EDISON INTERNATIONAL®

HARDWARE-IN-THE-LOOP TESTBED FOR SCE'S GRID MANAGEMENT SYSTEM

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RTDS Technologies AMETEK

OVERVIEW

- Background
- Objective
- Model Development
- Integration Testing
- Lessons Learned
- Q&A

SOUTHERN CALIFORNIA EDISON'S SERVICE AREA

- SCE provides electric service to approximately 15 million people through 5 million customer accounts
- SCE service area includes 15 counties and hundreds of cities
  - 50,000 square-mile service area

BACKGROUND

- Power Systems Lab
  - Bulk Power System Model
  - SVC Replica
  - Large multi-rack simulation
- Substation Automation Lab
  - IEC61850 SV and GOOSE
  - Evaluating network performance
  - Protection Testing
- DER Lab
  - PV and inverter testing
- Controls Lab
  - Microgrid simulation and control
- Distribution Engineering Automation
  - GMS HIL Testing

GRID MANAGEMENT SYSTEM (GMS)

Advanced Distribution Management System (ADMS)

- Load Flow
- Short Circuit Analysis
- Fault Location, Isolation, and System Restoration (FLISR)
- Load Volt/Var Management (LVM)
- Contingency Analysis

DER Management System (DERMS)

- Constraint Management
- Monitoring
- Optimizing DERs
- Managing DERs

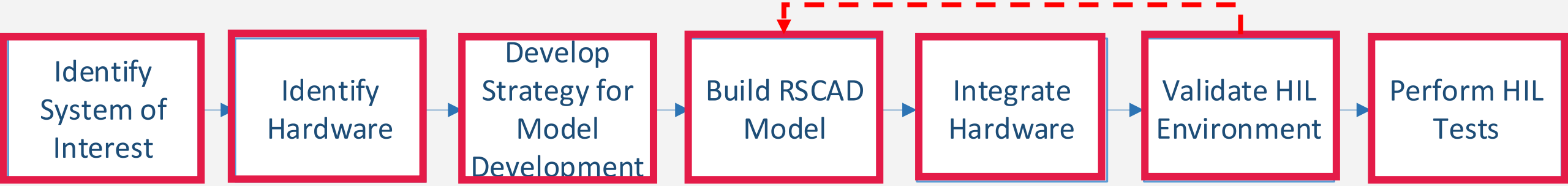
Advanced Grid Applications

- Adaptive Protection
- Data Historian Analytics
- Optimization Engine
- Short Term Forecasting Engine
- Device Management
- Business Role Engineering

OBJECTIVE

- Evaluate advanced applications using RTDS to perform HIL testing
  - Load Volt / VAR Management (LVM)
  - Fault Location Isolation and System Restoration (FLISR)
  - Communication Failure Scenarios
  - Hardware Failure Scenarios

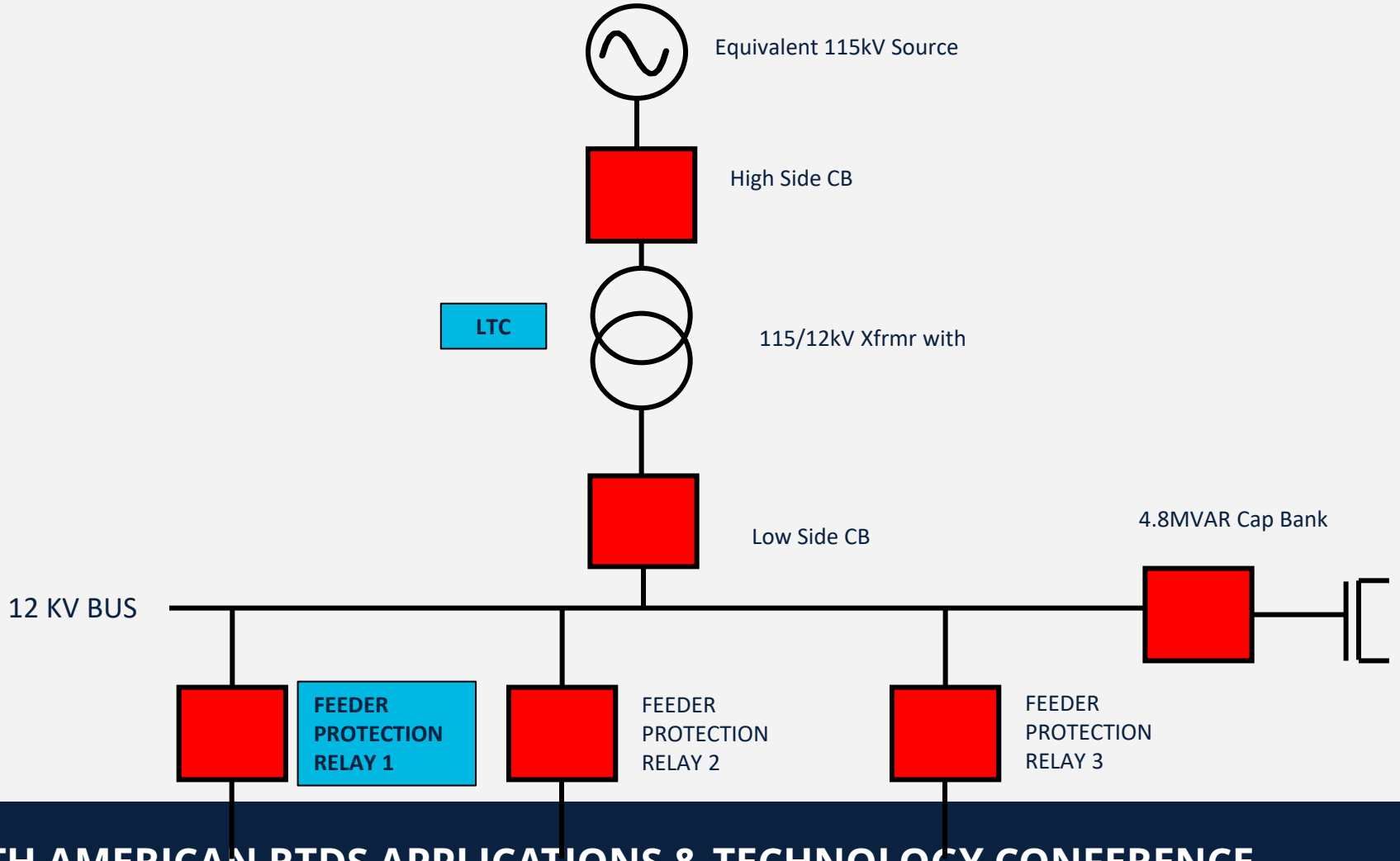
MODEL DEVELOPMENT



MODEL DEVELOPMENT

LTC = Load Tap Changer

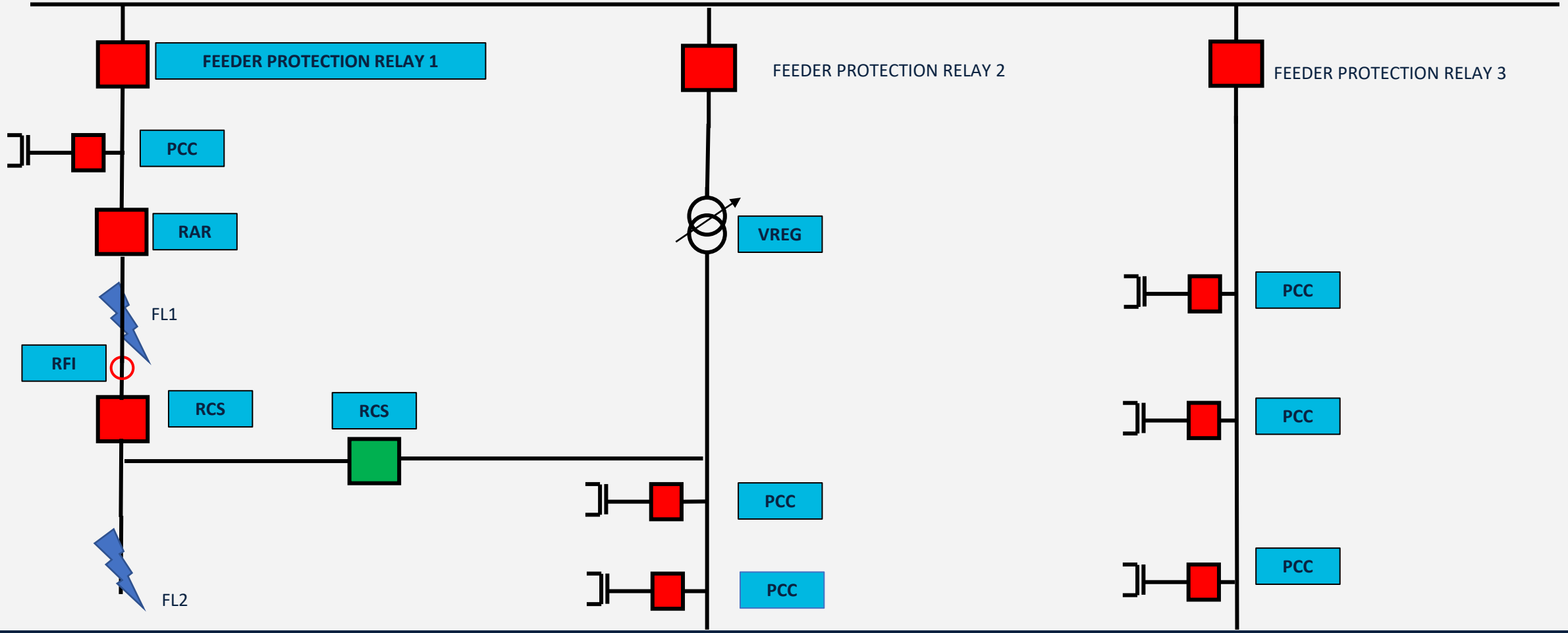
= HIL Device



MODEL DEVELOPMENT

RAR = Remote Automatic Recloser
RCS = Remote Control Switch
FL = Fault Location
VREG = Voltage Regulator
PCC = Programmable Capacitor Control

= HIL Device



MODEL DEVELOPMENT

Hardware	Quantity
PB5 Processors	6
GTDI	1
GTDO	1
GTAO	5-6
GTNETx2 (DNP3)	1

MODEL DEVELOPMENT

Feeder	# of Nodes *
FEEDER 1	3007
FEEDER 2	3879
FEEDER 3	4497
TOTAL (FEEDERS)	11,383

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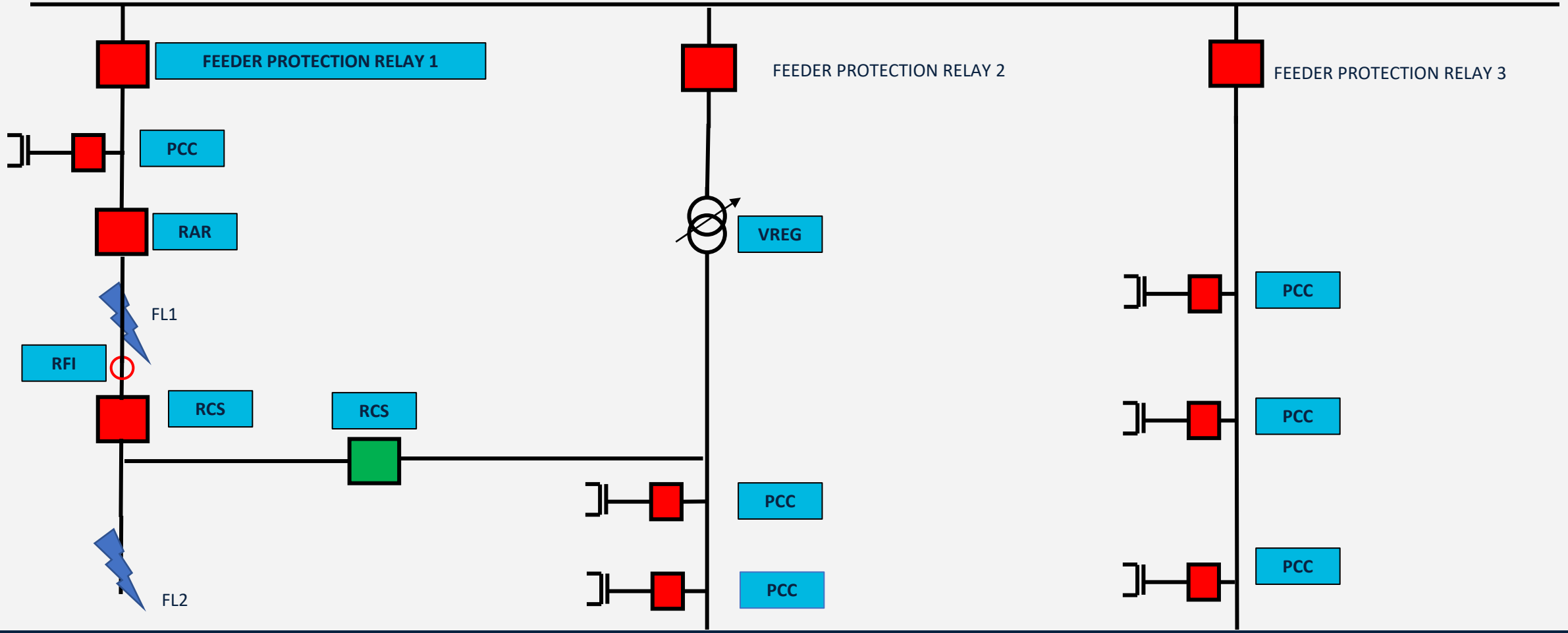
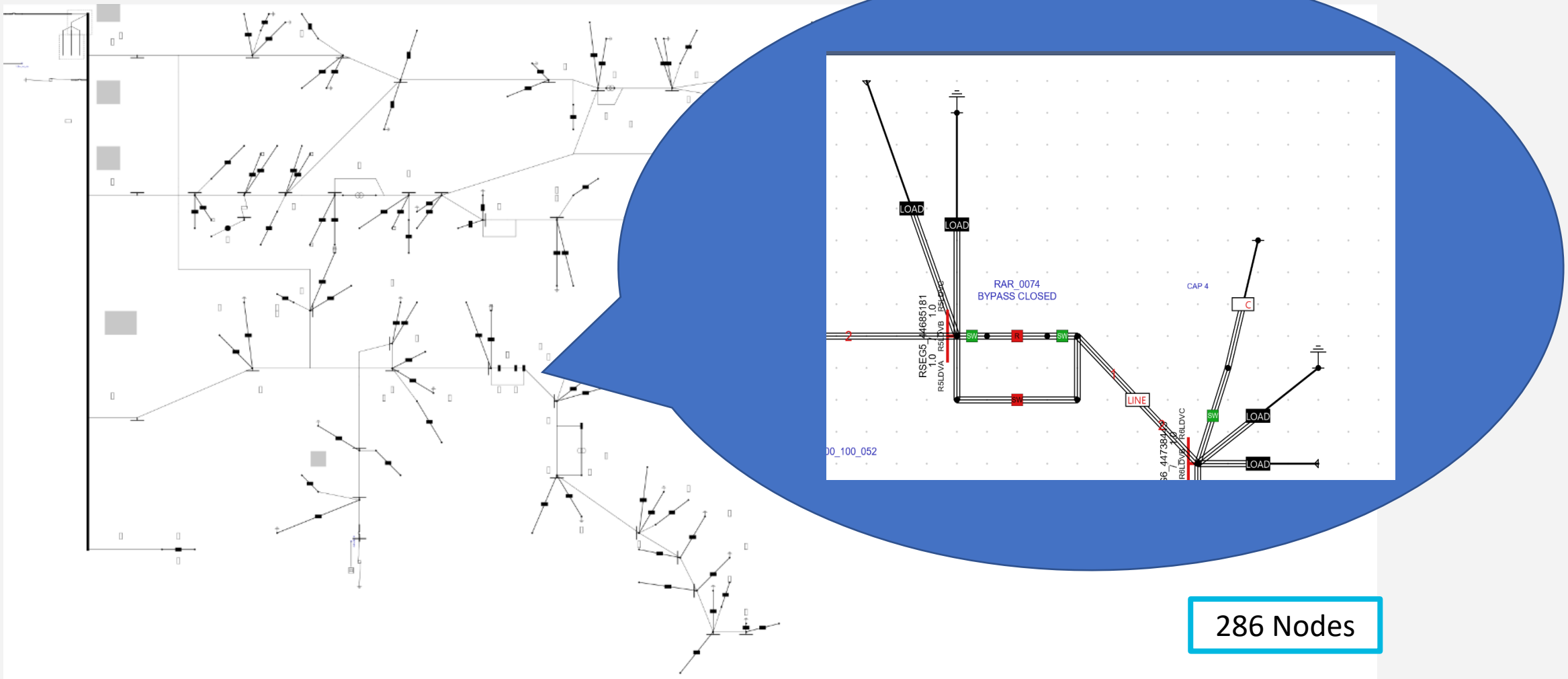
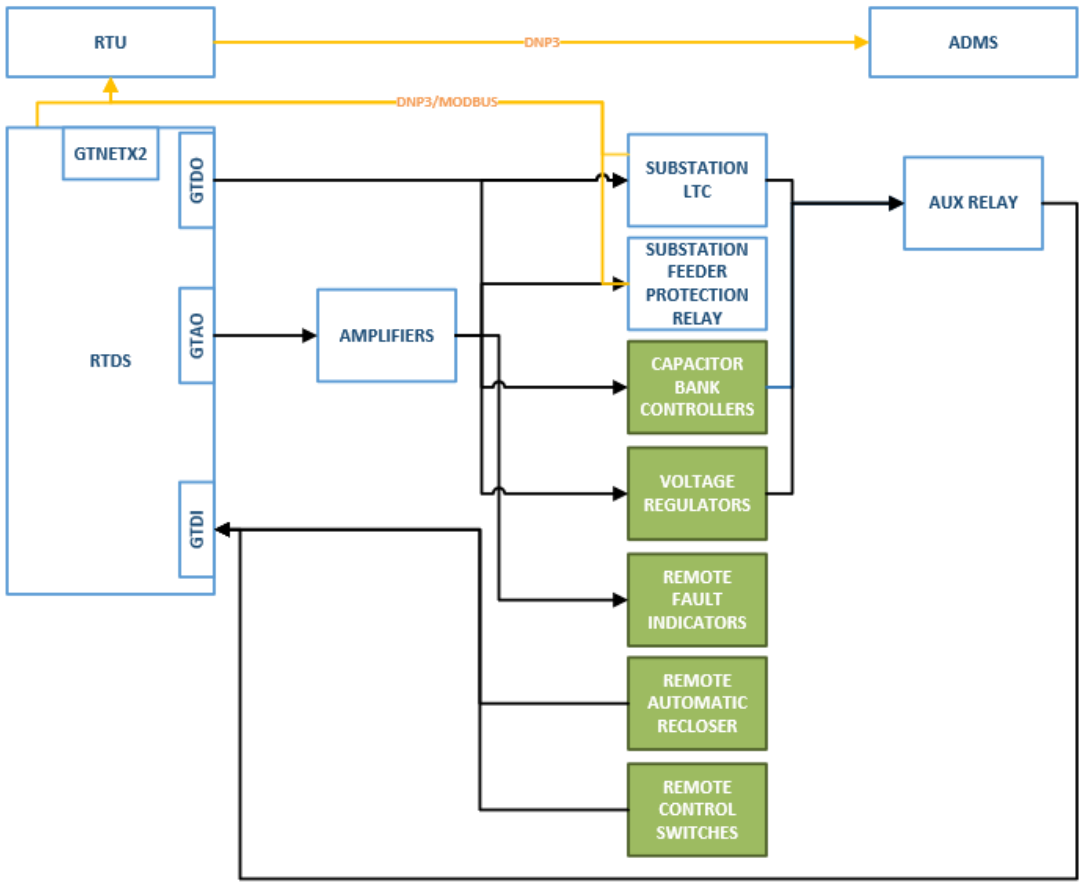


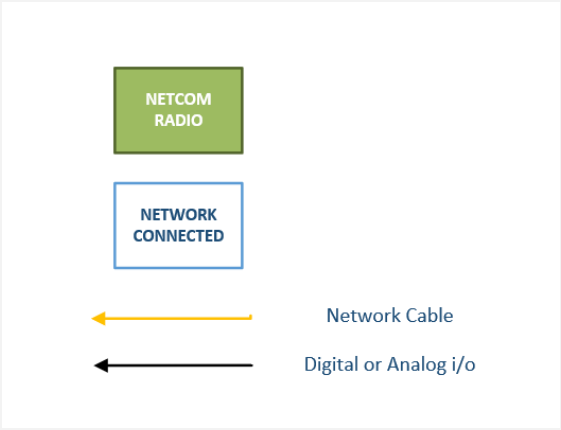
MODEL DEVELOPMENT



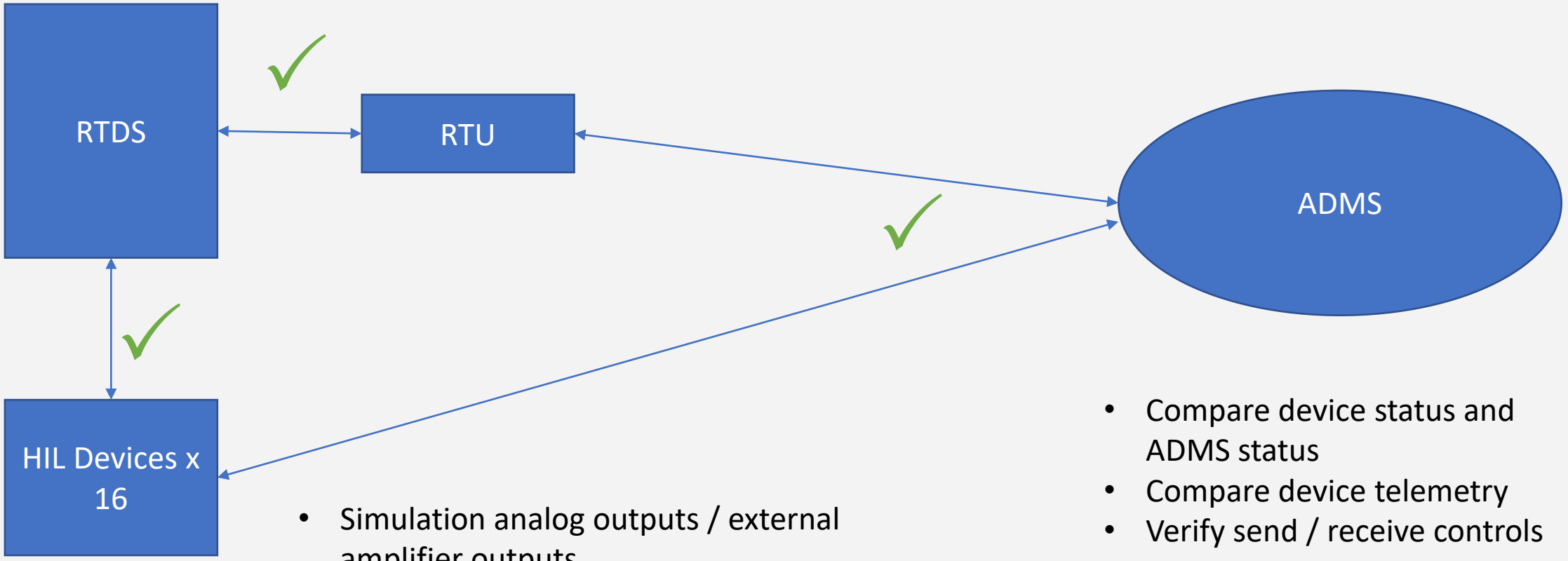
286 Nodes

MODEL DEVELOPMENT – HIL ENVIRONMENT





INTEGRATION TESTING

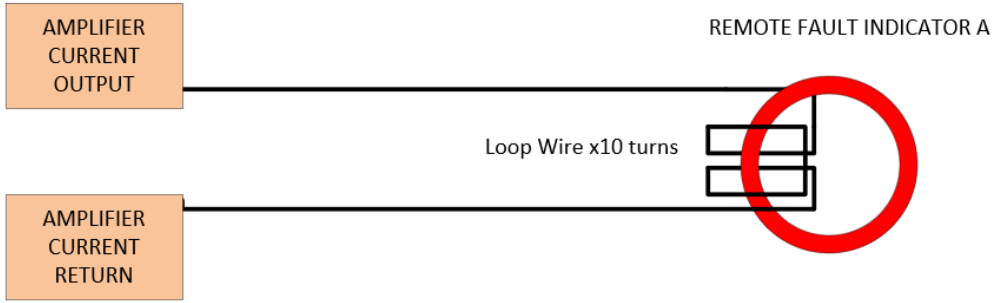


- Simulation analog outputs / external amplifier outputs
- HOI measurements
- Send / Receive controls via simulation i/o

- Compare device status and ADMS status
- Compare device telemetry
- Verify send / receive controls

INTEGRATION TESTING

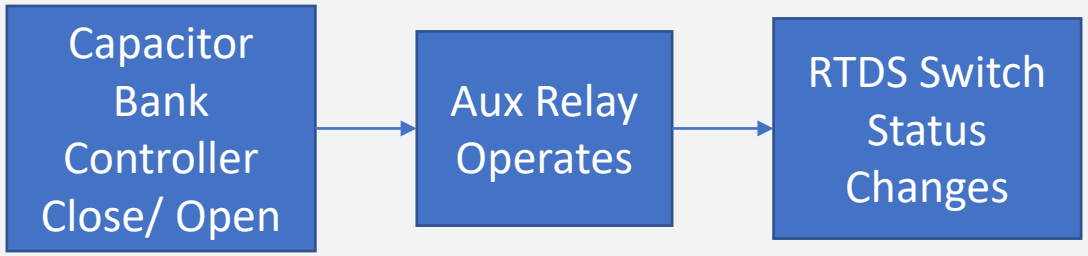
Remote Fault Indicators



- Amplifier cannot directly output line current under normal operating conditions
- Implemented logic to scale down fault current, metered value is scaled up in ADMS

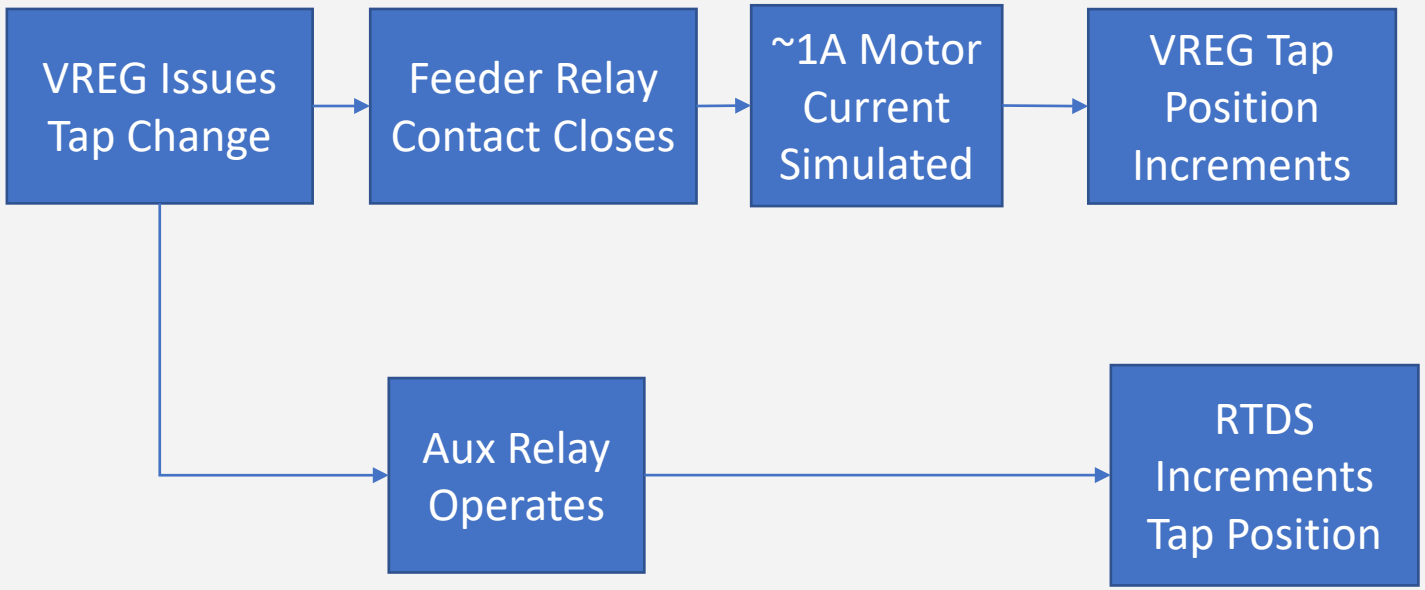
INTEGRATION TESTING

Capacitor Bank Controllers



INTEGRATION TESTING

Voltage Regulators



LESSONS LEARNED

- Converting models from CYME - reducing number of nodes
- Providing required inputs to each controller with mix of simulation & hardware
- External amplifier in-rush current limitations
- HIL testing helped identify defects that were difficult to find with simulation only

FUTURE USE CASES

- Regression testing
  - ADMS / GMS releases
  - Radio or Controller firmware
- New controller hardware / firmware integration
- DERMS

Q&A