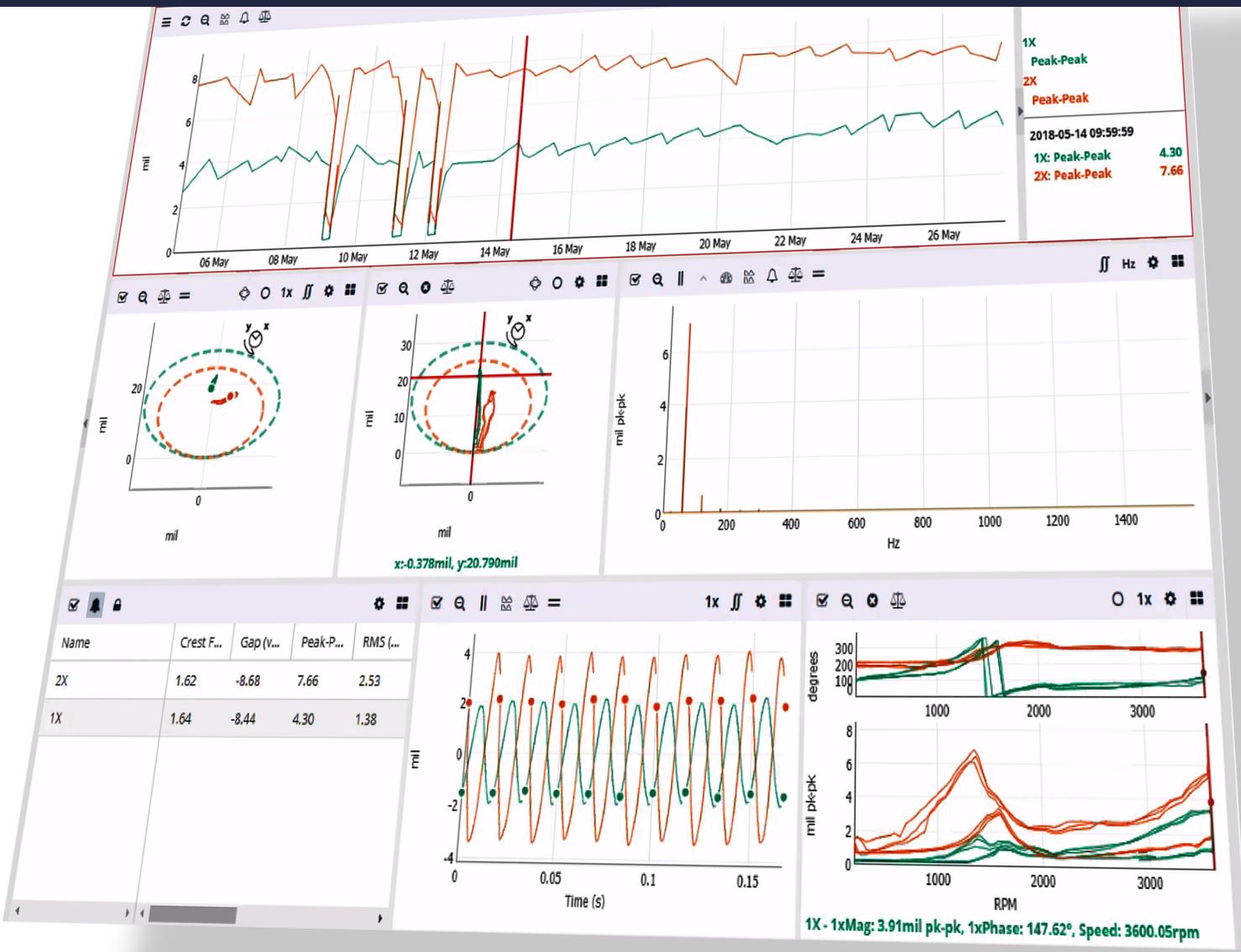


InsightCM™



Contents

InsightCM for Condition Monitoring	3
Open Condition Monitoring Software for Maintenance Professionals	3
Basic Solution Architecture	4
InsightCM Benefits	4
Improve Productivity with Remote Diagnostics.....	4
Minimize Change by Connecting to Existing Enterprise Software and IP.....	4
Manage Any Sensor with One Software Tool	5
Focus on the Most Relevant Data	5
Meet Your Security Needs	5
Prepare for the Future with an Open, Customizable System	5
Monitoring Devices for Any Asset	6
For Critical Assets with Protection Systems	6
Continuous Monitoring System Key Features	6
Intelligent Data Triggering with Continuous Monitoring Systems	7
Burst Mode	7
Streams	7
Spectral Limits	7
Security Implications with One-Way Measurement from Protection System	7
For Dynamic Assets that Need 24x7 Monitoring	8
Supported Sensor Inputs.	9
Vibration Analysis	9
Thermography	12
MCSA	13
For Assets Typically on Periodic Routes	15
Wireless Vibration Measurement Devices	15
Wireless Vibration Sensors	17
Monitoring Device Feature Comparison	18

InsightCM for Condition Monitoring

Open Condition Monitoring Software for Maintenance Professionals

InsightCM is online asset-monitoring software for subject matter experts and maintenance professionals who need:

- Full access to waveform data
- Multiple sensor technology inputs
- Connectivity to existing enterprise software packages
- A variety of configuration options for alarms and data management

InsightCM connects to a family of monitoring devices to monitor asset health sensor data from any critical equipment in your plant.

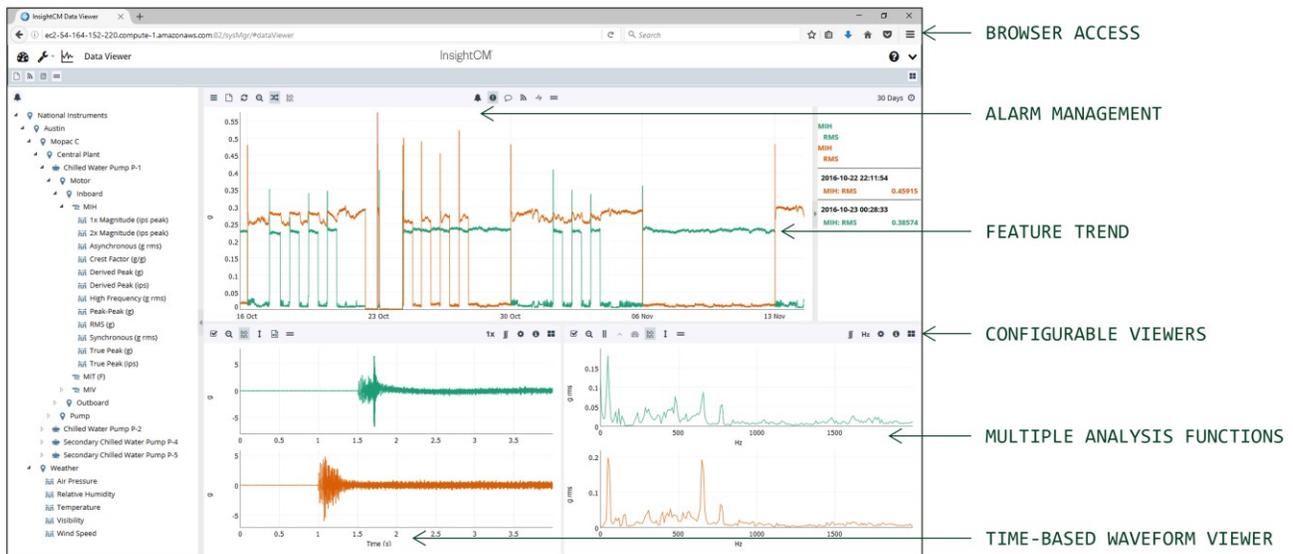


FIGURE 1.

Web-based trending and analysis tools help machine analysts diagnose problems from anywhere with network access. (Standard vibration analysis viewer shown in image)

Basic Solution Architecture

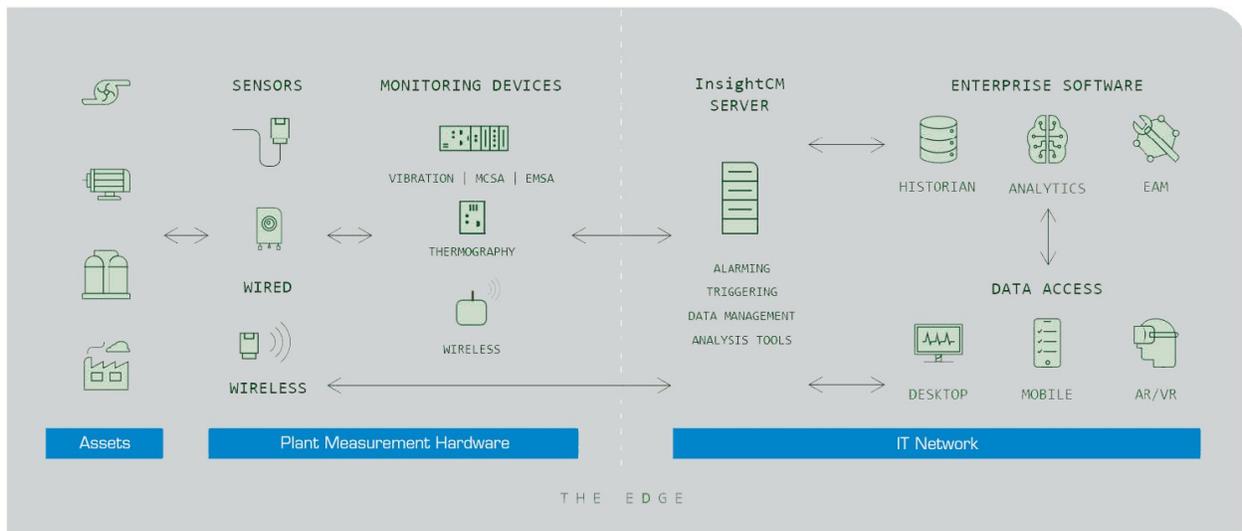


FIGURE 2.

The typical InsightCM system architecture connects wired and wireless sensors from multiple plant assets to IT networks, enterprise digital technology, and subject matter experts.

InsightCM Benefits

Improve Productivity with Remote Diagnostics

InsightCM helps analysts and plant personnel shift focus away from manual data collection, freeing up time for more value-add activities such as data analysis, maintenance planning, and plant operations. Included features let you:

- Log in to the InsightCM server from any web browser with network access and perform real time analysis
- Cover more assets across your fleet with your existing team
- Get to analysis faster with data screening, alarming, and multi-sensor analysis tools

Minimize Change by Connecting to Existing Enterprise Software and IP

InsightCM is the most open condition-monitoring application software on the market giving you the freedom to use the tools you need to meet your goals. Connect InsightCM data with:

- | | |
|----------------------------|-------------------|
| ■ The OSIsoft PI System™ | ■ IBM Maximo® |
| ■ Black & Veatch Asset360® | ■ Microsoft Excel |
| ■ GP Strategies EtaPRO | ■ AVEVA eDNA |
| ■ Avantis® PRiSM | ■ PTC ThingWorx |
| ■ Microsoft Azure IoT Hub | |

Manage Any Sensor with One Software Tool

InsightCM supports a variety of sensor technologies to help catch multiple failure modes and crosscheck diagnoses for greater confidence. Supported measurement technologies include:

- Vibration (accelerometers, proximity probes, temperature, 4-20 mA and ± 30 V static sensors)
- Motor-current signature analysis (MCSA) (potential transformers, current transformers)
- Thermography (infrared cameras)
- Generator Field Monitoring (includes shaft voltage and current as well as Rotor Flux Monitoring in one system)
 - Available for hydroelectric, nuclear, and compound generators
- EMI Monitoring (Monitoring Generators, motors, circuit breakers, and transformers for electrical defects)
- Partial Discharge Monitoring: The Partial Discharge (PD) measurement consists on a 2D histogram of PD Pulses known as PD Pattern or PRPD (Phase Resolved Partial Discharge) Pattern. All trending parameters are available in Insight CM
- Brush Condition Monitoring; Carbon Brush Length, Temperature and Vibration can be imported to Insight CM for trend analysis

Focus on Relevant Data

InsightCM systems can continuously (24x7) acquire and screen data from connected analog sensors. This architecture helps detect alarm limit excursions and operating-state changes in near real time, helping analysts focus on data with value, rather than parsing through numerous data sets collected during monthly routes.

Meet Your Security Needs

Only authenticated hardware and verified users have access to InsightCM. Secure remote password protocol provides authentication between asset monitoring systems and InsightCM. IT system administrators can specify a disconnection interval to force the asset-monitoring nodes to disconnect from the server and reauthenticate themselves. Access to InsightCM is role-based and gives IT system administrators the ability to restrict access to certain functionality to qualified users. These roles and user authentication can be linked to an existing corporate Lightweight Directory Access Protocol/Active Directory group for centralized role management. User activity between the client browser and InsightCM can be further secured using Secure Sockets Layer encryption.

Prepare for the Future with an Open, Customizable System

The Software Development Kit (SDK) for InsightCM helps customize the solution and prepare your business for almost any future needs, including new sensor technologies, communication protocols, and analysis methods. Add your custom analysis IP, connect to third-party hardware, or save to any file format using the SDK. Cutsforth offers a worldwide partner network that can customize InsightCM installations to fit specific needs and adapt them to future expansion.

Monitoring Devices for Any Asset

For Critical Assets with Protection Systems

Continuous Monitoring Systems connect directly to existing protection systems through the buffered analog outputs. This pass-through approach lets maintenance teams add modern, connected, online monitoring systems to legacy hardware with limited communication and analysis capability. Additionally, the buffered analog outputs serve as the security firewall to let plants connect data to standard, business IT networks, without a data diode, rather than the highly protected control networks.

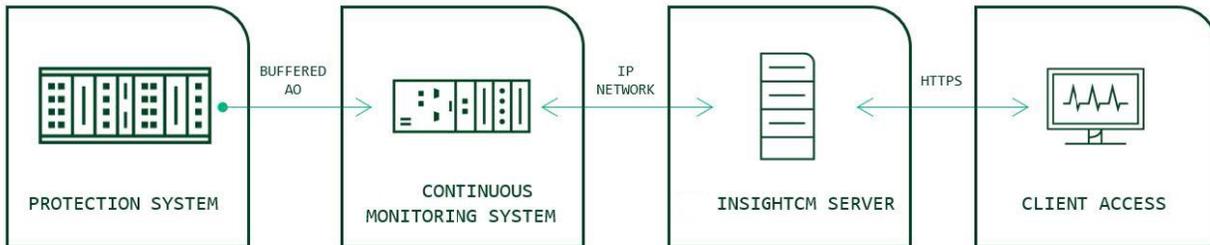


FIGURE 3.

Cutsforth Continuous Monitoring Systems connect to existing protection systems through the buffered analog outputs to add modern online monitoring analysis to legacy, or secured, protection systems.

Continuous Monitoring System Key Features

Continuous Monitoring Systems are built on a rugged measurement system (CompactRIO) and feature four or eight slots for sensor-specific modules. High-speed voltage input modules are used for connection to the output from the buffered analog output on the protection rack.

Note: Module configurations for Continuous Monitoring Systems are specific to the asset and InsightCM toolkits. Please [contact your Cutsforth sales representative](#) for configuration assistance.



FIGURE 4.

Continuous Monitoring Systems (eight-slot option shown) are built on CompactRIO systems; proven technology with more than 15 years of deployment in a variety of heavy industries.

Hardware Specifications

- Dual 10/100/1000 ENET Ports
- Up to Quad-Core Intel Atom Processor
- Passively cooled, -40 °C to 70 °C
- SSD for Temporary Local Storage
- InsightCM Monitoring System Firmware
- Linux Real-Time OS

Intelligent Data Triggering with Continuous Monitoring Systems

Continuous Monitoring Systems intelligently capture data based on a configuration you specify, which reduces overall data volume and provides a way to isolate important asset events. Use the following events to trigger a data capture:

- Time—Data is captured in user-configurable time intervals such as once an hour, once a day, three times a day, and so on. Choose when to capture the features calculated (less data), the full waveform (more data), or both.
- Change in engineering units (delta EU)—Data is captured when a calculated feature changes by the set delta value with respect to the initial measured value. Once the trigger condition is met, the trigger resets from the latest value but retains the same delta limit. This feature is most often used for ramp-ups and coast-downs, during which data recordings at periodic rotational speeds are desired; for example, recording a 4 s waveform every 50 rpm during ramp-up.
- Alarm limits—Data is captured when a measured feature crosses a preset limit. You must acknowledge alarms before retriggering.
- Force trigger—You can request a real-time reading using the force trigger option in the action menu for any device. This feature is good for troubleshooting sensor connections, spot-checking an asset, or investigating the current state before acknowledging an alarm.

Burst Mode

With burst mode, you can preset a time to collect data at higher acquisition rates (up to 102.4 kS/s per channel) to analyze assets with slow rotational speed. Continuous Monitoring Systems revert to the lower set acquisition rate for feature calculation, trigger, and alarm screening.

Streams

Streams are useful for grouping transient event data—such as run-ups or coast-downs—to ease analysis. During streams, data is generally sent more frequently, providing more context on how the asset is performing during critical periods. These events can be observed in real time or after the fact.

Spectral Limits

Screen data as it arrives on the server with spectral limits you set using a graphical tool to mask off frequency by amplitude across the spectrum. This tool is helpful to quickly isolate which machines may be experiencing signs of early stage bearing wear.

Security Implications with One-Way Measurement from Protection System

The only connection path from the protection system to the hardware is the one-way, analog signal connection from the buffered AOs on the protection system. The Continuous Monitoring System has no connection or path to send a signal back to the protection system. The one-way, analog-input topology provides no method for communication to, or control of, the protection system, which may assist with cyber-security policies when needed.

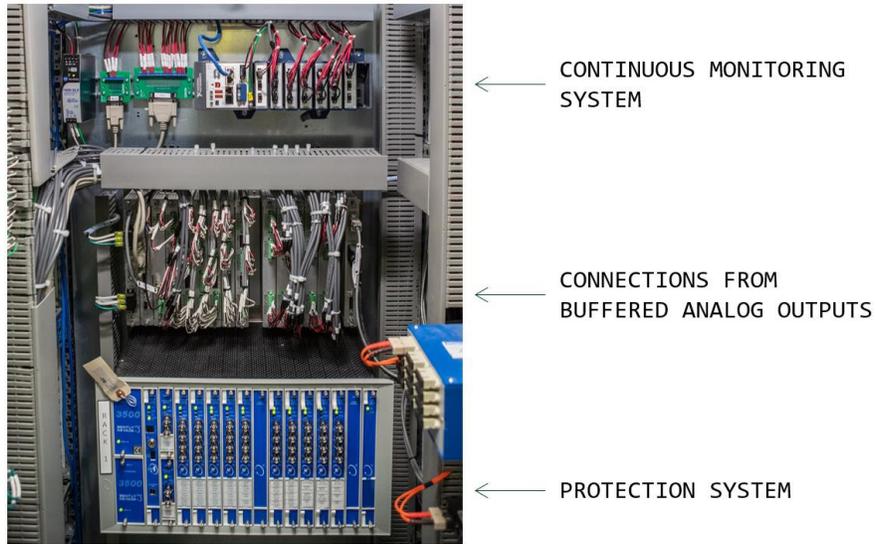


FIGURE 5.

Continuous monitoring systems for assets with protection systems typically install in the same rack as the protection system and connect through front or back-panel connectors to the buffered-analog outputs.

For Dynamic Assets that Need 24x7 Monitoring

Continuous monitoring systems cover a wide variety of dynamic and process sensors to monitor assets with multiple operating states or problematic assets with a higher propensity of failure between service intervals. The advanced acquisition modes referenced above (intelligent data triggering and burst mode) are available for continuous monitoring systems for dynamic assets.



FIGURE 6.

Multiple sensor module options help tailor the Continuous Monitoring System to specific asset sensor needs. Please contact your [Cutsforth sales representative](#) for assistance in configuring an InsightCM Continuous Monitoring Device.

Supported Sensor Inputs

You can connect Continuous Monitoring Systems to virtually any sensor technology and use them with rotational, electrical, static, and process asset types. The devices support the following sensor types out of the box:

- Accelerometer with or without Integrated Electronic Piezoelectric (IEPE) (vibration)
- Tachometer (speed)
- Keyphasor (speed)
- Proximity probe (displacement)
- Velometer (velocity)
- Temperature (resistance temperature detector or thermocouple)
- Voltage (± 30 V)
- Current (4–20 mA)
- Digital input
- Read from Modbus slave devices via TCP/remote terminal unit
- Infrared camera (thermography)
- High-voltage potential transformers for MCSA—120/240 V AC secondary
- High-current current transformers for MCSA—low-voltage secondary
- Power (calculated from voltage x current)
- RF/radio antenna for EMSA
- Data points from OPC UA tags
- Data points from the OSIsoft PI System
- Data points from AVEVA eDNA Enterprise Data Management

Vibration Analysis

Many vibration sensors, such as accelerometers, velocity sensors, and proximity probes, can ultimately provide the same type of information. Vibration signals consist of multifrequency components, and each component represents part of the vibration. These individual vibration components add up to create the overall vibration signal. You can perform two types of vibration analysis using InsightCM: Observing vibration levels to describe the waveform and analyzing spectral bands to describe the spectrum (essentially, a fast Fourier transform of the waveform).

Vibration analysis focuses on either levels that describe the waveform or spectral calculations that describe specific frequency content. InsightCM includes several default level and band calculations, and you can create custom bands to trend bands that correlate with known faults, such as a bearing or gear mesh issues. You can calculate these features on Cutsforth monitoring devices to immediately detect fault conditions and trigger data collections based on the asset operating state.



FIGURE 7.

Continuous Monitoring Systems are compatible with virtually any sensor technology, including standard IEPE accelerometers seen mounted via epoxy to the motor in this image.

InsightCM includes several industry-standard vibration analyses to help you identify faults. For example, you can use an orbit plot to see how a shaft is rotating in a bearing on a turbine and identify worn bearings or inadequate lubrication. Envelope (demodulation) analysis is commonly used for rolling-element bearings to better identify impacting frequencies that correlate with bearing faults.

Features

- 1x and 2x Magnitude
- 1x and 2x Phase
- Asynchronous
- Crest Factor
- Derived Peak
- High Frequency
- Peak-Peak
- RMS
- Synchronous
- True Peak
- Subsynchronous
- Kurtosis
- Custom Spectral Bands
- Gap
- Smax
- Residual

Analysis Viewers

- Trend
- Waveform
- Spectrum
- Waterfall
- Full Spectrum
- Order Waveform
- Order Spectrum
- Envelope Waveform
- Envelope Spectrum
- Orbit
- Bode
- Polar
- Shaft Centerline
- Table
- Time Synchronous Averaging (TSA) Waveform
- TSA Spectrum
- Autocorrelated Spectrum
- Autocorrelated Waveform



FIGURE 8.

The functions listed in the “Features” section above are available in the real-time viewer so analysts can get to a diagnosis, faster.

Thermography

The thermal Imaging Toolkit automates the process of collecting and monitoring images from infrared cameras, as seen in Figure 10. Trend data from regions of interest and alarm on transformer, motor control center, breaker box, and bus bar hot spots. Specify regions of interest (ROIs) and calculate maximum, minimum, and average temperature. With a delta feature, you can calculate the temperature difference between any number of ROIs to normalize for environmental conditions such as monitoring a transformer and looking for an outlier amongst the bushing temperatures.

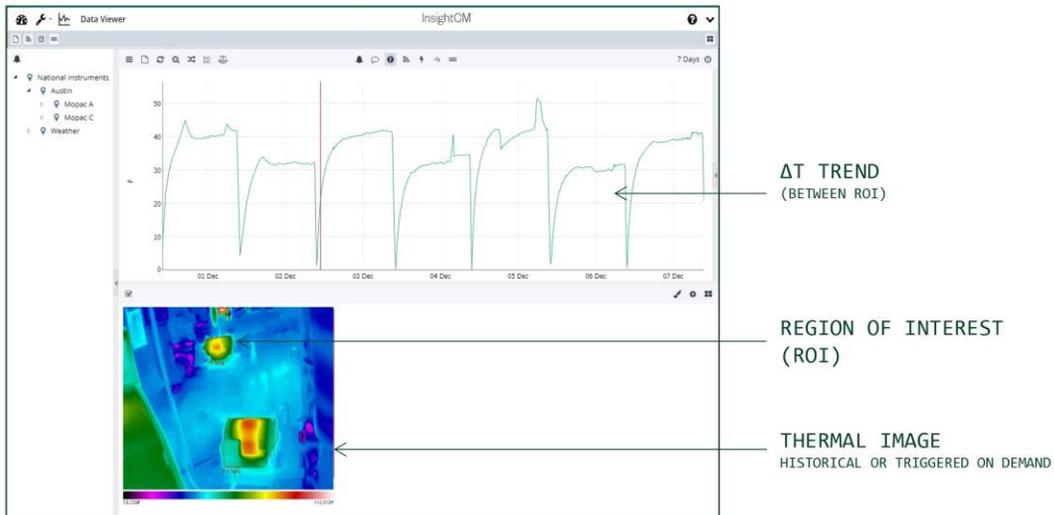


FIGURE 9.

This InsightCM infrared thermography image shows two chilled-water pump-motor skids with a temperature differential trend line. The temperature delta between regions of interest is a common way to look for hot spots on breaker panels, bus bars, and transformers.

Features

- Maximum Temperature within ROI
- Minimum Temperature within ROI
- Average Temperature within ROI
- Delta Temperature between Two or More ROIs

Analysis Viewers

- Trend
- Thermal Image
- Table

MCSA

Motor-current signature analysis (MCSA) uses voltage and current signals to identify motor faults including rotorbar damage, misalignment, eccentricity, mechanical looseness, and some bearing problems. When purchased with the MCSA toolkit for InsightCM, Continuous Monitoring Systems compute features specific to electrical data and motors in addition to the phasor and waveform analysis available.

Note: InsightCM is designed for three-phase AC induction electric motors. There is not support for variablefrequency drive motors at this time.

The 24x7 screening on the Continuous Monitoring System continuously samples voltage and current data at up to 10,000 samples per second looking for transients and in-rush currents. Use this toolkit to set operating states and trigger conditions for in-rush current so you never miss a startup signature.



FIGURE 10.

In a typical motor control cabinet install, CT signal wires run through conduit to Continuous Monitoring Systems with sensor modules for MCSA installed in an industrial cabinet.

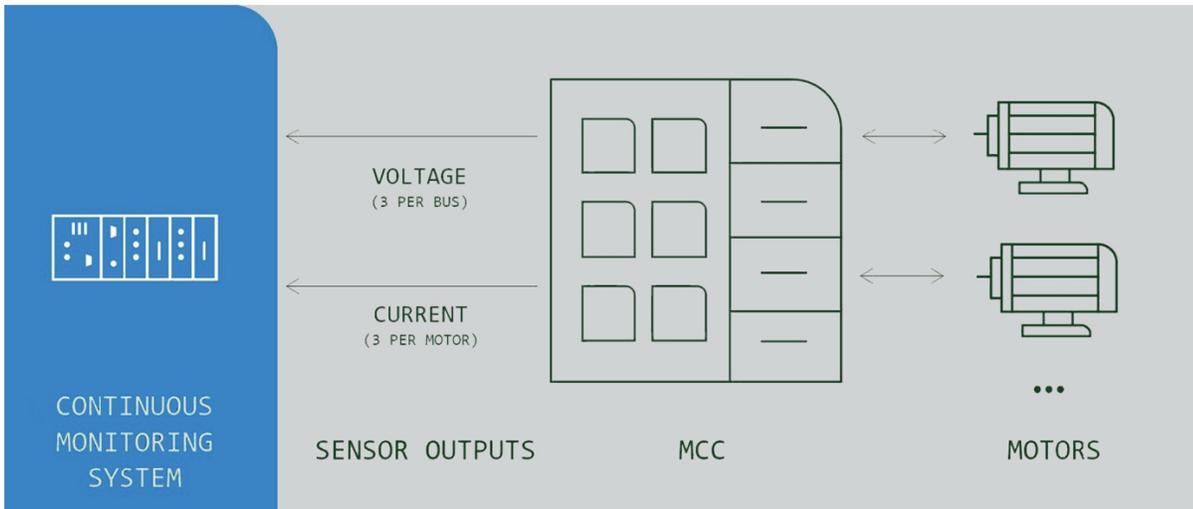


FIGURE 11.

Cutsforth monitoring systems for MCSA can connect to multiple motors on a single three-phase voltage bus. One module connects to voltage/potential transformers with accompanying modules in the chassis used for current transformers.

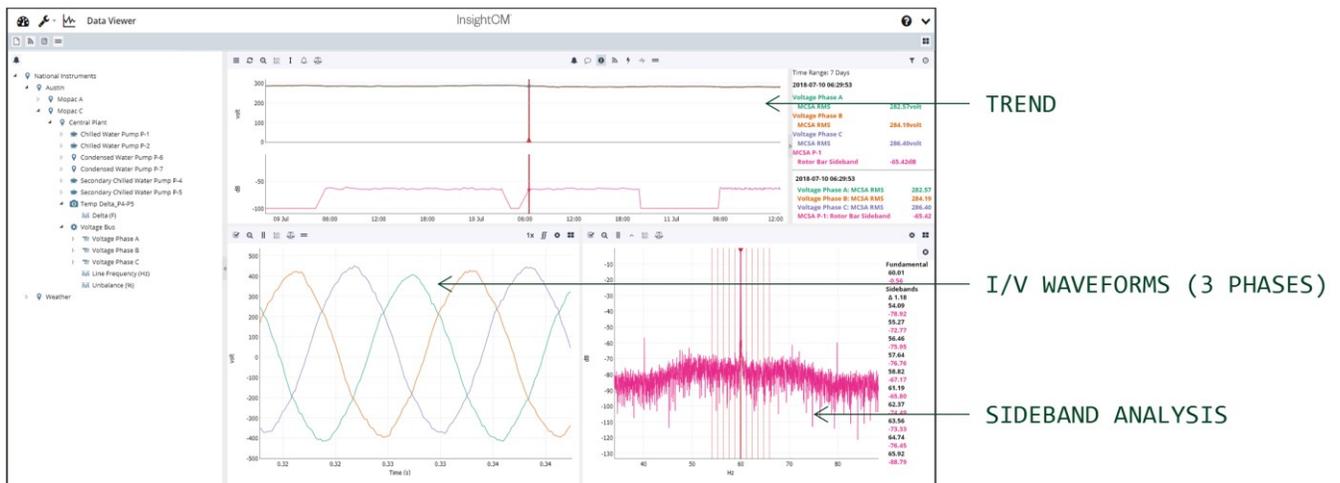


FIGURE 12.

This InsightCM analysis view shows three-phase voltage and the MCSA spectrum.

Features

- RMS
- Line Frequency
- Phasor: Magnitude
- Phasor: Phase
- Unbalance
- Effective Service Factor
- Derating Factor
- Active Power
- Reactive Power
- Apparent Power
- Power Factor
- Speed
- Torque
- Torque Ripple
- Rotor Bar Sideband
- Load
- Percent Load
- Efficiency
- Percent Full Load Amps
- Startup Peak Amps
- Startup Time

Analysis Viewers

- Trend Chart
- Waterfall
- MCSA Envelope Spectrum
- Waveform
- MCSA Spectrum
- Phasor Diagram
- Spectrum
- MCSA Torque Waveform
- Table

For Assets Typically on Periodic Routes

Plant maintenance teams often rely on manual, route-based data collection for less-critical plant assets. With Wireless Monitoring Devices, you can get daily machine health visibility without a trip around the plant.

Wireless Monitoring Devices are designed to wirelessly transmit diagnostic (waveform) data from wired analog sensors to a Cutsforth gateway and then to the InsightCM server, connected via your enterprise IT network. Wireless Monitoring Devices, when battery powered, dramatically reduce installation cost by eliminating the need for running cable/conduit for power and Ethernet. There are currently two types of Wireless Monitoring Devices: Wireless Vibration Measurement Devices and Wireless Vibration Sensors.

Wireless Vibration Measurement Devices

[Wireless Vibration Measurement Devices](#) connect to standard asset-mounted analog sensors and use wireless communication to send diagnostic-quality waveform data to an InsightCM server. Install the system near the monitored asset with the built-in mounting flange. The rugged enclosure is outdoor-rated for industrial environments and can handle wide temperature ranges as well as washdowns. The wireless monitoring devices have 12 analog input channels that support accelerometers, proximity probes, tachometers, and voltage or temperature sensors. All devices ship ready to install and connect to power (either line-powered or battery-powered) and sensors. Once you have installed and commissioned its hardware, the Wireless Monitoring Device transmits data back approximately once a day (user-configurable) via a wireless gateway to the InsightCM server installed on premises or in a virtual machine in your choice of cloud provider. The device also can be manually triggered to send data back to the server.

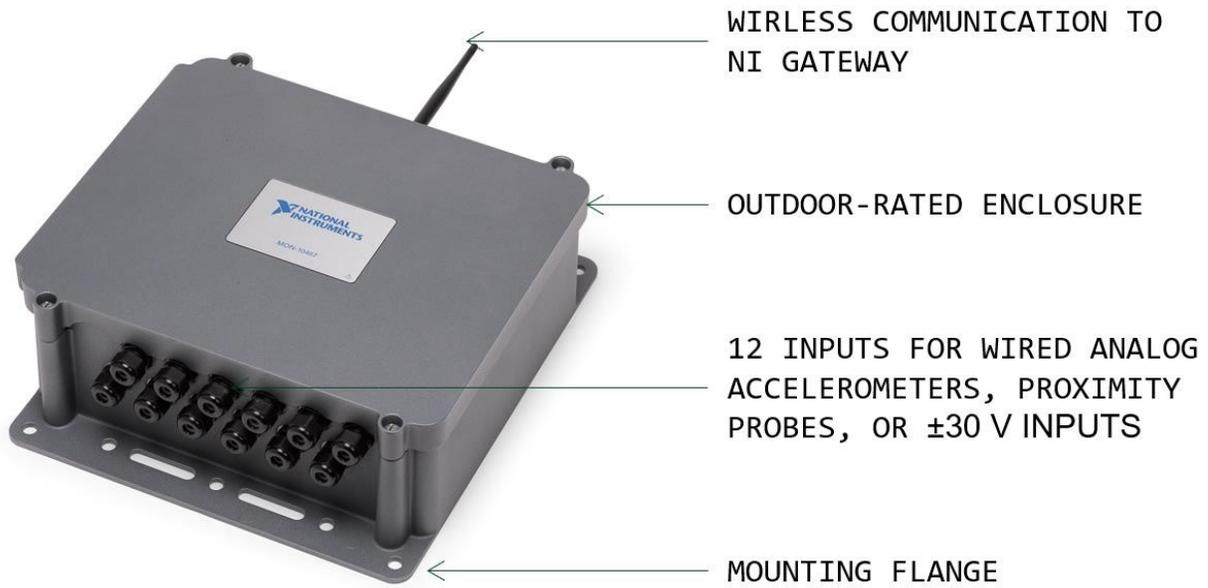


FIGURE 16.

Wireless Vibration Measurement Devices acquire full waveforms and transmit the data to InsightCM via a wireless gateway.

Sensor Support

The Wireless Vibration Measurement Device supports the following sensor types out of the box:

- Accelerometers (IEPE)
- Proximity probes (user-provided)
- Tachometers
- Voltage (± 30 V)
- Temperature

Wireless Vibration Sensors

Wireless Vibration Sensors contain an integrated triaxial accelerometer and use wireless communication to send diagnostic-quality waveform data at up to 2 kHz fmax to an InsightCM server. They also include an integrated temperature sensor that can trend temperature data. Install the sensor on the monitored asset with the built-in 1/4-28 stud mount. The rugged exterior is IP66/IP67-rated for industrial environments and can handle wide temperature ranges as well as washdowns. All devices are battery-powered and ship ready to install. Once you have installed and commissioned its hardware, the Wireless Monitoring Device transmits data back approximately once a day (user-configurable) via a wireless gateway to the InsightCM server installed on premises or in a virtual machine in your choice of cloud provider. The device also can be manually triggered to send data back to the server.



FIGURE 17.

Wireless Vibration Sensors contain an integrated triaxial accelerometer and temperature sensor and transmit the data to InsightCM via a wireless gateway.

Gating

Both Wireless Monitoring Devices are mounted near the asset and transmit data back to the InsightCM server via a wireless gateway approximately once a day (user-configurable). Because most of the wireless device's battery consumption occurs during wireless communication with the gateway, sending data only when the monitored asset is running helps prolong battery life. Wireless Monitoring Devices have a gating feature that checks whether the asset is on before acquiring and sending asset health data. Gating can be based on acquired sensor values or external systems via Modbus, OPC UA or the OSIsoft PI System.

Outdoor-Rated Enclosures

Wireless Monitoring Devices are designed to either IP54 or IP66/IP67 specifications for protection from liquid, dust, and particulates. Installers can mount the systems directly outside in any climate without an additional industrial enclosure.

Monitoring Device Feature Comparison

Feature	Continuous Monitoring System	Wireless Vibration Measurement Device	Wireless Vibration Sensor
Onboard calculation support	Full features, triggers, alarms, and burst mode	Vibration level check as data gate (for example, asset on or off?)	Vibration level check as data gate (for example, asset on or off?)
Streaming support (Continuous capture for transients)	Yes	No	No
Maximum fmax	40 kHz	10 kHz	2 kHz
Maximum LoR	50 k ++	50 k	4 k
Maximum number of accelerometers per device	28	12 (dynamic or static channels)	1
Maximum number of static (low-speed acquisition channels)	256	12 (dynamic or static channels)	1 (integrated temperature for trending data)
Storage for IT network outage ride-through	2 weeks (typical)	2 weeks (typical)	2 weeks (typical)
Battery option	No	Yes	Yes
Line-power option	120/240 V AC (using ext. power supply) 9-30 V DC (straight to device)	120/240 V AC option 9-30 V DC option	No
Sensor support	Any	IEPE accelerometer, ±30 V (proximity probes, temperature on dual output accelerometers, standard voltage input sensors)	Integrated triaxial accelerometer with temperature
Connect multiple assets to a single device	Yes	Yes	No
Environmental rating	IP40 (typically requires enclosure)	IP54 and outdoor-rated (no enclosure required)	IP66/IP67 and outdoor-rated
Operating temperature	-40-70° C	-20-70° C (battery-powered) -40-70° C (line-powered)	-20-70° C