Implementation of Low Cost Real Time GPS Using the Haversine Method in Fishermen Electronic Navigation

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Abstract: Fishermen who sail to catch fish in the sea generally already use electronic navigation in the form of the Global Positioning System (GPS). This tool is utilized to assist in determining the position of the ship at sea. Currently, GPS used by fishermen is still relatively expensive and quite difficult to operate. In this paper, GPS is designed using the Haversine method and uses electronic components that are easily got on the market at a price that is quite cheap and easy to use. In this system, the Ublox Neo-6M Module is used for communication with the satellite to determine the position point. While the Atmega328 microcontroller on the Arduino Uno board is used as the main controller of the system. To facilitate position monitoring, a LCD display with a screen size of 20x4 is used. The display on the LCD screen is in the form of real time position in DMS, distance in meters and directions to specify points, speed in knots and calendar. GPS design has been trials to carry out the reference points with a distance of 10 meters to 300 meters. Built on the test results, it was found that this GPS was able to show the position, direction of movement, ship speed and calendar quite accurately. However, the accuracy of the GPS positioning point is also determined by the weather.

1 INTRODUCTION

Navigation equipment such as GPS plays a major role in navigating the ocean (Sweet, 2003). It is easy to determine the position of the archipelagic boundaries by using GPS-assisted equipment (Yulius & Salim, 2013). As one of the navigation equipment, the use of GPS on modern ships is very widespread, but the price of this navigation equipment is quite expensive. Various brands and types of navigation tools have been sold in the market and are used extensively.

Research and design of GPS equipment to be applied in several places such as the installation of GPS modules to determine national boundaries (Arfianto et al., 2018). However, in this study, the modeling of regional boundaries still uses proximity sensors mounted on microcontroller equipment. In addition to point positions, directions to specify points, speed of movement and calendars, are discussed in this paper. In this paper, reference points are also determined that serve as the basis for calculations in the microcontroller program. Monitoring of position points can be seen using the 20x4 LCD screen which contains quite a lot of the required characters.

2 THEORETICAL BASIS

GPS is an electronic equipment used to determine the position of a place (E. Ceruzzi, 2018). GPS receivers work by figuring out how far from a number of satellites that are located in Earth orbit. This GPS is planned to find out which gps satellites are at a certain time. Satellites transmit information in the form of digital data wrapped in radio signals about the current position and time. This signal identifies the satellite and tells the receiver where it locates.

The radio receiver's electronic equipment calculates how far each satellite is by figuring out how long it takes for the signal to be provided. Once you have that information about the GPS can pinpoint your exact location on Earth. In general, no less than 3 satellites are accustomed. This process is commonly known as Trilateration (Engineers, n.d.) as showed in Figure1.

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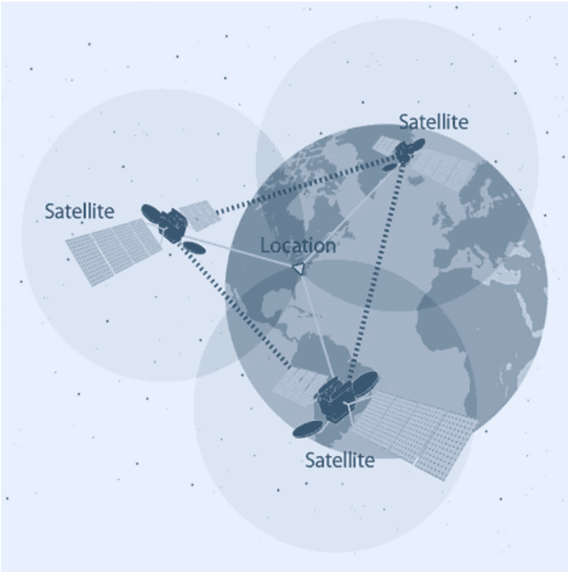

Figure 1: Trilateration GPS.

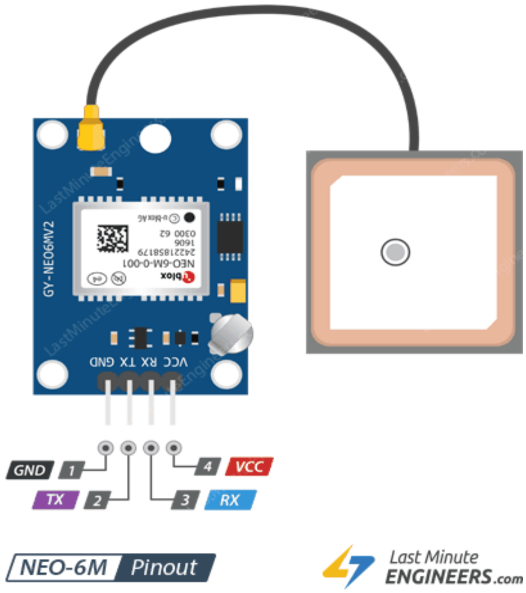

Figure 2: Ublox Neo-6M Module.

2.1 Ublox Neo-6M Module

In this paper, the satellite receiver module used is the Ublox Neo-6M module. This module is useful in modeling electronic devices to determine the position (Yulius &Salim, 2013), as well as position tracking (Budiman et al., 2020). This gps module has the advantage of being able to prove the fixed position in cold start conditions for about 27 seconds with a 50 channel receiver type. The sensitivity of the module in tracking and navigation conditions is -161 dBm. While the level of accuracy of the GPS horizontal position of this module is 2.5 m. communication systems interfaces and protocols that can be used are UART, USB and serial peripheral interface (SPI). The operating voltage of this module is a maximum of 3.6 V and a current of 100 mA (U-blox, 2017). The accuracy level of the Ublox Neo-6M module is quite mild compared to the Neo-M8N module (Firdaus & Ismail, 2020). The Ublox Neo-6M satellite signals receiver module and pin positions are shown in Figure 2. 3.

The pins contained in the Ublox Neo-6M module are 4 consisting of: (1) GND (ground) connected to Arduino ground, (2) TX (transmitter) is used for serial communication, (1) RX (receiver) is used for serial communication, (4) VCC is connected to the power supply or can be directly connected to 5V on the Arduino pin. The communication system between the Ublox Neo-6M Module and the microcontroller uses UART. This module supports baud rate 4800bps – 230400bps with the default baud rate of 9600. On the module there is also a LED that will flash every 1 second if the satellite is fixed. In addition there is a battery that can be charged, and a 3.3V voltage regulators. The module is further equipped with a serial EEPROM with a memory capacity of 4KB which is connected to the NEO-6M chip using I2C communication. In this module there is likewise a satellite receiving antenna with a sensitivity of -161 dBm. This antenna is attached to a U.FL cable and connector. Serial data generated from the Ublox Neo-6M module is in the form of NMEA sentences. NMEA is submitted to National Marine Electronics Association which is the standard format on all GPS receivers. The NMEA standard is in the form of rows of data called sentences. Each sentence is delimited by a comma to facilitate the parsing of data on a computer or microcontroller. This NMEA sentence will be transmitted in a certain interval called the update rate. Information updated by default on the Neo-6M module is one per second or 1Hz frequency, but can be set to 5 data per second or 5Hz frequency.

The most common is $GPRMC (Global Positioning Recommended Minimum Coordinates) which provides time, date, latitude, longitude and estimated speed. $GPGGA This sentence presents an essential data fix that provides 3D location and data accuracy.

2.2 Microcontroller

The microcontroller device is used as a controller and signal processor from the GPS receiver module. This microcontroller is Atmega328 which is built-in an Arduino Uno development board as showed in Figure

3. The operating voltage of this board is 5V. It has 32 KB of flash memory, and 2KB as a boot loader. The clock speed is 16 Mhz. This microcontroller is equipped with digital I/O, Analog IN, and PWM output pins (Arduino, 2021). In detail pins found on the Arduino Uno can be observed in Figure 4.

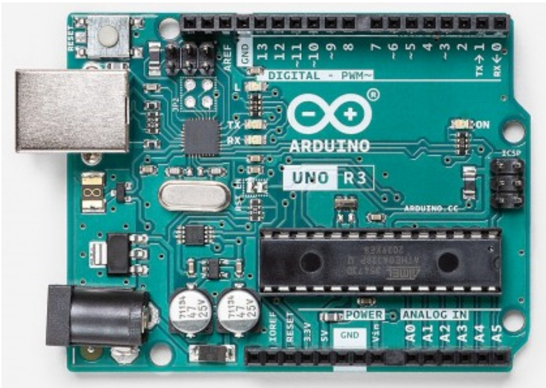

Figure 3: Arduino Uno Board.

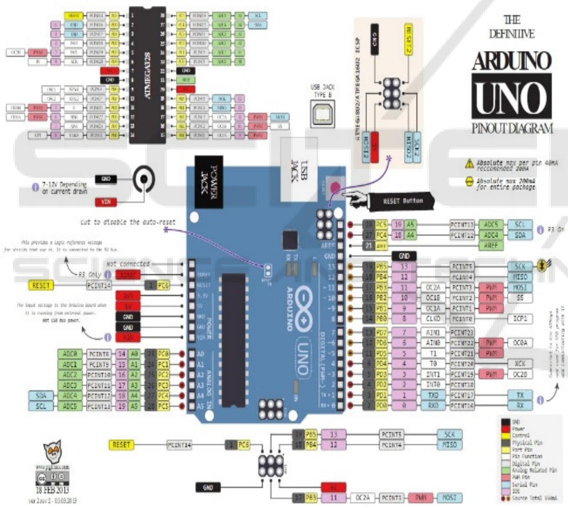

Figure 4: Pinout Arduino Uno.

Arduino Uno will process serial data from Ublox Neo-6M. The data will be processed and displayed on the LCD screen. Positioning modeling (Arfianto et al., 2018) is not equipped with a screen that shows the position directly. In this paper, because it serves as a navigational aid, a position indicator in the form of a screen is necessary. The addition of a 20x4 character LCD screen is supposed to be sufficient to display the required data.

2.3 LCD

The LCD module in this paper is a 20x4 LCD type. This LCD has 20 character columns and 4 rows. Each character makes up to 5x8 dots. Built-in controller with S6A0069 series or equivalent. Supply voltage 5V and fitted with LED backlight. This LCD module has 16 pins that are utilized to display characters on the screen. LCD is likewise composed of several blocks consisting of controller, driver, led backlight, and LCD panel. The block diagram can be viewed in Ga Figure 5. (Ocular, 2003). Turning on a 20x4 LCD requires a lot of cables to connect. To reduce the need for cables and pins on the microcontroller, in this paper the LCD is connected to the I2C serial interface module. The I2C serial interface module used has a PCF8574T chip (Semiconductors, 2002).

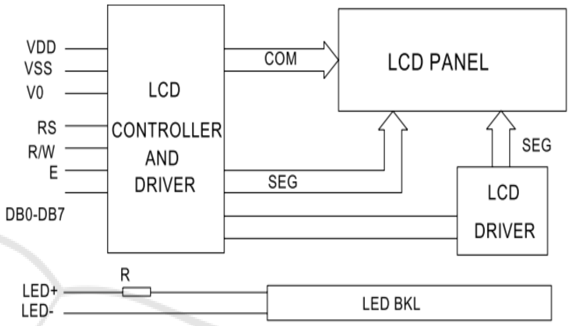

Figure 5: LCD Block Diagram.

The use of the I2C serial interface on the 2004 LCD only requires 4 pins to carry on the LCD. The four pins are: (1) GND which is connected to the microcontroller ground, (2) VCC is connected to a 5V voltage source, (3) SDA is connected to Analog pin 4, (4) SCL is connected to Analog pin 5. The shape of the I2C board can be observed in Figure 7. On the PCF8574T chip, the address for I2C is of the format: 0 1 0 0 A2 A1 A0. The factory default address is 0x27. While the address ranges is between 0x20 - 0x27.

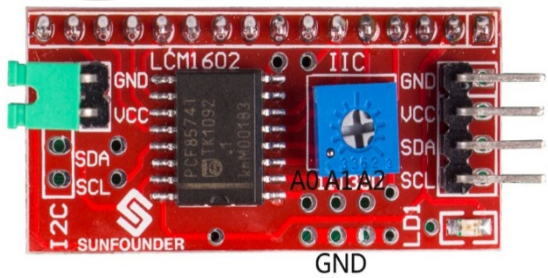

Figure 6: I2C Serial LCD Board.

2.4 DMS Conversion

Decimal Degree (DD) is a notation for expressing geographic coordinates of latitude and longitude as a decimal fraction of a degree. Decimal degrees are used in various geographic information systems

(GIS), web mapping applications such as Open Street Map, and GPS devices. Decimal degrees are an alternative to using sexagesimal degrees (degrees, minutes, and seconds - DMS notation). As with latitude and longitude, values are limited by ±90 and ±180, respectively (Wikipedia, 2022). Converting DMS coordinates to decimal degrees is a work of converting the minute and second components to decimal degrees. Converting minutes and seconds to degrees are equal to turning minutes and seconds into hours. Where 1 minute = 1/60 hour and 1 second = 1/3600 hour.
Positive latitudes are north of the equator. Negative latitudes are south of the equator. Positive longitude is east of the Prime Meridian while negative longitude is west of the Prime Meridian. Latitude and longitude are usually expressed in order of latitude before longitude. Nautical Miles is 60 miles = 1° flat = 1° long at the equator. If 1 degree latitude is 111.3 km at the equator, then the change in a fraction of a minute is: (1) 1 degree = 60 minutes, (2) 1 minute = 1 degree/60 = 111.32km / 60 = 1,855km, (3) 1 minute = 1855m, (4) 0.1min = 185.5m, (5) 0.01min = 18.55m, (6) 0.001min = 1.855m, (7) 0.0001min = 0.1855m = 185.5mm, (8) 0.00001min = 0.0185m = 18.55mm = 1.855cm. The more decimal places behind the comma, the higher the GPS accuracy will be.

Conversion of DD to DMS can be done as in the example: on GPS the geographical position is -7.020222 110.401566 then if converted to DMS is: -7.020222= 7(0.02022*60) = 1.21332= 1(0.21332*6)= 12.7992 S is written 7° 1 12.7992″ S 110.401566 = 110, 0.401566*60 = 24.09396 =24 0.09396*60 = 5.6376 E is written 110° 24′ 5.6376″ E. So the position in DMS is 7° 1′ 12.7992″ South Latitude 110° 24′ 5.6376″ East. In this paper, the position point display is displayed on the LCD screen in DMS format. It is intended to make it easier to read the position according to the paper map. Some characters such as degrees, minutes, and seconds are not part of the library. In this study, a special character was in addition to display it.

2.5 Haversine Method

In this paper, the Haversine method is utilized to calculate calculate the distance between coordinates in a geographic projection system (decimal degrees/DD). This method calculates the shortest distance between two points on a curved surface by utilizing the latitude (Y-value) and longitude (X-value) values at that point. This calculation is of great importance to use in navigation (Yulianto, Ramadiani, & Kridalaksana, 2018). Haversine own formula is as following:

$$a = sin^2\left(\frac{\Delta\varphi}{2}\right) + cos\varphi_1 . cos\varphi_2 . sin^2\left(\frac{\Delta\lambda}{2}\right) \quad (1)$$

$$c = 2. atan^2\left(\sqrt{a}, \sqrt{(1-a)}\right) \quad (2)$$

$$d = R.c \quad (3)$$

The following information: (1) φ = latitude, (2) λ = longitude, (3) R = earth radius/ mean radius = 6.371km. In order for trigonometric functions to work properly, the angle values must be in radians.

3 PROPOSED SYSTEM

In this paper, a schematic of the low cost GPS circuit design is shown as showed in Figure 7. In the figure, it consists of a Ublox Neo-6M GPS module connected to a microcontroller. The Tx data pin of the Ublox Neo-6M module is attached to pin 3 and the Rx data pin is connected to pin 4 of the Arduino Uno. The 20x4 LCD is utilized to display the current position and is connected to the PCF8574 I2C module. On the SCL and SDA pins of the I2C module, they are connected to pins on A5 and pins A4 of Arduino Uno, respectively. The indicator in the form of a LED that will flash when approaching the reference point at a distance of less than 300m is connected to pin 7.

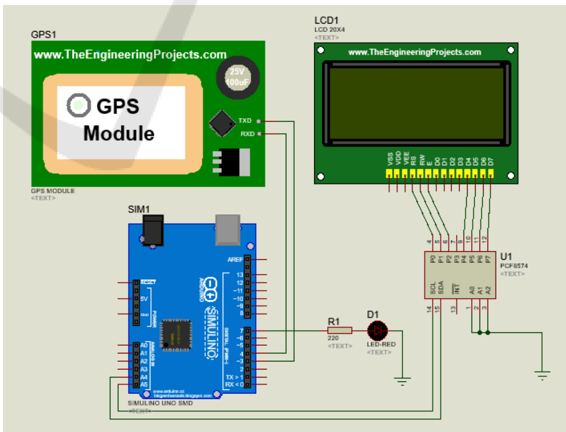

Figure 7: GPS circuit schematic.

In addition, to simplify the system design, a system architecture is made. This GPS architecture consists of a GPS module as an input signal to the microcontroller, a voltage source from 2 of 18650 batteries, and at the output of a LED lamp and a 20x4 character LCD module as showed in Figure 8.

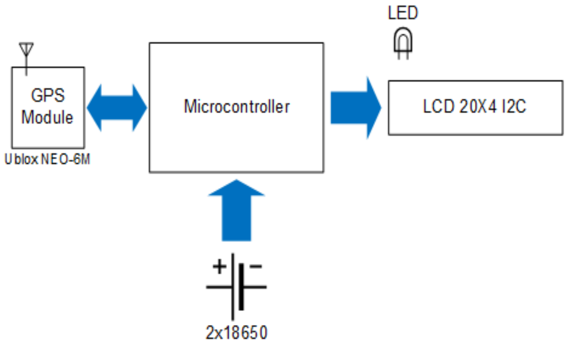

Figure 8: GPS architecture.

In this paper, all existing electronic components are contained in the X6 black plastic box. The design of the GPS box that makes as in Figure 9. On the front are placed a 20x4 LCD and LED indicators. The top is placed on the GPS signal receiving antenna. The voltage source to run all the equipment is obtained from 2 Lithium ions 18650 batteries. Both batteries are installed in series and each has a voltage of 3.7V, so the available voltage is around 7.4V.

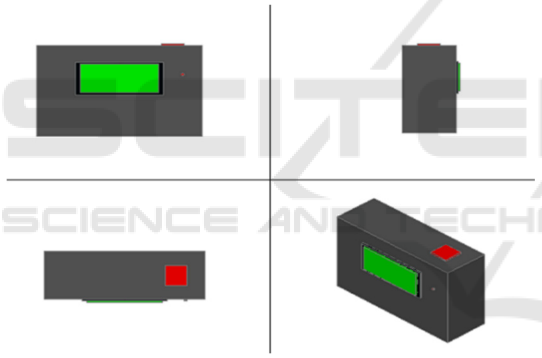

Figure 9: GPS box design model.

4 RESULT AND ANALYSIS

Data retrieval is achieved by bringing the GPS equipment that has been made close to the reference points that have been determined. After that, the coordinates are shown at that distance. The data generated in the position towards the reference points as indicated in Table 1. In the table the results of the display on the LCD screen are recorded. The resulting data are latitude and longitude positions in DMS format. On the screen will show the distance and bearing. In the column on the right are included in the results of calculations using the Haversine formula. The indication on the LCD screen and the calculation results is not too far apart.

Table 1: Data to reference points.

LCD screen				Calculating	
Distance (m)	Bearing (°)	Latitude	Longitude	Distance (m)	Bearing (°)
300	293	7 1 0.0047 S	110 23 58.440 E	300.4870	293.1840
250	291	7 0 59.058 S	110 23 57.039 E	249.7814	290.9347
200	297	7 0 59.045 S	110 23 55.281 E	200.1133	296.3454
150	305	7 0 58.952 S	110 23 53.441 E	150.0575	304.9887
100	307	7 0 58.125 S	110 23 52.040 E	100.3924	307.1594
50	309	7 0 57.172 S	110 23 50.750 E	51.22879	307.7593
25	303	7 0 56.612 S	110 23 50.145 E	26.17842	302.9771
10	299	7 0 56.317 S	110 23 49.733 E	10.62473	299.2503

To make it easier to analyze the test results. It is illustrated using a Google Map. The measurement position point is indicated by a blue marking on the Google map. Figure 10 indicates the position of the marking points to the reference points. Measurements are taken by walking along the road and getting closer to the points as a reference.

Figure 10: Plotting to reference points on Google Map.

In addition, the 20x4 LCD screen display can be seen as showed in Figure 11. The first row on the left is the number of satellites. The first and second rows indicate the latitude and longitude positions. CP or closes point shows the distance to the nearest point. BRG is the bearing to the nearest point in degrees. Data display on the LCD screen. Calculation results, and plotting on Google map shows the appropriate distance and bearing.

Figure 11: GPS LCD screen display.

5 CONCLUSIONS

Testing and data retrieval using the GPS design has been executed. The GPS design created can display the position in real time and is presented on a 20x4 LCD screen. The displayed position is in DMS format, making it more convenient for fishermen to read the position. In addition, in this paper, a point is determined as a reference point and the results of the data can show the distance to the reference points with results that is not too far apart. In this paper, the distance and bearing measurements are not more than 300m and not less than 10m.

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