Status and Inventions in Electrical Power and Thruster Systems for Drillships and Semi Submersible Rigs

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Dynamic Positioning Conference

DPC, Houston – Sep 28-30, 2004

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Outline

- Introduction
- Electric Power System Description
- Experiences
  - Response time dynamics of load reduction/blackout prevention
  - Diesel engine governor and AVR fault tolerance
  - Special characteristics of electric installations for ships and rigs
  - Harmonic distortion
- Technology Evolution
  - Electric Power Generation and Distributions
  - Variable Speed Drives
  - Electrical Podded Thrusters

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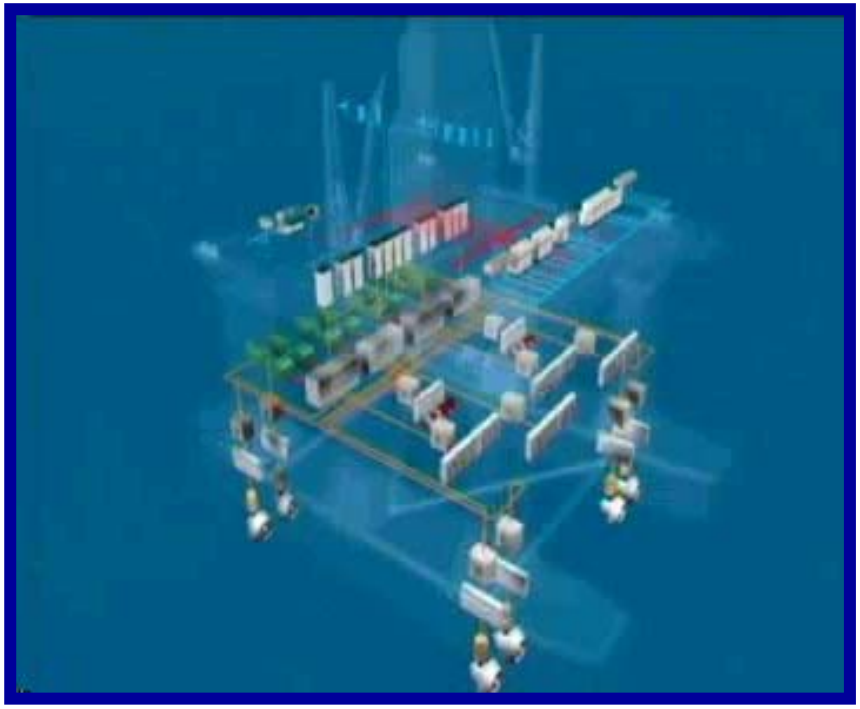
Deepwater Drilling Vessels



- More than 25 deepwater drilling vessels build after 1997
  - Drillships and Semi Subs
- Dynamic Positioning
  - DP2 or DP3, (or “DP2.5”)
- Electrical System
  - Medium Voltage, 6 or 11kV
  - 2, 4, 6, 8 -split
- Variable Speed Thrusters
  - Electrically driven with Current Source or Voltage Source Converters
  - Mechanical or podded azimuthing thrusters
- Drilling Drives
  - DC (SCR) drives
  - PWM Single or Multidrive
  - Regenerative or not

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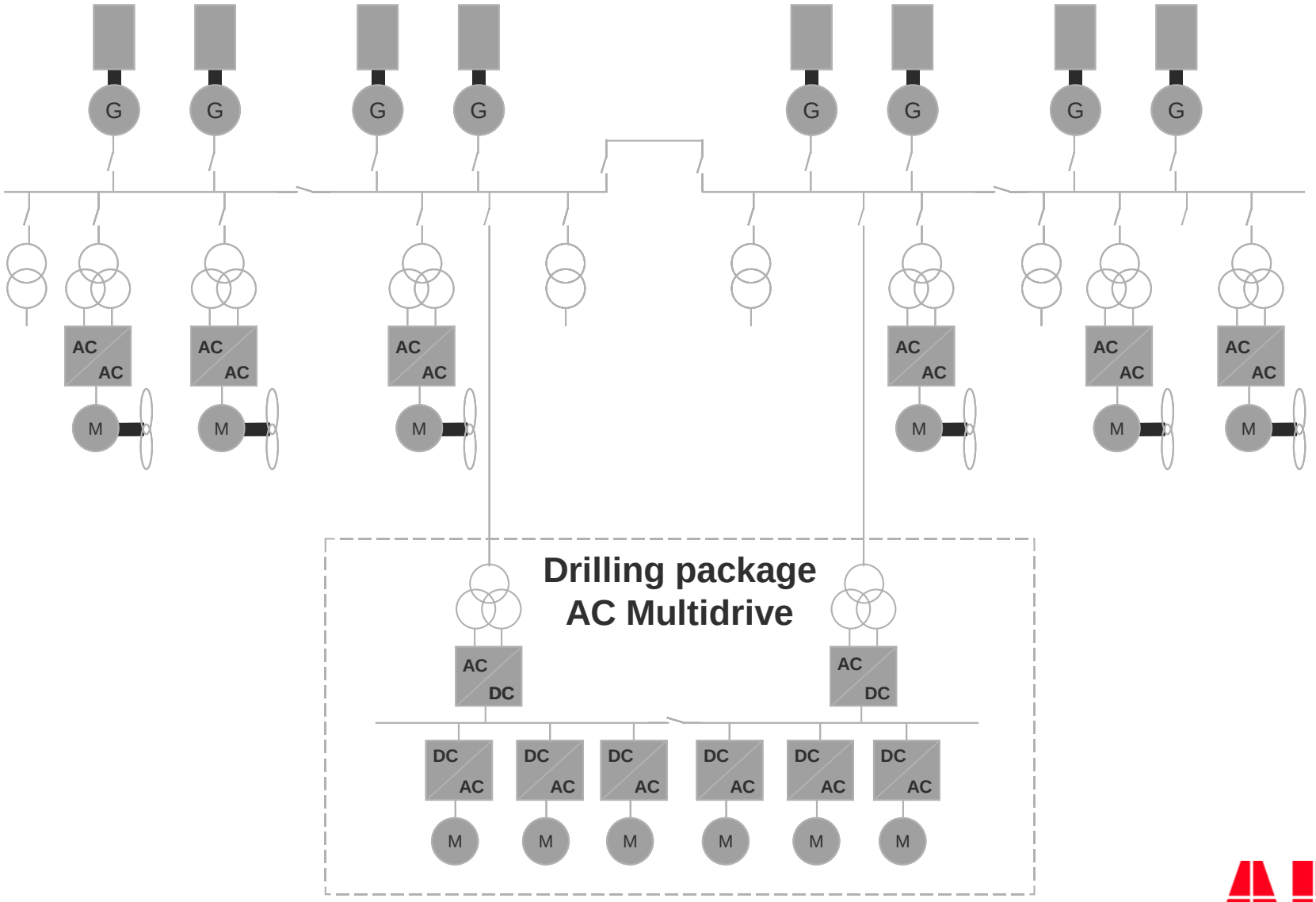
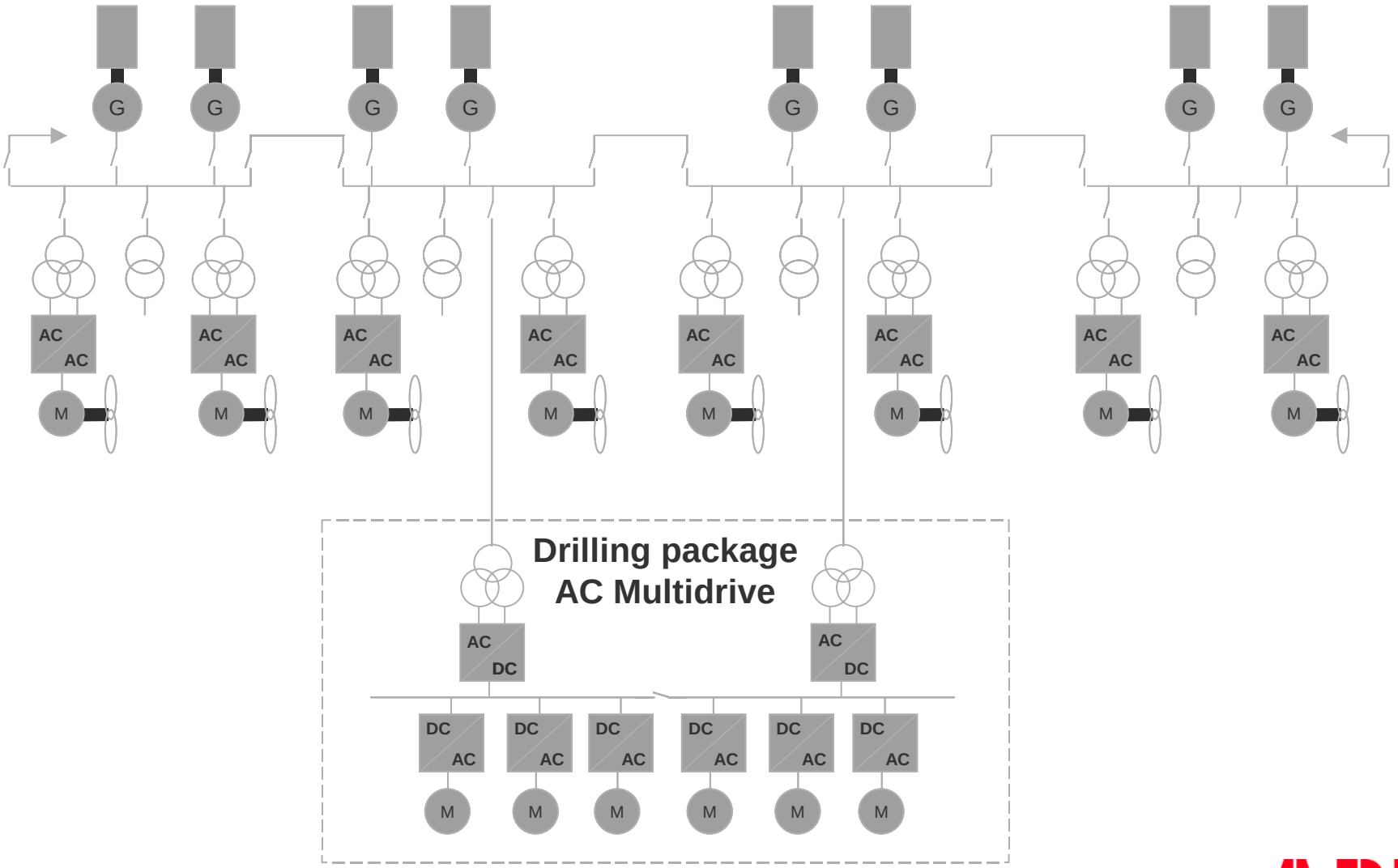
Electric Power System for Drillship

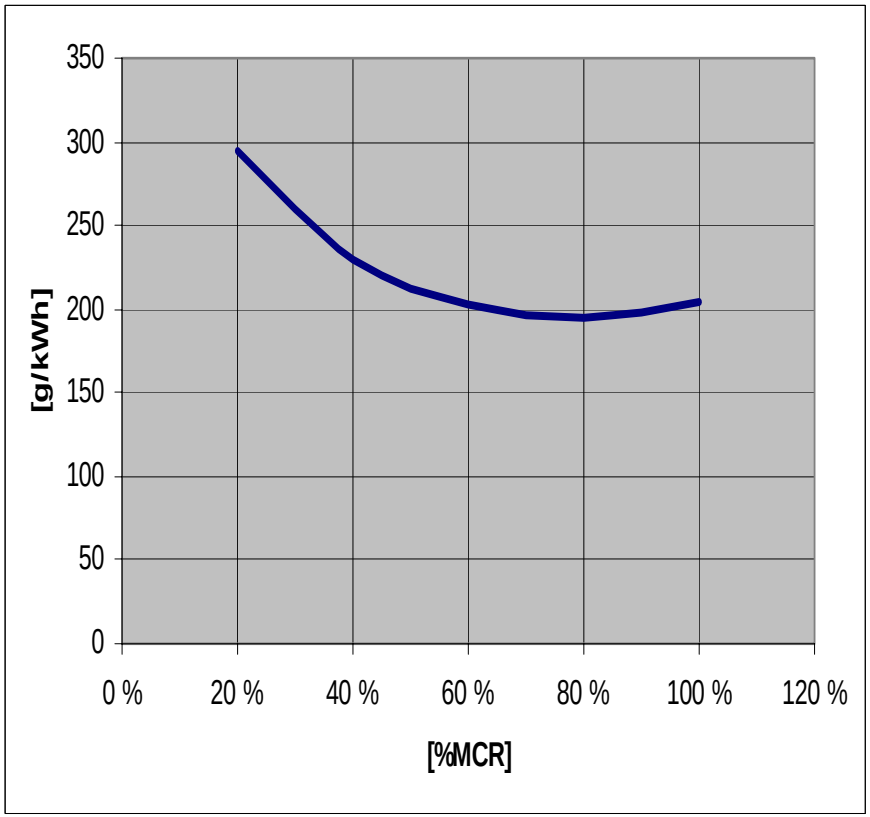


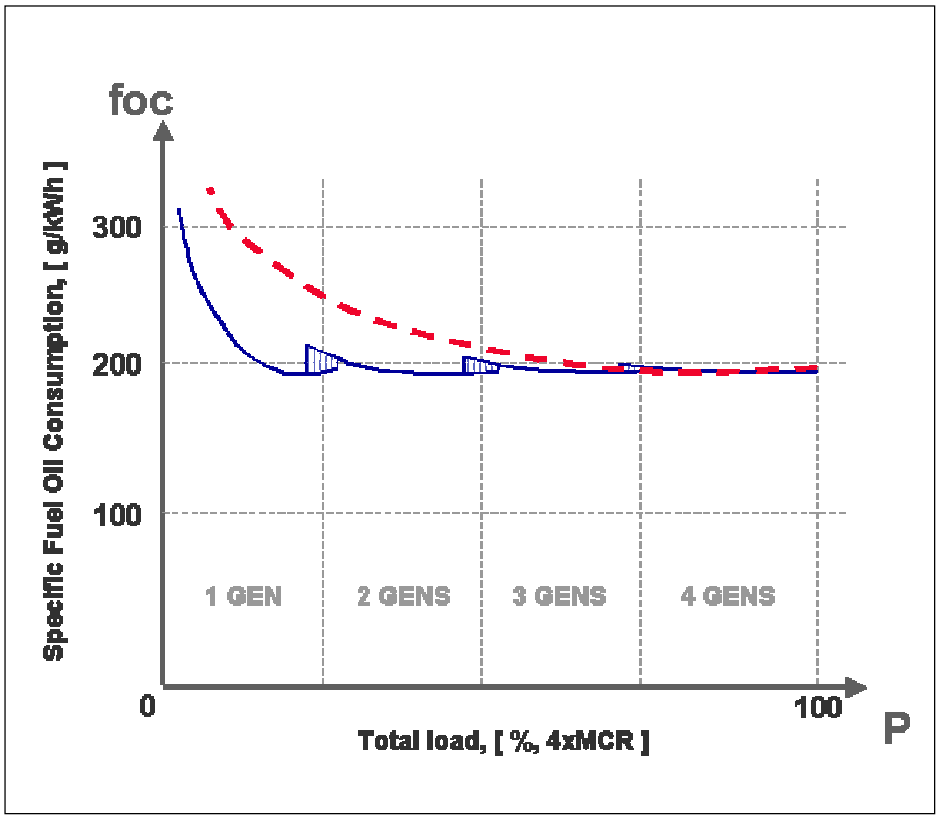
El. Power System for Semi Submersible



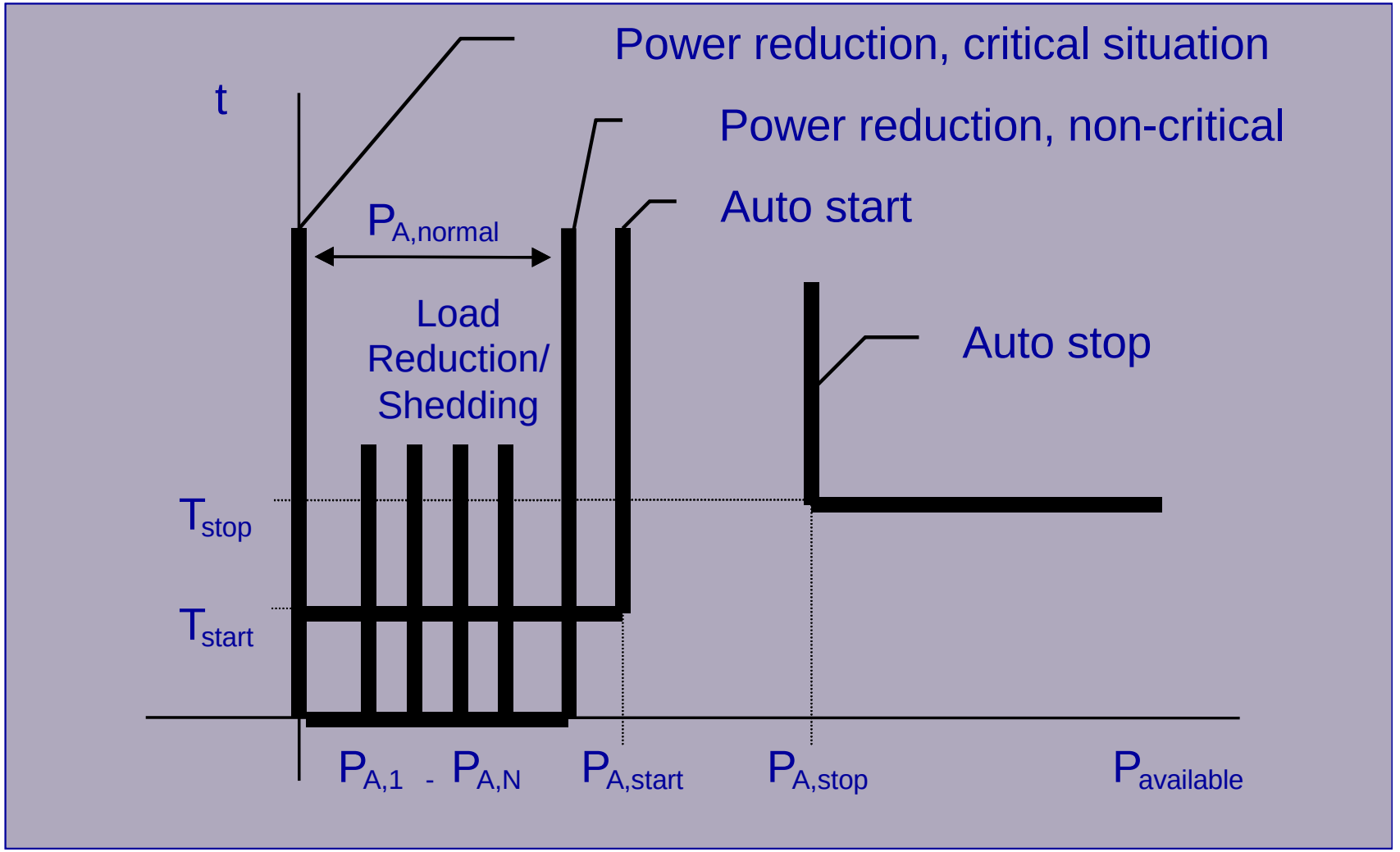
Black-out

Prime Mover - Diesel Engine





Power Management Power Reduction



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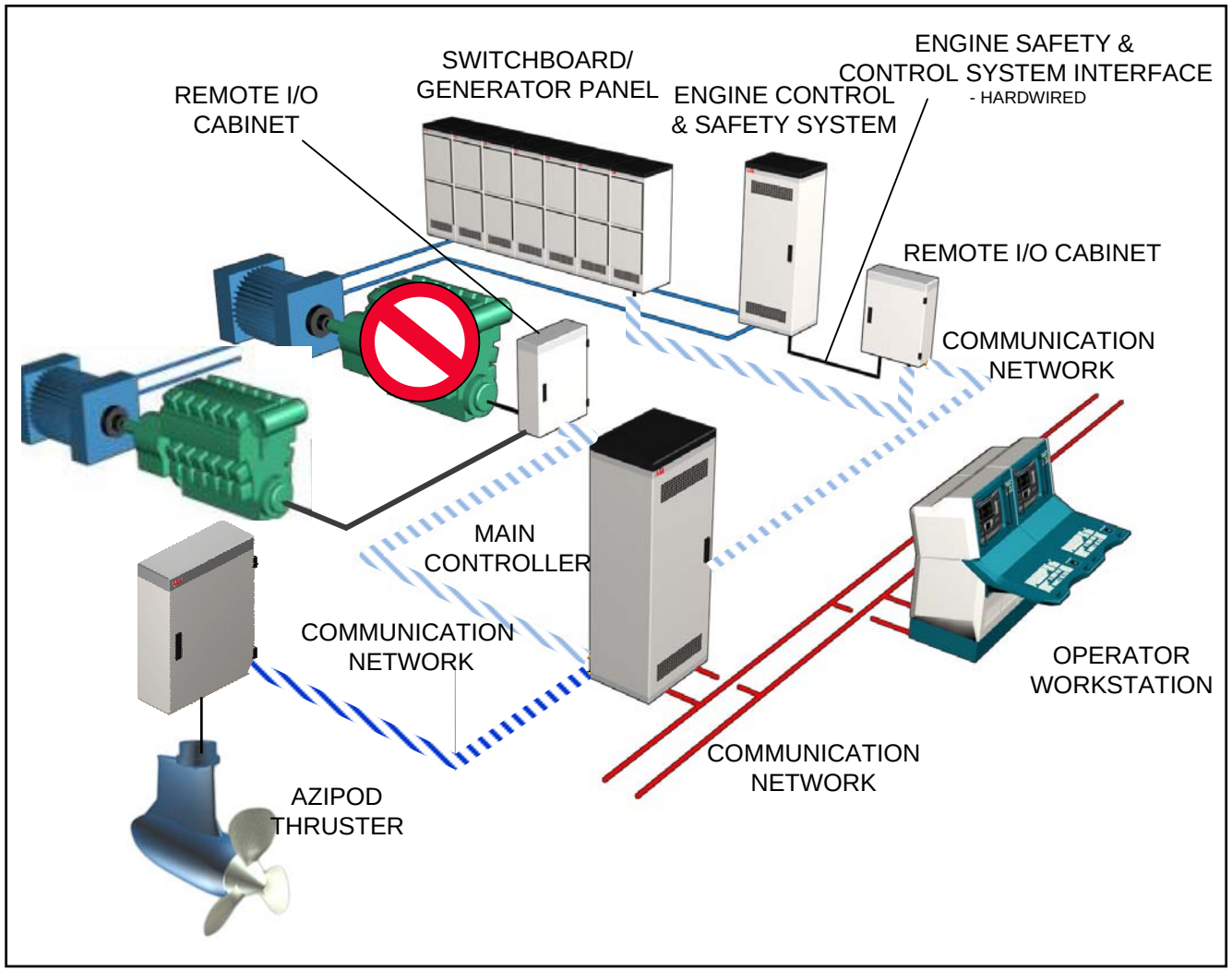
Black-out Prevention

PMS functions:

- **Automatic start/ stop of diesel generators**
- **Calculation of available power on each bus**
- **Load control**
- **Black-out prevention and recovery**
- **Heavy consumer handling**



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Black-out Prevention Functions

- **Thruster and thruster drives**:
  Variable speed FPP thrusters must have a load reduction scheme, either monitoring the network frequency and/or receiving a fast load reduction signal from the power management system, either as a power phase-back signal, maximum power limitation signal.
- **Drilling drives**:
  Similar to the requirements of the thruster drives, with built-in priorities for the individual drilling drives.
- **Power management system**:
  The power management system includes blackout prevention with load reduction/load shedding functionality.
- **Dynamic positioning system**:
  The dynamic positioning system is also equipped with a power limitation function, normally based on a permitted maximum power consumption signal from the power management system.
  Generally, this has shown to be effective in avoiding overloading of the running plant, but not fast enough to handle faults and loss of diesel-generator sets

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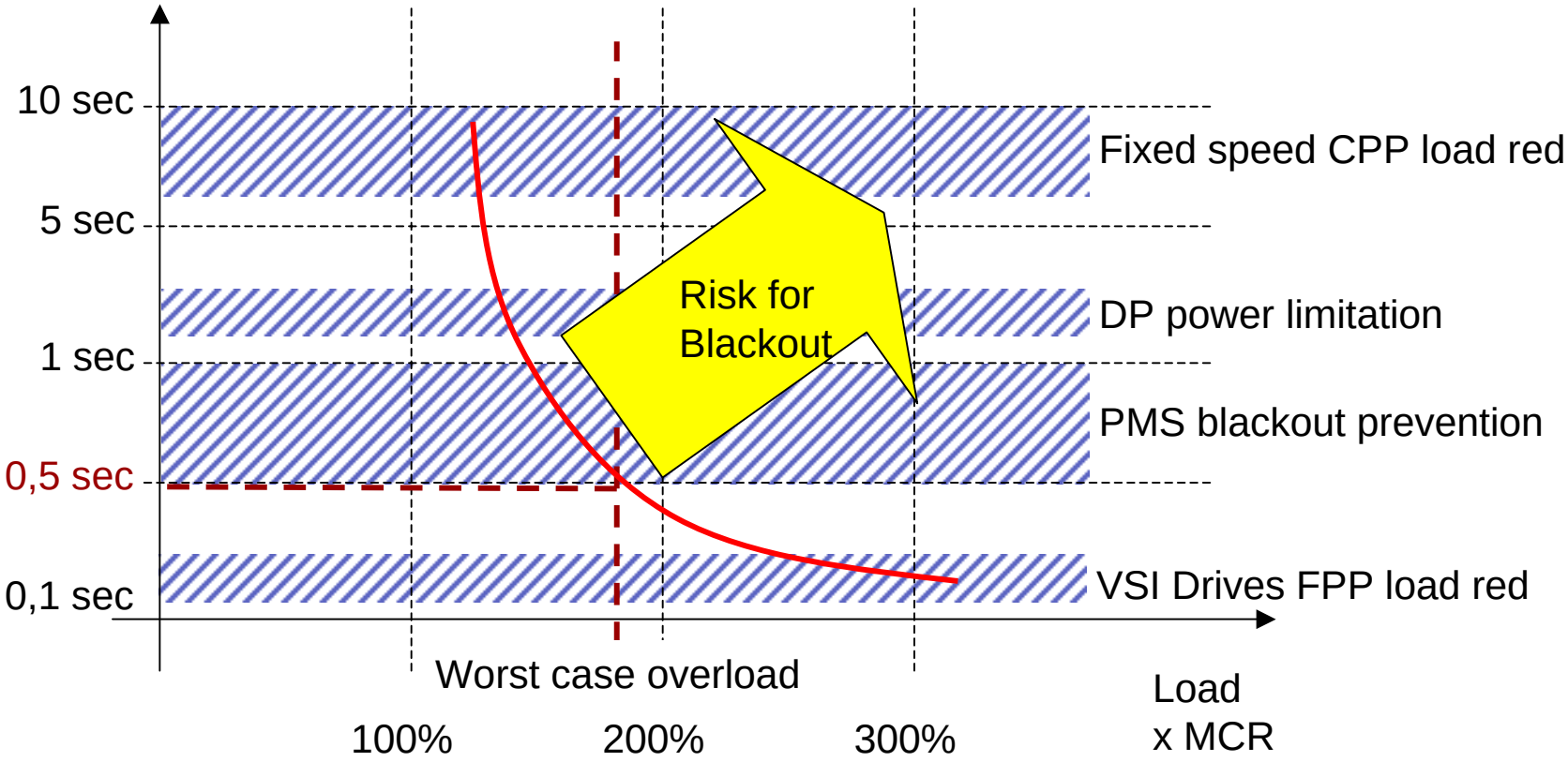
Time before under-frequency (Illustrative)



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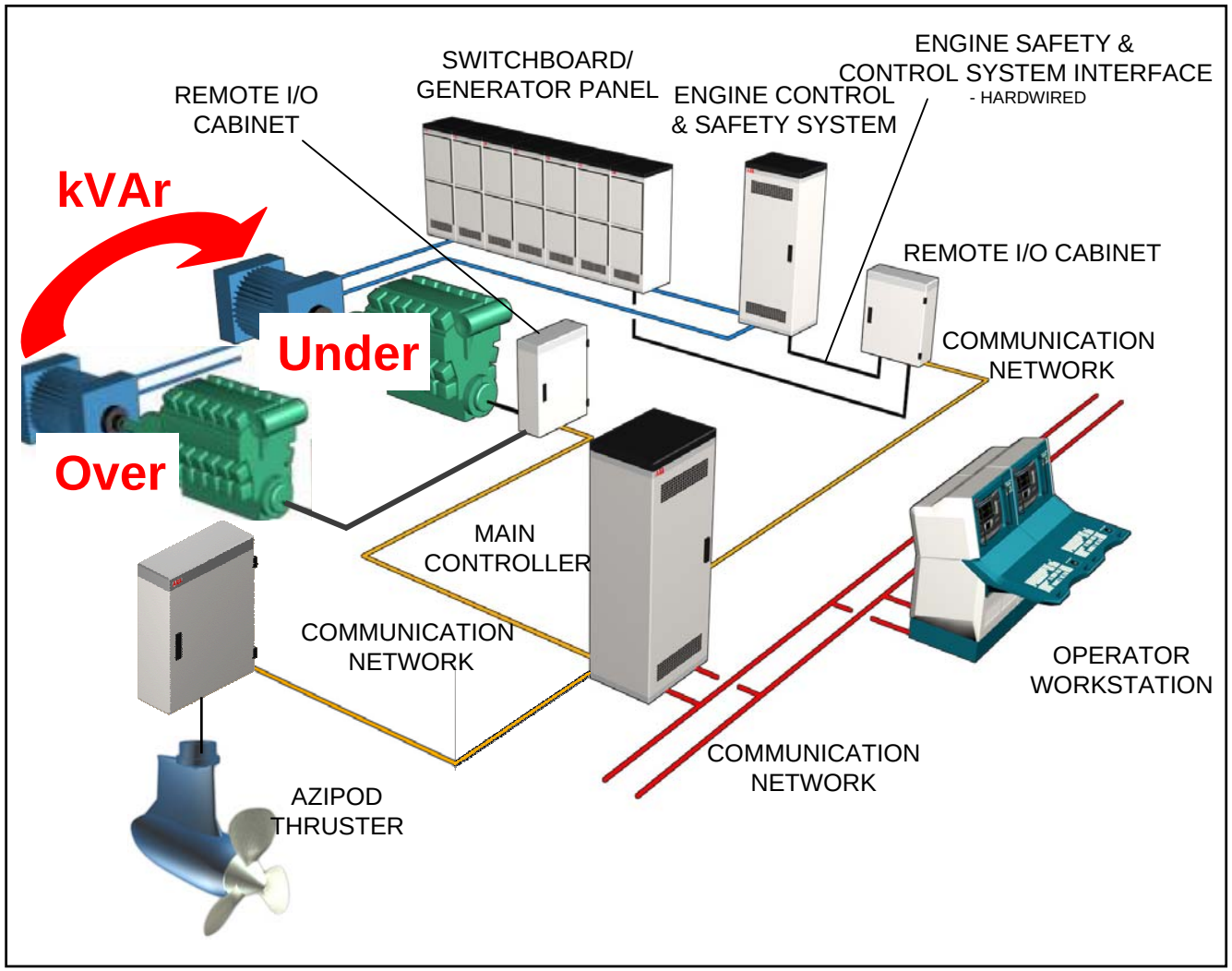
Governor or AVR Faults

AVR faults:

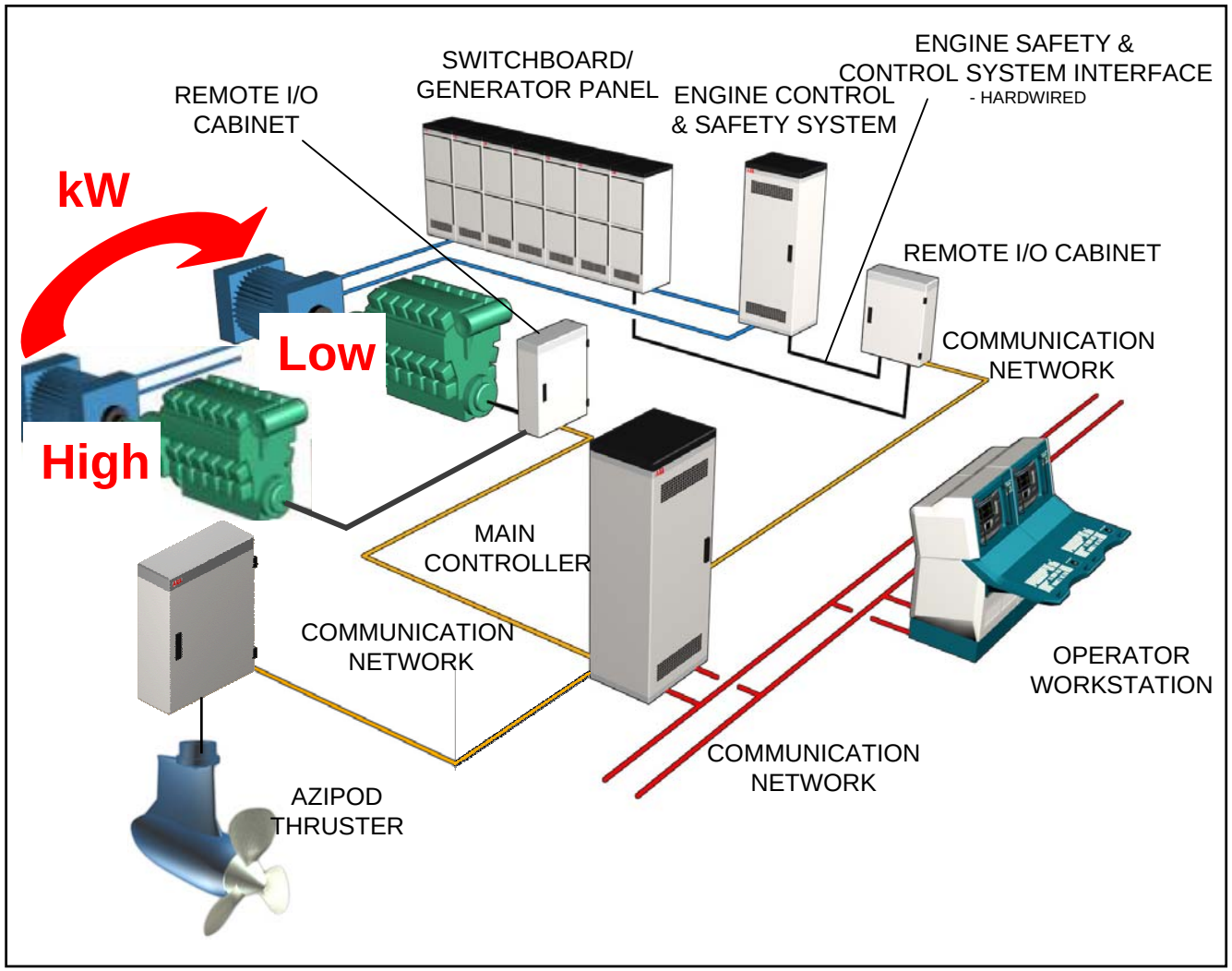
- **Under excitation**
  - **Inductive (kVAr import)**
  - **Under voltage**
  - **Min kVAR**
- **Over excitation**
  - **Capacitive (kVAr) export**
  - **Over voltage**
  - **Max Amp**
- **Intermittent faults**
  - **Rear**
  - **Combinations of over and under excitation**



Governor or AVR Faults

Governor faults:

- **To low fuel**
  - **kW reduces**
  - **RPM may reduce**
- **To excessive fuel**
  - **kW increases**
  - **RPM may increase**
- **Intermittent faults**
  - **Rear**
  - **Combinations**



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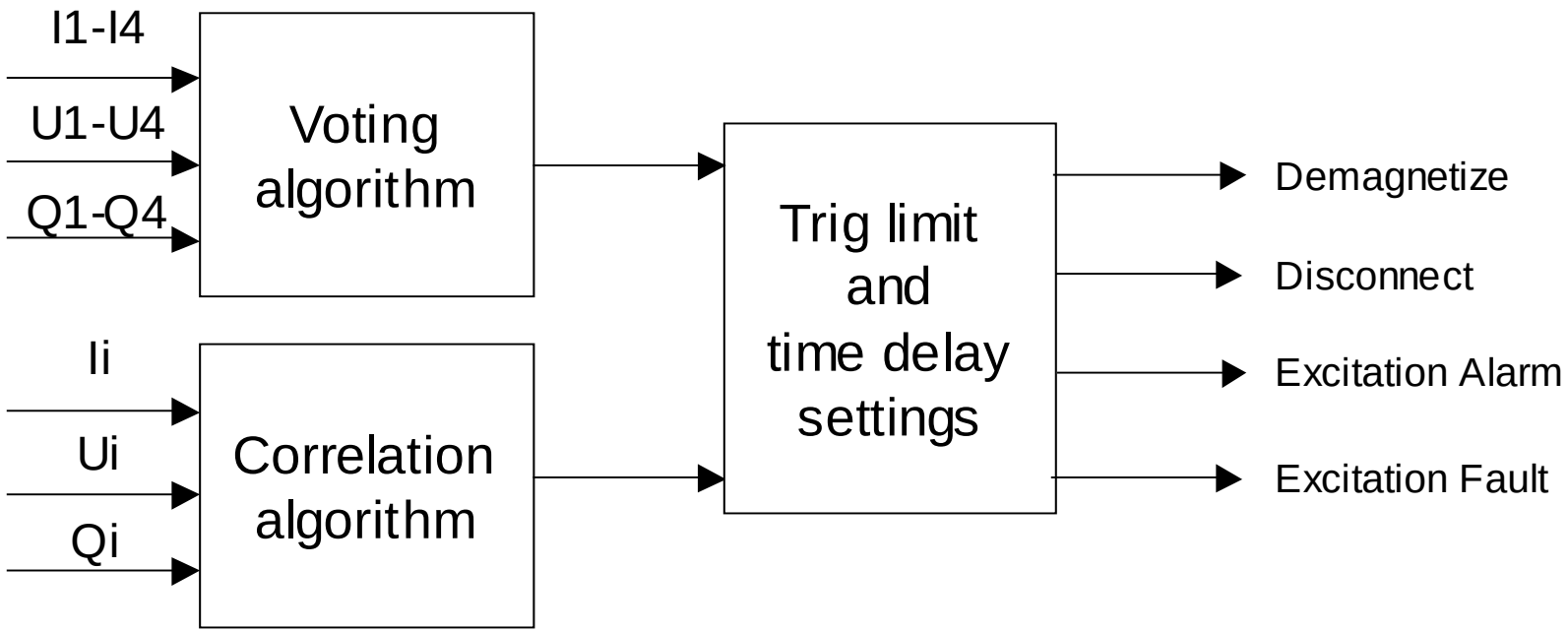
Diesel Generator Monitoring System



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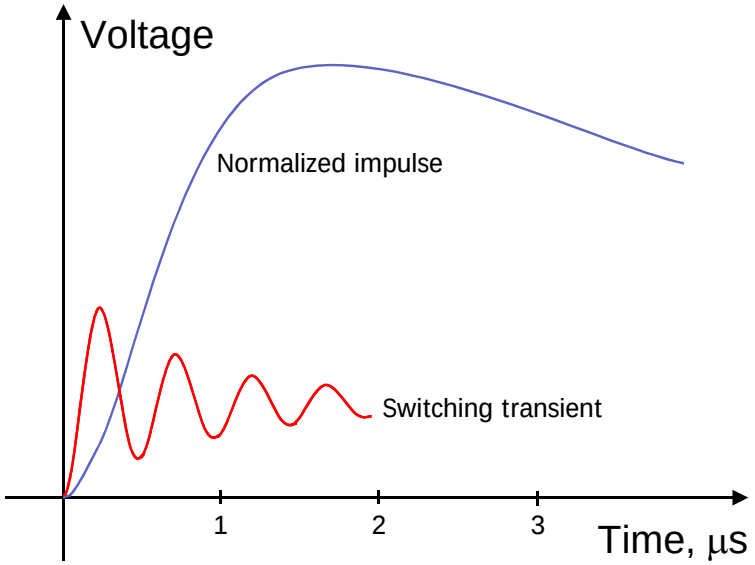
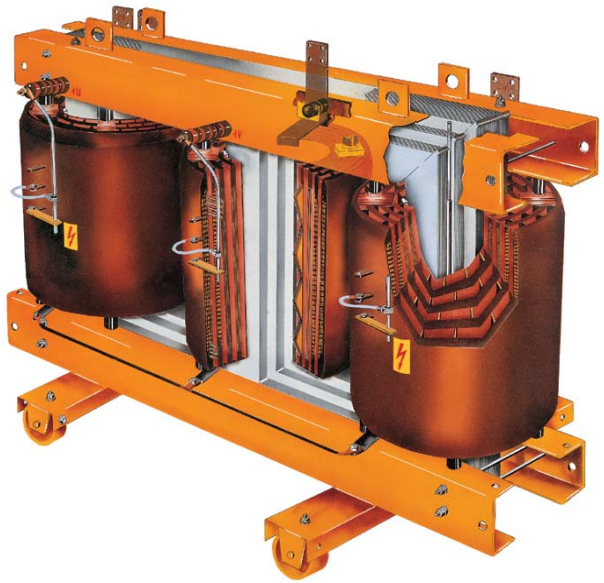
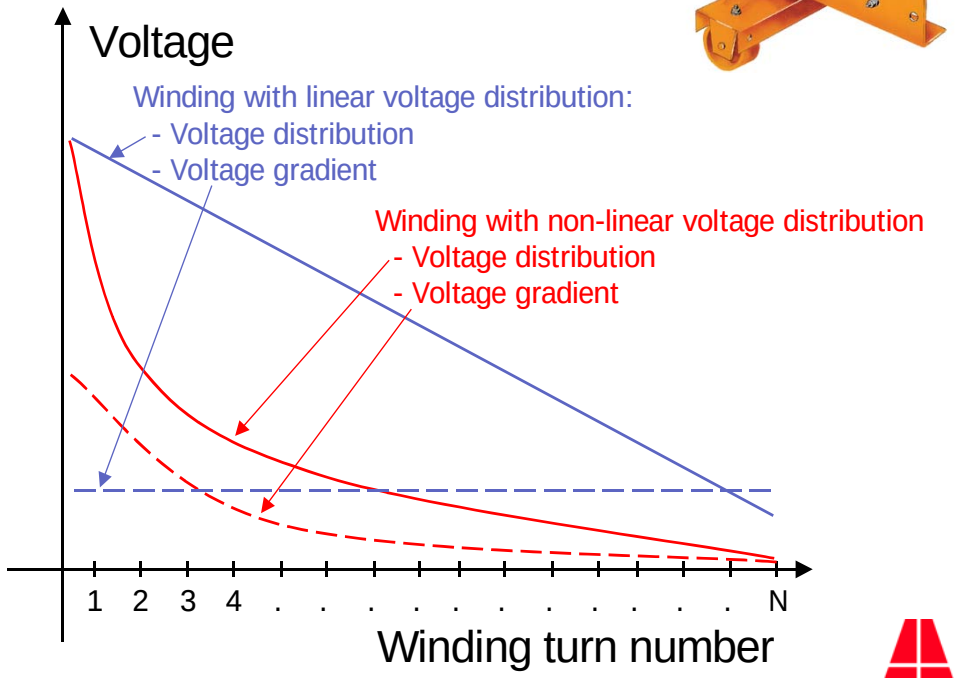
Electric System Characteristics







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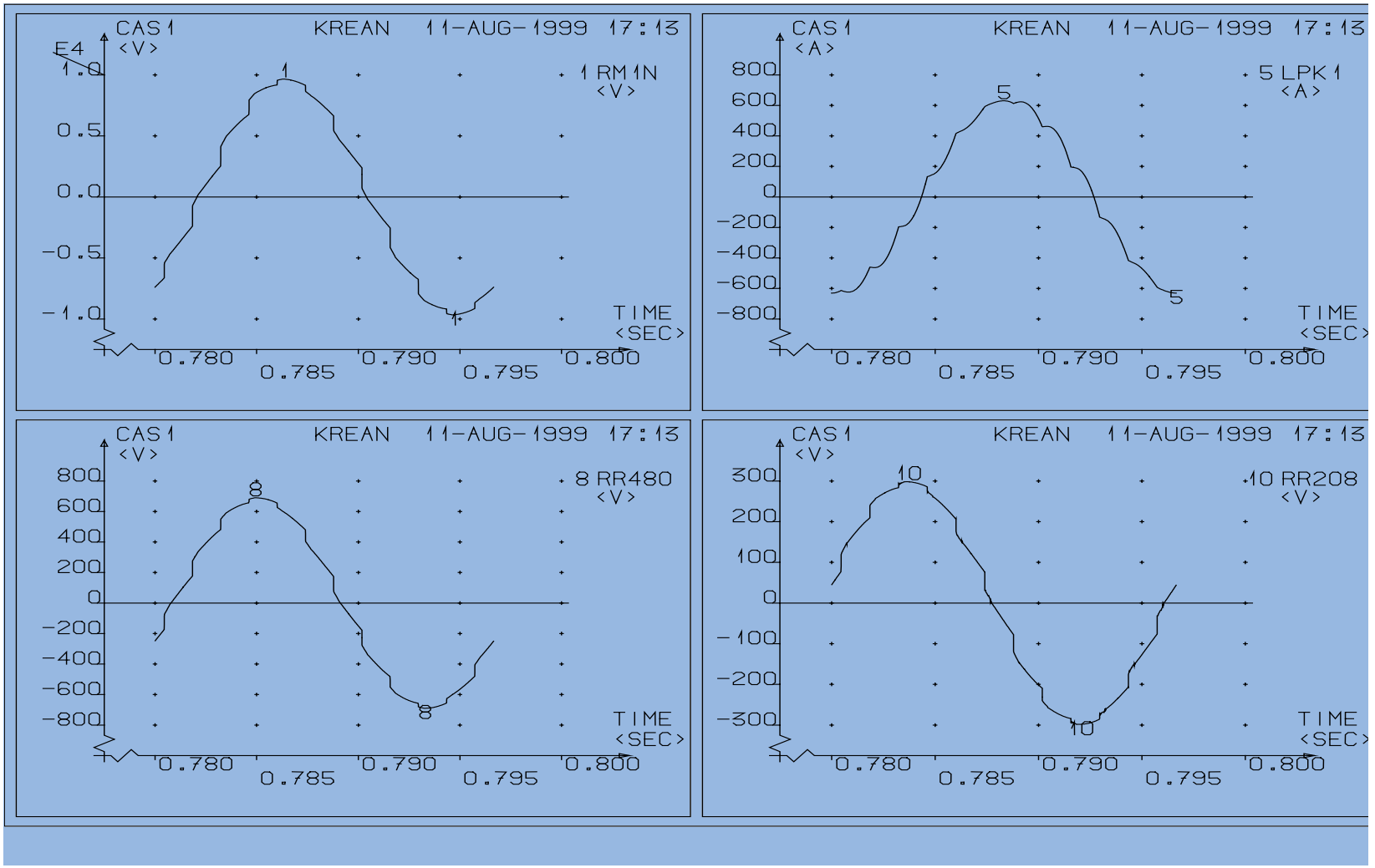
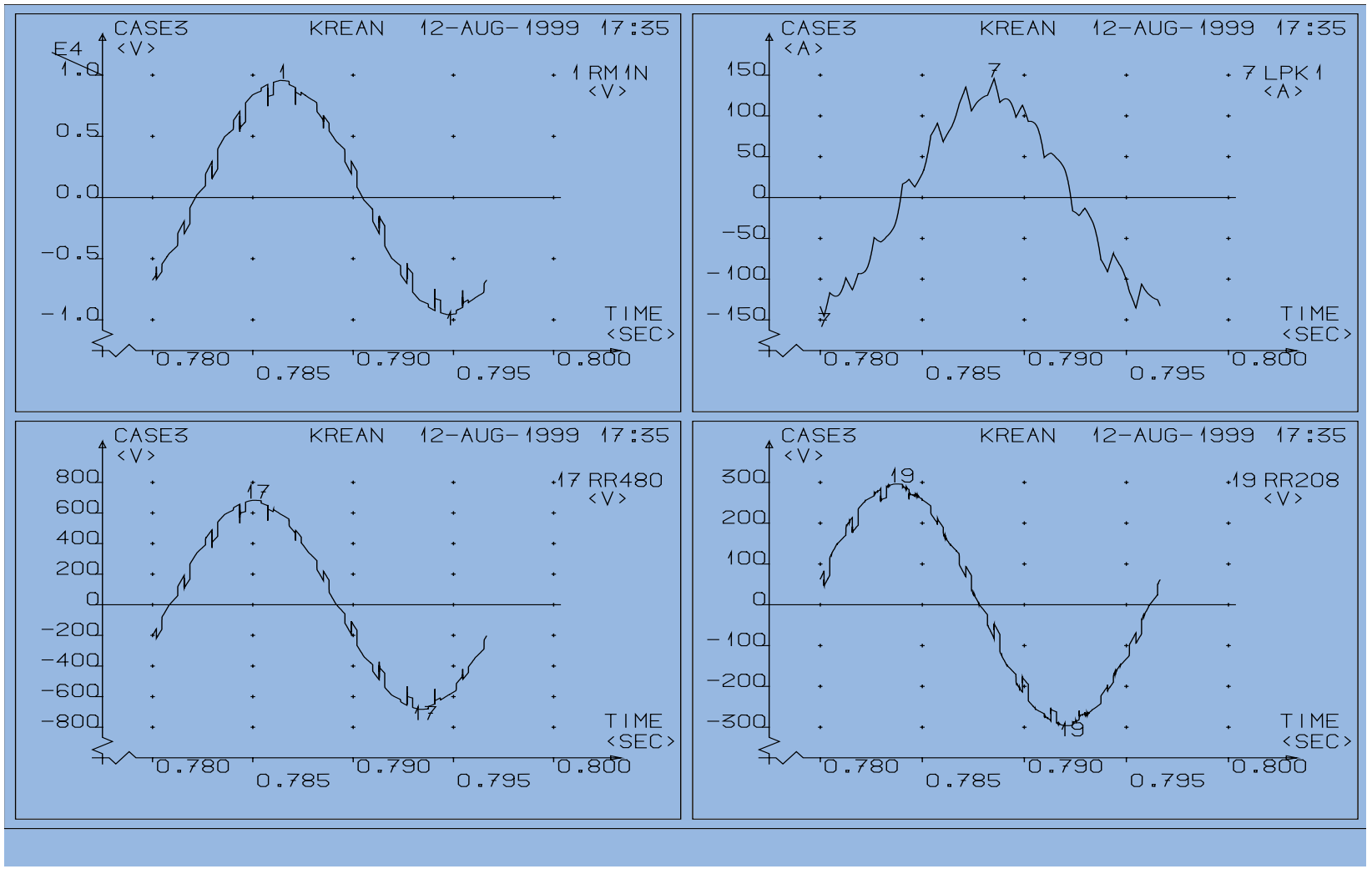
Harmonic Distortion



Harmonic Distortion



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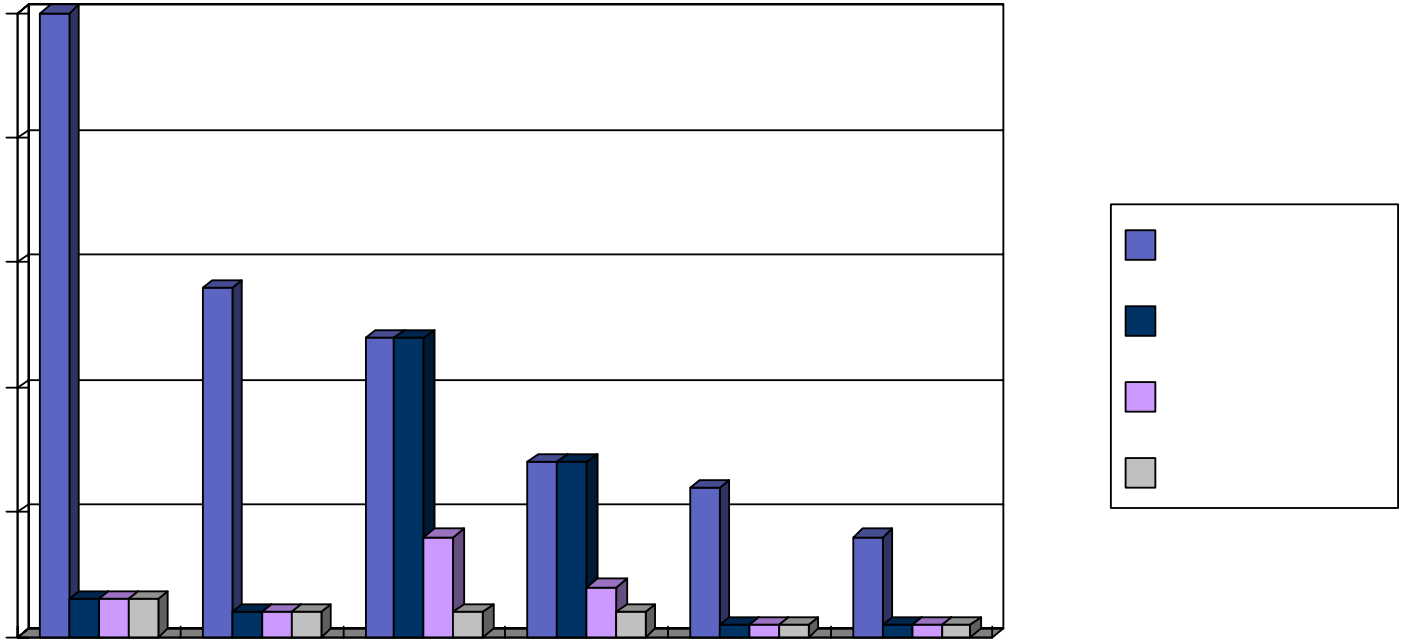
Harmonic Distortion (Examples)



NB: With High Gen Load	6-pulse	12-pulse	Q24-pulse	24-pulse
THD Main bus	10..13%	6..8%	<5%**)	<4%
THD Distribution bus	<5%*)	<6..7%	<5%**)	<4%

*) with harmonic filter
**) closed bus tie

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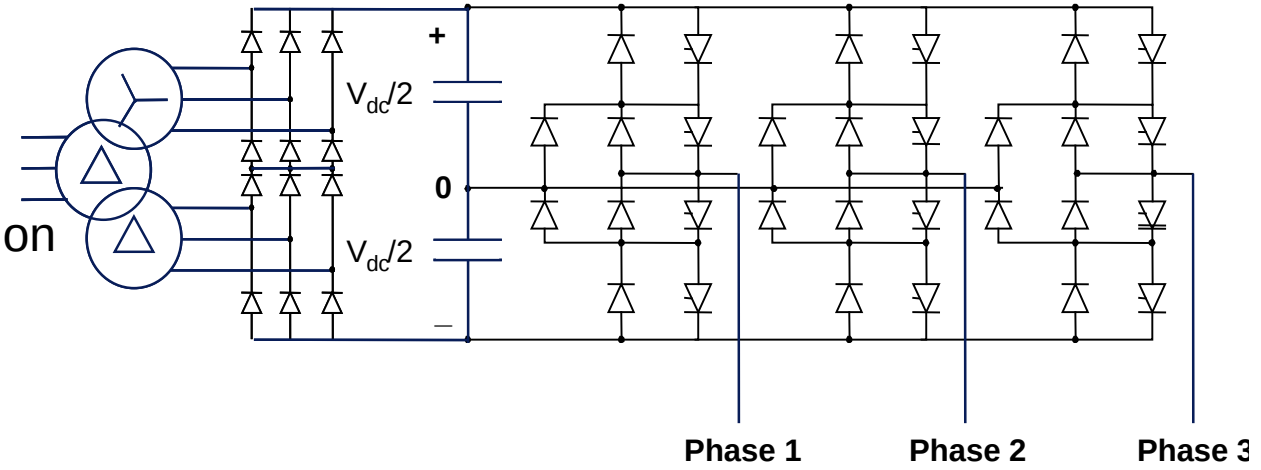
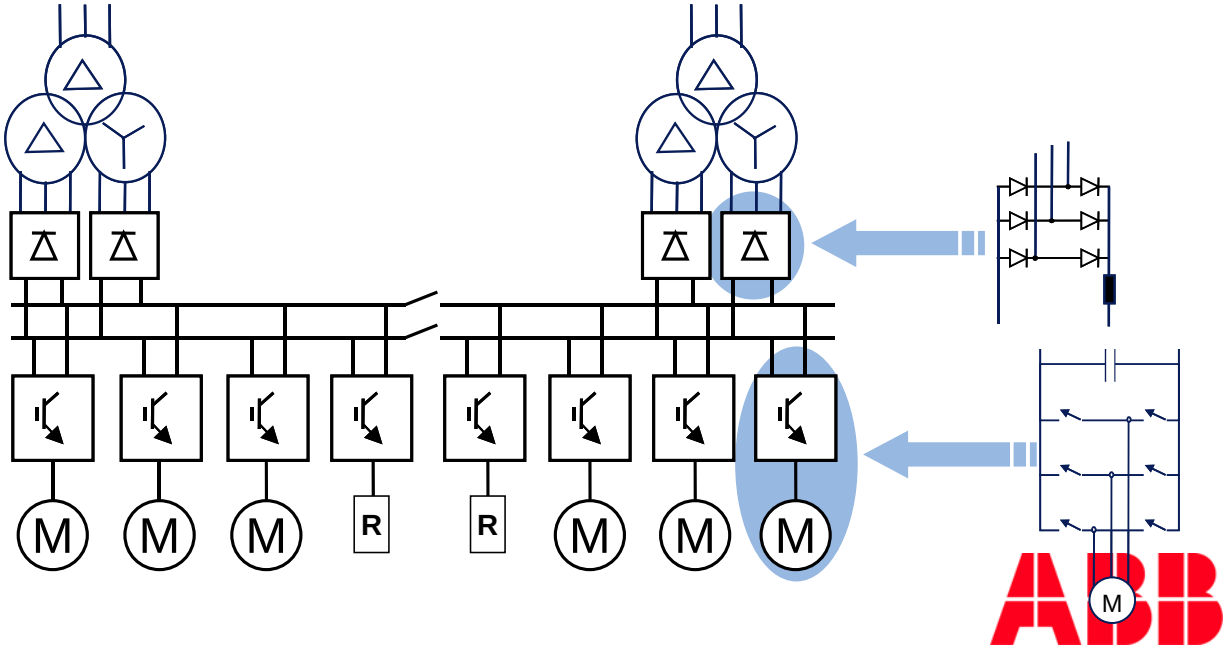
12-pulse Drives

Medium Voltage
Single Drive for
Thrusters and Propulsion



Low Voltage
Multi Drive for
Drilling, Winches, etc.



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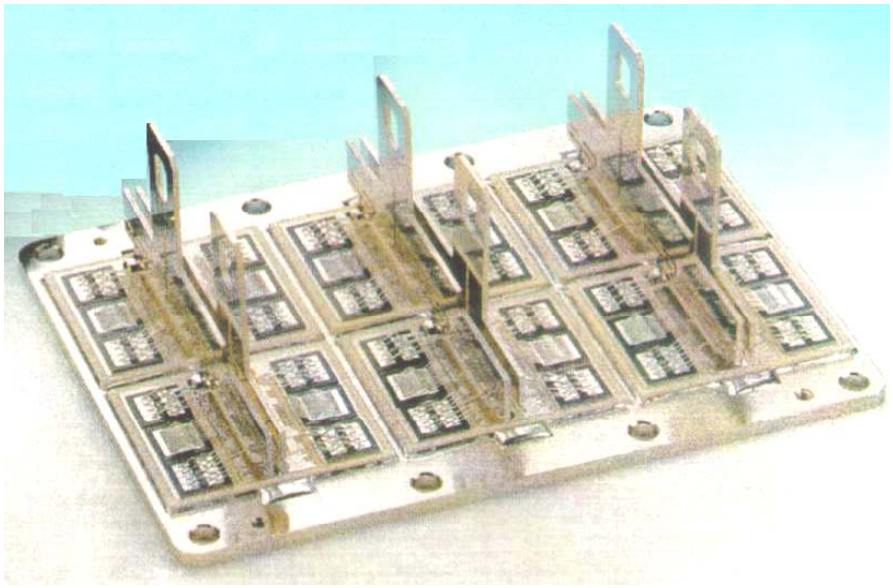
Semiconductors



IGBT Module
(for low voltage drives)

IGCT Component
(for medium voltage drives)

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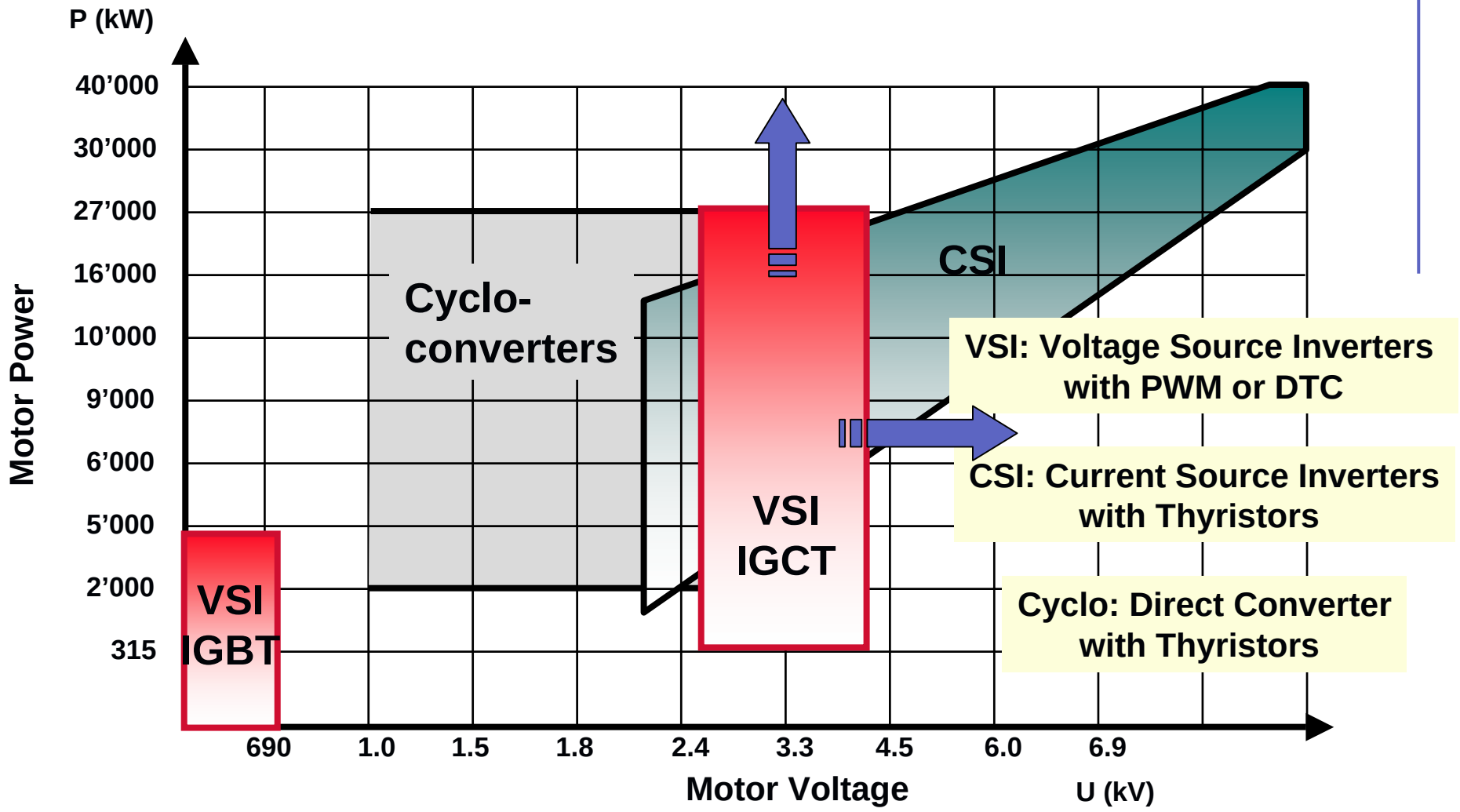
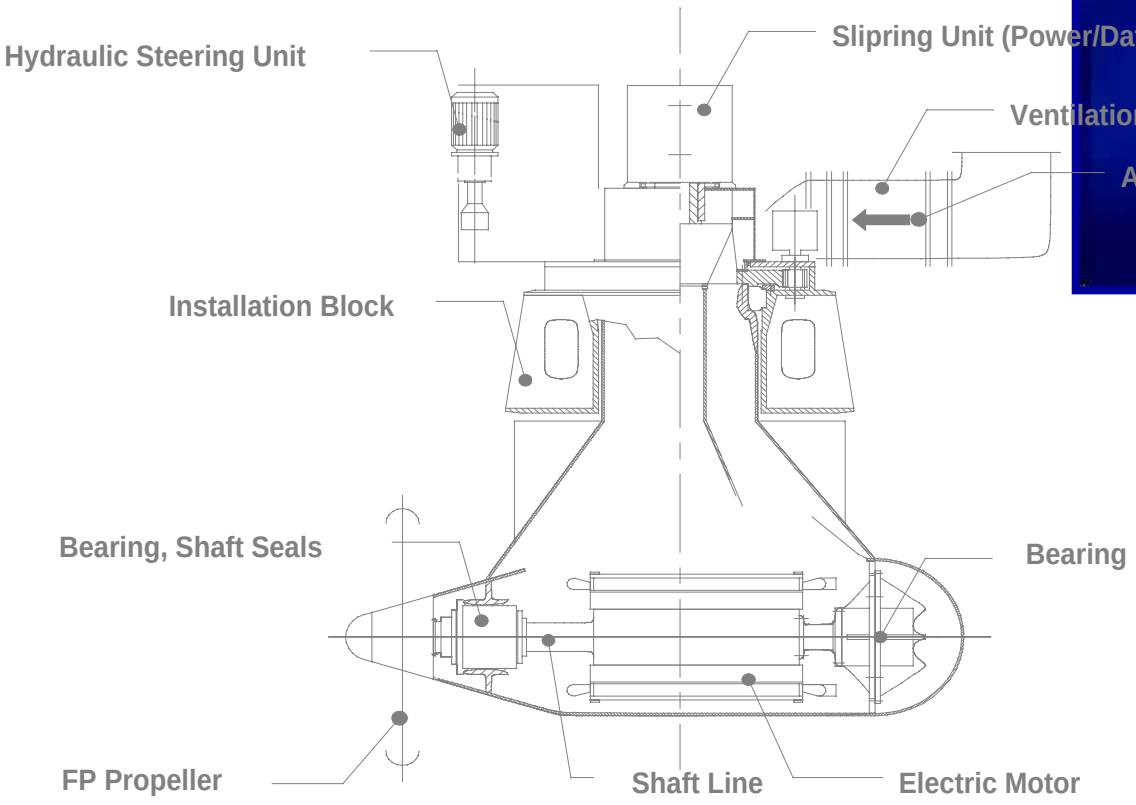
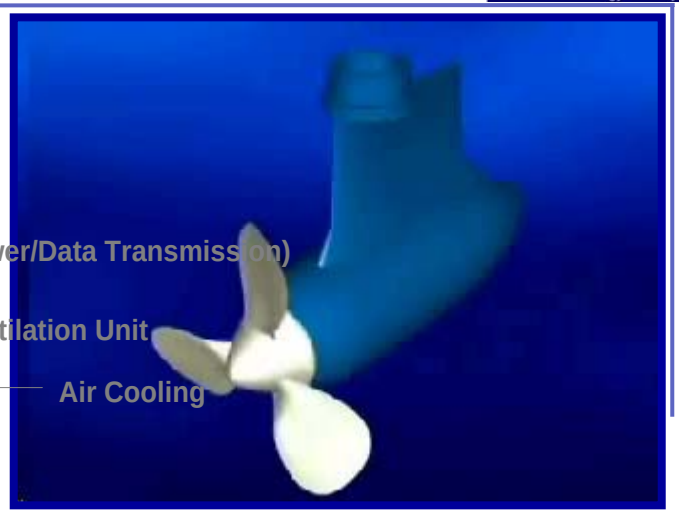
Drive Technology Map (Indicative)




Hydraulic Steering Unit
Slipring Unit (Power/Data Transmission)
Ventilation Unit
Air Cooling
Installation Block
Bearing, Shaft Seals
Bearing
FP Propeller
Shaft Line
Electric Motor



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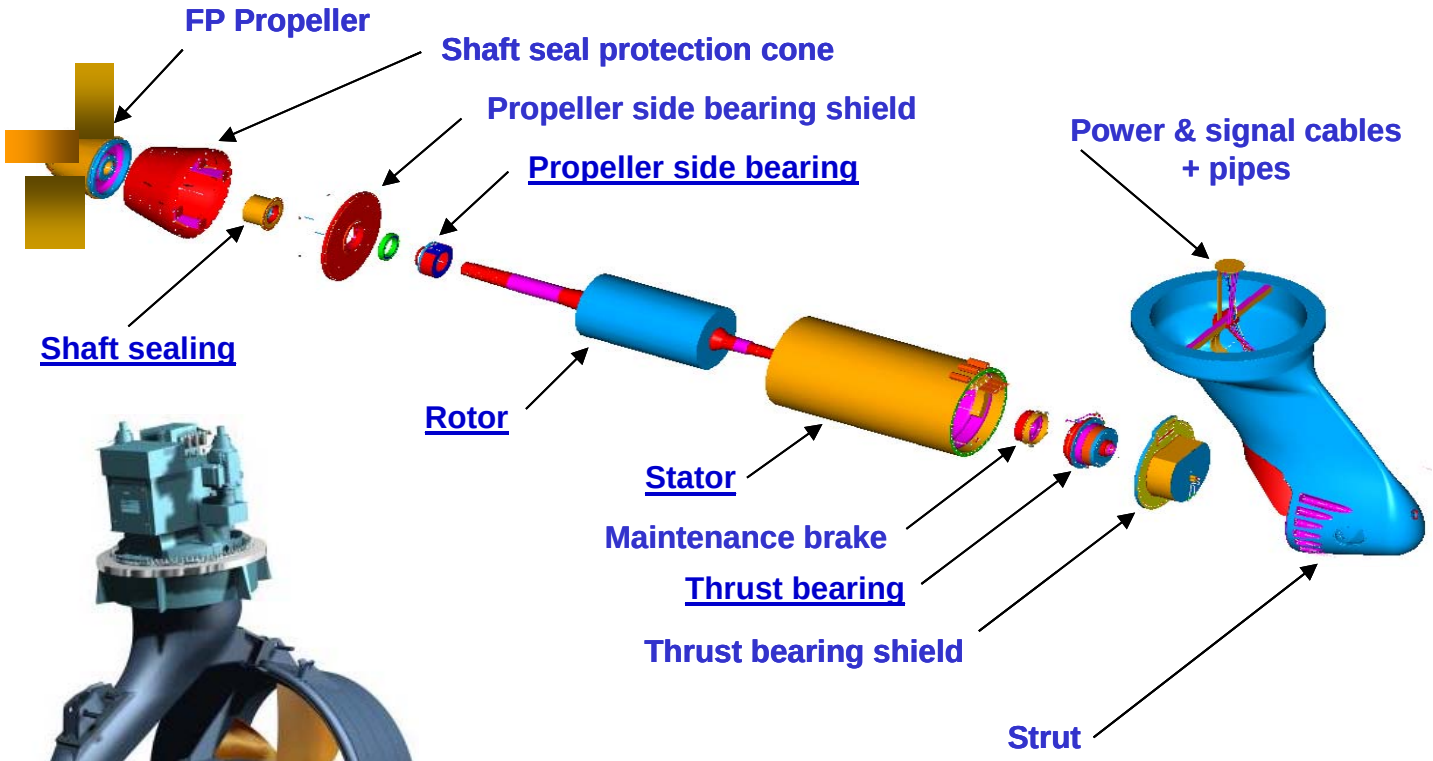
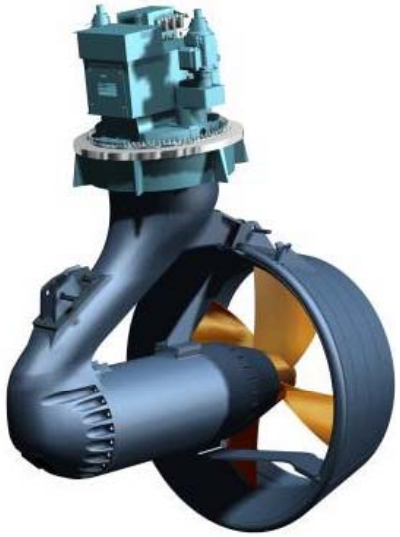
Podded Thruster for Drilling Vessels





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Summary

- The fleet of deepwater drilling rigs has generally performed well
  - Design, engineering, construction
  - Crew
  - Equipment selection
- Electric power generation and distribution
  - Experiences
- Technology evolution
  - Design improvements
  - Computerization
  - MV IGBT and IGCT converters
  - Podded thrusters