How Four-Channel Measurements Diagnosed a Ghost Frequency Issue

This paper describes a case study where machinery vibration data was measured and tests were performed using the AMS 2410 analyzer. Measurements were taken during steady state and shutdown of multiple machines.

Measurement and analysis was complete in hours rather than days. Efficiency and comprehensive analysis enabled the technicians to see a problem: a ghost frequency. The key was the AMS 2140 4-channel collection capability with a tachometer available simultaneously on a separate channel.

Technicians completed the tests and make plans to resolve the ghostfrequency issue.

Overview

Testing for and diagnosing machinery vibration often requires hours of technician time. To obtain a single vibration measurement, the process can involve attaching and reattaching sensors in sequence to a machine and configuring multiple sensor sites. In some cases, testing cannot be completed in the allotted time, and an existing problem might not be found.

Illustration 1. AMS 2140 Machinery Health Analyzer.

The portable AMS 2140 vibration analyzer (illustration 1) — with four channels and a tach pulse — significantly shortens the time required to measure, test, and diagnose machinery health.

This white paper describes a case study in which machinery vibration data was measured and tests were performed using the analyzer. Measurements were taken during steady state and shutdown of multiple machines.

In a matter of minutes rather than hours, the tests brought attention to a machine problem — a ghost frequency. The AMS 2140 enabled technicians to easily test the machinery and make plans to resolve the ghost-frequency issue.

Machinery Application

Vibration analysis tests were performed on four compressors that increased gas pressure for a pipeline distribution network stretching across thousands of miles.

As shown in illustration 2, each of the four machines included a frequency-driven 6300 kW motor (nominal speed 1800 RPM), a one-stage gearbox that converted the speed of motor to the higher speed, and a one-stage centrifugal compressor (nominal speed 12535 RPM).

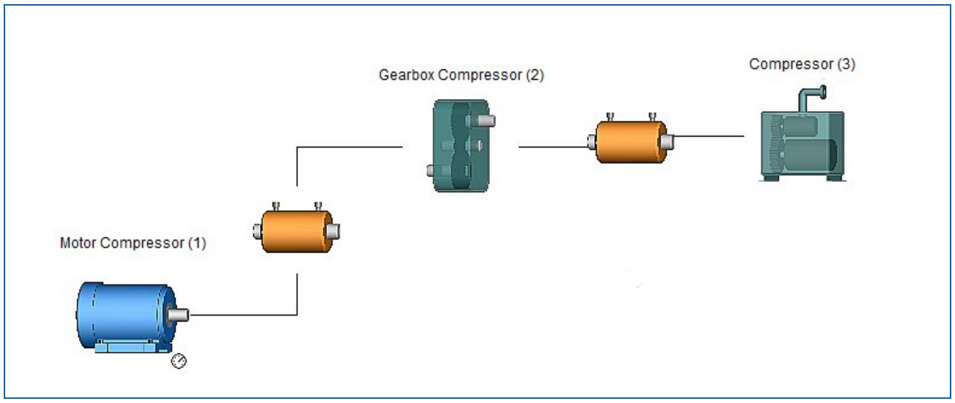

Illustration 2. A gearbox operated between the motor and compressor.

Displacement, thrust, and speed probes were installed on each machine (motor, gearbox, and compressor) to measure the radial and axial displacement and the speed of the shaft.

The four machines also included a protection system with buffered outputs.

Analysis Requirements

To diagnose potential machinery issues before full start-up of the lines, steady-state and transient shutdown measurements were taken.

Steady-state measurements are collected when a machine is in normal and stable working conditions. Those measurements are done to analyze the health of a machine during its normal operation.

Transient vibration tests are performed while a machine is starting up or stopping. These measurement data enable an understanding of machinery issues that steady-state analysis cannot provide, such as detecting resonance frequencies.

Having transient data in this particular study was key because the equipment was new. To assist with future operating reliability, the company needed a baseline of vibration data.

The key requirement of effective transient testing is the simultaneous measurement of multiple sensors and speed. Only when sensors and speed measurements are taken at the same time can plots such as orbit or polar be analyzed and used to determine an array of machinery problems including poor alignment or resonance frequencies.

Quick and Easy Test Configuration

Before measurements and tests could be run, technicians had to configure hardware and software.

Some analyzers can take a long time to configure before data collection can begin for a single vibration measurement. Using the AMS 2140, however, technicians set up the data collection in one minute.

Using the first of four configuration screens, the technician specified the frequency range, sample time, and inputs (illustration 3).

In this study, the frequency range was 2000 Hz. The raw waveform was measured for 12 minutes (720 seconds) from four displacement probes — shown on the screen as four inputs: A, B, C, and D.

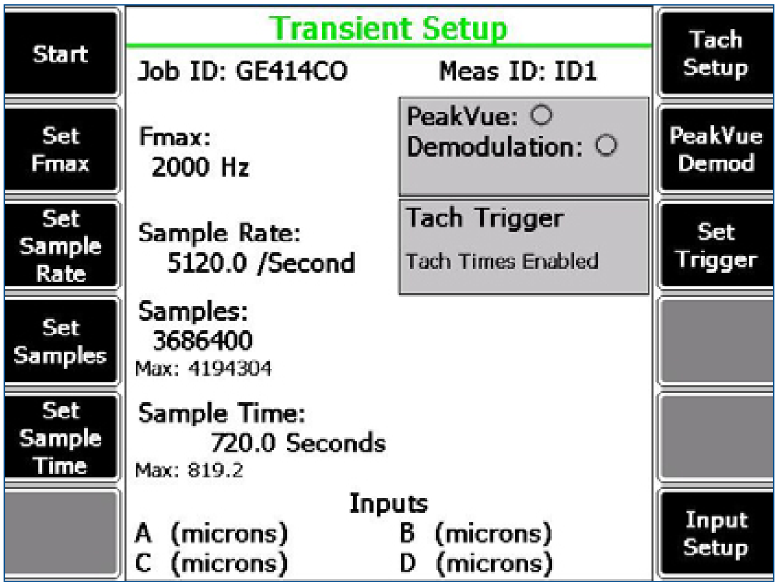

Illustration 3. The first of four measurement-configuration screens.

Because a separate speed-pulse channel is available on the AMS 2140, the technician configured tachometer settings (illustration 4).

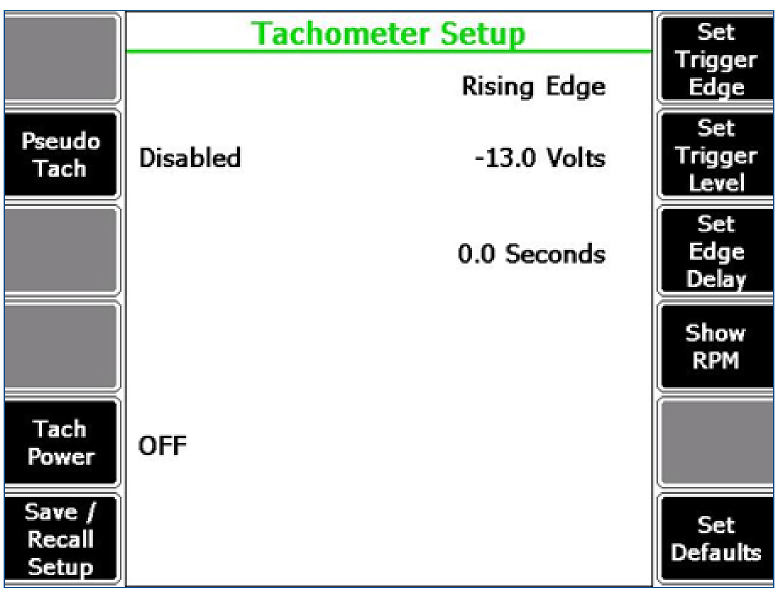

Illustration 4. A tachometer as the fifth channel.

Magnetic pickup probes (speed probes) do not require power to perform measurements, so tachometer power was deactivated. Normally the trigger value is a negative value; here it was -13V.

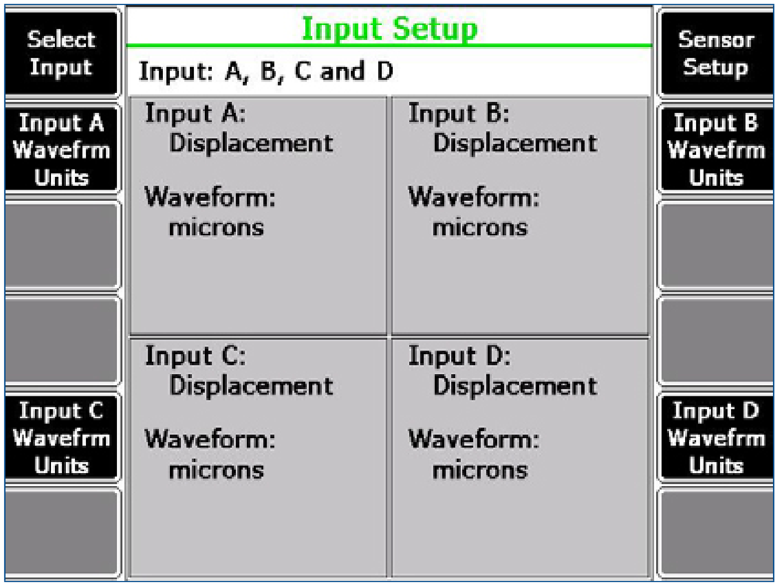

Illustration 5. Review the sensor input parameters.

During set up, the technician specified that the four inputs were displacement probes (illustration 5). In the final screen (illustration 6), the technician verified the sensitivity and the sensor power (OFF in this case).

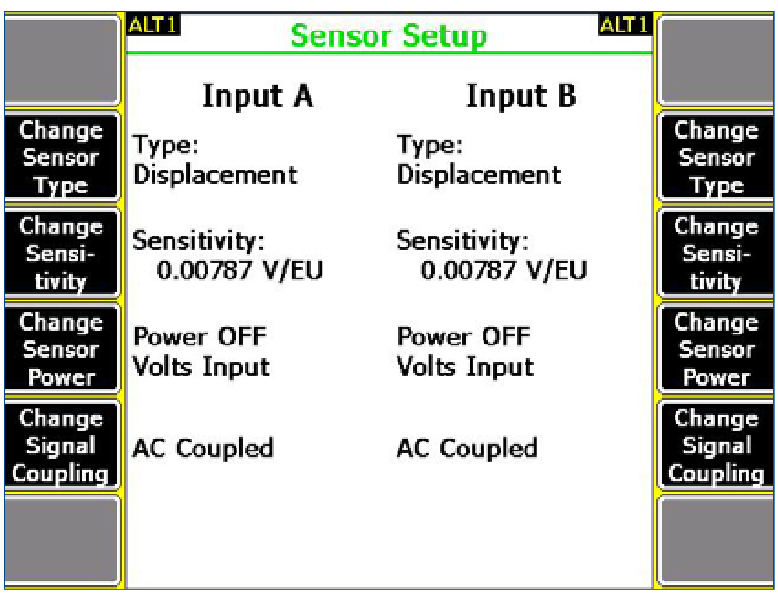

Illustration 6. Verify the configuration of sensor inputs.

Steady-state and shutdown testing were performed on all four machines. For each configuration, set up time was approximately one minute.

Early Detailed Plots Show Issues

At the compressor measurement site, the technician took steady-state measurements— simultaneously — for all four displacement-probe inputs and the speed input. This was accomplished with a single button push.

For each of the input points, the technician viewed the following two screens (illustrations 7 and 8).

The technician could choose to view the spectrum (top section of the screen) for any moment of the test, selected by placing the orange line on the waveform (bottom section of the screen).

As shown in illustration 7, the technician placed the orange line at approximately 47 seconds. He found the running speed frequency of the machine (210 Hz) and a ghost frequency (1900 Hz). Although not shown in the illustrations, the running speed frequency and the ghost frequency both appear at all times throughout the test.

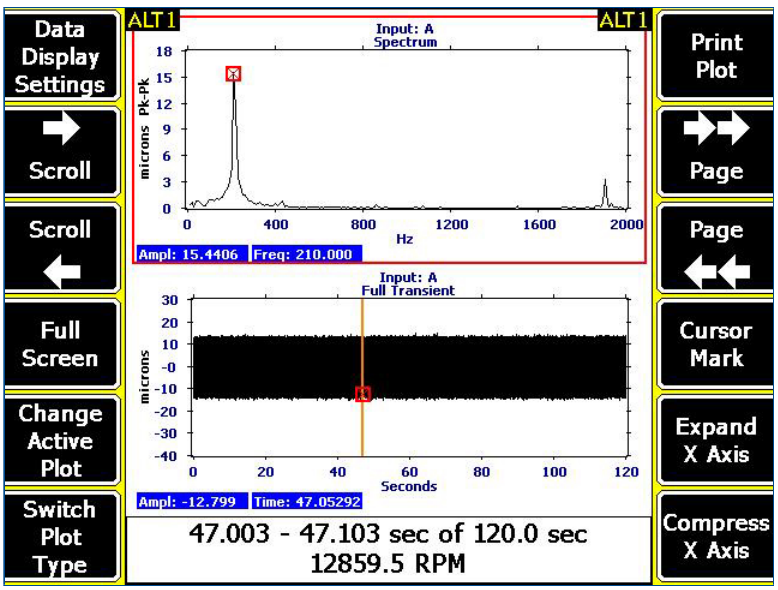

Illustration 7. Transient signal and spectrum for displacement probe A (channel 1).

Illustration 8 shows details for the channel data at the point of the orange line on the timeline, including the detailed spectrum and a detailed waveform.

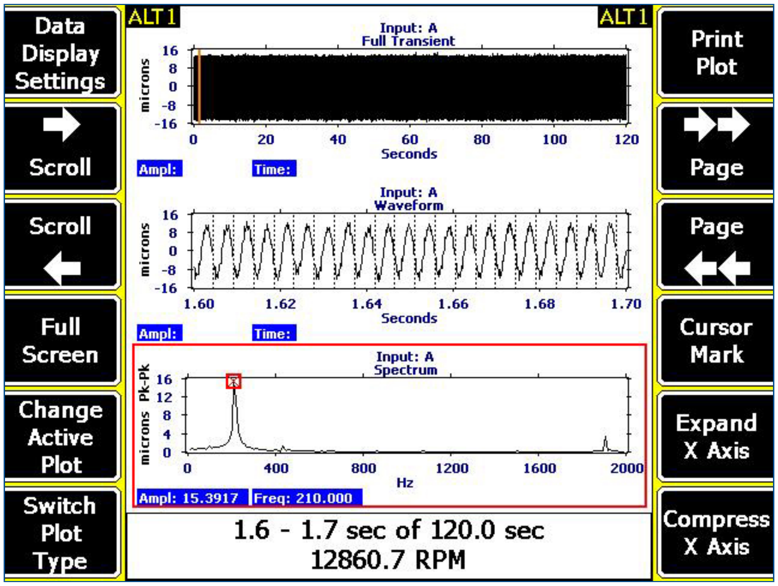

Illustration 8. Transient signal, waveform, and spectrum details for probe A (channel 1).

To identify instabilities or other conditions that could lead to machinery damage, the technician chose to view simultaneous dual-orbit plots of channels A and B and channels C and D (illustration 9).

Because the tach pulse (speed data) is gathered at the same time as the two radial measurements from each sleeve bearing, the technician had the option to view these two orbit plots simultaneously.

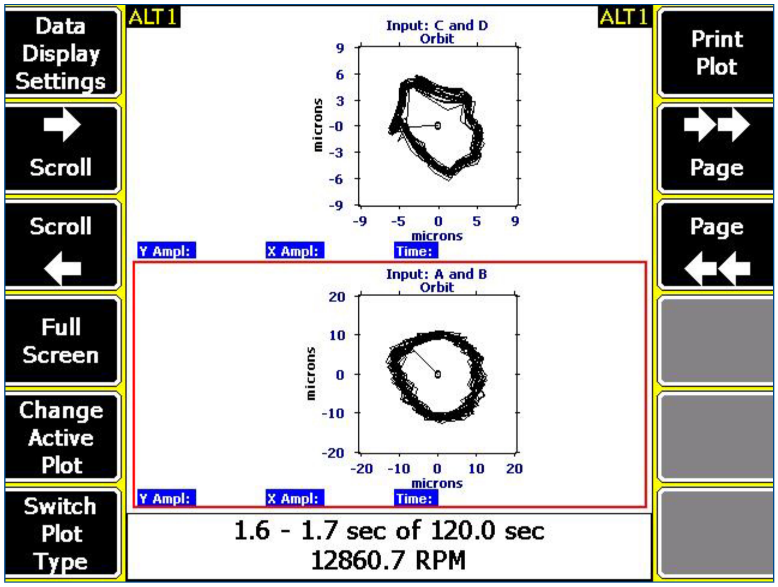

Illustration 9. A tach-pulse channel — independent of the main four channels — enables users to analyze speed related to vibration and see filtered orbit plots simultaneously for all inputs.

Focus on Analysis and Solutions Rather than Measurement

After the steady-state measurements and analysis were performed, coast-down measurements were taken between the time the machine was shut off and the time it actually stopped.

Illustration 10 shows the coast-down on all four channels on a single machine over ten minutes. The plots show the machine coasting down to zero speed.

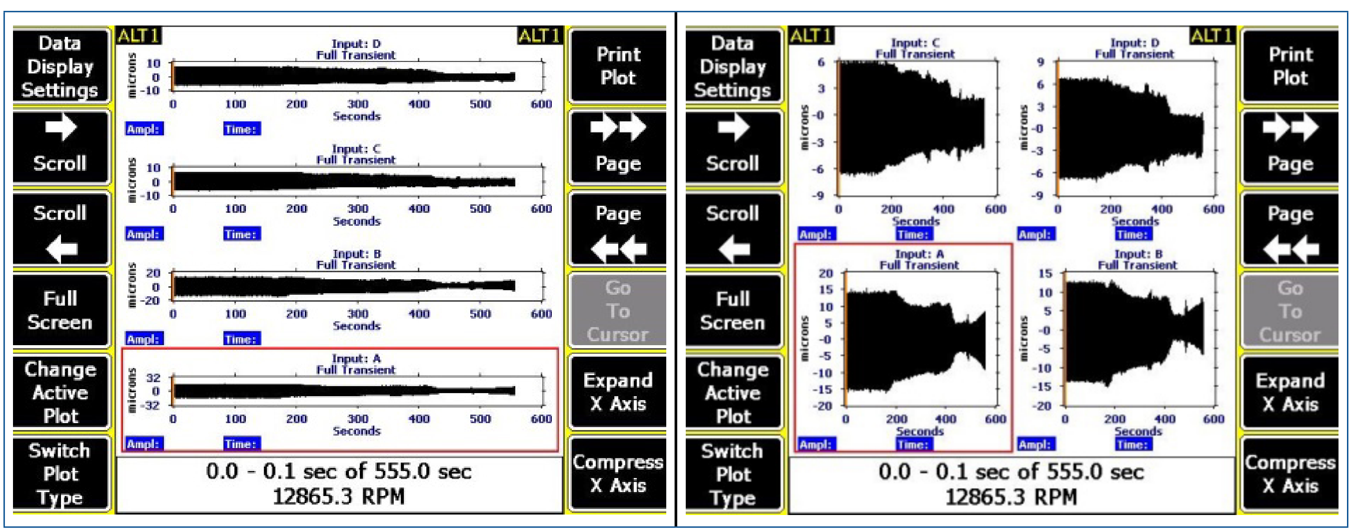

Illustration 10. Coast-down measurement plots can be analyzed together because the four input measurements were taken at the same time as the tach pulse measurement.

The technician viewed the spectrum data (illustration 11) as the machine slowed down and, as expected, the imbalance frequency was lower as the machine slowed. But the ghost frequency remained consistent at 1900 Hz throughout the run out.

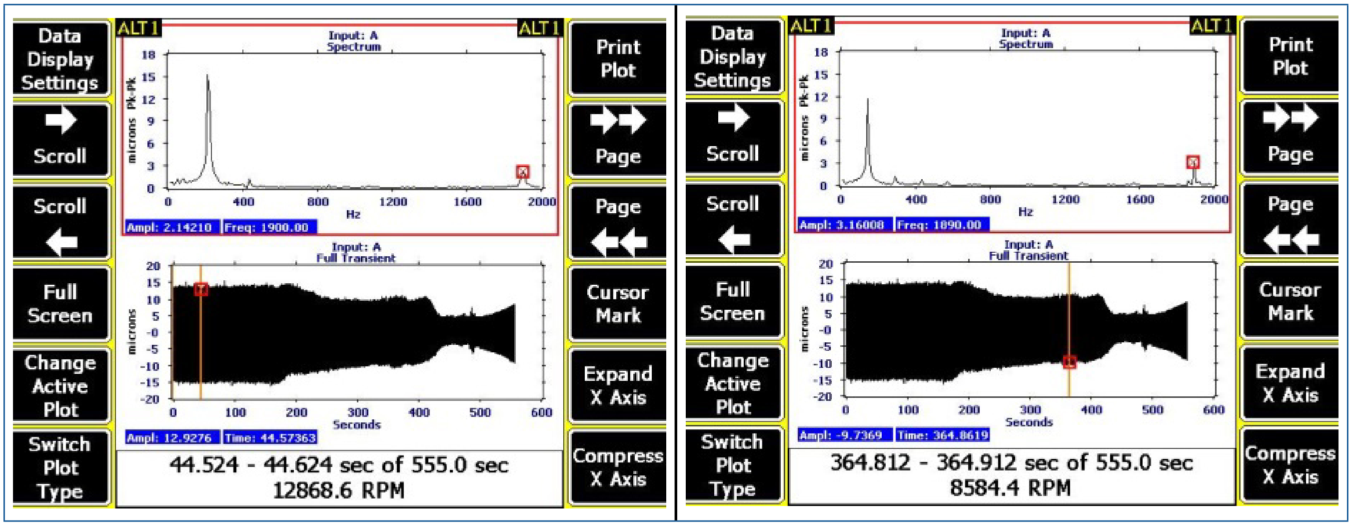

Illustration 11. Plots show that the imbalance frequency changed as the machine slowed, but the 1900 Hz remained constant throughout.

Next, the data was transferred to AMS Machinery Manager software for further analysis. The technician viewed the cascade (waterfall) plot that showed the speed of machine during coast-down. Illustration 12 shows the spectra represented in the 3D plot at the bottom of the screen.

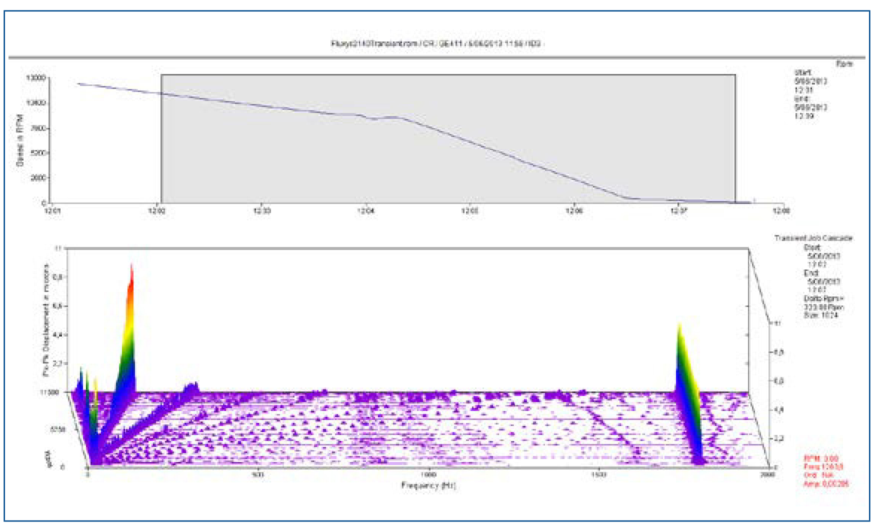

Illustration 12. Cascade plots show the ghost frequency stable as coastdown progresses. Data would not have been available if the four sensor inputs had not been measured at the same time as the tach pulse.

As shown in illustration 12, the peak for running speed frequency went from 210 Hz at turn-off time to 0 Hz when the machine stopped. But at 1900 Hz, the ghost frequency peak again remained stable throughout coast-down.

Vibration data collected with an accelerometer on the machine casing did not show the ghost frequency. All four machine lines had the ghost frequency issue, although the ghost frequency has the highest amplitude on the motors and the lowest on the compressors.

At certain points, the ghost frequency represented about fifty percent of the overall energy. The protection system was configured to trip the machines at a certain alarm level for overall energy. But since so much of the measured overall energy was due to the strange ghost frequency and not from mechanical vibration, the ghost frequency really should not be taken into consideration for protection. So, the protection system was not optimally configured.

In this situation, the ghost frequency could have caused an unwarranted machine trip and led to unnecessary costs. But because the technician was able to identify the ghost frequency in the field during testing, the team could optimize the settings on their protection system in accordance to the real world performance of their equipment.

The analyst surmised that the ghost frequency had nothing to do with the mechanical vibration of the machines. Further analysis (not detailed here) was performed using AMS Machinery Manager.

Future plans to solve the issue include:

- Check the protection system and installation for the frequency driven motor
- Find the source of the 1900 Hz
- Reduce the frequency range so that the 1900 Hz peak is not part of the protection system
- Perform further analysis
- Improve grounding and shielding for cables

Streamlined Analysis Avoided Shutdown

Throughout this case study, the AMS 2140 simplified and streamlined test configuration, field measurements, and plot analyses. In fact, some testing and analysis completed in this study would have been omitted, in many cases, due to time required.

Ease of measurements – Without the ease of use and four channel capability of the AMS 2140, time might have been spent measuring rather than designing additional tests and analysis to determine the source of the ghost frequency.

Depth of data – Some of the analysis would not have been possible without the tach pulse input that was simultaneously gathered with data from the four sensor inputs.

Rich analysis tools – The side-by-side plotting and the ability to select the points for further analysis made the AMS 2140 an invaluable tool in assessing the risk of the ghost vibration.

Currently, the results of the test plots are still under analysis to determine the source of the ghost frequency.

Emerson
Reliability Solutions
835 Innovation Drive
Knoxville, TN 37932 USA
+1 865 675 2400

www.emerson.com/ams