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REAL TIME DIGITAL SIMULATION

OPEN PROTOCOL COMMUNICATION  
WITH THE RTDS SIMULATOR



# Outline

Hardware Features

Software Support

GTFPGA-SV

Aurora Communication

Protection & Automation Suite

Questions and Answers



# GTNETx2

## What is the purpose of the GTNETx2 card?

- ❑ Provides an interface between the simulation and the real world using known substation automation protocols

- 1 – GTNET-SV
- 2 – GTNET-GSE
- 3 – GTNET-PMU
- 4 – GTNET-DNP
- 5 – GTNET-104
- 6 – GTNET-PB
- 7 – GTNET-SKT
- 8 – GTNET-MODBUS

# GTNETx2

## Main Hardware Features

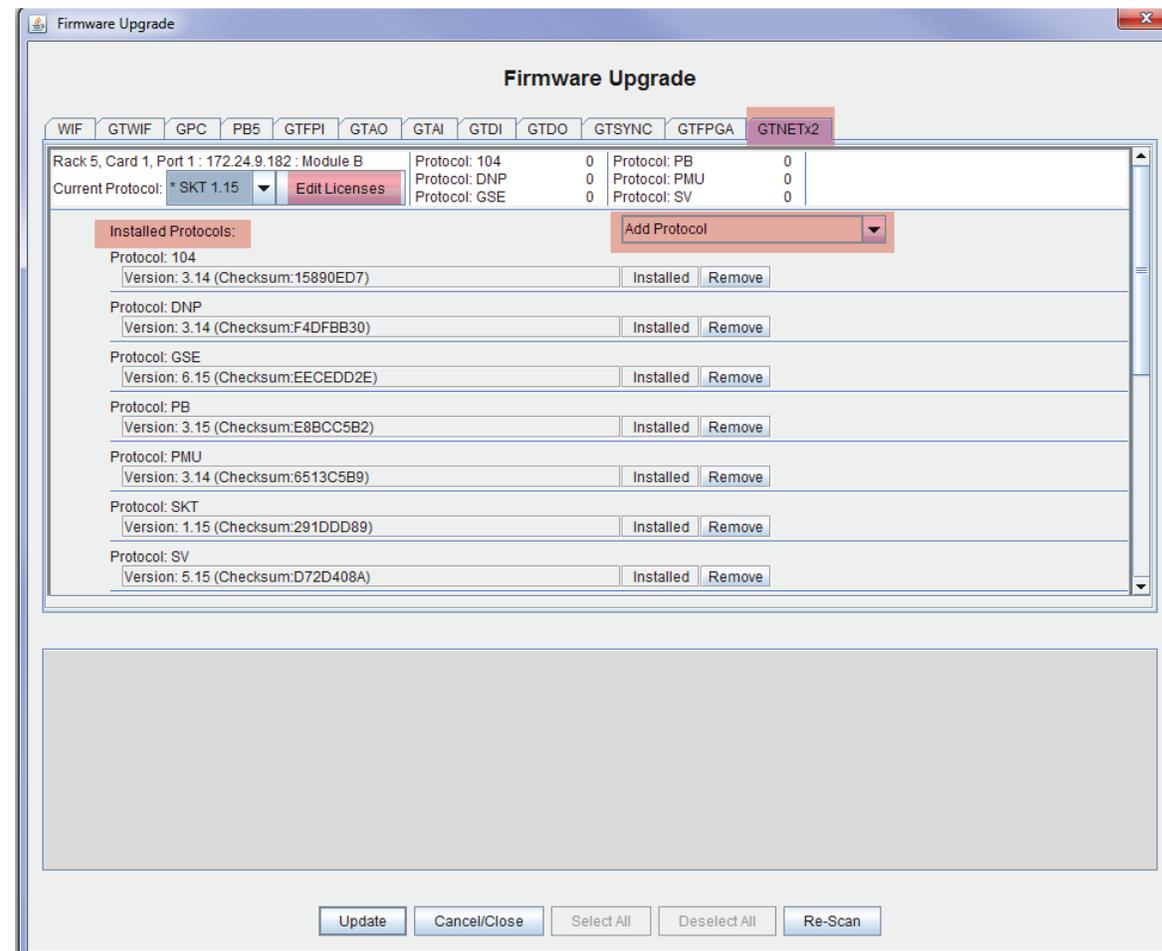
- ❑ Combined two existing GTNETs into one card
- ❑ Each 'module' is completely independent with no shared resources
- ❑ Support SFP modules for Ethernet
- ❑ Run 5-10 times faster than the previous GTNET card
- ❑ Separate front panel display
- ❑ Require GTWIF firmware OS 104 build 7



# GTNETx2

## Software Support

- ❑ Firmware upgrades are handled using software GUI
  - ❑ Switch protocols
  - ❑ Add new protocols & License management
  - ❑ Delete old version protocols



# GTNETx2

## Software Support

- ❑ Card parameters can be configured within the Config File Editor

▼ Rack 5 (172.24.4.5) Cards: GTWIF: 1, PB5: 1, GPC: 4, GTIRC: 1 I/O: GTSYNC: 1, GTNET: 2, GTFPI: 0, GTAI: 0, GTAO: 0, GTFPGA: 0, GTDI: 0, GTDO: 0

Slot	Card	Type	Param 1	Param 2	Param 3
0	0	GTWIF	4000	BACKPLANESPEED 60	GTSYNC7
1	0	UNUSED			
2	1	DIP PB5	1.00		GTNET_SKT (Port1) GTNET_SKT (Port7)
3	1	DIP PB5	1.00		
4	2	DIP GPC	1.00		
5	2	DIP GPC	1.00		
6	3	DIP GPC	1.00		
7	3	DIP GPC	1.00		
8	4	DIP GPC	1.00		
9	4	DIP GPC	1.00		
10	5	DIP GPC	1.00		
11	5	DIP GPC	1.00		
12	6	UNUSED			
13	6	UNUSED			
14	7	UNUSED			
15	7	UNUSED			
16	8	UNUSED			
17	8	UNUSED			
18	9	UNUSED			
19	9	UNUSED			
20	10	UNUSED			
21	10	UNUSED			
22	11	UNUSED			
23	11	UNUSED			

**Edit Card Parameters**

IP Address: 172.24.9.183  
Subnet: 255.255.0.0  
Gateway: 172.24.0.1  
SNTP Server IP Address: 172.24.9.22

**Edit Peripherals**

Available Peripherals

Card	Ports
GTAI	1 2 3 4 5 6 7 8
GTAO	1 2 3 4 5 6 7 8
GTDI	1 2 3 4 5 6 7 8
GTDO	1 2 3 4 5 6 7 8
GTFPGA	1 2 3 4 5 6 7 8
GTNET_GSE	1 2 3 4 5 6 7 8
GTNET_SV	1 2 3 4 5 6 7 8
GTNET_PB	1 2 3 4 5 6 7 8
GTNET_DNP	1 2 3 4 5 6 7 8
GTNET_PMU	1 2 3 4 5 6 7 8
GTNET_104	1 2 3 4 5 6 7 8
GTNET_SKT	1 2 3 4 5 6 7 8
GTFPI	1 2 3 4 5 6 7 8

Selected Peripherals

- GTNET\_SKT(Port1)
- GTNET\_SKT(Port7)

Message Area

Save Cancel

OK Cancel

OK Cancel

# GTNET

## GTNET-SV

- ❑ Simulates IEC 61850 9-2LE or IEC 61869-9 compliant Merging Unit

- ❑ 50Hz or 60Hz system frequency
- ❑ Publish and Subscribe to SV

- ❑ 9.2LE Output Mode

- ❑ Can be configured to publish up to 2 output data streams
- ❑ Sample rate at either 80 or 256 samples per cycle

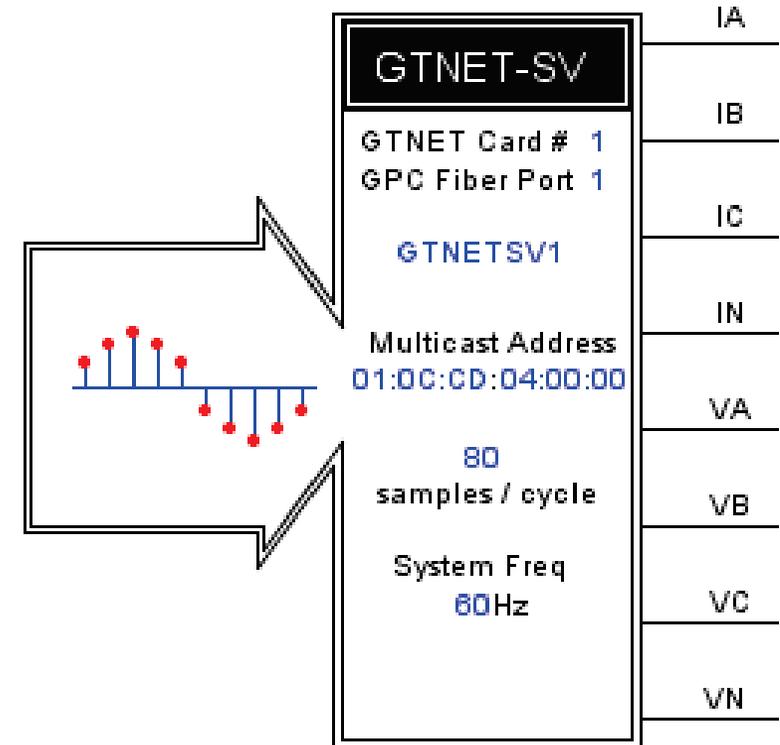
- ❑ IEC 61869-9 Output Mode

- ❑ Able to publish one data stream with up to 24 channels of voltages or currents
- ❑ Sample rate at 80 samples per cycle
- ❑ Jitter between samples is less than 10 usec
- ❑ Supports the Chinese National Standard for SV merging units

# GTNET

## GTNET\_SV9-2\_v5 Input Mode

- ❑ Can be configured to subscribe 1 data stream from 1 MU at 80 or 256 samples per cycle
- ❑ GTSYNC is needed for use of the GTNET\_SV9-2\_v5 component

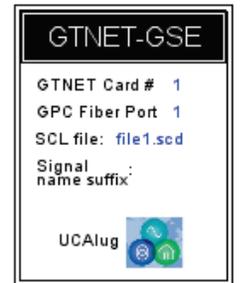


# GTNET

## GTNET-GSE

### GTNET\_GSE\_v5.def

- Provides IEC 61850 GOOSE communications
- Supports up to 4 TX/RX modules, which can be arranged to simulate 1-4 IEDs (i.e. 1 IED with 4 modules, 4 IEDs each with 1 module...)
- Each module can send up to 64 points (stVal) (Boolean, or INT32, or FLOAT32, or Dbpos), or 32 points with Quality
- Each module can receive up to 32 points (16 Booleans) with Quality
- Can receive GOOSE message from up to 16 unique external IEDs
- Required firmware GTNET-GSE v5.16 or higher (not compatible with GTNET\_GSE\_v2)



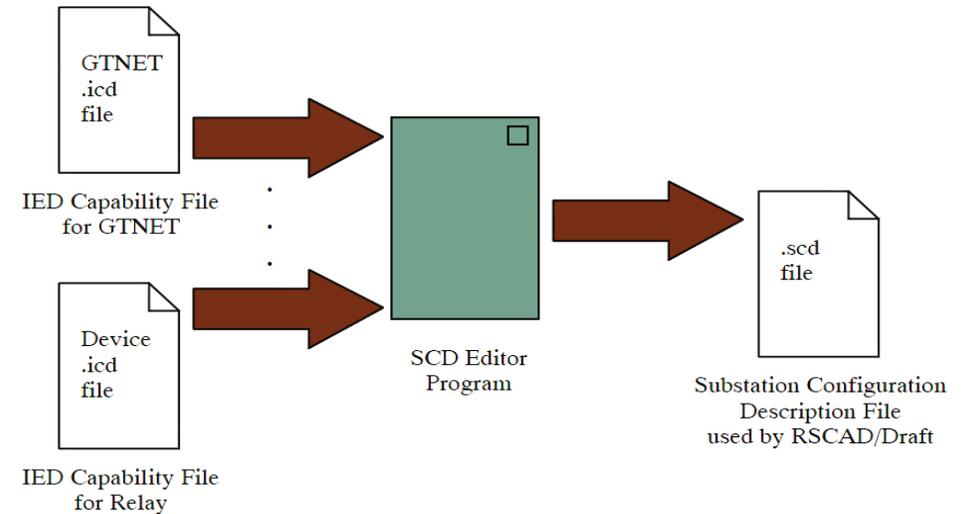
GTNET\_GSE\_v5

# GTNET

## GTNET-GSE

### SCD Editor (IED Configuration Tool)

- ❑ A engineering tool to generate required configuration files (IEC 61850 SCL format)
  - ❑ Exports GTNET-GSE ICD file - the configuration file defines the capabilities of the configured GTNET IED
  - ❑ Creates and edits a Substation Configuration Description (SCD) file
    - ❑ Firstly imports SCL files (SCD, ICD, CID, SSD...) of the external devices
    - ❑ Then maps the external references to the GTNET inputs



# GTNET

## GTNET-PMU

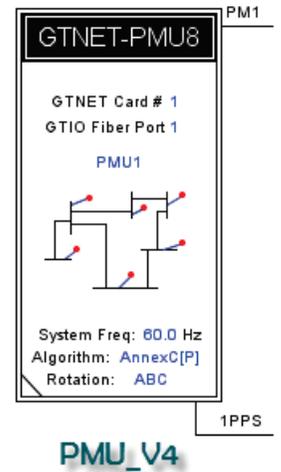
### PMUv4 & PMU\_v5

- ❑ Designed to provide symmetrical component information related to three phase sets of instantaneous values of voltage and current samples
- ❑ Large number of PMUs may be included in the simulated power system network
- ❑ Designed according to IEEE C37.118.1a™-2014 and IEEE C37.118.2 - 2011

# GTNET

## GTNET-PMU PMUv4

- ❑ Simulates up to 8 PMUs
- ❑ Provides phasor information for voltage and current, including phase values, positive, negative, and zero sequence values
- ❑ Up to 12 phasors can be enabled for each PMU
- ❑ Provides measured frequency and rate of change of frequency information
- ❑ PMU algorithm includes P class, and M class
- ❑ Two modes
  - ❑ Metering mode
    - ❑ GTNET card and GTSYNC are not needed
    - ❑ Enabled phasor data only available as named output variables
  - ❑ C37.118 data output mode
    - ❑ Need GTNET-PMU and GTSYNC
    - ❑ Send phasor data out to the network through GTNET



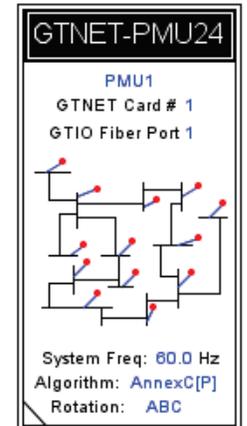
_rtds_GTNET_PMU_v4.def						
PMU1-8 AC SOURCE		PMU1-8 ANALOG/DIGITAL SOURCE				
CONFIGURATION		PMU1 CONFIG		PMU1-8 CALIBRATION		
Name	Description	Value	Unit	Min	Max	
eC37data	Enable output of C37.118 data using GTNET	Yes		0	1	
Name	GTNET Component Name	PMU1				
pmutype	PMU Model Type	Annex...		0	2	
cfgtype	Configuration frame format	Confia 2		0	1	
freq	Base Frequency (Hz)	60.0		0	1	
nPMU	Number of PMUs (maximum 8)	1		0	8	
adv	Delay Input Signal to align V & I	V bv 1dt		0	1	
eAngM	Enable Angle Difference Meter	NO		0	1	
nAngDiff	Angle Difference Meter Name (PMUx-PMUy)	angdiff		0	0	
sfx	Plot Signal Suffix					
calib_const	Common offset applied to all PMU inputs	0	degrees	-360.0	360.0	
dt_adi	Time-step adjustment to all input signals	-.3	dt	-500	500	

# GTNET

## GTNET-PMU

### PMUv5

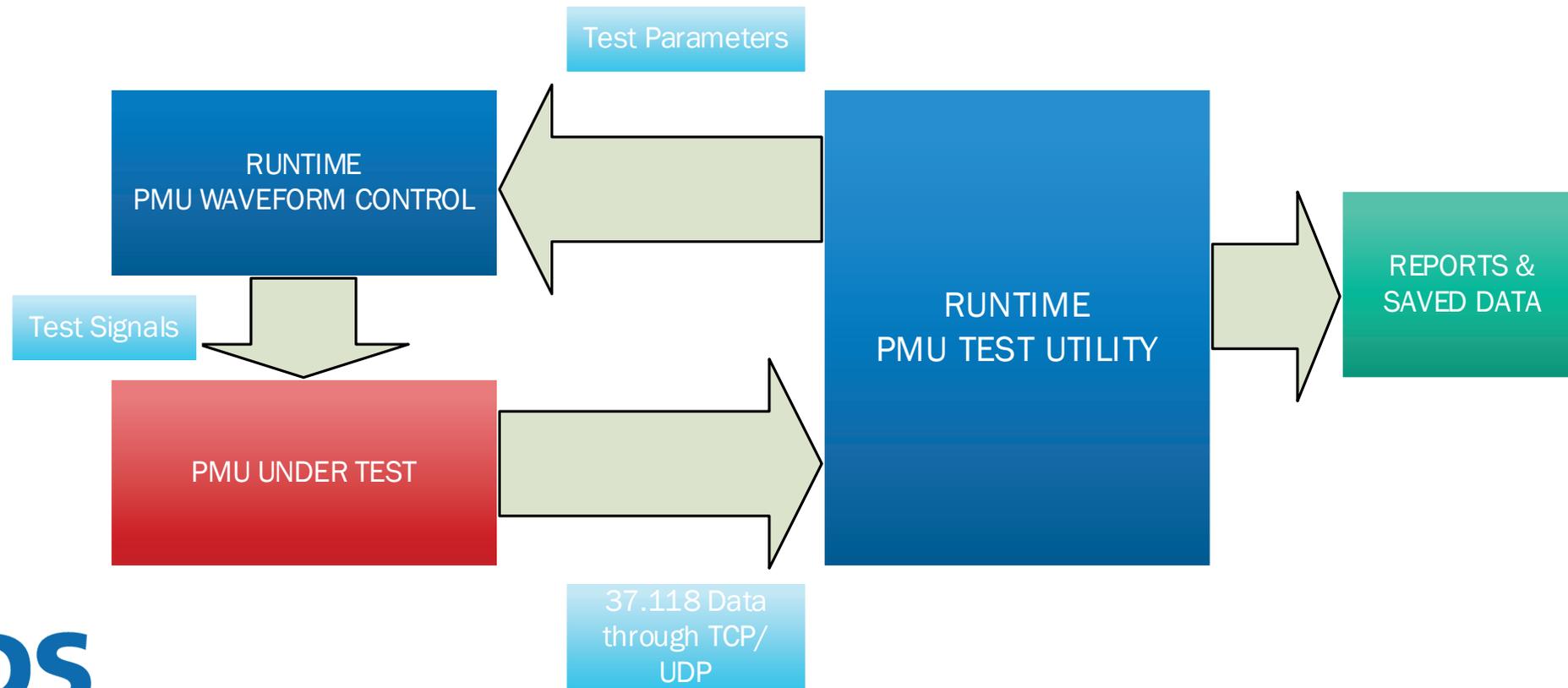
- ❑ Simulates more PMUs with few GTNETs for large networks
- ❑ Simulates up to 24 PMUs
- ❑ Up to 2 phasors can be enabled for each PMU, which are the positive sequence phasor information for voltage and current
- ❑ Provides measured frequency and rate of change of frequency
- ❑ PMU algorithm includes P class
- ❑ Two modes
  - ❑ Metering mode
    - ❑ GTNET card and GTSYNC are not needed
    - ❑ Enabled phasor data only available as named output variables
  - ❑ C37.118 data output mode
    - ❑ Need GTNET-PMU and GTSYNC
    - ❑ Send phasor data out to the network through GTNET



PMU\_V5

# PMU TEST UTILITY

## Testing External Physical PMUs A RunTime Feature - PMU Test Utility



# PMU TEST UTILITY

## Testing External Physical PMUs A RunTime Feature - PMU Test Utility

- ❑ Test PMU total vector error (TVE)
- ❑ Gather PMU data
- ❑ Control test parameters
- ❑ Analysis tools
- ❑ Export results

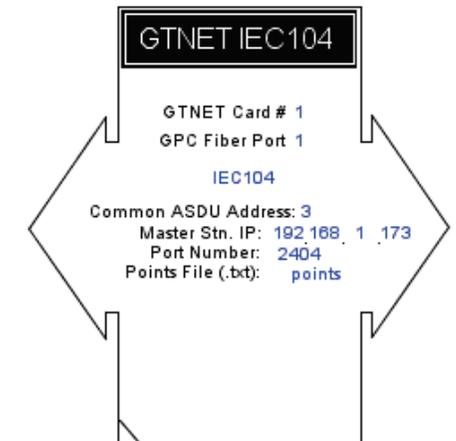
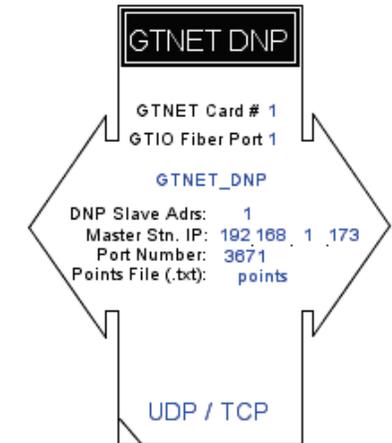
The screenshot shows the PMU Test Utility software interface. The window title is "PMU Utility". It is divided into several sections:

- Connection Parameters:** Includes fields for Host IP (172.24.9.43), Remote Port (4722), Device Id (2), and Config cnt. It has radio buttons for TCP (selected) and UDP, and a Protocol dropdown menu set to IEEE C37.118-2005. A Test button is present.
- PMU Summary:** Includes fields for STN, Chnl, and Name. A Real-Time Info section shows Time Sync (NA) and Phasors (NA). It also displays Frames/sec, Nom Freq, Phasors, Analogs, and Digital. A Test button is located below this section.
- Testing Parameters:** Includes a Current Control dropdown menu set to PMUSRC and a Current Test field. It has Load, Run/Analyze, and Save buttons.
- V/I Output (pu)(deg):** A grid of input fields for VA, VB, VC, IA, IB, IC, and their respective angles. It also includes V offset ang, I offset ang, and Frequency (60.0).
- Modulation and Step Change Parameters:** Fields for Mag. Modulation (Hz), Index, Mag. Step Change (pu), Delay (sec), Phase Modulation (Hz), Index, Phase Step Change, Delay (sec), Hz Ramp Rate, Stop Freq, and OOB Frequency (Hz), Index.
- HARMONIC Frequency should not exceed 1/2 the PMU sample rate:** Fields for 1 Harm (2 pu), 2 Harm (2 pu), and Frequency (60 Hz).
- Base:** Fields for Volts (1), kV, Amps (1), kA, and Frequency (60 Hz).
- Bottom Section:** Includes buttons for Generate HTML Report and Generate CSV Report, and a Message Area at the very bottom.

# GTNET

## GTNET-DNP & -104 (60870-5-104)

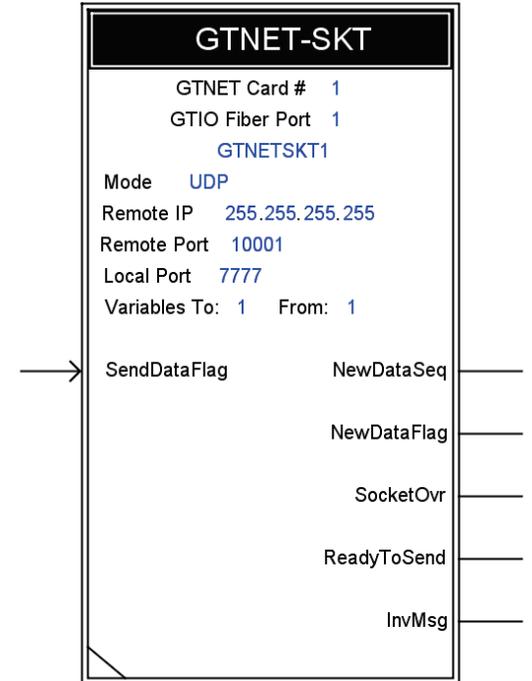
- Binary simulation status/input (i.e. breaker position)
  - 1024 (scan rate 1000 Hz)
- Binary simulation control/output (i.e. breaker commands)
  - 512 (scan rate 1000 Hz)
- Analogue status
  - 500 (scan rate 10 Hz)
- Analogue control
  - 100 (scan rate 10 Hz)
- The GTNET – DNP and -104 supports one master with a maximum polling rate of less than 5 Hz



# GTNET

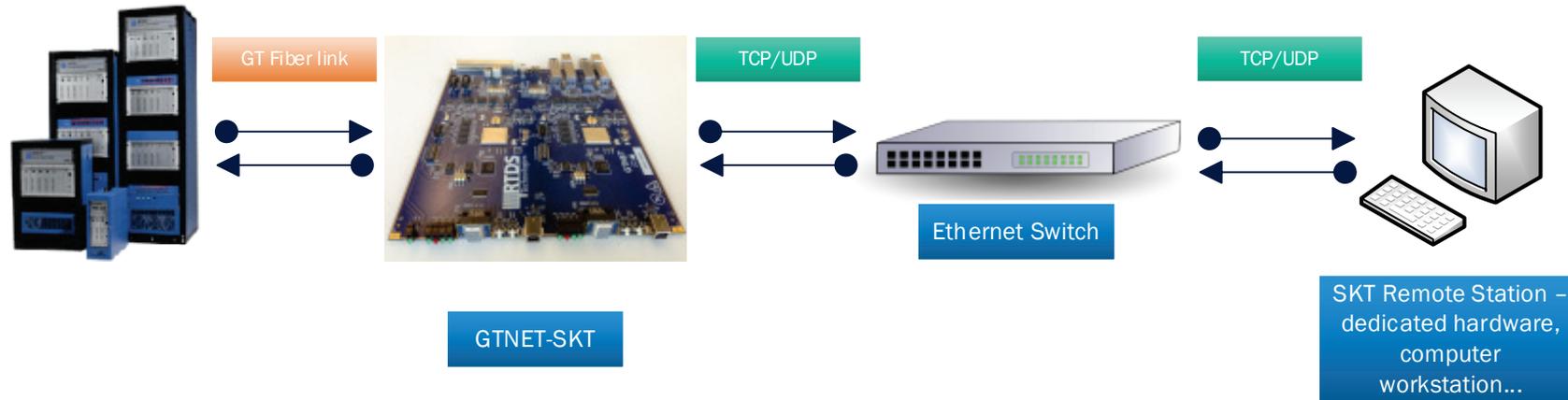
## GTNET-SKT

- ❑ Interface with external software/hardware over a LAN/WAN using TCP or UDP sockets
- ❑ The communication is
  - ❑ Bidirectional
  - ❑ Asynchronous
  - ❑ Unsolicited
  - ❑ Initiated by each side of the Ethernet based communication link
- ❑ Able to send data size up to 300 points (4 bytes/point) per packet
- ❑ Data type is defined either be Integer or Float (IEEE 754)
- ❑ Maximum recommended update rates
  - ❑ GTNETx2 - 1K Hz for 300 points or 5K Hz for less than 60 points
  - ❑ GTNET – 100 Hz for any number of points



# GTNET

## GTNET-SKT



# GTNETx2

## GTNETx2-Modbus

- ❑ The protocol is commonly used in SCADA system automation to facilitate communication between a Master Station and a RTU (Remote Terminal Unit)
- ❑ The GTNETx2 Modbus component provides Modbus communication over TCP/IP networks using the GTNETx2 hardware. Three variants are supported –
  - ❑ Modbus TCP
  - ❑ Modbus RTU over TCP
  - ❑ Modbus ASCII over TCP
- ❑ Operates as a Modbus Server/Slave to communicate with a Modbus Client/Master

GTNET-MODBUS	
GTNET Card #	1
GTIO Fiber Port	4
Mode	TCP
NAME	GTNETModbus
Points File (.txt):	points
Local Port	502
Slave Addr	1

# GTNETx2

## GTNETx2-Modbus Capability

Primary Table	Maximum Quantity	Data Reference Range
Discrete Inputs	2000	0 - 1999 (0x0000 - 0x07CF)
Coils	2000	0 - 1999 (0x0000 - 0x07CF)
Input Registers	125	0 - 124 (0x0000 - 0x007C)
Holding Registers	125	0 - 124 (0x0000 - 0x007C)
Exception Status	8	0 - 7

# GTNETx2

## GTNETx2-Modbus

### Update frequency

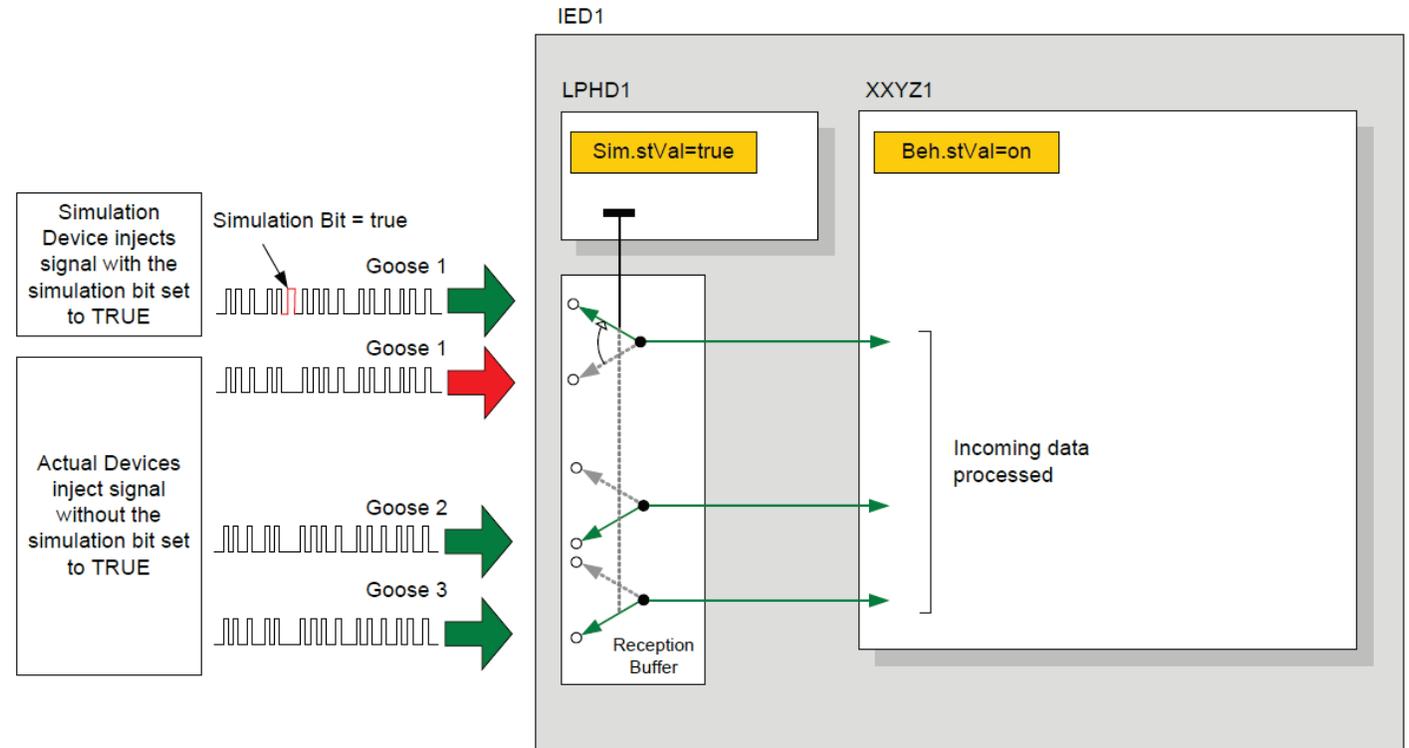
- ❑ The update frequency for the Discrete Inputs and Coils is 100 Hz; for Input Registers and Holding Registers is 10 Hz

Function / Operation	Modbus Function Code	Maximum Quantity
Read Coils	01 (0x01)	2000
Read Discrete inputs	02 (0x02)	2000
Read Holding Registers	03 (0x03)	125
Read Input Registers	04 (0x04)	125
Write Single Coil	05 (0x05)	1
Write Single Register	06 (0x06)	1
Read Exception Status	07 (0x07)	1
Write Multiple Coils	15 (0x0F)	1920
Write Multiple Registers	16 (0x10)	120
Mask Write Register	22 (0x16)	1
Read/Write Multiple Registers	23 (0x17)	120

# IEC 61850 Edition 2

## IEC 61850 ED2 – Testing and Simulated Signals

- ❑ In order to carry out functional, commissioning or maintenance tests, a communications network-based SAS that supports testing functions should offer some of the following facilities:
  - ❑ at the IED level, the option of receiving multicast simulation signals instead of actual signals
  - ❑ at the LN (function) level, the option of receiving test input signals instead of actual signals
  - ❑ at the LN (function) level, the option of setting a function or a group of functions of the system in test mode



**Example of an IED (IED1) receiving simultaneously simulation and actual signals -**  
To allow the IED1 to process the simulated Goose1 message instead of the actual Goose 1 message, the Data Attribute Sim.stVal in the LN LPHD1 shall be set to TRUE

# IEC 61850 Edition 2

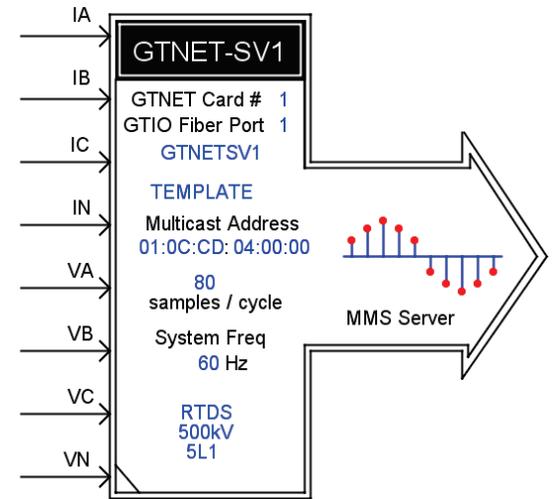
## IEC 61850 ED2 – Subscription Monitoring (LGOS and LSVS)

- ❑ The LGOS and LSVS logical nodes may be used to monitor subscription states to GOOSE or SV signals
- ❑ They contain mandatory information like status of the subscription (active, not active) and other optional information e.g. the source GOOSE or SV control block identification
- ❑ The root LD LPHD.Sim.StVal is used to switch the ability of the DUT to accept real or simulated test signals, then LGOS or LSVS will indicate the state of the incoming signals
  - ❑ For example if LPHD.Sim.StVal=true and there is a SV telegram with the simulation flag set=true then LSVS1.St.stVal=true and LSVS1.SimSt.StVal=true

# GTNETx2-SV-v6

## GTNETx2-SV-v6

- ❑ Only supported on GTNETx2 cards
- ❑ Supports IEC 61850 Edition 2
- ❑ Simulates a MMS server using a GTNETx2 module
  - ❑ Connects up to 4 simultaneous IEC 61850 MMS client sessions\*, which are able to -
    - ❑ Browse GTNETx2 data models
    - ❑ Read values from logical nodes
    - ❑ Enable/disable SV Control Block
    - ❑ Control the Sim.stVal under the logical node LPHD1 to process simulated SV messages
    - ❑ Support logical node LSVS which contains
      - ❑ Optional Data Attribute – St (status of the subscription -> True=active, False=not active)
      - ❑ Optional Data Attribute – SimSt (status showing that real Sim messages are received and accepted)
- ❑ Allows to use GTSYNC time of day for MMS and/or the "RefrTm" field in the SV telegram



rtds\_cti\_GTNET\_SV9-2\_V6.def

SV-1 OUTPUT IEC 61850 CONFIG		SV-1 OUTPUT CHANNEL QUALITY ENABLES		MMS SERVER ADDRESS	
CONFIGURATION		CHANNEL SCALING			
Name	Description	Value	Unit	Min	Max
Name	GTNET Component Name	GTNETSV1			
Mode	SV Mode	Output		0	1
nSV	Number of SVs	1		0	1
SYSFREQ	Nominal system frequency (Hz)	60			
SMPRT	Sample rate (samples/cycle)	80		0	1
IECVer	IEC 61850 Standard; Edition	UCA10a (9.2LE)		0	3
sName	Substation Name	RTDS			
iedNameA	IED Name part A	TEMPLATE			
iedNameB	IED Name part B				
iedNameC	IED Name part C				
nChan	Number of voltage and current channels	1		1	24
Port	GTIO Fiber Port Number	1		1	8
Card	GTNET_SV Card Number	1		1	8
Proc	Assigned Controls Processor	1		1	40
Pri	Priority Level	1		1	
prtyp	Solve Model on card type:	GPC/PB5		0	2
gtntype	GTNET Type	GTNETx2			
INCTOD	Use GTSYNC time of day for MMS and/or RefrTm	FALSE		0	0
GT_SOC	GTSYNC advance TIME signal name	ADVSECD		0	0
GT_STAT	GTSYNC advance STAT signal name	ADVSTAT		0	0

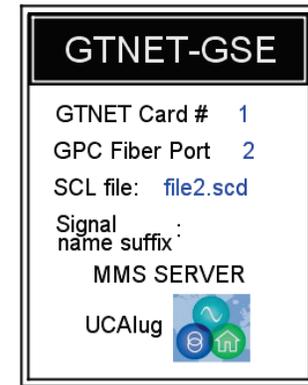
Update Cancel Cancel All

\*More connections may be supported if required

# GTNETx2-GSE-v6

## GTNETx2-GSE-v6

- ❑ Only supported on GTNETx2 cards
- ❑ Supports IEC 61850 Edition 2
- ❑ Can be configured to simulate a MMS server using a GTNETx2 module
  - ❑ Only one IED is simulated since there is only one IP address associated to each GTNETx2 module
  - ❑ Provides XCBR/XSWI status information and supports CSWI Control Service through MMS messages
- ❑ Allows to use GTSYNC time of day for MMS and/or the "RefrTm" field in the GOOSE telegram



Name	Description	Value	Unit	Min	Max
sCompName	Component name	G2			
Port	GTIO Fiber Port Number	2		1	8
Card	GTNET_GSE Card Number	1		1	8
prttyp	Type of Processor Card	GPC/PB5		2	2
gtnettype	GTNET Type	GTNETx2		0	1
IECver	IEC 61850 Standard; Edition	2		0	1
eMMS	Enable MMS Server	YES		0	0
Proc	Assigned Controls Processor	1		1	54
Pri	Priority Level	1		1	
TSYNCE	Use GTSYNC time of day for MMS and/or RefrTm	NO			
GT_SOC	GTSYNC advance TIME signal name	ADVSECD		0	0
GT_STAT	GTSYNC advance STAT signal name	ADVSTAT		0	0

Update Cancel Cancel All

# GTNETx2-GSE-v6

## GTNETx2-GSE-v6

- ❑ When the MMS Server is enabled, it can be Connected up to 4 simultaneous IEC 61850 MMS Client sessions\* which are able to –
  - ❑ Browse GTNETx2 data models
  - ❑ Read values from logical nodes
  - ❑ Enable/disable GOOSE Control Block
  - ❑ Control the Sim.stVal under the logical node LPHD1 to process simulated GOOSE messages
  - ❑ Support logical node LGOS which contains
    - ❑ Mandatory Data Attribute – St (status of the subscription -> True=active, False=not active)
    - ❑ Optional Data Attribute – SimSt (status showing that real Sim messages are received and accepted)

\*More connections may be supported if required

The screenshot shows the IEC 61850 MMS Voyager software interface. The main window displays a tree view of logical nodes under 'T1'. The 'Gcb01' node is expanded, showing its attributes: GoEna (True), ConfRev (1), GolD (1), DatSet (T1CTRL/LLN0\$GOOSE\_outputs\_1), NdsCom (False), and DstAddress. A table below the tree lists the GOOSE outputs with their references, names, values, and functional classes (FC).

Reference	Name	Value	FC
T1CSWI_XCBR/Obj1XCBR1.Pos.stVal	stVal	01	ST
T1CSWI_XCBR/Obj2XCBR2.Pos.stVal	stVal	10	ST
T1CSWI_XCBR/Obj1XCBR1.Loc.stVal	stVal	False	ST
T1CSWI_XCBR/Obj1CSWI1.Loc.stVal	stVal	True	ST
T1CSWI_XCBR/Obj1CSWI1.LocSta.stVal	stVal	False	ST

At the bottom of the interface, there is a 'Period (sec): 0.51' field and buttons for 'New', 'Start', and 'Stop'. A 'Message Area' at the very bottom shows the status: 'Data values updated. Updating data values... Data values updated.'

# GTNETx2-GSE-v6

## GTNETx2-GSE-v6

### MMS XCBR/XSWI/CSWI support

- Enabled from SCD editor
- Supports up to 32 Logical Node Instances
- Supported Control Mode
  - Direct with normal security
  - SBO (Select Before Operate) with normal security
  - Direct with enhanced security
  - SBO with enhanced security

Edit LD CSWI\_XCBR

CSWI Entries				
Add	Inst	ctlModel	Type	Del
	InClass="CSWI" inst="1"	sbo-with-enhanced-security	XCBR	
	InClass="CSWI" inst="2"	direct-with-normal-security	XCBR	
	InClass="CSWI" inst="3"	direct-with-normal-security	XCBR	
	InClass="CSWI" inst="4"	direct-with-normal-security	XCBR	
	InClass="CSWI" inst="5"	direct-with-normal-security	XCBR	
	InClass="CSWI" inst="6"	direct-with-normal-security	XCBR	
	InClass="CSWI" inst="7"	direct-with-normal-security	XCBR	
	InClass="CSWI" inst="8"	direct-with-normal-security	XCBR	
	InClass="CSWI" inst="9"	direct-with-normal-security	XCBR	
	InClass="CSWI" inst="10"	direct-with-normal-security	XCBR	
	InClass="CSWI" inst="11"	direct-with-normal-security	XCBR	

OK Cancel

# GTNETx2-GSE-v6

## GTNETx2-GSE-v6

### MMS XCBR/XSWI/CSWI support

- ❑ The position status of the enabled XCBR/XSWI can be monitored in a MMS Client

The screenshot displays the MMS Voyageur software interface. The main window shows a tree view of objects under 'file5 [172.24.9.233]'. The 'Obj1XCBR1' object is selected, and its configuration parameters are displayed in a table. Below the table, there is a 'Period (sec): 0.51' field and buttons for 'New', 'Start', and 'Stop'. The bottom of the window features a 'Message Area' with the text: 'Data values updated.', 'Updating data values...', and 'Data values updated.'.

Reference	Name	Value	FC
T1CSWI_XCBR/Obj1XCBR1.Pos.stVal	stVal	01	ST
T1CSWI_XCBR/Obj2XCBR2.Pos.stVal	stVal	10	ST
T1CSWI_XCBR/Obj1XCBR1.Loc.stVal	stVal	False	ST
T1CSWI_XCBR/Obj1CSWI1.Loc.stVal	stVal	True	ST
T1CSWI_XCBR/Obj1CSWI1.LocSta.s...	stVal	False	ST

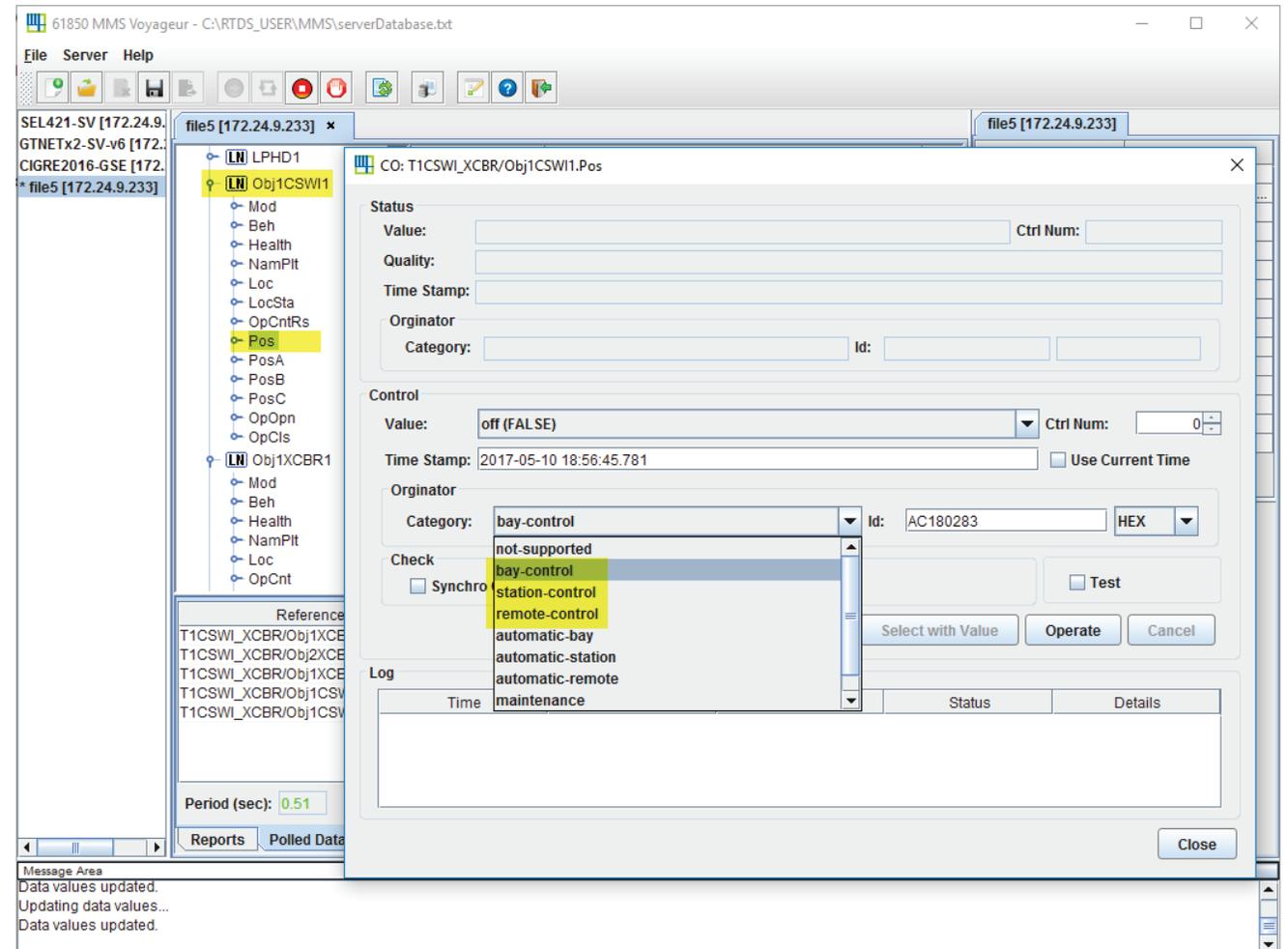
Parameter	Value
Name	file5
SCL File [...]	C:\RTDS_USER\file...
Local AE Qualifier	12
Local Application ID	1.1.1.999
Local Presentation ...	00000001
Local Session Sele...	0001
Local Session Time...	2000
Local Transport Sel...	0001
Remote IP address	172.24.9.233
Remote IP port	102
Remote AE Qualifier	12
Remote Application ...	1.1.1.999.1
Remote Presentatio...	00000001
Remote Session Se...	0001
Remote Transport S...	0001

# GTNETx2-GSE-v6

## GTNETx2-GSE-v6

### MMS XCBR/XSWI/CSWI support

- ❑ The CSWI Control Service commands can be sent to the GTNET MMS Server through MMS messages
- ❑ The control authority is compliant with the concept specified in Annex B of IEC 61850-7-4 Edition 2



# GTFPGA-SV

## GTNETx2-SV

### Challenges

- ❑ Publishes only maximum of two 61869-9 compatible SV streams per GTNETx2 card
- ❑ The non-configurable, sequential based architecture makes it challenging to meet the stricter jitter requirements defined by the Chinese National Standard (less than 10 us)

# GTFPGA-SV

## GTFPGA-SV

### Hardware – GTFPGA Unit

- ❑ 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
  - ❑ 100 Base-FX fiber SFP Module Finisar FTLF-1217P2xTL
  - ❑ 1000 Base-SX fiber SFP Module Finisar FTLF-8519P3BNL (the same insert used for the GT portscom)

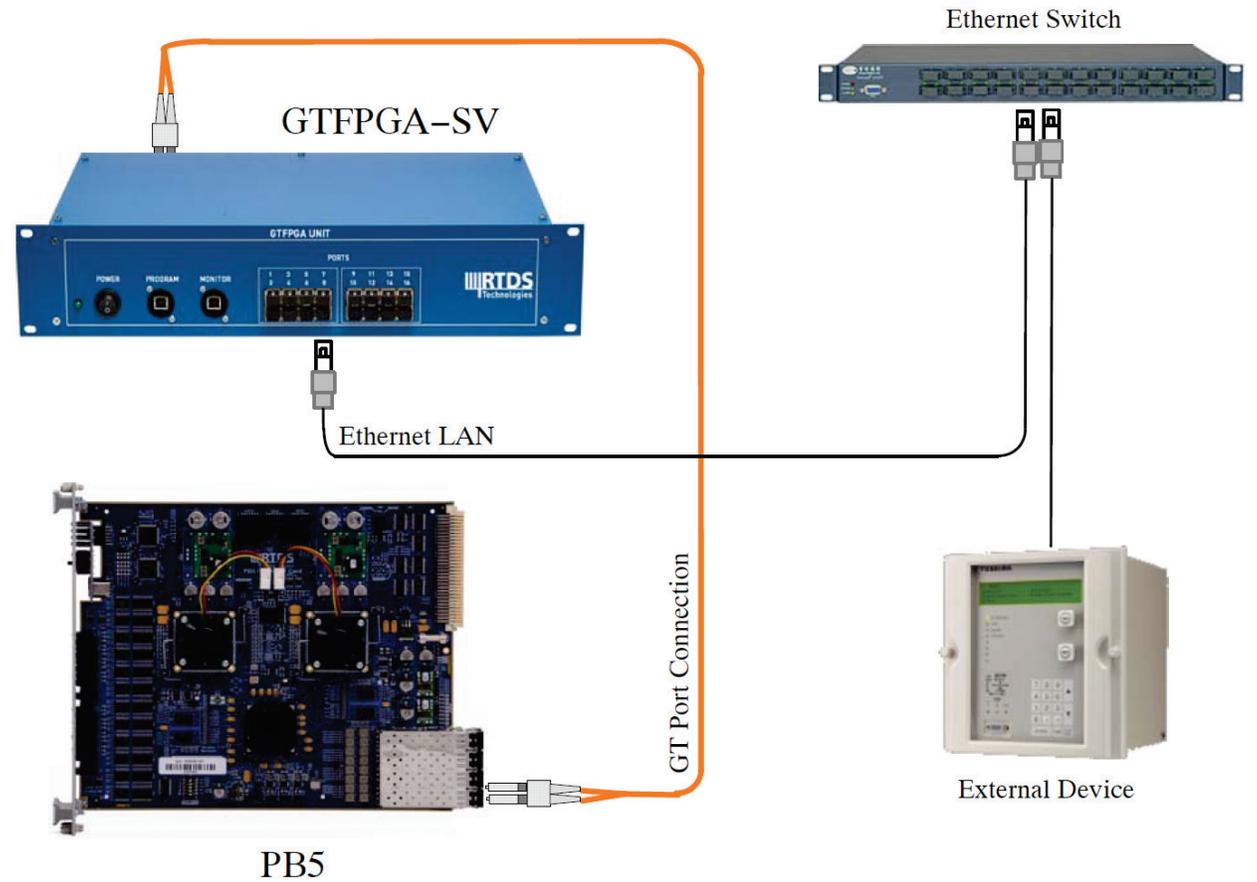


# GTFPGA-SV

## GTFPGA-SV

Hardware – GTFPGA Unit

□ Typical connection

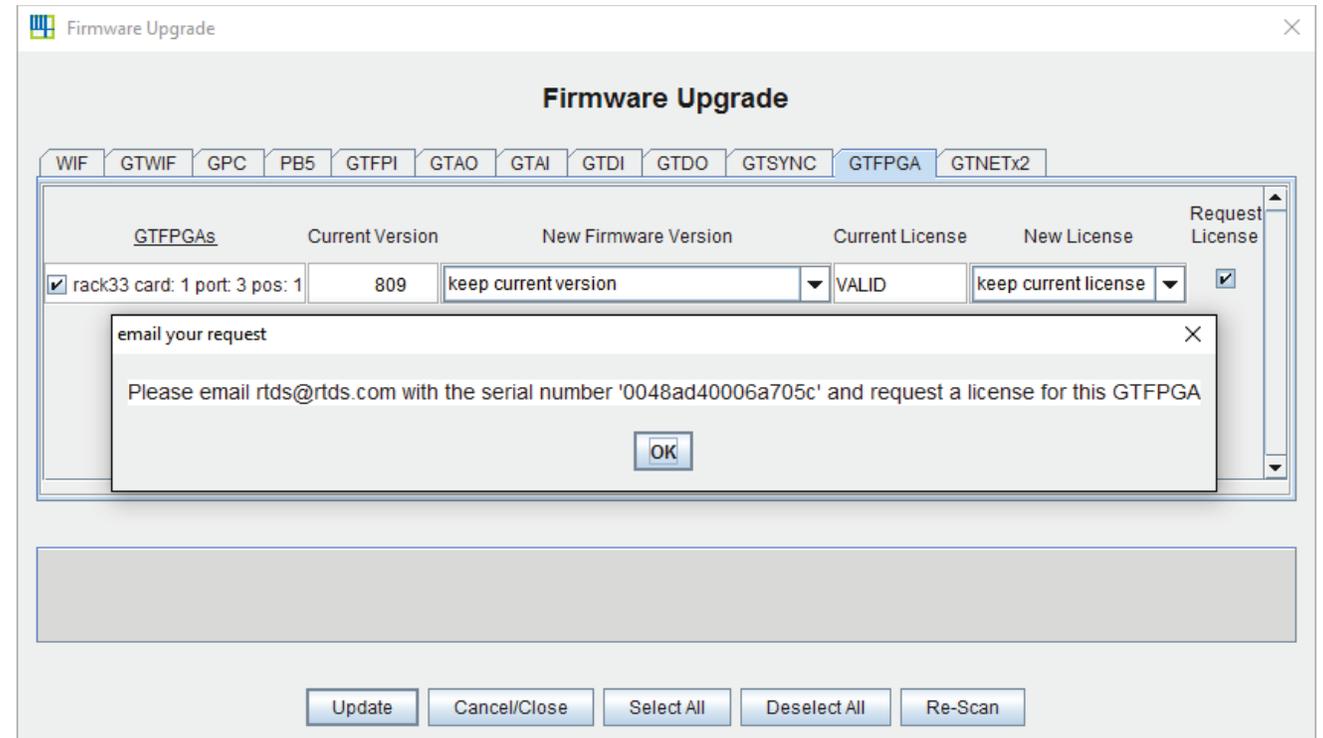


# GTFPGA-SV

## GTFPGA-SV

Hardware – GTFPGA Unit

- ❑ Firmware installation/upgrade can be done through Firmware Upgrade Utility





# GTFPGA-SV

## GTFPGA-SV

### RSCAD Component

- ❑ Currently supports output mode only
- ❑ Can be configured to have maximum of 16 outputs, 1 SV stream per output port\*
- ❑ Supports nominal frequency of 50Hz and 60Hz
- ❑ Runs either in 9-2LE mode or 61869-9 mode
  - ❑ UCAlug 9-2LE
    - ❑ 4 voltages and 4 currents per SV stream, fixed configuration
  - ❑ 61869-9 & Chinese National Standard
    - ❑ Up to 24 free-configured data channels per SV stream
      - ❑ 61869-9 limits to maximum of 24 channels for general measuring and protection and maximum of 8 channels for quality metering
      - ❑ Chinese National Standard typically uses 24 channels with the Time Delay assigned to the first channel

**\_rtds\_ctl\_GTFPGA\_SV0\_V0.def**

SV-15 SOURCE, QUALITY ENABLES	SV-16 SOURCE, QUALITY ENABLES		
SV-13 SOURCE, QUALITY ENABLES	SV-14 SOURCE, QUALITY ENABLES		
SV-11 SOURCE, QUALITY ENABLES	SV-12 SOURCE, QUALITY ENABLES		
SV-9 SOURCE, QUALITY ENABLES	SV-10 SOURCE, QUALITY ENABLES		
SV-7 SOURCE, QUALITY ENABLES	SV-8 SOURCE, QUALITY ENABLES		
SV-4 SOURCE, QUALITY ENABLES	SV-5 SOURCE, QUALITY ENABLES	SV-6 SOURCE QUALITY ENABLES	
SV-16 IEC 61850 OUTPUT	SV-2 SOURCE, QUALITY ENABLES	SV-3 SOURCE, QUALITY ENABLES	
SV-13 IEC 61850 OUTPUT	SV-14 IEC 61850 OUTPUT	SV-15 IEC 61850 OUTPUT	
SV-10 IEC 61850 OUTPUT	SV-11 IEC 61850 OUTPUT	SV-12 IEC 61850 OUTPUT	
SV-6 IEC 61850 OUTPUT	SV-7 IEC 61850 OUTPUT	SV-8 IEC 61850 OUTPUT	SV-9 IEC 61850 OUTPUT
SV-2 IEC 61850 OUTPUT	SV-3 IEC 61850 OUTPUT	SV-4 IEC 61850 OUTPUT	SV-5 IEC 61850 OUTPUT
CONFIGURATION	CHANNEL SCALING	SV-1 IEC 61850 OUTPUT	SV-1 SOURCE, QUALITY ENABLES

Name	Description	Value	Unit	Min	Max
Name	GTFPGA Component Name	GFPGASV1			
Mode	SV Mode	Output		0	1
nSV	Number of SVs	16		1	16
SYSFREQ	Nominal system frequency (Hz)	60			
IECVer	IEC 61850 Standard; Edition	UCAlug (9.2LE)		0	1
GT_SOC	GTSYNC advance TIME signal name	UCAlug (9.2LE)		0	0
GT_STAT	GTSYNC advance STAT signal name	IEC 61869-9		0	0
Port	GTIO Fiber Port Number	1		1	8
Card	GTFPGA Card Number	1		1	8
smvIDtype	Use 9.2LE convention for the smvID or use only LDPPre	Yes		0	1
Proc	Assigned Controls Processor	1		1	40
Pri	Priority Level	1		1	
prtyp	Solve Model on card type:	GPC/PB5		0	2
sfx	Add signal name suffix for multiple instances of GTFPGA-SV				
INCTOD	Use GTSYNC time of day for MMS and/or RefrTm	FALSE		0	1

Update Cancel Cancel All

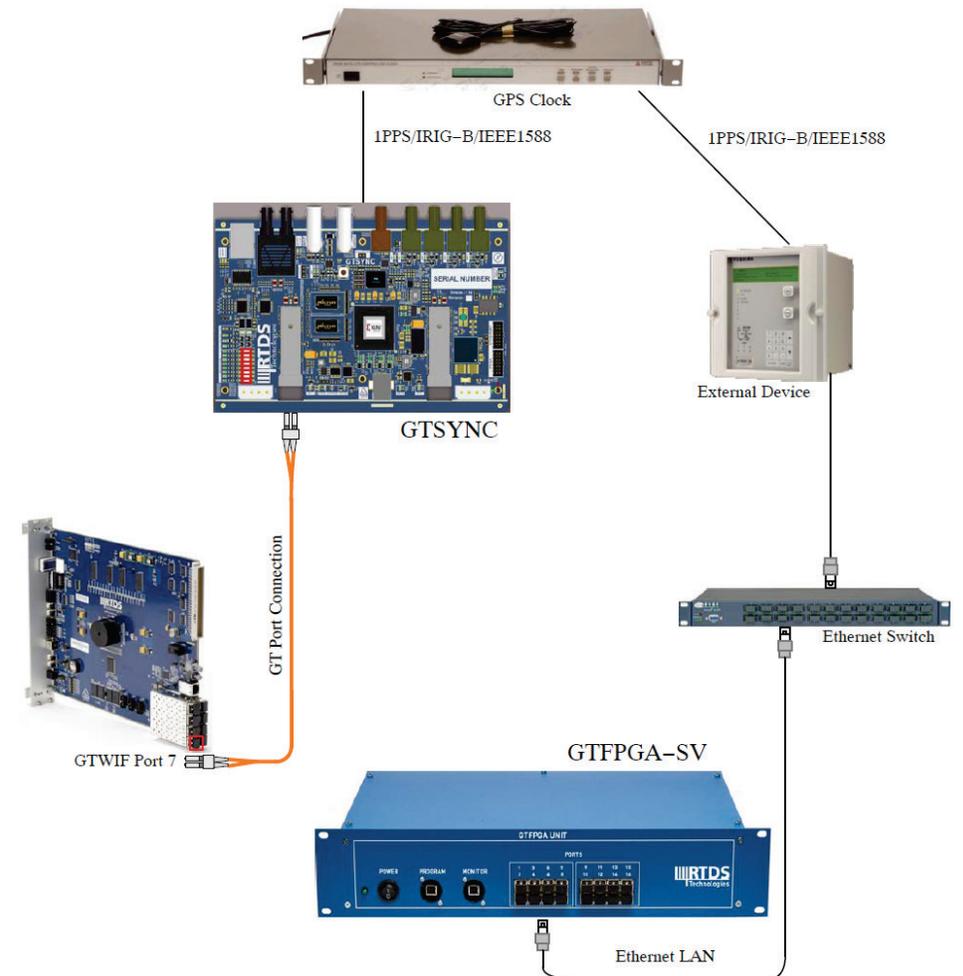
\*refer slide 21 for limitations

# GTFPGA-SV

## GTFPGA-SV

### Time Synchronization

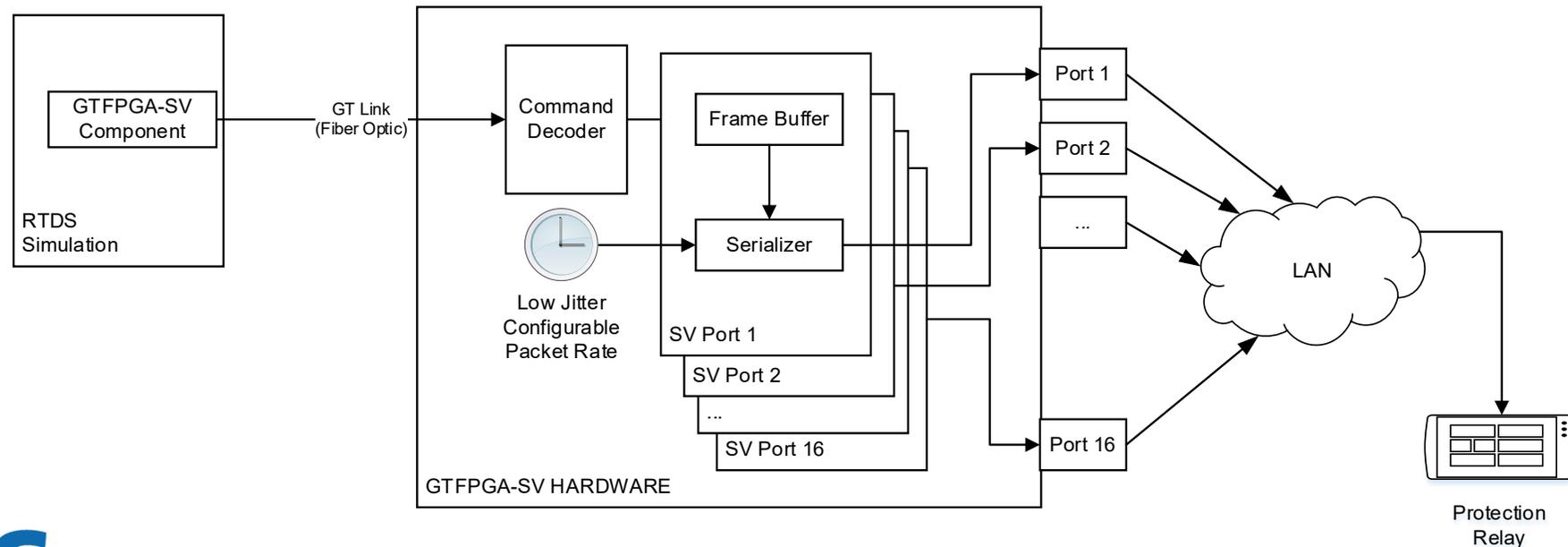
- ❑ The GTSYNC card is used to synchronize the RTDS simulation time step to an external time reference and to synchronize devices under test



# GTFPGA-SV

## GTFPGA-SV Data Flow

- ❑ RSCAD Component transmits SV samples to the FPGA using a dedicated fiber optic based GT link
- ❑ The FPGA triages the incoming simulated data and stores it to a specific Ethernet port frame buffer
- ❑ SV frame packets are assembled in the buffer then serialized to make eligible to be sent over the Ethernet link



# GTFPGA-SV

## GTFPGA-SV

### Testing and Validation

#### ❑ Omicron SVScout

- ❑ SVScout V1.50 was used in conjunction with a dedicated PCI network card, to validate the SV packet rate and jitter

#### ❑ Test setup

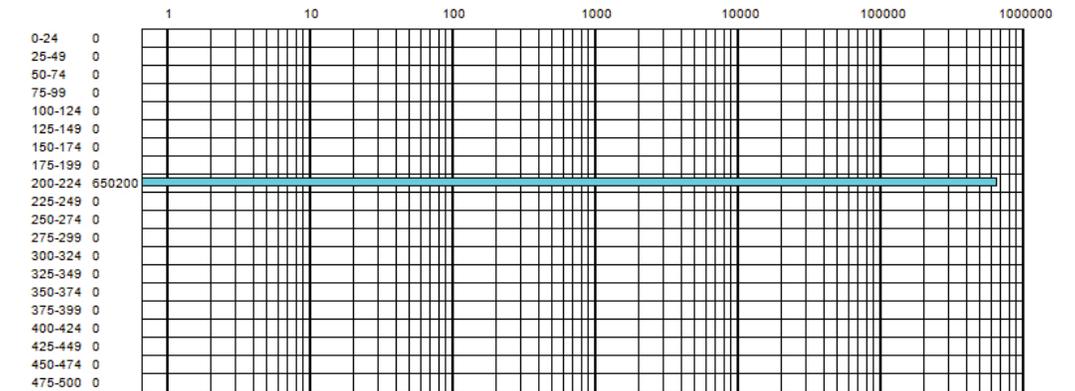
- ❑ The GTFPGA-SV was configured to run a single output stream of 60Hz at 80 samples per cycle
- ❑ The corresponding output port on the GTFPGA-SV Unit was directly connected via Ethernet to the computer running SVScout to eliminate any delay due to packet routing on the network

#### ❑ Test result

- ❑ The packet delay graph shows that packets are sent on average at a 208us frequency, with a measured standard deviation of 0us

#### Packet delays

Minimum delay: 208  $\mu$ s  
Maximum delay: 209  $\mu$ s  
Mean: 208  $\mu$ s  
Median: 208  $\mu$ s  
Standard deviation: 0  $\mu$ s  
Lower - upper quantile: 208 - 209  $\mu$ s



*The frequency of occurrence of the measured packet delays\* within the time intervals is displayed*

*\*Packet Delays - Time intervals between the Sample Values packets*

# GTFPGA-SV

## GTFPGA-SV

### Testing and Validation

#### ❑ Omicron SVScout

##### ❑ Test result

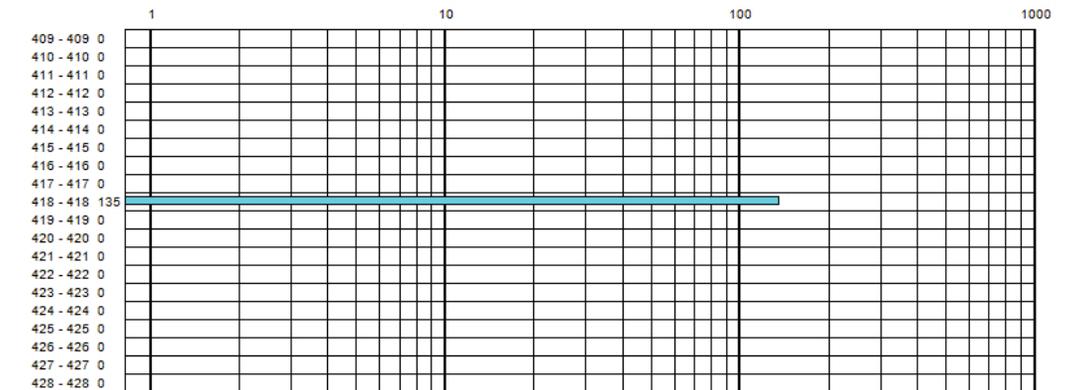
- ❑ The time offset graph shows that it takes 418us or about 2 sample periods from the time quantities are sampled until the time packets are sent

##### ❑ Testing showed that the GTFPGA-SV meets both:

- ❑ The SV frame jitter requirement of 10us defined in Chinese National Standard, and other applications where require a low jitter
- ❑ The maximum processing delay time limit for quality metering and protective and measuring applications (10 and 2ms respectively)

#### Time offset

Minimum: 418  $\mu$ s  
Maximum: 418  $\mu$ s  
Mean: 418  $\mu$ s  
Median: 418  $\mu$ s  
Standard deviation: 0  $\mu$ s  
Lower - upper quartile: 418 - 418  $\mu$ s



*The frequency of occurrence of the measured time offsets\* within the time intervals is displayed*

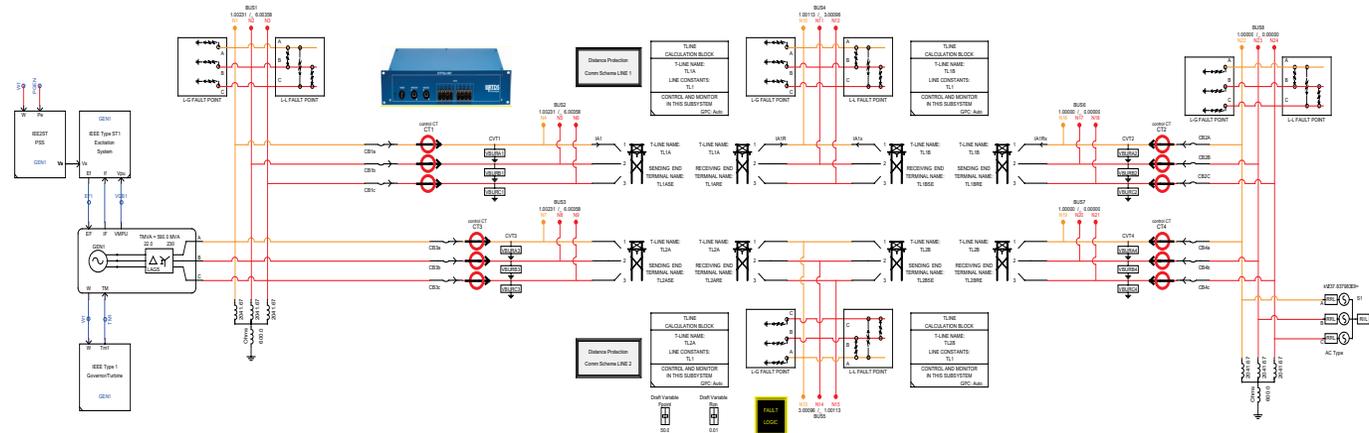
*\*Time Offsets - Time intervals from the theoretical sampling time (leading edge of the PPS signal) to the reception of the corresponding packet with sample count zero*

# GTFPGA-SV

## GTFPGA-SV

### Testing and Validation

- ❑ RTDS proprietary software suite
  - ❑ Developed to collect raw Ethernet packets and performs acceptance tests on any incoming SV packet
  - ❑ Accepts SV packets of any rate and quantities, and compares them against expected pattern
- ❑ GTNETx2-SV in Input Mode
  - ❑ Implements a closed loop test
    - ❑ Data is fed to the GTFPGA-SV which publishes it to a SV network, the GTNETx2-SV acquires the SV frames, and forwards them back into the case, where sent and received data are compared
- ❑ Testing of IEDs using GTFPGA-SV



# GTFPGA-SV

## GTFPGA-SV

### Performance and Limitations

- ❑ Currently capable of supporting –
  - ❑ 16 ports configured with maximum of 24 data channels, at 80 samples per cycle per SV stream
  - ❑ 16 ports configured with maximum of 9 data channels, at sample rates higher than 80 samples per cycle per SV stream
  - ❑ Several mixed sample rate configurations
- ❑ The present limitations of the system reside in the execution time of the component itself
  - ❑ The component is in charge of the interpolation, sampling, scaling and forwarding to the FPGA of each of the ports
  - ❑ The process is limited by the maximum length that the time step can take, which is driven by the following two factors –
    - ❑ The maximum time step the application requires
    - ❑ The maximum time step the SV sample rate allows

### Potential Improvements

- ❑ Some of the processing operations could potentially be relocated to the FPGA

# Aurora Communication

## Aurora Communication

We are offering

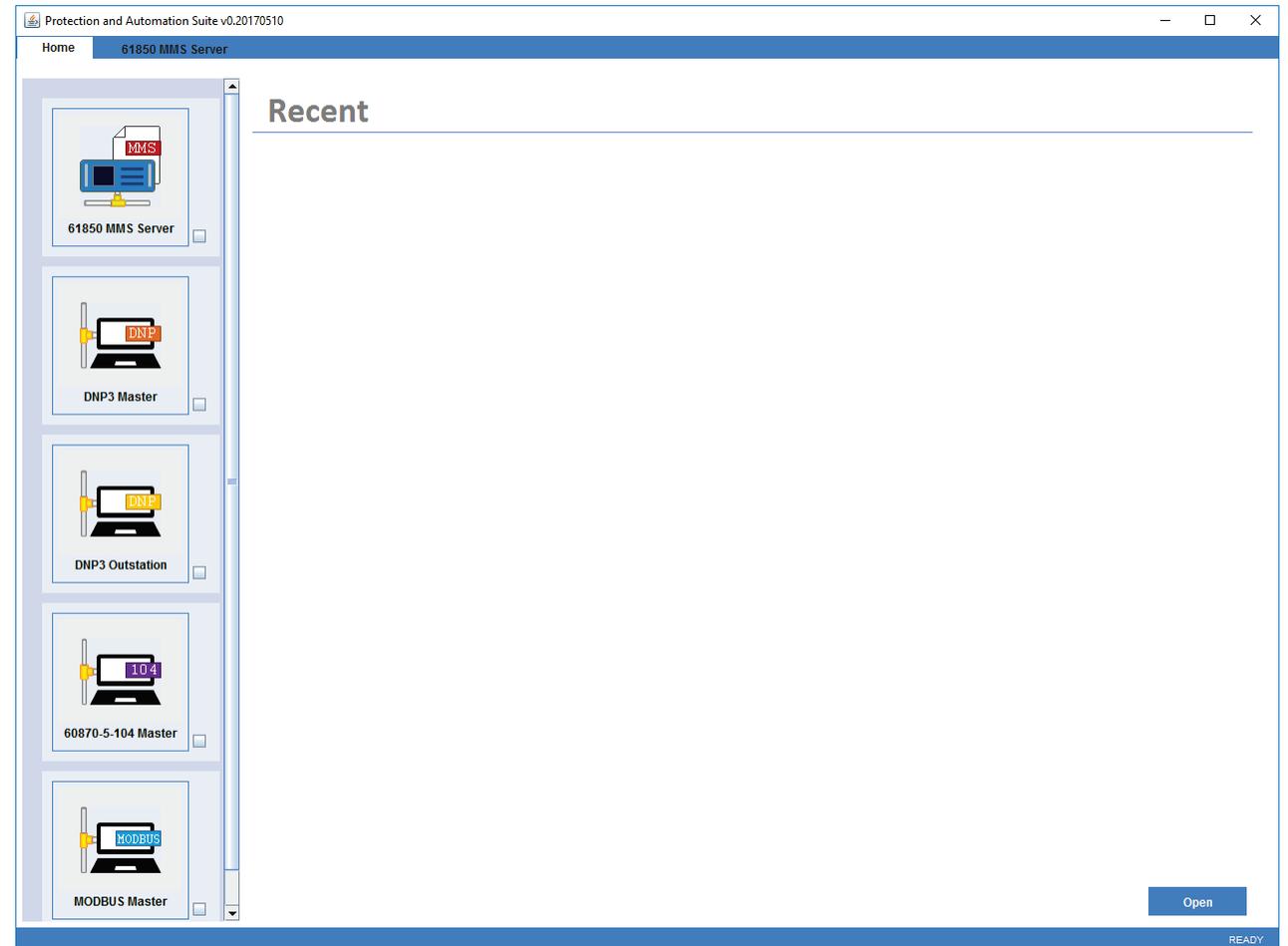
- ❑ Aurora protocol streaming from the GT fiber ports on a PB5 card
  - ❑ Will be licensed to a specific PB5 card(s) and port 4-8 on that PB5 card will be reserved for Aurora
  - ❑ Each PB5 Aurora license can have 4 Aurora streams from ports 4-8 on a PB5 card, each at a line rate of 2 Gbps
  - ❑ Each of the 4 streams can have 64 inputs and 64 outputs (each of them is a 32-bit word)
  - ❑ Each stream can come from either the large or small timestep

# Protection & Automation Suite

## Main Features

A stand alone program available in RSCAD that is capable of simulating:

- IEC 61850 MMS Servers
- DNP3 or IEC 60870-5-104 Masters
- DNP3 Outstations
- Modbus Masters



# Protection & Automation Suite

## IEC 61850 MMS Server

### Capability

- ❑ Simulates one or multiple IEC 61850 Servers using the corresponding SCL (Substation Configuration Language) files that comply with IEC 61850-6
- ❑ Supports the Simulation of GOOSE telegram defined in IEC 61850-8-1 Edition2
- ❑ Supports GOOSE subscription if it is defined in the SCL file
- ❑ Supports Logical Node Class LGOS\* (from IEC 61850 Edition2) if it is defined in the SCL file

\*Logical Node LGOS allows a subscriber to either subscribe not simulated GOOSE telegrams or simulated GOOSE telegrams

The screenshot displays the 'Protection and Automation Suite v0.20170425\_j' interface for configuring a '61850 MMS Server'. The interface is divided into several sections:

- Home:** Contains buttons for 'Validate SCL', 'OPEN SCL', 'START Server', 'STOP Server', 'Get All Data', 'START Monitor', and 'STOP Monitor'. It also includes checkboxes for 'Use URI Address', 'Enable All GoCB', 'GOOSE Simulation/Test', and 'Show Data References'.
- Server Properties:** A table listing attributes and values for the server.

Attribute	Value
SCL File	C:\Users\eric\works\pac...
SCL Edition	2.0
IP Address	127.0.0.1 [Software Loo...
Port	102
IED	IED_RTDS
Access Point	P1
- SubModel: IED\_RTDSDiagnostic/LGOS1:** A table listing attributes and references for the submodel.

Attribute	Reference	Value	Type	FC
LN LGOS1				
St				
Sim St				
GoCBRef	IED_RTDSDiagnostic/LGOS1\$GoCBRef			
- IED Model:** A tree view showing the IED structure:
  - IED\_RTDS
    - DataModel
    - DataSets
    - Reports
    - SettingsGroup
    - GOOSE
    - LGOS
      - Diagnostic
        - LPHD1
        - LGOS1
        - LGOS2
        - LGOS3

- Details and Configuration:** A section for 'LGOS Properties (Subscription)' with a table:

Attribute	Value
ICD File	
Subscription Enable	false
setSrcCB	"IED_TMWCCTL1/LLN0\$GOS\$gcbTMW"

Buttons for 'Load ICD', 'Enable', and 'Apply' are present.
- Data Monitor:** A table for monitoring data references:

Model Refere...	Data Reference	Attribute	Value	FC
-----------------	----------------	-----------	-------	----
- Log:** A yellow bar at the bottom showing status messages:

```
IED1 x
TEXTAREA
STATUS: Loading SCL 'RTDS_IED_Ed2_v1_newIPnewMAC.icd'...
STATUS: SCL 'RTDS_IED_Ed2_v1_newIPnewMAC.icd' loaded.
STATUS: <IED1> Server 'IED_RTDS' listening on rfc1006://127.0.0.1:102/0x0001/0x0001/0x00000001/1,1,1,999,1/12
STATUS: <IED1> Server closed.
```



THANK YOU

QUESTIONS?

