TITAN

DIY Dynamic Balancing Cradle

USER MANUAL V1.0

DYNEXHOBBY

SAFETY FIRST

High speed rotors contain enough energy to expel high velocity debris that will cause damage to property and injury to people including death. Manufacturer's safety precautions MUST be adhered to during testing and operation of devices.

Safety goggles and equipment 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.
- ✓ Impulse was **not** designed for full size vehicles or industrial applications.
- ✓ **Always** service engines in accordance with manufacturer's instructions including using authorized service agents for maintaining engines.
- ✓ Titan cradle was not designed to withstand high temperatures from running turbine equipment.

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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TITAN CRADLE OVERVIEW

Introduction

The Titan Balancing Cradle is the latest addition to the DynexHobby DIY balancer series. The Titan is constructed from CNC machined 6061 aluminum, ball bearing joints and stainless-steel fasteners. It is designed for quality at a hobbyist budget.

The Titan cradle provides a frictionless suspension system that allows the rotor to move freely about its centroid such that imbalance can be measured. The Titan is an intermediate level balancer and allows users to construct their own DIY balancing rig at low cost.

The Titan is supplied unassembled to reduce the chance of breakages during transit and requires assembly by the user. Assembly is illustrated in this manual.

This manual demonstrates how to assemble Titan for balancing devices. It **does not** demonstrate how to balance devices in general as this requires specific knowledge and experience.

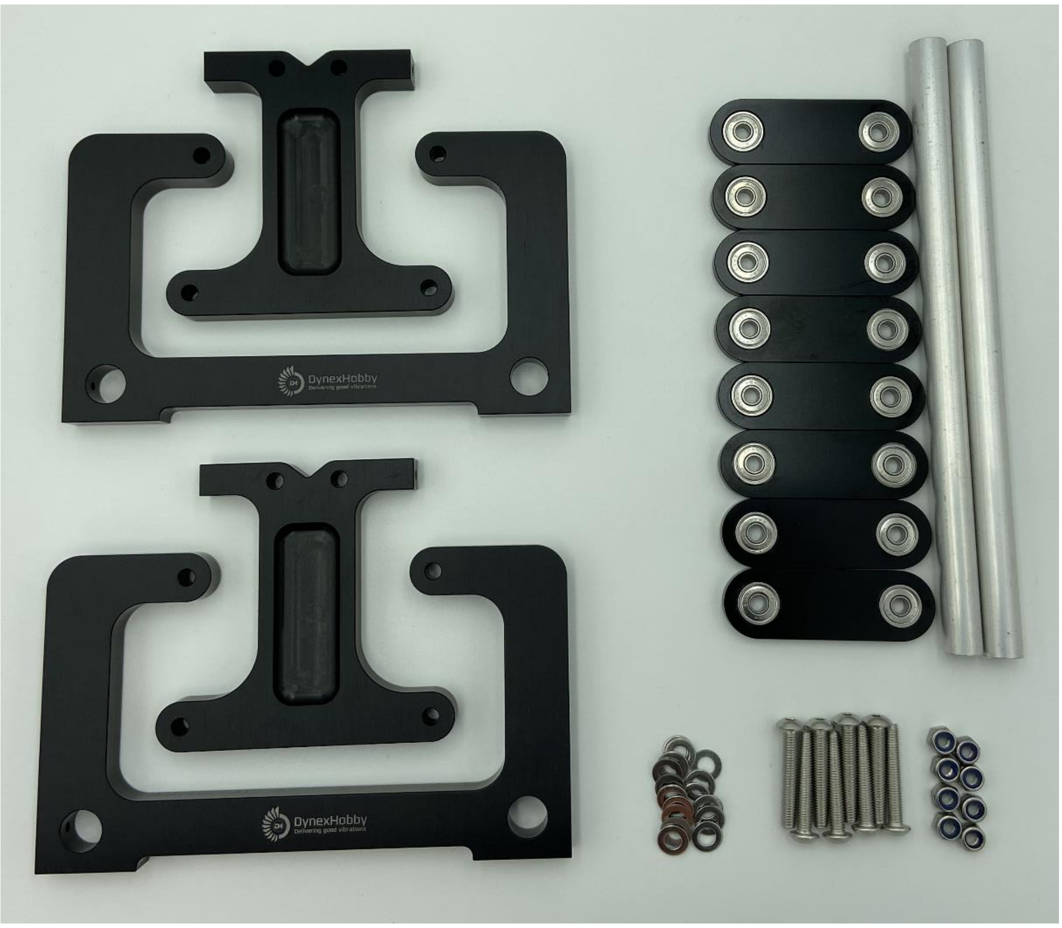
Warning! AT THE TIME OF WRITING THIS MANUAL, THE SOFTWARE IS STILL UNDER DEVELOPMENT AND IS LABELLED AS A "BETA" VERSION. USERS MUST VALIDATE THEIR RESULTS INDEPENDENTLY.

SPECIFICATIONS

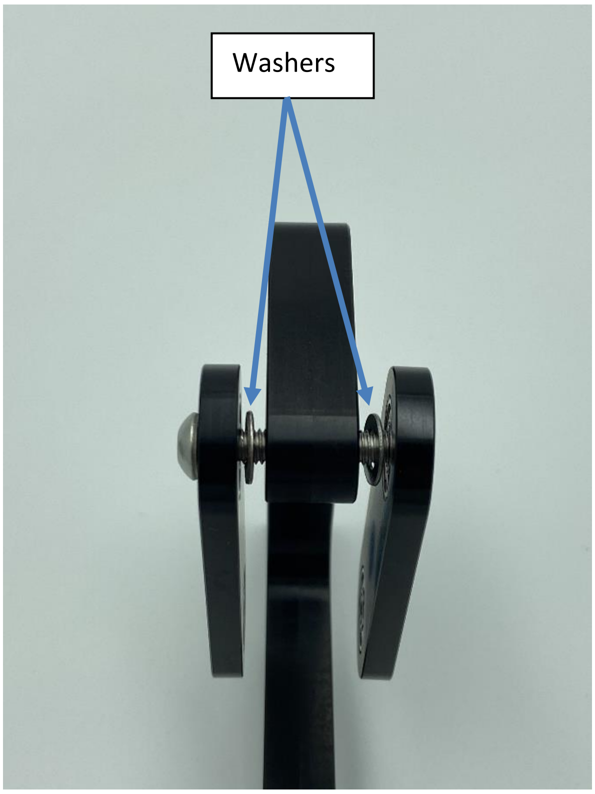
Item	Quantity
Titan Cradle	• Total Weight 900 gram • Dimensions (outer): 95mm(H)x160mm(W)x15mm(L) • Carry capacity (2.5kg) per arm.
Electronics	• Impulse series of balancers

ASSEMBLING THE TITAN CRADLE

1. The Titan is supplied as individual components. Open the box and lay out the components as follows.



2. Insert the M5 screws and washers into the aluminum sway bars as shown. Do these 8 times for the two frames. The washers sit between the sway bar and the main frame.

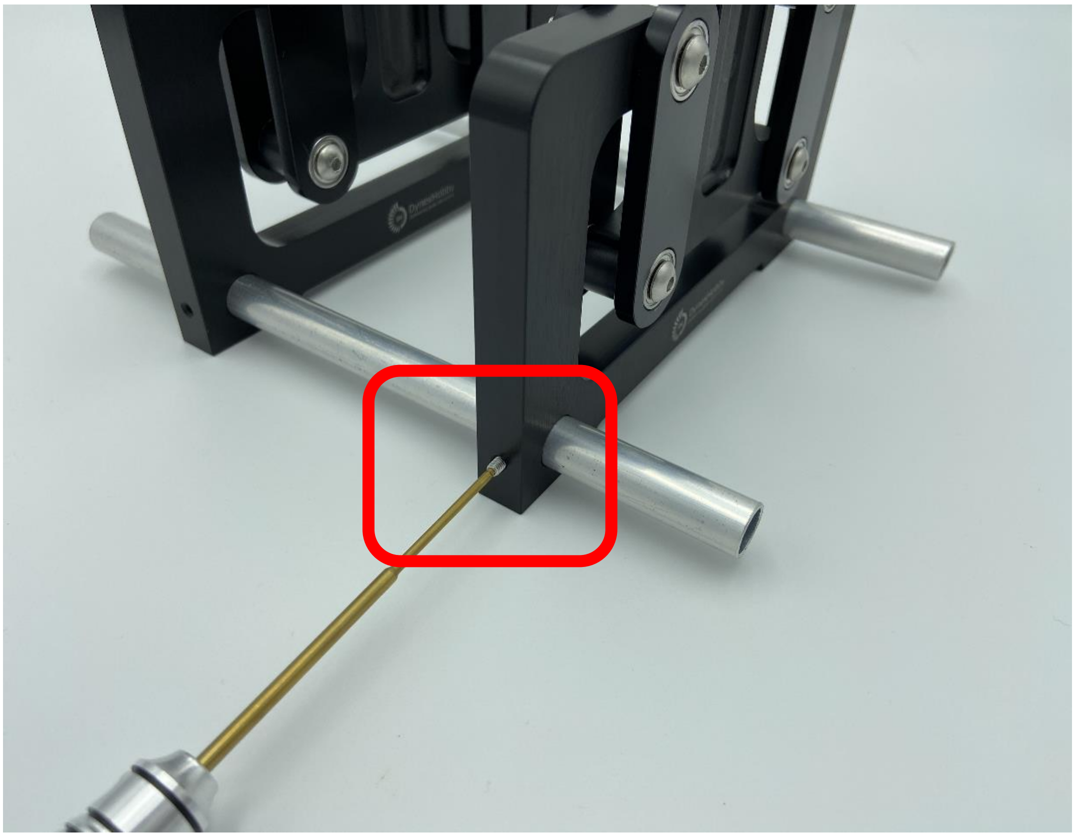


3. Install locknuts onto M5 fasteners and secure into position. Do not overtighten nuts at this stage.

4. Insert the sway arm assembly into the cradle frame as shown. Ensure washers are placed between the sway bars and the main frame. Install M5 fasteners and secure into position.

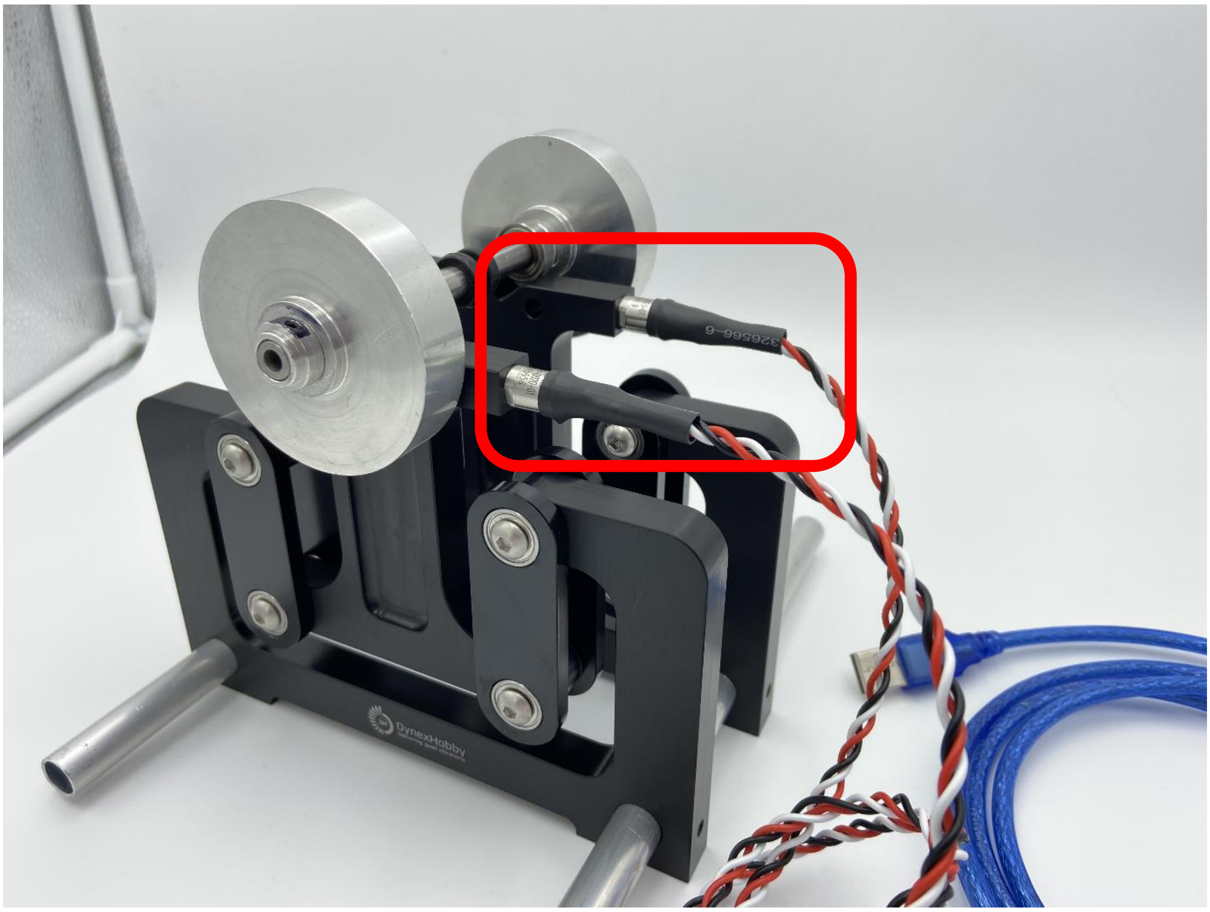
5. Tighten locknuts to secure assembly in place.

6. Insert the aluminum slide tubes into position as shown. The slide tube can be locked into any position using the M3 grub screw shown below (4 places).



INSTALLING THE ACCELEROMTER

Install the accelerometer on the back face of the sway arm. Optional piezoelectric accelerometers are available that can be screwed directly into the sway arm assembly as shown below.



CAUTION!

1. *Accelerometers must face in the same direction otherwise test results will be incorrect*
2. *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.*
3. *Do not install any part of Impulse to moving or rotating parts.*

BALANCING TOOLS

Introduction

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

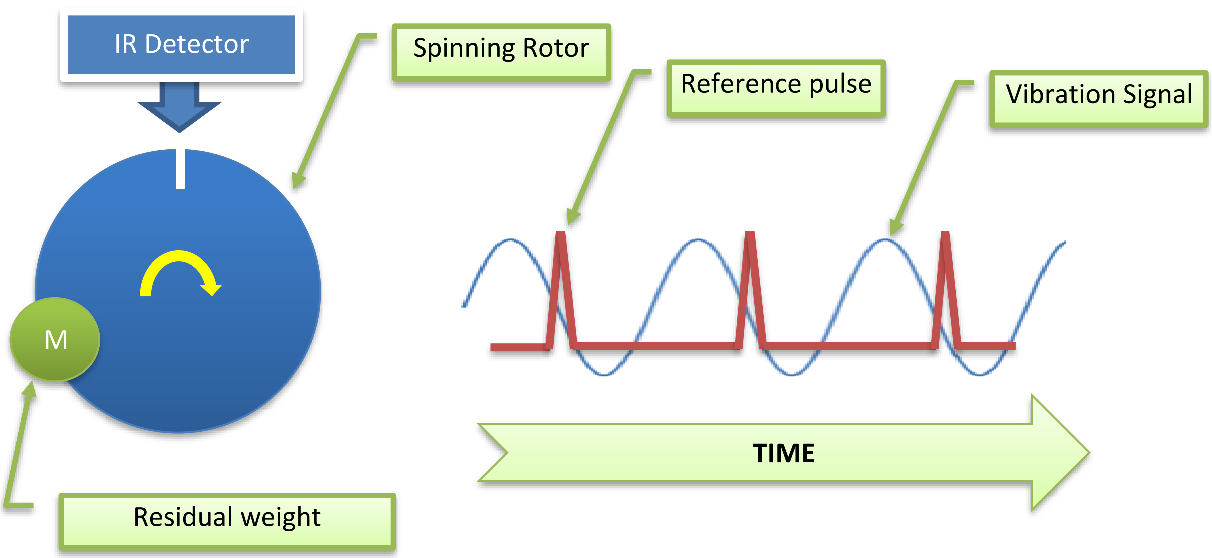
Name	Image	Application
Dynex Analysis		Used for all balance methods. This application runs under Microsoft Windows. Note that .NET 4 must be installed for this application to function.
Impulse Balancer		The Impulse & Impulse 2 provide the electronics for connecting from the PC to the balancing cradle.

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. Impulse can filter such noise by switching on the filter and adjusting the "filter" until a suitable waveform is obtained. Once the filter has been set, do not change for the remainder of the balancing operation.



BASIC THEORY OF BALANCING

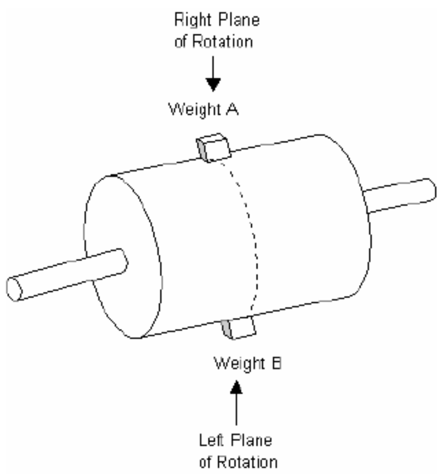
Introduction

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).

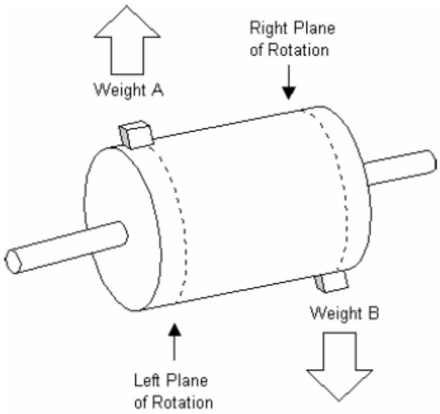
Static Unbalance

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.

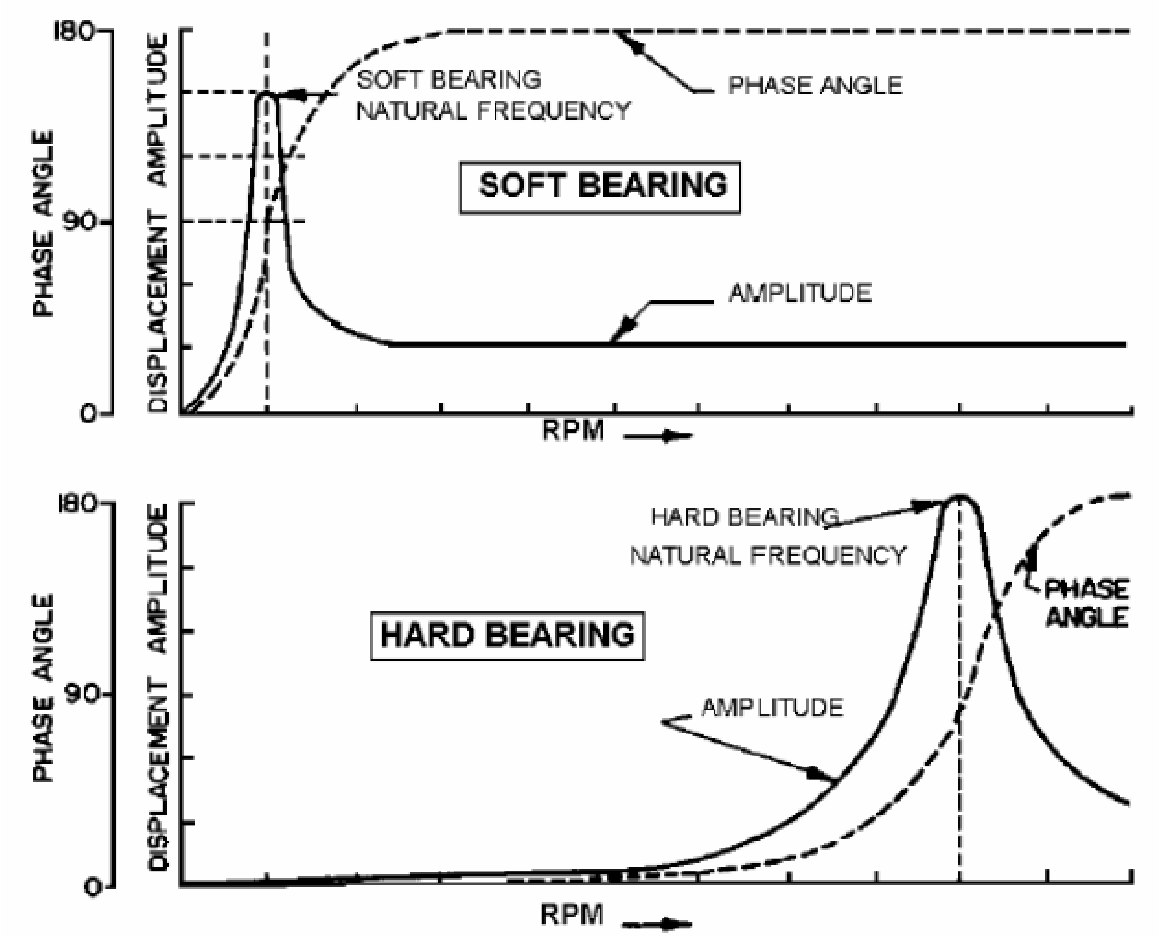


The couple unbalance can be compensated by two weights, which are positioned to counteract the couple unbalance at two planes. The ideal balancing task is to reduce the inhomogeneous mass distribution caused forces by adding or removing weights along the shaft.

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 Impulse to sense vibration and analyze the imbalance.

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 for soft bearing cradles. 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. Titan is a soft bearing cradle.
- Allow the cradle to rock smoothly using frictionless supports.
- Mechanically isolate the suspension system from the bench. This can be achieved by using a rubber mat.
- As starting point, the balancing speed for a soft bearing system would be close to 2 x Natural Frequency.

DETERMINING THE SUSPENSION SYSTEM NATURAL FREQUENCY

METHOD 1

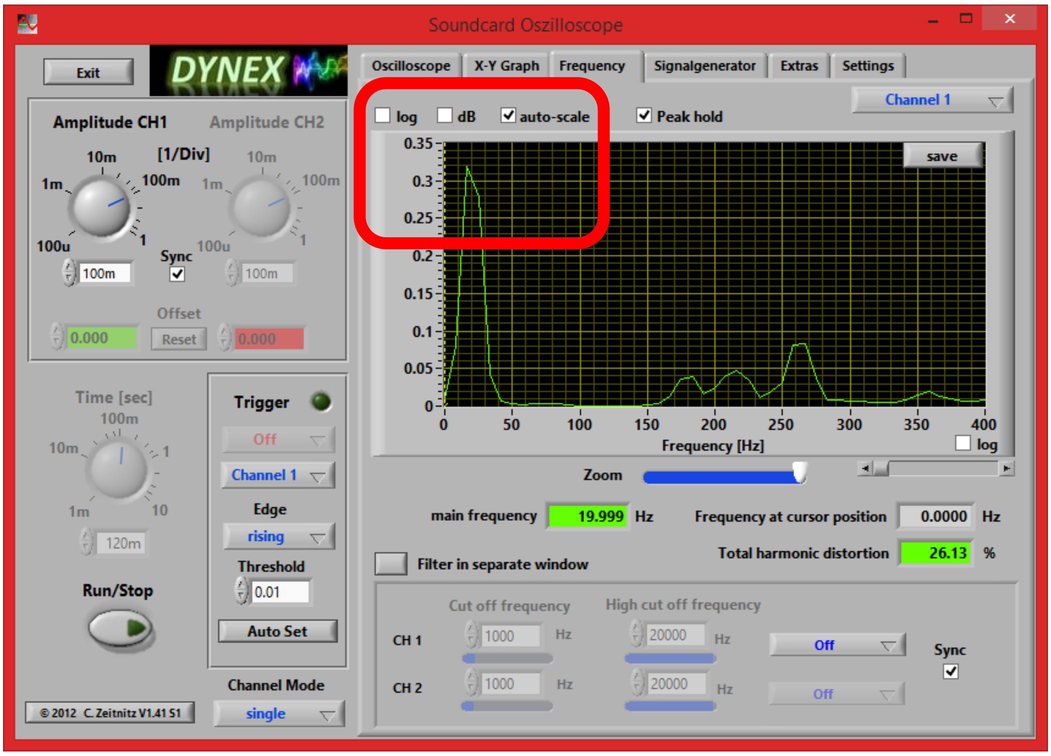
The following is a method for identifying the suspension system natural frequency.

- ✓ 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.

METHOD 2

The following method is simple and generally used by DynexHobby.

- ✓ Mount rotor in cradle.
- ✓ 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 shown below is the cradle natural frequency.



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