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Physical model of an automated ship electric power plant for didactic purposes

SUMMARY

A modernized educational model of ship electric power plant, which fulfils controlling, supervizing and graphical imaging functions of this object, is presented in this paper. The modelled object consisting of the main switchboard and three 27 kVA synchronous electric generators driven by 35 kW DC electric motors simulating drive by diesel engines, belong to Electrical Power Engineering Department, Gdynia Maritime University.

INTRODUCTION

Demand of broad professional education of students for future responsible posts on ships and in shipping companies made, in the1980ths, it necessary to build a typical ship electric power plant in the then Electrical Power Engineering Institute, Merchant Marine Academy, Gdynia.

Technical progress and continuously developing computerization of industrial and ship board processes induced the Academy's educational workers to critically review the existing object and to elaborate long-term modernization program of the electric power plant in order to adjust it to contemporary and future realities. In consequence of those activities a modernization of the object was performed and this way a modern didactic base open for future developments was built.

THE MODELLED SHIP ELECTRIC POWER PLANT

The modeled ship electric power plant consists of :

- RG 103 A main switchboard of 6 special panels, adapted for didactic purposes
- three synchronous electric generators (of 27 kVA; 400 V; 50 Hz; 1500 rpm) driven by DC compound motors (of 35 kW; 220 V; 1500 rpm) simulating drive by means of diesel engines.

The switchboard is designed for distribution of electric energy from the generators or land supply source, protection of the generators and circuits as well as control of electric insulation state. Manual operation control of the generators can be realized by means of the servicing block installed in 3rd panel of the switchboard.

Automation of operation of the electric generating sets

A modernized automation system of the electric power plant model in question was based on application of a programmable logic controller (PLC) because of its versatility, low cost and specific technical solution of the educational power plant (i.e. simulation of diesel engine drive). The controller, on the basis of signals obtained from measurement gauges and a stored control programme, generates output signals determining state of work of the electric generating sets.

Automation of operation of the electric power plant with the use of the PLC contains the following functions :

- choice of operation mode : manual/automatic
- manual control of a single generating set
- automatic adjustment of the plant's electric power to current demand (start/stop of the generating sets on demand)
- start of the generating sets after black-out state
- active power distribution and frequency regulation
- start/stop sequence
- blocking of the generating sets
- switching-off less important consumers in the case of overload
- automatic starting of a generating set if the set preceding in start sequence, failed to start
- protection of electric generator : against current excess, too-low voltage, too-low frequency
- protection of electric generating set : against too-high revolutions
- signalling of : electric supply of consumers, switching onto busbars, stand-by, block of a generating set, start/stop sequence.

The PLC cooperates with classical automation elements. It not only controls operation of the electric power plant but also collects information on all necessary parameters. Moreover a visualization system of electric power plant operation, graphically presenting collected data, was introduced to make operational situations more understable and easier for analyzing.

1st phase of modernization comprised introduction of a dozen or so synoptic screens showing, in different forms, operational parameters of the physical model of the power plant. In 2nd phase the control system was widened by possible controlling with the use of a computer. The design idea of operation control and visualization of the electric power plant is presented in Fig.1.

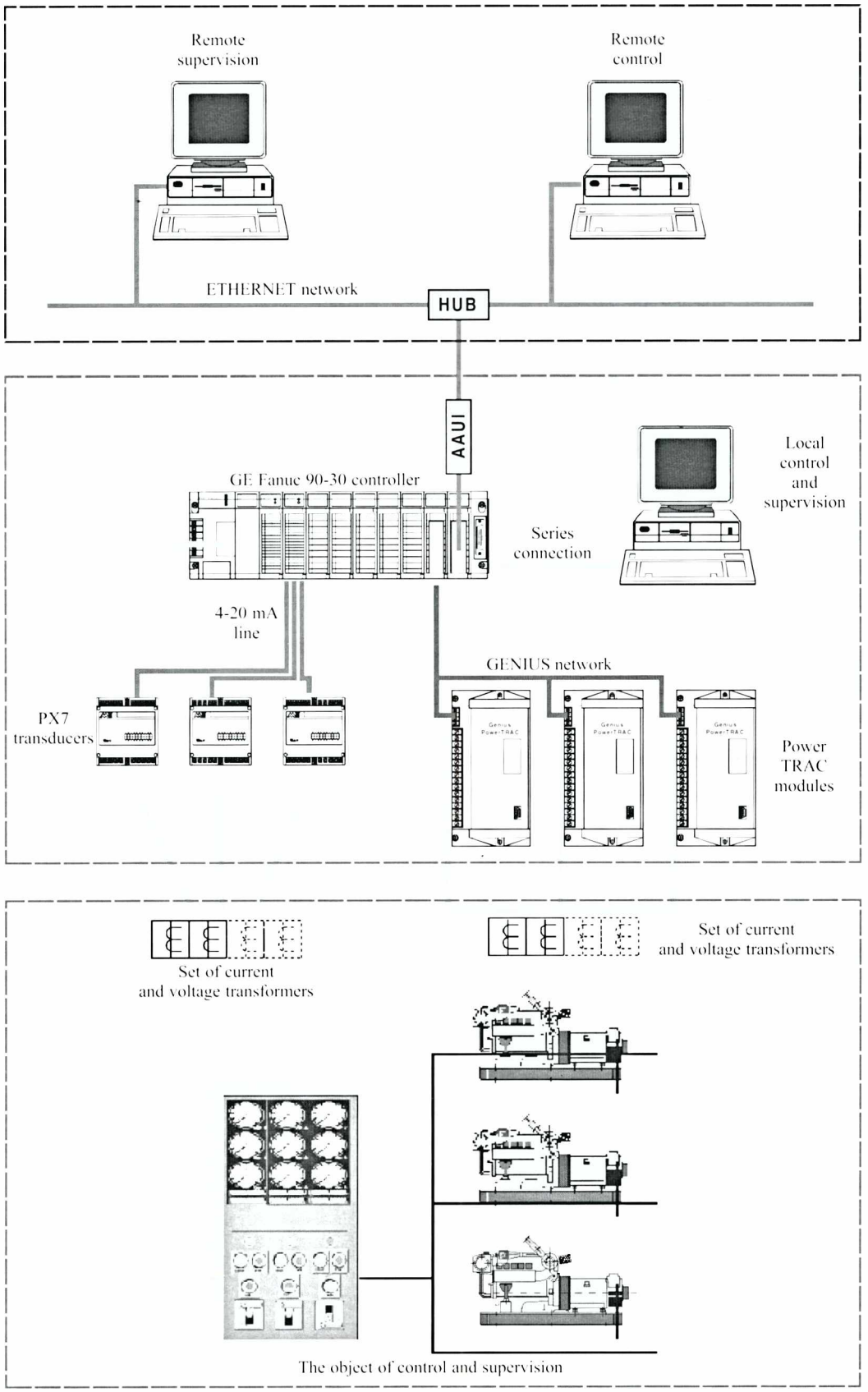

Fig.1. *The design concept of operation control and visualization of the modelled electric power plant*
Notations : HUB *Micro HUB 8TP 1008C 8-port Ethernet Repeater* ***AAUI*** *AAUI port*

Features of the applied PLC

GE Fanuc 90-30 modular programmable controller was applied to control the electric power plant model. It is an industrial computer which, on the basis of input signals from switch-keys and gauges, generates output signals for controlling machines and processes. Due to its specific design installing, programming, using and possibly expanding the system are easy. By means of its series connection it is possible to instal a manual programmer or IBM PC compatible computer used as a programmer. Just due to that feature on-line communication with a computer realizing local control and graphical visualization of data could be established.

For realization of the control model in question several modules contained in IC693CHS391 standard cassette were applied. Moreover, in the design Power TRAC /IC66*BMP100 external modules as well as a communication adapter and network card were used.

PowerTRAC external module

PowerTRAC modules making it possible to comprehensively monitor power consumption from the electric network and to protect the system against disturbances, were applied. The devices can serve as an element of GENIUS scattered input/output system; they can also operate idependently to each other.

The modules monitor voltage and current input courses, transform analogue signals into digital ones and store them in order to calculate effective power value, active energy (kWh) and other useful parameters. The data are automatically sent to the PLC or to the master computer. A synoptic screen of PowerTRAC module is presented in Fig.2.

GENIUS communication network

GENIUS General Electric standard communication network was used for control and visualization of the electric power plant processes. It makes it possible remote GENIUS I/O Blocks, 90-30 and 90-70 controllers, as well as computers equipped with PC Interface Module and software to work in the network. Hence controlling the electric plant model is practically possible from any place (terminal) in the University provided it is switched onto the GENIUS ETHERNET network.

Synoptic screens

The design was based on abilities of FIX system. The electric power plant processes and variables are visualized on the following synoptic screens elaborated with the use of View&Draw graphical prestentation module.

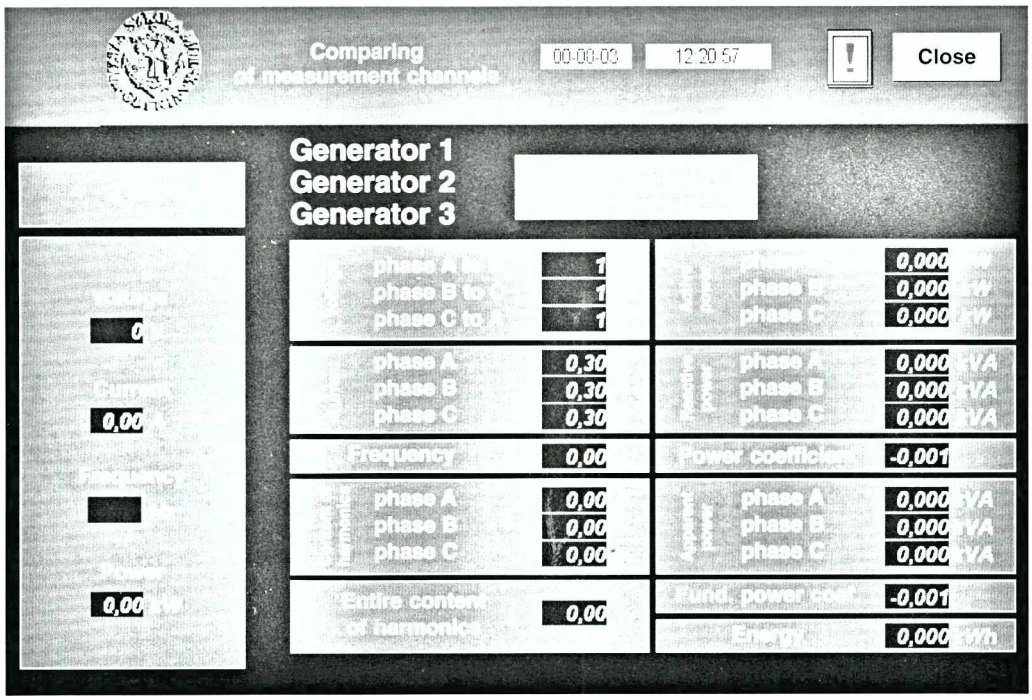

Fig.2. Synoptic screen of PowerTRAC module

No.	Name of screen	Description
1.	Start	Introductory screen
2.	Basic screen	Basic navigation
3.	Panels 1 , 2 , 3	Presentation of main switchboard panels
4.	Panels 1 , 2	Presentation of master switches of supply to driving systems
5.	Panels 3 , 4 , 5	Presentation of panel of generators and consumers
6.	Consumers	Screen for control of panel of consumers
7.	Panel 3	Presentation of working parameters of generators
8.	Control and measuring	Screen for control of generators
9.	Visualization mode	Screen for choice of visualization mode
10.	Multi-function screens	Screen for multi-monitor supervision system
11.		Screen for comparison of parameters of generators
12.	Generator 1	Screen for parameters of generator 1
13.	Generator 2	Screen for parameters of generator 2
14.	Generator 3	Screen for parameters of generator 3
15.	Alarms	Control desk of alarm states
16.	Information desk	Desk of combination of working parameters and alarms
17.	Generators	Control desk of generators
18.	Consumers	Control desk of consumers
19.	Old scheme	Animated electric energy scheme
20.	With desk	Electric energy scheme with control desk of consumers
21.	Interactive	Interactive electric energy scheme
22.	Drive supply	Supply scheme of driving systems
23.	Trend I	Presentation of current trend
24.	Trend P	Presentation of power trend
25.	Trend U	Presentation of voltage trend
26.	Trend F	Presentation of frequency trend
27.	TRAC 1	Combination of working parameters of generator 1
28.	TRAC 2	Combination of working parameters of generator 2
29.	TRAC 3	Combination of working parameters of generator 3
30.	LAN/COM	Screen for change of mode of communication with controller

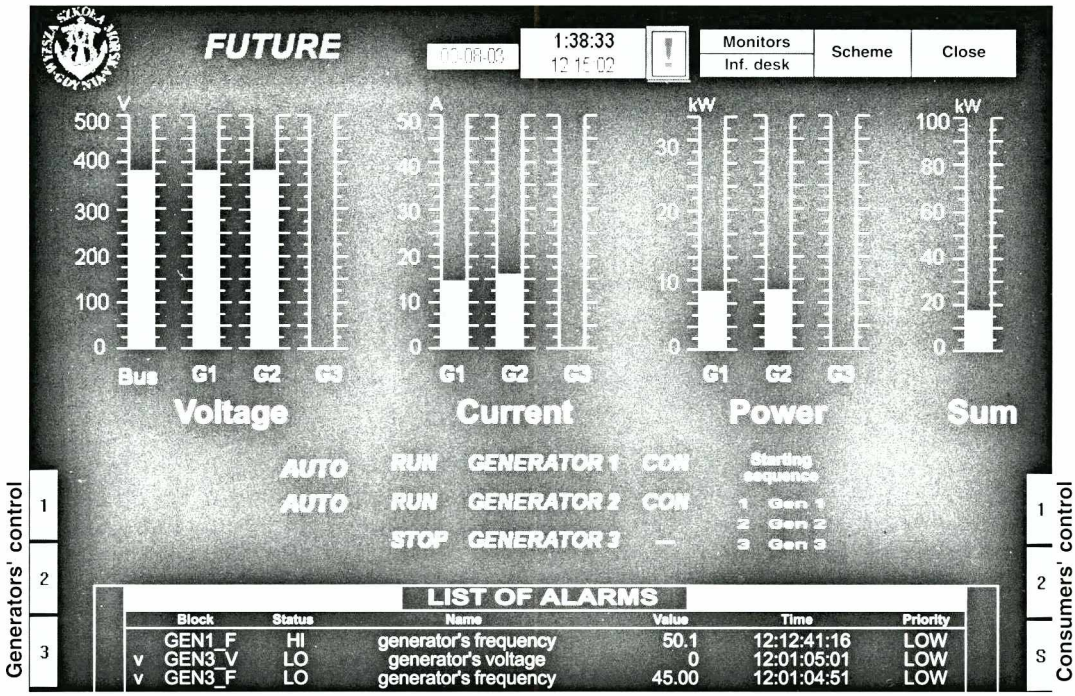

Fig.3. The synoptic screen presenting the control desk of generators
Notations:
BUS *main busbars*
Auto *cooperation of the system and power plant automation system*
Run *operation,* ***Con*** *computer-controller communication*
HI *high level,* ***LO*** *low level*

On the synoptic screens physical elements such as e.g. arm-, bar-, digital indicators, state switch-keys, control lamps and alarm state displays are graphically presented. From such single elements the entire sets of panel of generators in the main switchboard, operator desks etc are combined.

Passing from one screen to another is realized by means of push--buttons with a screen name or an icon representing function of a screen, or by activating a part of an image. Additionally, for fast changing or opening a given screen an auxiliary navigation strip can be used. All the synoptic screens were so designed as to obtain the possible highest functionality and legibility. In Fig.3. the synoptic screen presenting the control desk of generators is shown as an example.

FINAL REMARKS

The presented physical model of control and visualization of the ship electric power plant in operation is able – due to applied modern solutions of its systems – to serve as an advanced diagnostic and didactic tool open for future development.

Appraised by Janusz Mindykowski, Prof.,D.Sc.

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Conference

ZTM Gdańsk Gdynia Szczecin

Plenary scientific meeting of the marine technology unit

Faculty of Marine Technology, Technical University of Szczecin, hosted the Plenary Scientific Meeting of the Marine Technology Unit, (Section of Technical Transport Facilities, Transport Committee, Polish Academy of Sciences). The meting was held in Szczecin on 13 December 2002. Its program contained two parts : scientific and organizational one.

During its scientific part two papers prepared by authors from the Faculty of Marine Technology, Technical University of Szczecin, were read :

- *Reliability of elements of ocean engineering machines with taking into account overloading and material fatigue* by Włodzimierz Rosochacki
- *Identification and thermodynamical assessment of waste energy recovery from exhaust gases in ship diesel engine power plants* – by Ryszard Michalski

Both papers met with great interest manifested during thorough discussion.

In the organizational part of the meeting the passing year's activity of the Unit was summed up and the activity program for 2003 was adopted.

A great contribution to the Unit's activity, which Prof. Jerzy Girtler of Gdańsk University of Technology, Chairman of the Unit, has been doing so far, was greatfully recognized by the meeting participants.