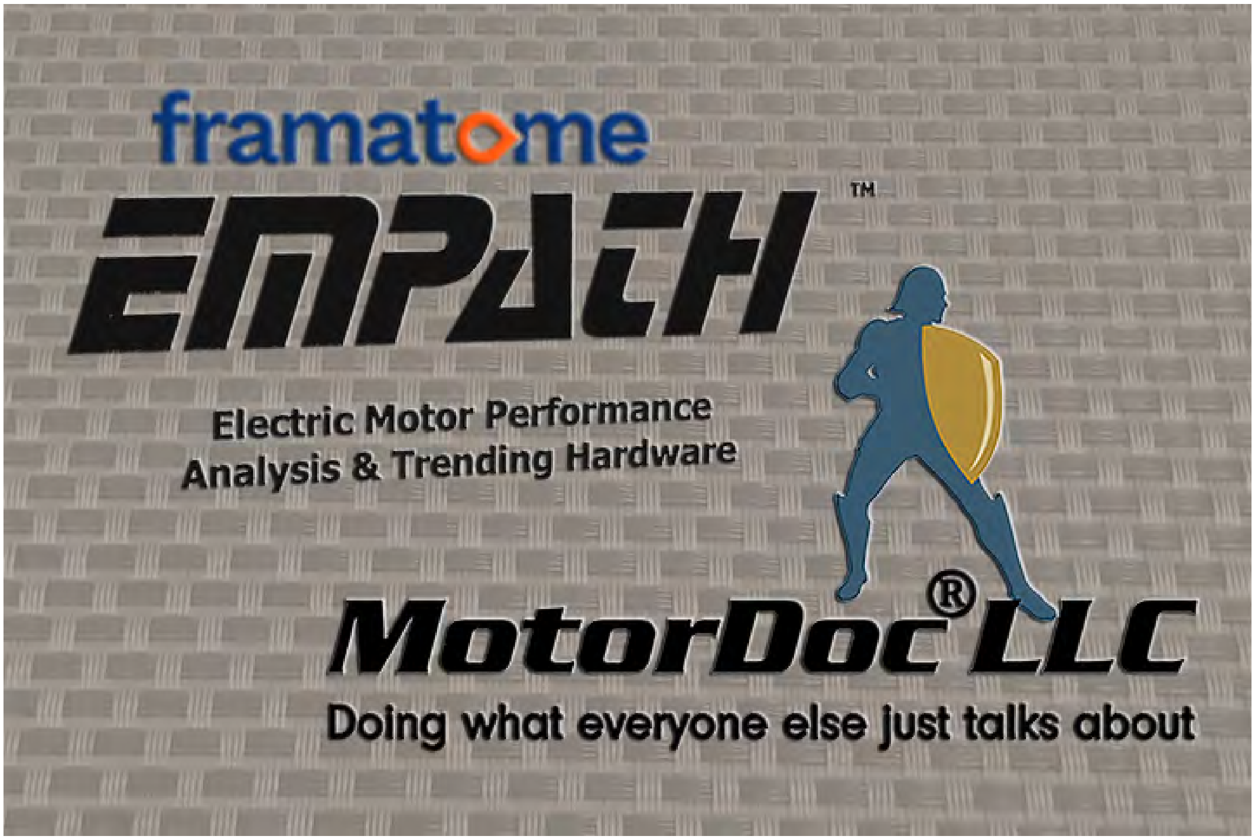


Case Study
Trending A Rotor Bar Failure with EMPATH™ Electrical Signature Analysis

MotorDoc® LLC
Lombard, Illinois
www.EmpathCMS.com
800-919-0156 ext 102

Trending a Rotor Bar Failure with EMPATH™ Electrical Signature Analysis Case Study

Howard W Penrose, Ph.D., CMRP
President, MotorDoc® LLC

Rotor bar failures are not common in properly applied systems. In this case study a 4000 hp motor without starting restrictions is followed through to rotor bar failure. Lessons in this case study include a demonstration that the load does not impact the relative relationship between peak voltage and current frequencies while trending a fault. In this application, recommendations to implement time between start limits were regularly by-passed and the motor was normally restarted multiple times due to driven equipment deficiencies.

The software used for this evaluation is the EMPATH™ to review data previously collected with an ATPOL™ ALL-TEST Pro LLC data collector.

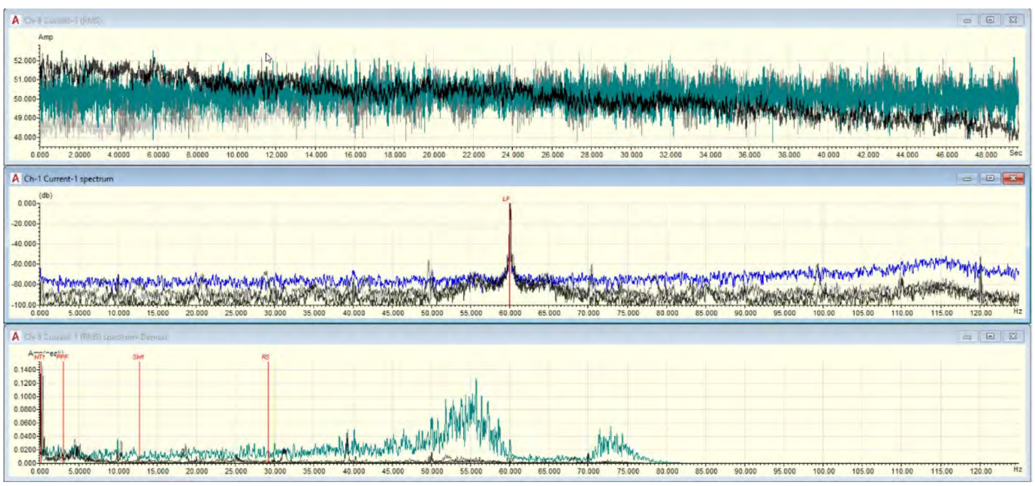


Figure 1: All Four Sets of Data Superimposed for Visual Comparison

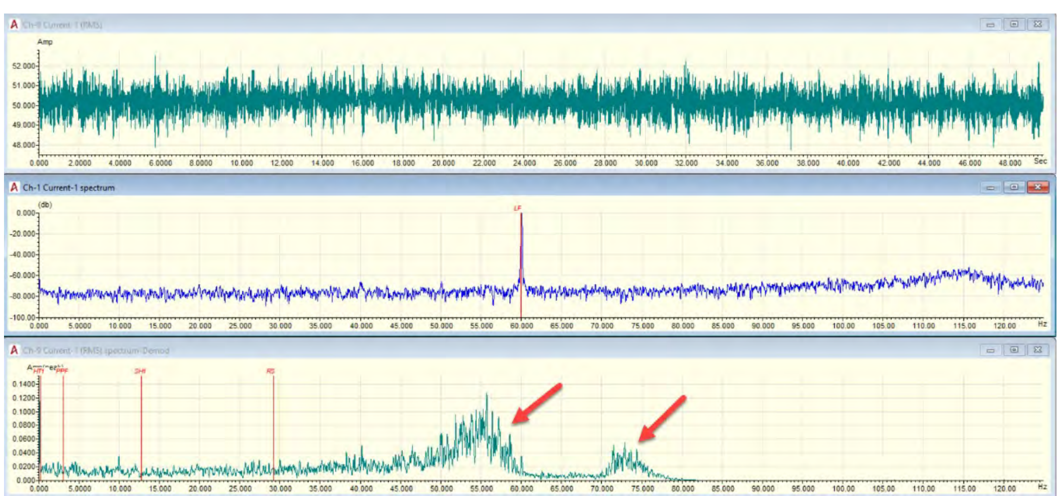


Figure 2: Baseline Low Frequency Data Light Load Showing Cavitation from Compressor – January, 2016

In the baseline data found in Figure 2, there is no real sign of the rotor bar problem. Due to the light load and almost synchronous RPM, very small PPF peaks can be found on either side of line frequency that are slightly above the noise floor.

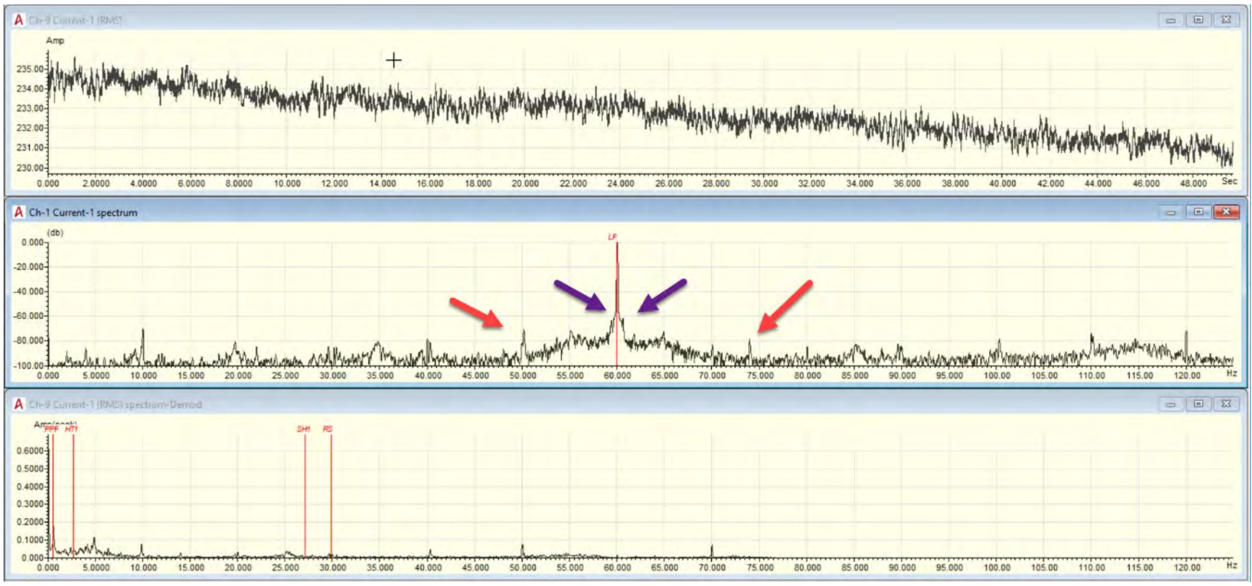


Figure 3: -62dB Down from the Peak Frequency PPF, Small Linear Peak in Demod at PPF and Gearbox Signatures Starting to Show Due to Gear Wear – May, 2016

As noted in Figure 3, under heavier loading, the gear frequencies (red) are beginning to show and Pole Pass Frequencies (PPF – blue), have increased in amplitude to -62 dB. In Figure 4, there are small dynamic eccentricity peaks, which are also impacted as the impact of weak fields around fractured and broken bars effect the airgap. There is no indicator in RMS current at this point.

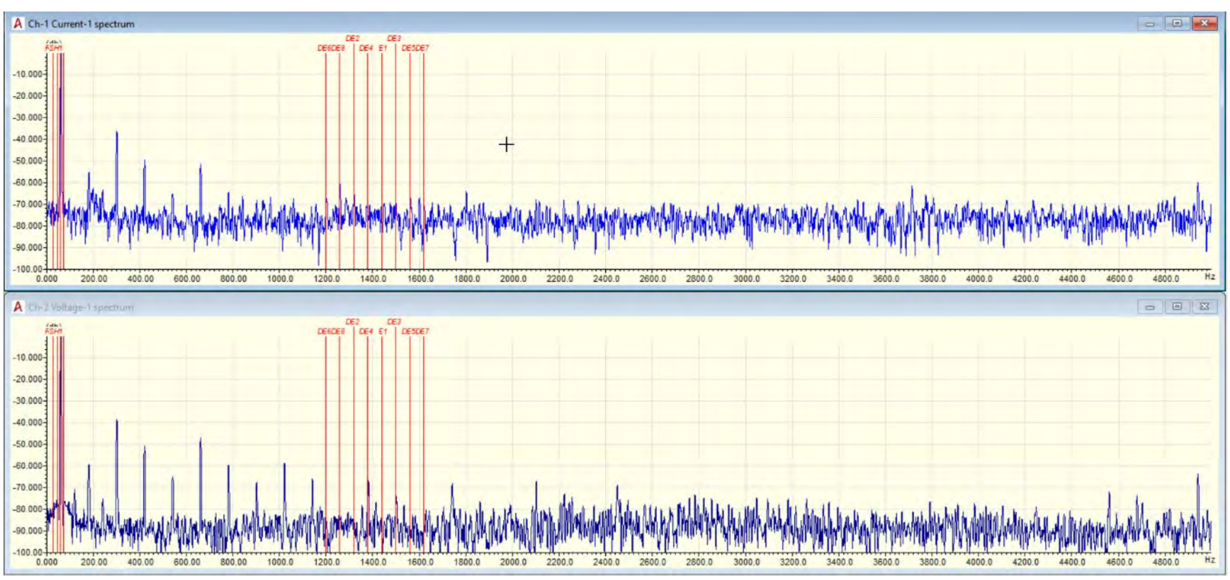


Figure 4: Dynamic Eccentricity Increases - May, 2016

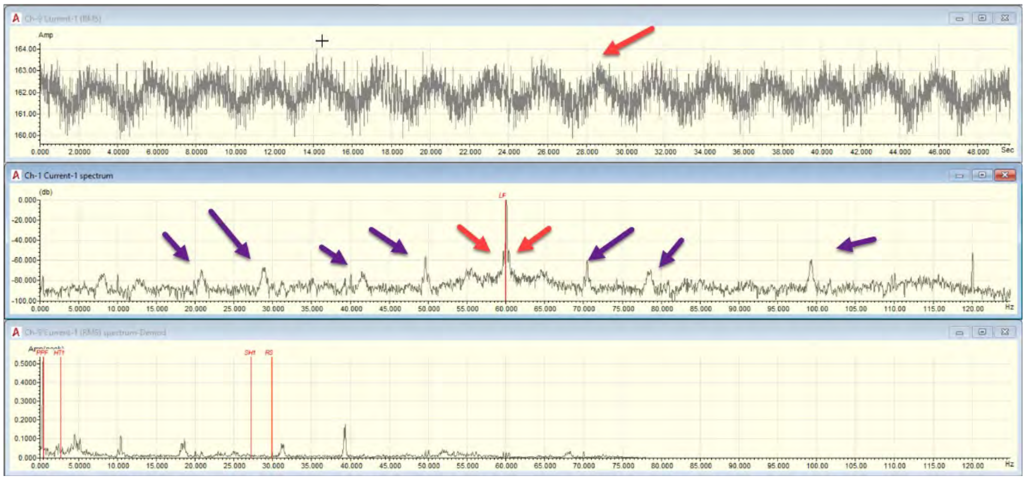


Figure 5: Lighter Load Conditions, Increased Rotor Bar and Gearbox Frequencies – December, 2016

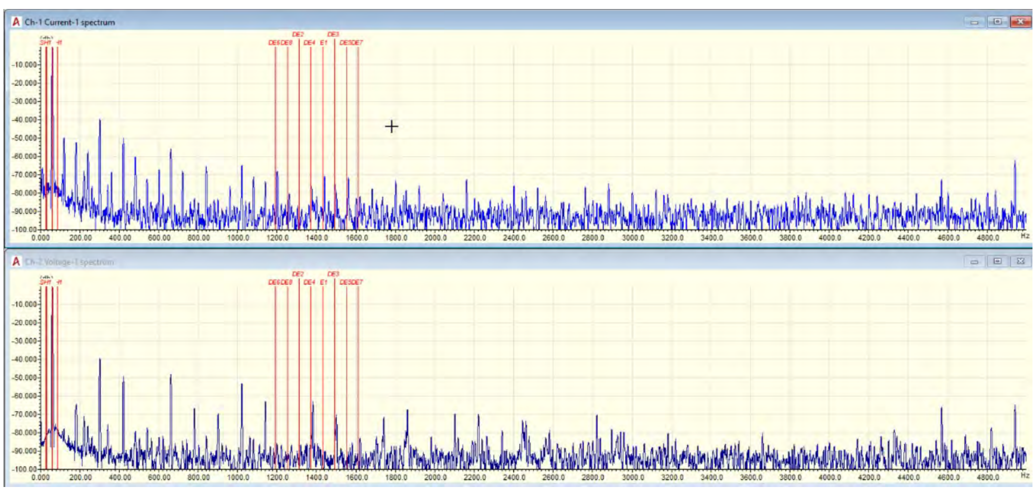


Figure 6: Increased Dynamic Eccentricity Peaks – December, 2016

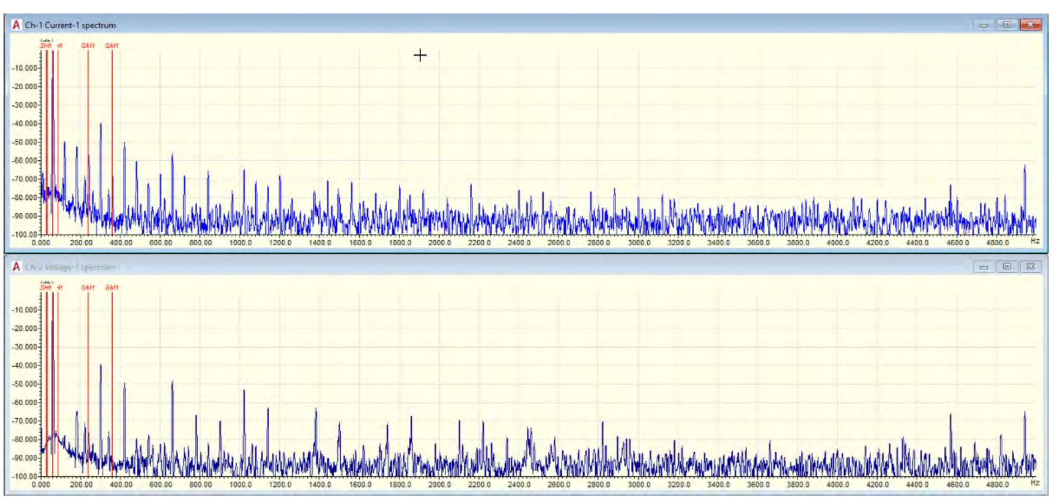


Figure 7: Gear Mesh Frequencies – December, 2016

In Figure 5, the PPF frequencies have increased again to -49 dB from the peak (red), and gearbox related peaks have become more numerous and increased. Figure 6 shows increased peaks and dB related to dynamic eccentricity as rotor bar problems become more dominant. This effect does not always show but is an indicator of change and can be used to confirm rotor bar conditions. As shown in Figure 7, gear mesh frequencies are now present as the gearbox wear increases in this application. There are also gearbox bearing signatures present, but that is for another case study.

The motor was operated for an additional 9 months until it was removed for rotor rebar and general overhaul. Minor work was performed on the gearbox, limited to availability of parts.

Figure 8: One of Several Fractured Rotor Bars Found During Shop Inspection

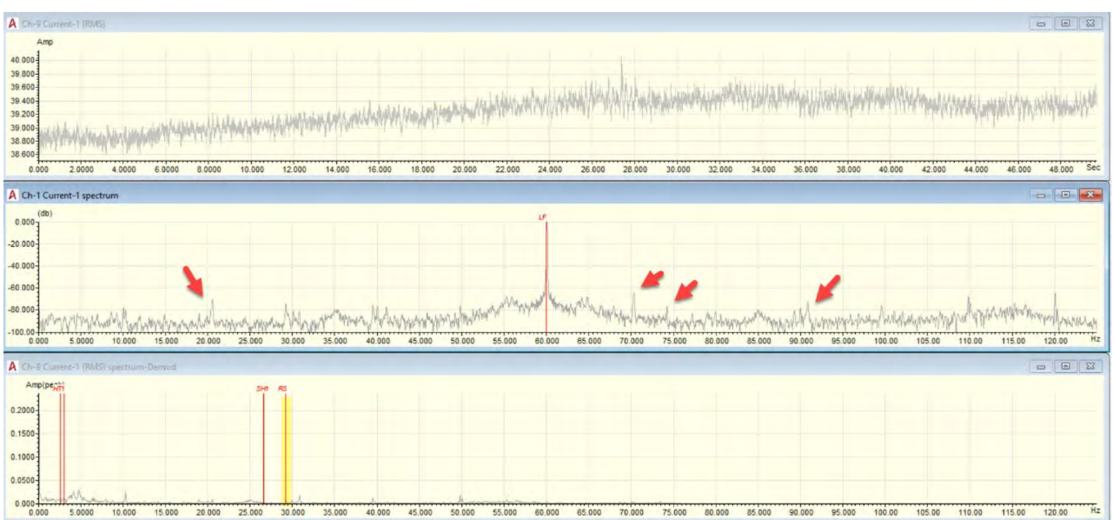


Figure 9: Following Repair Gearbox and Gearbox Bearing Signatures - March, 2018

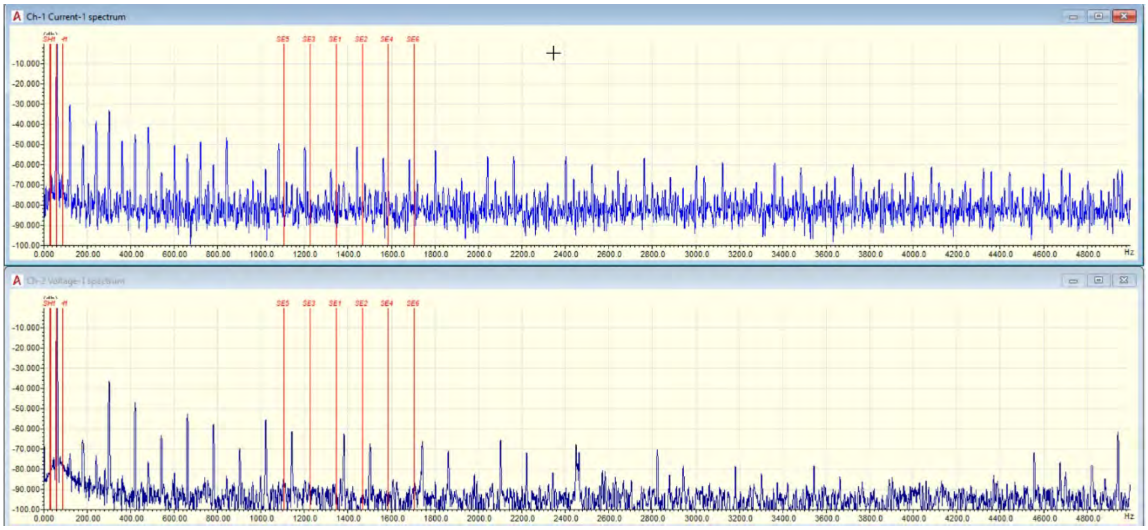


Figure 10: Following Motor Repair Very Small Levels of Static Eccentricity - March 2018

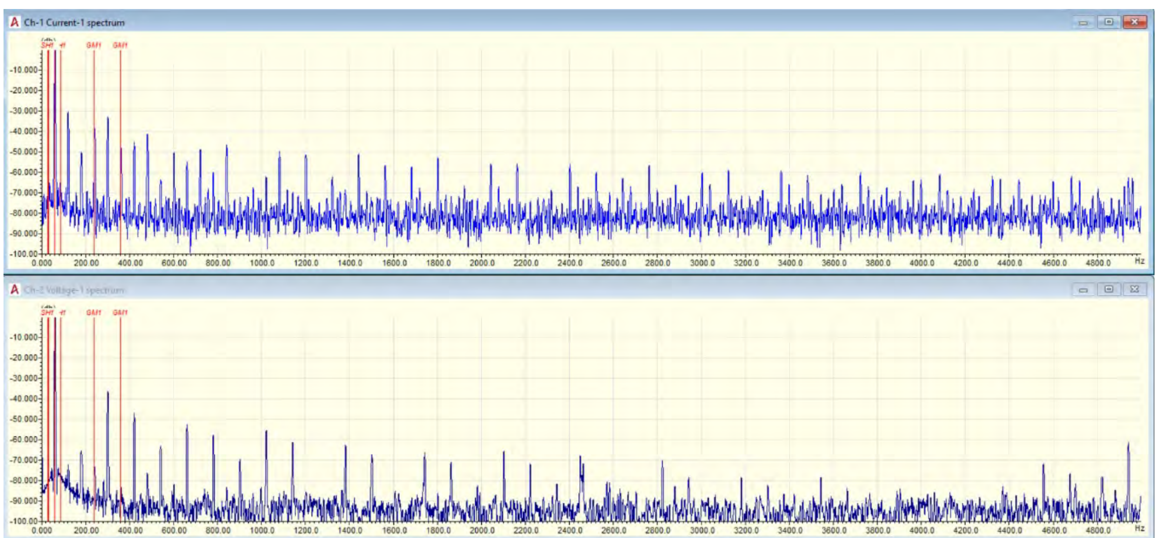


Figure 11: Following Repair Gear Mesh Frequencies - March 2018

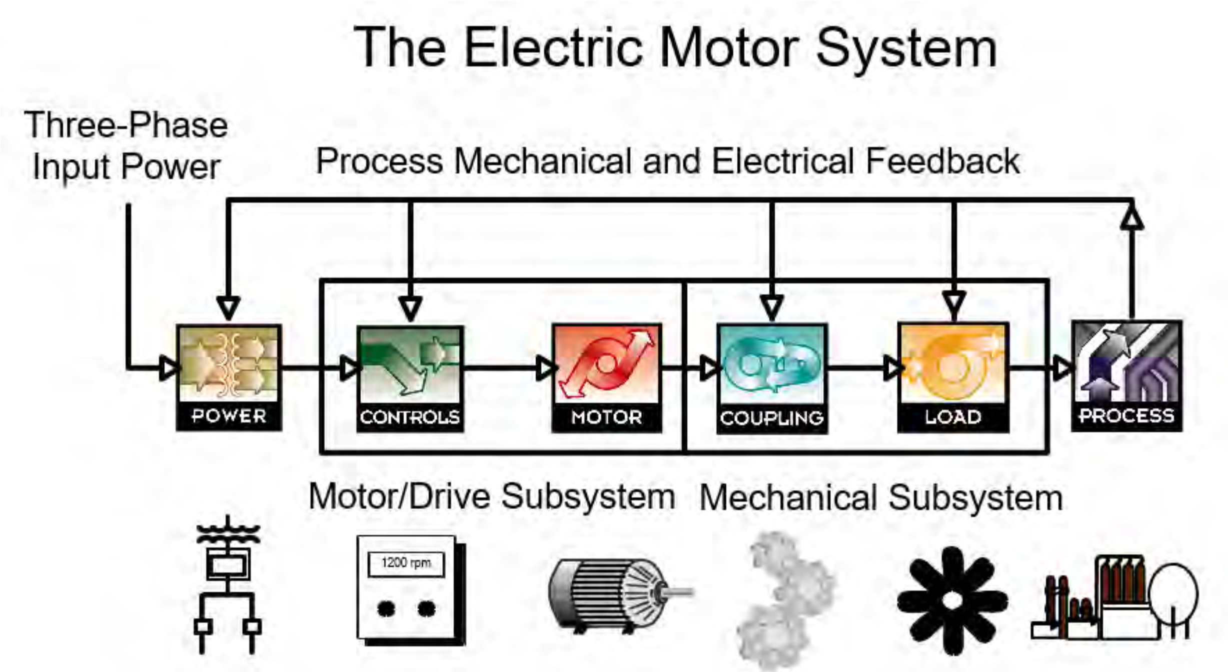
Figure 9 shows continued indications of the gearbox bearings and gear issues supported by the gear mesh frequencies indicated in Figure 11. Very low levels of static eccentricity are found in Figure 10, which are similar to previous levels, which are indicators of the rotor being slightly off-center in the air gap. Slight misalignment is indicated as the data was taken while the motor was just started and the off-set misalignment existed. Following data shows lower 1X RPM peaks (+/- ~30Hz sidebands of 60Hz).

Conclusion

Even broken rotor bar conditions are trendable in Electrical Signature Analysis. The EMPATH™ system is used for periodic testing of electric motor systems and provides a deep view through the entire system. While rotor bar failures are not common, they can be found and trended in both periodic testing with

20 Yorktown Convenience Ctr, Lombard, IL 60148
www.MotorDoc.com ph: 800-919-0156

EMPATH as well as the EmpathCMS™ continuous monitoring system. The continuous monitoring system will detect and allow you to trend these conditions as well as sending alerts when pre-set alarms are passed.



I can see this entire system with an EMPATH system – can you?

For More Information Contact MotorDoc LLC
www.EmpathCMS.com
www.motordoc.com
info@motordoc.com
800-919-0156 ext 102 in the USA

framatome

EMPATH™

Challenge

Electric motors and mechanical systems are subject to deterioration and damage that can suspend operations, leading to expensive repair and downtime.

Solution

Framatome offers the Electric Motor Performance Analysis & Trending Hardware (EMPATH™) system to conveniently measure and analyze electric motor current and voltage to obtain information on critical processes and equipment. EMPATH helps owners detect potential motor problems early, enabling timely repairs and avoiding serious damage.

The key to EMPATH's successful track record is its utilization of Motor Current Signature Analysis (MCSA) technology.

The Theory of MCSA

When an electric motor drives a mechanical system, it experiences variations in load caused by gears, pulleys, friction, bearings, and other conditions that may change over the life of the motor. The variations in load caused by each of these factors in turn cause a variation in the current supplied to the motor. These variations modulate the carrier frequency.

EMPATH utilizes a unique process to demodulate the signal from the carrier and present an unambiguous spectral display. Using normal and demodulated data permits analysis of not only the motor but also the load and the supplied power.

The EMPATH System

The EMPATH system consists of a laptop computer with our exclusive signal conditioning board. Analysis software stores data and gives a readout of the time and frequency signatures. The signal conditioning board collects data on all three phases of voltage & current and provides MCSA-filtered signals. Also, two general-purpose input channels give the customer the option of collecting additional data simultaneously (such as vibrations, temperature, pressure, etc.).

Your performance
is **our** everyday **commitment**

Customer benefits

- EMPATH hardware is CE qualified.
- EMPATH provides unique algorithms that can reliably detect the early stages of rotor bar failures in induction motors.
- EMPATH saves time and precludes plant walkdowns by monitoring plant motors and driven machinery from a central motor control center.
- Auxiliary channels allow acquisition and analysis of data from a variety of other sources such as accelerometers (vibration data collection), proximity probes or process measurements. This information, properly analyzed, can greatly enhance a predictive maintenance program.
- The EMPATH System permits data acquisition and analysis of not only AC induction motors but also DC motors, synchronous motors, generators and transformers. Efficient energy utilization is also indicated by the EMPATH analysis routines.

Technical Design

The EMPATH software provides spectral analysis of all inputs.

Inputs

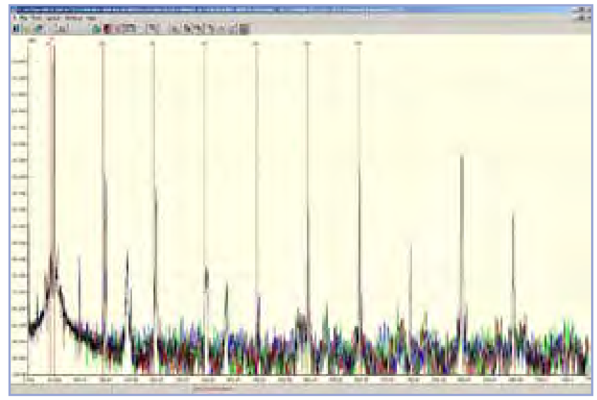
- Three Phases of Current (A,B,C)
- Three Phases of Voltage (A,B,C)
- Two Auxiliary Inputs (± 5V)

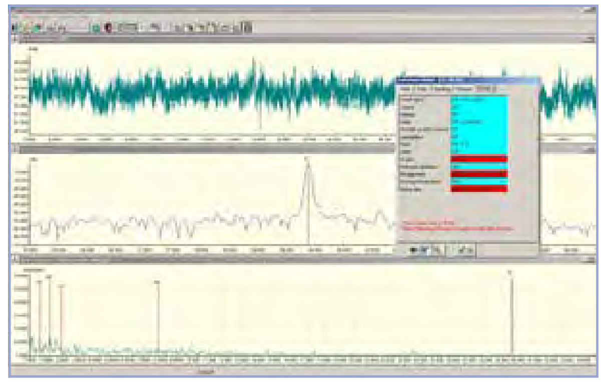
Outputs

- Three Conditioned Currents (A,B,C)
- Three Conditioned Voltages (A,B,C)
- Phase A RMS Current Level
- Phase A RMS Demodulated MCSA Signal
- Two Isolated Auxiliary Signals

Software

- Automatically marks traces
- Automatically tunes acquisition hardware for the incoming signals
- Adjusts sampling frequency and length of input sample
- Displays time and frequency data with cursors to read actual values
- Retrieves past data and compares with present data via plot overlays
- Comes with built-in
  - Tracking and trending database
  - Motor and bearing database
  - Motor enclosure and efficiency database
- Fully compatible with the existing data
- Fully compatible with Windows-XP, VISTA, Windows-7 and Windows-10 OS
- Fully compatible with Framatome's Continuous Motor Monitoring System (CMMS)





In the "High Frequency" data, EMPATH provides three phases of current and voltage and their associated spectra. An automatic on-screen assessment of the motor health is performed immediately after the data acquisition.

EMPATH indicates:

- Rotor bar deterioration
- Rotor eccentricity
- Stator phase imbalance
- Motor speed and slip
- Gear and belt imperfections
- Average running current, an indicator of motor torque
- Numerical and graphical display of Torsional vibration and dynamic loading
- Bearing degradation

Contact:

Charlie Stevens - MotorDoc LLC - 20 Yorktown Convenience Center - Lombard, IL 60148 USA

Ph: 800-919-0156 ext 102 USA or email info@motordoc.com

www.motordoc.com

MotorDoc LLC

Doing what everyone else just talks about

framatome

framatome

E-Plug Enhances Motor Analysis Safety

Challenge

Ensuring safety during operations is paramount at nuclear power plants. During motor analysis, opening a 460 or 480-volt motor control center cabinet door while equipment is energized has inherent dangers requiring protective clothing and qualified personnel.

Solution

Convent and Practical

Framatome's E-Plug hardware permits the acquisition of motor electrical signature analysis data at a motor control center (MCC) — without opening the MCC door. The user simply attaches a connector to the door, while cable from the innovative E-Plug module passes voltage and current data from probes inside the MCC to the connector. The connector then mates with a cable that permits direct feed into EMPATH 2000, expediting electrical signature analysis.

The E-Plug's efficient design comprises an enclosure with external attachment leads. Both current and voltage signals pass through these leads. Inside the enclosure, electronic circuitry processes the signals to prepare them for output to the through-door connector. In short, E-Plug contains everything you need for efficient signal transmission.

Customer benefits

- Enhances safety by avoiding exposure to potential dangers associated with opening a 460 or 480-volt cabinet door while equipment is energized
- Precludes both the need for protective clothing and the attachment/removal of probes inside the MCC
- Simplifies connections, requiring only one cable to perform testing
- Reduces overall testing time
- Convenient to use. Eliminates probe handling when performing tests
- One person can perform online motor testing with EMPATH 2000
- Fully compatible with Framatome's new generation Continuous Motor Monitoring System (CMMS) platform

Your performance
is **our** everyday **commitment**

Inputs to the E-Plug Module

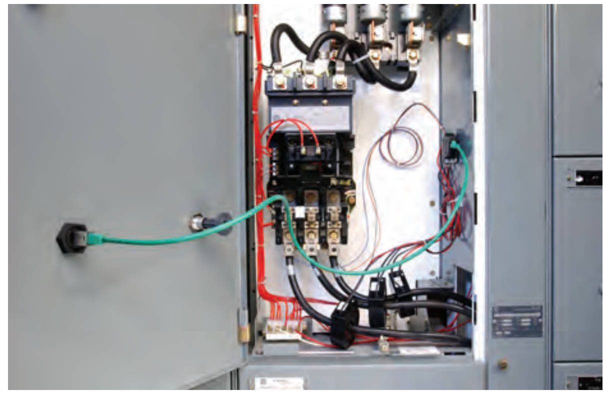
Power cables to the motor pass through current transducers (CTs) that measure the current flowing through the cable and produce a voltage output proportional to the current flowing to the motor. The voltage output from the current transducers is typically tens of milli-volts per amp, yielding an upper limit of 10 Vac for the current transducer output.

Fused wires attached to the power cables provide a voltage signal to the E-Plug module. For supplied power up to 600 Vrms, the E-Plug module will be directly connected to the voltage signal. For supplied power above 600 Vrms, output from existing potential transformers (PTs) will step the voltage down to 120 Vrms prior to feeding to the E-Plug Module.

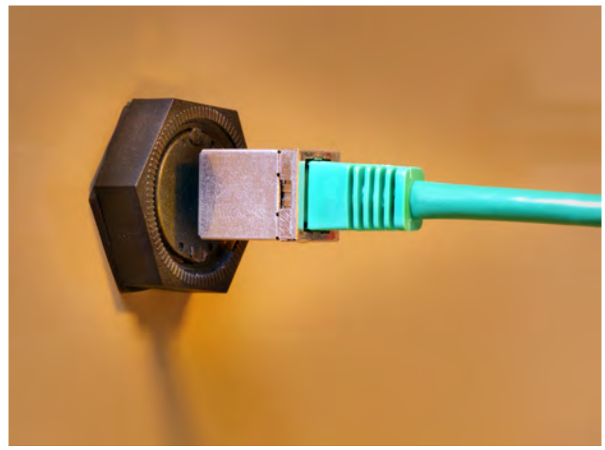
For both voltage and current measurements, the frequency response is DC to 5000 Hz, minimum.

Outputs From the E-Plug Module

The outputs from the E-Plug Module to the MCC through-door connector are 5 Vac peak for both current and voltage, limiting external voltages at the MCC door to 5 Vac peak. All outputs from the E-Plug Module provide a frequency response from DC to 5 kHz. The accuracy of all outputs is +/- 3%.



E-Plug's design contains everything you need for efficient signal transmission.



E-Plug simplifies motor analysis and enhances safety.

MotorDoc® LLC
Doing what everyone else just talks about

Contact: Charlie Stevens • Tel: 800 919-0156 x 102 (USA) • info@motordoc.com • www.motordoc.com

framatome