Guidelines and Use Cases for Power Systems Dynamic Modeling and Model Verification using Modelica and OpenIPSL

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This paper offers systematic guidelines for modeling power systems components in the phasor-domain using the Modelica language and their verification against the *de facto* domain-specific tools trusted by the power industry. It aims to consolidate and share the authors' experience in the development of component models for the Open-Instance Power Systems Library (OpenIPSL)[1] and the approaches used to meet the high expectations of the power industry w.r.t. to the models' response. While the modeling guidelines are generic, the verification procedure includes the validation against a domain-specific commercial software tool called PSS®E, that is the *de facto* "standard" used for power system transmission planning and analysis in North America and Scandinavia.

To formalize the proposed approaches, a schematic description of the processes of model implementation and validation is elicited through flowcharts. Challenging use cases are presented to point out some of the major difficulties that can be faced in the modeling steps because of unclear/missing documentation of the models' dynamics in the reference tool. Finally, unique features of the Modelica language that allow for power system modeling and verification unavailable in traditional tools are illustrated.

An example of the difficulties faced when implementing typical power system model like those of power system stabilizers (PSSs) PSS2A shown in Figure 1. The reference software tool PSS®E comes with several manuals to help understanding the implementation and behavior of the different components present in its libraries. In some cases, like for the aforementioned PSSs models, the documentation is insufficient and not helpful to understand the behavior of one of the blocks of the models, the ramp tracking filter highlighted in Figure 1. After following the proposed guidelines, the model is verified against the PSS®E software, as shown in Figure 2, using two Modelica-tools, Dymola and Modelon's Impact. The paper illustrates the process of following the guidelines for model implementation and verification for the example above and other interesting cases that raised several challenges for their successful verification. The results from this work is a new set of verified power system component models models for the OpenIPSL library[2] that have been included in the latest versions of the library, V2.0.0 and V3.0.X, as well as future version.

[1]https://github.com/OpenIPSL/OpenIPSL

[2]Verification results can be found online at: https://alsetlab.github.io/NYPAModelTransformation/

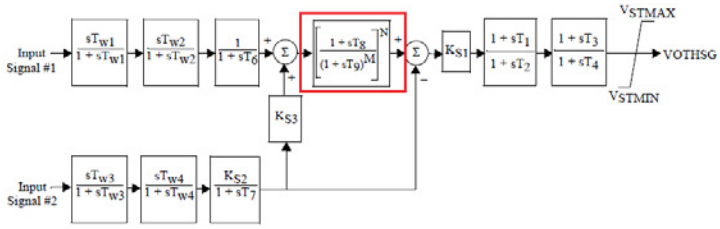

Figure 1. Block diagram of PSS2A from PSS®E manual (Siemens Industry 2013).

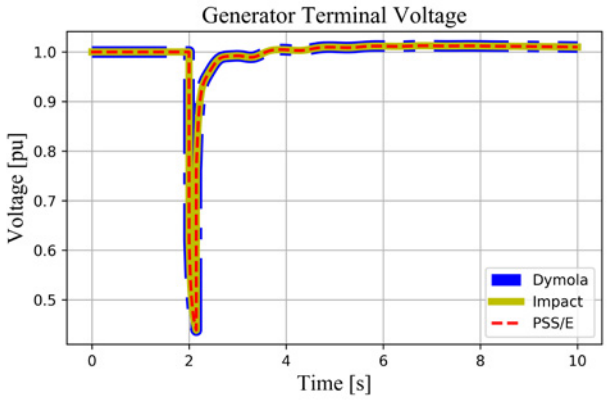

Figure 2. Generator terminal voltage being stabilized by the PSS2A model.