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Leap Wireless Sensor System

Motor Monitor and Vibration Data User Manual

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2. About this Manual

The Leap Sensor System's primary use is industrial preventative maintenance which typically catches machinery failures well before they happen. Phase IV will normally pre-configure a Leap Wireless Sensor System at the factory based on the network topology expected at the final location. The *Leap Sensor System QUICK START Guide* and the *Leap Sensor System User's Manual,* which walk through initializing and deploying the Leap Sensor System in greater detail, are located on the support page of the Phase IV website: Phase IV Engineering Technical Support.

This manual discusses good practices and recommended procedures to install the Leap Motor Monitor Node, as well as the initial analysis needed to determine baseline alerting thresholds for rotating equipment and machinery such as electric motors or bearings. **Leap Nodes which are not Motor Monitor Nodes (Vibration, Amp Clamp, Temperature) but have a vibration sensor can use the portions of this manual which are specific to vibration.**

The Leap Motor Monitor Node helps an end user predict when a failure is approaching for a piece of rotating machinery. When user-configurable vibration, temperature, and current draw thresholds are exceeded, a maintenance technician should then inspect the motor manually to determine the cause and take the appropriate corrective action. The alert threshold recommendations in this manual typically give ample time between an alert threshold alarming and a motor completely failing. When correctly configured the Leap System will help predict failures before they occur and give some insight into potential causes.

3. Vibration Module Mounting & Cable Connections

Figure 1 shows a Leap Vibration Module (some contain a temperature sensor as well) with a magnetic mounting kit pre-assembled. The label on top of the module enclosure shows the axial and radial vibration orientations. The reported axial and radial vibration data from this module will correspond with this orientation.

When mounting surfaces have poor magnetic attraction, steel washers (the same diameter as the magnet) may be glued to the surface.

FIGURE 1

Mount the Leap vibration and temperature module with the axle parallel with the axle drawn on the label. Figure 2 shows the correct installation of three Vibration Modules on a rear motor casing (1), motor driveshaft bearing (2) and a driven pump bearing (3). Mount the module with bolts, epoxy, or the magnets pre-installed and supplied by Phase IV.

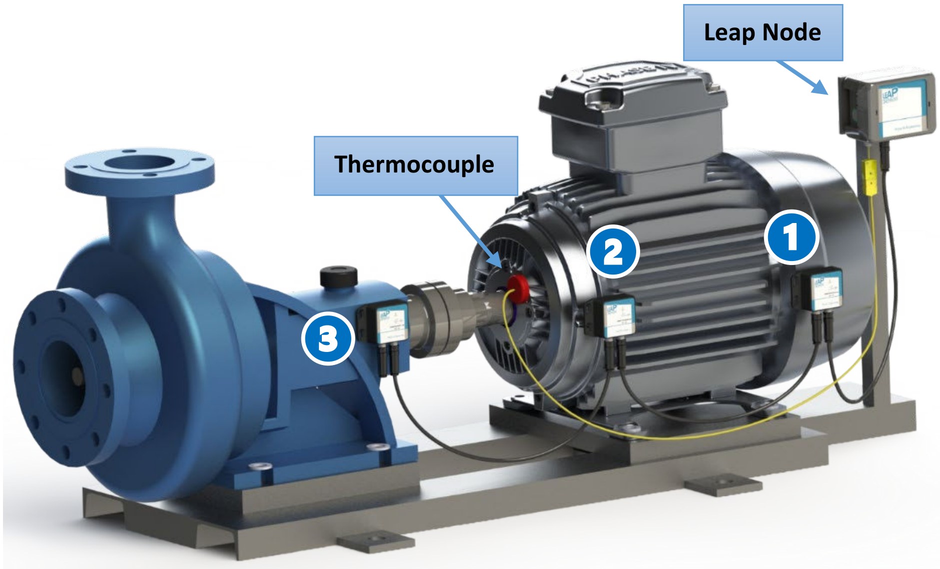

FIGURE 1

Connecting the Leap Motor Monitor and Leap Vibration Module(s) in the correct order is critical for proper module communication. If there are multiple Leap Vibration Modules as a part of a node's configuration, they will daisy chain together using the supplied cables with 6-pin M8 connectors. Each module has a numbered label on the bottom. The module labelled "1" connects directly to the Leap Node itself. A "2" indicates that it will be the second in the chain, connected to the first Vibration Module, and so forth…. The numbers in Figure 2 also illustrates how multiple Vibration Modules are connected relative to one another based on the number label on the back side of the enclosure.

4. Vibration Alerts

This section describes the readings collected from the Vibration module and describes how to set alerts after a brief baseline collection period. This section only gives high-level descriptions, specifics are documented in the *Leap Sensor System User's Manual* located on the support page of the Phase IV website: Phase IV Engineering Technical Support.

4.1 Vibration Data Readings

Phase IV's Vibration Module collects 3 seconds of raw vibration data from a triaxial accelerometer at 5.4kHz resulting in tens of thousands of raw datapoints. The raw datapoints are then edge-processed by the Leap Vibration Module into the 8 discrete readings listed in Table 1 below. These 8 readings (4 in the **Axial** orientation and 4 in the **Radial** orientation) are reported from the Node to the Data Server for analysis. These Vibration readings will typically remain stable over time for a well-functioning motor. Table 1 also associates what common failure modes occur based on an increase in each reading. This is meant to provide guidance to the maintenance technician, not to diagnose a specific root cause.

Table 1: Vibration Module Edge-Computed Readings	
Axial Acceleration [RMS]	**High-Frequency events:** Driveshaft run out, bearing deterioration, insufficient lubrication, and rotor issue.
Axial Acceleration [Max]	**Shock / impact forces:** Gearbox teeth meshing, or faulty bearings.
Axial Velocity [RMS]	**Low-Frequency events:** Oil Whirl, Loose Belts, other loose parts.
Axial Crest Factor	**Power Instabilities:** Drawing too much power, input power insufficient
Radial Acceleration [RMS]	**High-Frequency events:** Driveshaft run out, bearing deterioration, insufficient lubrication, and rotor issue.
Radial Acceleration [MAX]	**Shock / impact forces:** Gearbox teeth meshing, or faulty bearings.
Radial Velocity [RMS]	**Low-Frequency events:** Oil Whirl, Loose Belts, other loose parts.
Radial Crest Factor	**Power Instabilities:** Drawing too much power, input power insufficient

TABLE 1

4.2 Baseline Data Gathering

Once the Leap Motor Monitor Node is installed and is communicating with the Data Server, Phase IV recommends taking 2-4 weeks of "baseline" data at 5-minute sample and transmit intervals (configurable through the Web UI). This data will establish baseline performance readings of healthy rotating machinery and allow setting up alert thresholds to function properly as a predictive maintenance tool.

4.3 Setting Vibration Alert Thresholds

Based on internal testing, field experience, and academic white papers[1], **Phase IV recommends setting alert thresholds 2x the average of the baseline data for all 8 vibration readings**.

[1] A Brief Tutorial on Machine Vibration by Victor Wowk, P.E. Machine Dynamics Inc is a good resource and validates our recommendation for settings alert thresholds at 2x the baseline readings: "A 2x increase (or 6 dB) above a baseline normal level indicates that a significant physical change has occurred. A 5x increase is serious."

Figure 3 below shows a graph of the data captured from a Leap Vibration Monitor installed on an electric motor bearing. Taking the “Axial Accel Max 1” reading as an example, the average baseline value is roughly 4.5Gs. Phase IV recommends setting an alert for 9.0Gs on this reading. The same methodology for setting up alerts applies for the other 7 vibration readings.

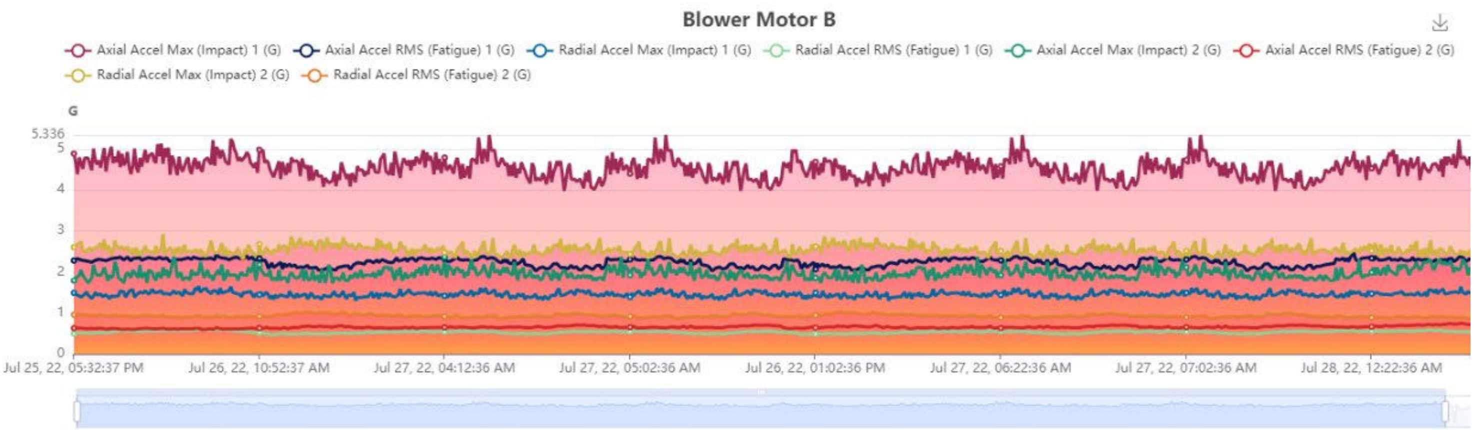

FIGURE 3

4.4 Setting Temperature and Current Alert Thresholds

Setting alerts for temperature and current draw readings do not follow this same process. Temperature alerts should be set referencing the motor name plate information for safe operating thresholds. Current draw alerts should be set based off the nominal motor current draw listed on the motor name plate as well. Temperature and current alerts can catch rapidly failing machines and bearings before they become critical.

4.5 Long Term Predictive Maintenance – Periodic Data Analysis

The alert thresholds described in the sections above are intended to notify users when a significant change in motor, pump, or bearing function has occurred which could indicate a pending failure. For the best results, Phase IV recommends periodic analysis of the Leap Motor Monitor data to track slow performance changes. Node data can be downloaded in a CSV format using the “Download Readings” feature in the Leap Web UI. Keeping track of how the reported vibration, temperature, and current draw values change over time is essential for planning maintenance intervals and to avoid unexpected machine failures.

5. Additional Resources

ISO 10816 is a standard that provides general guidance for vibration evaluation of industrial machinery. This includes expected values for displacement, velocity, and acceleration based on the power output of a machine, mounting of a machine, and other factors. It then categorizes each reported value based on the machine type into functional categories of “Good”, “Satisfactory”, “Unsatisfactory”, and “Unacceptable.”

This standard can provide insight into where a user-configured baseline alert (described in section 3.2) falls in the spectrum of total machine health. Figure 4 below is an image of ISO 10816-1, which establishes the general conditions and procedures for the measurement and evaluation of vibration, using measurements made on the non-rotating parts of machines.

Class I machines may be separate driver and driven, or coupled units comprising operating machinery up to approximately 15kW(approx 20hp).
Class I machinery (electrical motors 15kW (20hp) to 75kW(100hp), without special foundation, or Rigidly mounted engines or machines up to 300kW (400hp) mounted on special foundations.
Class III machines are large prime movers and other large machinery with large rotating assemblies mounted on rigid and heavy foundation which are reasonably stiff in the direction of vibration .
Class IV includes large prime movers and other large machinery with large rotating assemblies mounted on foundations which are relatively soft in the direction of the measured vibration (i.e.,turbine generators and gas turbines greater than 10MW (approx. 13500hp) output.

Velocity Severity		Velocity Range Limits and Machine Classes			
				Large Machines	
mm/s RMS	in/s Peak	Small Machines Class I	Medium Machines Class II	Rigid Supports Class III	Less Rigid Supports Class IV
0.28	0.02				
0.45	0.03	Good			
0.71	0.04		Good	Good	Good
1.12	0.06	Satisfactory			
1.80	0.10		Satisfactory		
2.80	0.16	Unsatisfactory (alert)		Satisfactory	
4.50	0.25		Unsatisfactory (alert)		Satisfactory
7.10	0.40			Unsatisfactory (alert)	
11.20	0.62	Unacceptable (danger)			Unsatisfactory (alert)
18.00	1.00		Unacceptable (danger)		
28.00	1.56			Unacceptable (danger)	Unacceptable (danger)
45.00	2.51				

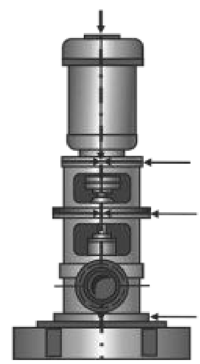

FIGURE 4