Get more from your gas turbines
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DLN1 Digital Combustion Pack

Improve DLN1 operation, availability and reliability through advanced sensors and software

GE’s DLN1 digital combustion pack is a combination of hardware and software products that are interconnected in order to optimize and enhance the reliability of the Dry Low NOx, 1 combustion system for Heavy Duty gas turbines. The platform helps recapture lost performance and lengthens asset life.

Benefits

Each product within the DLN1 digital combustion pack offers its own unique benefits; in addition, implementation of the entire smart DLN1 bundle improves overall machine operability.

Combustion Dynamic Monitoring (CDM)

- Reduce downtime (startup and commissioning) through the use of new probes that are suitable for up to 48K fired hours (no need to install/remove the temporary kit for standard tuning activities)
- Avoid stops before and after tuning activities to install/remove probes, saving 2 to 3 days of production time after each tuning activity
- Enable remote DLN1 tuning, avoiding time and labor, with online combustion diagnostics through our 24/7 RM&D service
- Enhance troubleshooting actions through the availability of combustion dynamics data

DLN1 Tuning Maintenance Software

- Keeps acoustic dynamics low when operating in Premix steady state
- Extends tuning durability during commissioning
High Load Premix Transfer (HLPT)

- Improve train operability over Extended Lean-Lean to Premix transfer sequence, particularly for process applications where continuous high load operation is critical
- Minimize time in Extended Lean-Lean (reduced time with higher maintenance factor)
- Significantly reduced impact on emissions (faster emissions recovery)

Radiation Free Igniter

- Improves turbine reliability thus avoiding the stand-by period of 25 minutes in OFF mode, as required by NIC10.04
- Compliant with Unit Safety and environmental regulations by eliminating Krypton-85 or Tritium gases
- Installation can be executed in the same junction box as the existing igniter for easy and fast installation
- Diagnostic indicators facilitate effective installation and troubleshooting during commissioning

Flame Tracker Dry FTD-325

- Eliminates water cooling
- Moves electronics to a cooler environment
- Built on proven SiC technology
- Extends operating life to 32K hours

What it is

The DLN1 combustion package is a suite of hardware and software solutions designed to help with the recovery of any type of gas turbine experiencing combustion issues, helping recapture lost performance and lengthening asset life.

It is comprised of five (5) products:
1. Combustion Dynamic Monitoring System (CDM)
2. DLN1 Tuning Maintenance Software
3. High Load Premix Transfer (HLPT)
4. Radiation Free Igniter
5. Flame Tracker Dry FTD-325
How it works

The DLN1 combustion pack improvements are designed to optimize and enhance the reliability of the Dry Low NO, 1 combustion system for Heavy Duty gas turbines by ensuring pollutant optimization through a two-stage combustor. Emissions control is achieved by managing premixed and non-premixed flames. The DLN1 is controlled by engine parameters to divide fuel flow between the primary and secondary stages of a DLN1 combustor operating in Primary, Lean-Lean, and Premix modes. Each combustion mode is associated with a load range. Whenever the combustion operating mode changes from Premix to Lean-Lean or Extended Lean-Lean, reignition of the primary zone is required.

The Combustion Dynamic Monitoring System detects any pulsations in the combustion chamber. If necessary, the dynamics are reduced and/or controlled by DLN1 Tuning Maintenance software. Then, if the system is able to completely overcome the combustion trouble and position the machine in the Extended Lean-Lean safe condition, with the new ignition transformer we secure a primary reigniting and the High Load Premix Transfer is able to return to Premix mode without impacting the gas turbine load.

The CDM system also enables remote DLN1 tuning which eliminates the need for a mapping engineer on site, enhances troubleshooting capability, and generates higher availability. In addition, DLN1 can be integrated with other Monitoring & Diagnostics services, enabling the detection of special issues which can be resolved through tuning activities.

Technical specifications

**PRODUCT APPLICABILITY**

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Combustion Dynamics Monitor (CDM)

Provides early detection of combustion trouble and enables remote DLN1 tuning saving (2-3 days, on average)

GE Oil & Gas has developed a permanent solution, suitable for installation on all Heavy Duty gas turbines, to measure and continuously monitor combustion dynamics. Measurements of combustion chamber dynamics also enable tuning activities, without the use of temporary tuning kits, since the permanent probes can survive inside the machine for up to 48K fired hours.

Benefits

- The CDM system allows for continuous monitoring of pressure pulsation levels for each combustion and can detect abnormal behavior of the combustion system, enabling diagnostics and prognostics through our M&D service
- In combination with other advanced sensors, CDM enables Condition Based Maintenance and unplanned outage management
- Permanent probes make it possible to perform DLN1 tuning whenever it’s necessary, allowing the CDM system to deliver at least 2 to 3 days of production savings
- New design with non-intrusive mechanical arrangement improves probe durability
- The CDM system also provides for future control and service functions such as DLN1 Tuning Maintenance software and remote DLN1 tuning
What it is
The Combustion Dynamics Monitor is a permanent measurement device for determining combustion chamber dynamic pressure. It consists of the following main items:
- Piezo-electric probes installed in each combustion chamber
- Extension cable from probes to a charge amplifier located in a junction box mounted at the skid edge
- Data Acquisition System, typically located in the unit control panel (control room area)
- CDM data is displayed on the unit control panel HMI screens for monitoring purposes
- Data collection to OSM allows the remote acquisition of acoustic parameters to GE Oil & Gas i-Centers

How it works
The Combustion Dynamics Monitoring system consists of pressure transducers mounted on each of the gas turbine’s combustors, which allow continuous measurement of pressure pulsation.

The full spectrum of dynamics data (amplitude vs. frequency over the complete analyzed frequency range) can be viewed in the enhanced toolbox trender. The full spectrum data is captured and saved to a file when demanded by the application code (limited to certain configurations).

Technical specifications
Applicability
The CDM package is applicable to the following Heavy Duty gas turbines:
- MS3002J SC DLN1
- MS5001P/PA DLN1
- MS5002C/D DLN1
- MS6001B DLN1
- MS7001EA DLN1
- MS9001E DLN1

Combustion dynamic measuring loops are suitable for installation in the high temperature environment of the gas turbine package and in hazardous areas, compliant with the following area classifications:
- US Cl.1 div.2 and Cl.1 Div.1
- EU Zone 2 ATEX and Zone 1 ATEX

Main scope of supply
The Combustion Dynamics Monitoring system includes the following main items:
- Measuring loops (probes, extension cables and charge amplifier) and relevant mechanical probe adaptors
- Junction boxes and relevant electrical hook-ups (trays, supports, interconnecting cables, etc.)
- Data Acquisition System and relevant connectivity with On-Site-Monitor (OSM)
- Monitoring & Diagnostic services (M&D)
In order to meet NOx and CO emission requirements, frame turbines can be equipped with the Dry Low NOx (DLN1) combustion system, which creates a premixed flame associated with reduced pollutant levels. In order to ensure correct operation of the combustion system across the entire operating range, both in terms of load and fuel gas composition, the DLN1 system needs to be tuned periodically. This activity means meeting the appropriate gas emission levels and combustion stability, including the verification and minimization of combustion dynamics when operating in Premix mode.

**Benefits**

- Maintains low acoustic dynamics when operating in Premix steady state
- Extends DLN1 tuning durability

**Lean Blow-Out**

**Cold-tone Dynamics**

**Acceptable Limits**

**Hot-tone Dynamics**

**NOx**

**Acceptable Window**

**Acceptable Limits**

**Fuel-to-Air Ratio**
What it is

DLN1 Tuning Maintenance software is a package designed to preserve the tuning of the DLN1 system with a focus on combustion dynamics. A dedicated algorithm optimizes the Premix operating parameters to limit combustion dynamics while maintaining a low impact on exhaust emissions.

How it works

The software monitors specific combustion operating parameters, such as combustion dynamics and flame detector intensity, and uses a dedicated algorithm to determine how the Premix operating window must be swept to limit combustion dynamics.

The Tuning Maintenance software is designed to work in conjunction with the Combustion Dynamic Monitoring (CDM) system, if it is already present; otherwise it can be provided in conjunction with the current Tuning Maintenance software.

The package operates with the gas turbine in Premix mode with a low impact on exhaust emission and without affecting the load. It can operate both reactivity (i.e. actively processing combustion dynamics levels detected by CDM, at load variations) and proactively (i.e. running system tests on a regular basis). Compliance with emission requirements for different load points is ensured by setting dedicated boundaries to adjustable parameters during the usual mapping activity.

Technical specifications

Applicability

MS5001 P/PA DLN1, MS5002 C/D DLN1, MS6001B DLN1, MS7001EA DLN1, MS9001E DLN1 equipped with Mark™ VI, Mark™ VIe control system.

Main scope of supply

DLN1 Tuning Maintenance software is a software modification; as such its scope consists of:

• Modification of relevant control logic
• New graphic pages
High Load Premix Transfer (HLPT)

Control software designed to improve the DLN1 premixed recovery process while maintaining base load operation

DLN1 gas turbines can operate at low NOX and CO emissions when running in “Premix” mode that is enabled only at a specific load threshold. Working over that threshold, the combustion mode is normally supposed to be Premix; nevertheless under some circumstances that mode is instead turned to Extended Lean-Lean, which is a high emission/maintenance mode. In order to restore the Premix mode, the gas turbine is unloaded down to the specific threshold and then loaded up again to initiate the Premix transfer sequence. The HLPT is a modification that allows the re-establishment of Premix from Extended Lean-Lean combustion mode without need of a load change. The transition from Extended Lean-Lean to Premix is possible at any load for generator drive units, and up to ~95% load for mechanical drive units.

Benefits

• Improves train operability over Extended Lean-Lean (Ex-LL) to Premix transfer sequence, particularly for process applications where continuous high load operation is critical
• Minimizes time in Ex-LL; reduced time with higher maintenance factor
• Significantly reduces impact on emissions; faster emissions recovery

What it is

When operating in Premix mode (combustion flame on secondary nozzles) there are several possible causes for unexpected re-ignition of the primary combustion zone, including combustion dynamics, air or fuel contamination, or a sudden change in fuel gas composition.

The current DLN1 recovery process requires that, after the detection of a mode change from premixed combustion to Extended Lean-Lean, the unit is unloaded below the Premix transfer point and then reloaded past the transfer point to return it to Premix mode. During the interval required for unloading and re-loading, the operation at high load is interrupted with consequent loss of production.
How it works

The HLPT package was initially developed for generator drive applications, to significantly reduce the time in Extended Lean-Lean and bring the unit back into Premix operation and emission compliance in as little as three to four minutes, executing the transfer in about 10-15 seconds. In power generation applications, the activation of the transfer sequence can be undertaken automatically, without operator intervention, upon detection of Extended Lean-Lean mode.

In mechanical drive configuration, the same strict requirement to re-establish emission compliance in a very short time, does not exist. Priority is given to performing a safe and smooth transfer from Extended Lean-Lean to Premix, without interfering with plant operations. Our experience shows that the HLPT system meets specific requirements to guarantee safe and smooth operation during transfer from Lean-Lean to Premix mode in mechanical drive applications.

The HLPT should be harmonized with other protection-logic systems and only be operated once the healthy status of the gas turbine has been confirmed (i.e. purge valve fully operational and no combustion trouble present). The HLPT system should not be over-used to mask real combustion problems, and it will abandon the attempt to transfer if it fails to extinguish the flame in the primary zone.

Technical specifications

Applicability

HLPT software is applicable for use on the following Heavy Duty gas turbines equipped with the Mark™ V, Mark™ VI or Mark™ VIe control system:

- MS5002C/D DLN1
- MS7001EA DLN1
- MS9001E DLN1

Main scope of supply

The High Load Premix Transfer is a software modification; as such its scope consists of:

- Modification of relevant control logic
- New graphic pages
DLE Tuning Maintenance Software

Increase the reliability of aeroderivative DLE units by reducing alarms and trips connected with combustion problems associated with the DLE system

Aeroderivative gas turbines equipped with Dry Low Emission (DLE) combustion chambers need to be tuned periodically in order to operate within design limits in terms of pollutant emissions and combustion hardware life.

DLE tuning is performed by a combustion specialist and requires the partial unavailability of the engine for production for one to three days, if not longer. The effectiveness of a tuning fades with machine fouling, ambient conditions and seasonal variations. As a result, it must be periodically renewed, with the attendant outage conditions described above. The main effect of faded mapping is high pressure pulsations in the combustion chamber that, if neglected, increase over time and can lead to reduced power output of the engine (stage down) and loss of production (step to idle).

Benefits
- Optimizes DLE tuning activities
- Reduces the number of tuning activities required by mapping specialists each year
- Reduces alarm, stage down and step to idle related to combustion/DLE by 50%
- Reduces downtime required for DLE mapping
- Lessens the probability of trips and loss of production due to high combustion chamber pulsations and blowout
- Extends parts life

What it is
DLE Tuning Maintenance software (DLE TuMas) is an easy to install software upgrade which requires minimal unit downtime. It increases the reliability and availability of aeroderivative DLE units by reducing events such as alarms and trips related to combustion problems associated with the DLE system.

The objective of the software package is to optimize the tuning activities of the DLE system. Tuning Maintenance software maps the operating space to determine the types of combustion corrections required to minimize dynamic pulsations.
How it works

When a DLE engine is operating in steady state there are several possible causes for an unexpected lack of production caused by combustion dynamics or incipient blowout condition. Faced with high pulsations or blowout, the standard DLE reacts by trying to keep the engine running. However, if acoustic conditions don’t disappear and high variances in combustion occur, the core engine will stage down and limit its performance for safety reasons.

DLE TuMas works proactively to prevent operation in high acoustic zones by keeping the engine running in the most stable condition possible. The DLE TuMas periodically verifies the variance between the current operating point and potentially critical conditions in order to define a correction curve to prevent operation in unstable conditions and maintain the gas turbine in production. These checks are conducted with complete transparency so operators can monitor their progress.

Technical specifications

Applicability
PGT25, PGT25+, PGT25+G4, LM2500, LM2500+, LM2500+G4 equipped with DLE1.0 or DLE1.5 combustion system and Mark™ VI or Mark™ VIe control system.

Main scope of supply
DLE TuMas is a software modification; as such its scope consists of:
- Modification of relevant control logic
- New graphic pages

Staging valves
DLE Efficiency Boost

Software designed to improve turbine efficiency by reducing fuel gas consumption during partial load operation

In order to meet NO\textsubscript{x} and CO emission requirements, the LM2500 gas turbine can be equipped with the Dry Low Emission (DLE) combustion system, which creates a premixed flame for the whole operational range of the engine. The DLE system allows a number of different burning configurations depending on delivered power, in order to match the fuel/air ratio that creates the lowest emissions level.

Within each burner mode, the fuel/air ratio is kept constant with fuel flow variation by overboard bleeding through a valve placed at the axial compressor discharge. When the bleed valve is completely closed or completely open, the fuel/air ratio can no longer be held constant through bleed valve regulation and a burner mode change is needed. When the unit is running with the bleed valve wide open, part of the consumed fuel is wasted as a result of the overboard bleeding. In the overlap of burner modes, the engine can deliver the same power and speed in two different burner modes.

Benefits

The DLE system is designed to increase gas generator (GG) efficiency at partial load by up to 8\% by reducing fuel gas consumption.

In addition, the new software will not increase atmospheric emissions above the limits guaranteed by the DLE 1.0 technology.
What it is
Software designed to improve turbine efficiency by reducing fuel gas consumption during partial load of the gas generator — from 50 to 95% of the GG speed limited to the overlap zone between combustion modes.

How it works
The DLE system has different combustion modes depending on power. Overboard bleeding is used to control emission levels within each combustion mode. Bleeding off air wastes fuel because it consumes energy in the passive part of the GT's thermodynamic cycle without producing energy in the active part. The efficiency boost logic works in the overlap range between combustion modes, forcing the DLE system onto a different path, whenever possible, in order to minimize the turbine’s running time in high bleed condition.

Technical specifications

Applicability
PGT25, PGT25+, LM2500, LM2500+ equipped with DLE1.0 combustion system and Mark™ VI or Mark™ VIe control system.

Main scope of supply
The DLE Efficiency Boost is a software modification; as such its scope consists of:

- Modification of relevant control logic
- New graphic pages
HP Recoup Monitoring System

Improve availability and reliability through advanced sensors and software

HP Recoup is a monitoring system designed to estimate thrust load for LM2500 engines by means of HP Recoup line pressure measurement and a dedicated control system algorithm upgrade. The system is mandatory to support the extension of LM2500 engine maintenance schedules.

Benefits

- Enables automatic evaluation of thrust load and HP Recoup orifice adjustment (control software upgrade)
- Improves Monitoring & Diagnostic and troubleshooting capabilities
- Increases #4B bearing health assessment capabilities
- Supports the extension of LM2500 engine maintenance schedules (10kh-30kh-60kh)

What it is

The system consists of a transmitter and a dedicated algorithm, in the control room, that runs real time thrust load calculations and estimates the required orifice adjustments.

Package modification includes installation of a pressure transmitter on the HP Recoup line.
The upgrade includes the following major components:
1. Pressure transmitter
2. Materials for primary hook-up assembly
3. Materials for electrical hook-up assembly
4. Materials for UCP modifications (barrier, cabling, accessories)
5. Mark™ VIe/HMI software modification (CD-ROM)

For service equipment, the following detailed mechanical design documentation must be retrieved to facilitate HP Recoup system installation:
- Synthetic oil console electrical hook-up
- Synthetic oil console mechanical arrangement
- Electrical cabling arrangement between the control room and the synthetic oil console

The HP Recoup control logic is available for Mark™ VIe. Any other control platform will require a control engineering preliminary assessment and software adaptation (Mark™ VI, Woodward, etc.).

**How it works**

The GG rotor is subject to forward loading from the High Pressure Compressor (HPC) and aft loading from the High Pressure Turbine (HPT), resulting in an axial load which thrust bearing #4B is required to sustain. Underload or overload conditions can reduce bearing life and lead to unexpected failures.

To ensure that the load against the #4B bearing remains within the acceptable operating range, a preload must be applied by adjusting HP Recoup pressure in the thrust balance chamber with a calibrated orifice. This pressure generates a net force in the forward direction which, combined with the HPC and HPT loads, creates the resultant forward force for proper operation of the #4B bearing.

**Technical specifications**

**Applicability**

The HP Recoup is applicable to all LM2500 family gas turbines, SAC and DLE (both HSPT and LSPT equipped):
- PGT25
- PGT25+
- PGT25+ G4
- LM2500
- LM2500+
- LM2500+G4
intelligent Human Machine Interface (iHMI)

Enhanced graphics and improved alarm management features facilitate more timely and accurate operator responses to critical problems

iHMI (intelligent Human Machine Interface) is an evolved, intelligent Windows®-based operating system and engineering workstation software library for GE Oil & Gas turbines, generators, compressors and balance of plant systems.

Benefits

**Better operability**

Improved alarm management helps enhance equipment operation. The iHMI is easier to interact with, improving operator awareness and reducing his or her cognitive workload.

**Productivity**

Better operability and the reduction in human errors that can be expected as a result, provide the potential for fewer unplanned shutdowns with an associated improvement in productivity.

**Improved availability**

Reaction times to alarms will decrease thanks to the optimized alarm system, this will lead to a reduced number of shutdowns. Operators are also supported by real-time instructions on the necessary corrective actions.
What it is

Intelligent Human Machine Interface is an evolved and intelligent Windows®-based operator station and engineering workstation software library for GE Oil & Gas turbines, generators, compressors and balance of plant systems. It consists of two main items which can be installed as an upgrade or supplied with your new equipment:

1. New graphic layout: easy to understand, fast issue recognition/resolution, task completion, seamless navigation to improve operator confidence in the control systems;

2. Advanced alarm management feature (ISA18.2 compliant): dynamically filters the process alarms based on current plant operation and conditions so that only the most important current alarms are highlighted. Dynamic alarm management focuses the operator’s attention by eliminating superfluous alarms, to improve recognition of critical problems, and facilitate more timely and accurate operator responses.

How it works

The industrial design field of human–machine interaction is the space in which interactions between humans and machines occur. The goal of this interaction is to allow effective operation and control of the machine from the human end, while the machine simultaneously feeds back information that aids the operators’ decision making process. The user interface or human–machine interface (HMI) is the part of the machine that handles the human–machine interaction. Our iHMI solution is equipped with a Control Toolbox ST software suite which includes several high-performance tools for ease-of-use by operators and maintenance personnel. These tools include the WorkstationST* HMI and Historian management software, the ControlST configuration and diagnostics software, CIMPLECTITY* graphic tools, and other packages for communications, monitoring and asset management.

The iHMI can be applied as a stand-alone operator station, an engineering workstation only, or as both. It communicates on an ethernet control network and on a separate ethernet information network for file transfers and communications to non-GE plant control and monitoring systems. Redundant HMIs and redundant ethernet networks are available for increased operations and communications reliability.

Technical specifications

Connectivity details

iHMI fits GE Oil & Gas customers equipped with PGT25 or LM2500 (all models) turbo-compressor and turbo-generator packages controlled by Mark™ VIe. iHMI requires Cimplicity (8.2) and ControlST (5.4) version or newer.

The product is partially applicable to existing control systems based on Mark™ VI or Mark™ VIe technology. New graphic pages will be fully compatible with both the platforms while ISA18.2 compliance is more oriented to the Mark™ VIe system.
Mark™ VIe Migration from Mark™ VI

A complete solution kit that allows you to quickly swap from your existing Mark™ VI control system to GE’s latest Mark™ VIe system, cost-effectively and with minimal downtime.

The Mark™ VIe Migration from Mark™ VI kit is a fast, simple and economical solution that will bring customers up-to-date with GE’s latest state-of-the-art control technology, with minimal impact to site wiring, field terminations, or turbine devices.

Benefits

- Minimal downtime and upgrade impact depending on site conditions, the migration can be completed in as little as seven outage days
- New Mark™ VIe parts have the same footprint and connections as the existing Mark™ VI; no modifications to cabinets and field connections are required
- Compatible with current programs for advanced and remote Monitoring & Diagnostics services
- Enables cyber security and functional safety performance
- Ready for fully integrated Mark™ VIe hardware and software solutions: anti-surge, load sharing, fire and gas, digital twin
- Delivers increased computing power and I/O capacity to improve turbine performance and reliability
- Provides the most up-to-date operational tools, with improved graphics, alarm/event management, trending, reporting, etc.
- Modern, high-speed industrial ethernet network with client/server capability, managed data access and configurable system throughput to enable improved analytic and diagnostic capabilities
- More efficient serviceability with one single modern software environment covering configuration, networking, processors, blocks and libraries, live editing, and multiple diagnostic levels

Upgrading to the Mark™ VIe platform creates a clear path for future enhancements and lifecycle support.
How it works

Installation

Installation of the new system begins with a site survey, including an evaluation of current software, comprehensive data collection, and development of a risk assessment report, plan and scope of work.

All necessary parts and upgrade materials are procured and shipped to a GE test bench facility, where a full software and hardware simulator (twin to the site panel) is used to conduct a comprehensive acceptance test.

The migrated “as running” software is installed, and networking and graphics are tested in a site-like simulation environment to ensure all parts and software functionality are fully reproduced, to reduce risks prior to site shutdown and to schedule dismantling and reassembling procedures.

All design documentation is updated.

Fully tested system is repackaged and optimized for fast site activities, labeled with tracked identification, and linked to site procedures to ensure the installation team is provided with a streamlined, straightforward installation plan.

Defined check points during the installation process allow progress monitoring; schedule is divided and consolidated until successful unit restart.

What is upgraded/replaced

- CPUs
- I/O Network
- VPRO machine protection
- I/O VME cards & racks
- Mark™ VI power supplies
- Some terminal boards, with new firmware
- Software migration and HMI update

What is kept

- Most of the existing T-type terminal boards
- Field cables, terminal board filed cables and plugs
- Passive power distribution devices
- Marshalling panels and interposing devices
- OEM equipment and powers supplies

Additional options

- Mark™ Vle anti-surge functions integration (Opticomp)
- Fire & Gas and OEM controls migration to Mark™ Vle
- ESD safety functions moved to Mark™ VleS (SIL3)
- Cyber security and DCS connectivity updates
- Expansion to manage machine and instrumentation upgrades (CDM, OSM, etc.)

Technical specifications

CONNECTIVITY DETAILS

<table>
<thead>
<tr>
<th>Speed of CPUs</th>
<th>Available up to 1,2 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ports</td>
<td>5 Ethernet, 1 USB, 1 COM</td>
</tr>
<tr>
<td>Configuration</td>
<td>Dual or Triple redundant</td>
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<tr>
<td>Scan rate</td>
<td>10, 20, 40, 80, 160, or 320 ms</td>
</tr>
<tr>
<td>I/O modules</td>
<td>Mark™ Vle I/O modules on proprietary I/O 100 Mbit full duplex deterministic Network (IOnet)</td>
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<tr>
<td>Status &amp; diagnostic</td>
<td>Front LEDs and networked alarms</td>
</tr>
<tr>
<td>Human machine interface</td>
<td>Cimplicity® (latest version)</td>
</tr>
<tr>
<td>Cyber security</td>
<td>Achilles™ certified - Level 1</td>
</tr>
<tr>
<td>DCS connectivity</td>
<td>Modbus over serial, RTU, TCP/IP, OPC DA, UA, AE</td>
</tr>
<tr>
<td>Typical power</td>
<td>18 to 32 V dc; 110Vdc/230Vac – 1.8KW</td>
</tr>
<tr>
<td>Electrical design regulations</td>
<td>IEC/EN; UL/CSA</td>
</tr>
</tbody>
</table>

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Mark™ Vle Migration from Suvimac II+

Minimize gas turbine downtime associated with upgrading your Suvimac II+ control system while retaining your existing interconnecting cable infrastructure

The Mark™ Vle migration from Suvimac II+ is a fast, simple and economical solution that will bring customers up-to-date with GE’s latest state-of-the-art control technology, with minimal impact to site wiring, field terminations, or turbine devices.

Benefits
- Features the proven Mark™ Vle technology platform; includes dual redundant CPU processor
- Uses existing main field interface connections, reducing the time and cost of wiring disconnection and reconnection while lowering the risk of rewiring errors. No need to tear out current turbine control cabinet
- Just 16 days required for the upgrade — 50% less than standard cabinet tear out — including safety and critical loop check/functional test
- Life extension of existing Suvimac II+ components leveraging Mark™ Vle lifecycle
- Control platform is capable of managing I/O expansion
- Supports the latest communication protocols

What it is
The Mark™ Vle migration kit provides customers currently using Suvimac II+ with a solution to address obsolescence of their internal core gas turbine control system.
How it works

Suvimac IIe is an upgrade kit based on Mark™ VIe and Versamax® Input/Output (I/O) modules. It is designed to substitute Suvimac II+ control panels for existing and obsolete gas turbine control system platforms.

The main advantage of this upgrade is that it allows operators to keep their existing interconnecting infrastructure while refreshing their gas turbine control system to the latest GE Control Technology. In addition, it delivers increased overall system reliability thanks to proven GE Mark™ VIe Dual CPU and redundant I/O network technology.

Control system architecture manages core signals through Mark™ VIe I/O modules and auxiliary signals trough Versamax® I/O modules.

Existing control panel power supply will be replaced with modular preassembled sections. New control system elements come pre-assembled and factory tested to ensure hardware and software integration. If required, in order to further reduce the unit control system installation time, dynamic string testing of the Suvimac IIe kit can be performed using a gas turbine model real-time simulator.

Technical specifications

<table>
<thead>
<tr>
<th>CONTROLLER CAPABILITIES</th>
<th></th>
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<tr>
<td>Frame rate</td>
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<td>Ports</td>
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<td>Configuration</td>
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<td>Power</td>
<td>• 18 to 32 V dc</td>
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<td></td>
<td>• Status LEDs</td>
</tr>
<tr>
<td>Security</td>
<td>Achilles™ certified — Level 1</td>
</tr>
<tr>
<td>I/O modules</td>
<td>• Mark™ VIe I/O modules on proprietary I/O Network (IOnet)</td>
</tr>
<tr>
<td></td>
<td>• Versamax I/O modules on Profibus DP Network</td>
</tr>
<tr>
<td>HMI (Human Machine Interface)</td>
<td>Cimplicity®</td>
</tr>
</tbody>
</table>
Oil Debris Monitoring (ODM)

Real-time early damage detection of auxiliary gearbox and bearing

ODM is an online condition monitoring technology designed to alert equipment operators of bearing and gear wear or damage long before equipment failure, thereby avoiding a high cost event.

Benefits

Installing an ODM system allows operators to monitor the accumulation of particles, by mass, indications of significant wear or component damage. This significantly reduces the occurrence of unplanned outages.

- Enhances availability
- Maintenance free
- Detects equipment damage early and quantifies its severity and rate of progression
- Provides the operator with detailed information that can be relayed to the technical assistance team in order to estimate the remaining useful life for machine operation

GE Oil & Gas aero-derivative gas turbines are equipped with magnetic chip-detection devices. The chip detectors are located in the lube and scavenge pump at the scavenge line connections for the accessory gearbox, B-sump, C-sump, D-sump and transfer gearbox. The instruments are factory calibrated to provide an alarm signal when the resistance across the detector falls below a certain value.

While the chip detector is an analogue device whose behaviors are comparable with a digital device, the values detected are not utilized for trend analysis. The detectors also cannot define the numbers and dimensions of solid particles present in the oil. Our ODM system uses a metallic particle analyzer designed to detect the passage of metallic particles in fluid lines. The sensor provides early warning of bearing and gear wear or damage (accessory and transfer). Installation of the Oil Detection Monitor can reduce unplanned outages or even catastrophic failures. Combined with monitoring software, the analyzer classifies wear-metal particles in fluid lines, and tracks their accumulation. The ODM monitors the accumulation of mass and provides operators with early warning of any abnormal activity.

What it is

ODM is an online debris monitoring system designed to detect the passage of metallic particles in synthetic oil lines. The system, which can be used in any pipe flow situation, is particularly well-suited to applications in which it detects metallic debris in a lubrication oil system to provide early indication of component damage.
How it works
The Oil Debris Monitoring system consists of the following major components:

- A non-intrusive flow-through sensor fitted to the fluid line to be monitored
- A custom low noise sensor cable connecting the sensor to the electronics
- A control unit which processes the raw signal from the sensor and extracts information about the size and type (ferromagnetic or nonferromagnetic) of metallic debris detected
- A host monitoring system integrated into the existing gas turbine control system that displays current count data and compiles trend data, computing equipment health indices, and announces warning/alarm exceedances

Technical specifications

Applicability
The ODM system is designed for use with the following equipment:

- LM2500
- LM2500+
- PGT25 DLE or SAC
- PGT25+ DEL or SAC
- PGT25+ G4 DLE or SAC
- LM6000 SAC or DLE

Main scope of supply
The main components of the ODM system include:

- Metallic particles synthetic oil analyzer sensor
- Accessory for sensors
- Sensor plumbing for A, B, C and AGB scavenge lines
- Sensor stand
- Additional kit for LM2500 + Gas Generator System Installation
- Multi-sensor Control Unit (24 VDC) + RS232/RS485 converter
- Software
- Electrical material

Certifications
The ODM system is suitable for installation in ATEX zone 2 hazardous areas.
The availability of oil and gas plants can be greatly impacted by torsional vibration phenomena, caused by Electro-mechanical Torsional Interactions (EMTI) in Variable Speed Drive System (VSDS) compressor applications or Sub-Synchronous Torsional Interactions (SSTI) in Turbo-Generator applications. The Torsional Vibration Control System (TVCS) is a comprehensive solution that allows operators to monitor, manage and mitigate torsional vibration phenomena, with tailored functionalities for different applications.

Benefits
The Torsional Vibration Control System helps operators:
- Minimize commissioning and startup time
- Optimize plant availability
- Reduce the impact of shaft-line fatigue life due to torsional vibrations

It also allows us to store and analyze relevant machine data through the GE Oil & Gas Remote Monitoring and Diagnostic (RM&D) system, in case of torsional events.

What it is
The TVCS is made up of the following main items:

**Control Module**
This is the TVCS base product; it provides specific monitoring and management of torsional vibrations.

**Torsional Active Damping System**
Effective mitigation of torsional vibration events is enabled by the Torsional Active Damping System.

For VSDS-driven compressor applications, no additional equipment is required, since active damping is provided through the VSDS itself.

For turbine-generator applications, this is a complementary item that can be supplied in addition to the TVCS Control Module.
How it works

The TVCS collects input from a magnetic speed pick-up on a geared wheel (installed in a suitable location of the shaft-line) and acquires voltages and currents from the relevant electrical machine. The following main features are provided:

Torsional Monitoring

A real-time fatigue-based analysis (Goodman Diagram) is carried out for the most relevant sections of the shaft-line, with different configurable thresholds for increasing levels of criticality.

The results are shown on a dedicated video page on the Unit Control Panel (UCP) Human Machine Interface (HMI) in the form of a user-friendly bar-plot summary.

In addition, a torsional protection function is included in the base algorithm of the TVCS Control Module. It provides a digital hardwired output to a protection relay, leading to the unit breaker trip if the specified fatigue-based threshold is overcome. The operator can decide whether or not to enable this function.
Technical specifications

Applicability
The Torsional Vibration Control System is suitable for the following applications:

- Turbo-Generators
- VSDS-driven Compressors

Scope of supply
The TVCS Control Module (one per unit) includes the following main items:

- Control Hardware to be installed inside the Unit Control Panel/Generator Control and Protection Panel, including a high-speed Field Programmable Gate Array (FPGA), real-time Operating System running on a high-performance CPU, modular I/O modules, and Ethernet connection
- Validated software for torsional vibration measurement and processing
- Set-up based on detailed train torsional analysis data and specific customer needs
- UCP HMI dedicated video page showing TVCS real-time analyses outcomes

For the active damping of VSDS-driven compressor shaft-lines, no additional hardware is needed. A control function able to receive the relevant control signal from the TVCS Control Module must be activated inside the VFD Control System.

The Grid Damping System (one for the entire plant) for the active damping of turbine-generator shaft-lines consists of the following main items:

- MV AC Switchgear
- MV Step-Down Transformer
- MV Thyristor Bridge
- MV Inductor
- Control and Protection Section

A dedicated e-house for the installation of all the above items can be supplied as an option, for a plug-and-play solution.

Real-time Insights
Based on the torsional monitoring outcomes, real-time insights are provided to the operator through the UCP HMI.

For turbo-generator applications, torsional vibration events (the crossing of a configured threshold) are correlated to significant changes in terms of active power of the key electrical loads (e.g., VFD's) in the plant. These insights allow the operator to take necessary actions to avoid excessive torsional vibrations (or even unit trips), thereby increasing plant availability. Preventative actions could include unloading a VSDS-driven compressor or increasing the number of turbine-generators in operation.

For VSDS-driven compressor applications, torsional vibration events are correlated to relevant changes in terms of the unit’s active power and speed.

Torsional Active Damping Control
A built-in algorithm enables control of equipment that provides positive torsional damping. For VSDS-driven compressor applications, this equipment is the VSDS itself, while for turbo-generator applications a Grid Damping System has to be connected to the plant to damp ongoing torsional interactions.

Data Storage and Provision for Remote Monitoring and Diagnostics (RM&D)
The TVCS has a provision for connecting to GE Oil & Gas Remote Monitoring and Diagnostic (RM&D) system, to store the most significant data in case of torsional events. This allows GE experts to provide technical support and troubleshooting in order to meet desired plant operational requirements.

These data also allow operators to continuously improve Real-Time Insight Rules, based on learning from real plant behavior and characteristics.

Ready for the Industrial Internet
The connectivity capabilities of the TVCS enable the development of a tailored App to run on the Predix Operating System for the Industrial Internet.