Ovation™ Electrical Control and Monitoring System

Data Sheet

Main Features:

Objectives:

- To satisfy process steam and power demands in the most cost effective manner
- To determine and implement the precise responses to electrical disturbances so stable conditions can be restored

Energy Management Features:

- Boiler control and optimization
- Steam and gas turbine controls
- Coordinated steam header pressure control
- Tie-line power monitoring
- Tie-line control
- Generator load (MW) control
- Optimization of steam and power production
- Performance calculations

Electrical Control features:

- Breaker control and interfacing with IEDs
- Load-shedding
- Voltage and reactive-power control
- Generator MVAr control
- Transformer OLTC control
- Capacitor bank control
- Synchronization

Benefits:

- Automates tasks previously performed manually
- Responds precisely to electrical disturbances
- Meets plant energy requirements efficiently
- Optimizes interaction between purchased power and internally-generated power
- Loads the plant more efficiently
- Aids in scheduling maintenance
- Improves safety
- Maximizes the life of plant equipment
- Minimizes costs associated with purchased fuel and power

Overview

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 in-plant generators and supplemented by power bought from the national grid. Emerson's Ovation™ Electrical Control and Monitoring System (ECMS) automates substation control and can be used to satisfy power and steam demands required by such facilities, or to maintain stable generating conditions when these sites experience electrical disturbances.

ECMS is also commonly referred to as a Power Management System (PMS) in the United States, an Electrical Network Monitoring and Control (ENMC) in Southeast Asia, and an Integrated Power Management and Control System (IPMCS) in the Middle East.

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The Ovation control system, designed specifically for the power generation industry, provides proven control and monitoring of power generation processes. The Ovation Network is based on standard, unaltered Fast Ethernet that serves as a control and information highway, providing easy connectivity to virtually any Ethernet enabled device. With an Intel-based processor at its heart, the fully-redundant Ovation Controller provides secure control and monitoring of mission-critical power applications. The Ovation Controller interfaces to the Ovation Network and various I/O sub-systems. With modular plug-in components, Ovation I/O delivers embedded advanced control applications with built-in fault tolerance and system diagnostics. With their inherent flexibility, Ovation I/O modules convert input signals and create output signals, performing a multitude of functions. Ovation workstations provide operations, engineering, security, and historical archiving and reporting capabilities.

Basic Functions

Data Acquisition

In a substation, there are switchboards with many incoming and outgoing feeders. If a data acquisition system does not exist, an hourly, manual, tedious account of the status of each feeder must be taken. The account includes the on/off status, the current, voltage, power consumption (MW and MVAr), and if there is any fault status on a feeder.

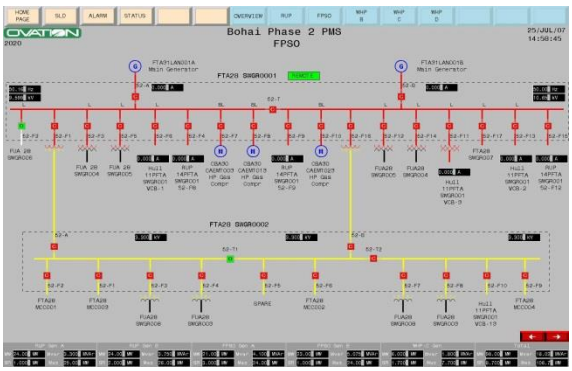
Data acquisition performed by the Ovation ECMS eliminates the time-consuming manual logging of feeder data by automatically gathering the status and values of each feeder. The data can then be displayed from one central location, such as an HMI monitor.

The Ovation Controller acquires data from Ovation's I/O modules every 100 ms and at 1/8 ms for sequence-of-event (SOE) digital inputs through a dedicated Ovation SOE I/O module. The Ovation Control may also gather data using communication links such as IEC 61850, Modbus, IEC 60870-5-104, OPC, Ethernet, etc. The data is then broadcast to the Ovation Network and made available to all controllers and workstations.

Data is broadcast both on exception and at regular periods. "On exception" means that the digital data has changed values, or that the analog data has exceeded a dead-band value over its previous value. This reduces the traffic on the Ovation data highway network.

Data Display

With every EMCS solution, Emerson develops project-specific graphics such as single-line diagrams (SLDs) that display the live status of the breakers. Using these displays, an operator can immediately determine if a breaker is open, closed, bad, or tripped. Critical analog values such as bus voltages, frequency and power, are also displayed.



Data History

The Ovation Process Historian provides mass storage and retrieval of process data, alarms, sequence-of events (SOE), and operator actions for an Ovation system. Because data is continuously acquired by the ECMS system, it can be stored in the historian for later retrieval and future analysis. The historian's retention of data is limited only by its disk space, and may be augmented by tape drives or DVD writers.

Alarms and Alarm Reporting

Operators manage system alarms through several viewing and acknowledge functions on the Ovation Operator Workstation. Alarms may be generated if an analog value goes above or below a certain set-point, for example if the bus voltage or frequency falls below an acceptable limit. Alarms may also be generated for a change of state of a digital value, such as the grid or generator breaker opening. All alarms can be reported on an

operator workstation or printed out. Additionally, the Ovation Process Historian creates a chronological record of operator actions and process alarms.

Report Generation

Reports can automatically be generated on an hourly, shift, daily, monthly, or yearly basis.

Control Functions

An industrial plant that contains a captive power plant consists of two areas that need to be controlled – the process and the power house. The control functions for the power house can be grouped under two categories: energy management and electrical control functions.

Energy Management Functions

Boiler Control and Optimization

Power houses frequently contain multiple boilers and heat recovery steam generators (HRSGs) that produce steam, a critical component to some industrial processes. The boilers may burn multiple fuels and may produce steam at different temperatures and pressures. Ovation is widely used in the utility industry, and is well-suited for providing boiler and balance-of-plant control, especially in cogeneration plants. Ovation also offers combustion optimization, intelligent soot-blowing and advanced steam temperature packages to help reduce emissions and improve efficiency.

Steam and Gas Turbine Controls

Controls for the industrial power house turbines are required just as they are for the turbines in utility plants. Ovation has a long proven history of providing steam and gas turbine controls for all of the major manufacturers' machines including GE, Westinghouse, Alstom, ABB, Siemens and much more.

Coordinated Steam Header Pressure Control

Cogeneration plants need to balance the interaction between the steam and power producers for optimized operations. For example, if the megawatt demand on a combustion turbine generator is increased, the amount of steam produced by the HRSG will increase. Often times, the steam producers are controlled as part of the process system; however, if the steam and power producers are managed by the same control system, then a coordinated steam header pressure control can be achieved. Ovation ECMS achieves this by minimizing header pressure disturbances, maximizing efficient generation by limiting the use of PRVs, prioritization of headers, and elimination of operator intervention during upsets and demand swings

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

A plant may have a tie-line connection to the national utility grid and a contract that stipulates the maximum quantity of energy (MW h) that is allowed to be consumed in a demand period (15 or 30 minutes). If this limit is exceeded, the plant will have to pay a penalty and often times increase the amount that must be paid for the next year.

Because the consumption is measured in energy (MW h) and not power (MW), the Ovation ECMS system can be used to predict the energy consumption at the end of the time period. An anticipated error can be estimated by measuring the present rate of power consumption and extrapolating to the end of the demand period. If this predicted value exceeds the maximum demand limit, the Ovation ECMS can automatically shed load or an alarm can be generated for the operator to take corrective action.

Tie-line Control

Most industrial sites must manage their tie-line to the national utility grid to monitor and control the amount of purchased electricity. This may be to validate electrical use in real-time, limit draw due to line constraints, manage demand intervals, or to determine how much electricity to buy versus how much to make on-site.

Tie-line control systems must be furnished with timely and accurate inputs, responsive to fast changes in demand or equipment availability, well integrated with overall powerhouse and site operations, and intuitive and straightforward to use for operating personnel.

The goal is typically to minimize electric purchase costs by effectively limiting demand at certain times and taking advantage of lower electric rates when they are available.

In situations where a plant is generating excess power, the decision may be to export the excess power to the grid. However, there may be a maximum and/or minimum limit on the amount of power that can be exported.

Controlling the import or export of the power is normally done with operator-entered set-points for tie-line desired MW and desired power factor. These grid set-point values may be positive (an import set-point) or negative (an export set-point).

The Ovation ECMS system controls the generators so that the power from the grid is kept at the desired set-point values, both for MW (using generator MW control logic) and for power factor (using generator MVAr control logic).

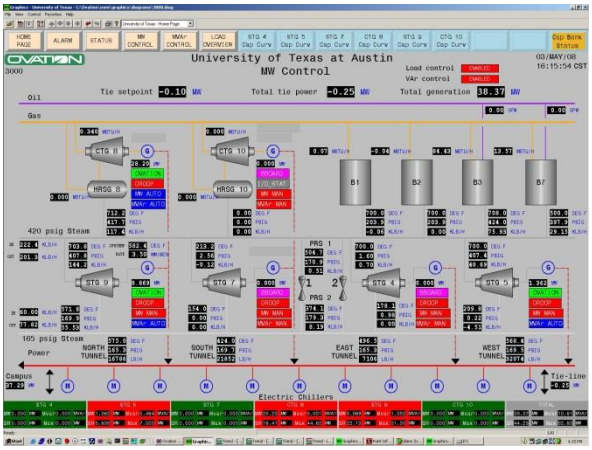
When generators are already working at their limits, the Ovation ECMS system can shed loads so that the maximum or minimum import/export limits are met.

Generator Load (MW) Control, Frequency Control

When a plant has a tie-line connection to the grid, the frequency of the plant is maintained by the grid. Ovation's ECMS load control logic adjusts the MW amounts on the in-plant generators to keep tie-line power at the desired operator-entered MW set-point.

If the plant has no grid connection and is always its own power island, then one of the generators must always be in isochronous (speed control) mode to maintain plant frequency. In this situation, the generators that are in droop mode are adjusted to keep the isochronous generator at a desired percentage load. If the plant generators are small machines, the turbine control logic would have already been modified so that more than one machine on the same electrical island can be in isochronous at the same time. It makes the group of machines respond as if it were one large machine giving better frequency control. This ensures that the generator always has room to react to changes in plant MW demand.

Appropriate graphics in the form of single line diagrams 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.



The Ovation ECMS system calculates the MW that should be generated from each machine while staying within the MW limits of the generators. For steam turbine generators, various steam process points are used to determine the maximum and minimum MW that can be made by each generator.

The load control logic can be placed in MW Auto or Manual mode from the operator workstations. When in MW Auto mode, the optimum MW set-points calculated by the load control logic are used. When in manual mode, operator-entered MW set-points are used. The operator may also manually raise or lower the MW by clicking on buttons. The Ovation ECMS system will then either send the MW set-point to the generator's turbine controller as an analog value, or send MW raise and lower signals, to bring the generators to their desired calculated set-points.

Based on project requirements, control logic can be designed for MW auto-mode control when the plant is grid-connected or when the plant is islanded, depending on normal plant configuration.

Optimization of Steam and Power Production

An industrial power house often contains multiple steam and power producers. In addition, there may be multiple fuels that can be burned with varying costs. Power can be purchased with prices that may vary based on the time of day. In some cases, the plant may be able to sell power back at sale prices based on the time of day. Whenever there are multiple items producing a common commodity, optimization is possible.
Emerson's optimization technology can be used to calculate the desired fuel flows and loads on the power and steam producers so that the process steam and power demands are satisfied at least cost. The results of the optimization can become supervisory set-points or the optimization can run in advisory mode. The optimization can also run in an off-line mode while the on-line optimization is running to provide the user with "what-if" capability.

Performance Calculation

Emerson's Global Performance Advisor (GPA) is available to calculate the efficiencies of the power and steam producers. This provides the user with the ability to know when maintenance should be performed on various pieces of equipment. In addition, if optimization is supplied, the GPA package is often required so the plant models can be kept up-to-date to reflect the current equipment efficiency. All calculations are based on ASME performance test codes.

Electrical Control Functions

Breaker Control and Interfacing to IEDs

Ovation's remote breaker control logic allows an operator to issue OPEN and CLOSE commands from the single line diagram graphics displayed on an operator workstation. Before an operation takes place, Ovation ECMS logic will check before executions are made to ensure that the breaker is in a proper state. This means to check for proper status (e.g. breaker open), open faceplate, activate faceplate, arm, and allow only the corresponding command (breaker close command). When a command is issued and the status indicator does not reflect the new state within a certain amount of time, an alarm is generated.

Ovation is capable of communicating with intelligent relays over different types protocols such as:

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

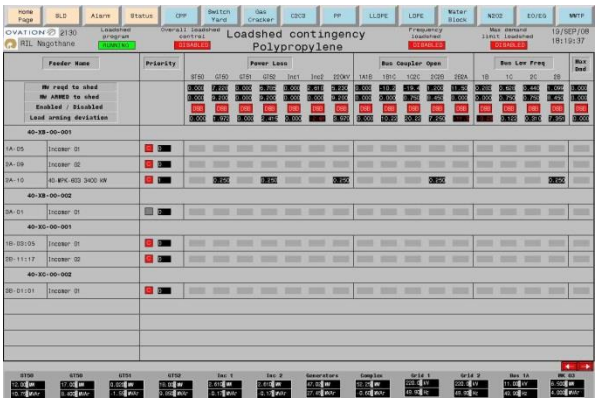
Fast Load-Shedding

Loss of a power source 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 Ovation ECMS contingency analysis and load shedding software automatically responds to such issues and significantly reduces the cost associated with the loss of production. This allows stable conditions to be restored.

If a power source (grid, generator, or an inter-connect breaker on a generation bus) is lost, then the power that was originally available from that power source has to be shed. This is required so that the remaining generators are not over-loaded, and process disturbance is minimized. Multiple downstream feeders must be shed immediately to prevent generator loss.

The Ovation ECMS software selects the feeders to be shed in order from the least important to the most important. The software also checks that the load-shed breaker is available for automatic tripping (e.g. closed and has a MW flow) and desirable (i.e. connected to the importing bus and not to the exporting bus). This list of breakers for each possible load-shed case is continuously updated and made available at the controllers.

The moment a power source is lost, the selected breakers are shed automatically by the system.



Since the loads must be shed immediately to avoid overloading the generators and to avoid a possible black-out, this function is commonly called “fast load-shedding”. Loads are shed on detection of the opening of a power-source breaker. The worst-case load-shedding time will be less than 100 ms.

Graphics are provided to inform the operator of the load required to be shed for each possible future load-shedding case, and also which loads have been selected for each case.

Slow Load-shedding

If any section of the plant is being fed from the grid or from the generators, the frequency of the plant is controlled by the frequency of the grid. The generators also follow the grid frequency.

If any section of the plant is being fed only from the generators and not from the grid, it is called an “island”. The frequency of the island is that of the generators. If the generators are overloaded, then the frequency of the island will slowly fall below the nominal value of 50 Hz (60 Hz in the USA). If the frequency goes below a minimum threshold value, the Ovation ECMS system will shed enough low-priority loads to bring the frequency back to the nominal value.

Since the event (lowering of frequency) happens over a long period of time, e.g. over a 1–10 minute interval, it is called “slow load-shedding”.

Slow load-shedding may also be required if grid tie-line transformers become over-loaded.

Reactive Power Control

In an industrial plant, when large motors and pumps are turned on and off, the plant experiences a varying active (MW) power demand. The motors are usually large, inductive loads causing the plant to also experience a varying reactive (MVAr) demand. The purpose of the reactive power control logic is to satisfy that reactive demand within the constraints of:

- Keeping the power factor of tie-line power close to unity or at the operator-entered power-factor set-point - this eliminates power-factor penalties
- Ensuring that generators always run within their reactive capability
- Keeping bus voltages within allowable limits

Within an industrial plant, Ovation’s ECMS can control the reactive power by:

- Turning capacitor banks on and off
- Adjusting the excitation on generators and synchronous motors
- Adjusting tap positions on transformers

Capacitor Bank Control

Industrial captive power plants often have capacitor banks. Switching capacitor banks on when reactive power demand is high helps satisfy the reactive demand and gives more MW capacity to the generators. This can lead to a monetary savings. When it is cheaper to generate power rather than buy power, it is desirable to have more in-plant generation capacity. If the generator can run at a higher power factor it can make more MW for the same amount of fuel and reduce the amount of purchased power.

Thus, switching on a capacitor bank reduces the MVAr load demand on that bus, and therefore reduces the MVAr imported from the grid which in turn may reduce the MVAr from the generators.

The Ovation ECMS 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 may either be automatic, or may be as an advice to the operator.

Generator MVAr Control

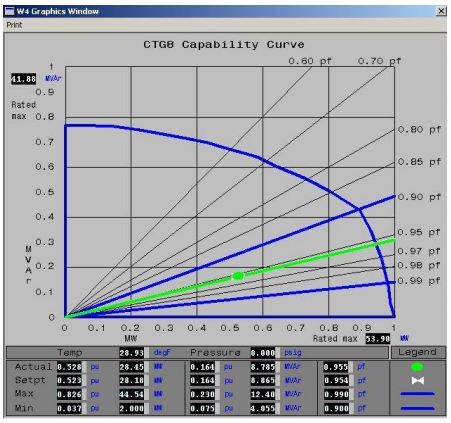
The amount of reactive power produced by a generator can be controlled by adjusting the Automatic Voltage Regulator (AVR) set-point on the machine. This can be done by issuing a raise/lower pulse or sending an analog set-point.

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 set-point. If there is no grid, the goal is to ensure that all the generators on the power island have equal power factors.

The MVAr control logic can be placed in MVAr Auto or Manual mode from the operator workstations. When in MVAr Auto mode, the optimum MVAr set-points calculated by the MVAr control logic are used. When in manual mode, operator-entered MVAr set-points or power-factor set-points are used. The operator may also manually raise or lower the MVAr by clicking on buttons.

The Ovation ECMS system will then either send the MVAr set-point to the generator's AVR as an analog value, or send MVAr raise and lower signals, to bring the generators to their desired calculated set-points.

The Ovation ECMS system also ensures that each generator stays within its reactive capability.

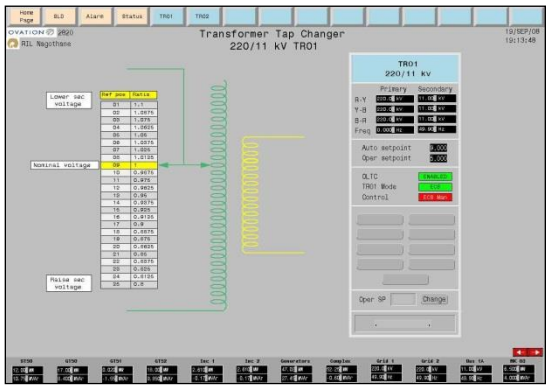


Since changing generator MVAr will automatically change the voltage of the bus downstream of the generator, Ovation control logic will also ensure that the operator cannot move the bus voltage outside its allowable operating range. If the bus voltage goes outside this range while in MVAr Auto mode, the ECMS system will automatically adjust the generator's MVAr to bring the bus voltage within limits.

Transformer OLTC Control

If plant transformers have on-load tap-changing (OLTC) control, the Ovation ECMS system can calculate the desired tap position of the transformer so the voltage of the bus immediately downstream of the transformer is kept within limits, normally within ±6% of the nominal value.

The OLTC control logic can be placed in auto or manual mode from the operator workstations. When in auto mode, the optimum tap positions calculated by the Ovation ECMS control logic are used so that the transformers' downstream buses are within their voltage limits. When in manual mode, operator-entered tap positions are used. The operator may also manually raise or lower the taps by entering the desired values.



Tap changing will affect the voltage of the downstream bus, the power factor of the plant, and the MVAr imported from the grid.

Ovation's OLTC control does not address MVAr import. OLTC control ensures that bus voltage is within limits. It is assumed that generator MVAr control will address grid MVAr import as well as voltage of the buses immediately downstream of the generators. This method ensures that the plant is in healthy working condition. If generation buses have healthy voltages, then the downstream buses will also have healthy voltages.

Synchronization

Power source breakers cannot be simply opened or closed. These are the generator incomer and grid incomer breakers, or bus-coupler breakers at generation buses.

To close these breakers, the voltages, frequencies and phase angles of the buses on both sides of these breakers must be within limits. In addition, as a precaution, these values must be validated by a synchro-check relay before the breaker can be closed.

Similarly, before opening these breakers, the current and MW flow across the breakers must be below certain limits.

Emerson designs Ovation control logic that involves both hardware and software checks for synchronization.

Auto Bus-Transfer

Auto bus-transfer (also called auto transfer or auto changeover scheme) is not required for all electrical networks, but may be required in some specific situations. It is meant only for the two incomers and bus-coupler breakers of a switchboard and not for any other breakers of that switchboard. Normally two breakers are closed. If one of the closed breakers trip (open), then the third breaker is automatically closed by fast control logic. Or, if the operator wants to open out one of the running breakers for maintenance, control logic will first close the third breaker, and then open out the desired breaker – this could be slow control logic. Normally this function is done within the switchboard using the switchboard's control logic. However, if it is a requirement of the electrical control system, it can be accomplished in Ovation.

Motor Reacceleration

Reacceleration is a method of automatically restarting motors after unexpected de-acceleration caused by system voltage events, such as, dips, outages, or bus transfers. Reacceleration schemes are designed to minimize process disruptions by rapid detection of supply loss, recovery/monitoring of acceptable transient torque limits, and then automatic reclosure of the motor contactors. Depending on the connected load and minimum available fault current, the reacceleration may be 'instantaneous' or a staged event designed to assure the bus voltage is maintained at an acceptable level during the process restart. Normally, reacceleration is performed within the switchgear's own control logic due to instant response (4-5 cycles); however reacceleration can also be configured in Ovation.

ECMS Summary Table

ECMS Application	Description
Boiler control and optimization	In addition to basic boiler controls, combustion optimization, intelligent soot-blowing and advanced steam temperature packages are also available to help reduce emissions and improve efficiency.
Steam and gas turbine controls	Turbine controls are required for the turbines in the industrial power house just like turbines in utility plants. Ovation has a proven history of providing gas and steam turbine controls on turbines from key OEMS and various turbine types.
Coordinated steam header pressure control	There is an interaction between the steam and power producers in a plant. Often times the steam producers are controlled as part of the process system, but if the steam and power producers are controlled by the same system then coordinated steam header pressure control can be achieved 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 set-points 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.
Optimization of steam and power production	Determines the fuel flows and loads on the steam and power producers so that the process steam and power demands are satisfied at least cost.
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 graphic representation (SLD) 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 set-point.
Generator MVAr control	Satisfies plant’s MVAr demands by adjusting the excitation of in-plant generators and synchronous motors.
Transformer OLTC 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.
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.