Stanford University

SLAC NATIONAL ACCELERATOR LABORATORY

Communication: Stanford & SLAC Labs

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Communications and Labs

- Challenges
- Approach
- Measurements
  - Measurement Points
  - Type
  - How are we doing it?
- Communications
  - Within home
  - Protocols
- Labs
  - Stanford Lab
  - SLAC Lab

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Challenges

- How to successfully run a large scale project with many different sources of data and communication interfaces?
  - Being able to correctly measure the right variables at the right points;
  - Understand bandwidth of variables and events – sampling rate;
  - Synchronization between data sources;
  - Understand different communication protocol requirements;
  - Create unit test to stress the system and identify potential problems.

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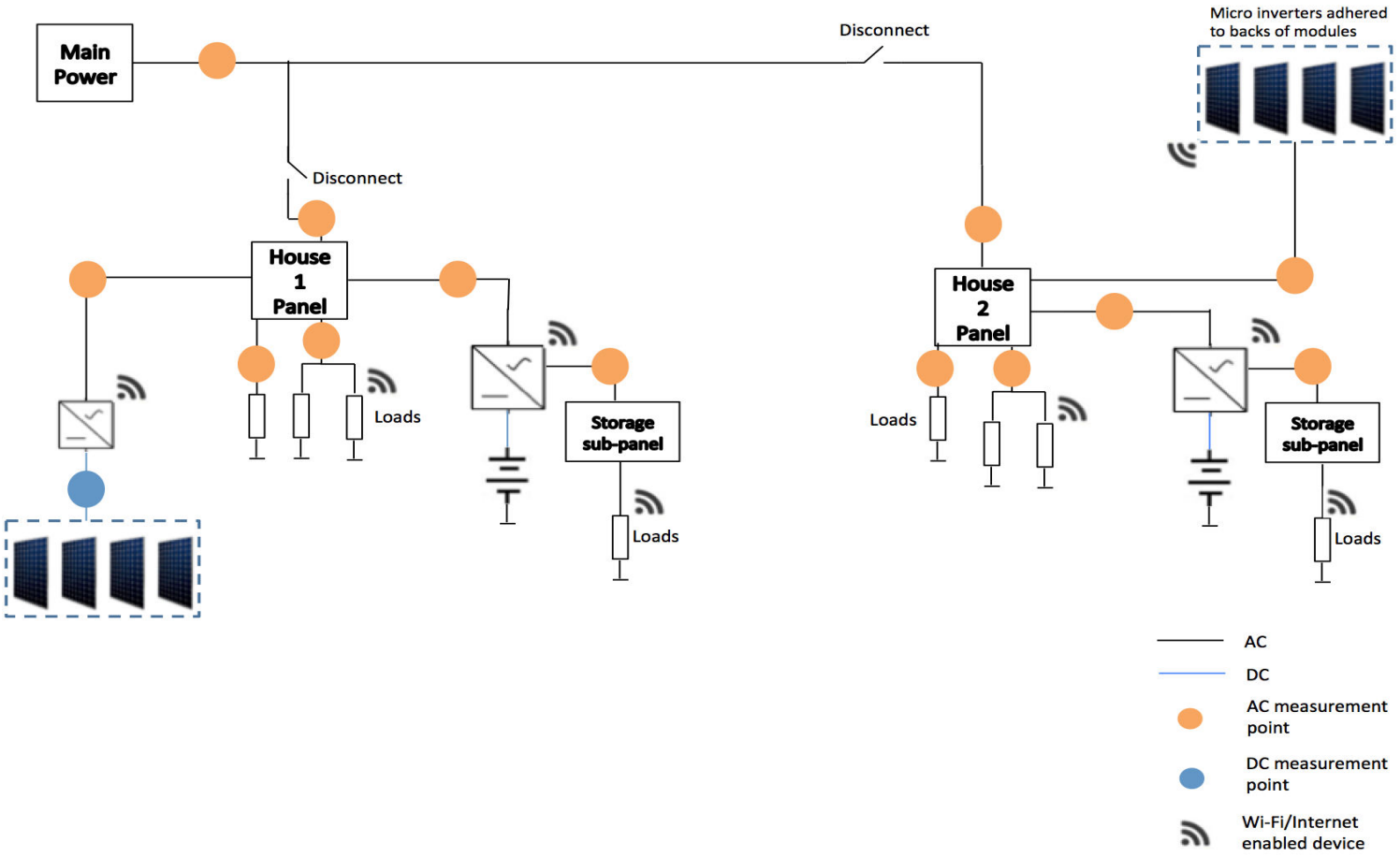
Approach

- Stanford University Lab (SU-Lab) and SLAC-Lab will follow same approach regarding measurement points within each home, such that:
  - Create a standard procedure that is easily replicable;
  - Utilize this procedure at the Navy homes.

Measurement Points



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Measurement: Types

MEASUREMENT POINTS	TYPE OF SIGNAL	CONNECTION
Mains	AC	Wired
Smart Dim Fuse (at breaker level)	AC	Wired
Loads (with smart plugs)	AC	Wireless
Loads (without smart plugs)	AC	Wired
Smart Appliance (available API)	AC	Wireless
Solar Inverter	AC	Wired/Wireless
Solar Panel	DC	Wired
Storage Inverter	AC	Wired/Wireless

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Measurement: How we are doing?

- Each home equipped with a Data Acquisition System (DAQ) -> concentrate measurements in single unit:
  - Flexible sampling rate -> different loads require different rates
  - Easy synchronization within home -> measurements share same reference clock

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Communication: Types

- Within homes – wireless and wired:
  - Wireless protocol: standard HTTPS
  - Wireless network: Wi-Fi and 4G (when former is not practical or as backup)
  - Wired: device dependent (see next table)

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Communication Protocols

- Wired protocols:

MEASUREMENT POINTS	PROTOCOL
Mains	Serial
Smart Dim Fuse (at breaker level)	Ethernet – UDP/Serial
Loads (without smart plugs)	Serial
Solar Inverter	Modbus/RS485
Solar Panel	Serial
Storage Inverter	Modbus/RS485

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Communication Protocols

- Other communications:
  - Home Hub (HH) with Cloud Coordinator (CC)
  - Utility/ISO with CC (and HH)

TO	FROM	PROTOCOL
HH/CC	CC/HH	HTTPS
Utility/ISO	CC/HH	IEC61850/IEEE2030/DNP3

Stanford Lab

- **Features**
  - Emulate 2 homes – one with real loads and one with simulated loads
  - 1021 sq-ft lab space
  - Electronic isolated from Stanford's electric grid
  - Excess energy is regenerated back to Stanford's grid
  - Roof top PV
  - Energy storage up to 20kWh
- **Equipment**
  - Grid Simulator
  - Home appliances: Washer, dryer, water heater, AC, smart appliances, inverters, etc
  - DERs: Solar panel systems, battery storage system
  - Simulated loads: AC and DC load simulators, solar array system simulator, battery simulator

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SLAC Lab

- Features
  - Emulate up to 4 homes on-site
  - 2000 sq-ft building space
  - Controllable loads and generation makes it possible to be on and off grid;
  - Flat roof top for PV installation
  - Energy storage up to 20kWh
- Equipment
  - Hardware-in-the-loop simulator: Opal-RT
  - Home appliances: Washer, dryer, water heater, AC, smart appliances, inverters, etc
  - DERs: Solar panel systems, battery storage system, EV charging station
  - Simulated loads: AC load simulators

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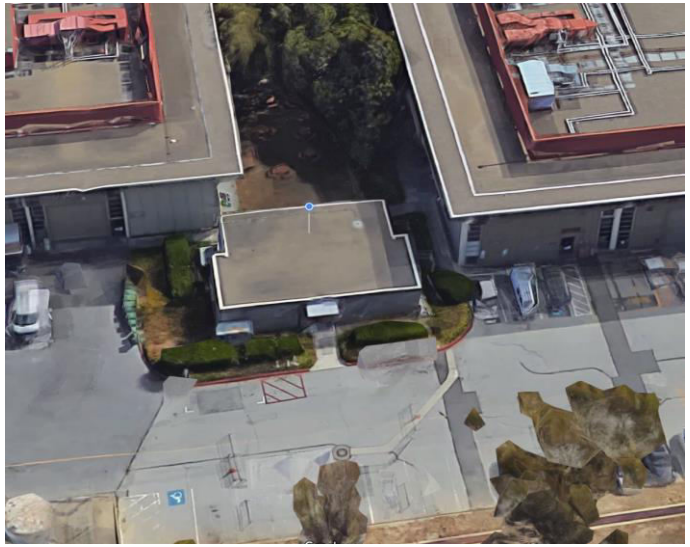
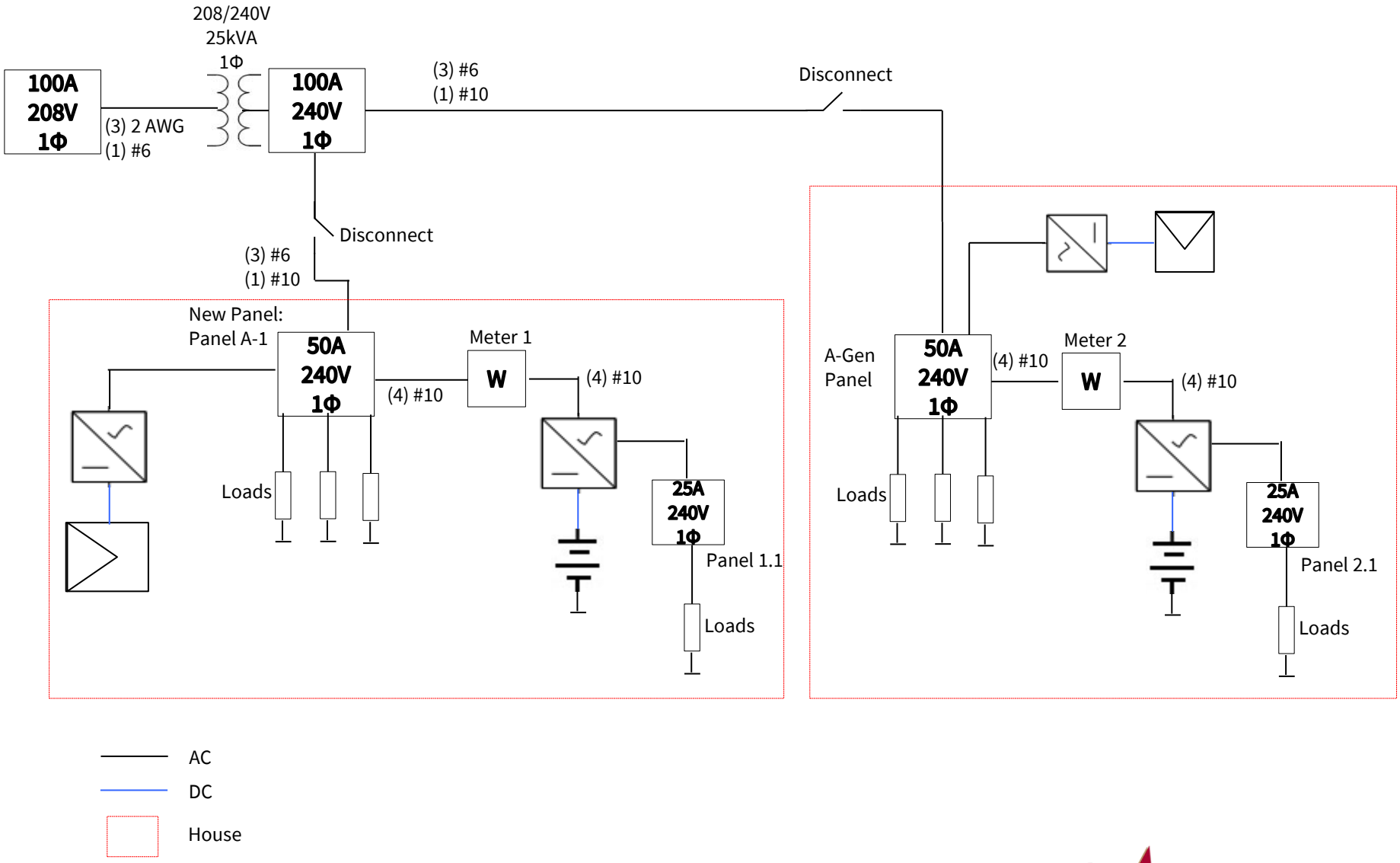
SLAC Lab



SLAC Lab



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Questions? Feedbacks?

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