Review of Recent New Developments for the RTDS Simulator

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Agenda

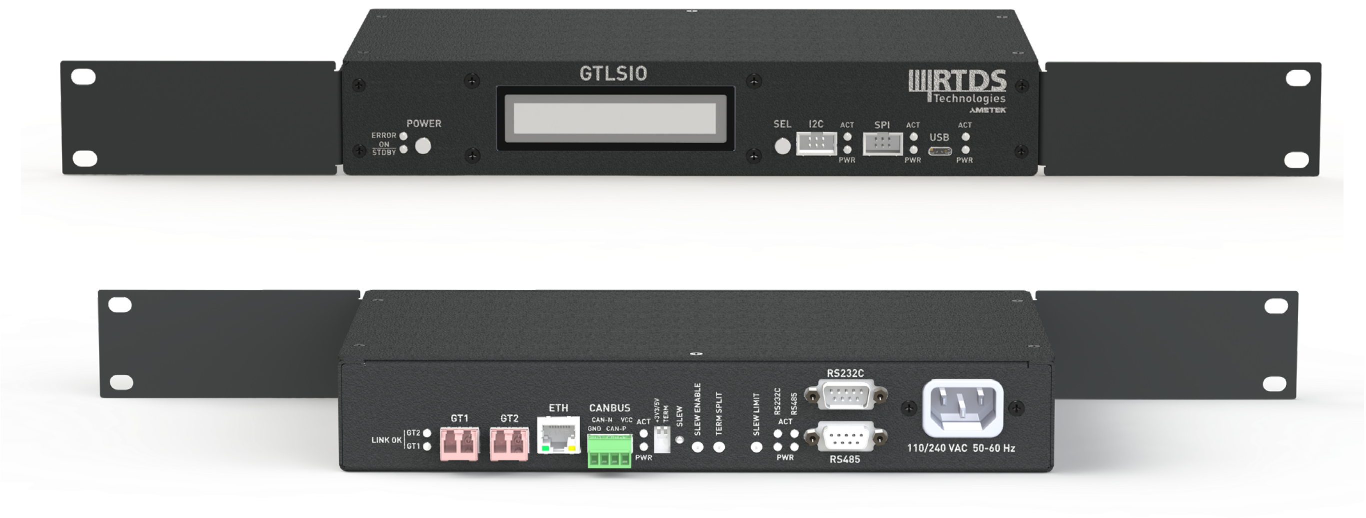
- Serial communication I/O device (GTSIO)
- Transient Stability Assessment (TSA) feature
- IEC 61850 Merging Unit
- Parallel Redundancy Protocol support
- Embedded MMC HVDC Models
- Blackbox modeling with the GTSOC
- Universal Converter Model (UCM)
- RSCAD FX Enhancements
- Questions

Not in Scope

- New Python scripting functionality
- Frequency scanning tool
- NovaCor Light

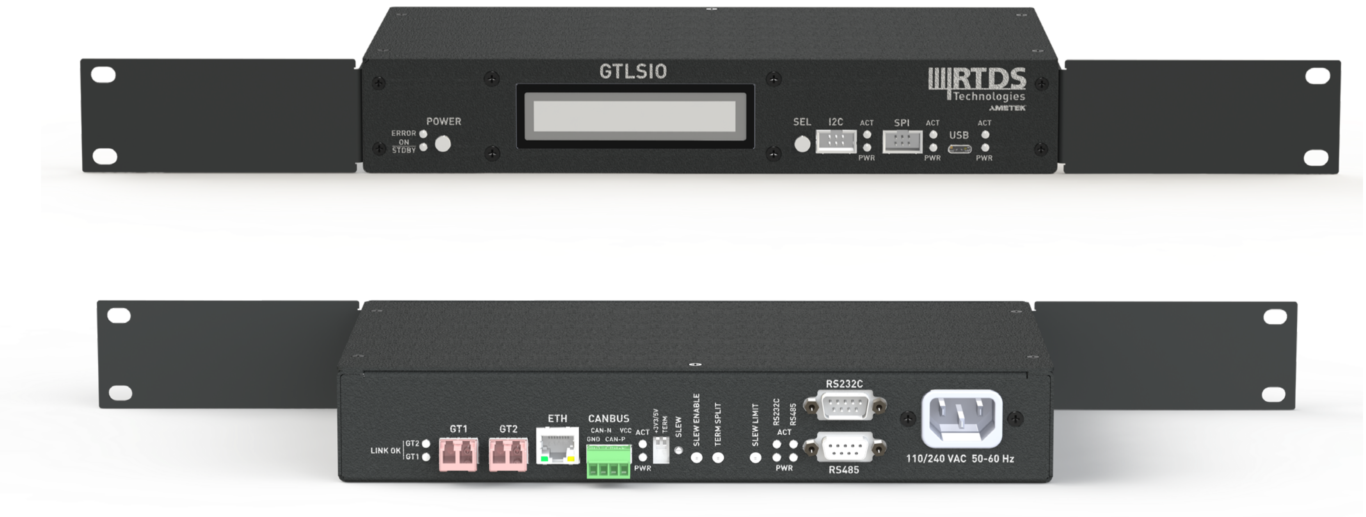
Under Development - GTSIO

- A new serial communication I/O card is under development
- Card will support
  - CAN
  - RS232-C
  - RS485
  - USB 2.0
  - I2C
  - SPI
  - Ethernet (UDP) protocols



Under Development - GTSIO

- 19” rack mounted
- Powered by standard wall outlet
- Connection to NovaCor chassis with fibre cable



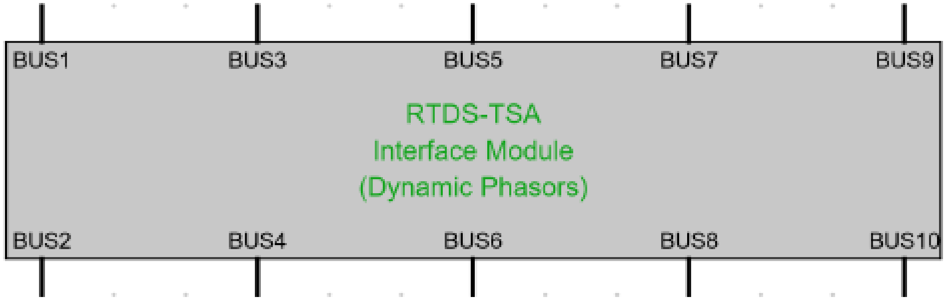
Transient Stability Analysis (TSA) module

- TSA
  - To determine the stability of a power system in phasor domain.
  - Simulate much larger networks than EMT

- TSA module in RTDS intended to:
  - Represent a portion of a larger power system (up to ~2000 buses)
  - Interface TSA module with EMT simulation (co-simulation/ hybrid simulation)
  - Standalone TSA simulation also supported.

- TSA module in RTDS is not intended for performing studies inside TSA environment.

Transient Stability Analysis (TSA) module



- Minimum requirements:
  NovaCor hardware, RSCAD FX 1.4
- PSS/E data files are required as input
- To interface the TSA module to an EMT model, an interface module based on Dynamic Phasors (DP) is available in the RSCAD library. A GUI named “RTDS-TSA Setup” is available to initialize the TSA in RTDS.
- A maximum number of EMT-DP interface buses allowed is 10, and the maximum number of DP-TSA interface buses permitted is 15.
- Large power systems can be partitioned and simulated using multiple TSA units. Up to four TSA units can be connected using the DP interface component.

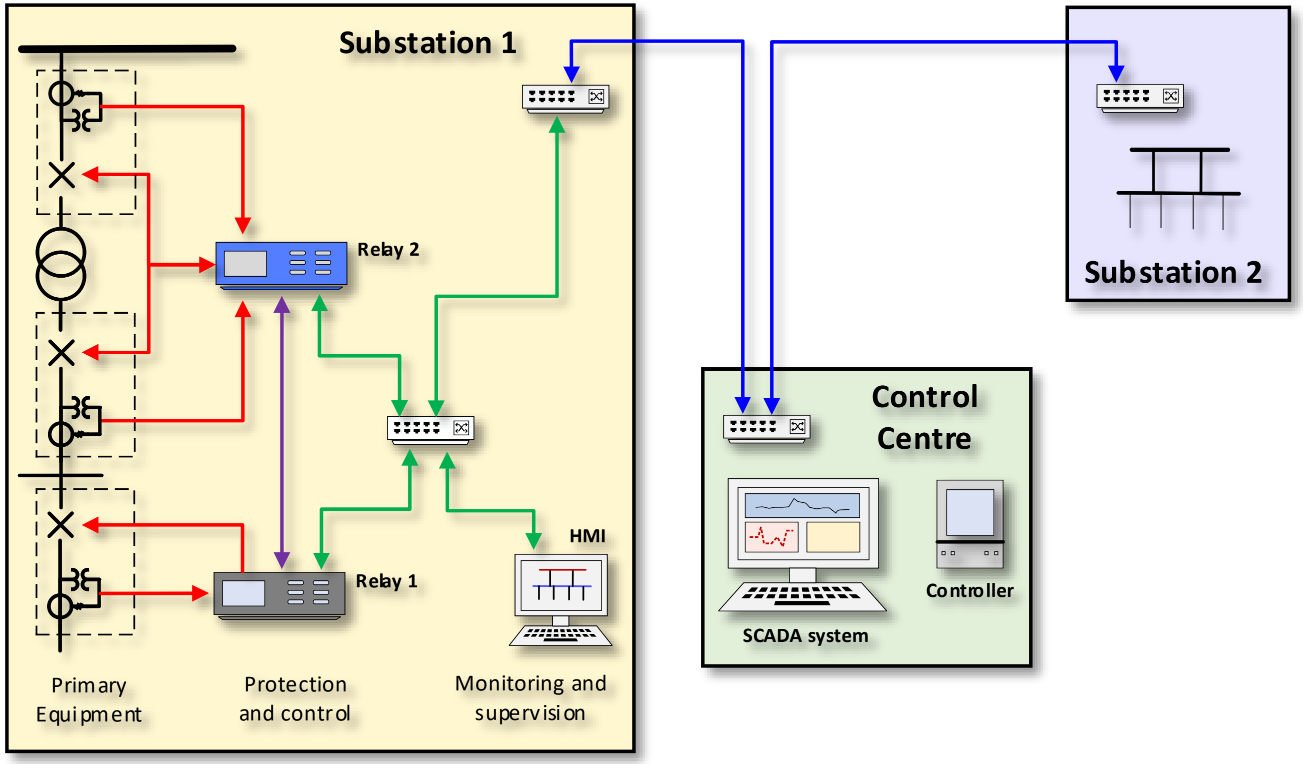
NEW FEATURE: ENHANCED NON-REAL TIME SIMULATION

New feature available on NovaCor 2.0

- **Enhanced simulation capacity** when using non-real time simulation
  - 3000 Load Units PLUS 300 nodes per core (approximately 10 times real time capacity)
  - Execution time per timestep is minimum 200μs, regardless of load
  - Execution time will automatically adjust above 200μs to accommodate load

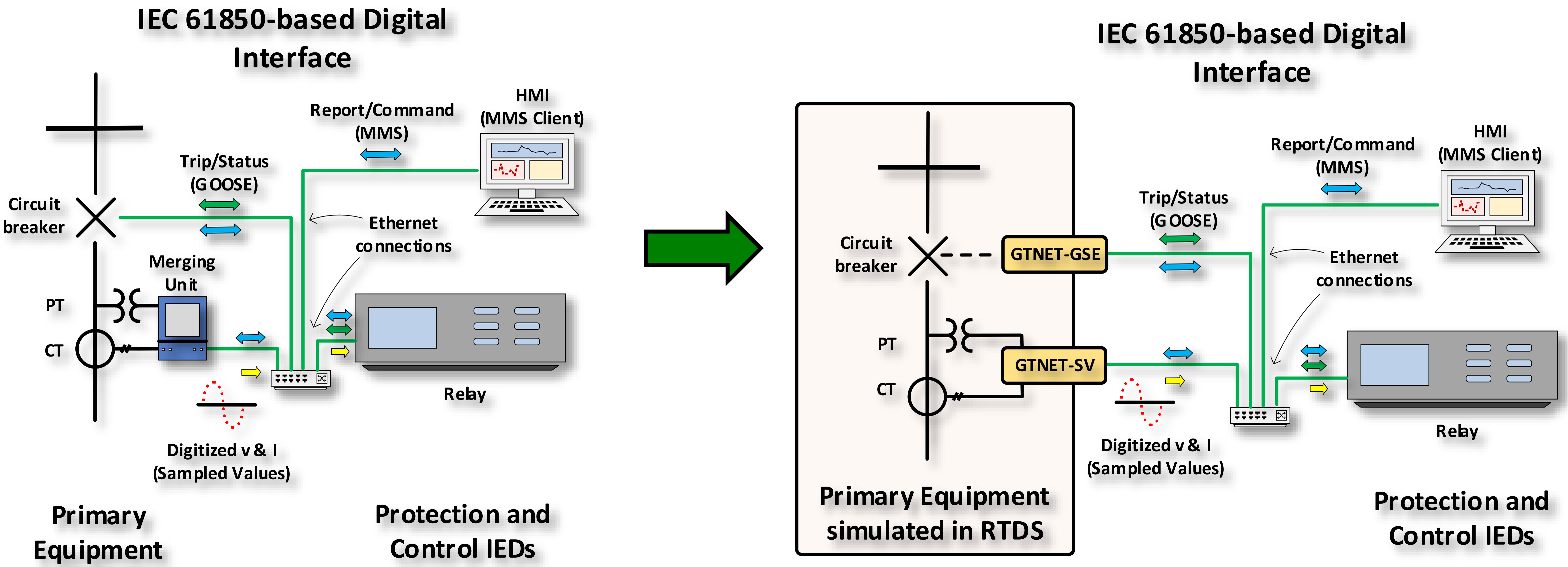
IEC 61850 MERGING UNIT

- **Information Exchanged in Power Systems**
  - Instantaneous measurements
  - Trip/status signals and alarms
  - Control commands
  - Phasor measurements
  - Communication-aided protection



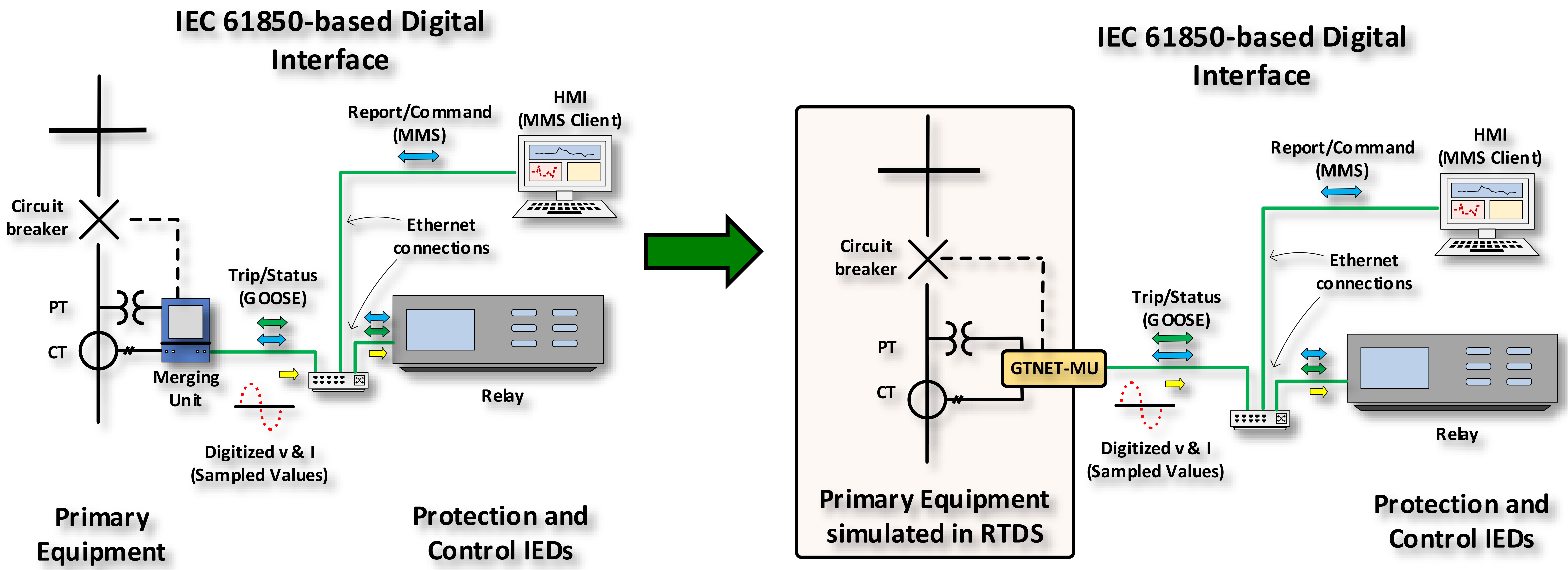
IEC 61850 MERGING UNIT

GTNET-SV / GTNET-GSE



IEC 61850 MERGING UNIT

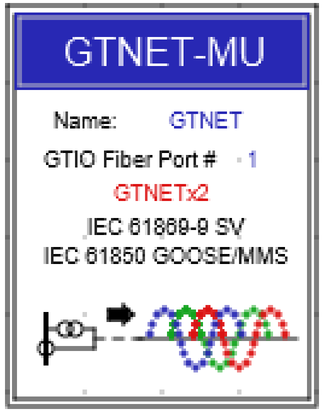
GTNET-MU



GTNET-MU

- GTNETx2 hardware already supports IEC 61850 GOOSE, SV and MMS functionalities
- GTNET-MU implementation provides the GOOSE, SV and MMS simultaneously, mimicking the operation of Process Interface Units

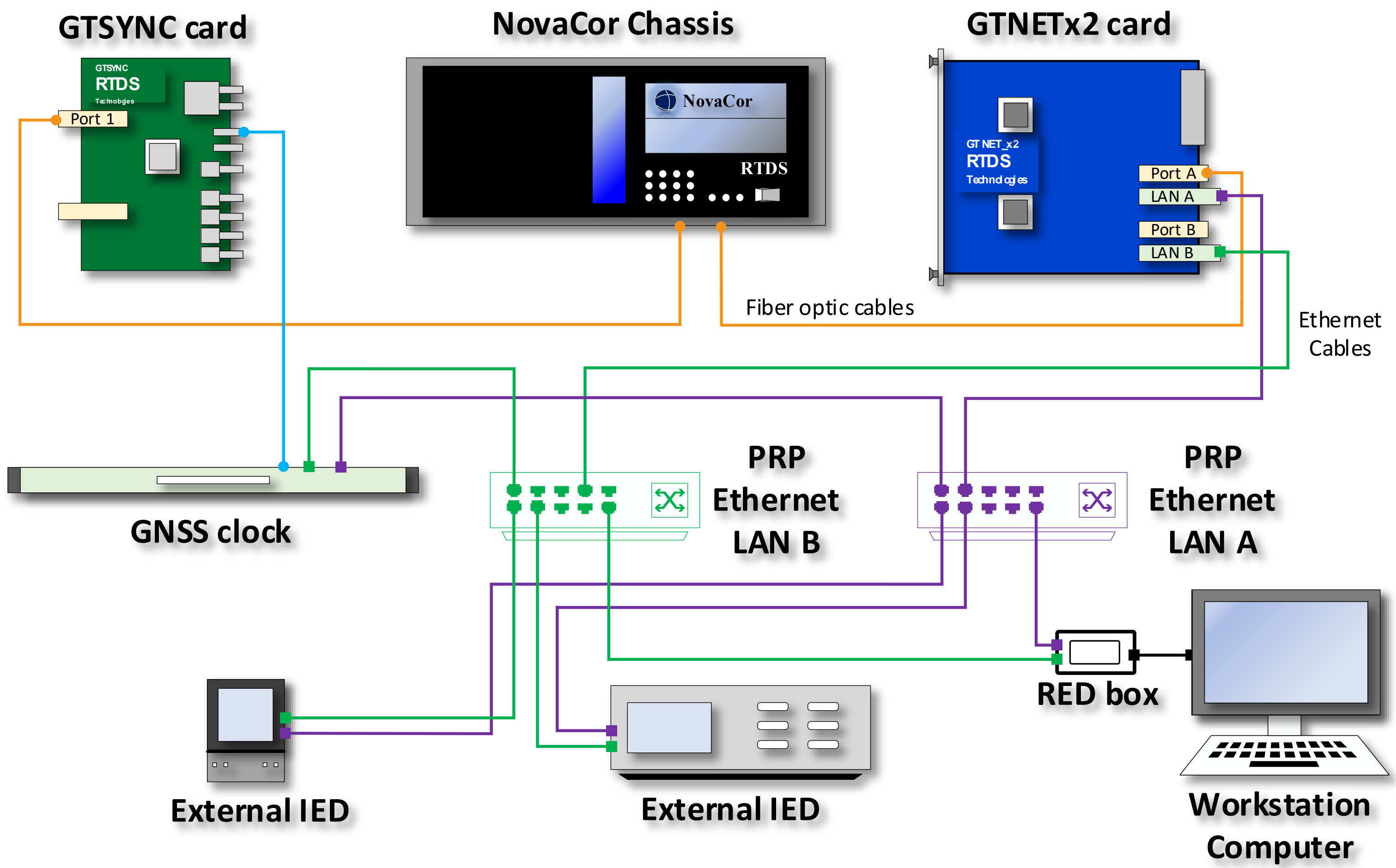
- **This integration allows our users to minimize the use of GTNETx2 hardware and reduce the required no. of Ethernet connections**
  - Save money
  - Save space



PARALLEL REDUNDANCY PROTOCOL

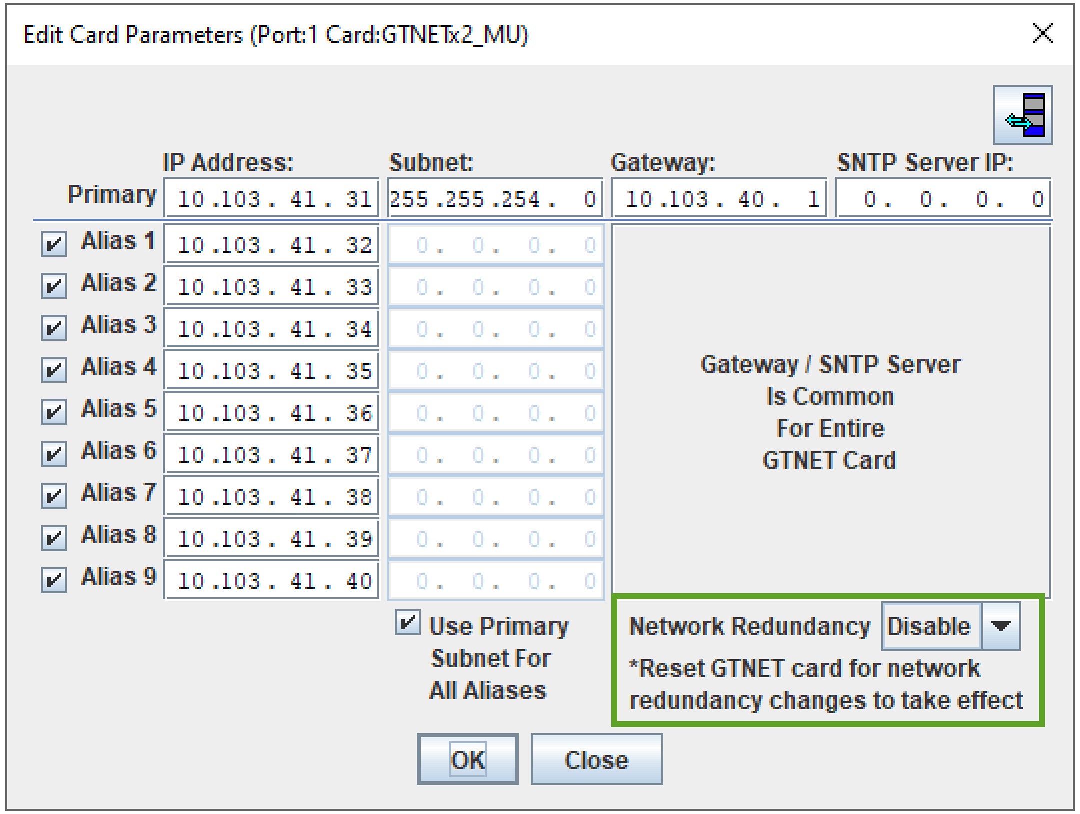
- **IEC 62439-3: 2016 defines Parallel Redundancy Protocol (PRP)**
  - Provides **zero** recovery time for time-critical applications
  - Uses two independent parallel networks of any topology
    - Duplication of the network: LAN A and LAN B
  - Network may contain normal switches (except for IEEE 1588 or IEC/IEEE 61850-9-3 PTP, which requires special switches)
  - Data frame last 16-bit tag identifier: 0x88FB
  - Each PRP node sends periodic (typically every 2 s) supervision frames

PRP CONNECTION OF GTNETx2 CARD



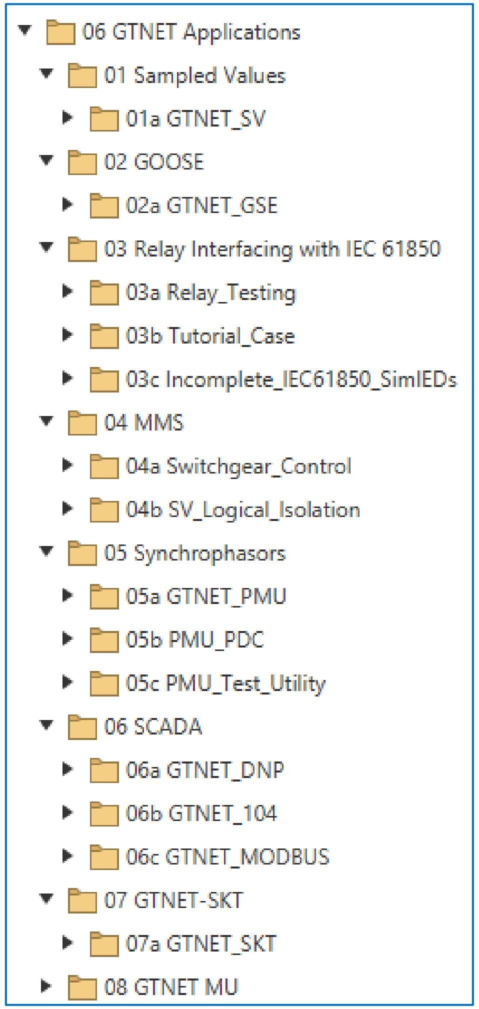
PRP SUPPORT GTNETx2 FIRMWARE FEATURES

- Supports all 9 GTNET protocols
- Requires **entire GTNETx2 card**
  - Both Ethernet LAN transceivers of a GTNETx2 card to obtain two redundant network connections (LAN A and LAN B)
- In order to enable network redundancy support, select the "**PRP**" option under "Network Redundancy"



NEW TUTORIAL AND EXAMPLE CASES

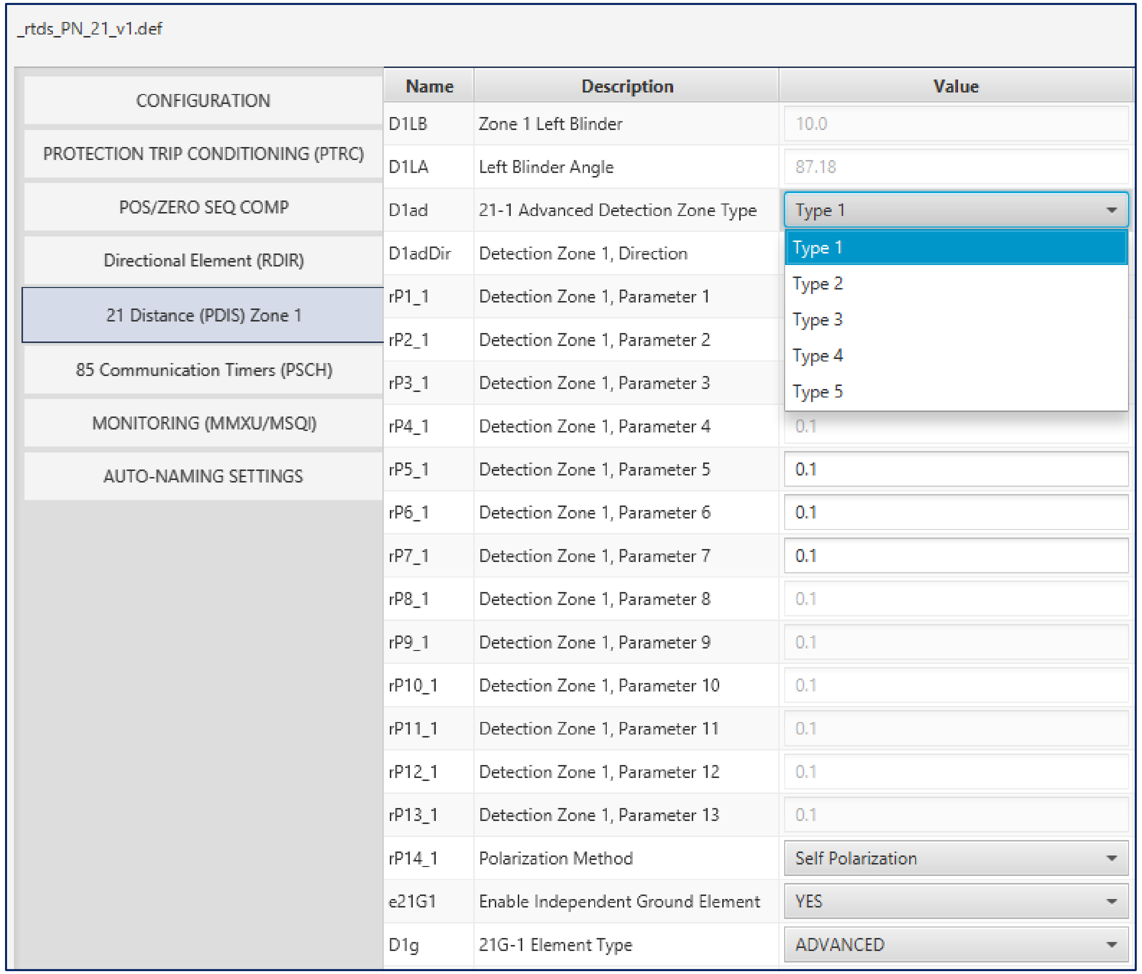
- **Protection Examples**
  - Generator Protection
  - Series-compensated Line Protection
  - SSO Protection
- **Automation Tutorials/Examples**
  - GTNET Tutorials - comprises a set of new tutorial cases that systematically present the process of simulating GTNET protocols
  - MODBUS Example Case



DISTANCE RELAY ENHANCEMENTS

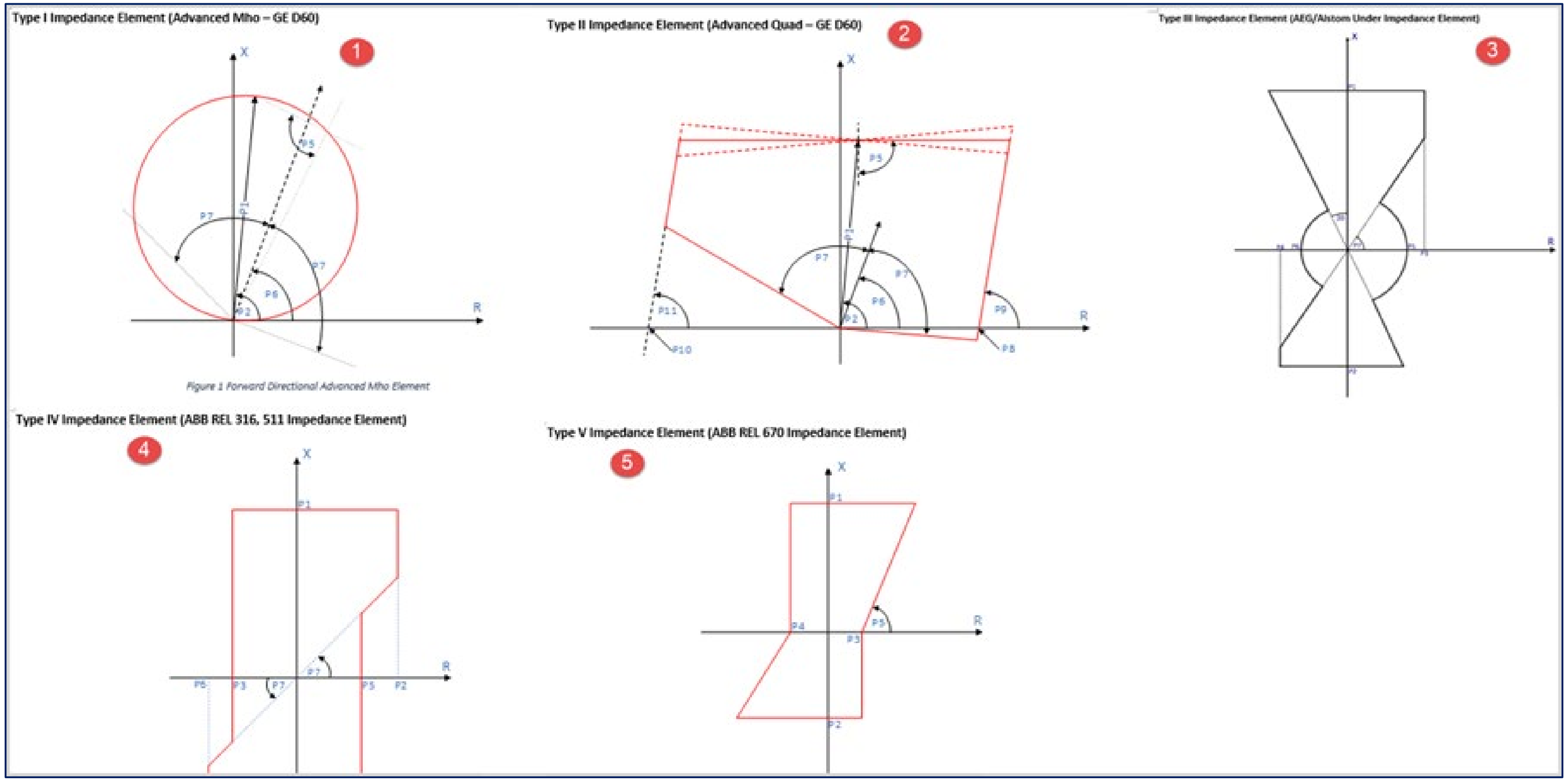
Impedance Element Options

- Five types of advanced detection zones
- Independent ground element option
- Polarization method options
- Trip sample counter feature for security



DISTANCE RELAY ENHANCEMENTS

Impedance Zones

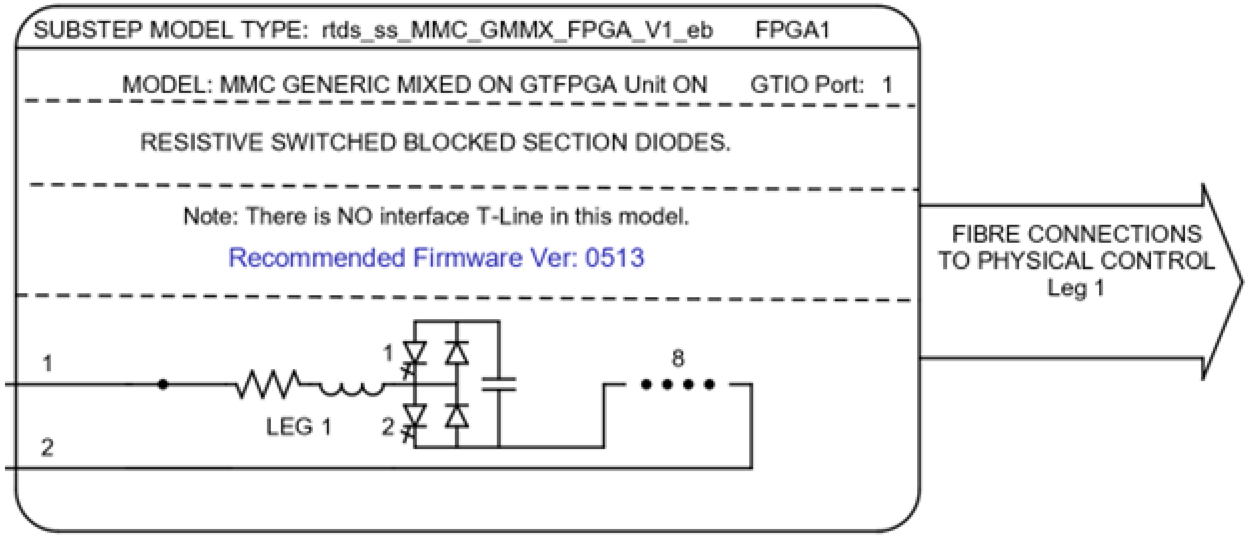


GTNETx2 MODBUS CLIENT

- Provide MODBUS client support
- Use the existing GTNETx2 hardware
- Connect with up to 10 Modbus servers (outstations) on one GTNETx2 module
- New user-friendly GUI for configuration

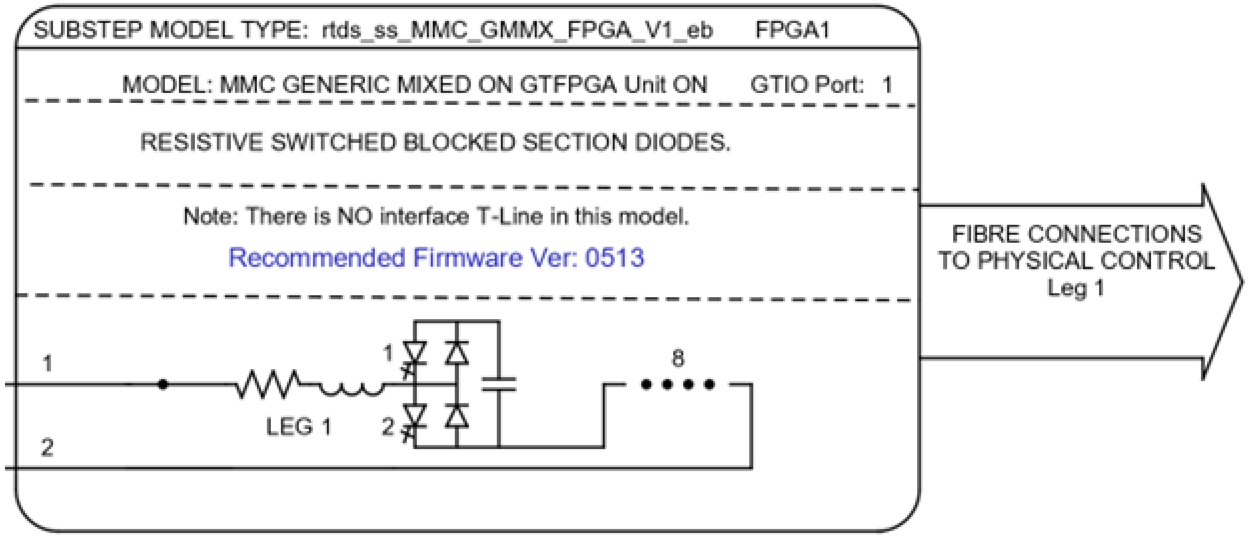
Embedded MMC Valve Models

- MMC-HVDC valve models run on the FPGA in the GTSOC auxiliary hardware
- In the past, traveling wave T-lines were used as an interface, 0.5 or 1 timestep delay
- Increases in simulation timestep caused a corresponding increase in T-line length



Embedded MMC Valve Models

- Recent updates have removed the need for a T-line interface
- Models can now be used in the main timestep environment
- Both GMMX and U5 components are available as embedded models in both mainstep and substep
- Embedded GMMX also includes an optional battery model

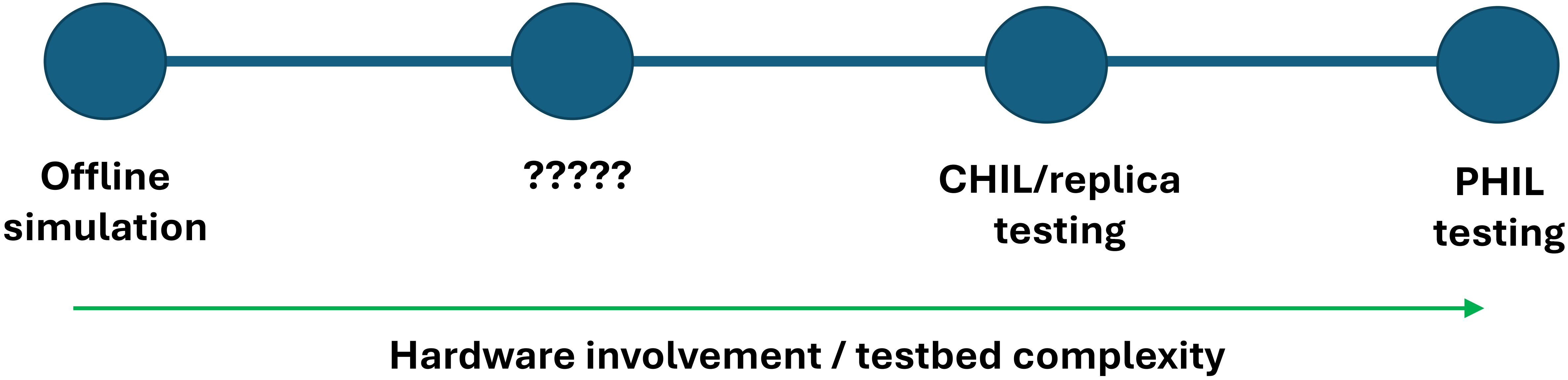


Black box control simulation

- Generic models do not always suit the purpose
- Vendors need a way to provide models that accurately reflect their control/protection to customers while protecting IP
- Most vendors have black-boxed offline (PSCAD) models of their controls which they can provide to utility customers
- Implementation challenges for real-time environment

Filling the gap

- Black box control simulation for accurately studying interoperability in the HIL environment without requiring all physical control hardware to be present
  - i.e. studying impact of renewables on protection



The new GTSOC V2

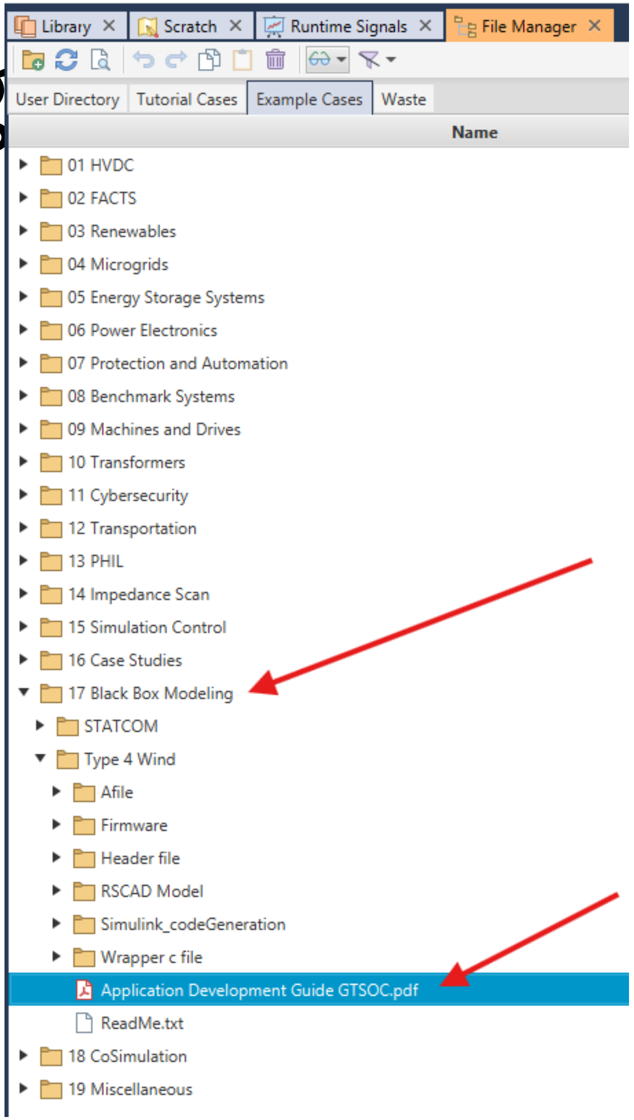
- ARM cores on the GTSOC V2 support execution of static library file (.a) compiled from original source code using .exe provided by RTDS Technologies

- Control code is not accessible by user, but vendor can choose to make some parameters changeable

- Compatible with NovaCor systems (connected via fiber cable)

GTSOC – Black Box Modeling

- Type 4 wind example case
- Application Development Guide



Future direction

- Currently working with vendors on a case by case basis for implementation – in the future, vendors will be able to create GTSOC models independently
- Not necessary for the vendor to have an RTDS (or GTSOC) to create the model using the cross-compiler, but very helpful for debugging

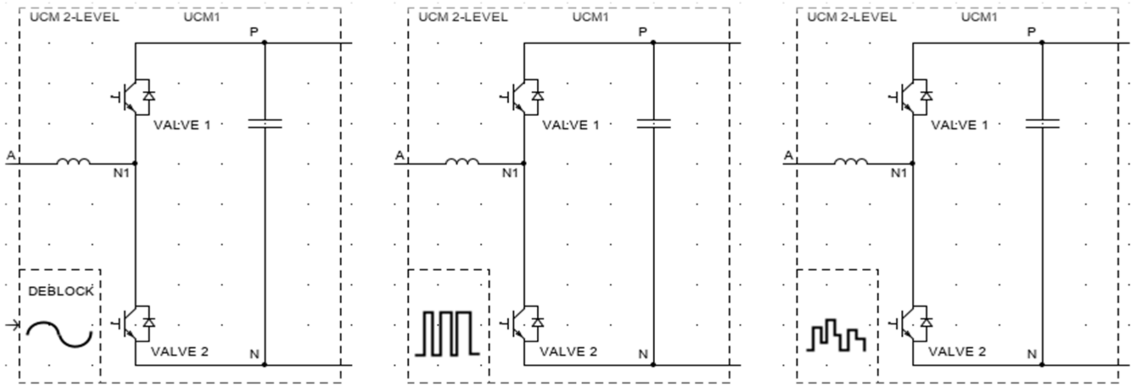
UNIVERSAL CONVERTER MODEL (UCM)

Motivation

- Demand for converter modelling and simulation with higher switching frequency (>30 kHz)
- Research found that average modelling may be used to achieve high resolution of firing
- Other average model implementation is decoupled on the DC bus – can cause instability

Solution: Universal Converter Model

- 2-level, NPC (ANPC), T-type, boost and buck, flying capacitor, DAB topologies available
- Multiple input (control) types
- Can be used in Mainstep OR Substep
- Improving performance and reducing computational burden
- **No decoupling / interface lines**



2-level UCM

UCM

Input Types

- Modulation Waveform
- Full Firing Pulse (reads firing pulse once per simulation timestep)
- **Improved Firing (with Mean Value High Precision)**
  - Captures firing pulses within a timestep at high resolution to calculate how much of the timestep the switch should be “on” (producing an effective duty cycle)
  - Multiple turn-on/turn-off transitions per timestep are allowed

UCM

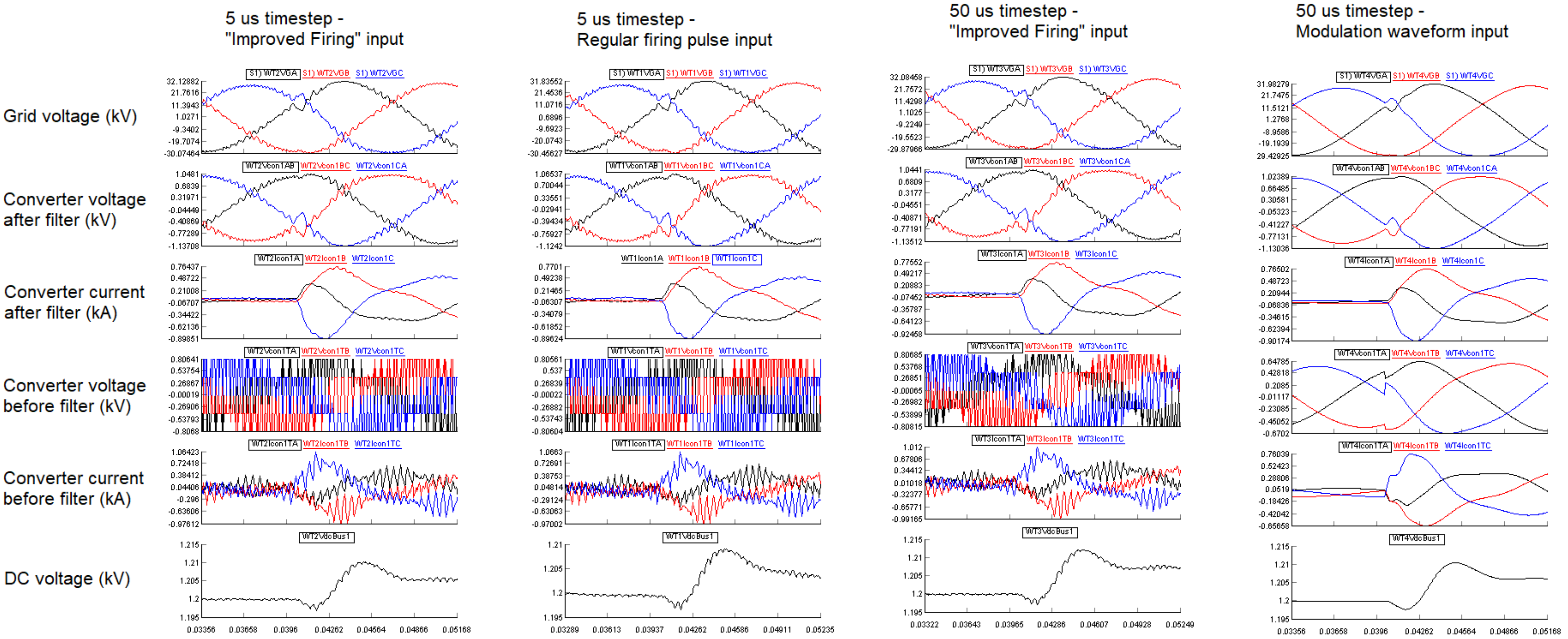
Substep Environment (<10 us)

- Full Firing Pulse Input
  - Similar to existing resistive-switching Substep models
- Modulation Wave Input
  - Similar to average model, but with improved performance
  - Proper transition between blocked and de-blocked states
- Improved Firing Input
  - Accurately represents converter performance with PWM firing **>150 kHz**

Mainstep Environment (30-50 us)

- Modulation Wave Input
- Improved Firing Input
  - Accurately represents converter performance in the **10 kHz range**
  - 10 load units per converter

UCM Performance



UCM

Benefits

- Good results even with a 30-50 us timestep – no need to maintain very small timesteps like other simulators which use decoupled models – fit many detailed converter models on a significantly reduced quantity of hardware

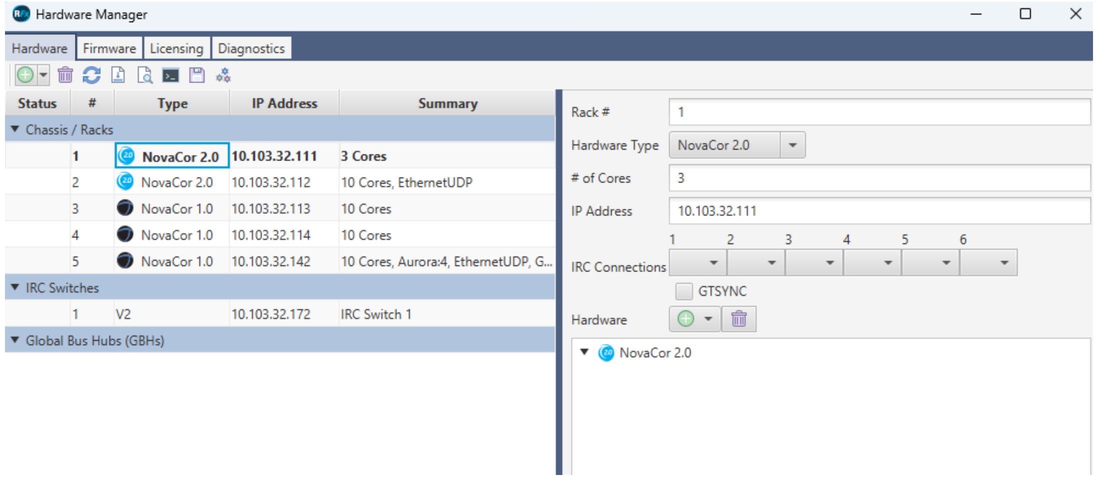
- Proper transitioning from blocked to deblocked states – UCM incorporates proprietary predictive switching technique from Substep models

- Improved Firing represents the characteristic harmonics very well and introduces minimal non-characteristic harmonics

- Improved firing has good comparisons with PSCAD

Coming Soon - RSCAD FX Enhancements – Hardware Manager

- Single integrated tool to manage all your RTDS hardware. Integrates:
  - Config_file Editor
  - Firmware Upgrade Utility
  - Global Bus Hub Configuration tools
  - Diagnostics
- User friendly interface
- Includes integrated SSH terminal for advanced diagnostics
- Increased speed when updating firmware for multiple racks simultaneously



Coming Soon - RSCAD FX Enhancements

- Improvements to UDP data logger
- New Aurora MUX component
- Support to save as SVG file
- Synchronous machine cross coupling effects
- Support for 18-conductor T-lines

THANK YOU!
QUESTIONS?