Choosing the right frequency conversion technology

Whether it is a ship wanting to connect to shore-side power, or a small process line purchased in a country with a different network frequency to the source of manufacture, the need to convert power between 50Hz and 60Hz is a job for static or rotary frequency converters. Jon Clews, principal engineer for power electronics at ABB, reviews the options.

Why do ships need frequency conversion?
A rotary or static frequency converter allows equipment to be connected to a grid which has a different frequency for which it was designed, without the need to change the motors and other wound components. This is particularly needed in shore-to-ship power, which helps ships in dock reduce fuel use and cut pollution.

Most power networks generate at 50Hz, whereas most ships use a 60Hz system. Using a rotary or static frequency converter ensures that the vessel can meet the grid requirements of the country where it is berthed.

What are rotary frequency converters?
The traditional frequency conversion technique uses a rotary frequency converter (RFC). This comprises a motor-generator set for speed control of the driven motor. They achieve the frequency change using a 10-pole motor with a 12-pole generator, or simply a fixed ratio gearbox.

While reliable, the RFC requires regular maintenance and has a conversion efficiency of less than 85 per cent. RFCs suffer fixed losses, which are inherent in any electromechanical system. Spare parts can be difficult to obtain for older equipment.

What are static frequency converters?
A static frequency converter (SFC) requires only a single annual service and has a much higher efficiency at 96 per cent, the result of lower losses from this purely electrical system. The SFCs power consumption is also more closely related to the connected load.

SFCs have lower standby losses and can be brought on-line and provide full output in a matter of seconds. They can automatically synchronise to an existing network, significantly reducing stresses on connected equipment.

SFCs offer a viable, modern and efficient alternative to RFCs, but can also be used in conjunction with traditional technology to provide a highly reliable hybrid solution.

Can they reduce noise levels?
Ships also need to ensure they produce low noise levels when docked. In certain parts of the USA it is compulsory for vessels to switch off their auxiliary generators and connect to shore power systems. The rotating parts of RFCs produce noise from the motor, generator and, if used, gearbox. The system may require noise attenuation to comply with local regulations.

SFCs have none of these problems. They can work in temperatures up to 45°C, or higher if chillers are used. Most are air-cooled, although larger units utilise liquid cooling which further reduces ambient noise. An SFC can be installed in switchrooms or supplied in weatherproof, ISO style containers. This means that connecting to a shore power supply using a SFC reduces the noise levels in ports.

Can they provide redundant supplies?
Ports that offer a 60Hz power supply may have a number of RFCs connected to a common bus. This allows a reasonable level of redundancy but also means that the generators can be kept to a practical size. In practice it also means that at least two RFCs are always in service to ensure availability of power should an RFC fail. System losses are higher as a result.

It is feasible to use SFCs in conjunction with RFCs to provide a highly efficient ‘duty/assist’ system. In this way an RFC can be allowed to run at full load and maximum efficiency, with the SFC providing top-up power to the system.

Other features can include auto synchronisation and load sharing.

Can variable-speed drives be used?
The most common frequency convener in use in industry is a variable-speed drive (VSD) using insulated-gate bipolar transistor semiconductor technology. These are designed to rotate induction motors with output frequencies in excess of 300Hz.

Unfortunately the output waveform from a VSD is unsuitable for connection to the type of loads found on board a ship. In addition, VSDs are designed to be connected to single loads with a large induction, and cannot be connected to multiple loads which may regularly be switched on and off. In fact, a conventional VSD may incorrectly interpret a switched load as either an under- or overcurrent and shutdown as a result.

Therefore this application requires specifically designed equipment, with a suitable output waveform and a very low total harmonic distortion (THD) of <2 per cent. Otherwise, the connected loads may malfunction, suffer damage, or become stressed.

This is why it is important to use equipment which is specifically designed for the application - effectively a generator simulator with identical characteristics. This ensures that the high starting currents of large fixed speed motor loads are not interpreted as a short circuit.

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