
Your world in real time.
RTDS
Technologies
RTDS.COM

REAL-TIME DIGITAL SIMULATION:

NEW DEVELOPMENTS & APPLICATIONS IN PROTECTION AND AUTOMATION

RTDS Technologies

RTDS.COM

OUTLINE

- GTNETx2New Developments.
- GTFPGASV New Development.
- Other Developments.
- Control Hardware In Loop Applications.
- Cyber Security Related Applications.
- Ongoing Projects.
- Questions and Answers .

GTNETx2 NEW DEVELOPMENTS

RTDS Technologies

RTDS.COM

GTNETx2 Overview

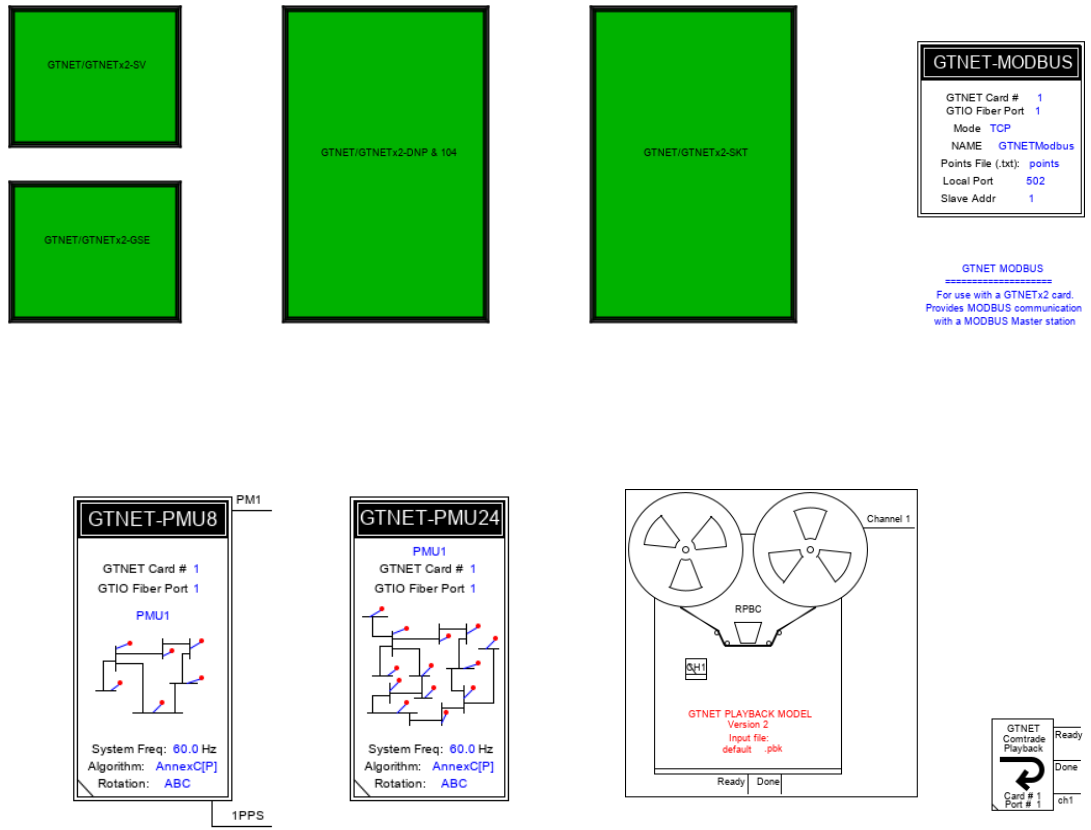
Hardware Features

- Provides an interface between the simulation and the real world using known substation automation protocols.
- Each GTNETx2 card has two “GTNET” modules.
- Each ‘module’ is completely independent with no shared resources.
- Support SFP modules for Ethernet.
- **Multi -IP support (RSCAD 5.007.2 and above).**

GTNETx2 Overview

Available Components/Firmware

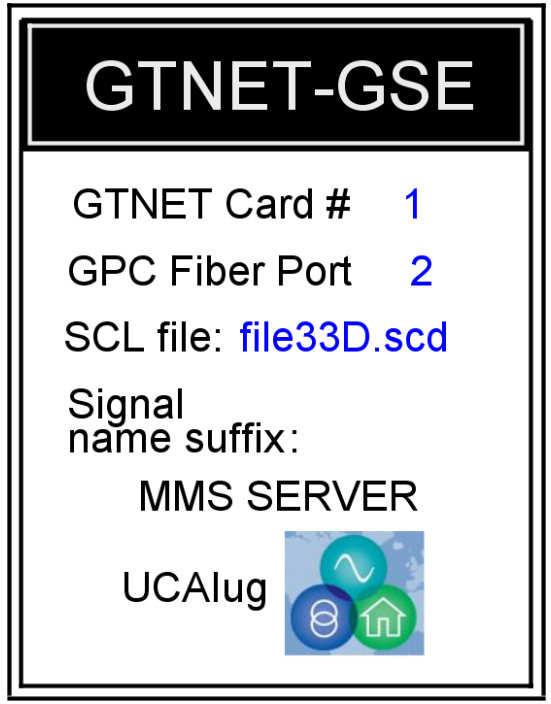
- GTNETx2-GSEfor IEC 61850 GOOSE.
- GTNETx2-SV for IEC 61850 Sampled Values (SV).
- GTNETx2-PMU for IEEE C37.118.
- GTNETx2-DNP for DNP3.
- GTNETx2-104 for IEC 60870-5-104.
- GTNETx2-SKT for TCP/UDP Socket.
- GTNETx2-PLAYBACK to replay captured waveform data.
- GTNETx2-MODBUS for Modbus communication over TCP/IP.



GTNETx2-GSEv6

For Use with IEC 61850 GOOSE & MMS

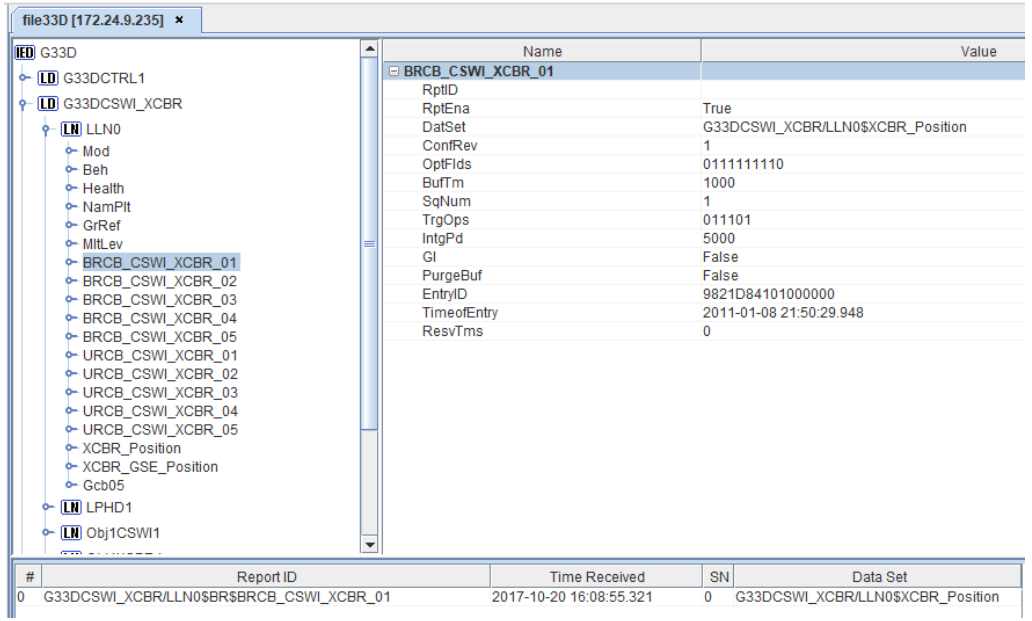
- IEC 61850 Edition 2.
- XCBR/XSWI outgoing GOOSE dataSet.
- IEC 61850 MMS Server.
- **Routable GOOSE (R-GOOSE, IEC 61850-8-1 Ed2.1 / IEC 61850-90-5 TR).**



GTNETx2-GSE v6

IEC 61850 MMS Server

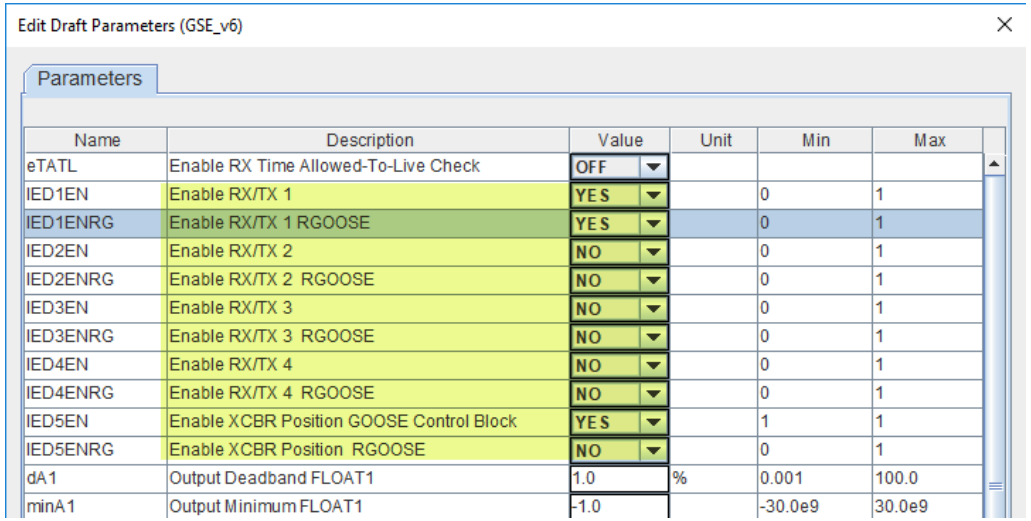
- A connected MMS client is able to perform the following MMS services -
  - Browse GTNETx2-GSE data models and read values from logical nodes (e.g. read breaker status from a LN XCBR).
  - Enable/disable GOOSE control blocks, buffered and unbuffered report control blocks.
  - CSWI control service (7-2 Ed2) with interlock (CILO) and synchronization (RSYN) check.
  - Loc/Rem and Control Authority (7 -4 Ed2).
  - Simulation mode (LPHD.Sim.stVal) and GOOSE supervision (LGOS) (7-1 Ed2).
  - Mode and Behaviour (7 -1/7-4 Ed2).



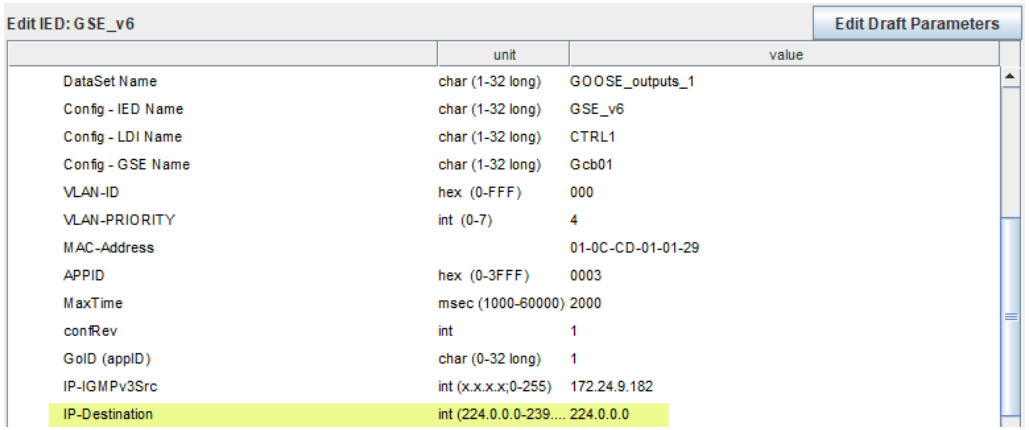
GTNETx2-GSE v6

R-GOOSE

- Uses Internet Group Management Protocol v3 (IGMP v3).
- “Tunnel” the currently existing Ethernet bound GOOSE packets over UDP/IP (8-1 Ed2.1).
- Each enabled GOOSE module may be configured to publish either regular GOOSE or R-GOOSE.
- Uses destination multicast **IP address** for subscription.



Name	Description	Value	Unit	Min	Max
eTATL	Enable RX Time Allowed-To-Live Check	OFF			
IED1EN	Enable RX/TX 1	YES		0	1
IED1ENRG	Enable RX/TX 1 RGOOSE	YES		0	1
IED2EN	Enable RX/TX 2	NO		0	1
IED2ENRG	Enable RX/TX 2 RGOOSE	NO		0	1
IED3EN	Enable RX/TX 3	NO		0	1
IED3ENRG	Enable RX/TX 3 RGOOSE	NO		0	1
IED4EN	Enable RX/TX 4	NO		0	1
IED4ENRG	Enable RX/TX 4 RGOOSE	NO		0	1
IED5EN	Enable XCBR Position GOOSE Control Block	YES		1	1
IED5ENRG	Enable XCBR Position RGOOSE	NO		0	1
dA1	Output Deadband FLOAT1	1.0	%	0.001	100.0
minA1	Output Minimum FLOAT1	-1.0		-30.0e9	30.0e9

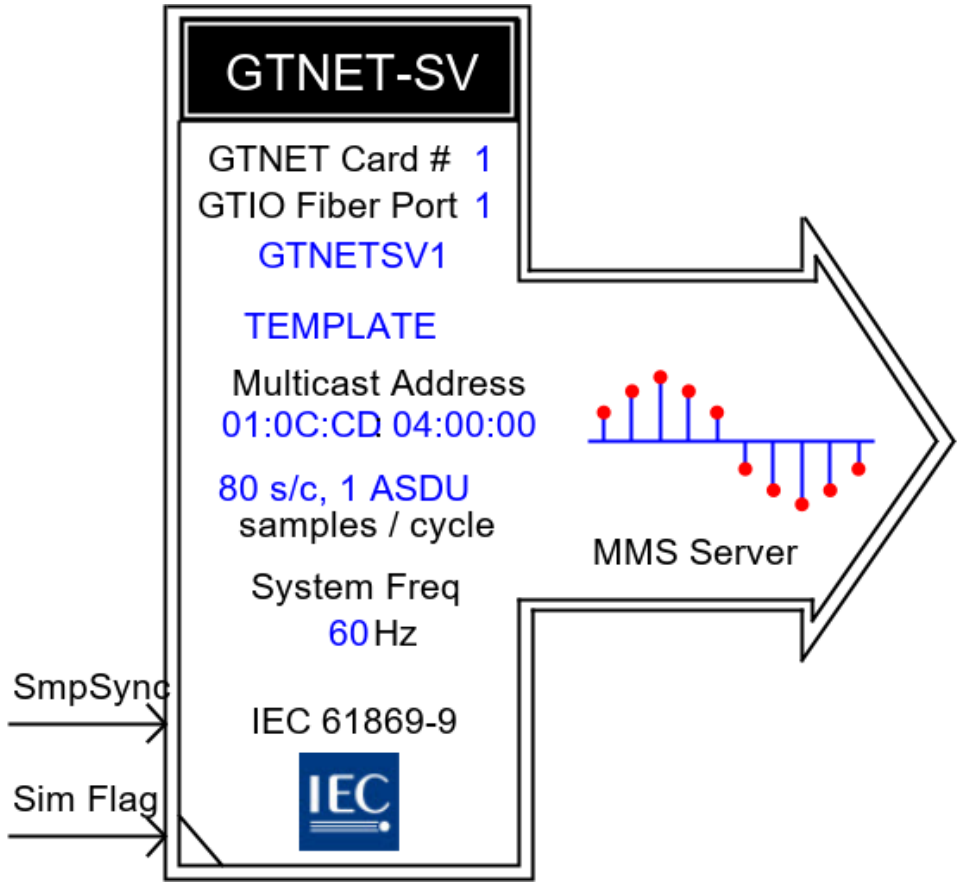


	unit	value
DataSet Name	char (1-32 long)	GOOSE_outputs_1
Config - IED Name	char (1-32 long)	GSE_v6
Config - LDI Name	char (1-32 long)	CTRL1
Config - GSE Name	char (1-32 long)	Gcb01
VLAN-ID	hex (0-FFF)	000
VLAN-PRIORITY	int (0-7)	4
MAC-Address		01-0C-CD-01-01-29
APPID	hex (0-3FFF)	0003
MaxTime	msec (1000-60000)	2000
confRev	int	1
GoID (appID)	char (0-32 long)	1
IP-IGMPv3Src	int (x.x.x.x;0-255)	172.24.9.182
IP-Destination	int (224.0.0.0-239....	224.0.0.0

GTNETx2-SV v6

For Use with IEC 61850-9-2 / IEC 61869-9 Sampled Value & IEC 61850 MMS

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



GTNETx2-SV v6

Sample Rates Supported (IEC 61869-9)

Digital output sample rates Hz	Number of ASDUs per frame	Digital output publishing rate frames/s	Remarks
4 000	1	4 000	For use on 50 Hz systems backward compatible with 9-2LE guideline.
4 800	1	4 800	For use on 60 Hz systems backward compatible with 9-2LE guideline, or 50 Hz systems backward compatible with 96 samples per nominal system frequency cycle.
4 800	2	2 400	Preferred rate for general measuring and protective applications, regardless of the power system frequency.
5 760	1	5 760	For applications on 60 Hz systems backward compatible with 96 samples per nominal system frequency cycle.
12 800	8	1 600	Deprecated, only for use on 50 Hz systems.
14 400	6	2 400	Preferred rate for quality metering applications, regardless of the power system frequency including instrument transformers for time critical low bandwidth d.c. control applications.

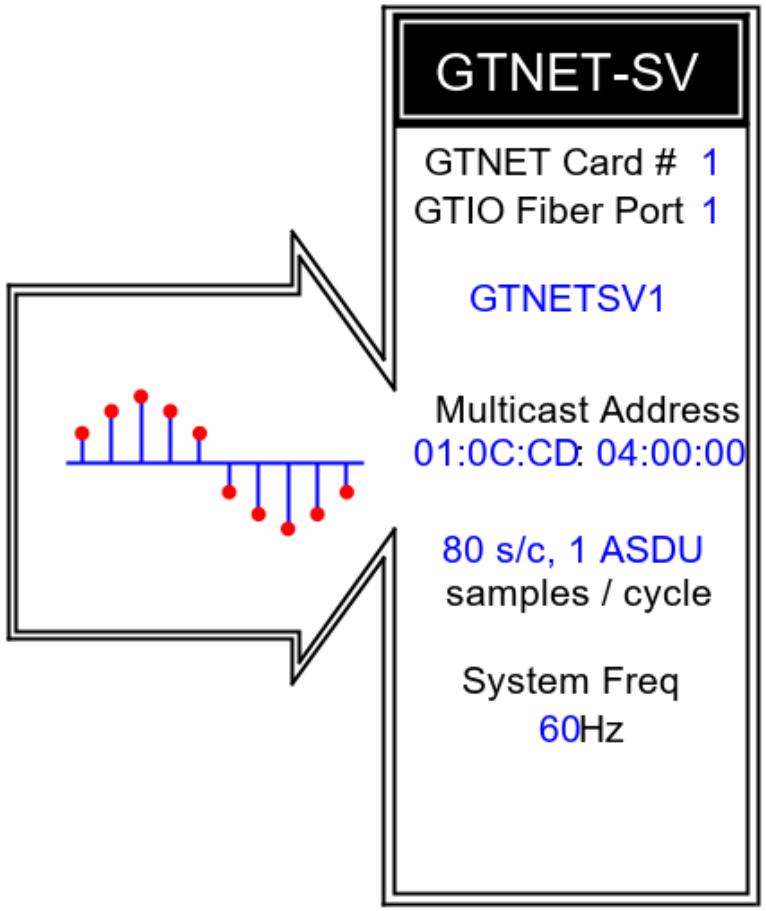
GTNETx2-SV v6

Output Mode

- Able to publish up to 2 streams with data type of either Float or Integer.
- Each stream may have up to 24 channels for sampling rates of 80, 96 s/c and 4800Hz.
- Each stream may have up to 9 channels for sampling rates of 256 s/c and 14,400Hz.

Input Mode

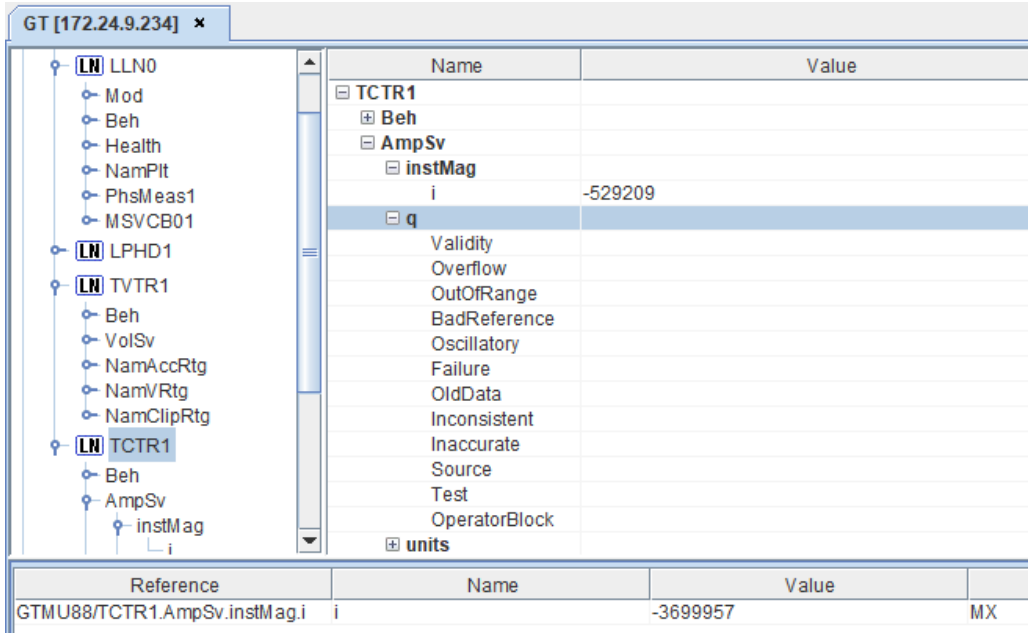
- Able to subscribe to 1 stream with data type of either Float or Integer.
- **Supports up to 24 channels for sampling rates of 80, 96 s/c and 4800Hz.**
- Supports up to 9 channels for sampling rates of 256 s/c and 14,400Hz.



GTNETx2-SV v6

IEC 61850 MMS Server

- A connected MMS client is able to perform the following MMS services -
  - Browse GTNETx2-SV data models and read values from logical nodes (e.g. read current from a LN TCTR).
  - Enable/disable SV control block.
  - Simulation mode (LPHD.Sim.stVal) and SV supervision (LSVS) (7-1 Ed2).
  - Mode and Behaviour (7 -1/7 -4 Ed2).



GTNETx2-SV v6

R-SV

- Uses IGMP v3.
- “Tunnel” the currently existing Ethernet bound SV packets over UDP/IP (8 -1 Ed2.1).
- Each enabled SV output may be configured to publish either regular SV or R-SV.
- Uses destination multicast **IP address** for subscription.

_rtds_ctl_GTNET_SV_v6.def

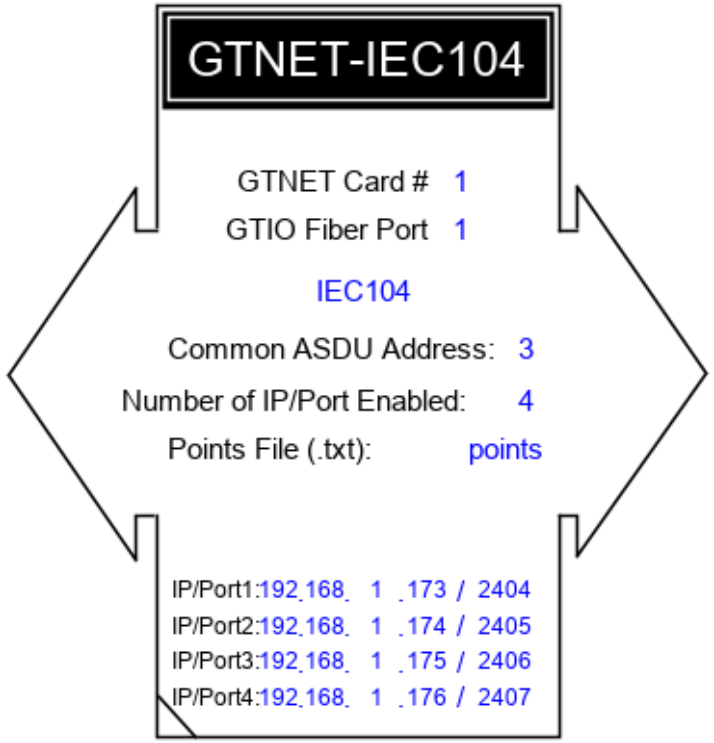
SV-1 CHANNEL SCALING | SV-1 CHANNEL OFFSET | SV-1 CHANNEL DELAYS
SV-1 OUTPUT IEC 61850 CONFIG | SV-1 SIGNAL NAME/FORMAT
CONFIGURATION | MMS SERVER ADDRESS | MMS CONFIGURATION

Name	Description	Value	Unit	Min	Max
APPID	APPID (hex) 0x4000...0x7FFF	4000		4000	7FFF
VLANPRI	VLAN priority	4		0	7
VLANID	VLAN ID (hex) 0x000...0xFFF	0		000	FFF
LDpre	LDName prefix (4-30 characters)	abcdefghijklmnopqrstuvwx...			
LDsuf	LDName suffix (eg. 1)	88		1	99
MACH	Output multicast address (eg. 01:0C:CD)	01:0C:CD		0	0
MACL	Output Multicast address (eg. 04:00:00)	04:01:d3		0	0
INCSSF	Include sample sync field in message	CC			
INCSR	Include sample rate field in message	FALSE		0	0
CONFREV	ConfRev (hex) 0x00000001...0xFFFFFFFF	1		1	FFFFFF...
sLevel	Voltage Level	500kV		0	0
sBay	Bay	5L1		0	0
nChan	Number of voltage and current channels	2		1	24
Tx1isRoutable	Whether or not to publish a routable stream	YES		0	1
Tx1MulticastIP	Multicast IP address destination	224.168.1.10		0	0

GTNETx2-104 v2

For Use with IEC 60870 -5-104

- Provides data exchange between RTDS and **up to 4 external 104 Master stations** .
- **Adds supports** for
  - Double point status and control.
  - Select and Execute control mode.
  - Time tagged control commands.
  - **End of Initialization status** .
  - Qualifier of Command 3 – persistent output.
  - **Double transmission of information objects with cause of transmission spontaneous** .
- Provides address mapping option based on Chinese National standard.



GTNETx2-104 v2

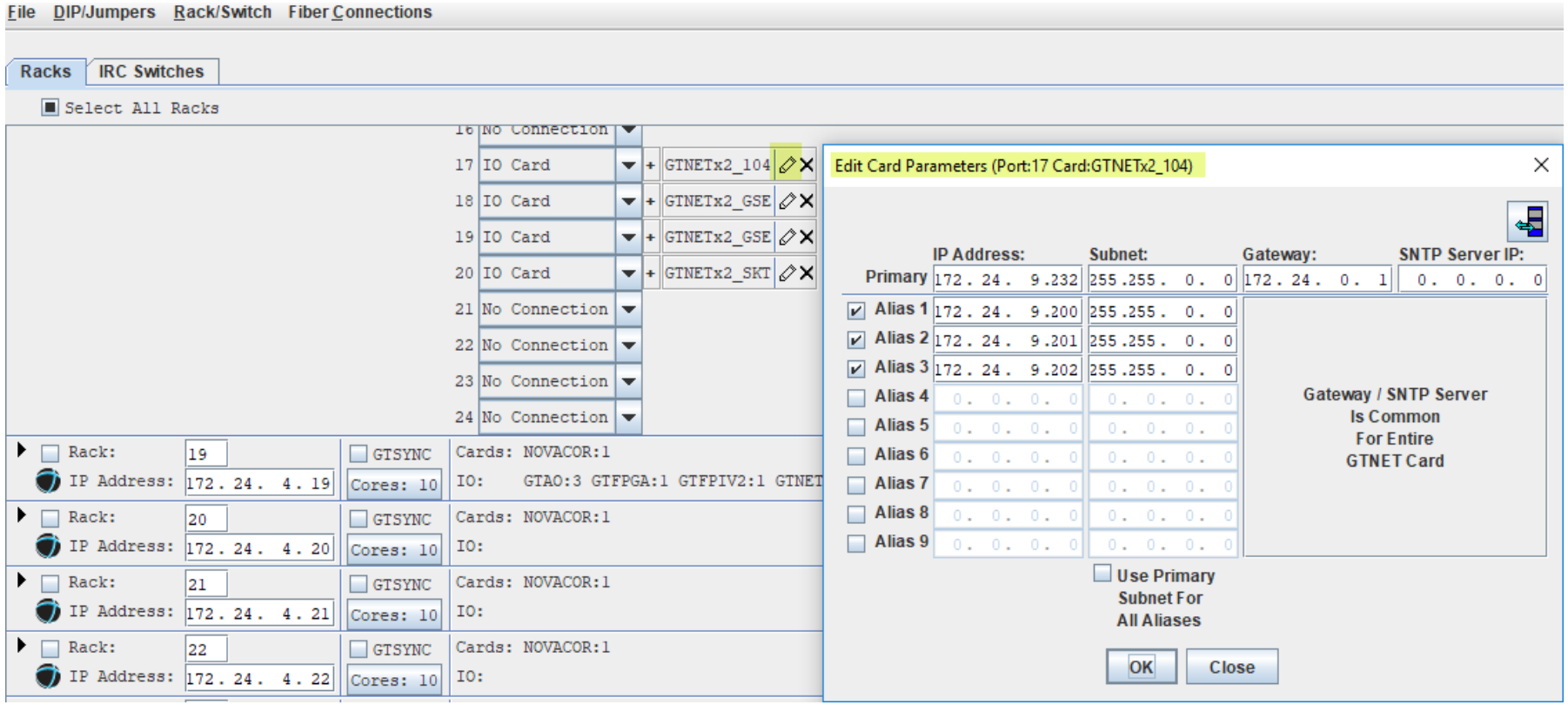
Data Quantity Supported :

Type	Quantity	Component Input/Output Format
Binary Status	1024	32 x 32 bit words
Binary control	512	16 x 32 bit words
Double point status	512	32 x 32 bit words
Double point control	256	16 x 32 bit words
Analog status	500	32 bit single precision
Analog control	100	32 bit single precision

Note: Status are sent to all connected 104 Master stations. Controls are handled in the order of arrival.

GTNETx2-104 v2

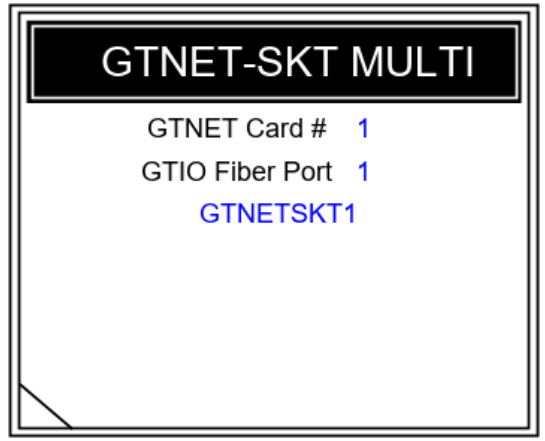
Up to 4 IP Addresses May Be Enabled



GTNETx2-SKT MULTI

For Use with TCP or UDP Sockets Communication

- Provides data exchange between RTDS and **up to 10 external equipment/software programs** .
- Main features
  - Up to 10 communication channels may be enabled.
  - Three mode options, UDP, TCP Server and TCP Client are available for each enabled channel.
  - Each channel sends up to 30 data points and receives up to 30 data points (Int32 or Float32).
- Update rates
  - 500Hz sampling rate, 10 channels, 30 points per channel.
  - 1000Hz sampling rate, 5 channels, 30 points per channel.



GTFPGA-SV NEW DEVELOPMENT

RTDS Technologies

RTDS.COM

GTFPGA-SV v3

Hardware – GTFPGAUnit

- Based on a Xilinx Virtex®-7 Field Programmable Gate Array (FPGA) evaluation kit
- Connects up to 16 SFP Ethernet Physical Layer adapters (copper or fiber optic based)
- LAN port SFP options
  - 100/1000 Base T Copper SFP Module Finisar FCLF-8521-3
  - 100/1000 Base T Copper SFP Module Avago ABCU-5730RZ
  - 1000 Base-SX fiber SFP Module Finisar FTLF-8519P3BNL (the same insert used for the GT portscom)

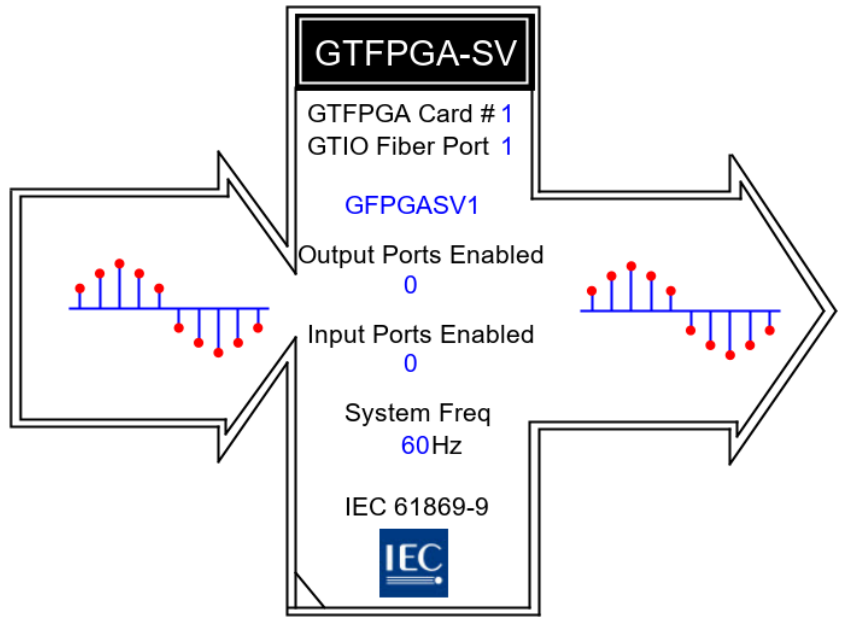
GTFPGA-SV v3

Mainstep Mode

- Able to **simultaneously publish and subscribe** up to 16 streams with data type of either Float or Integer.
- Each **output and/or input stream** may have up to 24 channels for sampling rates of 80, 96 s/c and 4800 Hz.
- Each **output and/or input stream** may have up to 9 channels for sampling rates of 256 s/c and 14,400 Hz.
- *Only able to subscribe 1 stream in PB5 based RTDS.*

Substep Mode

- Able to publish up to 2 streams with a maximum of 24 channels each for sampling rate of 96 kHz.
- Able to publish 1 stream with a maximum of 48 channels for sampling rate of 250 kHz.



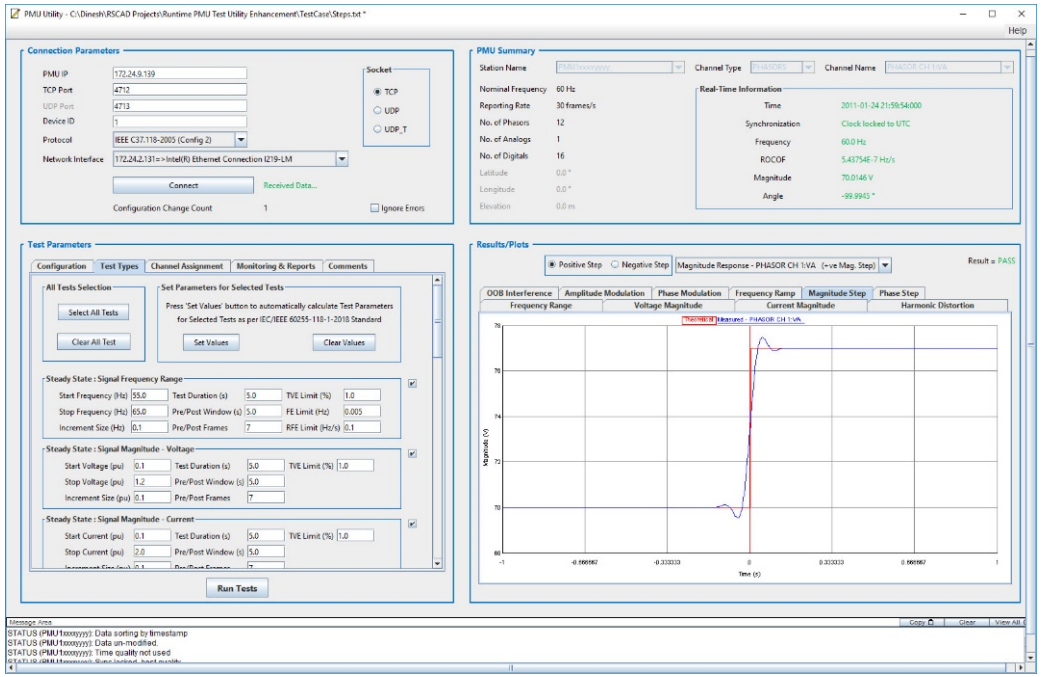
OTHER DEVELOPMENTS

RTDS Technologies

RUNTIME
PMU Test Utility v2

For Physical PMU Testing

- New Graphical User Interface to replace the scripting requirement.
- Complies for the requirements of the latest synchrophasor standard (IEC/IEEE 60255-118-1 : 2018) and IEEESynchrophasor Measurement Test Suite Specifications (version 3 – 2019)
- Automatically creates test results in html and CSV formats.



CHIL APPLICATIONS

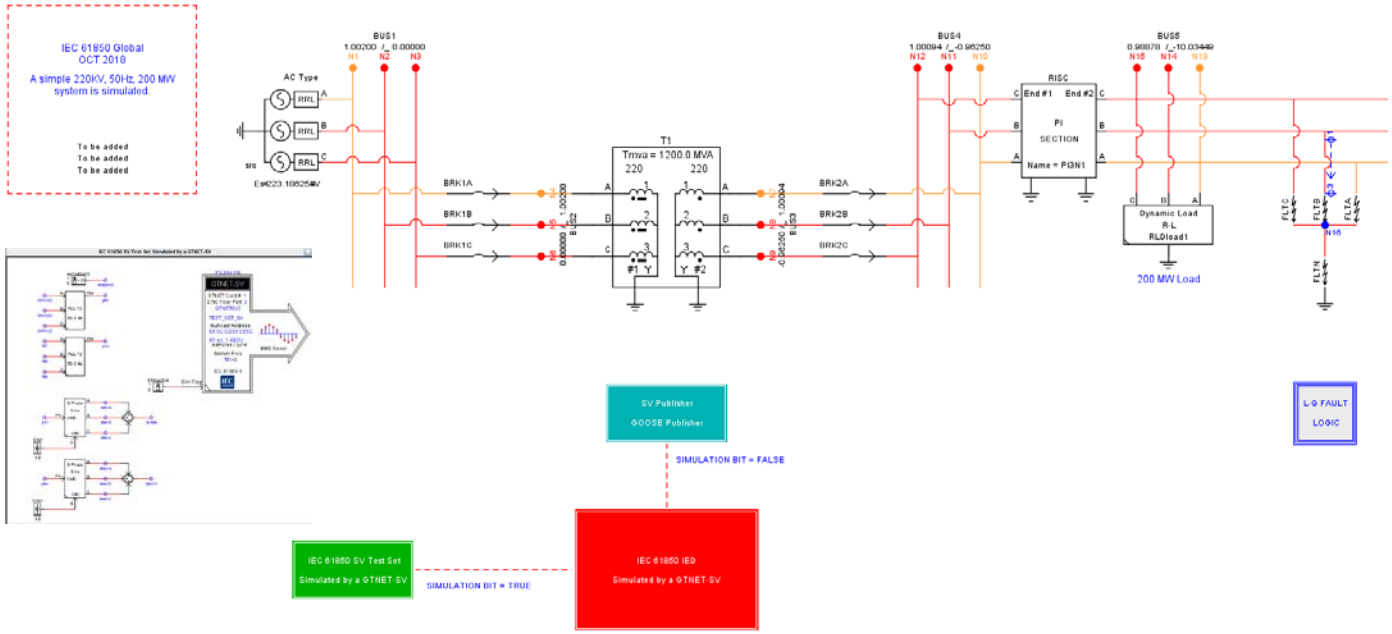
RTDS Technologies

RTDS.COM

CONTROL HIL

Protection – Substation Automation

- A simple demonstration.



DRAFT 5.006_ee

File Sequencer Racks Help

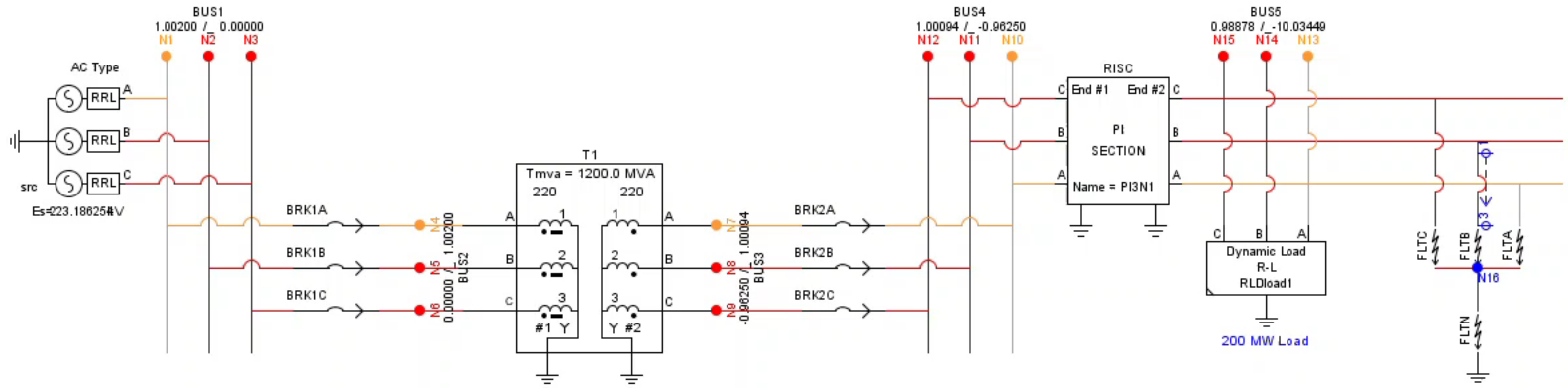
C:\RTDS_USER\fileman\Eric\Conferences\CIGRE_2018_Paris\cigre_2018_demo\Integrated_demo\Integrated_demo_v0.dft

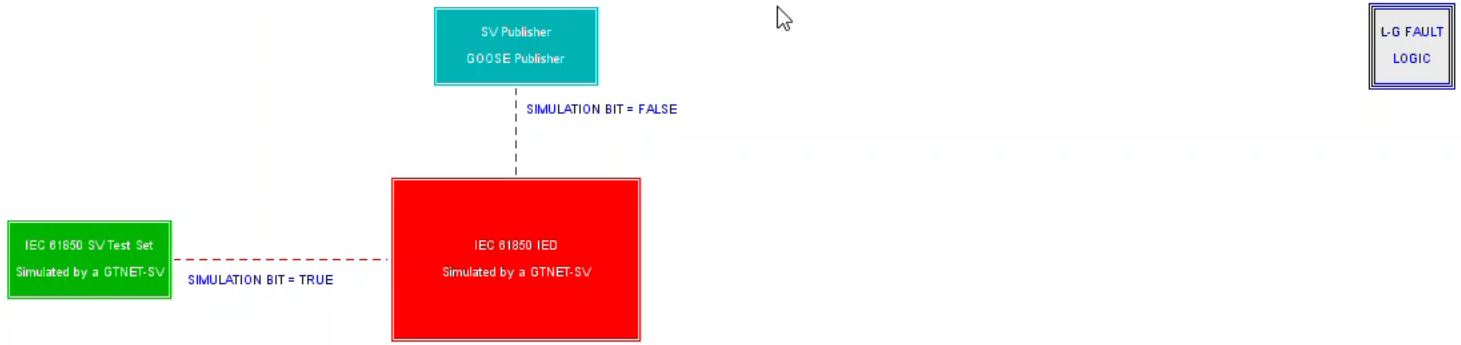
SS #1

CIGRE 2018
AUG 2018

A simple 220KV, 50Hz, 200 MW system is simulated.

To be added
To be added
To be added





Message Area

Copy Clear View All

At Line Number: 9921 of file C:\RTDS_SWMLIB\COMMON\GPCdefault.lib
WARNING - Unknown variable "scl" found in draft file for component "rtds_sharc_1phbkr".
At Line Number: 9922 of file C:\RTDS_SWMLIB\COMMON\GPCdefault.lib

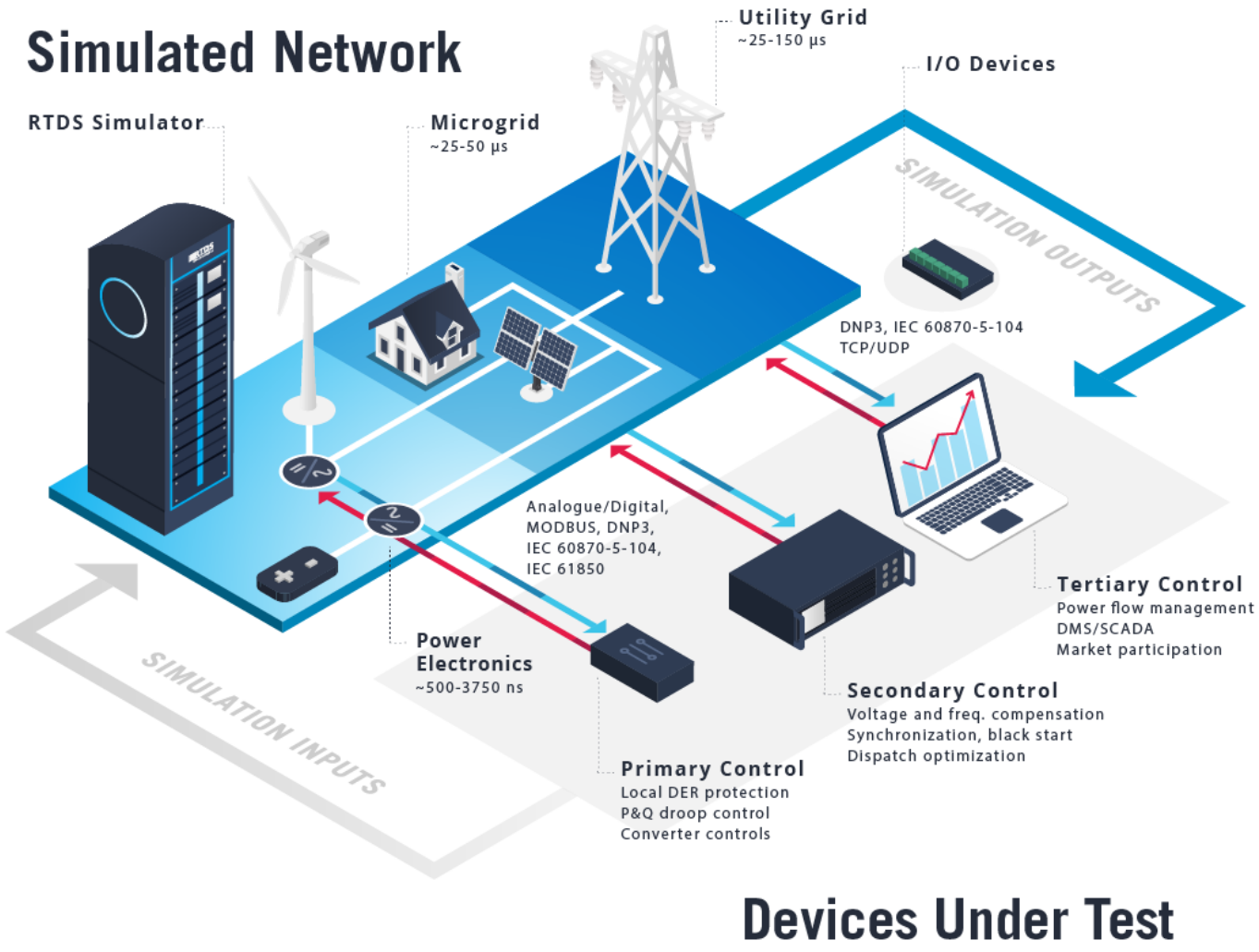
Type here to search

ENG 12:04 PM 2018-08-16

CONTROL HIL

Distribution – Microgrid

- Requires high -level communication:
  - *IEC 61850.*
  - *DNP3.*
  - *IEC 608705-104.*
  - *IEEE C37.118.*
- Alternative energy sources:
  - *Wind.*
  - *Solar.*
  - *Fuel cells.*
  - *Battery bank.*
  - *Power electronic converters*

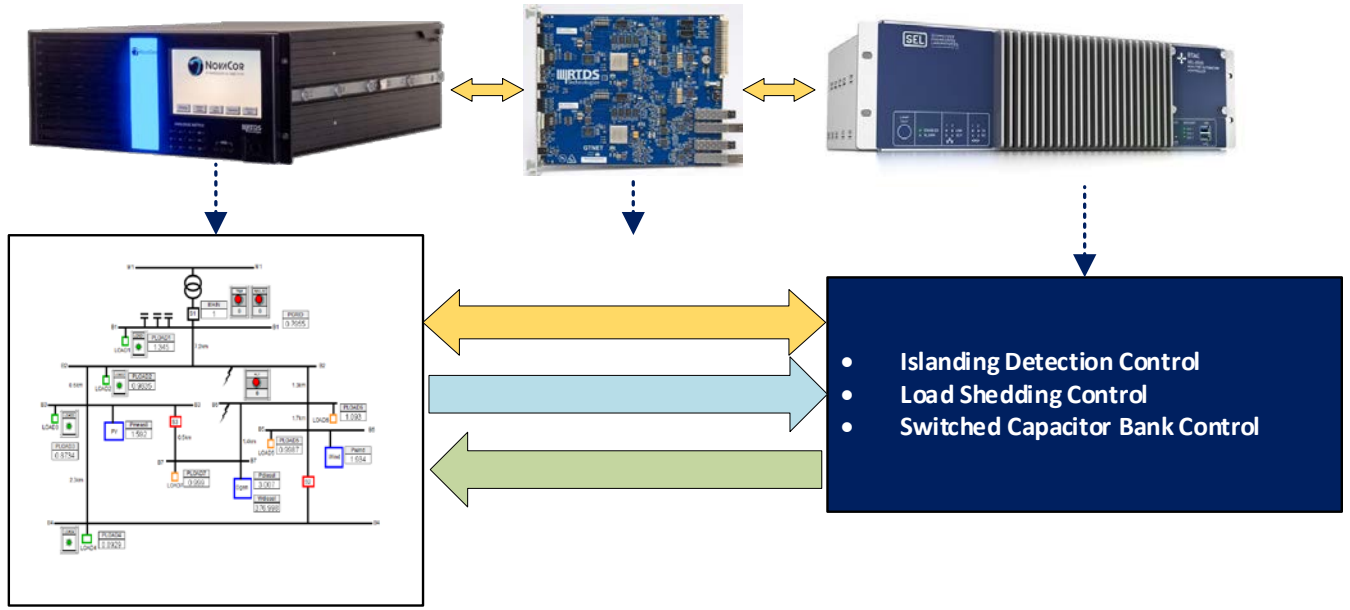


CONTROL HIL

Distribution – Microgrid

- Multiple DERs.
- Measurements sent through IEC 60870-5-104.
- Control commands received through IEC 61850 GOOSE.

Example: Microgrid Testing with a Physical Controller



DRAFT 5.008.1

File Sequencer Racks Help

Rack: 18 3PH: 151 all SS:

C:\RTDS_USER\fileman\Eric\Conferences\2019China\E_222_20191021-24_APAP\Microgrid2A_HIL_v1\Microgrid2A_HIL_v3_2_video.dft

SS #1

POWER CALCULATION

FAULT CONTROL

LOAD SHEDDING

SYNCHRONIZATION

ISLANDING DETECTION DROP

OVER CURRENT PROTECTION

GTNETx2-104 v2 GTNETx2-GSE v6

BUS2 BUS6 BUS7 BUS5 BUS3 BUS7a BUS1 BUS4 SRCBUS MAIN

RISC PI SECTION

3MW Diesel Generator

1.74MW Photovoltaic System

2MW DFIG Wind System

Switched Capacitors

L-G FAULT POINT

FLT POSITION 1 FLT POSITION 2 FLT POSITION 3 FLT POSITION 4

Dynamic Load R-L LOAD1 LOAD2 LOAD3 LOAD4 LOAD5 LOAD6 LOAD7

AC Type 138kV 1200MVA 0.1 SCR

TRF1 25 138 13.2 Leads

MAINA MAINB MAINC

control CT CT1

cvt1 control PT

S3A S3B S3C S2A S2B S2C

Message Area Copy Clear View All

Informational: Compile V5 completed with warnings.

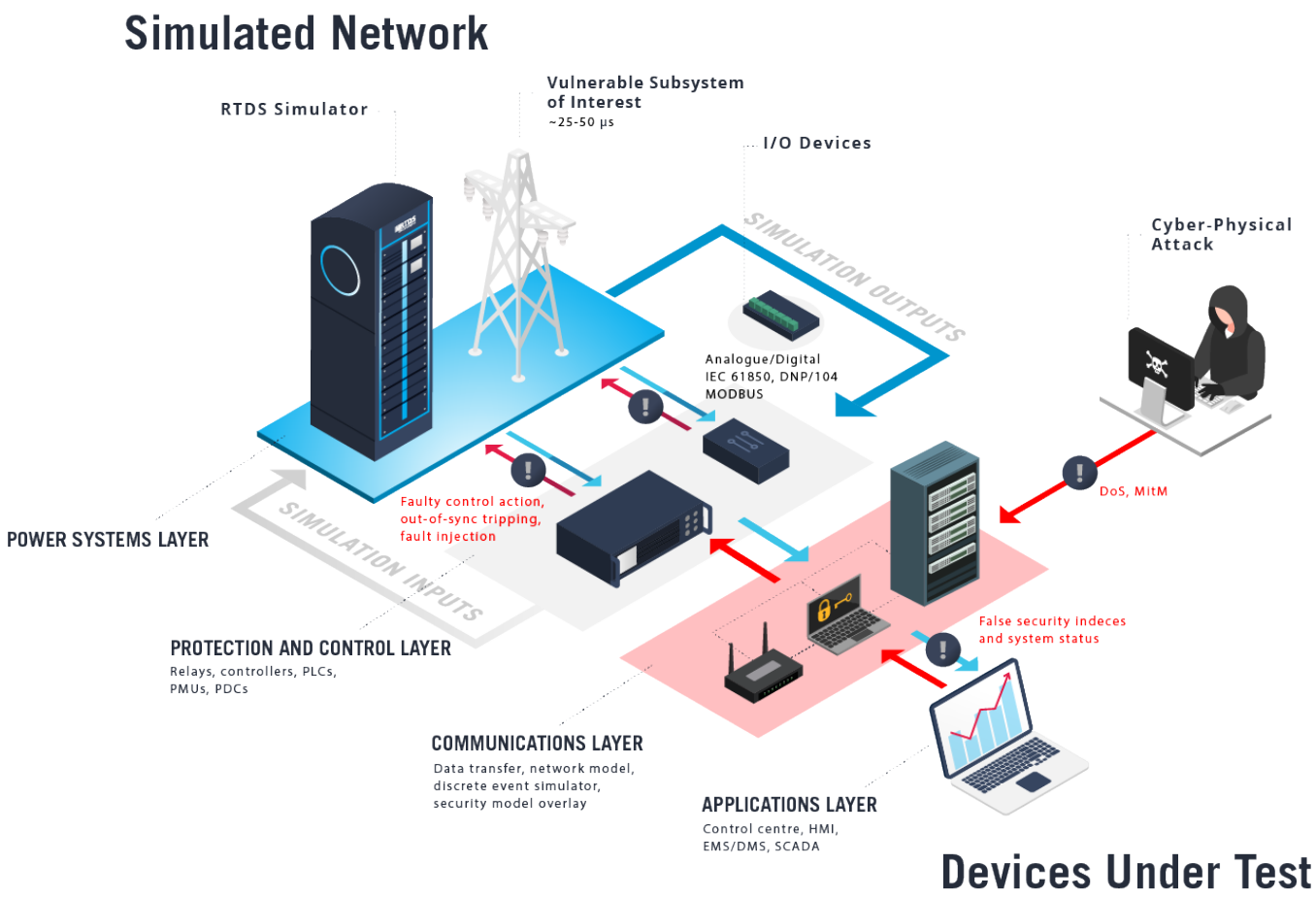
CYBER SECURITY

RTDS Technologies

RTDS.COM

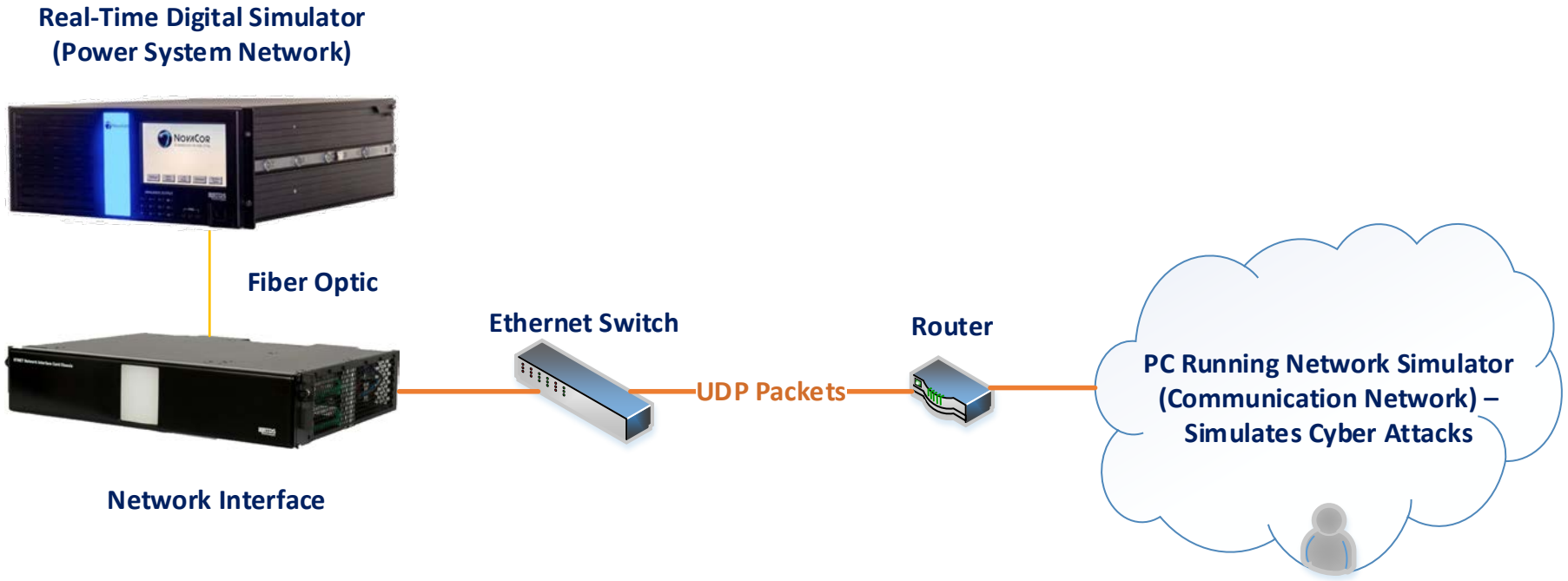
CYBER SECURITY

- Modernization of the power system involves in the integration of increasingly complex devices that are interconnected using communication networks .
- Split the different aspects of the model into separate layers.
- Each layer can be executed on different software/hardware platforms.
- Interface the different layers with one another.



CYBER SECURITY

- Communications between power system layer and the external simulated communications network using UDP sockets.

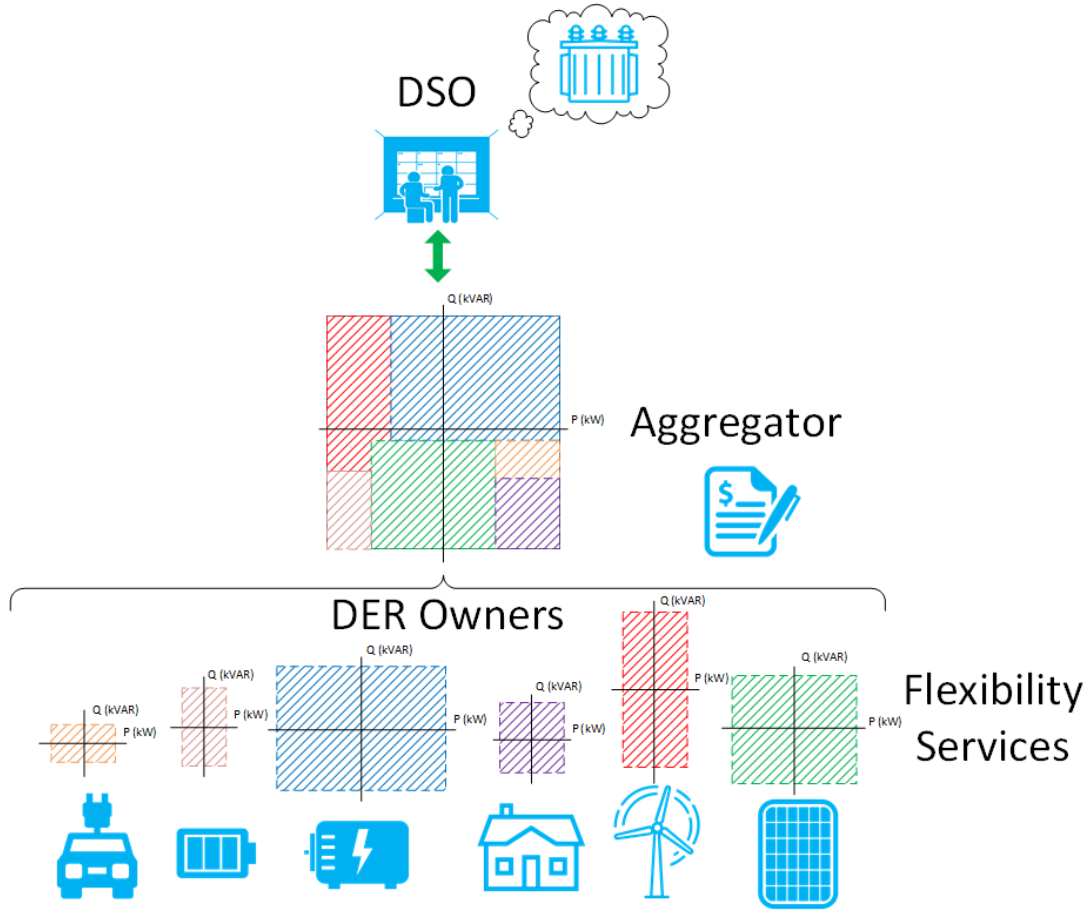


CYBER SECURITY

- **DER Owner:** Owns generation, storage or consumption connected to the distribution grid. These units have flexibility in their generation / consumption patterns, which can be sold to the DSO .
- **Distribution System Operator (DSO):** Owns and operates infrastructure needed for power delivery .
- **Aggregator:** Aggregates flexibility of consumers and DER Owners in order to sell *flexibility services* to the DSO.

Example: Distribution Feeder

- Low voltage distribution feeder in a residential area.
- Small number of DERs (PV, Wind, Diesel etc.), building loads.

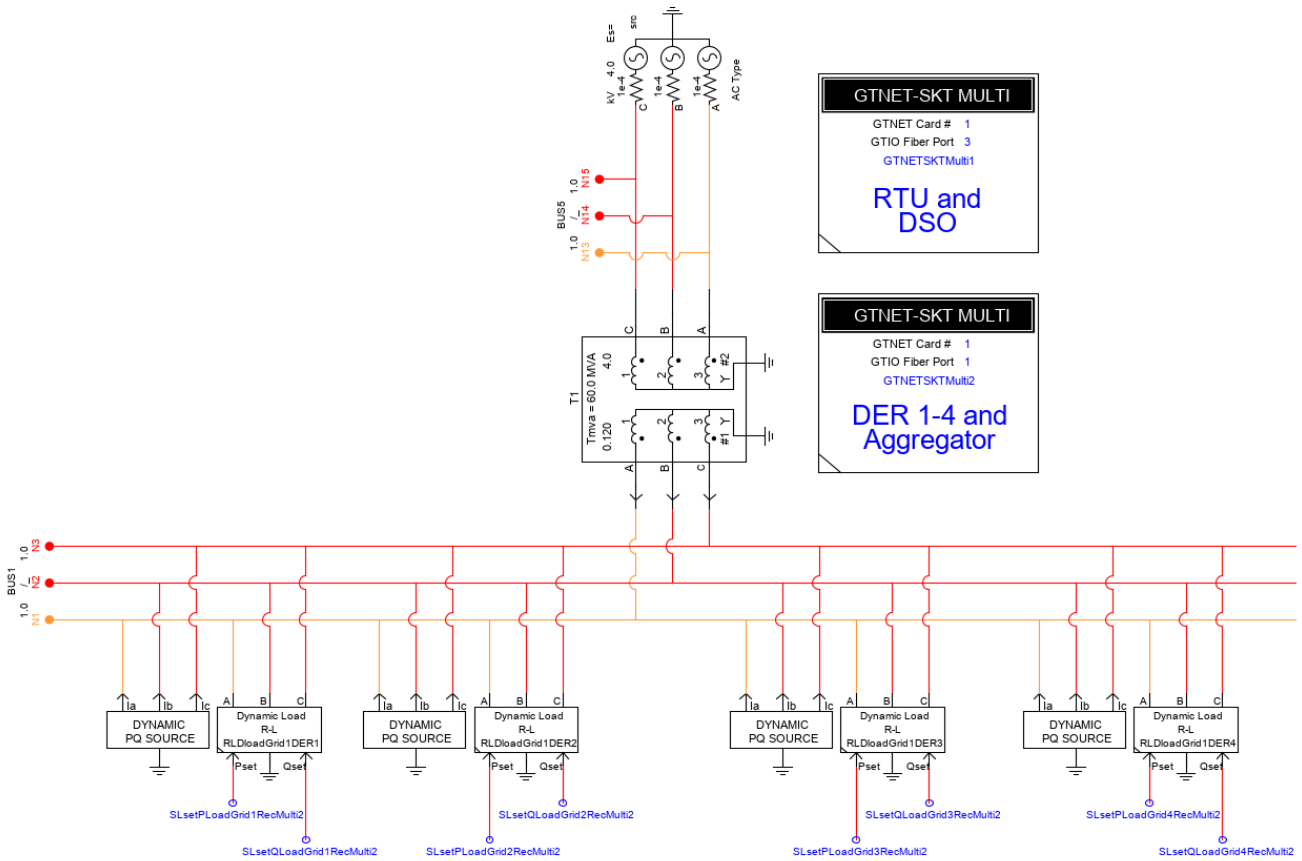


CYBER SECURITY

- RTU, DSO, DERs and aggregator nodes are modeled.
- Some of these nodes are then interfaced with the communication network model in the communications layer.

Example: Distribution Feeder

- Modeling power system layer .

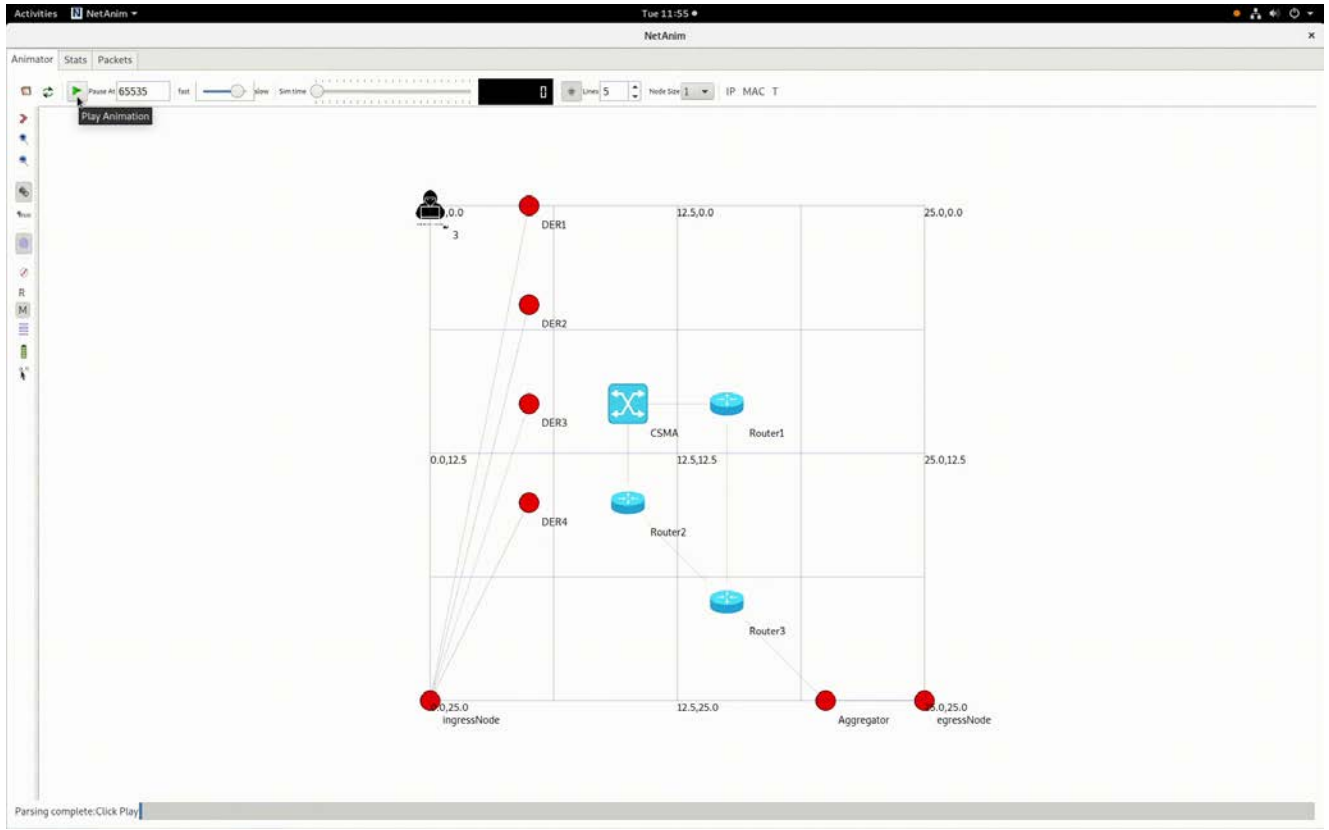


CYBER SECURITY

- ARP Spoofing Attack Demo .
- Attacker sends a spoofed ARP reply when DERs request the MAC address of the CSMA switch.
- Attacker then modifies flexibility information and sends it to CSMA switch.
- Flexibility information is such that load cannot be shed and generation cannot be increased.
- Therefore there is nothing the aggregator can do.
- Transformer remains overloaded.

Example: Distribution Feeder

- Communication layer modeled in a *Network Simulator* .



ONGOING PROJECTS

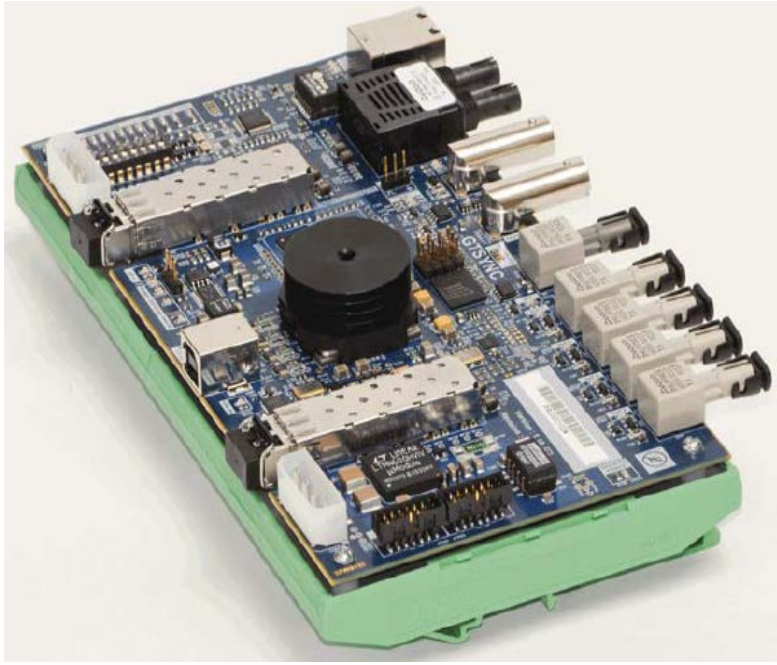
RTDS Technologies

RTDS.COM

GTSYNC Enhancement

For Synchronizing RTDS to An External Time Reference

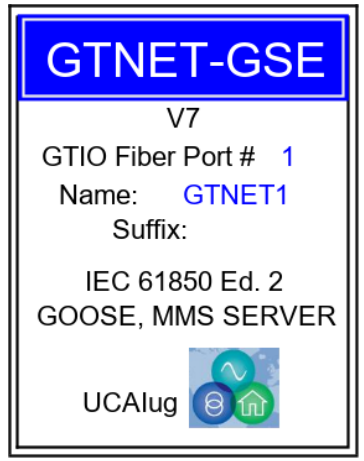
- IEC 61850-9-3 (Precision time protocol profile for power utility automation) Power Utility Profile, which allows compliance with the highest synchronization class of IEC 61850-5 and IEC 61869-9.
- Supports Master mode in 1588.
- IRIG-B input via optical fiber.

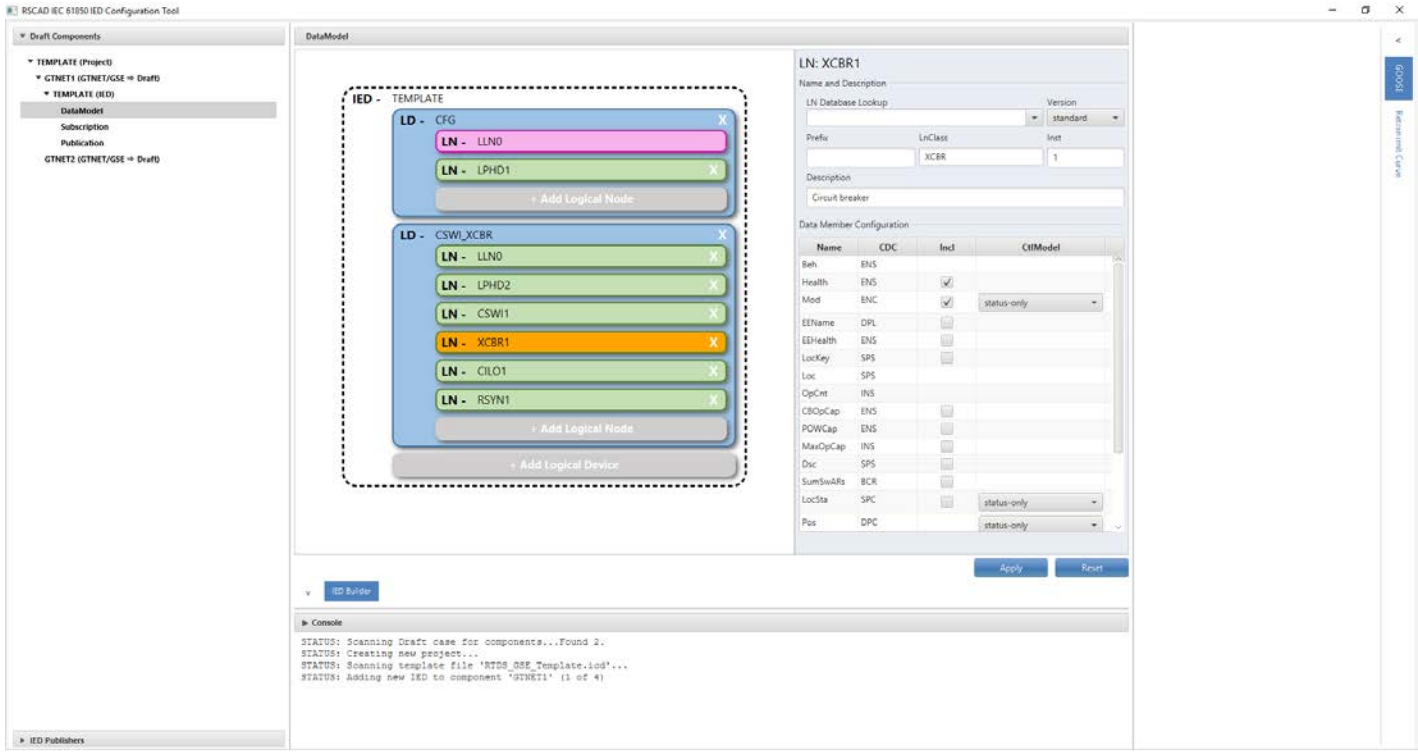


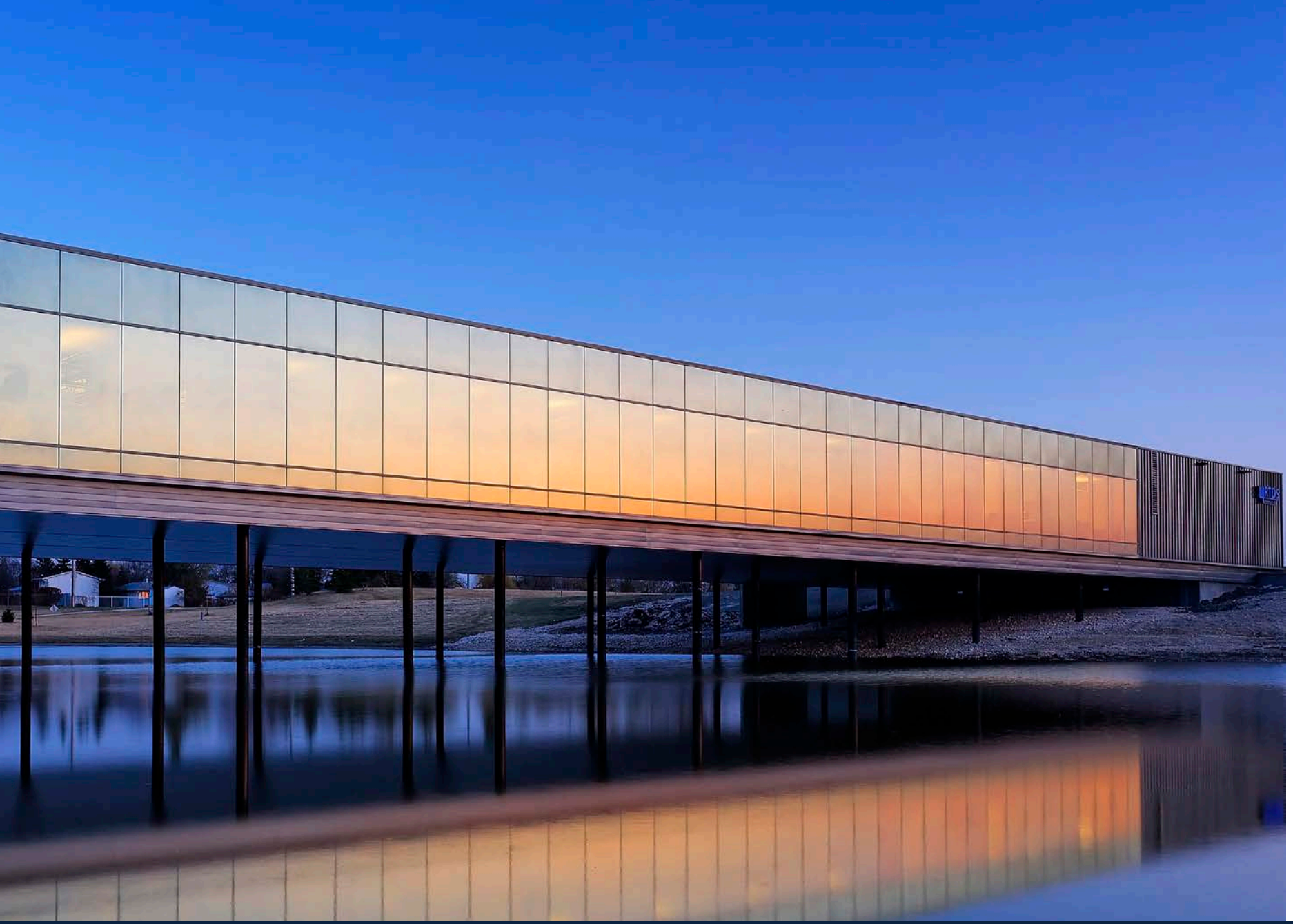
GTNETx2-GSE v7

Generic GOOSE Interface

- Emulates user's SCL files.
- Supports multi -IP to enable up to 4 IED instantiations.
- Provides new ICT editor for configuring SCLs.
- More efficient in binding GOOSE inputs/outputs to RSCAD Draft variables for large SCL files.







THANK YOU!
QUESTIONS?

INNOVATING

RTDS Technologies

RTDS.COM