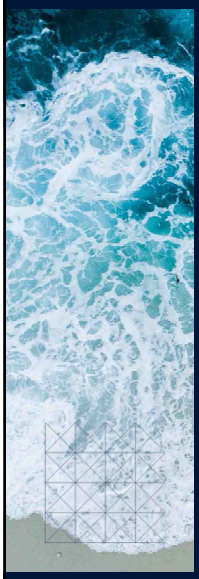

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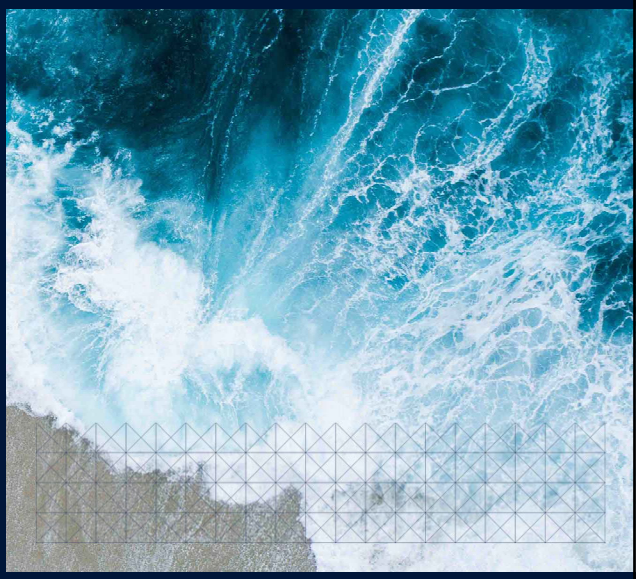
POWER MANAGEMENT SYSTEM



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Power Management System

References

- Kongsberg K-Chief 700 Integrated Control System Product Description, 304844/B
- Kongsberg K-Chief 700 Operator Manual Release 8.2, 302618/B

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Content

- Purpose of a PMS System
- K-Chief 700 Power Management System
- Main units and set-up of the PMS
- Operator menu's
- Heavy Consumers
- DP requirements
- Blackout prevention system
- Blackout recovery system
- Energy Management System

Power Management System

A system to efficiently and accurately control delivered electrical power to the various components in a system

The power management system is designed to:

- Improve the robustness to prevent blackout
- Handle major power faults
- Minimize the operational cost
- Keep the machinery components under minimal stress in all operational conditions
- Automatically restore power after a blackout situation in a predetermined sequence

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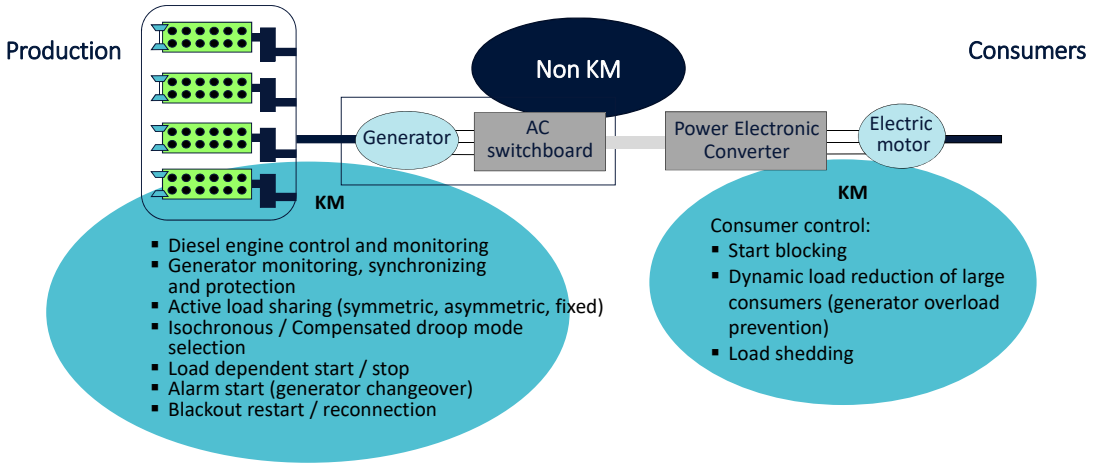
KM PMS interface and control the production, and the consumers



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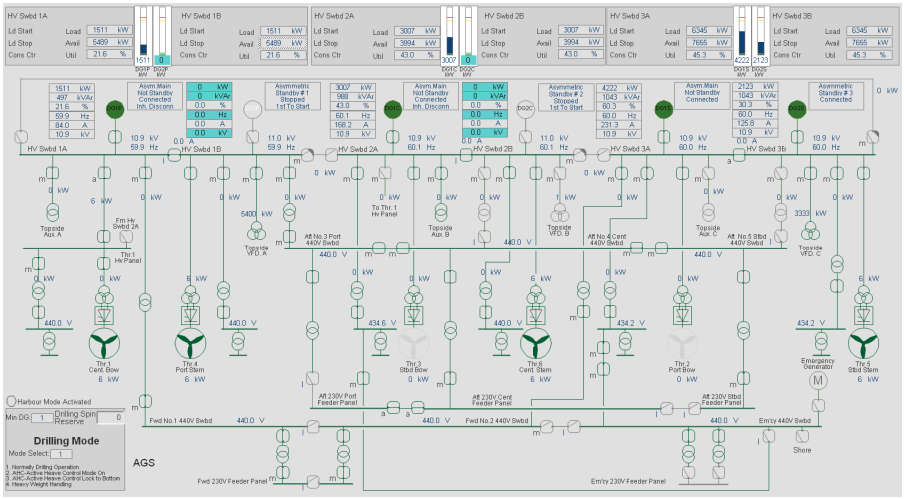
PMS Plant



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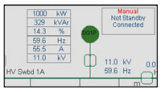
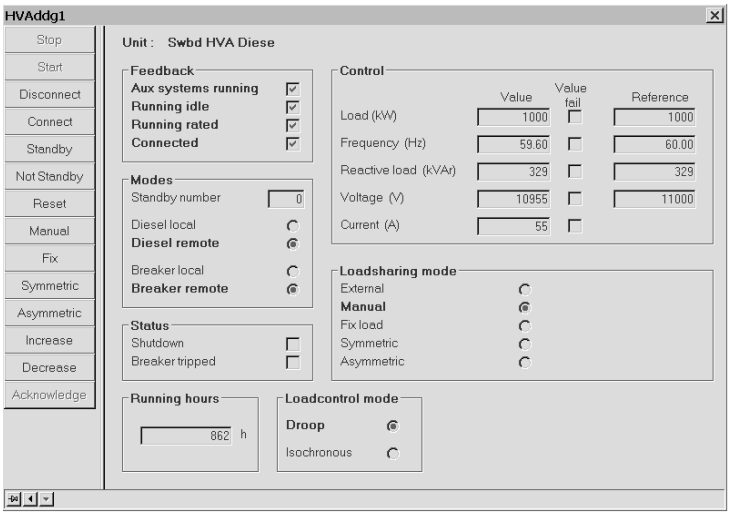
Generator Operator menu





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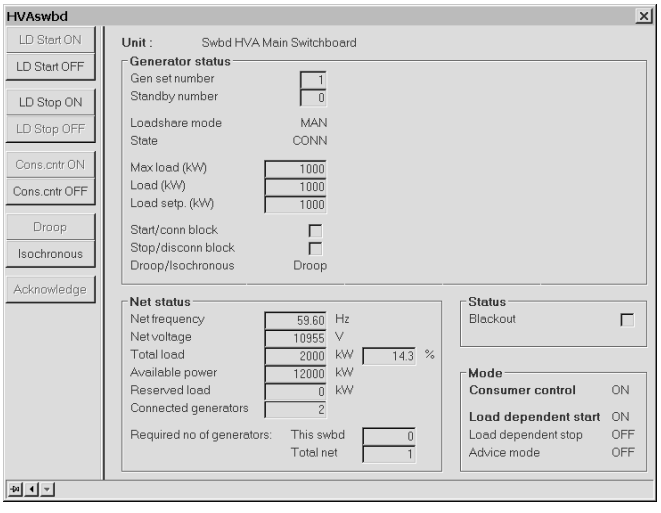
Switchboard Operator Menu



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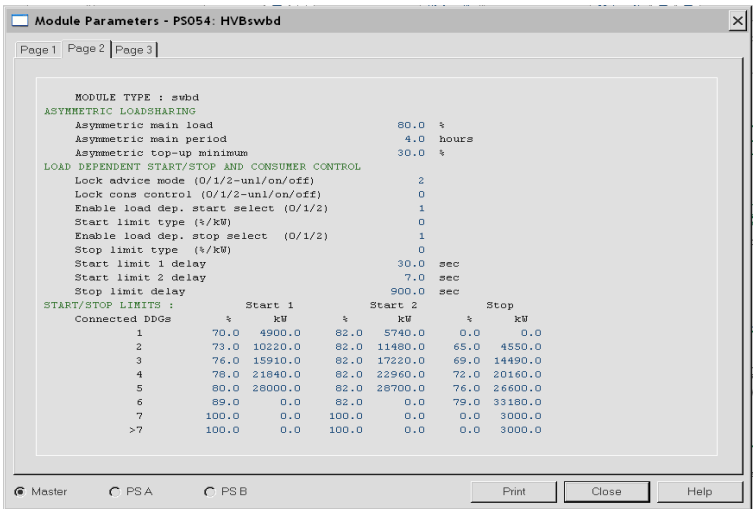
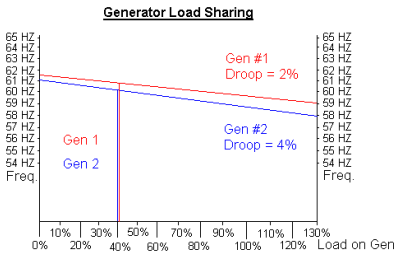
Switchboard Parameters



Isochronous/ Droop Mode

The different modes are selected on each Switchboard.

- **Isochronous Mode** is defined as a "unit with zero droop": The Generator will have the same frequency regardless of the load it is supplying
- **Droop Mode** means the frequency of the generator is not kept all the time at a predefined value, i.e. 60 Hz
- **Compensated Droop** means the frequency of the generator is kept at i.e. 60 Hz. This is done by adjusting the droop curve up or down



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Consumer Load Control

- When the Load Dependent Start is turned on, the PMS system will perform automatic start of standby generator when the percentage load of the generators exceeds a pre-set level, i.e. 82%. Each start-up function has adjustable time delay
- Load Dependent Stop function will stop generators when the system have more power available than necessary

Consumer Start Control

The Heavy Consumer Start Control function can be switched on and off in the Switchboard operator menu.

Heavy consumers send start request to PMS, if the capacity of the power plant is enough and other start conditions are fulfilled, electric motor start order is given.

If capacity is not enough, a standby generator is started. If the spare capacity is not reached within a specified time, the motor start order is timed out.

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Drilling operation modes

Drilling operation have four different modes:

1. Normal drilling operation
2. AHC -Active Heave Control mode on
3. AHC -Active Heave Control locked to the bottom
4. Heavy weight handling

When one of these modes is selected, the PMS will force the minimum predefined amount of generators to start.

The Power Management system will then add a predefined load to the switchboards, to have spare capacity for the drilling equipment.

Minimum Generators Online:

	DP Mode	Normal Drilling	Drilling Mode 2-4
Close Ring	2	1	2
Open Ring	2	1	2
2-Split Mode	2	1	2
3,4,5,6-Split Mode	1	1	1

DP requirements

Class 1: No PMS redundancy.

Class 2: PMS must have redundancy, Bus-tie breakers must automatically open separately upon failure.

Class 3: Redundancy and A60 bulkhead division (Separate DG Rooms), if PMS is located below waterline (Watertight separation) and Open Bus-Tie breaker.

DYNPOS-ER(DNV)/EHS(ABS): Class 2 or 3 operated with closed bus-ties.

For Class 2 and 3 it is of high importance that the Low Voltage Distribution also is set up correctly.

Description	IMO	Corresponding class notations		
	DP Class	ABS	LRS	DNV
Manual position control and automatic heading control under specified maximum environmental conditions.	-	DPS-0	DP (CM)	DPS 0 DYNPOS-AUTS
Automatic and manual position and heading control under specified maximum environmental conditions.	Class 1	DPS-1	DP (AM)	DPS 1 DYNPOS-AUT
Automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault excluding loss of a compartment. (Two independent computer systems).	Class 2	DPS-2	DP (AA)	DPS 2 DYNPOS-AUTR
Automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault including loss of a compartment due to fire or flood. (At least two independent computer systems with a separate back-up system separated by A60 class division).	Class 3	DPS-3	DP (AAA)	DPS 3 DYNPOS-AUTRO

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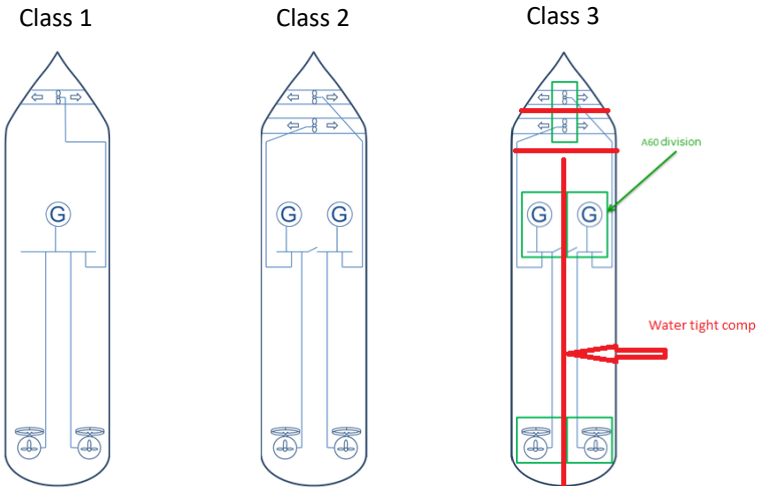
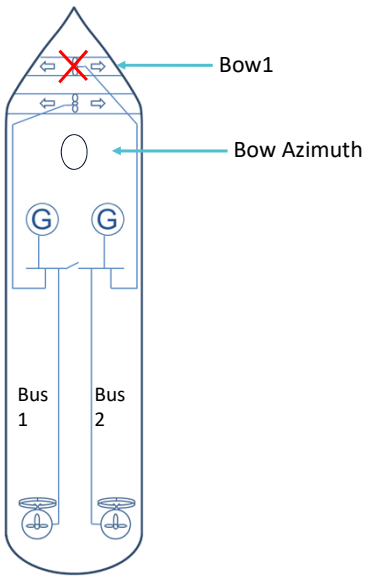


Example

Class 2, requires thrusters to be redundant.

Let`s say that the tunnel thruster Bow1 is not available due to maintenance.

To keep redundancy in the thruster set up, Bow azimuth should be set up on Bus2 to keep this vessel within the requirements.



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Blackout

How do blackouts occur?

- When electrical demand (load) exceeds the Power Management Systems ability to produce electric energy

Most blackouts occur when:

- Engine/Generators sets unexpectedly shut down without warning
- Fixed and variable load increases unchecked until the capacity of the on-line engine/generators is exceeded

Black-out Prevention Functions

Power management system:

- Blackout prevention with load reduction/load shedding functionality (Dynamic Load Control)
- Based on generator load, generator/bus tie breaker trip and net frequency

Dynamic positioning system:

- Power limitation function, based on power available signals from PMS

Thruster and thruster drives:

- Variable speed Frequency Controlled thrusters must have a load reduction scheme that is monitoring the network frequency and/or receiving a maximum power limitation signal from the fast load reduction system in PMS

Drilling drives:

- Like the requirements of the thruster drives, with built-in priorities for the individual drilling drives

Because this is a dynamic positioned vessel the thruster drives will always take precedence over the drilling drives.

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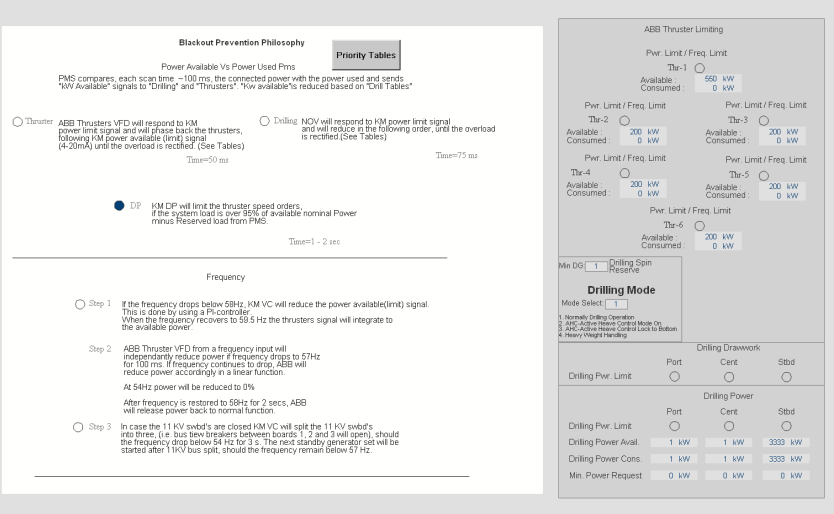
Blackout Prevention Philosophy



Energy Management System

Applications that utilizes the functionality of the PMS

- Advanced Generator Supervisor (AGS)
- Dynamic Load Prediction (DLP)
- Dynamic Load Compensation (DLC)

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Advanced Generator Supervisor (AGS)

The goal of the AGS is to detect and isolate generators with faulty speed or voltage control system.

- Avoid full or partial blackouts due to such failures
- Be able to operate with closed bus-ties to reduce the number of generators on line → less fuel consumption and emissions, running hours and maintenance

- First level of deviation:
  - Start standby generator(s) and give an alarm

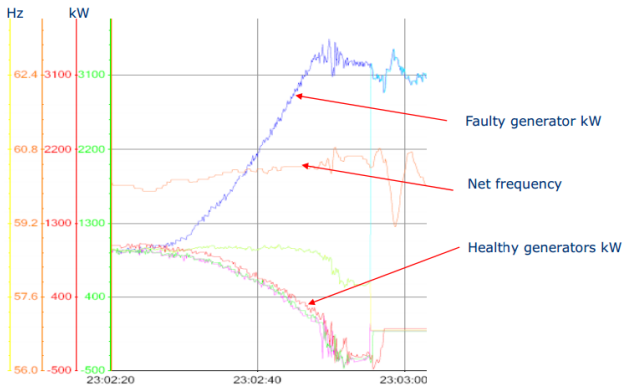
    If the deviations exceeds further:
    - Trip the faulty generator

Without AGS, Speed control failure

4 generators online.

One generator forced to increase load.

→ Trip of all 3 healthy generators by breaker protection!



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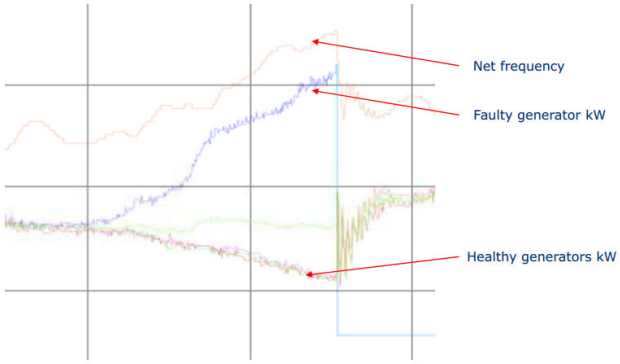
With AGS, Speed control failure

4 generators online.

One generator forced to increase load.

→ Trip off faulty generator by AGS.



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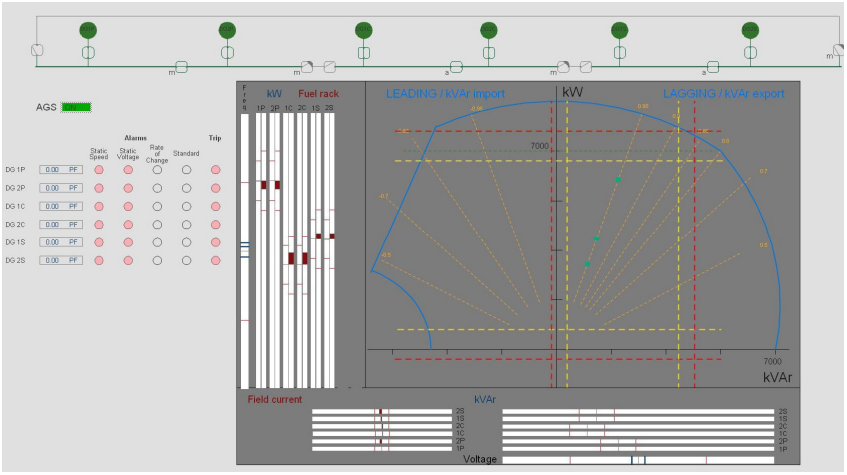
AGS



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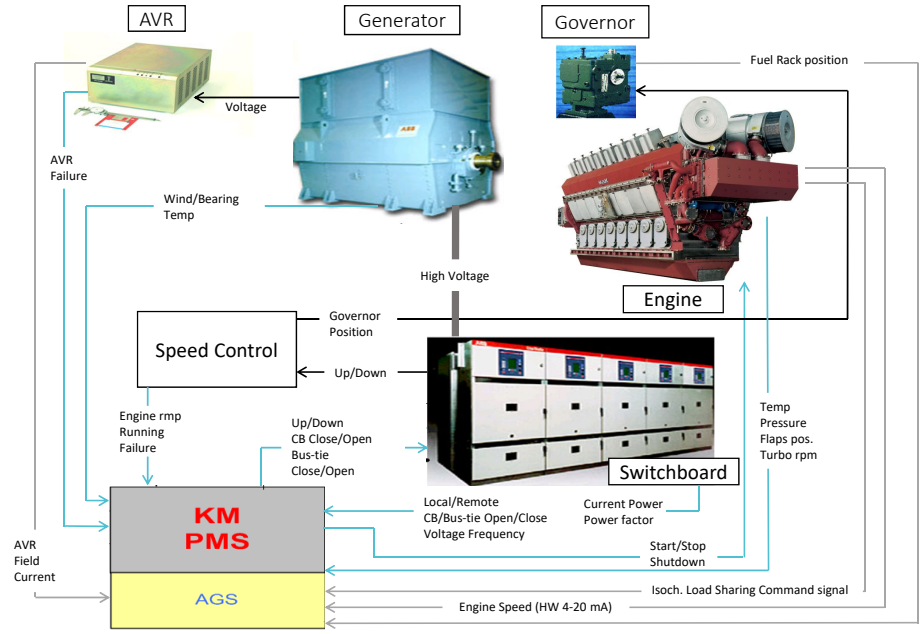

DLP – Dynamic Load Prediction

Method where prediction of future load changes are fed forward to the controllers to improve transient behaviour.

Including load change due to:

- A planned vessel speed change, which can be calculated by the DP control system
- Set point changes for dynamic heavy consumers such as cranes, heave compensation, drilling and manual thruster levers
- Main Generator failure, including shutdown, generator or tie-breaker tripping, and load limitation, predicting the amount of extra load required for the remaining main generators
- Start-up of heavy consumers
- Load shedding, predicting the amount of load to be reduced when consumers are tripped
- Cyclic loads, associated with e.g. heave compensation, classified by a pattern recognition function

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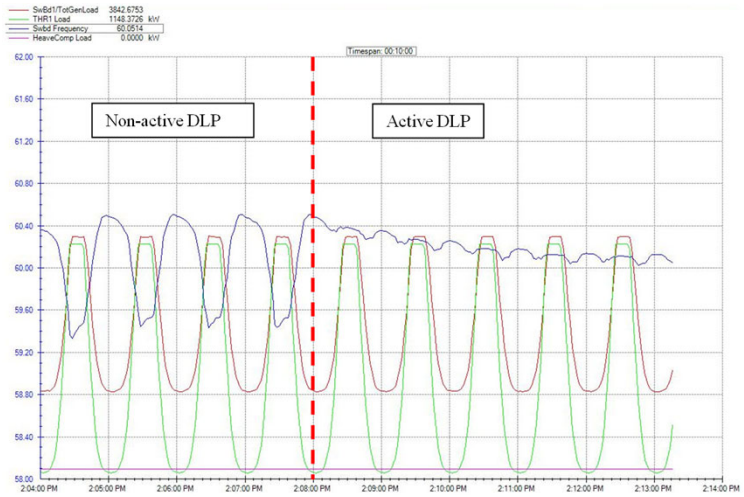
DLP – Dynamic Load Prediction



DLC – Dynamic Load Compensation

Situation with a periodic heave motion.

Traditional solution:

- The thruster load is maintained at a constant level
- Load variations must be handled directly by the generators, leading to unwanted wear and soothing

DLC solution:

- The thruster load counteracts the varying heave compensation load, while the vessel moves inside a small window
- The load variation is now moved to the thrusters, which are more suited to handle such variations than the generators
- Achieving a stable bus frequency
- A minimum of two freely rotatable thrusters must be available for DLC

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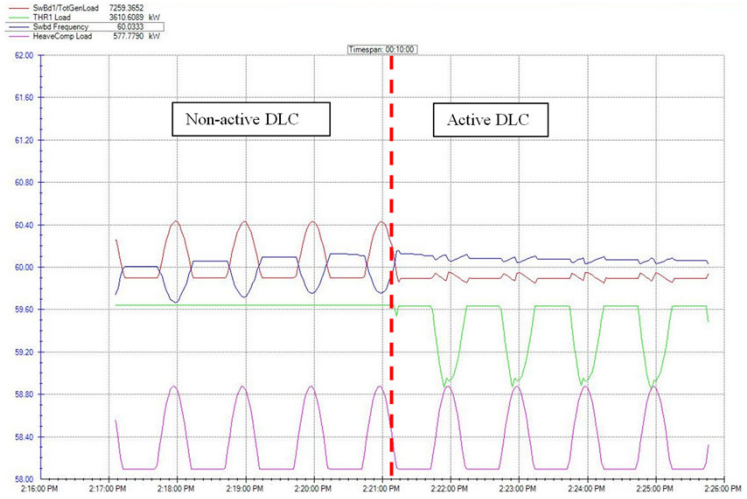
DLC – Dynamic Load Compensation



Blackout restart

There are two blackout scenarios possible. These are:

- Total blackout
  - In the event of a total blackout, all outgoing feeders to thruster, drilling, and distribution transformers will trip by under voltage protection
  - The bus tie breakers of the 11 kV switchboards will be opened because of the under-voltage trip of the breakers
  - If blackout on the 11kV switchboard is detected, the PMS will immediately give start order to:
    - All engines
    - Blocked engines will need a PMS Reset before they can start
- Partial blackout
  - In the event of a partial blackout, all outgoing feeders to thruster, drilling, and distribution transformers for the blacked-out switchboard, will trip by under voltage protection

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Exercises:

- Power Management System

Learning Objectives

- Identify a Power Management “plant“ in the HMI
- Describe the purpose of a PMS System
- Identify the main units and set-up of the PMS
- Identify and explain the Generator operator menu
- Give examples of heavy consumers
- Identify and explain the Switchboard operator menu
- Describe the usage of different bus tie set-ups
- Use the functions in the generator and switchboard menus
- Give examples of how the PMS prevents a blackout
- Explain how the PMS solves a recovery after blackout
- Give examples of Kongsberg applications that utilizes the functionality of the PMS


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