# Bearing Fault Detection Using MachineSense™

# White Paper

221 Thomas Ave. ▪ Baltimore, MD 21225 ▪ www.prophecysensorlytics.com ▪ +1-443-457-1165

# Bearing Fault Detection Using MachineSense™

**MachineSense is a multi-sensing MEMS based sensor which captures vibration, magnetic field, and infrared radiation from a machine. Depending on the type of machine and the failure, the sensor can be configured to detect common faults of the machinery. For example, MachineSense can detect an electrical winding failure in a motor by detecting its asymmetric magnetic field. It can also detect a bearing failure in the rotor by detecting unusual vibrations. Bearing defect is the most common fault in any rotating machine. Four kinds of bearing faults are widely known… cage fault, outer raceway fault, inner raceway fault and bearing defects. Each of the faults produce characteristic frequencies of their own when viewed in a vibrational spectrum.**

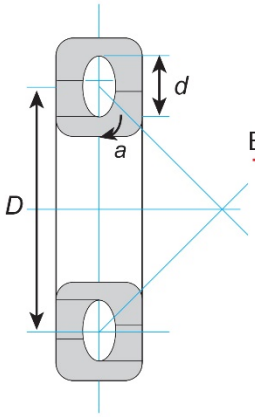
Vibrational frequencies associated with defective bearings have been discussed in many works [1]

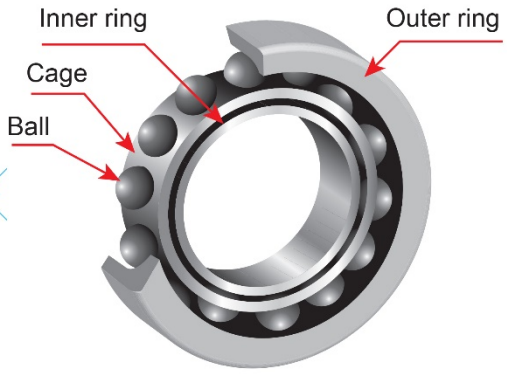
**Cage Fault Frequency:** $f_c = \frac{f_r}{2}\left(1 - \frac{d}{D_m}\cos a\right) = \frac{f_{bi}}{N_b}$

**Outer Raceway Fault Frequenc** $f_{be} = \frac{f_r}{2} N_b\left(1 - \frac{d}{D_m}\cos a\right)$

**Inner Raceway Fault Frequency** $f_{bi} = \frac{f_r}{2} N_b\left(1 + \frac{d}{D_m}\cos a\right)$

**Ball Fault Frequency :** $f_b = \frac{f_r N_b}{2d}\left(1 - \left(\frac{d}{D_m}\cos a\right)^2\right)$




**Traditional methods of detecting these faults, based on actual frequencies, requires extensive electronics and an analyzer. This is an expensive method and computations can only be done locally.**

**Prophecy Sensorlytics™ has developed a patented sub-sampling method in a Time domain which can detect bearing faults with high reliability in the Cloud using transmission of a low volume of data over a period of time. This helps to reduce the cost down to most affordable level. As it is well known, these additional fault frequencies will create a cluster in the phase space of the vibrational vector. Patented Prophecy algorithms detect those angular clusters and decide which faults are traditionally done in FFT (Fast Fourier Transform) domain.**

**The Prophecy sub-sampling time domain method has a couple of technical advantages over traditional FFT based methods in addition to being cost effective and lighter in band width. In traditional frequency domain analysis as described above, faults are detected from additional frequency components generated in the vibrational spectrum. Whereas in the Prophecy method, we track nearly 150+ different statistical features of vibration and at least 30+ features respond to bearing condition change.**

**Fig. 1: Prophecy Sensor mounted on a blower**

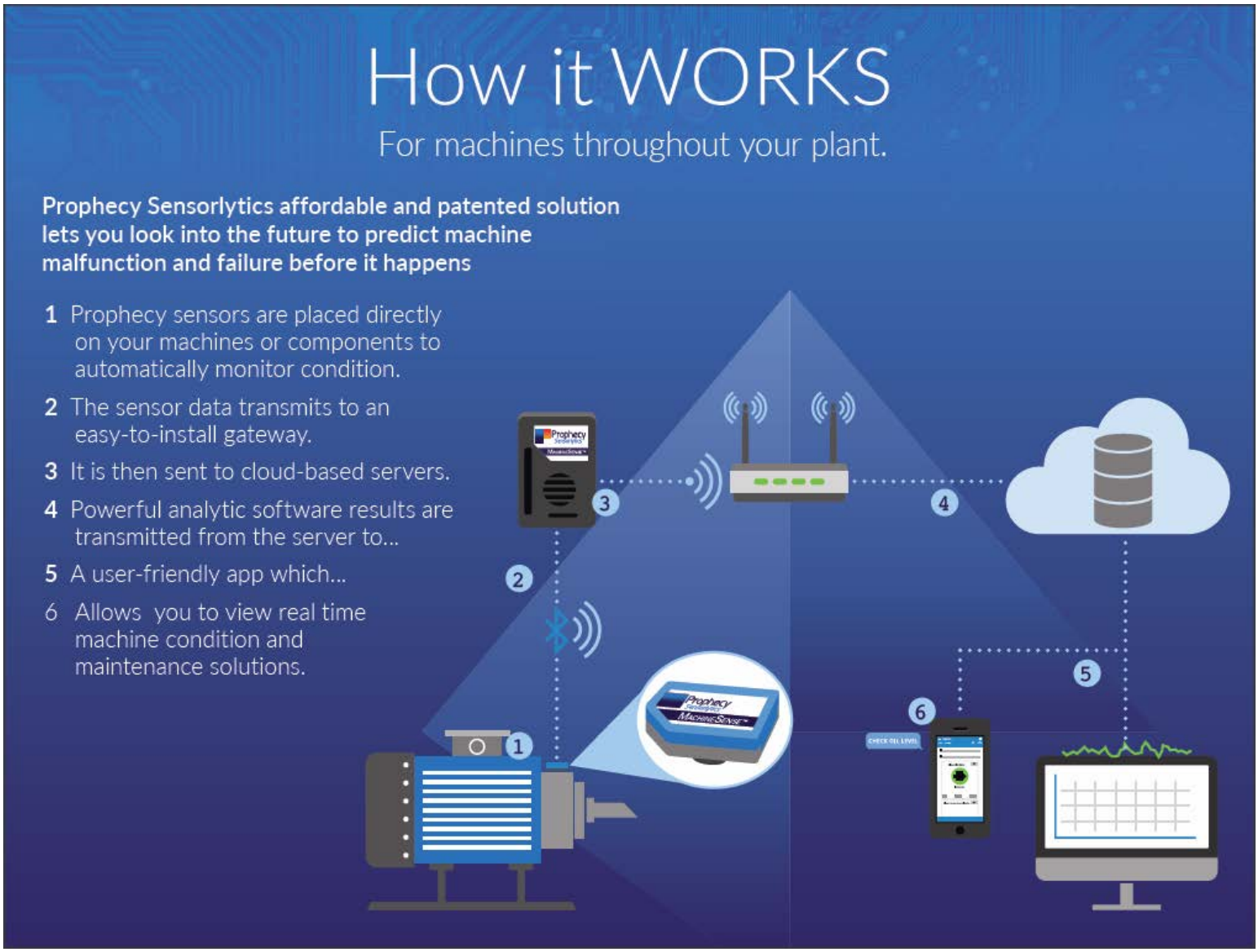



**Fig. 2: How MachineSense works in the Prophecy Predictive Maintenance IoT system**

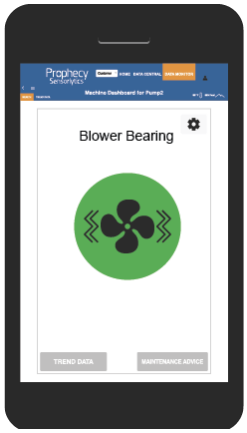



**Fig. 3: Blower Bearing Gauge-Real time indicator of Blower bearing is indicated**

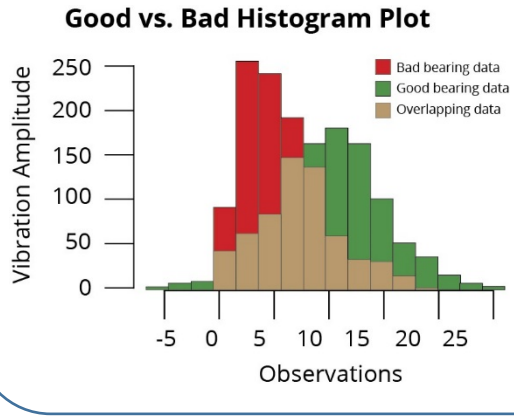



**Fig. 4: Shows two histograms of amplitude of vibration - good vs. bad bearing showing how symmetry in the pattern is broken (The red color depicts the bad bearing and the green color depicts the good bearing. The brown shows the intersection of the two regions.)**

Visualization of diagnosis and fault data 24x7 is done via several applications that run on the web, as well as in the Prophecy Mobile app (Fig. 3, 4 & 6). Visualization delivers both a real time gauge (Fig. 3), Trending of the fault for up to the last 6 months (Fig. 5) and a summary of faults of all the machines in a dashboard format (Fig. 6)

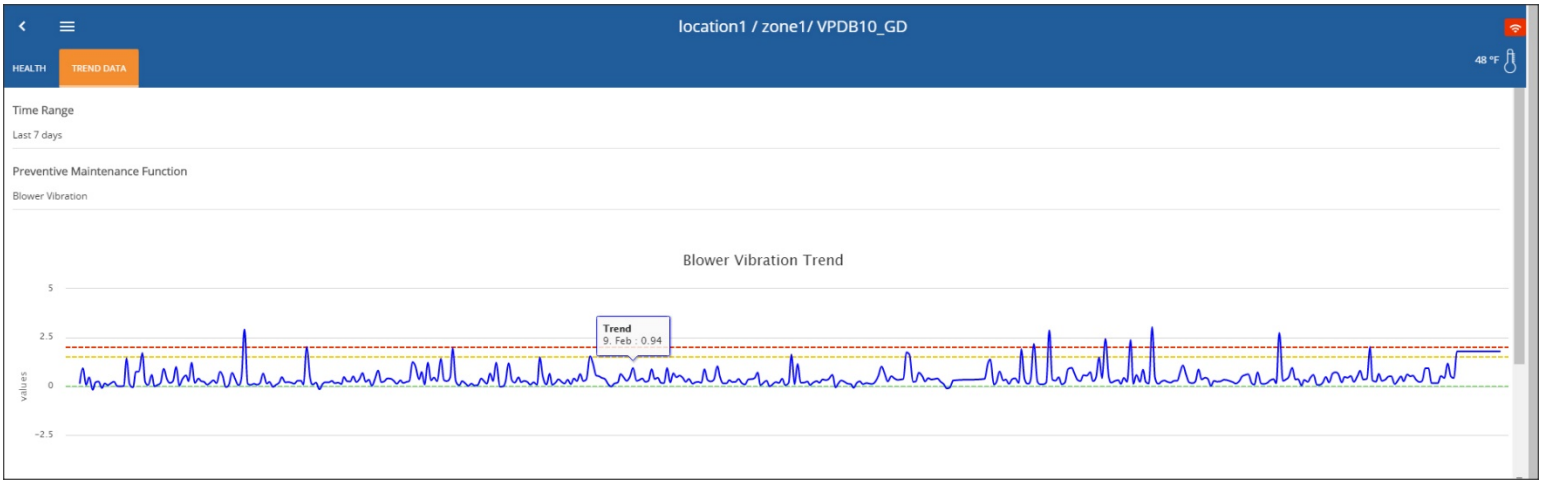



**Fig. 5: Trend line showing how a blower fault is being monitored over the last 7 days. The system will track up to the last 6 months**

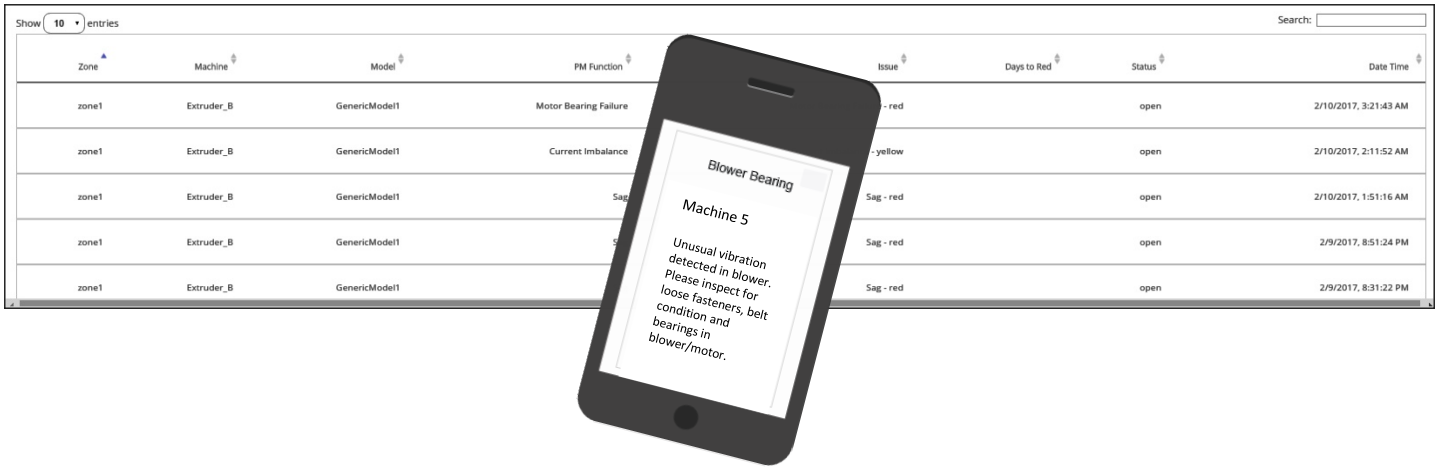



**Fig. 6: Alarms are sent via email/SMS if a Blower Bearing fault is detected. All of such alarms can be read from MRO (Maintenance Repair Operation) logs of the Prophecy Data Viewer and maintenance advice will be sent by text and email.**

**[1] R.B. Randall, J.Antoni, "Rolling element bearing diagnostics - a tutorial," Mech. Syst. Signal Process, vol. 25, 2011, pp. 485–520.**

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