SCADA UPGRADING FOR SHIP INTERNAL SYSTEM MONITORING

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Abstract

This paper introduces the development and upgrading of ship internal system monitoring is based on SCADA technology. The upgraded system covers seven subsystems on the ship, including main propulsion engines, auxiliary generator engines, tanks, controlled pitch propeller, steering gear, bow thruster, and other auxiliary equipments. Each subsystem has its own sensors and actuators, and is also provided with its own Graphical User Interface (GUI) screen including all information, measurements and alarms according to the predefined operating conditions. The developed SCADA system also provides the user with alarm saving and archiving for data logging and reporting facilities. The internal ship subsystems have been briefly illustrated, the old automated system has been discussed and the upgraded system has been implemented using ADAMS interfacing modules and LabVIEW software programming packages. Communication protocols to provide four SCADA networking levels have been discussed and merits of the final upgraded system have been highlighted.

Keywords: Automation, Communication, LabVEIW, SCADA.

1. Introduction

SCADA systems have become popular to arise the efficient monitoring and control of distributed remote equipments. SCADA encompasses collecting of information, transferring to the central site, carrying out any necessary analysis and control, and then displaying the information on a number of operator screens or displays [1]–[2]. SCADA systems have been introduced for many recent educational and industrial applications [3]-[10]. The modern integrated monitoring system of ships plays an important role in the ship safety, reliability, and energy consumption level [11]-[15]. The "LabVIEW" software "package" has been utilized as a professional tool for the implementation of many SCADA screens in different real applications [16]-[18]. Communication protocols and industrial networking buses have been continuously developed, since they have become the backbone of recent SCADA systems [19]-[21]. Through this paper, the NI LabVIEW software package [22] together with ADAMS interfacing modules [23] and communication networking have been utilized to upgrade the ship internal system by development of internal SCADA monitoring system for different control and operating levels.

2. THE SHIP INTERNAL SYSTEM TO BE UPGRADED

The ship internal system required to be upgraded based on SCADA through this work mainly includes seven subsystems, as depicted in Figure 1, and may be simply described as follows:-

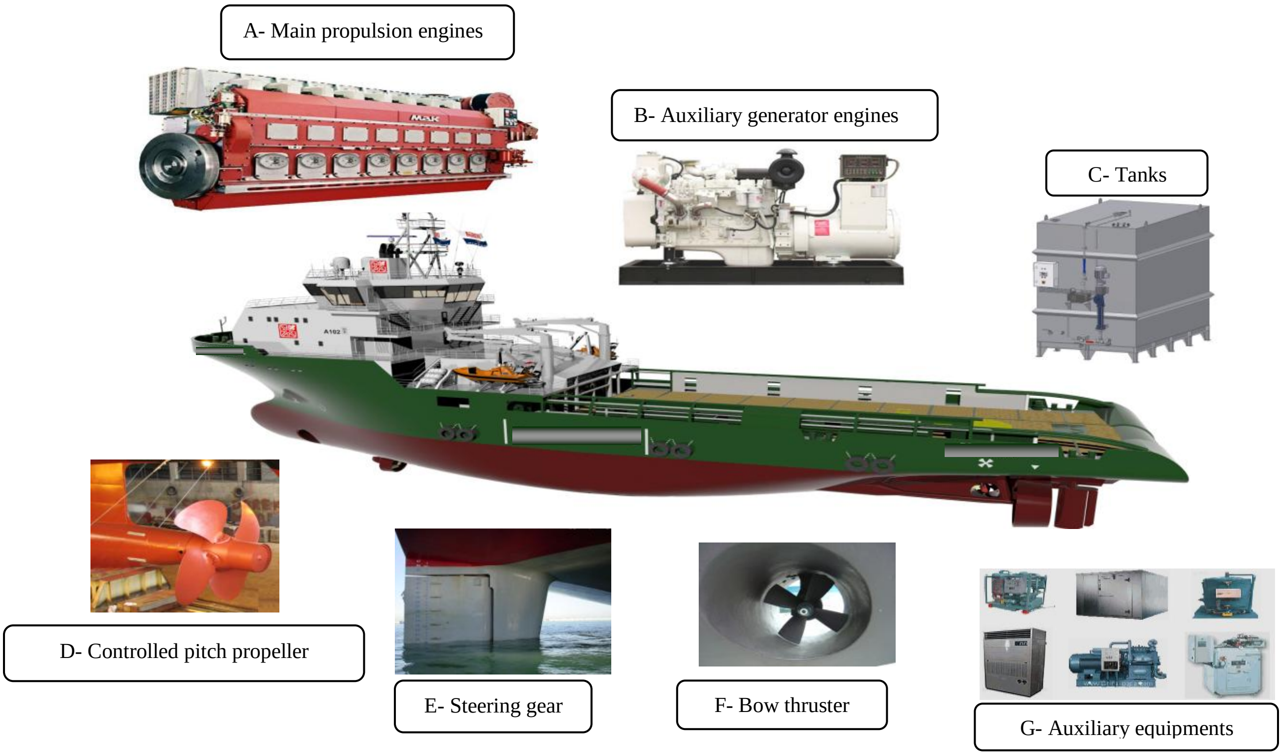


Fig.1. Internal ship subsystems to be upgraded within the SCADA system

A- Main Propulsion Engines

The ship has two main engines, right engine (usually called STBD engine) and lift engine (PORT engine).The two engines are identical and each one can be separately working. This system is responsible for moving the ship through the propeller coupled with a mechanical system that gives the required force for making the ship movement.

B- Auxiliary Generator Engines

The ship auxiliary engine is a combination of a diesel engine coupled with an electrical generator responsible for producing the electrical power in the ship. The ship has three auxiliary engines and each of them can be working separately.

C- Tanks

The storing system is a group of tanks used for storing different materials over the ship. There are many types of tanks in the ship. Each type has its own storing function such as: weight balance tanks for the ship hull, fresh water for the ship users, lubrication oil tanks, fuel tanks for ship engines, sewage tanks and other service tanks.

D-Controlled Pitch Propeller

This controlled pitch propeller is mechanically coupled with the main engine by the transmission and the clutch. It is responsible for converting the mechanical energy into a movement to move the ship hull. Since the ship has two main engines, the ship has two propellers. A controllable pitch propeller is associated with special blades that can be rotated around their long axis to change their pitch. Hence ship speed, while the reversible propeller can also create reverse thrust for braking or going backwards without the need of changing the direction of shaft revolution.

E- Steering Gear

This system can be considered a complementary part of the propulsion system, since the propulsion system is responsible of the longitudinal movement of the ship hull but the rudder is responsible for providing movement deviation according to the ship journey path. The main component of the steering system is the oil pump, which is responsible for giving the required hydraulic pressure to move the rudder. The system consists of two pumps; one is working while the other is standby. However, in some cases, it is required to work the system with the two pumps for extra steering force.

F- Bow Thruster

The bow thruster is responsible for side shift moving of the ship hull using an electrical motor coupled with the propeller. Bow thruster turns the ship to port or starboard, without using the main propulsion mechanism, which requires more forward motions for turning, thus making the ship more maneuverable.

G-Auxiliary Equipments

This system may have several separate components arranged in many places in the ship, while each component has its own function, such as freezer compressor, starting air compressor, lube oil pumps and etc.

3. The ship internal system to be upgraded

The main objectives of the ship automated system are to monitor and control the ship internal system, while the ship is off-shore or sailing. Each of the seven subsystems described in Section II has its own working conditions and components including sensors, actuators, commands and information devices. Figure 2 indicates examples of the already existed devices including mechanical sensors, switches and gages. It should be noted that each of the old subsystems has its own local monitoring and operating devices, so the operators should always move from one positions to other for continuously check and alarming responses. Using the upgraded SCADA system, all data will be provided in certain selected positions (operators and captain), hence reducing the human efforts and errors with more safe and comfort operation environments.

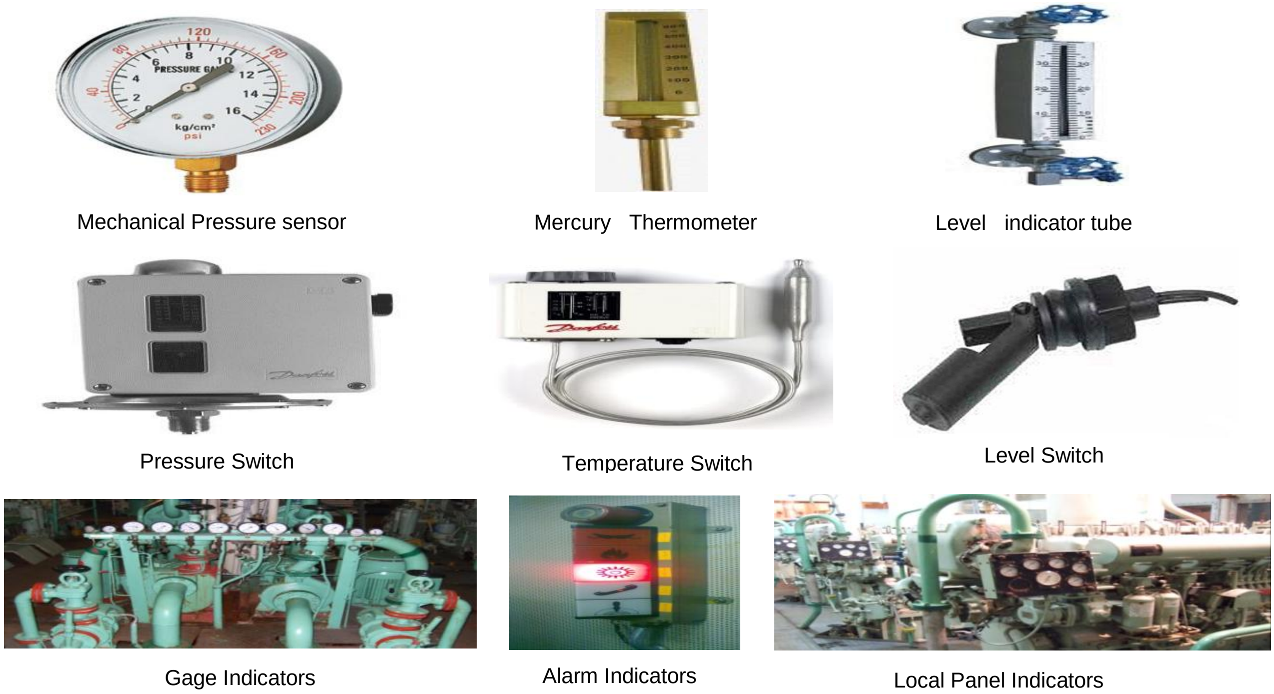


Fig.2. Examples of old automated system components

4. The upgraded SCADA passed automated system

The overall upgraded system is illustrated in Figure 3, where it can be divided into two main parts: hardware and software.

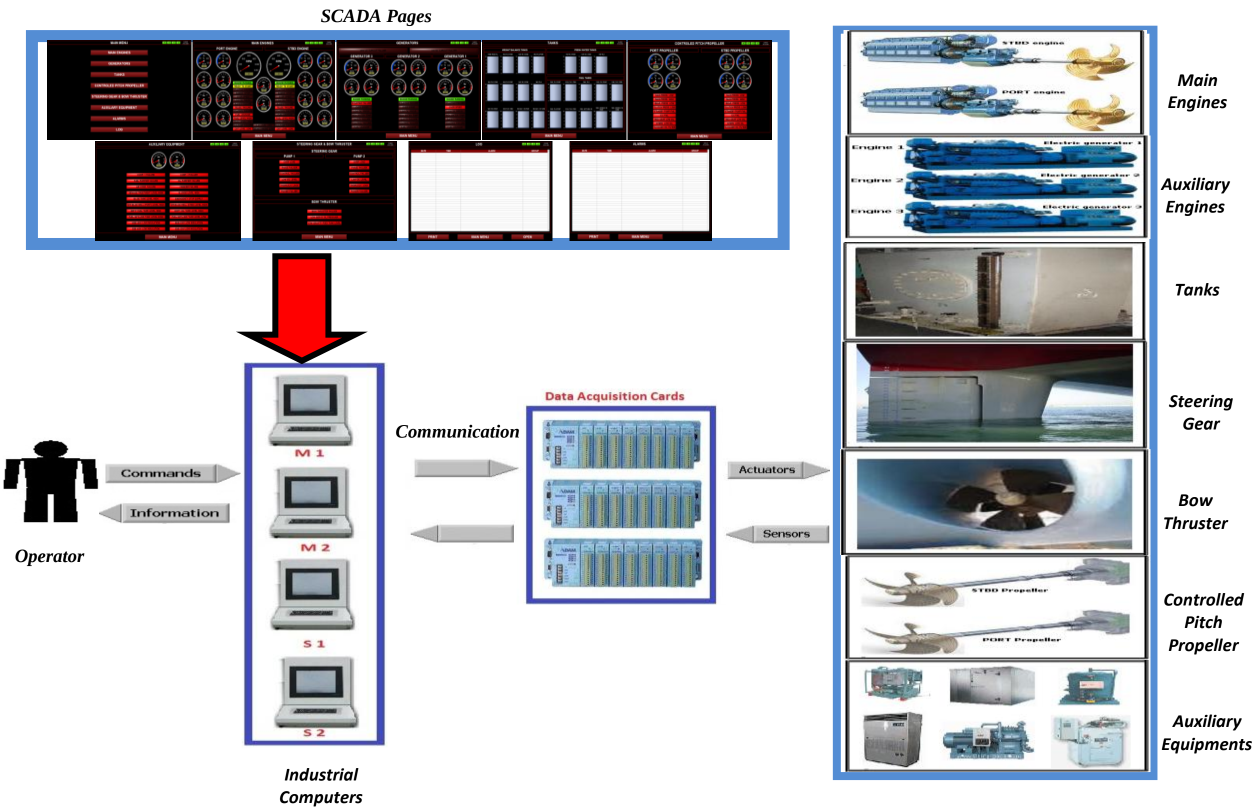


Fig.3. Overall upgraded SCADA based ship automated system.

A-The Hardware Part, is divided into three sections:
I- Additional electrical sensors and actuators (see Figure 4) are responsible for measurements and taking actions.

Temperature sensor | Pressure sensor | Level sensor | Speed sensor | Interfacing modules

Fig.4. Examples of the additional components for the upgraded system

II- ADAM [23] data acquisition modules series 5000 (see Figure 4) which are responsible for collecting and interfacing between signals from/to sensors/actuators.
III- Industrial computers responsible for taking decisions according to the program scenario and provide the GUI screens for operators. It should be noted that the additional utilized electrical sensors and interfacing input modules are of 4-20 mA standards, while the output modules and actuators are 24 V DC.

B-The Software Part, divided into three sections:
I- ADAMS Software program which is responsible for configuring the data acquisition modules
II- LabVIEW software program [22] which is responsible to provide the GUI screens of the SCADA program
III- LabVIEW special library that is utilized to provide system with communications and networking facilities

5. GUI screens of SCADA system

Figure 5 depicts the graphical user interface (GUI) screens of the upgraded system designed and implemented using LabVIEW software. Nine pages are introduced; the main starting page, six pages for the ship subsystems (main engines page, auxiliary generators page, tanks page, steering gear and bow thruster page, controlled propeller pitch page and auxiliary equipments page) and also extra two pages for alarm recording and archiving logging. Each page has its own design, working within its own subsystem parameters and conditions, while providing monitoring and indication of each parameter state, similar to the old local monitoring gages and panels, through four networking industrial computers (as will be seen in the next section). Page navigator is available through the main page, while each page can be return back to such main page by clicking the "main page" button. Each page indicates its own alarms by sound and flashing on the alarmed parameter, while such alarms can be seen and archiving for data history and reporting through the alarms and log pages. A simplified flow chart describes the main concept of the overall implemented software is depicted in Figure 6.

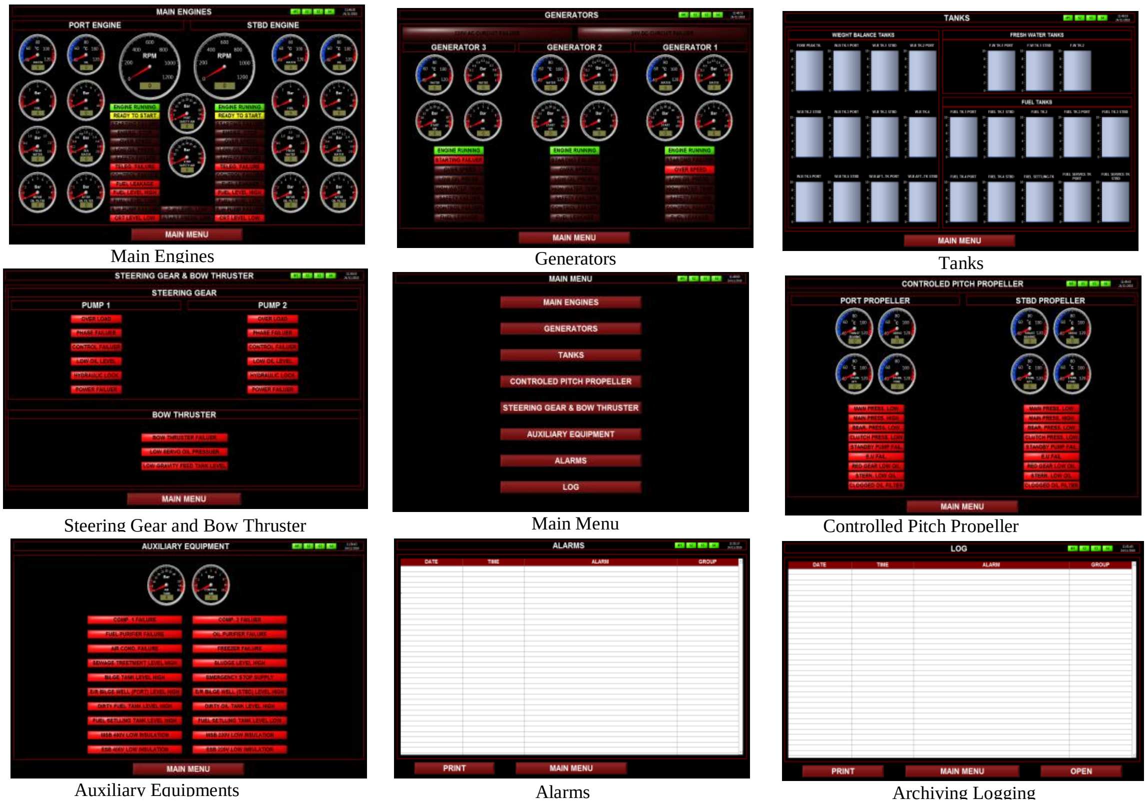


Fig.5. SCADA GUI screens of the upgraded system

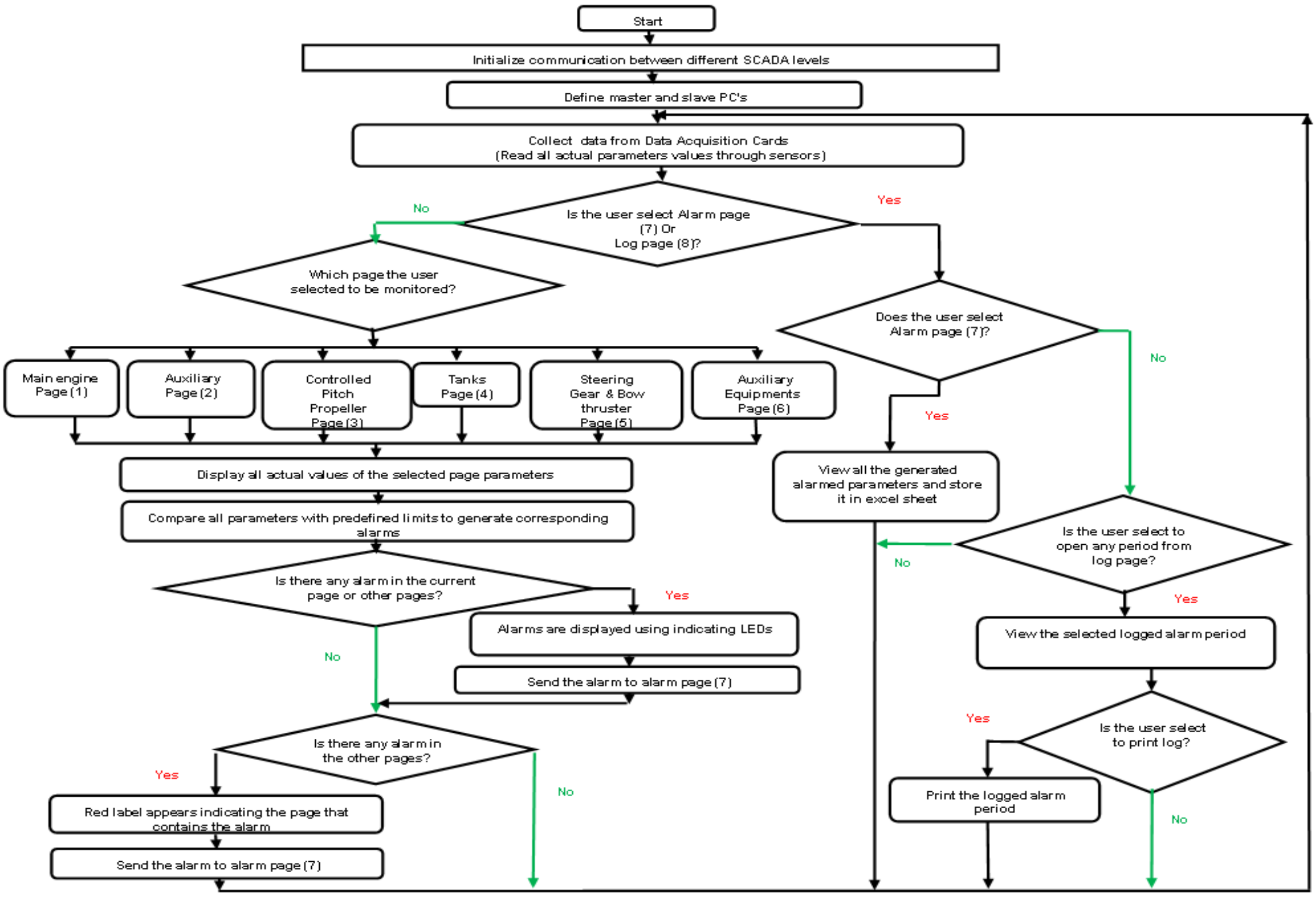


Fig.6. Simplified flow chart of the implemented overall program

6. The implemented communication and networking system

The implemented SCADA system utilizes different communication protocols, depending on the nature of data and the available communication buses in the utilized devices, to transmit the data from/to four different SCADA levels as depicted in Figure 7.

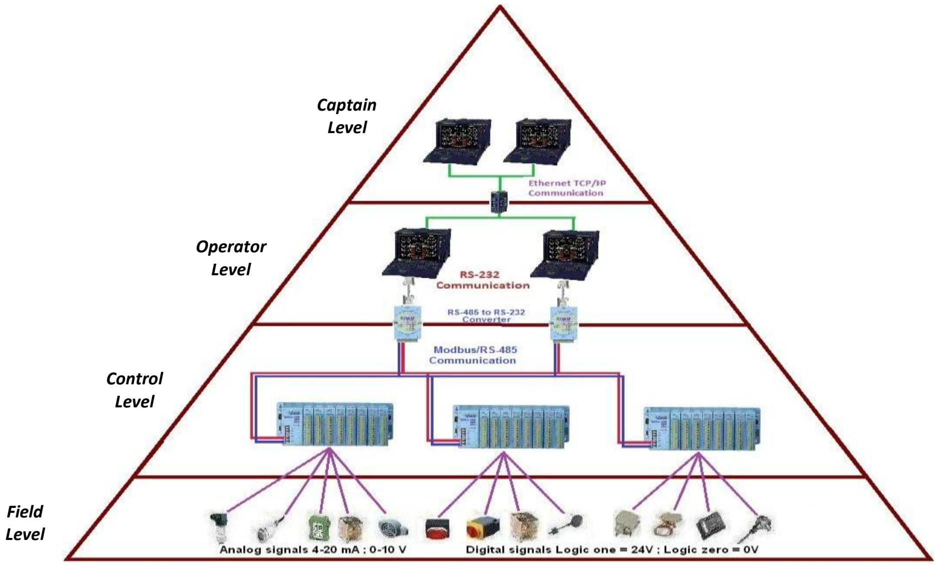
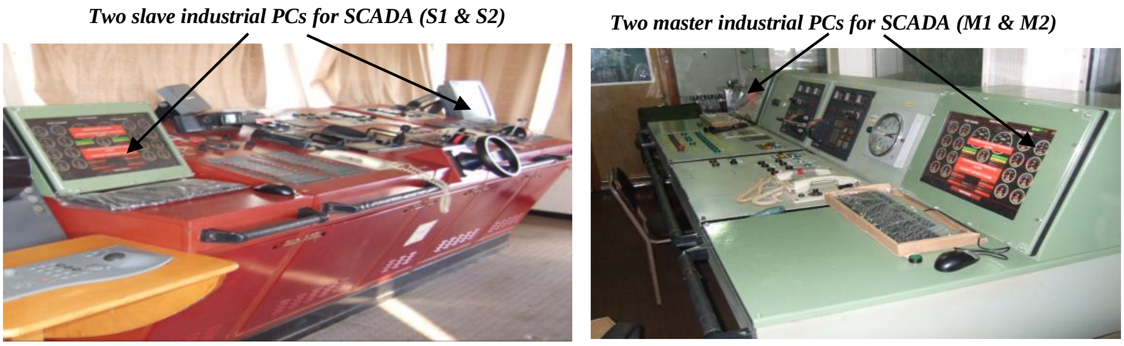


Fig.7. Implemented communication networking and SCADA levels

For the field level, the data comes from/to the additional sensors/actuators with standard electrical signals connected with electrical wires to the ADAM data acquisition modules in the control level (see Figure 4). Each eight modules are connected with each other through central unit while the central modules are then connected with each other using RS-485 modbus protocol. The modbus protocol is then converted to RS-232 serial communication to send the data to the two industrial computers in the operator level (M1 and M2), then the data is transferred to other two industrial computers in the captain level (S1 and S2), using the Ethernet TCP/IP protocol. It should be noted that, one of the two computers in the operator level can be selected to be the master while others will be slave. The final upgraded control systems for both operator and captain rooms are illustrated in Figure 8, where two industrial computers are added in each room, enabling for SCADA monitoring of the whole ship internal system from such rooms together with the old local monitoring panels.



(a) Captain control level **(b) Operator control level**

Fig.8. Final SCADA upgraded ship control system

7. Conclusion

Development of a complete SCADA system, using additional standard electrical sensors and actuators, NI- LabVIEW program together with ADAMS interfacing modules and communication networking, has been introduced to upgrade the ship internal monitoring system. Four industrial computers have been utilized to provide different control and operating levels. Such development facilitates collect and transfer information to different sites in order to be displayed on a number of operator screens and carry out many necessary analysis and control operations. This upgraded SCADA system reduces the human efforts and errors with more safe and comfort operation environments.

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