

Applications Note

Bently Nevada* Asset Condition Monitoring



Connecting SCOUT to Continuous Monitoring Systems

The most effective installations of continuous monitoring instruments – such as the 3500 system – include integration with the System 1* Condition Monitoring (CM) Platform. However, monitoring systems are sometimes used in a “stand-alone” installation, without the benefits of a CM platform. With such an application, the monitor system provides continuous automatic shutdown protection for the monitored assets, but it does not store data for use in condition monitoring and diagnostic evaluations.

One way to increase the CM capabilities of a stand-alone monitor system is to collect periodic samples from the buffered outputs as part of an existing “walk-around” program. Historical data from the monitor system is then available for long-term trending and diagnostics.

This document provides guidance on how to incorporate the collection of vibration data from an online monitoring system with a condition monitoring program enabled by SCOUT portable devices and Ascent software.

Plant Assets and Monitoring Philosophies

The typical industrial plant consists of a diverse range of assets that combine to provide a service such as the generation of electricity or production of petroleum based products. Maintenance and operational philosophies are generally established based on the criticality of the individual assets and their role in the given system. At a high level, assets fall into three categories; “continuously monitored”, “periodically monitored” and “unmonitored”.

Continuously Monitored Assets

- ✓ Critical assets customarily have continuous monitoring systems that provide the operations team with real time information about the asset’s condition. These systems can include automatic shutdown and are the focus of this document.

Periodically Monitored Assets

- ✓ The majority of plant assets fall into this category. Monitoring can range from simple indicators (gauges, LEDs, visual etc...) next to the machine that are periodically reviewed by operations, to a full CM program with a portable data collector (PDC).

Unmonitored Assets

- ✓ Monitoring and/or CM are not practical due to low criticality (cost, spare capacity etc...)

Condition Monitoring Overview

CM involves trending and alarming on important parameters that provide clues about the operating condition of an asset over time. Examples of such parameters are vibration, bearing temperature, process flow, or thermodynamic efficiency to name a few.

The goal of this strategy is to enable intelligent planning for asset maintenance based on conditional information, as opposed to reactively solving problems when they arise or applying premature maintenance to assets that could have continued to operate without consequence.

Well-organized CM programs can reduce maintenance costs and improve plant reliability

CM Platform Recommendations

System 1 for Continuously Monitored Assets

- ✓ Bently Nevada’s System 1 software platform represents the CM solution for continuously monitored machinery. Vibration data provided by Bently monitoring systems can be combined with process information to provide real time asset health analysis with long term trending, alarming and analytical capabilities.



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What to do when an online monitoring system like 3500 has not been connected to System 1

- ✓ GE's Bently Nevada Ascent* software combined with a SCOUT* series data analyzer can be configured to collect periodic data from these systems. This will enable basic condition monitoring for the critical asset.

Step 1: Understand the system

For optimal SCOUT configuration, consider the questions below prior to configuration:

- ✓ Is the monitoring system configured to automatically trip the machine, if so what conditions will cause a trip?
- ✓ What application is the monitor configured for? (Radial Vibration, Acceleration, Thrust etc...)
- ✓ How is the monitor configured? (Variables, filters, set points etc...)

Step 2: Measurement Choices

Useful measurements supported by SCOUT instrumentation:

- ✓ **Dynamic (Waveform) Data**
 - Asynchronous [No Tach] and Synchronous [Tach] Sampling
 - Spectrum (Spec)
 - Overall [rms]
 - Spectral Bands [0.5X, 1X, Blade Pass etc...]
 - Waveform (Wfm)
 - Waveform True Pk-Pk
 - Crest Factor
 - Orbit Plots [Dual Channel Required]
 - Dynamic motion of the shaft centerline within bearing clearance
- ✓ **Average Value Recording**
 - Gap Voltage for Proximity Probes
 - Monitor position of shaft within bearing clearance
 - Monitor Sensor Health

- Thrust Position
 - Monitor the axial position of the shaft
- Bias Voltage for applicable Acceleration and Velocity Probes
 - Monitor Sensor Health

- ✓ **Coast-down/Run-up**

- Bode plot analysis, identify and analyze resonant frequencies (rotor and structural)

- ✓ **Balancing**

- Single and Multi-Plane

Step 3: Example Configuration

The subsequent example describes how to configure dual-channel synchronous measurements with gap voltage for radial vibration applications. Configuration is performed in Ascent* software and then downloaded to SCOUT instrumentation. Modifications can be made if single channel collection or asynchronous waveforms are preferred.

The same methodology can be used to configure measurements for acceleration or velocity data. Gap voltage will be replaced with Bias Voltage for applicable sensors.

Ascent* Software Configuration

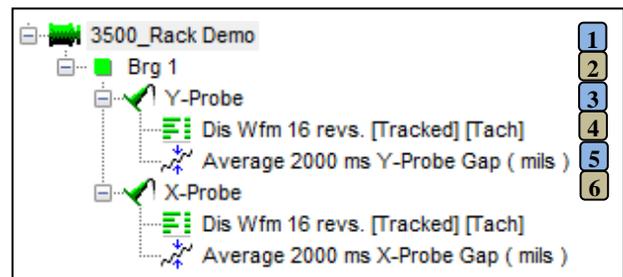


Figure 1: Ascent "Data Folder" Configuration

Data Folder Configuration Steps (Figure 1):

1. Configure a "New Machine" for the asset. Set "Default Speed".
2. Create new "Point" for the bearing location.
3. Create "Measurement Location" for the sensor. Example shown has custom locations, "Y-Probe" and "X-Probe". Do this by clicking "Add

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New in the **“Add Measurement Location”** dialog box.

4. Configure **“Schedule Entry”** [Waveform/Spectrum]. See **Figure 2**.
5. Configure **Average Value “Schedule Entry”** for the gap voltage measurement. See **Figure 4**.
6. Copy/Paste bearing configuration required number of times. Create **Route** for the newly created machine upon completion.

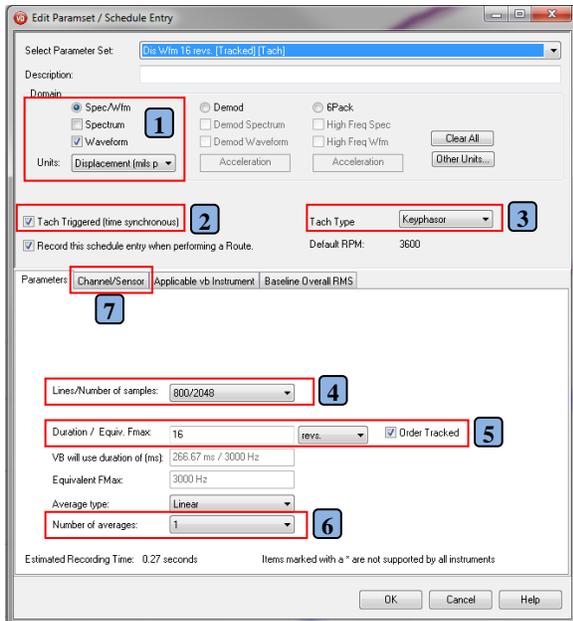


Figure 2: “Schedule Entry” Configuration

Wfm/Spec Configuration Steps (Figure 2):

Waveforms and spectra also referred to as dynamic data provide the backbone of the analysis and CM capabilities within Ascent. Trended variables such as Waveform True Pk-Pk, Overall (O/All) Energy and Spectral Bands are derived from dynamic data.

1. Select data type: spectrum, waveform, or both, and desired units. This example demonstrates a radial vibration configuration.
2. If synchronous data is desired, check **“Tach Triggered”** box.
3. Select appropriate **“Tach Type”** for application.
4. Select sample resolution.
5. Select number of shaft revolutions desired and check **“Order Tracked”** box so that true synchronous sampling is enabled. Example

shown will collect 128 samples per shaft revolution [2048 samples / 16 revolutions]

6. Averaging is not typical for displacement measurements so set **“Number of Averages”** to 1. This results in NO AVERAGING.
7. Configure **“Channel/Sensor”**, see **Figure 3**.

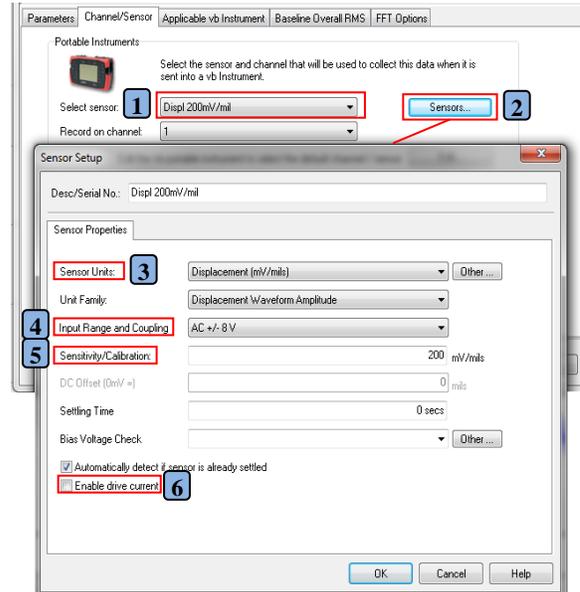


Figure 3: Displacement Transducer Configuration

AC-Coupled Sensor Configuration (Figure 3):

1. Select appropriate **Sensor**.
2. To add or edit existing sensor properties, select **“Sensors”**.

Sensor Setup Dialog Box:

3. Select appropriate **“Sensor Units”**
4. Select **“Input Range and Coupling”** for sensor type. Recommend **AC +/- 8V** for most applications.
 - Removes DC component [Gap or Bias Voltage] so that time waveform can be centered around zero engineering units on Y-Axis
5. Enter sensor **“Sensitivity/Calibration”**
6. Ensure that **“Enable drive current”** checkbox is **NOT** selected. Click **Ok**, sensor is configured.

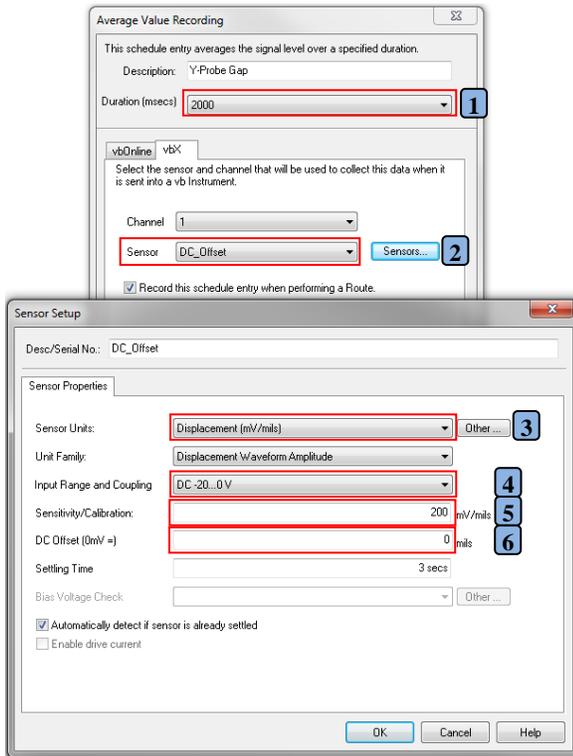


Figure 4: Gap Voltage and Thrust Position Measurement Configuration

Gap Voltage Configuration Steps (Figure 4):

Trending the “Gap Voltage” for proximity probes monitoring radial vibration is highly recommended. This important parameter represents the DC component of the proximity probe signal and provides information about the position of the shaft centerline within a journal bearing and the health of the sensor itself.

Valuable parameter for CM, as certain conditions can cause the position of a shaft to change within its bearing housing without causing a noticeable change to the radial vibration which is why trending and alarming on gap voltage is very useful.

For radial vibration measurements, the trended value will be in units of displacement (monitor readings are provided in units of voltage). To produce the DC component of the transducer signal, an average value is calculated from a DC-Coupled waveform.

1. Configure **Duration (msec)** over which average value is to be calculated. 2000 ms worked well in the example shown.

2. Select sensor. Sensor output must NOT be AC-Coupled. Select **Sensors** button to add or edit a sensor configuration.

Sensor Setup Dialog Box:

3. Select **Sensor Units**
4. Select appropriate DC-Coupled **Input Range and Coupling** for the given sensor. Typically Bently Nevada probes are powered by negative voltage so select **DC -20...0V**.
5. Select **Sensitivity/Calibration** for sensor. Ignore the warning about negative sensitivity for the sensor Click **Okay**, sensor is configured.
6. Select 0 for DC Offset

Thrust Position Configuration Steps (Figure 4):

Machines that experience axial loading during operation (Steam Turbine, Pump, Compressor etc...) have thrust bearings designed to constrain the axial motion of the shaft. Proximity probes measure the axial position of the shaft relative to their installed position which can be on the thrust bearing viewing the thrust collar or if this is not feasible a position very close to the thrust bearing viewing an exposed section of shaft.

Collecting thrust position from a monitor is very similar to that of gap voltage; with a few extra steps required to ensure that the SCOUT measurement matches that of the monitor. Start by configuring a new **Average Value Schedule Entry** for the thrust position measurement and then refer to Figure 4 and follow the steps below:

1. Set **Duration (msec)** to 2000 ms
2. A new sensor will likely have to be created for each thrust position application within the database because the **DC Offset (0mV=)** is unique for each application and dictated by the monitor configuration.
3. Select **Sensor Units**
4. Select **Input Range and Coupling** to **DC -20...0V**.
5. Select **Sensitivity/Calibration** for sensor. Must be (+) for applications where the “Normal Thrust Direction” is “Toward Probe” and (-) when “Away From Probe”. This information is contained in the monitor configuration.
6. Set the **DC Offset (0mV =)** to the configured “Zero Position (Direct)” configured in the monitor. This value must be (+) for applications

where the "Normal Thrust Direction" is "Toward Probe" and (-) when "Away From Probe". The **DC Offset (0mV=)** entry must be in units of displacement, refer to the example provided below:

Thrust Example:

A 3500 monitor has been configured to measure thrust position with a 3300-8mm Proximitor. The "Normal Thrust Direction" is set to "Toward Probe" and the "Zero Position (Direct)" is set to -10.0V, see Figure 5 which shows the 3500 rack configuration software dialog box.

1. Sensor sensitivity will be **(+) 200mV/mil** because the 3500 configuration is configured with *Normal Thrust Direction* to *Toward Probe* for a 3300-8mm Proximitor
2. *Zero Position (Direct)* is equal to -10.0 V. Ascent requires this information converted to displacement units, which can be done because the sensitivity of the Proximitor is known.

$$200\text{mV/mil} = 0.2 \text{ V/mil} = 5 \text{ mil/V}$$

$$-10.0 \text{ V} * 5 \text{ mil/V} = -50 \text{ mils}$$

So now that the *Zero Position (Direct)* value has been converted to displacement this value should be entered into Ascent as **(+) 50 mils** because "Normal Thrust Direct" is configured as "Toward Probe"

**If the monitor had been configured with "Normal Thrust Direction" set to "Away From Probe" Sensor Sensitivity and DC Offset (0mV =) would have been set (-)

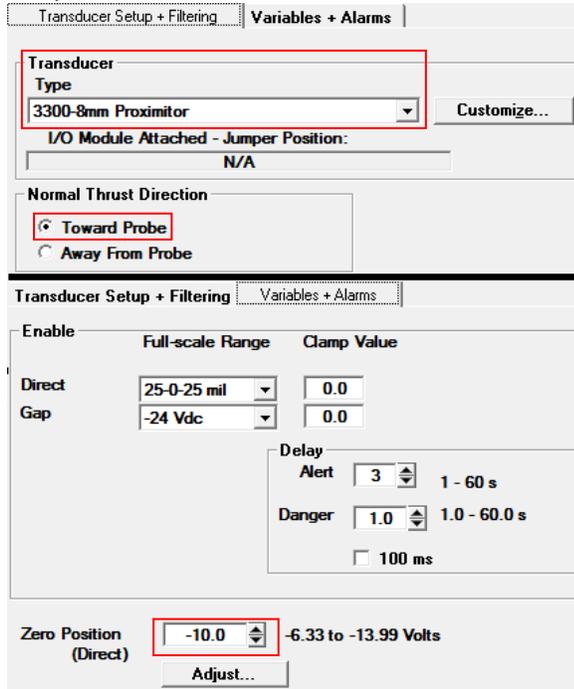


Figure 5: 3500 Rack Configuration for Thrust Position

Configuring the SCOUT PDC for Dual Channel Recordings

Now that the software has been configured and the route has been downloaded to the PDC, the instrument must be configured to take dual channel readings (only required when dual channel data collection is needed). See Figure 6.

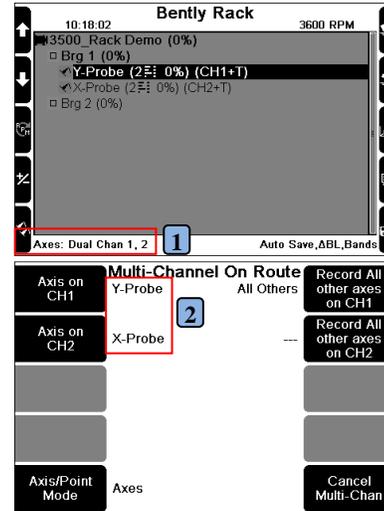


Figure 6: Instrument Configuration

Configuring SCOUT for dual channel collection (Figure 6):

1. Enter the **Route** that was configured in the previous steps. Select "**Axes**", Button 5 on the instrument.
2. Map the desired axes in the appropriate channel locations. Device is now configured to take dual channel readings.

Step 4: Alarm Considerations

Now that the basic configuration has been completed, it is time to establish alarms on key parameters. Alarms are the key to an effective CM program because they provide the trigger for investigation. Time is a precious commodity for the rotating equipment engineer commonly in charge of hundreds of assets, it is therefore essential that their focus be directed to the assets experiencing problems that have the potential to negatively affect the business operation.

Where to Start?

The data being collected is from an online monitoring system which will typically be programmed with alarm set points on critical parameters based on OEM guidelines, common standards or end user requirements. These set points represent a great starting point when first applying alarms to the applicable parameters; however caution must be taken to ensure that a fair comparison can be made.

Protection Systems vs. Data Analyzers

Protection systems like 3500 series monitors serve a different purpose than data analyzers like SCOUT or ADRE and as such discrepancies in readings can arise. Refer to the following *Orbit* articles for an in depth look into how readings are calculated by common instruments.

Orbit [Vol.25 No.2 2005], Page 18

["Understanding Discrepancies in Vibration Amplitude Readings Between Different Instruments, Part 1 of 2"](#)

Orbit [Vol.26 No.1 2006], Page 40

["Understanding Discrepancies in Vibration Readings Between Different Instruments, Part 2 of 2"](#)

What Parameters Should Have Alarms?

Condition monitoring platforms like Ascent and System 1* provide a wide range of alarming capabilities for trended parameters. It is helpful to configure parameters and alarms based on the machine being monitored and its failure modes.

A minimal set of recommended parameters that should be configured and have alarms is provided, see Table 1. Alarm bands are created by right clicking on the **Schedule Entry** of interest and selecting **New>Alarm Band**. See Figure 7.

Table 1: Trended Parameters by Application

Application	Trended Parameters In Ascent SW		
	Waveform True Pk-Pk	O/All Power (RMS)	Average Value Recording
Radial Vibration	X		Gap Voltage
Thrust ¹	X		Position
Acceleration ²	X	X	Bias Voltage
Velocity ²	X	X	Bias Voltage

1. Thrust position alarms will be for the Average Value Recording. Monitoring the dynamic portion "True Pk-Pk" is also valuable however this parameter is not calculated by the monitor, review trend and set alarms accordingly.
2. **Monitor Sub Units = Pk**
Alarm levels should be configured on the Waveform True Pk-Pk value for the waveform **schedule entry** of interest. Monitor produces readings in pk so the set points must be multiplied by 2 in Ascent.

Monitor Sub Units = RMS

Alarm levels should be configured on the O/All Power (RMS) level for the waveform/spectrum **schedule entry** of interest.

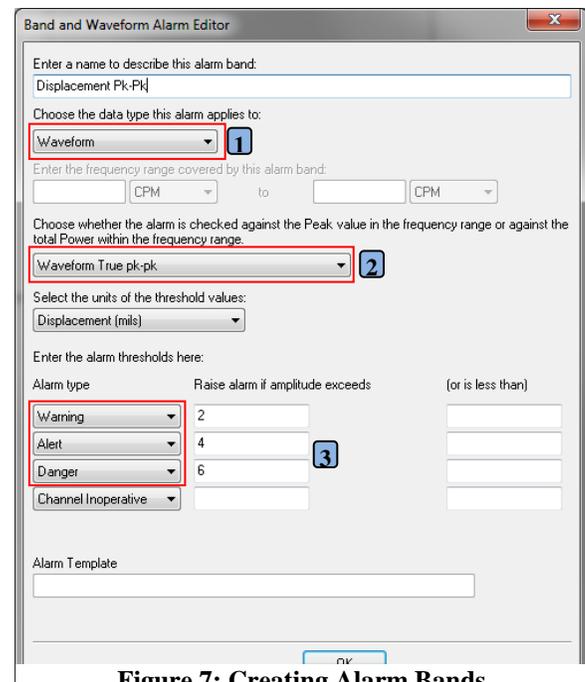


Figure 7: Creating Alarm Bands

Configuring Alarm Bands in Ascent (Figure 7):

1. Choose the data type that the alarm band will apply too. Example shown is for a Waveform
2. Choose the desired type of alarm band. Example shown is for a Waveform True pk-pk value that will be applied to a displacement waveform **schedule entry**. If a Power level (rms) is desired for a velocity or acceleration measurement, select accordingly.
3. Choose alarm thresholds. If monitor set points are known, it is helpful to add these as “Alert” and “Danger and then configure a third “Warning” or management alarm if the trended data is far below the monitor set points.

Initially the parameter sets may be limited to “overall or Pk-Pk” values, however as the CM program evolves it can be advantageous to establish fault specific alarm bands based on the knowledge gained from the historical data.

“Management” Alarms

It is not uncommon for the trended parameter’s amplitude to be far lower than the monitor alarm levels so it is useful to add an additional “management” alarm in order to catch smaller changes in the measured parameter, see trend plot in Figure 8. Create trend plots by selecting desired alarm band or trended parameter and pressing F4 on the keyboard. Management below the Alert and Danger set points will help expose issues prior to serious machine problems or trips.

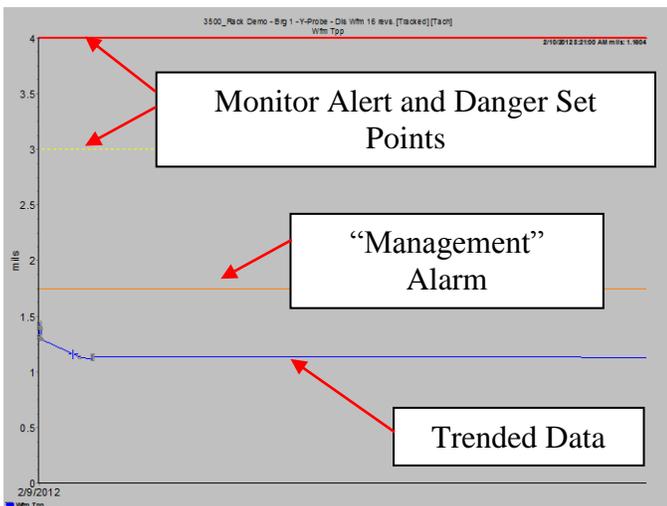


Figure 8: Waveform Pk-Pk Alarm Set Points

Step 5: Viewing Data

Waveform/Spectrum Plot

To display a waveform and spectrum plot in Ascent highlight desired **Schedule Entry** in the folder hierarchy and then select **Chart>SpecWfm**. Note, if a spectrum was not stored as part of the data collection, the SW can perform the FFT, in this case select **Chart>WaveformFFT**. Spectrum and waveform plots can be generated separately by using hot keys F2 and F3 respectively.

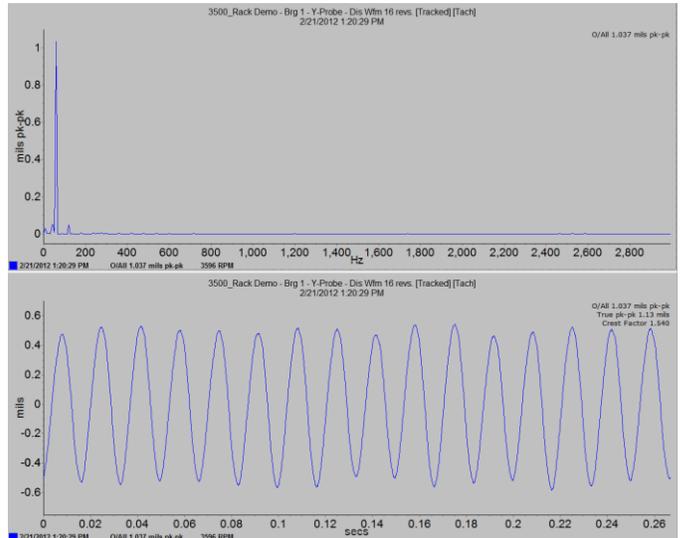


Figure 9: Spectrum Waveform Plot Orbit Plot

To display an Orbit plot in Ascent, highlight the appropriate **Schedule Entry** in the folder hierarchy and then select **Charts>Orbit**, or press Shift+y on the keyboard.

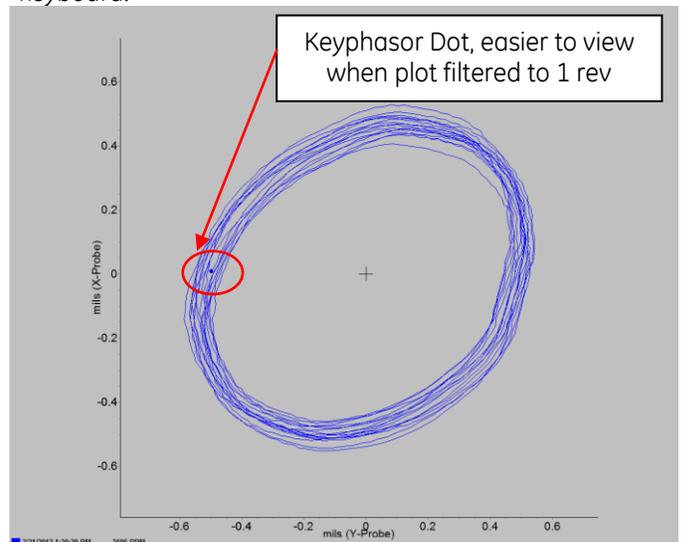


Figure 10: Orbit Plot for X-Y Displacement Probe Pair

Comparing SCOUT data with 3500 Readings

The data depicted in Figure 11 shows a comparison between the Direct readings for an acceleration measurement from a 3500 monitor and a buffered output reading collected by SCOUT from the monitor. For comparison, the same accelerometer signal was fed into two monitor channels so that the rms and pk acceleration could be calculated.

As can be seen in Figure 11 and Table 2, the readings compare favorably for both RMS and Pk. Remember the True Pk-Pk reading must be divided by two for a comparison to the 3500 Direct reading.

Table 2

	G's RMS	G's Pk
3500	0.29	0.93
SCOUT	0.28	0.89
% Diff	3.4	4.3

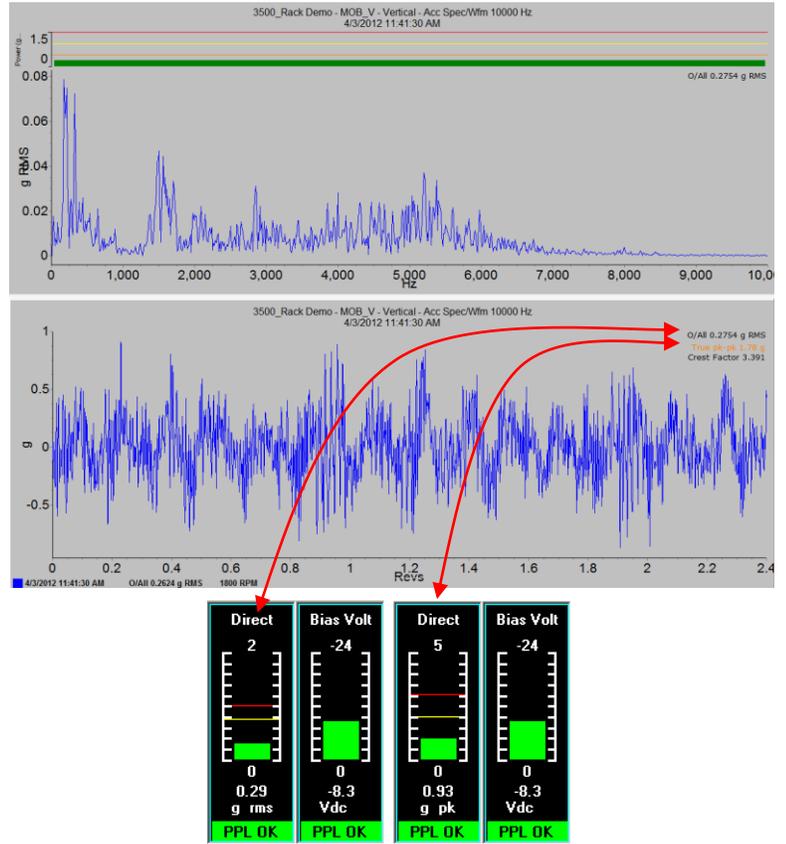


Figure 11: SCOUT and 3500 Data Comparison

Bode Plot

SCOUT instrumentation can be configured to collect "start-up"/"shut-down" data which is a very valuable tool in the field of rotor dynamics. Collecting this type of data with SCOUT will enable the Bode plot in Ascent, shown in Figure 12. This powerful plot combines amplitude and phase information and opens up the potential to identify many important characteristics about the system being investigated. Rotor and structural resonances can be identified in the Bode plot. Figure 12 displays a classic rotor balance resonance, notice the spike in amplitude and phase roll at 2350 RPM. SCOUT was used to collect this information from the buffered output of a 3500 rack monitoring radial vibration.

The **Coast-down/Run-up** measurement is configured in the SCOUT instrument (In field measurement), and requires a tachometer signal. Once collected, the data can be uploaded into the Ascent SW for review.

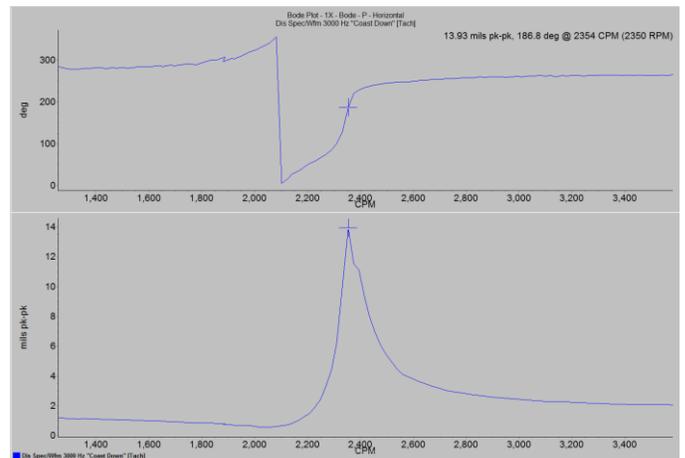


Figure 12: Bode Plot

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