Electrical Control & Energy Management For Cogeneration Plants

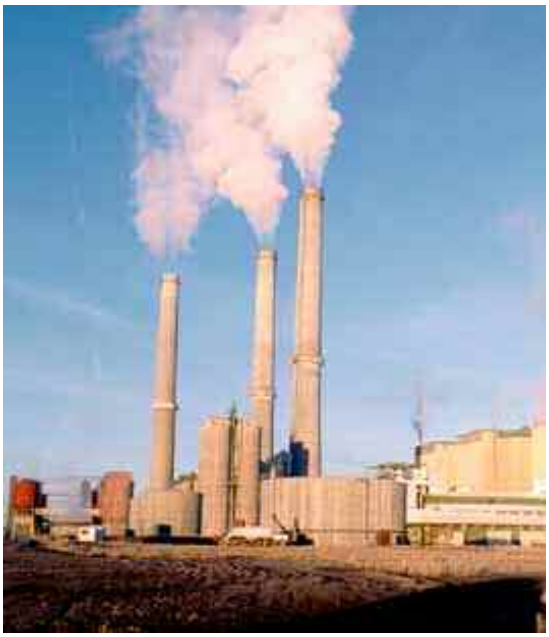
Data Sheet

Features

- Generator load control
- Tie-line control
- Load shedding
- Synchronizing
- Voltage and reactive power control
- Remote breaker control

Benefits:

- Efficiently meets plant energy requirements
- Minimizes costs associated with purchased fuel & power
- Optimizes interaction between purchased power & internally generated power
- Aids in scheduling maintenance
- Improves safety
- Maximizes the life of plant equipment
- Efficient plant loading
- Responds precisely to electrical disturbances



Overview

Industrial plants consume various forms of energy in their day-to-day operation, including electrical energy. By constructing in-house combined cycle and cogeneration plants, many industrial facilities are able to internally meet their steam and electricity demands. Depending on the availability, quality, and cost of the external electricity supply, an industrial facility has the flexibility to either import electricity from the local grid or generate their own electricity. In many cases industries prefer to find a balance between generating a portion of their demand and importing from the local grid.

Emerson Process Management has worked closely with customers all over the world to develop solutions for electrical control and energy management in industrial cogeneration power plants. Our solutions span various industries from petrochemical complexes to small paper plants to improve plant productivity through energy optimization and control.

Emerson's electrical control and energy management system (ECMS) not only satisfies plant energy demands in an optimal manner, but also increases cost savings and improves plant efficiency and availability. Experience shows that an investment made in electrical control & energy management is usually recovered in less than two years.

ECMS Base Applications

Emerson's ECMS solution not only satisfies plant process steam and electrical demands, but also provides a precise response to electrical disturbances such as loss of tie-line and generator tripping to restore stable conditions. The following applications are included in the system:

- Generator load control
- Tie-line control
- Load shedding
- Synchronizing
- Voltage and reactive power control
- Remote Breaker Control

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Generator Load Control

The load control logic maintains in-plant generation by adjusting load governors of in-plant generators. When the plant is connected to tie-line, this software keeps the tie-line set-point at a predetermined level and allocates the balance power to most efficient generator.

The load control logic is run every second to determine the megawatt set point for the combustion and steam turbine generators. The turbine controllers can be placed in auto or manual mode from the operator station. When the controllers are set in auto mode, setpoints calculated by the load control software are used. When in manual mode, operator entered setpoints are used. Appropriate graphics in the form of single line diagram of process steam and power generation system are provided for the operator to observe any system interaction due to changes in generation amounts on gas and steam turbines.

Tie Line Control

An important aspect of cogeneration optimization is the interaction between purchased and internally generated power. The ECMS tie-line control application ensures that the demand limit for a given demand period does not exceed contract values. Control of demand limits can adjust internally generated loads, or in an emergency, shedding discrete loads. An anticipated error can be estimated by measuring the present rate of power consumption and extrapolating to an end of the demand period. The error is corrected by adjusting the amount of internally generated loads. A table of loads is provided complete with priorities for picking and shedding loads in an emergency. Provisions are made to make accurate measurement of error even if the pulse signal from the utility indicating the end of demand period is not available.

Contingency Analysis & Load Shedding

Consequences of a prolonged disturbance may not only result in a direct loss of production, but if not corrected can seriously plug equipment and extend an outage well beyond the duration of the original disturbance. The ECMS contingency analysis and load shedding software automatically responds to such contingencies and significantly reduces the cost associated with the loss of production.

The software is run with the unit on-line to establish given electrical conditions and the precise response which will allow stable conditions to be restored. All possible islands that may arise due to a breaker trip are determined and an attempt is made to save the island from collapsing due to power deficiency or generation. Loads, if required to be shed, will be selected based on their current magnitude and their priority from a predefined table. The pre-calculated tables are updated after each scan.

Circuit breaker status is read by the load shedding program in 0.1 second or less intervals. This allows for immediate action in case of a possible collapse of generators due to islanding based on the contingency analysis already done. Thus a two level execution of the full functionality is provided.

Priority tables are updated to inhibit any breaker from load shed outside of the assigned loads. For some of the contingencies, for example the starting or tripping of plant load, the immediate response can be changed in tie-line power. In such cases the unit load control and tie-line control respond automatically restore the tie-line power to its desired value. In case of generator over load due to motor acceleration or decrease of utility frequency, the load shedding program sheds an amount of load that is calculated at the occurrence of the overload (real time shed). In this case the shed action does not need to be as fast as the case of pre-calculated shed.

For each sheddable load there is a bus assignment pertaining to the bus to which it is connected. If the bus assignment of a load changes due to bus transfer, the assignment is dynamically updated based on the monitored status of the network.

Synchronization

Synchronization of generators and all the tie breakers and incomers from the grid are performed from the system operator console.

Synchronization occurs through a series of graphic display screens that enable the operator to select/control components of sub-system and to monitor the power plant and switchyard configuration. These graphic displays allow for quick manual or automatic synchronizing of all the likely unsynchronized power sources. A check-back-before-operate protocol is provided to promote a safer plant operating environment.

Voltage & Reactive Power Control

The voltage and reactive power control application of the ECMS controls the VARS delivered by each turbogenerator and synchronous motor. The voltage and reactive power control module includes the following:

- **Static Load Flow Analysis (SLFA) Program** that estimate the VARS and voltages at different busses, given the impedance network for the plant, the amount of real power being consumed and generated at each bus, and the nominal voltages, transformation ratios and power factors on selected busses.
- **Optimization program** that fine tunes the results of the SLFA program. This program adjusts the bus voltage setpoints and transformation ratios to maintain bus voltages within assigned constraints and machines within their reactive capability. In automatic mode, the optimized values are used as the VAR setpoints and the transformation ratio is transferred to a tap changing subsystem.
- **Control of VARS** on a particular machine (to a manually or automatically adjusted setpoint value) by pulsing the excitation servomotor.
- **Tap changing subsystem** that moves the tap to a position determined by the operator or the optimization program.

A special graphic shows the tap position, voltages and frequencies of HV & LV sides, state of HV & LV sides (energized or de-energized) and any other message required.

Remote Breaker Control

The remote breaker control logic allows an operator to issue OPEN and CLOSE commands from the operator station. Before an operation takes place, checks are made to ensure that the breaker is in a proper state. Once a command is issued, if the status indicator does not reflect the new state within a certain amount of time, an alarm is generated indicating the command was issued, but the breaker did not respond

ECMS Optional Applications

Two optional applications, equipment performance monitoring and on-line optimization, can be provided in addition to the base applications described above.

Equipment Performance Monitoring

Equipment performance monitoring includes comprehensive performance calculations for major plant equipment such as heat recovery steam generators, combustion turbine generators and steam turbine generators. Typical calculations include:

- Heat balances
- Unit efficiencies
- Component efficiencies
- Deviation from expected performance
- Overall plant heat rates

Calculated results are displayed on the operator's console and used to adjust equipment models, improve performance and identify possible maintenance areas.

Online Plant Modeling & Optimization

The online plant modeling and optimization program minimizes the cost associated with fuel and purchased power. The program calculates a set of load assignments for the gas and the steam turbine generators that satisfy the steam and power demands in an optimal manner (i.e. lowest cost). Dynamic plant models are developed with equations that represent individual equipment performance and system power & steam demand relationships for various main equipment. The model is continuously updated based on operating conditions and observed performance.

Both on-line and off-line versions of the optimization program can be provided. The software uses standard mathematical programming techniques such as linear and non-linear programming. Before each run, the program takes a snapshot of the plant and updates the model for details like equipment availability, current power demand, and current steam demand at various header pressures, current fuel and cost of purchased power. The software is suitable to run for any possible combination of power plant equipment (e.g., GT, ST, HRSG, UB etc.) with and without tie line support. The plant configuration is determined by online measured data.

The equipment models and constraints reflect all possible modes of operation e.g. HRSG in normal/bypass/FD fan mode and generators in manual/auto control mode. The software is suitable for all fuel mixes for which the power plant is designed and their associated availability and/or operational constraints. Output of the optimization program is used to bias the setpoints calculated by the load control software.

ECMS Summary Table

ECMS Application	Description
Tie-line Demand 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.
Contingency Analysis/Load Shedding	Provides on-line contingency analysis based on current plant conditions to implement predetermined strategies for a variety of abnormal or emergency situations, such as tie-line loss, interconnect bus breaker status changes and generator trips.
Remote Breaker Control	Allows operators to control status of any breaker from a central location
Generator Load Control	Maintains internal generation by adjusting the load governors of in-plant generators
Synchronization	Employs an automatic generator synchronization device in conjunction with control system software for synchronization of one or multiple generator busses.
Optimization	Uses plant models, measured demands and plant equipment status and constraints to optimize plant performance and energy costs. Also satisfies a plant's instantaneous energy demands in an optimum manner.
Reactive power Control	Satisfies plants MVAR demands by adjusting the excitation of in-plant generators and the tap settings on tap changing transformers within the generators reactive capability, tie-line power factor, and the required bus voltages. .
Equipment Performance Monitoring	Executes comprehensive performance calculations for major plant operating equipment, Results are used to improve equipment performance and identify possible maintenance areas.
Static Load Flow Analysis	Determines optimal MVAR and tap-changing transformer settings for a network of given real power assignments using Newton-Raphson and modified SSDEVOP experimental design methods.