

**Business Unit Naval
Projects**

**Imtech Marine &
Offshore B.V.**

Sluisjesdijk 155

P.O. Box 5054

3008 AB Rotterdam

The Netherlands

Harbour number 2137

Tel. +31 (0)10 487 19 11

Fax. +31 (0)10 487 17 02

Power Management System

User Manual

Project: TNI-AL
Projectnumber: 190134
Main title: Power Management System
Sub title: User Manual
Special remark:
Issue: 2.0
Date: 14 March 2006
Total number of pages: 47
Registration code: 190134-3900-UM

Name

Signature

Author: A. Hartman

Quality control: A. de Vos

Acknowledge: R. van Treuren

Table of contents

Title page

Administrative page

Figures	5
References	6
Abbreviations	9
Updates	9
1. Introduction	10
1.1 Purpose of this document	10
1.2 Relationship to other documents	10
2. Electrical Power Plant	11
2.1 General	11
2.2 Functionality power management system	11
2.3 MSB AFT	12
2.4 MSB FWD	12
2.5 ESB	12
2.6 Modes of operation	12
3. User interface	13
3.1 Main Switch Board	13
3.1.1 Shore connection panel	13
3.1.2 Interconnection panel	14
3.1.3 Generator panel	15
3.1.3.1 MSB PMS display panel	16
3.1.3.1.1 Control panel	16
3.1.3.1.2 Dedicated keys	17
3.1.3.1.3 Mode control	17
3.1.4 Distribution panel	18
3.2 Power Management System	19
3.2.1 PMS in IPMS	19
3.3 Emergency Switch Board	20
3.3.1 Generator / interconnection panel	20
3.3.1.1 ESB PMS display panel	21
3.3.1.1.1 Mode control	22
3.3.2 Distribution panel	23
4. Operating	24
4.1 Principles of operation	25
4.2 Manual mode	26
4.2.1 Dead bus bar	26
4.2.2 Generator parallel	27

4.2.3	Power export.....	28
4.2.4	Synchronise bus bars	29
4.3	Semi automatic mode	30
4.3.1	Dead bus bar	30
4.3.2	Generator parallel	31
4.3.3	Synchronise bus bars	32
4.4	Automatic mode	33
4.4.1	Dead bus bar	33
4.4.2	Ship to shore.....	34
4.4.3	Shore to ship.....	35
4.4.4	Generator parallel	36
4.5	Emergency	37
4.5.1	Dead bus bar	37
4.5.1.1	Manual mode	37
4.5.1.2	Semi automatic mode	38
4.5.1.3	Automatic mode.....	39
4.5.2	Take over after restoring normal power supply	40
4.5.2.1	Manual mode	40
4.5.2.2	Semi automatic mode	41
4.5.2.3	Automatic mode.....	42
4.5.3	Take over in normal situation	43
4.6	Operator control PMS and IPMS	44
4.6.1	Manual mode	44
4.6.2	Semi automatic mode.....	45
4.6.3	Automatic mode.....	46
5.	Maintenance	47
5.1	General	47
5.2	Earth connections	47
5.3	Protection covers	47
5.4	Anti-condensation heating	47
5.5	Earth-fault measurement test.....	47
5.6	Bus bar connections	47
5.7	Circuit breakers	47

Figures

Figure 1 Documentation set	10
Figure 2 Configuration of Main Electrical Plant.....	11
Figure 3 Control and monitoring shore connection panel.....	13
Figure 4 Control and monitoring interconnection panel	14
Figure 5 Control and monitoring generator panel	15
Figure 6 PMS display panel front face MSB.....	16
Figure 7 PMS general layout	19
Figure 8 Control and monitoring generator / interconnection panel	20
Figure 9 PMS display panel front face ESB	21

References

- [1] **Title:** **Technical Specification**
Description: Technical Specification between Schelde Naval Shipbuilding and IMTECH Marine & Offshore
Ref.: I 1005
From: Schelde Naval Shipbuilding
Issue: D
Date: 23 September 2004
- [2] **Title:**
Description:
Ref.:
From:
Issue:
Date:
- [3] **Title:** **IAS System Specification**
Description: Overall System specification of the Integrated Automation System
Ref.: 190134-4000-IAS-SSC
From: E.J. Middeldorp
Issue: V1.0
Date: 9 May 2005
- [4] **Title:** **PMS Functional Specification**
Description: Functional Specification of the Power Management System
Ref.: 190134-3900-FSC
From: C. Schouten
Issue: V2.0
Date: 22 August 2005
- [5] **Title:** **IO List PMS**
Description: IO list PMS Gensys
Ref.: 190134-3900-IOL
From: C. Schouten
Issue: V1.0
Date: 5 August 2005
- [6] **Title:** **Power Conversion and Distribution – Electrical Plant General**
Description: Overview diagram power distribution (one-line diagram)
Ref.: 190134-3000-GRS
From: A.H. de Groot
Issue: V2.2
Date: 2 May 2005
- [7] **Title:** **Power Conversion and Distribution**
Description: User Manual
Ref.: 190134-3000-UM
From: A.W. Hartman
Issue: V1.0

Date: 13 March 2006

[8] Title: Main Switch Board AFT Z3001

Description: Production Document List
Ref.: 190134-Z3001-PDL
From: C. Schouten
Issue: V1.0
Date: 14 March 2005

[9] Title: Main Switch Board AFT Z3002

Description: Production Document List
Ref.: 190134-Z3002-PDL
From: C. Schouten
Issue: V1.0
Date: 21 April 2005

[10] Title: Emergency Switch Board Z3003

Description: Production Document List
Ref.: 190134-Z3003-PDL
From: A.W. Hartman
Issue: V1.0
Date: 21 October 2005

[11] Title: Generator Management GENSYS

Description: Technical documentation
Ref.: A40Z090004-f
From: CRE
Issue: f
Date: February 2002

[12] Title: MASTERPACT NW08-63

Description: User manual
Ref.: 04443720AA-B
From: Schneider Electric
Issue: B
Date: <>

[13] Title: MICROLOGIC 5.0A

Description: User manual
Ref.: 04443724AA-A
From: Schneider Electric
Issue: A
Date: <>

[14] Title: Moulded Case Circuit Breakers

Description: User manual
Ref.: 190134-MER NS-TM
From: Schneider Electric
Issue: 48940-183-01
Date: <>

[15] Title: A-Isometer IRDH 375B

Description: Operating manual
Ref.: TGH 1352en
From: Bender
Issue: <>
Date: November 2004

[16] Title: Synchronoscope SQ0214

Description: User manual
Ref.: 190134-4380-IOL
From: Iskra Instrumenti
Issue: Version 1
Date: March 2004

[17] Title: IPMS User Manual

Description: An operator guide that describes the entire user scoped IPMS functions
Ref.: 190134-4380-UM
From: R. Langeveld
Issue: V1.0
Date: <>

Abbreviations

AFT	After
CB	Circuit Breaker
DG	Diesel Generator
DGR	Diesel Generator Room
EM	Emergency
ESB	Emergency Switch Board
FWD	Forward
IAS	Integrated Automation System
IMO	Imtech Marine & Offshore
I/O	Input / Output signals
IPMS	Integrated Monitoring & Control System
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LRS	Lloyd's Register of Shipping
MCR	Machinery Control Room
ME	Main Engine
MER	Main Engine Room
MSB	Main Switch Board
PMS	Power Management System
PS	Portside
SB	Starboard
SNS	Schelde Navel Shipbuilding

Updates

Underneath are the updates indicated of those parts, which have been changed related to the previous release.

Issue:	Date:	Change:	Reason:
0.1	21-11-2005	Initial version	
0.2	20-12-2005	Several layout and functional changes	Update
1.0	22-12-2005	FAT issues: <ul style="list-style-type: none">- Import / export text on panel indicator power defined.- Functionality of 'PREF' is described.- Synchronizing bus bars when MSB AFT is on shore power and MSB FWD is on generator power is described.	Initial release
2.0	14-03-2006	Several changes	Update

1. Introduction

1.1 Purpose of this document

This document shall be used as a guide for both operators and maintainers to operate and maintain the Main Switch Boards and the Emergency Switch Board.

This document presents the operating functions of the Power Management System of the Main Switch Boards and the Emergency Switch Board, available to the operators. As it is an Operating Manual, details of the underlying hardware / software shall not be discussed unless they will improve the understanding of the specific functionality.

This document covers the following topics:

- Section 1 – (this section) Introduction, detailing the purpose and scope of the document;
- Section 2 – Functional overview, showing the system architecture of the Electrical Power Plant;
- Section 3 – User interfaces;
- Section 4 – Operator handling;
- Section 5 – Maintenance issues.

1.2 Relationship to other documents

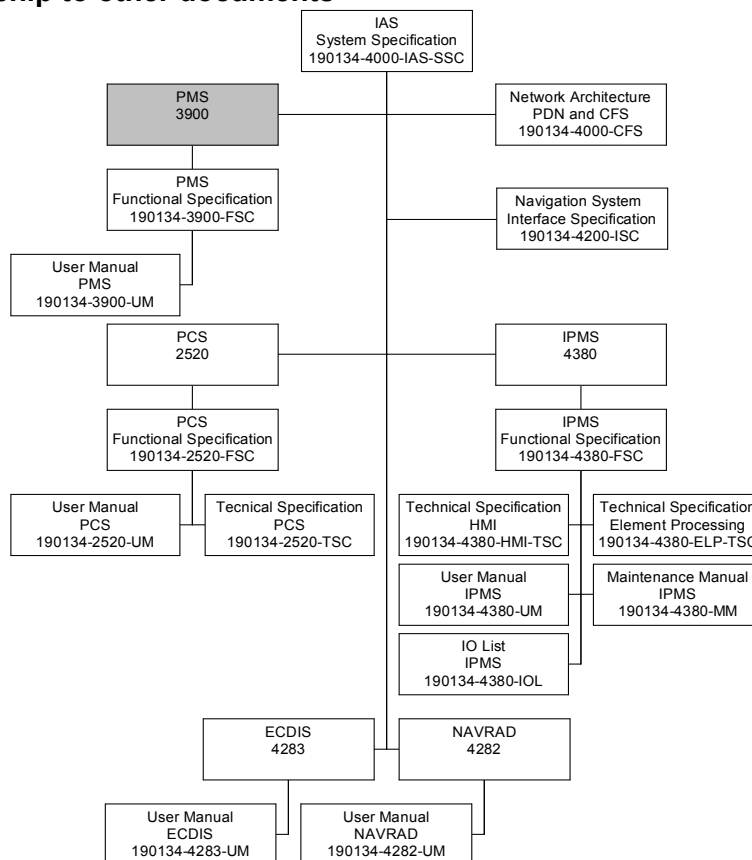


Figure 1 Documentation set

2. Electrical Power Plant

2.1 General

The main configuration of the electrical power plant, see also Single Line Diagram, ref. [6], consists of 2 auxiliary generators Aft, 2 auxiliary generators Fwd and 1 emergency generator, distributed over the Main Switch Board Aft, Main Switch Board Fwd and Emergency Switch Board according to Figure 2:

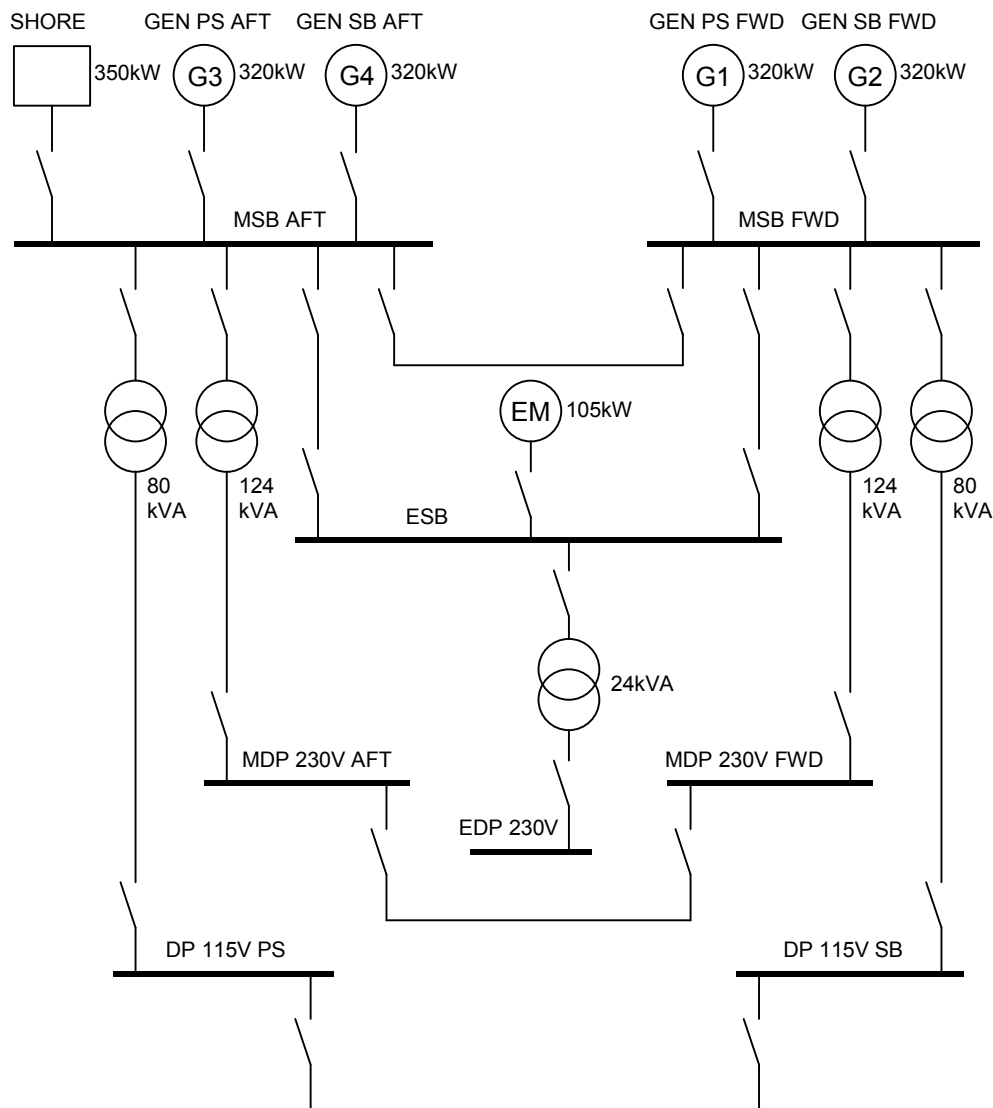


Figure 2 Configuration of Main Electrical Plant

2.2 Functionality power management system

The PMS is incorporated in Main Switch Board AFT and Main Switch Board FWD. Also the non-essential consumers (load shedding) are controlled by the PMS. The basic functionality of the power management system is described in the Technical Specification Power Management System, ref. [4].

2.3 MSB AFT

This Main Switch Board is located in Switchboard Room Aft MCR / DCHQ (3084) and consists of six cubicles, from left to right:

1. Shore connection panel;
2. Interconnection panel;
3. Generator panel (diesel generator 4);
4. Generator panel (diesel generator 3);
5. Distribution panel;
6. Cable entrance.

For the electrical and front layout drawings refer to Production Document List Z3001, ref. [8].

2.4 MSB FWD

This Main Switch Board is located in Switchboard Room Fwd (3063) and consists of six cubicles, from left to right:

1. Spare panel;
2. Interconnection panel;
3. Generator panel (diesel generator 2);
4. Generator panel (diesel generator 1);
5. Distribution panel;
6. Cable entrance.

For the electrical and front layout drawings refer to Production Document List Z3002, ref. [9].

2.5 ESB

This Emergency Switch Board is located in Emergency DG Room (5055) and consists of three cubicles, from left to right:

1. Emergency generator / interconnection panel;
2. Cable entrance;
3. Distribution panel.

For the electrical and front layout drawings refer to Production Document List Z3003, ref. [10].

2.6 Modes of operation

The following modes of operation are defined:

- Slow speed 3 diesel generator sets running;
- Max speed 3 diesel generator sets running;
- Patrol 3 diesel generator sets running;
- Combat Minimum of 2 diesel generator sets running;
- Sonar ultra quiet mode 2 diesel generator sets running;
- Harbour Shore connection or 1 diesel generator set running;
- Anchor 2 diesel generator sets running;
- Emergency Emergency generator set running;

The functionality of the electrical power plant is described in the User Manual of the Power Conversion and Distribution, ref. [7].

3. User interface

3.1 Main Switch Board

3.1.1 Shore connection panel

The shore connection panel contains the following control and monitoring elements in front of the panel:

- Panel indicator power:
 - Import = receiving power from shore;
 - Export = exporting power to shore / other vessel;
- Panel indicator current with selection switch;
- Synchronoscope indicator;
- 'CB OPEN' lamp push button;
- 'CB CLOSE' lamp push button;
- 'MAN' / 'OFF' / 'AUTO TAKE OVER' selector switch.

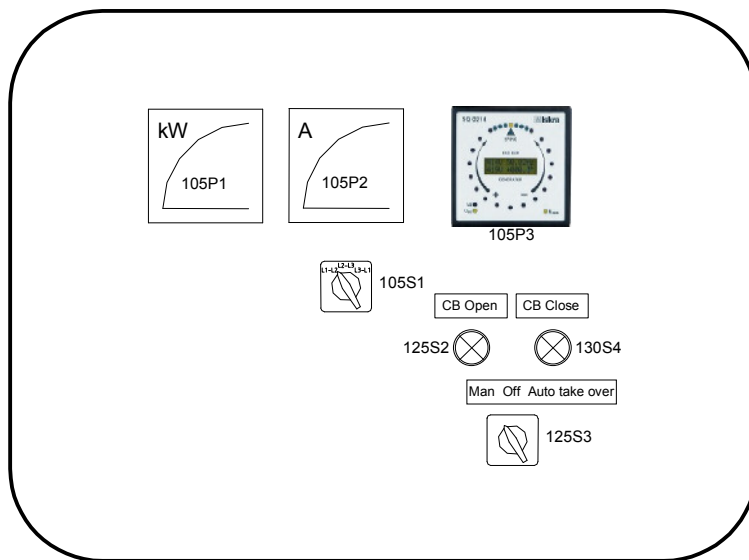


Figure 3 Control and monitoring shore connection panel

For instructions of the Synchronoscope indicator, see user manual Synchronoscope SQ0214, ref. [16].

3.1.2 Interconnection panel

The interconnection panel contains the following control and monitoring elements in front of the panel:

- Panel indicator power:
 - Import = receiving power from other MSB;
 - Export = exporting power to other MSB;
- Synchronoscope indicator;
- 'CB OPEN' lamp push button;
- 'CB CLOSE' lamp push button with;
- 'MAN' / 'OFF' / 'AUTO CLOSE' selector switch;
- Insulation resistor monitor;
- 'AC HEATING ON / OFF' switch.

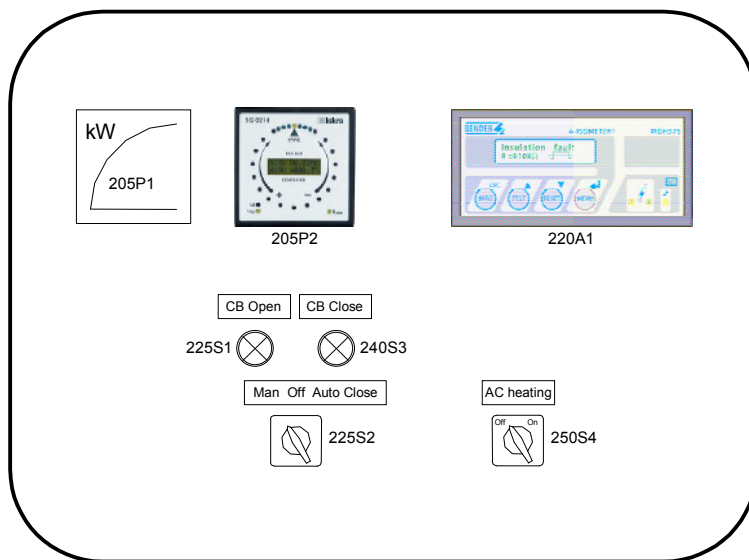


Figure 4 Control and monitoring interconnection panel

For instructions of the Synchronoscope indicator, see user manual Synchronoscope SQ0214, ref. [16].

For the operating instructions of the insulation resistor monitor, see operating manual A-Isometer IRDH 375B, ref. [15].

3.1.3 Generator panel

A generator field (2x) contains the following control and monitoring elements in front of the panel:

- Panel indicator power;
- Panel indicator voltage with selection switch;
- Panel indicator current with selection switch;
- PMS display panel with control buttons.

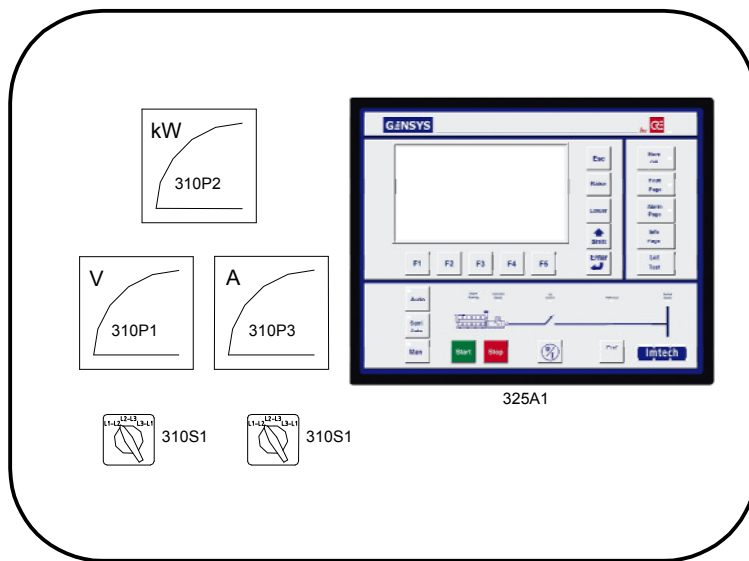


Figure 5 Control and monitoring generator panel

3.1.3.1 MSB PMS display panel

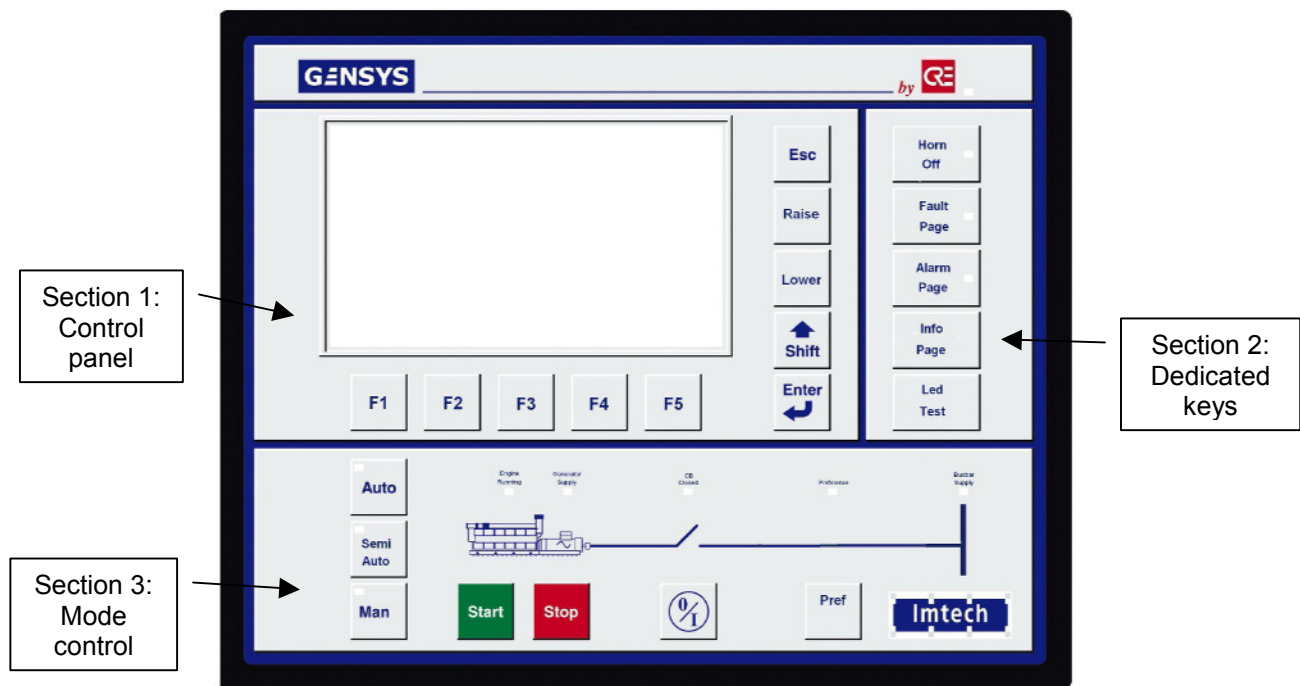


Figure 6 PMS display panel front face MSB

The front of the PMS display panel is made up of 3 parts

- Section 1 – Control panel with LCD display and navigation keys;
- Section 2 – Dedicated keys;
- Section 3 – Mode control.

The LED in the upper right corner of the front panel will light up when a key is pressed and will be switched off when all keys are released.

3.1.3.1.1 Control panel

The control panel allows setting up and monitoring the PMS display panel configuration and the power plant controls. It provides an LCD display and a keypad.

Key	Navigation mode	Input mode (during parameter modification)
Navigation bar (5 keys)	Scroll / select menus and parameters	Change parameter value
Enter 	Enter a menu / switch to 'Input mode'	Validate parameter and return to 'Navigation mode'
 Shift	Used with other keys only (F1, F2, I)	Not used

Raise	Shortcut to special function (increase speed or voltage (with Shift) in manual mode)	
Lower	Shortcut to special function (decrease speed or voltage (with Shift) in manual mode)	
Esc	Return to parent menu	Discard parameter changes and return to 'Navigation mode'

3.1.3.1.2 Dedicated keys

The five dedicated keys allow switching to a special menu or functioning directly.

Key	Function
Horn Off	Stop horn
Fault Page	Direct access to the fault menu
Alarm Page	Direct access to the alarm menu
Info Page	Direct access to global monitoring page
Led Test	LED test

Three of the five dedicated keys have LEDs.

LED	Function
Horn Off	Blinks when horn is ringing
Fault Page	Blinks when a fault is present
Alarm Page	Blinks when an alarm is present

3.1.3.1.3 Mode control

The mode control part of the front panel allows controlling the generator.

Key	Function
Auto	Diesel generator set in automatic mode
Semi Auto	Diesel generator set in semi-automatic mode
Man	Diesel generator set in manual mode
Start (green key)	Start diesel generator set
Stop (red key)	Stop diesel generator set
O/I	Open / close generator circuit breaker
Pref	Diesel generator set to preference mode

The mode control part has 8 LEDs.

Key	Function
Auto	Switched on when in automatic mode
Semi Auto	Switched on when in semi-automatic mode
Man	Switched on when in manual mode
Engine Running	Switch on when diesel engine is running
Generator Supply	Switched on when generator is supplying power to the Main Switch Board
CB Closed	Switched on when main circuit breaker is closed
Preference	Switched on when diesel generator set is set to preference mode
Busbar Supply	Switched on when bus bar is powered

3.1.4 Distribution panel

The switched off status of essential circuit breakers is signalled on the distribution panel of the MSB (by means of a control light in the door that will light up when the non-essential consumers are switched off) and on the IPMS. The non-essential (=non preferent) consumers are switched off by the PMS in case of overload of the generator(s). After the non-essential consumers are switched off, the trip must be reset by means of the 'RESET' pushbutton in the door of the distribution panel. Then the individual groups can be switched on manually.

The non-essential consumers are also switched off at a black out.

3.2 Power Management System

The PMS is configured according Figure 7. This figure shows the several components, which are located in the Main Switch Boards.

Each generator panel contains a part of the PMS.

- G1 = (generator PS FWD);
- G2 = (generator SB FWD);
- G3 = (generator PS AFT);
- G4 = (generator SB AFT).

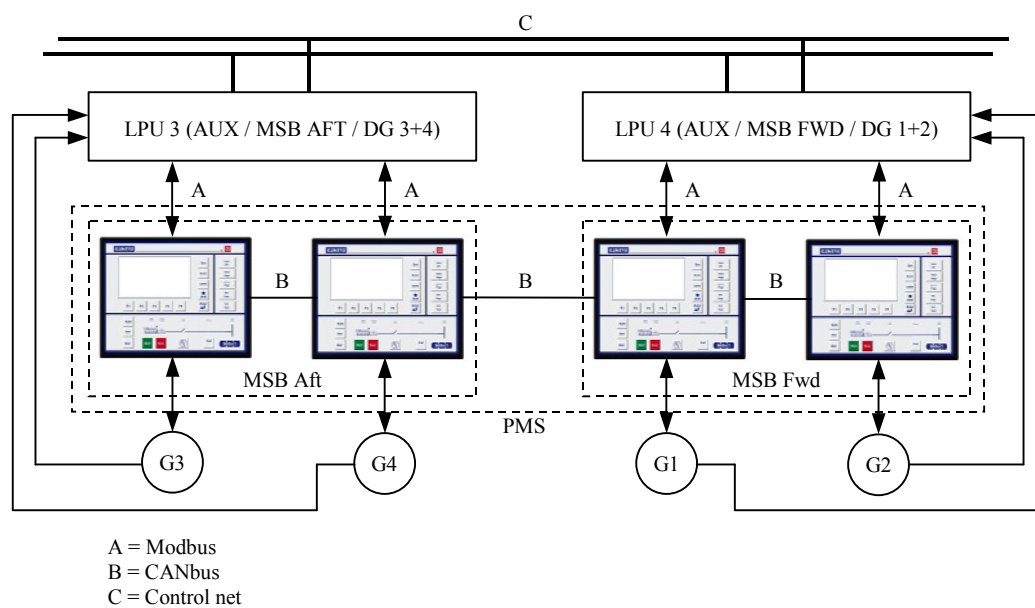


Figure 7 PMS general layout

3.2.1 PMS in IPMS

The PMS is also available in the IPMS and available via the Power Distribution mimic. For operating the mimic, refer to the user manual IPMS, ref. [17].

3.3 Emergency Switch Board

3.3.1 Generator / interconnection panel

The generator / interconnection field contains the following control and monitoring elements in front of the panel:

- Panel indicator power;
- Panel indicator voltage with selection switch;
- Panel indicator current with selection switch;
- PMS display panel with control buttons;
- Selection switch 'INT CB AFT' / 'OFF' / 'INT CB FWD';
- Panel indicator current with selection switch;
- 'AC HEATING ON / OFF' switch.

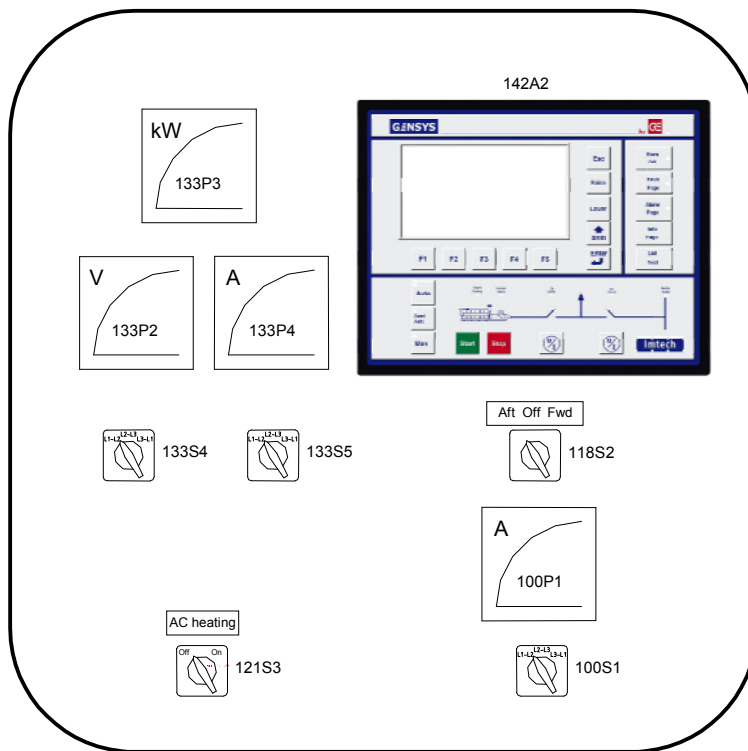


Figure 8 Control and monitoring generator / interconnection panel

3.3.1.1 ESB PMS display panel

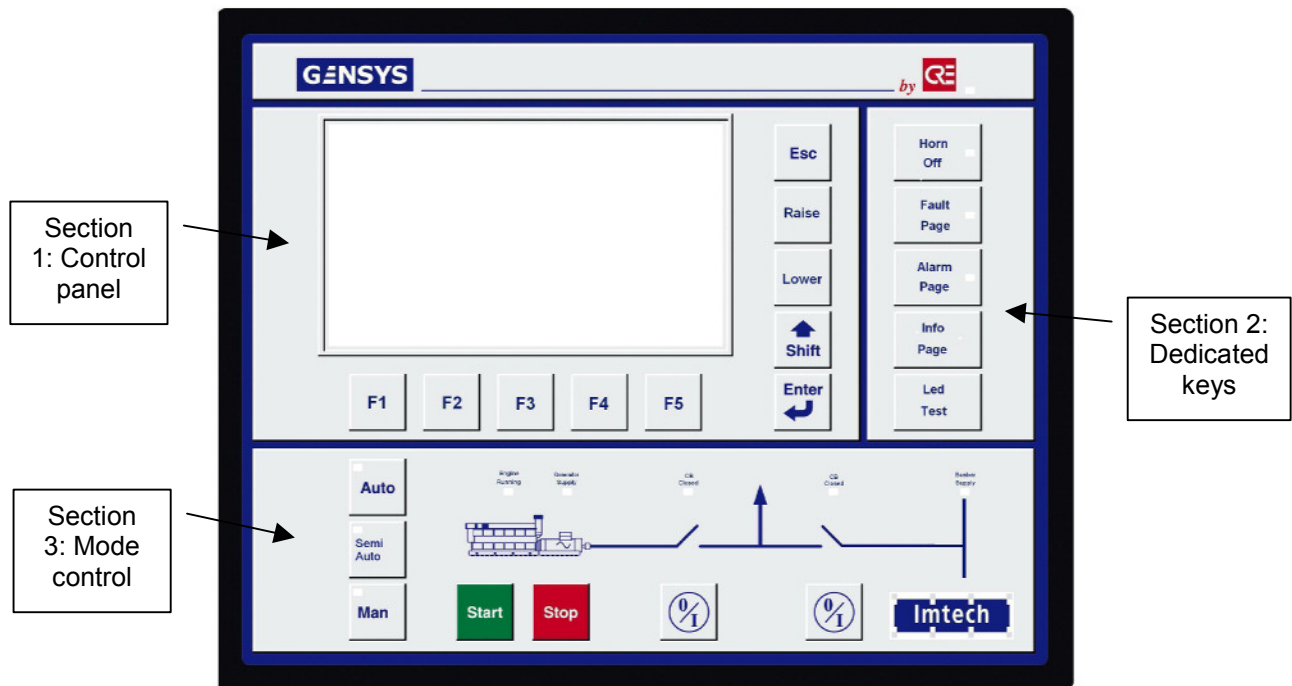


Figure 9 PMS display panel front face ESB

Note: The emergency generator is not part of the PMS of the MSB Aft and MSB Fwd. The PMS display panel in the ESB is a stand-alone unit.

The front of the PMS display panel is made up of 3 parts

- Section 1 – Control panel with LCD display and navigation keys;
- Section 2 – Dedicated keys;
- Section 3 – Mode control.

The LED in the upper right corner of the front panel will light up when a key is pressed and will be switched off when all keys are released.

The control panel has the same pushbuttons and LEDs as the PMS display panel of the MSB, see paragraph 3.1.3.1.1.

The dedicated keys have the same pushbuttons and LEDs as the PMS display panel of the MSB, see paragraph 3.1.3.1.2.

3.3.1.1.1 Mode control

The mode control part of the front panel is slightly different from the MSB PMS display panel and allows controlling the emergency generator.

Key	Function
Auto	Diesel generator set in automatic mode
Semi Auto	Diesel generator set in semi-automatic mode
Man	Diesel generator set in manual mode
Start (green key)	Start diesel generator set
Stop (red key)	Stop diesel generator set
O/I (left)	Open / close generator circuit breaker
O/I (right)	Open / close interconnection circuit breaker

The mode control part has 8 LEDs.

Key	Function
Auto	Switched on when in automatic mode
Semi Auto	Switched on when in semi-automatic mode
Man	Switched on when in manual mode
Engine Running	Switch on when emergency diesel engine is running
Generator Supply	Switched on when the emergency generator is supplying the Emergency Switch Board
CB Closed (left)	Switched on when emergency generator circuit breaker is closed
CB Closed (right)	Switched on when interconnection circuit breaker is closed
Busbar Supply	Switched on when bus bar of the Main Switch Boards is powered

3.3.2 Distribution panel

The switched off status of essential circuit breakers is signalised on the distribution panel of the ESB (by means of a control light in the door that will light up when the non-essential consumers are switched off). The non-essential (=non preferent) consumers are switched off by the ESB PMS in case of overload of the generator. After the non-essential consumers are switched off, the trip must be reset by means of the 'RESET' pushbutton in the door of the distribution panel. Then the individual groups can be switched on manually.

The non-essential consumers are also switched off at a black out.

4. Operating

In order to operate a diesel generator set from the PMS display panel or IPMS mimic, the control unit in the local control panel of the diesel generator set must be set in 'STANDBY' mode.

Each PMS display panel can operate in 3 modes, 'MAN' / 'SEMI AUTO' / 'AUTO'.

In manual mode the following functions are available:

- Manual start / stop by means of the pushbuttons on the PMS display panel;
- Manual opening and closing of generator circuit breakers by means of pushbuttons on the PMS display panel;
- Manual opening and closing the interconnection circuit breakers by means of pushbuttons on the MSB;
- Manual synchronizing by means of the 'LOWER' and 'RAISE' pushbuttons on the PMS display panel;
- Manual load sharing by means of the 'LOWER' and 'RAISE' pushbuttons on the PMS display panel;
- Non-essential consumers tripping and reducing;
- Under- and over-voltage monitoring;
- Under- and over-frequency monitoring;
- Generator reverse power protection.

In semi automatic mode the following functions are available:

- Manual start / stop by means of pushbuttons on the PMS display panel or via the IPMS mimic;
- Manual opening and closing of generator circuit breakers by means of pushbuttons on the PMS display panel or via the IPMS mimic;
- Automatic synchronizing of diesel generator sets;
- Automatic loading and unloading the generators;
- Automatic load sharing;
- Non-essential consumers tripping and reducing;
- Under- and over-voltage monitoring;
- Under- and over-frequency monitoring;
- Generator reverse power protection;
- Automatically synchronizing the bus bars;
- Automatic synchronizing to shore.

In automatic mode the following functions are available:

- Load dependent automatic start and stop of diesel generator sets;
- Automatic opening and closing of generator circuit breakers;
- Automatic synchronizing of diesel generator sets;
- Automatic closing of interconnection circuit breakers;
- Automatic loading and unloading the generators;
- Automatic load sharing;
- Non-essential consumers tripping and reducing;
- Black-out start;
- Automatic start on pre-alarm of running generator;
- Under- and over-voltage monitoring;
- Under- and over-frequency monitoring;

- Generator reverse power protection;
- Automatically synchronizing the bus bars;
- Automatic synchronizing to shore.

4.1 Principles of operation

The next chapters will describe how to start up / shut down diesel generator sets, synchronize diesel generator sets, loading / unloading diesel generator sets and open / close circuit breakers, starting on MSB AFT, due to the fact that the MCR AFT is continuous manned.

A main circuit breaker can only be closed if:

- Spring is charged;
- Protection unit not activated;
- Miniature circuit breakers measuring circuits are closed (refer to Production Document List Z3001, ref. [8], Production Document List Z3002, ref. [9] and Production Document List Z3003, ref. [10].)

To reset a tripped main circuit breaker requires 2 steps:

- Reset the MICROLOGIC 5.0A, refer to user manual MICROLOGIC 5.0A, ref. [13];
- Activate the 'RESET' pushbutton on the circuit breaker, refer to user manual MASTERPACT NW08, ref. [12].

A distribution group can be switched 'ON' and 'OFF' by opening the door of the distribution panel. If the circuit breaker of a distribution group is tripped, the handle is switched to the 'TRIP' position. The handle must be switched to the 'OFF' position to reset the circuit breaker.

4.2 Manual mode

In this mode, the diesel generator set(s) can only be controlled from the Main Switch Board / Emergency Switch Board.

4.2.1 Dead bus bar

This paragraph describes how to power up the electric power plant from black out.

On the generator panel MSB AFT:

- Set the PMS display panel to manual by activating 'MAN';
- The light 'MAN' comes on;
- Start up a diesel generator set by activating 'START';
- When the diesel engine is running at certain speed, the light 'ENGINE RUNNING' comes up;
- When the generator reached nominal voltage, the light 'GENERATOR SUPPLY' comes up;
- Activate 'O/I' to close the generator circuit breaker;
- The light 'CB CLOSED' comes up;
- The light 'BUSBAR SUPPLY' comes up.

On the interconnection panel MSB AFT:

- Set the selection switch 225S2 to 'MAN';
- To power up MSB FWD, activate 'CB CLOSE' to close the interconnection breaker;
- The light 'CB CLOSE' comes up.

On the distribution panel MSB AFT:

- To power up ESB, switch circuit breaker 510Q5 'ON' (see back sticker in the distribution panel).

On the interconnection panel MSB FWD:

- Set the selection switch 225S2 to 'MAN';
- Activate 'CB CLOSE' to close the interconnection circuit breaker;
- The light 'CB CLOSE' comes up;
- On the PMS display panels, the light 'BUSBAR SUPPLY' comes up.

On the distribution panel MSB FWD:

- To power up ESB, switch circuit breaker 510Q5 'ON' (see back sticker in the distribution panel).

On the generator / interconnection panel ESB:

- Set the selection switch 118S2 to 'AFT INT CB';
- The light 'BUSBAR SUPPLY' comes up.
- Activate 'O/I' (right) to close the interconnection circuit breaker;
- The light 'CB CLOSED' comes up.

In order to power up the complete ship, all circuit breakers in the distribution panels that are tripped, must be reset and switched on.

4.2.2 Generator parallel

This paragraph describes how to synchronise and switch on a generator with a running generator.

On the generator panel:

- At least one generator set is running and the LED 'BUSBAR SUPPLY' is on;
- Set the PMS display panel of the generator that will be synchronized to the busbar to manual by activating 'MAN';
- The light 'MAN' comes on;
- Start up the diesel generator set by activating 'START';
- When the diesel engine is running at certain speed, the light 'ENGINE RUNNING' comes up;
- When the generator reached nominal voltage, the light 'GENERATOR SUPPLY' comes up;
- Check the PMS display panel synchronoscope indicator;
- If necessary, adjust the speed of the generator by activating 'RAISE' or 'LOWER';
- When the generator is synchronised (top light of the circle is on), activate '0/I' in order to close the generator circuit breaker;
- The light 'CB CLOSED' comes up and the generators are running parallel;
- To share the load between the generator sets, activate 'RAISE' or 'LOWER' until both generator sets are delivering the same amount of power.

4.2.3 Power export

This paragraph describes how to export power from the ship to another vessel via the shore connection box.



WARNING:

Beware that exporting power is a manual action executed by the operator. This action causes unprotected live parts in the shore connection box. Before switching on the shore connection circuit breaker in the MSB beware that the cable to shore / other vessel is connected properly and the shore connection box is locked to prevent unauthorised entry.

On the generator panel MSB AFT:

- At least one generator set is running and the LED 'BUSBAR SUPPLY' is on;
- The light 'CB CLOSED' is on;
- The light 'ENGINE RUNNING' is on;
- The light 'GENERATOR SUPPLY' is on;
- Set the PMS display panel of the running generator set to manual by activating 'MAN';
- The light 'MAN' comes on;

On the shore connection panel MSB AFT:

- Set the selection switch 125S3 in 'MAN';
- Activate 'CB CLOSE' to close the shore connection circuit breaker;
- The light 'CB CLOSE' comes up and another vessel can receive power from the ship via the shore connection box.

4.2.4 Synchronise bus bars

This paragraph describes how to synchronise the bus bars when both bus bars are live.

On the generator panel MSB FWD:

- At least one generator set is running and the LED 'BUSBAR SUPPLY' is on.
- Set the PMS display panel of the running generator set to manual by activating 'MAN';
- The light 'MAN' comes on;

On the interconnection panel MSB FWD:

- Set the selection switch 225S2 to 'MAN';
- Activate 'CB CLOSE';
- The light 'CB CLOSE' comes up.

On the interconnection panel MSB AFT:

- Set the selection switch 225S2 to 'MAN'.

On the generator panel MSB AFT:

- At least one generator set is running and the LED 'BUSBAR SUPPLY' is on;
- Set the PMS display panel of the running generator set to manual by activating 'MAN';
- The light 'MAN' comes on;
- Check the interconnection panel Synchronoscope indicator;
- If necessary, adjust the speed of the generator by activating 'RAISE' or 'LOWER'.

On the interconnection panel MSB AFT:

- When the bus bar is synchronised (green light of the Synchronoscope indicator is on), activate 'CB CLOSE' in order to close the interconnection circuit breaker;
- The light 'CB CLOSED' comes up and the bus bars are connected.

When the bus bars are separated and MSB AFT is on shore power and MSB FWD is running on generator power, synchronizing the bus bars is only possible when all PMS display panels are in manual mode and the selection switch 125S3 on the shore connection panel is in 'MAN'.

The running diesel generator set on MSB FWD must be synchronized to the shore power. When the diesel generator set is synchronized, the generator circuit breaker must be closed by activating 'O/I' on the PMS display panel in order to close the generator circuit breaker.

On the shore connection panel, the pushbutton 'CB OPEN' must be activated to open the shore connection circuit breaker.

Now the bus bars are connected and the ship is receiving power from the running diesel generator set.

4.3 Semi automatic mode

In this mode, the diesel generator set(s) can be controlled from the Main Switch Board / Emergency Switch Board or the IPMS.

4.3.1 Dead bus bar

This paragraph describes how to power up the Main Switch Boards from black out.

On the generator panel MSB AFT:

- Set the PMS display panel to semi-auto by activating 'SEMI AUTO';
- The light 'SEMI AUTO' comes on;
- Start up a diesel generator set by activating 'START';
- When the diesel engine is running at certain speed, the light 'ENGINE RUNNING' comes up;
- When the generator reached nominal voltage, the light 'GENERATOR SUPPLY' comes up;
- Activate 'O/I' to close the generator circuit breaker;
- The light 'CB CLOSED' comes up;
- The light 'BUSBAR SUPPLY' comes up.

On the interconnection panel MSB AFT:

- Set the selection switch 225S2 to 'AUTO CLOSE';
- The interconnection breaker will close automatically;
- The light 'CB CLOSE' comes up.

On the distribution panel MSB AFT:

- To power up ESB, switch circuit breaker 510Q5 'ON' (see back sticker in the distribution panel).

On the interconnection panel MSB FWD:

- Set the selection switch 225S2 to 'AUTO CLOSE';
- The interconnection circuit breaker will close automatically;
- The light 'CB CLOSE' comes up;
- On the PMS display panels, the light 'BUSBAR SUPPLY' comes up.

On the distribution panel MSB FWD:

- To power up ESB, switch circuit breaker 510Q5 'ON' (see back sticker in the distribution panel).

On the generator / interconnection panel ESB:

- Set the selection switch 118S2 to 'AFT INT CB';
- The light 'BUSBAR SUPPLY' comes up.
- Activate 'O/I' (right) to close the interconnection circuit breaker;
- The light 'CB CLOSED' comes up.

In order to power up the complete ship, all circuit breakers in the distribution panels that are tripped, must be reset and switched on.

4.3.2 Generator parallel

This paragraph describes how to synchronise and switch on a generator with a running generator.

On the generator panel:

- At least one generator set is running and the LED 'BUSBAR SUPPLY' is on;
- Set the PMS display panel of the generator that will be synchronized to the bus bar to semi-auto by activating 'SEMI AUTO';
- The light 'SEMI AUTO' comes on;
- Start up the diesel generator set by activating 'START';
- When the diesel engine is running at certain speed, the light 'ENGINE RUNNING' comes up;
- When the generator reached nominal voltage, the light 'GENERATOR SUPPLY' comes up;
- Activate 'O/I' in order to close the generator circuit breaker;
- The PMS will automatically synchronize and close the generator circuit breaker;
- The light 'CB CLOSED' comes up and the generators are running parallel;
- The PMS will automatically share the load between the generator sets.

4.3.3 Synchronise bus bars

This paragraph describes how to synchronise the bus bars when both bus bars are live.

In 'AUTO CLOSE' mode, the PMS closes the interconnection circuit breaker automatically when the bus bar is live.

4.4 Automatic mode

In this mode, the diesel generator set(s) are controlled by the PMS.

4.4.1 Dead bus bar

When a black out occurs, all breakers will open; all diesel generator sets in 'AUTO' mode will receive a start command by the PMS. All circuit breakers of the running diesel generator sets will receive an 'ON' request.

When one diesel generator set is supplying the bus bar, the superfluous diesel generator sets, depending of the required load, will be stopped after a period of time.

In order to power up the complete ship, all circuit breakers in the distribution panels that are tripped, must be reset and switched on.

4.4.2 Ship to shore

This paragraph describes how to switch over from generator power to shore / other vessel power.

On the generator panel MSB AFT:

- Only one generator set is running and the light 'BUSBAR SUPPLY' on MSB AFT is on;
- Set the PMS display panel to auto by activating 'AUTO';
- The light 'AUTO' comes on.

On the shore connection panel MSB AFT:

- Set the selection switch 125S3 in 'AUTO TAKE OVER';
- Activate 'CB CLOSE' to close the shore connection circuit breaker and the PMS will automatically synchronise the generator to the shore supply;
- The light 'CB CLOSE' comes up;
- On the Synchronoscope indicator the light will turn green if the generator and shore supply are synchronised;
- When synchronised, the shore connection circuit breaker will close and the generator circuit breaker will open.

4.4.3 Shore to ship

This paragraph describes how to switch over from shore / other vessel power to generator power.

On the shore connection panel MSB AFT:

- Set the selection switch 125S3 in 'AUTO TAKE OVER'.

On the generator panel MSB AFT:

- The light 'BUSBAR SUPPLY' is on.
- Set the PMS display panel to manual by activating 'MAN';
- The light 'MAN' comes on;
- Start up a diesel generator set by activating 'START';
- When the diesel engine is running at certain speed, the light 'ENGINE RUNNING' comes up;
- When the generator reached nominal voltage, the light 'GENERATOR SUPPLY' comes up;
- Set the PMS display panel to auto by activating 'AUTO';
- Activate 'O/I' to close the generator circuit breaker and the PMS will automatically synchronize the generator to the shore supply;

On the shore connection panel MSB AFT:

- On the Synchronoscope indicator the light will turn green if the generator and shore supply are synchronised;

On the generator panel MSB AFT:

- When synchronised, the generator circuit breaker will close and the shore connection circuit breaker will open;
- The light 'CB CLOSED' comes up.

4.4.4 Generator parallel

This paragraph describes how the PMS synchronise and switch on a generator with a running generator.

When the load of the running generator sets reaches 85% of its individual power, the PMS will automatically start up a diesel generator set, which is set to 'AUTO' and next in the sequence of starting (for a description of the starting and stopping sequence, refer to the functional specification of the Power Management System, ref. [4]), synchronize the generator set to the bus bar and close the generator circuit breaker. When the generator set is running parallel, the PMS will automatically share the load between the running generator sets.

When the load of the running generator sets reaches 75% of its nominal power, the PMS will automatically switch off the generator circuit breaker of the diesel generator set which is next in the sequence of stopping, and stop the diesel generator set.

When a diesel generator set is in 'AUTO' and the 'PREF' is activated, the selected diesel generator set will automatically receive a start command, synchronise to the bus bar and the generator circuit breaker will receive an 'ON' command, regardless the demanded power-need of an additional diesel generator set.

The 'PREF' is activated in order to achieve maximum functionality.

Only one diesel generator set must be set in preference mode by activating 'PREF'.

4.5 Emergency

4.5.1 Dead bus bar

This paragraph describes how to power up the emergency generator from black out in the three different modes.

4.5.1.1 Manual mode

On the generator / interconnection panel ESB:

- Set the ESB PMS display panel to manual by activating 'MAN';
- The light 'MAN' comes on;
- Start up the emergency diesel generator by activating 'START';
- When the emergency diesel engine is running at certain speed, the light 'ENGINE RUNNING' comes up;
- When the emergency generator reached nominal voltage, the light 'GENERATOR SUPPLY' comes up;
- Activate 'O/I' (left) to close the emergency generator circuit breaker;
- The light 'CB CLOSED' comes up;
- The light 'BUSBAR SUPPLY' comes up.

On the distribution panel ESB:

- All circuit breakers, except the non-preferent groups, that are tripped must be reset and switched on.



WARNING:

If in emergency mode, do not switch on the tripped non-preferent groups (refer to the feeder table inside the distribution panel ESB).

This can cause an overload of the running emergency diesel generator, which can cause an unforeseen shut down of the emergency diesel generator.

In order to power up the complete ship with the normal diesel generator sets on the Main Switch Boards in manual mode refer to the respective paragraph of 'Manual mode', see paragraph 4.2.

4.5.1.2 Semi automatic mode

On the generator / interconnection panel ESB:

- Set the ESB PMS display panel to semi-auto by activating 'SEMI AUTO';
- The light 'SEMI AUTO' comes on;
- Start up a diesel generator set by activating 'START';
- When the diesel engine is running at certain speed, the light 'ENGINE RUNNING' comes up;
- When the generator reached nominal voltage, the light 'GENERATOR SUPPLY' comes up;
- Activate '0/I' (left) to close the emergency generator circuit breaker;
- The light 'CB CLOSED' comes up;
- The light 'BUSBAR SUPPLY' comes up.

On the distribution panel ESB:

- All circuit breakers, except the non-preferent groups, that are tripped must be reset and switched on.



WARNING:

If in emergency mode, do not switch on the tripped non-preferent groups (refer to the feeder table inside the distribution panel ESB). This can cause an overload of the running emergency diesel generator, which can cause an unforeseen shut down of the emergency diesel generator.

In order to power up the complete ship with the normal diesel generator sets on the Main Switch Boards in semi automatic mode refer to the respective paragraph of 'Semi automatic mode', see paragraph 4.3.

4.5.1.3 Automatic mode

When a black out occurs, the emergency diesel generator will automatically start up and the circuit breaker of the emergency diesel generator set will automatically receive an 'ON' request.

All circuit breakers, except the non-preferent groups, that are tripped must be reset and switched on.



WARNING:

If in emergency mode, do not switch on the tripped non-preferent groups (refer to the feeder table inside the distribution panel ESB).

This can cause an overload of the running emergency diesel generator, which can cause an unforeseen shut down of the emergency diesel generator.

In order to power up the complete ship with the normal diesel generator sets on the Main Switch Boards in automatic mode refer to the respective paragraph of 'Automatic mode', see paragraph 4.4.

4.5.2 Take over after restoring normal power supply

This paragraph describes how to take over the Emergency Switch Board from power of the emergency generator to power of the Main Switch Boards in the three different modes.

In this situation the normal diesel generator sets must be running and the Main Switch Boards must be powered up.

4.5.2.1 Manual mode

To display the synchronoscope in the LCD display of the PMS display panel:

- Press 'ESC';
- Press 'ENTER' 3 (three) times;
- Scroll to Synchronizing;
- Press 'ENTER'.

Now the synchronoscope is visible.

On the generator / interconnection panel ESB:

- The ESB PMS display panel is set to manual mode;
- The light 'MAN' is on;
- Select from which Main Switch Board the Emergency Switch Board will receive power;
- Set selection switch 118S2 to 'AFT' or 'FWD';
- Check the PMS display panel synchronoscope indicator;
- If necessary, adjust the speed of the emergency generator by activating 'RAISE' or 'LOWER';
- When the emergency generator is synchronised (top light of the circle is on), press continuously 'O/I' (right) in order to close the interconnection circuit breaker;
- The light 'CB CLOSED' (right) comes up;
- Activate 'O/I' (left) to open the emergency generator circuit breaker;
- The light 'CB CLOSED' (left) goes off;
- Activate 'STOP' to stop the emergency generator after the cooling down period.

On the distribution panel ESB:

- All circuit breakers, including the non-preferent groups, that are tripped must be reset and switched on.

4.5.2.2 Semi automatic mode

On the generator / interconnection panel ESB:

- The ESB PMS display panel is set to semi automatic mode;
- The light 'SEMI AUTO' is on;
- Select from which Main Switch Board the Emergency Switch Board will receive power;
- Set selection switch 118S2 to 'AFT' or 'FWD';
- Activate 'STOP' to stop the emergency generator;
- The PMS display panel will automatically synchronize and close the interconnection circuit breaker;
- The light 'CB CLOSED' (right) comes up;
- The emergency generator circuit breaker will open;
- The light 'CB CLOSED' (left) goes off;
- The PMS display panel will automatically stop the emergency generator after the cooling down period.

On the distribution panel ESB:

- All circuit breakers, including the non-preferent groups, that are tripped must be reset and switched on.

4.5.2.3 Automatic mode

When the PMS display panel of the Emergency Switch Board is in automatic mode, take over is done automatically when the power is restored on the busbar of the Main Switch Boards.

Which Main Switch Board will feed the Emergency Switch Board is selected via the selection switch. When the PMS display panel measures a voltage at the Main Switch Board, the emergency generator will be synchronized automatically to the selected incoming power supply. The PMS display panel will automatically close the interconnection circuit breaker of the selected Main Switch Board and opens the emergency generator circuit breaker.

The PMS display panel will stop the emergency generator automatically after the cooling down period.

All circuit breakers, including the non-preferent groups, that are tripped must be reset and switched on.

4.5.3 Take over in normal situation

When it is required that the emergency generator supplies the consumers of the Emergency Switch Board instead of Main Switch Board Aft or Fwd (i.e. change over the power supply to the Emergency Switch Board from Main Switch Board Aft to Main Switch Board Fwd), it is possible to take over the power supply from the Main Switch Boards.

On the generator / interconnection panel ESB:

- The light 'CB CLOSED' (right) is on;
- Set the ESB PMS display panel to semi-auto by activating 'SEMI AUTO';
- The light 'SEMI AUTO' comes on;
- Start up a diesel generator set by activating 'START';
- When the diesel engine is running at certain speed, the light 'ENGINE RUNNING' comes up;
- When the generator reached nominal voltage, the light 'GENERATOR SUPPLY' comes up;
- Activate 'O/I' (left) to close the emergency generator circuit breaker;
- The PMS display panel will automatically synchronize and close the emergency generator circuit breaker;
- The light 'CB CLOSED' (left) comes up;
- The PMS display panel will automatically opens the interconnection circuit breaker;
- The light 'CB CLOSED' (right) goes off;

Now the normal generator(s) are supplying the consumers of the Main Switch Boards and the emergency generator is supplying the consumers of the Emergency Switch Board.

To switch over, so that the normal generators are supplying the consumers of the Emergency Switch Board instead of the emergency generator, refer to paragraph 4.5.2.2.

4.6 Operator control PMS and IPMS

The following paragraph gives an overview of the operator control functions of the PMS display panel and the IPMS mimic.

4.6.1 Manual mode

Manual mode operator control:

Diesel generator	MSB	Mimic
Start engine	Yes	No
Stop engine	Yes	No
Increase speed	Yes	No
Decrease speed	Yes	No
Close breaker	Yes	No
Open breaker	Yes	No

Interconnection	MSB	Mimic
Select manual mode	Yes	No
Close breaker	Yes	No
Open breaker	Yes	No

Shore connection	MSB	Mimic
Select manual mode	Yes	No
Close breaker	Yes	No
Open breaker	Yes	No

4.6.2 Semi automatic mode

Semi automatic mode operator control:

Diesel generator	MSB	Mimic
Start engine	Yes	Yes
Stop engine	Yes	Yes
Synchronise / close breaker	Yes	Yes
Unload / open breaker	Yes	Yes
Interconnection	MSB	Mimic
Select auto close mode	Yes	No
Close breaker	Yes	No
Open breaker	Yes	No
Shore connection	MSB	Mimic
Select auto take over mode	Yes	No
Close breaker	Yes	No
Open breaker	Yes	No

4.6.3 Automatic mode

Automatic mode operator control:

Diesel generator	MSB	Mimic
------------------	-----	-------

Start engine	N/A	N/A
Stop engine	N/A	N/A
Synchronise / close breaker	N/A	N/A
Unload / open breaker	N/A	N/A
Set preference	Yes	Yes

Interconnection	MSB	Mimic
-----------------	-----	-------

Select auto close mode	Yes	No
Close breaker	Yes	No
Open breaker	Yes	No

Shore connection	MSB	Mimic
------------------	-----	-------

Select auto take over mode	Yes	No
Close breaker	Yes	No
Open breaker	Yes	No

5. Maintenance

5.1 General

Each MSB / ESB shall be yearly visually inspected for dust / dirt and cleaned if necessary. The insulating material must especially be kept free from dust and other sorts of dirt.



WARNING:

In case cleaning is required, the power supply to the Main Switch Board / Emergency Switch Board must be switched off for safety reasons. The maintenance must be properly executed by qualified personnel using proper materials and tools.

5.2 Earth connections

The earth connections of each MSB / ESB shall be visually inspected yearly.

The earth connections of each MSB / ESB shall be tested using measuring equipment 5 yearly.

5.3 Protection covers

To prevent contact with live parts, each cubicle of the MSB / ESB shall be inspected yearly for missing / damaged protection covers.



WARNING:

In case transparent protection covers in a cubicle are missing / damaged they shall be replaced by same size, insulating protection covers.

5.4 Anti-condensation heating

The anti-condensation heating shall be checked yearly.

5.5 Earth-fault measurement test

The earth-fault measuring instrument in each MSB / ESB shall be tested yearly by pushing the test button.

5.6 Bus bar connections

The bus-bar connections shall be inspected under nominal load conditions every year using a thermal imaging camera to detect defects. The assemblies are maintenance free and should not be tightened up!

5.7 Circuit breakers

For maintenance of the air circuit breakers refer to: user manual MASTERPACT NW08, ref. [12].

For maintenance of the moulded case circuit breakers refer to: user manual Moulded Case Circuit Breakers, ref. [14].