Southern California Edison Bulk Power System RSCAD Model Development and Its Application for SVC Replica Controller Testing

- Venkat Lakshminarayanan (Nayak Corporation)
- Joshua Park (Southern California Edison)

NAYAK Corporation

- Established in 1999, located in Hamilton, New Jersey, USA
- Independent representatives for

RTDS real time digital simulator from RTDS Technologies

PSCAD emt simulator from Manitoba Hydro International

DSATools from Powertech Labs

Linear Power Amplifiers from Spitzenberger and Spies

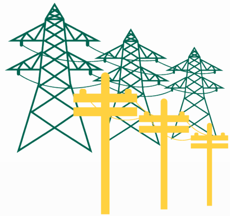
Product sales, support, and training
RTDS HIL Testing, PSCAD/PSSE modeling & studies

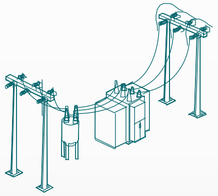
Southern California Edison

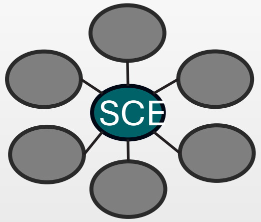
We provide electric service to
15 million customers

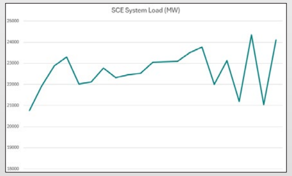
Our service territory spans
50,000 square-miles
430 Cities and Communities located within 15 Counties across a diverse geography

We support 5,000 large and 280,000 small businesses









Circuit miles:

5,500 Transmission
- **161 kV-500 kV**

7,000 Subtransmission
- **33 kV-115 kV**

98,000 Distribution
- **Below 33 kV**

Substations

~850 Substations

Interconnections

19 Interconnections with neighboring utilities

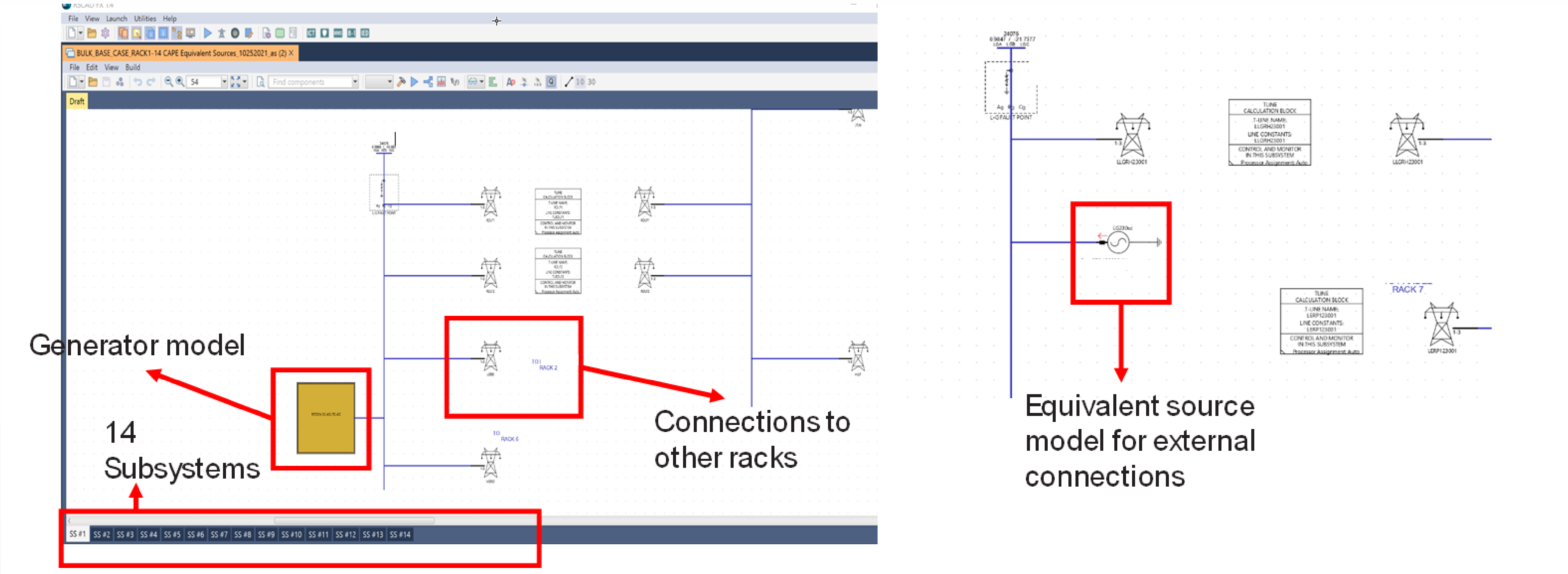
All-time Peak Load

24,345 MW in Sept. 2022

Background

- Southern California Edison (SCE) initiated the development of a RTDS model of its bulk power transmission network to support transmission-level studies, including Hardware-In-Loop (HIL) testing.
- The original model was developed using earlier versions of RSCAD and PB5 racks
  - 319 busses including the intermediate busses, 286 loads, 115 generators and 526 branches which includes transmission line and transformers
  - It was distributed across 14 racks (subsystems) interconnected through transmission lines.
  - It captured the complete 230 kV and 525 kV SCE transmission network and selected 345 kV, 115 kV, and lower voltage buses.
- Since then, SCE transmission system has undergone significant changes. With renewed interest from various departments in leveraging the model for advanced studies, the original model was updated in 2024 to reflect the latest network configuration and was migrated to the NovaCor platform.

Old Model – PB5 Version



Model Upgrade Objectives

- Migrate the PB5 bulk power system case to the latest RSCAD FX version and NovaCor system
- Update the network model
  - Add new substations or buses
  - Add/update T-lines and transformers
  - Set up power flow scenario
    - Set up series and shunt compensation levels
    - Set up generation and load levels
  - Calculate new positive sequence boundary equivalents from CAPE model and update them in the RSCAD model
- Validate Power Flow: against appropriate PSLF case
- Validate Short Circuit: against appropriate CAPE case

Project Stages

Stage 1

- Convert to latest RSCAD version and disassemble
- Update power flow

Stage 2

- Re-assemble into fewer subsystems
- Overall power flow validation

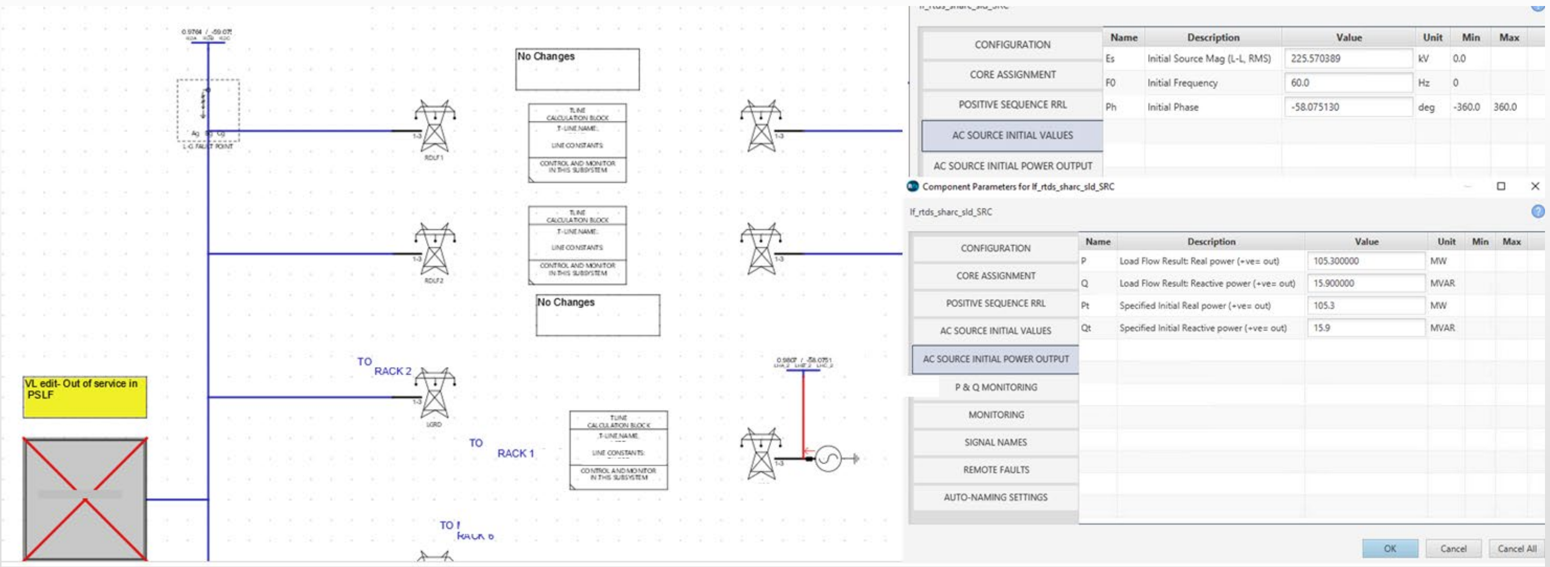
Stage 3

- Get the reduced model from short circuit program
- Update the boundary equivalents
- Perform short circuit validation

Stage 1

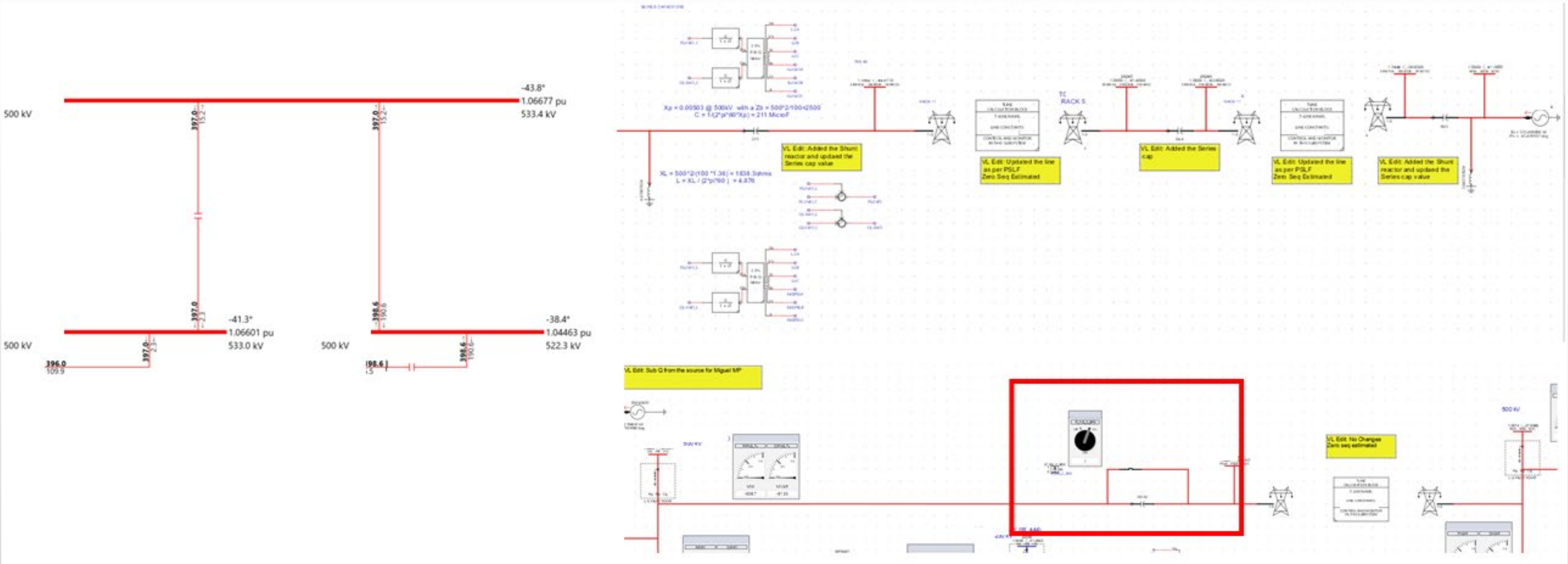
Individual Rack Cases

- Convert the case to latest RSCAD FX version
- Study the case and identify new cross-rack connection points
- Split the large case into individual rack-cases by adding boundary equivalent at the cross-rack connection points
- Check the power flow for the line from PSLF



Update Rack-case Individually

- Compare in detail each line RXB data with the PSLF data. Update the line if necessary.
- Update the generation station and any load at the bus
- Update the shunt and series compensation

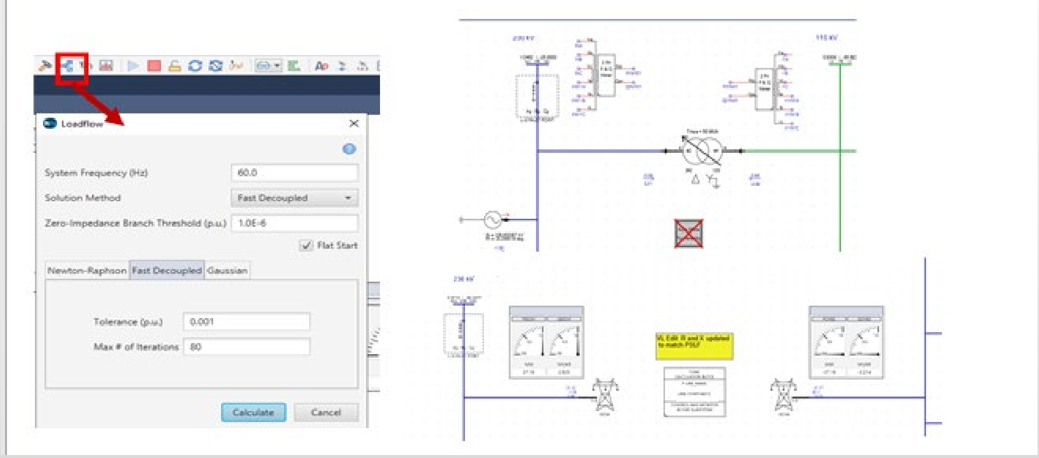


Loadflow Validation

- RSCAD Load Flow tool can be used to check the initial loadflow condition.
- Note: This load flow is an offline tool just to initialize the case. This does not guarantee a flat run.
- Meters are added to each line to check the real and reactive power flow in that line at both ends at the end of a flat run simulation.
- The power across transformers can be calculated by adding 3ph P& Q meter.
- RMS meter can be added to check the voltage at each bus.

From		To	PSLF	
	49		36.9	4.6
230.0	kV		-36.9	-1.7
0.97229	pu			
-60.36372	deg			
223.6				
		Total	0.0	2.9
	98		-132.1	-1.8
230.0	kV		-36.9	-5.2
0.97213	pu	Load at 66 kV	169.00	6.9
-60.4	deg		295.81327	19.21871
223.6				
		Total	295.8	19.1
	40		132.1	-10.0
230.00	kV		-241.8	4.1
0.9722	pu		-241.8	4.1
-60.28	deg		36.9	-11.0
			126.8	4.9
223.6		Load at 66kV	187.8	7.8
		Total	0.0	-0.1

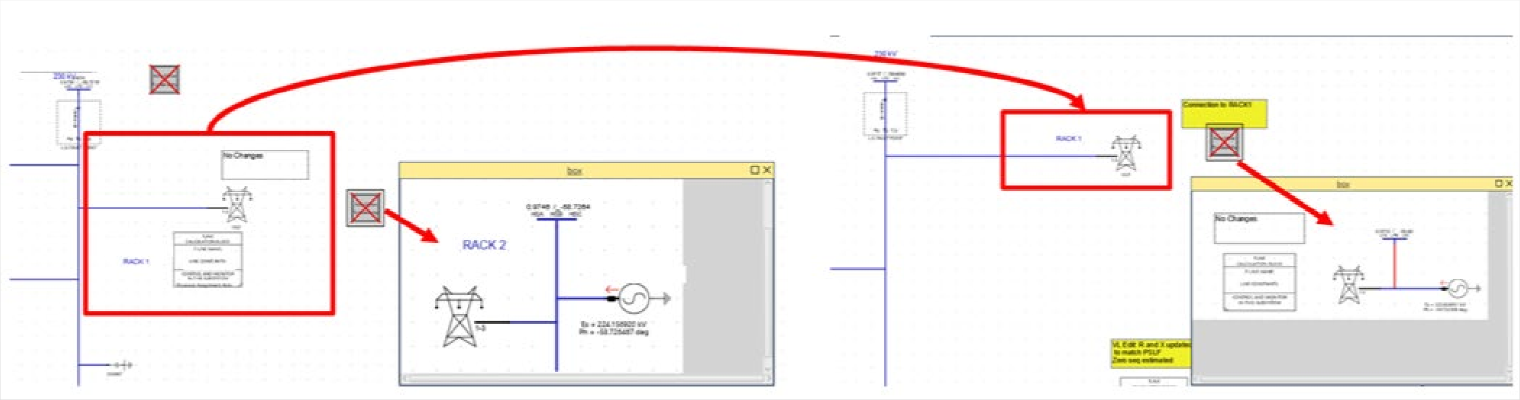
Rack1 Rack2 Rack3 Rack4 Rack5 Rack6 Rack7 Rack8 Rack9 Rack10 Rack11 Rack12 Rack13



Stage 2

Cross-rack Connection

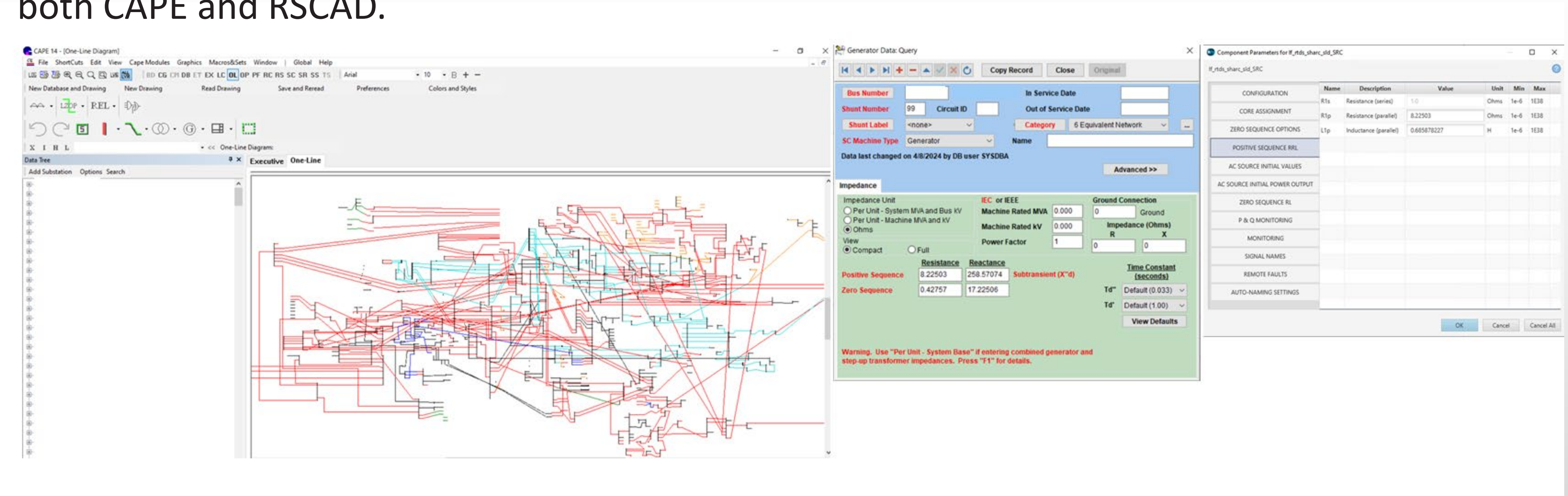
- The populated load table for the individual cases is verified.
- NovaCor with 10 cores can simulate up to 600 nodes. Therefore, approximately, each NovaCor chassis can simulate a network that required 4 PB5 racks.
- Points to ensure:
  - Identify the cross-rack connection lines and remove the sources
  - No duplication T-line calculation block, sending end interface, and receiving end interface
  - Unique bus labels and the signal names.
  - Assign only one slack bus for the combined case
  - Loadflow verification using the tool and with the meters



Stage 3

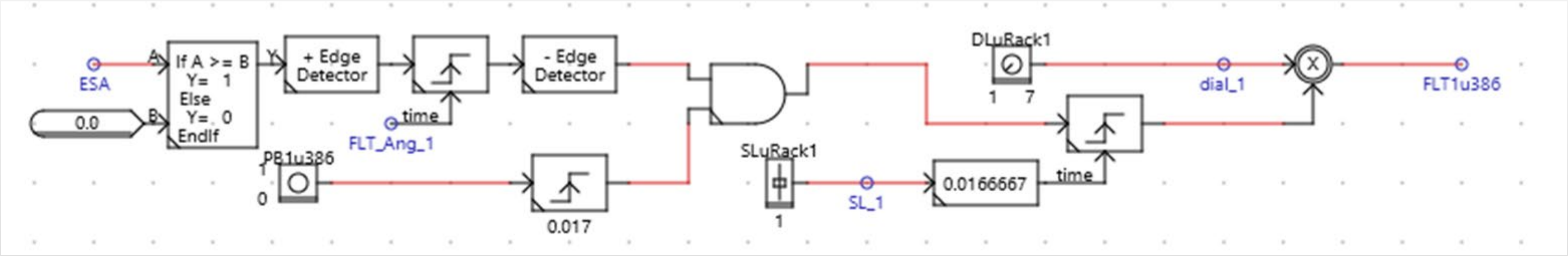
Short Circuit Reduction Using Cape

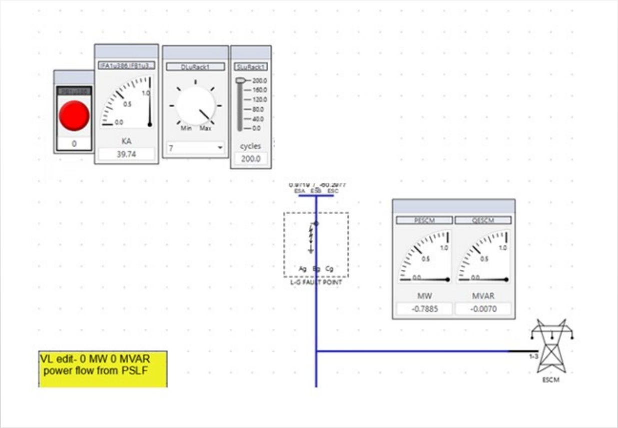
- The bulk power area of SCE network is obtained for the CAPE database
- This model is reduced and the short circuit impedance values at the boundary is obtained
- Based on the equivalent source models from the CAPE program we can update the RX values of the source model used in RSCAD for representing network beyond boundary and external connection from the buses
- To verify the SC equivalences added to the RSCAD model, we can check the fault current values in both CAPE and RSCAD.



Short Circuit Validation

- The RSCAD model has been created with the fault logic and the fault at the Bus. The fault logic for each bus can be found inside the fault hierarchy box
- The fault is applied in the positive half of the node voltage. The fault duration and type can be selected through a slider and a dial respectively
- Fault current for every bus is populated in a sheet and compared with CAPE values
- The final RSCAD model is accurate representation of the SCE bulk power system which can be a good starting point for further HIL studies.





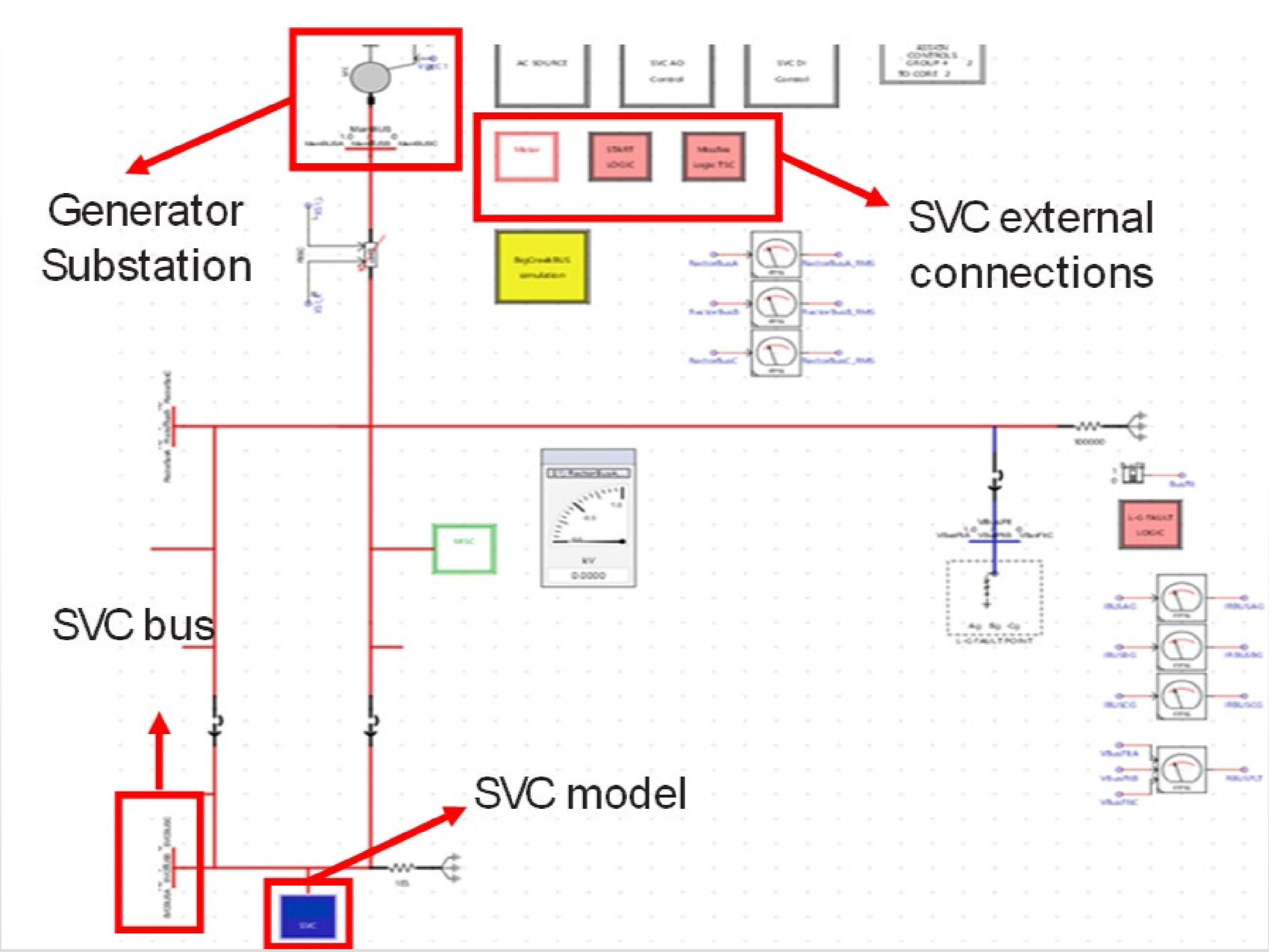
Bulk Power Model - SCE Lab

Application

SVC Integration

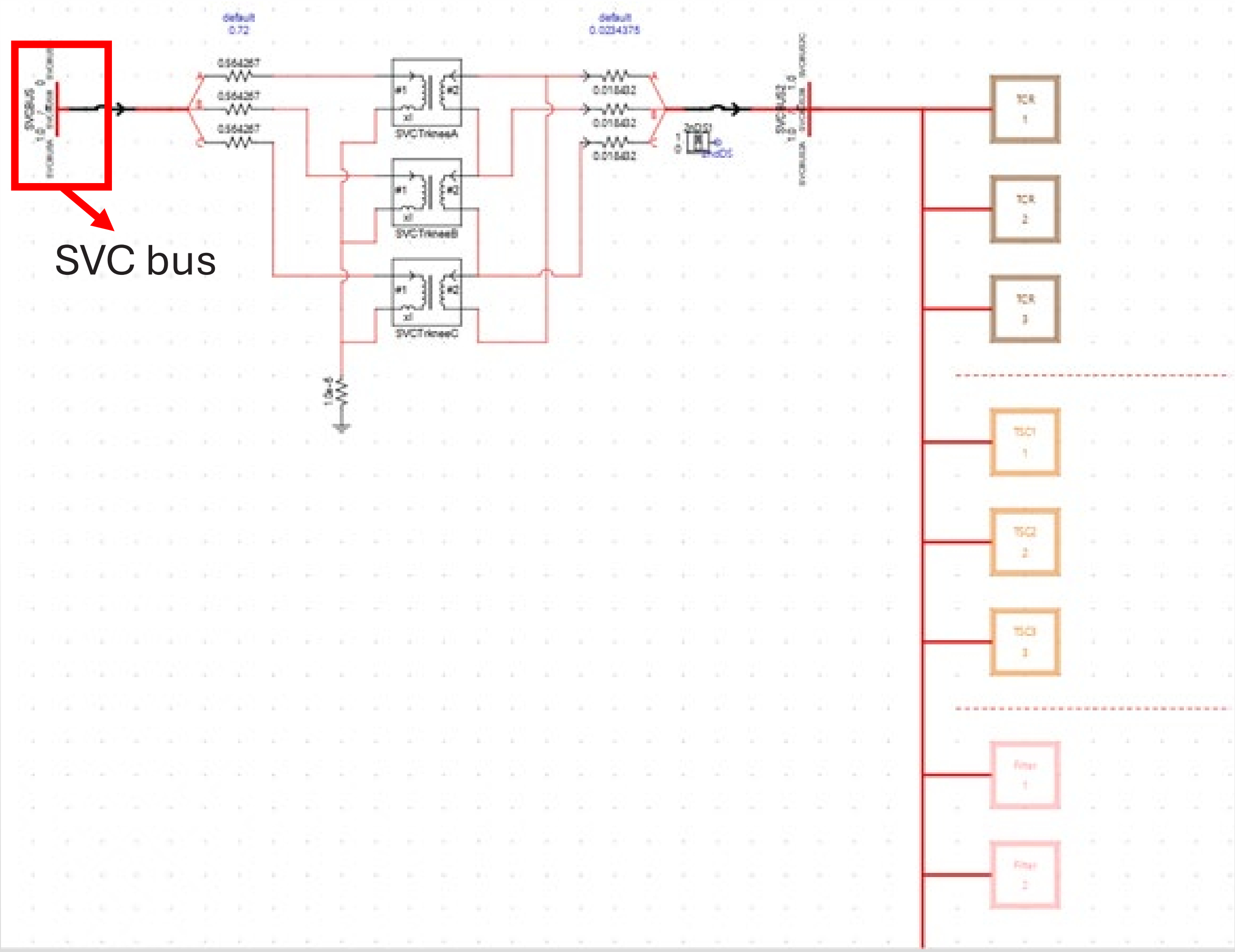
- SCE is working on upgrading the Static Var Compensator (SVC) at a substation. As part of the upgrade, SCE procured a replica controller of the SVC controller for RTDS HIL studies
- The SVC (electrical) power circuit model is developed RSCAD and provided by the SVC OEM
- This model is integrated into the bulk power model and with the replica controller in HIL to perform system level studies.

SVC Setup



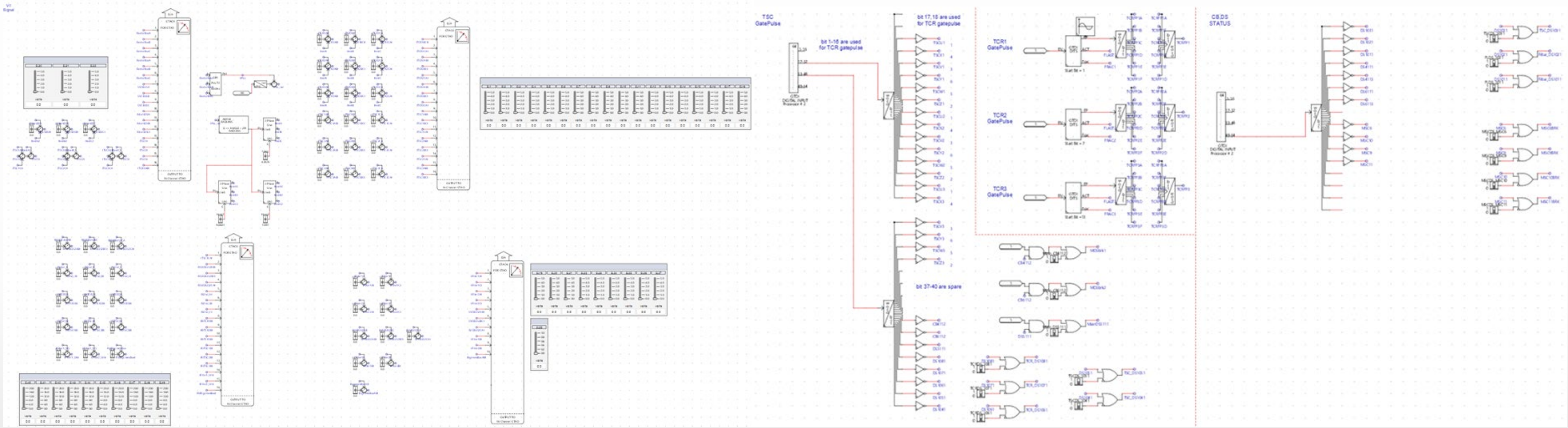
- Manufacturer provided SVC model
- The SVC replica controller is integrated to this model
- Initial HIL test are conducted with this simple case
- A standalone machine is initially used for testing SVC replica.

SVC Setup

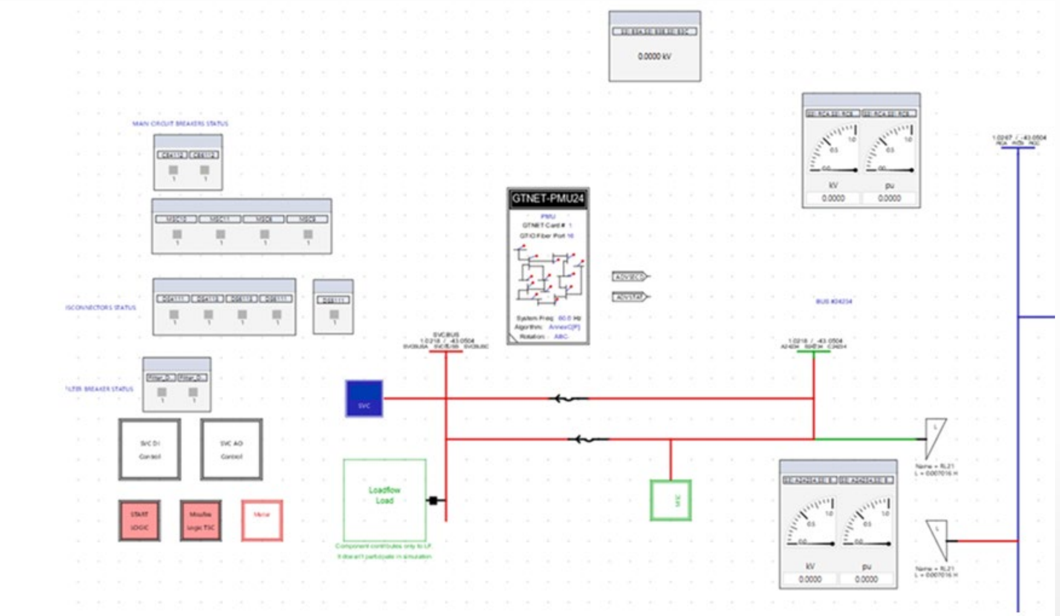


- 3 reactor banks with 70 MVAR each
- 3 capacitor banks of 40 MVAR each

SVC Hil Connections



SVC Integration to Bulk Power Model

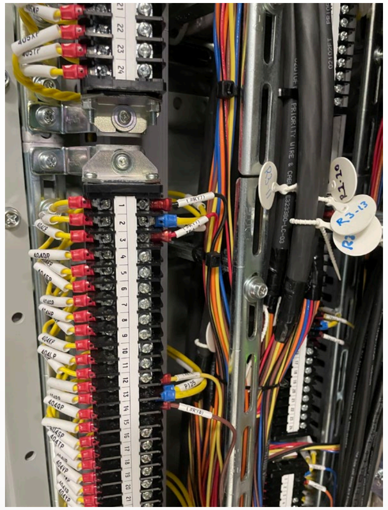


- In the initial bulk power model, the SVC bus is modeled as a load with 100 MVAR directly connected to the 230 kV bus.
- The SVC model was transferred to the main bulk power case without altering the GTAO and GTDI connections
- All the signal names are verified to ensure correct connection, and the case is compiled
- During the initial phase, the RTAC at the SCE lab was programmed to read the voltages and currents from the GTAO and transfer them to the replica control through DNP
- The objective of this work is to replicate the model as it is set in the field. Hence, the PMU component is added to the bulk power case which will communicate the bus voltage and current phasor to the SVC replica as it will be in the field

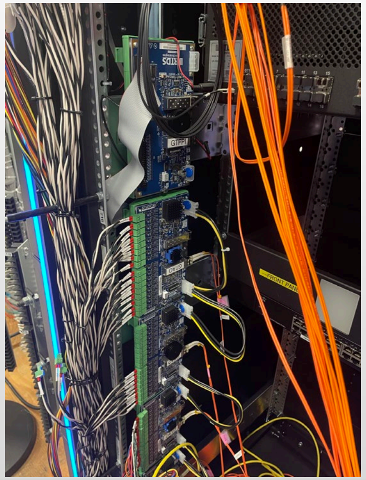
HIL Setup and Testing

SVC Replica controller

Replica panels wiring



GTAO Connections



- One system voltage control test was successfully conducted with the RSCAD model where the SVC model was integrated into the bulk power model.
- This test case had the initial voltage of SVC bus greater than the reference.
- As expected, the SVC started absorbing maximum reactive power to bring the Rector bus voltage within its limit.

Challenges & Key Takeaways

Challenges & Key Takeaways

- Data handling and its procurement from multiple platforms
  - Mismatches between the databases
  - Information from SLD, T-line geometry, etc.
- Obtaining a close reactive power match
  - Shunt and series compensations lines
- Power flow and short circuit information on the boundaries
  - Missing busses
- Phase shifting transformer
- PMU setup in HIL
  - Obtaining the correct phasor names
- Switching from standalone system (simple SVC case) to the Bulk power model
  - IO connections and GTSYNC

Future Work

- Additional development on the bulk model could be done:
  - Scripts could be used to auto-adjust load blocks to represent different profiles
  - Coordinate with planning teams to incorporate details from neighboring utilities around boundaries
  - Add T-line Geometry to replace Bergeron model
- Future applications:
  - IBR integration and HIL testing
  - Black-Start HIL assessment with Protection & Control devices
  - Protection Scheme HIL evaluation including:
    - Travelling Wave Protection
    - Wide Area Monitoring Protection & Control Assessment
  - SVC replica model for transmission substation (2027)
    - Could be used to further evaluate tools for identifying FACS optimized locations
  - Synchronous Condenser Replica Integration with BPS Model

Thank You!