TEXT: HARRIET ÖSTER

LOW LOSS CONCEPT
offers improved performance at lower cost

The Wärtsilä Low Loss Concept (LLC) is an effective way of avoiding the use of heavy and space-consuming transformers in the power distribution systems for electric propulsion solutions on ships. Winner of the 2010 Wärtsilä Technology & Innovation Award, LLC solutions also offer improved levels of redundancy.

TRADITIONAL SOLUTIONS for electrical ship propulsion consist of two or more propulsion units - a generating set (engine and generator) and a drive system consisting of a propulsion transformer, a frequency converter for speed control, and a propeller system. The transformers in such systems are heavy and take up a lot of space, and medium-sized vessels employ at least four propulsion units and sometimes as many as seven.

"We've eliminated the propulsion transformers, replacing them with either one or two Low Loss Concept transformers in a central location," says **Svein Djuve**, Project Manager, Wärtsilä Ship Power Offshore. "Each transformer becomes part of the switchboard unit and is used in controlling several propulsion units."

Wärtsilä LLC is available for low-voltage and medium-voltage applications, covering power requirements of 5-70 MW. Low-voltage systems have already been installed on some 65 vessels, and medium-voltage installations are in the pipeline.

IMPROVED SYSTEM EFFICIENCY SAVES FUEL

"The LLC solution is based on a transformer in which the main windings are phase shifted by 30° to cancel the 5th and 7th harmonic currents introduced into the network by rectifying bridges," says Djuve. "The bridges are supplied from the two phase-shifted sides of the LLC transformer, with each providing 50% of the required power. An LC filter combined with a filter winding in the LLC transformer results in total harmonic distortion (THD) of less than 5%, and the majority of the harmonic currents pass through the transformer, not into the generators."

LLC eliminates the need for propulsion transformers by allowing genset power to be applied directly to the frequency converters used for speed control. This configuration means that system efficiency is 2-4% higher than in traditional transformer-based systems, while the current supplied from the switchboard to the frequency converter is 10% lower.

Lower electrical losses in the system result in better fuel economy and reduce the need for auxiliary systems. Depending on the vessel type and operational profile, the reduction in electrical losses can yield annual fuel savings of between EUR 30,000 and EUR 100,000.

HIGHER LEVELS OF REDUNDANCY

"The primary argument for LLC is that it allows propulsion transformers to be eliminated, saving →

The winners of this year's Wärtsilä Technology & Innovation Award Egil Hystad, General Manager, Power Systems, Ship Power Technology (left) and Svein Djuve, Project Manager, Ship Power Offshore (right). The award was given by Kari Hietanen, Group Vice President, Legal Affairs and HR (middle).

Ships have to be able **to reach harbour** even when they **suffer an engine fault.**

weight, freeing-up space and reducing initial investment costs," says **Egil Hystad**, General Manager, Wärtsilä Power Systems, Ship Power Technology. "Of equal importance are the resultant energy savings and higher levels of redundancy in the vessel's propulsion system." Hystad and Djuve, the inventors of LLC, developed the solution at the Wärtsilä unit at Stord in Norway.

"With LLC, a vessel's propulsion system can be divided into several units that work independently," says Hystad. "If a major equipment failure occurs, the consequences are less severe than in a traditional system. In the case of a short circuit, power generation can be reduced by 25%, but all the ship's propellers continue to function and the vessel can be steered. Ships have to be able to reach harbour even when they suffer an engine fault, and steerability is of the utmost importance for offshore support vessels, which often employ electrical propulsion systems."

QUATTRO LLC FOR UP TO 20 MW PROPULSION POWER

In traditional systems, the use of low-voltage components is restricted to applications with a maximum of about 10 MW installed propulsion power. By using LLC, propulsion systems with higher installed power can be designed using low-voltage (690 V) components, reducing equipment weight and saving valuable space. In some applications, weight reductions of 35-40% can be achieved.

The basic LLC concept - two propulsion units served by one LLC transformer - can be used with low-voltage power distribution for installed power levels up to 12–14 MW. Both offshore support vessels (OSVs) and seismic survey vessels use basic system installations.

The range of applications for LLC has been extended through the Quattro system. In LLC Quattro, four LLC transformers are connected in a ring and maintain a constant 30° phase shift between the electrical distribution bus bars. As well as improved fuel economy, this configuration provides maximum propeller availability by making several supplies available to the propeller drive systems.

"Quattro LLC was originally designed for medium-voltage power distribution, but it extends the low-voltage power range up to a total of 20 MW propulsion power," says Hystad. "Components for low-voltage power distribution are a great deal cheaper than medium-voltage components and crew training is easier. There's a shortage of people who have been trained to operate medium-voltage equipment."

With medium-voltage components (6600 V), installed propulsion power using traditional design configurations can be in the range 30-40 MW. "The LLC design enables the use of standard medium-voltage components in large vessels and offshore platform applications equipped with up to 70 MW of installed power," says Hystad.

FIRST INSTALLATION WAS ON A PSV

The invention on which the Wärtsilä Low Loss Concept solution is based was made in 2003. "The idea came to us when customers were less than

[INNOVATION]

FACILITIES

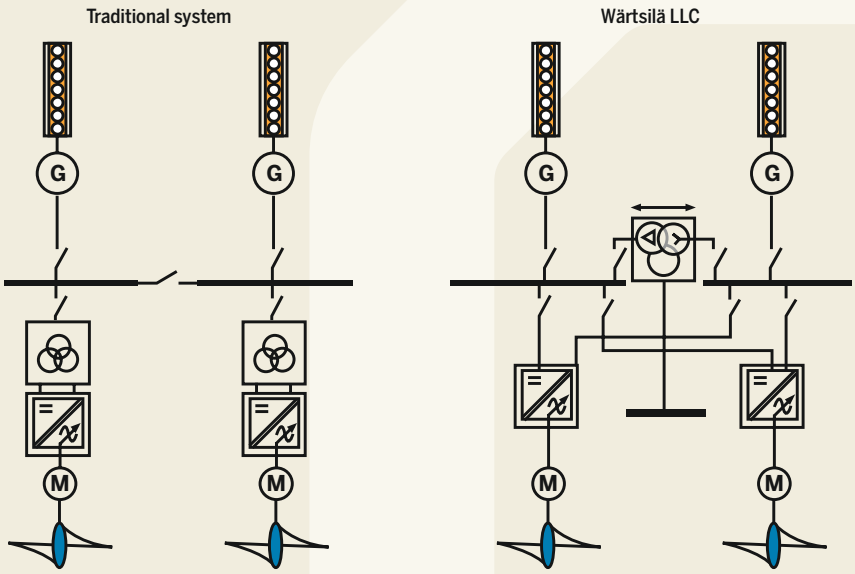
Wärtsilä facilities at Stord in Norway proved an ideal location for developing the Low Loss Concept. **All the required control technology**, frequency converters, knowledge and analysis services were readily available.

BENEFITS

By avoiding the need for large and heavy transformers, the Wärtsilä LLC solution allows compact and efficient installations, **freeing-up valuable space and reducing the costs** associated with mountings, cooling equipment, cable termination and the routing of input/output signals to switchboards and other control equipment.

REDUCTIONS

Using LLC, propulsion systems with higher installed power **can be designed using low-voltage (690 V) components, reducing equipment weight and saving valuable space.** In some applications, weight reductions of up to 40% can be achieved.



happy with the huge and heavy transformers that take up so much space in traditional solutions," says Djuve. "There were plenty of doubts about whether our idea could work, but we continued to develop the concept as it was quite clear that the market for a successful solution would be significant." The first complete LLC system was delivered in 2004 and installed on the Normand Skipper, a platform supply vessel (PSV). The main patent for LLC was granted in 2006. Patents have subsequently been granted for the Quattro LLC design and for LLC in medium-voltage applications.

By the end of 2010, some 70 ships featuring low-voltage versions of the Wärtsilä LLC will have been delivered. Pilot sales of Quattro LLC began this year, and medium-voltage versions of the LLC solution are being marketed for use in vessel and drilling platform applications.

Phase shifting eliminates unwanted harmonic currents

Odd as it may sound, the idea behind the Low Loss Concept involves passing electrical energy around the transformer, not through it. "In traditional solutions, each propulsion unit consists of a propulsion transformer, a frequency converter for speed control, a motor and a propeller," says Svein Djuve. "All the energy supplied to each unit passes through the system, and electrical losses are the result. The phase-shifting LLC transformer filters out undesirable harmonic currents before they reach the generator."

Phase shifting involves splitting the electrical supply into several parts, with the phase of each part being arranged so that harmonics are eliminated. "By shifting harmonic currents to the opposite phase, they are effectively cancelled out," says Egil Hystad. "We use Fourier analysis to build a mathematical model that shows us which harmonic frequencies will result in voltage distortion. The phase-shift transformer is then constructed in a way that eliminates the dominant harmonic components."

Each phase-shift transformer is fed by two generators and serves two propulsion units. If a failure in one genset occurs, electrical energy from the other genset can still be fed to both propulsion units. Even though overall efficiency in this case is lower, both propellers will still be operational and the resulting level of redundancy is much better than in a traditional propulsion transformer system.

The first complete LLC system was delivered **in 2004.**