RTDS Technologies

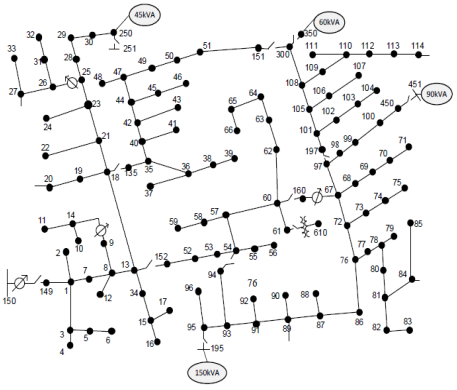
the world standard for real time digital power system simulation

Simulation and closed-loop testing with Distribution Systems

As the power industry shifts toward the grid of the future, distribution-level systems become both more relevant and more complex to control and operate. The RTDS® Simulator is used by electric utilities, protection and control equipment manufacturers, and learning/research institutions worldwide for distribution system studies and the closed-loop testing of distribution-level protection and control equipment.

Simulating distribution networks with the RTDS Simulator

The RTDS Simulator's Distribution Mode was developed to allow users to simulate large-scale distribution feeders in real time. Distribution Mode works in a substantially similar way to the normal simulation mode, but a few key differences, including a radial network structure and slightly larger timestep, allow the user to model significantly more power system nodes in one tightly coupled area using Distribution Mode.

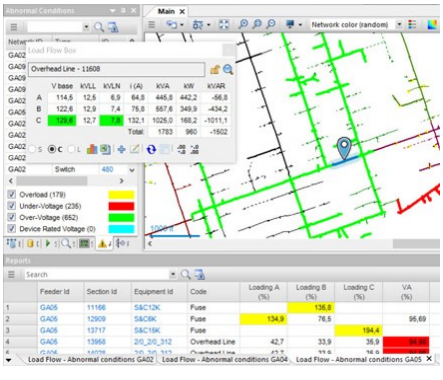


The IEEE 123 Node Test Feeder modeled on the RTDS Simulator with DERs

Using Distribution Mode, feeders of 1200 single-phase nodes can be simulated on a single RTDS Simulator chassis, with timesteps in the 100 microsecond range.

The component library available in Distribution Mode is a limited subset of the RTDS Simulator's modelling library. Components available include sources, transformers, induction machines, pi-section T-lines, renewable energy models, and the synchronous machine model (e.g. diesel generator, gas turbine, etc.). Fully-switched models for power electronics are not available for use in Distribution Mode—instead, average models are available to represent the steady state and transient behavior of converters in a computationally efficient manner.

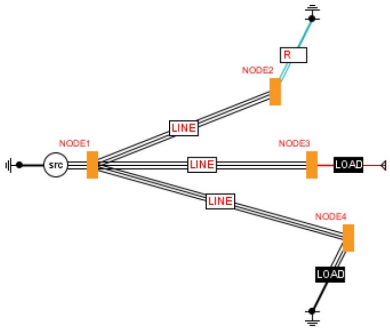
CYME to RSCAD Conversion



CYMDIST is a non real time distribution system analysis program

The RSCAD software includes an import utility that converts data from CYME™ International's CYMDIST software for use with the RTDS Simulator. The program is designed for converting distribution feeder models.

RSCAD's component library contains special stretchable components designed to more closely resemble the drawing style in CYME and other distribution system modelling packages. These new components accommodate the larger number of nodes and close proximity of components typical of distribution systems, and can represent either single or multi-phase branches.



Special stretchable components easily represent large systems with single or multiple phases

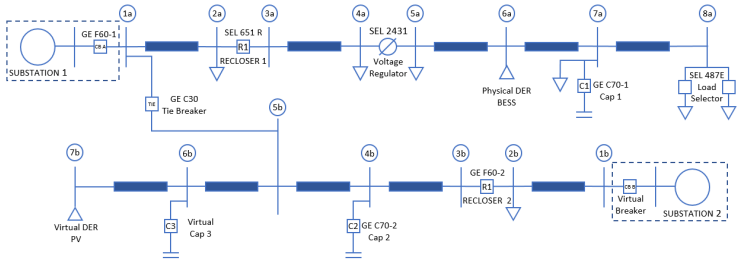
System requirements for using Distribution Mode

Distribution Mode is available in RSCAD Version 5 and above. It can be run on NovaCor chassis or RTDS Simulator racks containing PB5 Processor Cards (not compatible with earlier generation cards).

Closed-loop testing of distribution automation, protection, and control equipment

The introduction of Distribution Mode allows users to interface Volt-VAR controllers, load shedding and balancing schemes, multi-level microgrid control, SCADA systems, and other protection and control devices with a simulated large-scale distribution feeder in the real time simulation environment.

Distribution automation case study: A typical utility distribution feeder setup



An electric utility might simulate this feeder in real time using the RTDS Simulator's Distribution Mode. Sections of the feeder have been equivalenced, retaining the buses that have automation devices needed to exercise the testing scenarios. The equivalencing process is validated by comparing the RSCAD model results to load flow and short circuit data for the system.

All devices are modeled on the RTDS Simulator in a single HIL simulation in order to test full control and protection system interaction.

Hardware in the loop

Several commercial automation devices have been connected in a closed loop with the simulated feeder:

Feeder protection • Bay automation control • Advanced recloser control • Capacitor bank protection and control
Voltage regulator control • Load selector switch

The HIL interface has been achieved using both conventional I/O (via the RTDS Simulator's GTIO cards) and LAN-based I/O (via the GTNETx2 card):

- A total of 74 analogue and digital I/O channels
- 2 communication protocol channels (DNP and MODBUS)

Power hardware in the loop

A battery storage system and inverter have been connected to the simulated network. A four quadrant amplifier is used to exchange power between the storage system and the simulation. The terminal voltage at Bus 6 is sent from the simulation to the amplifier via analogue output, and the inverter current is sent back into the simulation via analogue input.

The inverter can be controlled from a control HMI using MODBUS communication.

Virtual automation components

Three virtual controllers, which can communicate to centralized control via standard protocols, have been added to the simulation. This allows the number of communication test points to be expanded beyond the available physical devices in order to fully exercise the central control system.

Example HIL tests

- Test R-GOOSE messaging to close capacitor bank 1 and OpenFMB command to initiate manual voltage regulation in case of excess reactive power at circuit breaker A — also close capacitor bank 2 if circuit breaker B is open, recloser 2 is open, and tie switch is closed.
- On overvoltage at capacitor bank 1, refuse the close command from the Control Portal and indicate blocking action to circuit breaker 1 via message.
- Monitor and control the virtual capacitor bank and solar PV from the control panel via DNP and MODBUS, respectively.