Project: Notional System Modeling

Project Completion: Ongoing

Output: Several technical reports pertaining to IPES notional system information [1], [2], implementation on two different platforms [3], [4] were developed describing the system models and their implemented. Modeling efforts on the four zone notional shipboard power system model was presented at AMTS on March 2018 [5]. A modeling working group named, 'Time Domain Electrical Simulation Modeling Working Group (TDESMWG)' has been established that comprises of several ESRDC members which works on arriving at a notional SPS system that can be utilized for various types of studies. The goal of the group is to arrive at a common SPS model with its characteristics defined such that implementation of the SPS model in various simulation platforms can be mapped, verified and validated.

Notional Integrated Power and Energy System (IPES) architecture based shipboard power systems (SPS) are being realized with continued development. Real time constraint based power system models were implemented and realized on two different power system simulator tools. The power system models developed are being used for evaluating advanced control schemes using the controls evaluation testbed framework and platform.

Project Motivation: Real time dynamic simulation models of future naval shipboard power system are a precursor for validation of advanced control algorithms and their evaluation on a testbed platform. Several iterations of various zonal SPS models have been developed and are being improved. The following notional SPS models exist within the library and are available for access through ESRDC library

- Two Zone SPS model
- Four Zone SPS model based on S3D 10k ton ship model
- Six Zone SPS model (IPES 1.0)

The two zone SPS model developed in 2016 was utilized for MVDC fault management studies. Consequent ESRDC work utilizes the four zone SPS system over the two zone system as it contains four zones and several mission load and power system modules as described in the NGIPS architecture. The six zone power system model which will hence forth be called IPES 1.0 SPS model is under development through the TDESMWG and is expected to be available by November 2018. Figure 1 shows the four overview of the notional four zone SPS model. The four zone SPS model is based on a zonal architecture with 12 kV DC as its primary distribution system. The power system consists of 4 zones, 5 power generation modules (PGM) three main and two auxiliary, 2 propulsion motor modules (PMM), several power conversion modules (PCM-1A), integrated power node centers (IPNC), energy storage modules (EMRG), and mission loads. Power system ratings for the modules described above have been derived from S3D report and data on the 10k ton ship study. System dynamic data not available through S3D was derived through discussion through working group. Only electrical characteristics have been considered for modeling purposes. The current iteration of the model supports power and energy management as well as fault management. The four zone SPS system describes not only system architecture and its rating but also the data required for implementation of modules, their inherent functionality, performance metrics and information regarding electrical coupling of modules, their interface features such as control signal exchange and monitoring to an external control system that is tasked to perform a specific function to SPS such as power management, energy management, fault management and so on. Detailed description and implementation of the modules is available on the ESRDC library.

Real-time implementation of the four zone SPS model has been undertaken on RTDS and Opal-RT. The Opal-RT model is capable of running with time-step size of 50 µs. Module implementation on Opal-RT platform is based on ideal system behavior and was used as a starting point for controls development and deployment for the evaluation framework. The RTDS implementation of the four zone model which also runs with a 50 µs (with portions of system running in ~2 µs time-step) consists of switching level converter based modules as well as averaged switching mathematical representation of modules. Several papers

Project Extent: This project involved multiple researchers from one several ESRDC institutions and has been documented in report [1].

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References:

[1]. Report prepared by ESRDC team, "Notional Two Zone MVDC SPS Model Implemented on RTDS". Submitted to Office of Naval Research, available on ESRDC library 2016.

[2]. Report prepared by ESRDC team, "Notional Four Zone SPS Model Description V1.0". Submitted to Office of Naval Research, available on ESRDC library 2017.

[3]. Report prepared by ESRDC team, "RTDS Implementation of SPS Model V1.0". Submitted to Office of Naval Research, available on ESRDC library, 2018.

[4]. Report prepared by ESRDC team, "Opal-RT Implementation of SPS Model V1.0". Submitted to Office of Naval Research, available on ESRDC library, 2018.

[5]. Ravindra, H., Chalfant, J., Stanovich, M., Schoder, K., Vu, T., Vahedi, H., Edringon, C., & Steurer, M. Dynamic Real Time Simulation Model of a Notional Zonal Medium Voltage DC Shipboard Power System for Controls Evaluation. Advanced Machinery Technology Symposium (AMTS), March 2018.

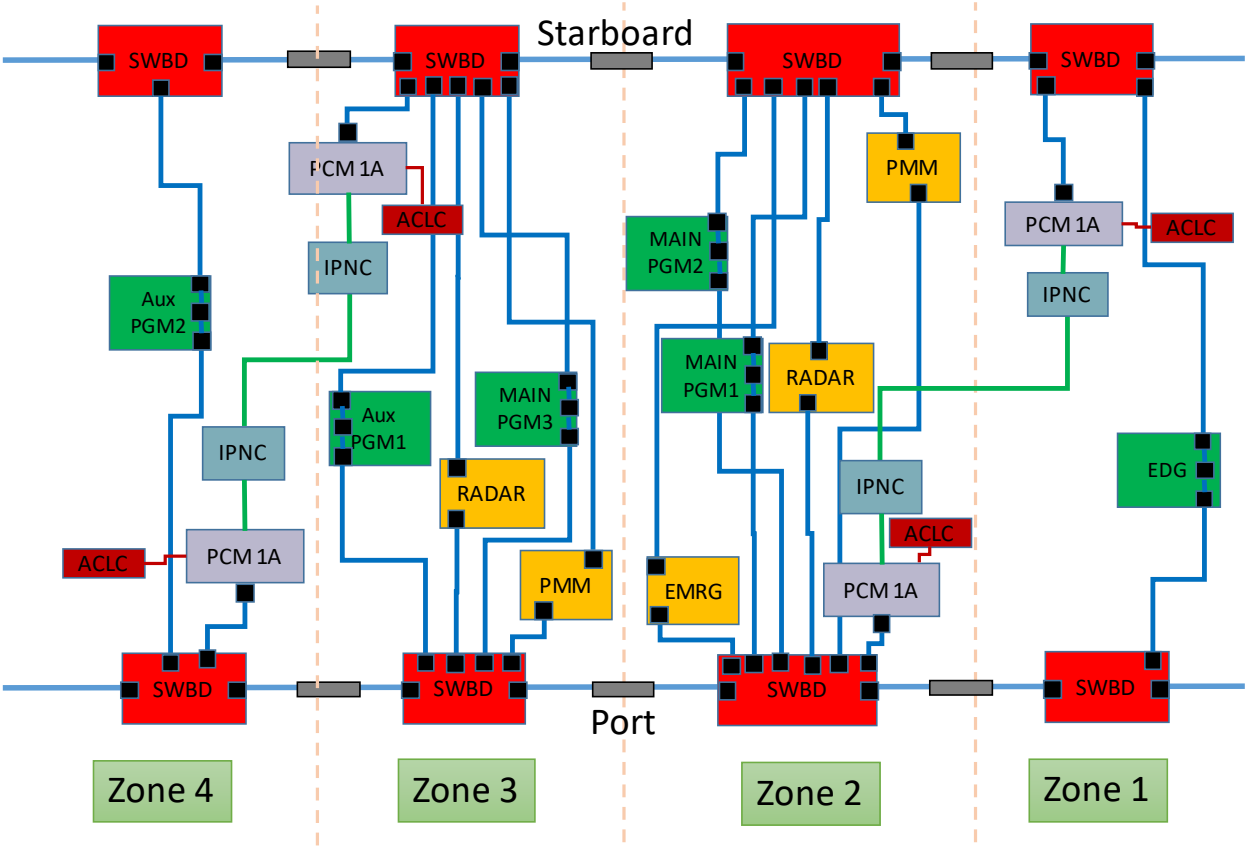
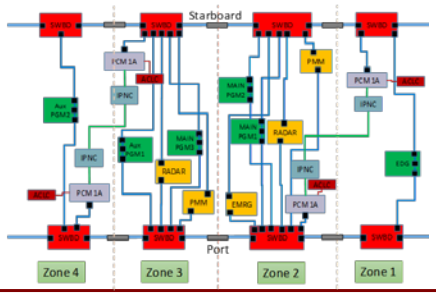


Figure 1 One-line diagram of notional four zone MVDC shipboard power system

Notional Shipboard Power System Models

Motivation

- Need to have an unified effort on developing and documentation of models for use by ESRDC team members
- Need for models that are well documented and agreed upon members of ESRDC community
- Desire to have notional ship models of various flavors that adhere to zonal architecture
- Real-time constraint based shipboard power system models implemented on various EMTP platforms by different ESRDC members



Approach

- Established a working group, 'Time Doamin Electrical Simulation Modeling Working Group' as a platform for discussion
- Electrical requirements as well as interface and communication requirements for each module in the shipboard power system model was derived and documented
- Implementation of said documented models on various EMTP platforms were achieved by ESRDC members with accompanying implmenetation of SPS model documents

Outcomes

- Two Zone SPS model developed was used for protection and fault management studies
- A four zone SPS model developed on several real-time simulators is being used by research teams in evaluating advanced control algorithms on the controls evaluation testbed
- A six zone SPS model named the IPES 1.0 is currently being developed as the benchmark SPS model for the community