Ocean Engineering : Jurnal Ilmu Teknik dan Teknologi Maritim
Vol. 1, No. 3 September 2022
e-ISSN: 2963-5454; p-ISSN: 2963-5012, Hal. 118-127

Incremental Rotary Encoder Accuracy Testing On Ship Rudder Simulation

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Abstract. *Incremental rotary encoder is a sensor that can be used to measure the degree of rotation in ship steering simulations. To create a ship steering simulation, Visual Basic software was used to simulate the movement of the rudder and ship. Meanwhile, to obtain incremental rotary encoder reading data, serial communication is used via Universal Serial Bus (USB) media bridged by Arduino which is programmed to convert incremental sensor signals into ASCII signals with a bolt rate of 9600 bps. The aim of this research is to test the accuracy level of the incremental rotary encoder sensor in ship steering simulations using Visual Basic software on commercial ships by using the Solas rule that a ship's rudder must comply when rotated from the midship position to the 35 degree port side position followed by the 35 degree position. starboard side and returning to midship, the rudder movement time was less than 28 seconds. Test results in terms of response speed of the incremental rotary encoder sensor are very good, while in terms of accuracy level for one degree of steering rotation, the result is 4.571 on the Arduino IDE serial monitor reading..*

Keywords: *Incremental rotary encoder, Arduino Uno, Visual Basic, Steering gear..*

INTRODUCTION

Simulators are widely used to assist learning activities for lecturers in maritime vocational education environments for practical courses. One of the existing simulators according to the 1978 Standard Training and Watchkeeping (STCW) is a bridge simulator which simulates a ship's bridge which is made according to the conditions on an actual ship. One of the components in the bridge simulator is the ship's rudder which is used to move the rudder which is located at the stern of the ship or behind the propeller. One of the sensors that can be used to measure the degree of rotation is the incremental rotary encoder which will be tried to be applied to measure the degree of rotation of the rudder in the starboardship and portship directions in ship steering simulations created using Visual Basic software.

Ship steering gear is one of ship’s equipment which is used to convert and determine ship’s direction, either the straight direction or the turning direction of the ship. It is placed at the rear end of the hull / stern behind the ship's propeller. The common ship simulator used are full mission bridge simulator, where the entire working system and equipment are made to resemble the real conditions on the ship. The simulator is used by the students of Nautical study program as the reinforcement before carrying out sea project (sea internship). The rudder in this simulator is used to determine the direction of the ship by moving it towards the port and starboard side using an incremental rotary encoder sensor to specify how many degrees the steering angle is.

Received: Juli 07, 2022; Revised: Agustus 2, 2022; Accepted: September 22, 2022
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The rotary encoder consists of a cable for power and a cable for sending data in the form of pulses. Incremental rotary encoder sensor can be implemented to measure the angular position of a rotating ship's rudder and determine the direction of the rudder rotation either in a clockwise or anticlockwise direction. The incremental rotary encoder uses a disc with several holes in which an LED and a photodiode are placed. The output of photodiode is two pulses consisting of channel A and channel B. When the channel A precedes the channel B, it shown that the rudder is rotating as a clockwise or to the starboard side in the ship navigation system. Meanwhile if the channel B precedes the channel A, it shows that the rudder rotates as an anticlockwise or to the port side.

Based on the SOLAS 1978 Regulation, a system of ship rudder able to navigate the ship from the position of port 35º to the starboard 35º or vice versa when the maximum machine rotation and the maximum loading of time is 28 second. According to the background described above, the research problem in this study focuses on the making of simulator design particularly for designing ship rudder which able to respond in 28 second, and also have the capability to navigate the ship from 35º port to 35º starboard or conversely. The steering wheel is positioned at the rear end of the hull / stern behind the ship's propeller and mechanically driven. By placing the rudder at the stern behind ship’s propeller, it makes the performance of the steering wheel more leverage, especially to change the tone on the ship by utilizing the current which is generated from the rotation of the propeller.

The aim of this research is to determine the level of accuracy of the incremental rotary encoder sensor for ship steering simulations and to determine the response of the sensor according to the Solas rules regarding ship steering.The benefits of this research include as a teaching and learning tool in the classroom and laboratory as learning about ship steering and how to assemble it using Arduino. It also benefits to know the process of ship simulator design. The making of this tool aims to make a prop / simple simulation for the procedure of steering and designing a ship steering simulator independently.

METHOD

The research method used in this research is an applied method by designing a ship steering system which is created in a simulation using visual basic software. The sensor used is an incremental rotary encoder sensor which will be tested to obtain the level of accuracy and the response produced by the sensor according to Safety of Life at Sea (SOLAS)

regulations. The equipment used to design a ship steering simulation to test the incremental rotary encoder sensor includes the following:

1. Microcontroller

   The microcontroller used is an Arduino which can be programmed using the C language which includes the Arduino IDE facility which functions to write the programming language. The processing of data that received from the rotary encoder sensor via Arduino Uno using the Arduino IDE (Integrated Development Editor) serial monitoring. Then, the data is transferred by using USB series in the form of ASCII data with baud rate of 9600. Baud rate indicates the speed of data which sent via serial communication (USB). Baud rate is mentioned in bits per second (bps). The data monitoring process will be continuous and repeated until the specified time limit of data collection.

2. Incremental Rotary Encoder

   Incremental rotary encoder is a sensor used to measure how many degrees the steering wheel has rotated with the output of three signals, namely signal A, signal B and clock. The reference voltage used is 5 volts so that the output from signals A, B and C produces a voltage of 5 volts which can be connected directly to the Arduino. The output is a box signal between 0 and 5 volts depending on the reference voltage used.

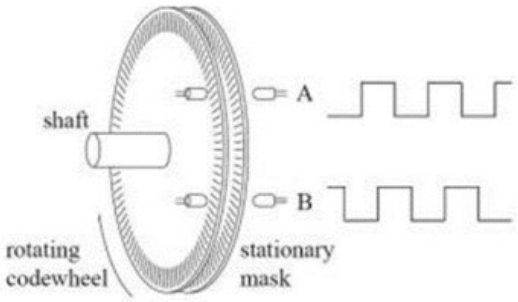

Figure 1. Structure of incremental rotary encoder

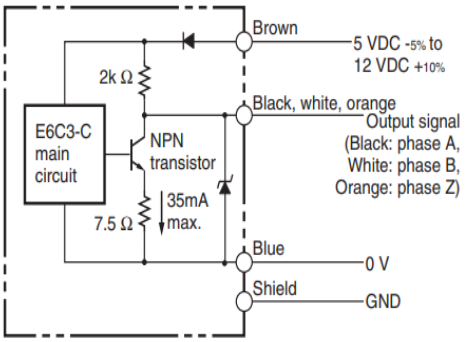

Figure 2. Incremental rotary encoder circuit

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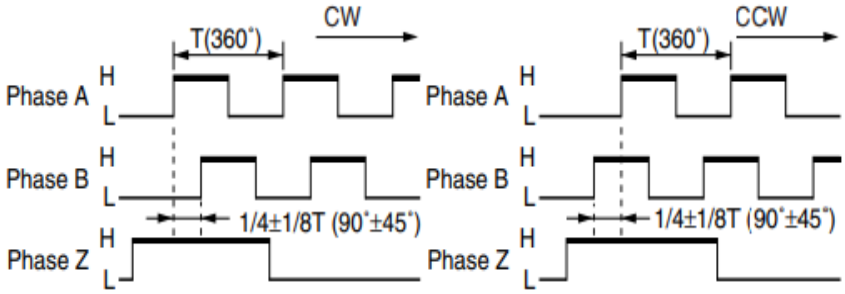


Gambar 3. Output of incremental rotary encoder

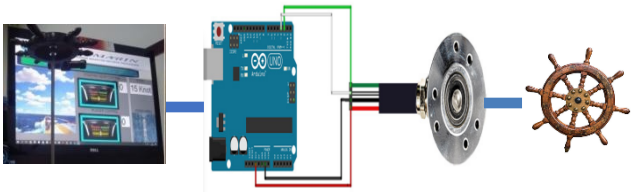
3. Visual Basic Software

The software for this ship's crew simulation uses Visual Basic software which is connected to Arduino via serial communication. This software is needed to monitor ship movements and the degree of rudder based on input from the incremental rotary encoder sensor. One of way to communicate the Arduino and computer is by accessing the port series by using Visual Basic through MSCOMM components. The General baud rate used are 110, 300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800, 921600 bits/second. The Visual basic program is used to show the ship movement and also the changes of the steering from port 35 to starboard 35. The steering movement then followed by the opposite direction of rudder, so as the ship will move slowly in line with the steering wheel motion to port or starboard side. This rudder movement obtain the input from incremental rotary encoder sensor in form of pulse of two output cables, A and B.

RESULT AND DISCUSS

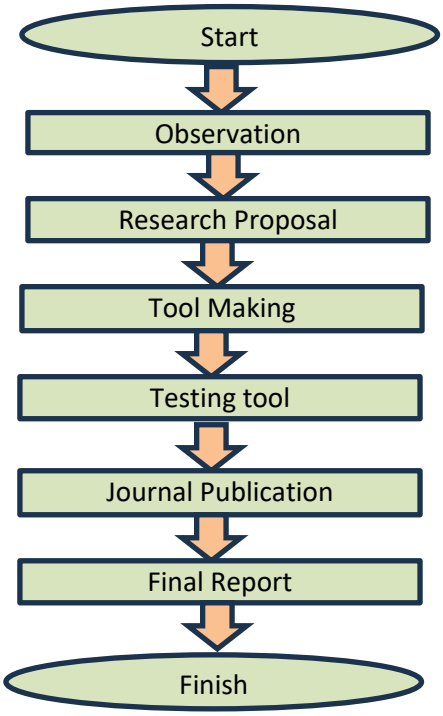
The preparation activities include conducting literature review that is collecting data from some references such kind of previous research journals which relate to ship steering rules and other supporting components such as research on the use of incremental rotary encoder sensors and so on.

This research is conducted in the computer laboratory of Polimarin by means of Visual Basic Software to present ship steering simulation. Ship steering simulation hardware is a circuit system consisting of an incremental rotary encoder sensor, Arduino and computer, as well as a steering wheel connected to the incremental rotary encoder using a shaft. Meanwhile, the software used is visual basic which is programmed using a programming language equipped with images displaying the movement of the ship and rudder.



Picture 4. Tool Scheme

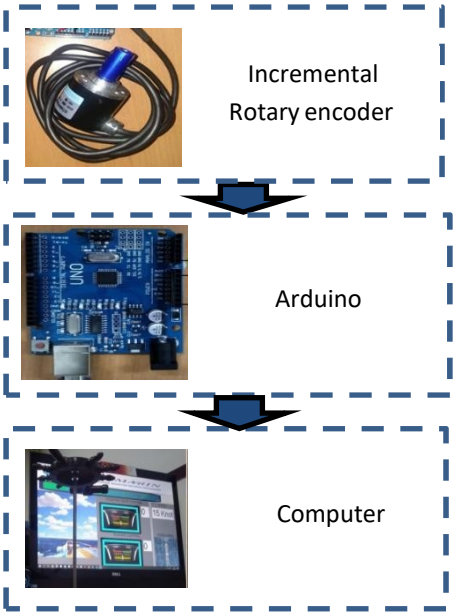
The research data were taken by monitoring serial of Arduino. In order to provide the accuracy level of incremental rotary encoder, the researcher also monitoring the serial of Arduino by turning 35º to the right and 35º to the left so the accuracy from the incremental rotary encoder can be gained. Furthermore, in accordance with SOLAS regulation of rudder, it is necessary to take the data when the testing steering of port 35º and starboard 35º of rudder is not more than 28 second at the maximum speed.



Picture 5. Tool Scheme

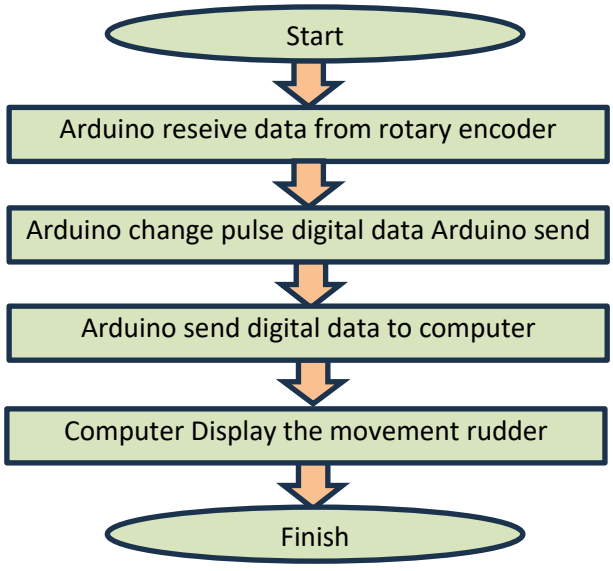
In simulating the rudder of this ship, the equipment used are an incremental rotary encoder as a sensor, Arduino as a control and a computer programmed using Visual Basic Software as a display of the ship simulation. The incremental rotary encoder sensor is used to determine how many degrees the steering gear rotates and establish the steering gear to turn to the port side or starboard side. The signal released from the incremental rotary encoder is a readable digital or pulse signal in computer. When the steering gear or rudder is moved to

port side and starboard side, so it followed by the motion of rudder at the stern of the ship which can be seen from the movement of the rudder on the computer.



Picture 6. Tool Scheme

The data from Arduino is transferred to the computer by USB port using Visual Basic Software as seen in picture 6. Steering gear control functions to monitor how many degrees the steering when it is turned and the rudder control works to monitoring how many degrees are the rudder position when the steering is turned, there are both an analog and digital reading.



Picture 7. Research tool design

The rotary encoder asensor is connected to the Arduino, releasing a digital signal in the form of two pulses, namely A and B. Design of the steering used the incremental rotary

encoder as shown on figure 7 is used to calculate the steering rotation degree and determine the direction of rotation of the steering turning right or left. The output of incremental rotary encoder as digital signal consists of two pulse for degree measurement and to specify the rotation to right or left. Data from the pulse of incremental rotary encoder is processed by Arduino by programming it using serial monitor Arduino IDE. Moreover, this data pulse is converted into number and transferred by computer USB serial. These data are read by Arduino serial communication as an included facility in Arduino IDE Software. The results of the reading of rotary encoder on the Arduino IDE serial monitor. Data on the serial monitor Arduino IDE is displayed in visual basic software and programmed to determine the ship's rudder movement and the position of the steering wheel.

Picture 8. The scheme of rotary encoder use

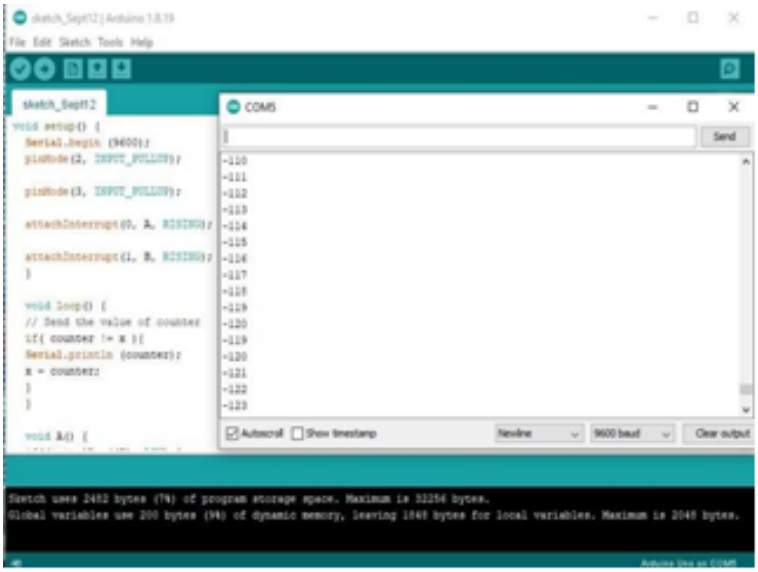
DISCUSSION

The port 35º test is carried out by turning the steering gear to the left by 35º with observing the steering movement and obtained 4 seconds until the rudder reach 35º adding by rotating the steering gear back to the midships or 0º and get 4 seconds until the rudder reaches 0º.

Picture 9. Port 35º on computer

The reading of incremental rotary encoder signal for the port side using the Arduino serial monitor is shown in figure 7 and the testing result of the sensor when turning left or port 0º up to 35º is presented in figure 10. Output of the sensor itself is in the form of two pulse signals then transferred to the computer in the form of number 0 up to -160 on the port testing by Arduino data. The pulse data then being processed by computer with applying Visual Basic software to display the rudder position then adding 'delay' to present the steering wheel position shown in the rudder control. When the rudder is steered to the port side then the steering wheel moves to the right, otherwise if the rudder is rotated to starboard, the steering wheel moves to the left.

The reading value of Arduino serial monitor when the rotary encoder in midship position is 0, it is positive when positioned on starboard and negative on the port side. The signal reading of incremental encoder for starboard side uses serial monitor of Arduino. The testing results of the incremental rotary encoder when turning left (port side) is 0º up to 35º. The testing obtained data 0 for 0º to 160 for 35º starboard. When the rudder is turned to starboard, the steering wheel moved to left and the ship slowly turn to right. The incremental rotary encoder's response is good when the rudder is rotated, it indicates that it almost has no time differences when the rudder is turned by the reading of steering gear control, then delay is given slowly for the rudder control to fit the steering gear control position. The accuracy level of incremental rotary encoder sensor is 4,571 for one degree of steering rotation from the Arduino IDE serial monitor reading results.



Picture 10. Reading signal of incremental rotary encoder via Arduino Serial Monitor

In accordance with Solas 1978 a ship's steering system is capable of steering the ship from a 35º port position to a 35º starboard or vice versa, at maximum engine speed and maximum load in a maximum period of 28 seconds and from the test results obtained a time of 16 seconds. The test is carried out by positioning the steering wheel or staring gear from 0° to 35° port side, then positioned it on 35º port side to 0º or midship then to starboard 35º and back to midship 0, the maximum travel time for the steering wheel according to the Solas regulations must be less than 28 seconds.

CONCLUSIONS AND RECOMMENDATIONS

According to the test results using the Arduino IDE serial monitor software when the port position is 35º, the reading value is -160 and when the position is starboard 35º, the reading value is 160. Based on Solas 1978, a ship' steering system able to navigate the ship from position of port 35º or vice versa, at the maximum engine speed and maximum loading within 28 seconds, and from the test, it's gained 16 seconds.

ACKNOWLEDGMENT

We do thank to all the lecturers and staffs who have contributed this study and also for executive unit of Polimarin's Computer laboratory which have provided the facilities during the process of this study.

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