A CO-SIMULATION APPROACH FOR LEGACY MODELS

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Topic: Application of general purpose or dedicated software

Abstract

The paper describes an experience on the simulation of a complex electrical plant: the all-electric icebreaker Healy of the US Coast Guard.
This project represents an interesting experience from many points of view:

- Validated data were available for comparison
- A model of part of the system was already available
- The target was to insert a legacy model in a wider and more complete simulation of the ship

As far as modeling and simulation theory is concerned, the most important problem addressed has been the analysis of a process of reuse of a legacy model and the correspondent co-simulation approach adopted.
In effect, a previous simulation experience [1] was conducted in the past focusing on the propulsion system. This analysis was performed using the ACSL platform. ACSL is a very good time domain differential equation solver but it is somewhat awkward to use for the analysis of electrical networks.
The authors decided to focus on another platform, the Virtual Test Bed (VTB) that is a circuit-oriented time-domain simulator [2].
One of the most interesting features of VTB is the possibility to interact with external solvers and in particular with ACSL. This allows the user to import an external model in the new environment [3-4].
Two separate challenges can be identified and will be discussed in detail in the final paper:

- ACSL is a signal flow simulator, whereas VTB is a circuit simulator. To use the terminology of VHDL-AMS [5], we can say that models in ACSL are connected via signal coupling, and models in VTB are connected via nature coupling connections that enforce power conservation at the interface between models.
- Electrical variables in the previous ACSL model were described in a dq coordinate frame, while variables in VTB are described in an abc coordinate frame.
Two different systems were simulated. The approach was to start from a simpler system and gradually move to a more complex one.

System 1 is shown in Figure 1. The ACSL simulation includes the diesel generator creating the high-voltage bus (block G), the cycloconverter (AC-AC block) powering the synchronous propulsion motor (block M). The propeller and the ship inertia and water resistance are modeled as well. Details on this simulation are given in [1]. In Figure 1 the ACSL simulation is left unchanged and a dq-abc transformation of the bus voltages and currents is performed to create abc bus terminals in VTB. The two distribution buses (called sensitive and non-sensitive bus) are added using native VTB models. The figure shows the motor-generator set used for the sensitive bus and the transformer used for the non-sensitive bus. Various loads are connected to the two buses.

System 2 is shown in Figure 2. In this case the ACSL simulation is "broken" at the connection between the generator and the input of the cycloconverter to allow insertion of the power cable model. Two dq-abc transformations are used to transform the ACSL terminal variables to VTB variables. The cable model is realized in VTB. The sensitive and the non-sensitive buses can be added as well with their respective cables.
The first step of the analysis has been the verification of the accuracy of the co-simulation approach. This has been evaluated in the following manner. A co-simulation was performed with the propulsion system in ACSL and a ship service load in VTB connected to the high voltage bus. Then a simulation was performed in ACSL by itself coding in ACSL the same ship service load. For simplicity an R-L load was used, so that it is straightforward to implement in ACSL. The system realized completely in ACSL was considered the reference case and results of the co-simulation were compared with results of the ACSL standalone simulation.

In the final paper the main information concerning the co-simulation algorithm will be introduced. A detailed analysis of the comparison for accuracy will be presented together with the results obtained for the final system.

The experience of this project seems to be extremely interesting for many points of view:

- Description of a procedure to interface different simulators together
- Possibility to easily manage legacy models
- Possibility to implement detailed simulation of complex system with an incremental approach

![Figure 3: The VTB model used for the accuracy test. The block on the left wraps the whole ACSL system](image-url)
Figure 4: Verification of accuracy for system 1 case. RMS generator current. Comparison of co-simulation and ACSL standalone simulation.

Figure 5: A VTB schematics where a lot of service loads have been introduced

References