INVITED PAPER

Power Flow Control and Network Stability in an All-Electric Ship

This paper compares the approaches to power flow control and network stability of an integrated ship power system through reducing the dynamics of large loads to operate in compatibility with the dynamics of a traditional generating system, or through the methods of "smarter" generators through its power electronic interface.

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ABSTRACT | The concept of an all-electric ship, while offering unprecedented advantages from the point of view of efficiency and flexibility of operation, has introduced new challenges in terms of stability and power flow control. The advent of a full power electronics power system has raised new questions from the point of view of system dynamics, particularly when dealing with the new medium-voltage direct current distribution. The overall goal of guaranteeing a secure operation of the power system has brought researchers to consider two main approaches: reducing the dynamics of the large load to operate in a range of dynamics compatible with traditional generation systems, or making the generator set smarter through its power electronics interface. This paper compares these approaches to stable operation, focusing on the latter considered more in line with the progress of technology and in general more appealing.

KEYWORDS | Centralized control; control nonlinearities; decentralized control; load management; microgrids; power distribution; power system stability; stability analysis; stability criteria; system-level design

I. INTRODUCTION

Traditionally, the electrical power system did not play a big role in the design of ships. The first change occurred with the introduction of electrically propelled ships. A further major push originated from the introduction of the concept of the all-electric ship (AES) proposed by the U.S. Navy. The key technology that has really changed the design options is power electronics and, in particular, the idea of a power electronic building block [1], [2]. The AES, at least as design concept, is one of the first real power-electronics-based power system that was ever considered. Similar development happened in the avionic field with the concept of more electric aircraft [3]. Power electronics enabled the possibility to actively control the flow of power in the system to an unprecedented level. Standardization activity has led to concepts of automation design that are completely hardware independent and able to operate effectively at system level [4]. In this respect, ship power systems as well as avionic systems anticipated terrestrial power systems proposing architectures based on a full control of the power flow [6]. A good example in this direction is given by the interest in direct current (dc) technology that is now making its way to terrestrial

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