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NMEA2000 Ship Area Network (SAN) design and Test Bed using Power Line Communication (PLC) with the 3-Phase 3-Line Delta Connection Method

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Abstract. In this paper, the Integrated Ship Area Network which is suitable for the old or special ships built prior to the implementation of e-Navigation regulation by designing the PLC-based NMEA2000 integrated Network technology using the Ship-PLC. Since the Ship-PLC communication basically provides the Ethernet communication which has been used to support RS232/ 422/485 communications, technological implementation of various convergent multimedia communication was possible. With the test bed results using proposed technology in an actual ship, we've provided the possibility of shipbuilding cost reduction following plant structure changes and their numbers through integration of ship's power lines and circuits.

Keywords: 3Phase 3Line, Ship-PLC, NMEA2000, e-Navigation

1 Introduction

Along with current development of shipbuilding industry, mutual growth of the marine equipments business has been pursued. Especially, the marine equipments industry continues to thrive both quantitatively and qualitatively such that the paradigm in the field of the marine equipment technology is in a state of changing from the past concept of machine and electronic-based automation to a network-type concept where the IT technology has been converged. The provisions in several international treaties, which the International Maritime Organization (IMO) will re-amend, are expected to be tightened and with an all-out implementation of introduction of e-Navigation starting from the year 2000, various studies and standardization plans are now being carried out actively for this subject.

Meanwhile, the Global Navigation Satellite system and the Graphic Information System, both of which are the core systems of the e-Navigation, requires communication network and application system infrastructures. The main technical field among these is the supporting technology for the Maritime Communication System, and due to the increase in a necessity for the various types of electronic

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equipments' interfaces which directly affect safe vessel navigation, the appropriate data must be provided immediately following the NMEA2000 protocol standard (i.e., the standardization scheme for the serial data networking) when application systems such as the Voyage Data Recorder (VDR), Alarm Monitoring System (AMS) and others request data transmissions for the safety of navigation. The electronic equipments mounted in the vessels currently built in the Republic of Korea are manufactured in accordance with such international standard and they operate as an integrated network on all levels of the ship through the Ethernet-based Ship Area Network (SAN).

In response to recent tendency to build new vessels in a larger scale (e.g., container ships), the paradigm of vessel network infrastructure construction is also changing. Since the NMEA2000 is set to minimum of 200m and 250Kbps, the method that uses Ethernet-based UTP/STP cables, which could not overcome the range limitation of 100m, has been changed to using fiber-optic cables and wireless communication to solve the problem. Nevertheless, for those old vessels that are not equipped with such inboard communication infrastructure will face spatial, timely and costly obstacles once the e-Navigation becomes an obligation following the international agreement. In that regard, we've designed and implemented NMEA2000 SAN using the vessel power lines already routed in the most part of the ship to surmount the obstacles and to respond to the revision of international agreements with speed.

2 Related studies

2.1 Ship-PLC

Ship-PLC is networking technology enabling the transfer of data through existing power lines at the ship [1 - 5]. It provides high-speed transfer and needs no extra cables [6 – 9]. [Fig. 3] shows Ship-PLC. For the vessel which has been already wired entirely, the PLC can save costs and time. Our PLC unit provides up to 200Mbps for data transfer. The PLC promises fast and efficient network on vessel deck. Definition of PLC The communication technology that transfers data on the high frequency signal, using carrier frequency on power lines as a medium.

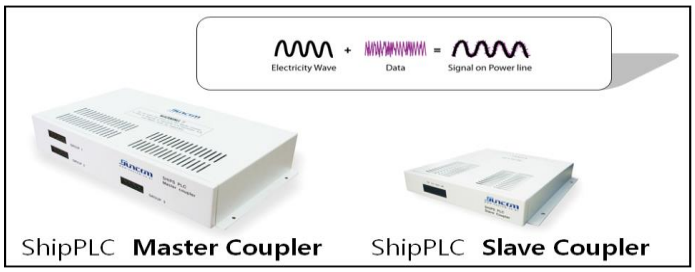

Fig. 1. Ship-PLC

3 NMEA2000 Ship Area Network (SAN)

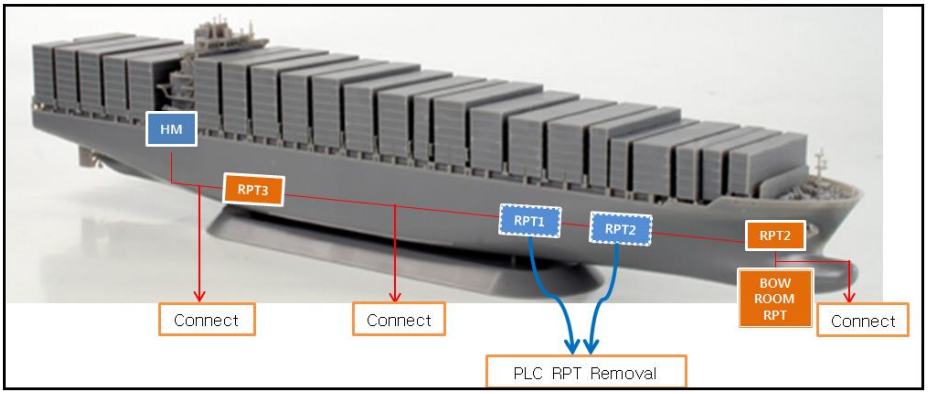

Fig. 2. General diagram for the test bed results of NMEA2000 SAN

[Fig. 2] is a general diagram for the test bed results of NMEA2000 SAN. The goal is to first establish a network from the ship's Marine House (inboard) to the Bow Room using PLC for an actual application then finally adapting it to the cargo hold. First, upper deck 220V emergency breaker panel master coupler was installed. Other installation details are: BOW ROOM SLAVE COUPLER installment; SLAVE COUPLER on the point of 100m from the passage way; SLAVE COUPLERS on the 2/5 and 4/5 distance points on the passage way; PASSAGE WAY 220V EMERGENCY BREAKER PLC RPT; and finally, PLC RPT on the ROTARY SW at the BOW Room entrance – all of which to check their network connections.

4 Performance evaluation

The performance evaluation was performed 3 times. For the first test, The Main Master Coupler was installed by selecting a breaker that control the range up to the BOW room among the breakers located in the emergency electricity generation room on upper deck and after moving to the Bow room, the Slave Coupler was subsequently installed to conduct the test. However, We've acknowledged no connection between the Emergency Breaker and BOW room modem. Thus, after removing the Repeater Modem installed on the half-way point on the Passage Way and newly installing the same modems on the 2/5 and 4/5 distance points, the test was resumed. The results confirmed that the connections were successful between the Emergency Generator Room and each Repeater Modem but the network connection between this room and the BOW room was still unavailable.

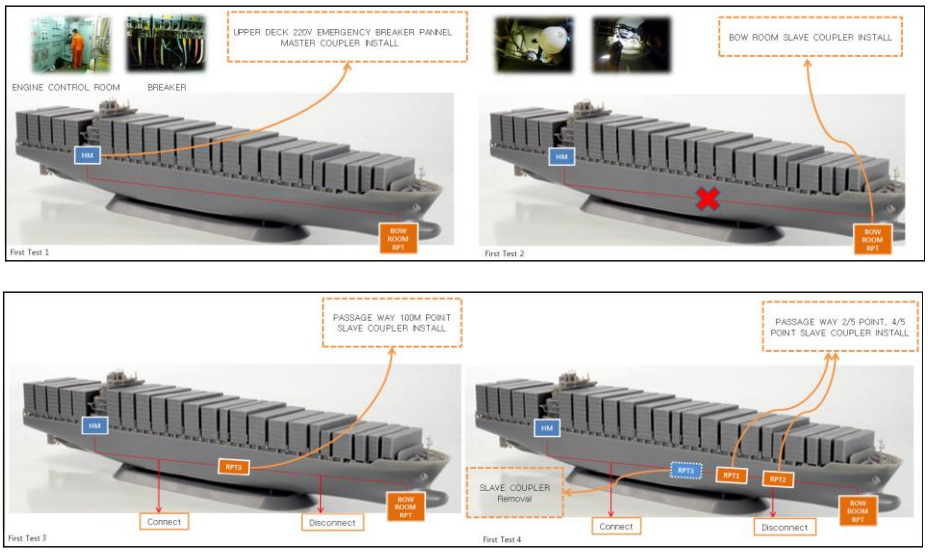

Fig. 3. First test

For the second test, the location of Main Coupler in the Emergency Generator Room was the same. After installing the Slave Modem on the Breaker that could control the BOW room among the 200V single-phase breakers located on the Passage Way (the same location with the Engine Room Line), the connection status between the Emergency Generator Room Emergency single-phase Modem was checked, though the network between both rooms was not identified. Therefore, maintaining the above mentioned modem, the test was carried out but this time the Slave Modem was installed to the single-phase Emergency Rotary S/W located at the entrance of BOW room on the Passage way. The result showed that the connection was successful.

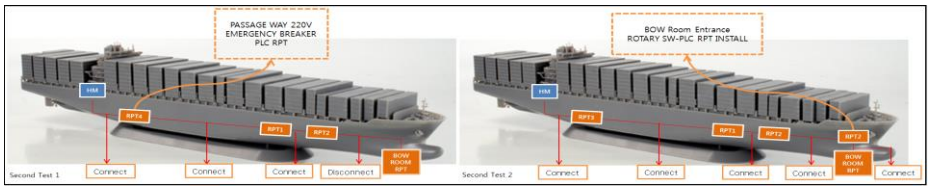

Fig. 4. Second test

The third test revealed successful network connection between both rooms after removing the Slave Coupler on the 4/5 distance point. The same success was observed after removing the Slave Coupler on 2/5 distance point. Finally, we organized wirings for the Slave Couplers installed in each section and after the notebook installation work, the basic precautions were delivered. The quality measurement log values using Jperf after the works are as shown in [Fig. 5]

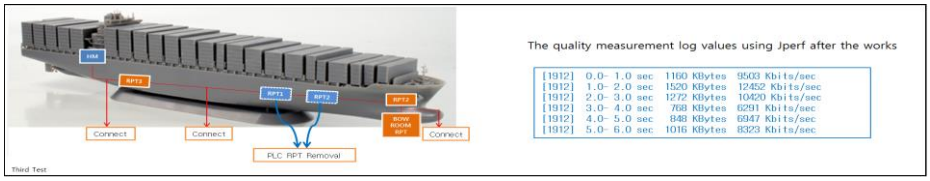

Fig. 5. Third test

5 Conclusion

The goal of e-Navigation related policies and standardization schemes such as IMO, IEC, ISO and IALA is to secure ship's safe navigation, the maritime safety and maritime environmental protection through convergence of shipbuilding technology and IT by collecting, integrating and analyzing the sensor-oriented data from the variety of ship's electronic devices and mechanical equipments via informative data transmission concerning the navigation safety, ship logistics and communications in whole process covering departures to entries.

Should the e-Navigation policy implementation become obligatory, existing ships subjected to the regulations would have to prepare measures to be adequately certified, and considering past cases, performing the obligations imposed by various international agreements will result in the unilateral damages (e.g., cost-loss derived from temporary navigation suspension, addition and replacement of equipment and installation of integrated network cables, etc.) for the ship owners.

In this paper, a test bed has been constructed in actual ship to make it possible to exchange NMEA2000 protocol between the parties by designing and implementing a technology that enables integrated network communication using the PLC with the 3-Phase 3-Line Delta Connection Method without installing separate network cables to

the existing ships that might experience some difficulties (e.g., aged ships subjected to the provisions in international agreements and ship-type characteristics) in installing additional network cables. As a result, we've suggested the possibility of shipbuilding cost reduction led by the modification of plant's structures and reduction of their numbers through integration of ship's power lines and circuits.

6 Expected effects

The network communication technology which assumes the role of nerve system has continued to develop and formed the basis for the next generation intelligent vessels. The ships with about 30,000 parts are the perfect constituting body of mechanical engineering, electronics and IT. Its advancement will lead to the development of cutting-edge sensor-based monitoring technologies which would prevent all kinds of accidents and protect lives. This technological development will also substitute several crewmen. Also, most of new born technologies and their development will generally be applied to the future cutting-edge ships yet to be built preferentially. However, the ship area network communication technology designed in this paper is quite effective for the aged ships built decades ago or sailing in inadequate environments so that requiring safety measures. Through such international technical standard, we expect that the realization of the e-Navigation will be accelerated.

Moreover, advances in the sensor technology can prevent safety-related accident as much. These sensor technologies will achieve recognitions for their values along with their advancement. However, for the ships, even though the sensor technology for the mechanical and electronic devices have already been developed and applied, they inevitably share the burden of a huge communication cable installation costs. Along with the development of sensor technology, the convergent design and test bed for the Ship-PLC communication adopting NMEA2000 in this paper is expected to become the network technology that supports the role of intelligent control center which can prevent maritime accidents in advance with remote maintenance and navigation information analysis through real-time monitoring of navigation statuses.

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