Facing safety challenges towards smart ships and ports

J Prousalidis[1]* PhD, MIMarEST, Professor, School of Naval Architecture and Marine Engineering, National Technical University of Athens, jprousal@naval.ntua.gr

D Spathis Electrical Engineer, Protasis s.a., dspathis@portasis.net.gr

V Papaspilitopoulos Electrical Engineer, Protasis s.a., vpapaspiliotopoulos@protasis.net.gr

V Georgiou, Electrical Engineer, Protasis s.a., vgeorgiou@protasis.net.gr

T. Kourmpelis, electrical Engineer, Lloyd's Register, theo.kourmpelis@lr.rg

F Kanellos, PhD, Associate Professor, School of Electrical and Computer Engineering, Technical University of Chania, kanellos@ece.tuc.gr

* Corresponding Author.

Synopsis

Following the global concern and IMO directives, in particular for greener shipping, ships and ports tend to become more efficient in terms of environmental friendliness, energy consumption as well as services provided. This paper deals with facing the challenges emerged within this framework, as in the ship case, certain retrofitting works have to take place onboard a ship such as the installation of water ballast treatment systems, scrubbers, cold-ironing facilities, and LED lights. The paper discusses the necessity to perform a number of studies (e.g. harmonic distortion, short-circuit, arc-flash etc) so that major safety requirements are met, while on the other hand, the electric energy system has to be tuned to a significant extent so that it operates in an optimum manner which is most often interpreted as minimum fuel consumption and emissions. Further, the paper makes a similar discussion for the case of the ports.

Keywords: green shipping; water ballast treatment system; scrubber units; LED lights; short-circuit study; arc-flash study

1. Introduction

The global concern and the directives of IMO and EU for greener shipping, has made ships but also ports to accomplish their missions in a more environmental friendly manner.

Within this framework, certain retrofitting works have to take place onboard a ship such as the installation of the following equipment:

- ballast water treatment system (BWTS)
- exhaust gas cleaning systems ('scrubbers') to reduce emissions
- ship-to-shore power supply (or "cold ironing")
- replacing illuminating lights by modern ones of LED technology

Besides any problems in acquiring the additional space onboard and accomplishing all safety requirements (ABS 2014, ABS 2017, DNV-GL 2014, Lloyd's 2015), from the energy point of view, these challenges consist

[1]**Author's Biographies**

John Prousalidis is Professor at the School of Naval Architecture and Marine Engineering of the National Technical University of Athens.

Dimosthenis Spathis is an electrical engineer working with Protasis s.a

Vassilios Papaspiliotopoulos is an electrical engineer working with Protasis s.a

Vassilios Georgiou is an electrical engineer and the c.e.o of Protasis s.a.

Theodore Kourmpelis is an electrical engineer working with Hellenic Lloyd's the subsidiary of Lloyds' Register of Shipping in Greece

Fotios Kanellos is Associate Professor at the Electrical and Computer Engineering of the Technical University of Crete

 http://doi.org/10.24868/issn.2515-8198.2019.005

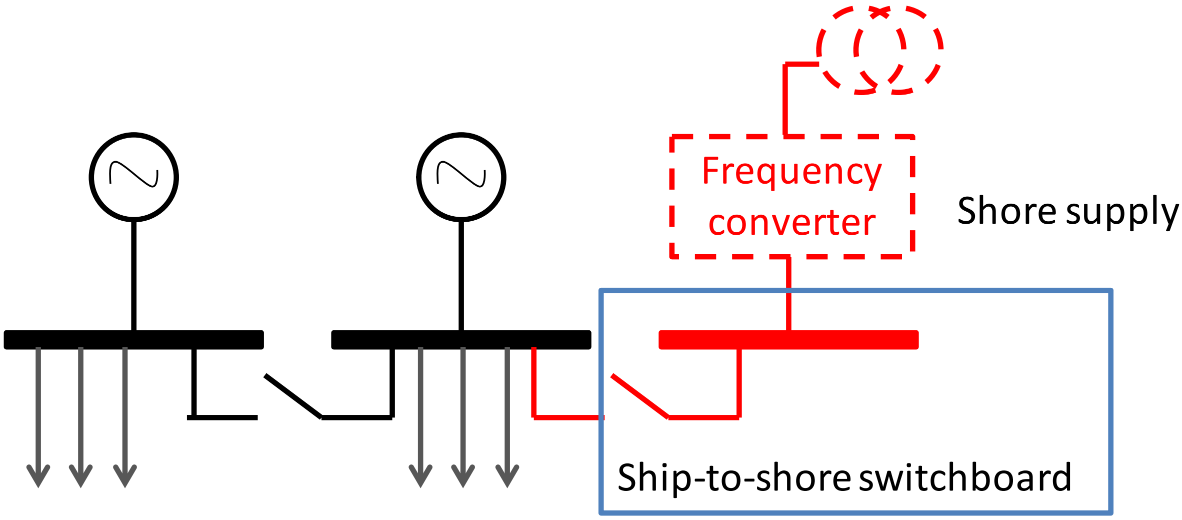

Figure 4: Retrofitted ship energy system for cold-ironing *(retrofits in red, options in dashed lines)*

This integration of ship-to-shore interconnection facility onboard a ship entails another retrofitting, this time in the existing shore-supply switchboard. The latter in most ships is designed to serve only during dry-docking providing electric power from shore to a complete dead ship, while of course in such an operating condition any synchronized operation of the ship generators with the port mains is meaningless. On the contrary, the new shore-to-ship switchboard must be treated as an "extra power supply" that can (and probably must) operate in synchronized mode with the ship generators so that no "black-out" during "switch-over from ship to port" takes place, see Figure 4. Moreover, the capacity of this switchboard must be able to meet all ship energy demands in "port operating" mode, e.g. hotel loads, galleys, accommodation, cargo handling, lighting, air conditioning etc which are, in general, greater than the dry-docking demands. Further implications both of technical and economical nature can be introduced if the power supply of the port is of different voltage and frequency compared to that of a ship. In this latter case, voltage transformers and frequency converters must escort the shore-switchboard retrofitting.

2.4 LED lights

LED technology has attained to provide lighting devices of high illuminating capacity but of low energy consumption. The latter actually refers only to active power demands and not the reactive ones which include among others harmonic distortion components. Thus, as it can be seen in Figure 5, where the measured harmonic spectrum of the current waveform absorbed by a representative LED bulb is depicted, the current has a significant distortion comprising odd-order harmonics which result in a THD equal to 172.2%. Moreover, while it is confirmed that the active power consumption is fairly low, the power factor is measured to be of very low value, too, being 0.478 inductive. This is reflected to high reactive and apparent power demands (being almost two times the active one), see Table 1.

Table 1: Indicative Power indices of a LED bulb *(Apparent power S is used as reference)*

Active Power	**Reactive Power**	**Apparent Power**	**Power factor**
P(%)	***Q(%)***	***S(%)***	***pf(-)***
47.80	87.8	100	0.478