WEBINAR

HIL TESTING OF MODERN PROTECTION SYSTEMS VIA IEC 61850

RTDS Technologies

RTDS.COM

RTDS TECHNOLOGIES - THE COMPANY

- Based in Winnipeg, Canada
- ~75 employees
- World pioneer of real-time simulation and exclusive supplier of the RTDS Simulator
- Representatives in over 50 countries
- Hardware and software development, model development, customer support, sales and marketing, finance, product assembly and testing all under one roof

WORLDWIDE USER BASE

Manufacturers

SIEMENS

TOSHIBA

Schneider Electric

ABB

SCHWEITZER ENGINEERING LABORATORIES

WORLDWIDE USER BASE

Utilities

WORLDWIDE USER BASE

Research and educational institutions

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

University of Strathclyde

MANCHESTER 1824
The University of Manchester

DTU Technical University of Denmark

DUT DURBAN UNIVERSITY OF TECHNOLOGY

FLORIDA STATE UNIVERSITY 1851

CENTER FOR ADVANCED POWER SYSTEMS

APPLICATION AREAS

Distribution

- Microgrid testing.
- Renewables/DERs.
- Distribution automation.
- Inverter testing.

Power Electronics

- HVDC and FACTS.
- Energy conversion.
- Drives.

Smart Grid

- Wide Area P&C testing.
- PMU studies.
- Cyber security.

Protection

- **Digital substations.**
- Travelling wave testing.

WEBINAR

HIL TESTING OF MODERN PROTECTION SYSTEMS VIA IEC 61850

RTDS Technologies

RTDS.COM

OUTLINE

- Overview of Closed-Loop Protection Testing.
- Hardware & Software.
- Demonstration.
- Questions and Answers.

CLOSED-LOOP TESTING ADVANTAGE

Synthetic Testing

- "Synthetic" waveforms (often unrealistic).
- Can misrepresent how a relay will function.

Playback Testing

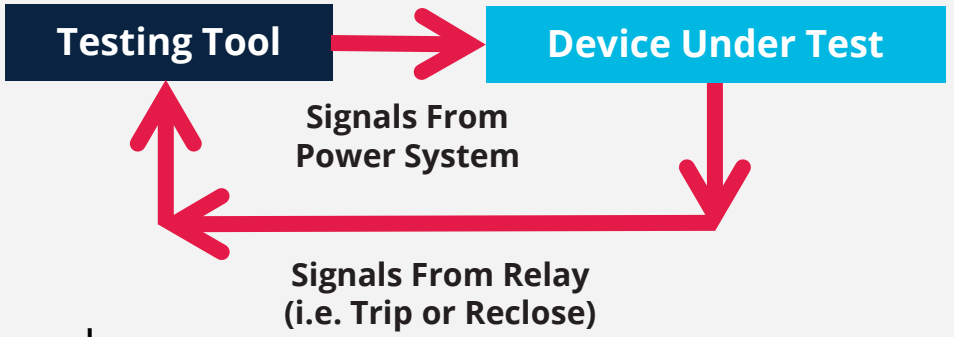
- Recorded or simulated waveforms.
- Waveforms only valid until the relay trips.

Closed-Loop Testing

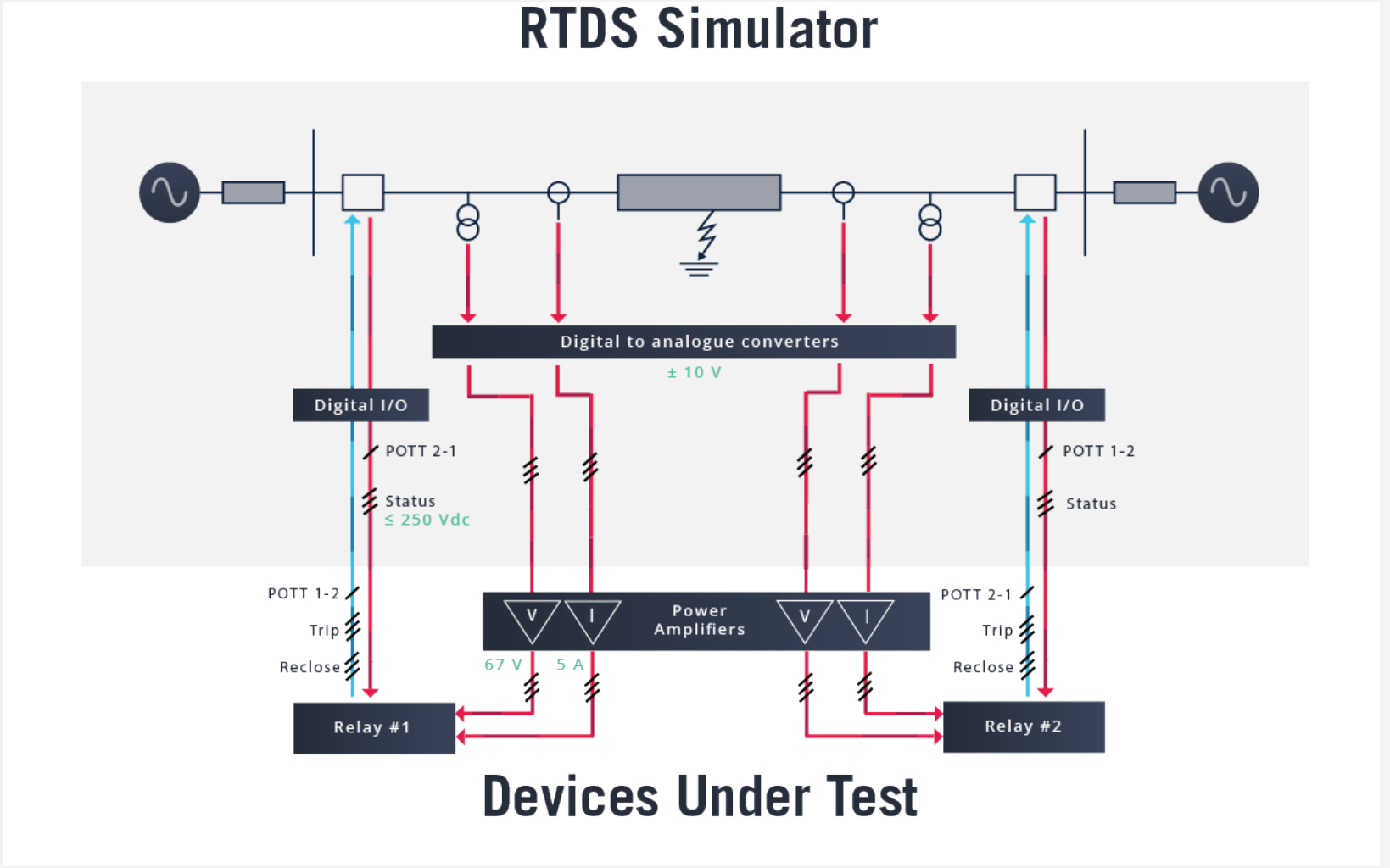
- Real-time simulator to provide realistic power system signals.
- Complete interaction between the relay and the simulated power system.
- Multiple devices can be tested.

Open-Loop Protective Relay Testing

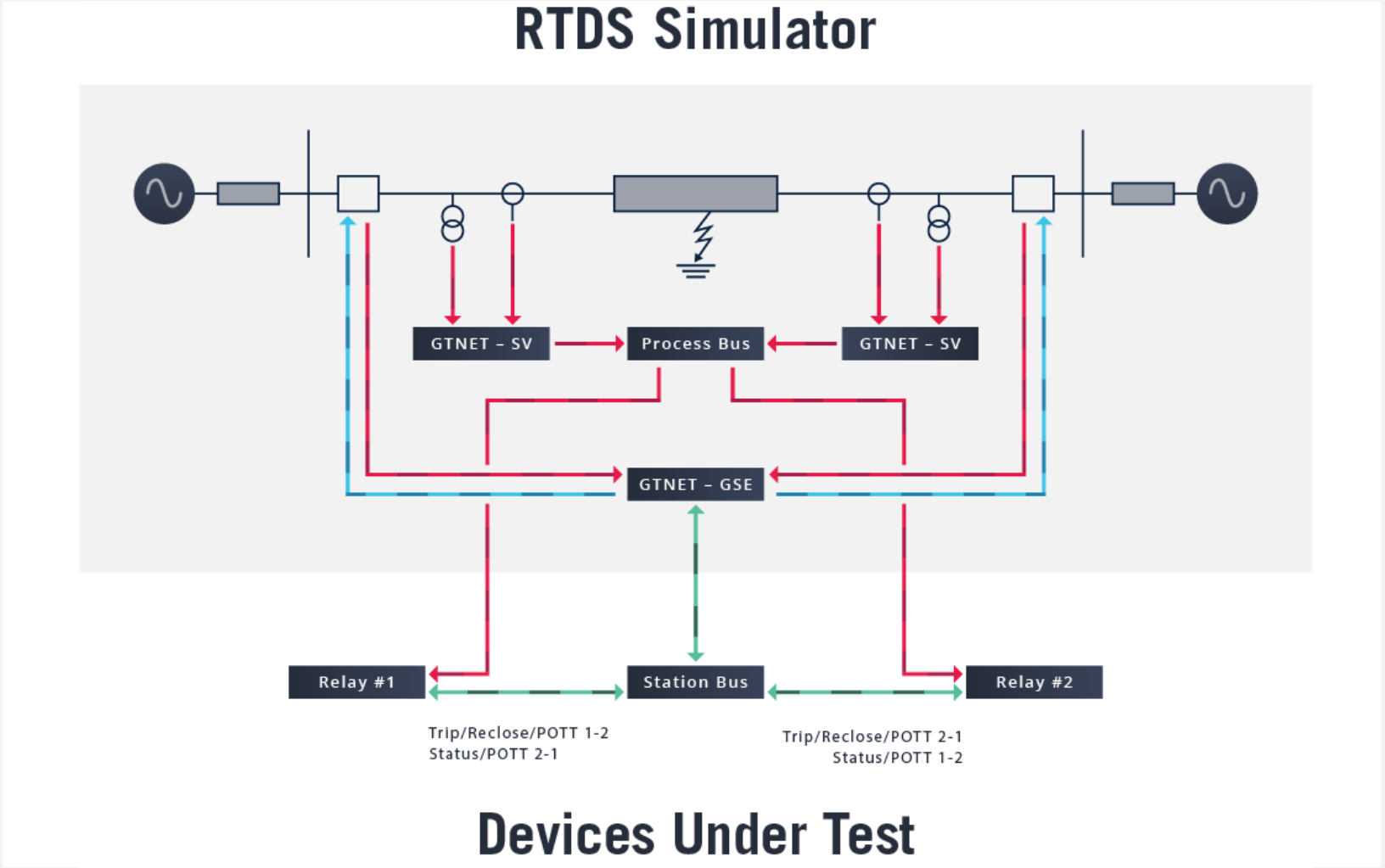
Closed-Loop Protective Relay Testing



ELECTRICAL INTERFACE



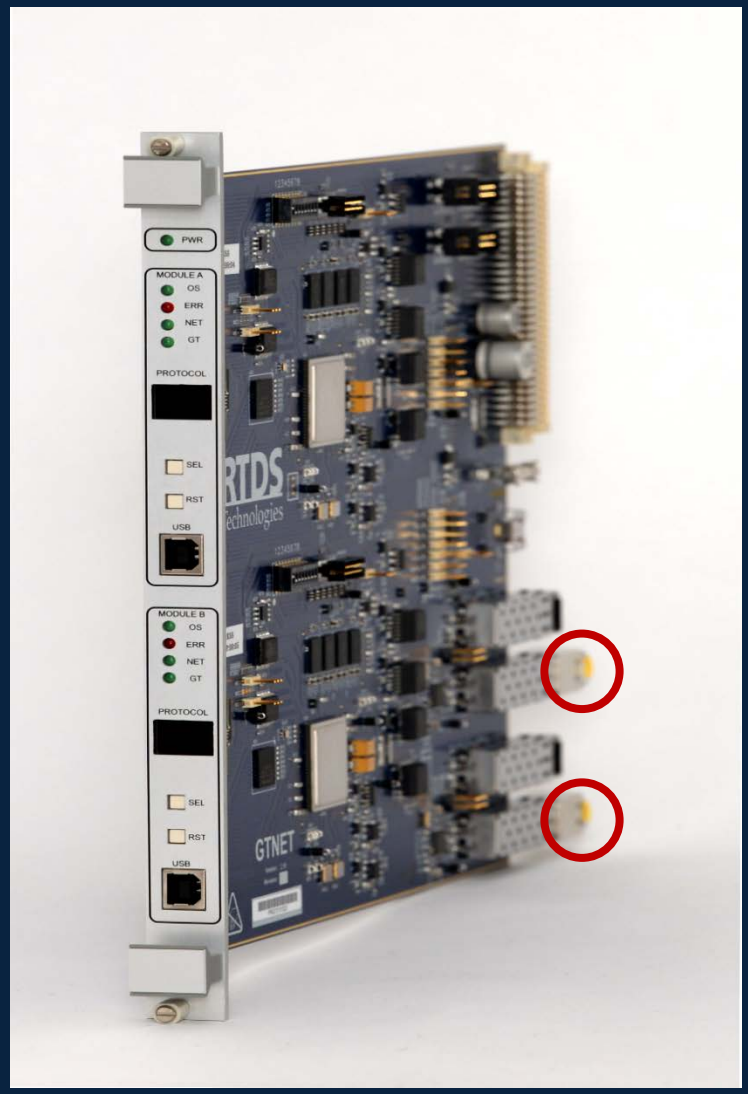
IEC 61850 INTERFACE



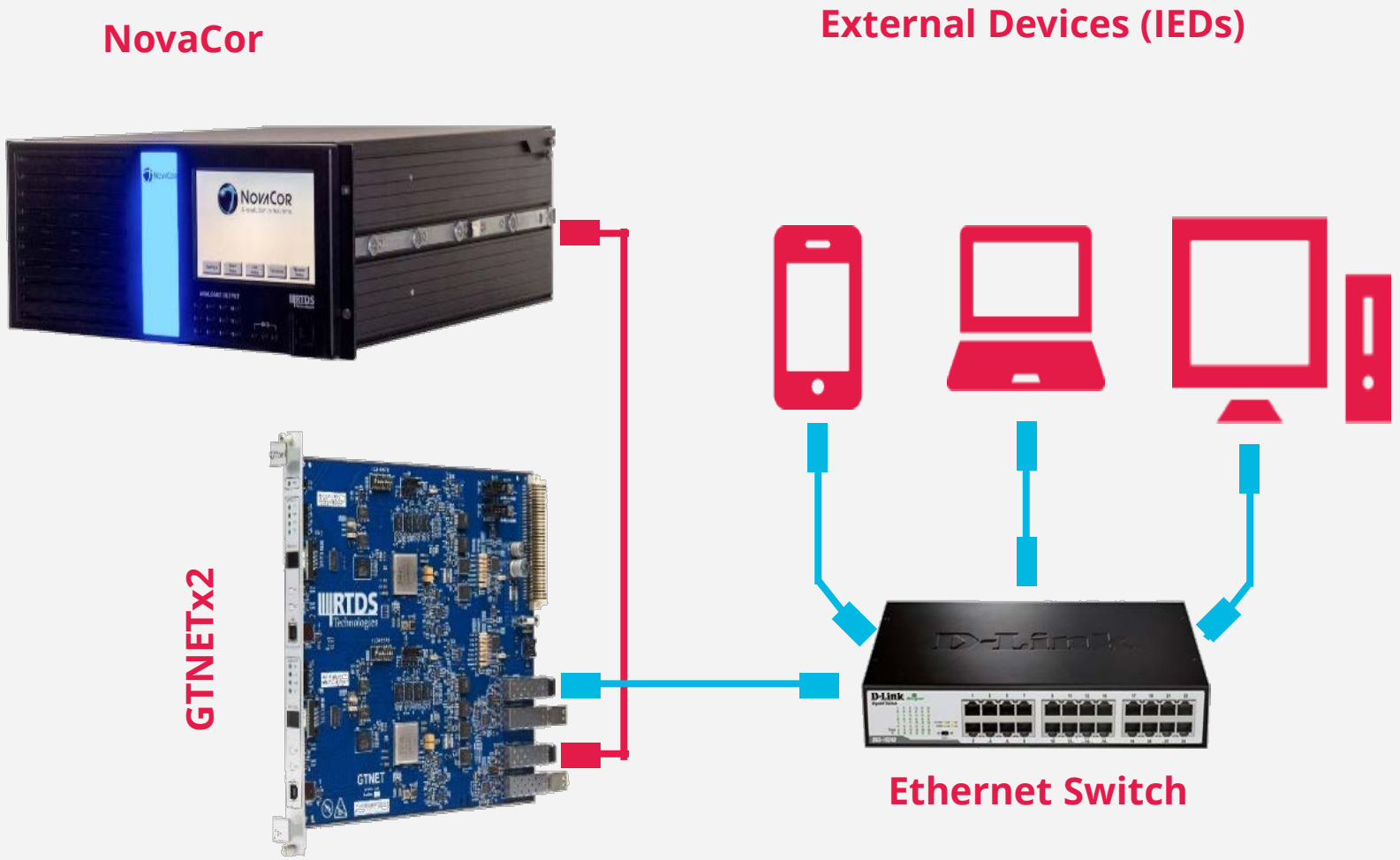
GTNETx2 Overview

GTNETx2 – Hardware Features

- An interface between the simulation and the real world using known substation automation protocols.
- Has two “GTNET” modules.
- Each ‘module’ is completely independent with no shared resources.
- Supports SFP modules for Ethernet.
- Runs 5-10 times faster than the GTNET card.
- Multi-IP support (RSCAD 5.007.2 and above).



HARDWARE CONNECTIONS

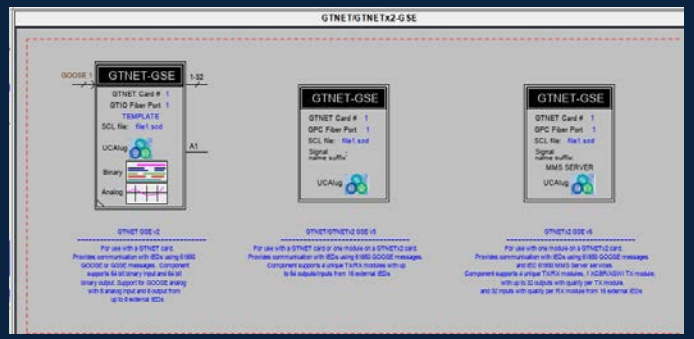


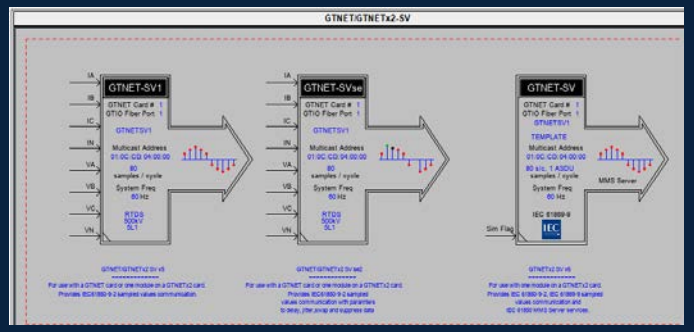
GTNETx2 Overview

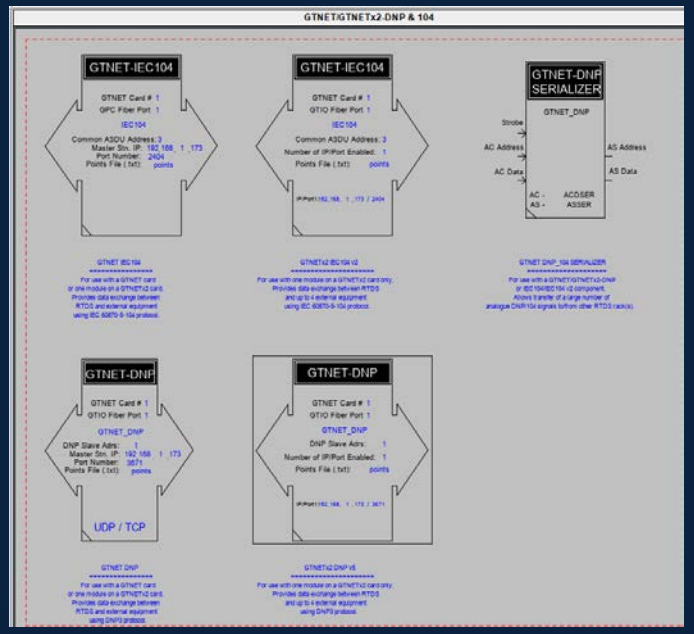
GTNETx2 –

Available Components / Firmware

- GTNETx2-GSE for IEC 61850 GOOSE.
- GTNETx2-SV for IEC 61850 Sampled Values (SV).
- GTNETx2-DNP for DNP3.
- GTNETx2-104 for IEC 60870-5-104.





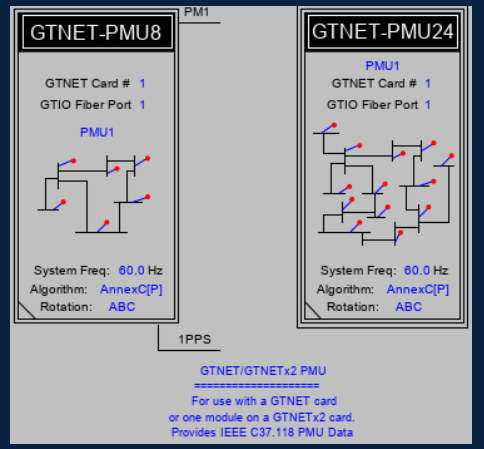


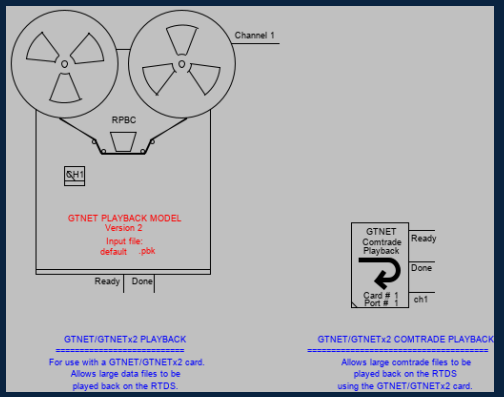
GTNETx2 Overview

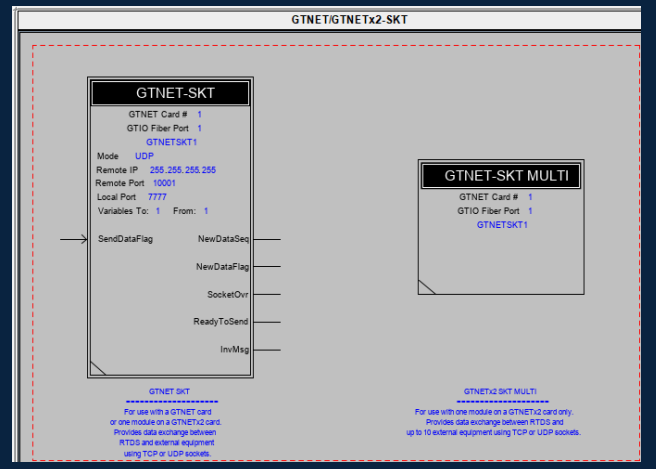
GTNETx2 –

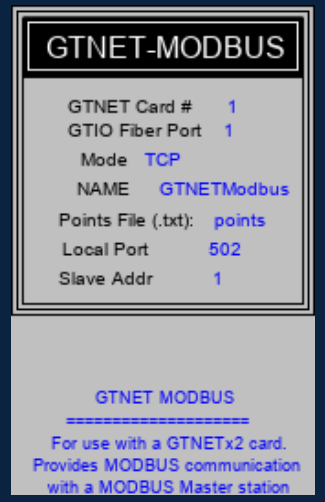
Available Components / Firmware

- GTNETx2-PMU for IEEE C37.118.
- GTNETx2-SKT for TCP/UDP Socket.
- GTNETx2-PLAYBACK to replay captured waveform data.
- GTNETx2-MODBUS for Modbus communication over TCP/IP.





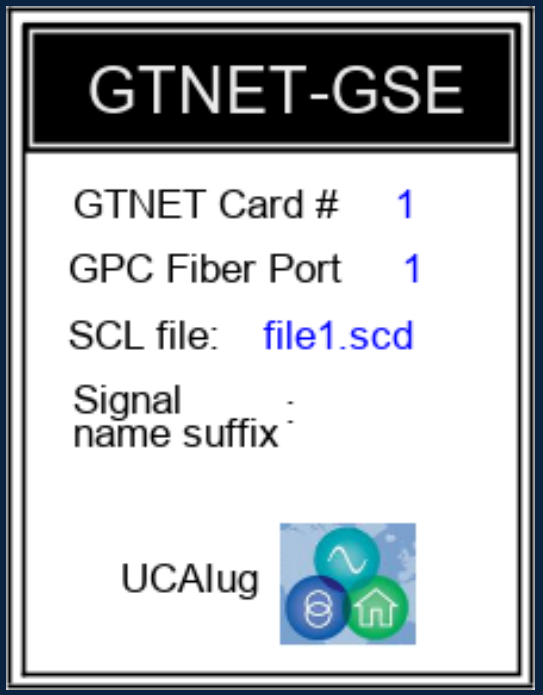




IEC 61850 GOOSE

GTNETx2 – GSE v5

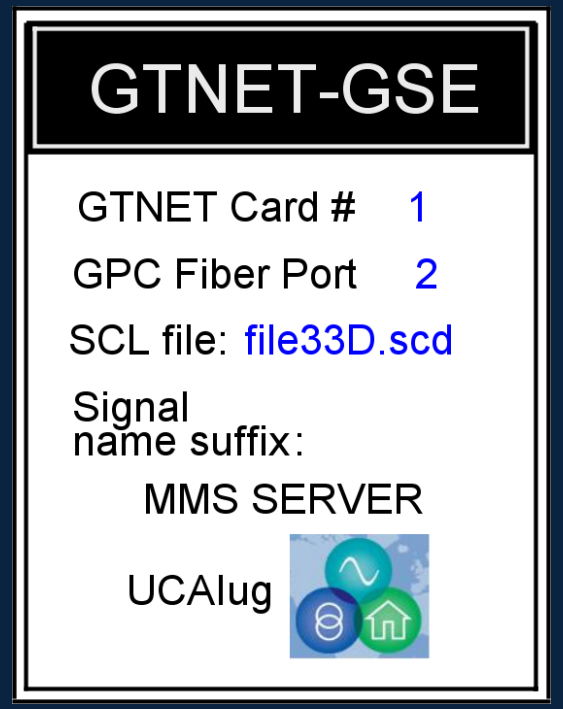
- IEC 61850 Edition 1.
- GGIO outgoing GOOSE dataset.
- Publishes/subscribes up to 256 points (Boolean, or INT32, or FLOAT32, or Dbpos), or 128 points with Quality.
- Up to 4 GOOSE messages may be published.
- Up to 16 GOOSE messages may be subscribed.



IEC 61850 GOOSE & MMS

GTNETx2 – GSE v6

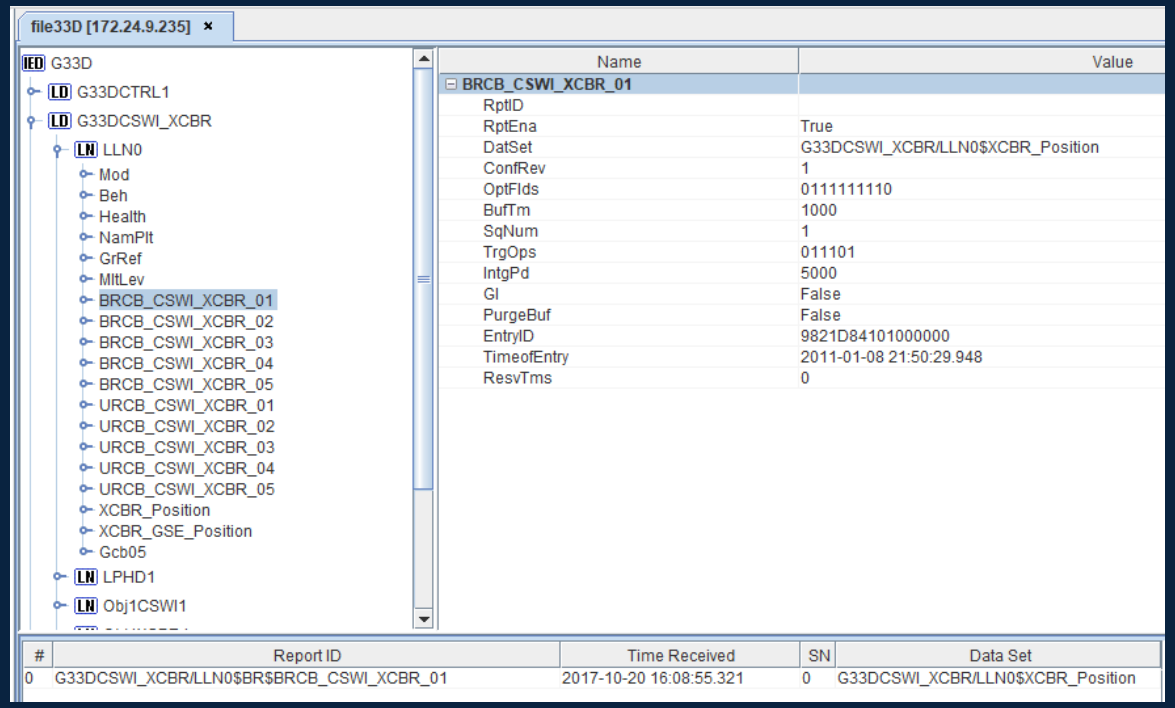
- IEC 61850 Edition 2.
- XCBR/XSWI outgoing GOOSE dataset.
- IEC 61850 MMS Server.
- Routable GOOSE (R-GOOSE, IEC 61850-8-1 Ed2.1 / IEC 61850-90-5 TR).



IEC 61850 MMS

GTNETx2 – GSE v6 MMS Server

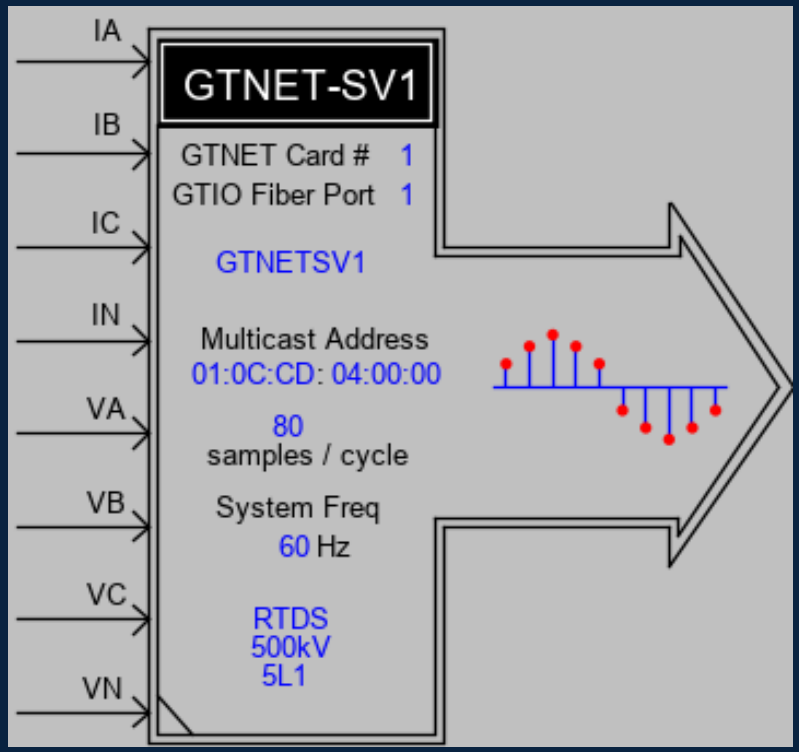
- A connected MMS client is able to perform the following MMS services -
  - ❑ Read breaker status from a LN XCBR.
  - ❑ Enable/disable GOOSE control blocks.
  - ❑ CSWI control service.
  - ❑ Simulation mode and GOOSE supervision.



IEC 61850 SV

GTNETx2 – SV v5

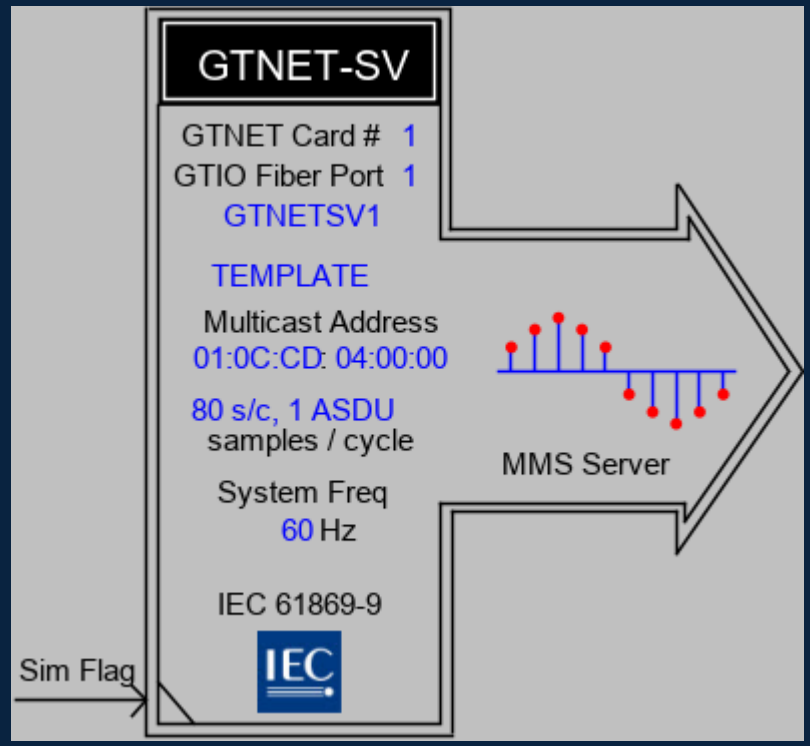
- IEC 61850 Edition 1.
- Output mode or input mode.
- Supports sample rate of 80 or 256 samples per cycle.



IEC 61850 SV & MMS

GTNETx2 – SV v6

- IEC 61850 Edition 2 & MMS Server.
- Output mode or input mode.
- IEC 61850 Routable Sampled Values (R-SV, IEC 61850-8-1 Ed2.1 / IEC 61850-90-5 TR).



IEC 61850/61869 SV

GTNETx2 – SV v6

Mode	Max Number of SV Streams	Sampling Rate	Max Number of Channels per Stream
Output	2	80 s/c, 90 s/c, 4800 Hz	24
		256 s/c, 14400 Hz	9
Input	1	80 s/c, 90 s/c, 4800 Hz	24
		256 s/c, 14400 Hz	9

IEC 61850/61869 SV

GTFPGA-SV v3

- Xilinx Virtex®-7 FPGA evaluation kit.
- 16 SFP ports.
- LAN port SFP options
  - 100/1000 Base T Copper.
  - 1000 Base-SX fiber.

IEC 61850/61869 SV

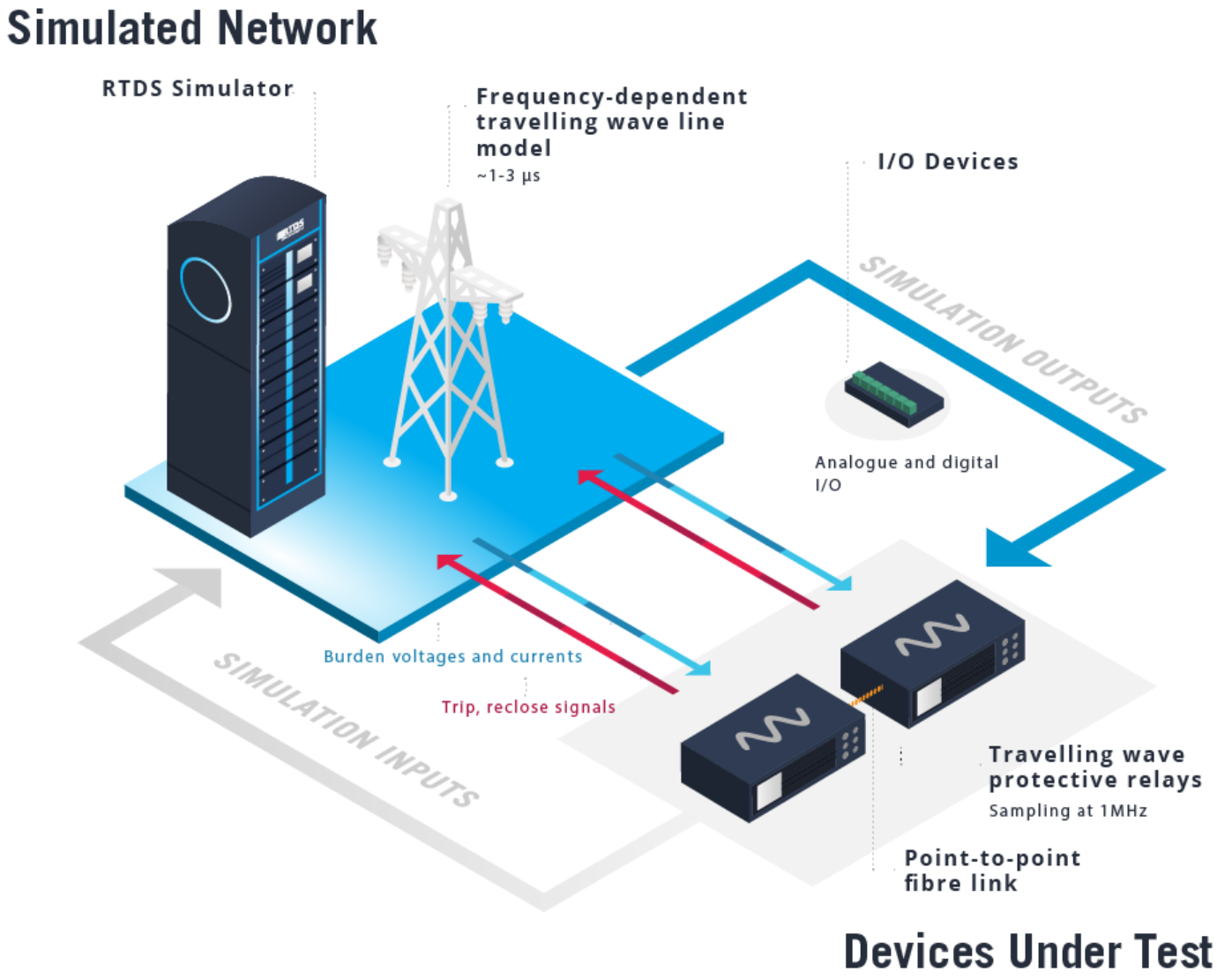
GTFPGA-SV v3

Mode	Max Number of SV Streams	Sampling Rate	Max Number of Channels per Stream
Mainstep	16 input and 16 output	80 s/c, 90 s/c, 4800 Hz	24
		256 s/c, 14400 Hz	9
Substep	2 (output only)	96000 Hz	24
	1 (output only)	250000 Hz	48

CONTROL HIL

Protection – Traveling-Wave Relay Testing (TWRT)

- TW-based Protection is based on a short window of power system high frequency response after fault inception.
- Advantages over traditional phasor-based protection –
  - *Fast tripping for improving system stability.*
  - *Protection of hybrid underground and overhead lines.*
  - *Protection of series (over) compensated lines.*
  - *Distribution systems with small zero-sequence current magnitude.*

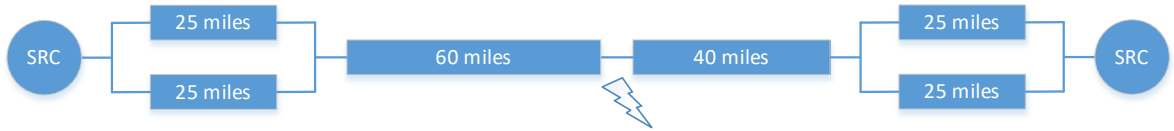


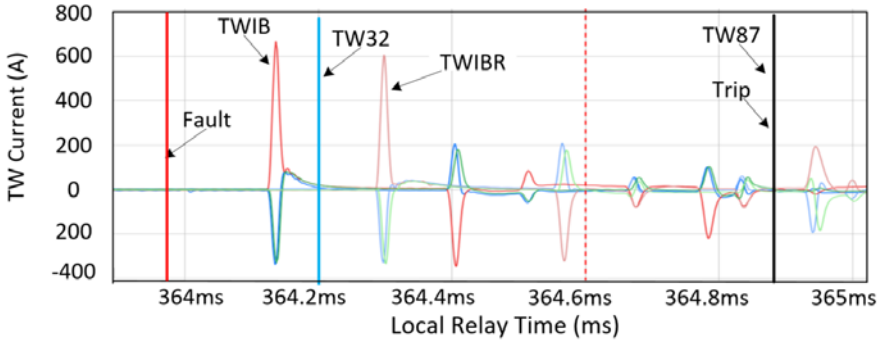
CONTROL HIL

Protection – Traveling-Wave Relay Testing (TWRT)

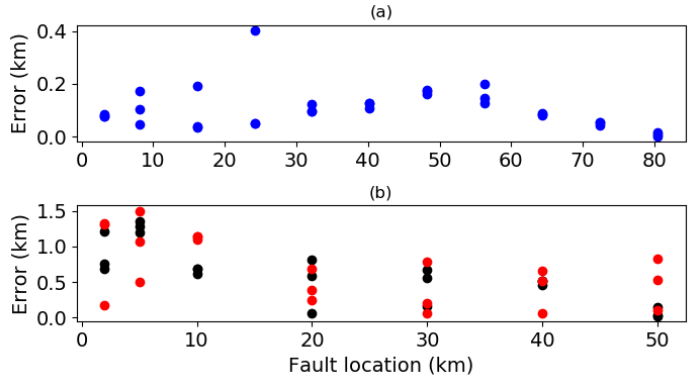
- Two real-time simulation approaches –
  - *FPGA-based.*
  - *NovaCor-based.*
- Leading technology.

Example: Multi-Core CPU-based Simulation





Internal Phase B to Ground Fault



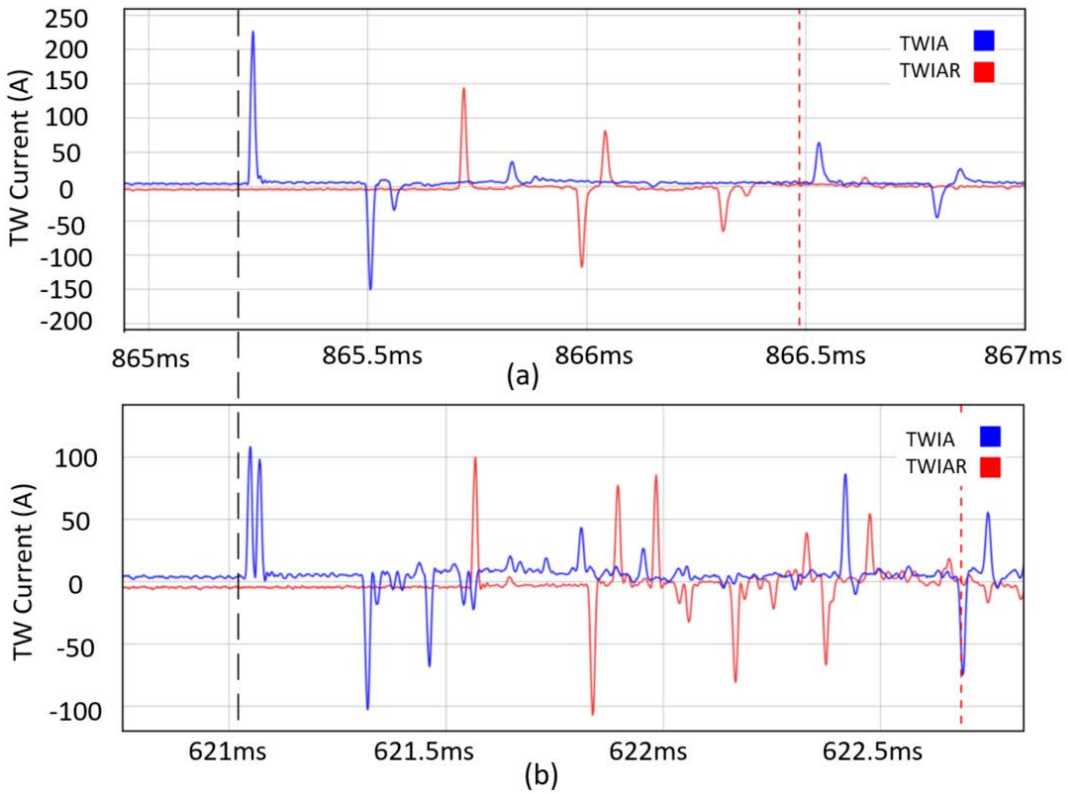
TWR fault location error for (a) vendor S' TWR device and (b) TWR developed by University A (black) and University B (red).

CONTROL HIL

Protection – Traveling-Wave Relay Testing (TWRT)

- Bergeron transmission line model.
  - *Fundamental frequency.*
  - *Low computational burden for real-time simulation.*
- Frequency-Dependent Phase Domain (FDPD) transmission line model.
  - *Wide frequency range.*
  - *Relatively large computational burden for real-time simulation.*

TW Signals* using FDPD and Bergeron



Phase A current TW signals for local (blue) and remote buses (red), using (a) FDPD model and (b) Bergeron model.

** Using two Vendor S' TWR devices*

Thank you!

Please contact marketing@rtds.com with any additional questions.

Attendees will receive an email with the webinar recording and Q&A document in the next few days.

RTDS Technologies

RTDS.COM