Advanced Inverter Controls to Support Grid Stability

Overview

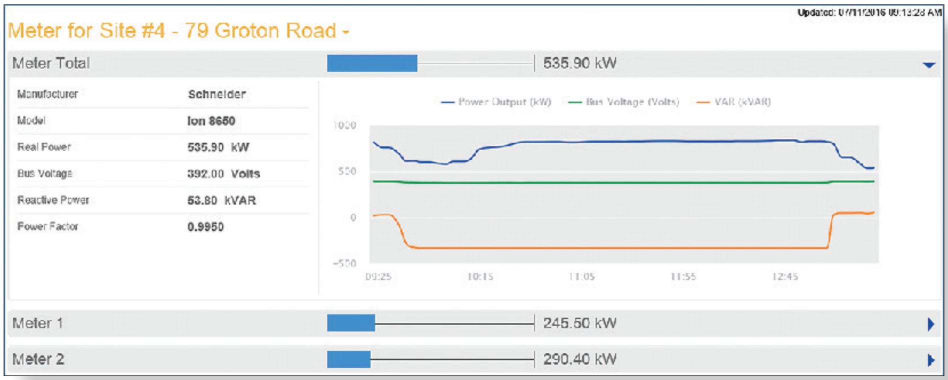
- Meet grid stability requirements with sophisticated controls that coordinate operation and output of inverters with static reactive devices.
- Take advantage of Trimark SCADA to increase profitability using real-time system monitoring and automated control.
- Support compliance while maximizing power output at the point of interconnection.

The increased penetration of intermittent photovoltaic (PV) resources is often linked to concerns about grid stability. To mitigate these concerns and help PV generation resources be an asset to the electric grid, Trimark has developed advanced power plant controls that:

- Ensure effective PV site management;
- Optimize power generation;
- Maximize revenue;
- Deliver consistent power at the point of interconnection (POI); and
- Support grid stability for utility-scale resources.

Trimark SCADA is a complete system that integrates control of PV inverters, tracker systems, capacitor banks, and substation devices.

Trimark's system ensures consistent power characteristics at the POI. That's critical because power characteristics at the POI can vary from measurements taken at the inverters. Variances such as "system losses" and other excursions can be caused by transformers, breakers, and line impedance.



Voltage Regulation is a fundamental capability required for advanced control. In this example (for demonstration) Trimark SCADA set the Bus Voltage to 380 V with +/- 2V DB, then reset to unity power factor

Resolving Grid Stability Issues With Advanced Site Controls

Trimark SCADA includes power plant controls required to operate a utility -scale photovoltaic (PV) resource.

The Power Plant Controller (PPC), within Trimark SCADA, helps operators meet requirements of the utility, ISO, interconnection agreement, PPA, and resource owner.

Trimark's PPC monitors multiple inputs/outputs, target set point commands, and real power at the POI.

The PPC compares the set point with values measured at the POI, then sends commands to inverters and CAP banks to adjust power characteristics as necessary.

Trimark SCADA and the PPC can be configured to meet your specific requirements for automated response, power stability and optimization.

The following table describes the business imperatives, functions and features included in Trimark SCADA.

Imperative	Objective	Function
Performance Monitoring	Track, report and analyze generation, environmental conditions and performance.	T1-S Vantage (Trimark's SCADA HMI) monitors and reports real-time and historical values to provide operators and owners a clear view of performance.
Automatic Voltage Regulation	Follow the assigned voltage schedule and minimize voltage deviations at the POI.	The PPC coordinates inverters and static reactive devices to ensure that inductive and capacitive VARs follow the assigned voltage schedule. Adjustments follow a defined ramp rate to eliminate upsets.
Utility Response	Adjust power output at the POI in response to an authorized set point command from the utility/ISO.	The PPC adjusts inverters to deliver real power and reactive power at a specific set point or Power Factor provided by the ISO or utility. Controls follow a defined ramp rate to minimize frequency or voltage transients (spikes) at the POI.
Automatic Generation Control (AGC)	Adjust power delivered at the POI in response to a dispatch by a utility/ISO.	The PPC coordinates all devices to deliver real power based on the ISO or utility's dispatched set point. Controls follow a defined ramp rate in order to minimize frequency or voltage transients at the POI.
Active Power Optimization	Deliver maximum allowable power at the POI even when conditions (shading, soiling, losses, maintenance) derate an inverter's potential generation.	The PPC measures power delivered at the POI. It will automatically adjust inverters' output to maximize allowable power at the POI and minimize variances caused by "cloud edge" effect or individual inverter issues.
Power Quality Management	Manage operational characteristics (e.g. VARs, Power Factor, Voltage, Frequency) at the POI.	The PPC measures power characteristics at the POI then adjusts devices to deliver the desired VARs, Power Factor, Voltage, or Frequency at the POI. The system applies real-time, closed-loop logic to measure and adjust power.
Remote Device Control	Control inverters, trackers, and relays without visiting the site.	Through T1-S Vantage, operators can set or change set points, start/stop events and monitor real-time effects, wherever they have Internet access.

Monitoring

Imperative	Portfolio View	Dashboard Key Indicators	Browser & Mobile Access	Equipment Status	Interactive Site Diagram	Meteorological Data	Meter Values	Reporting	Alerts / Alarms	Substation Devices
Performance Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring
Automatic Voltage Regulation	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	
Utility Response	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	
Automatic Generation Control (AGC)	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	
Active Power Optimization	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	
Power Quality Management	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	
Remote Device Control	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring

Controls

Imperative	Inverter Connect / Disconnect	Max Power Generation	Closed Loop, Site Real Power	Closed Loop, Site Reactive Power	Closed Loop, Site Power Factor	Automatic Voltage Regulation / Capacitor Bank Integration	Voltage – VAR Compensation	Frequency Droop Correction	Power Factor Compensation	Substation Relays & Reclosers	Tracker Positioning
Performance Monitoring											
Automatic Voltage Regulation						Operator Initiated; Secure, third-party set point; Closed-loop logic					
Utility Response	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic		Operator Initiated; Secure, third-party set point; Closed-loop logic	Operator Initiated; Secure, third-party set point; Closed-loop logic	Operator Initiated; Secure, third-party set point; Closed-loop logic		
Automatic Generation Control (AGC)	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic								
Active Power Optimization		Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Secure, third-party set point; Closed-loop logic								
Power Quality Management				Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic		Operator Initiated; Secure, third-party set point; Closed-loop logic	Operator Initiated; Secure, third-party set point; Closed-loop logic	Operator Initiated; Secure, third-party set point; Closed-loop logic		
Remote Device Control	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Scheduled; Secure, third-party set point; Closed-loop logic	Operator Initiated; Secure, third-party set point; Closed-loop logic	Operator Initiated; Secure, third-party set point; Closed-loop logic	Operator Initiated; Secure, third-party set point; Closed-loop logic	Operator Initiated	Operator Initiated

Legend

- Monitoring
- Operator Initiated
- Scheduled
- Secure, third-party set point
- Closed-loop logic

Control	Execution	Description
Initiating Commands	PPC functions can be initiated via operator command (✋), scheduled events (🕒), secure third-party set points (🔒), and/or closed loop logic (🔁).	
Inverter Connect / Disconnect	✋ 🕒 🔒	Operators can connect or disconnect inverters. Inverters remain synchronized but inverter output current is zero.
Max Power Generation (WMax)	✋ 🕒 🔒 🔁	Maintain maximum allowable power at a specific set point. During variances (e.g. "cloud edge") the control automatically increases generation of unaffected inverters to maintain consistent power output.
Closed Loop, Site Real Power	✋ 🕒 🔒 🔁	Maintain real power at the POI based on a set point. The PPC continually adjusts the inverters' output based on meter readings at the POI.
Closed Loop, Site Reactive Power	✋ 🕒 🔒 🔁	Set maximum reactive power flow for the plant. The controller continually adjusts all inverters' reactive power output as a percentage of the inverters' Qmax, as measured at the POI.
Closed Loop, Site Power Factor	✋ 🕒 🔒 🔁	Set the Power Factor (PF) for the PV plant based on values measured at the POI. The PPC adjusts each inverter's PF output as a function of cos phi.
Automatic Voltage Regulation / Capacitor Bank Integration	✋ 🔒 🔁	Coordinate inverters' output and capacitor banks' status to ensure that dynamic reactive power (VAR) follows the voltage schedule. The power plant controller sets inductive and capacitive VARs at a defined ramp rate to minimize voltage transients at the POI.
Voltage-VAR Compensation	✋ 🔒 🔁	Deliver a defined percentage of available VARs based on system voltage measured at the POI. The power plant controller sets the inverter's inductive and capacitive VARs to follow a defined ramp rate, thereby minimizing voltage transients.
Frequency Droop Correction	✋ 🔒 🔁	Mitigate grid frequency deviations by increasing or decreasing power generated by the PV plant. Real power ramp rates / hysteresis can be integrated into this function to minimize real power deviations that may exacerbate frequency events at the POI.
Power Factor Compensation	✋ 🔒 🔁	Adjust inverter power factor according to the real power generation from the PV array. Power factor ramp rates can be applied automatically or by the user to minimize voltage transients/real power deviations at the POI.
Tracker Positioning	✋	Operators can override tracker automation to stop tracker unit(s) from following the target setpoint. Tracker(s) can be moved to emergency/stow (0°), snow (35°), or clean (45°) position.
Substation Devices	✋	Operators can open a recloser. For safety, the switch must be closed locally.

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