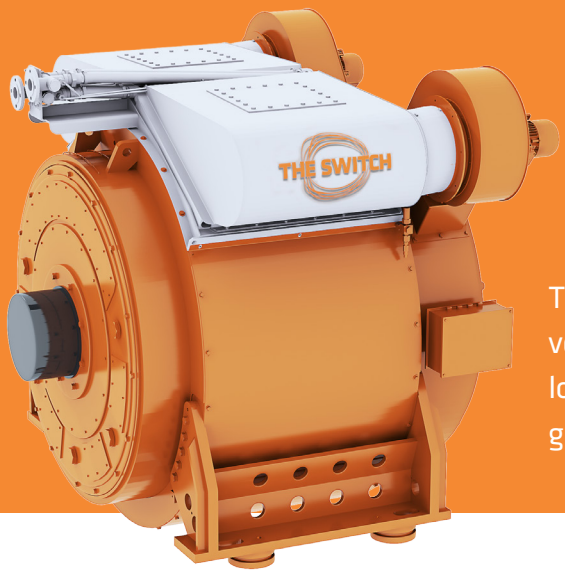
THE SWITCH
A YASKAWA COMPANY



Thanks to operational modes, vessels can operate more efficiently, lowering fuel consumption and generating profit.

Operational modes in marine shaft generator applications

Drive trains with permanent magnet machines (PMM) and frequency converters offer advantages for:
- *Merchant ships*
- *Tug boats*
- *Short-distance ferries*
- *Supply/multipurpose vessels*

Introduction

Marine vessels are constantly navigating extremely fluctuating conditions as they move goods and passengers from one coast to another. Waves, wind, ice, currents and many other natural and operational conditions place highly fluctuating demands on the loads of ships throughout their voyages.

Until recently, conventional drive train technology used in shipping for decades has been quite inflexible. This has led to remarkably inefficient operations and high fuel consumption, causing ships to face problems with eroding profit margins.

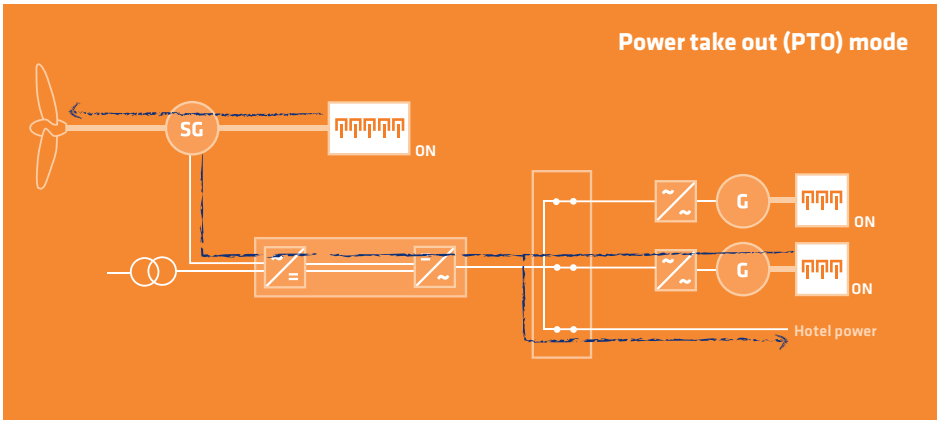
Today, drive trains with permanent magnet machines (PMM) and frequency converters are gaining attention because they are proven to offer overwhelming technical advantages for distributed power generation. The benefits are manifested in better power production, wider speed operational range, better quality electricity, stable voltage and frequency.

In the marine industry, the benefits of these advanced drive trains are bringing ship owners significant value. One application is the shaft generator in which the main engine is connected to a PMM either via a gearbox or directly to the main shaft to provide electric power. The shaft generator power is fed through the frequency converter, which creates a stable grid.

Operational modes offer an opportunity to optimize and adjust how you run a ship according to fluctuating conditions.

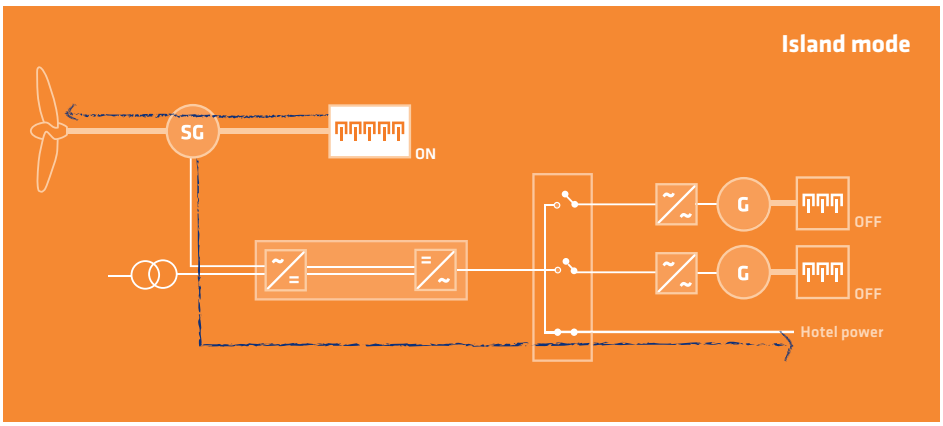
Operational modes offer a unique opportunity to optimize and adjust how you run a ship according to the fluctuating conditions. Moreover, they support the main engine in special conditions when flexibility is required most. For instance, you can save energy when more time is available or you can save time when you are under deadline or other target pressure.

POWER TAKE OUT – PMM works as a generator



During PTO operation, the ship's load is handled by the PMG and frequency converter, which reduces the running hours of the auxiliary generators and improves full efficiency.

Power take out (PTO) is an operational mode that focuses on energy-efficient power generation. The main engine serves as the power plant for the entire ship. The PM machine works as a generator, and the converter synchronizes the voltage and frequency created by the auxiliary gensets to the grid and stabilizes it. During PTO operation, the ship's load is handled mainly by the PMG and frequency converter, which reduces the running hours of the auxiliary generators and improves full efficiency.

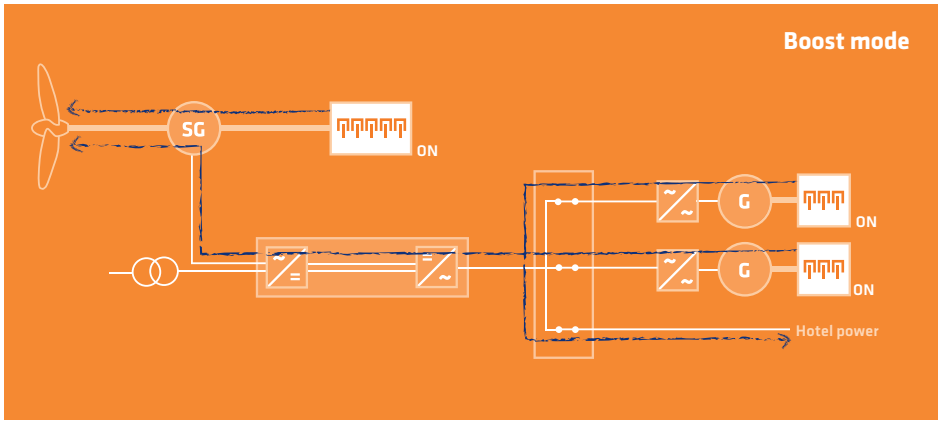


Island mode allows the entire electrical network to be created by the drive train.

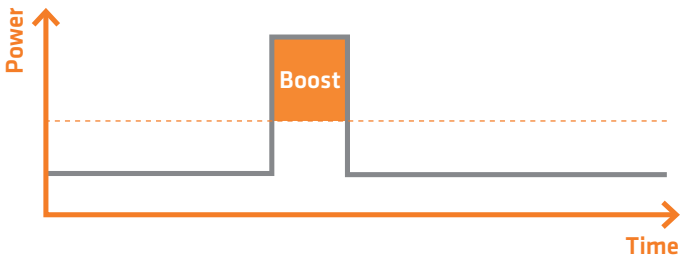
Island mode allows the entire electrical network to be created by the drive train to feed all electricity needed by the network. The auxiliary gensets are switched off. The shaft generator and converters take care of all power needed.

POWER TAKE IN – PMM works as a motor

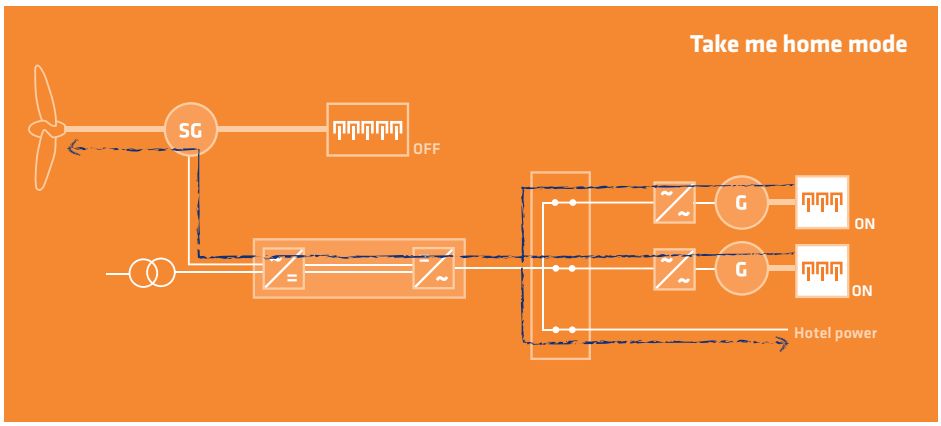
Power take in (PTI) mode provides propulsion power that either functions in **Boost** mode to provide the main engine with temporary extra power or alone in **Take me home** mode if the main engine is out of operation. The main idea is to provide an alternative or additional source of mechanical power for the propulsion, thereby increasing redundancy. The PM machine works as a motor, and the converter is necessary for smooth operation of the PMM.



Boost mode is used when peaks in power are needed. In this mode, both the auxiliary generators and the shaft generator are used to boost the propulsion power of the main engine. This auxiliary power is needed, for example, to boost the main engine in demanding operational conditions, such as with heavy towing tasks or sailing in icy waters. With the availability of the Boost mode, it is possible to use a main engine with smaller power and size dimensions. For example, ships can reach ice class without increasing the main engine size.

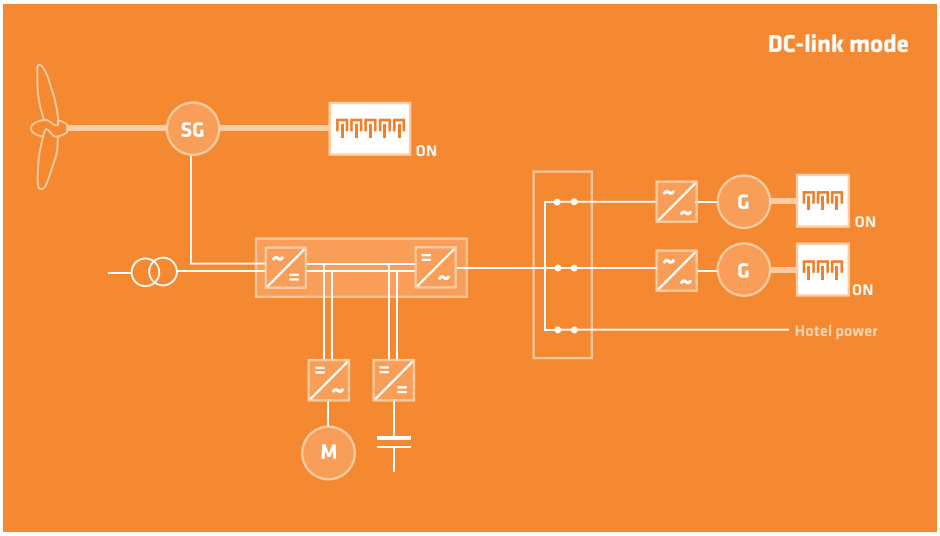


Boost mode when peaks in power are needed.



Take me home enables compliance with environmental and safety regulations to come in or quickly leave a port.

Take me home is used with the entire propulsion power to the propeller and main engine switched off. This propulsion operation enables vessels to safely leave or return to port while decreasing environmentally harmful emissions. This mode can be used to take a ship the so-called last mile to comply with the ever-stricter environmental regulations of certain ports, which include lowering SOx, NOx and noise. Additionally, you are able to use this mode to escape from a harbor in case of fire when carrying out any maintenance operations on the main engine.



DC-link mode: with the inclusion of a DC/DC converter and battery bank, the PTI mode can achieve a really advanced operational optimization. The DC-link creates new possibilities for advanced ship design. The main switchboard can be smaller, and heavy users, such as big pumps, thrusters or battery banks, can be run more efficiently.

Value for ship owners

PMM technology offers a wide variety of functionalities provided through different operating modes, giving ships an opportunity to fully optimize their operation. By using these modes, it is possible to run a ship taking all parameters into consideration in the most optimal way. Additionally, ship owners have the chance to optimize the dimensions of the main engine, auxiliary gensets and other major components.

Operational modes allow vessels to operate much more efficiently and manage fluctuating load demands.

Thanks to these operational modes, vessels can run much more efficiently and take into consideration all conditions that place fluctuating demands on their loads. This leads to high-efficiency performance and significantly lowers fuel consumption, allowing ship owners to gain higher profit margins from their business.