Ovation™ Electrical Control and Energy Management of Captive Power Plants

Data Sheet

Benefits:

- Balances process steam and power demands in the most cost effective manner
- Detects electrical disturbances and implements precise responses to maintain stable conditions
- Optimizes interaction between internally-generated and grid purchased power in the most cost effective manner
- Provides efficient plant loading
- Simplifies operation and maintenance of multiple plant processes through the use of common hardware, HMIs and user-friendly engineering tools
- Strengthens cybersecurity posture

Most of the power required by an industrial plant (such as a refinery, petro-chemical station, steel or paper mill) or a university complex is provided by captive, in-plant generators and supplemented by power purchased from the national grid.

Emerson Automation Solutions has over 25 years of experience managing 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 captive power plant generators to cost-effectively satisfy power and steam demands while maintaining stable operating conditions in the event of an electrical disturbance.

Emerson's Ovation solution for captive power plant 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
▪ Data acquisition ▪ Process graphics ▪ Alarm management ▪ Data archiving ▪ Report generation	▪ Power house control and optimization ▪ Optimization of steam and power production ▪ Coordinated steam header pressure control ▪ Tie-line power monitoring and control ▪ Generator load (MW) – frequency control ▪ Performance calculations	▪ Breaker control and interfacing with IEDs ▪ Load shedding (demand management) ▪ Voltage and reactive power control - Generator MVAR control - Transformer tap changer control - Capacitor bank control ▪ Auto bus-transfer ▪ Motor reacceleration ▪ Grid synchronization

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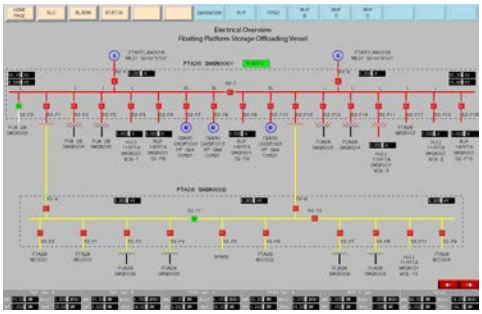
Overview

The Ovation 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. 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 and control captive power plant processes.



Electrical substation overview graphic

Standard Integrated Functions

Data Acquisition

Substations include switchboards with incoming and outgoing feeders that require frequent (hourly) updates including on/off status, fault status, current, voltage and power consumption (MW and MVAr). Ovation data acquisition eliminates time-consuming manual data logging by automatically gathering the status and values of each feeder and displaying that information on a centrally located HMI.

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, including single-line diagrams, that display real-time breaker status such as open, closed, bad or tripped. Critical analog values (bus voltages, frequency and power) are also displayed.

Alarm Management

Ovation includes an integrated intelligent alarm management system that prioritizes alarms to quickly isolate and address problems. The Ovation alarm management system focuses the operator on important plant processes 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

Power House Control and Optimization

Emerson has a long history of providing integrated cogeneration power house controls for boiler, heat recovery steam generator, burner management, balance-of-plant, generator excitation, steam turbine and gas turbine processes. Our portfolio is highlighted by numerous new and retrofitted systems for legacy OEM-supplied controls. Emerson Ovation-based solutions also include embedded advanced applications that optimize combustion, sootblowing and steam temperature to reduce emissions and improve efficiency.

Controlling the entire power house from a single Ovation platform enhances reliability, but also provides further opportunities for operational improvement such as increased plant efficiencies and megawatt production as well as long-term operation and maintenance savings.

Optimized Steam and Power Production

Industrial captive power houses often contain multiple steam and power producers using different fuels at varying costs. Emerson's optimization applications calculate desired fuel flows and loads on the power and steam producers to satisfy demand in the most cost effective manner. Ovation optimization can run in advisory mode or the results can become supervisory setpoints. Off-line optimization allows for testing and validating various 'what-if' scenarios.

Coordinated Steam Header Pressure Control

Ovation coordinated steam header pressure control balances steam and power production from one system as opposed to separate platforms. Operational efficiency is increased by minimizing header pressure disturbances. This is accomplished by limiting pressure reducing valves (PRVs), prioritizing header use and eliminating the need for operator intervention during upsets and demand swings.

Tie-line Power Monitoring (Maximum Demand-Limit Control)

Captive plants with a tie-line connection to the national utility grid have contracts that stipulate the maximum quantity of energy (MW h) allowed to be consumed within a demand period (15 or 30 minutes). If this limit is exceeded, the plant will have to pay a penalty that often incurs annual increases.

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 sheds load while generating an alarm that alerts the operator to take corrective action.

Tie-line Control

Most industrial sites monitor and control the amount of purchased electricity by managing their tie-line to the national utility. Tie-line management includes validating electrical use in real-time, limiting draw due to line constraints, governing demand intervals or determining how much electricity to buy versus how much to make on-site.

Ovation tie-line control generates accurate inputs that are responsive to fast changes in demand or equipment availability. Electric purchase costs are minimized by limiting demand at certain times while taking advantage of lower electric rates when available. The Ovation system controls the generators to keep

the grid power at the desired setpoint values, both for MW (using generator MW control logic) and for power factor (using generator MVAr control logic). Loads are automatically shed when the generation limits or the maximum or minimum import/export limits are met.

Generator Load (MW) Control - Frequency Control

The frequency of captive plants with tie-line connections is maintained by the grid. Ovation's load control logic adjusts the MW amounts on the in-plant generators to keep tie-line power at the desired operator-entered MW setpoint. The Ovation system calculates the MWs generated by each machine while staying within limits. For steam turbine generators, various steam process points are used to determine the maximum and minimum MWs that can be produced by each generator.

If the plant has no grid connection and is its own power island, Ovation adjusts the generators that are in droop mode to keep the isochronous generator at a desired percentage load.

Performance Calculations

Emerson's Global Performance Advisor is available to calculate the efficiencies of any gas and/or steam turbo-generators in a captive plant. 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 performance calculations (based on ASME Performance Test Codes) to match the specific plant equipment set.

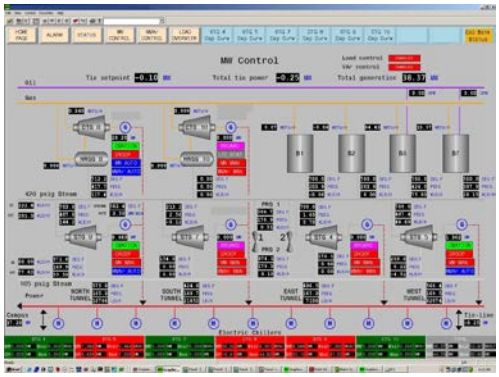
Electrical Control Functions

Breaker Control and Interfacing to IEDs

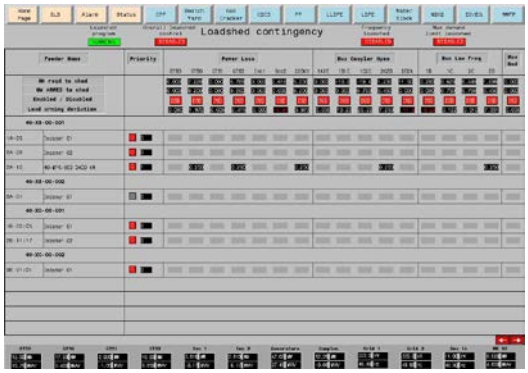
Ovation's embedded breaker control logic allows an operator to issue OPEN and CLOSE commands from single-line diagrams displayed on operator workstations. Before an operation takes place, the logic checks to ensure that the breaker is in the proper state to perform that operation. If a command is issued 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.

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



MW control graphic



Load shed contingency graphic

Load Shedding

Load shedding is a critical captive power plant control function. Ovation 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 process disturbance is minimized.

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.

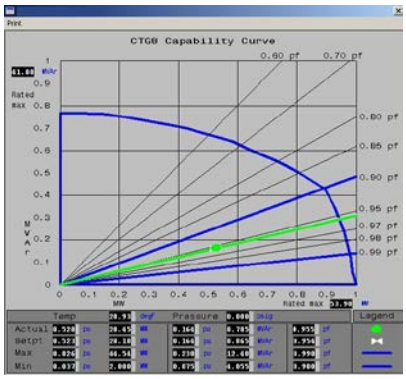
Ovation graphics readily show operators the list of loads to shed in a contingency. At any time, the operator can adjust a load's priority or temporarily remove it from the load shedding system to prevent it from being shed during a contingency. Ovation's fast load shedding logic avoids generator overload and a possible blackout. Loads are shed when the power-source breaker is opened.

Captive plants operate as an independent electrical island if the industrial process or campus is powered only from the captive generators and not from the grid. The frequency of the island must be maintained by the island's own power producers. If the generators are overloaded, then the island frequency will slowly fall below a nominal value of 60 Hz (50 Hz in many world areas).

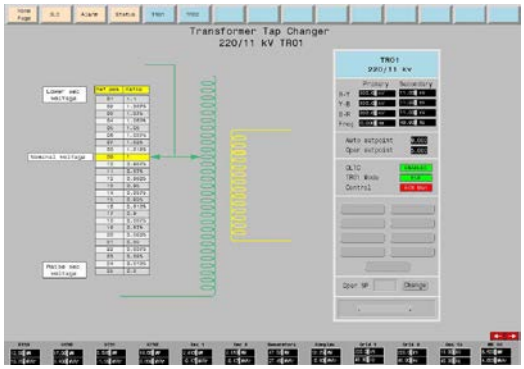
When the island frequency goes below a minimum threshold value, the Ovation logic sheds enough low-priority loads to bring the frequency back to the nominal value. Lowering frequency typically happens over a long period of time and thus this is commonly referred to as "slow load shedding". Slow load-shedding may also be required if grid tie-line transformers approach an overload condition.

Capacitor Bank Control

Captive power plants often have capacitor banks. Switching capacitor banks on when



Generator capability curve



Transformer tap changer graphic

reactive power demand is high satisfies the reactive demand by providing more MW capacity to the generators, thus reducing the amount of purchased power.

The Ovation system calculates which capacitor banks need to be switched on or off so that the MVAr demand at that switchboard is minimum, but not leading. Capacitor-bank control can be automatic or set as advisory-only.

Generator MVAr Control

The amount of reactive power produced by a generator can be controlled by adjusting the Automatic Voltage Regulator (AVR) setpoint on the machine. When a plant is connected to the grid, the reactive power produced by the generators is adjusted to keep the power factor of the plant at its operator-entered desired setpoint. If there is no grid, all the generators on the power island must have equal power factors.

Ovation control logic sends the MVAr setpoint to the generator's AVR as an analog value or sends MVAr raise/lower signals to meet the generator's calculated setpoints. The logic also ensures that the operator cannot move the bus voltage outside its allowable operating range and automatically adjusts the generator's MVAr to bring the bus voltage within limits.

Transformer On-Load Tap-Changing Control

Tap changing affects the voltage of the downstream bus, the plant's power factor and the MVAr imported from the grid. While Ovation ensures that bus voltage is within limits, MVar import is addressed by the generator MVar control.

The Ovation system calculates the optimum transformer tap position to keep the voltage of the bus immediately downstream of the transformer within limits (normally ±6% of the nominal value).

Auto Bus-Transfer

Auto bus-transfer is applied only on a switchboard's two incoming and one bus-coupler breakers. Normally this function is performed by the switchboard's control logic. However, if it is a requirement of the electrical control system, it can be incorporated into the Ovation system.

Motor Reacceleration

Reacceleration automatically restarts motors after an unexpected de-acceleration caused by system voltage events such as dips, outages or bus transfers. Reacceleration schemes minimize process disruptions by rapid detection of supply loss, recovery/monitoring of acceptable transient torque limits and automatic reclosure of the motor contactors. Reacceleration is typically performed by the switchgear control logic; however, this application can also be configured within the Ovation system.

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 captive plant to the grid for energy exchange.

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

The Ovation system includes both hardware and software checks for synchronization, along with an auto-synchronizer interface that synchronizes the islanded captive plant with grid.

Ovation Electrical Control and Energy Management Summary

Application	Description
Power house control and optimization	Provides full power house control capability from a single platform including all boiler, heat recovery steam generator, burner management, balance-of-plant, generator excitation, steam turbine and gas turbine processes. Embedded advanced applications for combustion, sootblowing and steam temperature optimization are also available to help reduce emissions and improve efficiency.
Optimized steam and power production	Determines the fuel flows and loads on the steam and power producers to satisfy the process steam and power demands in the most cost effective manner.
Coordinated steam header pressure control	Coordinates steam header pressure control through a single Ovation system.
Tie-line power monitoring (maximum demand-limit control)	Provides a strategy for controlling a plant's purchased electric power demand charges, involving the use of in-plant load-shedding or increasing in-plant generation.
Tie-line control	Maintains the import from the grid or export to the grid at operator-entered MW and MVAr/power factor setpoints by using generator MW control and generator MVAr controls.
Generator load (MW) control	Maintains internal generation by adjusting the load governors of in-plant generators.
Performance calculations	Calculates the efficiencies of the steam and power producers plus plant heat rate. All calculations are based on ASME performance test codes.
Breaker control	Interactive single line diagram graphic representation of substations on operator workstations allows operators to control status of any breaker from any central location like control rooms.
Contingency analysis and load-shedding	Provides on-line contingency analysis based on current plant conditions to implement pre-determined strategies for a variety of abnormal or emergency situations, such as tie-line loss, inter-connect bus breaker status changes, and generator trips.
Reactive power control	Satisfies plant's MVAr demands using generator MVAr control, transformer OLTC control and capacitor bank control. Plant MVAr demands are satisfied within the following plant constraints: generator's reactive capability, generator-bus voltage, tie-line MVAr/power-factor setpoint.
Generator MVAr control	Satisfies plant's MVAr demands by adjusting the excitation of in-plant generators and synchronous motors.
Transformer tap changer control	Ensures the transformer's downstream-bus voltage is within limits.
Capacitor bank control	Minimizes load MVAr demand of switchboards by switching on or off the capacitor banks.
Auto-bus transfer	Applied only on a switchboard's two incoming and one bus-coupler breakers.
Motor Reacceleration	Automatically restarts motors after an unexpected de-acceleration caused by system voltage events.
Synchronization	Employs an automatic generator-synchronization device in conjunction with control system software for synchronization of a power source to a generation bus or synchronization of two generation buses.