Powering marine applications – the many challenges

We are all aware of self-driving cars and many other exciting projects that the automotive industry is engaged in, but far fewer of us have heard about unmanned ships and associated projects that will operate large fleets of vessels that are capable of navigating from port to port without operational crews (Figure 01). Although in its early stages, projects such as the Maritime Unmanned Navigation Through Intelligence In Networks (MUNIN) project have investigated the feasibility of such projects and also test-bed development for future developments. The use of unmanned ships will require extreme reliability from the main generator through to the single point-of-load, and the challenges and demands placed on power designers will be far beyond anything experienced to date.

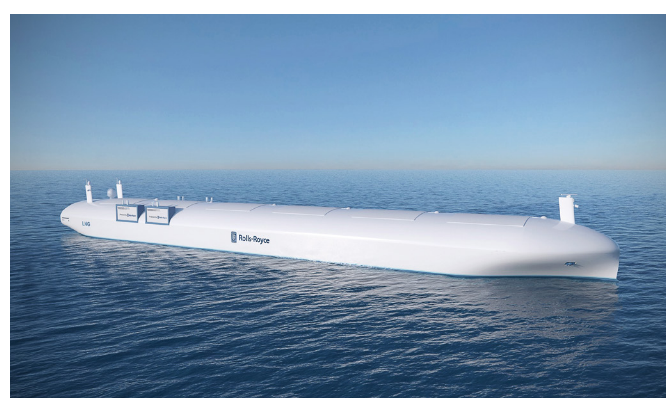

Figure 01 – Rolls-Royce unmanned ship project (source: Rolls-Royce).

State of the art in marine power
Future generations of power supplies for unmanned ship are still under definition although it is important to understand the specificity of the marine segment that is quite unique in terms of its environmental needs and regulations. Due to the nature of the business, the requirements imposed on products and systems deployed in shipping and offshore installations are greater than what are currently required for land industrial and office environments. In addition, international regulations and standards applying to the marine industry are very complex, requiring an in-depth knowledge of the application and where it will be operated. Power designers must be knowledgeable about marine specific voltage distribution, combining DC and AC networks, safety regulations, and many other aspects such as 'operational zones' that can vary wildly from ship to ship and also with the nature of the merchandize being transported.

The Zones
Generally two zones are distinguished on a ship; the 'bridge and the open deck zone', and the 'general power zone', which basically refers to all other spaces on the ship.

One example of a specific requirement per zone is the electromagnetic emission and immunity (EMC). The areas open deck and bridge place extra demands on the EMC, as a lot of sensitive equipment is housed in those areas such as communication, radar and navigation devices. These EMC requirements are well below the known EN55022 Level B and measurements begin at 10kHz instead of the usual 150kHz.

The limits regarding mechanical and climatic requirements are also higher than for the average industrial application. Vibration levels up to 4g are common, as well as large temperature fluctuations from -25 to + 70 degrees C, and also high relative humidity conditions where condensation cannot be excluded.

The rules
Every country with a maritime sector has its own certification authority with specific demands for local certification, forcing power designers to keep track of the final application where the power supplies will be installed. In general, there is a common group of standards and qualification processes that have similar roots for all countries' certification, though from country to country and maritime sub segments there are also a number of very specific requirements that increase complexity. The difficulty is, there is no de-facto percentage of 'common standards' versus specific, thus requiring power designers to start any new project by reviewing a large number of documents prior to designing anything – a lot of time consuming, but very necessary, hard work.

In order to develop a sustainable way-of-working to ensure that the power solutions can be utilized all over the world, marine power supplies designers used to combine the requirements from all countries active in marine construction and operation to establish a cross reference table with equivalence and specific action in the case of major deviations - for example, higher demands on shock and vibration. Once such an equivalence table is established, the toughest requirements of each category is selected and used as a reference for designing, verifying and qualifying the final power supply. This is done in close cooperation with the final customer, reducing the risk of under-specifying the power supply and missing final qualification.

Combining this design methodology with an in-depth knowledge of local standards and regulations results in a test protocol that meets international and local requirements. This test protocol is then applied to all products, simplifying not only the final approval, but also confirming that the power supply can be used for replacement or system-upgrade purposes in any country.

Usually marine customers expect the power supplies to comply with and be certified and stamped with the type approval logo of Germanischer Lloyd (GL) because of the extensive testing to meet EN60945 for extended approvals by Bureau Veritas (BV), Lloyds Register (LRS), America Bureau of Shipping (ABS), Det Norske Veritas (DNV), Korean Register of Shipping (KR) and many other notified bodies in the maritime world.

More power in a smaller footprint
With the increased amount of embedded electronics, the marine industry requires more functionality in a smaller space. Nowadays, ship owners want to equip their vessels with broadband internet connections for both passengers and crew while embracing - as much as is possible - the same features as when ashore.

As a further example, position tracking systems are built-in to the monitor, requiring very compact power supplies operating in a confined environment without a fan. Such power supplies have to be designed for conduction cooling, with high attention paid to the placement of dissipative components and optimized conduction cooling (figure 02).

For most power distribution systems, power units are preferably in cassette format, hence simpler to install, maintain and upgrade. The marine cassettes are usually mounted on DIN rail, although electrical designers within the ship industry require that the power supply is also compliant with standalone conduction cooling installations anywhere on the ship, meaning - as for the embedded power supplies - that the design has to be highly optimized for conduction cooling (figure 03).

Packaging more power in a smaller box with optimized conduction cooling requires a high degree of integration of the power circuits. The efficiency needs to be as high as possible because a small housing also means that the cooling surface is smaller. By using the most recently developed resonant circuits and switching control methods, efficiency levels up to 95% are achieved although power designers are exploring new technologies such as digital control and the latest generation of Gallium Nitride (GaN) power FETs, targeting higher efficiency and a flatter curve, maintaining high efficiency from very low through to high loads. All new technologies are explored, although the nature of the business - ships are often in the middle of oceans and weeks from land – means that extremely high reliability levels apply, and so new technologies have to be verified for use in extreme conditions. This is an ongoing process that is mandatory for future unmanned ships where maintenance during operation is almost impossible. Reliability and zero downtime are the rule. Accordingly, power supplies should be able to be connected in parallel for redundancy operation. It is common practice to add an external ORing block (usually with similar dimensions to the power supply) that electricians interconnect to the power supplies. This conventional way will tend to disappear and electronics paralleling circuitry built-in to the power supply itself will take over. Adding that function into the power unit saves space for more vital equipment, but requires power designers to integrate more into a smaller package.

Figure 02 – Powerbox PT571
Marine grade power supply design optimized for conduction cooling in confined environments.

Figure 03 – Powerbox PT577
Marine grade power supply in cassette format with built-in ORing diodes.

What's next in marine?
Existing power solutions for the marine industry have proven their robustness and meet international compliances. Power designers are exploring new technologies to permanently improve efficiency, and to decrease power consumption and dissipation. Unmanned ships will require a level of reliability that will be close to a mythical 'zero faults' level, and the ability for power supplies to be controlled and monitored from a central office (Figure 04) that could be on the other side of the planet! For the power designer it will be an incredible challenge to combine state of the art technologies in switching, thermal management, control and intelligence. We are close to a new era where power supplies will become self-controlled and able to diagnose early signs of failure in order to apply corrective action. Is that a dream or reality? In my opinion it's knocking at the door and we will soon be there!

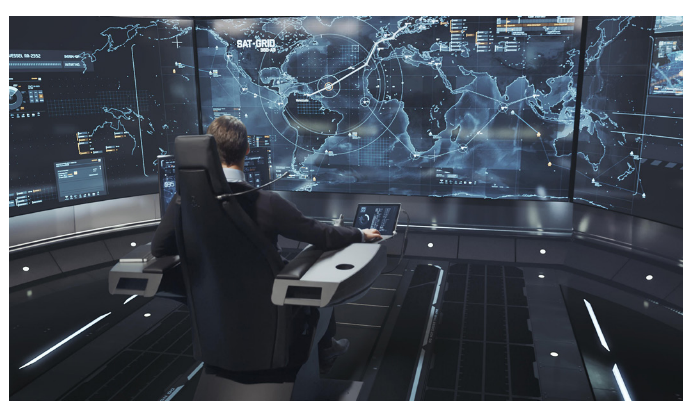

Figure 04 - Rolls-Royce oX land-based control center (source: Rolls-Royce).

About Powerbox

Founded in 1974, with headquarters in Sweden and operations in 15 countries across four continents, Powerbox serves customers all around the globe. The company focuses on four major markets - industrial, medical, transportation/railway and defense - for which it designs and markets premium quality power conversion systems for demanding applications. Powerbox's mission is to use its expertise to increase customers' competitiveness by meeting all of their power needs. Every aspect of the company's business is focused on that goal, from the design of advanced components that go into products, through to high levels of customer service. Powerbox is recognized for technical innovations that reduce energy consumption and its ability to manage full product lifecycles while minimizing environmental impact.

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