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D 5.2 The automation and control system for the pilot ship with fuel cells and energy storage systems

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Summary

This document presents the automation and control system for the pilot vessel M/S Aranda with fuel cells and energy storage systems in MARANDA project

The basic control system and the connections towards the vessel power management and automation systems are presented. Basic functionality in normal operation as well as starting and stopping of the system are explained. Some safety aspects are also considered for emergency shutdown procedures.

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Contents

1. Introduction

This document gives analysis for the automation and control system for the pilot ship with fuel cells and energy storage systems in MARANDA project. The control part concerns the fuel cell control. Energy storage system is excluded from the project since there will be energy storages in the main propulsion converter system outside of the scope of the fuel cell powertrain. Energy storages are important, however, for the fuel cells, too, since the fuel cell system itself is not maintaining the network voltage nor the network frequency, but only feeding the power to it.

2. Control structure

The fuel cell power train control structure is presented in Fig. 1. The vessel automation and the power management system are combined into one system in the vessel, which is reducing the number of the external connections.

The communication between the vessel systems will be impelemented with Modbus/TCP fieldbus. The commands to the main switchboard circuit breaker will be implemented by hardwired signals.

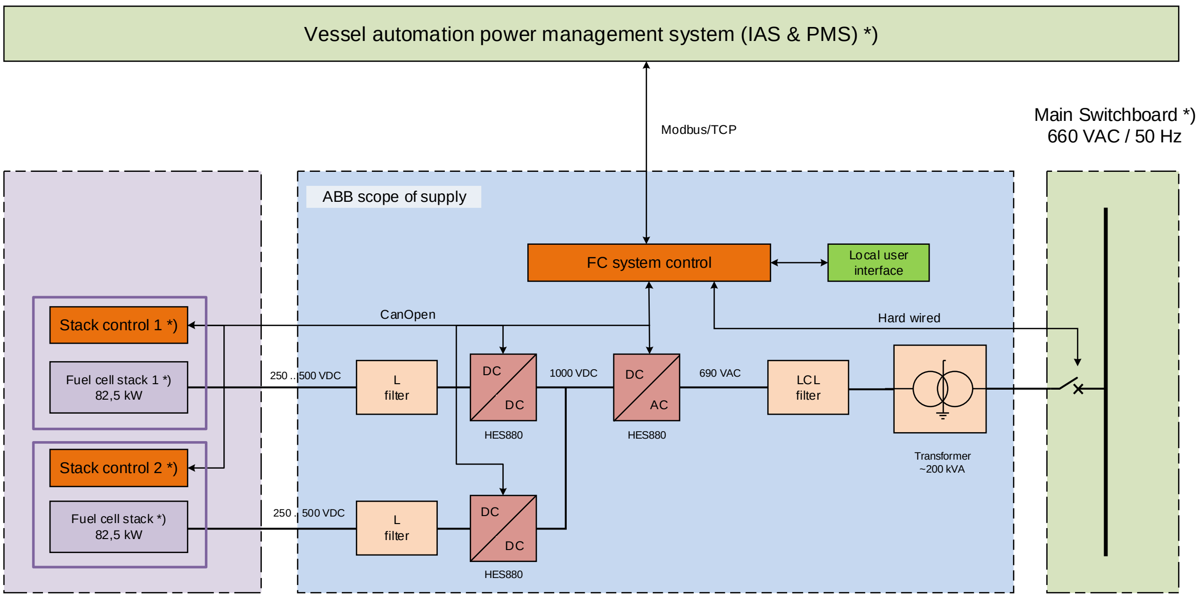

Figure 1. Control structure.

3. Control functionalities

3.1 Basic control principle

The basic control principle of the system is power control from the power management system (PMS). When the system is running it will read the power reference value from the PMS and then command the fuel cell system accordingly. The two DC/DC converters will be operating in parallel and dividing the power production equally. The DC/AC converter connects to the DC-link voltage and feeds energy to the main switchboard.

It is the power management system that takes care of the power distribution between different power producing units. This will isolate the system level optimisation into the PMS and the fuel cell unit will follow the orders. In case of load transients, the primary source of immediate power should be the emergency storage and the PMS should increase the fuel cell power reference moderately to respect the power increase slopes of the fuel cells.

Similarly, the power reference decrease should not be too fast for the fuel cells. Instead, the energy storage can act as a buffer for excess energy.

3.2 Starting and stopping of the system

Starting and stopping of the system is initiated from the PMS. Fuel cell control system (FCCS) will indicate when the system is enabled for the start, i.e. there are no active interlocks. While this is the case, the PMS can initiate the start procedure. During the start, the system will first start the fuel cells one by one and then release the DC/AC control to start power feeding to the vessel main switchboard.

Stopping of the system is also initiated from the PMS in normal conditions. PMS will give the stop request to the FCCS and the fuel cell system will shutdown in managed procedure.

In case of emergency, there is also a possibility for an emergency shutdown. This will give a forced opening command directly to the main circuit breaker in the main switchboard and at the same time shutdown the power electronics equipment.

3.3 Status, indications, alarms and events

The fuel cell system will inform its status for monitoring as well as important alarms and events to the vessel automation systems (IAS). These signals are transmitted in the Modbus/TCP fieldbus. There is no time stamping for the signals in the sending equipment to achieve effective transfer speeds.

4. Conclusions

The control structure for the system has been designed in a scalable manner. It is important that the system connectivity resembles the traditional behaviour of the diesel-generating sets since the fuel cells are planned to be utilized as power generating units in general. With the selected structure, it is easy to separate the functions of the power management from the functions of the power production unit. This will offer flexibility in the desing work and will also help system building in cases where the different parts of the system are delivered by different makers.