OPAL-RT TECHNOLOGIES

Power System Reliability Studies & Simulations at Tenaga Nasional Berhad (TNB)

TENAGA NASIONAL

Application

- Wide Area Monitoring Protection And Control (WAMPAC)

Related Product

- RT-LAB
- ePHASORSIM
- OP5600

Type of Simulation

- Hardware-in-the-Loop (HIL)

SUCCESS STORY

INTRODUCTION | TNB

Tenaga Nasional Berhad (TNB)

Many national energy producers and distributors have research labs, since they are frequently state-owned: they thus have mandates to ensure their users receive reasonably priced and reliable power, as well as build, strengthen and expand the reaches of their grids.

Tenaga Nasional Berhad (TNB) is the Malaysian multinational electricity company and is the only electric utility company in Peninsular Malaysia--and the largest publicly listed power company in Southeast Asia. TNB Research (TNBR) has been the in-house solution provider for TNB. TNBR provides a centralized, one-stop center for technical solutions and innovation.

Backed by years of experience, TNBR is the specialist in offering technical knowledge and expertise on power system reliability and efficiency through studies and simulations. They are also passionate about ensuring outcomes from research studies that can help their customers to deliver a resilient, reliable, high quality power grid which can optimize power system operations.

OBJECTIVE

Currently, the department of Power System Reliability Studies & Simulation at TNB focuses on system planning and improvements of power system reliability and the efficiency of existing TNB systems. They use advanced power system modeling and Hardware-in-the-Loop simulation tools such as OPAL-RT's ePHASORSIM, PSS/E, DIgSILENT PowerFactory, and MATLAB SimPowerSystems. The power system study and analysis includes load flow studies, frequency stability studies, voltage stability studies and transient stability studies.

TNB faced some distinct challenges with their status quo as they planned strategically and shored up their strengths against the future.

Special Protection Scheme (SPS) systems are designed to detect power system conditions through direct detection of pre-defined contingencies that have been determined to cause unusual stress to the power system, and in response to initiate pre-planned corrective control actions to maintain the power system in a satisfactory operating state.

Development of such complex protection systems with the goal of mitigating system wide disturbances requires a comprehensive platform for closed-loop testing in a controlled environment before it can be deployed to the actual system.

The need for a suitable real-time simulator capable of simulating the large-scale power system network and its components is omnipresent, as this is essential when emulating the actual dynamic response of the power system network during the interaction with the designed protection system.

Nik Sofizan Nik Yusuf, Chief Engineer Grid of the Future at Tenaga Nasional Berhad

SOLUTION & IMPLEMENTATION

ePHASORSIM is a solution for projects that involve power system transient stability simulation. It is used in the testing and integration of EMS/SCADA systems, wide area protection and control schemes, and for training and power system studies. ePHASORSIM's solver simulates a power grid at a time-step of a few milliseconds to provide transient stability simulation analysis, such as voltage/current magnitude and angle, power transfer, speed of machines.

This unique electromechanical transient real-time simulation system enables precise simulation of large-scale networks to perform hardware-in-the-loop (HIL) testing.

With the increasing levels of inherent complexity in SPS development requirements, system-level testing for SPS became more challenging and therefore, real-time HIL simulation techniques were seen as an effective approach towards performing system-level testing in a comprehensive, cost-effective and repeatable way.

OPAL-RT's ePHASORSIM was selected over other HIL simulators mainly because of its ability to vary the simulation time-step duration. This enabled large-scale power systems to be simulated using less computing power without jeopardizing the accuracy of the simulation.

The theory behind this is that some power system phenomena like thermal overload or voltage and transient stability known as electromechanical transients (in a Phasor-type simulation), which use a simplified or averaged form of electromagnetic transient models, can perform at a larger time step compared with EMT-type simulations, thus allowing simulation of the power system with thousands of buses and generators at very high speed using just standard processors.

Most power system transient phenomena related to SPS applications can be simulated using electromechanical transient simulation engines, and thus the selection of OPAL-RT's ePHASORSIM provides greater advantage since it will reduce the cost of the real-time simulator.

SOLUTIONS & DEVELOPMENT

Implementation of the HIL testing platform for SPS included several distinct pieces of equipment:

• **Simulator Workstation:** High-end PC for modelling and interface with simulator

• **Real-time Hardware Simulator:** Perform real-time computation

• **Analog Signal Amplifiers:** Amplify simulator analog signals (voltage and current) into suitable secondary voltage and current for physical IED

• **Physical IEDs and an Ethernet network switch**

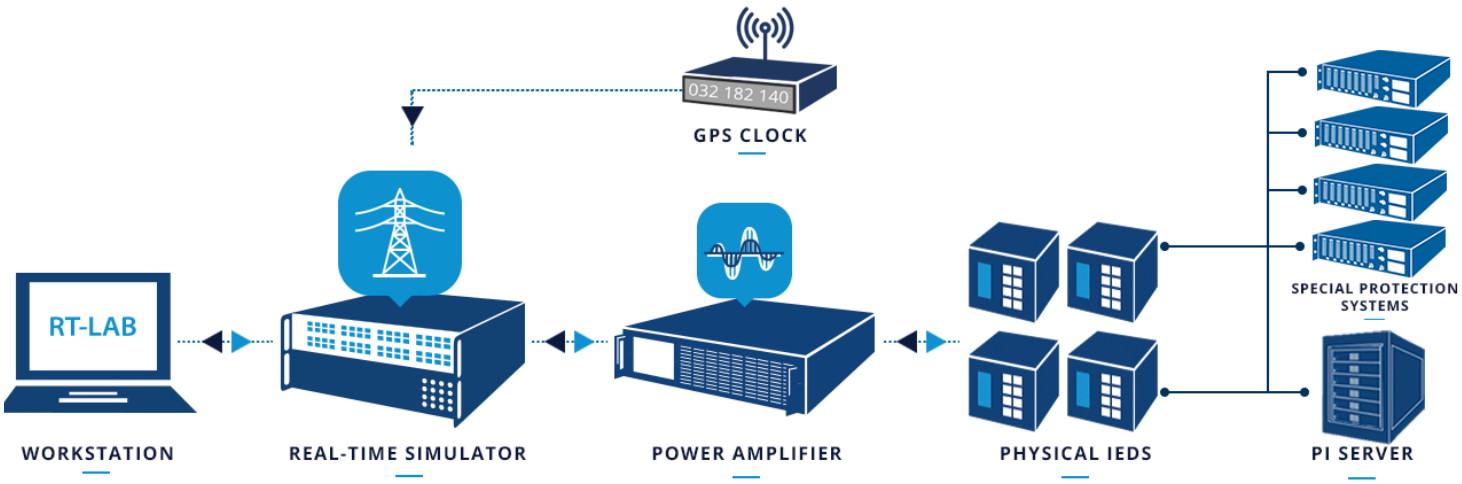
• **SPS Hardware:** Embedded system for automation and control which used to retrieve data from the simulator and perform SPS control logic algorithm called RTAP (Real Time Application Platform)

• **PI Server:** Record and archive all input and output signals in the SPS subsystem

• **GPS clock and antenna:** Time synchronization source with PMU devices

• **WAMS application:** Monitor grid response and behavior

• **SPS systems** implemented in TNB's system currently consist of 190 IEDs and 25 RTAPs



RESULTS

Generally, the HIL test system involves three main software, which are RT-LAB, ePHASORSIM and MATLAB/Simulink.

The following describes the software:

• RT-LAB is real-time simulation software that offers model-based design interacts with real-world environments.

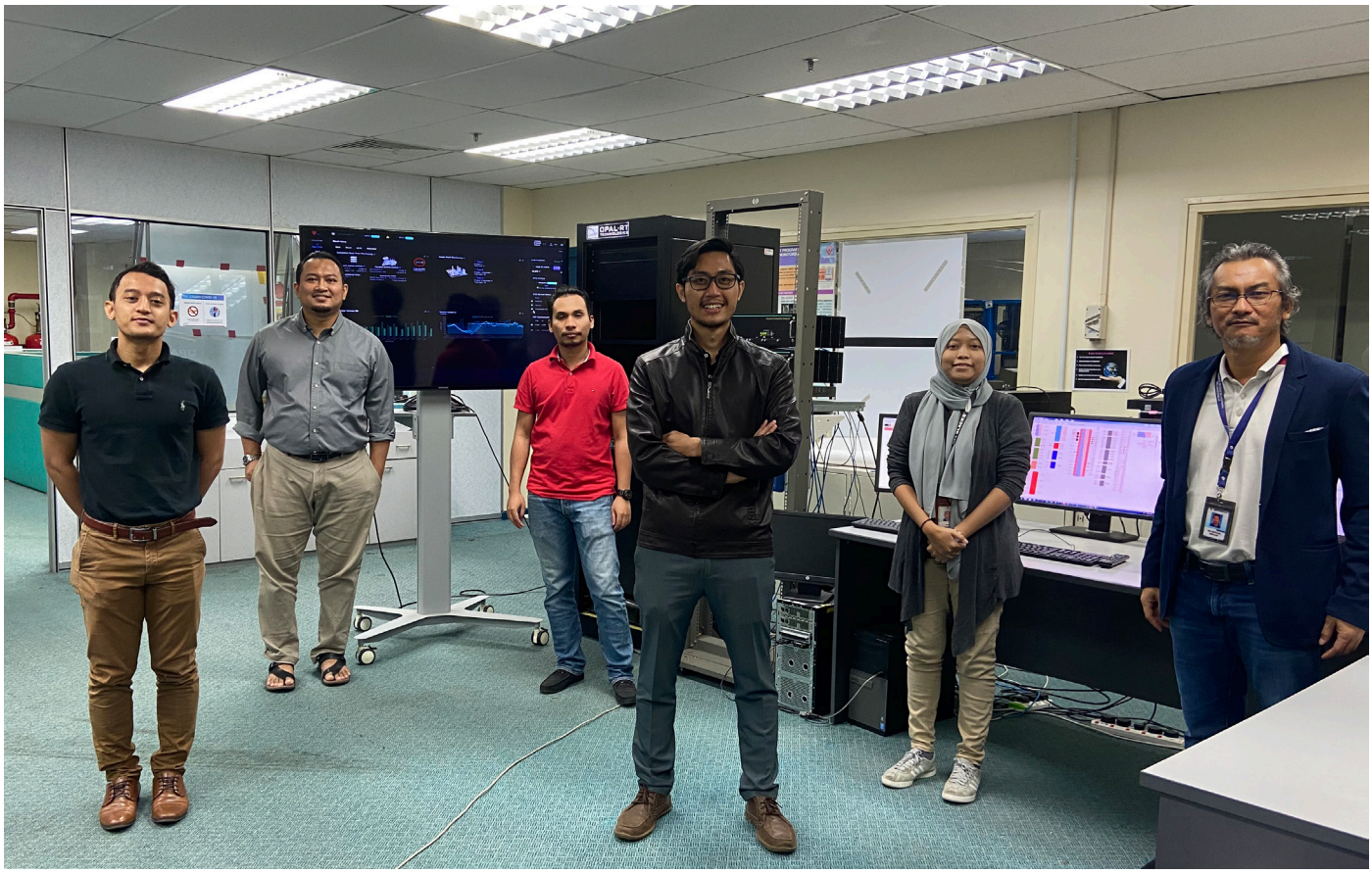
• ePHASORSIM is a phasor-domain type power system dynamic simulation tool. It performs simulation at a typical time-step in the range of milliseconds i.e., a 10 ms time-step in this HIL test system, and provides phasor voltage and current information that enables simulation of a large-scale power grid within the constraints of real time.

• MATLAB/Simulink is a graphical programming environment for multi-domain simulation and model-based design. Integrated with RT-LAB enables MATLAB/Simulink model to interact with the real-world environment.

A 1,100-bus TNB grid system is modelled in this HIL platform as a case study to verify the effectiveness of this platform in conducting the system level testing for the newly developed SPS system.

Results of the case study verified that this platform is very useful in helping engineers to test their SPS system under various grid conditions and contingencies in controlled environment.

This significantly reduces the time required to detect design issues and therefore reducing risk of design errors or hidden failures and increase the statistical confidence in the protection system.



Researchers at the TNB Research Laboratory