



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



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Power Management System

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

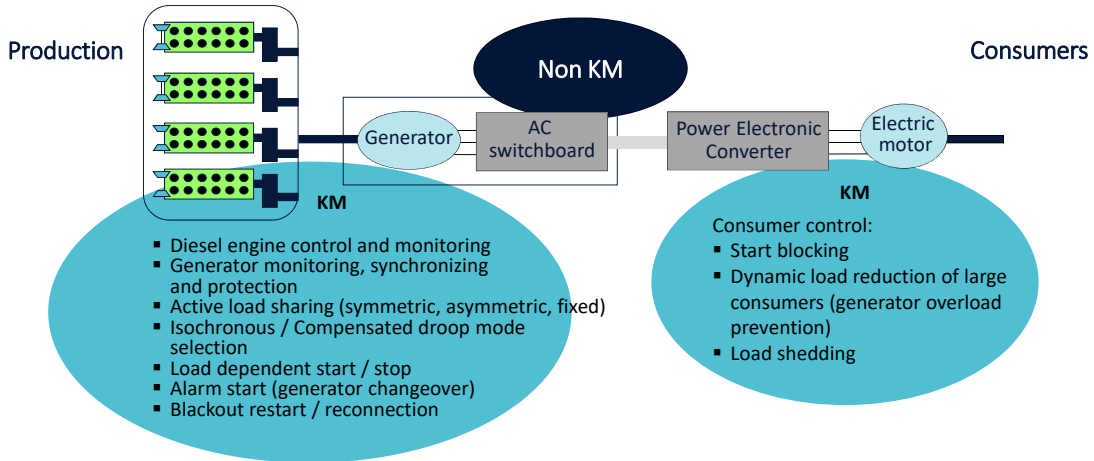
The power management system is designed to:

- 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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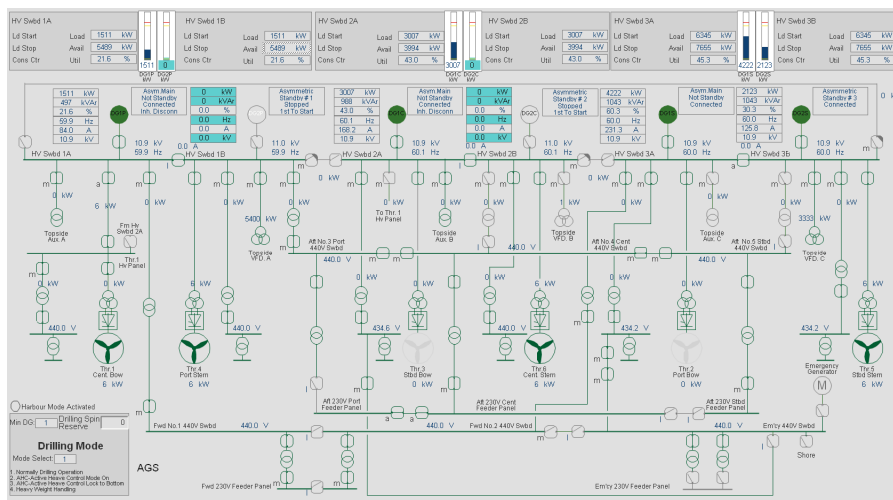
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PMS Plant



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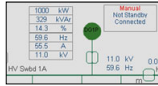
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Generator Operator menu



HVAddg1

Unit : Swbd HVA Diese

Feedback

Aux systems running
 Running idle
 Running rated
 Connected

Modes

Standby number:

Diesel local
 Diesel remote
 Breaker local
 Breaker remote

Status

Shutdown
 Breaker tripped

Running hours: h

Loadcontrol mode

Droop
 Isochronous

Control

	Value	Value fail	Reference
Load (kW)	<input type="text" value="1000"/>	<input type="checkbox"/>	<input type="text" value="1000"/>
Frequency (Hz)	<input type="text" value="59.60"/>	<input type="checkbox"/>	<input type="text" value="60.00"/>
Reactive load (kVAr)	<input type="text" value="329"/>	<input type="checkbox"/>	<input type="text" value="329"/>
Voltage (V)	<input type="text" value="10955"/>	<input type="checkbox"/>	<input type="text" value="11000"/>
Current (A)	<input type="text" value="55"/>	<input type="checkbox"/>	

Loadsharing mode

External
 Manual
 Fix load
 Symmetric
 Asymmetric



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Switchboard Operator Menu

HV Subd 1A Droop

Load kW
 Avail kW
 Util %

HVAswbd

Unit : Swbd HVA Main Switchboard

Generator status

Gen set number:
 Standby number:
 Loadshare mode: MAN
 State: CONN
 Max load (kW):
 Load (kW):
 Load setp. (kW):
 Start/conn block
 Stop/disconn block
 Droop/Isochronous

Net status

Net frequency	<input type="text" value="59.60"/> Hz
Net voltage	<input type="text" value="10955"/> V
Total load	<input type="text" value="2000"/> kW <input type="text" value="14.3"/> %
Available power	<input type="text" value="12000"/> kW
Reserved load	<input type="text" value="0"/> kW
Connected generators	<input type="text" value="2"/>
Required no of generators:	This swbd: <input type="text" value="0"/> Total net: <input type="text" value="1"/>

Status

Blackout

Mode

Consumer control ON
 Load dependent start ON
 Load dependent stop OFF
 Advice mode OFF



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Switchboard Parameters

Module Parameters - PS054: HVBSwbd

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MODULE TYPE : swbd
ASYMMETRIC LOADSHARING
Asymmetric main load           80.0 %
Asymmetric main period        4.0 hours
Asymmetric top-up minimum     30.0 %

LOAD DEPENDENT START/STOP AND CONSUMER CONTROL
Lock advice mode (0/1/2-unl/on/off)  2
Lock cons control (0/1/2-unl/on/off)  0
Enable load dep. start select (0/1/2)  1
Start limit type (%/kW)              0
Enable load dep. stop select (0/1/2)  1
Stop limit type (%/kW)               0
Start limit 1 delay                 30.0 sec
Start limit 2 delay                 7.0 sec
Stop limit delay                     900.0 sec

START/STOP LIMITS :
  Connected DPGs  %      Start 1      Start 2      Stop
                   %      kW          %      kW          %      kW
1                 70.0  4900.0    82.0  5740.0    0.0   0.0
2                 73.0  10220.0   82.0  11480.0   65.0  4550.0
3                 76.0  15910.0   82.0  17220.0   69.0  14490.0
4                 78.0  21840.0   82.0  22960.0   72.0  20160.0
5                 80.0  28000.0   82.0  28700.0   76.0  26600.0
6                 89.0   0.0       82.0   0.0       79.0  33180.0
7                 100.0  0.0      100.0  0.0       0.0  3000.0
>7                100.0  0.0      100.0  0.0       0.0  3000.0

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Master PSA PSB Print Close Help

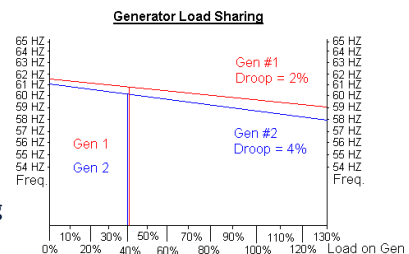


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Isochronous/ Droop Mode

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

HV Swbd 1A Droop			
Ld Start	ON	Load	0 kW
Ld Stop	OFF	Avail	0 kW
Cons Ctr	ON	Util	0.0 %



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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.

HV Swbd 1A Droop			
Ld Start	ON	Load	0 kW
Ld Stop	OFF	Avail	0 kW
Cons Ctr	ON	Util	0.0 %



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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



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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			
	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

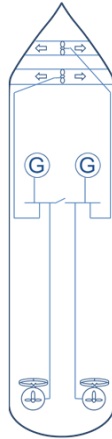


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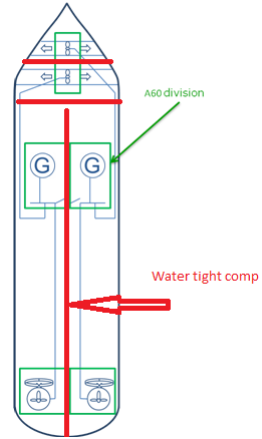
Class 1



Class 2



Class 3



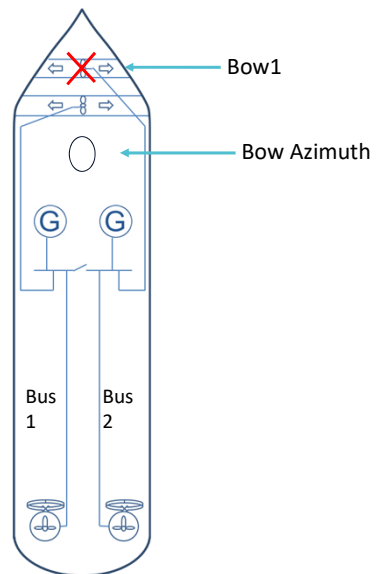
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Example

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



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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

Blackout Prevention Philosophy

Power Available Vs Power Used Pms

PMS compares, each scan time ~100 ms, the connected power with the power used and sends "kW Available" signals to "Drilling" and "Thrusters". "Now available" is reduced based on "Chill Tables"

Priority Tables

Thruster: ABB Thrusters VFD will respond to KM power limit signal and will phase back the thrusters, following KM power available (limit) signal (t=20ms) until the overload is rectified. (See Tables) Time=50 ms

Drilling: NCV will respond to KM power limit signal and will reduce in the following order, until the overload is rectified (See Tables) Time=75 ms

DP: KM DP will limit the thruster speed orders, if the system load is over 90% of available nominal Power minus Reserved load from PMS. Time=1 - 2 sec

Frequency

Step 1: If the frequency drops below 58Hz, KM VC will reduce the power available(limit) signal. This is done by using a PI controller. When the frequency recovers to 58.5 Hz, the thrusters signal will integrate to the available power.

Step 2: ABB Thruster VFD from a frequency input will independently reduce power. If frequency drops to 57Hz for 100 ms, if frequency continues to drop, ABB will reduce power accordingly in a linear function. At 54Hz power will be reduced to 0%. After frequency is restored to 58Hz for 2 secs, ABB will release power back to normal function.

Step 3: In case the 11 kV svcb's are closed KM VC will split the 11 kV svcb's into three, (i.e. bus bar breakers between boards 1, 2 and 3 will open), should the frequency drop below 54 Hz for 3 s. The next standby generator set will be started after 110V bus split, should the frequency remain below 57 Hz.

ABB Thruster Limiting

Pwr. Limit / Freq. Limit

Thr-1

Available: 650 kW
Consumed: 0 kW

Pwr. Limit / Freq. Limit

Thr-2

Available: 200 kW
Consumed: 0 kW

Pwr. Limit / Freq. Limit

Thr-3

Available: 200 kW
Consumed: 0 kW

Pwr. Limit / Freq. Limit

Thr-4

Available: 200 kW
Consumed: 0 kW

Pwr. Limit / Freq. Limit

Thr-5

Available: 200 kW
Consumed: 0 kW

Pwr. Limit / Freq. Limit

Thr-6

Available: 200 kW
Consumed: 0 kW

Min DG: 1 Drilling Spin Reserve

Drilling Mode

Mode Select: 1

1. Normally Drilling Operation
2. ABB Thruster Control Mode On
3. ABB Thruster Control Lock to Bottom
4. Heavy Weight Handling

Drilling Drawwork			
Drilling Pwr. Limit	Port	Cent	Stbd
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Drilling Power			
Drilling Pwr. Limit	Port	Cent	Stbd
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drilling Power Avail.	1 kW	1 kW	3333 kW
Drilling Power Cons.	1 kW	1 kW	3333 kW
Min. Power Request	0 kW	0 kW	0 kW



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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.

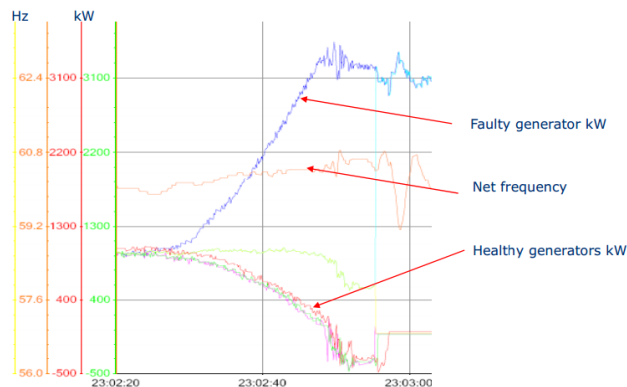
- Avoid full or partial blackouts due to such failures
- Be able to operate with closed bus-ties to reduce the number of generators on line → less fuel consumption and emissions, running hours and maintenance
- First level of deviation:
 - Start standby generator(s) and give an alarm
- If the deviations exceeds further:
 - Trip the faulty generator



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Without AGS, Speed control failure

4 generators online.
One generator forced to increase load.
→ Trip of all 3 healthy generators by breaker protection!

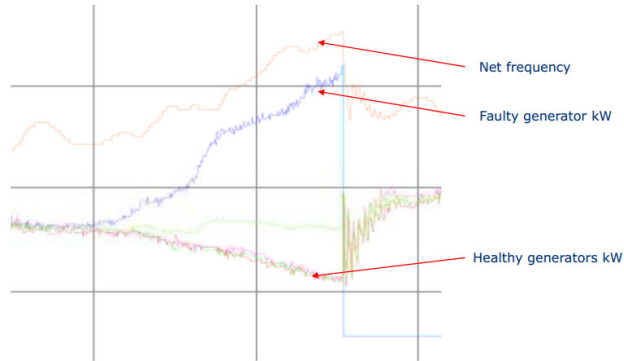




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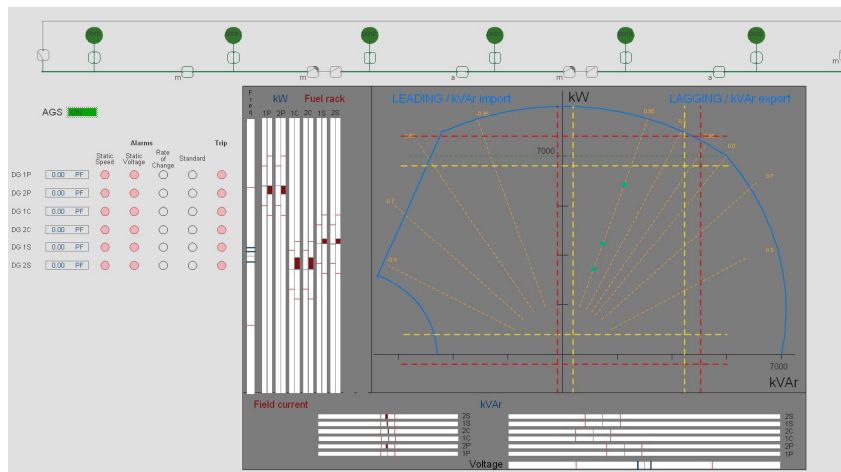
With AGS, Speed control failure

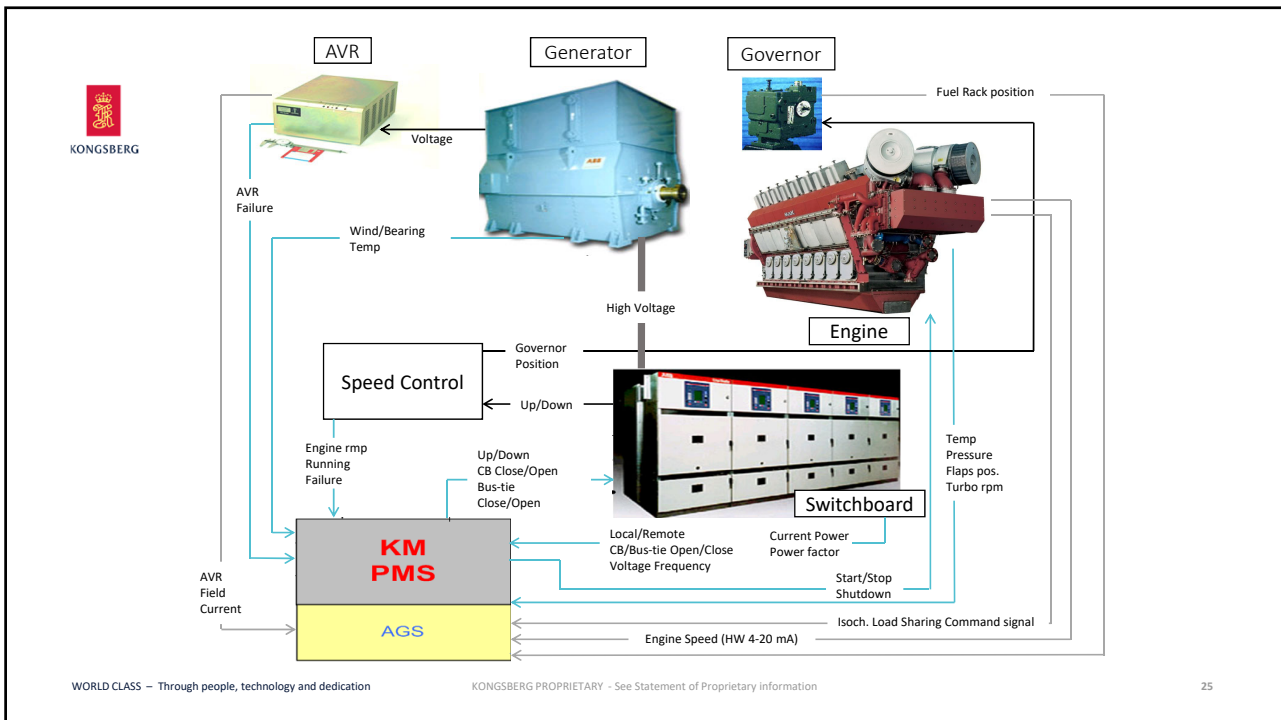
4 generators online.
One generator forced to increase load.
→ Trip off faulty generator by AGS.



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AGS





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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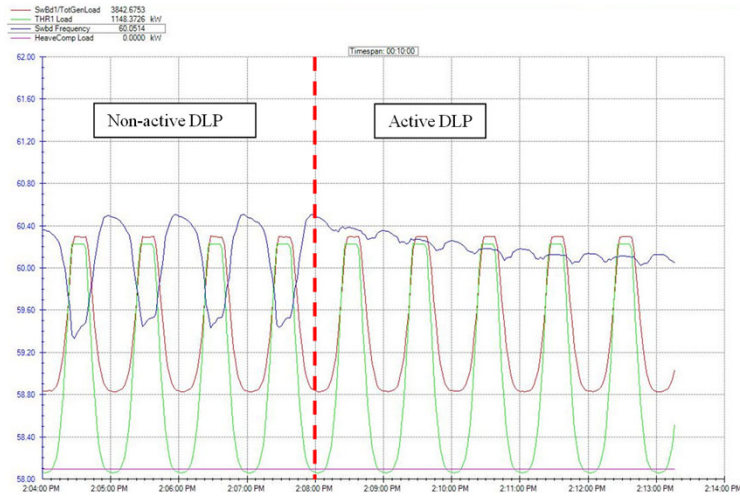
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DLP – Dynamic Load Prediction



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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 sooting

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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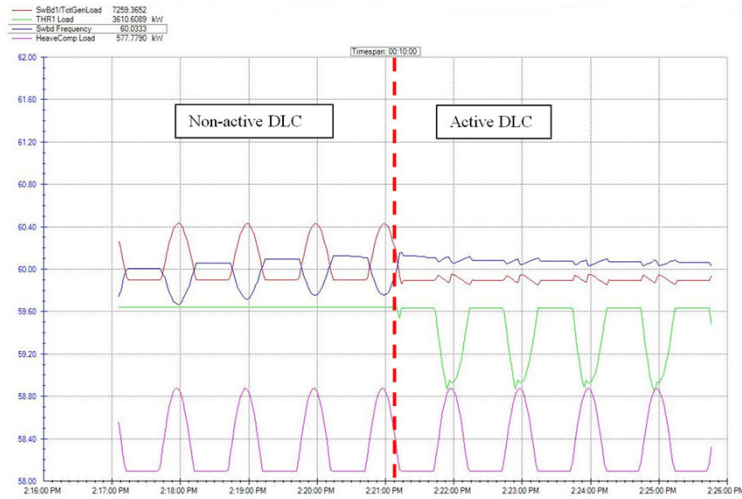
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DLC – Dynamic Load Compensation



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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



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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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**End of the
presentation**

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