SMARTdiagnostics®

Give Your Machines a Voice

SmartDiagnostics® Application Note
Vibration Indicator Types

Publication Date: March 8, 2018

KCF Technologies, Inc.

Background

This document details the calculation method used to generate each of the vibration indicator types available for machine condition monitoring in SmartDiagnostics®.

336 S. Fraser Street
State College, PA 16801
www.kcftech.com

Sales and Support
(814) 867-4097
(814) 690-1579 Fax
sales@kcftech.com

Overview

SmartDiagnostics® is capable of calculating a wide variety of indicator types from a given raw data sample set measured by a vibration sensor. A single sensor may be used to trend dozens of different indicators. Knowing how each indicator is calculated and what features of machine health it highlights can help users decide which are the most important to track for their particular application.

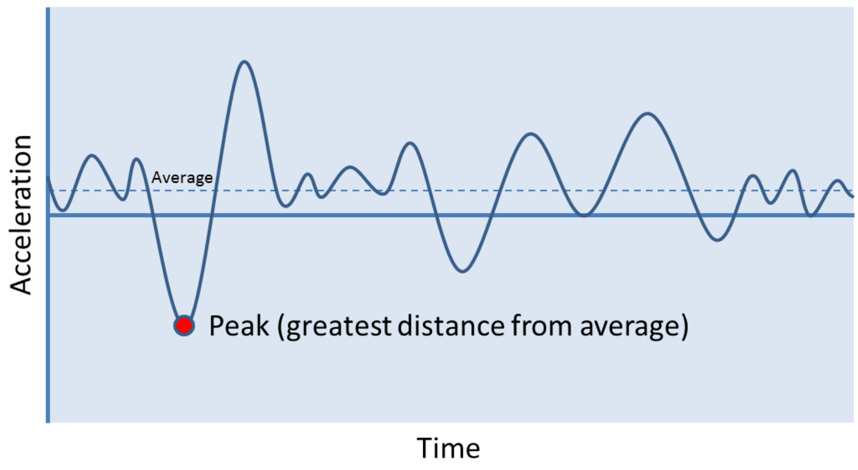
KCF's SmartDiagnostics® vibration sensors are accelerometers. The raw data measured is an acceleration time waveform. From this time waveform, it is possible to calculate an acceleration frequency spectrum by performing an FFT, and also to convert to time-domain and frequency-domain signals in velocity. This creates four possible plots that are available to be viewed in the SmartDiagnostics® software window:

- Acceleration time waveform (raw measured signal)
- Acceleration frequency spectrum (calculated)
- Velocity time waveform (calculated)
- Velocity frequency spectrum (calculated)

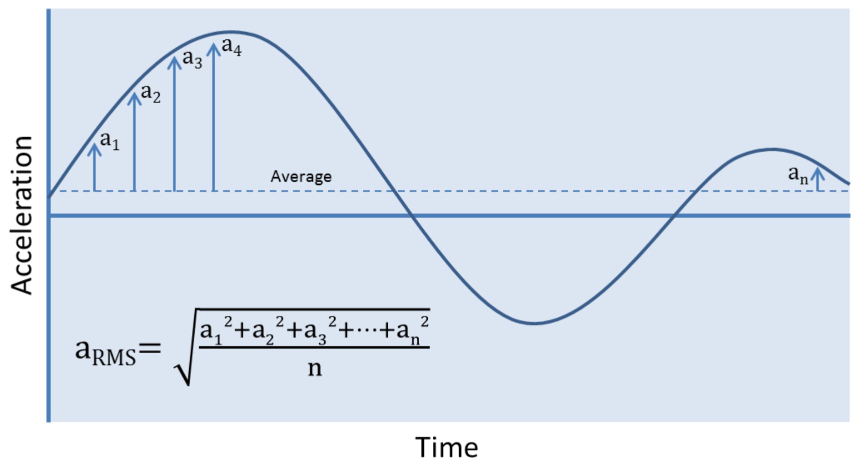
From these four data sets, many indicator values can be calculated and trended to measure different characteristics of machine vibration.

Acceleration

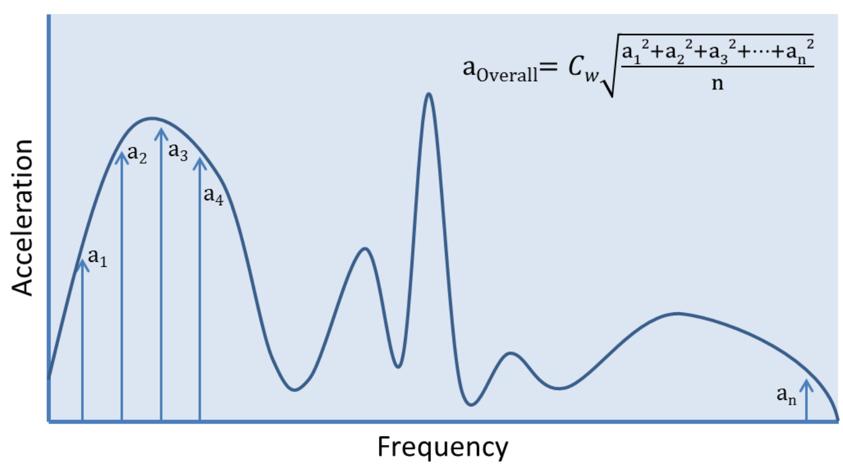
- **Peak Acceleration** is the most basic indicator, and simply reports the highest acceleration value recorded in a sample set. Because the acceleration time waveform includes the DC acceleration based on the physical orientation of the sensor, the average is subtracted from the sample set before determining the peak value. Peak Acceleration can be a good detector of impact or transient behavior or overall vibration severity, but can be misleading as an indicator of chronic behavior, since a high peak value may only be from a single spurious event, or may be from continuous high-amplitude oscillation.



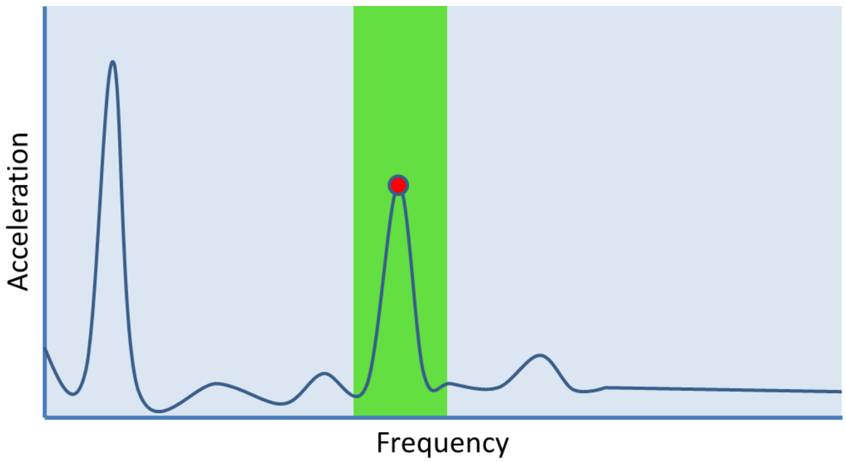
- **RMS Acceleration** or Root Mean Square is effectively the average acceleration level during the entire sample set. It is a representation of the total vibration energy within the sample set. RMS is calculated by summing the squares of every data point in the time series, dividing by the number of points, and taking the square root. As with Peak Acceleration, the DC average is subtracted from each data point to eliminate the effect of the sensor's orientation. RMS can be a better measure of the overall vibration severity of the machine than peak, since it calculates the total energy of the sample set, not just a single peak value, which could be an outlier. However, an RMS measurement can mask the effects of severe, short-duration impact events.



- **Spectrum Overall Acceleration** is very similar in concept to RMS, and is a representation of the total vibration energy within the sample set. As its name implies, it is calculated from the frequency spectrum rather than the time domain. It is obtained by summing the squares of every line in the spectrum, dividing by the number of lines, and taking the square root. Spectrum Overall will calculate a slightly different value than RMS, since RMS is performed on the raw time domain data, while Spectrum Overall is performed on the frequency spectrum which has passed through windowing and filtering during the FFT calculation, and is modified by a windowing factor to account for this.



- **Band Acceleration** tracks the highest acceleration value in the frequency spectrum within a specified band. The user defines the upper and lower frequency bounds of the band. It is important to note that Band Acceleration reports the *maximum* value within the band, not the average or any other calculated total energy value. Band acceleration can be useful in tracking the vibration level at a particular frequency of interest, for instance a turning speed, bearing fault frequency, or blade pass frequency.



- **Crest Factor Acceleration** is a measure of the severity of peaks within the time waveform. It is defined as the ratio of Peak Acceleration over RMS Acceleration. A high crest factor is an indicator of impacting or similar short-duration, high-amplitude behavior.

- **Skewness Acceleration** is a statistical measurement defined as the third standardized moment of the data set, and is related to the symmetry of the distribution of the data. A high skewness value is the result of asymmetry of the data set, suggesting vibration with higher deviation in one direction from the mean than the other.

- **Kurtosis Acceleration** is a statistical measurement defined as the fourth standardized moment of the data set, and is related to the shape of the distribution of the data. A high kurtosis value is the result of infrequent extreme deviations from the mean.

- **Damage Accumulation Acceleration** is a unique overall machine health indicator developed by KCF which calculates the rate at which damage is occurring to the machine relative to a healthy baseline. This measurement takes into account both the severity and frequency of oscillatory acceleration, accounting for time-varying symptoms in machines which are often overlooked by traditional vibration diagnostic frequency analysis or time series analysis. It also considers the contribution of repeated load reversal cycles to component damage and the nonlinearity in the relationship between damage and vibration amplitude.

Velocity

The methods for calculating velocity indicators mirror those described above in the acceleration measurement, but are performed after the data has been converted either to a time-domain or frequency-domain velocity signal. In general, acceleration tends to highlight high-frequency vibration, while velocity is more appropriate for analyzing vibration across the entire frequency spectrum.

Indicator Dependent

These indicators are calculated from one or more existing indicators, and typically require parameters of the referenced indicators to be defined first, for instance an alarm level or an off threshold.

- **Warning Percentage** tracks the percentage of time a selected indicator has spent in warning range over a rolling time range. Requires a warning level to be set on the selected indicator.
- **Alarm Percentage** tracks the percentage of time a selected indicator has spent in alarm range over a rolling time range. Requires an alarm level to be set on the selected indicator.
- **Off Percentage** tracks the percentage of time a machine has spent offline over a rolling time range. Requires an off threshold to be set on the selected indicator.
- **On Percentage** tracks the percentage of time a machine has spent online over a rolling time range. Requires an off threshold to be set on the selected indicator.
- **Warning Time** tracks the total amount of time a selected indicator has spent in warning since being reset. Requires a warning level to be set on the selected indicator.
- **Alarm Time** tracks the total amount of time a selected indicator has spent in alarm since being reset. Requires an alarm level to be set on the selected indicator.
- **Off Time** tracks the total amount of time a machine has spent offline since being reset. Requires an off threshold to be set on the selected indicator.
- **On Time** tracks the total amount of time a machine has spent online since being reset. Requires an off threshold to be set on the selected indicator.
- **Math** permits the creation of an indicator which is a mathematical relation between existing indicators. For instance, a user could track a differential pressure across a filter by subtracting an outlet pressure from an inlet pressure, or compare the performance of two machines by trending the ratio of their RMS velocity levels.

336 S. Fraser Street
State College, PA 16801
www.kcftech.com

Sales and Support
(814) 867-4097
(814) 690-1579 Fax
sales@kcftech.com