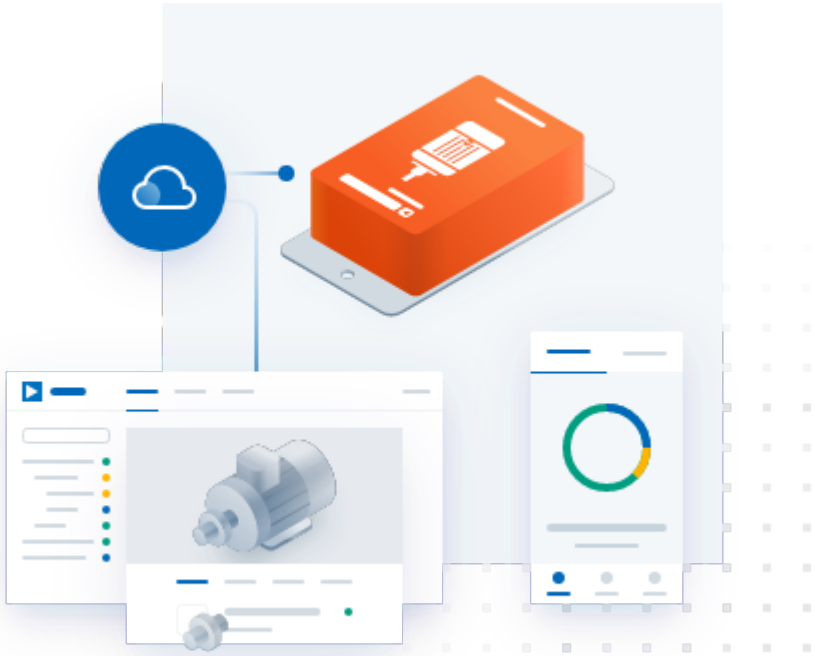
ADI OtoSense™ Smart Motor Sensor Analytics Guide



Introduction

Combining real-time data from ADI OtoSense™ Smart Motor Sensors with AI-driven machine learning cloud-based analytics, the ADI OtoSense™ SMS Cloud platform provides unparalleled insight into assets' operating conditions and maintenance needs. Thanks to proprietary ADI OtoSense™ predictive maintenance analytics, you can identify and remediate faults before they affect motor operation.

- ADI OtoSense™ Smart Motor Sensors are equipped with five Analog Devices best-in-class sensors that monitor both motor and environmental conditions.
- Smart Motor Sensors are non-intrusive, and can be affixed to motors that are currently in use, avoiding downtime.
- Sensors can analyze data from low-voltage (<1000V) 3-phase induction motors with a motor shaft height of 90 to 400, corresponding to a rated power ranging between 0.37 and 500kW, including almost all IEC and NEMA motors.
- Smart Motor Sensors provide vibration, temperature, and magnetic field data with high degrees of precision and accuracy.
- ADI OtoSense™ Cloud analytics uses machine learning algorithms to not only predict hardware failures but also provide suggestions for remediation.
- Hardware issues are rated on a 10 point fault index scale, providing granular insight into motor conditions.
- Smart Motor Sensors transmit data at regular intervals, ensuring timely delivery of alerts.
- Sensor data, diagnostics, and prescriptive recommendations are made available via a mobile application, a cloud dashboard, and an API.
- Sensor data is stored in the ADI OtoSense™ Cloud, preventing data loss due to power failure.
- Smart Motor Sensors are powered by four replaceable Lithium AA batteries.
- A built-in voltage sensor transmits battery life data to the cloud, issuing alerts as needed.

How it works

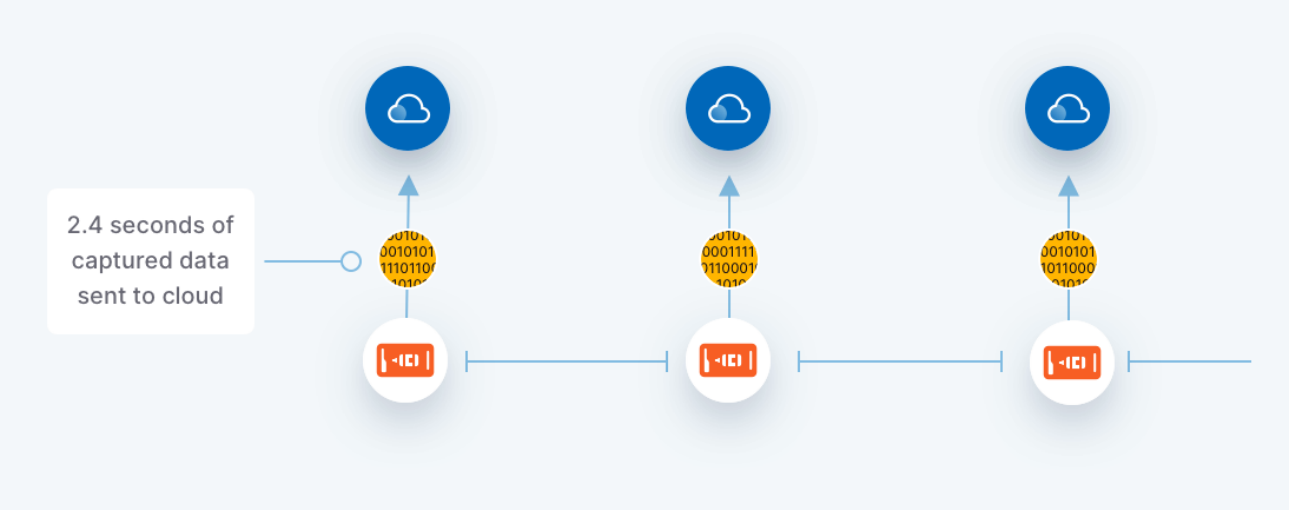
Overview

After an ADI OtoSense™ Smart Motor Sensor (SMS) is attached to a motor, the device begins transmitting data from its on-board sensors to the ADI OtoSense™ Cloud. At regular intervals, the SMS device sends a 2.4 second sample of all sensor data (see Figure 1).

During an initial learning period, the Smart Motor Sensor works alongside the ADI OtoSense™ Cloud to create a uniquely tailored baseline model of a motor's operation.

Once the learning period has finished, the ADI OtoSense™ Cloud is able to detect motor performance anomalies and generate alerts about impending motor issues.

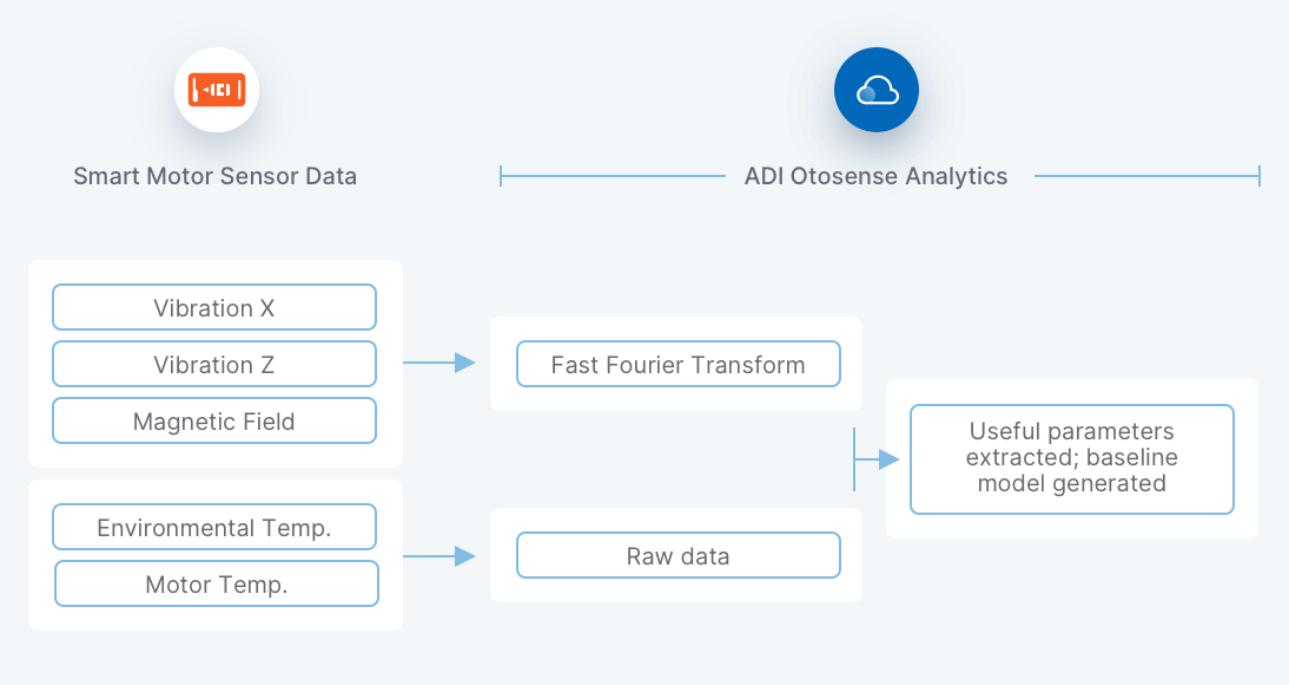
Figure 1: The ADI OtoSense™ Smart Motor Sensor Communicating with the ADI OtoSense™ Cloud



About the learning period

At regular intervals, the SMS device sends 2.4 second samples of sensor data to the ADI OtoSense™ Cloud. A proprietary algorithm extracts the most useful parameters for analytics purposes and generates a baseline model tailored to each motor's operation (see Figure 2).

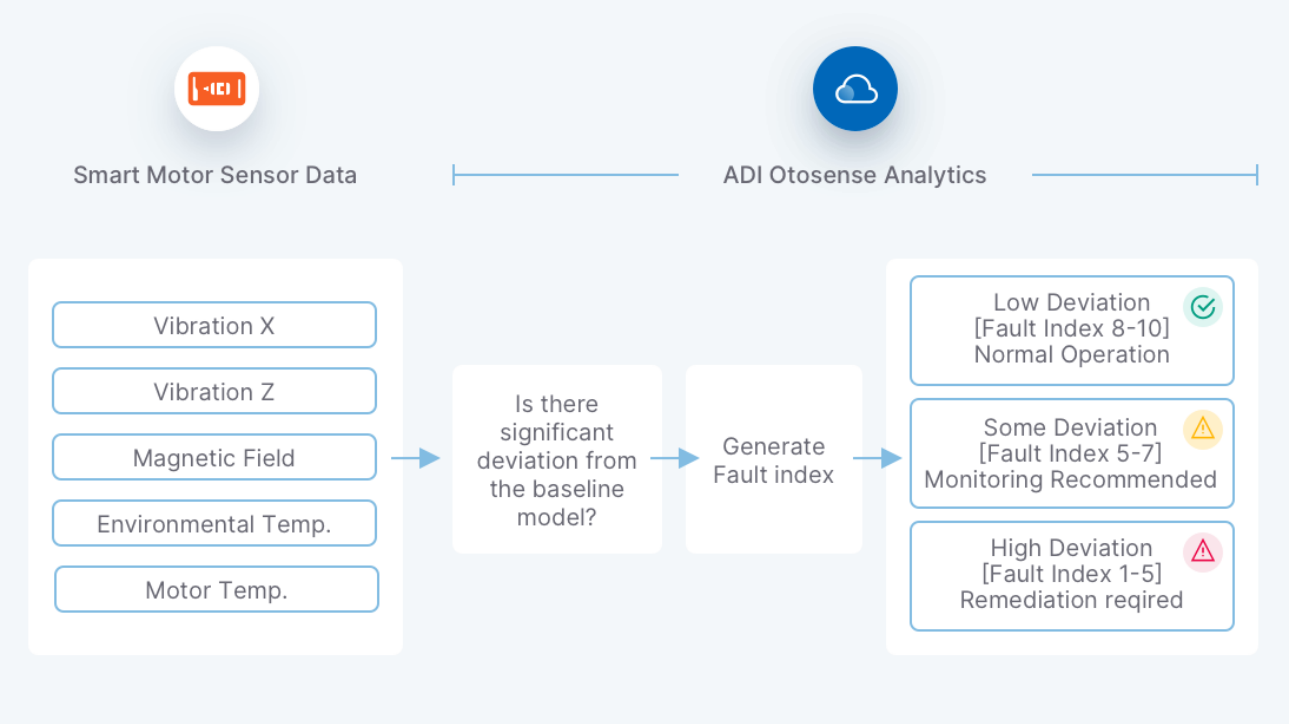
Figure 2: The Learning Period



Normal operation mode

Once the learning phase has finished, the ADI OtoSense™ Cloud platform compares incoming sensor data to the baseline model to detect impending motor failures (see Figure 3). Status updates regarding ten key motor attributes (see Motor condition monitoring) as well as raw and processed sensor data (see Appendix A) are available via the ADI OtoSense™ SMS Cloud dashboard, the ADI OtoSense™ SMS mobile application, and the ADI OtoSense™ SMS API.

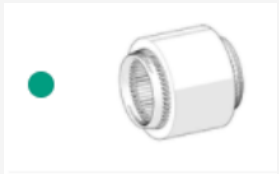
Figure 3: Normal Operation Mode



Motor condition monitoring

Based on incoming sensor data, ADI OtoSense™ Cloud analytics provides insight into 9 motor attributes as well as overall motor performance (see Table 1). Motor condition status is rated on a 0-10 scale, wherein '10' indicates normal operation, '5' indicates that monitoring is recommended, and '0' indicates imminent motor failure (see Figure 4, Figure 5, Figure 6, and Figure 7). Motor attribute insights are accessible via the ADI OtoSense™ Cloud Dashboard, the ADI OtoSense™ SMS mobile application, and ADI OtoSense™ SMS API.

Table 1: Motor Attributes Monitored by the ADI OtoSense™ Cloud Platform

	Motor Attribute	Type	Description	Example Problem
	Power System	Electrical	Problems in the three phases of the power supply, which could lead to a motor current imbalance.	Lost phase
	Stator Winding	Electrical	Problems in one of the phases of the motor, which could cause an imbalance of the motor currents.	Coil short circuit
	Rotor	Electrical	Short-circuit ring or rotor bar related problems.	Broken rotor bar
	Motor Shaft / Balance	Electromechanical	Unequal distribution of mass, causing the center of gravity to shift from the center of rotation.	Rotor flexion
	Eccentricity	Mechanical	Asymmetric air gap between the rotor and stator.	Bent shaft; improper bearing installation
	Bearing	Mechanical	Mechanical stress or contamination leading to small cracks or defects that occur in the bearing, creating vibration problems.	Pitting
	Alignment	Mechanical	Occurs when two rotating shafts (motor and load) are not aligned, creating external misalignment.	Angular or parallel misalignment

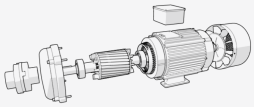
				
	Cooling System	Temperature	Problems with fans attached to the shaft or externally attached to the motor.	Fan cover collapse
	Loose Foot	Mechanical	Structural looseness occuring when the motor base (or connection to the motor base) is not properly tightened.	Motor not fixed to base frame
	Performance	N/A	Used to capture abnormal events such as an overall increase in vibrations, unusual changes in motor RPM, motor load or temperatures, etc. Indicates faults that do not correspond to any of the other nine fault categories, which could be related to machine process.	N/A

Figure 4: Stator Winding Fault Index 10 on the ADI OtoSense™ Cloud Dashboard

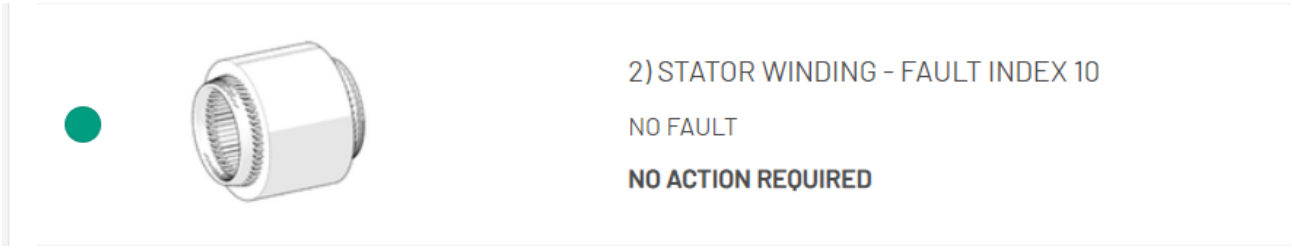


Figure 5: Loose Foot Fault Index 5 on the ADI OtoSense™ Cloud Dashboard

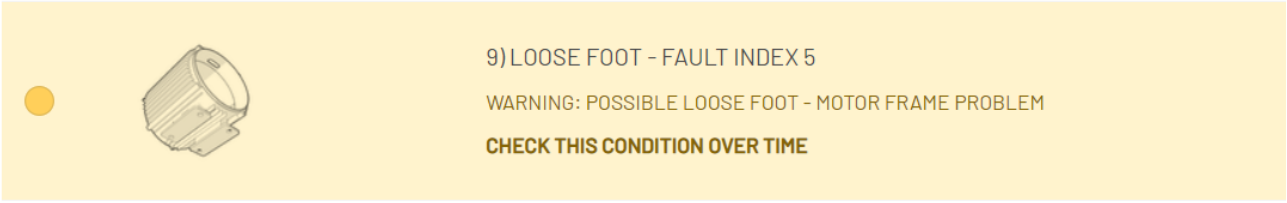


Figure 6: Power System Fault Index 2 and Suggested Remediation Action on the ADI OtoSense™ Cloud Dashboard

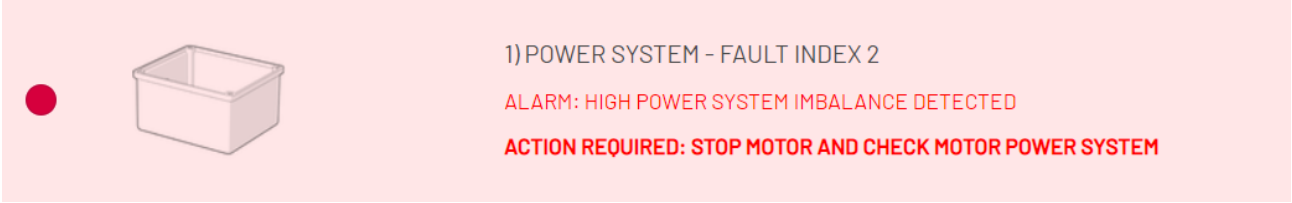
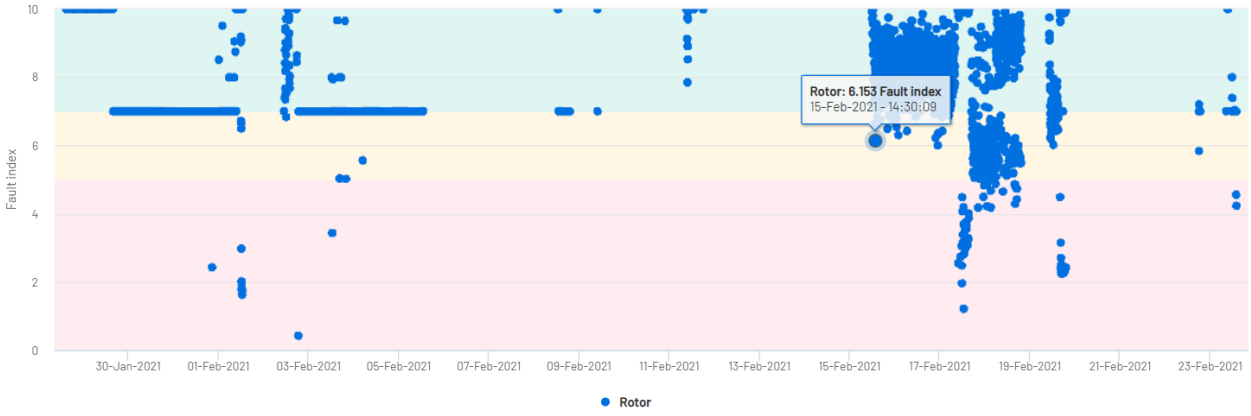


Figure 7: Rotor Fault Index Historical Data on the ADI OtoSense™ Cloud Dashboard



Detailed sensor information and specifications

Vibration sensors

Vibrations monitoring and analysis are at the core of most condition based monitoring systems as vibrations and harmonic signatures are often the first indication of an impending motor failure.

ADI OtoSense™ Smart Motor Sensors are equipped with a Vibration X-axis (tangential vibration) sensor as well as a Vibration Z-axis (axial vibration) sensor (see Table 2 for specifications).

Since each motor has a unique vibrational profile, the ADI OtoSense™ SMS first determines a motor's baseline operating condition during the learning period (see About the learning period).

The ADI OtoSense™ SMS Cloud platform, mobile application, and API provide both time and frequency domain data. Fast Fourier transform (FFT) data allows for the quick identification of discrete frequency peaks.

Table 2: Vibration Sensor Specifications

Sensor Type	Amplitude Range	Frequency Range	Sampling Frequency	Number of Samples	Data Formats	Data Type
X-Axis Vibration Y-Axis Vibration	±40 g.	1Hz to 3.1 kHz	6.25kHz	15,000 - 2.4 seconds	waveform, FFT, rms	Float

Figure 8: Vibration X-Axis Time Waveform in m/s^2 (three samples, overlaid)

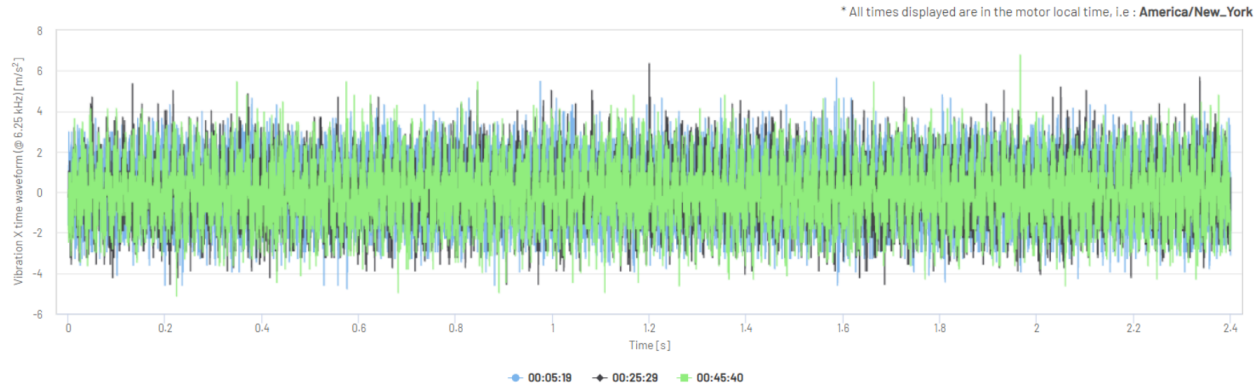


Figure 9: Vibration X-Axis FFT in dB

Figure 10: Vibration Z-Axis Time Waveform in m/s^2 (one 2.4 second sample)

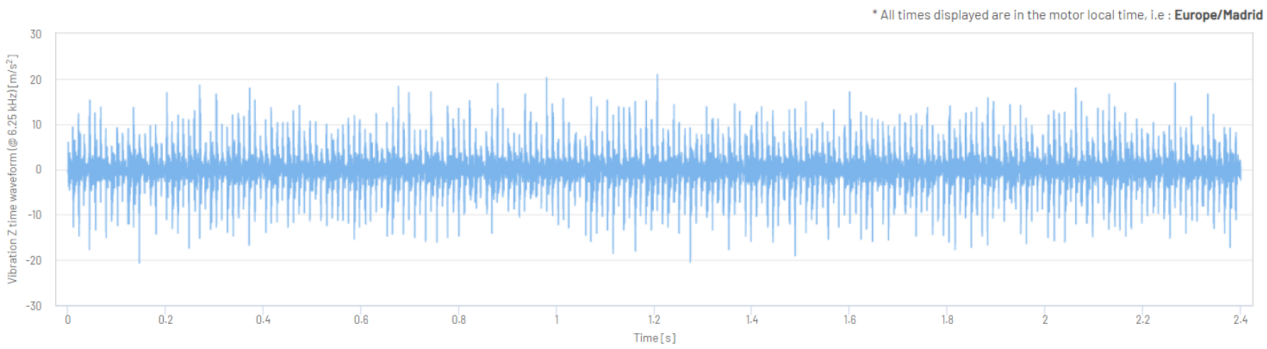
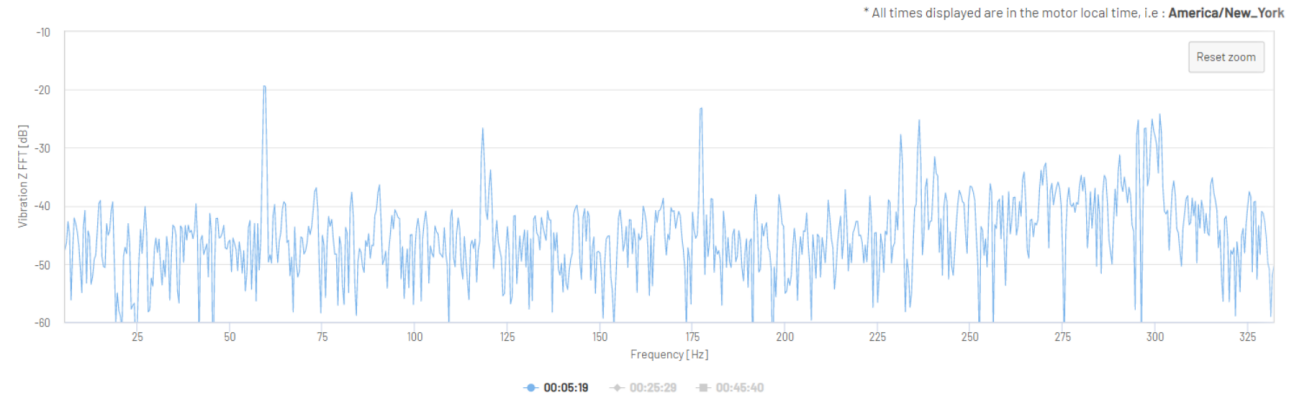


Figure 11 and 12: Vibration Z-Axis Time Waveform in m/s^2 (one 2.4 second sample, zoomed-in views)

Figure 13: Vibration Z-Axis Fast Fourier Transform in dB (one 2.4 second sample)



Magnetic field sensor

Measurement of the magnetic field around a motor allows for insights into electrical and mechanical motor performance issues.

ADI OtoSense™ Smart Motor Sensors are equipped with a single magnetic field sensor (see Table 3 for specifications).

Table 3: Magnetic Field Sensor Specifications

Sensor Type	Sampling Frequency	Number of Samples	Data Formats	Data Type
Magnetic Field	6.25kHz	15,000 - 2.4 seconds	waveform, FFT	Float

Figure 14: Magnetic Field Time Waveform in mV (one 2.4 second sample)

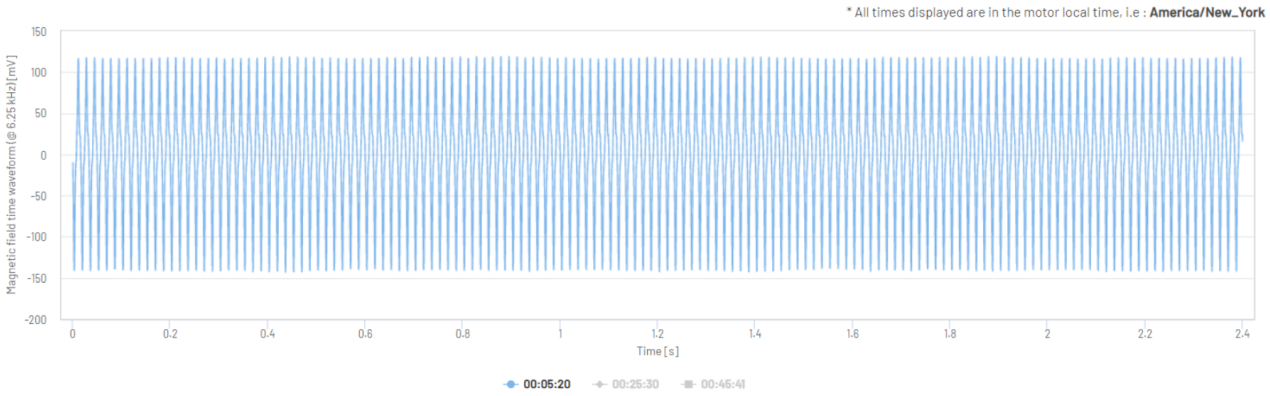


Figure 15: Magnetic Field Time Waveform in mV (one 2.4 second sample, zoomed-in view)

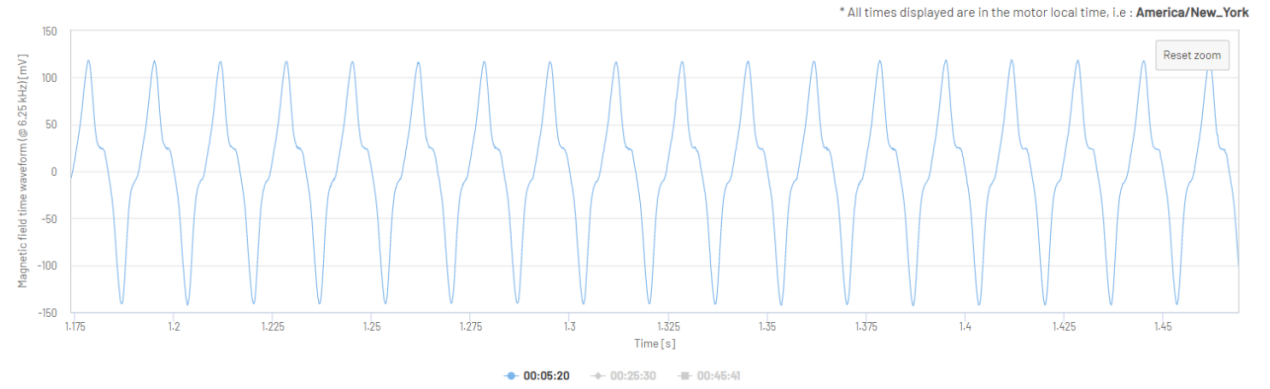


Figure 16: Magnetic Field Time Waveform in mV (three 2.4 second samples, overlaid)

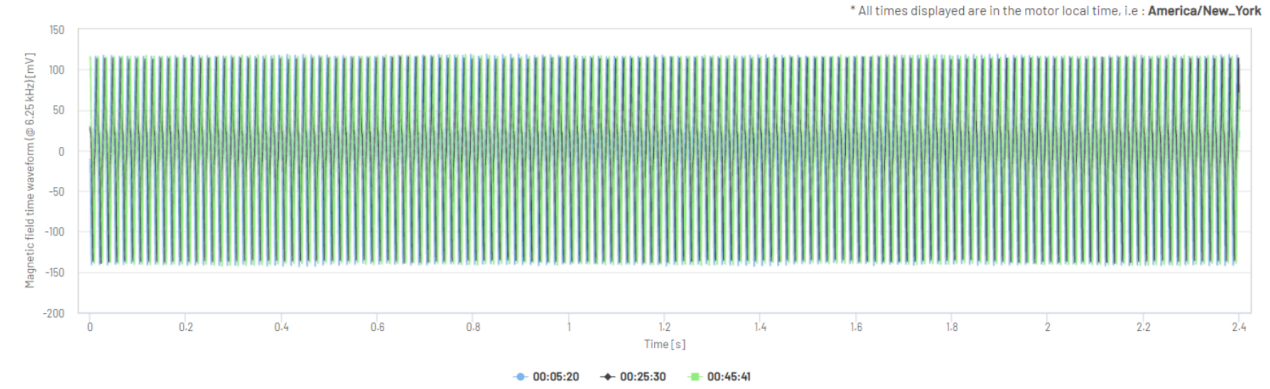
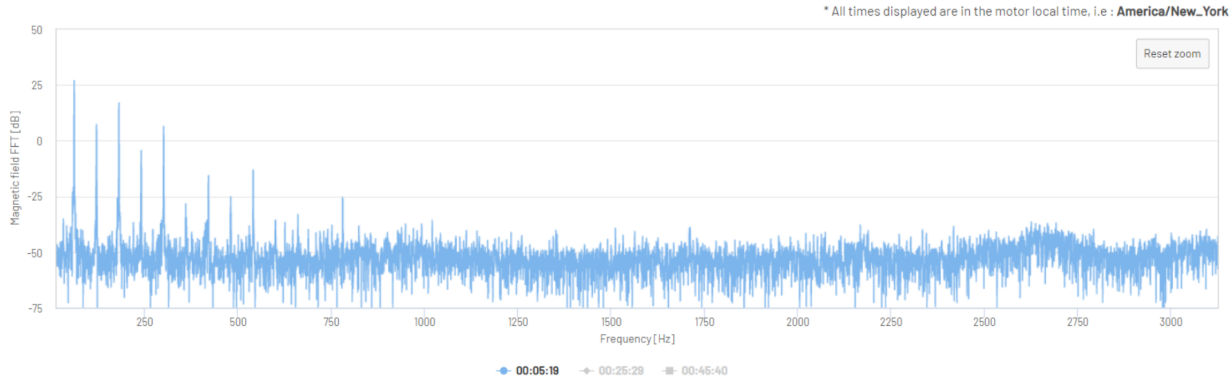


Figure 17: Magnetic Field Fast Fourier Transform in dB (one 2.4 second sample)



Temperature sensors

The majority of motor faults will eventually result in high temperatures. These high temperatures can be an indication of the excessive friction within a motor or fan issues. ADI OtoSense™ Smart Motor Sensors are equipped with two on-board temperature sensors: an environment temperature sensor and a motor temperature sensor (see Table 4).

The environment temperature sensor allows for ADI OtoSense™ SMS to take ambient operating conditions, such as sunlight exposure, into account when assessing a motor's temperature status.

Table 4: Temperature Sensor Specifications

Sensor Type	Measurement Range	Precision Accuracy	Data Type
Environment Temperature Motor Temperature	-40°C to +150°C	0.0625 ± 0.5°C	Float

Figure 18: Motor Temperature in °C

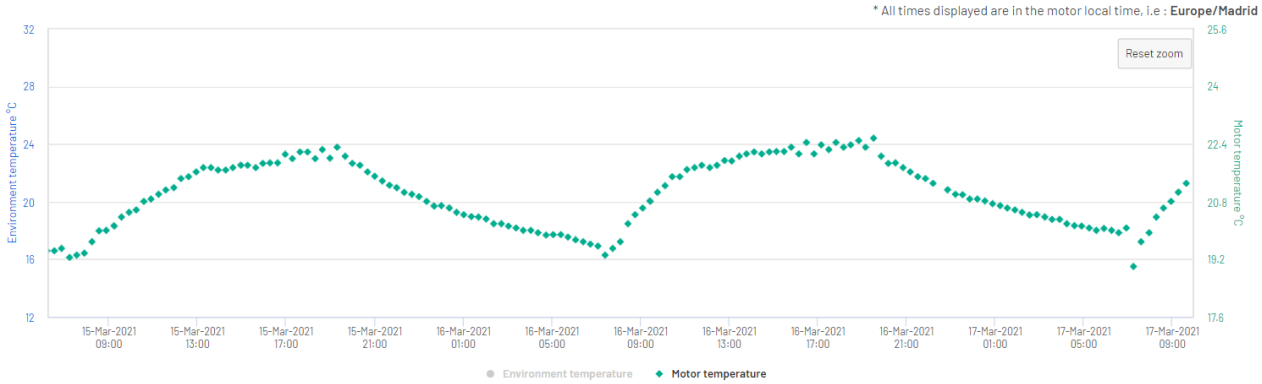
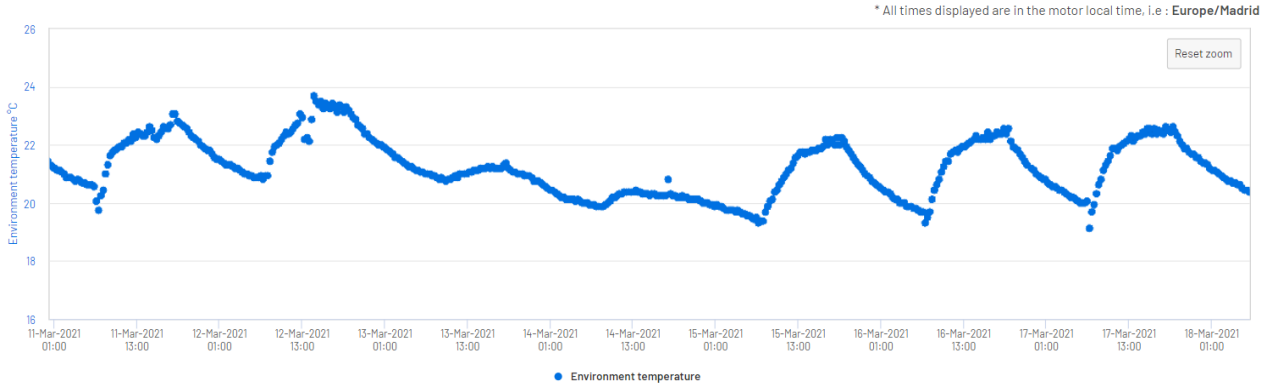


Figure 19: Environment Temperature in °C



The Motor Object

The motor object consists of a *components* map. Each component has a Fault Score Index (FSI) and a Code. The FSI is a value between 0 and 10, related to the motor conditions described above. An FSI below '5' indicates the corresponding motor component is in an **Alarm** state. FSI of '5' or '6' indicates a **Warning**, and an FSI above '6' means the corresponding motor component is **Good**. The lower the FSI value the greater the severity of the component fault. For each component in a **Warning** or an **Alarm** state, an appropriate **Code** is assigned by the ADI OtoSense™ Cloud analytics. Each code defines both the recommended *Action* and the *Description* of the associated fault (see Table 5). Each component has multiple possible codes depending on the severity of the fault. For example, a Power System component with an FSI of '3' or '4' will be assigned code '1002' and a Power System component with an FSI of '2' or below will be assigned code '1003'.

Table 5: Component Codes Definitions

Code	Action	Description	Notes
0	No action required	No fault	
1001	Check this condition over time	Warning: Possible Power System Imbalance	
1002	Action Required: Check Motor Power System	Alarm: Power System Imbalance Detected	
1003	Action Required: Stop Motor And Check Motor Power System	Alarm: High Power System Imbalance Detected	
2001	Check this condition over time	Warning: Possible Stator Shortcircuit	
2002	Action Required: Check Stator Winding Condition	Alarm: Stator Shortcircuit Detected	
2003	Action Required: Stop Motor And Check Stator Winding Condition	Alarm: Stator Shortcircuit Detected	
3001	Check this condition over time	Warning: Possible Rotor Active Parts Problem	
3002	Action Required: Check Rotor Condition	Alarm: Rotor Active Parts Problem Detected	
3003	Action Required: Replace Rotor	Alarm: Rotor Active Parts Problem Detected	
4001	Check this condition over time	Warning: Imbalance Detected	
4002	Action Required: Balance Motor In Next Stop	Alarm: Imbalance Detected	
4003	Action Required: Balance Motor As Soon As Possible	Alarm: High Imbalance Detected	
5001	Check this condition over time	Warning: Possible Eccentricity	
5002	Action Required: Check Rotor Eccentricity	Alarm: Eccentricity Detected	
5003	Action Required: Check Rotor Eccentricity	Alarm: Serious Eccentricity Detected	
6001	Check this condition over time	Warning: Possible Bearing Outer Race Malfunction	
6002	Action Required: Lubricate Bearings	Alarm: Bearing Outer Race Fault Detected	
6003	Action Required: Replace Bearings As Soon As Possible	Alarm: Bearing Outer Race High Fault Detected	

6004	Check this condition over time	Warning: Possible Bearing Inner Race Malfunction	
6005	Action Required: Lubricate Bearings	Alarm: Bearing Inner Race Fault Detected	
6006	Action Required: Replace Bearings As Soon As Possible	Alarm: Bearing Inner Race High Fault Detected	
6007	Check this condition over time	Warning: Possible Bearing Rolling Element Malfunction	
6008	Action Required: Lubricate Bearings	Alarm: Bearing Rolling Element Fault Detected	
6009	Action Required: Replace Bearings As Soon As Possible	Alarm: Bearing Rolling Element High Fault Detected	
6010	Check this condition over time	Warning: Possible Bearing Cage Malfunction	
6011	Action Required: Lubricate Bearings	Alarm: Bearing Cage Fault Detected	
6012	Action Required: Replace Bearings As Soon As Possible	Alarm: Bearing Cage High Fault Detected	
6013	Check this condition over time	Warning: Possible De Bearing Outer Race Malfunction	
6014	Action Required: Lubricate Bearings	Alarm: De Bearing Outer Race Fault Detected	
6015	Action Required: Replace Bearings As Soon As Possible	Alarm: De Bearing Outer Race High Fault Detected	
6016	Check this condition over time	Warning: Possible De Bearing Inner Race Malfunction	
6017	Action Required: Lubricate Bearings	Alarm: De Bearing Inner Race Fault Detected	
6018	Action Required: Replace Bearings As Soon As Possible	Alarm: De Bearing Inner Race High Fault Detected	
6019	Check this condition over time	Warning: Possible De Bearing Rolling Element Malfunction	
6020	Action Required: Lubricate Bearings	Alarm: De Bearing Rolling Element Fault Detected	
6021	Action Required: Replace Bearings As Soon As Possible	Alarm: De Bearing Rolling Element High Fault Detected	
6022	Check this condition over time	Warning: Possible De Bearing Cage Malfunction	
6023	Action Required: Lubricate Bearings	Alarm: De Bearing Cage Fault Detected	
6024	Action Required: Replace Bearings As Soon As Possible	Alarm: De Bearing Cage High Fault Detected	
6025	Check this condition over time	Warning: Possible Nde Bearing Outer Race Malfunction	

6026	Action Required: Lubricate Bearings	Alarm: Nde Bearing Outer Race Fault Detected	
6027	Action Required: Replace Bearings As Soon As Possible	Alarm: Nde Bearing Outer Race High Fault Detected	
6028	Check this condition over time	Warning: Possible Nde Bearing Inner Race Malfunction	
6029	Action Required: Lubricate Bearings	Alarm: Nde Bearing Inner Race Fault Detected	
6030	Action Required: Replace Bearings As Soon As Possible	Alarm: Nde Bearing Inner Race High Fault Detected	
6031	Check this condition over time	Warning: Possible Nde Bearing Rolling Element Malfunction	
6032	Action Required: Lubricate Bearings	Alarm: Nde Bearing Rolling Element Fault Detected	
6033	Action Required: Replace Bearings As Soon As Possible	Alarm: Nde Bearing Rolling Element High Fault Detected	
6034	Check this condition over time	Warning: Possible Nde Bearing Cage Malfunction	
6035	Action Required: Lubricate Bearings	Alarm: Nde Bearing Cage Fault Detected	
6036	Action Required: Replace Bearings As Soon As Possible	Alarm: Nde Bearing Cage High Fault Detected	
7001	Check this condition over time	Warning: Possible Misaligment	
7002	Action Required: Align Motor In Next Stop	Alarm: Misaligment Detected	
7003	Action Required: Align Motor As Soon As Possible	Alarm: High Misaligment Detected	
8001	Check this condition over time	Warning: Cooling System Malfunction	
8002	Action Required: Check Cooling System	Alarm: Cooling System Malfunction	
8003	Action Required: Check Cooling System As Soon As Possible	Alarm: Dangerous Cooling System Malfunction	
9001	Check this condition over time	Warning: Possible Loose Foot - Motor Frame Problem	
9002	Action Required: Check Motor-Bench Assembly	Alarm: Loose Foot - Motor Frame Problem Detected	
9003	Action Required: Check Motor-Bench Assembly	Alarm: Loose Foot - Motor Frame Severe Problem Detected	
10001	Check this condition over time	Global Vibration Acceleration Increasing <50%	
10002	Check this condition over time	Global Vibration Acceleration Increasing <70%	
10003	Stop Motor: Check Bearing Lubrication, Bearings Condition, Coupling and Mechanical Parts	Global Vibration Acceleration Increasing <100%	
10004	Stop Motor: Check Bearing Lubrication, Bearings Condition, Coupling and Mechanical Parts	Global Vibration Acceleration Increasing <200%	

10005	Stop Motor: Check Bearing Lubrication, Bearings Condition, Coupling and Mechanical Parts	Global Vibration Acceleration Increasing <250%	
10006	Stop Motor: Check Bearing Lubrication, Bearings Condition, Coupling and Mechanical Parts	Global Vibration Acceleration Increasing <300%	
10007	Stop Motor: Check Bearing Lubrication, Bearings Condition, Coupling and Mechanical Parts	Global Vibration Acceleration Increasing >300%	
10008	Check this condition over time	Global Vibration Velocity Increasing <50%	
10009	Check this condition over time	Global Vibration Velocity Increasing <70%	
10010	Stop Motor: Coupling Alignment, Structure Looseness, Bearings Condition and Mechanical Parts	Global Vibration Velocity Increasing <100%	
10011	Stop Motor: Coupling Alignment, Structure Looseness, Bearings Condition and Mechanical Parts	Global Vibration Velocity Increasing <200%	
10012	Stop Motor: Coupling Alignment, Structure Looseness, Bearings Condition and Mechanical Parts	Global Vibration Velocity Increasing <250%	
10013	Stop Motor: Coupling Alignment, Structure Looseness, Bearings Condition and Mechanical Parts	Global Vibration Velocity Increasing <300%	
10014	Stop Motor: Coupling Alignment, Structure Looseness, Bearings Condition and Mechanical Parts	Global Vibration Velocity Increasing <300%	
10015	Check this condition over time	Warning: Motor's RPM Has Increased	
10016	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: Motor's RPM Is Higher Than Normal Operation	
10017	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: Motor's RPM Is Much Higher Than Normal Operation	
10018	Check this condition over time	Warning: Motor's RPM Has Decreased	
10019	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: Motor's RPM Is Lower Than Normal Operation	
10020	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: Motor's RPM Is Much Lower Than Normal Operation	
10021	Check this condition over time	Warning: Motor's Load Has Increased	
10022	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: Motor's Load Is Higher Than Normal Operation	
10023	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: Motor's Load Is Much Higher Than Normal Operation	
10024	Check this condition over time	Warning: Motor's Load Has Decreased	
10025	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: Motor's Load Is Lower Than Normal Operation	

10026	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: Motor's Load Is Much Lower Than Normal Operation	
10027	Check this condition over time	Warning: The Environment Temperature Has Increased	
10028	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: The Environment Temperature Is Higher Than Normal Operation	
10029	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: The Environment Temperature Is Much Higher Than Normal Operation	
10030	Check this condition over time	Warning: The Environment Temperature Has Decreased	
10031	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: The Environment Temperature Is Lower Than Normal Operation	
10032	Action Required: If This Is Normal Operation Mode For The Motor, Please Perform Relearning	Alarm: The Environment Temperature Is Much Lower Than Normal Operation	
-1	Check SMS device	Disconnected	

The `status` of the motor object indicates the overall state of the motor. The `state` property reflects the component with the most severe fault (lowest FSI value). For example, if a motor has multiple components with faults; one an Alarm and another a Warning, the `state` property of the motor object's `status` will indicate `alarm`. Additionally, the `status` specifies connection information; online or disconnected, as well as last online datetime.

Each Motor has an associated *Motor Log*. This log comprises of historical entries that record the various events that the motor has experienced:

State	Description
learning	Motor is learning in order to generate model
alarm	One or more components have an FSI below ‘5’
comment	Operator added a comment through the cloud dashboard or mobile application
repaired	Operator took action and marked the motor as repaired
recovered	Analytics detected that the motor condition has improved; the FSI increased to ‘5’ or above

API Datasets

vibx

Each record contains an array of 15,000 samples captured on the specified timestamp.

The *Vibration X (vibx)* is the vibration acceleration measured in the tangential direction of the motor. This recorded data shows the vibration X waveform data, in the unit of m/s^2. With the vibrations X and Z measured from the motor, the Otosense PdM system can detect the mechanical failures of the motor.

It is necessary to generate the corresponding X-axis data to plot this *Vibration X (vibx)* waveform data in a graphic: The X-axis data is a vector of 15,000 data points with a step of 0.00016s. For example:

> *[0, 0.00016, 0.00032, 0.00048, ... 2.39984]*

The following two datasets *Vibration Z (vibz)* and *Magnetic Field (flux)* also need the same X-axis data to generate the waveform graphic.

vibz

Each record contains an array of 15,000 samples captured on the specified timestamp.

The *Vibration Z (vibz)* is the vibration acceleration measured in the axial direction of the motor. This recorded data shows the vibration Z waveform data, in the unit of m/s^2. With the vibrations X and Z measured from the motor, the Otosense PdM system can detect the mechanical failures of the motor.

flux

Each record contains an array of 15,000 samples captured on the specified timestamp.

The *Magnetic Field (flux)* is the magnetic field leaked from the motor and measured on the surface of the frame. This recorded data shows the magnetic field waveform data, in the unit of mV. With the magnetic field from the motor, the Otosense PdM system can detect the electrical failures of the motor.

tempe

Each record contains an array of 2 samples captured on the specified timestamp.

It is the environment temperature measured by the SMS device. There are two temperature sensors on both sides of the SMS device: the temperature sensor on the outside side (not towards the motor) measures the environment temperature.

tempm

Each record contains an array of 2 samples captured on the specified timestamp.

It is the motor frame temperature measured by the SMS device. The temperature sensor on the inside side (towards the motor) measures the motor temperature.

vibxFFT

Each record contains an FFT of the vibx samples captured on the specified timestamp.

This data is the result of the FFT transformation with the vibration signal X, in the unit of dB.

It is necessary to generate the corresponding X-axis data to plot this *vibxFFT* data in a graphic. The X-axis data is a vector of 7,500 data points with a step of 0.41667Hz, for example:

> *[0.41667, 0.83334, 1.25, ... , 3125]*

The following two datasets *vibzFFT* and *fluxFFT* also need the same X-axis data to generate the FFT graphic.

vibzFFT

Each record contains an FFT of the vibz samples captured on the specified timestmap.

This data is the result of the FFT transformation with the vibration signal Z, in the unit of dB.

fluxFFT

Each record contains an FFT of the flux samples captured on the specified timestmap.

This data is the result of the FFT transformation with the magnetic field, in the unit of dB.

performance

Each record contains a collection of performance parameters:

Parameter	Mesurement Value	Description
rmsVx	m/s^2	RMS value fo the vibration X acceleration (tangential)
rmsVxV	mm/s	RMS value fo the vibration X velocity (tangential)
rmsVxD	µm	RMS value fo the vibration X displacement (tangential)
rmsVz	m/s^2	RMS value fo the vibration Z acceleration (axial)
rmsVzV	mm/s	RMS value fo the vibration Z velocity (axial)
rmsVzD	µm	RMS value fo the vibration Z displacement (axial)
rmsFlux	mV	RMS value fo the magnetic field
rpm	RPM (rev/min)	Motor rotating speed in RPM
tempMotor	ºC	Temperature of the motor (ºC)
tempEnv	ºC	Temperature of the motor environment (ºC)
operationHours	hours	Approximation of the motor running time
running	Integer flag	Running flag, 1 if running, 0 if not running. When the motor is rotating at a very low speed, less than 25% of its rated speed (rated RPM), the analytics may interpret the motor as stopped. `running` is used to calculate the **Number of Starts** in a time range. Chronologically sort the `performance` records in the time range, and count the number of times `_running_` transitions from '0' to '1'. This approximates the number of times the motor started in the specified time range.

conditions

Each parameter in the following table represents the Fault Score Index (FSI) of the corresponding motor component condition. These predicted health indicators for motor components are generated each time the analytics processes data samples received from a running motor. The values are between zero and ten:

1. A value of 10 corresponds to a perfect state for the component.
2. A value of 0 corresponds to a catastrophic state for the component.

Parameter	Motor Component	Description
powerSystem	Power System	Problems in the three phases of the power supply, which could lead to a motor current imbalance.
statorWinding	Stator Winding	Problems in one of the phases of the motor, which could cause an imbalance of the motor currents.
rotorBar	Rotor	Short-circuit ring or rotor bar related problems.
imbalance	Motor Shaft / Balance	Unequal distribution of mass, causing the center of gravity to shift from the center of rotation.
eccentricity	Eccentricity	Asymmetric air gap between the rotor and stator.
bearing	Bearing	Mechanical stress or contamination leading to small cracks or defects that occur in the bearing, creating vibration problems.
misalignment	Alignment	Occurs when two rotating shafts (motor and load) are not aligned, creating external misalignment.
cooling	Cooling System	Problems with fans attached to the shaft or externally attached to the motor.
motorStructure	Loose Foot	Structural looseness occuring when the motor base (or connection to the motor base) is not properly tightened.
performance	Performance	Used to capture abnormal events such as an overall increase in vibrations, unusual changes in motor RPM, motor load or temperatures, etc. Indicates faults that do not correspond to any of the other nine fault categories, which could be related to machine process.

operations

Each record contains operational details captured on the specified timestmap.

Parameter	Description
batteryStatus	Battery status, g for full, y for medium, r for low.

Appendix A: Cloud Platform Parameters

Parameter	Description	Data Format	Unit
vibx	Vibration X-axis waveform	array	m/s^2
vibz	Vibration Z-axis waveform	array	m/s^2
flux	Magnetic flux	array	mV
vibxFFT	Vibration X-axis FFT magnitude	array	dB
vibzFFT	Vibration Z-axis FFT magnitude	array	dB
fluxFFT	Magnetic flux FFT magnitude	array	dB
tempe	Environment temperature	array	°C
tempm	Motor temperature	array	°C

Appendix B: ADI OtoSense™ Smart Motor Sensor Technical Specifications

Networking Standards	Wi-Fi b/g/n
Radio Standards	IEEE 802.11 b/g/n
Networking Frequency	2.4 GHz
Wi-Fi Security Standards	WPA2
Wireless Range	>50 m
Battery Life	1 year (estimated)
Operating Temperature	-40°C to +60°C
Storage Temperature	50°C max
Weight	0.5 kg
Certifications	 IP Class IP55