Condition Monitoring

PRÜFTECHNIK

TechNote #CM18 VIBXPERT®

Analysis of radial shaft movement in journal bearings

Introduction

Damage diagnosis on machines with journal bearings is performed by measuring shaft movement with non-contacting proximity sensors that are attached at right angles to each other. The main diagnosis information is provided by two signal components:

The **DC signal component (DC)** indicates the average position of the shaft axis relative to the sensor and is equivalent to the static position of the shaft in the bearing housing. When the machine starts up, the shaft axis generally moves out of the rest position to the operating position. Based on the so-called '**shaft centerline path**' relative to the rest position and direction of rotation, conclusions can be drawn on the radial reaction forces, alignment errors, bearing conditions, oil film thickness, etc.

The movement of the shaft axis about its average position is indicated by the **AC signal component (AC)** of the two proximity sensors. The signals can be plotted on polar coordinates to obtain the so-called '**shaft orbit**', which describes the path of the shaft axis in the bearing housing over one rotation. In addition to the amplitude values, another valuable quantity for diagnosis is the phase information in the signal. It is recorded using a Keyphasor® sensor.
The shaft orbit in VIBXPERT® is generally averaged RPM synchronously over several rotations to suppress disturbance signals. The standard display is the (order) filtered shaft orbit, which shows the synchronous movement of the shaft axis in the respective order.
To display the direct shaft orbit for every rotation, the averaging and order filter must be deactivated and the number of displayed rotations (standard = 1) must be increased accordingly.

Section A below describes how to record and display the direct shaft orbit over multiple rotations in VIBXPERT®. Shaft centerline path measurement and analysis is treated in section B.

Note on sensor

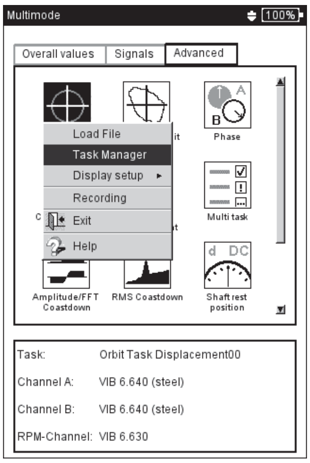
The measurement in the following example is performed using inductive PRÜFTECHNIK proximity sensors of the VIB 6.640 series. This sensor type is always measured in a DC-coupled manner, meaning that the sensor measures both the DC signal component and the AC signal component. In contrast, proximity sensors with a voltage output (such as IN 085 from B&K Vibro) can be measured AC- or DC-coupled. The VST 24V adapter VIB 5.341 is needed to connect these sensor types to VIBXPERT®.

A. Displaying shaft orbits over multiple rotations

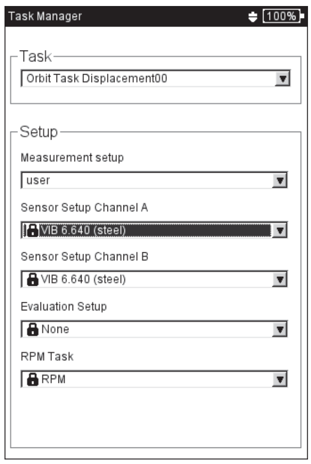
To display the direct shaft orbit (0th order), the measured quantities in the measurement setup and in the sensor setup must be the same.

Setting up the measurement task

1) Select the 'Orbit, filtered' icon and open the task manager.



Step 1)



Steps 2) and 3)

2) Select the 'Orbit Task Displacement' measurement task, press the MENU button and click on 'New'.

3) Create a new, user-defined measurement task, e.g. 'Orbit Task Displacement00'.

4) Adjust the setup parameters:
- Measurement setup: create a user-defined measurement setup; see the next page for the settings.
- Sensor setup channel A/B: proximity sensor (e.g. VIB 6.640)
- Evaluation setup: none
- RPM task: RPM

5) Save the changes and close the task manager.

PRÜFTECHNIK Condition Monitoring - LIT.53.618.EN.11.2009

Settings for the user-defined measurement setup:

- MEASURED QUANTITY: **Displacement**;
  This parameter is fixed and is dictated by the factory set measurement task selected under Step 2).

- LOWER FREQUENCY: **DC**;
  This setting is necessary when using PRÜFTECHNIK proximity sensors VIB 6.640 (DC-coupling). When using proximity sensors with a voltage output, a suitable high pass frequency can be selected (AC-coupling).

  Note on display:
  When using PRÜFTECHNIK proximity sensors (VIB 6.640), the DC and AC signals can be displayed. To display the shaft orbit, the 'AC only' parameter must be activated in the display setup (see the figure at the bottom right).

- NO. OF MEASUREMENTS: **10**
  for example

- TIME SYNCH. AVERAGES: **Manual**

- NUMBER: **1**
  Only one measurement is displayed per rotation.

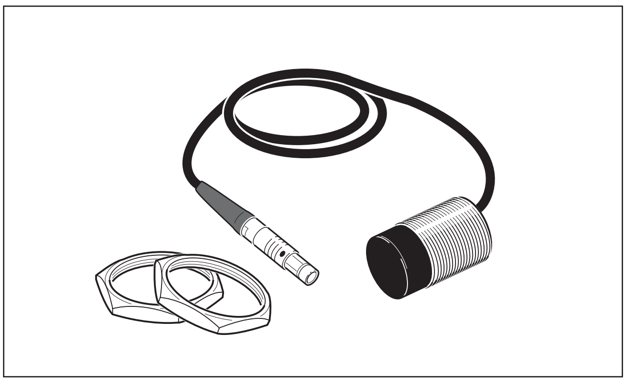
- ORDER: **1**
  The order is changed to 0 after the measurement.

- MEASUREMENT RANGE: **Auto**

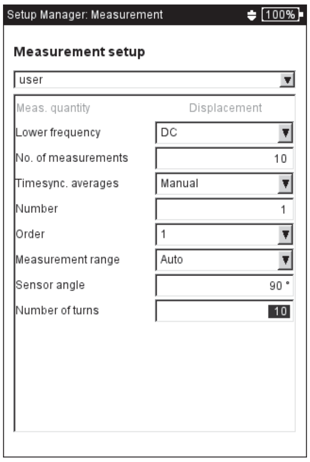
- SENSOR ANGLE: **90°**;
  if sensors are installed with a 90° offset.

- NUMBER OF TURNS: **10**

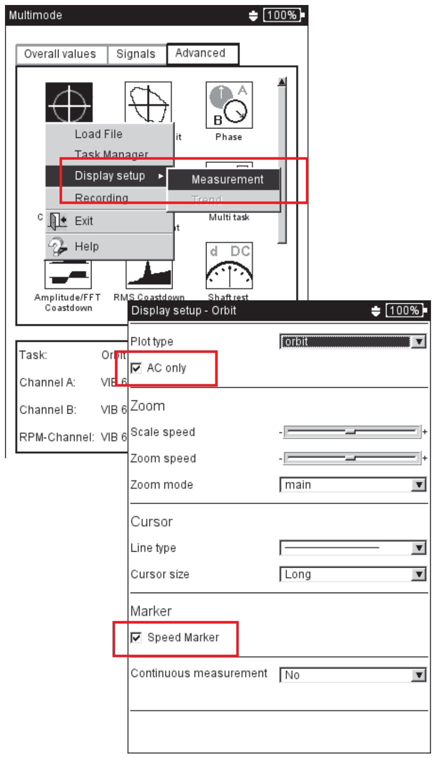
  Note on 'Number of turns':
  The 'No. of measurements' and 'Number of turns' parameters must be identical for VIBXPERT® to display all measured rotations.



Inductive proximity sensor VIB 6.640



Settings in the measurement setup



Settings in the display setup:
For orbit measurements with PRÜFTECHNIK proximity sensors (VIB 6.640), the 'AC only' option must be activated.
The following applies to all sensor types:
For the Keyphasor® markers to be displayed in the shaft orbit and time signal, the 'Speed marker' option must be activated.

PRÜFTECHNIK Condition Monitoring - LIT.53.618.EN.11.2009

Starting and evaluating the measurement

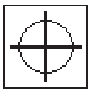
6) Check the measurement setup before beginning the measurement:
- Sensor installation OK?
- Sensors, cables, Keyphasor® correctly connected?
- Machine running at a constant speed?

7) Click on the 'Orbit (filtered)' measurement task icon to start the measurement.

8) After the measurement is completed, press the F button and select 'Order > 0'.

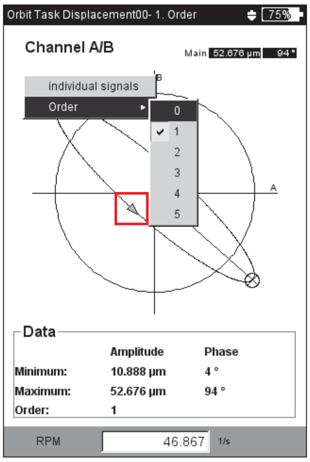
One shaft orbit is displayed for each measured rotation. The grey arrow on the curve indicates the Keyphasor® marker. It points in the direction of shaft rotation and indicates the position of the shaft axis when the reference marker on the shaft passes the Keyphasor®. If this marker remains stable over multiple rotations, the phase is constant. If the Keyphasor® marker wanders, an experienced vibration specialist can determine the type of fault.

9) To display the time signal of both channels, press the F button and click on 'Individual signals'.

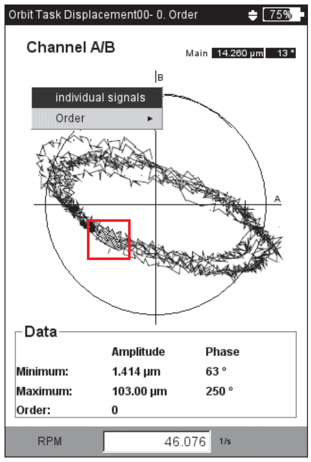


Orbit
(filtered)

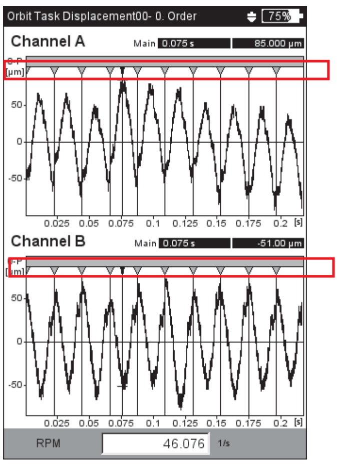
Step 7)



Step 8)



Step 9)

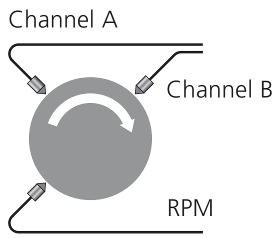


Keyphasor® marker(s)

PRÜFTECHNIK Condition Monitoring - LIT.53.618.EN.11.2009

B. Measuring the shaft centerline path

The shaft centerline path is measured while the machine is starting up and coasting down. In VIBXPERT®, measurements are taken using the 'Dual Coastdown' measurement task.

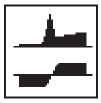


Preconditions for a correct result interpretation

- The proximity sensors are arranged at 90° to each other.
- The direction of shaft rotation is from sensor A to sensor B. The sensor arrangement can later be mirrored in VIBXPERT®.

Selecting the measurement task

1) In the selection screen, select the 'Amplitude/FFT Coastdown' icon (-> 'Advanced' tab).

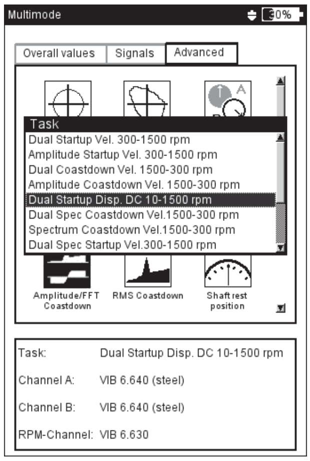


Step 1)

Amplitude/FFT Coastdown

2) Press the F button and select the 'Dual Startup Disp. DC 10-1500 rpm' measurement task. In this measurement task, the setup parameters are preset as follows:

- Measurement setup: fixed and variable parameters for startup measurement; the latter can be adjusted prior to measurement (see 4).
- Sensor setup channel A/B: proximity sensor VIB 6.640.
- Evaluation setup: none
- RPM measurement: RPM sensor VIB 6.630



Step 2)

Starting the measurement

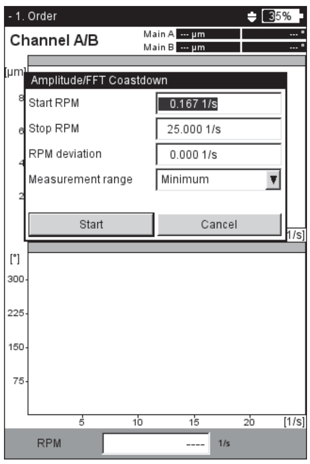
3) Check the installation before beginning the measurement:

- Sensor installation OK?
- Proximity sensors, speed sensors, cables correctly connected?

4) Click on the 'Amplitude/FFT Coastdown' measurement task icon (see also 1). The measurement screen appears in which the start and stop RPM, the RPM deviation and the measurement range can be adjusted if necessary.

- START/STOP RPM: depending on whether taking a startup or coastdown measurement, set this parameter to a suitable value.
- RPM DEVIATION: the speed range in which a value is measured. To obtain a sufficient quantity of measurement data, a small value should be selected for machines that start up or coast down rapidly and a large value should be selected for slow machines.
- MEASUREMENT RANGE: should be set to 'Minimum' for startup measurements and to 'Maximum' for coastdown measurements.

5) Click on 'Start' to start the measurement.



Step 4): Adjust variable measurement parameters prior to measurement if necessary

PRÜFTECHNIK Condition Monitoring - LIT.53.618.EN.11.2009

6) Startup or coastdown: Switch the machine off or on. Measurement begins when the set start RPM is reached.

Displaying the shaft centerline path

7) After measurement is completed, press the F button and click on 'Shaft centerline'. The average movement of the shaft axis within the bearing appears as a curve on the shaft centerline diagram.

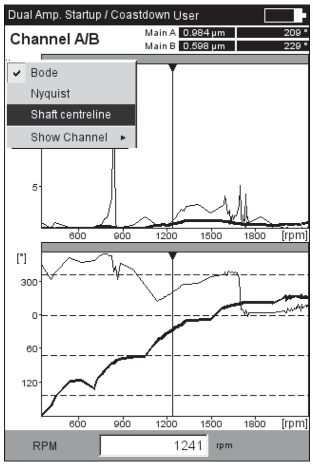
Adjusting the shaft rest position

Generally, the DC signal component defines the shaft rest position at the lowest recorded speed. Alternatively, you can also define or determine this position in another way:

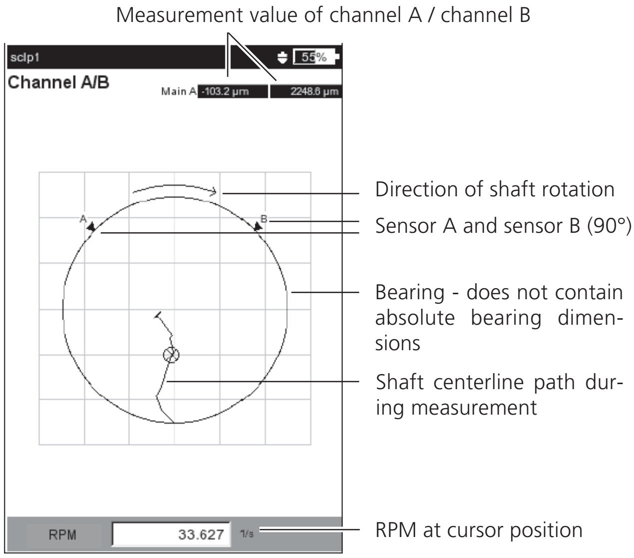
- Cursor coordinates in the shaft centerline diagram.
- Manual input of coordinates.
- Import from a result file of the coordinates that were measured with the 'Shaft rest position' measurement task.
- Measurement.

8) Proceed as follows to change the shaft rest position determined by a standard measurement:

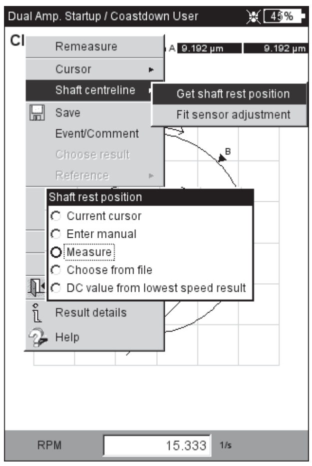
- Press the MENU button in the shaft centerline diagram.
- Select 'Shaft centerline' and click on 'Get shaft rest position'.
- Select one of the available methods.



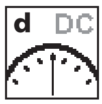
Step 7)



Shaft centerline diagram



Step 8)



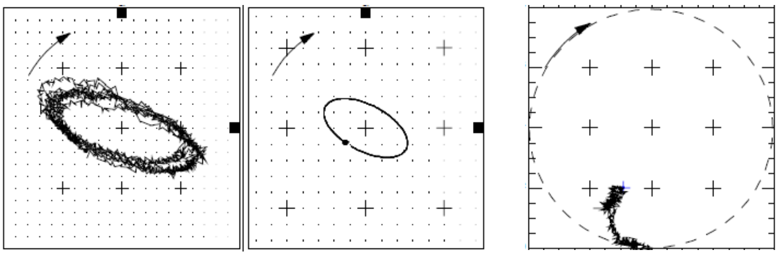
Shaft rest position

C. Typical examples

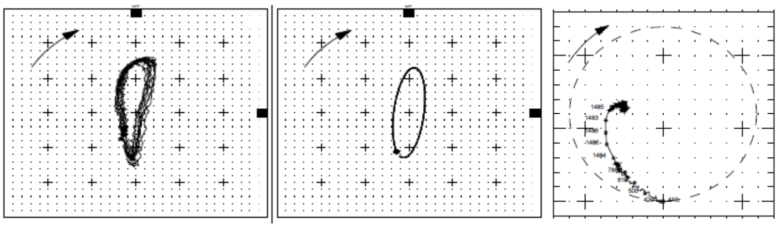
This section shows examples of fault patterns that occur frequently and their causes:

- Preload caused, for example, by misalignment at the coupling
- Instabilities in the oil film (oil whirl, oil film vibrations)

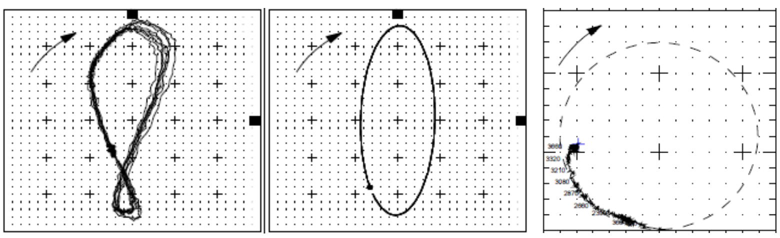
The examples on this page were taken from 'What are shaft orbits anyway', 5th edition, 2003, by Mark A. Jordan



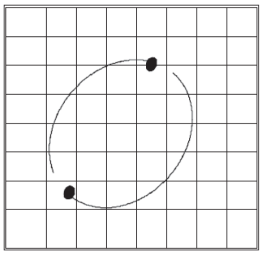
Unfiltered and 1st order shaft orbit for a virtually preload-free machine with a clockwise rotation. The shaft centerline rises by less than half of the bearing clearance in the direction of rotation when the machine is started up. If the machine turns counterclockwise, the diagrams are mirrored along a vertical axis.



Shaft orbit and shaft centerline path in the presence of radial preloads caused by machine misalignment. The orbit has a very flat elliptical form, and the shaft axis rises by more than half of the bearing clearance in the direction of rotation.



Shaft orbit and shaft centerline path in the presence of very strong preloads caused, for example, by misalignment and loads due to connected pipes. The unfiltered orbit shows opposing movement ('figure 8'), the filtered orbit is very flat and the shaft centerline runs along the bearing housing.



The shaft orbit in the first order shows subharmonic vibration at approximately half the rotational frequency (two Keyphasor® markers) caused by self-excited oil whirl. In VIBXPERT®, an order filter of the 0.5 order can be set to be able to recognize this fault pattern.

PRÜFTECHNIK Condition Monitoring
Oskar-Messterstr. 19-21
85730 Ismaning, Germany
www.pruftechnik.com
Telefon: +49 (0) 89 99 61 60
Fax: +49 (0) 89 99 61 63 00

PRÜFTECHNIK Condition Monitoring - LIT.53.618.EN.11.2009