Internship Accomplishments

May – August 2025

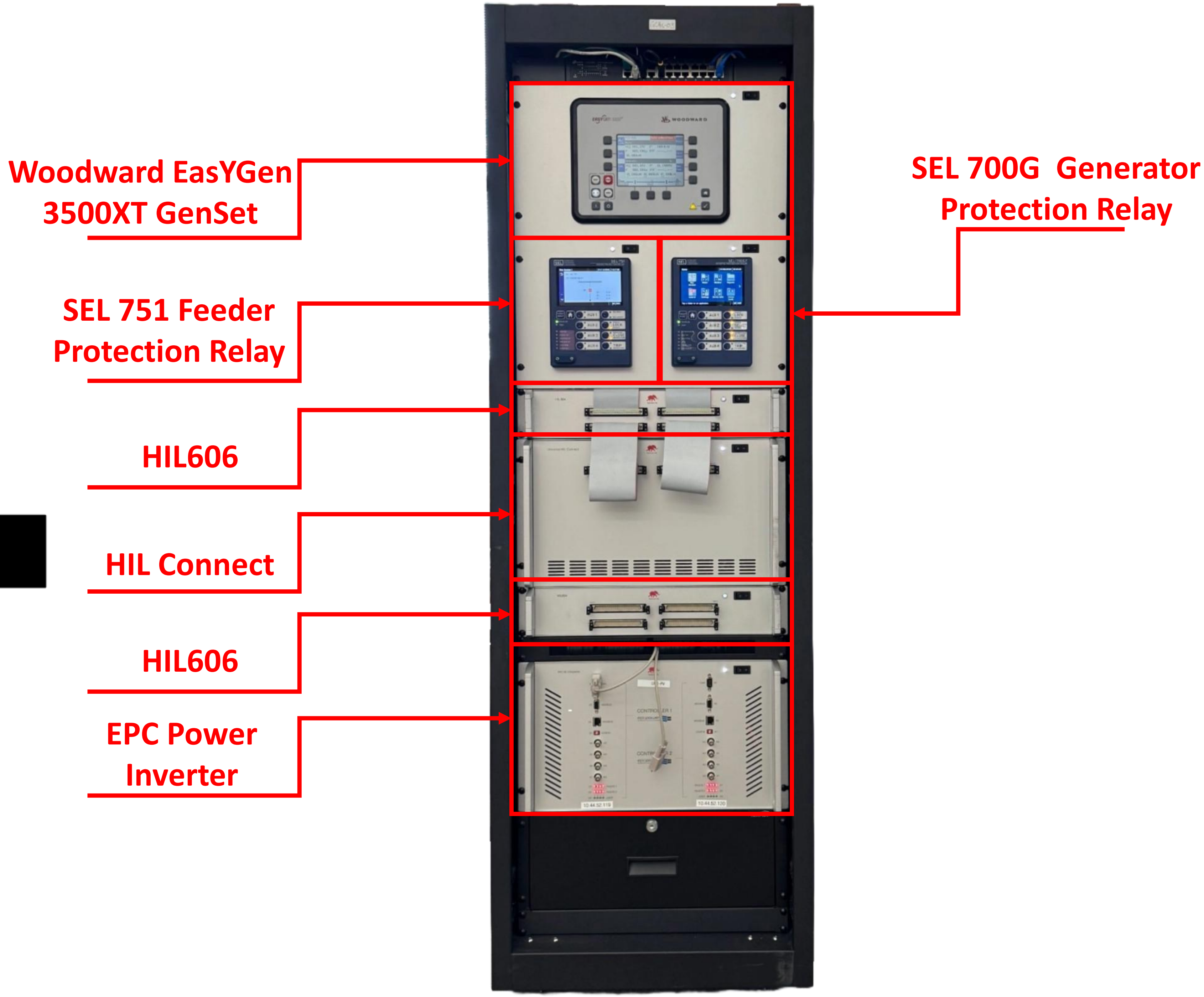
Henry Warfield
Grid Modernization Internship

About Me:

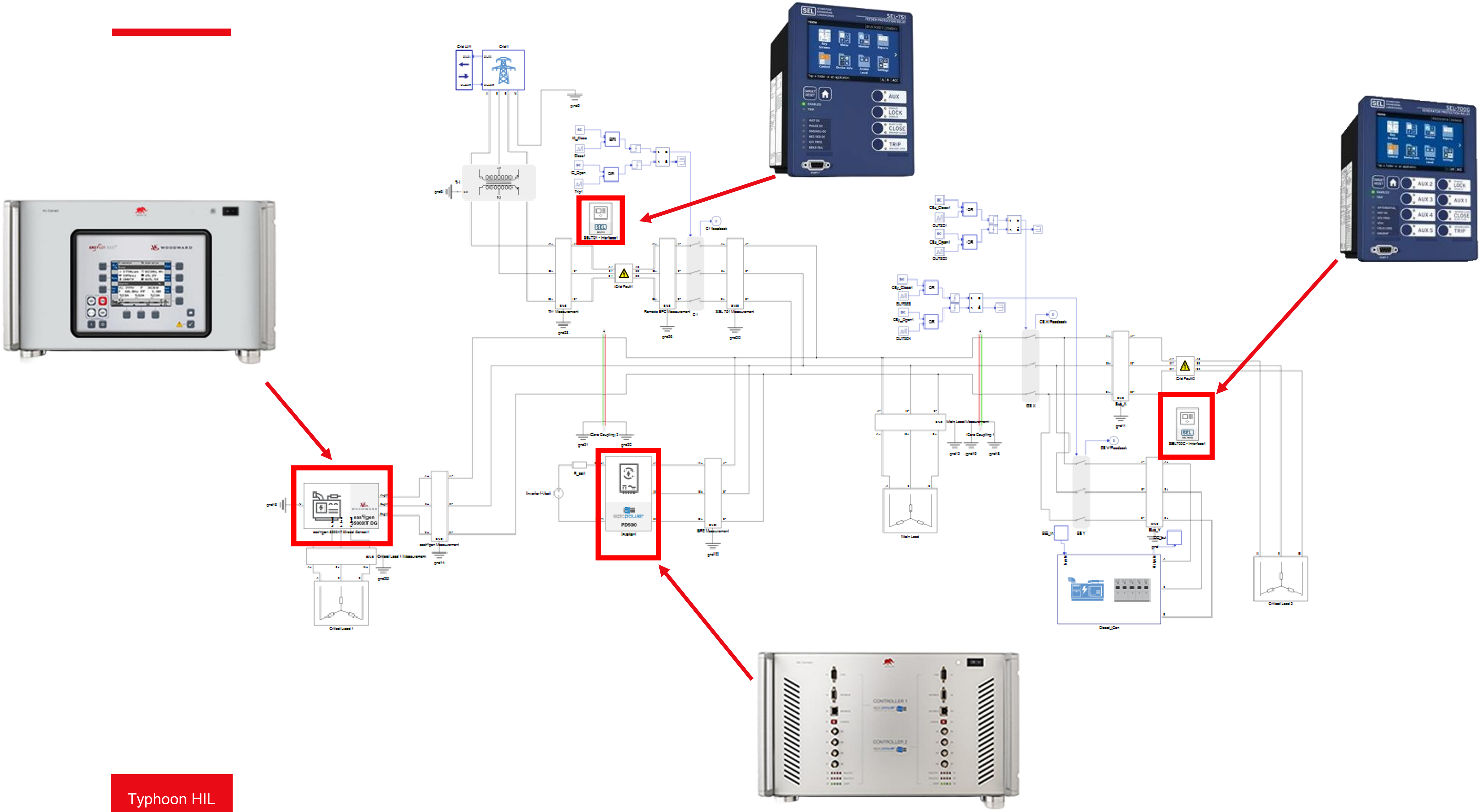
- Junior E.E. Major at Virginia Tech with a Concentration in Power Systems
- Intern at Boston Office since May 2025
- [redacted]
- Vocational Degree in Electrical Engineering (4 Years)

Generic Microgrid Testbed Demo

Assigned by [redacted]



Microgrid Circuit

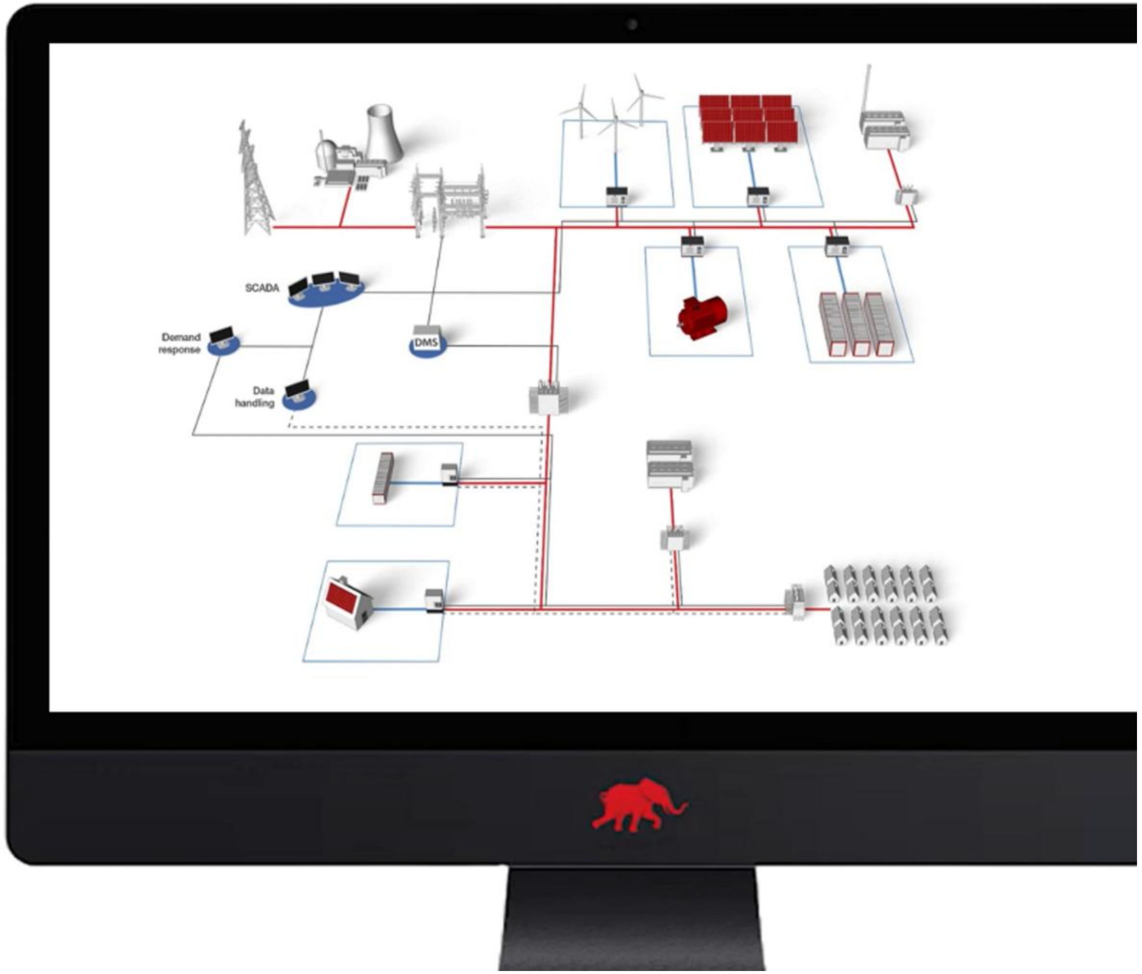


Tests Overview

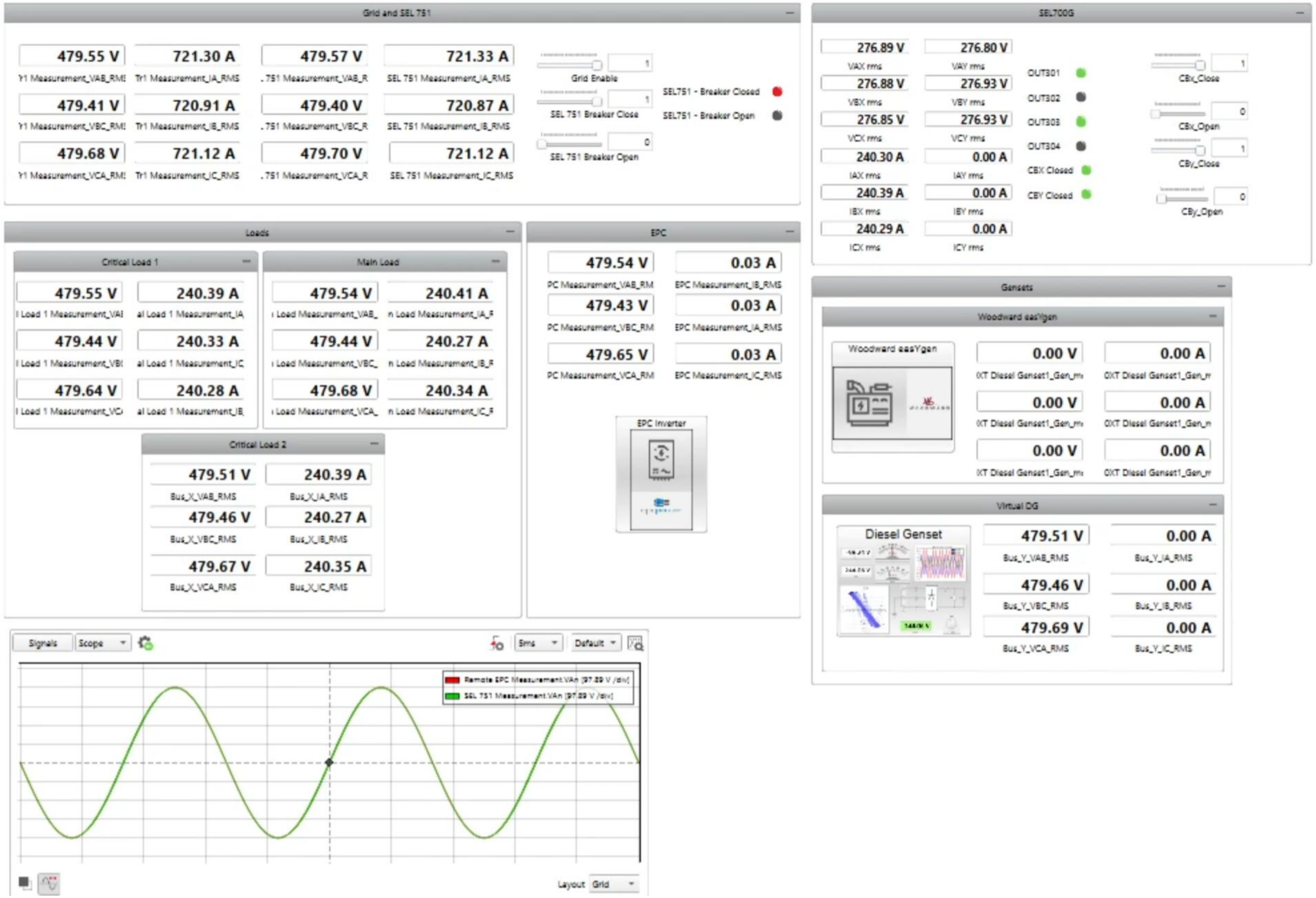
- ☐ Showed normal grid-connected operation with generator and EPC inverter in grid-following mode.
- ☐ Simulated grid faults to verify selective breaker operation and fault isolation.
- ☐ Operated EPC inverter in grid-forming mode during main grid loss, with gensets supporting in following mode.
- ☐ Demonstrated islanded operation of virtual genset for critical load supply.
- ☐ Verified safe reconnection through synchronization checks on SEL-700G and SEL-751.
- ☐ Compared transition effects between operating modes to assess system stability.
- ☐ Tested equipment fault response (virtual genset overspeed) with protection logic isolating the fault while keeping loads powered.

Video

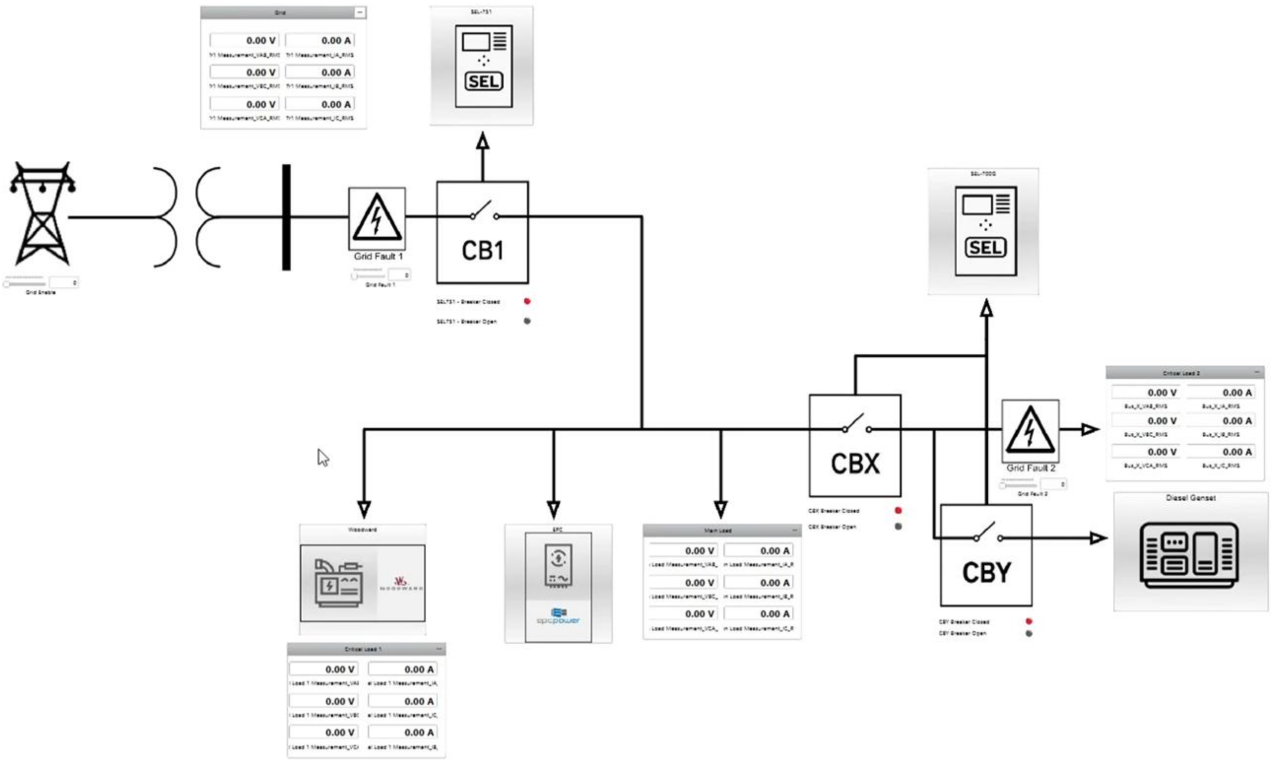
Full Microgrid
Testbed Demo

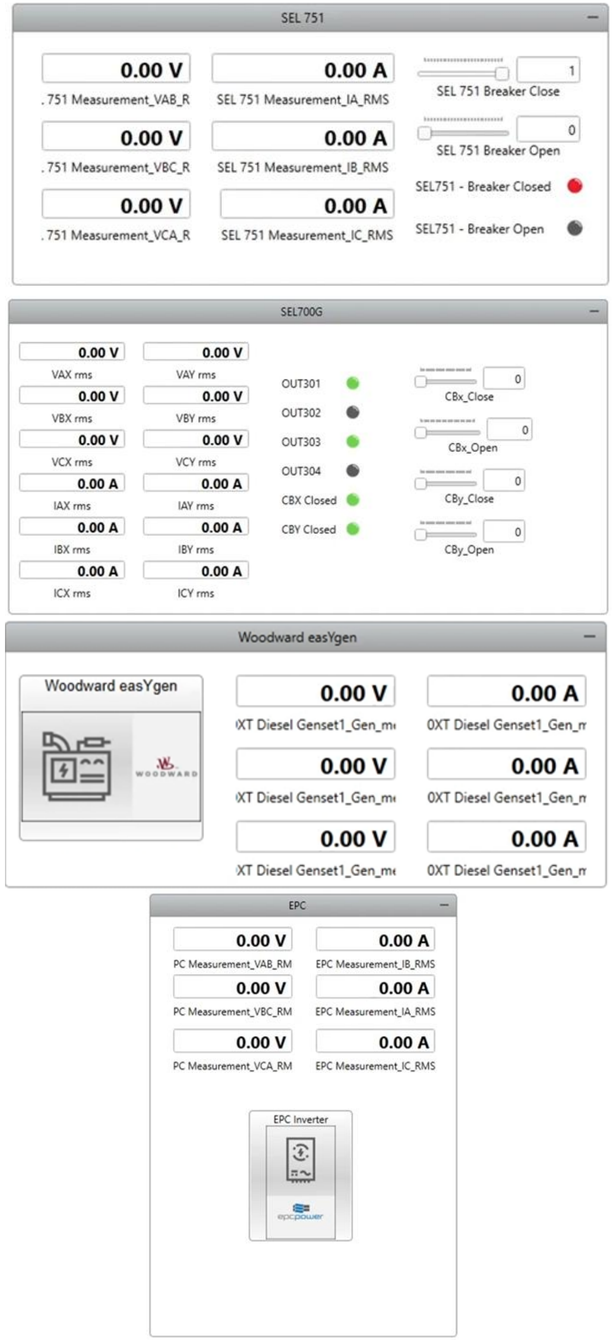


Original SCADA Panel



New SCADA Panel

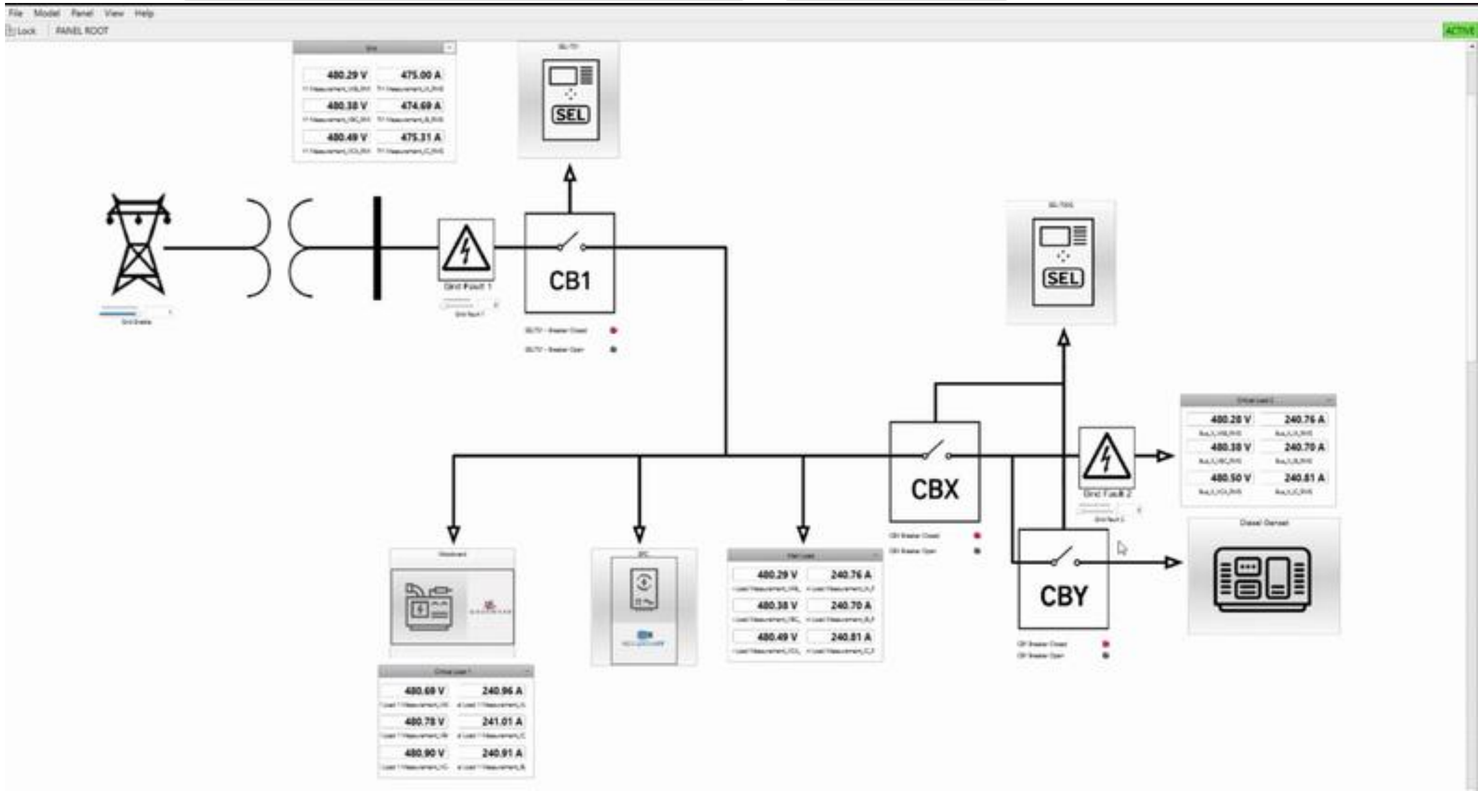




Microgrid Testbed Demo – Why?

- **Shows Real-World Capability** – Demonstrates how Typhoon HIL can simulate an entire microgrid with real hardware, controllers, and protection devices in real time.
- **Demonstrates Integration** – Shows seamless operation between different devices (SEL relays, EPC inverter, Woodward genset controller) under one HIL platform.
- **Already show to be useful in presentations with** [redacted] **&** [redacted]
- **Builds Trust & Credibility**
- **Reusable Resource**
- **Covers Diverse Scenarios**

[redacted] [redacted]



Boston VPAC

Assigned by [redacted]

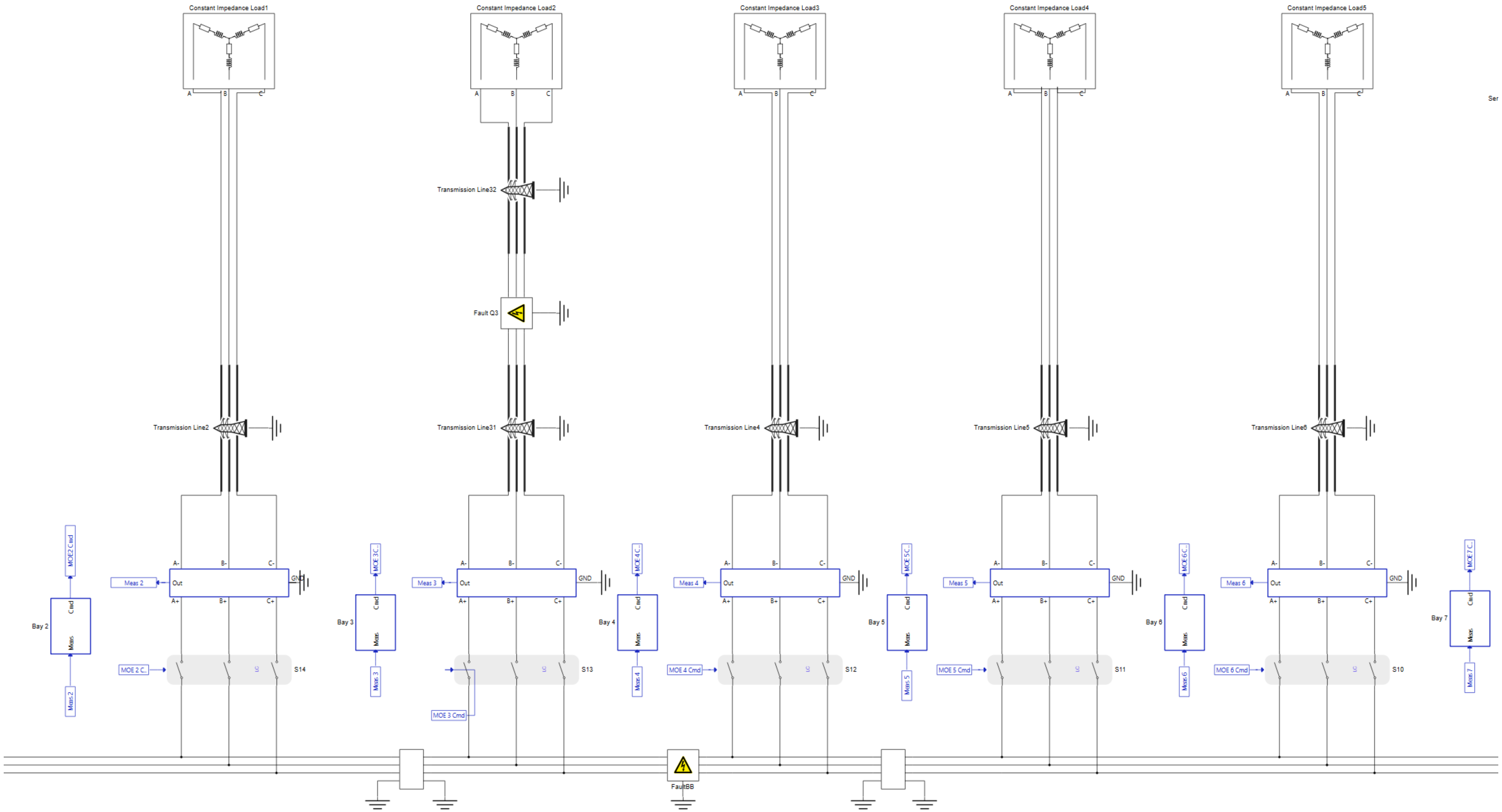
& [redacted]

Typhoon HIL

Boston VPAC

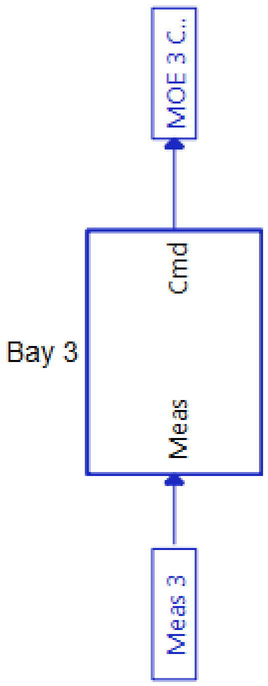
- ☐ Assembled the physical rack, including secure mounting and cable management for all devices.
- ☐ Installed, configured, and calibrated each component — including protection relays, control units, network equipment, and precision time synchronization devices.
- ☐ Verified communication across IEC 61850, PTP/NTP, and other relevant protocols to ensure accurate time stamping and event correlation.
- ☐ The rack is designed to support **voltage protection and control simulations**, enabling the testing of complex power system scenarios such as fault detection, isolation, load transfer, and system restoration.
- ☐ Demo already proven to be useful in presentation with [redacted]

Section of the test circuit



Bay Simulation Protocol

Sends IEC61850 Commands to act like the SMU615 station monitoring and control unit to monitor and protect substations



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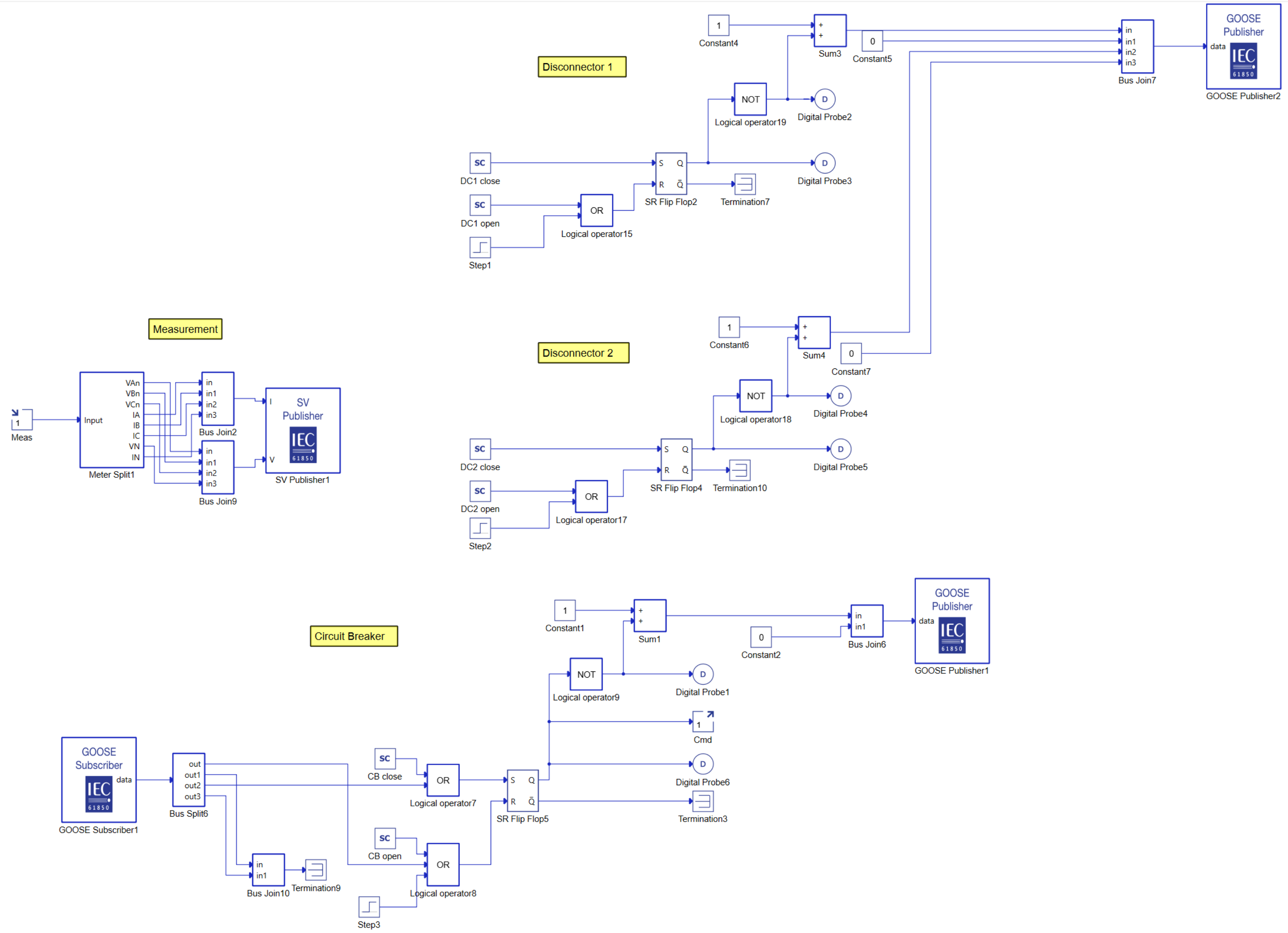
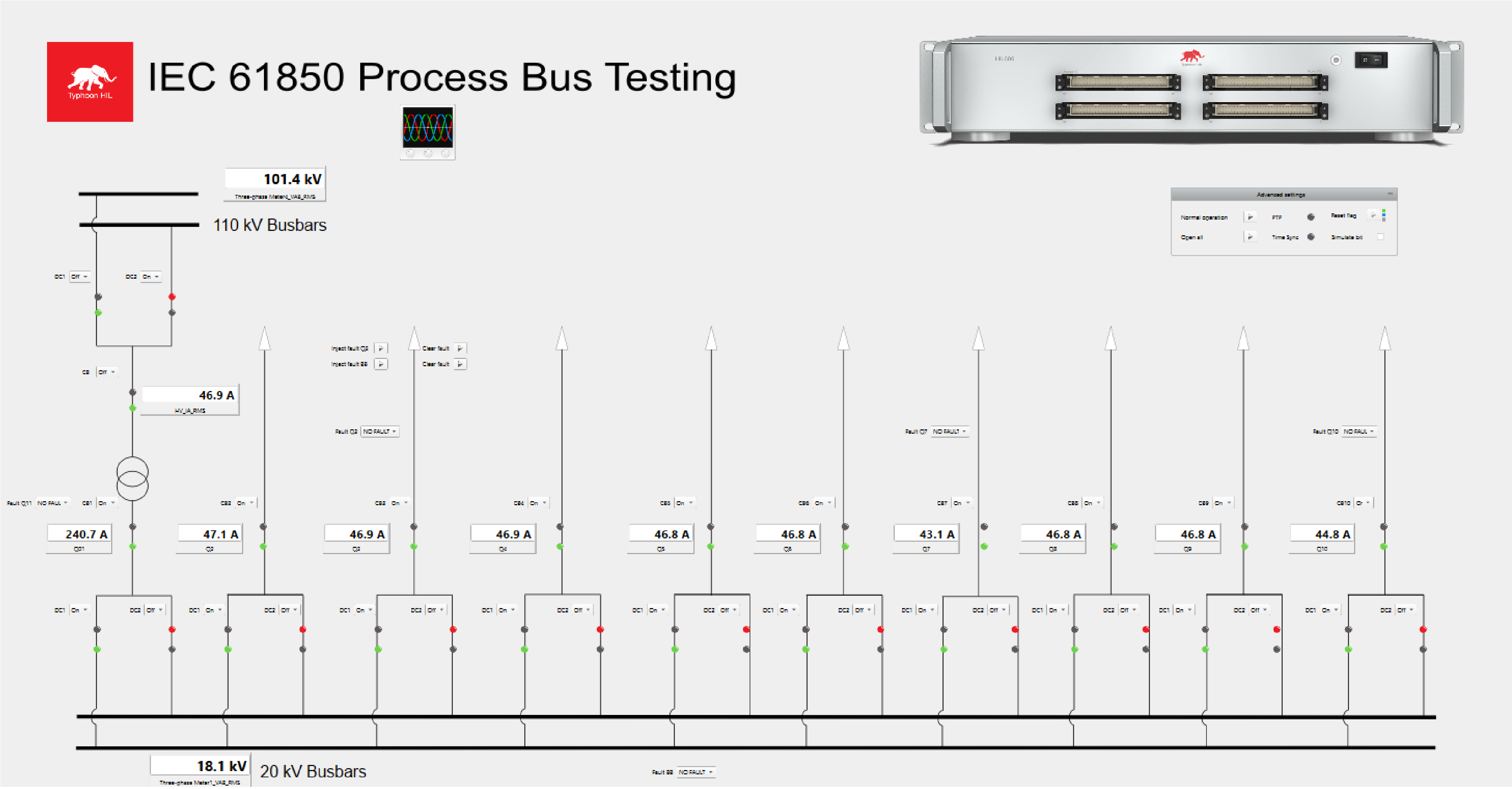
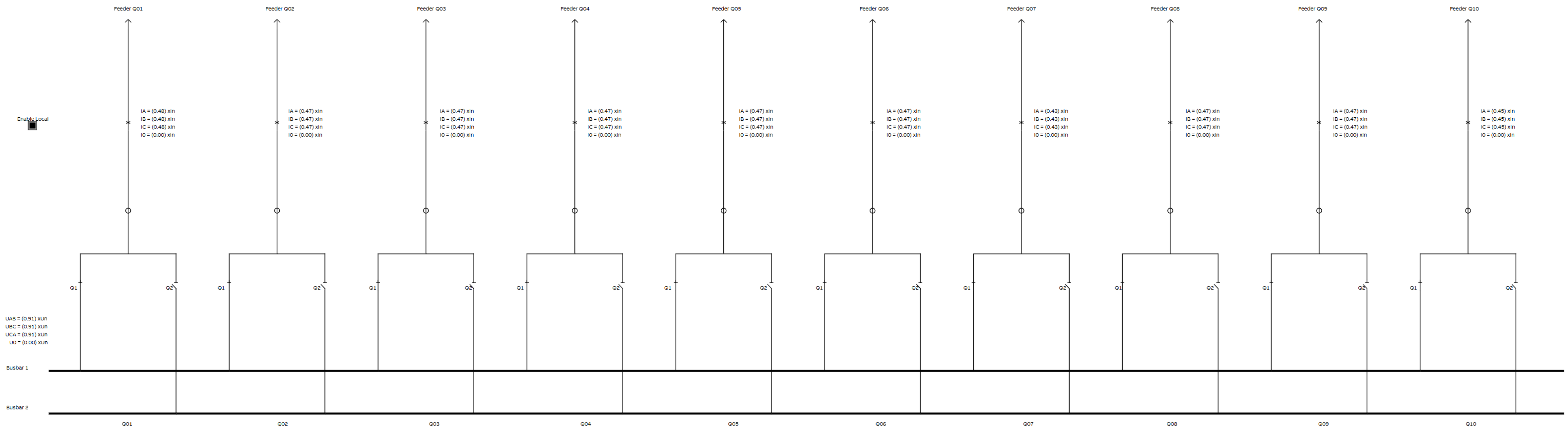


SCADA Panel



IEC 61850 Process Bus Testing
101.4 kV
110 kV Busbars
46.9 A
240.7 A
47.1 A
46.9 A
46.9 A
46.8 A
46.8 A
43.1 A
46.8 A
46.8 A
44.8 A
18.1 kV
20 kV Busbars

SSC600 Web HMI

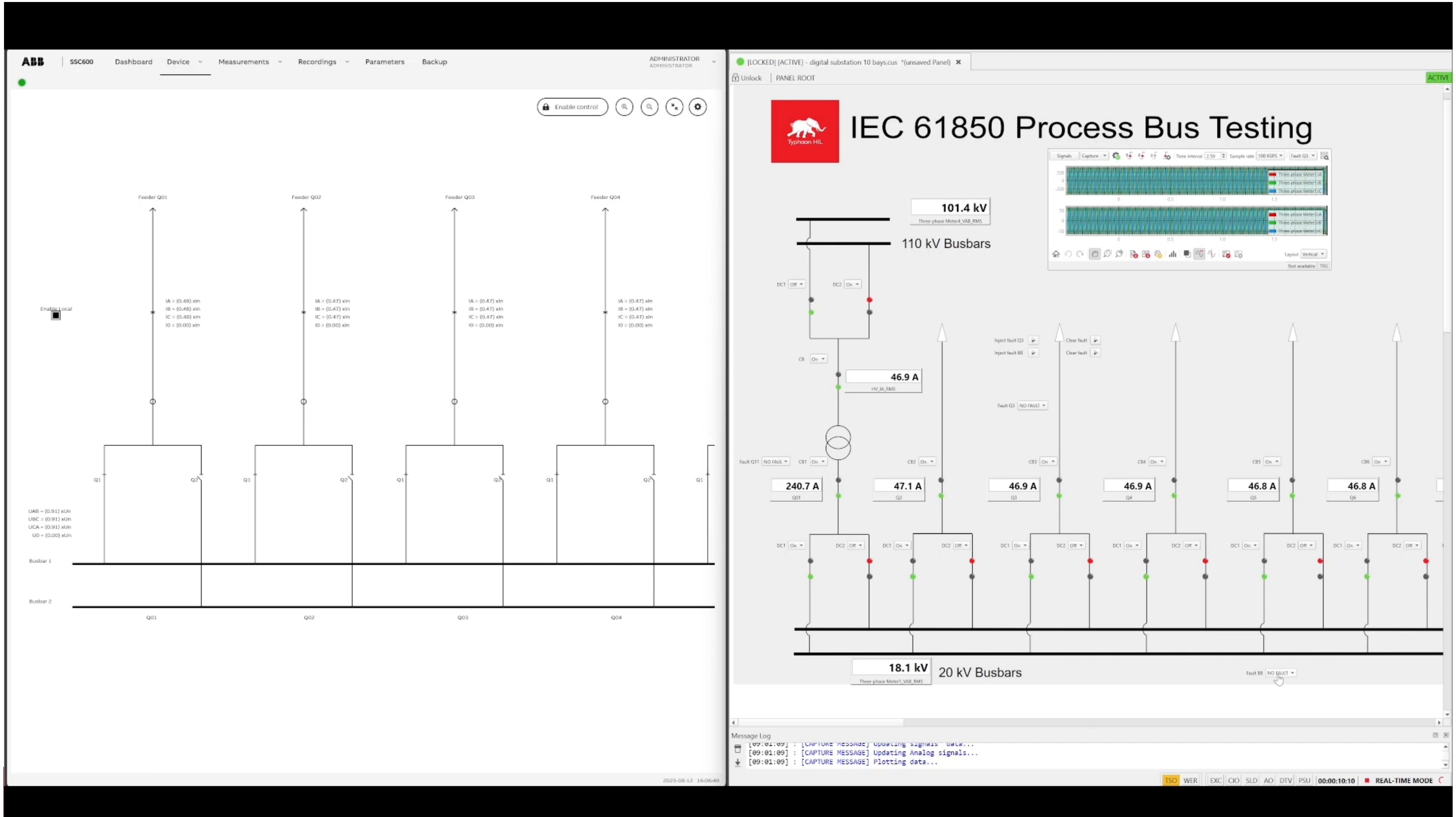


Typhoon HIL

Operation

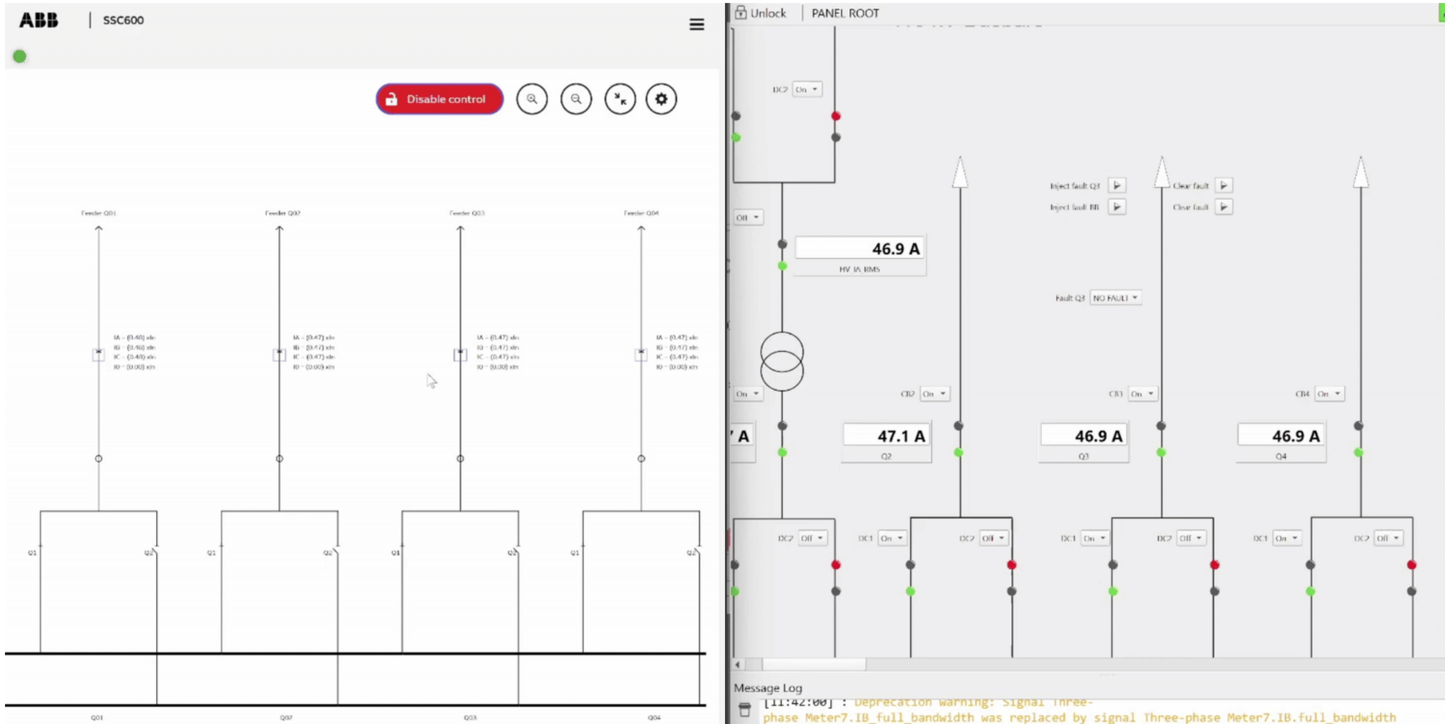
Active alarms

STATUS	NUMBER	DESCRIPTION
●	1	BB_Diff_OPERATE



Boston VPAC – Why?

- **Demonstration Tool** – Provides a ready-made platform for customer demos and proof-of-concept testing
- **Protocol & Testing** – Validates IEC 61850, PTP/NTP, and other communication protocols across multiple vendors before deployment.
- **Flexible Scenario Testing** – Supports grid faults, islanding, synchronization, reclose logic, and recovery in a repeatable and safe environment.

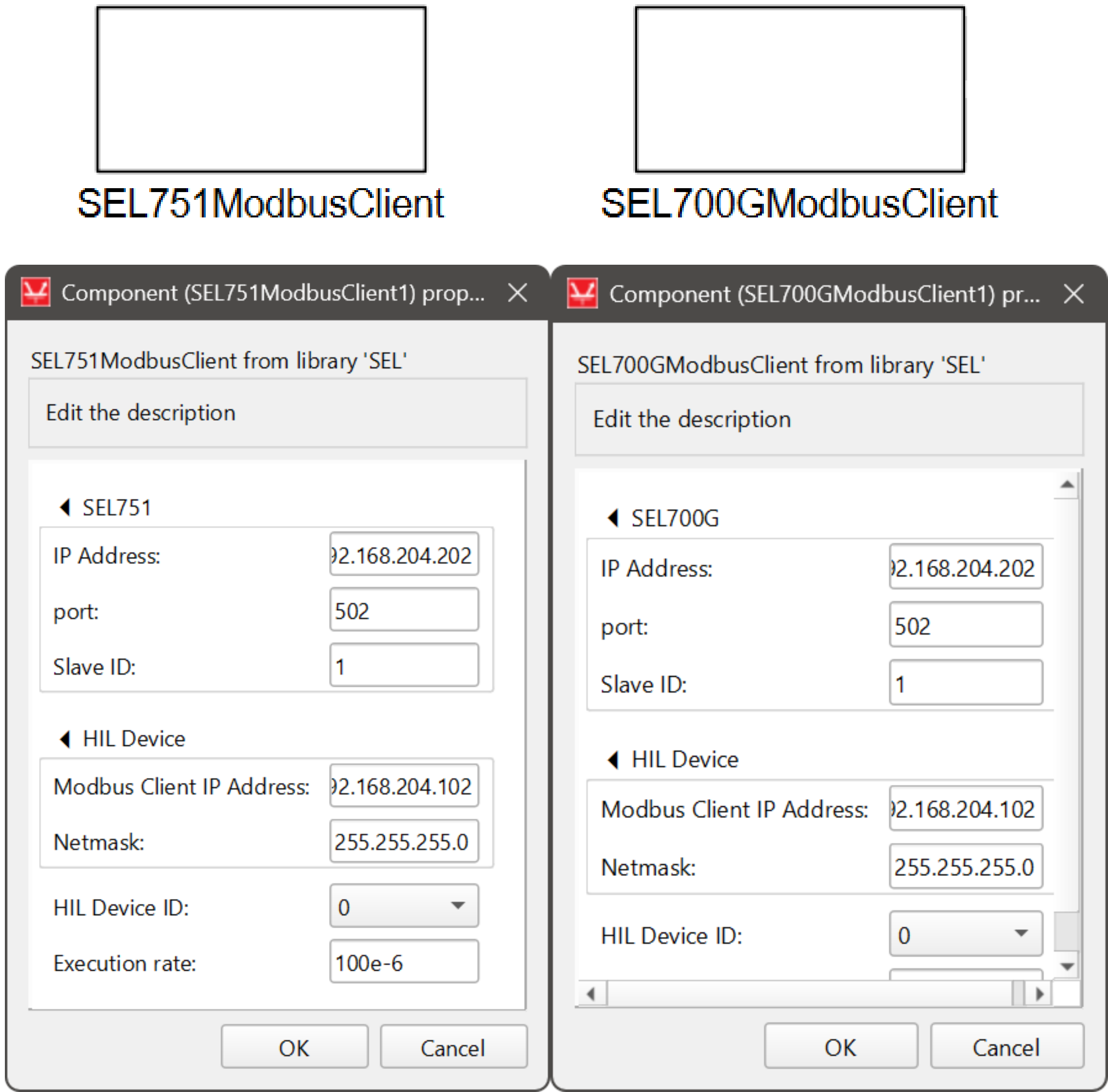


SEL 751/700G Modbus Interface

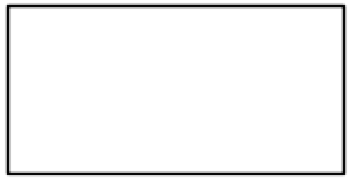
Assigned by [redacted]

SEL 751/700G Modbus Interface

- Developed Modbus TCP link between SEL-751 & SEL-700G and Typhoon HIL via HIL Client.
- Created SCADA Panels for both based on HIL Client
- Mapped key measurements, breaker states, and trip/alarm signals from SEL Modbus register maps.
- Implemented control commands (Close/Open/Target Reset) with status feedback.
- Also created separate SCADA Panels based on both using a class-based structure via Modbus API



SEL 751 Subsystem



SEL751ModbusClient

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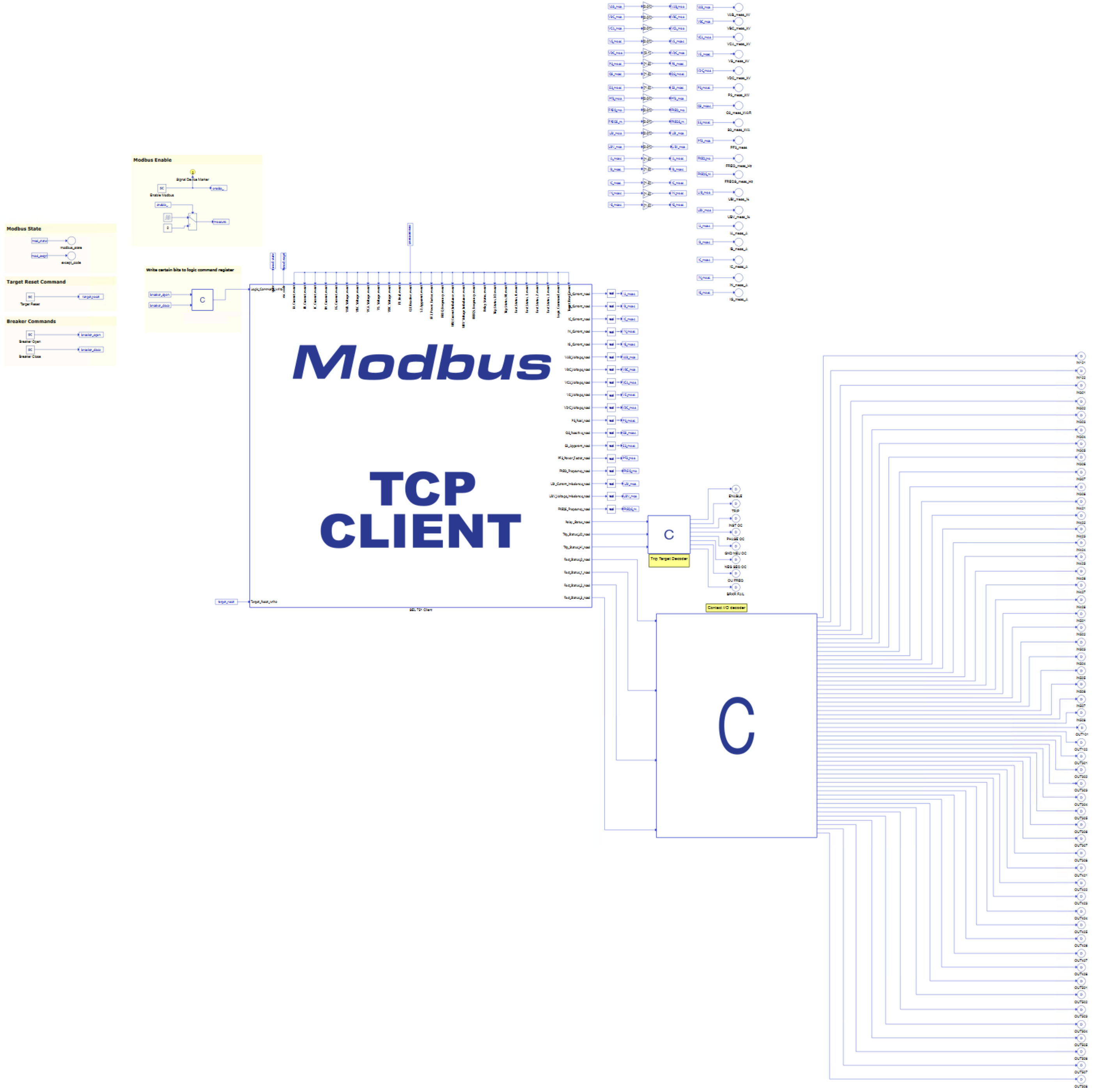
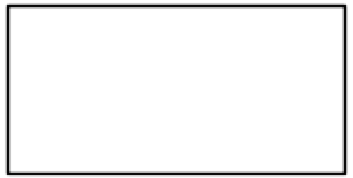


SEL 700G Subsystem



SEL700GModbusClient

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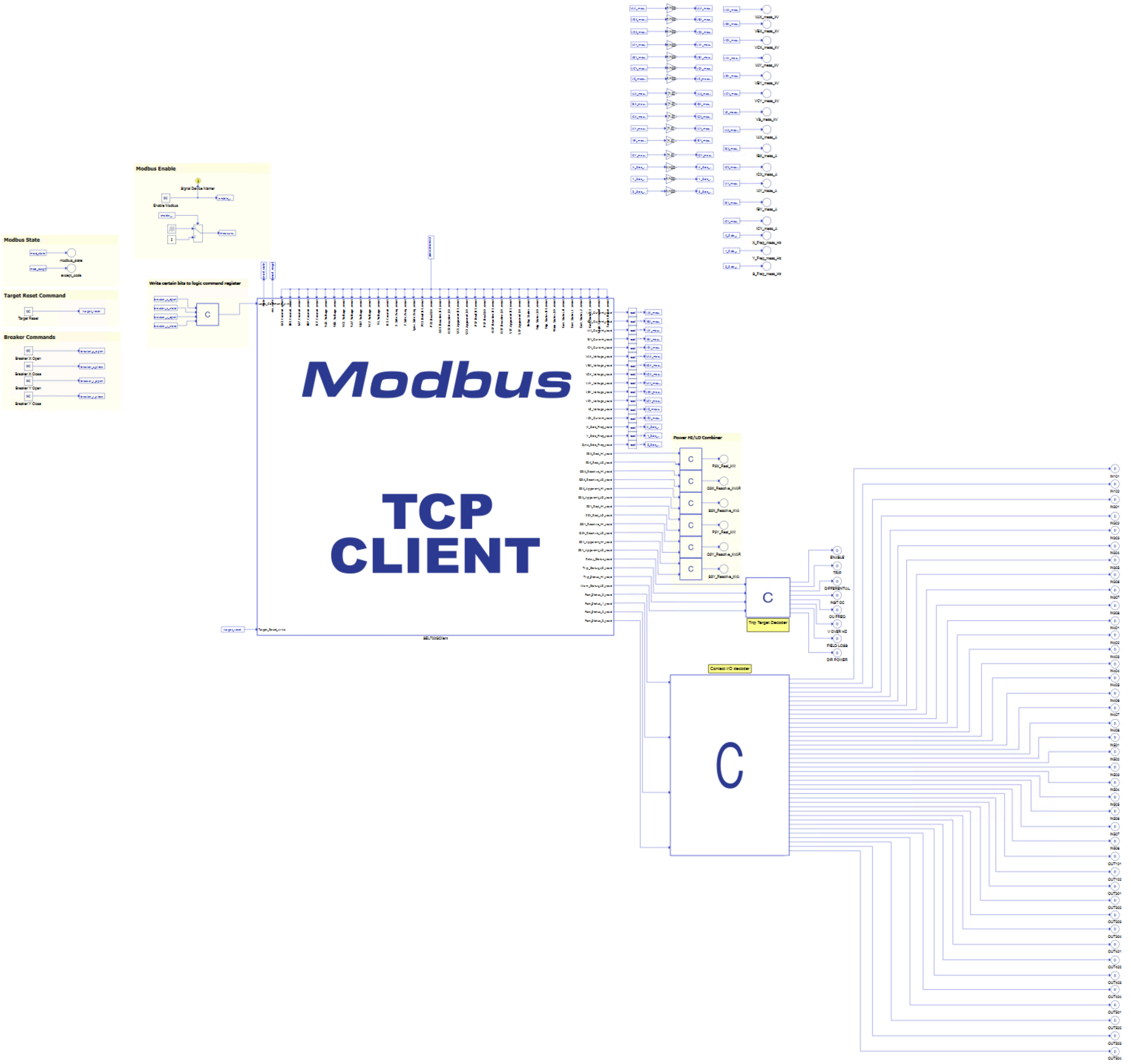
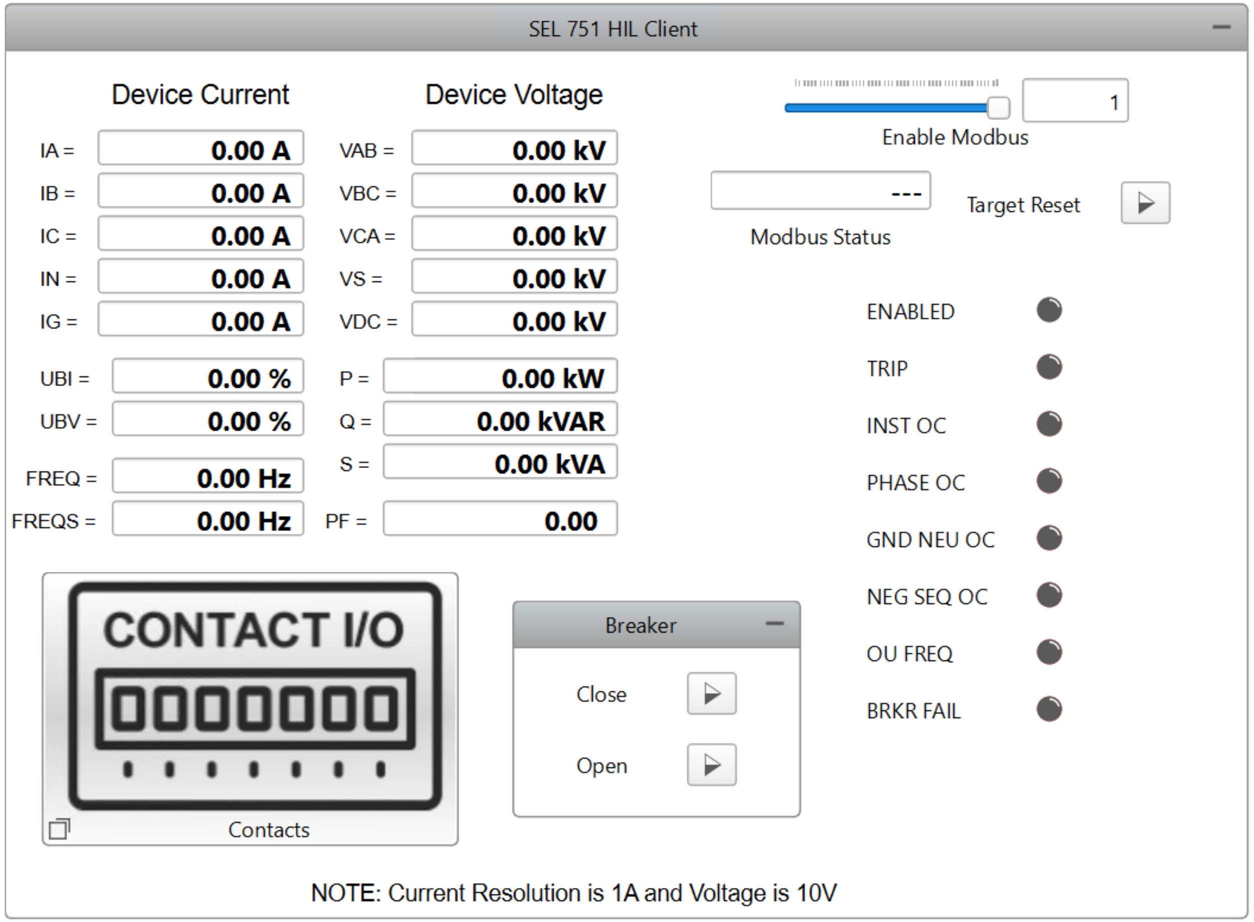
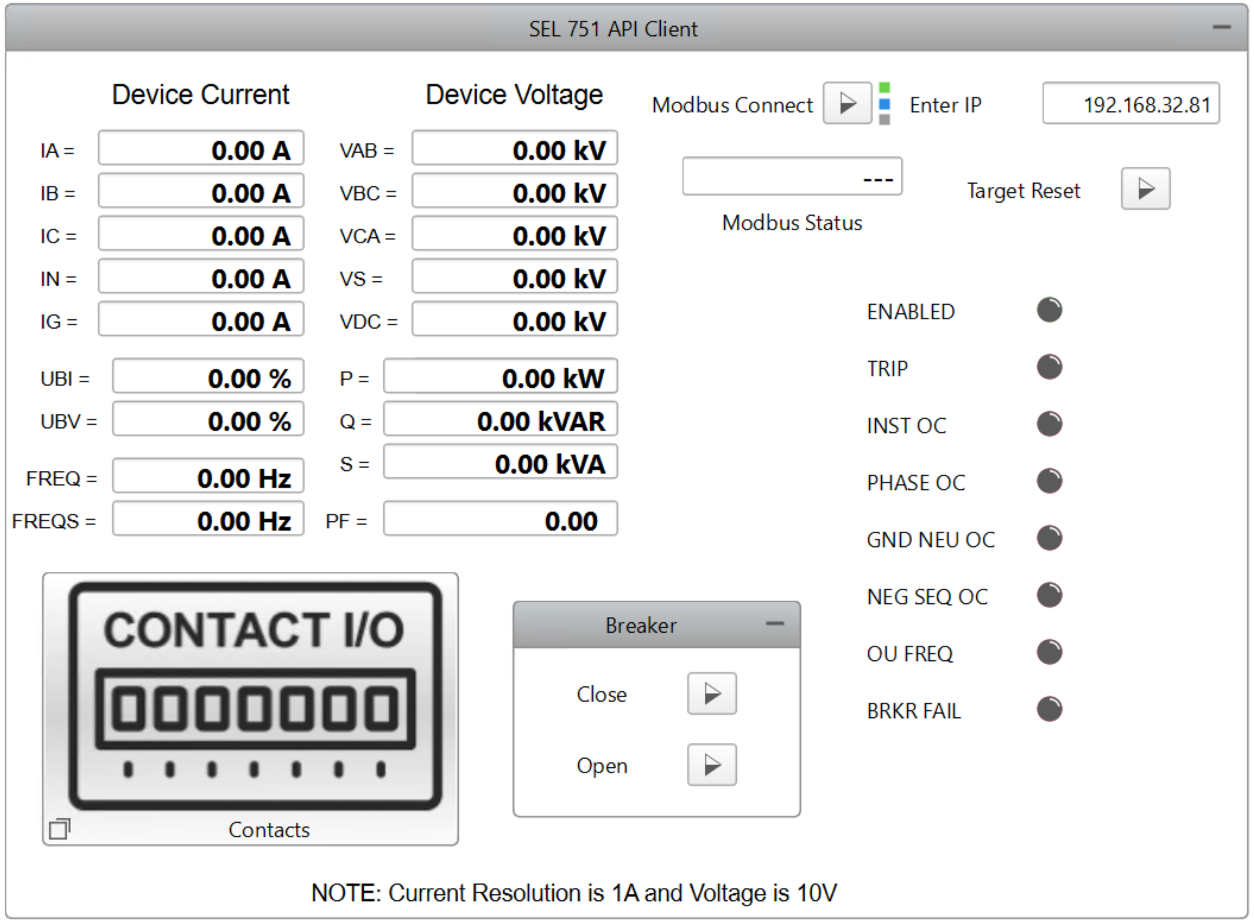
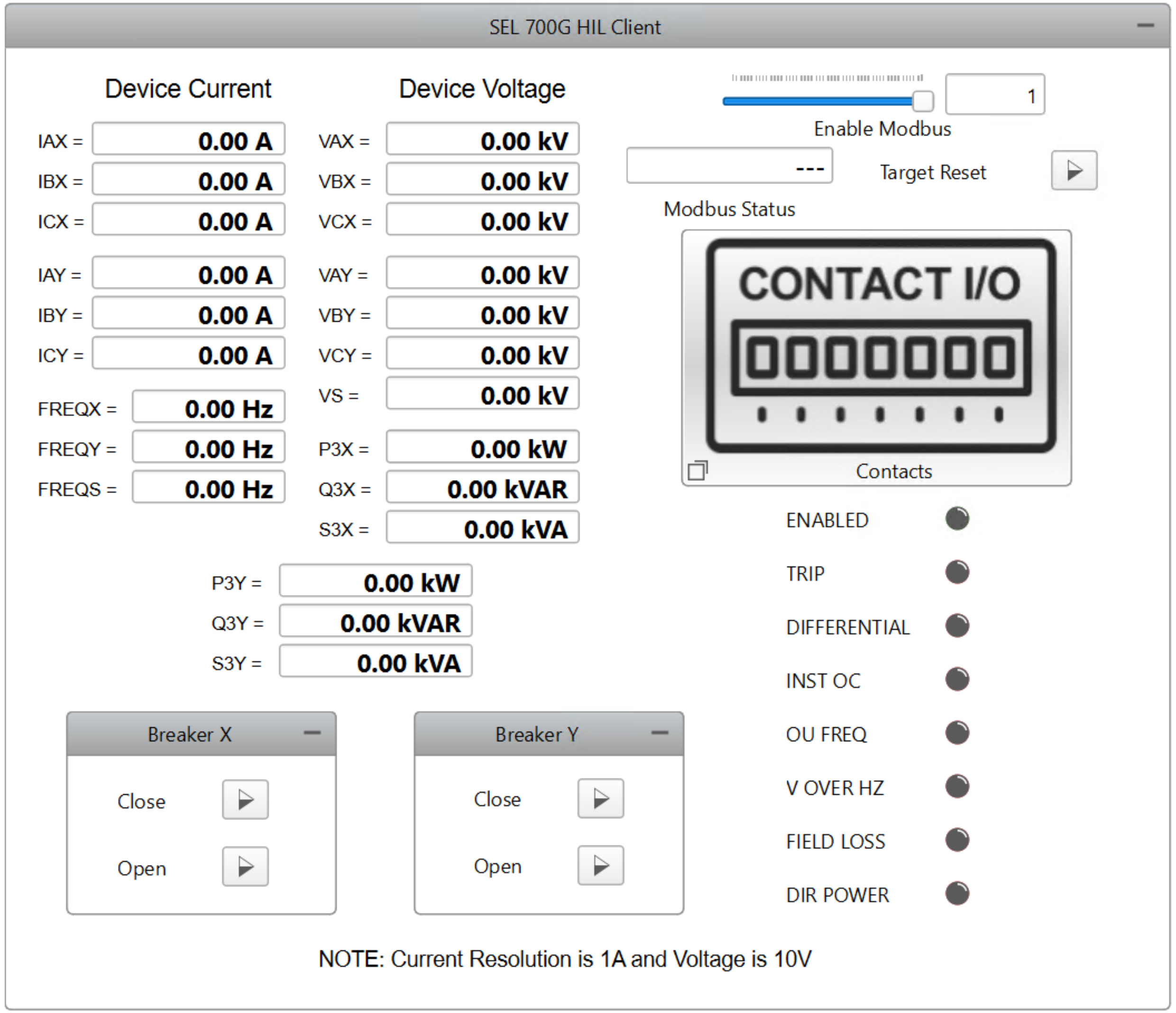


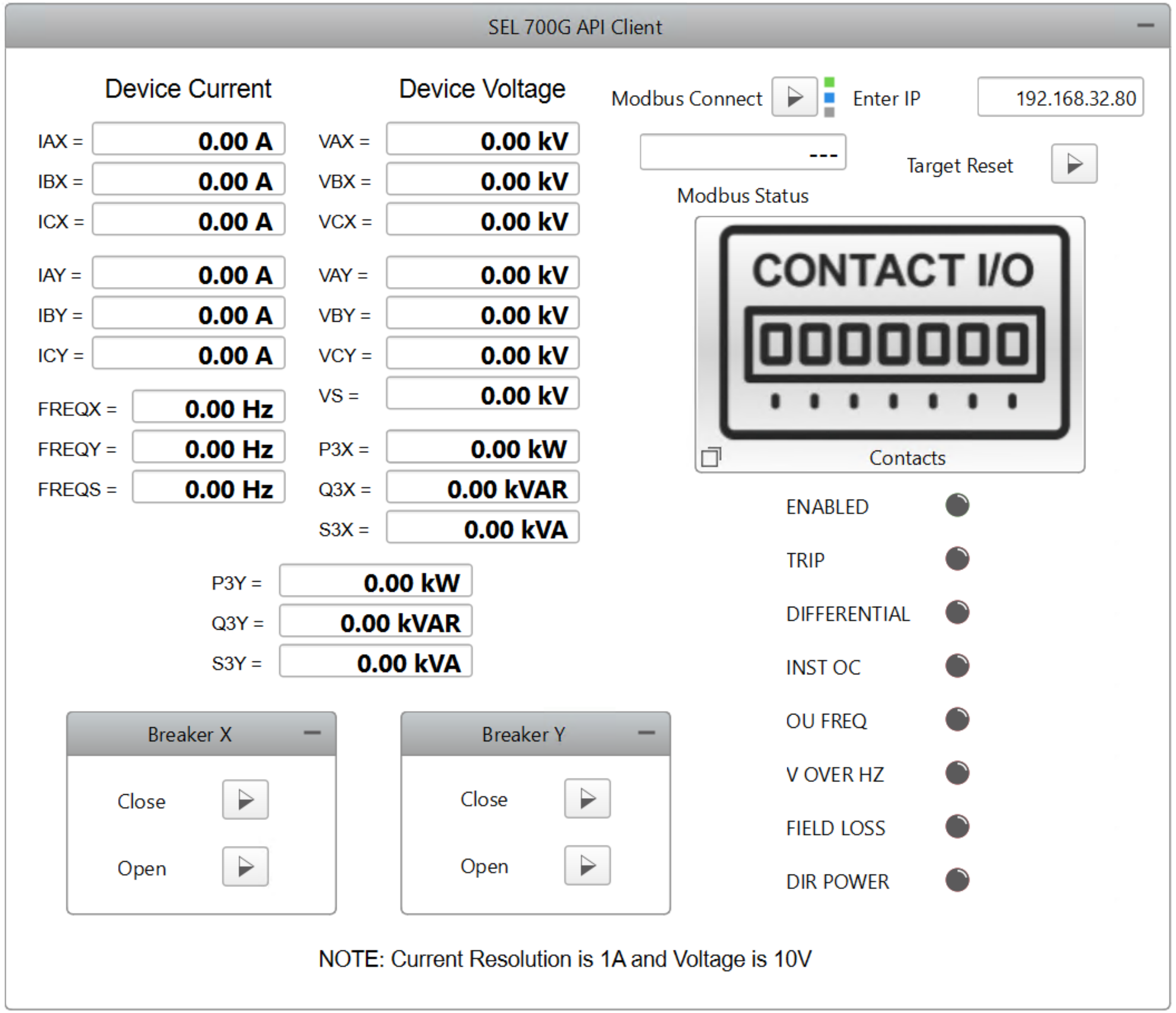
SEL 751 Panels





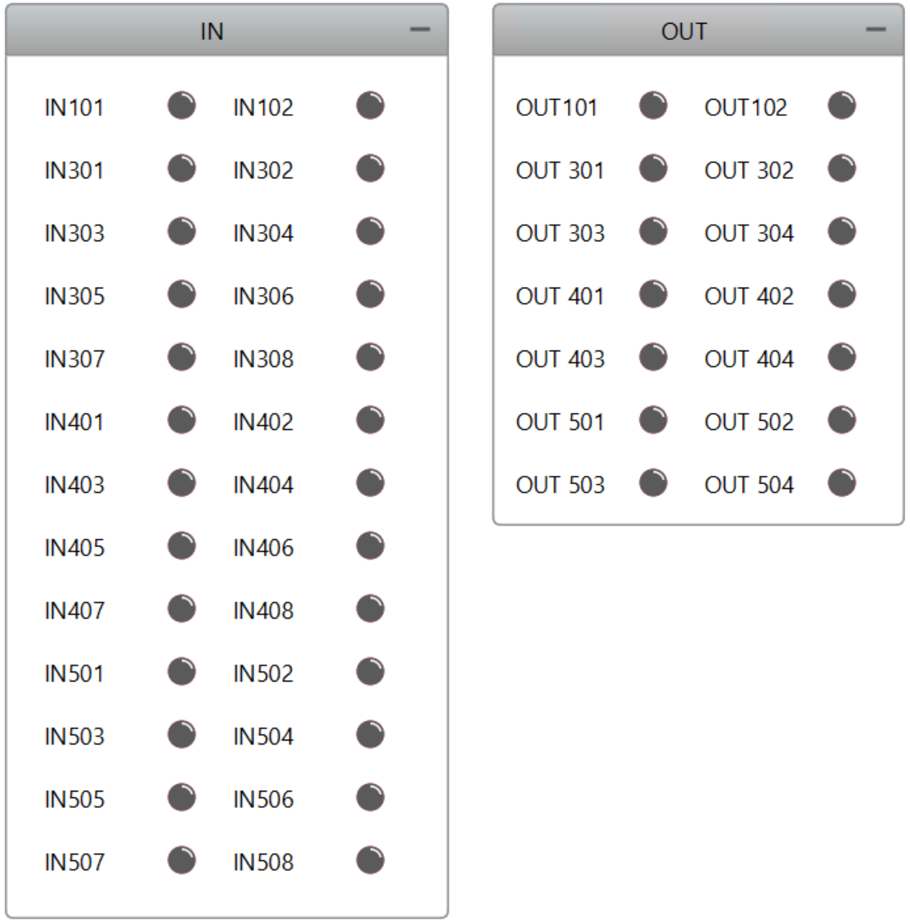
SEL700G Panels



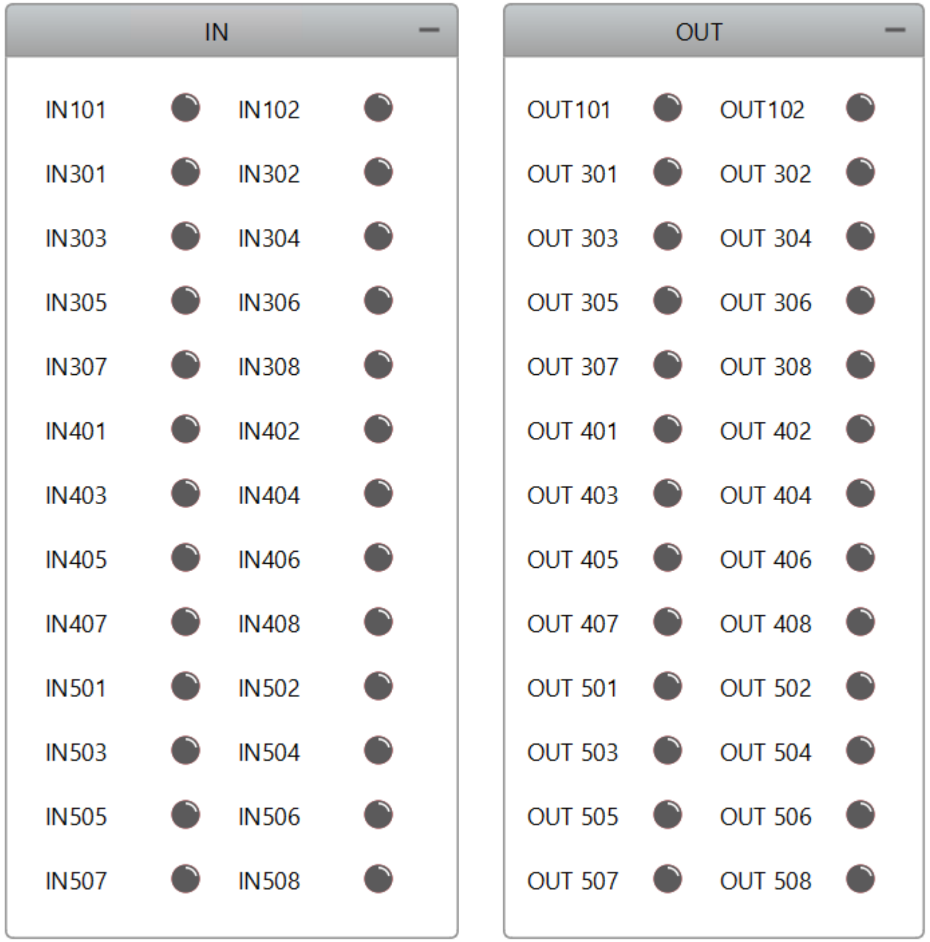


Contacts Subpanel

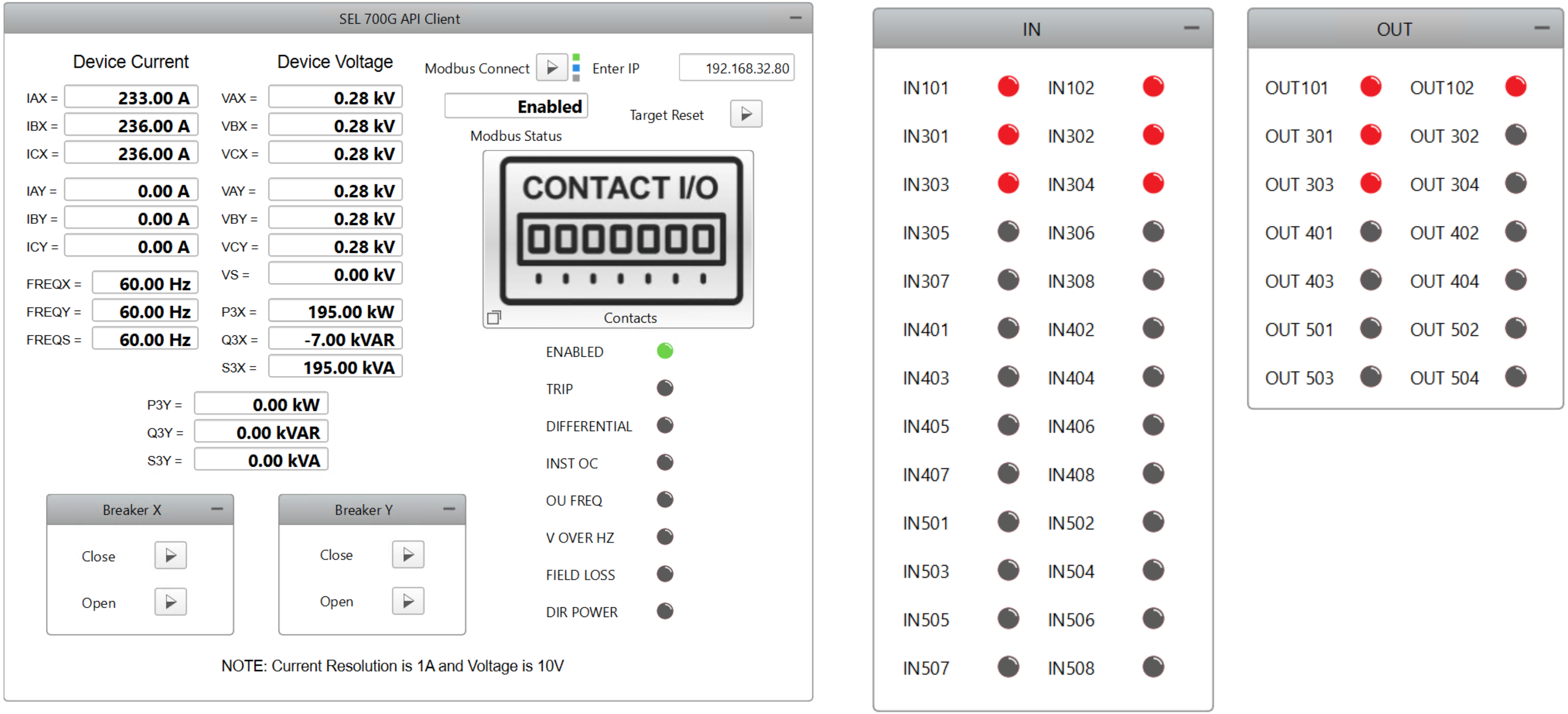
SEL700G



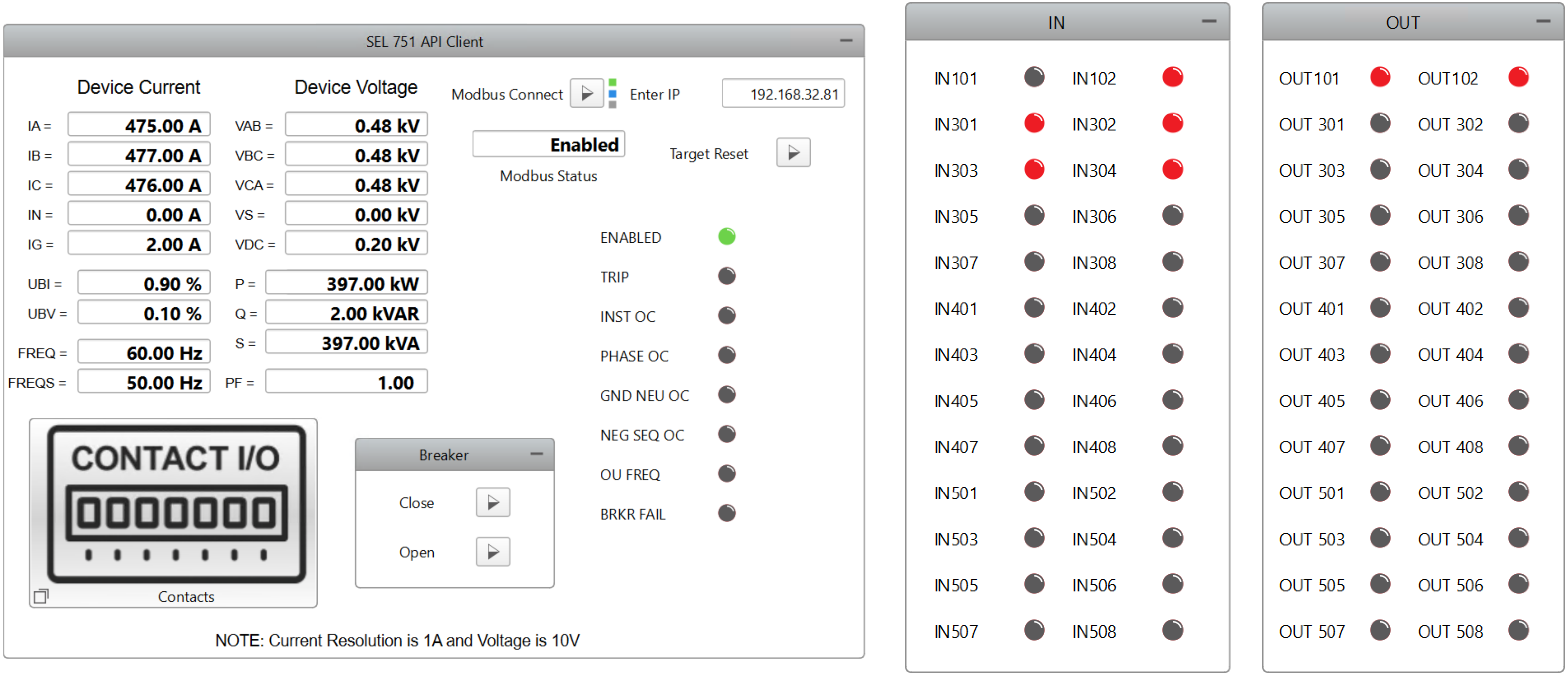
SEL751



SEL700G in Action

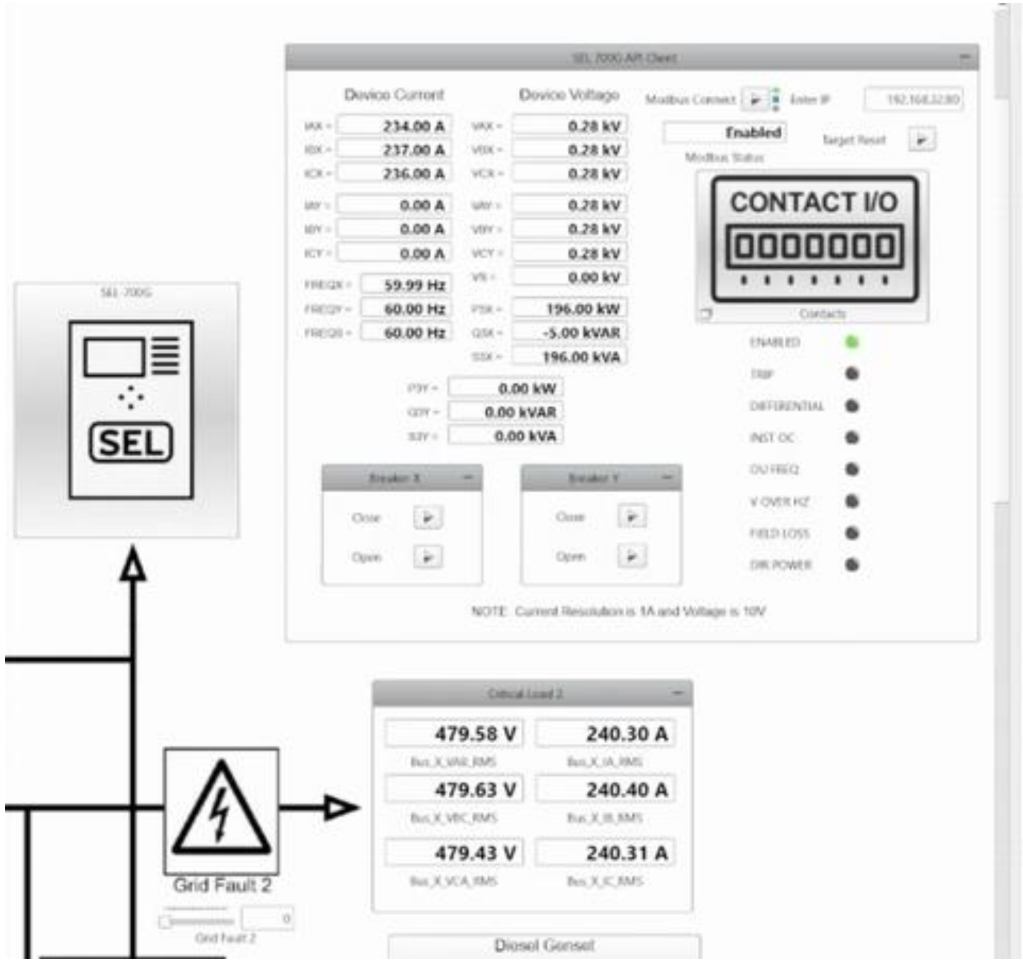


SEL751 in Action



SEL 751/700G Modbus Interface – Why?

- **Streamlined SCADA Integration** – View real-time values, breaker status, and trip signals directly in Typhoon HIL SCADA panels.
- **One-Stop Control & Monitoring** – No need to switch between SCADA and SEL's AcSELerator for target resets or breaker X/Y operations.
- **Class-Based API Structure** – Organized, reusable Python code for fast integration into future Typhoon HIL projects.
- **Centralized Operations** – Control commands (close/open/reset) and status verification all from a single dashboard.
- **Time-Saving & User-Friendly**

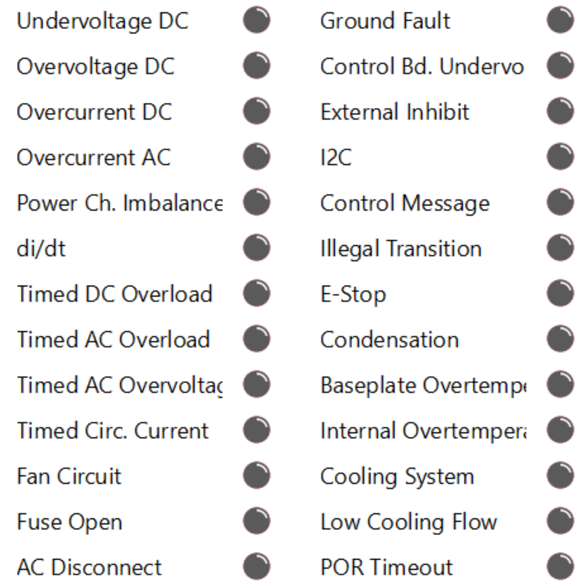


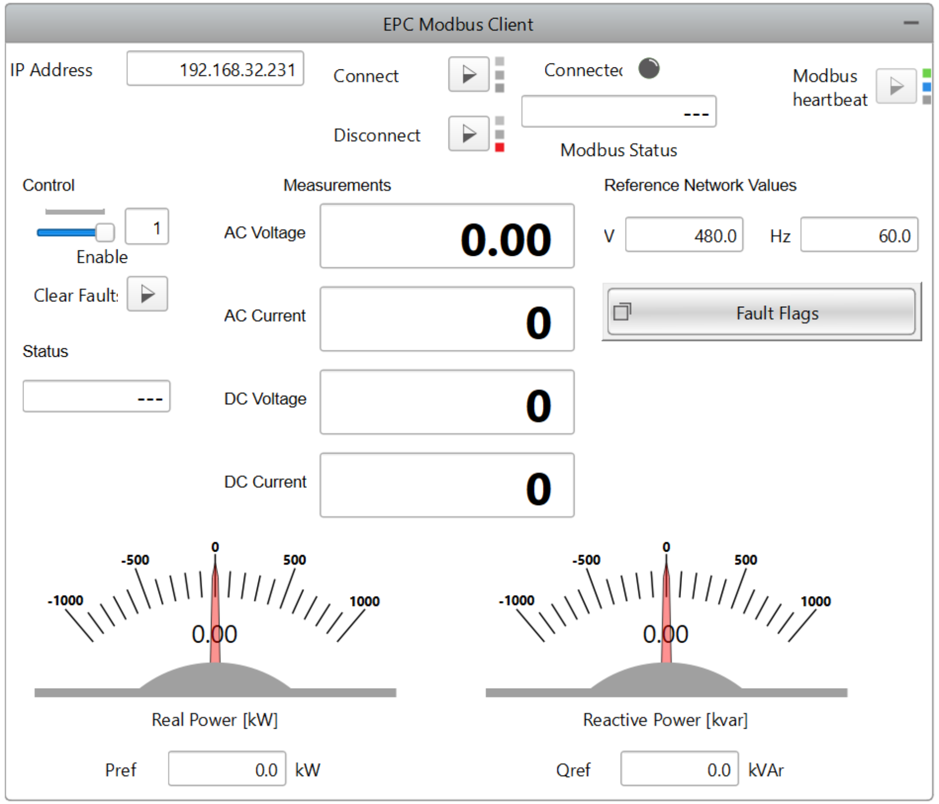
EPC Modbus on SEL RTAC

Assigned by [redacted]

EPC Modbus on SEL RTAC

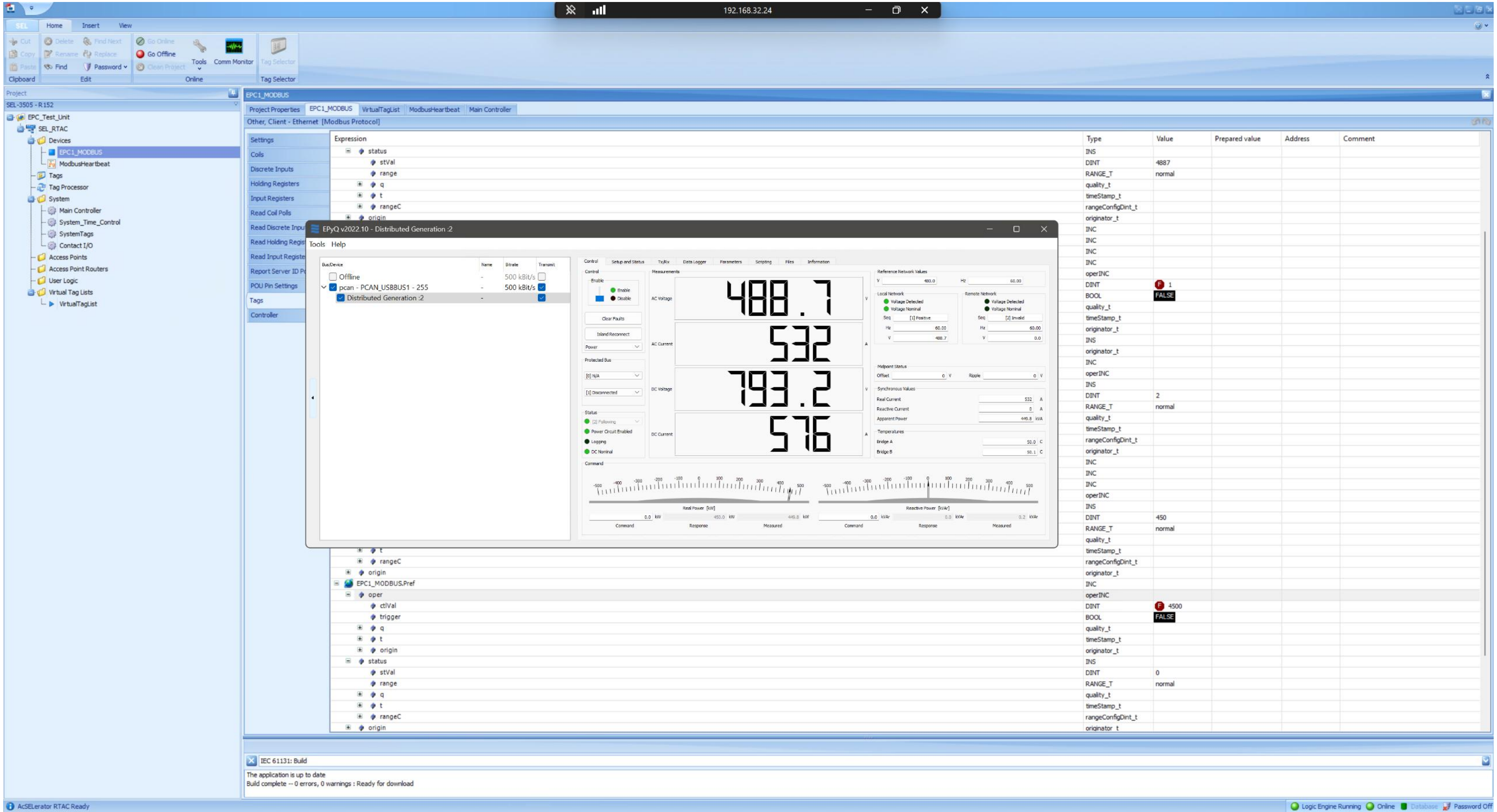
- **Resolved long-standing issue** where [redacted] could not read/write Modbus values from the EPC.
- Developed **SEL RTAC project file** capable of both reading and writing EPC Modbus registers.
- Implemented custom code to **enable/disable write triggers** dynamically, simulating a Modbus heartbeat for reliable communication.
- Created a reusable approach for future Modbus-based EPC integrations.





[redacted]

RTAC in Action



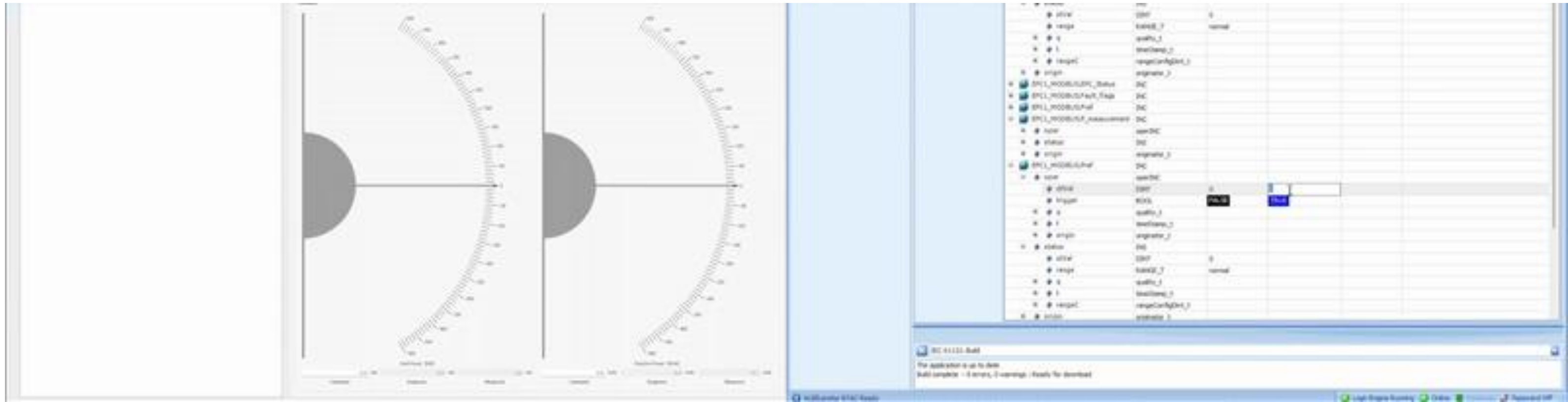
RTAC in Action

VirtualTagList.AC_Disconnect	BOOL	FALSE
VirtualTagList.B_EE_S	BOOL	FALSE
VirtualTagList.Bad_EE_Header	BOOL	FALSE
VirtualTagList.CF	BOOL	FALSE
VirtualTagList.CmdMsg_Invalid	BOOL	FALSE
VirtualTagList.Conden	BOOL	FALSE
VirtualTagList.CR	BOOL	FALSE
VirtualTagList.CS	BOOL	FALSE
VirtualTagList.Ctrl_Board_Voltage	BOOL	FALSE
VirtualTagList.E_Stop	BOOL	TRUE
VirtualTagList.External_Inhibit	BOOL	FALSE
VirtualTagList.Fan_Circuit	BOOL	FALSE
VirtualTagList.Fuse	BOOL	FALSE
VirtualTagList.Ground_Fault	BOOL	FALSE
VirtualTagList.I2C	BOOL	FALSE
VirtualTagList.Illegal_Transition	BOOL	FALSE
VirtualTagList.Overcurrent_AC	BOOL	FALSE
VirtualTagList.Overcurrent_DC	BOOL	FALSE
VirtualTagList.Overload_Thermal	BOOL	FALSE
VirtualTagList.Overtemp_Baseplate	BOOL	FALSE
VirtualTagList.Overtemp_Device	BOOL	FALSE
VirtualTagList.Overtemp_Internal	BOOL	FALSE
VirtualTagList.Overtemp_Inverter	BOOL	FALSE
VirtualTagList.Overvoltage_AC	BOOL	FALSE
VirtualTagList.Overvoltage_DC	BOOL	FALSE
VirtualTagList.POR	BOOL	FALSE
VirtualTagList.Power_Imbalance	BOOL	FALSE
VirtualTagList.Timed_Circ_Current	BOOL	FALSE
VirtualTagList.Timed_Overload_AC	BOOL	FALSE
VirtualTagList.Timed_Overload_DC	BOOL	FALSE
VirtualTagList.Undervoltage_DC	BOOL	FALSE
VirtualTagList.UTM	BOOL	FALSE

Undervoltage DC	Ground Fault
Overvoltage DC	Control Bd. Undervo
Overcurrent DC	External Inhibit
Overcurrent AC	I2C
Power Ch. Imbalance	Control Message
di/dt	Illegal Transition
Timed DC Overload	E-Stop
Timed AC Overload	Condensation
Timed AC Overvoltag	Baseplate Overtempe
Timed Circ. Current	Internal Overtempera
Fan Circuit	Cooling System
Fuse Open	Low Cooling Flow
AC Disconnect	POR Timeout

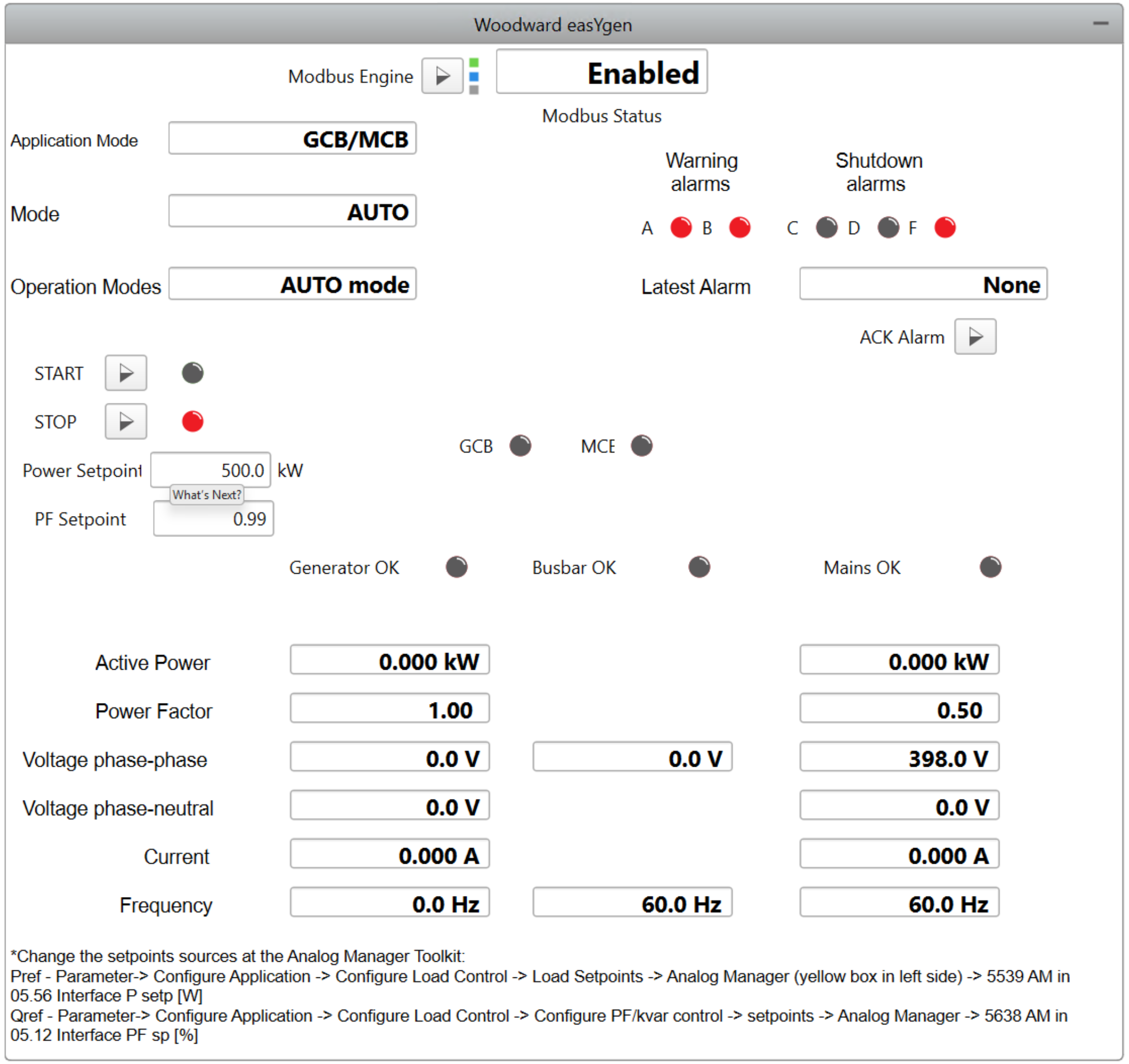
EPC Modbus on SEL RTAC – Why?

- ☐ **Direct Customer Impact** – Resolved a long-standing issue for Texas Tech where EPC Modbus values could not be read or written.
- ☐ **Enhanced Functionality** – Delivered an SEL RTAC project file enabling full read/write access to EPC Modbus registers.
- ☐ **Reusable Solution** – Created a framework that can be applied to other EPC Modbus integrations.
- ☐ **Builds Customer Trust** – Demonstrates Typhoon HIL's ability to quickly solve real-world interoperability problems.

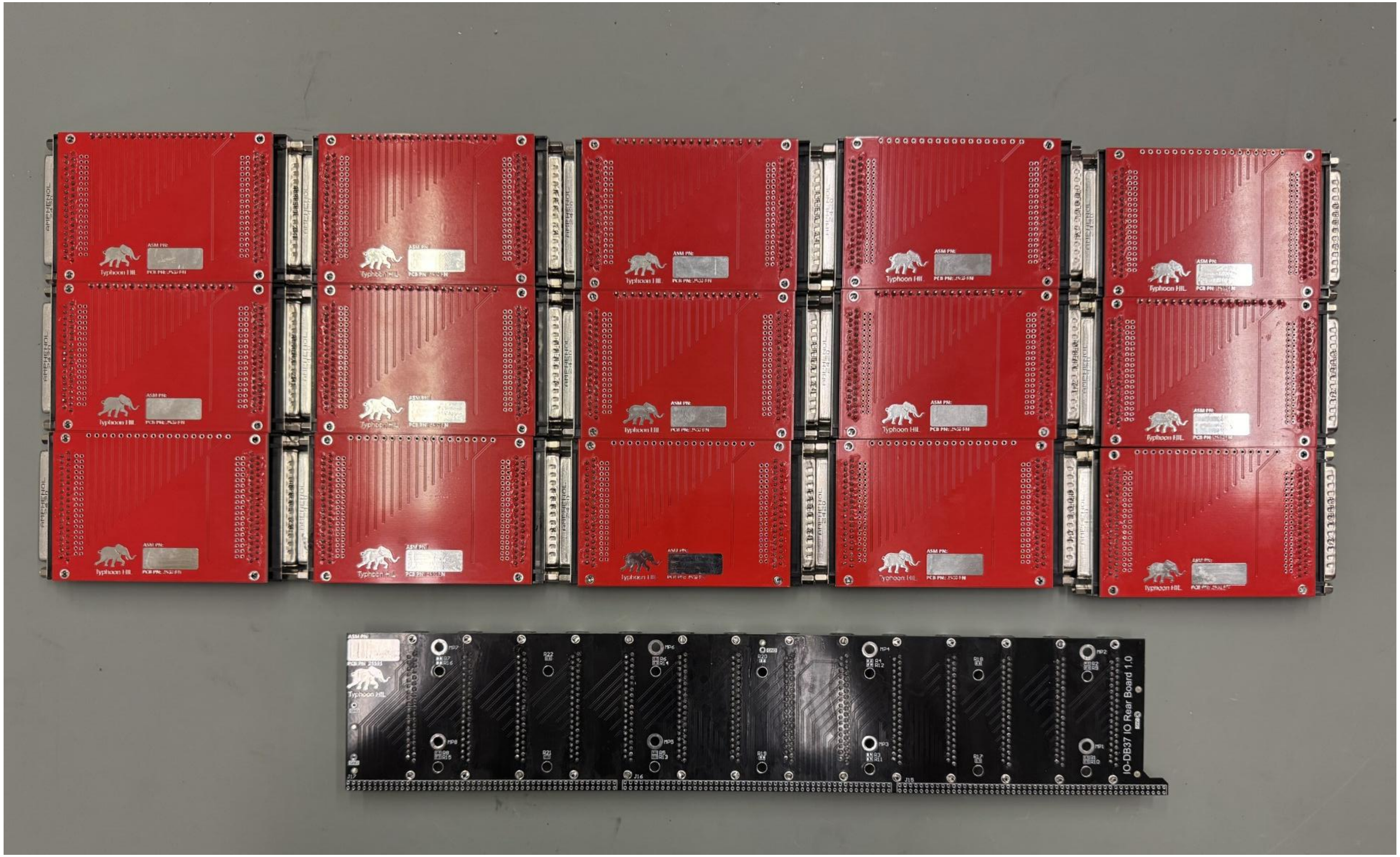


Miscellaneous Tasks

- ☐ Soldering
- ☐ Rack Construction, Shipping, and Receiving
- ☐ Created SEL 700G Unit Test Settings File
- ☐ Helped debug Woodward easYgen Modbus widget
- ☐ Helped with CNC machine project
- ☐ Presentations with [redacted] & [redacted]



Soldering



What's Next?

- Finish up my Junior & Senior year
  - Graduation: May 2027
- Plan to Stay in Greater Boston next Summer & the following Summer
- Hope to continue my learning
  - Through Work
  - [redacted]
  - Through Classes

Thank You!