NEW FEATURES, COMPONENT MODELS, AND EXAMPLE CASES IN RSCAD-FX

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RTDS TECHNOLOGIES INC.

OUTLINE

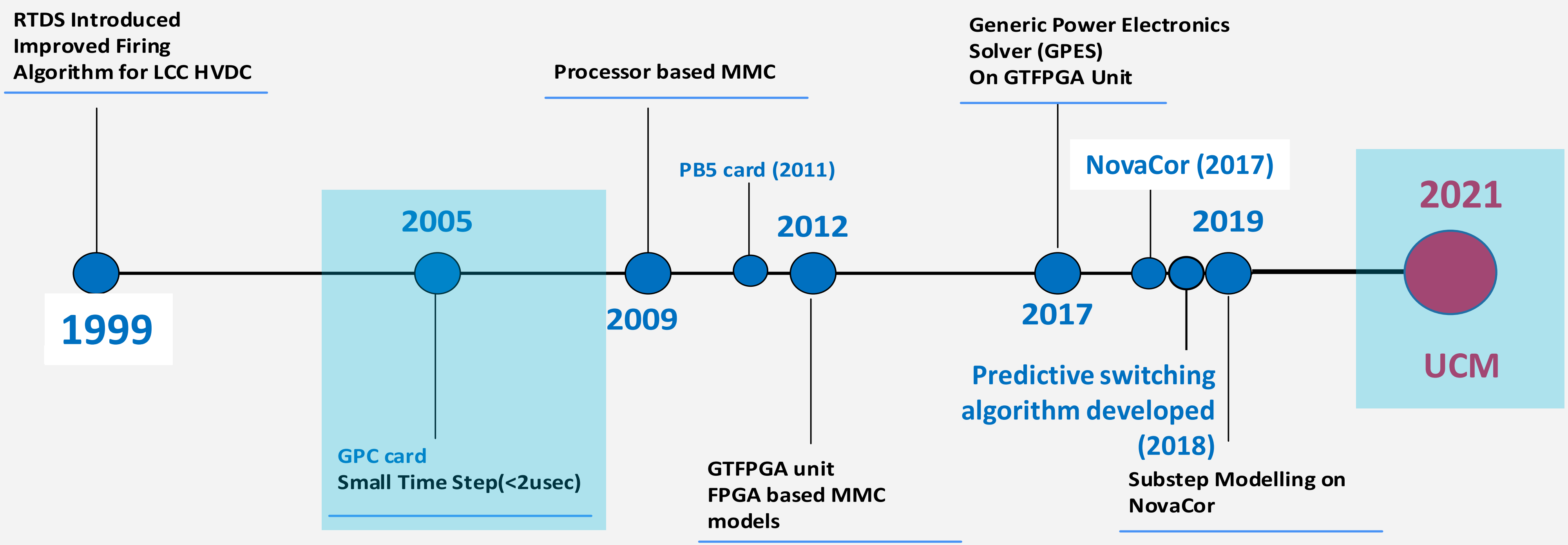
- Features, Components, and Example Cases for
  - Power Electronics Simulation
  - Multi Energy Simulation
  - Protection & Automation
  - Cyber-Physical Simulation
  - Large Scale Power System Simulation

- Other New Components

- Questions

POWER ELECTRONICS (PE) SIMULATION

Evolution of PE Simulation in RTDS



POWER ELECTRONICS SIMULATION

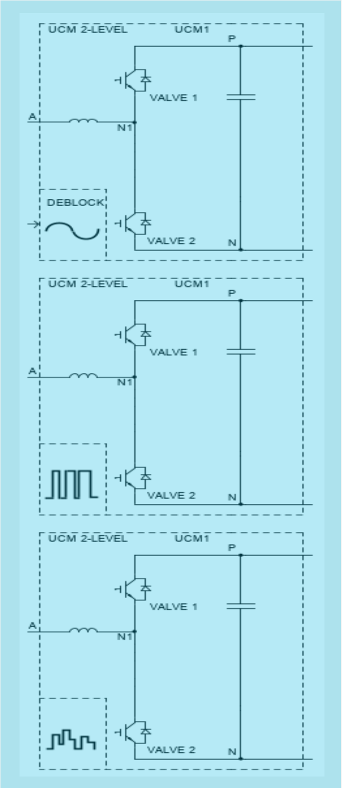
Universal Converter Model (UCM)

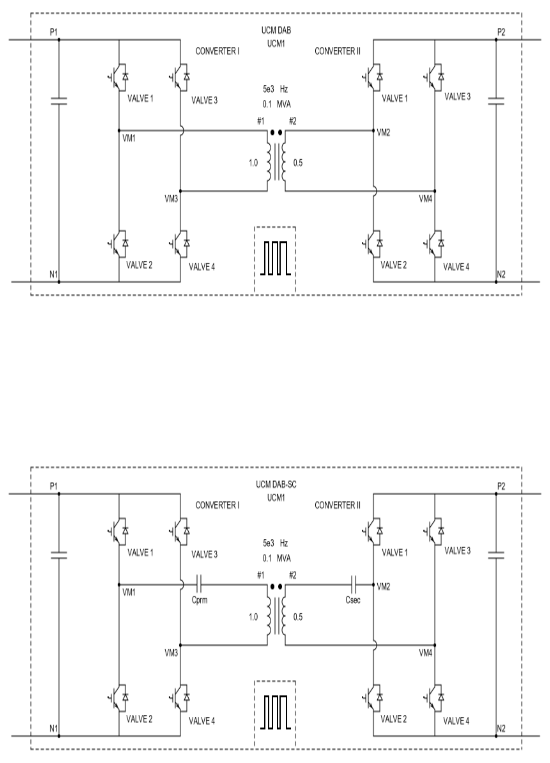
- Can run on NovaCor and PB5-based RTDS Hardware.
- Supports Different Simulation Environments.
  - SubStep (<10us)
  - MainStep (30~50 us)
  - Distribution Mode (150~200 us)
- Supports Software-in-the-loop (SIL) and Hardware-in-the-loop (HIL) Testing.
- Supports Different Inputs.
  - Modulation Waveform or Averaged Value Model
  - Firing Pulse
  - Improved Firing Pulse with Mean Value High Precision

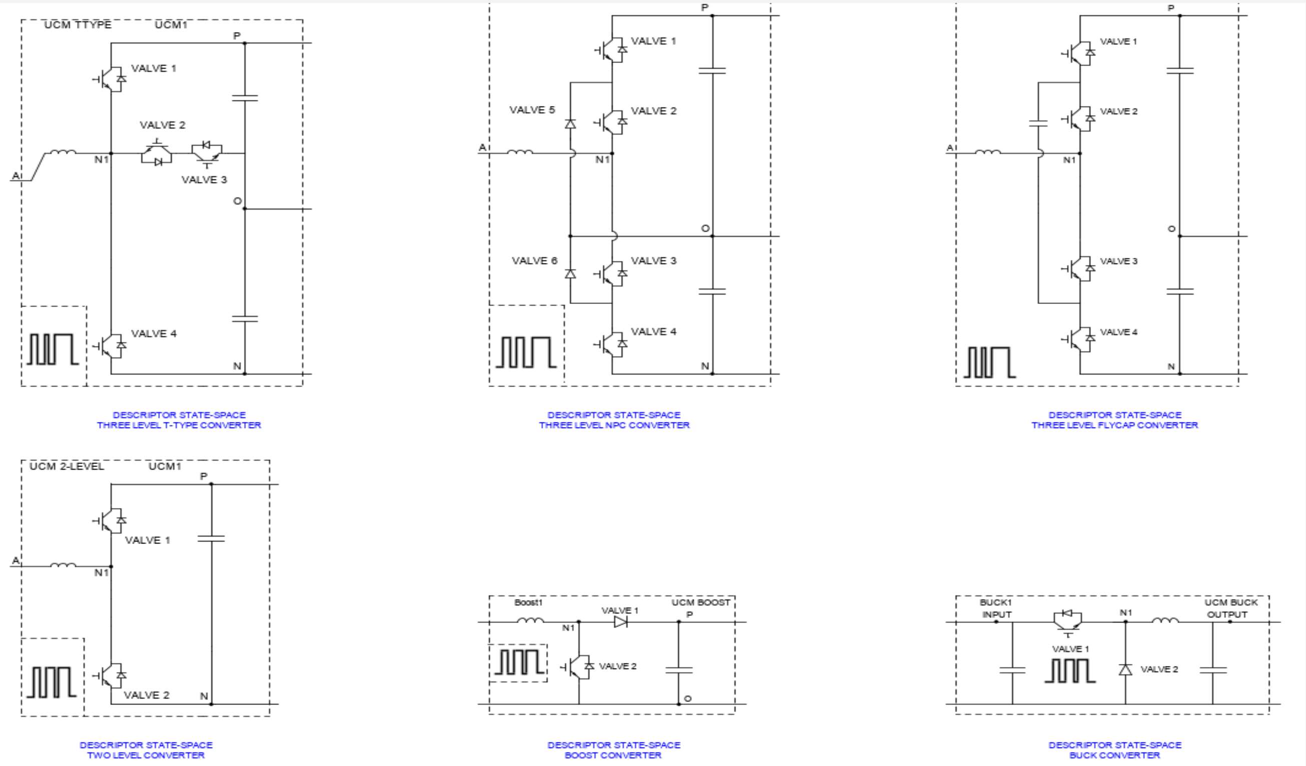
Universal

POWER ELECTRONICS SIMULATION

UCM Components



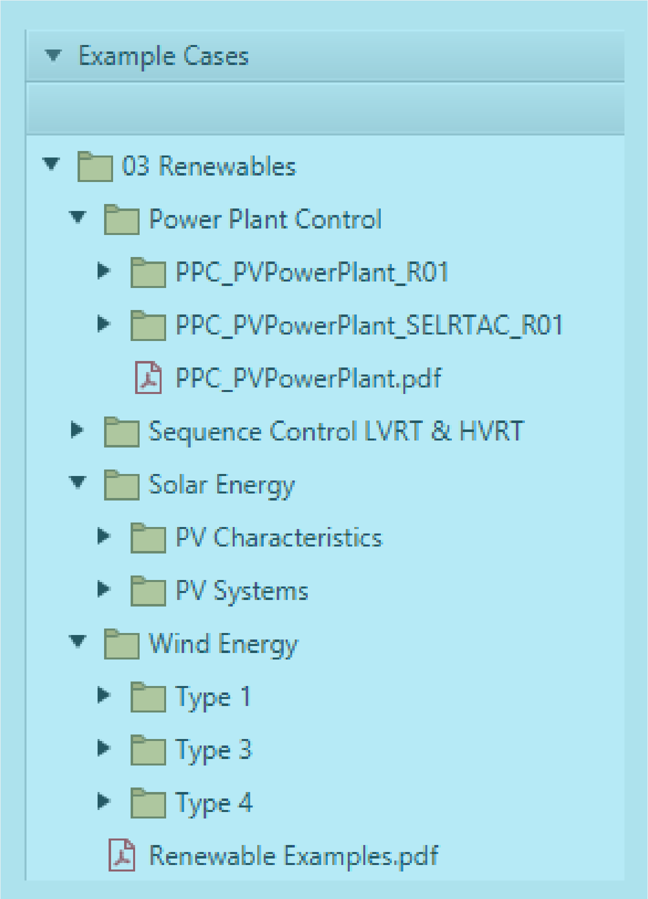




POWER ELECTRONICS SIMULATION

Renewable Energy Example Cases

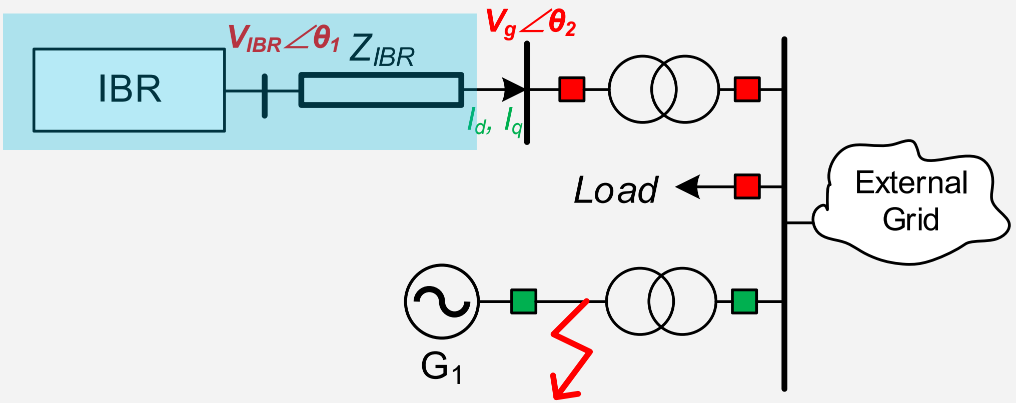
- Cases include
    - Wind Energy System (Type-1, Type-3, and Type-4)
    - Solar PV System
    - Power Plant Control
    - LVRT and HVRT Controls
- All cases use UCM model and separate versions available for
    - Substep with switching model converter
    - Mainstep with switching model converter
    - Mainstep with average model converter
- Easy to Modify (Scale/Change Ratings) and Duplicate.



POWER ELECTRONICS SIMULATION

Grid Forming Converters

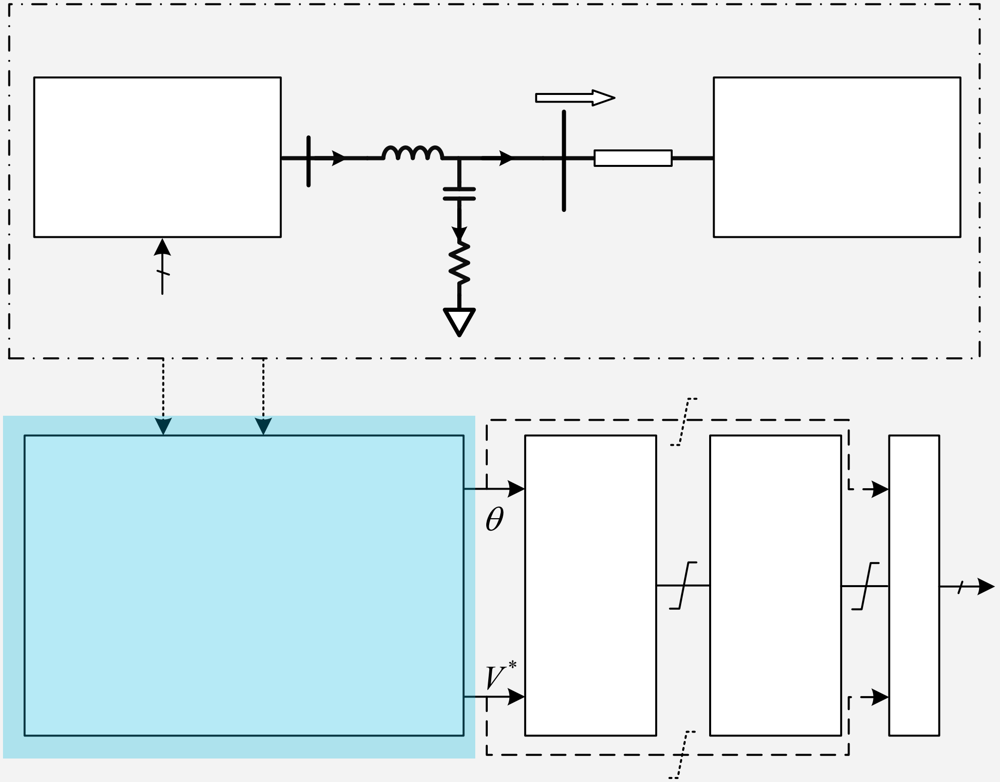
- A Grid Following (GFL) IBR tries to hold its output current, Id and Iq, at a constant value during the transient.
- A Grid Forming (GFM) IBR tries to hold an internal voltage phasor, $V_{IBR} \angle\theta_1$, during the transient.



POWER ELECTRONICS SIMULATION

Typical Grid Forming Converter Control

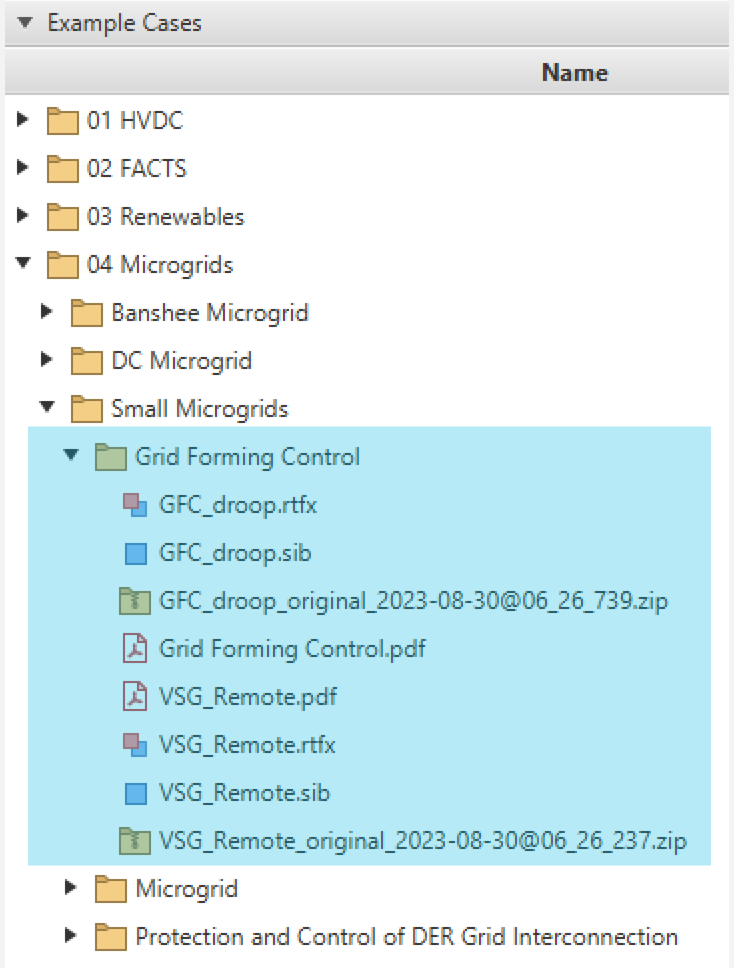
- Several options available to generate θ and V*
  - Virtual Synchronous Generator Technique
  - VF and Droop Control Technique
  - Synchronverter Technique
- The voltage and current loop have limiting capabilities, and can provide fast control of the voltage at the PCC



POWER ELECTRONICS SIMULATION

GFM Example Cases

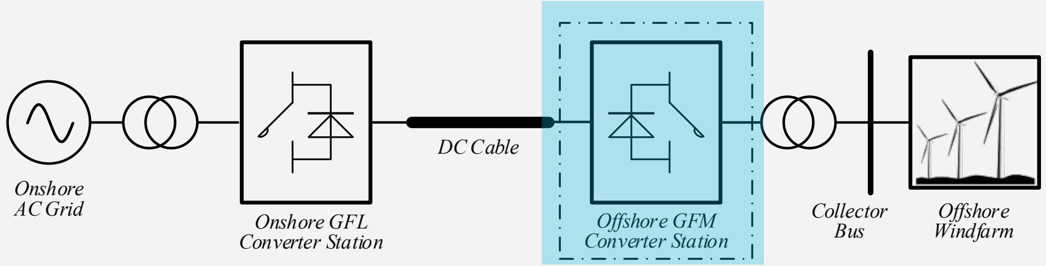
- Separate example cases available for each category of Grid Forming Converter Controls.
- Details about the cases are given in the help document associated with the help documents.



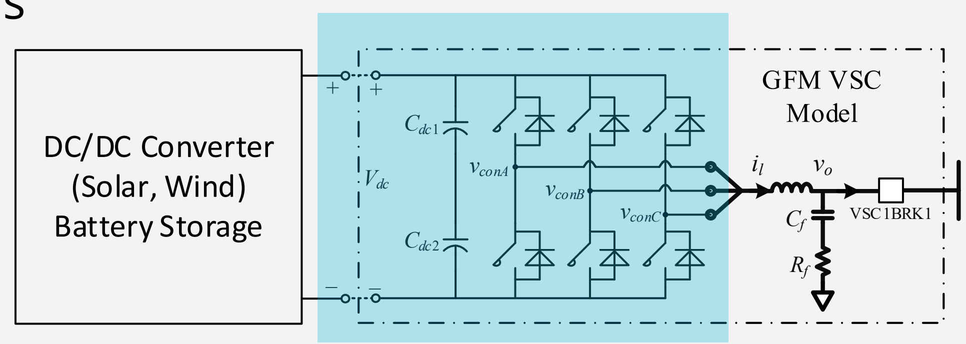
POWER ELECTRONICS SIMULATION

Grid Forming Converter Examples (*Under Development*)

- Wind Energy Applications



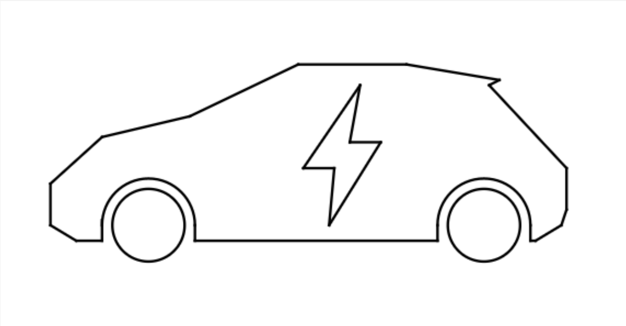
- Microgrid Applications

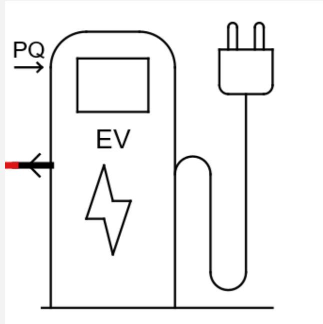


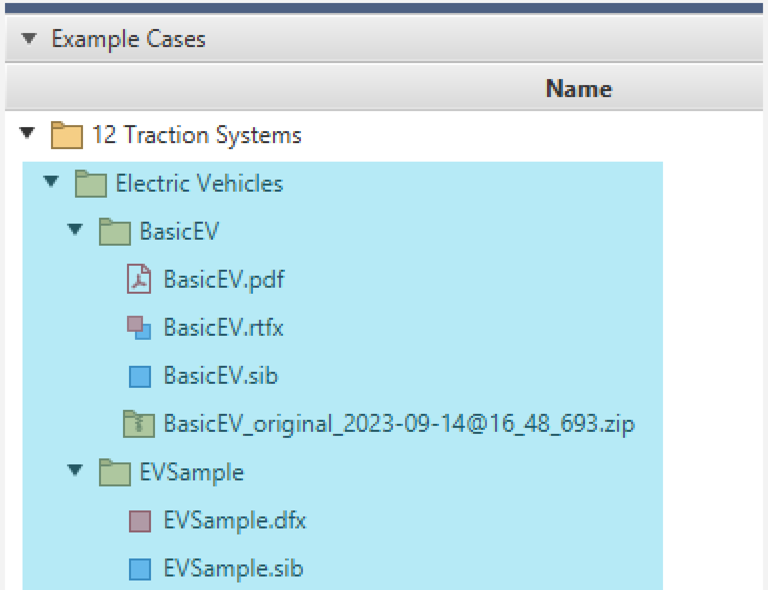
POWER ELECTRONICS SIMULATION

Electric Vehicle Example Case

- Models for Electric Vehicle and Charging Station.
- EV model uses V2G Control in Automatic and Manual modes.
- Suitable for Steady State and High-Level Control Studies.



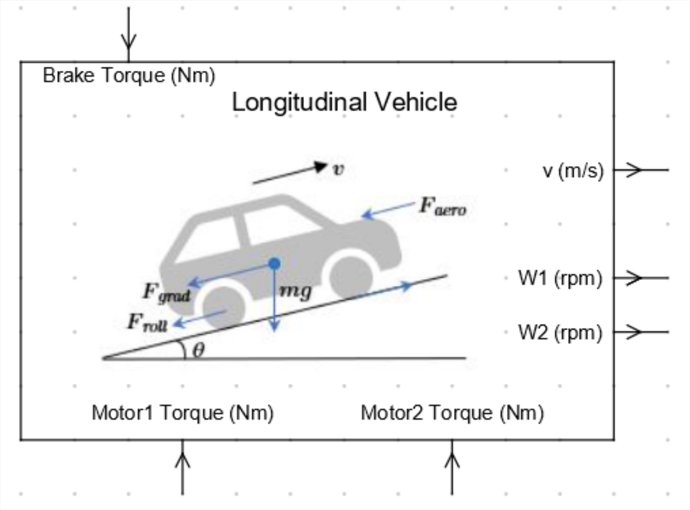




POWER ELECTRONICS SIMULATION

EV Powertrain Component and Example Case (*Under Development*)

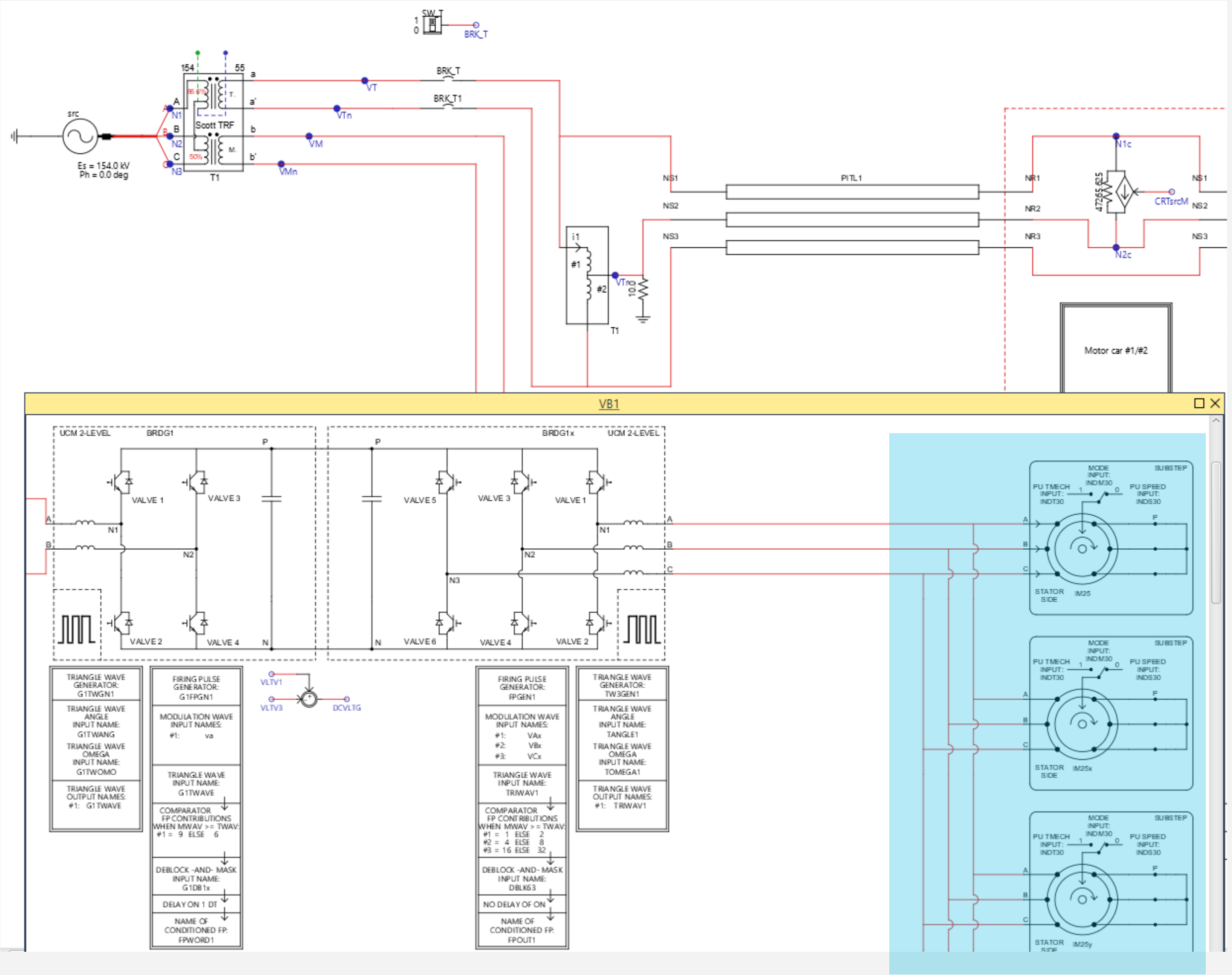
- Longitudinal Vehicle component has been developed.
- A detailed example case on EV Powertrain is being developed.
- Suitable for Switching Transient Studies on EV systems.



POWER ELECTRONICS SIMULATION

Railway Example Case

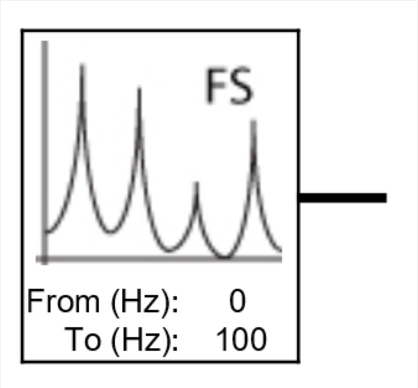
- Models/Circuits to represent
  - Train Sets
  - Utility Grid
  - AC Voltage Conversion
  - Feeder Configuration
  - Trolly Lines



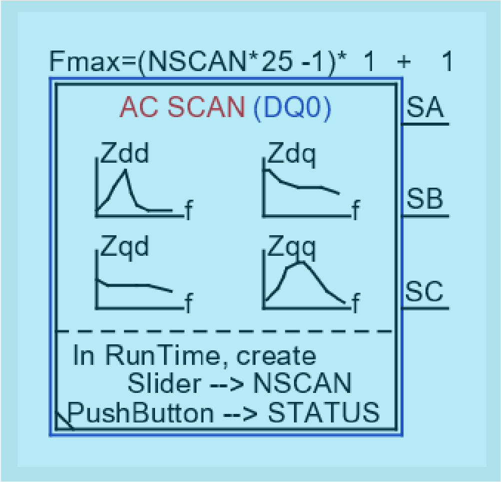
POWER ELECTRONICS SIMULATION

Impedance Scan

- Analytical Method
  - System admittance is generated using equivalent circuits.
  - Suitable for conventional power systems.



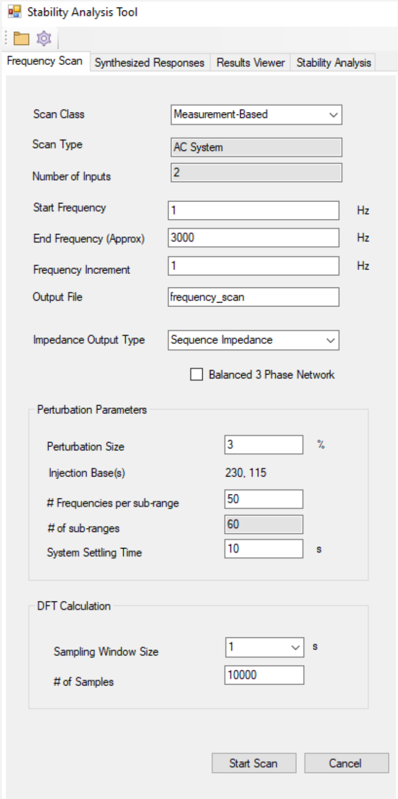
- Measurement Based Method
  - Injects voltage/currents to measure impedance.
  - Can incorporate effects of operating conditions.
  - Suitable for power electronic dominated power systems

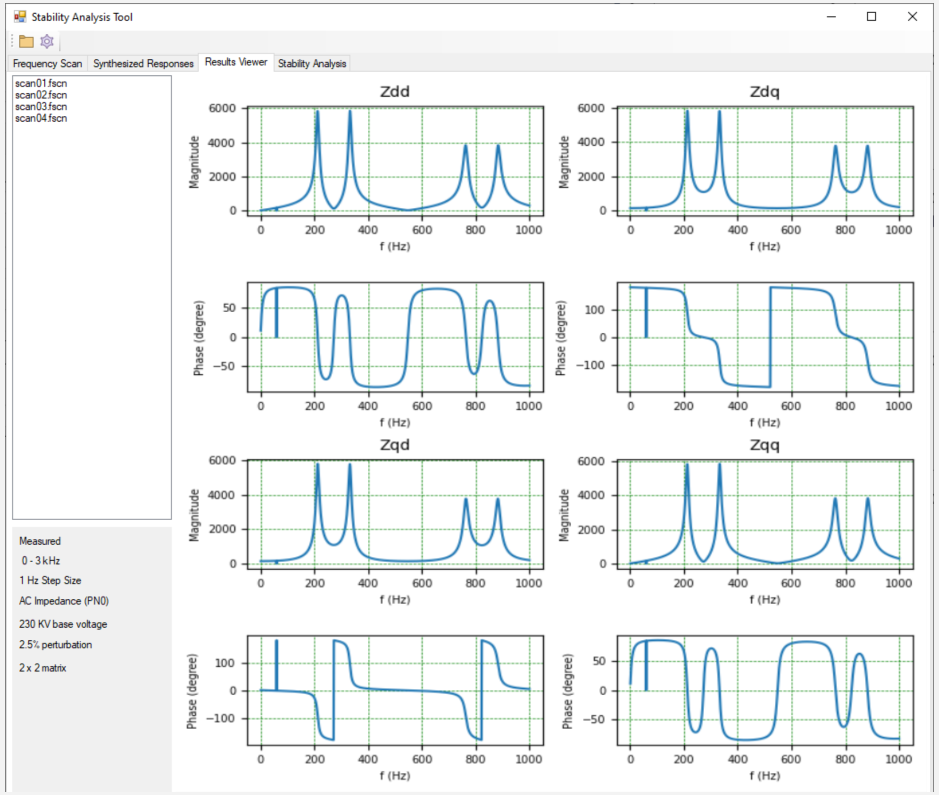


POWER ELECTRONICS SIMULATION

Stability Analysis Tool (*Under Development*)

- Configure the scan process
- View scan results

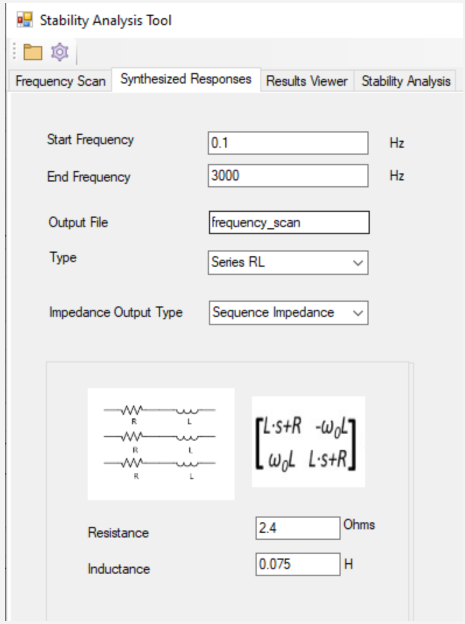


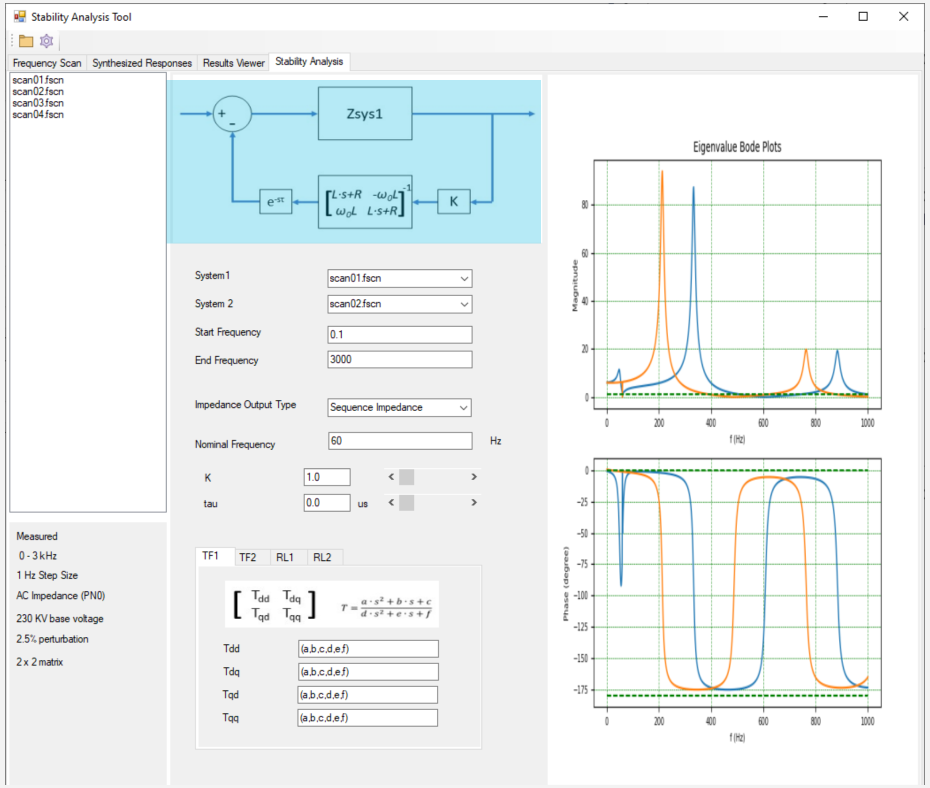


POWER ELECTRONICS SIMULATION

Stability Analysis Tool (*Under Development*)

- Synthesized Response
- Stability Analysis





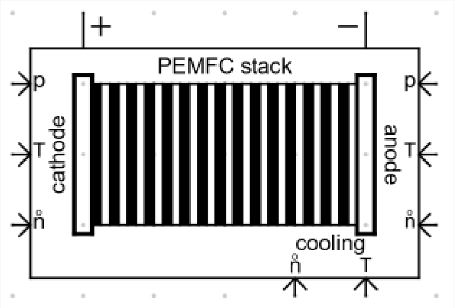
POWER ELECTRONICS SIMULATION

MMC Model for Mainstep (*Under Development*)

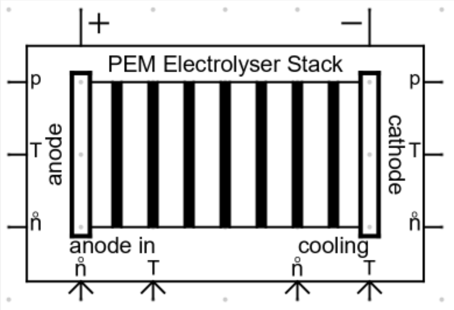
- An improved model of MMC to run on mainstep
- This eliminates the need of transmission line interface between the substep to mainstep.

MULTI ENERGY SIMULATION

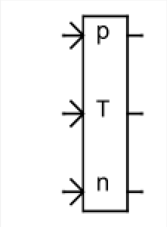
Hydrogen System Models and Example Cases



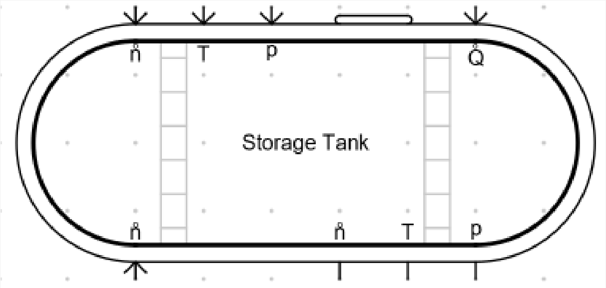
PEM Fuel cell stack



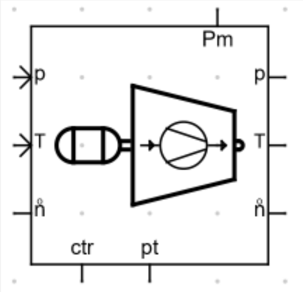
PEM Electrolyzer stack



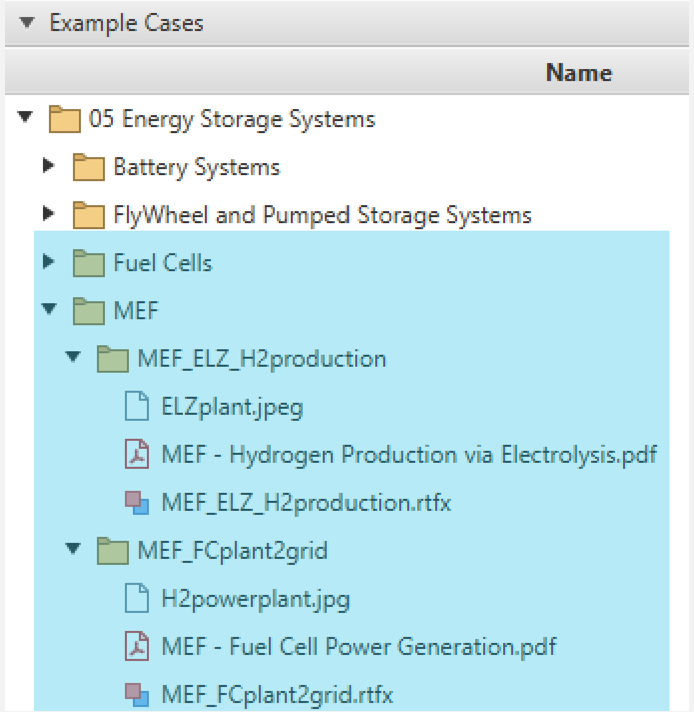
Gas property calculator



Storage tank

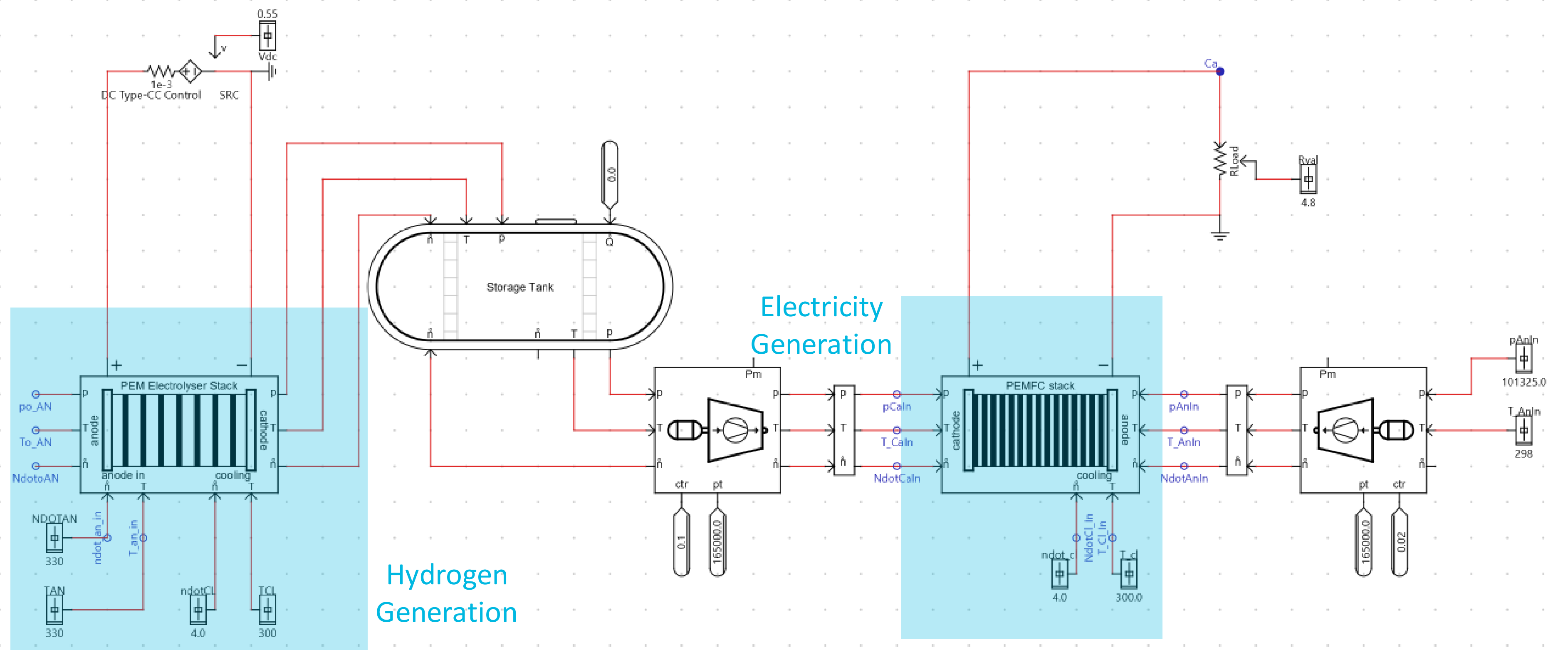


Air compressor



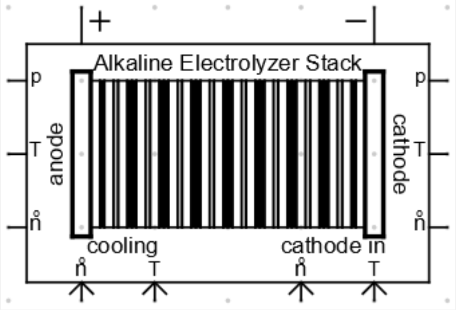
MULTI ENERGY SIMULATION

Hydrogen System Connection

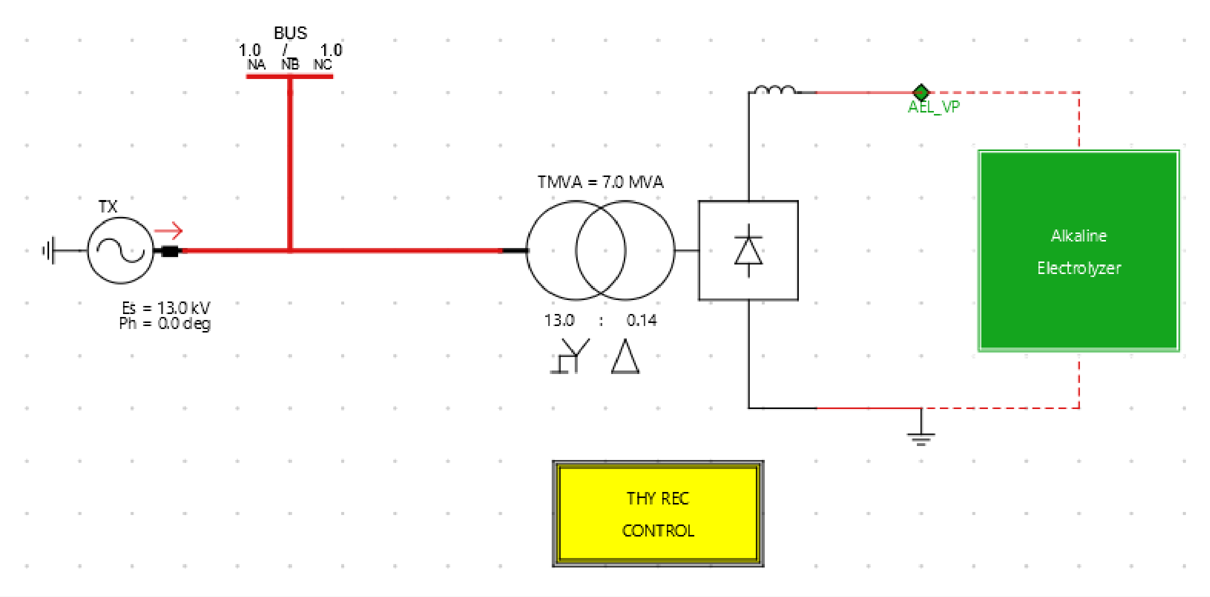


MULTI ENERGY SIMULATION

Alkaline Electrolysis Model and Example Case (*Under Development*)



Alkaline Electrolyzer stack

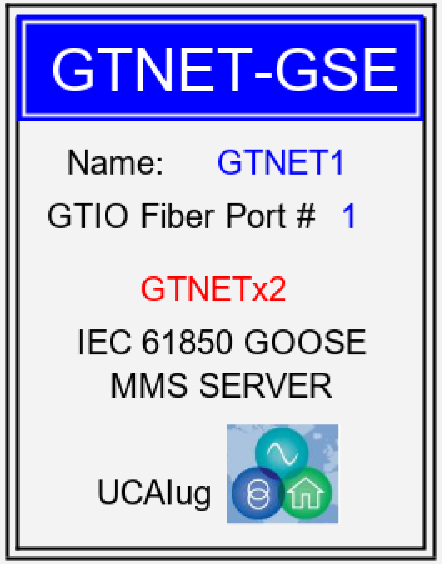


Grid connected AWEL plant via a six-pulse thyristor rectifier

PROTECTION AND AUTOMATION

GSE-v7 Component

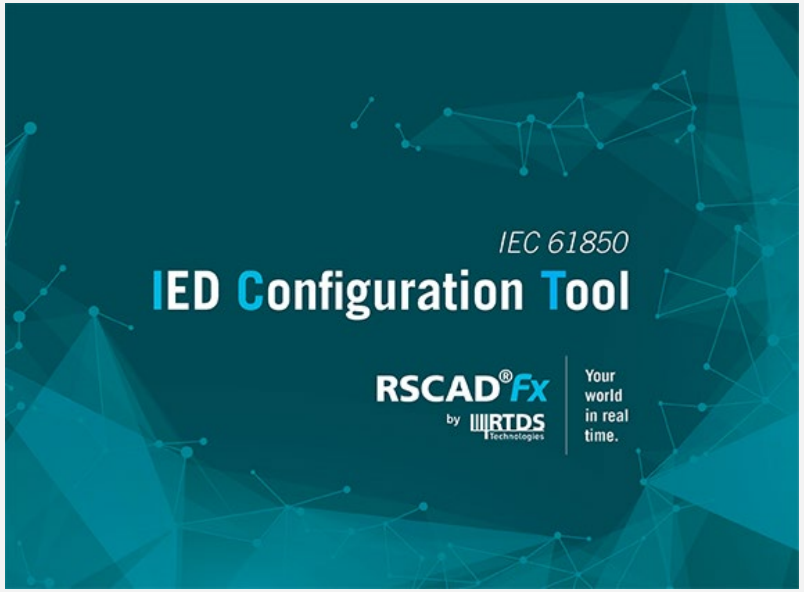
- Provides IEC 61850-8-1 Ed. 2.0 / 2.1 GOOSE communication and MMS Server functionality
- Simulates up to 4 IEDs (Generic or Third Party)
- Publish up to 16 GOOSE messages (4 GCBs per IED and 512 data items in total)
- GOOSE subscription up to 32 different GOOSE streams (512 data items in total)



PROTECTION AND AUTOMATION

IED Configuration Tool (ICT)

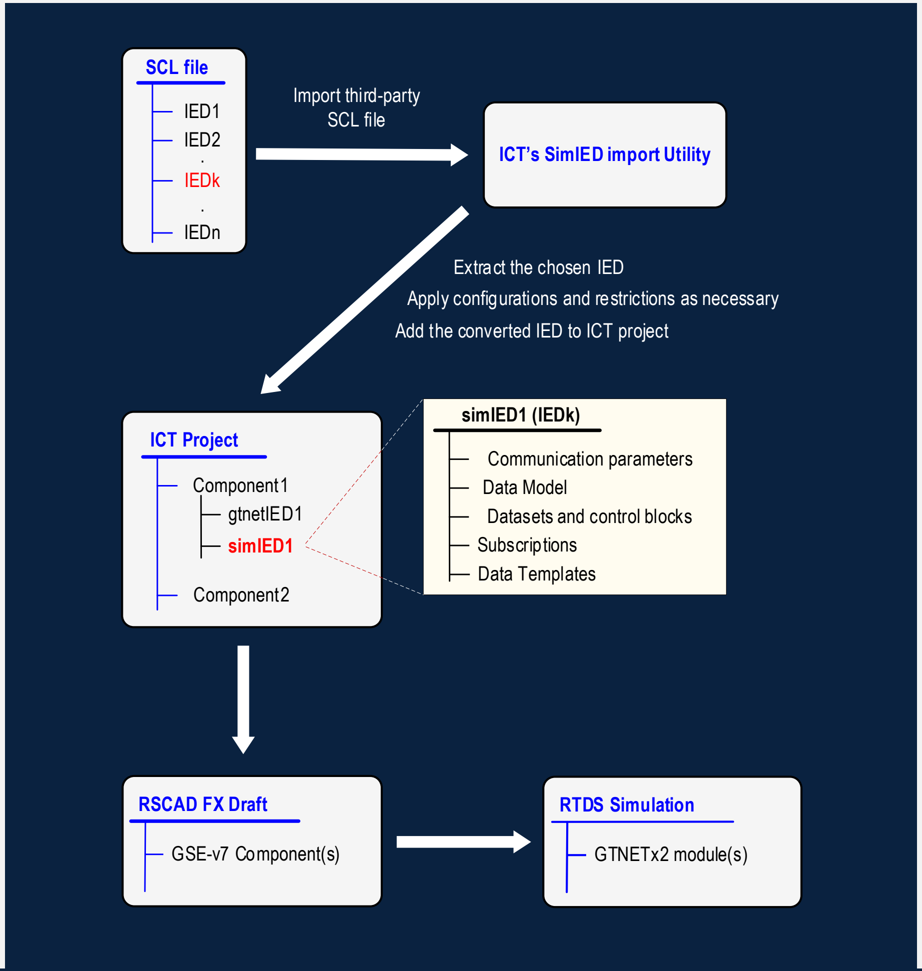
- Build IEC 61850 data models from the inbuilt LN database
- Emulate third-party IEDs from SCL files
- Bind input/outputs to RSCAD FX draft signals
- Import non-RTDS SCL files for GOOSE subscription configuration
- Generate CID and other auxiliary configuration files for GSE components



PROTECTION AND AUTOMATION

SimIED Feature

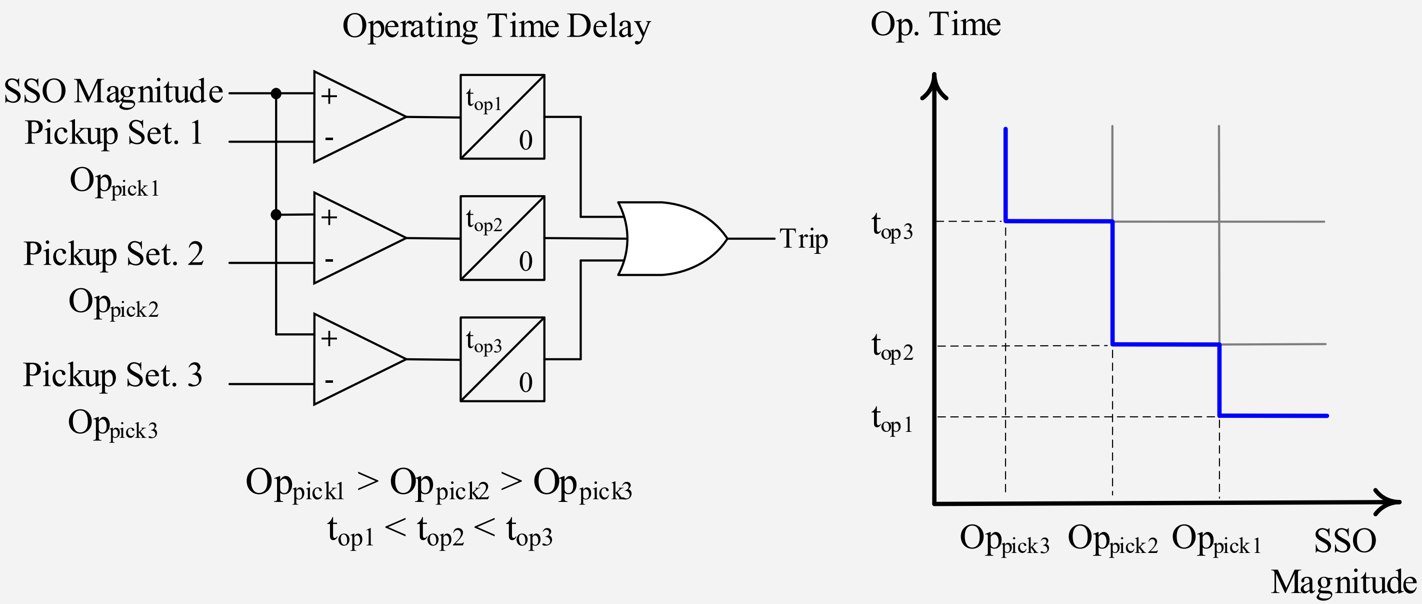
- Emulate third-party IEDs
- Supports any valid IEC 61850 SCL file (such as ICD, CID or SCD) with one or more IEDs
- Only standard data types and LN classes are supported (as defined in IEC 61850-7-x)



PROTECTION AND AUTOMATION

Sub Synchronous Oscillation (SSO) Relay Model

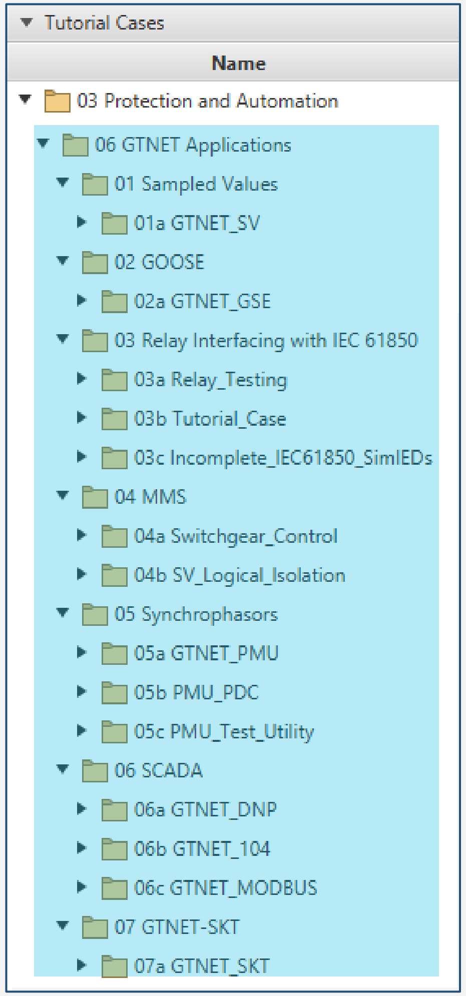
- Supports ‘Single’ and ‘Multiple’ frequency modes (up to 3 SSO elements)
- Monitor SSO frequencies and corresponding magnitudes



PROTECTION AND AUTOMATION

New Set of Protection and Automation Example Cases

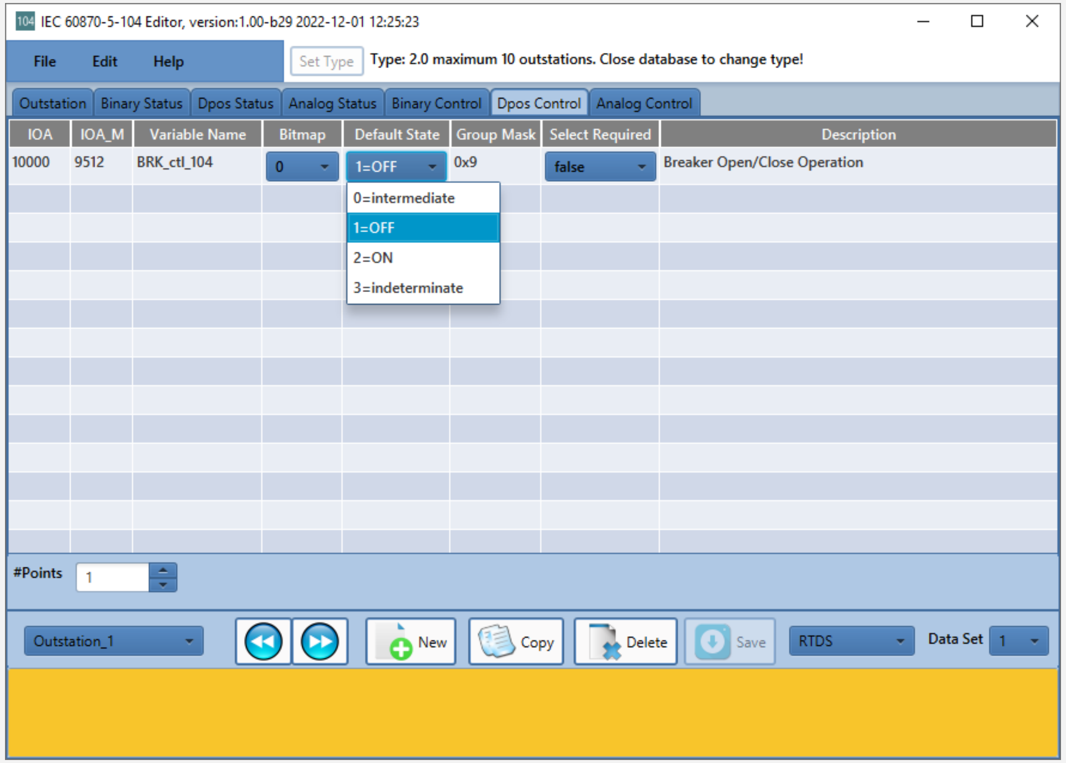
- Protection Examples
  - Generator Protection
  - Series-compensated Line Protection
  - SSO Protection
- Automation Tutorials/Examples
  - GTNET Tutorials - comprises a set of new tutorial cases that systematically present the process of simulating GTNET protocols
  - MODBUS Example Case



PROTECTION AND AUTOMATION

Editors for SCADA Protocols

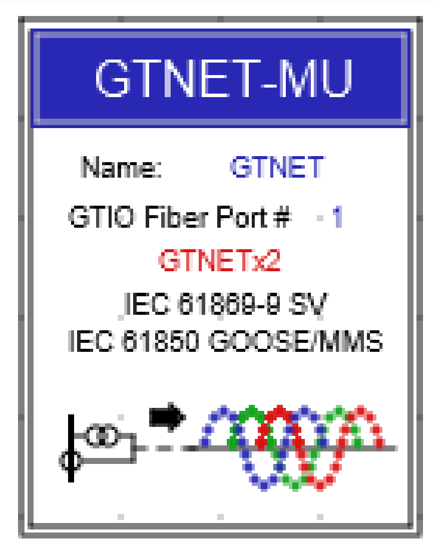
- Automatic conversion of legacy text-based mapping file to XML-based file.
- Description fields for each point to better identify the purpose of the simulation.
- Intuitive combo-box options in each point's cell data.



PROTECTION AND AUTOMATION

GTNETx2 Merging Unit with PRP Support (*Under Development*)

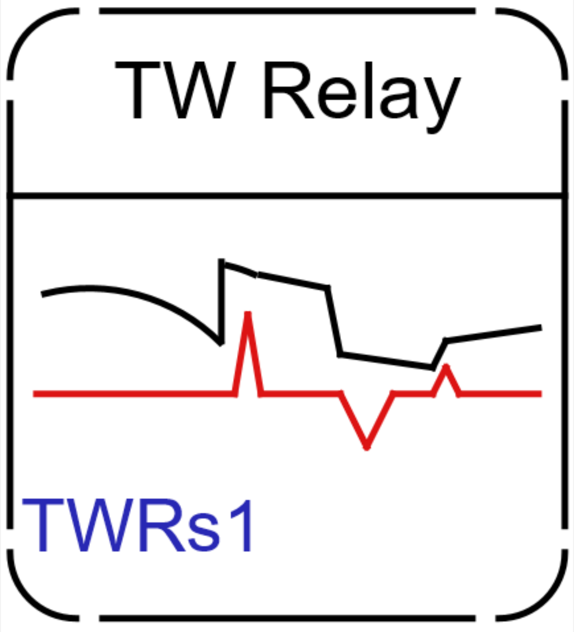
- Provide the GOOSE, SV and MMS functionality necessary to emulate MUs
- Support Parallel Redundancy Protocol (PRP) for GOOSE and Sampled Values networks
- Since both LAN A and LAN B ports are required for the redundancy the GTNETx2 card will only run one firmware version when the redundancy feature is enabled



PROTECTION AND AUTOMATION

Traveling Wave Relay Model (TWR) – Based on Differentiator-Smoother (DS) Technique (*Under Development*)

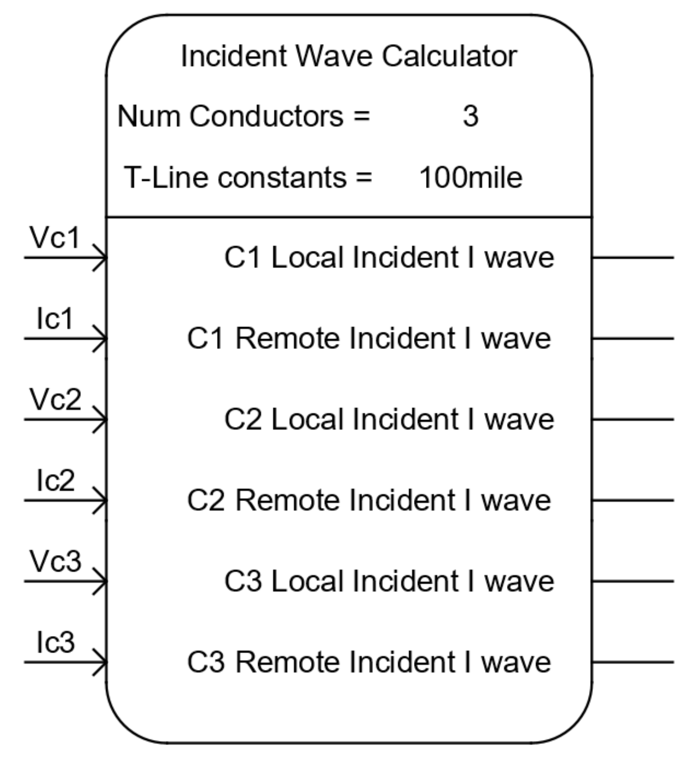
- Includes current TW different protection scheme (TW87):
- Uses double-ended TW-based method.
- Supports single/three-pole tripping.
- Provides calculated fault location and faulted mode information.
- Option to detect an external fault on a parallel line.



PROTECTION AND AUTOMATION

Incident Wave Calculator (IWC) Model (*Under Development*)

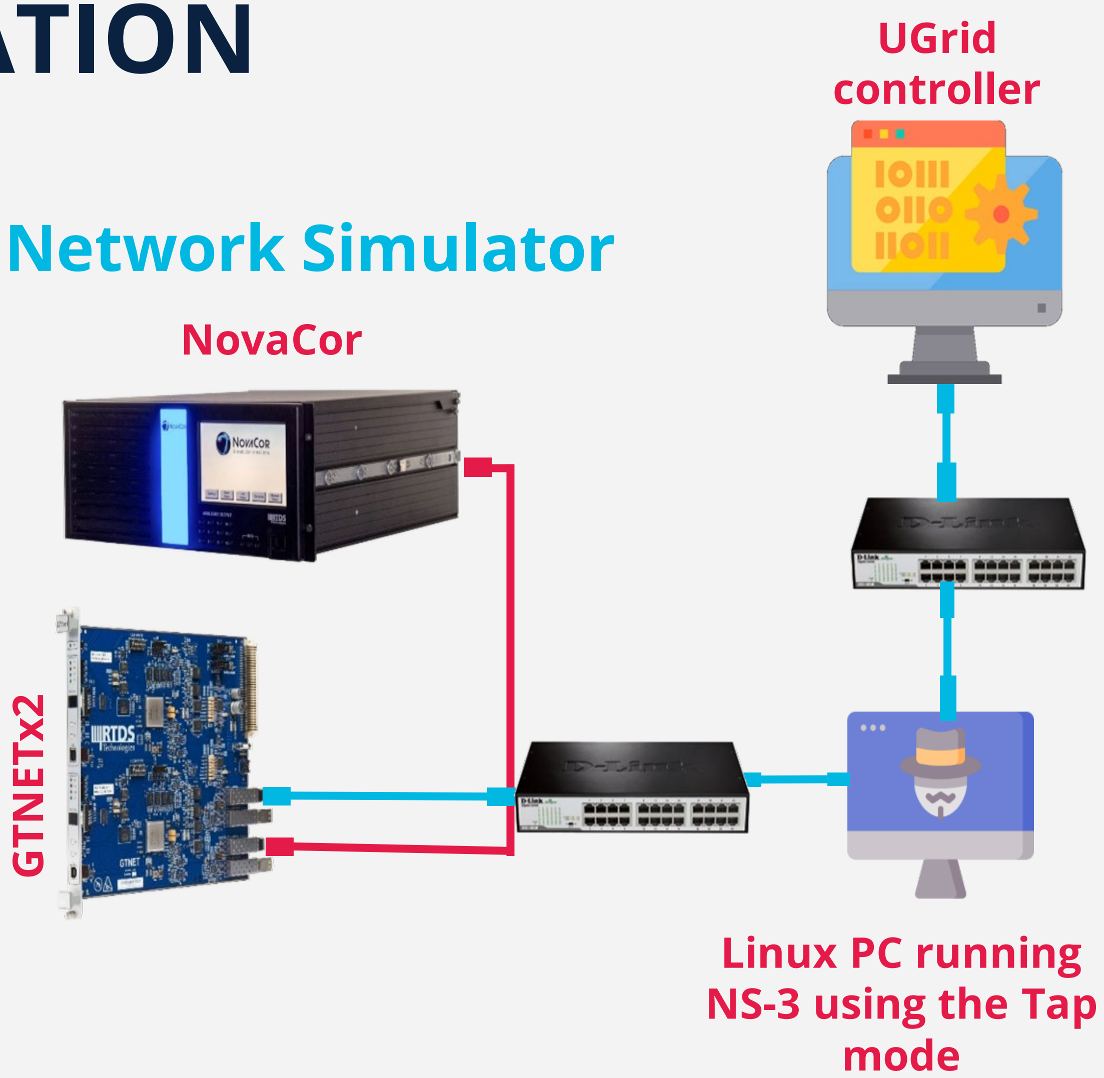
- Uses Frequency Dependent Phase Domain (Universal Line Model) transmission line theory to calculate:
    - The local incident current.
    - The local reflected current.
    - The expected remote incident current.



CYBER PHYSICAL SIMULATION

RTDS Simulator Interfaced with NS3 Network Simulator

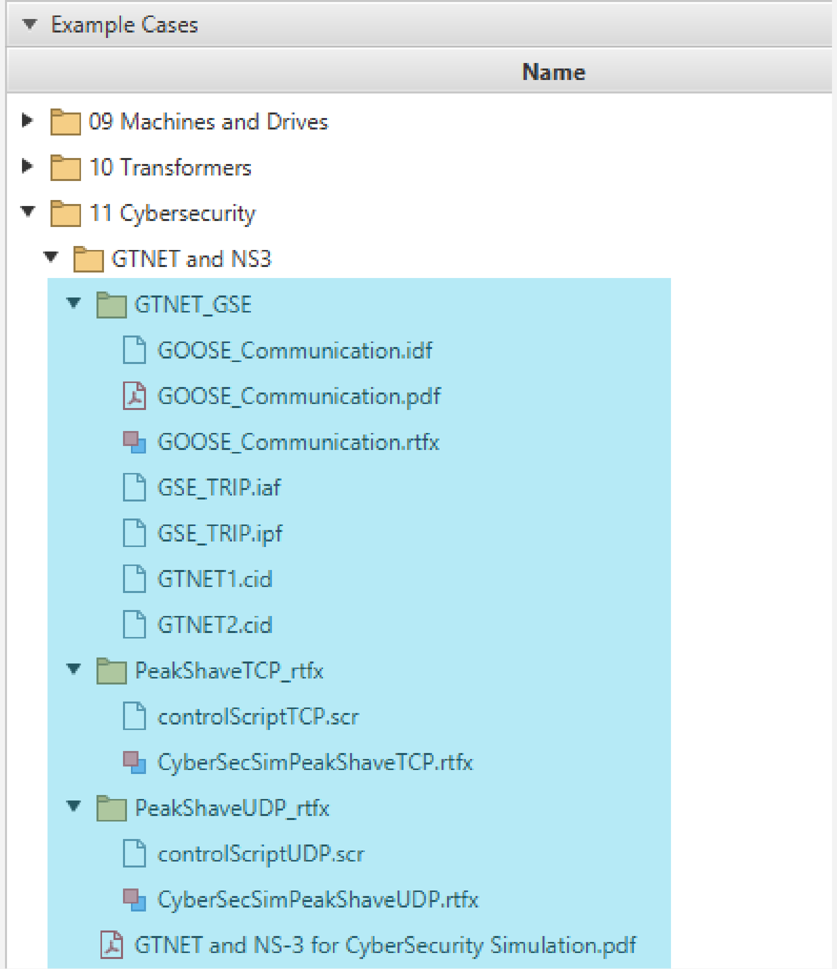
- Advantages:
  - Can model an entire communications network.
  - Can Modify packets and frames of Protocols DNP3, MODBUS, IEC104, PMU, GOOSE and SV.
- Limitations:
  - The amount of traffic it can handle is limited.



CYBER PHYSICAL SIMULATION

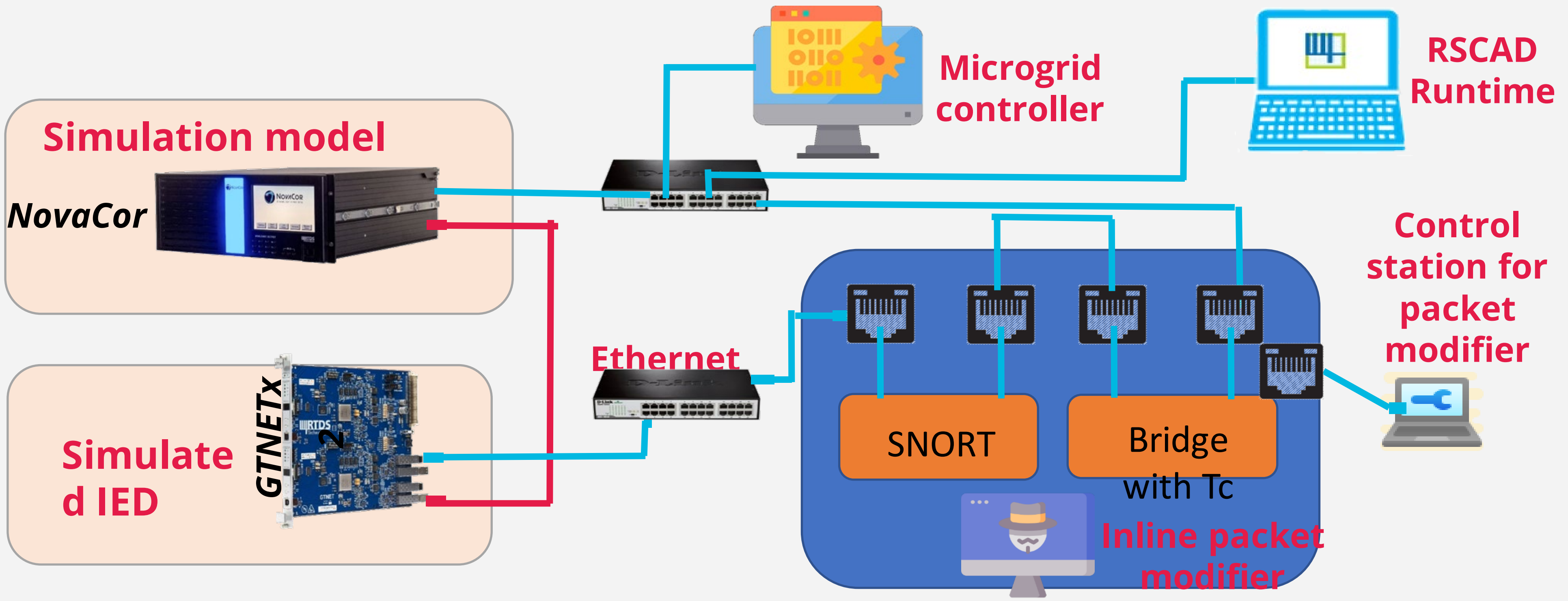
Example Cases to Run Jointly with NS3

- Separate examples are provided to alter data for
    - DNP3,
    - MODBUS
    - IEC104
    - PMU
    - GOOSE and SV



CYBER PHYSICAL SIMULATION

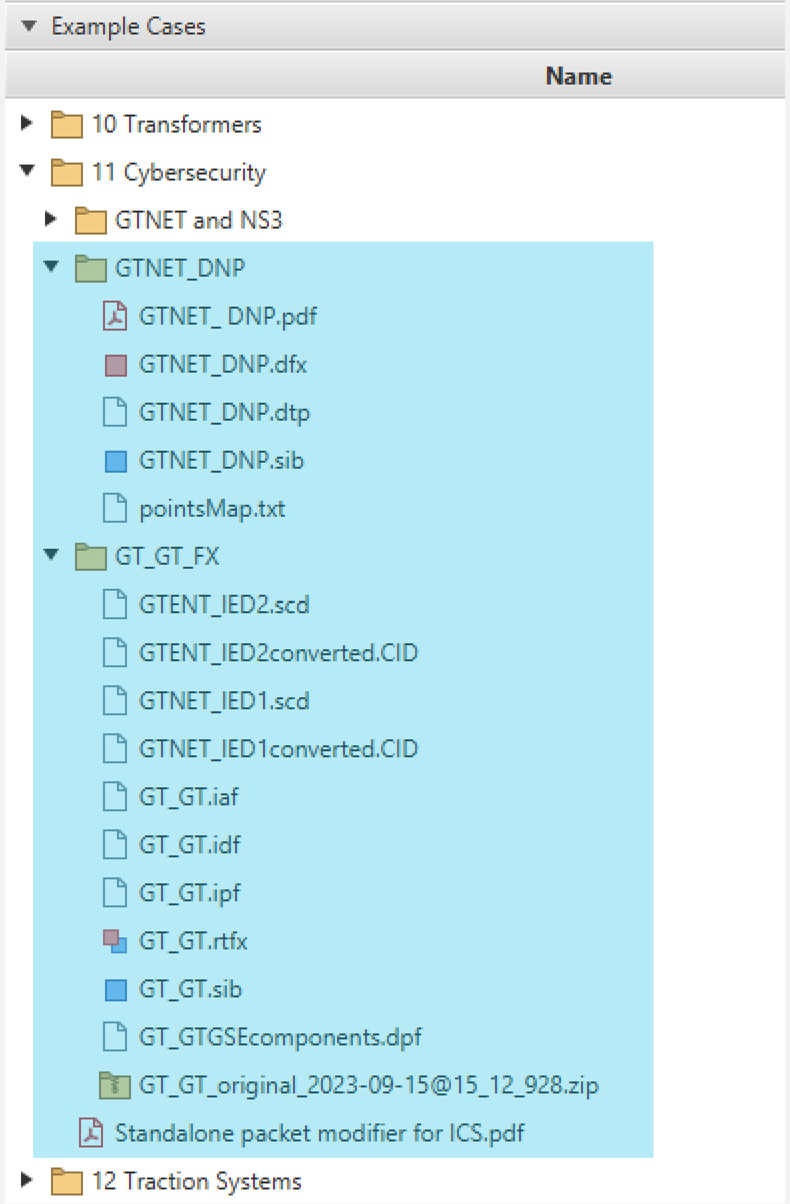
RTDS Simulator Interfaced with SNORT Packet Modifier



CYBER PHYSICAL SIMULATION

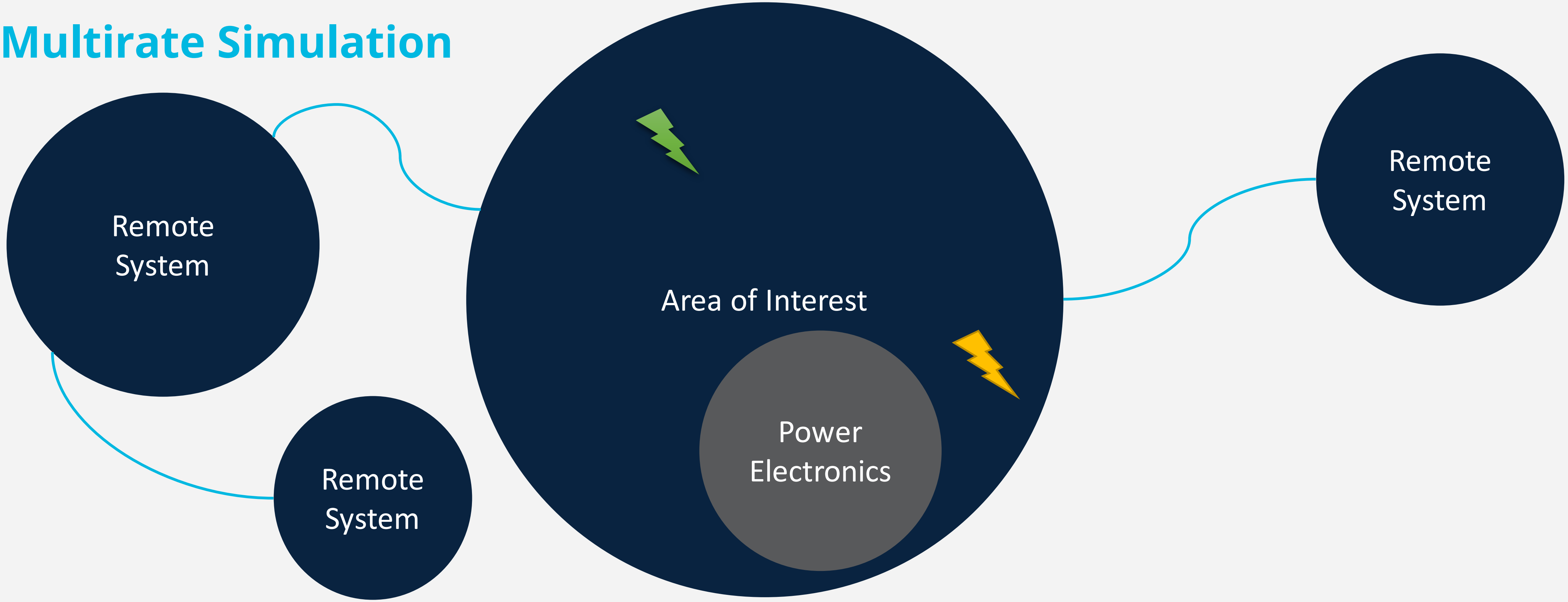
Example Cases to Run Jointly with SNORT

- A Linux machine running the packet modifier is placed between the actual Client (User PC running P&A suite) and the Server (GTNET card) for the TCP/IP based protocols
- We cad add delay, jitter, reorder, corrupt, duplicate or drop packets.



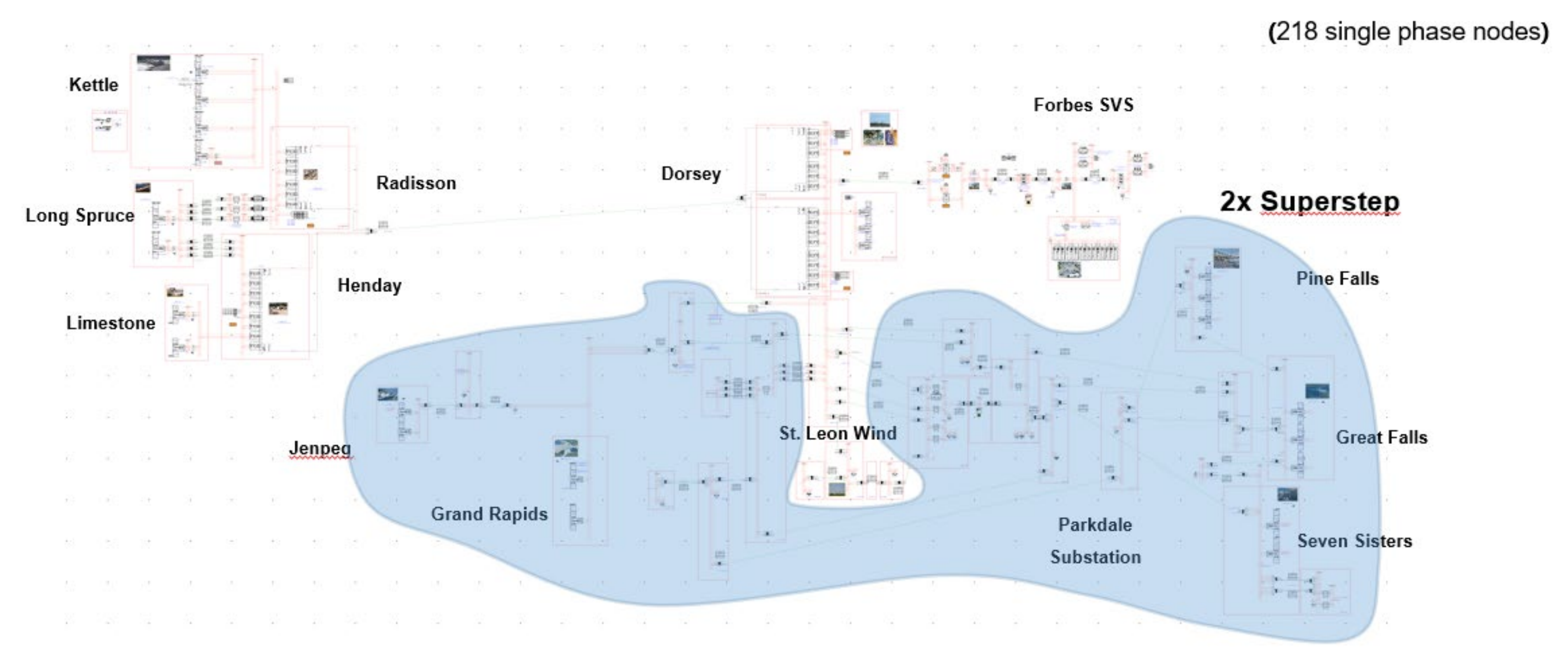
LARGE SCALE POWER SYSTEM SIMULATION

Multirate Simulation

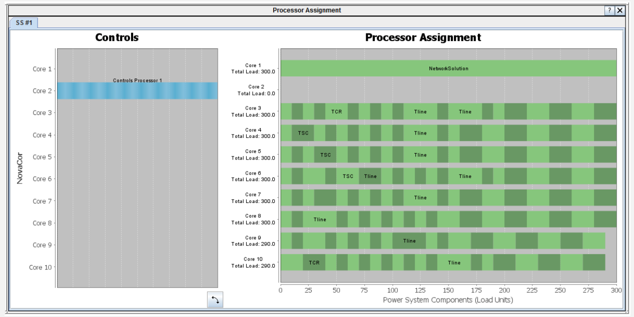


LARGE SCALE POWER SYSTEM SIMULATION

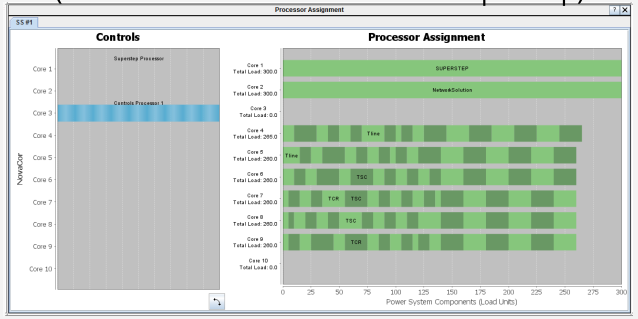
Superstep Simulation



Conventional Single-Rate Simulation
(218 nodes and 2980 load units on Chassis**)**



Multi-Rate Simulation
(75 nodes and 815 load units in Superstep)



Saving of ~ 500 Loadunits

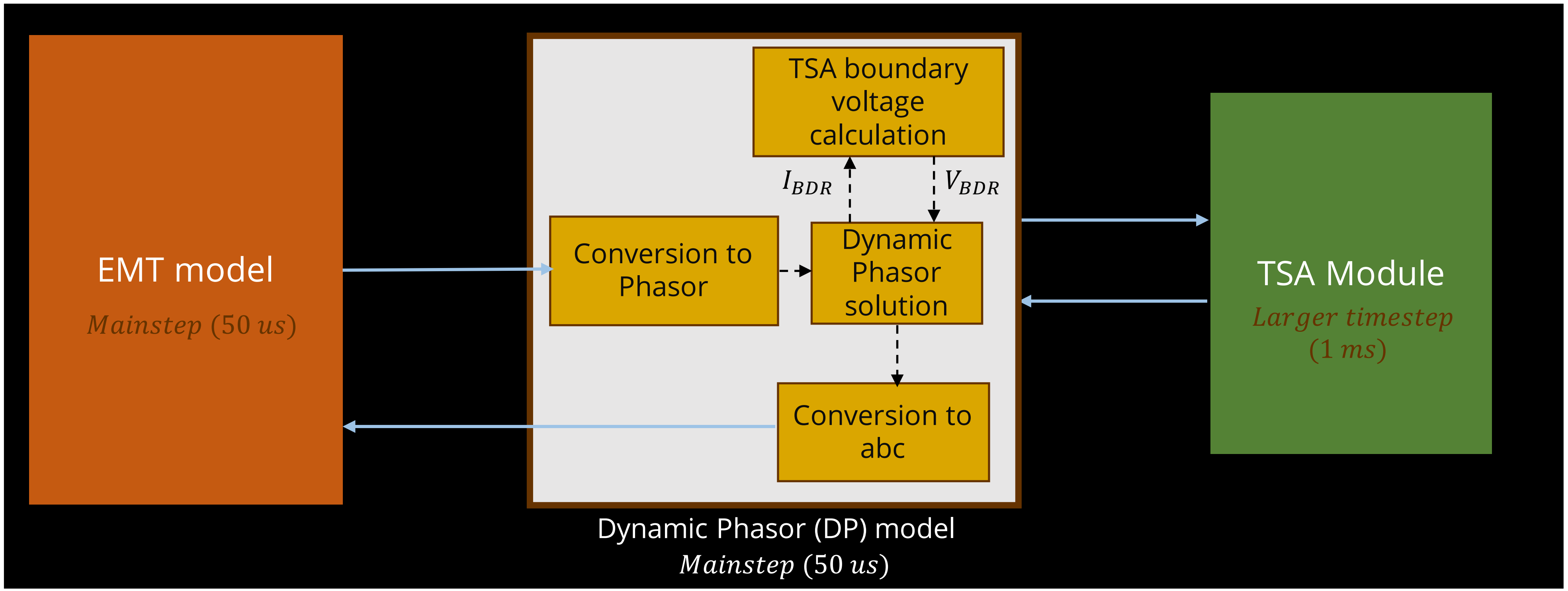
LARGE SCALE POWER SYSTEM SIMULATION

Transient Stability Analysis (TSA) Module

- TSA module in RTDS intended to:
  - Represent a portion of a larger power system (up to ~2000 buses) using an equivalent TSA component.
  - Interface TSA module with EMT simulation (co-simulation/ hybrid simulation)
  - Standalone TSA simulation is also supported.
  - Reduced number of cores (TSA module requires one core).

LARGE SCALE POWER SYSTEM SIMULATION

EMT-TSA Interface

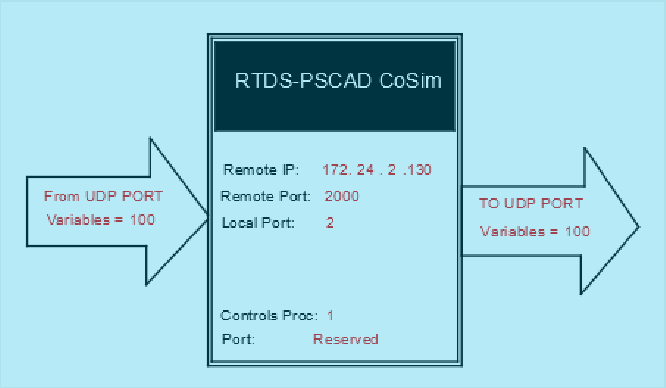


LARGE SCALE POWER SYSTEM SIMULATION

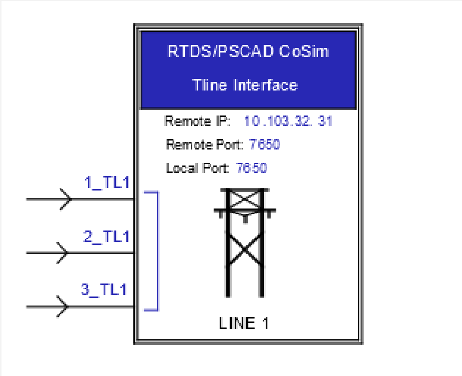
PSCAD-RTDS Co-Simulation

- Interface between NovaCor simulator and PSCAD has been developed.
- Main application is to run Blackbox models running in PSCAD which cannot be successfully migrated to RTDS.
- Intended for non-real time applications.
- Control interface has been released and electrical interface is under development.

Control Interface



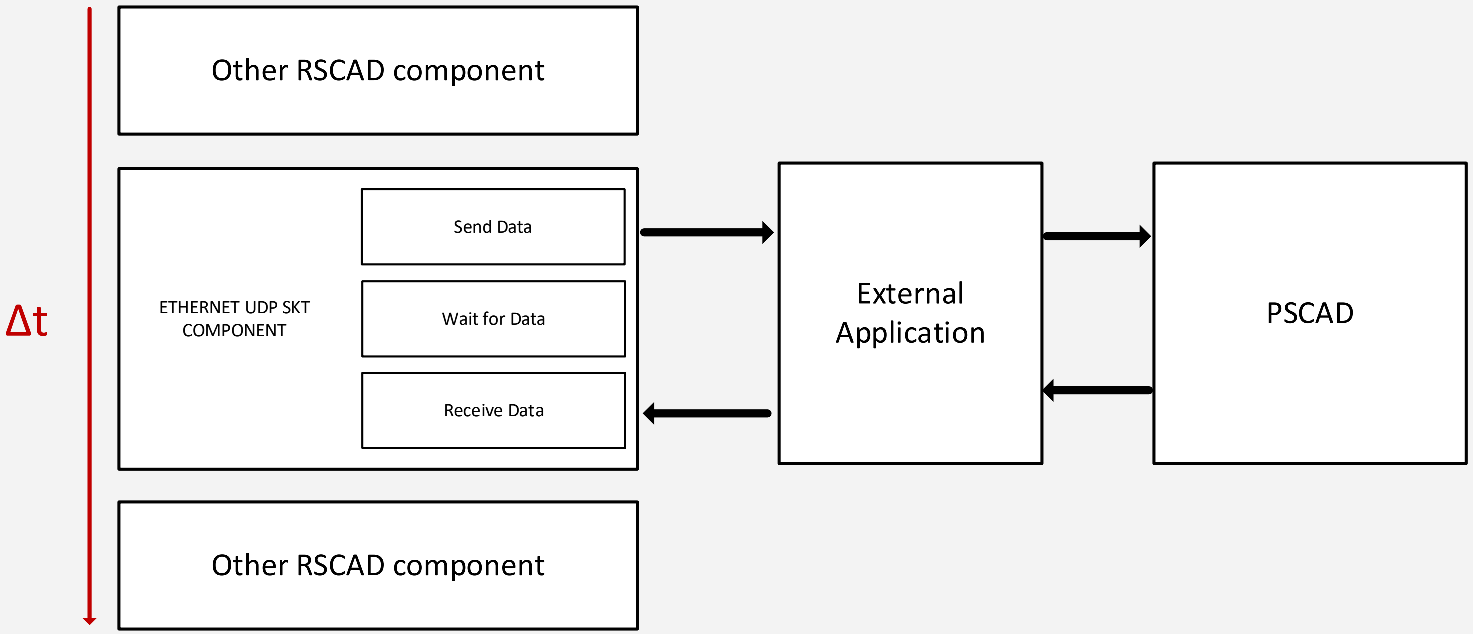
Electrical Interface



LARGE SCALE POWER SYSTEM SIMULATION

PSCAD-RTDS Co-Simulation

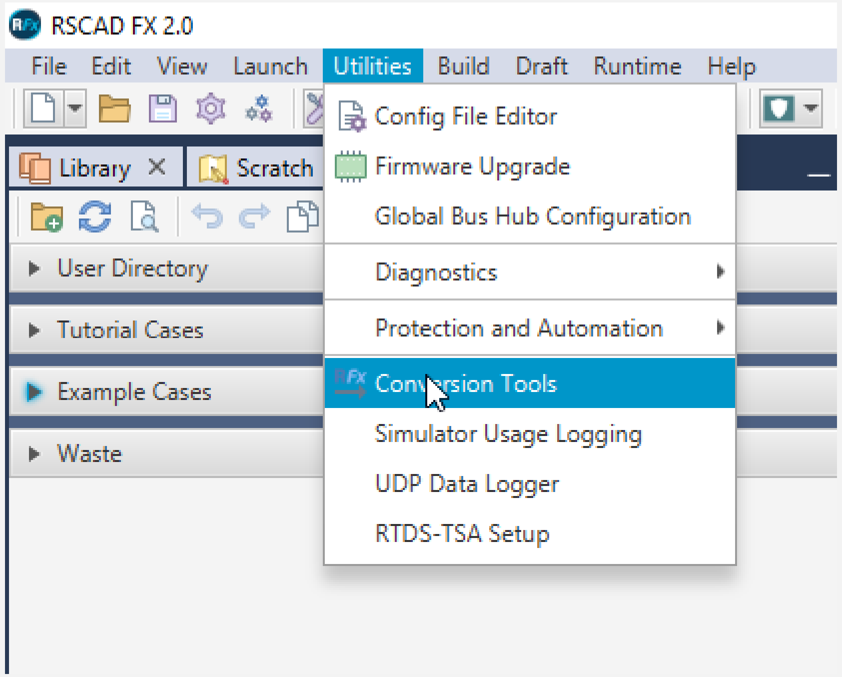
- UDP communication.
- PSCAD V5 Support only.

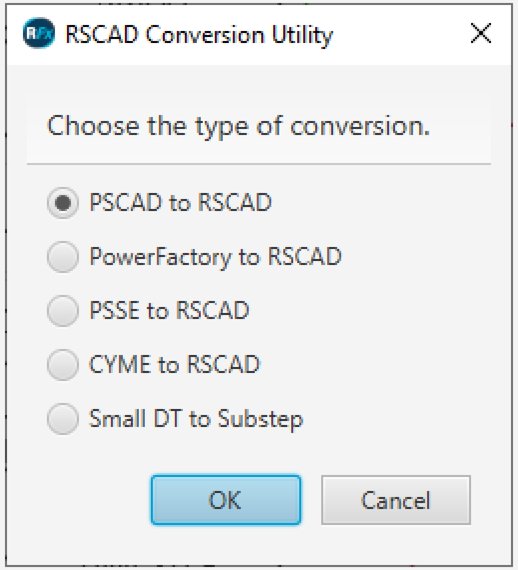


LARGE SCALE POWER SYSTEM SIMULATION

Data Conversion Programs

- RSCAD supports conversion of cases from other widely used offline tools

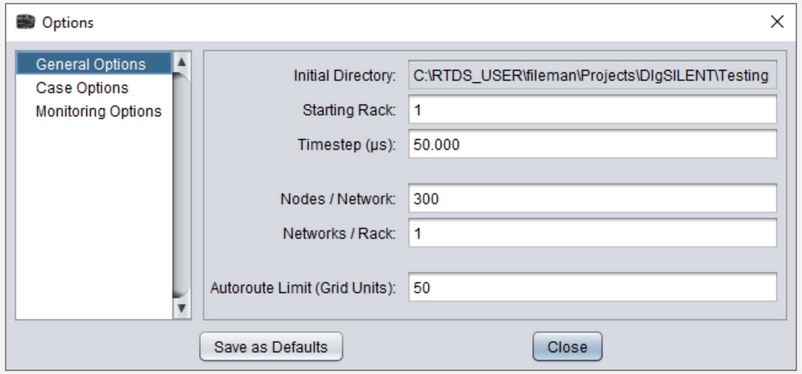


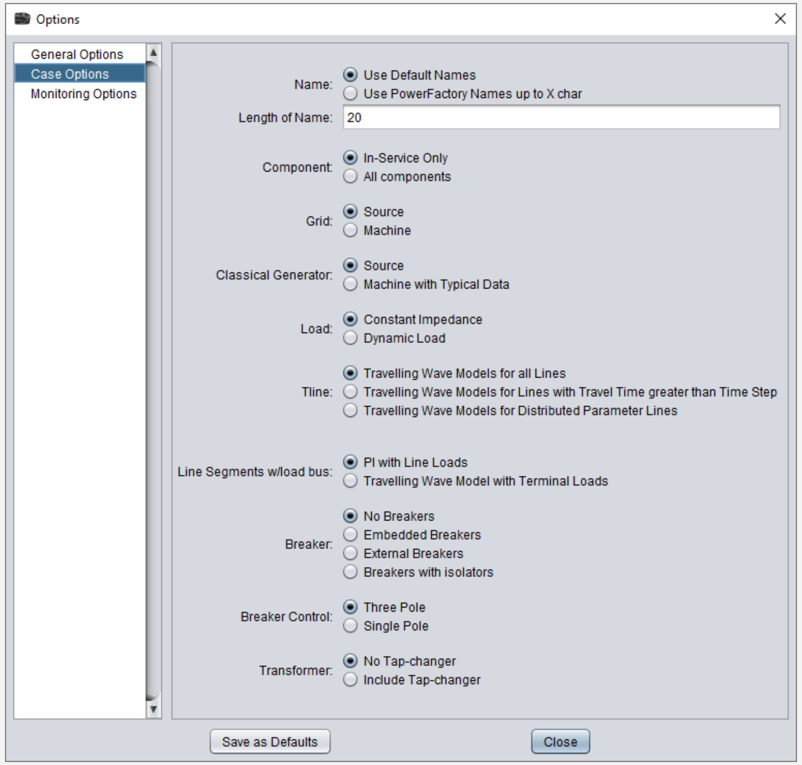


LARGE SCALE POWER SYSTEM SIMULATION

PowerFactory (PF) Conversion Program

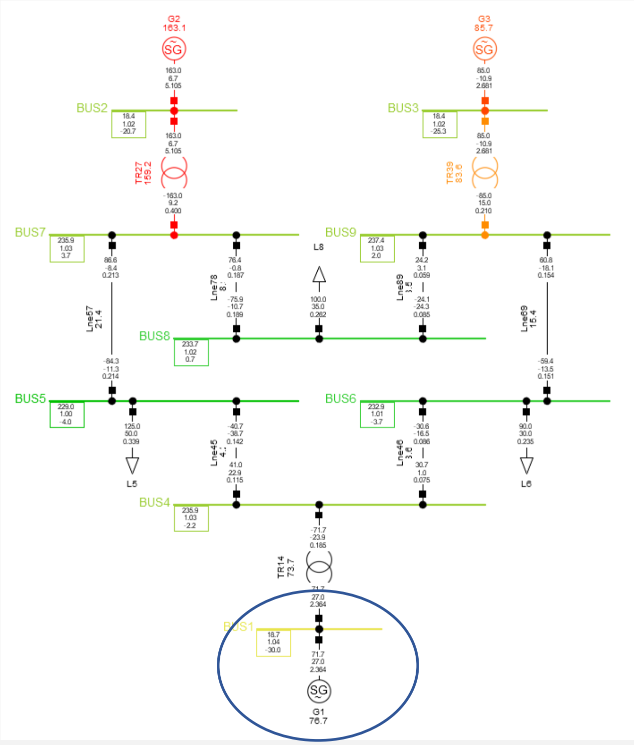
- Similar to the PSCAD Conversion.
- Conversion can be customized.

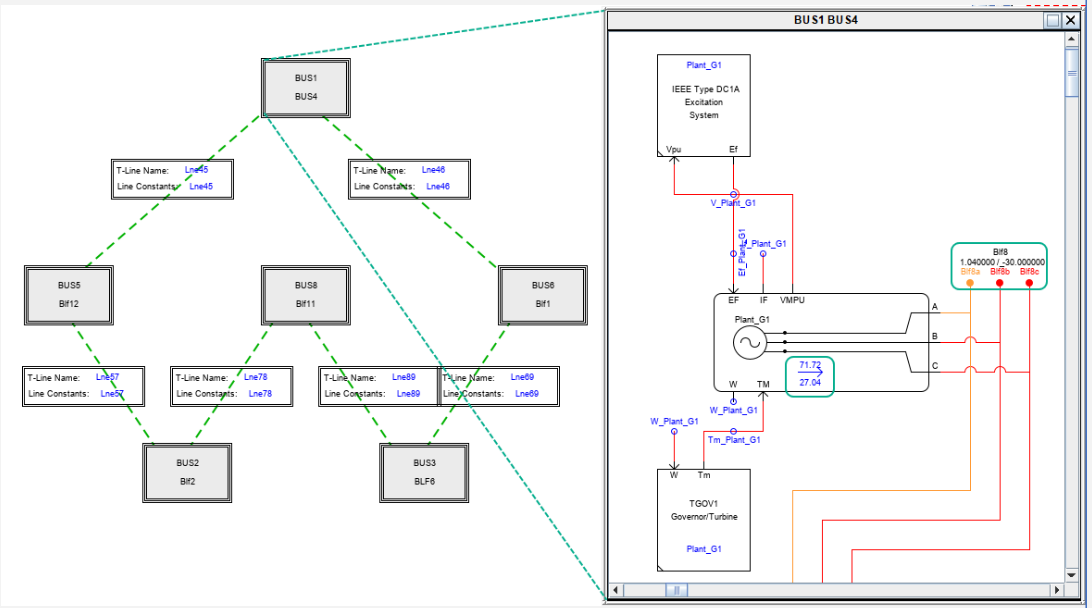


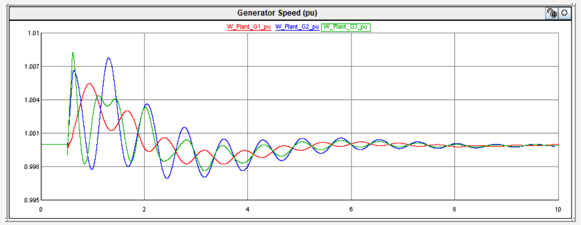


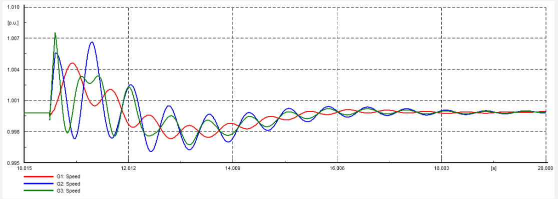
LARGE SCALE POWER SYSTEM SIMULATION

PowerFactory (PF) Conversion Program Example









LARGE SCALE POWER SYSTEM SIMULATION

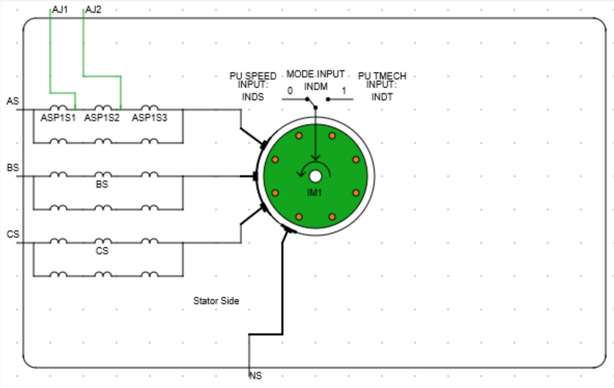
Enhanced Non-Real Time Simulation (*Under Development*)

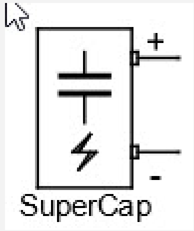
- To help
  - EMT network planning studies
  - Consultants
- Support larger network (~10 times the capacity of NovaCor 1.0)
- Larger execution timestep (> 200 μs)
- No support for I/O and GTNET
- Will Support GTSOC

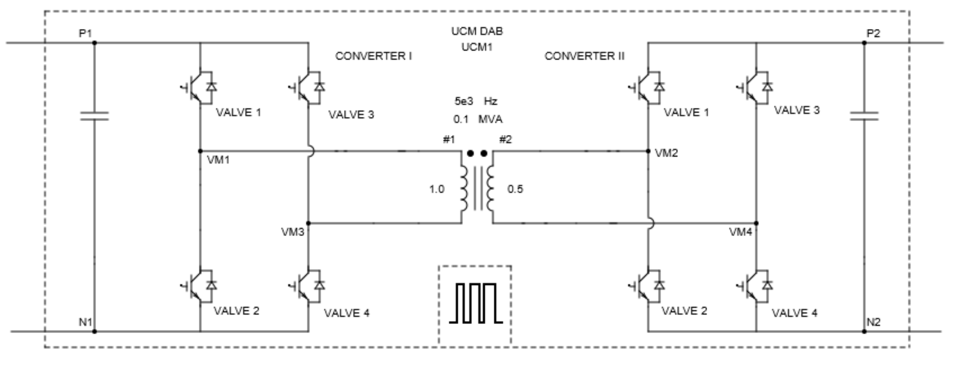
OTHER NEW COMPONENTS

Recently Released RSCAD Components

- Faulted Induction Machine
- Super Capacitor Bank
- Dual Active Bridge (DAB) UCM with scaling
- UMEC transformer models with hysteresis







Questions?