

Ovation™ Microgrid Control

Features

- Balances distributed energy resources to reduce the total cost of energy produced while minimizing environmental impact
- Maximizes microgrid resiliency by providing on-demand or automatic grid-connected and islanded control
- Detects electrical disturbances and implements precise responses to maintain microgrid stability
- Simplifies operation and maintenance of distributed energy resources using common hardware, HMIs and user-friendly engineering tools
- Strengthens cybersecurity posture



Introduction

Emerson Automation Solutions has nearly 20 years of experience managing microgrid and similar independent electrical control systems on university, medical, industrial and corporate campuses around the world.

Designed specifically for the power industry, the Ovation™ control system manages a microgrid's distributed energy assets to cost-effectively produce low-carbon electricity while maintaining grid stability and operational resiliency. It effectively automates control of all microgrid components and macrogrid interconnections to satisfy power demand and maintain stable operating conditions in the event of a macrogrid electrical disturbance.

Emerson's Ovation solution for microgrid management consists of standard integrated functions such as data acquisition, alarm management and historical archiving, as well as embedded energy management and electrical control applications.

Standard Integrated Functions	Energy Management	Electrical Control
<ul style="list-style-type: none"> ▪ Data acquisition ▪ Process graphics ▪ Alarm management ▪ Data archiving ▪ Report generation 	<ul style="list-style-type: none"> ▪ Optimization of power production, power purchasing, energy storage and demand response ▪ Protection from high macrogrid demand charges ▪ Management of energy flow and voltage regulation at the point of common coupling 	<ul style="list-style-type: none"> ▪ Breaker control and interfacing with IEDs ▪ Load-shedding (demand management) ▪ Voltage control <ul style="list-style-type: none"> - Generator VAR control - Transformer tap changer control - Capacitor bank control ▪ Grid synchronization

Overview

The Ovation control system, designed specifically for the power industry, provides proven control and monitoring of power and energy management processes.

Ovation's Fast Ethernet network serves as both a control and information highway providing easy connectivity to virtually any Ethernet-enabled device including battery management systems and photovoltaic power inverters.

The fully-redundant Ovation controller, equipped with an Intel-based processor, provides secure control and monitoring of mission-critical power applications. The controller interfaces to the Ovation network and the Ovation input/output (I/O) sub-system to deliver embedded advanced control with built-in fault tolerance and system diagnostics. Ovation I/O modules access and process input signals to create and transmit output control signals. Ovation workstations provide operations, engineering, security, historical archiving and reporting capabilities.

The Ovation network, workstations, controllers and I/O work together to continuously monitor microgrid system conditions and send control signals to microgrid components.

Standard Integrated Functions

Data Acquisition

Ovation I/O modules acquire data every second or 100 milliseconds to support control applications or information capture requirements. Dedicated Ovation sequence-of-event modules provide 1/8 millisecond event time tag resolution. The control system also obtains information, typically at 1-5 second intervals, using communication link protocols such as IEC 61850, Modbus, IEC 60870-5-104, OPC, Ethernet and DNP3.

The collected data is transmitted across the Ovation network for use in operator workstations, control panels and process historians.

Process Graphics

Every Ovation solution is delivered with project-specific graphics, such as single-line diagrams, that display real-time microgrid status. Control parameters entered into the graphic automatically manage microgrid processes. Critical analog values such as bus voltages, frequency, power flow, temperatures, inverter statuses, switch and breaker positions are also displayed.

Alarm Management

Ovation includes an integrated intelligent alarm management system that prioritizes microgrid alarms to quickly isolate and address problems.

The Ovation alarm management system focuses the operator on important microgrid situations that deviate from normal operation. Abnormal conditions, such as points out of range (high or low electrical bus voltage or frequency), digital state changes (opening the grid breaker or automatic transfer switch operation) and drop time-outs are alarmed on Ovation operator workstations. Alarms displayed on the operator workstations are also sent to an alarm printer and the Ovation Process Historian which creates a chronological record of all process alarms and subsequent operator actions.

Data Archiving

The Ovation Process Historian provides mass storage and retrieval of process data, alarms, sequence-of-event indications and operator inputs to the Ovation system. Data continuously acquired by the Ovation system is archived in the historian for retrieval and analysis. Data retention of the process historian is limited only by its disk space, which may be augmented by tape drives or a DVD drive.

Report Generation

The Ovation Process Historian includes a reporting system that presents relevant historical data in various formats. Predefined templates can be used for common reporting tasks. Custom report capabilities are available for more complex data analyses. Reports can be generated automatically on an hourly, shift, daily, monthly or yearly basis.

Energy Management Functions

Protection from High Macrogrid Demand Charges

A microgrid may have a “point of common coupling” connection to the distribution utility (or macrogrid) and a rate structure/contract that stipulates the maximum quantity of energy (MW h) that is allowed to be consumed in a given demand period. If this limit is exceeded, the microgrid manager may incur permanently higher demand charges.

Because the consumption demand is measured in energy (MW h) and not power (MW), the Ovation system predicts energy consumption at the end of the time period. Anticipated errors are estimated by measuring the present rate of power consumption and extrapolating to the end of the demand period. If the predicted value exceeds the maximum demand limit, the Ovation system automatically trims load or increases generation from generation resources or energy storage to limit the energy consumed from the macrogrid. It also generates an alarm to alert the operator to take corrective action.

Management of Energy Flow and Voltage Regulation at the Point of Common Coupling

Macrogrid operators view microgrids as distributed energy resources whose energy consumption or supply rate and its effect on system voltage must be tightly controlled. While microgrid operators can sell and deliver energy through the macrogrid, they can also provide critical voltage support not only to the microgrid itself but to the macrogrid as well.

The Ovation system manages the energy flow and voltage regulation at the “point of common coupling” at predetermined setpoints, which are consistently reached through high-speed responses to demand changes or equipment availability. Microgrid control goals often entail maximizing generation by renewable energy resources and minimizing electricity purchase costs. When a microgrid generates more power than demanded by its internal

load, the Ovation system controls the flow of energy to energy storage resources, the macrogrid or both, as determined by the operator.

In situations where a microgrid cannot generate enough power to satisfy its internal loads, the Ovation system can disconnect (or shed) non-essential loads to minimize the need to draw power from the macrogrid if it is economically beneficial. Similarly, the Ovation system will shed microgrid loads if a weather or other emergency event disrupts macrogrid operation such that the microgrid cannot draw needed power. It will do so in order from least to most essential, preserving its ability to operate autonomously and self-supply the most essential loads for as long as possible.

Optimization of Energy Production, Storage and Purchase

Microgrids are comprised of any number of energy supply, energy storage and adjustable load (energy consumption) resources. They also have the ability to buy energy from or sell energy to macrogrid-connected suppliers and customers. Distributed energy resources may use various fuels, each with different costs and environmental impacts.

Microgrid performance objectives are often focused on minimizing the cost of energy, minimizing total environmental impact or a combination of the two. Emerson's integrated Ovation advanced power applications use state-of-the-art optimization technology to assist microgrid operators in meeting their performance goals. The applications determine the best control setpoints to optimize distributed energy resource management.

Performance Calculations

Emerson's Global Performance Advisor is available to calculate the efficiencies of any gas and/or steam turbo-generators in the microgrid. The advisor allows operators to identify controllable losses, track equipment performance against design specifications, and quickly identify problematic process areas to reduce operating costs. This solution provides a complete set of boiler and turbine performance calculations (based on ASME Performance Test Codes) to match the specific plant equipment set.

Electrical Control Functions

Breaker Control and Interfacing to IEDs

Ovation's embedded breaker control logic allows an operator to issue OPEN and CLOSE commands from single-line diagrams displayed on operator workstations. Before an operation takes place, the logic checks to ensure that the breaker is in the proper state to perform that operation. If a command is issued and the status indicator does not reflect the new state (i.e. the breaker does not indicate that the operation was successful) within a certain amount of time, an alarm is generated.

The Ovation system continuously monitors macrogrid power quality. When a macrogrid problem is detected, Ovation can open the breaker at the point of common coupling within 50 microseconds. This action immediately islands the microgrid, protecting and preserving its ability to continue serving native load.

Ovation communicates with intelligent electronic devices (IEDs) using various protocols including:

- Modbus over RS485 serial link
- Modbus over TCP/IP
- DNP
- Profibus
- IEC 61850
- IEC 60870-5-104

Load Shedding

Load shedding is a critical microgrid control function. Ovation microgrid contingency analysis and load shedding applications automatically respond to electrical disturbances, such as loss of grid or loss of a power producer, to restore stable conditions.

If a power source such as a grid, generator or inter-connect breaker on a generation bus is lost (a contingency) the corresponding load in the amount originally supplied by that power source must be immediately shed. This ensures that the remaining power producers are not over-loaded and disturbance to the microgrid is minimized.

Failure to immediately reduce load to match available generation results in a blackout of the microgrid.

Ovation's load shedding application selects the feeders serving loads to be dropped from a list of available feeders. Feeders are selected in order from the least to the most critical. The logic also checks that the load-shed breaker is available (closed and has MW flow) for automatic tripping and connected to the importing bus, not to the exporting bus.

The list of breakers for each possible load-shed case is continuously updated and shared with the controllers. The Ovation system automatically and instantaneously sheds the selected breakers when a power source is lost.

Ovation graphics readily show microgrid operators the list of loads to shed in a contingency. At any time, the operator can adjust a load's priority or temporarily remove it from the load shedding system to prevent it from being shed during a contingency. Naturally, care must be taken not to remove too much load from the load shedding system, since this could cause a general blackout of the microgrid.

Ovation's fast load shedding logic avoids generator overload and a possible blackout. Loads are shed when the power-source breaker is opened.

A microgrid disconnected from the macrogrid operates as an independent electrical island, where the island's frequency must be maintained by the island's own power producers. If the microgrid load exceeds generation, then the island frequency will relatively slowly fall below the nominal value of 60 Hz (50 Hz in many world areas).

When the island frequency goes below a minimum threshold value, the Ovation logic sheds enough low-priority loads to bring the frequency back to the nominal value. Lowering frequency typically happens over a long period of time and thus this is commonly referred to as "slow load shedding".

Slow load-shedding may also be required if grid tie-line transformers approach an overload condition.

Supply/Demand Balancing (Frequency/Voltage Control)

Control techniques for balancing power supply with demand within the microgrid vary depending on the types of power generation, storage and load equipment inside the microgrid's boundaries; whether the microgrid is connected to the macrogrid; and whether the microgrid's load uses alternating current (AC), direct current (DC) or a hybrid of the two.

Macrogrid-connected systems always ensure that there is enough power available to supply the microgrid's loads. In this case, Ovation controls the microgrid's production, storage and use of energy and power, using macrogrid-supplied energy and power within limits defined by the goals of the microgrid. This includes use of reactive power in cases where there may be charges from the macrogrid operator for consumption or production of reactive power beyond some limit.

Islanded microgrids ensure a balanced supply with demand by adjusting setpoints on generators, inverters, transformers and controllable load elements, such as thermostats. Islanded loads are shed only when necessary to keep frequency, voltage and power factor throughout the microgrid at desired values.

In the special case of AC and hybrid power microgrids with rotating generators, frequency control is used to balance real power supply. Voltage is controlled using various reactive power elements such as generator excitation adjustments, transformer on-load tap-changers (OLTCs) and capacitor banks.

For microgrids that do not have rotating generators (AC, DC or hybrid), voltage and power factor (or reactive power) measurements taken throughout the microgrid are kept within desired ranges by adjusting setpoints on inverters, transformers and controllable load elements. Load shedding is also used in this scenario as a last resort.

In any case, Ovation microgrid control ensures the most reliable, economical and environmentally responsible operation possible.

Synchronization

Synchronization is the process of measuring and controlling the voltages, frequencies and phase angles of the systems on either side of a breaker. Synchronization ensures that differences between these parameters are within specified limits before closing the breaker. Failure to do so risks catastrophic failure of equipment in both systems. This is a critical function when connecting an islanded microgrid to a macrogrid to exchange energy.

Similarly, before opening the breakers, the current and power flow across the breakers must be below defined limits.

Ovation microgrid control includes both hardware and software checks for synchronization, along with an auto-synchronizer interface that synchronizes the microgrid with the macrogrid.

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