



WEBINAR AND DEMO: New and improved IEC 61850 GOOSE features for the RTDS Simulator



AGENDA

- GTNETx2 overview: achieving HIL via communication protocols
- **GSEv7 component**: updated GOOSE Messaging capabilities
- New **IED Configuration Tool**
- New **GOOSE Analyzer Tool**
- RSCAD demonstration
- Q&A



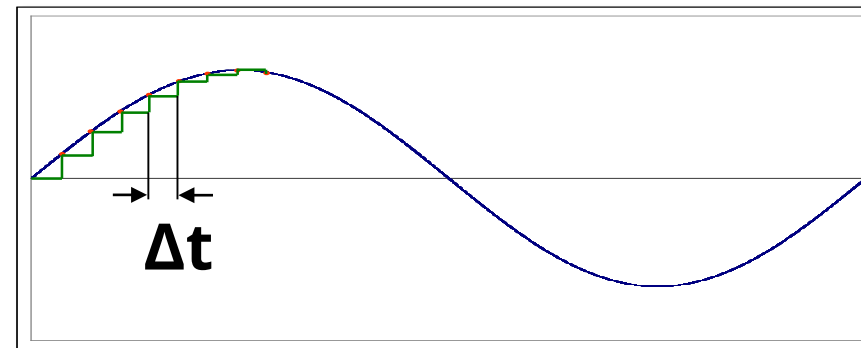
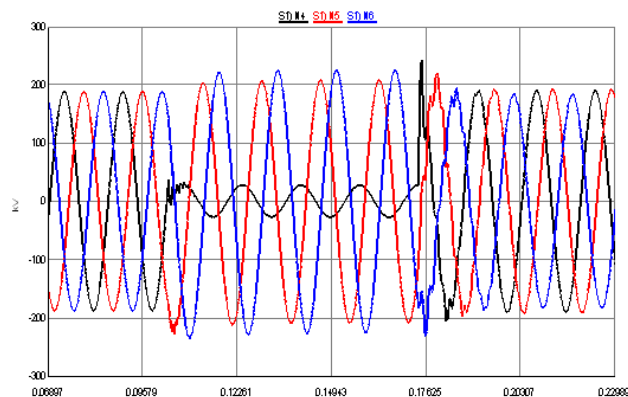
THE RTDS SIMULATOR AND IEC 61850



- The IEC 61850 standard defines communication protocols for substation IEDs and provide an overview of the communication/interaction architecture for substation automation systems
- RTDS Simulator development team actively participates in various industry events and working groups, including those focused on IEC 61850:
 - UCA IUG
 - IEC TC 57
- Industry direction and RTDS users drive development of new capabilities and features

WHAT IS EMT SIMULATION?

Type of Simulation	Load Flow	Transient Stability Analysis (TSA)	Electromagnetic Transient (EMT)
Typical timestep	Single solution	~ 8 ms	~ 2 - 50 μ s
Output	Magnitude and angle	Magnitude and angle	Instantaneous values
Frequency range	Nominal frequency	Nominal and off-nominal frequency	0 - 3 kHz (<15 kHz)



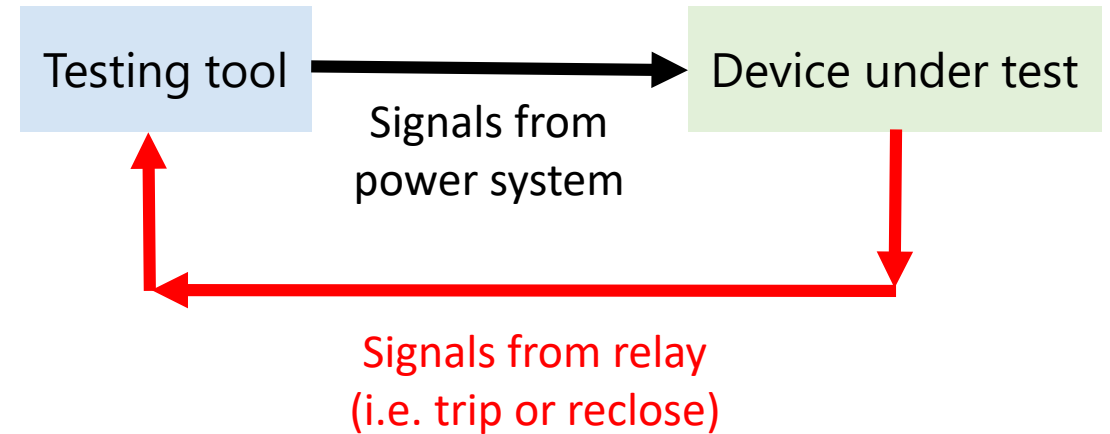
WHAT IS REAL TIME?

- **Real time it takes for an event to occur = Simulation time of an event.**
 - E.g. 3 cycle fault for 60Hz system = 0.05 seconds. RTDS simulates this fault in real time i.e. 0.05 seconds
 - Non-real-time simulations will simulate events faster or slower than real time depending on case complexity
- **Values updated each timestep**
 - All calculations and servicing I/O completed within a timestep.
 - Every timestep has same duration and is completed in real time
- **Requires dedicated parallel processing hardware**

ADVANTAGES OF CLOSED-LOOP (HIL) TESTING

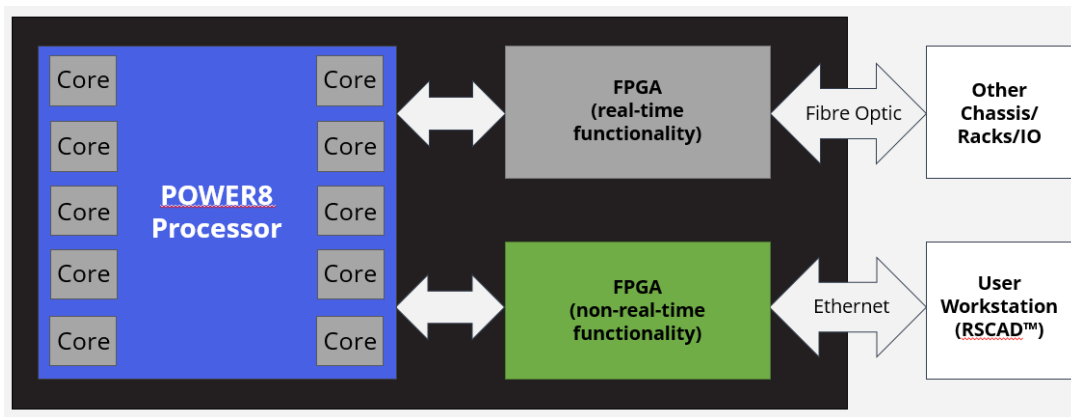
Real time operation is what allows us to connect physical devices in a **closed-loop** with the simulated environment (**hardware-in-the-loop HIL**)

- Test continues after the action of the protection/control device, showing dynamic response of the system
- Test multiple devices (and entire schemes) at once
- Much more detailed system representation than open-loop test systems provide (e.g. modelling power electronics)



HARDWARE REQUIRED FOR REAL-TIME SIMULATION AND HIL TESTING

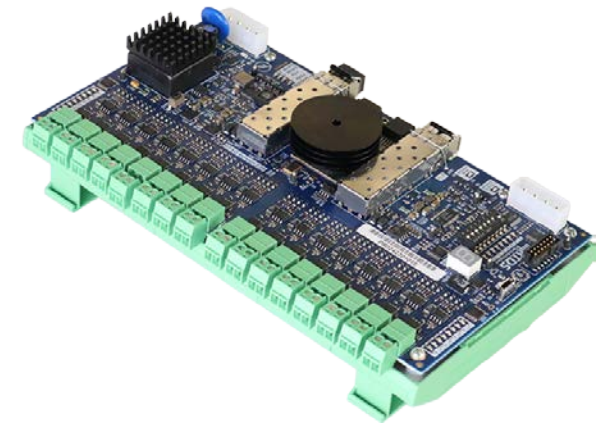
Parallel processing hardware



Input/output devices

Communication protocol based

Analogue/digital



GTNETx2 Card for Network Communication

- Communication with external devices over Ethernet.
- Card has two “modules”, and can have two network protocols operating simultaneously.

Available firmwares:

IEC 61850

GOOSE Messaging
IEC 61850-9-2LE, IEC 61869-9

SCADA

DNP3 and IEC 60870-5-104

Large data playback

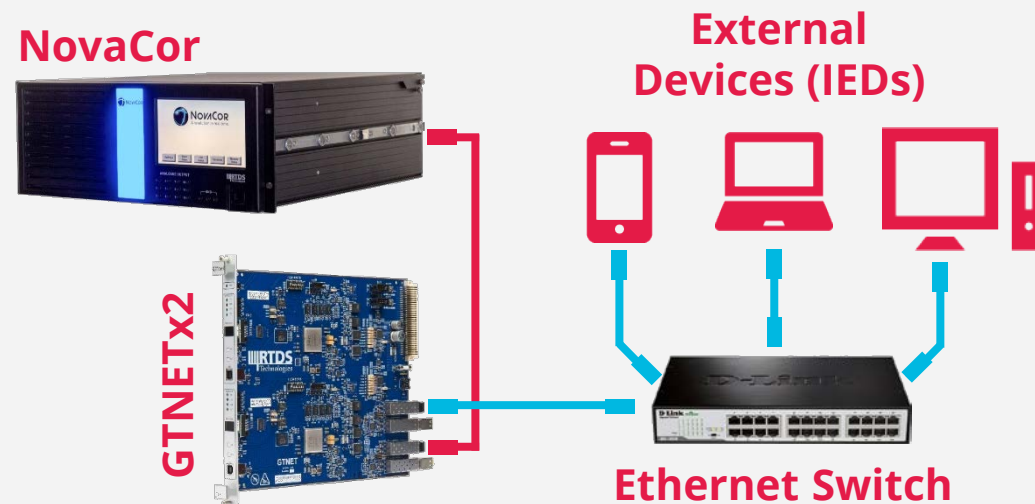
PMU

IEEE C37.118

MODBUS

TCP, RTU over TCP,
ASCII over TCP

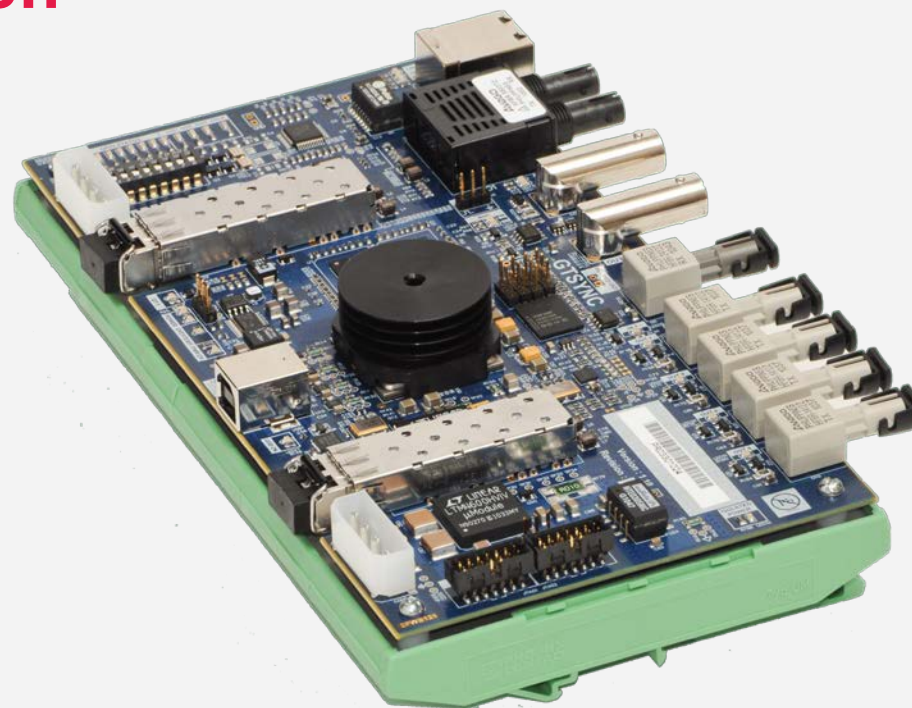
**Generic TCP/UDP
Sockets**



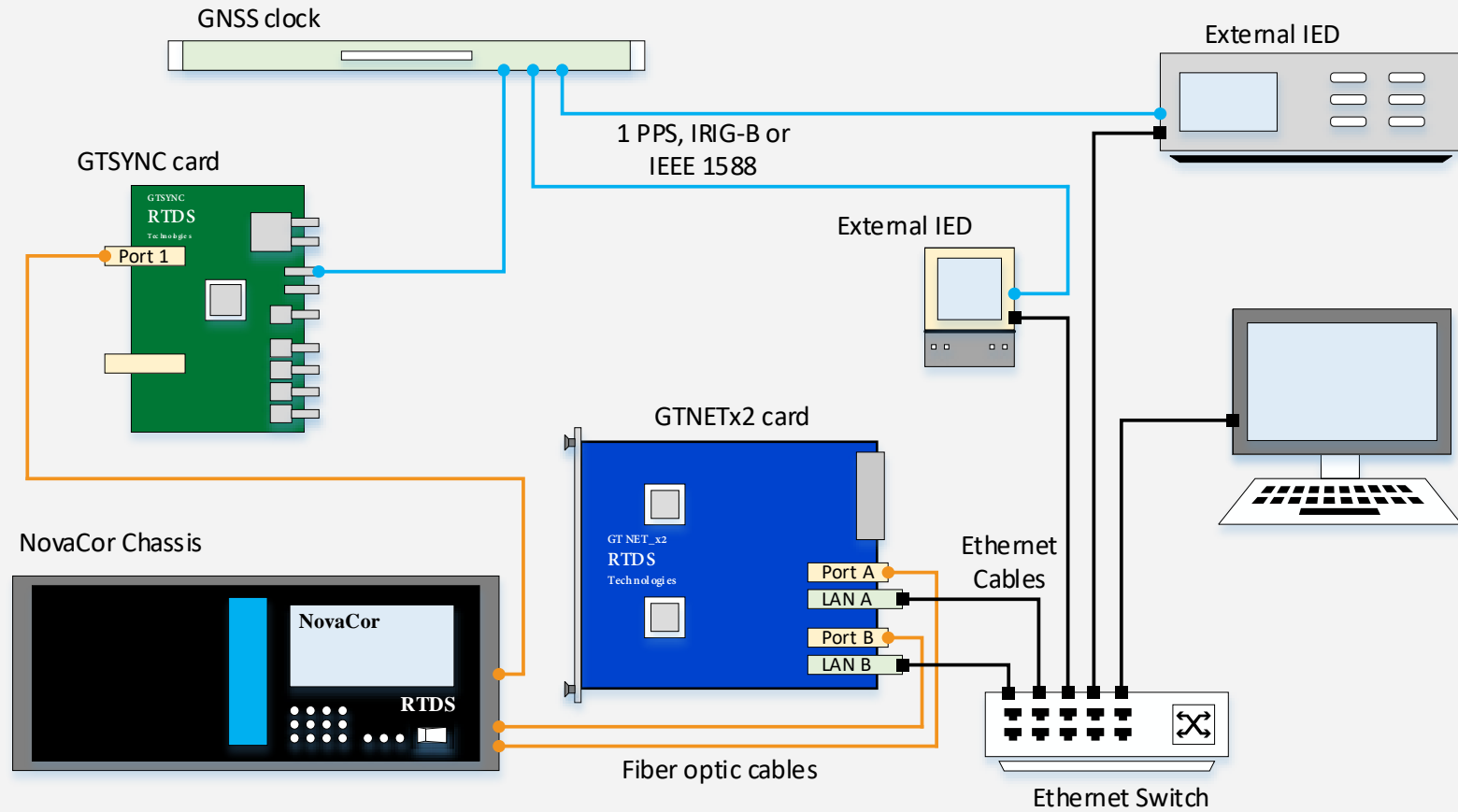
CUSTOM HARDWARE COMPONENTS

GTSYNC: External Time Synchronization

- The GTSYNC card synchronizes the simulator to an external time reference (e.g. GNSS clock)
- Accepts external time reference inputs as,
 - 1 PPS (in/out via BNC or ST fiber)
 - IEEE 1588 PTP (in via RJ45 or ST fiber)
 - IRIG-B (in via BNC)
- If an external time reference is not available, an internal 1PPS source can provide a time reference
- Necessary for PMU testing and advantageous for SV output.

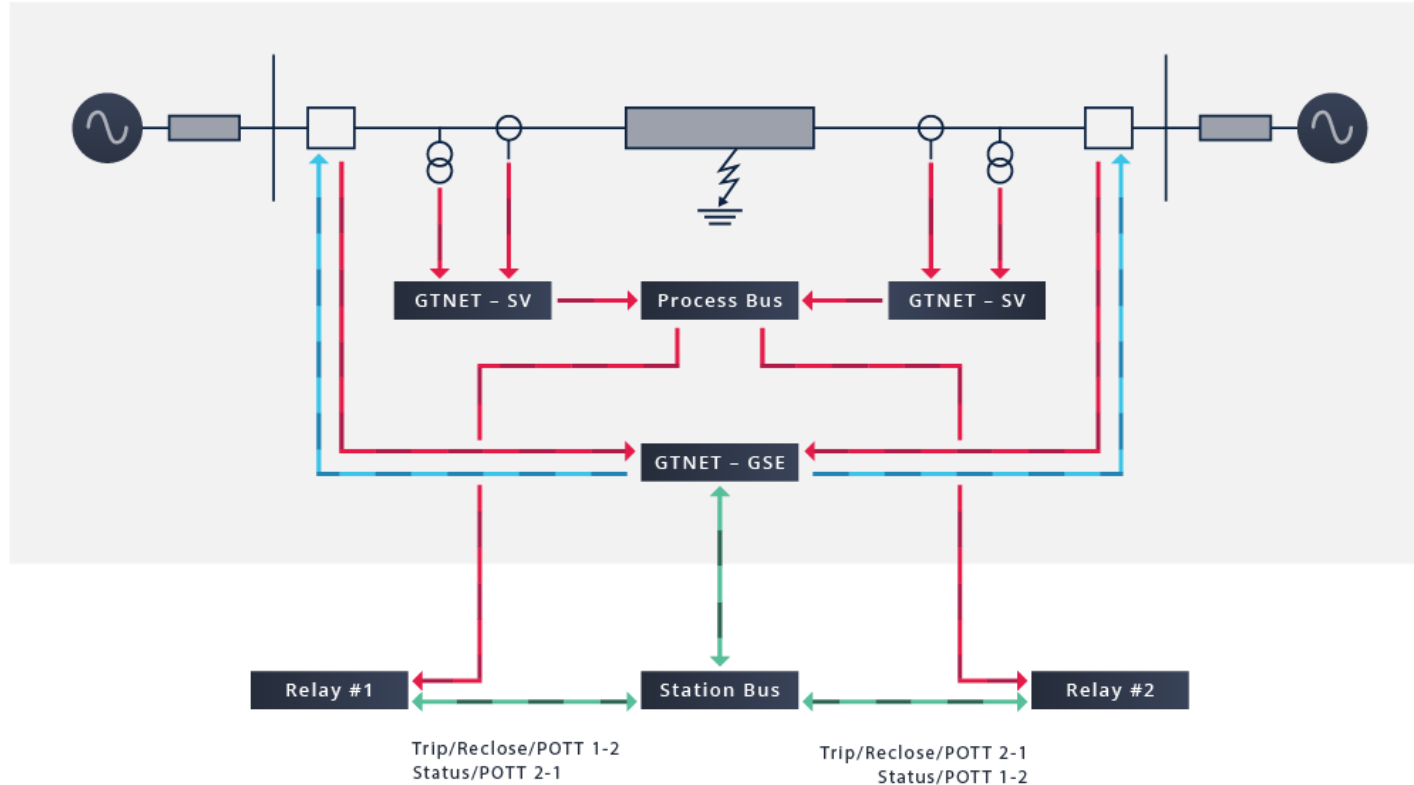


TYPICAL CONNECTIONS



HIL INTERFACE WITH IEC 61850

RTDS Simulator



Devices Under Test

CONFIGURE IEC 61850 COMPONENTS IN RSCAD

The screenshot displays the RSCAD FX 1.1 software interface. On the left, a 'Master Library' pane lists various components categorized into Power System, Controls, Protection & Automation, IO, Distribution Stretchable, GPES, TWRT, and Small Timestep. The main workspace shows a power system diagram with a central overlay for the 'IEC 61850 IED Configuration Tool'. This tool is provided by RSCAD[®] FX by WVRTDS Technologies and is described as 'Your world in real time.' The diagram includes a source (S1) with parameters $P_n = 7.2500 \text{ GVA}$ and $E_n = 220.227 \text{ kV}$, a parallel line, and several transmission lines (L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, L16, L17, L18, L19, L20, L21, L22, L23, L24, L25, L26, L27, L28, L29, L30, L31, L32, L33, L34, L35, L36, L37, L38, L39, L40, L41, L42, L43, L44, L45, L46, L47, L48, L49, L50, L51, L52, L53, L54, L55, L56, L57, L58, L59, L60, L61, L62, L63, L64, L65, L66, L67, L68, L69, L70, L71, L72, L73, L74, L75, L76, L77, L78, L79, L80, L81, L82, L83, L84, L85, L86, L87, L88, L89, L90, L91, L92, L93, L94, L95, L96, L97, L98, L99, L100). The diagram also features a busbar (BUS1) with parameters 0.9974 p.u. and 1.0 p.u. , and a transformer (CVT1) with parameters 1.0 p.u. and 1.0 p.u. . The IED Configuration Tool overlay includes a title 'IEC 61850 IED Configuration Tool' and the RSCAD[®] FX by WVRTDS Technologies logo. The tool is designed to configure IEC 61850 components in real time.



Thank you!



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IEC 61850 GOOSE Communication using the RTDS Simulator



GOOSE Communication

- RTDS simulator supports multiple system automation and communication protocols using the GTNETx2 hardware
- IEC 61850 GOOSE (GSE) is one of the most commonly used system automation protocols to interface the simulator with external IEDs
- GSE components in RSCAD draft facilitate GOOSE communication using the GTNETx2 hardware

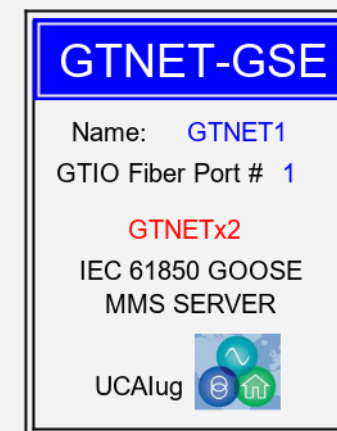
GSE-v7 and the IED Configuration Tool (ICT)

- GSE-v7 component was introduced with the initial release of RSCAD FX
- It encompasses a brand new component and a firmware
- In addition, a modern IEC 61850 IED Configuration Tool (i.e. the ICT) for the GSE-v7 component has also been introduced
- RSCAD FX replaces the old SCD Editor with the newly introduced ICT

Introduction of these developments significantly broadens the flexibility, the scope and the capability of existing GOOSE implementations, and marks an important milestone for IEC 61850 implementations in the RTDS simulator.

Features of GSE-v7

- Provides IEC 61850-8-1 Ed. 2.0 / 2.1 GOOSE and MMS communication
- Supports,
 - Simulating up to 4 IEDs per component
 - ✓ can built a generic IEC 61850 data model from inbuilt LN database
 - Publish up to 16 GOOSE messages
 - ✓ 4 GCBs per IED
 - ✓ up to 512 data items in total
 - GOOSE subscription up to 32 different GOOSE streams
 - ✓ up to 512 data items in total



Features of GSE-v7

- Also supports,
 - RTDS switch-objects to simulate switchgear operations
 - ✓ provides circuit breaker control via MMS communication
 - Simulated GOOSE and subscription monitoring (LGOS)
 - Publish/subscribe Routable-GOOSE messages
 - IEC 61850 MMS communication
 - ✓ act as an IEC 61850 MMS server device
 - ✓ buffered and un-buffered reports

Legacy GSE Components vs. GSE-v7

Data Binding

Legacy GSE Components	GSE-v7
Support one type of generic logical node (LN) class (GGIO) for interfacing output data (publishing)	Supports LN classes defined in IEC 61850-7-4 for interfacing output data (publishing)

Legacy GSE Components → *IED1.LD1.outGGIO1.Ind1.stVal*

GSE-v7 Component → *IED1.LD1.PTRC1.Tr.general*

Legacy GSE Components vs. GSE-v7

Configuration of the Component

Legacy GSE Components	GSE-v7
Configurations must be carried out in the SCD Editor as well as the component itself	Almost all the configurations are carried out in the ICT

Legacy GSE components and the SCL files generated by the SCD Editor, once initially configured, are **attached to each other**.

The GSE-v7 component **configures itself by reading the files** generated by the ICT during compile time.

Legacy GSE Components vs. GSE-v7

IEC 61850 IED Configurations

Legacy GSE Components	GSE-v7
Data models of IEDs are not flexible	Offers far greater flexibility in data models
Only support one IED and up to 4 LDs per component	Supports up to 4 IEDs per component and no rigid limit on number of LDs per IED
Maximum of 64 LN instances per LD	No rigid limit on number of LN instances per LD
Placement of datasets and GCBs is not configurable	Placement of datasets and GCBs is configurable

Legacy GSE Components vs. GSE-v7

Capability (Publish)

Legacy GSE Components	GSE-v7
Hold up to 4 datasets (one from each LD) for generic data and 1 for switchgear operations per component	Holds up to 32 datasets per component (8 per IED) in total
Publish 4 GOOSE streams for generic data (one from each LD) and 1 for switchgear operations per component	Publishes up to 16 GOOSE streams per component (datasets and GCBs are application independent)
Publish up to 256 data items in total per component	Publishes up to 512 data items in total per component

Legacy GSE Components vs. GSE-v7

Capability (Subscribe)

Legacy GSE Components	GSE-v7
Up to 16 GOOSE streams for per component	Up to 32 GOOSE streams per component
Up to 256 data items in total per component	Up to 512 data items in total per component

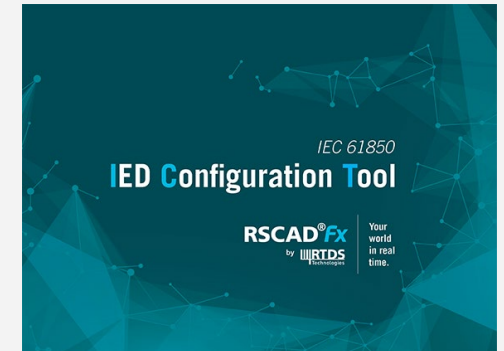
Legacy GSE Components vs. GSE-v7

MMS Capabilities

Legacy GSE Components	GSE-v7
Support 1 Report Control Block (RCB) per component	Supports up to 16 RCB per component
Reporting feature is only supported for switchgear operations	Reporting feature is application independent
Report datasets are not user configurable	Can use any user created dataset for reporting
Cannot disable the MMS feature	Users can decide what features to enable

RSCAD IEC 61850 IED Configuration Tool (ICT)

- Configure IEDs simulated by GSE components in RSCAD FX draft
 - Build IEC 61850 data models from inbuilt LN database
 - Configure GOOSE and MMS communication of GTNET IEDs
 - Bind input/outputs to RSCAD FX draft signals
 - Add RTDS switch-objects
 - Configure GOOSE subscription monitoring
- Import non-RTDS SCL files for GOOSE subscription configuration
- Generate CID and other auxiliary configuration files for GSE components



SCD Editor vs. ICT

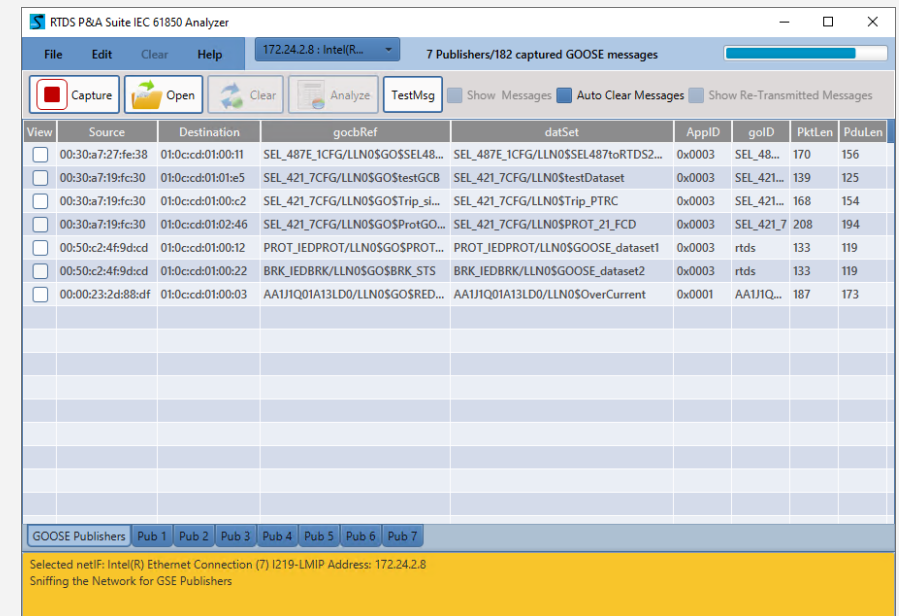
SCD Editor	ICT
Each component must be configured by launching the Editor individually multiple times	All the GSE components in draft are configured in a single ICT project
Generates one SCD file with all the IEC 61850 IEDs, configurations, etc.	Generates CID files and other auxiliary configuration files (IDF, IAF and IPF)
Not responsible for binding input and output data to signals in the simulation (occurs in the component)	Data binding is also carried out in the ICT
Launched as an integrated part of RSCAD	Operates as a standalone application

Additional new Features in GSE-v7 and the ICT

- GSE-v7
 - Source MAC address emulation
- ICT
 - Easier to navigate between different panes
 - Offers improved usability
 - IO summary view provides a concise view of the project

GOOSE Analyzer

- RSCAD GOOSE Analyzer is a standalone tool used for the testing and the validation of GOOSE packets
- Supports,
 - GOOSE (layer 2)
 - Ratable-GOOSE (layer 3)
 - Wireshark capture files
 - Deep level packet inspection
 - Visual representation of information



The screenshot displays the RTDS P&A Suite IEC 61850 Analyzer interface. The window title is "RTDS P&A Suite IEC 61850 Analyzer" and the status bar indicates "7 Publishers/182 captured GOOSE messages". The interface includes a menu bar (File, Edit, Clear, Help), a toolbar with buttons for Capture, Open, Clear, Analyze, and TestMsg, and several checkboxes for Show Messages, Auto Clear Messages, and Show Re-Transmitted Messages. The main area contains a table with the following columns: View, Source, Destination, gocbRef, datSet, AppID, goID, PktLen, and PduLen. The table lists seven captured GOOSE messages with their respective source and destination MAC addresses, GOOSE object references, data sets, application IDs, GOOSE IDs, packet lengths, and payload lengths.

View	Source	Destination	gocbRef	datSet	AppID	goID	PktLen	PduLen
<input type="checkbox"/>	00:30:a7:27:fe:38	01:0cccd:01:00:11	SEL_487E_1CFG/LLN0\$GOSSEL48...	SEL_487E_1CFG/LLN0\$SEL487toRTDS2...	0x0003	SEL_48...	170	156
<input type="checkbox"/>	00:30:a7:19:fc:30	01:0cccd:01:01:e5	SEL_421_7CFG/LLN0\$GStestGCB	SEL_421_7CFG/LLN0\$testDataset	0x0003	SEL_421...	139	125
<input type="checkbox"/>	00:30:a7:19:fc:30	01:0cccd:01:00:c2	SEL_421_7CFG/LLN0\$GOSTrip_si...	SEL_421_7CFG/LLN0\$Trip_PTRC	0x0003	SEL_421...	168	154
<input type="checkbox"/>	00:30:a7:19:fc:30	01:0cccd:01:02:46	SEL_421_7CFG/LLN0\$GOSProtGO...	SEL_421_7CFG/LLN0\$PROT_21_FCD	0x0003	SEL_421_7	208	194
<input type="checkbox"/>	00:50:c2:4f:9d:cd	01:0cccd:01:00:12	PROT_IEDBRK/LLN0\$GOS\$PROT...	PROT_IEDBRK/LLN0\$GOOSE_dataset1	0x0003	rtds	133	119
<input type="checkbox"/>	00:50:c2:4f:9d:cd	01:0cccd:01:00:22	BRK_IEDBRK/LLN0\$GOSBRK_STS	BRK_IEDBRK/LLN0\$GOOSE_dataset2	0x0003	rtds	133	119
<input type="checkbox"/>	00:00:23:2d:88:df	01:0cccd:01:00:03	AA1J1Q01A13LD0/LLN0\$GOSRED...	AA1J1Q01A13LD0/LLN0\$OverCurrent	0x0001	AA1J1Q...	187	173

At the bottom of the interface, there are tabs for "GOOSE Publishers" and "Pub 1" through "Pub 7". The status bar at the very bottom indicates "Selected netIF: Intel(R) Ethernet Connection (7) I219-LMIP Address: 172.24.2.8" and "Sniffing the Network for GSE Publishers".

GOOSE Analyzer

- Displays,
 - Communication details
 - Data contents (data and quality items)
 - Information of last received GOOSE message
 - Changes in GOOSE message (state number, sim bit, TATL)
- Able to publish pre-recorded GOOSE and R-GOOSE messages for testing



RSCAD Demonstration



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