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Design and Implementation of Engine Order Telegraph With RS485 Communication for Ship Maneuvering

Sri Mulyanto Herlambang
Shipping Polytechnic Surabaya, Indonesia
suksesbareng20@gmail.com

Frengki Imanto
Shipping Polytechnic Surabaya, Indonesia
frenk.fr1@gmail.com

Slamet Winardi*
Departement of Computer Engineering Narotama University, Surabaya, Indonesia
slamet.winardi@narotama.ac.id

Arief Budijanto
Departement of Computer Engineering NSC Politechnic, Surabaya, Indonesia
arief@dsn.nsc.ac.id

ABSTRACT
EOT (Engine Order Telegraph) is the embodiment of a machine-human interface that is controlled by the captain of the ship for safe and sustainable ship maneuvers as a basic part of a connected remote propulsion system. Remote control systems on modern ships usually have a control transfer system that allows control to be transferred between locations. Remote control is usually possible from two locations: the platform and the Engine Control Room (ECR). Some ships do not have a remote control handle on the ECR. When in bridge control mode, the bridge handle directly controls the engine set point. When in Engine Control Room mode, the bridge handle sends a telegraph signal to the ECR and the ECR handle controls the control system set point. In local control, the remote control system is inactive and the bridge handle sends a telegraph signal to the local control position and the machine is operated by its manual control in the engine room. In this study, an EOT device will be realized using the Arduino Mega2560 microcontroller and data communication using the RS485 serial from the bridge to the engine control room.
Keywords: EOT; ECR; Arduino Mega2560; RS485; Ship Control

1. INTRODUCTION
Every passenger ship is equipped with internationally recognized safety standards including communication standards. On ships, the navigation officer controls the ship's navigation system from the bridge and the engineer controls the propulsion plan from the engine room. The bridge is right above the ship, so the officers on the bridge do not know the condition of the propulsion engine and the driver in the engine control room does not know where the ship is going because the engine room is located under the ship's line of water. Therefore fail-safe communication is required between navigation and engineer officers to ensure smooth and safe voyage of ships. the onboard telegraph was used as a communication tool to transfer speed or direction change orders from the bridge to the engine control room. The telegraph sequence machine consists of a lever that can be moved at different speed positions for the front and rear directions.

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In this research, an Engine Order Telegraph (EOT) simulation tool on the ship will be made using the Arduino Mega 2560 microcontroller using RS485 serial communication from the Pavilion Deck to the Engine Control Room. Two-way communication can be done using a minimum wire line consisting of only 4 wires, in the form of plus and minus voltage lines and D+ and D-.

2. METHODOLOGY

Engine Order Telegraph (EOT) is equipment used to communicate speed orders from Wheelhouse/Bridge to Engine Control Room (ECR) or Engine Room and receive replies from ECR/ER to Wheelhouse. Commands are initiated by pressing the respective command button on the wheelhouse panel. These commands are transmitted via a two-wire serial interface to the engine room panel. The engine room station will flash the appropriate LED and activate beacons and sirens until the command is received. The LED will then stop flashing and the alarm will turn off. An engine sequence telegraph (sometimes called an engine room telegraph) is a navigational instrument used to communicate the ship's position between the captain of the ship and the engine room. Operating a machine-ordered telegraph required the captain of the ship to move the telegraph handle to a different position on the dial. This will ring the bell in the engine room and move the pointer to the position on the dial selected by the captain of the ship on the bridge. The technicians heard the bell and moved their handles to the same position to signal the telegraph order on the bridge, and adjusted the engine speed to the ship's captain's preference.

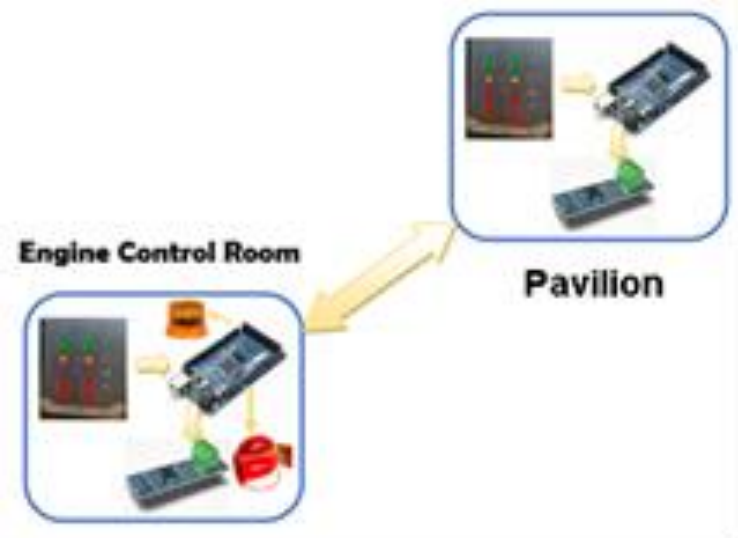

Figure. 1. Engine Order Telegraph Block Diagram

2.1. Schematic of Order Telegraph Engine using ATMega2560 Microcontroller

The ATMega2560 microcontroller is the brain of the Engine Order Telegraph system both on the bridge and in the engine control room. A set of push buttons that have their respective functions are connected to a microcontroller, which will give a signal to the microcontroller to run according to the request of the captain of the ship or the technician in the engine control room. Then the Microcontroller will process the input information from the push button and then send that information to the receiving module in the engine control room. Sending data via RS485 serial communication which has a fairly long distance. The following is a schematic for a series of engine order telegraphs located on the bridge and in the engine control room.

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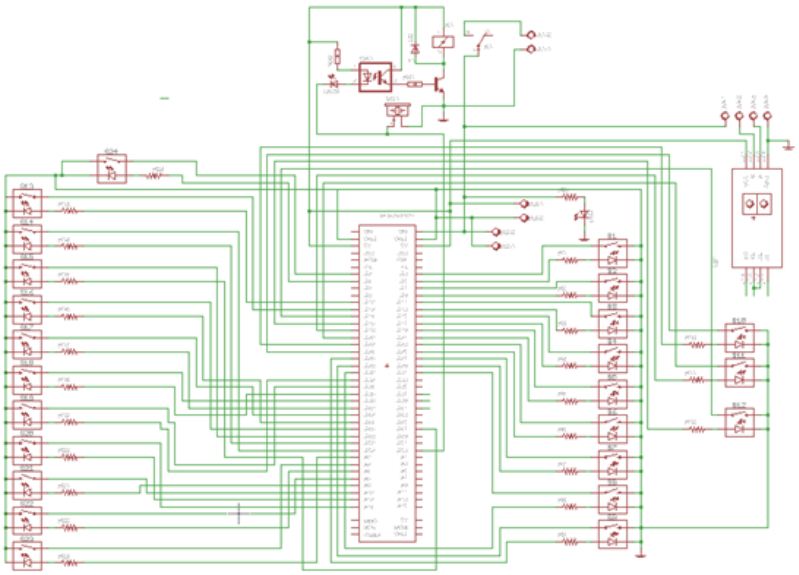

Figure 2. Schematic of the Order Telegraph Engine Circuit

2.2. Schematic of Buzzer Circuit

As an indicator of communication between devices, besides using LEDs, a buzzer is also used because apart from being in the form of a visual indicator, it is also equipped with a sound indicator, so that when you do not see the engine order telegraph panel, you can still hear the buzzer sound as a sign that you have received orders from the captain of the ship, and the captain of the ship as well. know the information has been responded to or not by listening to the buzzer sound, if the buzzer still sounds then the technician has not responded to the command signal given.

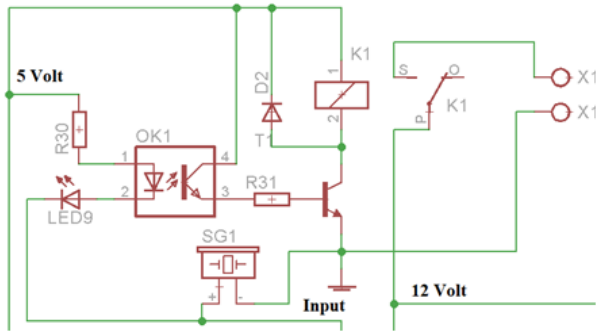

Figure. 3. Buzzer Driver Circuit Schematic

The Buzzer pin is connected to pin 53 of the Arduino Mega 2560, on the platform in the form of a buzzer which is driven by a voltage of 5 volts because the situation in the cabin deck is not too noisy, while the buzzer in the engine room uses a relay to disconnect and connect the 12 volt voltage.

2.3. Schematic of RS485 . Communication Circuit

To transmit the information generated by the push button from the ship captain's command, it will be sent to the engine control room using serial communication with the RS485 protocol. The reason for using RS485 communication is because it is noise resistant and has a long range.

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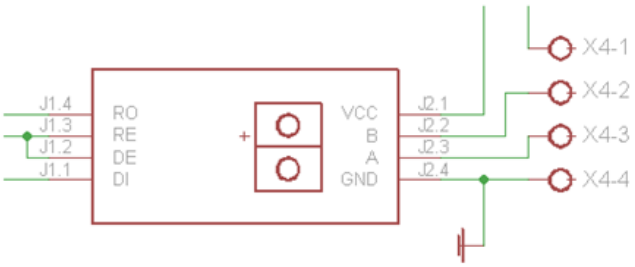

Figure. 4. RS485 Serial Communication Circuit Schematic

2.4. Telegraph Order Engine Software With Arduino Mega2560 On The Pavilion

To operate the Engine Order Telegraph, a program is needed on the bridge. The Arduino Mega2560 microcontroller will read the buttons that have been coded according to the commands that will be sent to the engine control room, namely: Full Ahead, Half Ahead, Slow Ahead, Dead Slow Ahead, Stop, Finished with Engine, Dead Slow Astern, Slow Astern, Half Astern, Full Astern Bridge Control, Standby. After the button is pressed and read by the microcontroller, it will turn on the LED light on the board as a sign that the button is pressed and give an alarm signal indicating that the command has been sent by the microcontroller and will then be sent via RS485 serial communication. The engine order telegraph board on the bridge will continue to light up and sound until there is a response from the technician in the engine control room.

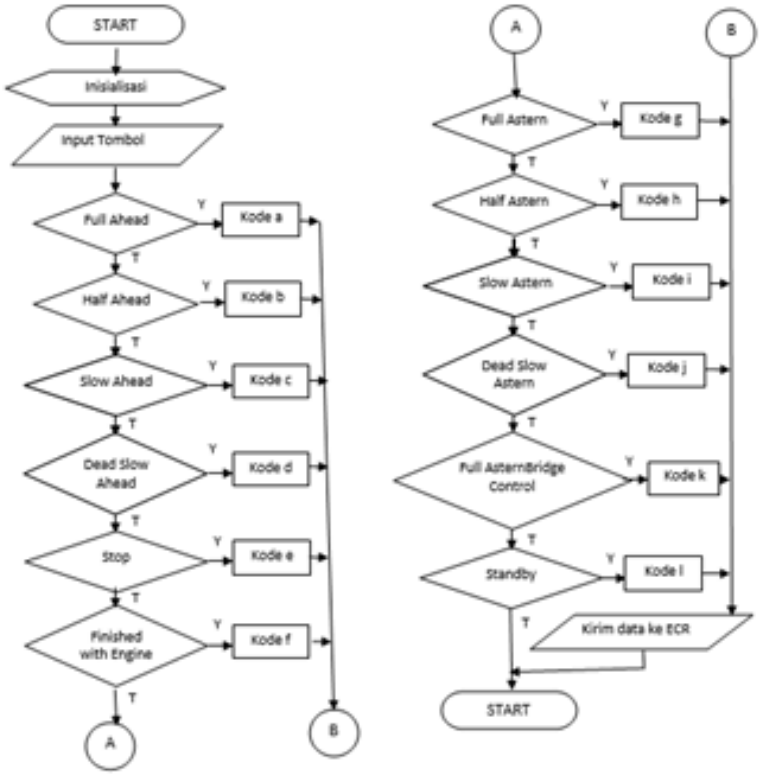

Figure. 5. EOT Flowchart For Pavilion

2.5. Engine Order Telegraph Software In Engine Control Room

After receiving a telegraph signal from the Pavilion in the form of a command code pressed by the captain of the ship, the EOT tool in the engine control room will turn on an indicator according to the button pressed and sound an alarm and a rotator light as a sign to the technician to carry out his orders. Then the technician will press the button according to the request of the captain of the ship in response to the reply that the technician will carry out his

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orders. After the button is pressed, the alarm goes off and the lights go out and the code is also sent to the bridge and turns off the alarm as a sign to the ship captain that the technician has carried out the orders according to his instructions so that the ship can run in the desired direction.

After designing the telegraph engine tool and testing the designed tool, a prototype engine telegraph tool that can communicate remotely with the RS485 protocol covers a distance of about 1000 meters. The two tools have similarities in the work process, but the tools installed in the engine room control cannot work if they don't get information commands from the tools installed on the bridge deck. So the equipment on the bridge deck must send an information signal first, then the tool in the engine room control will respond to the information then will carry out the information according to the instructions that must be done by the technician, and the technician will provide feedback to the bridge deck that he has done work in accordance with the orders given by the captain of the ship so that the ship can walk or maneuver according to the route of travel or park the ship.

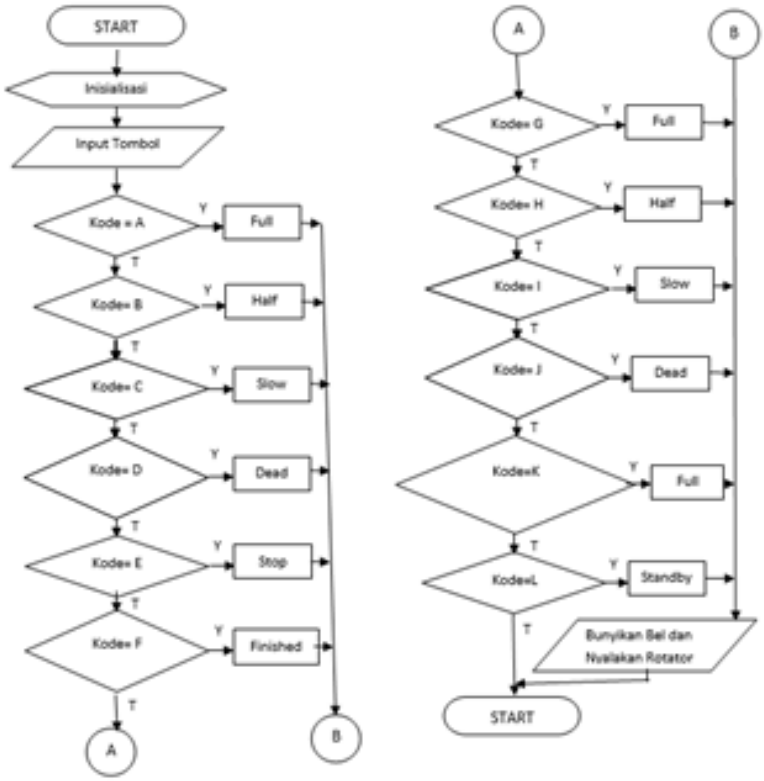

Figure. 6. Flowchart EOT Untuk Engine Room Control

3. RESULTS AND DISCUSSION

After designing the telegraph engine tool and testing the designed tool, a prototype engine telegraph tool that can communicate remotely with the RS485 protocol covers a distance of about 1000 meters. The two tools have similarities in the work process, but the tools installed in the engine room control cannot work if they don't get information commands from the tools installed on the bridge deck. So the equipment on the bridge deck must send an information signal first, then the tool in the engine room control will respond to the information then will carry out the information according to the instructions that must be done by the technician, and the technician will provide feedback to the bridge deck that he has done work in accordance with the orders given by the captain of the ship so that the ship can walk or maneuver according to the route of travel or park the ship.

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Figure. 7. Order Telegraph Engine Prototype

3.1. Engine Order Telegraph on the Pavilion Deck

The order telegraph engine tool which has colored buttons is placed on the bridge deck which will be operated by the captain of the ship, if the automatic control experiences problems or problems. The command buttons on the EOT board consist of two, namely to adjust the speed of the right engine (Port) and the left engine speed (STBD), both of which have the same button function which is connected to the ATMega2560 microcontroller consisting of:

Port_ahead_full Button connected to pin 22
Port_ahead_half Button connected to pin 18
Port_ahead_slow Button connected to pin 28
Port_ahead_deadslow Button connected to pin 30
Port_astern_full Button connected to pin 3
Port_astern_half Button connected to pin 7
Port_astern_slow Button connected to pin 11
Port_astern_deadslow Button connected to pin 15
Port_standby Button connected to pin 27
Port_stop Button connected to pin 23
Port_finish Button connected to pin 19
Stbd_ahead_full Button connected to pin 14
Stbd_ahead_half Button connected to pin 12
Stbd_ahead_slow Button connected to pin 52
Stbd_ahead_deadslow Button connected to pin 48
Stbd_astern_full Button connected to pin 0
Stbd_astern_half Button connected to pin A10
Stbd_astern_slow Button connected to pin A14
Stbd_astern_deadslow Button connected to pin 34
Stbd_standby Button connected to pin 46
Stbd_stop Button connected to pin 42
Stbd_finish Button connected to pin 38
Mute_send Button connected to pin A2
Dim Button connected to pin 2
port_ahead_full LED_ connected to pin 24
port_ahead_half LED_ connected to pin 20
Port_ahead_slow LED connected to pin 26

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Port_ahead_deadslow LED connected to pin 30
Port_astern_full LED connected to pin 5
Port_astern_half LED connected to pin 9
Port_astern_slow LED connected to pin 13
Port_astern_deadslow LED connected to pin 17
Port_standby LED connected to pin 29
Port_stop LED connected to pin 25
Port_finish LED connected to pin 21
Stbd_ahead_full LED connected to pin 14
Stbd_ahead_half LED connected to pin 10
Stbd_ahead_slow connected to pin 50
Stbd_ahead_deadslow LED connected to pin 47
Stbd_astern_full LED connected to pin A4
Stbd_astern_half LED connected to pin A8
Stbd_astern_slow LED connected to pin A12
Stbd_astern_deadslow LED connected to pin 32
Stbd_standby LED connected to pin 44
Stbd_stop LED connected to pin 40
Stbd_finish LED connected to pin 36
Mute_send LED connected to pin A0
DIM LED connected to pin 4

Figure. 8. Engine Order Telegraph Prototype on Pavilion Deck

To send a message a ship captain must press the button on the EOT panel until the LED lights up, if the information sent turns out to be wrong then the button is pressed again so that he can press another button which will send the message, here is a snippet of the button pressing program and the results of pressing the button the. Then after the button is pressed and the LED lights up, the message is ready to be sent by pressing the SEND button, after the message is sent, the buzzer on the EOT board will sound indicating the data has been sent to the EOT in the engine room control, via RS485 communication.

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```
void tekan_tombol(){
  if (digitalRead(port_ahead_full) == LOW){
    status_port_ahead_full = !status_port_ahead_full;
    lock_tombol = true;
    delay(300);
    while (status_port_ahead_full == true){
    digitalWrite(LED_port_ahead_full, HIGH);
    kode = 'a';
   // Serial.println(" tombol ditekan");
    if (digitalRead(port_ahead_full) == LOW){
       status_port_ahead_full = false;
       digitalWrite(LED_port_ahead_full, LOW);
       lock_tombol = false;
       delay(300);
    }
    if (digitalRead(mute_send) == LOW){
      digitalWrite(LED_mute_send, HIGH);
      status_mute_send = true;
      kirim(kode);
      delay(350);
      digitalWrite(LED_mute_send, LOW);
      buzzer_on();
      delay(100);
      status_port_ahead_full = false;
      lock_tombol = true;
   }
  }
}
```

Figure. 9. Program part of One Button

Figure. 10. One Button Pressed

3.2. Engine Order Telegraph in Engine Room Control

The second engine order telegraph device is installed in the engine control room which will be operated by the technician on the orders of the captain of the ship. The second EOT cannot operate, it must first wait for the message sent from the EOT on the bridge deck has been sent, then the EOT will provide information in the form of a flashing LED and a loud buzzer sound so that the technician can see and hear it.

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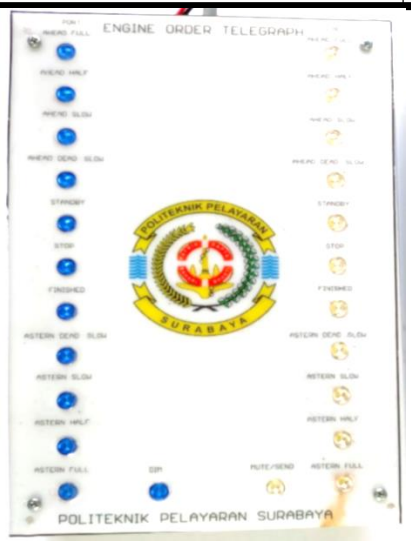

Figure. 11. Engine Order Telegraph Prototype on Engine Room Control

3.3. Send Messages Between Engine Order Telegraph

The following is the result of sending messages from EOT on the bridge deck and received by EOT in the engine control room. The captain of the ship presses the EOT button as a message that will be executed by the technician until the button lights up then to send a message by pressing the SEND button, after the message data is sent the buzzer on the bridge deck will sound, until the engine room control message will be received and the LED will flash according to the message desired by the captain of the ship and the alarm sounds. Technicians will carry out orders as desired by the captain of the ship. To reply to the received message, a technician will press the flashing button and immediately the alarm in the EOT engine room control will go off, and a message is sent to the bridge deck and will turn off the LED and buzzer, so that the captain of the ship knows that the message has been received and executed.
Part program to run the above as follows:

```
if (digitalRead(port_ahead_half) == LOW){
  status_port_ahead_half = !status_port_ahead_half;
  lock_tombol = true;
  delay(300);
  while (status_port_ahead_half == true){
    digitalWrite(LED_port_ahead_half, HIGH);
    kode = 'b';
    if (digitalRead(port_ahead_half) == LOW){
      status_port_ahead_half = false;
      digitalWrite(LED_port_ahead_half, LOW);
      lock_tombol = false;
      delay(300);
}
if (digitalRead(mute_send) == LOW){
    digitalWrite(LED_mute_send, HIGH);
    status_mute_send = true;
    kirim(kode);
    delay(350);
    digitalWrite(LED_mute_send, LOW);
    buzzer_on();
    delay(100);
    status_port_ahead_half = false;
    lock_tombol = true;
 }
}
}
```

```
178 void terima(){
179  // digitalWrite(Pin_TxControl, RS485Receive);
180   if (SerialRS485.available())
181   {
182     byteReceived = SerialRS485.read();   // Read the byte
183     Serial.println(byteReceived);
184   }
185     if (byteReceived == 'a'){
186       status_port_ahead_full = true;
187       while (status_port_ahead_full == true){
188          digitalWrite(LED_port_ahead_full, HIGH);
189          buzzer_on();
190          delay(30);
191          Serial.println("setelah terima data");
192          digitalWrite(LED_port_ahead_full, LOW);
193          //buzzer_off();
194          delay(30);
195          kode = 'A';
196          if (digitalRead(port_ahead_full) == LOW){
197             kirim(kode);
198             digitalWrite(LED_port_ahead_full, LOW);
199             buzzer_off();
200             status_port_ahead_full = false;
201             delay(300);
202          byteReceived = 0;
203       }
204     }
205   }
```

Figure. 12. To the right of the Send Program section, to the left of the Receive Program section

4. CONCLUSION

4.1 Conclusion

This Engine Order Telegraph is a tool used to move the ship forward or backward and to maneuver manually by sending a message to the engine room control to temporarily replace the

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automatic control if it doesn't work. Because the distance between the bridge deck and the engine room is far enough to send messages using serial communication with the RS485 protocol. Each key represents a message sent from the bridge deck to the engine room which is encoded using a character distinguished between uppercase and lowercase letters, from the bridge deck sending one uppercase letter and from the engine room sending one lowercase letter. It is advisable to use the same LED color between the EOT on the bridge deck and the EOT in the engine room, because the integrated LEDs and buttons are difficult to find in the market so the color of the LED lights is different, so the equipment is not standard with those on the market.

4.2 Suggestion

To clarify the information conveyed from the bridge to the engine room, a text display should be added which will provide clearer information.

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