OPAL-RT TECHNOLOGIES

POWER CONVERSION & HIL SIMULATORS KEEP THE GERMAN TRAINS ON TIME

GE VERNOVA

Application

- Railway

Related Products

- RT-LAB
- eHS | FPGA-based Power Electronics Toolbox

Type of Simulation

- Hardware-in-the-Loop (HIL)

SUCCESS STORY

INTRODUCTION

Heading Bravely Forward into the 'Green' Revolution

Intriguingly, and perhaps as a demonstration of how larger companies can address both the multi-faceted and inter-related concerns of de-carbonization and forward-looking sustainability for the 21st century, **GE Vernova's 12 lines of business (shown below)**—operating across 140 countries—share a primary focus on **researching**, **managing**, **setting up**, and **running digitally-hosted renewable energy and carbon reduction businesses**, as well as **R&D labs of various types**.

In an encouraging and surprising nod to the wide variety of energy forms to come, GE Vernova is responsible for helping in one way or another with a staggering **30% of the world's electricity generation**; has **over 54,000 wind turbines installed in over 50 countries;** and invests about **1 billion in advanced research**.

GE VERNOVA'S 12 LINES OF BUSINESS

ONSHORE WIND

- 7GW of ONW reduces our carbon intensity 1 g/kWh
- Repowering extends life and improves capacity factor of aging wind farms

OFFSHORE WIND

- 5GW of OFW reduces our carbon intensity 1 g/kWh
- Higher capacity factors get more TWh per unit of capacity

LM WIND

- Blade technology vital to higher capacity factors
- Two-piece blades reduce transport logistics (and associated indirect emissions)

HYDRO POWER

- Efficiency upgrades increase TWh of zero-carbon hydro
- Pumped storage projects enable greater variable renewables

GAS POWER

- 8 MTPA of CCUS reduces our carbon intensity 1 g/kWh
- 8GW of peakers upgraded to 100% H_2 reduces our carbon intensity 1 g/kWh

NUCLEAR POWER

- 3GW of SMR reduces our carbon intensity 1 g/kWh
- Refueling and life extensions enable more TWh of carbon-free power

POWER CONVERSION

- Enables decarbonization of mission-critical industrial applications
- Off-grid microgrids enable low-carbon solutions in remote locations (Ports, FPSO, Mines)

GRID SOLUTIONS

- Enables necessary grid expansion, stability and flexibility to renewables growth in the power system
- Grid-tied microgrids enable resilient, decentralized low-carbon power islands

STEAM POWER

- Upgrade/extend life of nuclear plants and maintain a largely renewable industrial fleet in the Americas
- Support global customers with best-in-class services including end of life as they transition away from coal

DIGITAL

Software that:

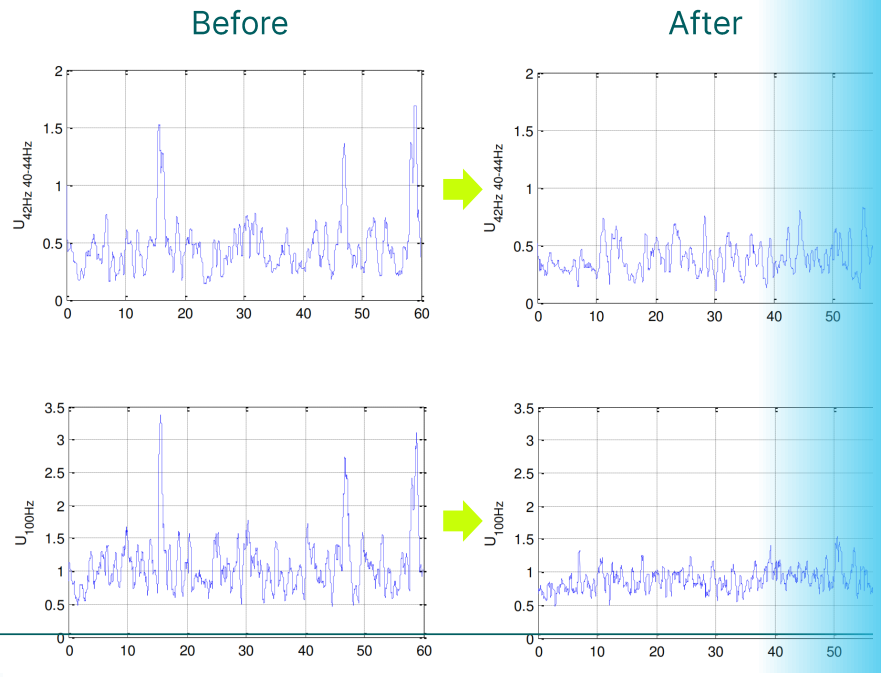
- Orchestrates a secure, cleaner energy grid
- Accelerates the transition to zero- and low-carbon energy resources
- Reduces emissions & waste today through efficiency insights

SOLAR & STORAGE SOLUTIONS

- Batteries and hybrids extend dispatch of renewables enabling reduction of fossil generation for short-durations
- Refueling and life extensions enable more TWh of carbon-free power

FINANCIAL SERVICES

- Financing and securing tax equity are key enablers for zero-carbon projects
- Project development and carbon monetization schemes vital to early carbon capture demonstration pilots



"I was asked if I had some cost-benefit ratio for this, but what it comes down to is this: a Hardware-in-the-Loop simulator costs money, but the need to deliver fast and exactly right [in terms of budget and compliance] supersedes anything else."

Dominik Hofmeyer of GE Vernova

HIL USE CASES

Abundant Test Benches for Abundant HIL Use Cases

All power converters rely on advanced controllers, and all these controllers must be **set up, tested, re-tested, supported and maintained using HiL platforms**. Power Conversion Germany, through their Berlin offices, operates a total of **20 test benches fed by 10 kV**, of which 3 Motor, 4 High Voltage, 2 High Current and 11 Low Voltage test benches.

Additionally, they can handle **three separate and distinct HiL applications professionally and on behalf of their clients**:

1

DIGITAL TWIN

Where a fixed, unchanging, and maintained exact digital replica (made of a model, controller, and real-time simulator) of the customer's on-site setup is maintained for customer support purposes, to be able to spot, diagnose, correct, and re-test issues before and as they arrive

2

REGRESSION TESTING

Where upgrades and/or changes are made, and when it is then tested whether these upgrades/ changes enable the customer to continue with 'business as usual', or whether further configuration and testing is required

3

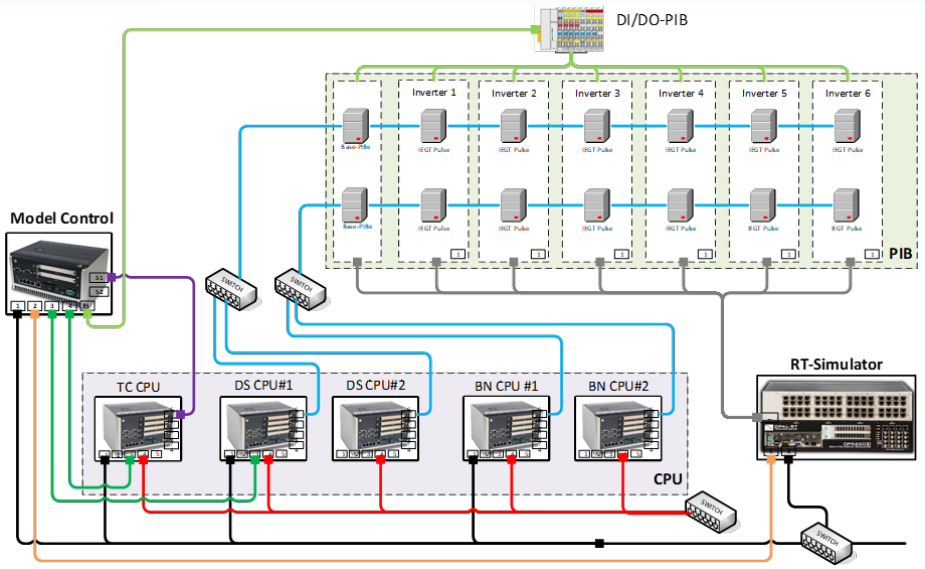
CUSTOMER FAT (FACTORY ACCEPTANCE TEST)

Where specific benchmarked requirements are made and must be tested, frequently because of a purchase, upgrade, installation, to make the proof of concept that the gamut of promised functionality can be delivered

TESTING

Testing the Catenary Supply Medium Voltage SFC

When trains run on time, it does not happen by accident; a plethora of engineers toil in the background to keep things running smoothly as much as possible, and GE Vernova – Power Conversion engineers make no exception. Their **MV7308 stacked converter** consisting of **6 converters of 19 MVA** each, switching at 150 Hz, is controlled by no less than **5 embedded CPU controllers** and **14 FPGA controllers**, having a total of **116 analog inputs** and **126 IGBT firing signals**. This highly complex controller architecture **necessitates extensive testing capabilities** that can fortunately be found in OPAL-RT simulation systems.



Electromagnetic Compliance (EMC) Testing

The test case at hand involves by necessity the **prevention of EMC interference with train detection systems**. In Germany, EMC is the subject of safety certification by the Federal Railway Authority, the governmental body responsible for trains.

Where **tests were typically executed on real-size test trains, a time consuming and expensive procedure** that needs to be planned a year in advance, more and more customers are working on replacing measurements of traction currents by output voltages, simplifying the overall setup. Nevertheless, **very high precision** is required in measurements as calculated limits on **resonant frequencies can be in ranges as low as a few volts on a 15 kV catenary line**. This is achieved by combining a sampling frequency of 200 kHz, several filters and a window-based RMS calculation including overlapping. And all this needs also be **modeled in the real-time simulator** as well.

Since in Germany (and many other countries) transportation systems are **highly regulated** for reliability and safety, when a flaw is found, it must be **diagnosed and fixed immediately and on-site**, allowing **little to no flexibility for down time**.

"You want to do a controller revamping, and you have a hard-earned certification; you don't want to lose this same certification, so you must guarantee in some sense that before and after it behaves the same. This is what we typically do."

Dominik Hofmeyer of GE Vernova

When Performance Index Spikes are Detected...

From the time when a performance index spike is indicated, engineers have a grueling and challenging **10 days** to perform **all diagnostic steps required to get everything back up and running**. These steps are performed in sequence and as follows:

DIAGNOSTIC STEPS

1. **REPLICATE THE SPIKE ON AN HIL SYSTEM**
2. **IDENTIFY THE ROOT CASE OF THE ANOMALY**
3. **IMPLEMENT THE FIX AND PERFORM REGRESSION TESTING**
4. **SITE RECERTIFICATION** * required before everything is considered fixed—and without HiL, is costly and time-consuming

All this could be achieved **within less than 10 days** thanks to the **HiL simulator**, what would have otherwise been **over half a year with offline simulation only**.

CONCLUSION

How HiL Simulation Transformed GE Vernova's Development Process

The implementation of Hardware-in-the-Loop (HiL) simulation has proven to be a transformative solution for GE Vernova, significantly **enhancing their ability to identify and resolve issues** in a **timely manner**. The efficiency gained from this technology allowed the team to **pinpoint the root causes of field challenges in less than the stipulated 10 days**, demonstrating a remarkable improvement in issue resolution time.

The integration of new tests into the regression testing process showcases the newfound knowledge and insights derived from HiL simulation. This not only **fortifies the product development lifecycle** but also ensures a proactive approach to **addressing potential issues before they impact end-users**. The acquired expertise has become an invaluable asset, contributing to a **more robust and reliable product development strategy**.

Moreover, the success with HiL simulation has translated into an **increasing number of projects for GE Vernova**, leading to a **growing backlog of HiL testing initiatives**. This surge in demand is a testament to the **efficacy of HiL simulation as an essential component of control development and the overall product lifecycle**. The simulator's capabilities have not only addressed existing challenges but have positioned GE Vernova as a leader in innovative testing methodologies.

"You can run whichever tests you want; you can do hundreds or thousands, and it's never enough. Issues will absolutely occur and what you must do is to replicate them in a HiL simulator. If you don't have one, you're lost—that's for sure."

Dominik Hofmeyer
of GE Vernova