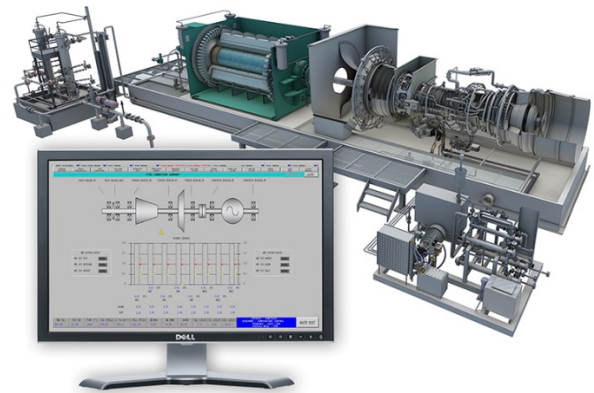


Ovation™ GE LM6000 Control System Retrofit

Features

- Fully engineered and field-proven retrofit for LM6000 turbines equipped with legacy Netcon, Micronet, Mark V, Mark VI Millennium and other control systems
- Ovation™-based solution with redundant 1.1GHz processors specifically designed to meet the critical needs of LM6000 turbines
- Incorporates best practices and control enhancements that enable:
 - Better operator decision making
 - Improved unit operation and performance
 - Simplified troubleshooting and maintenance
- User-friendly tools and direct access to turbine logic facilitates in-house maintenance and reduces dependence on specialist support
- Comprehensive suite of integrated products and services to support cybersecurity programs and obligations
- Easily integrates balance-of-plant systems for unified plant control
- Options available for wireless control and monitoring, simulation, sensors and valves, vibration monitoring and generator excitation and control



Legacy Control Challenges

General Electric (GE) LM6000 aero-derivative turbines, packaged by companies such as GE Energy, Stewart & Stevenson, European Gas Turbines (EGT) and others provide efficient operation and fast startup in peaking and cogeneration applications.

Today, many LM6000 turbines installed in the 1990s and 2000s with legacy controls such as Netcon 5000 and Micronet, Speedtronic™ Mark V and Mark VI

Millennium and GE-Fanuc 90-30 and 90-70 are experiencing control system failures and obsolescence which result in forced outages and reduced starting reliability. Support and maintenance for these systems can be expensive and difficult to schedule.

Ovation™ LM6000 Control

Emerson's gas turbine automation portfolio includes a fully-engineered and field-proven controls retrofit for LM6000 SAC and DLE turbines. Emerson's Ovation™ system features specially designed high-

speed algorithms to execute the demanding operational requirements for LM6000 applications.

Emerson's comprehensive retrofit program for the LM6000 fleet encompasses core engine controls development and application enhancements, version management, project-specific content, installation and commissioning as well as application lifecycle support and updates.

Ovation LM6000 Retrofit Applications

Emerson's Ovation LM6000 retrofit solution is a fully integrated control system that includes all governor and sequencer turbine controls. Balance-of-plant and auxiliary control functions may also be integrated based on customer requirements. A typical Ovation architecture for an LM6000 unit includes a redundant fast Ethernet-based network, dual sets of redundant controllers with high speed 1.1 GHz processors and associated I/O modules, as well as a local gas turbine workstation for operator interface, trending and maintenance functions. One set of Ovation controllers is used for governor applications while the second set is for control of the sequencer and auxiliaries.

Ovation is equipped with all the I/O modules required for LM6000 turbine control, including native turbine I/O modules that interface to speed detectors, LVDT, servos and other turbine instruments without using external signal conditioners. Ovation's direct interface to existing turbine instruments provides fully integrated control of all turbine systems including:

- Variable geometry – VIGV, VSV, VBV actuators
- Fuel systems – gas and liquid
- Water injection system
- Hydraulic starter system
- Turbine & generator lube oil systems
- Thrust balance system
- Chip detection system
- Vibration monitoring (engine-generator sensors)

- Generator temperature monitoring
- Auxiliary systems

Replaced Legacy Components

The Ovation LM6000 retrofit solution covers the replacement of all legacy Woodward, Speedtronic and GE-Fanuc controller equipment including HMI systems and other special devices where applicable, while retaining the existing field wiring and turbine instrumentation.

The following LM6000 legacy components are replaced during an Ovation upgrade:

Woodward Netcon 5000 and Micronet Systems

- Woodward Netcon / Micronet controller
- Woodward LINKnet distributed IO
- Power monitor
- HMI and embedded application (Wonderware® Intouch® / Proficy IFIX)
- Engineering workstations and programming tools – Woodward and HMI

GE Mark V LM Systems

- GE Mark V controller
- <I> or HMI and embedded application
- Mark V Engineering programming tools

GE Mark VI LM (Millennium) Systems

- GE Mark VI LM governor controller
- GE Fanuc 90-70 sequencer controller
- GE Fanuc remote I/O – Genius, field control
- Power monitor
- HMI and embedded application (Cimplicity or iFix)
- Engineering workstations and programming tools – MkVI, PLC Logicmaster and HMI

Benefits of an Ovation LM6000 Control Retrofit

Benefit	Ovation Enhancement
Enhanced operator decision making	<ul style="list-style-type: none"> ▪ Unit operation maintenance summary calculates factored hours/starts ▪ Smart dashboard displays start and trip data as well as gross, net and auxiliary megawatt-hours for each run ▪ Automatic turbine trip reports provided by the Ovation process historian ▪ Enhanced exhaust display includes color-coded tabular views of combustion data ▪ Generator capability monitor shows capability curve with automatic alarming outside of generator limits
Improved unit operation and performance	<ul style="list-style-type: none"> ▪ Unit start profile compares startup and coast-down times with a baseline to identify blade tip rub and other issues ▪ Gas turbine performance indicator that includes megawatt capability predictions as well as real-time heat rate and efficiency calculations ▪ Manual synchronization from the operator workstation ▪ Manual bias of water injection for improved NOx control ▪ Automatic droop tests and frequency response
Simplified troubleshooting and maintenance	<ul style="list-style-type: none"> ▪ Dedicated start permissives and trip displays enable fast problem identification ▪ High-speed trending to pinpoint event data ▪ Overspeed testing from HMI ▪ Fuel valve calibration from HMI ▪ Monitoring of 125 VDC voltage battery levels

Optional Upgrades and Enhancements

Emerson offers a wide range of complimentary products that when combined with Ovation LM6000 controls can provide a comprehensive solution for the unit including:

- Integration of balance-of-plant control processes directly into the Ovation system or interface Ovation to those stand-alone systems
- Connectivity to other Ovation system networks within the unit, plant or fleet to optimize dispatch or generation
- 10-minute fast start
- Starting reliability check
- Electronic overspeed upgrade to SIL-rated system. Includes Eddy current type speed sensors for improved diagnostics and true zero speed detection
- Gas fuel flow measurement upgrade for accurate compensated flow measurement used as the basis for NOx water flow schedule in the control system
- Ovation security center provides higher levels of compliance with cybersecurity obligations
- Generator control, protection and excitation systems
- Fuel system or fuel valve upgrades
- Instrumentation and control valve upgrades
- Additional monitoring instrumentation including a full range of wireless devices that reduce installation time and cost
- Additional workstations for remote operations and historical functions
- Simulation for control validation and operator training

One Platform for Integrated BOP Control

Most LM6000 units include auxiliary balance-of-plant (BOP) controls for gas compressor, inlet chiller, SCR, demineralized water and electrical yard systems. Some LM6000 units installed in combined cycle plants also have OSTG/HRSG controls on balance-of-plant system. In addition to control of auxiliary balance-of-plant equipment, an LM6000 unit may require interfaces to other existing third-party systems such as RTUs, CEMS and plant data. Use of multiple systems within a unit presents a myriad of challenges associated with maintenance, spare parts, training, obsolescence and cybersecurity compliance.

Emerson's Ovation-based solution seamlessly interfaces to legacy third-party BOP systems. As an option, Emerson's LM6000 retrofit solution can be expanded to incorporate these BOP applications directly into the Ovation system for integrated control, simplified operations and streamlined maintenance.

Ovation - Designed for Power

The foundation of Emerson's LM6000 control solution is Ovation technology. Ovation was designed specifically to meet the critical requirements of the power generation industry.

- **Eliminates obsolescence concerns** by using commercially available, off-the-shelf technology that allows the system to progress with rapidly advancing technologies.
- **Provides intuitive built-in diagnostics** that enables personnel to quickly determine where a system problem may reside.
- **Secures operations** with standard features that address security concerns such as machine

authentication, password management, workstation hardening, and disabling prohibited activities.

- **Simplifies configuration and maintenance** with integrated user-friendly tools for programming, graphic creation and navigation, logic interrogation, historical functions and alarm management.

Summary

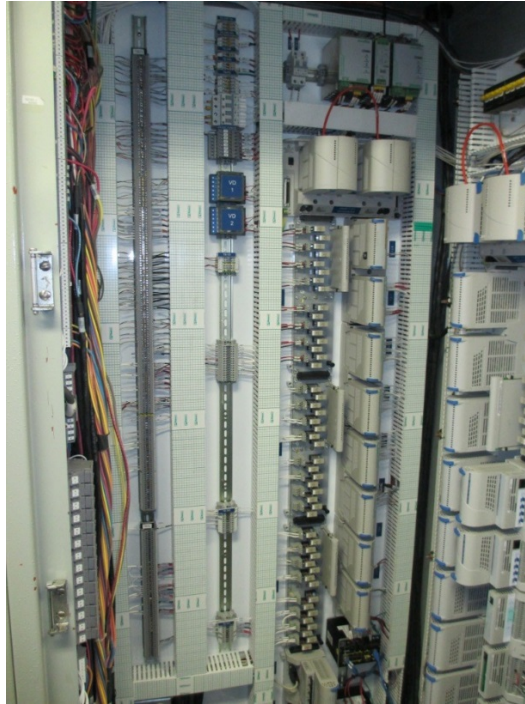
Emerson understands the changing dynamics of the power industry and stands ready to apply its expansive portfolio of solutions to help increase performance and reliability of LM6000 generating assets. Emerson's systems control almost one million megawatts of electricity worldwide from all types of power generation facilities and virtually every manufacturer of heavy equipment.

Emerson's product development philosophy emphasizes technical compatibility and preservation of previous investments. The Emerson team is committed to providing long-term product support and cost-effective migration paths to minimize lifecycle costs while keeping pace with technological advancements.

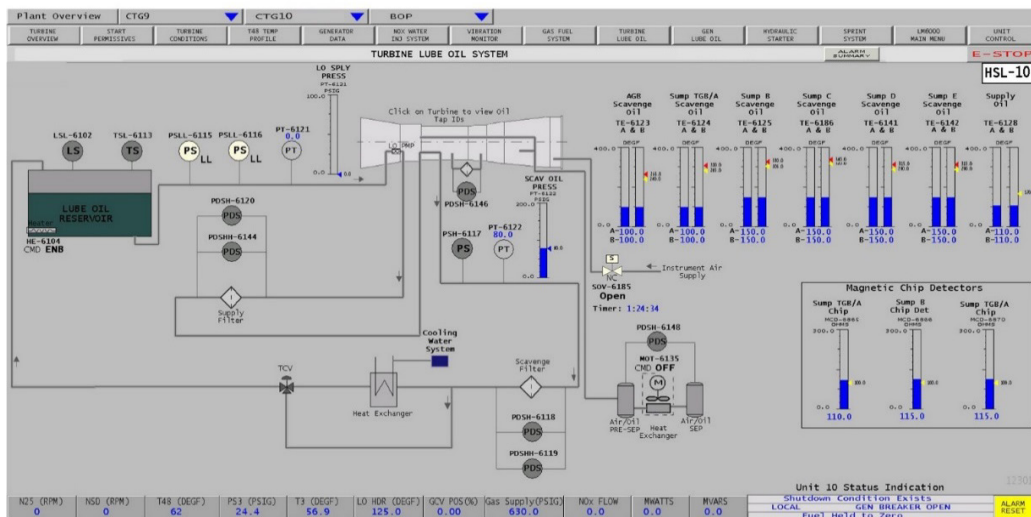
The LM6000 retrofit program was developed by Emerson's dedicated gas turbine solutions group that includes highly specialized experts with years of experience designing, implementing and supporting turbine controls from every major OEM including GE, Westinghouse, Siemens, ABB, Pratt & Whitney, Solar, Rolls Royce and more.

Emerson's turbine control solutions combine state-of-the-art technology, experienced project implementation, long-term support and dedicated customer service to increase asset performance while extending life cycle.

Example Images



Example of an Ovation LM6000 solution including controller and I/O installed in existing termination panel; replacing legacy Netcon chassis and LinketNet modules.



Sample Ovation turbine lube oil system graphic

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