Industrial EKG

Sensing and interpreting the pulse of machinery and business processes
What We Do

We help you reduce energy and operating costs by using EKGs to monitor the health of industrial equipment instead of people, like industrial cardiologists.

Our uniqueness:

– we don't need sensors on the monitored machines, no cables to install;

– an experience database of over tens of thousands of motors to compare your equipment against;

– multiple monitors in one product – energy efficiency & consumption, power line condition, electrical and mechanical motor condition; and mechanical condition of driven equipment;

– we *directly* measure how even mechanical faults like unbalance, misalignment, and loose connections waste energy dollars, making ROI calculation fast, easy, clear and unambiguous.
Electric Power
Water
Shop Air
Hydraulics
<table>
<thead>
<tr>
<th>Man</th>
<th>Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>Motor Kilowatts</td>
</tr>
<tr>
<td>Physical Balance</td>
<td>Phase Balance</td>
</tr>
<tr>
<td>Food</td>
<td>Coal, Oil, Gas, Wind</td>
</tr>
<tr>
<td>Blood Pressure</td>
<td>Motor Voltage</td>
</tr>
<tr>
<td>Blood Flow</td>
<td>Motor Current</td>
</tr>
<tr>
<td>Temperature</td>
<td>Temperature</td>
</tr>
<tr>
<td>Pulse Frequency</td>
<td>Line Frequency</td>
</tr>
</tbody>
</table>
Common Faults

**Man**
- High blood pressure
- Injured knee
- Headache
- Heart valve failure
- Kidney stones
- Blocked artery
- Food Poisoning
- Blood disease
- Hearing Loss

**Machine**
- Unbalance
- Worn Out Bearings
- Contaminated Oil
- Misalignment
- Loose hold-down bolts
- Shorted Motor windings
- Overheating
- Fatigued fittings, connections
- Unbalanced Volts, Amps
- Inefficient operating point
EKG

Electrocardiograph

An instrument used in the detection and diagnosis of heart abnormalities that measures electrical potentials on the body surface and generates a record of the electrical currents associated with heart muscle activity.
EKG = Electrical Measurement

Non-invasive
Easy to Measure, Trivial Procedure
Large Amount of Information
Directly Related to Condition
But --- difficult to interpret.
A few examples....
Automotive Fuel Pump

Motor armature

Pressure limiting valve

Non return valve

Motor Current
Machine Electrical Measurements

Non-invasive

Trivial Procedure – *No sensors on, or instrument cables to, the machine*

Large Amount of Information

Directly related to Machine Condition

But - - *difficult to interpret*
NYSE: GG

Stock Market

Commonly-used trigger signal (trade at peak)

Daily Stock Price
Retail Sales

Source: Department of Commerce, Seasonally Adjusted

- Monthly Change (left)
- Annual Change (right)
Business Data

Non-invasive
Easy to Acquire data
Large Amount of Information
Directly related to Condition
But -- difficult to interpret
Why Bother?
Reduce Costs, Improve Availability.

- 50% of breakdown maintenance
- 10% of breakdown maintenance
- Predictive maintenance
- Planned maintenance
- Breakdown maintenance

Save Energy
Industrial EKG

Sensing and interpreting the pulse of machinery and business processes
Industrial Motors

62% of all electricity generated worldwide, powers industrial motors.
There are a LOT of motors out there...

One Chemical Plant in Louisiana, USA:
>2,000 motors
12,000 Horsepower to 1 Horsepower
10% of these are driving “Critical” systems

- Plant stops producing final product
- Widespread collateral damage if unexpected stop
- No spare, long lead time for replacement
Fundamental Pulse, Induction Motor

Small Anomalies & Disturbances =
Clues to Supply, Motor, and Driven Equipment Condition
How to take a Motor's Pulse?

Motor Control Center (MCC)
3 Voltages, 3 Currents

“EKG” Instrument

No Sensors On the Motor!

All in the Motor Control Center!

3 Phase AC Motor

Converter

Current Transformers
Class: 0.5 - Secondary: 5A

RS 422/RS 485 Communication Cable
(2x2x0.22 LST C, twisted pair)
Sensors

Fixed speed – Passive current transformers

Variable speed – Hall-effect current transducers

Medium/high voltage – potential transformers
Typical Installations
Connects with other systems

- Serial
- Ethernet
- GPRS (cell phone network)
- Custom configuration
What kinds of things can be monitored and diagnosed?

- Energy consumption
- Power line condition
- Electrical condition of motor
- Mechanical condition of motor
- Mechanical condition of driven load
- Process Variation
What kinds of **Electrical faults** can be diagnosed?

- Unbalanced Voltage, Current
- Faulty Rotor Bars
- Energy + Power for individual phases
- Efficiency
- Insulation Breakdown
- Winding faults
- Capacitor Failure
- Weak / Loose Connections
What kinds of **Mechanical faults** can be diagnosed?

In the motor **AND driven machine:**

- Unbalance
- Misalignment
- Bearing faults
- Looseness
- Drive belt, transmission, gearbox, coupling faults
- Impeller, blade, vane, piston degradation
- Motor rotor eccentricity
- Process anomalies

No sensors or cables On the motor or machine!
How Early is Detection Required?

Increasing Detection Horizon

Incipient Fault Initiation
High Frequency Analysis
Multi-Spectral Analysis
Oil-Debris Monitoring
Traditional Frequency Vibration
Temperature Indicators
Control System Shutdown
Catastrophic Failure

Time

Lead time to Schedule Repair, Order Spares, Perform Repair
Cost of Repair and Downtime vs Production
5 HP Industrial AC Induction Motor Phase Unbalance

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average voltage</td>
<td>230 230 230</td>
</tr>
<tr>
<td>Percent unbalanced voltage</td>
<td>0.3 2.3 5.4</td>
</tr>
<tr>
<td>Percent unbalanced current</td>
<td>2.4 17.7 40</td>
</tr>
<tr>
<td>Increased temperature * rise (°C)</td>
<td>&lt;1 11 60</td>
</tr>
</tbody>
</table>

* A 10 deg-C rise in operating temperature reduces motor life by 1/2
How Does it Work? (Theory)

Measured Voltage

Internal Model

Measured Current

Differences

Predicted Current

Model is based on testing & analyzing <em>tens of thousands of motors</em>
How Does it Work?
(Operation)

Install ➔ Train ➔ Run

Unattended!
Condition assessment reports

Produced automatically after learning

Summary of current condition of equipment

Action advice based on fault severity

Detailed fault descriptions

CONDITION ASSESSMENT REPORT
Company: Econ-Gasp
Coordinator: Dan Jones
Equipment: Feed pump #3
Analysis: John Wood
Date: 25 August 08

Performance Summary
Motors and machines are operating normally.
WATCHEO: Voltage changes in supply voltage causes this alarm. If alarm persists, check harmonic levels, capacitor supply, motor, and equipment terminals, conductors, transistors, and converter connections.
WATCHEO LOAD: If the process has not been altered deliberately check load actors (double and single adjustments, pressure gauge readings), transmission problems, and flow bleeding. If the process has been altered deliberately, MONITOR should be updated.
PERFORM MAINTENANCE: There are indications of mechanical and/or electrical faults developing as shown below. Maintenance should be scheduled according to the severity level.

Simplicity Level
Critical Low Medium High Urgent

Energy Efficiency
Power factor (Cos Ph) is below x.

Current and Voltage
The average RMS values of the current phases are 5% above the nominal current values. Monitor for increased hot spot temperatures.
Voltage variation is beyond normal limits. A source should be determined and corrected.

Current Harmonic Distortion
There is an exceedance of harmonic distortion. If Total Harmonic Distortion (THD) is more than 10%, this causes heating, and vibration. Because of this harmonic causes heating in the stator winding. If THD increases, this causes vibration. Harmonics can be used for very high values if appropriate and economical.

Current and Voltage Unbalance
Current unbalance is more than 5%. Motor or machine should be checked and remedied for stator, short circuit, isolation, partial discharge, etc. faults.
Voltage unbalance is more than 5%. Voltage unbalance causes heating by increasing the current unbalance more. It should be checked and remedied.

Electrical Fault Indicators
There is evidence of partial electrical fault. Motor or machine should be checked for stator, rotor, short circuit, isolation, winding, shortness, etc. faults.
There is evidence of partial electrical fault. Cables, connector, compressor, and motor connections should be checked.
Stator, short circuit, slackness, isolation, and partial discharge faults should be checked.
Rotor and rotor bars (such as stiffness, or cracking) should be checked.

Mechanical Fault Indicators
There is evidence of misalignment. Misalignment, imbalance, bearing, coupling, and rotor shaft faults.
Transmission elements, gearing, shafts, and motor components should be checked.
Bearing(s) should be checked.
Loose motor foundation and loose motor component should be checked.
Diagnostic information

- Fault diagnosis and severity level
- Condition assessment report
- Action urgency
- Motor or generator data
- Energy and power quality information
- Advanced analysis
Detailed, Traditional Trends & Spectra
If Required for Diagnosis
Typical Data

- Motor nameplate information
- Model Parameters + Energy Use
- 20+ “RMS” condition indicators
- High-resolution time histories of V,A
- High-resolution Spectra
- Proprietary algorithm results
- Condition assessment report
- Diagnostic condition information summary
- Visual action urgency status bars
What about Energy Monitoring?

- Over-sized motors = largest category of wasted energy; detectable via power factor measurement, this is the main driver behind conversion to Variable Frequency Drives
- EFF3 to EFF1 Motor Upgrade = 1-2 % energy gain
- Mechanical unbalance, misalignment = 1-2 % energy loss!
- Unbalanced voltages (usually due to unequal single phase equipment loads) result in 5-8x current imbalance, overheating, drastically reduced motor life
- Loose or poor electrical connections can cause several % energy loss
- Line Harmonics can cause several % energy loss
- KWH consumption is measured on all 3 phases
What equipment can it monitor?

- Virtually all equipment driven by 3 phase motors, induction or synchronous
- Continuous or variable duty, including variable-frequency drive
- Generators and alternators
- Especially effective for remote or inaccessible equipment
- Especially effective on slow-speed equipment where vibration measurements are difficult or impossible (conveyors, crushers, transfer line motors...)
Why is it Unique?

Experience database  >4000 installed, 
Proven technology

No sensors or cables  on the motor or driven equipment

Multiple instrument functionality in one integrated, affordable unit

Return on Investment calculation is fast, simple, clear and unambiguous
What about Competition?

Surprisingly, there are no direct competitors for this solution, there is nothing like it in the market. In fact, most people's first reaction is, “It's too good to be true.”

We appreciate that our customers have many alternatives for spending money to improve reliability and lower energy and operating costs. But they keep coming back....
### Some Existing Customers

<table>
<thead>
<tr>
<th>Water</th>
<th>Petrochem</th>
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<tbody>
<tr>
<td>Severn Trent</td>
<td>bp</td>
</tr>
<tr>
<td>Wessex Water</td>
<td>Jordan Petroleum Refinery Company</td>
</tr>
<tr>
<td>Environment Agency</td>
<td>Eramco Saudi Arabia</td>
</tr>
<tr>
<td>Yorkshire Water</td>
<td>VENTURE Production Company Limited</td>
</tr>
<tr>
<td>anglianwater</td>
<td>China Petroleum &amp; Chemical Corporation</td>
</tr>
<tr>
<td>United Utilities</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy</th>
<th>Food and Pharmaceutical</th>
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<tbody>
<tr>
<td>British Energy</td>
<td>Novartis</td>
</tr>
<tr>
<td>posco</td>
<td>Frito Lay</td>
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<tr>
<td>International Power</td>
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<tr>
<td>EDF Energy</td>
<td>Tetra Pak</td>
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<tr>
<td>Primary Energy</td>
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<tr>
<td>BNFL</td>
<td>PHILIP MORRIS INTERNATIONAL</td>
</tr>
<tr>
<td>Unilever</td>
<td>S&amp;N</td>
</tr>
<tr>
<td>KEPCO</td>
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</tbody>
</table>
Some Existing Customers

**Metals**
- Mittal
- ERDEMIR
- posco
- ŞİSECAM
- Arcelor
- ArcelorMittal

**Manufacturing**
- ALARKO
- Carrier
- BEKO
- Norbord
- Driveline and Chassis Technology
- ZF

**Automotive**
- Volkswagen
- HPP
- RENAULT
- TOYOTA
- Autoliv
- Mercedes-Benz
- TOFAS
- BOSCH
- GOOD YEAR

**Transportation**
- Fisher
- Carnival
- BAA
- Department of the Navy
How Much Does It Cost?

- Villa in the South of France
- Small used Learjet
- BMW 750i
- Ford F150 pickup truck
- 2-week family vacation in Mexico
- Tata Nano
- Weekend trip with your partner
- Dinner at a fancy restaurant
- One night in a hotel room
- Fill your car with petrol

Week of lost production
New motor or machine
Motor rewind
New bearing parts
Machine oil change

Approximately...
Buying Models

• Rent for validation period or lease for long-term use.
• Buy and operate in-house. Integrate into your existing plant-wide monitoring and diagnostic framework. System integration service is available
• Contract as a monitoring & diagnostic service operated remotely or on-site.
• Small PC board available for OEM integration
Questions?

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