



Maintenance+ Asset Performance Management (APM) for Rotating Machines

Maintenance +

If you're looking for ways to reduce downtime and enhance the performance of operations and assets, GE Power Conversion's simple suite of clever software applications can help. Its flexibility includes 'on-prem' and cloud-based options which help to optimize operations and energy, and enable predictive maintenance and cyber-secure service solutions. GE Power Conversion's digital suite is based on a straightforward, modular range of digital app's, tools and services, connecting data with the right people. Already, more than 500 sites are benefiting from Power Conversion's digital solutions. Each of our three easy-to-navigate modules focuses on a key area of improvement: Operations+, Maintenance+ and Services+ tools and app.

Maintenance+ is your Asset Performance Management range of tools, protecting your investment in valuable equipment by helping to improve its availability. It provides a view on the health of your critical assets with early warnings of developing issues to help you take timely, corrective actions. This can unlock a shift from unplanned to planned downtime, or even contribute to avoidance of downtime altogether.

Asset Performance Management (APM) transforms equipment maintenance with unique analytical techniques and support. GE's Maintenance+ APM tools evaluate asset health by analyzing data from key systems, like rotating electrical machines and power electronics, using KPI analysis and Electrical Signature Analysis (ESA). Our tools assess asset health and monitor for performance degradation, providing an early warning system and helping you to reduce unplanned downtime.

Maintenance+ APM for Rotating Machines is a cloud based or on-prem analytic solution that analyzes high frequency data and Key Performance Indicators (KPIs) with predefined algorithms to provide early warning information of potential failures and help reduce unplanned downtime.

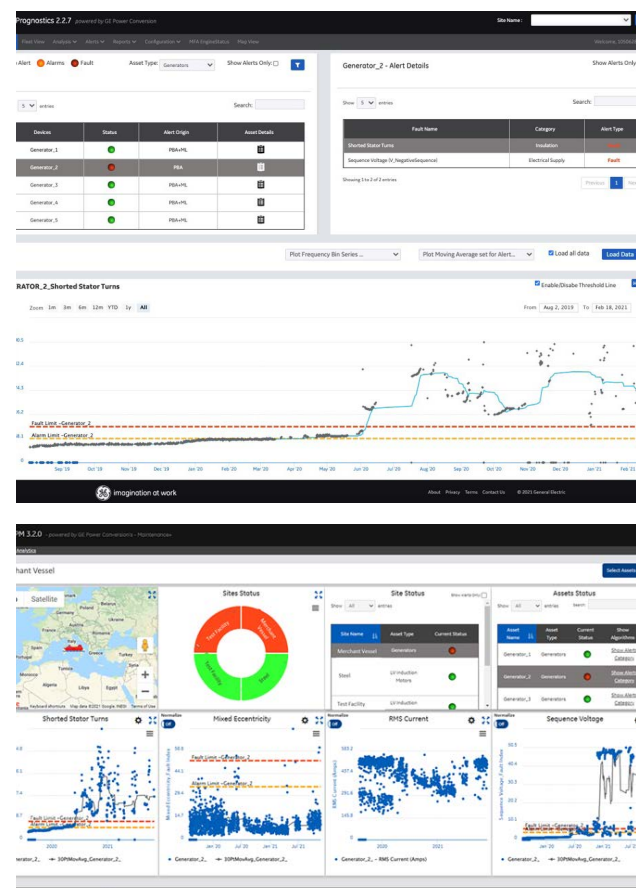
USE CASE: Many organizations already benefit from our **Maintenance+ APM for Rotating Machines** and Drives solutions, which collect indepth data when applied to drives manufactured by GE as well as rotating machines manufactured by GE or third parties. With extensive expertise in variable frequency drives and more than 100 years of experience engineering motors, generators and control equipment, our specialists put their software, data and domain expertise to work. We can provide early warning information of potential failures—with input from high-frequency sampling, Electrical Signature Analysis (ESA), Usage-based Models (UBM) and Machine Learning (ML)—to help you shift from unplanned to planned maintenance, thereby enabling reduced downtime.

Supporting Maintenance Management and Reducing Unplanned Downtime

GE's **APM for Rotating Machines** specifically targets rotating machine assets including medium voltage (MV), low voltage (LV) generators and motors that are either fixed speed or variable speed converter fed. **APM for Rotating Machines** can provide particular benefit where the failure of any one of these machines or their associated equipment can cause unplanned downtime, loss of production, loss of product quality or a combination of all three.

Our **APM for Rotating Machines** solution uses Electrical Signature Analysis (ESA), coupled with advanced algorithms and machine learning (ML) to provide a wide range of failure mode detection versus conventional vibration and temperature monitoring.

Applying Electrical Signature Analytics (ESA) either alone or in conjunction with vibration and temperature monitoring can help to increase the range of potential failures that can be predicted well before they actually happen.



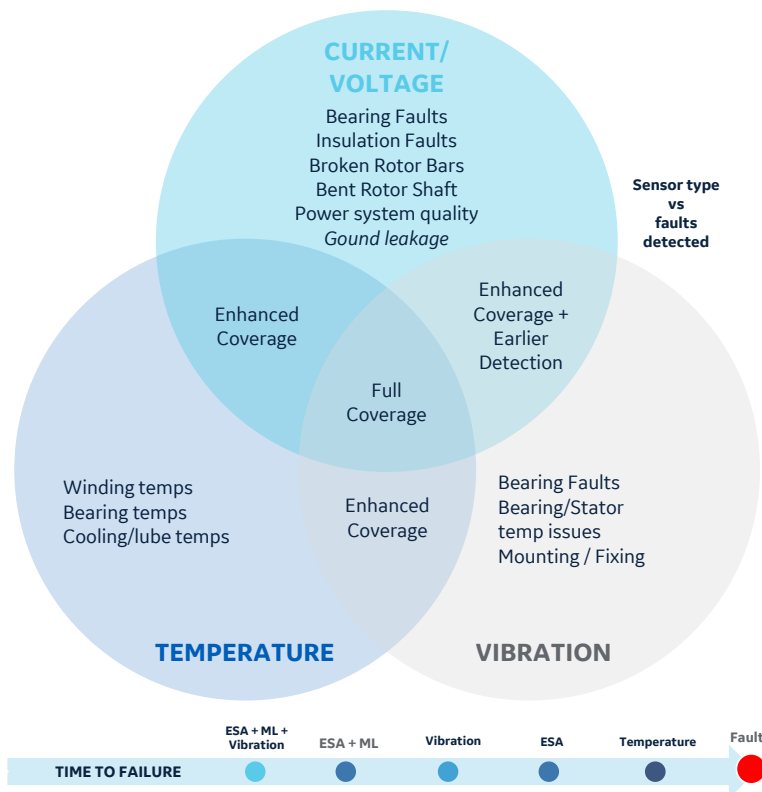
Maintenance+ APM - Overview Dashboard

DIGITAL

How adding ESA to traditional sensor types allows full coverage and earlier detection

Electrical Signature Analysis (ESA)

- Ideal for existing installed base where GE edge devices can act as the sensor to record high frequency (HF) data
- Can be interface to non-GE systems where HF data can be requested via their PLC or protection relays
- Provides good coverage for many rotating equipment issues and power system quality
- Lower cost of deployment when a GE drive is already installed
- Non-invasive method of detecting issues with no modification required to equipment
- Scalable solution with flexibility to add sensors to address specific failure modes



Customer Success Story

The solution has been implemented across various industries including steel rolling mills, cruise ships and wind farms, and APM for drives has been implemented on solar farms.

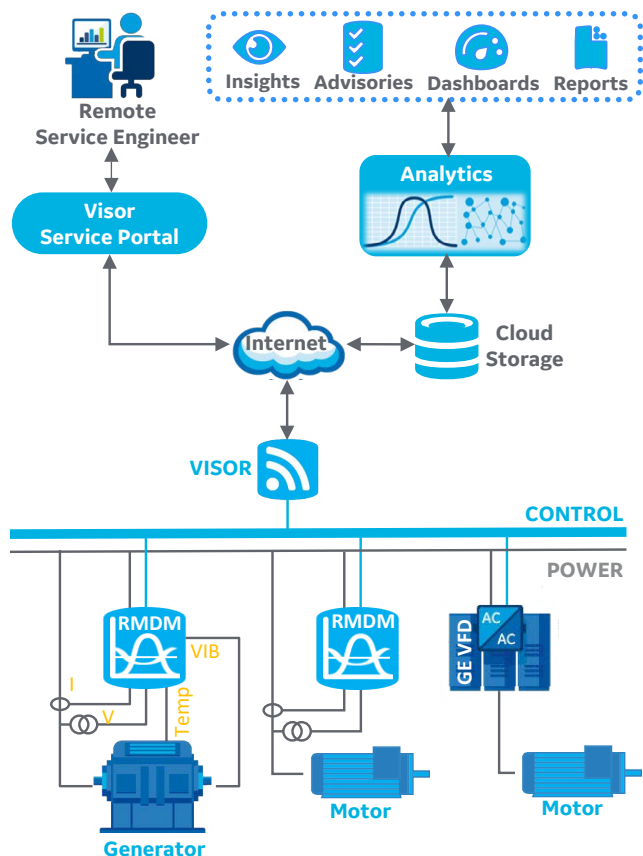
Maintenance+ APM was deployed in a steel plant to monitor 20 process motors controlled by a customer owned, non-GE variable frequency drive (VFD).

The customer saved an unplanned shutdown thanks to **Maintenance+ APM for Rotating Machines** solution. An increasing trend of outer race defect algorithm and mixed eccentricity was observed indicating an alignment issue. The misalignment was detected in advance and corrective actions taken, thereby avoiding an unplanned outage.



Typical Architecture - Flexible and Scalable

Maintenance+ APM for Rotating Machines Solution is flexible and scalable, therefore can be applied to sites with one electrical machine, or hundreds of electrical machines.



Options To Meet Multiple Topologies

Option 1: GE Drive as an Edge Device

If GE drives exist in your plant, it is straightforward to install requiring minimal hardware. Often only one additional item of hardware is required, the Visor Connect Box (VCB), which provides a gateway for remote support and cloud connectivity.

Visor is GE Power Conversion's remote access solution, also featuring a powerful data historian. Through VCB, information can be remotely accessed via a security compliant site

Option 2: RMDM box, if no GE drive exists

If you have non-GE drives or DOL machines, we can still support you via our Rotating Machine Diagnostics Module (RMDM). The RMDM box will be deployed to capture the required data from your machines to execute the analytics. One RMDM box can cover up to 100+ machines

Option 3: Standalone APM Box (On-Prem only)

The Standalone APM box offers an on-prem solution capable of monitoring up to 40 machines. The APM box captures the required high frequency data from your machine and performs the analytics, all within the same box. The result of analytics and dashboards are available via a monitor connected to the APM box.

Cloud or On-Prem options available

The APM solution can be deployed as a cloud-based solution, or On-Prem if remote connectivity is an issue.

Cloud Analytics and Dashboards

- Advanced algorithms and machine learning
- Single or multi-site view of assets
- Cloud storage of data
- Auto-reporting
- Alert management and case tracking

Site Data Storage and Secure Transport

- Communications interface to site equipment
- Storage of collected data and files
- Deadband and reporting options for streaming
- Automatic file push to cloud (buffered)

Data Collection

- Direct from GE or customer-owned non-GE equipment/systems
- Indirect using existing equipment
- Variable capture frequency to suit application
- High fidelity data capture up to 25kHz

Analytics Covered

| Fault Category / Trend | Fault Type | Detection Method | | | | Type Of Electrical Machine | |
|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|------------------|----|-----------|------|----------------------------|----|
| | | ESA | ML | Vibration | Temp | IM | SM |
| Bearing faults (Ball/Roller bearings) | Outer race defect | ✓ | | ✓ | | ✓ | ✓ |
| | Inner race defect | ✓ | | ✓ | | ✓ | ✓ |
| | Ball defect | ✓ | | ✓ | | ✓ | ✓ |
| Bearing faults (thrust/sleeve bearing) | Bearing fault | | | ✓ | | ✓ | ✓ |
| Stator faults | Shorted stator turns | ✓ | | | | ✓ | ✓ |
| Rotor faults | Broken rotor bars | ✓ | | | | ✓ | |
| Mechanical faults | Mixed eccentricity (applicable when number of poles in motor/generator >2) | ✓ | | | | ✓ | ✓ |
| | Mechanical issues (Through vibration discrete tone identifier) | | | ✓ | | ✓ | ✓ |
| | Mechanical issues (Through vibration RMS) | | | ✓ | | ✓ | ✓ |
| | Gear box issues | ✓ | ✓ | ✓ | | ✓ | ✓ |
| | Mechanical issues - through generic FFT (e.g. coupling/bearing/vibration) | ✓ | | | | ✓ | ✓ |
| Electrical supply-faults* | Negative sequence current | ✓ | | | | ✓ | ✓ |
| | Negative sequence voltage | ✓ | | | | ✓ | ✓ |
| Electrical supply-KPI trends* | Voltage THD | ✓ | | | | ✓ | ✓ |
| | Current THD | ✓ | | | | ✓ | ✓ |
| | KPI-frequency, estimated speed, current RMS, active power, reactive power, total power, power factor, voltage RMS, dv/dt at the point of sampling | ✓ | | | | ✓ | ✓ |
| Anomaly detection | Asset anomaly detection with individual asset baselining | | ✓ | | | ✓ | ✓ |
| | Asset anomaly detection in comparison to a good asset | | ✓ | | | ✓ | ✓ |
| Temperature | Bearing temperature | | | | ✓ | ✓ | ✓ |
| | Stator temperature | | | | ✓ | ✓ | ✓ |

*Values at sampling point of motor (i.e. location of sensors) and calculated offline- for trending purposes only.

ESA - Electrical Signature Analytics

TEMP - Temperature

ML - Machine Learning

IM - Induction Machine

SM - Synchronous Machine

THD - Total Harmonic distortion

For other machine types contact your GE representative.

Conceived for Operators

GE Power Conversion's Digital Suite is built on GE's industry wide expertise in IT, OT (operating technology) and IIoT (the industrial internet of things). Above all we believe it should be intuitive, visual and customized for your operational needs. Featuring simple, clear interfaces it provides organizations of all sizes with access to GE's powerful data analytics, made accessible and usable by providing better intel and situational awareness. Genuine performance improvements are within reach, to help your organization work with increased efficiency and profitability.

To find out more:
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