Fault Management of Electrical Drives Onboard Ship using Power Line Communication

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Abstract - *To maintain the continuity and reliability of an electric drive onboard ship, it is very important to develop an efficient fault management system. This primarily involves continues monitoring of electrical drives and initiating necessary actions for quick fault clearance. In this paper, an experimental setup is developed to integrate different sensors for monitoring and controlling the electric drives from a remote center using Power Line Communication. Compared to other communication technologies, PLC has the advantage of avoiding extra communication cables and thus reducing the weight of the ship*

Key Words: **Directional sensor, Electric drives, Power line communication, Propulsion, Speed Sensor**

1. INTRODUCTION

The transformation of ship propulsion system from direct drive to completely electrical based system has yielded numerous advantages. The fuel consumption has reduced and the mechanical efficiency as improved. A single set of generators, unlike in the traditional systems, can be used to cater both propulsion and non-propulsion loads. In the recent past, the power generation onboard ship is also supported by renewable energy sources to reduce the carbon emissions [1].

However, this advancement in technology has also brought in the complexity of handling the electrical machinery. Due to the large number of electrical drives used in ship, from propulsion to water pumping, a centralized controlling mechanism will be of great help. To achieve this, a continuous monitoring should also be developed. The parameters to be monitored also includes the power consumption pattern, reactive power management of the ship [2][3].

The ship power system is not exactly same as the conventional power system. Due to the constraints in the space, the generators and the electrical loads are placed in a congested location and it is not very easy to physically monitor these equipment. Though a large number of sensors can be placed to update to monitor the data, what really matters is the medium used to transfer the data.

The monitoring of the equipment can be carried out by using communication cables like Ethernet or DSL cables [4][5]. But this extra cabling will only add weight to the ship, there by compromising the space and speed of the ship. Another issue with using communication cables is the interference created due to the proximity of communication cables with power cables. A non intrusive monitoring technique like power line communication can be more suitable option [6].

Communication over power lines will make use of the existing infrastructure and hence will have very minimal installation costs. Since all the equipment are powered by electrical supply, the reach of electrical cables is maximum. Since the medium of communication is a cable, the faults in them can also be monitored [7].

In this paper, a non-intrusive methodology is discussed to the communication between the electrical drives and the control room is carried out. The existing power lines are used to continuously monitor the electrical drives and fed the data into the centralized control room. In fact the same power cable can also be used to control the drives from the centralized location.

In the subsequent sections of this of the paper are organized as follows. In the section II, the implementation of power line communication onboard ship is discussed. In the section III, the monitoring and control of electrical drives is explained. In the section IV, the hardware implementation of this project is discussed. Finally, the paper is concluded with the advantages and limitations of this methodology.

2. POWER LINE COMMUNICATION

Power line communication (PLC) makes use of the existing electrical cables to transfer data from one node to another. Though, PLC offers many advantages to the user, it should be noted that the power lines were actually not intended to transfer data. The medium may be hostile to communication. Hence, prior to the implementation of this technology, the medium need to be thoroughly analyzed [8]. Various modeling techniques have been worked out to analyze the power line channel [9].

Since the medium of communication is high voltage supply, the data cannot be transferred directly. A coupling interface is to be placed along with the modem to avoid any direct contact. This coupling circuit is to be developed as per the frequency of operation and the voltage level of the power line [10]. Though coupling circuit can be of inductive type or capacitive type, the latter is the commonly used. The capacitive type coupling circuit is usually a combination of capacitor and transformer connected in series as shown in Fig. 1. This type of capacitor circuit as the advantage of easy to build and is also cost effective. The capacitor filters out the 50 Hz power supply and transformer provides the required galvanic isolation to the modem.

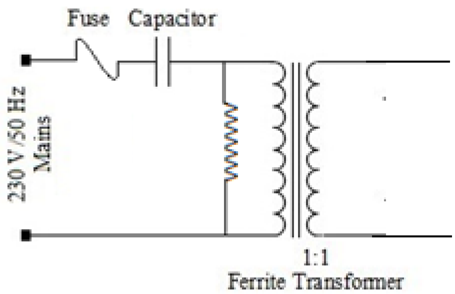

Fig -1: Coupling Circuit

The capacitor used in this paper is a metalized polypropylene type and the transformer is of ferrite core material. The coupling circuit is of 1:1 ratio and address the problem of Impedance mismatching.

In the interest of this paper, the coupling interface is developed to operate in the frequency range of 1-500 kHz with cut-off frequency of 125 kHz. The circuit operates at a voltage of 230V. The circuit is also provided with a fuse to avoid any excessive current in the power lines. A bleeder resistor is also placed in the circuit to discharge the capacitor during short circuit conditions. Additional surge protective device can be placed in the circuit but they may attenuate the signal transmission.

To communicate between the electrical drive and the control room, the data is transferred in the frequency range of 150 kHz over the power lines. Since the distance between the control center and the electrical drive is expected to be of smaller distance in a ship, a basic modulation technique will serve the purpose. In this project the communication signals are modulated using FSK technique and are transferred at a buadrate of 1096.

Power line communication can also be carried out in higher frequency ranges i.e. in MHz range. But for specific applications like monitoring and controlling the equipment, the signals can be transferred in Narrowband frequencies. Broadband power line communication i.e signals transmitted in the frequency range of MHz are generally used for network connectivity, gaming and HDMI applications. An example for this is Indoor power line communications.

3. SYSTEM ARCHITECTURE

The monitoring and controlling of electrical drives can be implemented as shown in Fig. 2. The electric drives can be fixed with a sensor to monitor the operational conditions. The sensor will detect the abnormality in the motor operation and can signal the microcontroller. The microcontroller will process the signal and transfer it to modem. A PLC modem is used to isolate the circuit and the signal is transmitted on to the power line using the FSK modulation technique.

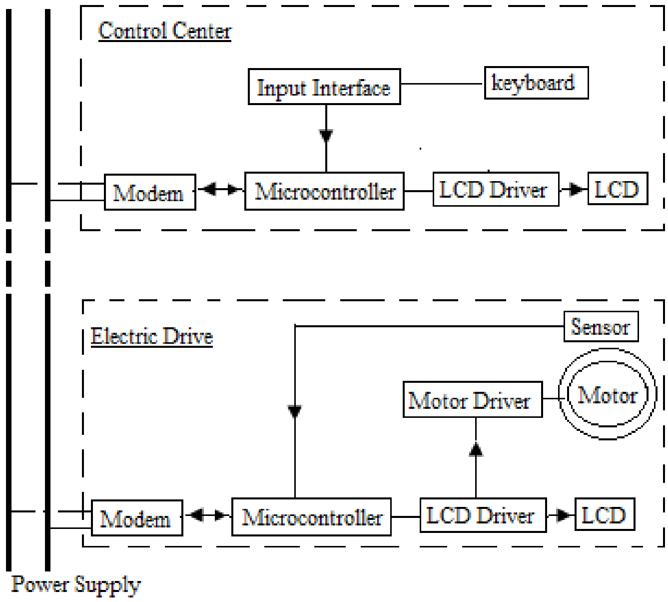

Fig -2: Block Diagram

The control center also consists of a modem which will demodulate the received signal. The microcontroller sends the signal to the LCD display for the notice of the control personnel.

The electrical drive can be controlled directly from the control center. The microcontroller is triggered with an input interface and thereby the required action is transmitted to the power line through the modem. The data is received at the drive location and the microcontroller takes the necessary action on the drive.

4. HARDWARE IMPLEMENTATION

In this project, a DC geared motor is used for exhibiting the usage of power line communication for monitoring and controlling a electric drive. The motor is monitored for speed and direction using the RPI-151 sensor. The monitored and control information in this project is accessed through ATMEGA 327 microprocessor. The motor driver used in this project is L298N. The operation of this project is shown in Fig. 3.

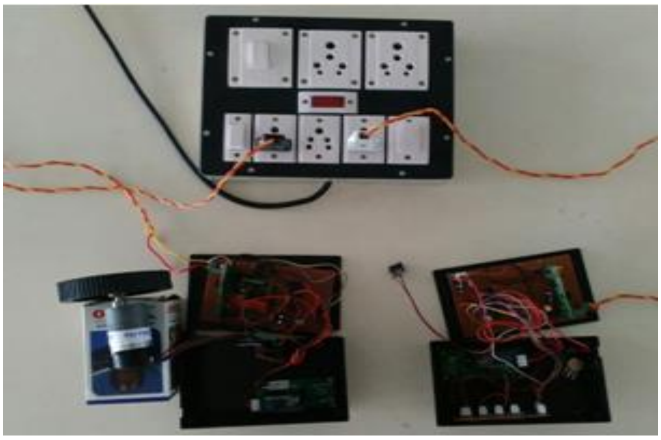

Fig -3: Hardware Implementation

4.1 Sensor

RPI-151is used to sense the motor speed and direction of a motor. This sensor is an integration of two sensors into one with high accuracy. It as an advantage of space saving, improved signal accuracy and high sensitivity. The operation of this sensor can be depicted in Fig. 4.

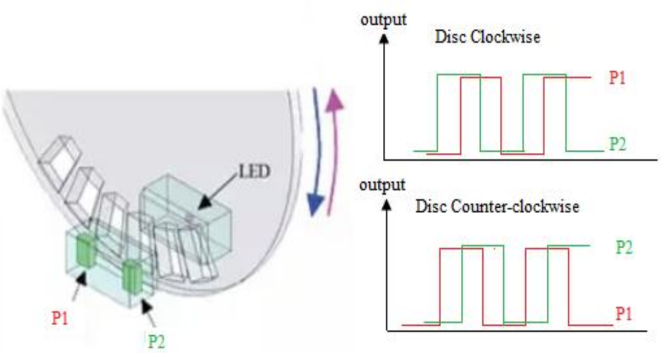

Fig -4: RPI -151 Sensor

The direction and speed is sensed with respect to the location of P1 and P2. With the variation between P1 and P2, the direction of motor is identified. In this project, the sensor will detect the speed and direction of the motor and sends the signal to the microprocessor for onward transfer to the control center.

4.2 DC geared motor

It is a DC motor with gears attached to it. These gears are used to vary the torque and control the speed of the motor. In this project, based on the signal send from the control center, the microprocessor will control the torque of the motor as shown in Fig. 5.

4.3 Motor driver

The DC geared motor in this project is controlled using the L298N driver. This is dual full bridge driver and triggers with standard TTL logics. In this project, since a DC motor is used, the driver makes use of only one bridge. The output voltage of the drive chops the current amplitude. It also provides the required over current protection.

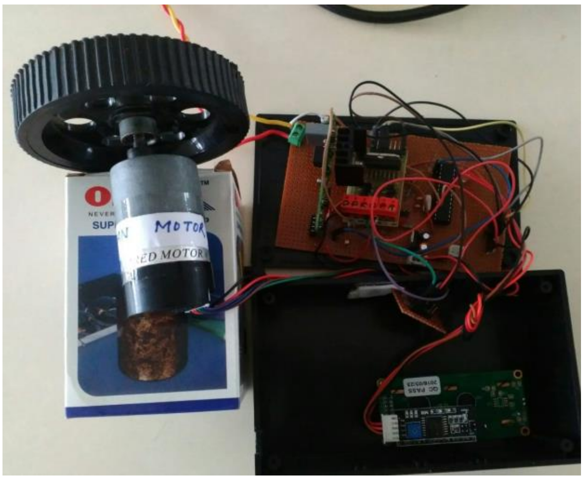

Fig -5: Motor with driver

5. RESULTS AND DISCUSSION

Though various techniques are implemented to monitor and control the drives, PLC technology as its own advantages. Using PLC, higher data rates can also be achieved by using an additional wire. In simple words, apart from live and neutral, the earth wire can also be used to simultaneously leading into a MIMO communication [11][12].

The main limitation in PLC technology is the variable load impedance and noise in the power line. This leads into unpredictable signal attenuation. This problem can be overcome using advanced modulation techniques like MC-CDMA and OFDM [13][14][15].

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