Synchrophasor (PMU) Development

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McIlvaine Company Hot Topic Hour on "Solar & Wind Strategies, Projects and Technology Developments"

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AMERICAN CAPITAL ENERGY

Interconnect Issues Contributing to "Soft" Costs in PV Plant Deployment

- PV and wind intermittency is basic issue
- Current SCADA-based PV power plant supervision and control is system of choice for utilities
- SCADA is not suited for real time PV plant control that will best deal with intermittency
- Combination of Smart Grid for demand-side and enhanced real time PV plant generation-side monitoring and control may be solution

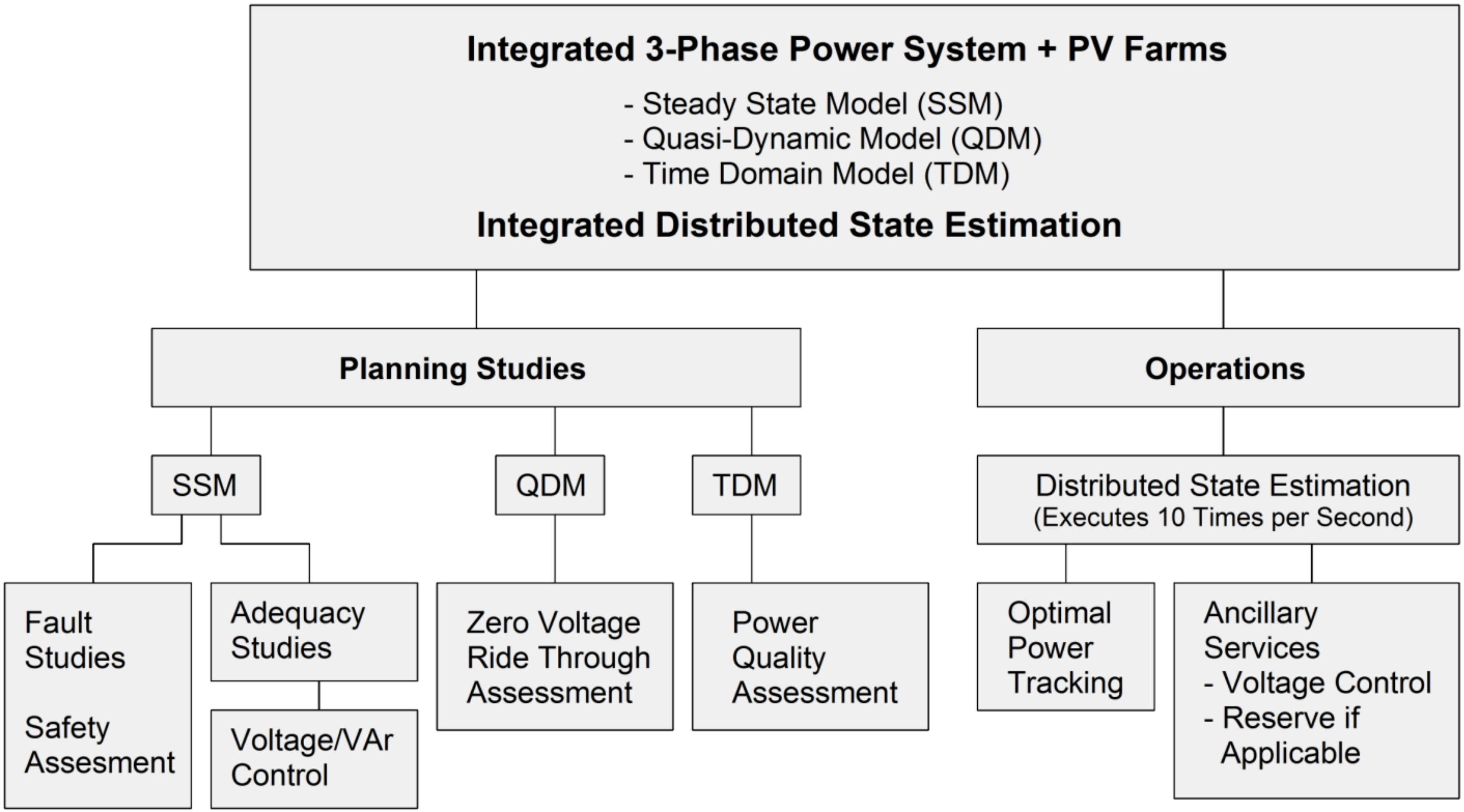
Reference: "Development of a Model for Integrated PV Power Plant Design, Impact Studies, Commissioning and Operations", A. P Meliopoulos, A. Ellis and J. Kalejs, paper presented in session on PV Power Plants at Intersolar Europe, June, 2012)

Planning Model Requirements

- Many types of models
  - Transient, Dynamic, Power Flow, Short Circuit
- Different applications
  1. Plant/Controls Design or Interconnection Studies
     - Use best model available
  2. System Planning
     - Reliability organizations are required to maintain power flow and dynamic base cases for regional planning
       - Strongly discourages user-written black-box, non-standard models
       - Proprietary models are generally inadmissible for this application
     - Must be validated periodically

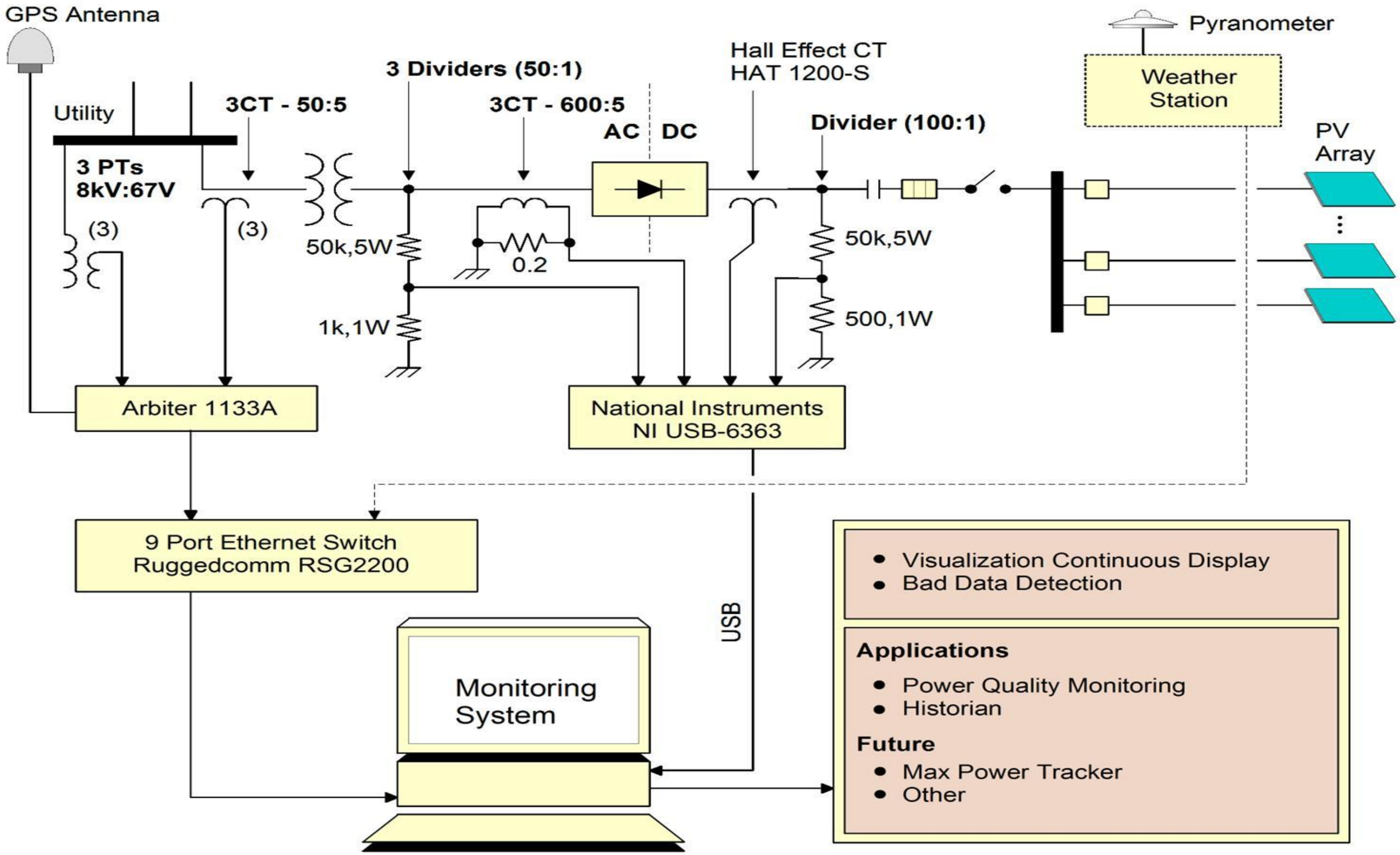
PV Plant Performance Analysis and Control Strategy

One Physical Model for Three Types of Analysis: (a) Steady State, (b) Quasi-Dynamic, and (c) Time Domain
Seamless Applications: (a) Ancillary Services, (b) Fault Studies, (c) Adequacy Studies, etc. (see graph below)



PMU-Based PV Plant Real Time Operation and Control

The system collects data at 60 times per second. GPS synchronized data acquisition systems are preferred (figure shows the use of Arbiter 1133A PMU and the National Instruments USB-6363. Both AC and DC sides are monitored. The data are collected at a PC which time-aligns the data, performs state estimation that provides the validated real time model for utility ancillary services.



Product Development and Validation

Alpha test site – ACE 1,160 kW PV plant for Buckman water treatment site, Santa Fe, NM

Buckman PV Monitoring Installation

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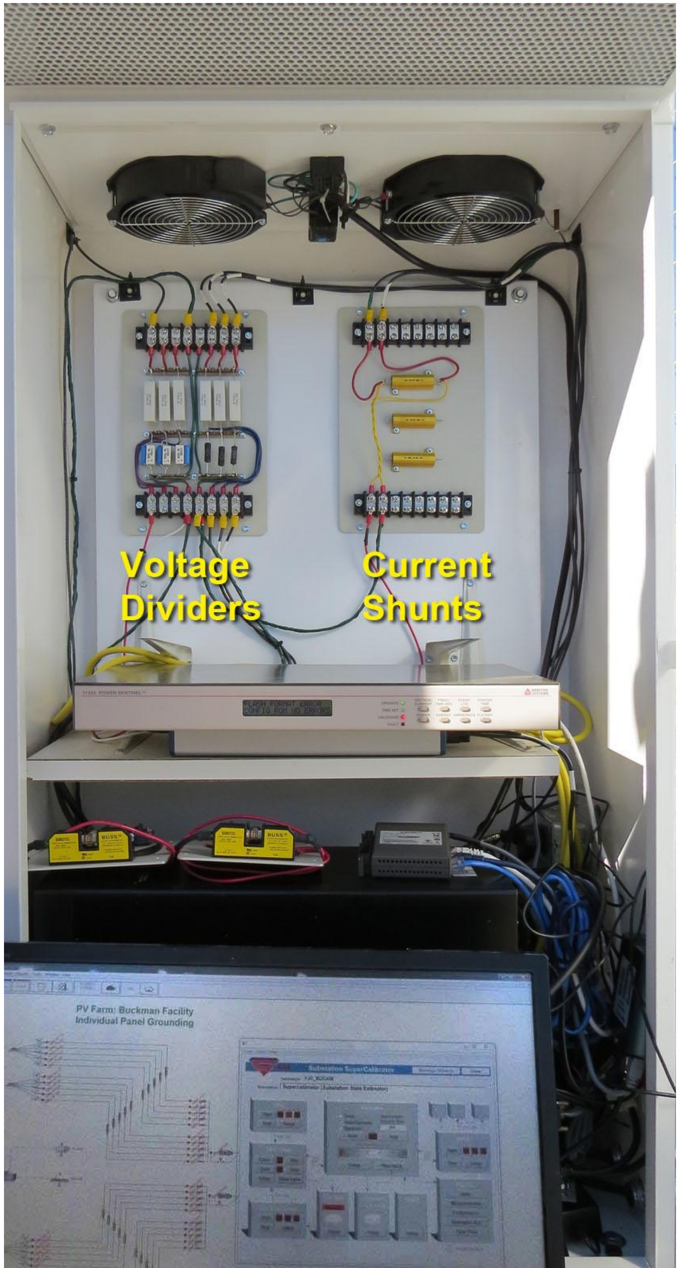
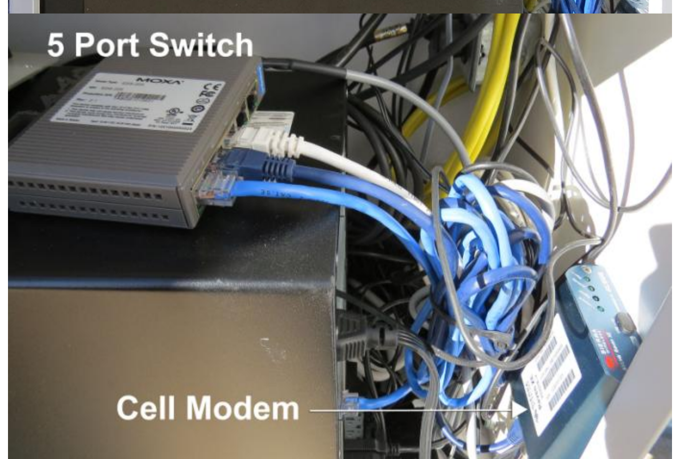
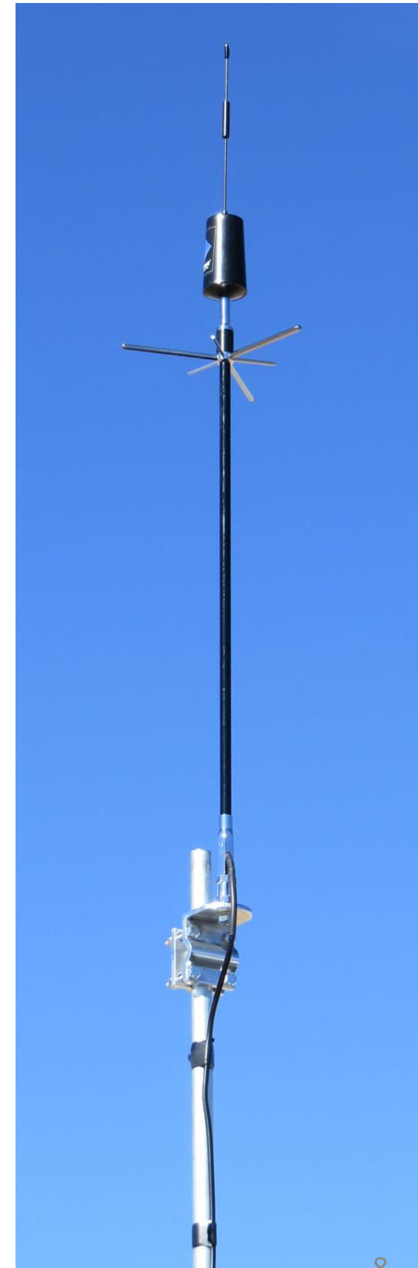
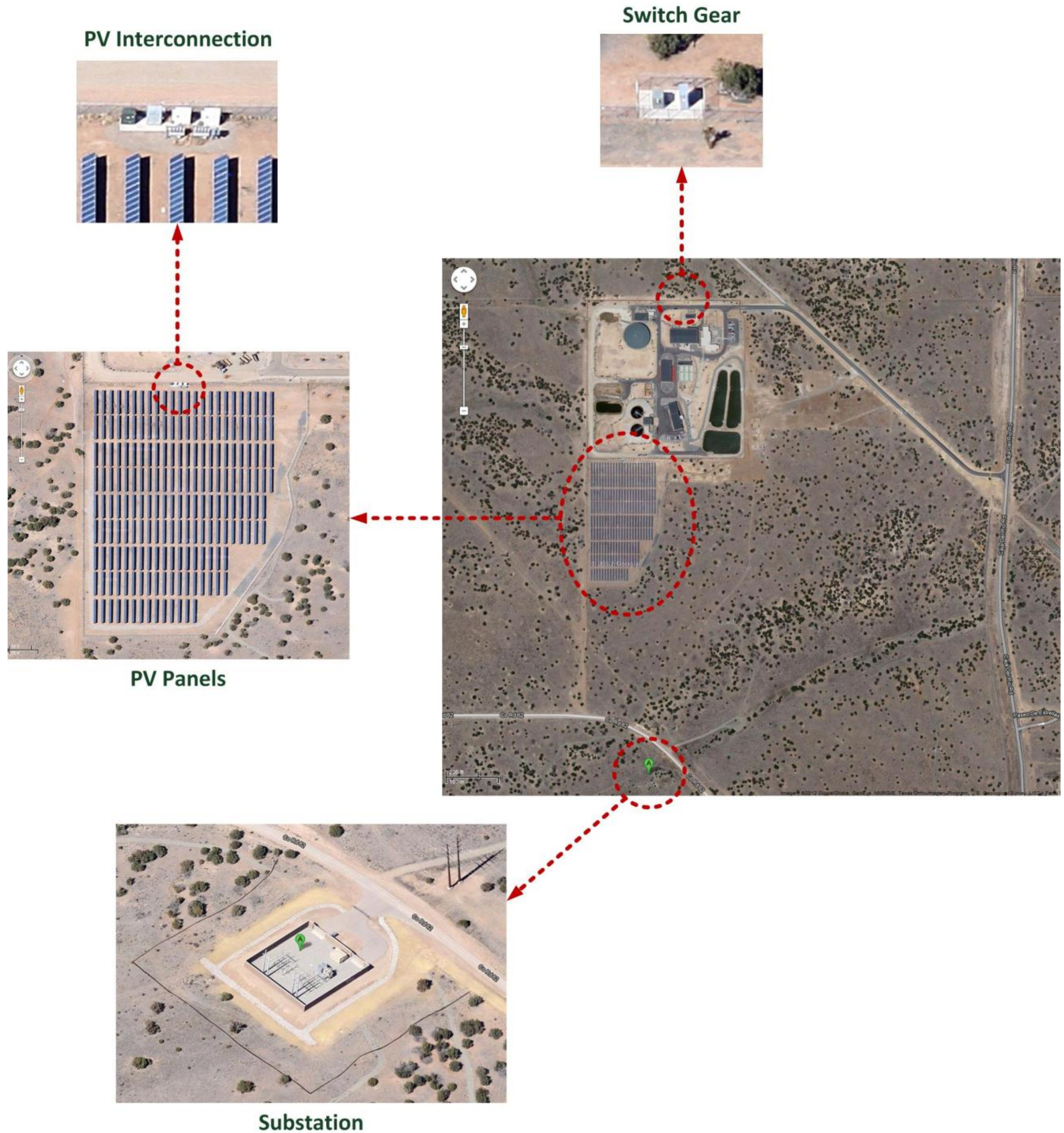






Model Overview



Buckman PV Array WinIGS Model

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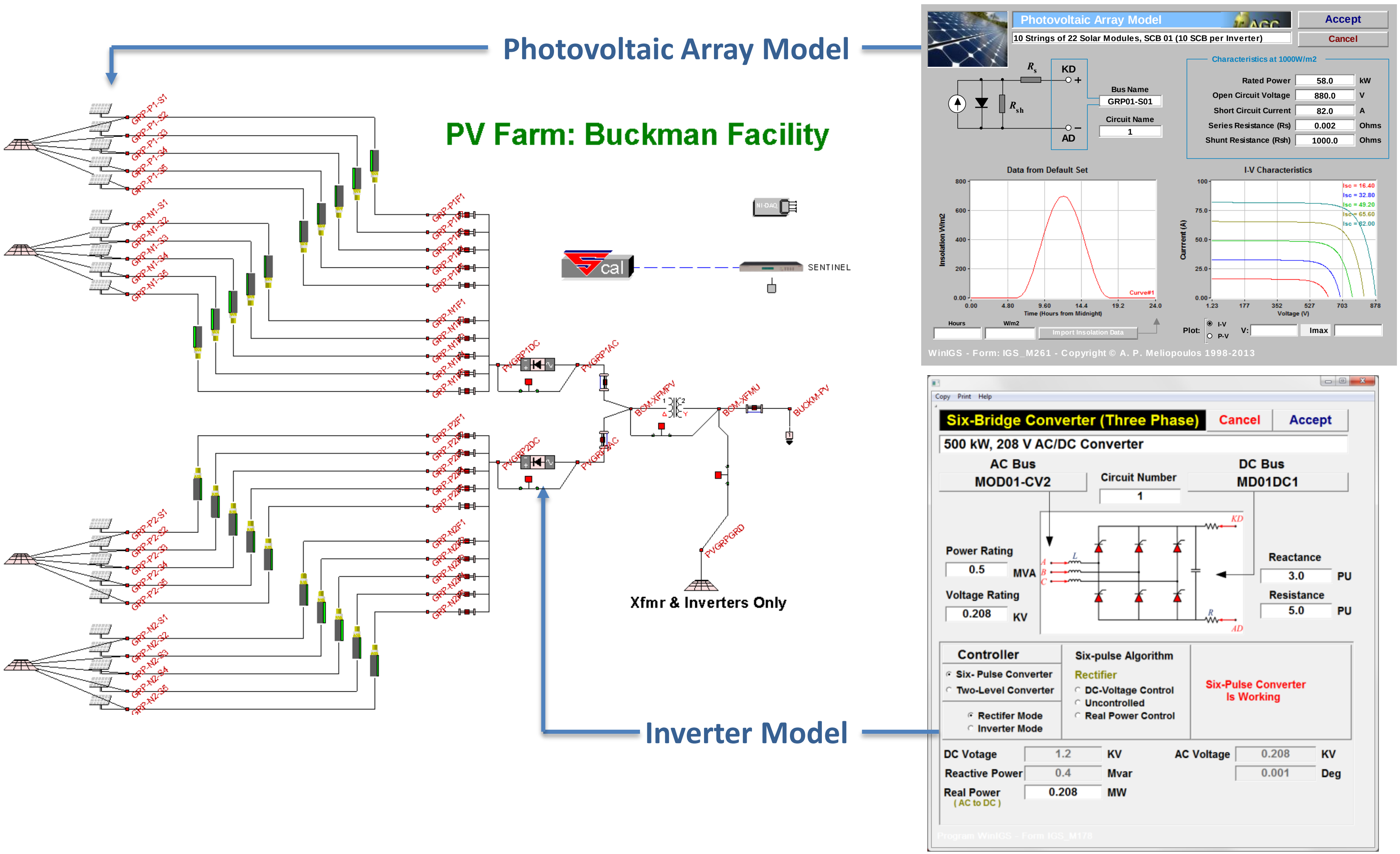
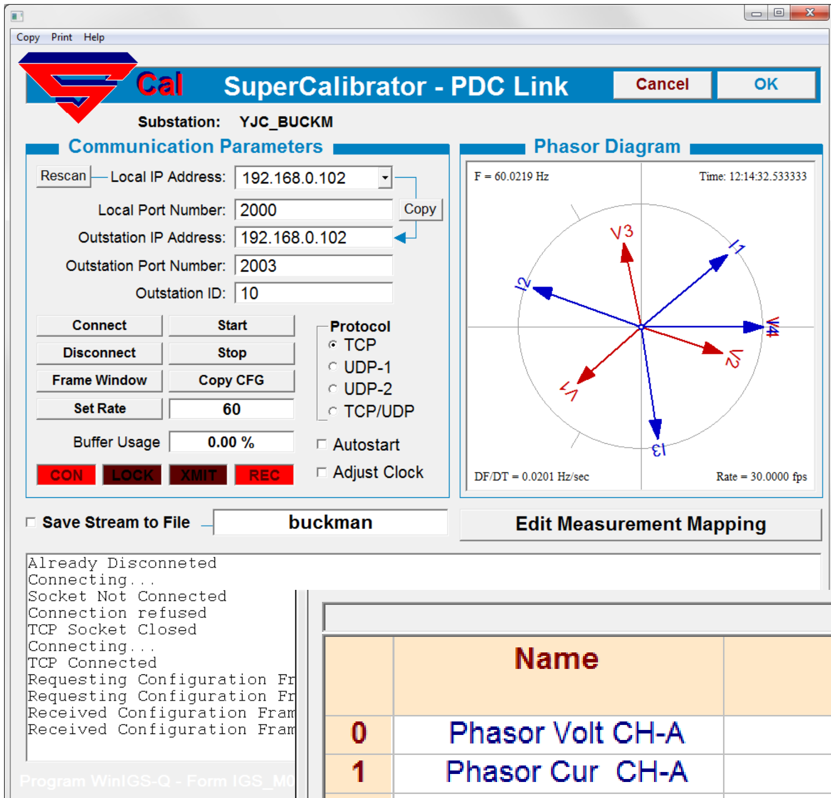
PV Module Model: PV Strings, PV String model, Inverter Model



Synchrophasor Field Data Snapshot

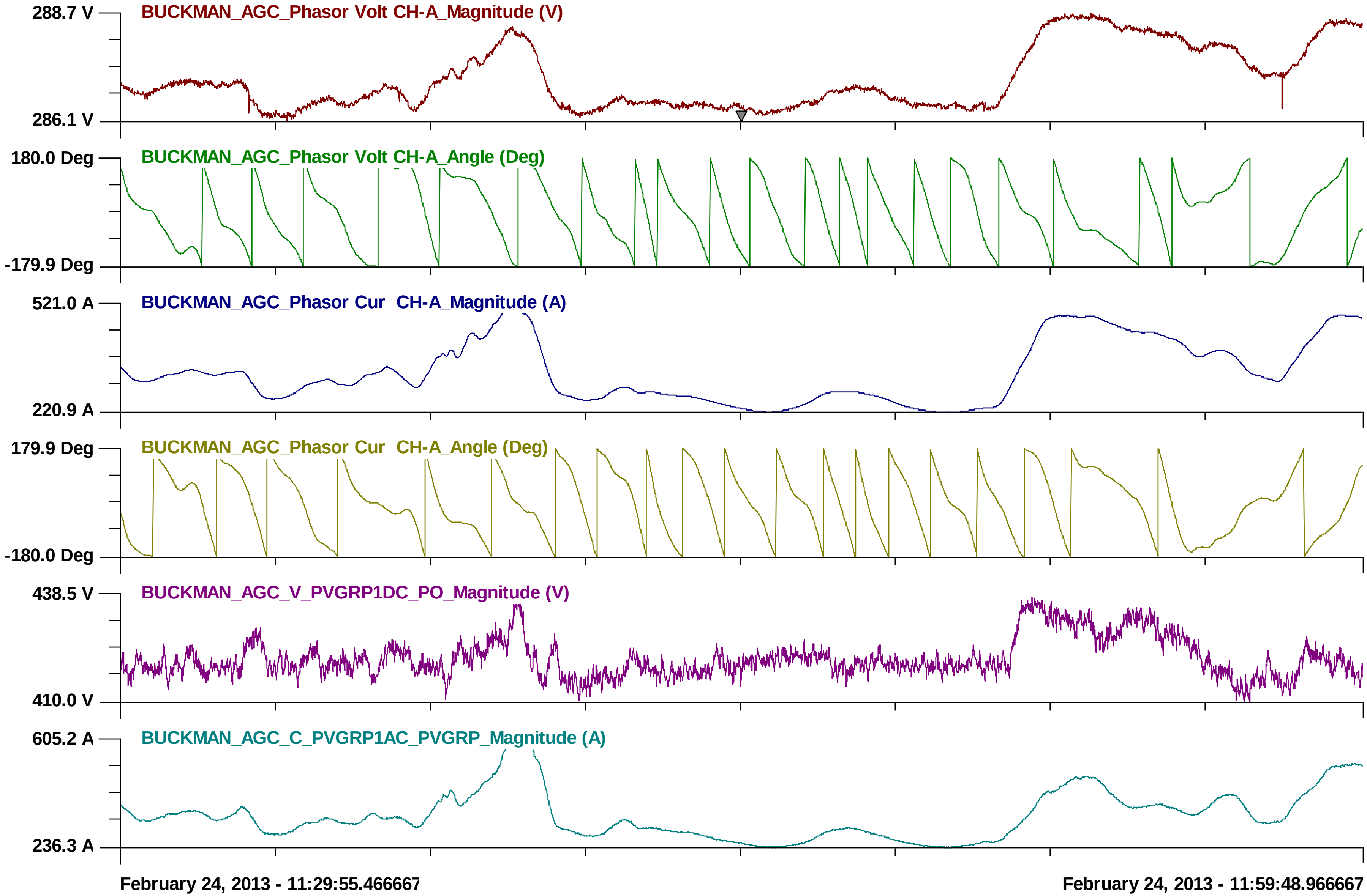


Phasors

	Name	Type	Magnitude	Phase (Degrees)
0	Phasor Volt CH-A	Voltage	288.8389	123.4191
1	Phasor Cur CH-A	Current	435.2258	-58.5011
2	Phasor Volt CH-C	Voltage	289.0181	-116.4568
3	Phasor Cur CH-C	Current	444.2625	62.1891
4	Phasor Volt CH-B	Voltage	288.8625	3.3638
5	Phasor Cur CH-B	Current	441.4685	-179.7037
6	V_PVGRP1DC_PO	Voltage	395.0335	0.0000
7	C_PVGRP1AC_PVGRF	Current	494.9604	0.0000

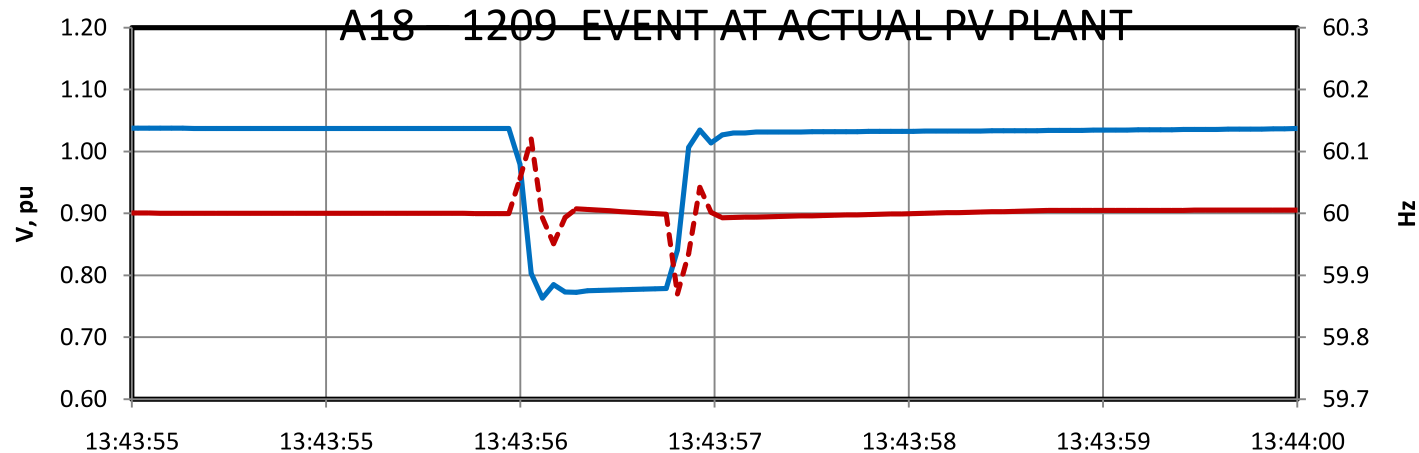
Program WinIGS-Q – Form IGS_M007_DATA_WIN

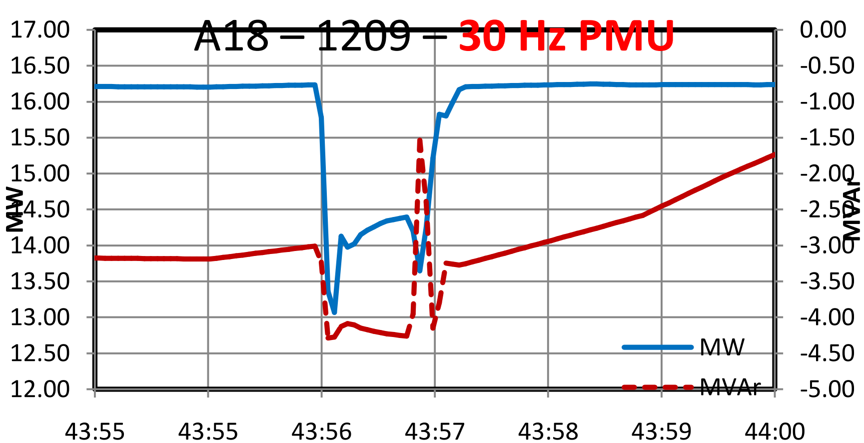
Field Data – 9:30 – 10:00 am (30 Samples / Sec)

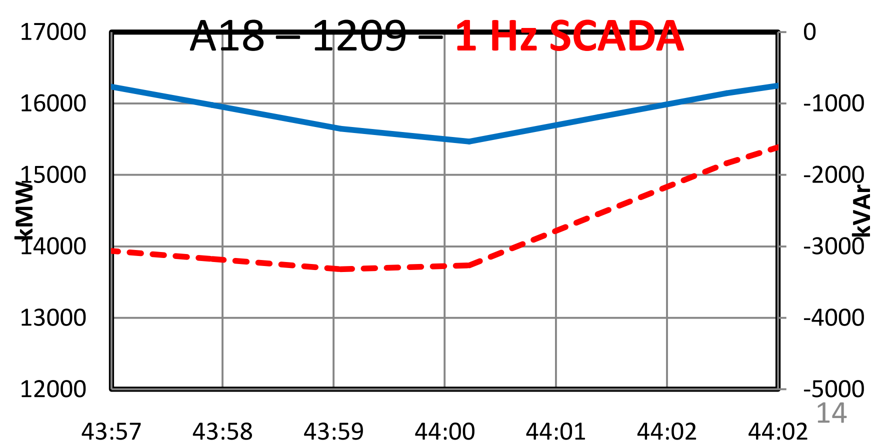


PV Plant Monitoring with PMUs

- **PMU data below (courtesy of SunPower) is useful for model validation.**
- **Typical SCADA data, even at 1-sec resolution, does not have sufficient detail**
- **Control function implementation will require next generation of "smart" inverters in addition to software upgrades to real time monitoring**







Technology Capabilities

Monitoring a PV Plant via State Estimation enables: (a) validation of data, and (b) extension of plant control. In addition:

PV Plant

- Model validation
- Identify string (module) deterioration
- Determine root cause of disturbances

Utility

- Assist utility to support AC side voltage
- Provide PV plant model for control and studies

What Do We Hope to Learn From PMU-Based Analysis

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- Can PMU technology contribute to improved PV plant monitoring and control?
- What is added value of PV with PMU technology from the utility perspective (Ancillary Services)?
- Are monitoring and control technologies robust enough to be deployed remotely?
- Can the proposed PMU based State Estimation provide real time information for condition-based maintenance?

American Capital Energy

- Founded in 2006 to design, develop and install PV power plants
- Cumulative installations of over 50 MW of commercial PV plants in >45 projects; over 70 MW currently under contract
- Engineering, Procurement, Construction (EPC) specialists for commercial rooftop, landfill, and brownfield utility-scale PV power plants