Power Hardware-in-the-Loop Test Bench for the Integration of Renewable and Distributed Energy Resources

An approach to design a lab-based close-to-reality testing environment for performing smart grid integration investigations

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Introduction

Power Hardware-in-the-Loop (PHIL) systems proved to provide an efficient option to perform laboratory investigations focusing on stability and operation of power systems while allowing to integrate physical hardware and related controls and to consider complex and close-to-reality scenarios. Furthermore, PHIL testing environments have the advantage of offering a close-to-reality or worst-case testing environment that enables repetitive investigations, thus de-risking field tests.

A scientifically accepted and standardized procedure on how a PHIL setup should be designed is of high general interest. International working groups (e.g., IEEE P2004 WG, ISGAN-SIRFN) and projects (e.g., Horizon 2020 ERIGrid[1] project) in the field of advanced testing methods depict the necessity for a standardized description of the design of PHIL testing environment setup, as well as for PHIL-based testing procedures.

This publication proposes a successfully implemented approach for designing PHIL-based testing environments. This suggestion will be introduced to the above-mentioned international scientific platforms to become an internationally accepted harmonized approach.

From the Design to the Execution of PHIL Experiments

For the design and the execution of a successful PHIL-based test, a process is being depicted in Fig.1 and described as follows. In the first step, preliminary research is required to understand the exact dynamics and stability of the PHIL setup. The outcome of this activity will consist of possible operational ranges of the PHIL setup related to the several used interfaces and parameter sets for the system. By considering the operational range analyzed in the first step, step 2 resides in the parametrization of the digital real-time simulation environment of the PHIL system. Step 2 can only be performed after the PHIL testing environment had been set up and it has to be repeated for every considered scenario and model.

After verifying the PHIL test setup and the real-time simulation environment, the systems' secure operation has to be checked after each rearrangement of the system (e.g., change of hardware under test, safety parametrization, etc.) and before each new test case performance, as described in Step 3.

Step 4 depicts the systematic process of adjusting the input and output signals as preparation for the final closed-loop test.

Conclusions

This publication introduces a process supporting the design and the execution of successful PHIL-based tests. This approach was developed and has been successfully implemented in the project DEA-Stabil[2]. Furthermore, it is now subjected to being accepted as harmonized common procedure within international scientific committees.

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[1] "ERIGrid: European Research Infrastructure supporting Smart Grid Systems Technology Development, Validation and Roll Out" – Grant Agreement No.: 654113

[2] "DEA-Stabil: Beitrag der Windenergie und Photovoltaik im Verteilungsnetz zur Stabilität des deutschen Verbundnetzes" (FKZ 0325585)

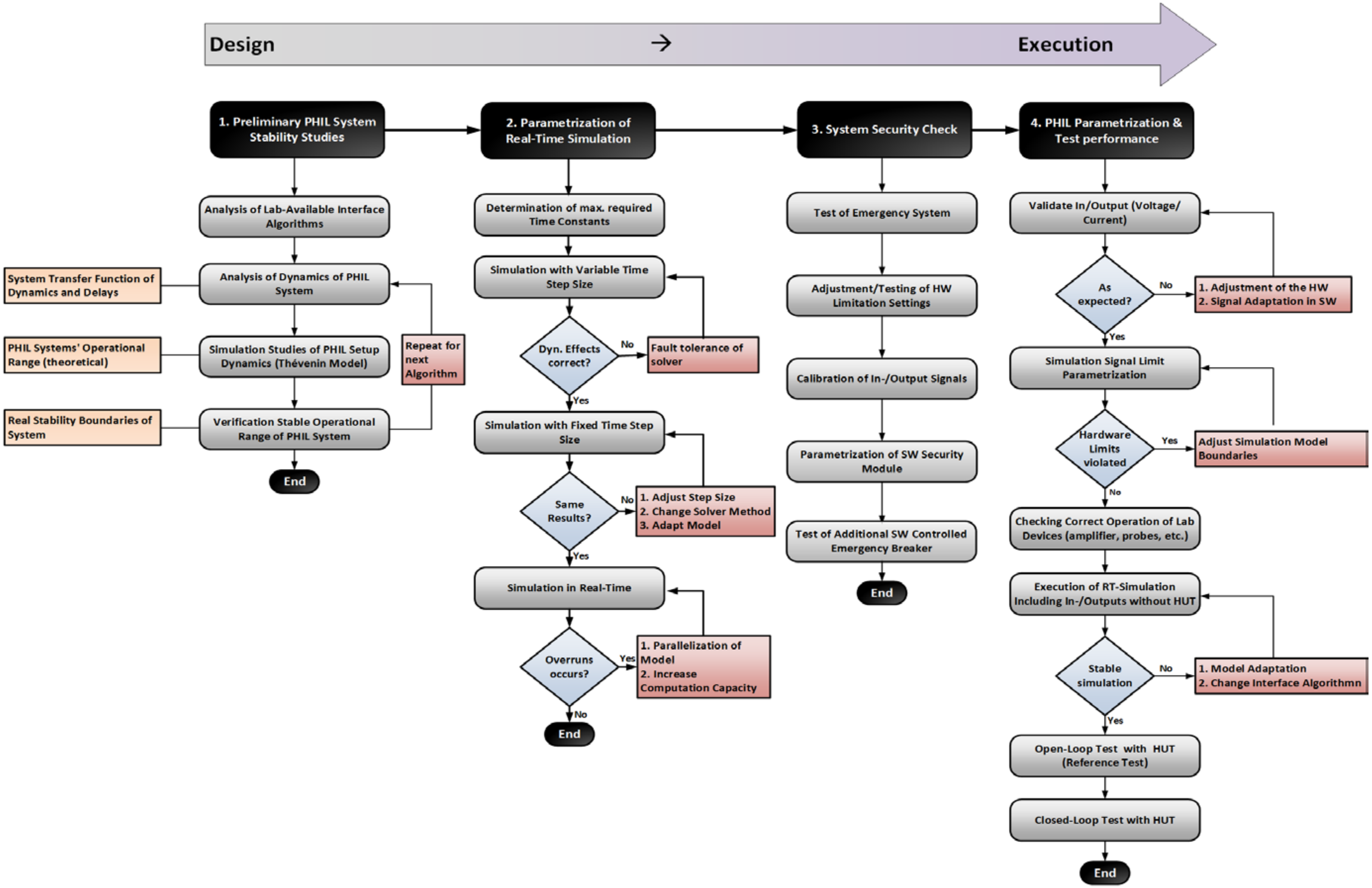

Figure 1 Process for the set-up and execution of PHIL experiments (modified from [3])

[3] Ron Brandl, "Entwicklung einer PHIL-fähigen Echzeit-Valdierungsumgebung zur Stabilitätsuntersuchung von el. Netzen." PHD Thesis, Uni Kassel, Germany 2018