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Sensors with Intelligent Measurement Platform and Low-cost Equipment (SIMPLE)

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ComEd – Smart Grid and Innovation

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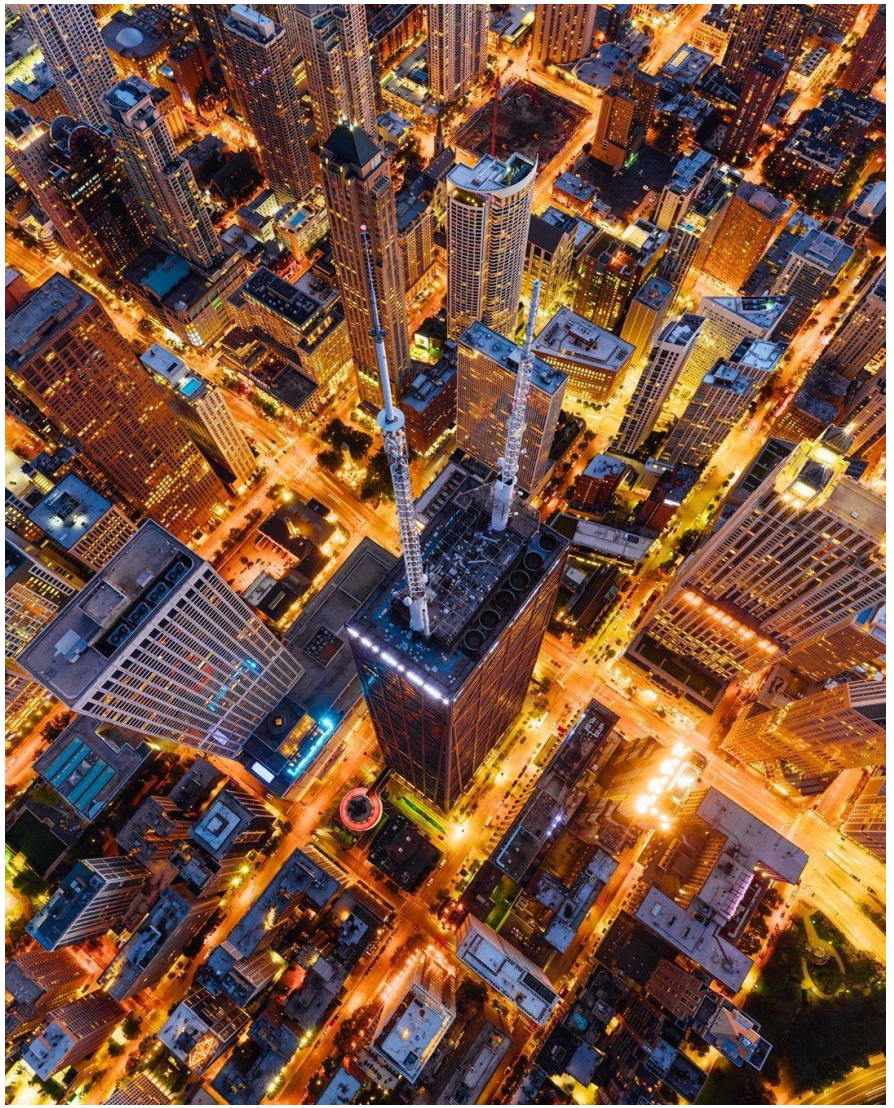
Our Company:
- One of six utilities owned by Exelon. (Exelon also owns generation and energy sales businesses.)
- 6,400 Employees
- Service Territory: 11,428 square miles

Our Customers:
- 4 million custcmers in northern Illinois, including the city of Chicago

Our Grid:
- Peak Load: 23,753 MW (7/20/2011)
- 553,800 distribution transformers
- 66,200 circuit miles of primary distribution
- 5,800 circuit miles of transmission
- 93% overhead, 7% underground



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Outline

- SIMPLE: Objective and Scope
- SIMPLE Architecture
- SIMPLE Use cases and Hardware-in-Loop Testing
- Field Demonstration
- Summary/Conclusion

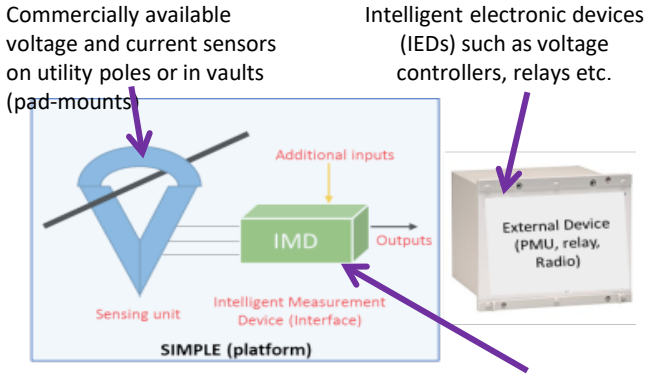
SIMPLE: Objectives and Scope

Objectives

- Development and introduction of voltage/current sensors with enhanced characteristics (accuracy, bandwidth and harmonic range) and high measurement granularity for medium voltage distribution system monitoring, DER monitoring, protection, and controls
- Enhancement of existing (commercially available) voltage/current sensors that are used as inputs to Advanced SCADA Devices and Power Quality Measurement units for applications involving distribution PMUs and field power quality analyzers
- Development of performance requirements and functional specifications for voltage/current sensors

Scope

- Develop new prototype system
- Perform high voltage/high current testing
- Perform hardware-in-loop application testing at ComEd's RTDS lab
- Field demonstration within ComEd service territory



Intelligent Measurement Device (IMD): An electronic platform

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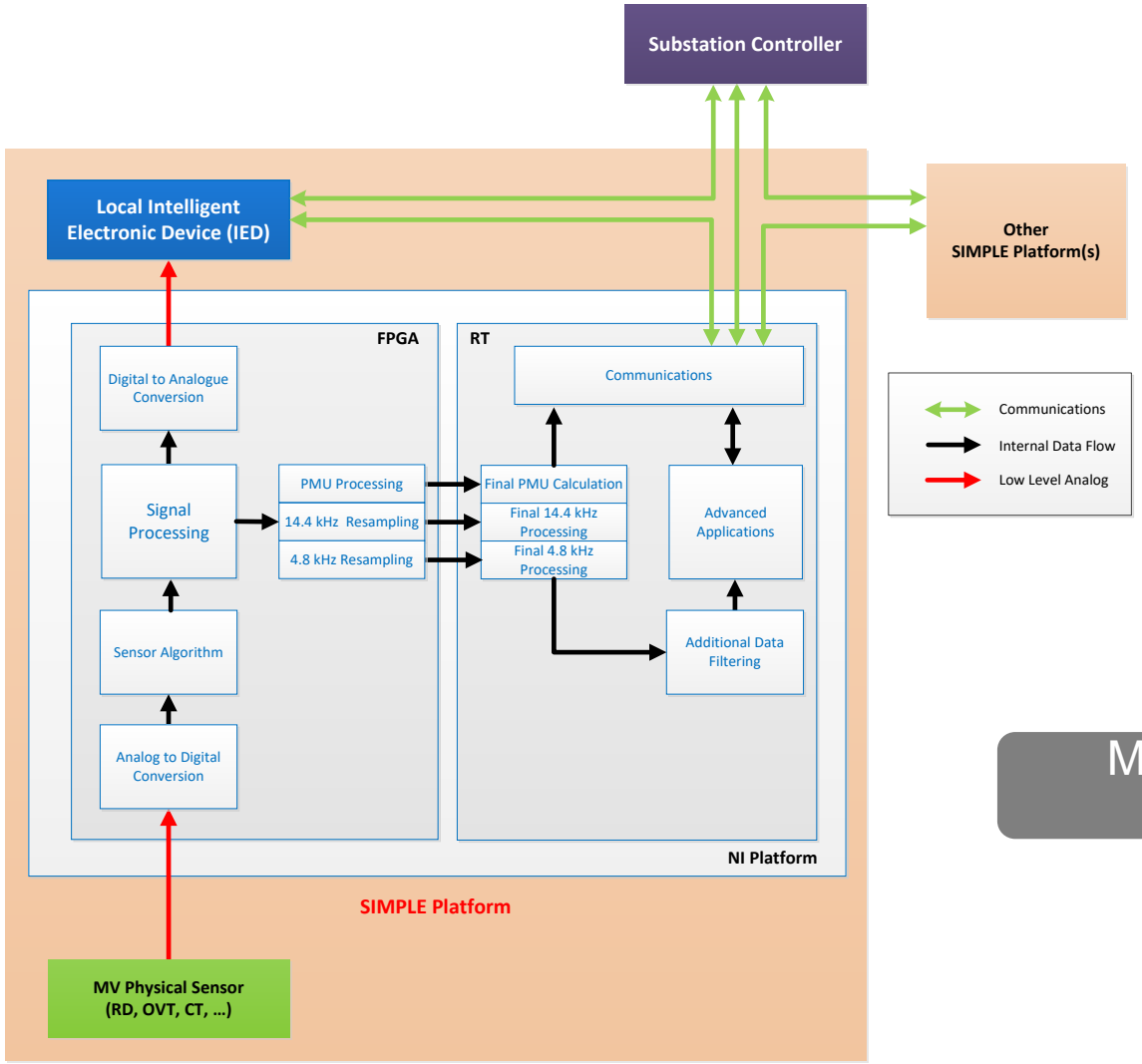
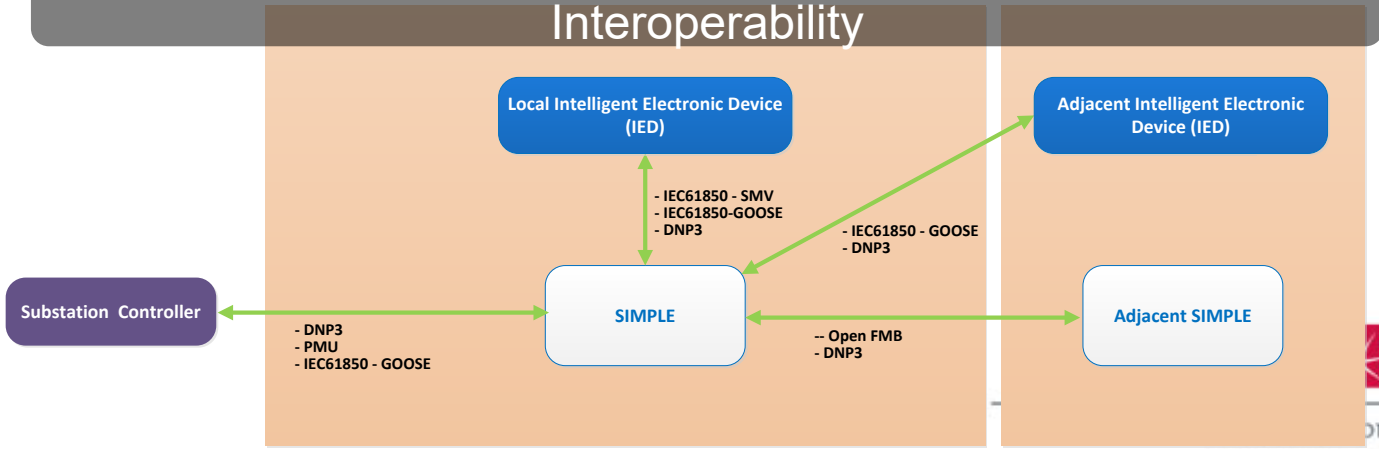
SIMPLE Architecture and Prototype



SIMPLE Prototype

Multiple Communication Protocol Support to enhance Interoperability



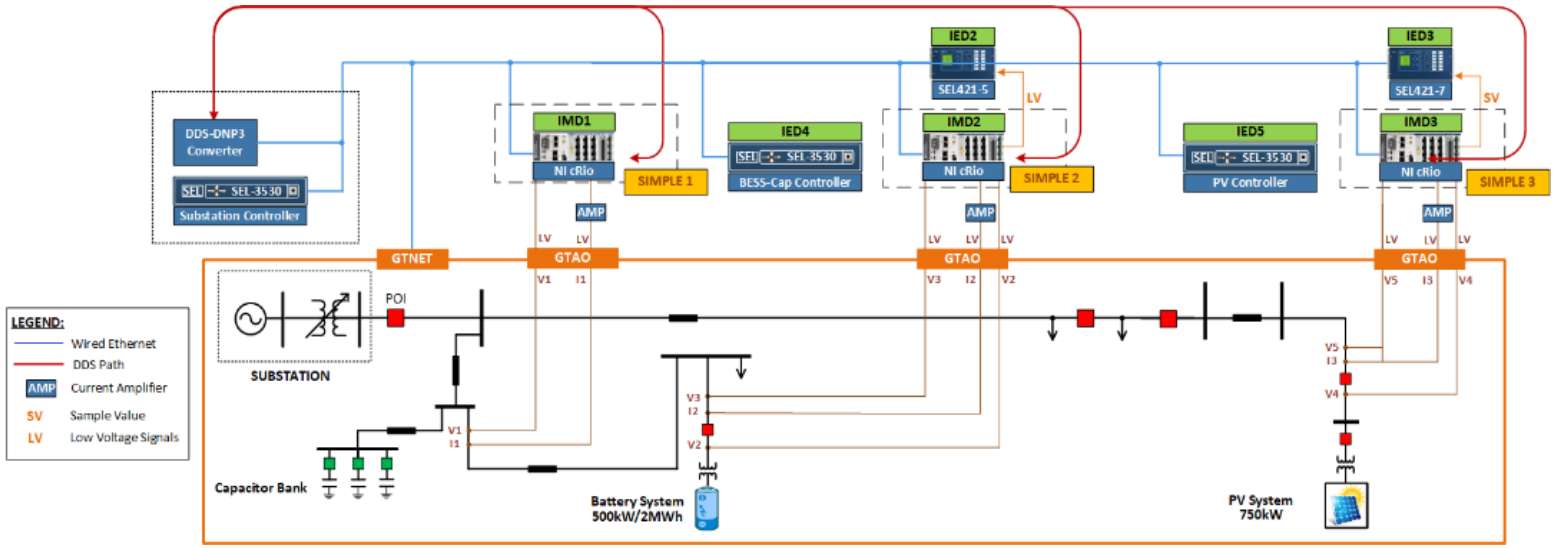
SIMPLE: Use Cases and HIL Lab Test Setup

Use Case 1: Distribution Circuit Monitoring (DCM)

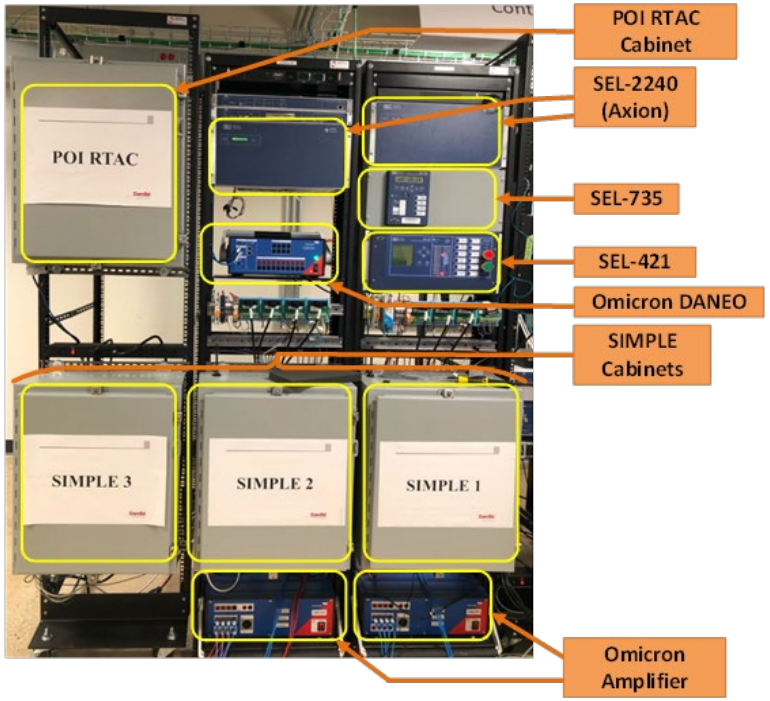
a) Monitoring voltage and power flow across the distribution system
b) Obtain data for root-cause analysis, maintenance, and pre-event analysis

Use Case 2: Automatic Resource Control (ARC)

a) Manage operation of DERs with feeder-level devices to improve feeder voltage profile
b) Coordinated dispatch of DERs to manage feeder power flow



HIL Testbed schematic



HIL laboratory test setup

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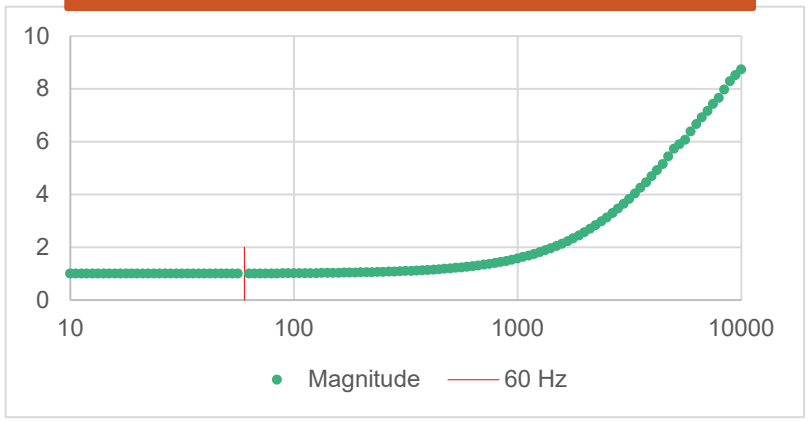
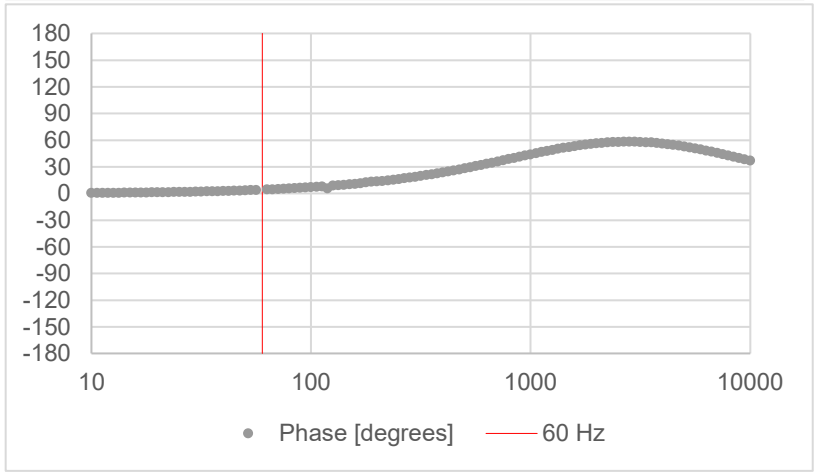
Sensor Characterization and Compensation – Voltage Sensor

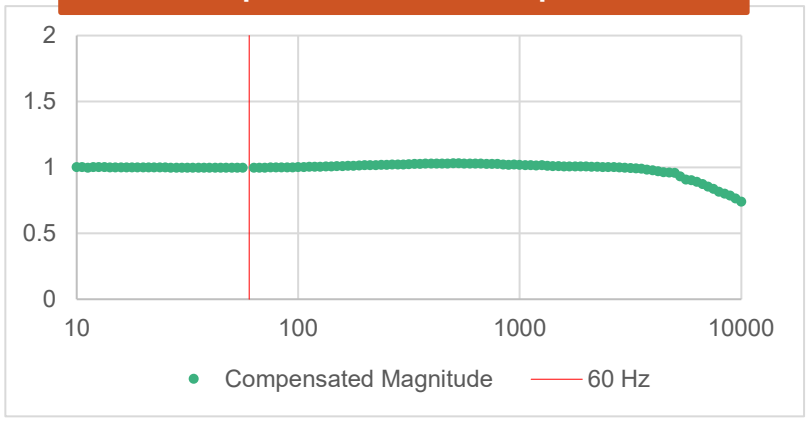
Frequency Response of a Lindsey 9E650 (Voltage Sensor) Combined Sensor with Compensation is compared with Response of Uncompensated Sensor

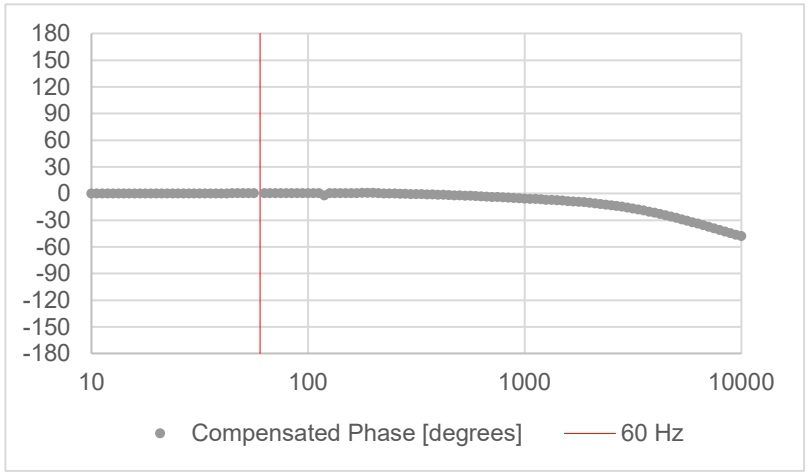
Uncompensated Response





Compensated Response





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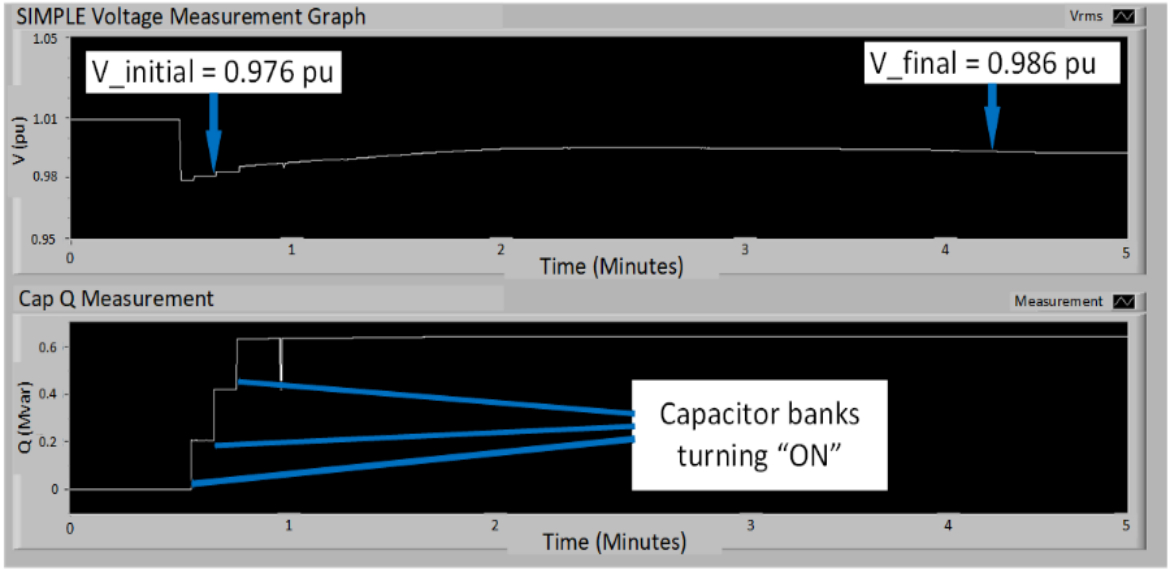
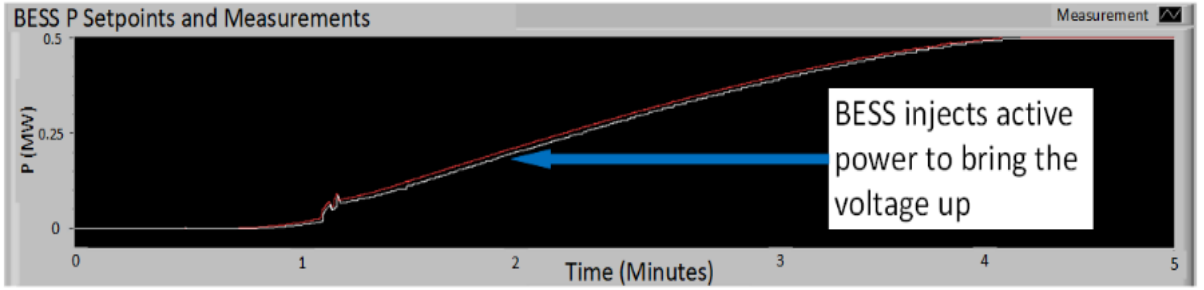
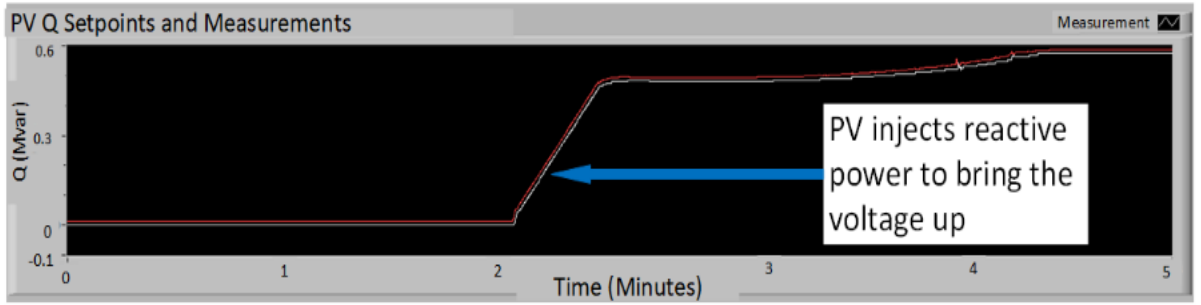
Automatic Resource Control: Voltage Control

- SIMPLE coordinates controllable distribution assets to achieve voltage control and power flow control objectives.

Management of DER Operation to Improve Voltage Profile







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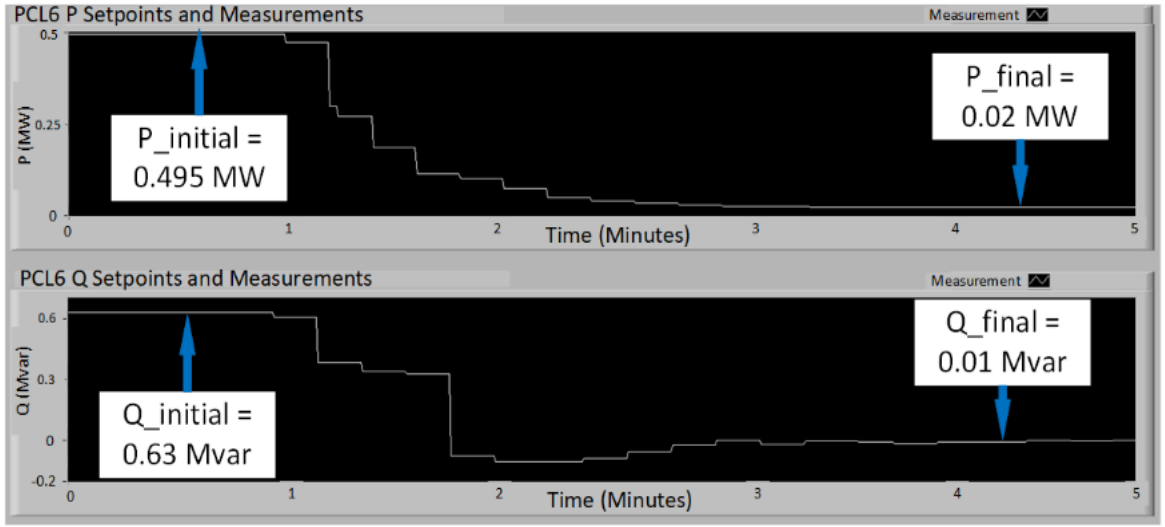
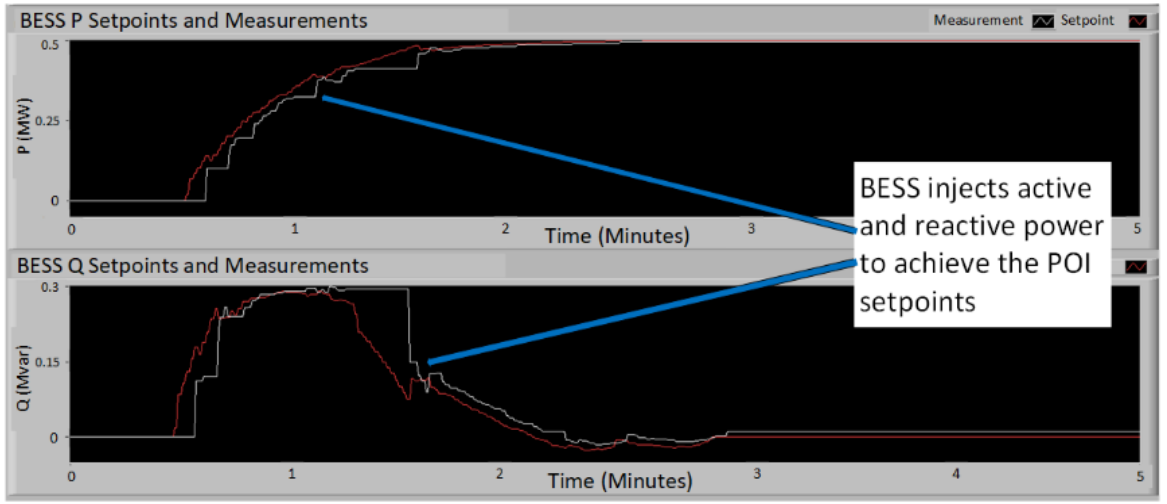
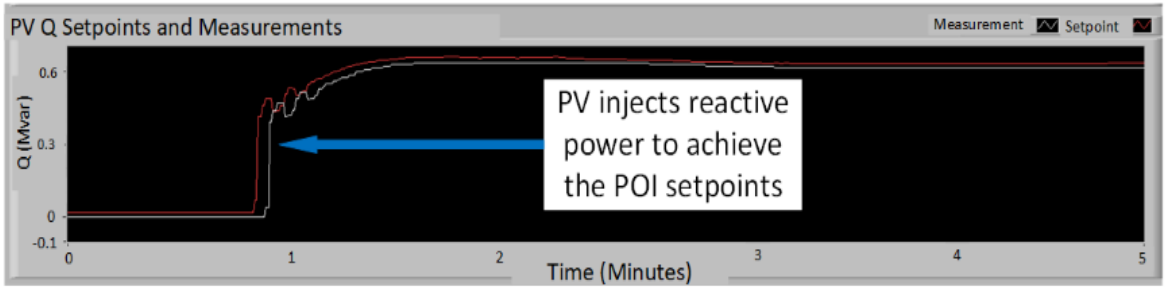
Automatic Resource Control: Feeder Power Flow Control

- SIMPLE coordinates controllable distribution assets to achieve voltage control and power flow control objectives.

Coordinated Dispatch of DERs to Manage Power Flow







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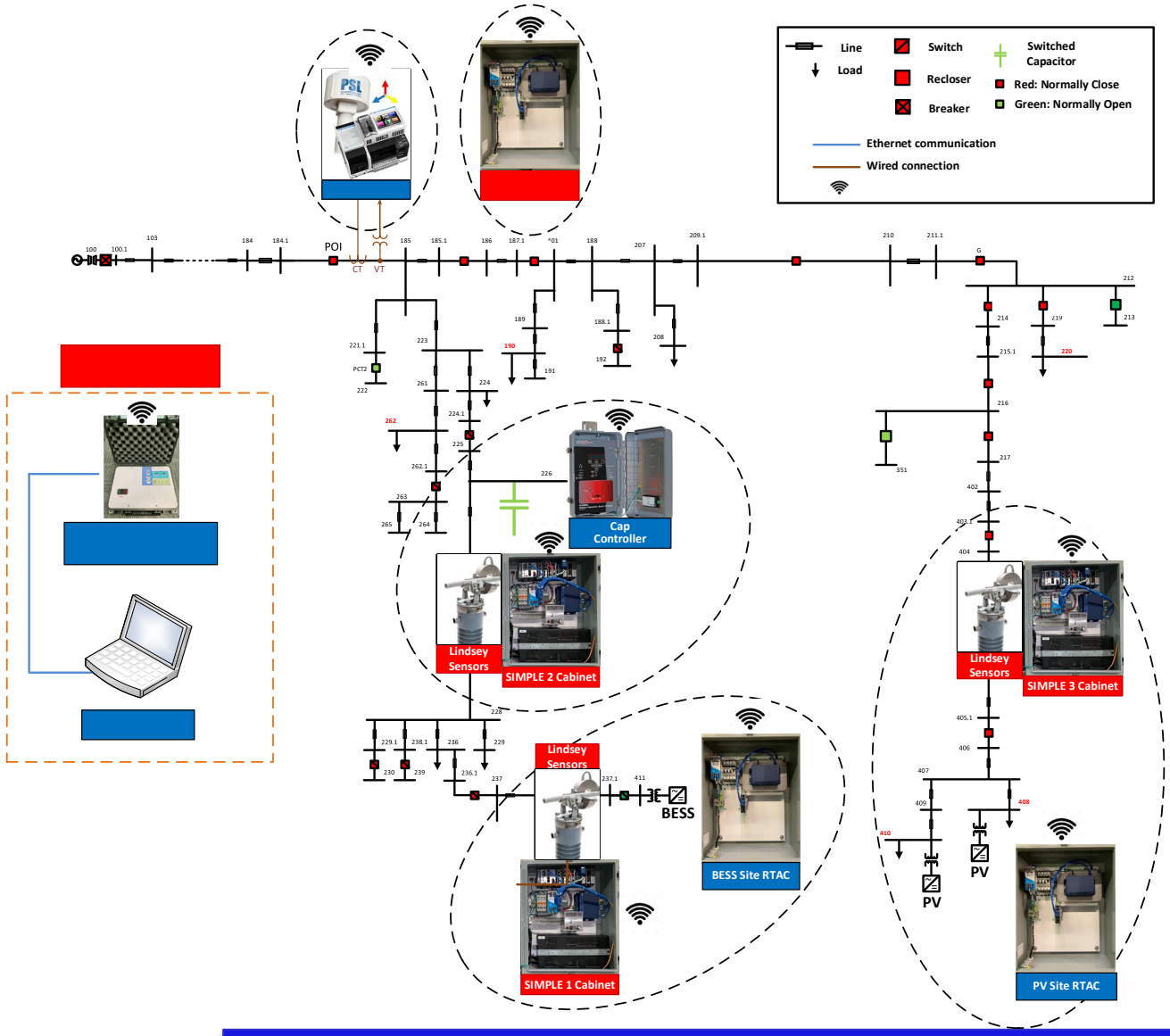
SIMPLE: Field Demonstration Use Cases



Field demonstration testbed

SIMPLE 1, SIMPLE 3 and the POI cabinet

SIMPLE 2 and MVCAL Cabinet

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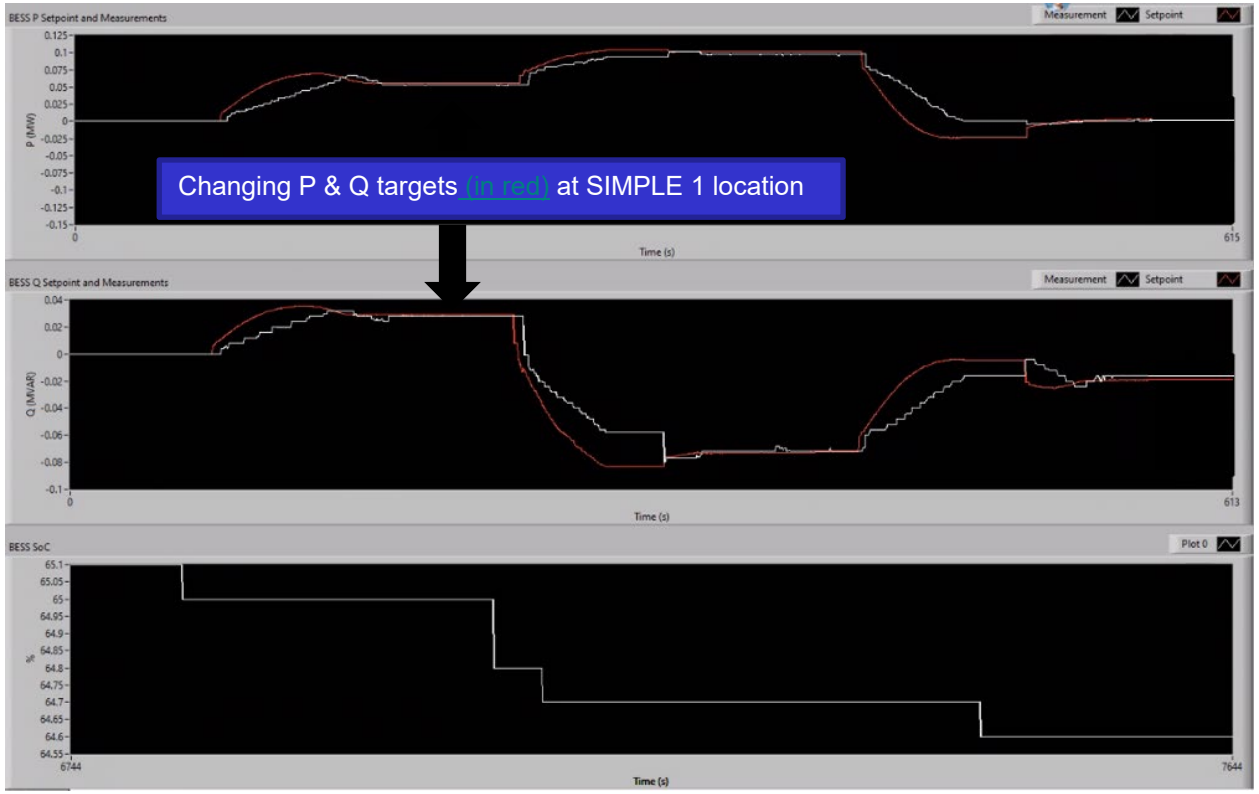
Field Test Cases: Communication Test and Application Test

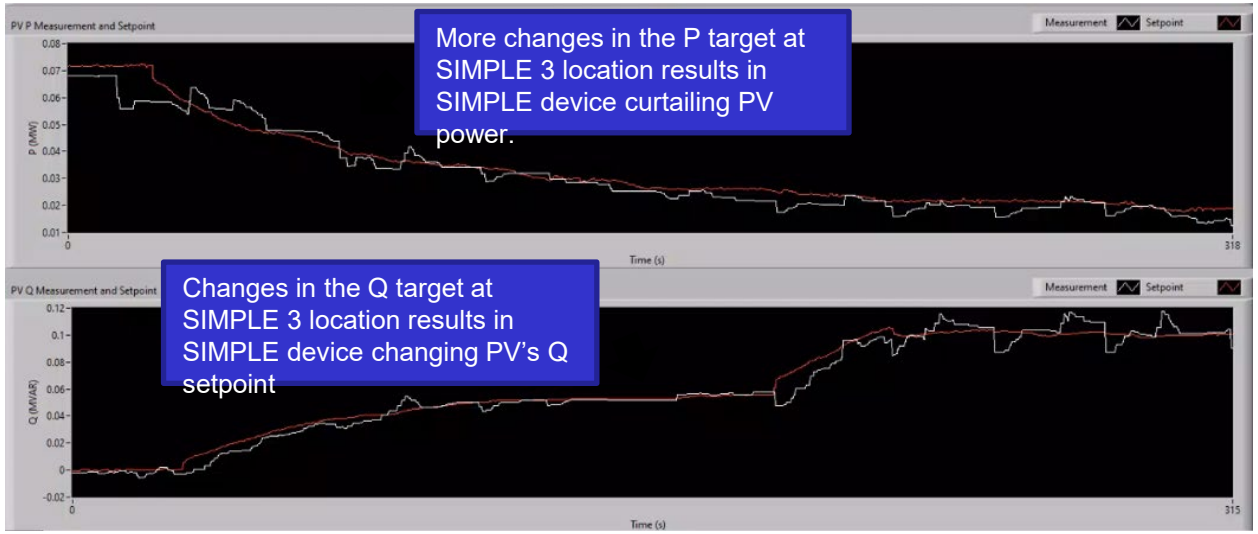
The communication tests focus on verifying the device-to-device communication and serves as a preparatory step for performing application tests. The application tests focus on application of SIMPLE for monitoring and control.

Test Case #	Radio Communication Test	Objective
1	Capacitor radio test	Verify capacitor controller's radio is functioning correctly and can receive/transmit data from the portable unit via DNP3 over radio
2	BESS RTAC radio test	Verify BESS RTAC's radio is functioning correctly and can receive/transmit data from the portable unit via DNP3 over radio
3	PV RTAC radio test	Verify PV RTAC's radio is functioning correctly and can receive/transmit data from the portable unit via DNP3 over radio
4	MicroPMU radio test	Verify radio communication between portable unit running PMU connection tester software and PSL MicroPMU
5	POI cabinet radio test	Verify radio communication between portable unit and the industrial PC (inside POI cabinet) with remote desktop connection
6	SIMPLE 1, 2 & 3 radio tests	Verify communication between the remote interface (i.e. HMI running on the portable unit) and SIMPLE 1, 2 & 3
7	DDS network communication test	Verify the DDS network where the devices communicate with each other through monitoring and control using the HMI running on the portable unit

Application Test Category	Application Test Description	Application Test Objective
1-a	Monitor voltage and power flow across the distribution system	Verify the ability of the SIMPLEs to monitor the voltage and power flow at their point of connection and to generate reports and alarms if required
1-b	Obtain data for root-cause analysis, maintenance, and pre-event analysis	Verify the ability of the SIMPLE devices to obtain data used for root-cause analysis, maintenance, and pre-event analysis, such as device loadings, capacitor switching, etc.
2-a	Local dispatch of each DER or distribution asset to manage local power flow	Evaluate the ability of each SIMPLE in managing the operation of its adjacent DER or distribution asset to manage local power flow
2-b	Coordinate dispatch of DERs and distribution assets to manage power flow	Evaluate the ability of the SIMPLE devices to do coordinated dispatch of DERs and distribution assets to manage feeder power flow
2-c	Local control of each DER or distribution asset to regulate local voltage	Evaluate the ability of each SIMPLE in managing the operation of its adjacent DER or distribution asset to regulate local voltage
2-d	Coordinated control of DERs and distribution assets to regulate feeder voltage	Evaluate the coordinated control of SIMPLE devices in managing the operation of DERs and distribution assets to regulate feeder voltage

Field Test : Local Dispatch of BESS to Manage Local Power Flow





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Field Test : Coordinate Dispatch of DERs to Manage Feeder Power Flow

SIMPLE devices coordinate the operation of BESS and PV to regulate the power flow at the POI.

#	POI Target Values*		Maximum Power Limit Settings for DERs		POI Power Measurements		
	P_{set} (MW)	Q_{set} (MVA)	BESS (MVA)	PV (MVA)	P (MW)	Q (Mvar)	Timer (starting at time 00:00:00)
1	P_{meas}	Q_{meas}	0.1	0.4	0.6	-0.15	00:00:00
2	P_{meas} - 0.05	Q_{meas}	0.1	0.4	0.55	-0.15	00:02:00
3	P_{meas} + 0.05	Q_{meas}	0.1	0.4	0.65	-0.15	00:12:00

** P_{meas} and Q_{meas} are the power measurements at POI before the 'feeder power control' is activated. For instance, if initially POI P_{meas} = 0.6MW, Q_{meas} = -0.15Mvar, then in row #2: P_{set} = 0.55MW, Q_{set} = -0.15Mvar.*

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Summary/Conclusion

- An intelligent digital sensor platform has been designed that facilitates enhanced performance and improved accuracy and bandwidth with digital voltage and current measurement.
- The platform serves as an interoperable solution with sensor correction and digital compensation, and can also host advanced grid monitoring and control applications.
- The solution has been tested and validated in laboratory using HIL environment.
- The characterization and correction of sensor data using digital platform has been validated in both laboratory and field environment.
- The application of this new platform for both monitoring and coordinated control of distribution assets in an actual feeder has been demonstrated successfully to meet DOE requirements.

Thank you!