Webinar: HIL Testing of Modern Protection Systems via IEC 61850

Thursday, May 28, 2020

Questions and Answers

Note: In this document and in general, the terms "GTNET" and "GTNETx2" are used interchangeably. These terms refer to the RTDS Simulator's network interface card, which is used for creating a closed-loop interface via communication protocols. GTNET is the original version of the card, and GTNETx2 is the most recent version. The main difference is that the GTNETx2 can run two protocols simultaneously instead of one. For more information, visit https://www.rtds.com/technology/communication-protocols/.

Q1: Will the slides/recording/RSCAD case files be made available?

Yes. The presentation and webinar recording are available to all participants. A link has been included with this document in the post-webinar email. A package including the RSCAD case files for the demo and some SV/GOOSE configuration tutorial documents is available to RTDS Simulator users. Logging into your user account at support.rtds.com and clicking on "Downloads" allows access to these files. Please contact support@rtds.com if you have any issues.

Q2: If I use your GTNET card, it directly sends IEC 61850 protocol messages to the relay and other devices under test – no amplifier or other device required, right?

Yes, that's correct. Power amplifiers are typically required when the low-level (+/- 10 Vdc) analogue signals produced by the RTDS Simulator are being sent to a device that requires a higher-voltage input (e.g. relays seeking secondary-level voltage and current signals). When creating a closed-loop interface via IEC 61850 Sampled Values instead of analogue signals, an amplifier is not required. The GTNET card communicates with the relay via Ethernet, so often a network switch is used in these setups.

Q3: How many GTNETx2 cards are required for test setup shown in Slide 6?

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150 Innovation Drive
Winnipeg, MB R3T 2E1
CANADA
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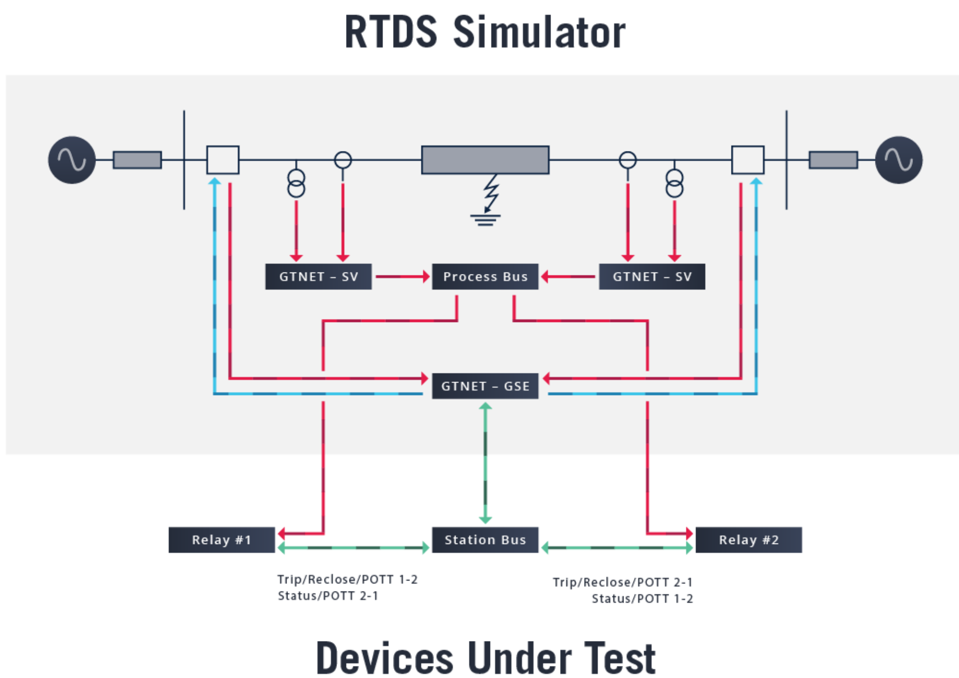

Each GTNETx2 card has two "modules" (processors) which can each run one communication protocol component, so each card can run two components simultaneously. This means you could run SV and GOOSE at the same time with one GTNETx2 card. For the particular setup shown here, one GTNETx2 card would be sufficient, because the SV and GOOSE channel requirements are within the capabilities of a single instance of each component. If additional SV streams or GOOSE data was necessary, additional cards may have to be added.

You can find a detailed description of the SV and GOOSE component capabilities (in terms of point quantities, streams, channels, and sampling rate) in our online Knowledge Base here: https://knowledge.rtds.com/hc/en-us/articles/360034788593-GTNETx2-The-RTDS-Simulator-s-Network-Interface-Card

Q4: If we lose one part of sampled values during the test, what is the influence on the relay, or what is the influence on the HIL test?

This depends on the settings/design of the relay under test. Many commercial IEDs are designed to handle such a situation and will block the execution of protection functions. From a HIL testing perspective, we do have a component in RSCAD called GTNET SV Special Edition (rtds_ctl_GTNET_SV_SE2). This component can be configured to suppress SV packets, change the order of consecutive packets, or delay packets. This component may be useful to

RTDS Technologies Inc.
150 Innovation Drive
Winnipeg, MB R3T 2E1
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users who wish to test the effects of such communication issues on the response of protection and control equipment.

Q5: Is it possible to use the GTNET card to develop and verify applications other than protection system testing, such as Energy Management System (EMS) testing?

Yes. The GTNETx2 card supports a number of other standard-compliant communication protocols popular in the power systems industry in addition to IEC 61850: DNP3, IEC 60870-5-104, MODBUS, synchrophasor data, and generic TCP/UDP socket communication are all supported. For more information, visit https://www.rtds.com/technology/communication-protocols/.

Q6: Since the GTNETx2 cards are essentially simulating a Merging Unit (MU), do they support PRP/HSR?

No, unfortunately the GTNETx2 card does not support PRP/HSR at this time. If you have a specific question or requirement, please send a message to support@rtds.com.

Q7: How can we see or convert to C-code from the developed block diagram based controller in RSCAD? Like in Matlab, where we can convert block diagram to C-Code, Is it possible to do the same with RSCAD?

RSCAD does not generate C-code for master library control block components. Note that we do have a program that allows users to convert Matlab/Simulink control blocks for use in RSCAD.

Q8: How do I convert my GTFPGA Unit to a GFPGA-SV unit?

Users who have access to the RTDS Simulator's GTFPGA Unit can add the SV streaming capabilities by acquiring a GTFPGA-SV firmware license and installing it on the unit. Those interested in doing so can contact marketing@rtds.com.

Q9: Not directly focusing on the interface of protection devices, but do you also work on the digital interface/protocol defined in "ENTSO-E Standardized control interface for HVDC SIL/HIL conformity tests"?

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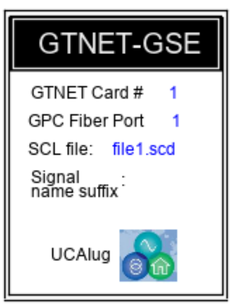
We are aware of the digital interface/protocol proposed by ENTSO-E. We would be able to support this protocol if it is deemed appropriate for the testing of HVDC and FACTS devices.

Q10: Is there a possibility to create custom templates for the Substation Configuration Description (SCD) file to reduce the required manual configuration effort?

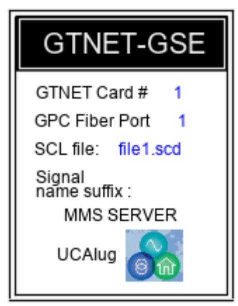
This feature is currently under development. Users can be apprised to its availability by checking the RSCAD Release Notes.

Q11: Why are there 2 versions of the GSE component? Is MMS the only reason?

One version (v5) supports IEC 61850 Edition 1. The newer version (v6) supports IEC 61850 Edition 2 and includes MMS services.



GTNET/GTNETx2 GSE v5
==================================
For use with a GTNET card or one module on a GTNETx2 card.
Provides communication with IEDs using 61850 GOOSE messages.
Component supports 4 unique TX/RX modules with up
to 64 outputs/inputs from 16 external IEDs



GTNETx2 GSE v6
==================================
For use with one module on a GTNETx2 card.
Provides communication with IEDs using 61850 GOOSE messages
and IEC 61850 MMS Server services.
Component supports 4 unique TX/RX modules, 1 XCBR/XSWI TX module,
with up to 32 outputs with quality per TX module,
and 32 inputs with quality per RX module from 16 external IEDs

Q12: The GTNET SV and GOOSE use multicast right? E.g. SV messages are published to one address group and subscribed to by an IED?

Yes, that is correct. The GTNETx2 card also supports Routable (R-) SV and GOOSE.

Q13: Are there any developments within the GTNET GOOSE firmware to implement Logical Nodes names which are specified in the IEC 61850 standard Edition 1 or Edition 2 other than the GGIO LN?

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This feature is also currently under development. Users can be apprised to its availability by checking the RSCAD Release Notes.

Q14: What was the sampling frequency used for SV in the demonstration? 80 sample / cycle? How can traveling wave signal relay work with such a low sampling rate?

Yes, a sampling frequency of 80 samples/cycle was used for the SV in this demonstration. The relay tested was an SEL-421 for phasor-based distance protection, so this sampling frequency is appropriate.

Thus far, closed-loop testing of commercial travelling wave relays has employed simulations with a relatively small timestep (in the 1 to 3 microsecond range) and conventional analogue outputs that are interfaced directly to the relay inputs. This is sufficient for the high sampling rates (~1 MHz) of travelling wave relays. Presently these relays have not been deployed with Sampled Values compatibility.

Note that the RTDS Simulator is capable of a wide range of SV sampling rates.

Rates achievable by the processor-based SV component (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

Rates achievable by the GTFPGA Unit (GTFPGA-SV v3):

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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

Q15: Can you recommend some literature explaining the bases of IEC 61850?

We unfortunately don't have a specific document to recommend for IEC 61850 basics, but several companies offer training in the general area. The vendors of protection and control systems also offer documentation explaining IEC 61850 as it relates to their products.

If you are interested in more detail regarding IEC 61850 basics in the context of the RTDS Simulator, we offer training courses at our headquarters in Winnipeg, Canada. Normally, there is at least one course per year focused on IEC 61850 applications with the RTDS Simulator. For more information on upcoming training, please visit https://www.rtds.com/news-events/rtds-events/?_sft_event_tags=training. We have also included some basic tutorials on SV and GOOSE implementation with the RTDS Simulator as part of the post-webinar package. Users can access those documents via the client login area, as indicated in the post-webinar email.

Q16: Does that SEL 421 relay allow you to input either SV or conventional current and voltage inputs?

The relay used in this particular demonstration only supports SV inputs (and not conventional current/voltage signals). However, different configurations are available that would support both input options.

Q17: How is the reclose bit configured in cb2a?

From the relay side, that information needs to be included in the relay's outgoing dataset. Configuration can be done via the vendor's manual. Once the configuration file has been exported from the relay and loaded by the RTDS Simulator's SCD file editor, we can see that the reclose signal has been mapped to GTNET-GSE component input number 4. This corresponds to the 4th bit in the "GOOSEIN" variable which represents all 32 boolean inputs.

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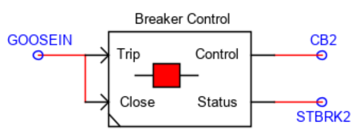
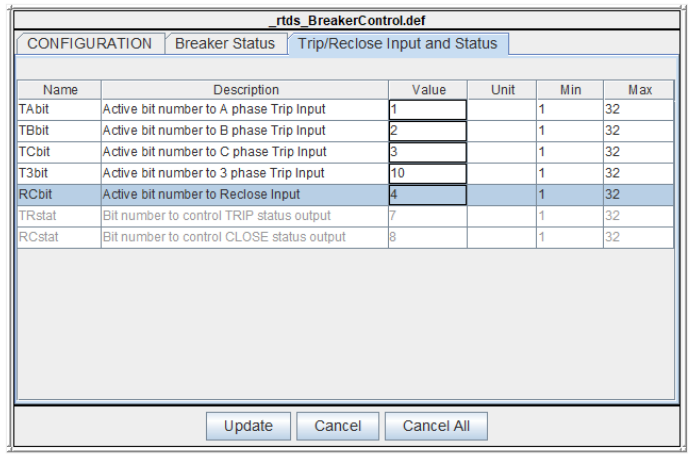
In the breaker control component of RSCAD, the GOOSEIN variable has been set as the input, and the 4th bit has been specified as the reclose signal bit.





Q18: Can you please elaborate about the timestamping of the GOOSE messaging service? We were observing the year 2006 in when you showed the Wireshark capture of the GOOSE messages.

The reason for this is that even though we're using the GTSYNC to synchronize the simulation and the relay via IRIG-B, the GTSYNC's internal master clock doesn't have the correct time of day onboard. In the GTNET-GSE component, we have a parameter asking if we want to use the GTSYNC time of day, and we have set it to "no" because of this. So, the time of day information in Wireshark is not relevant (although the relay is synchronized so the closed-loop test itself is valid).

Users can connect an external GPS clock to the GTSYNC card rather than using the internal master clock, and the message timestamps would then have the proper time of day.

Q19: In the future will be a GTNETx2 to support Edition 1 and edition 2 at the same time in order to run the test in one GETNETx2

Using the current GTNETx2 card, you could run the GSE v5 component (which supports Edition 1) on one module of the card while running the GSE v6 component (which supports Edition 2) on the other module. This would work on a single GTNETx2 card if you just required GOOSE messaging in your tests. If you required Sampled Values in the same test case, you would need an additional GTNETx2 card to also run those simultaneously.

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Q20: Is there a way to ensure cyber security for GOOSE and SV? IEC 61850 Edition 2 mentions HMAC or other authentication mechanisms.

We have not currently implemented HMAC or other authentication methods for IEC 61850. See the below question for more information on cyber security studies in general.

Q21: I am working on cyber security aspects of SV and GSE. Is there a way to simulate different attacks on them and do related study using RTDS?

Yes, it is possible to simulate cyber security attacks using the RTDS Simulator. One way of doing so is to connect the RTDS Simulator to a third-party communication network emulator such as NS-3. NS-3 represents the communication aspects of the testbed and allows for various cyber events to be carried out (e.g. Man in the Middle or Denial of Service events) and their impact on the power system to be studied. Typically, the GTNETx2 card is used to form a real-time interface between the power system simulation and network simulation via TCP/UDP sockets.

As mentioned above, unfortunately we have not currently implemented authentication methods for IEC 61850, so their hardiness under cyber attacks cannot be testing using the RTDS Simulator environment.

Q22: Are there many modifications needed in case of testing GE or Siemens relays (except those needed in the relays themselves)?

From the RTDS Simulator side, this case can theoretically be used as is to connect to relays from GE, Siemens, or other manufacturers. Most changes would be required on the relay side, for example in configuring the SV or GOOSE parameters.

Q23: How can I improve accuracy of the fault location? We see that the relay is around 0.5 to 1 km off.

This demonstration case is focused on the hardware-in-the-loop interface itself and not so much on reducing the error of fault location. Much of this error is related to the internal logic of the relay. Accuracy of the line parameters and CT/PT data could contribute to the error as well.

Q24: Is the RTDS Simulator compatible with Siemens DIGI twins?

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There are not really specific "RTDS-compatible" devices. The RTDS Simulator can theoretically be connected to any external device that is correctly configured from an I/O perspective (i.e. analogue/digital signals or various communication protocols).

If you are referring to Siemens control replicas, note that the RTDS Simulator has been successfully used to perform hardware-in-the-loop testing of Siemens HVDC and FACTS controls for many years. Siemens is an established user of the RTDS Simulator.

Q25: Would you please explain the need for GOOSE control logic? And Word/Bit or Bit/Word conversion?

In this case we're using all-Boolean data, which we have chosen to combine into a single variable rather than using separate variables for each signal. In the signal word, each Boolean is represented by one bit. The Bit/Word conversion is related to preparing the output word from simulation signals (A-, B-, and C-phase breaker status and permissive). The Word/Bit conversion is related to utilizing the different bits of the input signal word in the simulation: sending A-, B-, and C-phase trip or three-phase reclose signals to the breaker, or sending the permissive trip signal to the remote breaker.

The other logic you see is related to obtaining the trip time via a timer component. Application of the fault starts a timer, and any incoming trip signal (A-, B-, or C-phase) will cause the timer to stop. The timer signal can be monitored in RunTime to obtain the trip time.

Q26: What delay times should be considered when using control Hardware in the Loop in a PB5? I used a microcontroller whose processing time is less than 50 us (delay time between input and output signal measured with an oscilloscope), yet the delay between the same input and output signals in RSCAD is 150 us? Why is that difference?

The closed-loop time partially depends upon external hardware processing. Typically, the minimum delay is one timestep but it depends on when the simulator sees an update from the external hardware. In your case, the RTDS Simulator needs one time step (50 us) to process input and your microcontroller needs 50 us. To process output we need another time step (50 us). So, 150 us seems to be a reasonable closed-loop time. Other factors, including the length of optical cable used between the I/O cards and external hardware, can influence delay as well and the user should be aware of these.

If you need any further assistance for a specific case please send your question to support@rtds.com.

RTDS Technologies Inc.
150 Innovation Drive
Winnipeg, MB R3T 2E1
CANADA
+1 204 989 9700