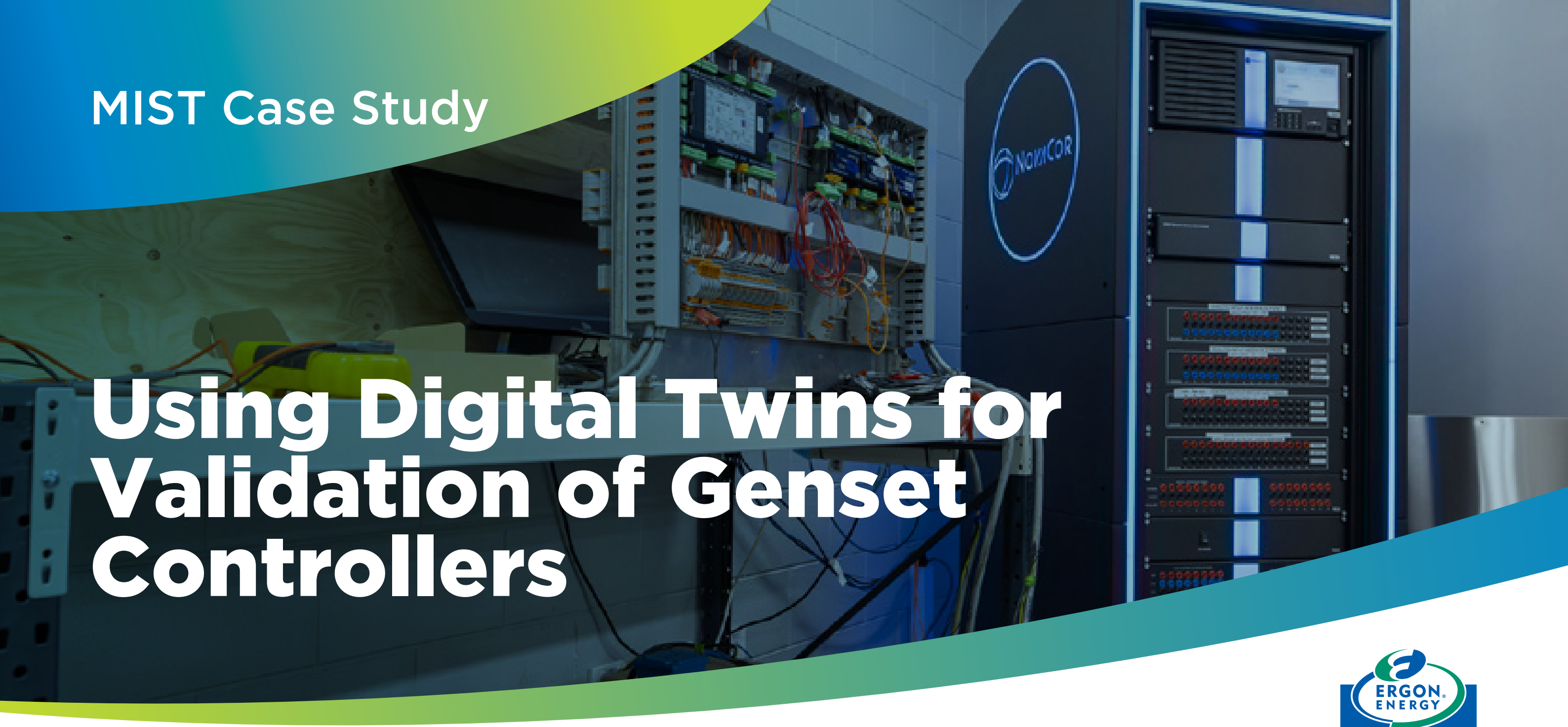

MIST Case Study

Using Digital Twins for Validation of Genset Controllers

ERGON ENERGY NETWORK
Part of Energy Queensland

The Challenge

Modern digital control systems are equipped with advanced processors, high-speed communications, and sophisticated machine-learning algorithms. These enhancements significantly expand the functional capabilities of control systems, enabling them to perform a wide range of complex tasks. However, increased functionality brings with it considerable challenges in the areas of testing and validation, particularly concerning protection mechanisms, control performance, and cybersecurity.

Traditional devices were typically designed to perform a limited number of well-defined and robust functions. In contrast, today's microcontroller-based systems are capable of executing intricate and, at times, non-intuitive decision-making schemes. Examples include advanced optimisation routines and neural network-based controls. Such complexity often falls outside the scope of standard testing methodologies, which struggle to effectively address and validate these modern approaches.

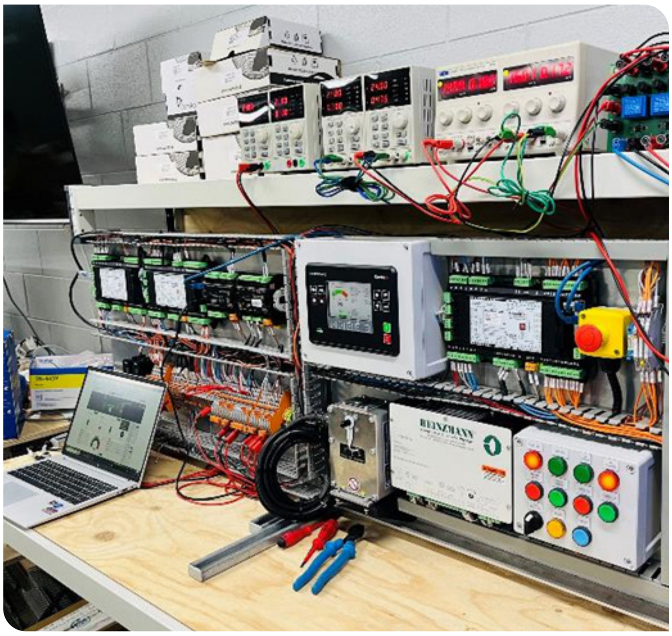

Figure 1: ComAp controller HIL test bench.

Our Approach

To verify the performance of generator controllers, we implemented a black-box testing methodology that utilises the Real-Time Digital Simulator (RTDS) in conjunction with hardware-in-the-loop (HIL) techniques. This strategy allowed a range of different generator operation scenarios to be simulated to confirm the response of the physical controllers.

The RTDS was programmed to provide a digital twin of a diesel generator that included all required digital and analogue inputs/outputs for sensors such as temperatures, pressures and level floats. This approach enabled accelerated testing cycles, maintained the integrity of system dynamics, and provided an efficient pathway for integrating emerging technologies into existing legacy systems.

To perform the HIL testing, a specialised platform for validating ComAp controller performance and subsequent controller firmware updates was developed as shown in Figure 1. This environment allowed for dynamic and automated testing of the ComAp controllers in a controlled environment without needing to subject physical diesel generators to the range of fault scenarios being tested.

This supported real-time fault simulation and autonomous data logging. Data was captured and analysed automatically to enable streamlined testing procedures and reduced likelihood of human error as shown in Figure 2.

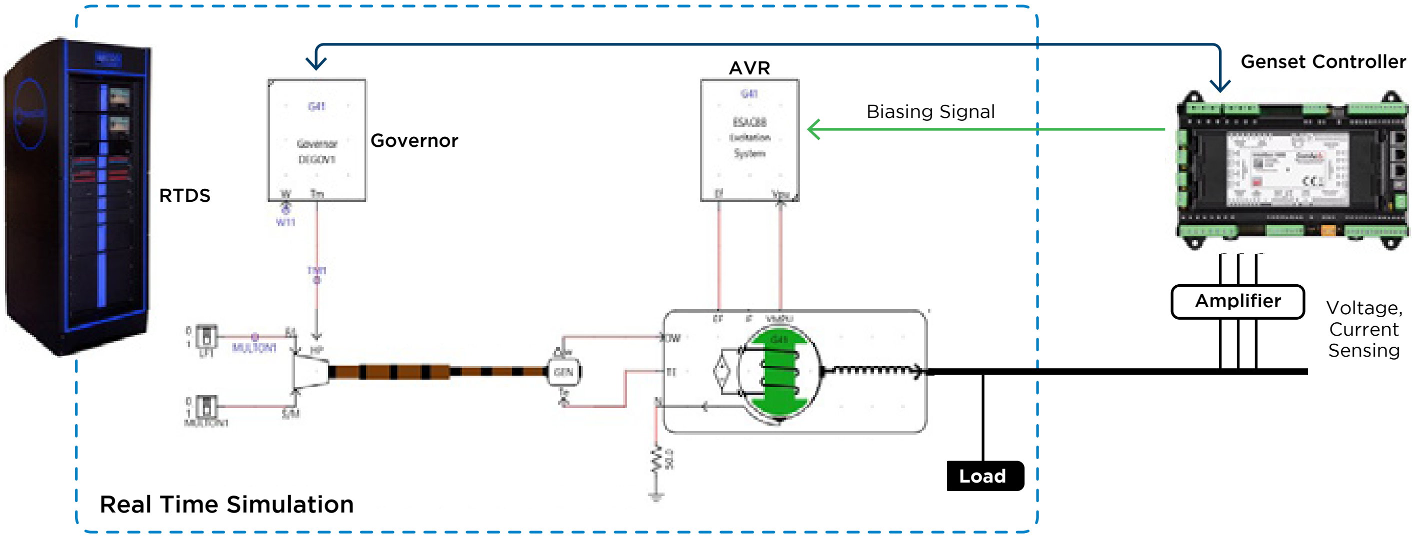

Figure 2: Snippet of RTDS logic for generator control.

Test Results and Analysis

Type testing of the generator controller confirmed consistent and dependable performance across a wide range of fault and load conditions. The testing process utilised high-resolution data captured via RSCAD plots, alongside automated analysis carried out using Python-based tools. This combination facilitated clear and effective visualisation of test outcomes. Live monitoring and control window were also used to perform the protection tests and to verify the required warnings/alarms were raised within the desired timeframe. An example of this is shown in Figure 3.

Automated Pass/Fail assessments were systematically applied to critical operational scenarios, including emergency shutdown procedures, overspeed and underspeed events, frequency deviations, synchronisation failures, and a variety of power management events. This approach ensured that any unexpected behaviours could be rapidly identified and addressed, supporting thorough and efficient validation of controller reliability.

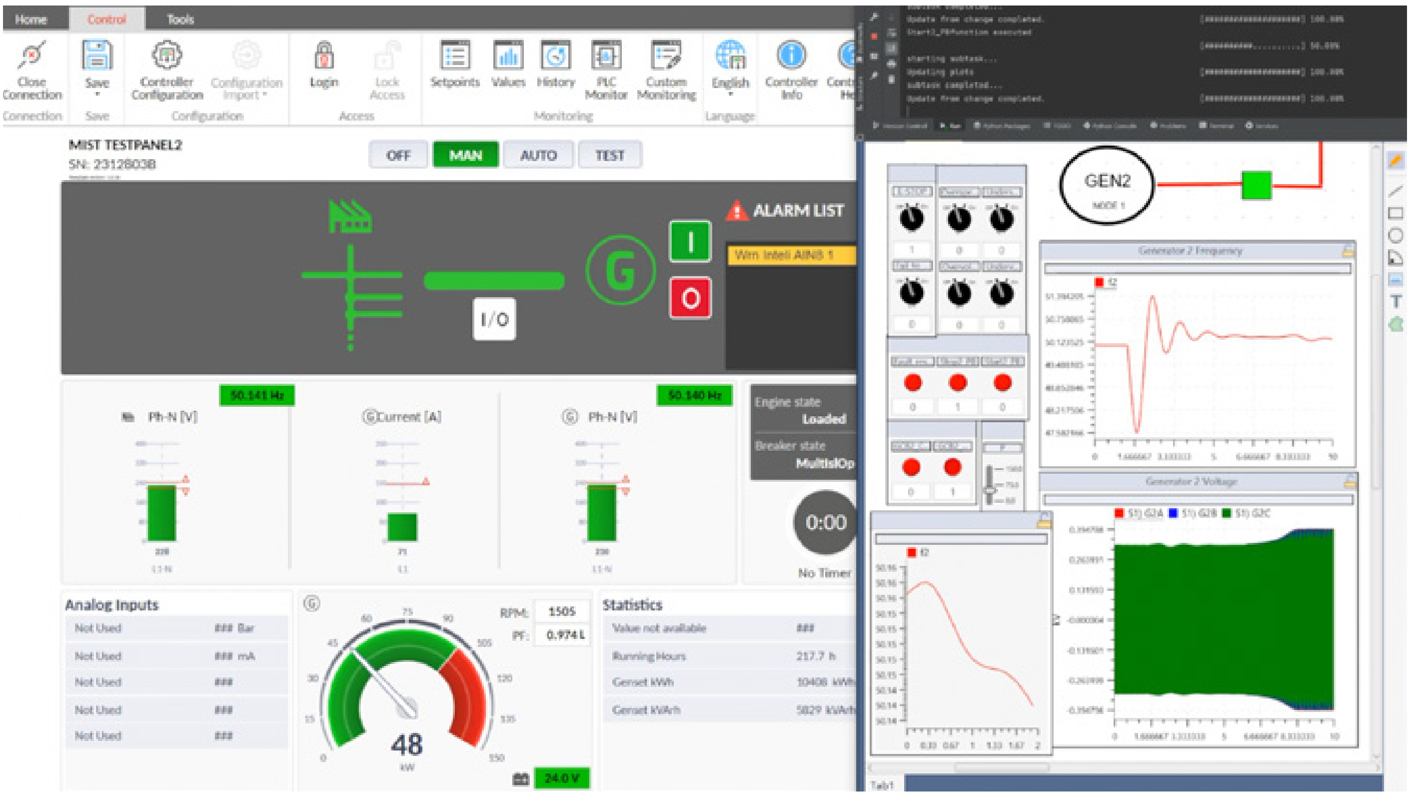

Figure 3: ComAp controller's response to an analogue input warning generated by the RTDS.

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