

5.10 Hybrid Propulsion System - PTO/PTI

Hybrid is considered a merge of electrical and mechanical source of rotating energy. In case of power production, it is a merge of different types of power sources.

ABB Marine approach to the hybrid propulsion is looking the system as a complete. In the end, the performance of the system is defined in the command bridge. Sub-optimization of certain part of the system – or favouring of any technology – should follow the best possible system configuration decision.

Example: On majority of vessels, the possibility of transferring a slow steaming operation mode onto the slow speed with electrical mode is an interesting option. ETA (estimated time of arrival) planning and vessel performance capability are guiding the decision making currently. This may turn into different story, while performance limitations are strip and ETA slots are efficiently available?

Parallel hybrid propulsion concept is normally designed with dual-in / single-out reduction gearbox. There the electrical propulsion component may be used to

- Power-take-off generator (PTO, commonly known also as a Shaft Generator) to work as a part of power plant. Part of the propulsion engines mechanical rotating power is transferred into the electrical network via gearbox and generator. For frequency variations and voltage matching, complete drive chain is required for utilizing the energy. This is in many situations more efficient manner to make needed electrical power, than run additional engine to produce it.

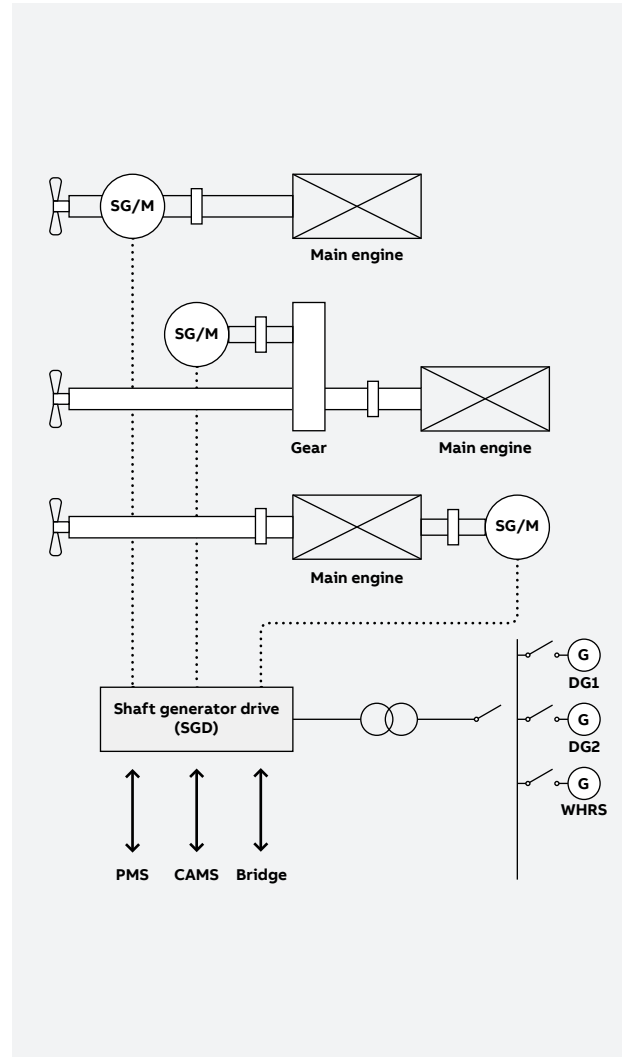
- Propulsion electrical motor (PTI, Power-take-in) to work as a part of propulsion system. The electrical propulsion has several options for utilization:
 - Electrical mode: Used typically lower in power range, for example to sail out from harbour or emission-free(if using energy storage as source of energy)operation within city limits. If operational profile contains slow speed or idling, this mode is very interesting option.
 - Hybrid mode:Used typically either to improve propulsion engine performance by taking the power off or to boost maximum speed / thrust out of the propulsion train. If operation profile contains short term need for full power, like pushers, harbour tugs often do, or in case small propulsion engine size brings benefit to vessel design, this mode is very interesting option
 - This mode also called PTH(Power-take-home), it also can increase propulsion system redundancy by electrical driving, in case of absence of Main Engine.

Parallel hybrid propulsion is very interesting solution for example for ferries, where shaft generators have been traditionally in the original design. Often this configuration is generated by the selection on the medium speed (>500 rpm) propulsion engines and shaft generator is dedicated to bow thruster motors only by isolating the shaft generator from the electrical network and bypass it with the thruster motors. There, the propulsion is typically with Controllable Pitch Propeller (CPP)

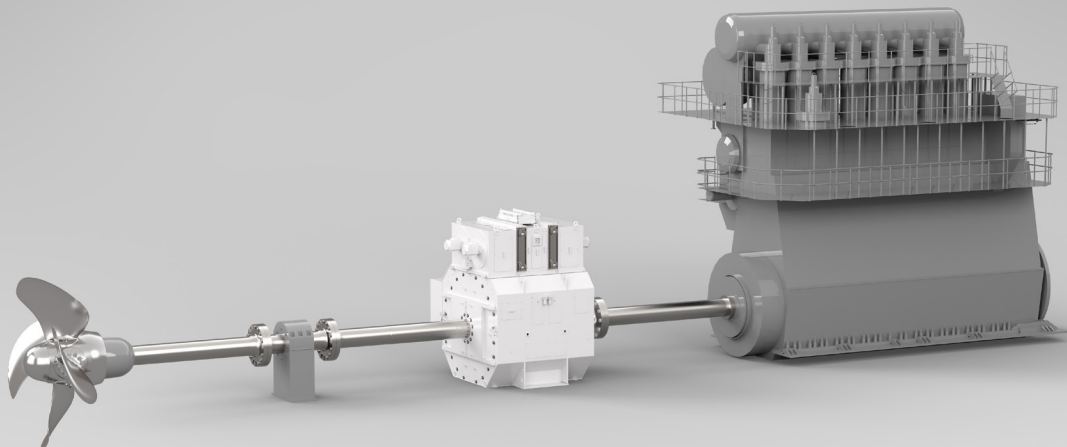
and Hybrid propulsion system needs to interface with pitch control.

When considering Serial Hybrid Propulsion, the main difference comes in the physical size of the electrical motor. In this propulsion concept, propulsion electrical motor (PEM) is installed in the same shaft line as the main propulsion engine. Then PEM revolutions are corresponding to the propeller speed, making the electrical motor slower. This equals larger in weight and investment.

- The physical installation may bring benefit, when there is no room to put equipment parallel. This is often a case with single propeller vessels.
- In case the utilized energy is so large in quantity, that savings in the gear losses becomes meaningful and serial hybrid propulsion does seem to look interesting.
- In two-stroke engine category, this concept normally does not include gearboxes and the main engine is also a slow speed engine.
- With medium speed engine, the existing gearbox offset (position of input and output shafts) may define that installation has to be done in serial form.



— Shaft propulsion



OPTIONS FOR INTEGRATIONS

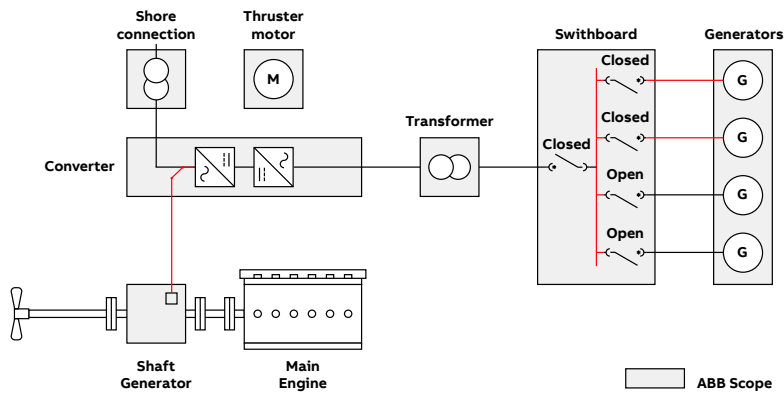
1. Shore connection

Shore connection to be integrated with the PTO frequency converter in case the ship side or the shore side has different frequencies, the frequency drive converts from 50 Hz to 60 Hz or vice versa

2. Energy storage

Batteries to be integrated with the frequency converter to ensure Electrical / hybrid mode with ES, advance ES functions ,enhance operation mode and safety

— Integration with Shore connection



— Integration with Energy storage

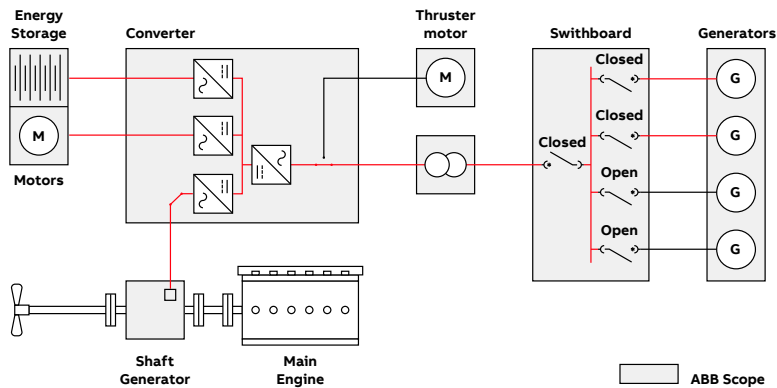


ABB is offering PTO/PTI-drives

for hybrid propulsion systems through-out the power scale

	Drive type	Power range
Small systems	HES880*	100 – 650kW / electric propulsion
Low voltage network and small medium voltage network	ACS880	500 – 4500kW / electric propulsion
Medium voltage network	ACS6080	3500 – 20 000kW / electric propulsion

*) request for availability

Comparison

of the hybrid propulsion options

Benefits

Parallel hybrid propulsion	Serial hybrid propulsion
Motor dimensioning for fast RPM	Suits single propeller hull shape
Low torque and transfer torque dimensioning	No gear losses on electrical generation
Investment is smaller than serial hybrids	No gear losses on electrical propulsion
Electrical mode improves the operational efficiency at slow speed range	Electrical mode improves the operational efficiency at slow speed range
Hybrid mode improves the operational efficiency at higher speed range	Hybrid mode improves the operational efficiency at higher speed range
Gearbox “protects” the electrical motor from axial shaft forces. This provides freedom in choosing PEM bearings.	Design process without gearbox is easier

Down sides

Parallel hybrid propulsion	Serial hybrid propulsion
Gearbox weight and investment	PEM dimensioning for transfer torque through motor shaft
Gear losses in the generator mode	Slow speed makes PEM heavy and increases the investment
Gear losses in the motor mode	Axial forces from propeller requires dedicated thrust bearing. Motor bearing solution has to be designed accordingly.
Requires width (space reservation)	Requires length (space reservation)
Gearbox is a single point of failure.	PEM is a single point of failure.