VORTEX

DYNAMIC BALANCER AND VIBRATION ANALYSER



USER MANUAL V7.0

DYNEX HOBBY

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SAFETY FIRST



High speed rotors contain enough energy to cause damage to people and property. Manufacturer's safety precautions MUST be adhered to during testing and operation of devices.



Safety goggles must be worn during testing and operation of devices. High speed rotors can expel high velocity debris during an adverse event.

WARNING!

- ✓ Never stand in front of or alongside a spinning rotor. Stand behind at a safe distance.
- ✓ Ensure bystanders are well away from the test article at a safe distance.
- ✓ NEVER run a rotor at full speed when balancing. Mounting cradles are not designed to restrain running devices at operational speeds.
- ✓ Run devices at the slowest possible speeds to avoid injury.
- ✓ Do not leave loose items nearby that can be caught by a spinning rotor.
- ✓ Secure all loose cables to prevent being caught in moving parts.
- ✓ Always stop running devices before working on them.
- ✓ Never place a limb in front of a rotor to stop it or slow it down.
- ✓ Fasten devices in secure mounts when operating at full speed. Follow the manufacturer's instructions for correct device operation.
- ✓ **Strobe** light may cause seizures.
- ✓ Vortex was **not** designed for full size vehicles or industrial applications.

Before you begin

Your safety is your own responsibility, including proper use of equipment and safety gear, and determining whether you have adequate skill and experience. Improper use of modeling gear is dangerous, unless used properly and with adequate precautions, including safety gear. Some illustrative photos do not depict safety precautions or equipment, in order to show operating instructions more clearly. These products are not intended for use by children. These products are intended for radio control model applications and should never be used on industrial equipment.

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VORTEX SYSTEM OVERVIEW

Introduction

Vortex is a combined dynamic balancer and vibration analyzer for hobbyist. It is capable of balancing rotors and shaft assemblies to reduce wear and improve performance. The vortex system can operate as a stand-alone device or it can be connected to a PC for advanced analysis. This manual outlines the Vortex system and leads the operator through examples on its application.

The Vortex system consists of the following parts. The analyzer or "black box" is the central processing unit. It collects and analyses vibration signals for dynamic balancing and spectrum analysis. Vortex is connected to a PC via the "microphone" port using a 3.5mm stereo cable.

The system includes an accelerometer for measuring the acceleration levels of vibration. An infra-red detector and strobe light is also supplied for synchronizing the location of corrective weights required for balancing.



Vortex Analyzer



3.5mm Stereo Cable



Accelerometer



IR Sensor (Optional)



Strobe Light (Optional)

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SPECIFICATIONS

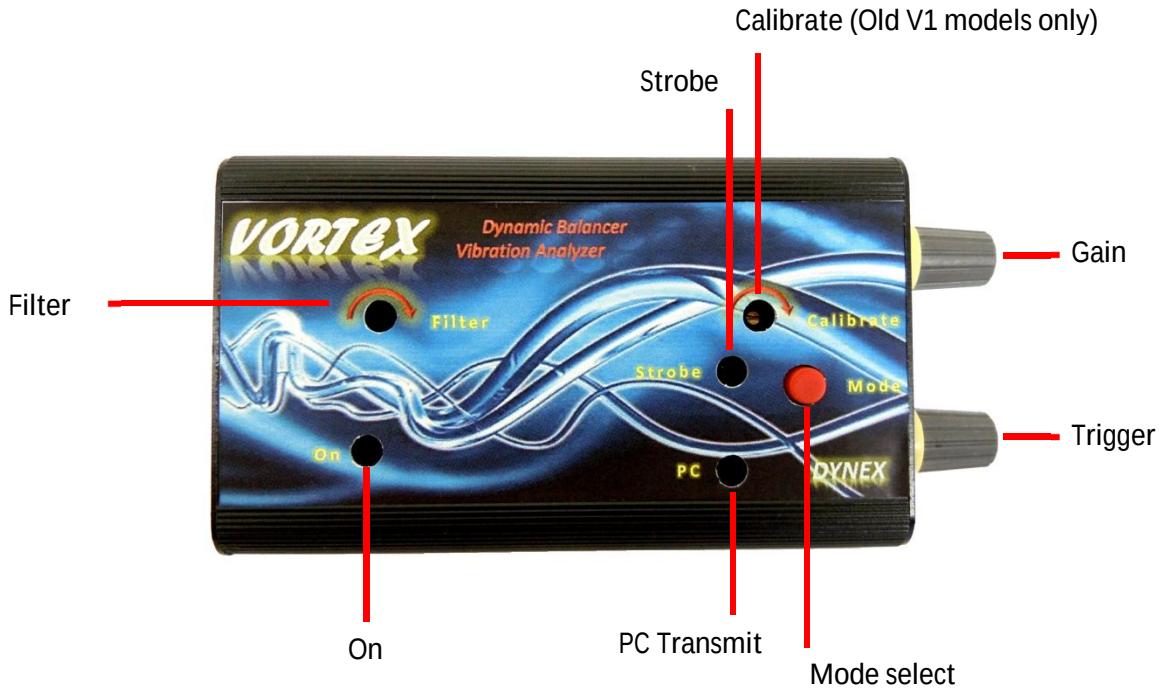
Item	Quantity
Vortex	• 9~12 VDC power supply • Anodized aluminum case • Dimensions (outer): 24mm(0.94")(H)x66mm(2.6")(W)x110mm(4.33")(L)
IR Detector	• Dimensions: 0.3" x 0.5" x 0.1" • Operating voltage: 5.0V • Supply current: 25mA • Output format: analog voltage • Optimal sensing distance: 0.125" (3 mm) • Maximum recommended sensing distance: 0.25" (6 mm)

Accelerometer (ACC1)	• Range: +/- 3g
	• Sensitivity: 300 mV/g
	• Small, low-profile package
	• 1.8 V to 3.6 V operating range
	• 10,000g shock survival
	• Excellent temperature stability
	• Output Type: Analog
	• Typical Bandwidth (kHz):
	  o 1.5kHz without capacitor
	  o 50 Hz with capacitor installed
	• Noise Density (µg/rtHz): 300

STROBE LIGHT	• Intensity 25000~35000 MCD • Viewing angle 25 degrees

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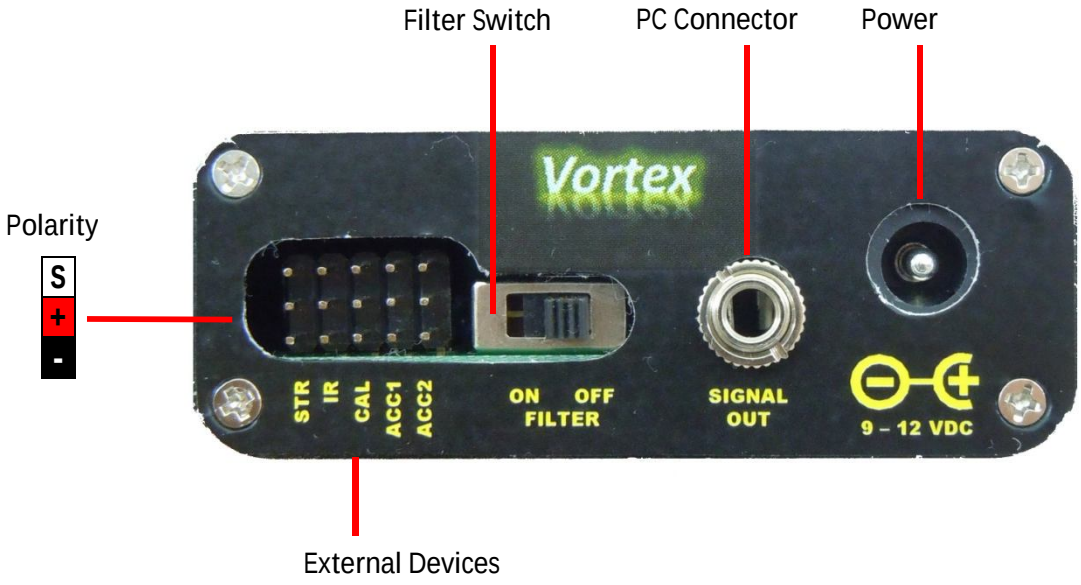
VORTEX FEATURES





Item	Function
On	Light illuminates when power is applied to Vortex
PC Transmit	Light illuminates when Vortex transmits data to PC. Activated by **mode** button.
Strobe	Light illuminates when Vortex is in Strobe Mode. Activated by **mode** button.
Calibrate	Rotate clockwise/anticlockwise to zero accelerometer
Mode Select	Press to active PC or Strobe modes. When pressed, the button remains locked. Press again to unlock mode.
Trigger	Rotate right to increase strobe sensitivity. Rotate left to decrease sensitivity.
Gain	Rotate left to increase accelerometer sensitivity. Rotate right to decrease sensitivity. *Note: Do not change gain setting between test runs.*
Filter	Rotate right to increase signal filtering. Rotate left to decrease filtering.

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Item	Function
Power	DC power supply. Recommended supply of 9 ~12 VDC. Center pin is "+"
PC Connector	Stereo cable socket. This connects to PC sound card at "microphone input"
Filter switch	Turn signal filtering on or off.
STR	Connection for LED Strobe Light
IR	Connection for infra-red reference detector
CAL	Connection for accelerometer calibration
ACC1	Connection for accelerometer "ACC1". For accelerometers that use 3V power supplies. ACC1 is supplied in the standard kit.
ACC2	Connection for accelerometer "ACC2". For accelerometers that use 5V power supplies.
Polarity	Black wire of connector always faces downward.

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CONNECTING VORTEX

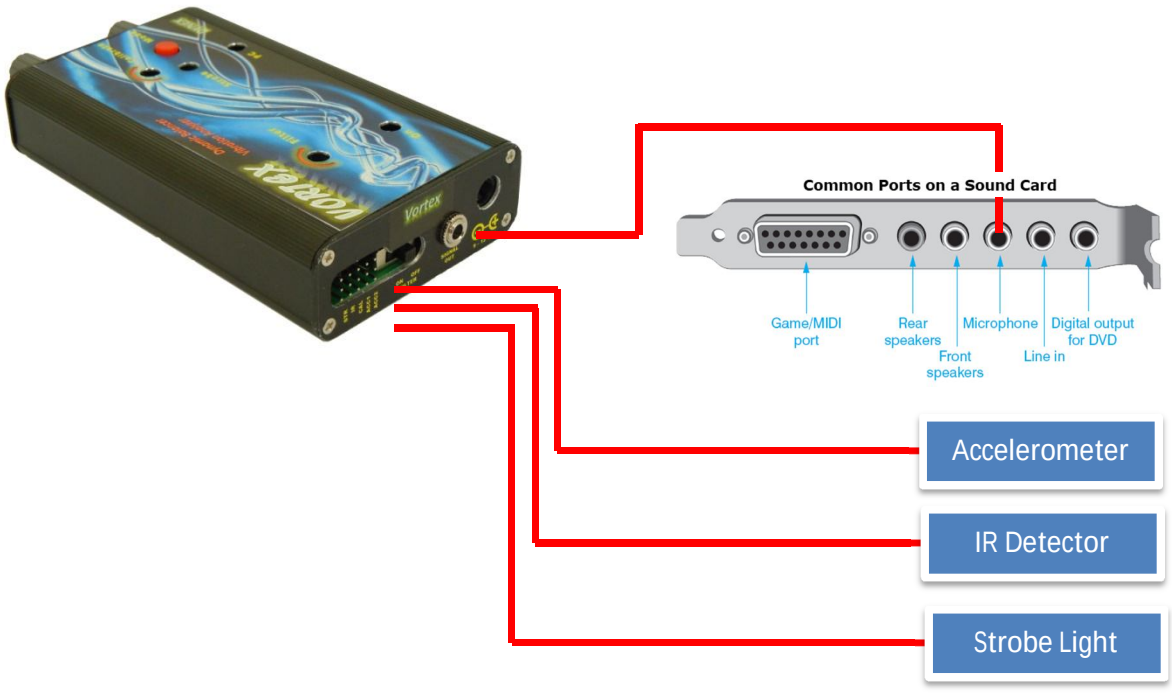
The diagram below illustrates the typical connections for the Vortex system.

STEREO CABLE: Vortex communicates to a PC via 3.5mm stereo cable which is connected to the microphone input of the PC sound card. The stereo cable can be connected at any time, however the cable must be connected when performing balancing or vibration spectrum analysis. The cable is not required for the "Strobe Balancing Method".

ACCELEROMETER: Must be connected to ACC1. Port ACC2 is not currently used. ACC2 is reserved for future development of sensors.

IR SENSOR: Must be connected to the IR port. The IR Sensor is used during balancing only. It is not required for the "Strobe Balancing Method".

STROBE LIGHT: Only required for the "Strobe Balancing Method".



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It is possible that some modern PC's do not have adequate sound cards. In absence of a sound card, DynexHobby highly recommends using the Griffin iMic. It has high resolution and provides excellent connectivity between the Vortex and your PC.

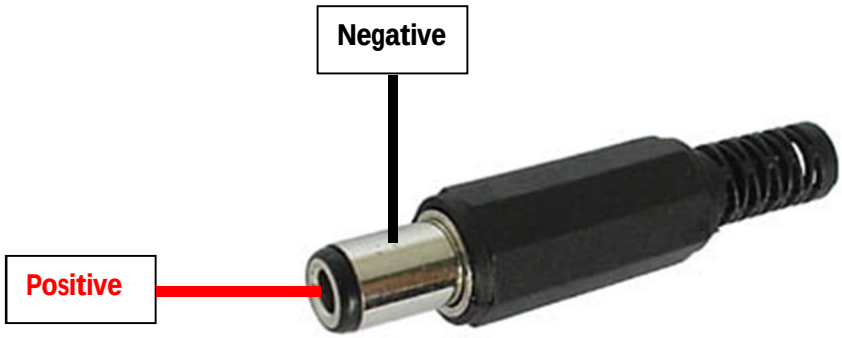


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POWERING VORTEX

Vortex is designed to be powered by a 9~12 V DC source (9VDC preferred). Do not use a mains power pack as tests have shown some packs can induce noise in the system. A battery such as a Lithium Polymer or Lithium Ion is recommended as this creates a noise free power source. Please follow manufacturer's instructions on proper handling of batteries.

DC POWER PLUG CONNECTION

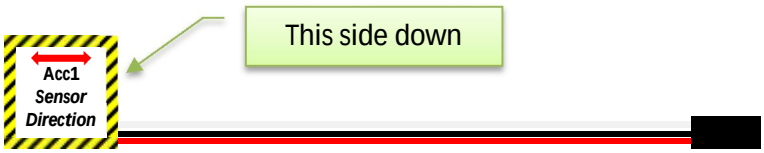


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INSTALLING THE ACCELEROMTER

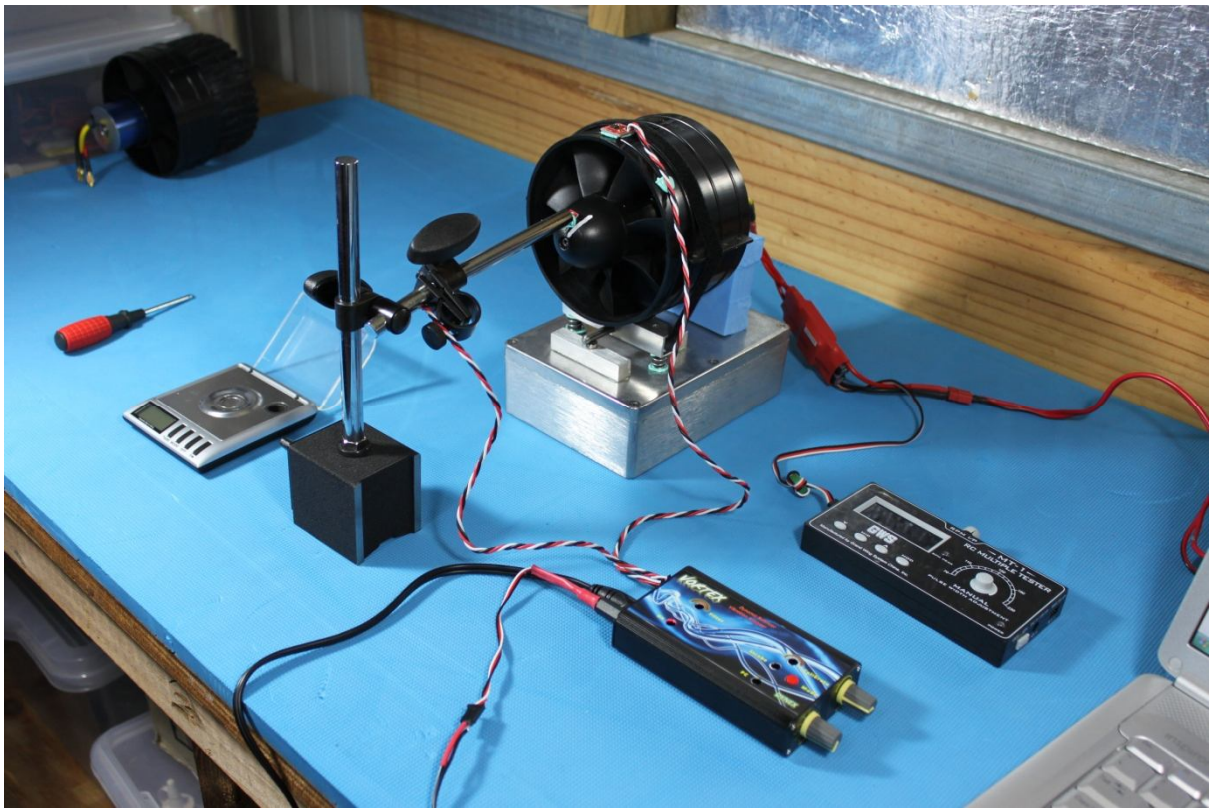
Install the accelerometer on the rotor suspension system. It is best to install it in a horizontal position. The accelerometer can be positioned at any angle as desired, however the full scale deflection can be limited.

The side that has the yellow label is positioned downward and glued to the device under test. Experiments have shown that attaching the accelerometer using “Blu-tack” is adequate.



CAUTION!

1. *Secure any loose cables to the device using “Blu-tack” or tape. This will prevent cables from getting caught in the spinning rotor and reduces mechanical noise during testing.*
2. *Do not install any part of Vortex to moving or rotating parts.*



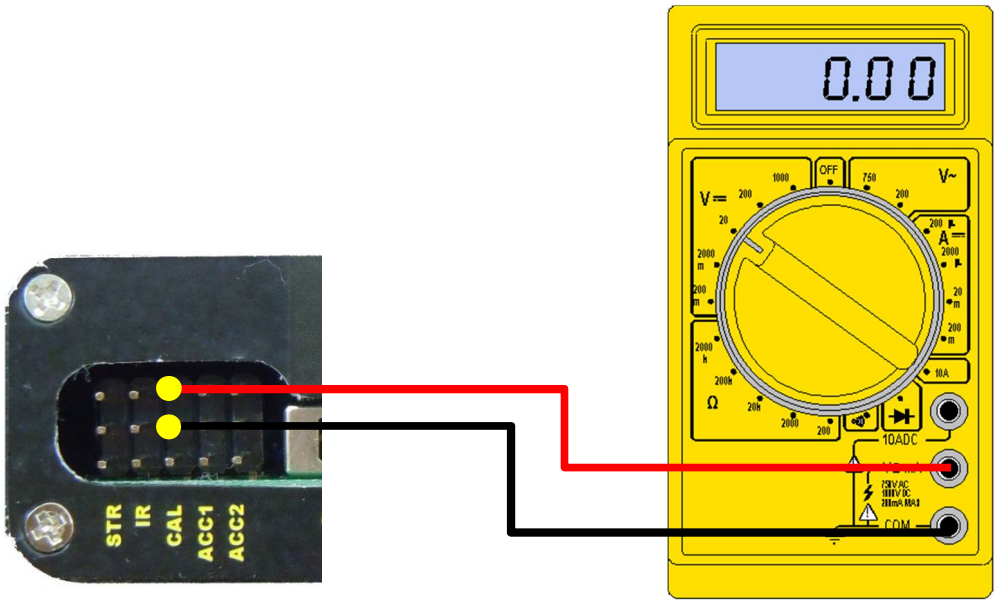
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CALIBRATING THE ACCELEROMTER

If you have the latest version of Vortex, **ignore this section**. The latest version of the hardware is self-calibrating. However if you have the older version, calibration can be performed as follows.

To calibrate Vortex for the accelerometer location, follow the steps below:

1. Connect accelerometer to Vortex ACC1 port. Install accelerometer on test article.
2. Power on Vortex. Do not spin rotor.
3. Attach a multimeter to the pins illustrated below.
4. Turn the "calibrate" dial using a flat blade screw driver until the multimeter reads zero (±10mV is fine).
5. The Vortex is now calibrated and ready for use.

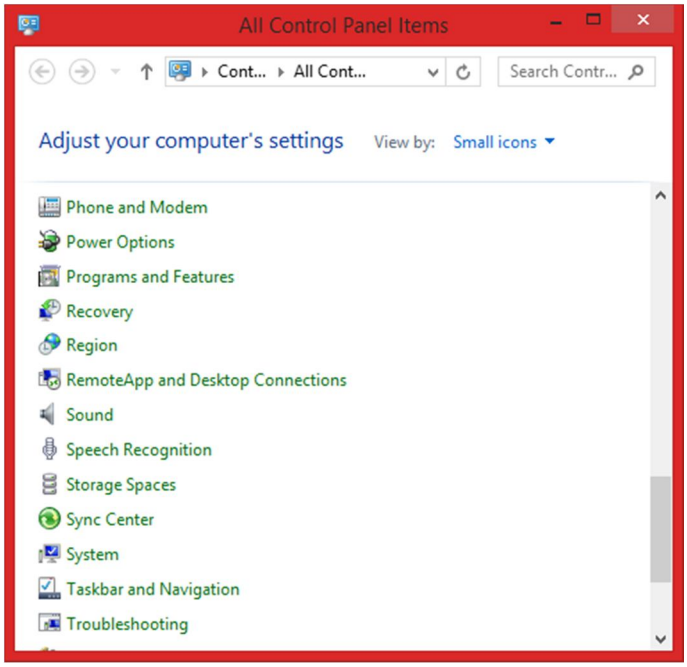


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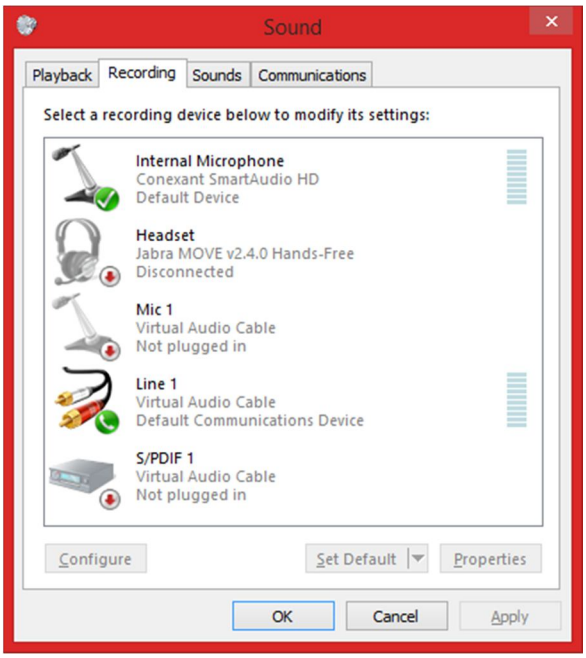
HARDWARE SETUP

The Vortex requires configuration in Windows. The following method illustrates the preferred setup method.

- ✓ Open “Control Panel” in Windows. Click on “Sound” to open the available sound devices.

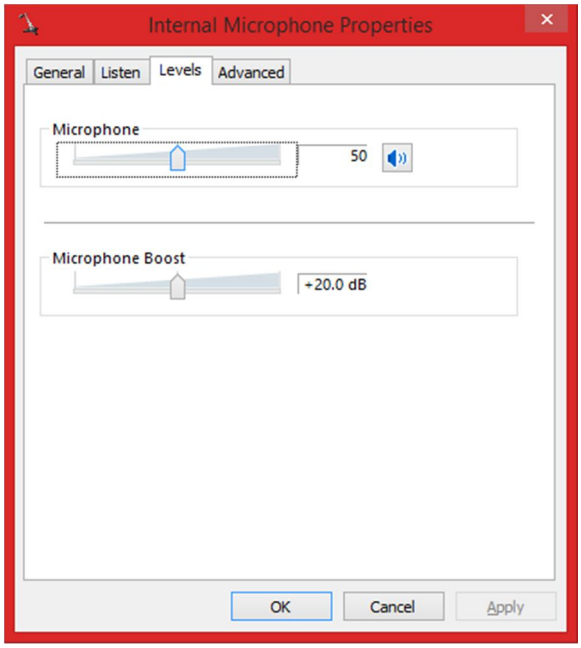


- ✓ Click on the “Recording” tab and double click on the recording device that Vortex is connected to. e.g. Internal Microphone.

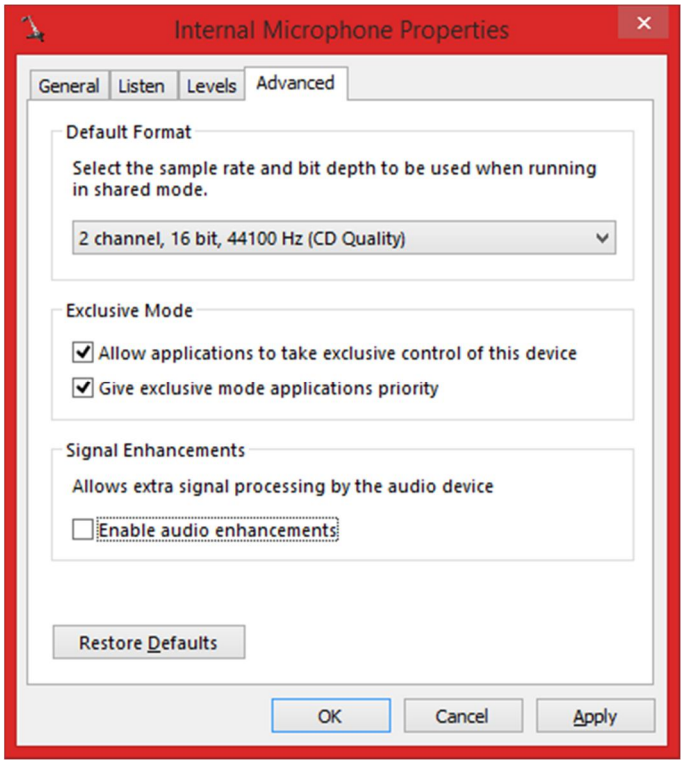


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✓ Click on “Levels” tab. Ensure the volume is not muted and microphone boost is at least +10dB.



✓ Click on “Advanced”. Ensure that the default format has “2 channel, 16 bit, 44100Hz” selected. You can choose other levels if you wish but must be “2 channel”



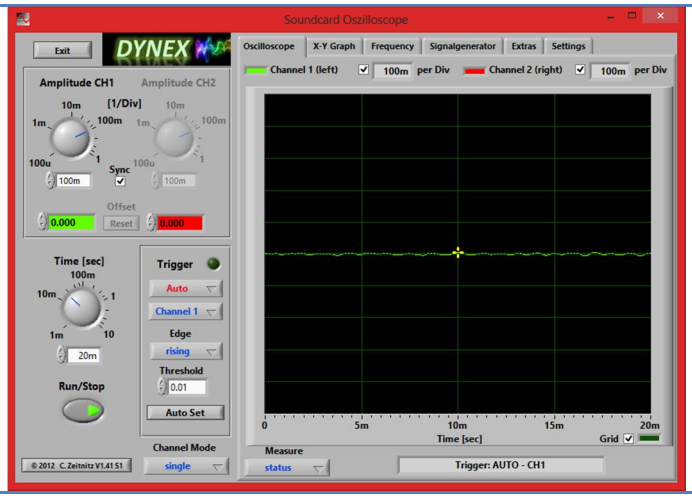
✓ Click “Apply” and “OK”

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BALANCING SOFTWARE

Introduction

DynexHobby provides analysis tools to determine the balance of rotors. There are two tools available listed below. These can be downloaded from www.dynexhobby.com.

Name	Image	Application
Dynex Analysis		Used for all balance methods. This application runs under Microsoft Windows. Note that .NET 4 must be installed for this application to function.
Scope Tool		The scope tool can be used as an alternative to the Dynex Analysis package. It has a few additional features such as signal generation and vibration recording. This program is now superseded.

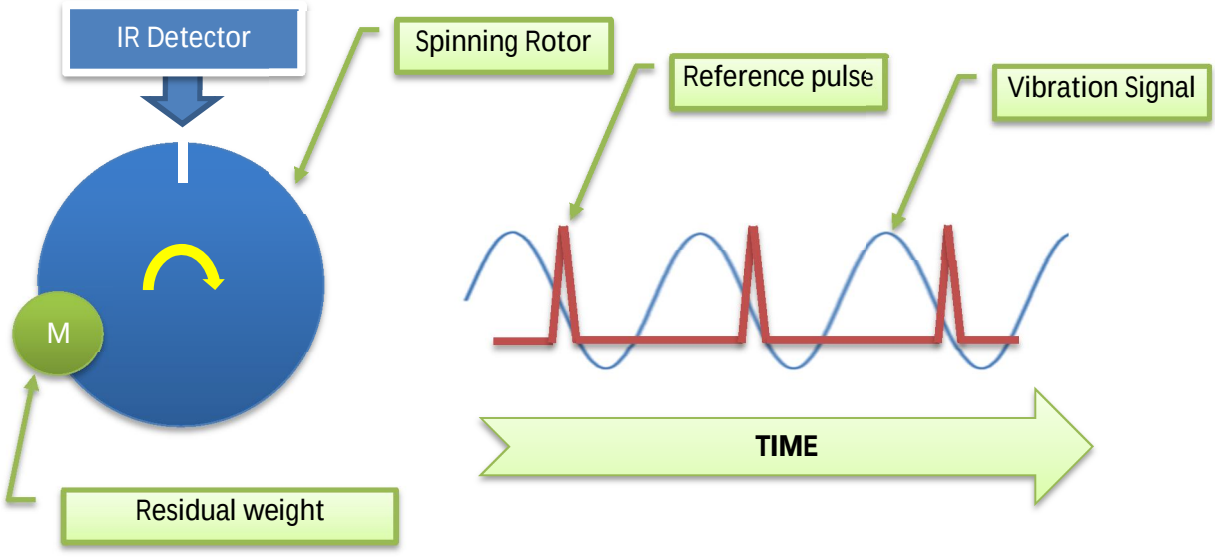
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HOW THE SOFTWARE MEASURES VIBRATION FOR BALANCING

The following image illustrates how the software measures vibration amplitude and phase. Vibration amplitude is typically measured by channel 1 in the oscilloscope software. An imbalance appears as a **sinusoidal** waveform.

A marker is applied to the rotor such as a white line or a reflective strip. As the marker passes the IR Sensor, a pulse is registered. This pulse refers to a **zero** degree reference position on the rotor. The pulse is typically measured by channel 2 in the oscilloscope software. The time difference between the reference pulse and the sinusoidal waveform is referred to as the **phase shift**. Phase shift usually measured in **degrees** of rotation.

Note: Sometimes a perfect waveform cannot be achieved due to external noise from bearings or loose mechanical connections. Vortex can filter such noise by switching on the filter and adjusting the "filter" dial on the front panel until a suitable waveform is obtained. Once the filter has been set, do not change for the remainder of the balancing operation. Additional filtering can be achieved using the DynexHobby software.



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BASIC THEORY OF BALANCING

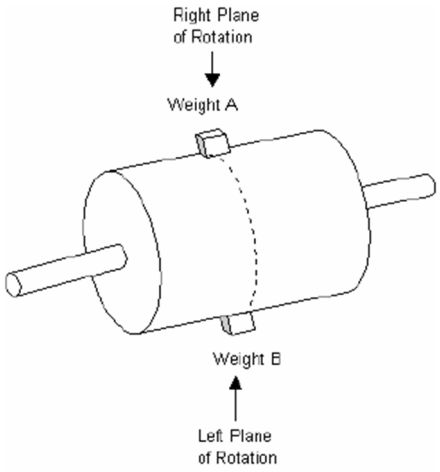
Introduction

Unbalanced rotors have relatively high force effects on bearings. High levels of unbalance can cause vibration, deformation, power degradation, friction and can degrade service life. In the case of a rotating shaft, the unbalance causes periodical forces to the suspension system which corresponds to the rotational speed. In other words it is synchronous with rotational speed (first order). In order to balance the rotor the correct running speed should be selected in the balancing instrument. The test speed is usually much lower than the operational speed for safety reasons. The correct running speed reduces the disturbance caused by the noise, harmonics, bearings and blade frequencies.

The unbalance is radial in their line of action and it is a vector quantity. A vector has both magnitude and direction. The direction can be characterized by the phase between the unbalance vector (from the center of the shaft) and a vector to the reference point at the shaft (from the center of the shaft).

Static Unbalance

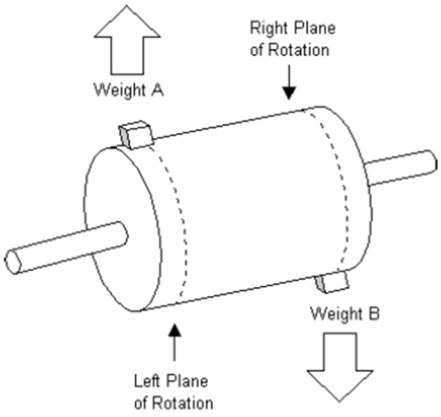
The general dynamic unbalance consists of the static (**single plane)** unbalance. This is when the mass center line is **parallel** and not coincidental with the rotational axis. This kind of balance exists in disk shape structures. It can be eliminated by a compensating weight. This method is appropriate for balancing ducted fan units, wheels or any disc shaped rotors.



Coupled Unbalance

The other type of unbalance is when a pair of weights are at two ends of the shaft but on opposite sides to each other (180°). The rotor is in static balance, but the centrifugal forces will produce a moment about the center of mass when the rotor turns. In this case, only a couple unbalance exists. The mass center line **crosses** the shaft axes at the center of gravity.

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The couple unbalance can be compensated by two weights, which are positioned to counteract the couple unbalance at two planes. The ideal balancing task is to reduce the inhomogeneous mass distribution caused forces by adding or removing weights along the shaft.

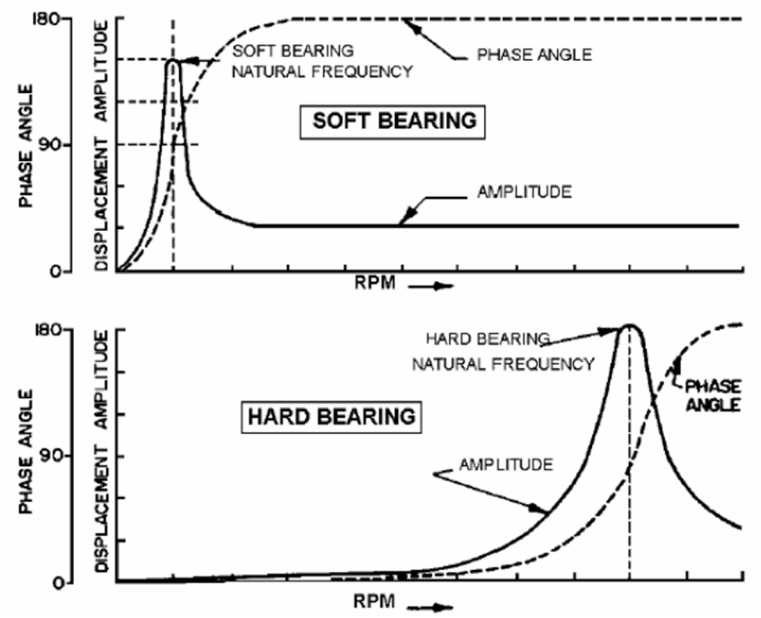
Note: To perform balancing, refer to DynexHobby's Balancing Methods Manual.

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SUSPENSION SYSTEM (MOUNTING CRADLE)

The suspension system or the mounting cradle is crucial for single or double plane balancing. The cradle allows the rotor system to oscillate back and forth near its natural state. The oscillation is important for Vortex to sense vibration and analyze the imbalance. *Note: Mounting cradles are not supplied by Dynex Hobby. Cradles can easily be made from components supplied by your local hardware or electronics store*.

Each suspension system has a natural mode of vibration or natural frequency. If tests are conducted at the natural frequency (a specified RPM that cause's natural vibration of the system), then the balancing results will be difficult to achieve.



To avoid this, the following recommendations should be considered:

- Run balancing at speeds above the natural frequency. This would be in a region where phase angle and amplitude are flat in the charts above.
- Soft suspension construction to provide a low resonance frequency.
- Allow the cradle to rock smoothly using frictionless supports. Teflon bearings or magnetic supports are ideal.
- Provide additional damping to reduce overshoot of the cradle. Foam rubber works well.
- Mechanically isolate the suspension system from the bench. This can be achieved by using a rubber mat.

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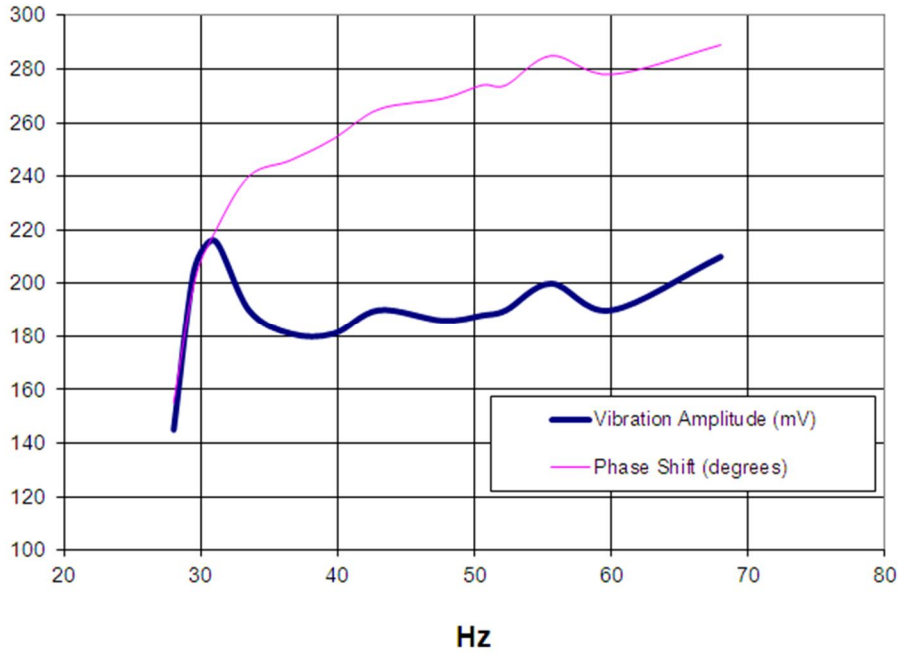
DETERMINING THE SUSPENSION SYSTEM NATURAL FREQUENCY

METHOD 1

The following is a method for identifying the suspension system natural frequency.

- ✓ Mount rotor in cradle.
- ✓ Run motor incrementally from the lowest possible RPM to the highest **safest** speed. Please ensure safety when operating the rotor and follow manufacturer's instructions. Protective gear is recommended.
- ✓ Plot the vibration amplitude and phase angle with incremental RPM.
- ✓ The natural frequency is identified by the peak in the vibration amplitude.

A sample of the Vortex suspension system is shown below. The ideal running speed would be above 40Hz.



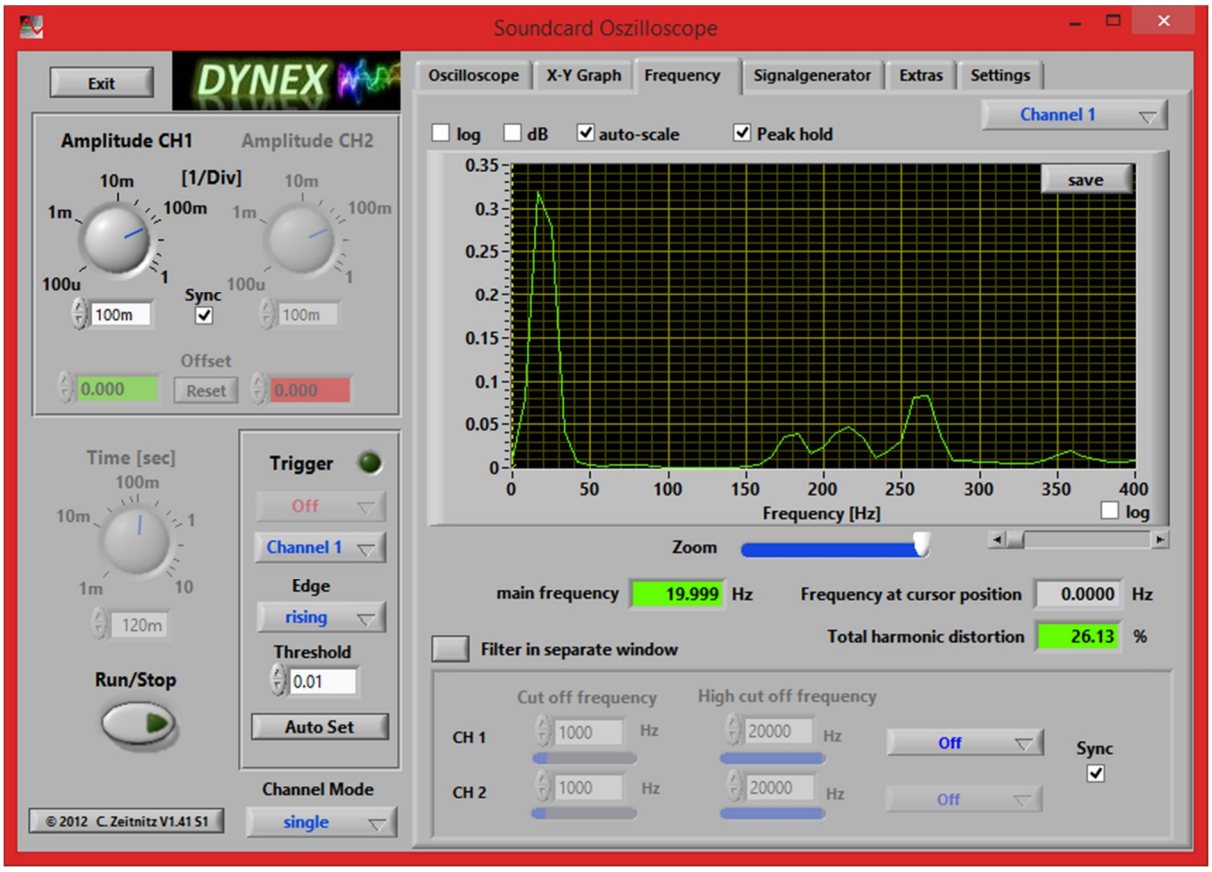
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METHOD 2

The following method is simple and generally used by DynexHobby.

- ✓ Open the “Scope” software and click on the “frequency” tab.
- ✓ Click on “peak hold”.
- ✓ With your rotor at rest on the cradle and sensor attached, quickly tap the cradle support with a tap hammer. A light tap is all that is needed.

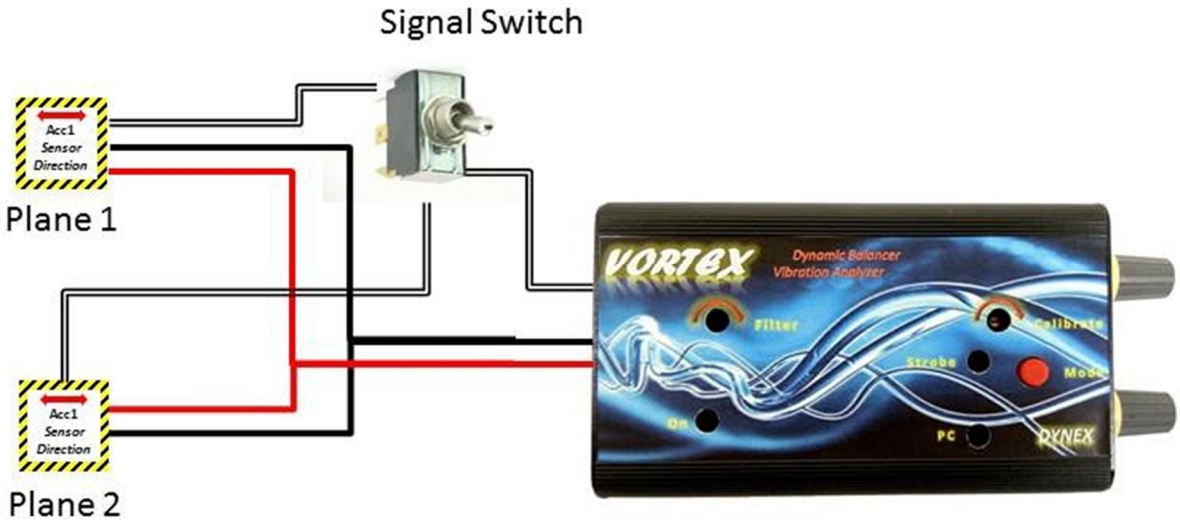
The peak frequency generated is your cradles natural frequency, example below. Generally DynexHobby cradles are around 20~30Hz, so balancing can be carried out about 40~60Hz.



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TWO PLANE BALANCING

The Vortex is capable of supporting two plane balancing. In order to achieve this, two independent accelerometer sensors are required, one for each plane. The diagram below illustrates a typical wiring diagram. In essence, the power (red) and ground (black) wires are connecter together and also to Vortex. However, the signal (white) wires are connected to Vortex via a switch. The switch toggles between Plane 1 and Plane 2 accelerometer signals accordingly.

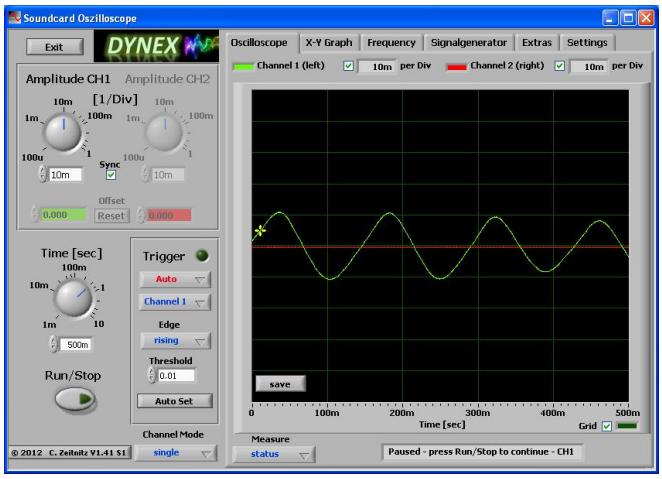


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VORTEX LIMITATIONS

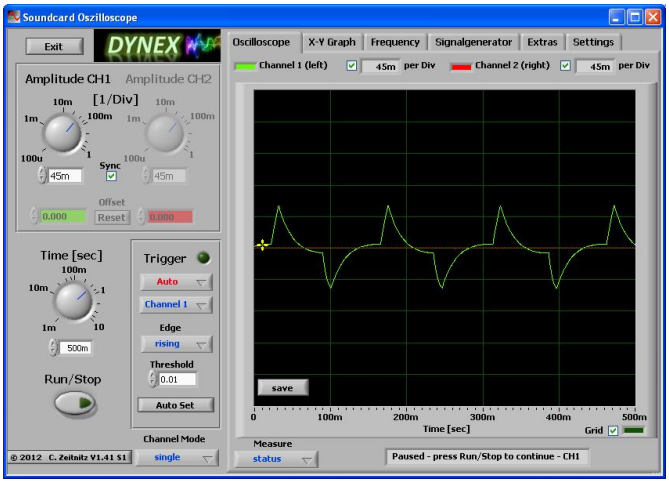
Introduction

Vortex operates by converting vibration into an electrical signal. These signals are conditioned by onboard circuitry and sent to the PC soundcard. A normal signal when filtered will look like the one below.



However when vibration levels exceed Vortex limits, the onboard circuitry will "clamp" the signal down to safe operating limits. This is designed to prevent damage to the PC soundcard.

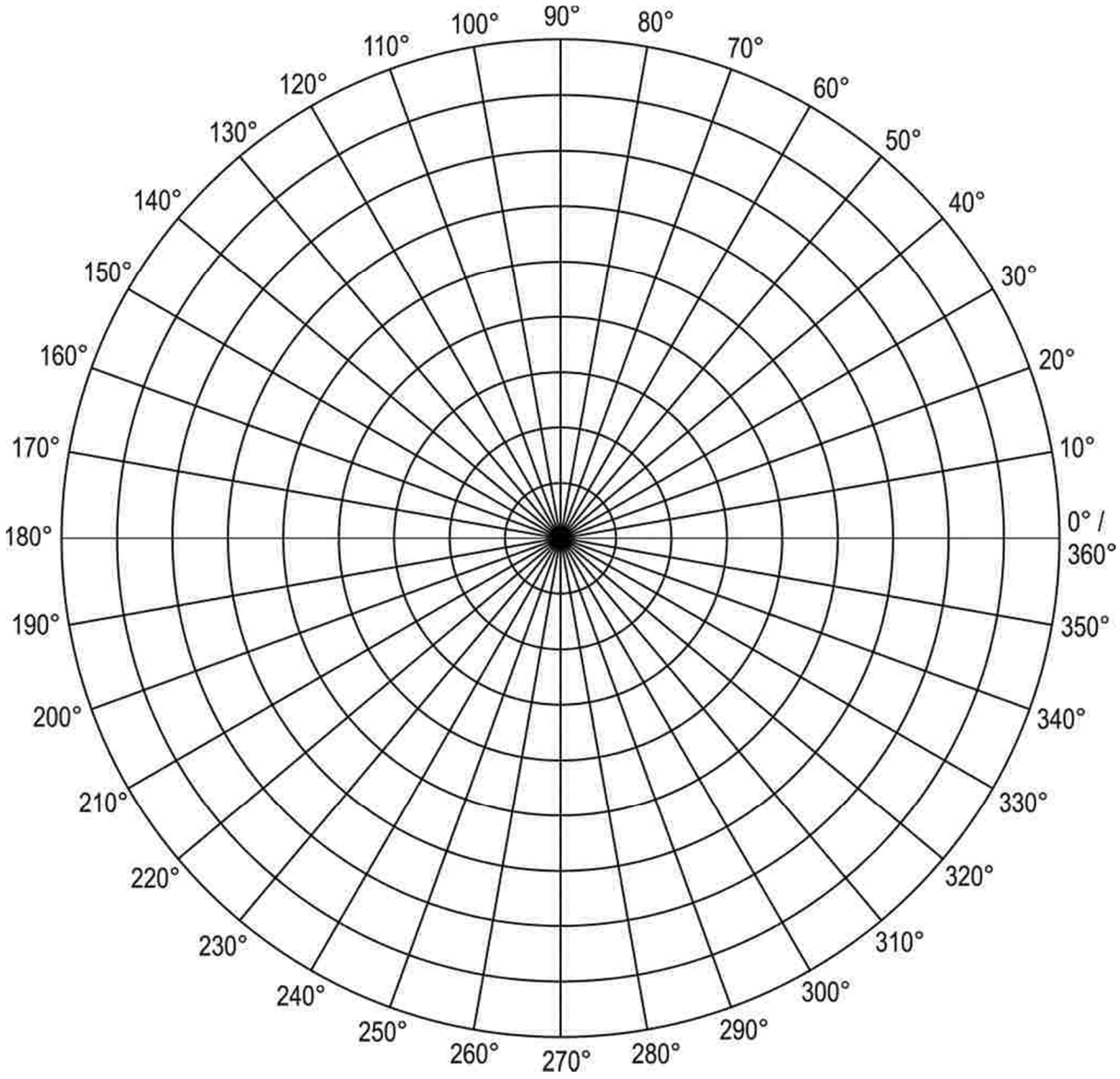
When a vibration signal reaches the physical limits of Vortex, the signal will appear distorted particularly at the signal peaks when viewed in the oscilloscope. A sample of distortion is shown below. Distortion may also appear as a square wave.



Should the operator experience signal distortion, **immediately** turn down the "Gain" dial until the signal appears as a normal sine wave. If the distortion continues, cease operation of Vortex.

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APPENDIX – STROBE BALANCE SHEET



First run trigger level (O)	
Correction vector length (C)	
Trial weight (W)	
Correction weight = O / C x W	

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