the delay obtained from the system can be done by recalculating the incoming data and data leading to the servo motor.
- The implementation of this system is also expected to be used on unmanned ships and drones.

5. Acknowledgement

The authors greatly acknowledge the support from Indonesian Naval Technology College STTAL Surabaya Indonesia for providing the necessary resources to carry out this research work. The authors are also grateful to the anonymous reviewers and journal editorial board for their many insightful comments, which have significantly improved this article.

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