

VIBRORACK1000 Analyzer System Hardware Manual

OPERATION AND MAINTENANCE
MANUAL



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□ Introduction:

VIBRORACK1000 is a multi-purpose vibration analyzer which has been developed to be used in different conditions from harsh environmental situations to laboratory modal testing applications. Based on the software and hardware options the customer chooses, it may be used as:

1- Condition monitoring system installed parallel to other 3rd party vibration protection systems:

In this application, VIBRORACK1000 is connected to the buffered output signals of vibration protection systems like Vibrometer® VM-600, Bently-Nevada® 3500, Schenck VibroControl® 4000 etc. and use transducers connected to the aforementioned protection systems as inputs to VIBRORACK1000 and perform all the required on-line vibration analysis like waterfall, FFT spectrum, time signal, historic trend and so on to improve the system from protection monitoring to on-line condition monitoring.

2- Protection & Condition monitoring system:

In this application, vibration transducers are installed on different points of the machine and connected to VIBRORACK1000 through cabling and junction boxes. All the required processes for an on-line condition monitoring system is done and data is monitored to the user via a control PC.

3- Laboratory Vibration Analyzer:

For this application, a pack of useful modal analysis, acoustics and vibration analysis software modules are installed to be used for the determination of mode shapes and natural frequencies of the structure under test (SDOF & MDOF FRF), ODS (Operating Deflection Shape) analysis, sound quality (loudness & harshness) analysis, OMA (Operational Modal Analysis).

□ VibroRack1000 Overview:

- Function

The VibroRack1000 System provides continuous, online analyzer suitable for machinery protection applications, and is designed to fully meet the requirements of API 670 standard for such systems.

For the majority of applications, ABP Co. recommends the use of our VibroRack1000 Series Machinery Analyzer System.

- Rack

The VibroRack1000 is available in a 19-inch 2unit Size. VibroRack1000 dimensions defined through following items :

Length: 48 cm

Width :9 cm

Depth : 27 cm

- Back

At the Back side of VibroRack1000, there are 3 connectors in 1 row (refer to figure1)

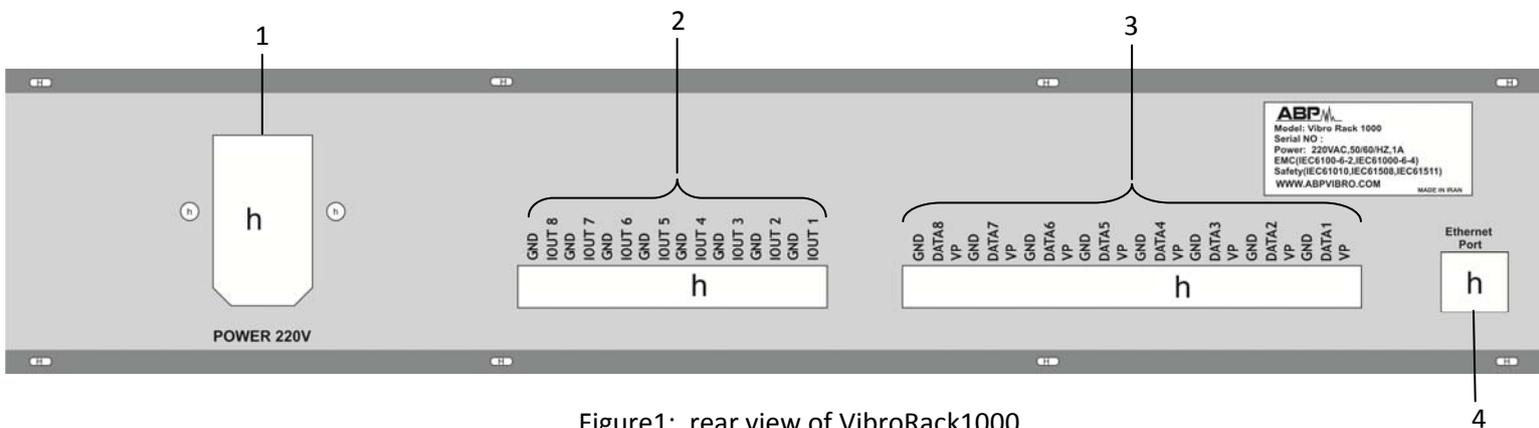


Figure1: rear view of VibroRack1000

1. Power supply is available in AC version.
2. Current output of sensors (4~20mA) is available on the each channel which can be used for connecting to PLC or DCS systems.

- Input vibration sensors (accelerometer sensors, velocity sensors and eddy current sensors) tachometer sensors, conditioners and vibration switches are connected to VibroRack1000

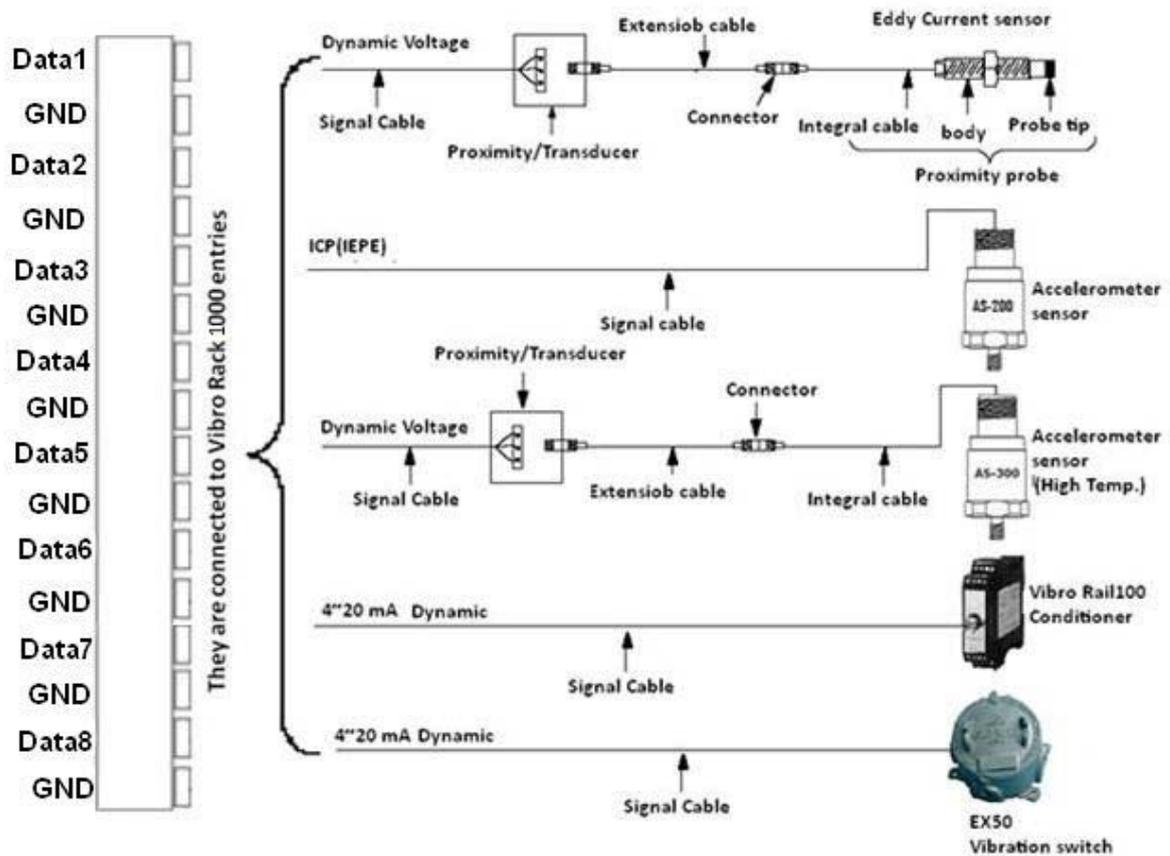


Figure2: Method of connecting sensor

- Ethernet port which provides TCP/IP protocol. Via this port, VibroRack1000 can be connected to a diagnosis software installed on for example panel PC

□ Jumper status on VibroRack1000 card:

There are several jumpers on the VibroRack1000 card, in the following each of them will be explained.

- JGS-X jumper:

Gain is an approach to define a particular range to display units in a better manner. You can observe gains with each defined range per them at 1000 system (refer to table 1) Gain is adjusted to gain1 by default which values between (0-100) Can be displayed by this gain and user can select other range by changing gain jumper. (Refer to table1)

Jumper	Jumper Status	Comment
JGS-X		Gain10 (0- 20mm/s)
		Gain5 (0-50 mm/s)
		Gain2 (0-100mm/s)
		Gain1 (0-200mm/s)

Table 1: JGS-X jumper

- filter jumpers:

There are 3 jumpers about filter:

- 1. JBWS-X (jumper band width selector-channel No.):** Operator can select the value of filter with JBWS-X jumper. (Refer to table2)

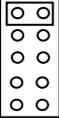
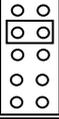
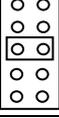
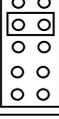
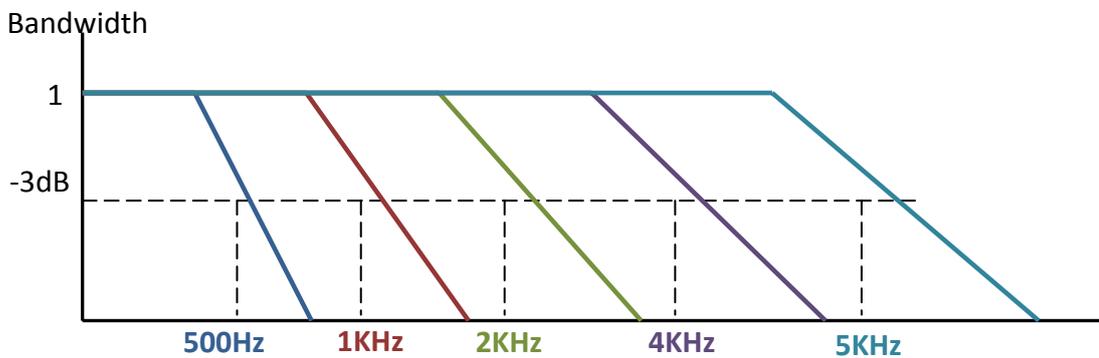
Jumper	Jumper Status	Comment
JBWS-X		500 Hz Bandwidth
		1KHz Bandwidth
		2KHz Bandwidth
		4KHz Bandwidth
		5KHz Bandwidth

Table 2: JBWS-X jumper



2. JOS-X jumper (jumper order selector-channel No.): Operator identifies the order of filter with select filter out jumper. (Refer to table3)

Jumper	Jumper Status	Comment
JOS-X		Root raised cosine linear phase 5 th order lowpass filter
		Root raised cosine linear phase 10 th order lowpass filter

Table 3: JOS-X jumper

3. JFIS-X jumper (jumper first integrator selector-channel No.):

(Refer to table 4)

Jumper	Jumper Status	Comment
JFIS-X		Integrator (mm/s)
		Filter output (m/s ²)

Table 4: JFIS-X jumper

- JIS-X jumper (jumper input sensor selector-channel No.):

To select this jumper depends on the type of input sensors. For example: if input sensor is accelerometer, operator must choose ICP select. (refer to table5)

Jumper	Jumper Status	Comment
JIS-X		ICP Select
		DC-gap Select
		Current input Select

Table 5: JIS-X jumper

- JCVS-X jumper (jumper current/voltage selector-channel No.):

If JCVS-X jumper is used to select source signal for related channel, then output will be 0 -5 Volt or 4-20 MA.

There are two jumpers on the vibroRack1000 card for each channel to select overall/dynamic data or signal source. These two jumpers let you select overall/dynamic data of channels for sending analog output (4~20MA) or vibration source signal. (Refer to table 6).

Jumper	Jumper Status	Comment
JCVS-X		Voltage signal , 0-5 V
		Current signal, Dynamic/ Overall

Table 6: JCVS-X jumper

- **JDS-X jumper (jumper DC-Gap signal-channel No.):**

This jumper is used when the JCVS jumper is selected in Voltage mode. (Refer to table7).

Jumper	Jumper Status	Comment
JDS-X		In this mode ,Voltage signal of JCVS-X must be selected
		-

Table 7: JDS jumper

- **JSS-X jumper (jumper source selector-channel No.):**

This jumper let operator to select the output type. The signal is transferred to JCVS jumper after through from JSS jumper. (Refer to table8)

Jumper	Jumper Status	Comment
JSS-X		DC-gap output value
		Output Dynamic signal
		Overall output value

Table 8: JSS-X jumper

- **JDGS-X jumper (jumper DC-gap signal-channel No.):**

For measuring the DCgap, there is one jumper on the VibroRack1000 card that can select negative or positive power supply for eddy current sensor: (refer to table9)

Jumper	Jumper Status	Comment
JDGS-X		Select Negative Power Supply
		Select Positive Power Supply

Table9: JGS-X jumper

- **JDRS-X jumper (jumper DC reference selector-channel No.):**

Operator can choose DC reference with JDRS-X jumper. (Refer to table10)

Jumper	Jumper Status	Comment
JDRS-X		If input sensor <u>isn't</u> eddy current, this jumper will be selected in this mode and use the DC-gap reference value (2.5VDC)
		If input sensor is eddy current, this jumper will be selected in this mode and use the DC-gap value of sensor

Table10: JDRS-X jumper

- **JBOS-X jumper (jumper buffer output selector-channel No.):**

The status of this jumper depends on the input sensor (accelerometer sensor or eddy current sensor). (Refer to table 11)

Jumper	Jumper Status	Comment
JBOS-X		If input sensor is accelerometer (absolute),this mode will be selected and the signal is without DC
		If input sensor is eddy current (relative),this mode will be selected and the signal have DC value

Table11: JBOS-X jumper

- **JBIOS-X jumper (jumper BNC Input/output selector-channel No.):**

This jumper let operator select BNC as a buffer output or a sensor input.
(Refer to table 12)

Jumper	Jumper Status	Comment
JBIOS-X		BNC as a sensor input
		BNC as a buffer output

Table12: JBIOS-X jumper

□ Potentiometers on VibroRack1000 card:

Potentiometers	Application
POT1	Identify the value of ICP
POT3	Identify the value of DC-gap
POT4	For calibration of integrator of Filter out jumper

Table13: Potentiometers

□ Power supply LED

There are 3 LEDs on vibrorack1000 card for test point.

	Application
+5v and – 5 v	Indicates that Internal system boards voltage and COMMUNICATION voltage is provided or not.
+24v	Indicate that the driving power of sensor is provided or not
The related LED will be turned off, during disconnection or fuse defection.	

Table14: LED status of power supply

□ Power Supply Maintenance

This section shows how to verify that the system is operating properly and identify parts of the system that are not working properly.

When performed properly, this module may be removed from the rack while power is applied to the rack.

 <p>CAUTION</p>
<p>Proper rack chassis grounding requires that this metal strap remain connected. Failure to follow this warning could expose personnel to dangerously high voltage levels that could cause shock, burns, or death.</p>

 <p>Warning</p>
<p>Power Supply shield may be hot when the rack is operating at elevated temperatures or under full load.</p>

□ Type of channels

Each channel can receive input from any type of sensor (displacement, velocity, accelerometer), in addition supports tachometer sensor on channel 1 .

Tachometer sensors:

- Frequency or RPM represents the machine rotation.
- Alarm set point & shutdown set point, represent the maximum permissible deviation from frequency reference. Regarding to alarm and shut down respectively.

For example if frequency reference is 3000 rpm and alarm set point is 100. When rpm become less than 2900 or exceed 3100, alarm 1 or alarm 2 will be activated respectively.

- Reset Alarm & Reset shutdown are used to reset activated alarm & shutdown respectively.
- Delay is defined as time delay between accruing an alarm or shutdown and relay activation.
- Scale represents the scale of sensor when Eddy current is used as a tachometer.
- DC- Gap default, represents the default distance between eddy current sensor and shaft, the type of tachometer is defined eddy current.
- Type of sensor defines type of the connected tachometer sensor (It can be eddy current or photo electric)

NOTE: We have two type of Tachometer:

- Eddy current Tachometer
- Optical Tachometer

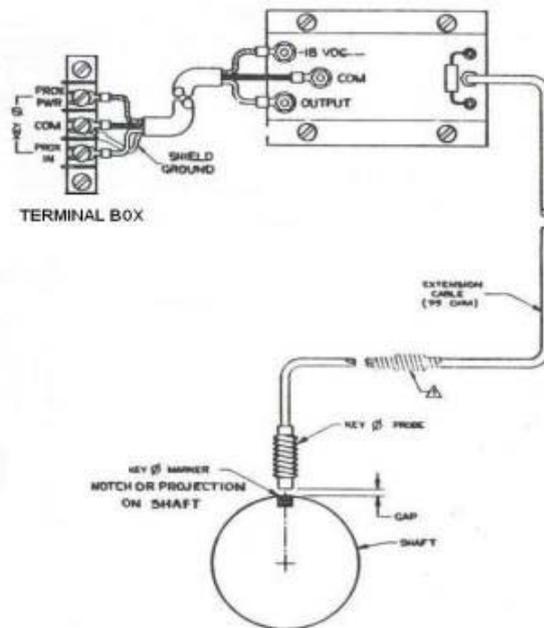


Figure2: Tachometer Sensor

- Eddy current Tachometer:

KEYPHASOR PERFORMANCE TESTING

A Keyphasor is a special application of a probe and Proximitor. The probe views a shaft marker (either a notch or projection) to give rotational reference of shaft speed and phase. Figure 15 shows a relationship of probe pickup to oscilloscope display for both notch and projection.

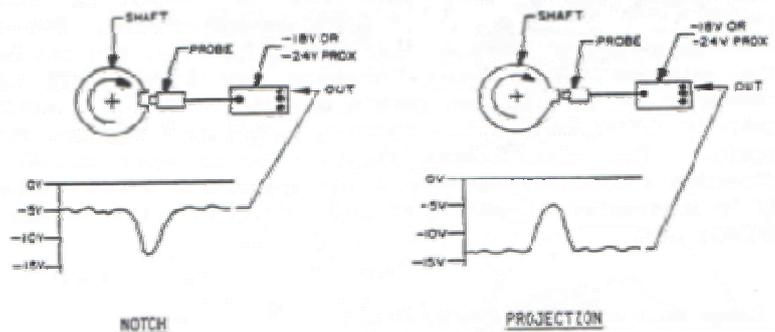


Figure3: keyphasor Typical Optical

a. Connect an oscilloscope between the Keyphasor and COM terminals on the Power Supply Signal Module. With the machine running, the oscilloscope display should be

Similar to one of the two illustrations in Figure 15. Depending upon whether Keyphasor probe observes a notch or a projection.

b. If no output is obtained in step a, check for faulty wiring between the Power Supply Signal Module and the Proximitors.

c. If step b does not isolate the trouble, disconnect the 95-ohm extension cable at the Proximitors and measure 4 to 10 ohms between the center conductor and the shield.



NOTE

The approximate resistance of the probe with 50-ohm integral cable and connector is 4 to 10 ohms. The 95-ohm extension cable has an approximate resistance of 0.0762 ohms per meter (0.25 ohms per foot). However, the wide variation in resistance of probe with 50-ohm integral cable and connector causes most measurements to be between 4 to 10 ohms, except for very long extension cables. The measurement should not be a short nor much more than 10 ohms.

d. If step c is not satisfactory, disconnect the 95-ohm extension cable from the probe 50-ohm integral cable and connector and measure 4 to 10 ohms between the probe center conductor and the shield. If this measurement is not satisfactory, replace the probe.

e. If steps b through d is satisfactory and trouble is still indicated, replace the Proximitors

- Optical Tachometer:

This type of tachometer uses when we cannot puncture shaft.

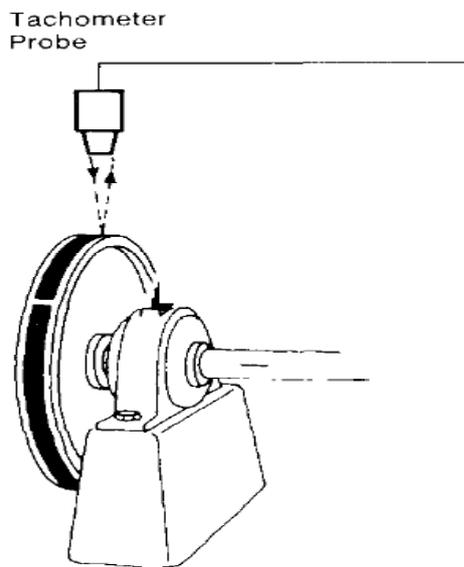
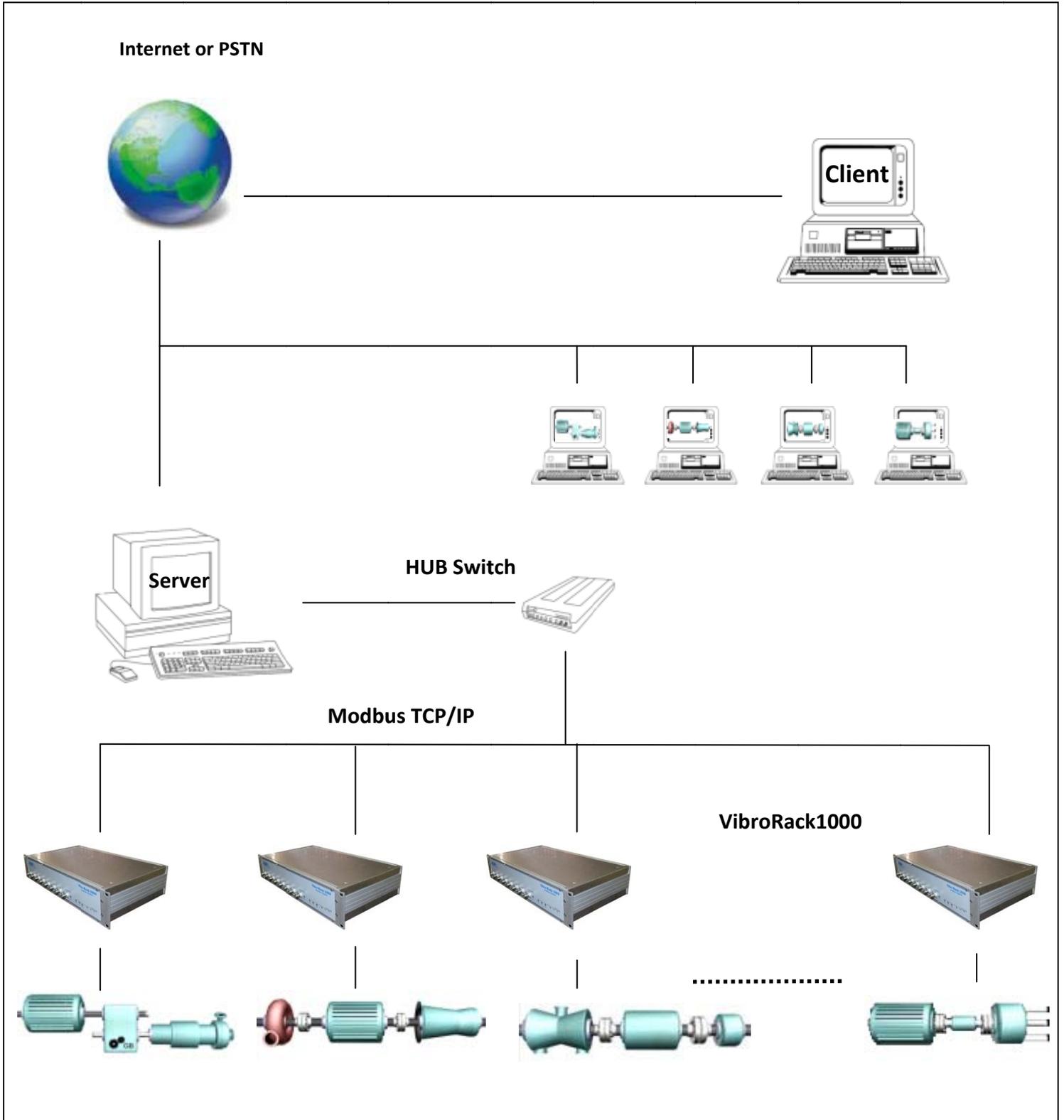


Figure4-Optical Tachometer

Ethernet

Ethernet refers to a hardware protocol. Many VibroRack1000 systems can be connected on a Ethernet protocol network and can communicate with each other. By TCP/IP protocol you can connect two or more VibroRack1000 systems and they either connect to HMI software by this protocol. The VibroRack1000 diagnostic software uses Modbus Ethernet protocol for all its network transmissions. This means it can be integrated to an already existing Ethernet network without affecting the current operation of the existing one.

- VibroRack1000 (TCP/IP) Networking Diagram



❑ **Sensor testing method:**

- Accelerometer sensor

For Accelerometer sensor testing with ICP type and voltage type, sensor data connector should be connected to VibroRack1000 card sensor connector and sensor com connector should be connected to VibroRack1000 card GND connector.

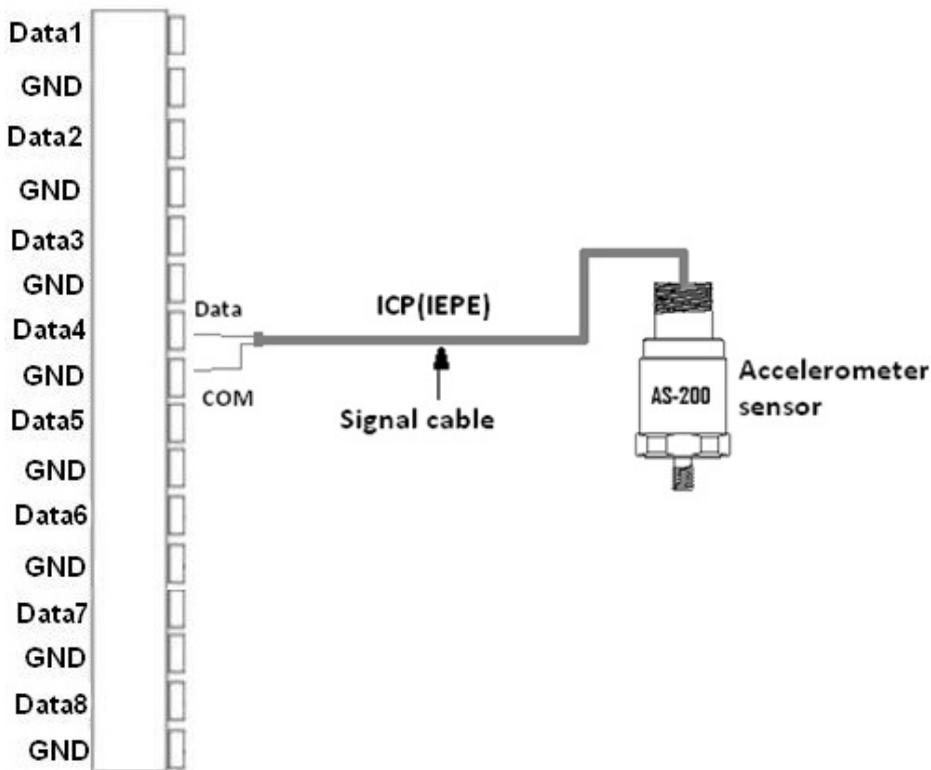


Figure5: Accelerometer sensor testing with ICP mode (3ma)

- Accelerometer sensor

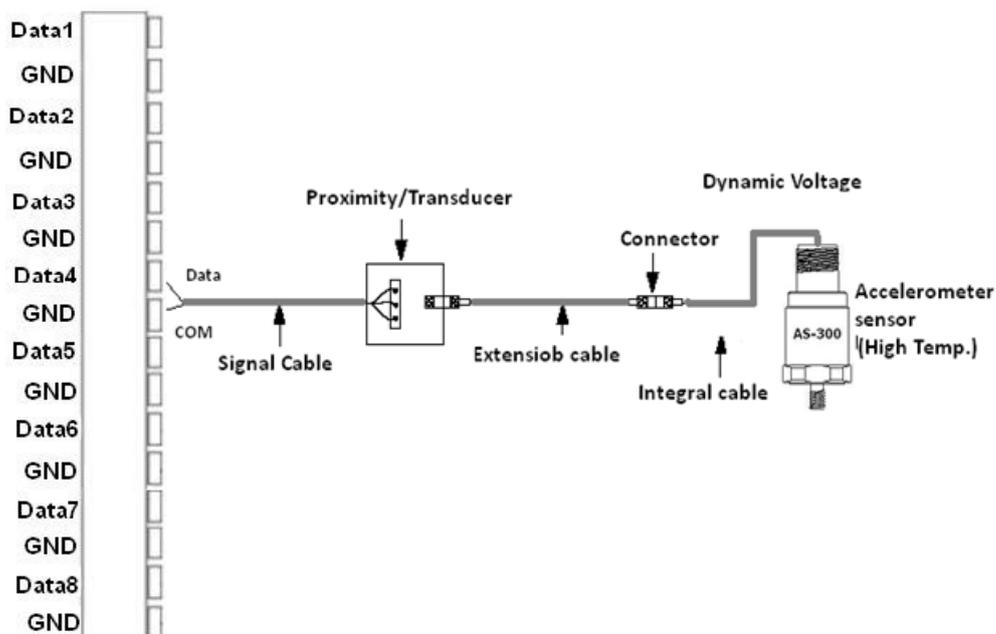


Figure 12: Accelerometer sensor testing with voltage mode

- Eddy current sensor

For Eddy current sensor testing with voltage type, sensor data connector should be connected to VibroRack1000 sensor connector, sensor com connector should be connected to VibroRack1000 GND connector and sensor third connector (vcc connector) should be connected to -24v.

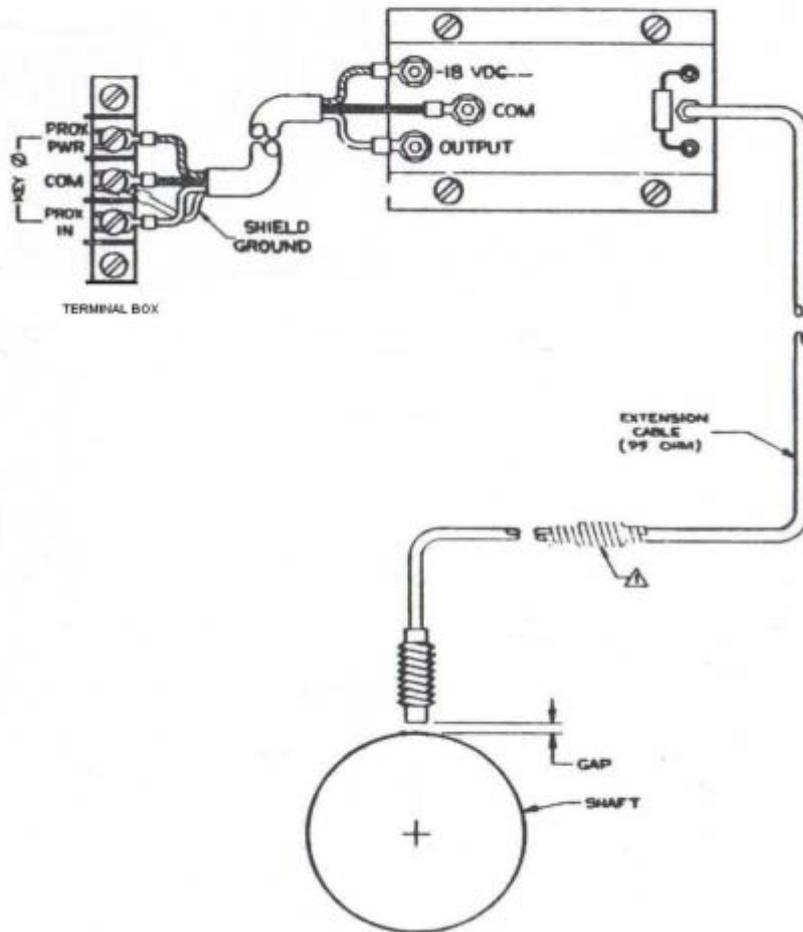


Figure 5: Eddy current sensor testing with voltage mode

- There are 8 LEDs on the front view of the VibroRack1000 for each channel that shows the testing of sensors is OK and sensor operate correctly.

□ **VibroRack1000 card and sensor Testing steps through digital Shaker**

The shaker is a portable calibration device for accelerometers, velocity sensors, vibration transmitters, and proximity probes. The portability of the shaker allows for using in the laboratory and field. The shaker has a built-in electro-magnetic shaking head that will generate vibration. The vibration can be digitally tuned for acceleration, velocity, or displacement with RMS, peak, or peak-peak readings. There is a display option for English or metric units. To obtain the standard calibration curve, the shaker will supply sensor power, receive the output from the sensor and compare the sensor output vs. the standard accelerometer output. The shaker is digitally controlled. Software is available to remotely control or display the calibration status. It can also be used as an automatic vibration test device by using third party software that interfaces with a standard RS232 port.

- **Sensor Installation steps**

1. Remove the wrench attached on the portable shaker. Fix the shaker head with one hand. Mounting the seismic sensor onto the shaker head with another hand. There are four different screws inside the shaker. You may just pick the one that fit the thread size on the seismic sensor. The thread on the shaker head is a standard 1/4-28 English thread.
2. Connecting the sensor with connectors and monitors.
3. Different seismic sensors have different ways in connection. Be aware of that the shaker head will not withstand large torque. Minimum vertical displacement should also be maintained while connecting the connectors to

the sensor. If necessary, the wrench has to be fixed on the shaker head to protect it.

4. Connecting the signal cables to monitor. Be aware of the field-wiring connection of the monitor

5. For calibration the sensor with shaker's internal circuitry, signal cable will connect with the green connectors on the front panel of the shaker.

6. Operation of the shaker.

- After performing this setting for this module, the observed overall vibration data on the shaker display should be equal to the observed overall vibration data on the VIBRORACK3000 display.

The low percent of fault can be ignored.

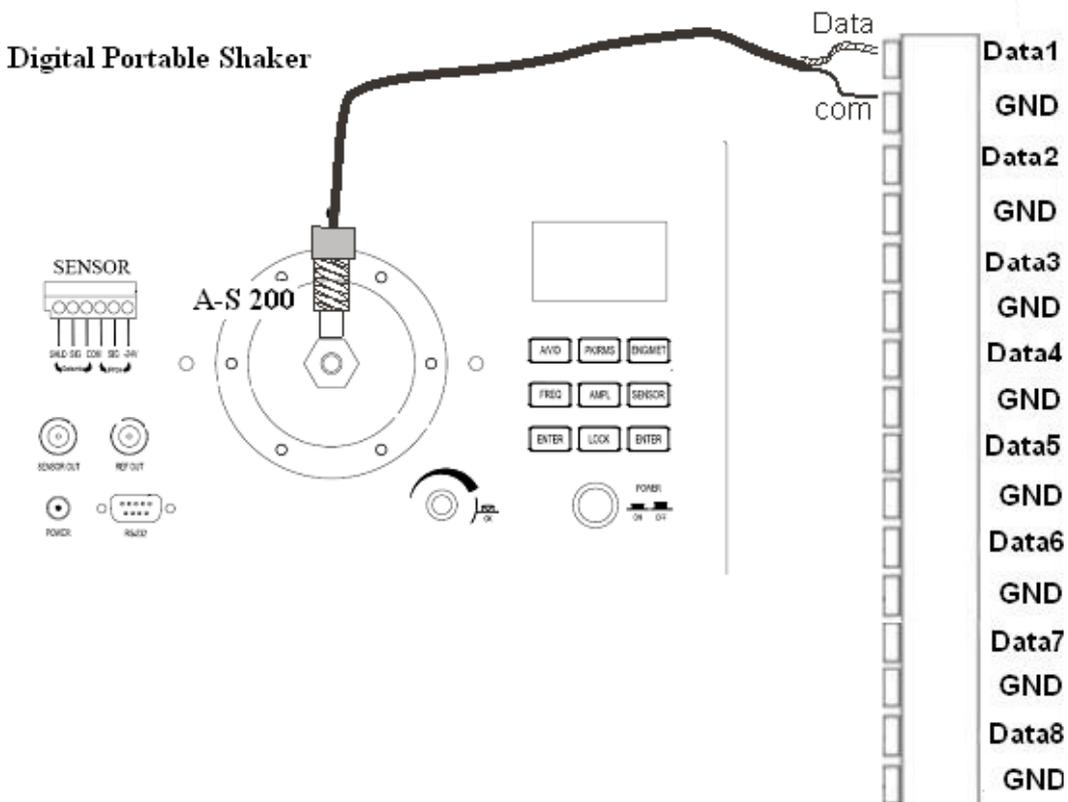


Figure6: VibroRack1000 card and sensor testing with shaker

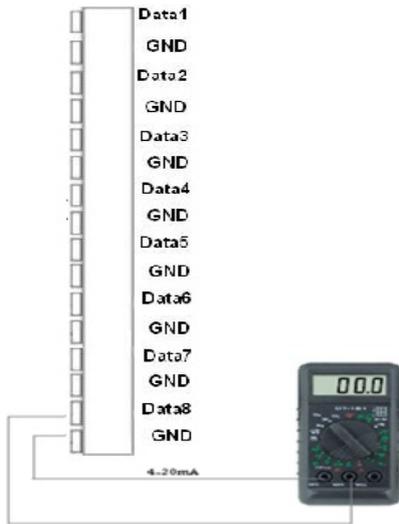


Figure7-current mode

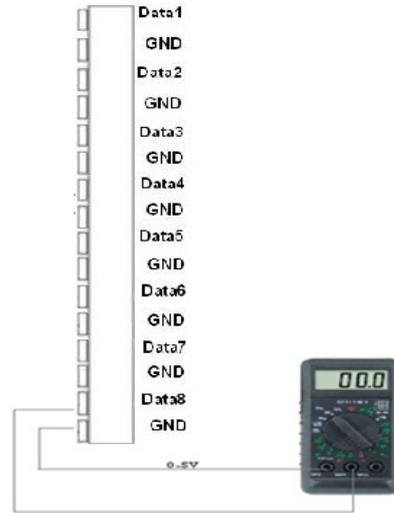


Figure8-voltage mode

We have applied calibrated signal to shaker and read output current and voltage for Gain 1. (Refer to Table 15)

Read vibration was logged from shaker	4-20 mA out put	0-5 volt out put
5mm/s	4.4mA	49mV

Table15- vibration was logged from shaker (for Gain 1)

Jumper	Jumper Status	Comment
JCVS-X		Voltage signal , 0-5 V
		Current signal, Dynamic/ Overall

Table16: JCVS Jumper status

❑ Cable Testing

In case of long length, in which both sides of cable can't be connected to the ohm meter simultaneously, so this approach will be advised in such case:

- 1) If user applies short circuit on pins(no.2,3) and checks green and black wires on the other side of cable by ohmmeter, low ohm(0~3) should be observed.
- 2) If user applies short circuit on pins(no.2,4) and checks red and black wires on the other side of cable by ohmmeter, low ohm(0~3) should be observed.
- 3) If no pins has been short circuited, by checking wires on the other side of cable, no value should be displayed.

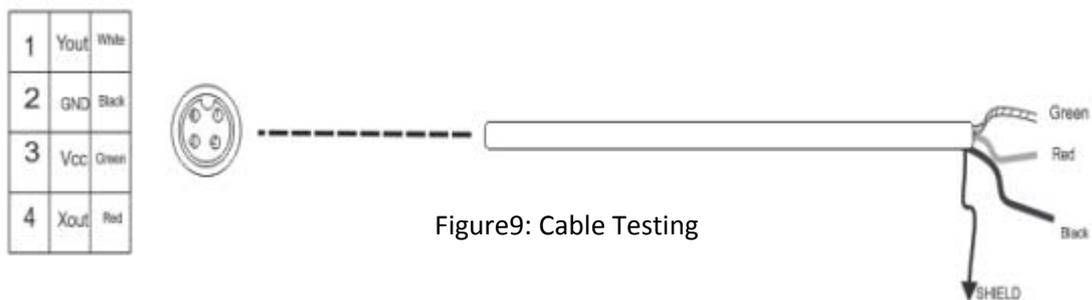


Figure9: Cable Testing

Accelerometer mounting:

Coupling:

General rule.

The weight of the acceleration sensor should always be lower at least by a Factor ten than the weight of the object onto which it is mounted.

The acceleration sensor is an additional parasitic mass which loads the object on which it is mounted and this changes the vibration behavior if it is too large.

Mounting the acceleration sensor

The acceleration sensor requires a friction-locked, contact resonance-free, rigid mounting to the object, particularly for measurements at high frequencies.

- ◆ The sensor is to be attached using the supplied threaded stud, either:
- ◆ Threaded stud M5

The sensor may be mounted in any direction.

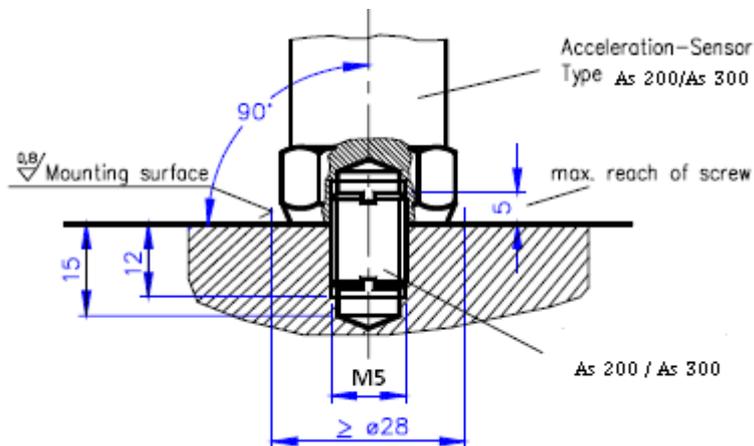


Figure10- Accelerometer Sensor Mounting

- ◆ The mounting surface in the area of the sensor must be flat and machined
- ◆ Provide a size M5, resp. 1/4" threaded hole 12 mm deep in the surface of the machine
- ◆ Apply a thin film of silicone grease on the mounting surface to prevent contact resonance

- ◆ Screw the M5, resp. 1/4", stud into the mounting surface in accordance with Fig. 4 and secure it with sealing, e.g. LOCTITE 243 medium strength, or LOCTITE 270 high strength
- ◆ Maintain a max. length of the threaded stud ≤ 5 mm for acceleration sensors
- ◆ Screw the sensor onto the threaded stud, observing the corresponding maximum torque for the threaded stud
- ◆ Recommended maximum torque for the supplied threaded stud is 3,5 Nm

Bearing Housing Mounting:



Notes:

1. Drill and tap housing for 3/4"NPT (typical).

2. Set sealing adapter tight in bearing housing before pulling lead wires.

3. Identify leads prior to installation. Use tag numbers as required.

* Probes must be mounted perpendicular to shaft.

* Do not pull thermocouple wire and probe lead wires into same outlet without Engineering Department approval.

6. Check gap Volts after Es500 assembly has been installed.

Set gap at -10 volts (50mil)

7. Extending cable connectors . Then wrap

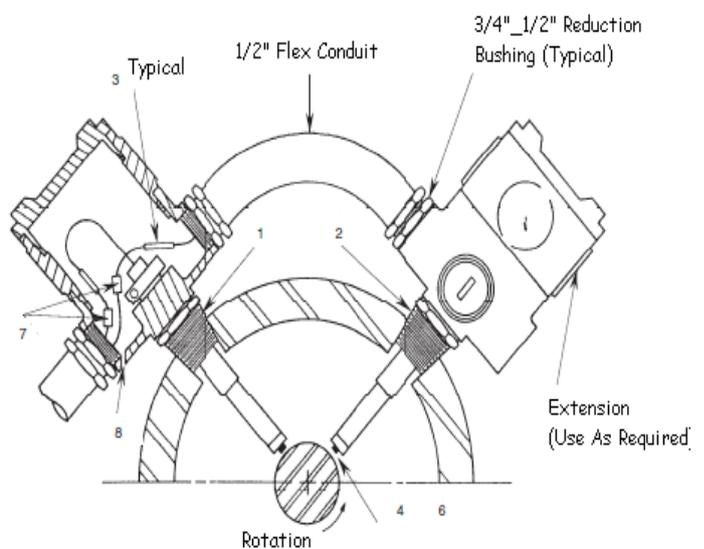


Figure11

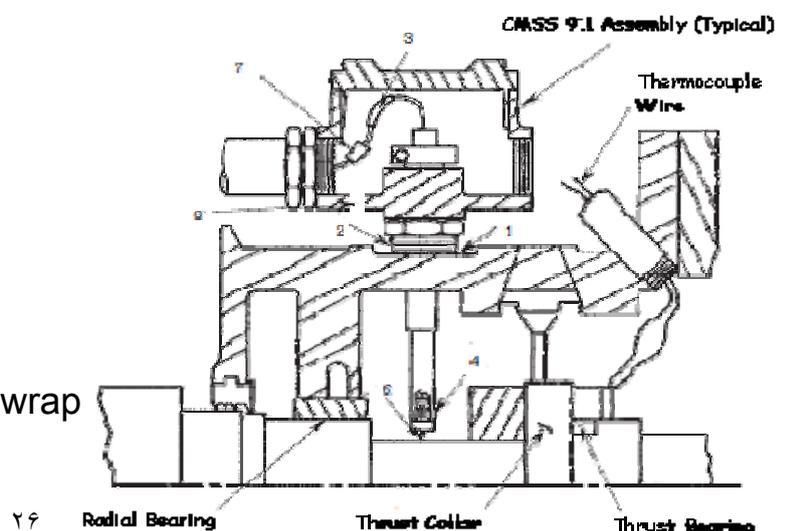


Figure12

connections with Teflon tape (typical).

8. Drill 1/4" drain hole in lowest point of box (typical)

Axial Probe Installation:

Thrust Probe Installation

Recommendations:

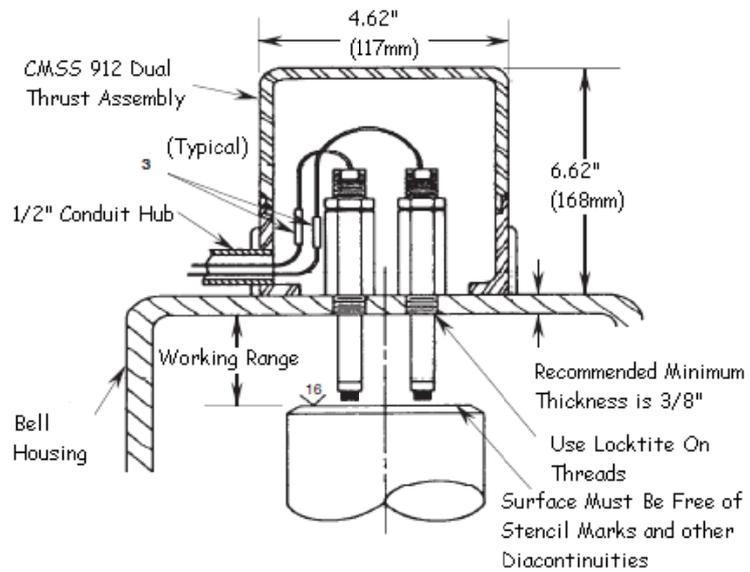


Figure 13

- * At least two probes per rotor are recommended.
- * Where the probes cannot be changed without shutting down the machine, install spare probes.
- * Calibrate probe, cable and driver and record final response curves for primary as well as spare probes. The ABP Condition Monitoring Gjx-3 Static Calibrator may be used.
- * Try to observe the thrust collar with one probe and the shaft with the other.
- * Probes must be mounted within one foot of the thrust collar.
- * Avoid mounting probes through thin plates or bell housings that may bow with thermal expansion.
- * Determine the float zone of the rotor by jacking the rotor in both directions. Use up to 2 tons pressure.
- * Measure the rotor movement with dual indicators on the shaft, the Eddy Probe voltage change at the driver and the monitor reading. (All

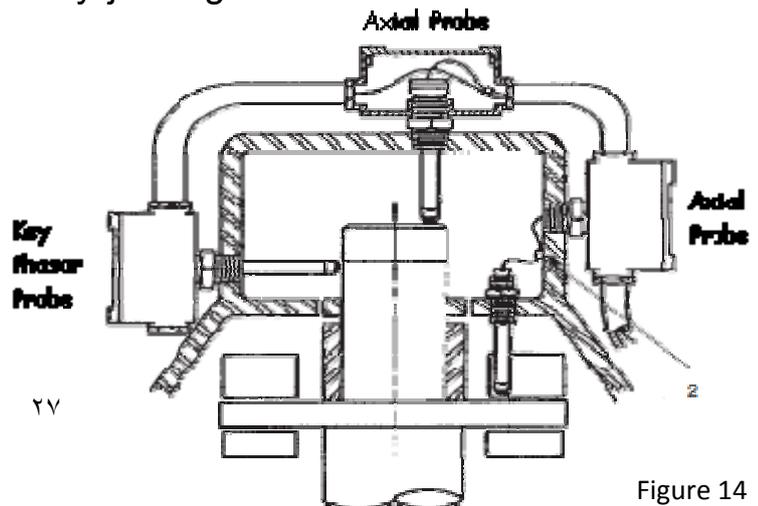


Figure 14

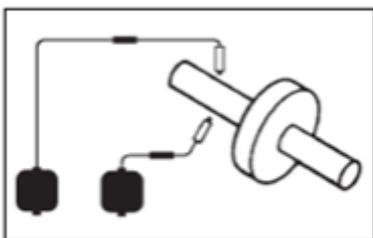
three should agree.)

- * Jack the shaft several times each way to verify readings.
- * Set the probe gap so that the center of the probe's range is in the center of the float zone.
- * Securely lock the probe and any adapters in place.
- * Be sure the probe tip has a side clearance of at least 0.200".

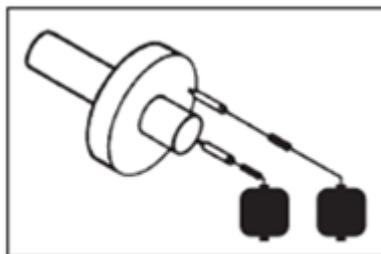
! Notes:

There are other types of mounting for Eddy current sensors:

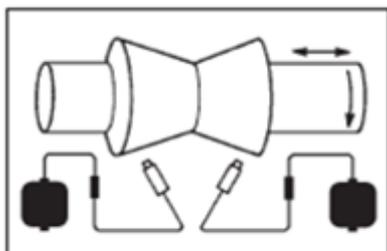
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|---|--|--|
| <p>1. Set sealing adapter tight in housing before pulling lead wires through.</p> <p>2. Probe lead wires must be secured against internal whipping and rubbing.</p> <p>* Identify probe leads prior to installation. Use tag numbers as required.</p> | <p>* Probes must be mounted perpendicular to shaft or surface it is "seeing".</p> <p>* Do not pull thermocouple wires and probe lead wires into same outlet without engineering department approval.</p> | <p>* Check gap volts after Es-500 assemblies have been installed. Use digital voltmeter</p> <p>* Set gap at midpoint of probe range at the center of the float zone.</p> <p>*extending cable connectors . Then wrap connectors with Teflon tape.</p> |
|---|--|--|



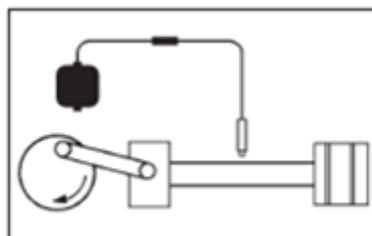
Radial Motion of Rotating Shaft



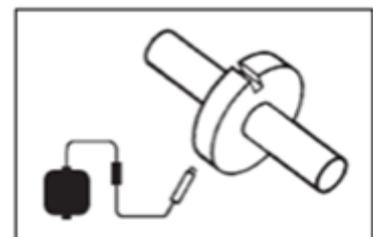
Axial (Thrust) Position



Differential Expansion

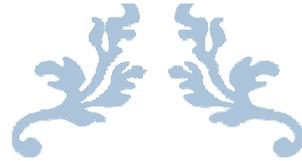


Rod Drop



Key phasor/Speed

Ver.1



VIBRO-CONDITION MONITORING SOFTWARE

Software manual



JULY 26, 2014
ABPVIBRO

www.ABPVibro.com

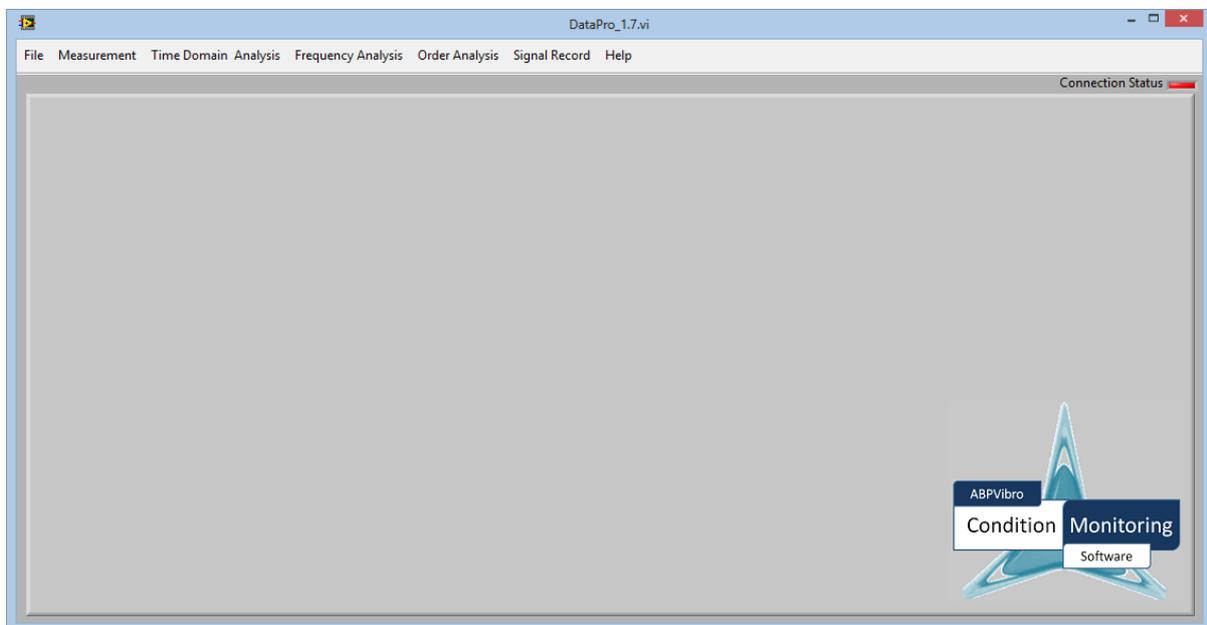
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Vibro-Condition Monitoring software

Introduction to VIBRO-CMS:

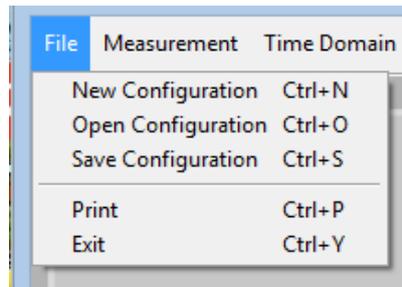
VIBRO-CMS (Condition Monitoring Software) is an application which has been developed for the measurement & recording of signals from transducers/ sensors; it can be used for machine condition monitoring, acoustic signal recording, trend monitoring, order analysis etc. moreover, it records data needed for MDS which is used for off-line data review and analysis. It contains mostly used functions to provide engineers with a collection of the most beneficial tools for condition monitoring & vibration analysis .VIBRO-CMS connects to VibroRack 1000 & VibroRack 3000 data acquisition modules and performs measurements & recordings. It gets measurement files of ABPVibro condition monitoring systems as input.



Vibro-Condition Monitoring software

File menu

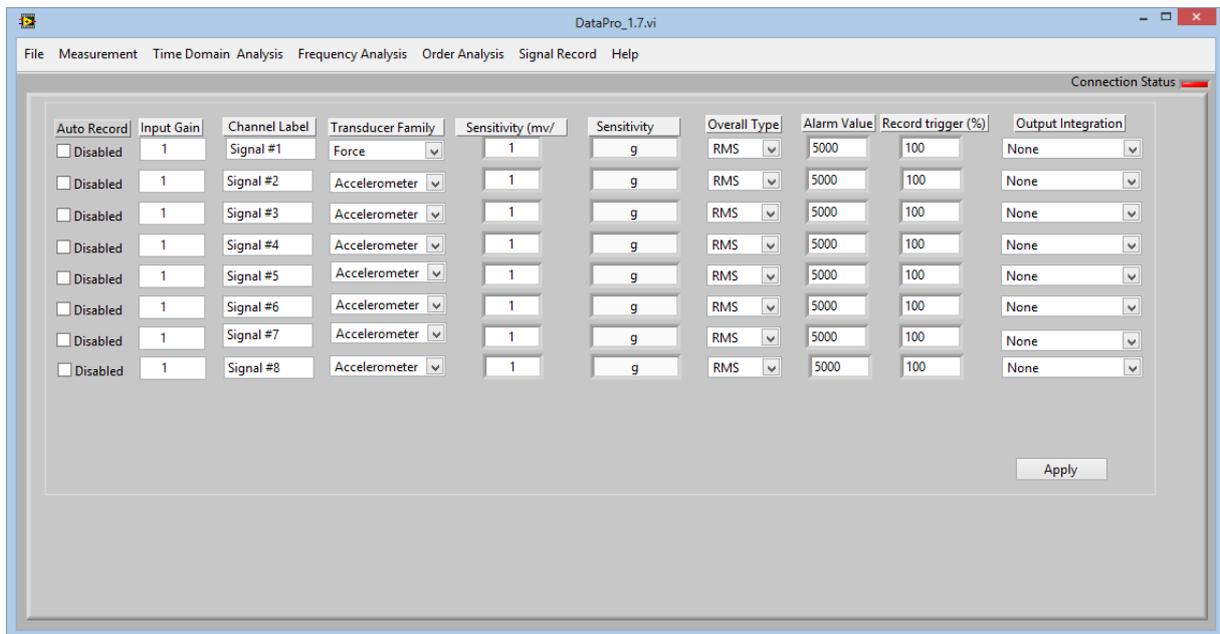
File menu contains menus which are needed for the configuration of the sensors & transducers which are connected to the analyzer. It has functions like New, Open & Save configuration with print and exit options. File menu is shown below.



File menu

New Configuration

New configuration is the menu which is used to call the sensor settings and is depicted below.



The first column is auto record enable/disable option and is used when user wants the recording function to start automatic as soon as an input value goes beyond a set value (Record trigger). Second column is input gain. User has to enter this value for each measurement channel from the input gain hardware on the analyzer board. Third column, Channel label is used for signal labeling and easier use, one may tag it as MDEV for Motor End Drive Vertical direction. Fourth column labeled as Transducer family is used for the determination of type of transducer. It may be

Vibro-Condition Monitoring software

displacement, velocity, acceleration, force, tachometer or microphone. Fifth column which is labeled sensitivity is the nominal voltage sensitivity of the sensors e.g. 100 mv/g for a typical accelerometer or 200 mv/mil for a typical displacement transducer. Sixth column is for the setting of sensitivity unit g, mm, mm/sec etc. For example for acceleration measurement there are a number of common units such as: g, m/sec², in/sec².

Column number 7 or overall type is related to the overall value parameter which is used for the status of the machine determination and also for activating the auto record function. There are 3 options RMS, Peak & Peak to Peak for measurement which may be selected separately for overall value calculation of each channel. Usually peak-peak is used for displacement while RMS is used for acceleration signal measurement.

Column 8, Alarm value is for setting the alarm value which is used for overall monitoring page in time domain menu. Moreover it is used for auto record definition.

Column 9, Record trigger (%) is the value in percent which is used for the activation of auto record signal. For example if Alarm is set to 3 g & Record trigger to 70 % and Overall RMS then whenever RMS of the overall vibration acceleration on the corresponding channel is more than $70\% * 3g = 2.1g$ software starts to record vibration signals into .dat measurement file.

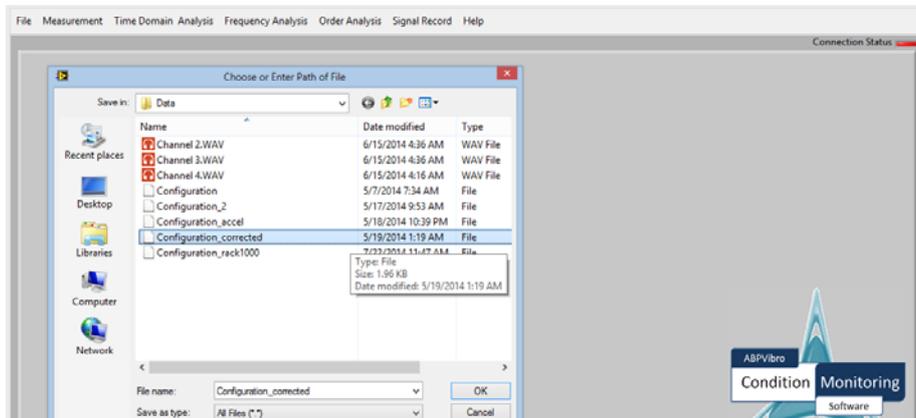
Column 10, Output integration is used for the integration of vibration signal output and is just valid for two kinds of transducers:

- 1) Acceleration signal may be integrated once for velocity calculation and integrated twice to output displacement signal.
- 2) Velocity signal may be integrated once to output displacement signal.

Open Configuration:

By choosing this option the user may browse the computer for VibroRack 1000 / VibroRack 3000 previously saved configuration file. User may save configuration files for different measurement settings i.e. transducer type, sensitivity, etc.

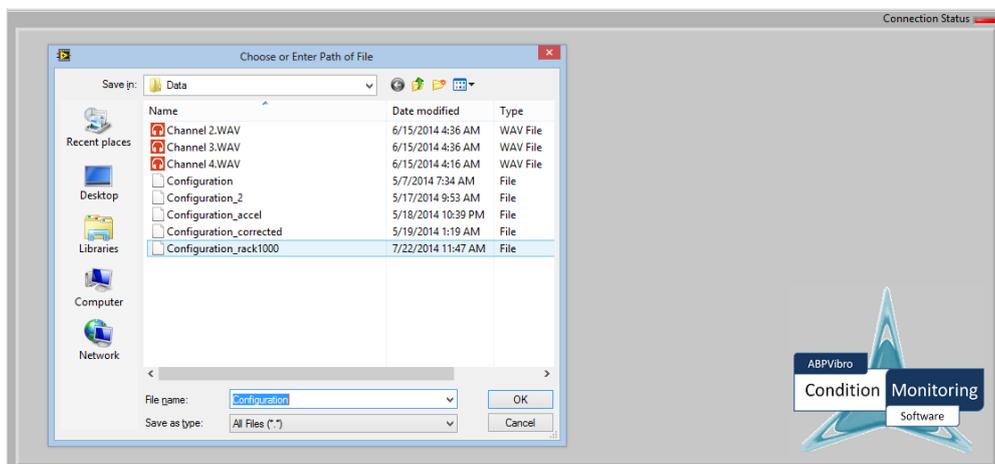
Vibro-Condition Monitoring software



Open configuration browser window

Save configuration

User may save all the sensor settings and measurement settings which have been set in the software in a file called configuration file which may be later used for MDS software or for future calls. This file includes: channel settings, alarm values and all other parametric settings which the user had input to VIBRO-CMS when taking measurements. This submenu Save is used for saving these data once and using them from load data after that.



Save configuration window

Print menu

This menu prints the current screen.

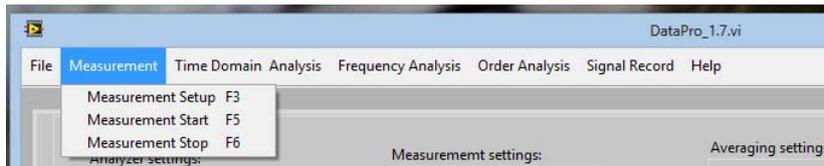
Exit menu

Vibro-Condition Monitoring software

This option is used for closing the software.

Measurement

Measurement menu contains options related to measurement settings and start/stop triggering of the analyzer. It has 3 options Measurement settings, Measurement start & Measurement stop.



Measurement Setup

By choosing measurement setup option on measurement menu, user is faced with the following window. Measurement parameters are categorized as: Analyzer settings, Measurement settings, Averaging settings & Tachometer settings.

Analyzer settings consists from the following options:

- 1) Analyzer IP which depends on the network which is the network LAN TCP/IP V4IP address of the analyzer like: 192.168.0.101. Please make sure that the ip configuration of the computer on which VIBRO-CMS is installed must be in the range like: 192.168.0.210.
- 2) Port is the port address number and is usually 80 for most VibroRack 1000 and VibroRack 3000 systems. Otherwise, the number may be obtained by contacting the company customer support center.
- 3) Measurement record path: user should select the folder in which .dat measurement record files should be saved in. These files are later used by MDS software.
- 4) Save interval: this option is the time difference between two consecutive signals save. For example if set on 10 minutes save interval, signal is recorded into .dat once in file every 10 minutes.

Measurement settings consists from the following options:

- 1) FFT window which is used for decreasing the spectral leakage of the frequency spectrum while maintaining the maximum possible amplitude accuracy and has different types: hamming, uniform, flat top, force- exponential ...
- 2) Frequency bandwidth is the maximum frequency bandwidth of interest i.e. 1000 Hz or more. This determines the sampling frequency which is two times the frequency bandwidth. Always remember that this number should be completely consistent with the frequency jumper setting of the hardware board.
- 3) Samples is the number of samples measured from every transducer each time measurement is performed. Always bear in mind that acquisition time is equal to samples divided by 2* bandwidth. For the measurement shown in the following window, it is calculated as follows:

Vibro-Condition Monitoring software

$2000/2*1000=1$ second

Moreover, frequency resolution between 2 consecutive lines of the FFT plot is calculated by inverting the acquisition time so if acquisition time is 2 seconds frequency resolution is $df= \frac{1}{2}=0.5$ Hz.

- 4) Y axis scale is for the scaling of Y axis (amplitude axis) in different plots which may be set to linear or logarithmic.
- 5) High pass frequency, one of the main problems for signal integration happens when the main input signal frequency is low since it causes problems for the integration circuit and introduces some error in the waveform. So it is recommended to put this value a bit lower than the main frequency to minimize integration error. Another way is to increase the acquisition time by increasing number of samples or decreasing the bandwidth.

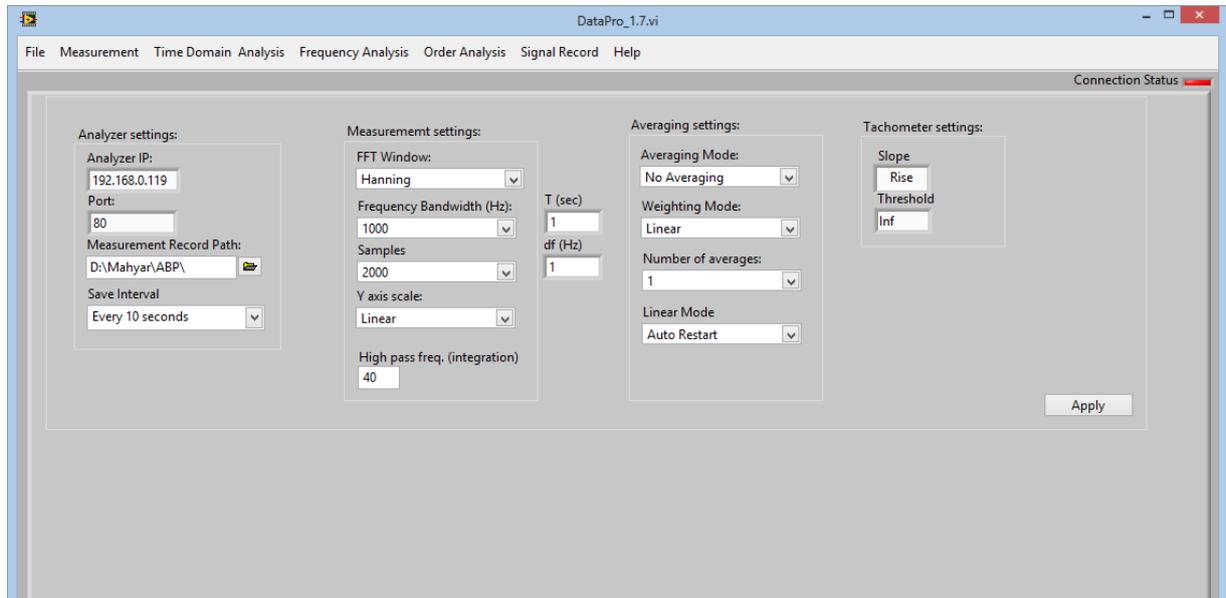
Averaging settings consists from the following options:

- 1) Averaging mode is for the determination of the averaging type and has 3 different averaging algorithms Vector, RMS & H averaging.
- 2) Weighting mode of the averaging can be selected from linear / exponential type.
- 3) Number of averages is for frequency spectrum plot and may be selected from 1 to 32 frames.
- 4) Linear mode defines the averaging process either one shot or auto restart.

Tachometer settings consists from the following options:

- 1) Tachometer settings is for the configuration of speed or Keyphasor™ transducer. Slope is the kind of phase / speed triggering either rising edge or falling edge.
- 2) Threshold is the voltage value which defines reference degree of phase or speed.

Vibro-Condition Monitoring software



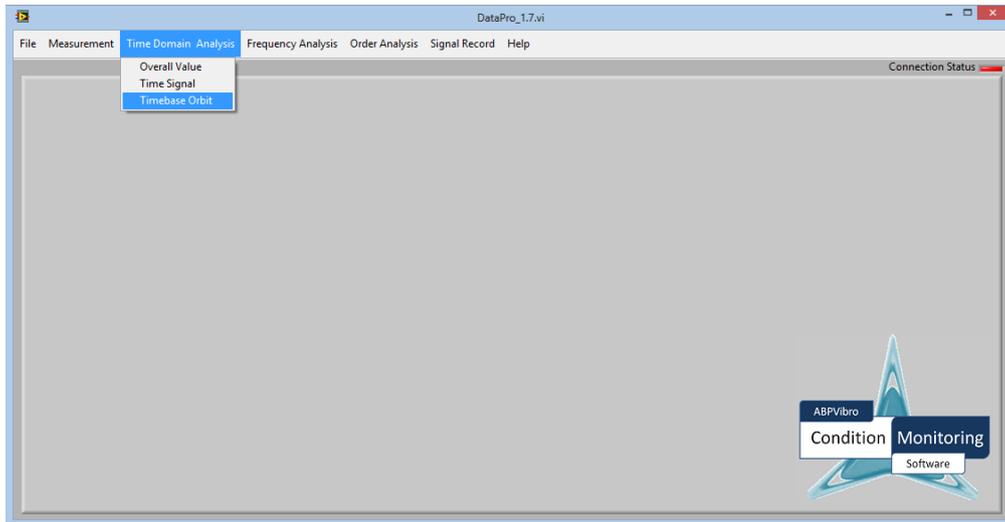
Measurement settings window

Measurement Start / Stop is for the activation and inactivation of the measurement and may be reached by F5 / F6 shortcut keys from the keyboard.

Vibro-Condition Monitoring software

Time domain analysis

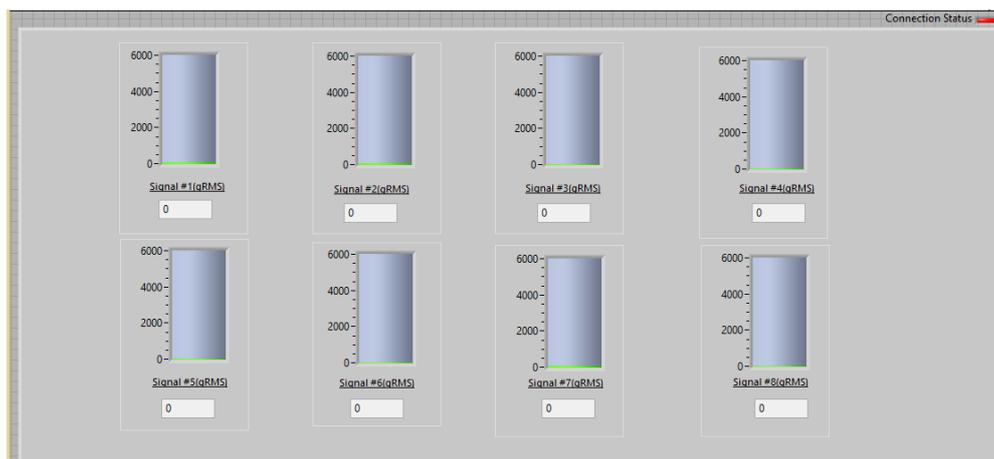
Time domain menu contains functions needed for sensor output analysis in time domain. It contains 3 options Overall value, Time signal & Time base orbit.



Time domain analysis menu

Overall Value

In this page, user can see the overall value of measured parameters in terms of the configuration which has been set for alarm, overall type & sensor type. For each channel label overall value and measurement unit is shown and condition of the machine is plotted in a vertical tank indicator as a graphical layout.



Overall value window

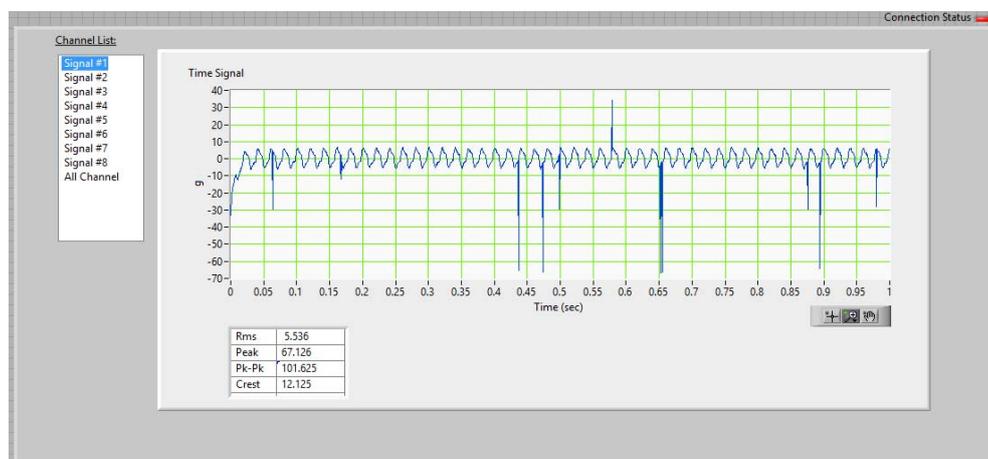
Time Signal

Vibro-Condition Monitoring software

Time waveform is the fundamental graphic presentation of machinery dynamic data. It shows how a single parameter (most often displacement, velocity, or acceleration, but also any other dynamic measurement) from a single transducer changes on a very short time scale, typically a fraction of a second. This is in contrast to trend plots, which display the value of a slowly changing parameter over a much longer time scale, typically hours to months.

A time waveform plot represents a small slice of time in the vibration history of the machine. Usually, the amount of time involves only a few revolutions of the rotor. During this short length of time, the overall behavior of the machine is not likely to change significantly. However, unfiltered time waveform plots can clearly show a change in machine response if sudden events occur in the machine or if the machine is rapidly changing speed (such as an electric motor startup). Time waveform plots have several important uses. They have the advantage in being able to clearly display the unprocessed output from a single transducer. This allows us to look for noise on the signal or to detect the presence of multiple frequency components. An important use of a time waveform plot is to identify the presence and timing of short term transient events like rubs. Large amounts of information such as rub, peak-to-peak amplitude, the filtered vibration frequency, the rotor speed, the nX amplitude and phase of a filtered signal can be obtained from a time waveform plot.

Time signal window shows the time waveform, channel selection bar in the left and overall value measurements at the bottom of the page.



Time Signal Window

Timebase orbit

While the time waveform plot can provide important and useful information, it is inherently limited to one dimension of rotor motion. Since, in any lateral plane along the rotor, the rotor moves in a two-dimensional path, or orbit, this one-dimensional picture provided by a single transducer is not adequate. To measure this motion, a second transducer must be installed perpendicular to, and

Vibro-Condition Monitoring software

coplanar with, the first transducer. Only then will there be enough information to observe the complete motion of the rotor in that plane. This motion is presented on two separate time waveform plots and one two-dimensional dynamic motion plot called orbit plot. The orbit represents the path of the shaft centerline relative to a pair of orthogonal transducers. These transducers are usually mounted rigidly on the machine casing near a bearing; thus, the orbit typically represents the path of the shaft centerline relative to the bearing clearance of the machine. Because of its ease of interpretation and extensive information content, the orbit is probably the most powerful time domain plot format available to the machinery diagnostician. Orbit analysis is a tool used to detect failures like rubs, unbalance, misalignment or oil whip in journal bearing machines.

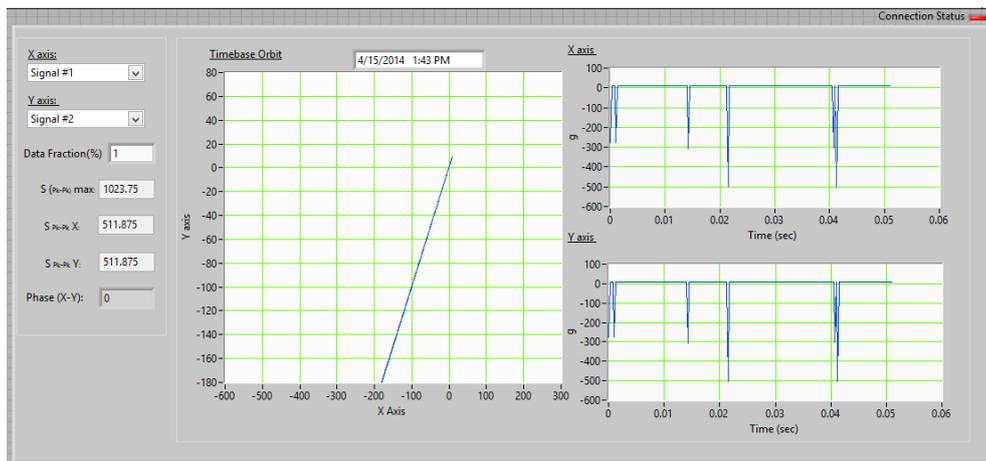
There are two orbit plot types available: Time base and Order base orbit

For time base you should have two perpendicular installed transducers, while on ordered orbit one needs a tachometer to be used for phase, speed and order measurements. Controls available in time base orbit are as follows:

X axis & Y axis correspond to the measurement signals connected to vibration analyzer.

S pk-Pk X, Y and max are maximum displacement values calculated according to ISO 7919-1.

Data Fraction is a number between 0 to 100 % which shows the software what the fraction of data plotted should be, the higher the rotational speed of the shaft the lower this number should be to decrease noise from several revolutions on the screen.



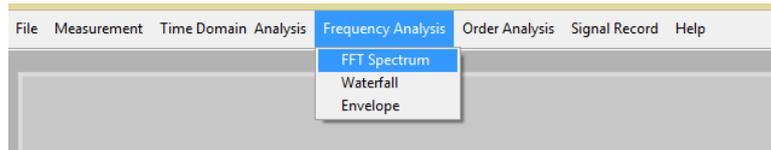
Time base orbit window

Vibro-Condition Monitoring software

Frequency Analysis

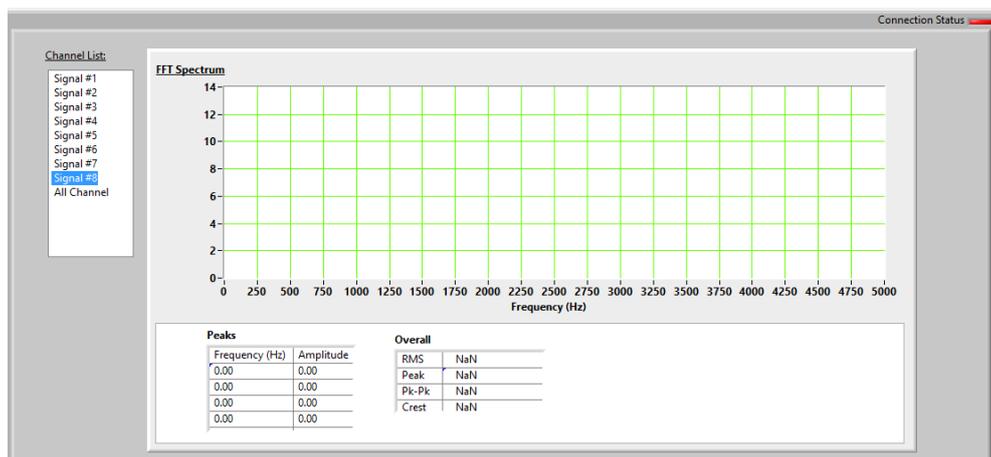
This menu contains the most useful frequency domain functions for performing a frequency analysis on time signals measured by the analyzer and it contains:

- FFT Spectrum
- Waterfall
- Envelope Spectrum



FFT Spectrum

Machines can vibrate at many different frequencies simultaneously. These frequencies can be related or unrelated to running speed and include both subsynchronous and supersynchronous frequencies. Since these frequencies are associated with the operating condition of the machine, the machinery diagnostician must have some way to determine the frequency content of a vibration signal in order to make an accurate diagnosis. Vibration frequencies sometimes appear as a series of harmonics. The series consists of the rotational frequency of the machine, called the fundamental, and a number of frequencies at integer multiples of the fundamental. FFT (Fast Fourier Transfer) is used to seize out the frequency contents of a vibration signal. FFT window looks like the figure shown below.



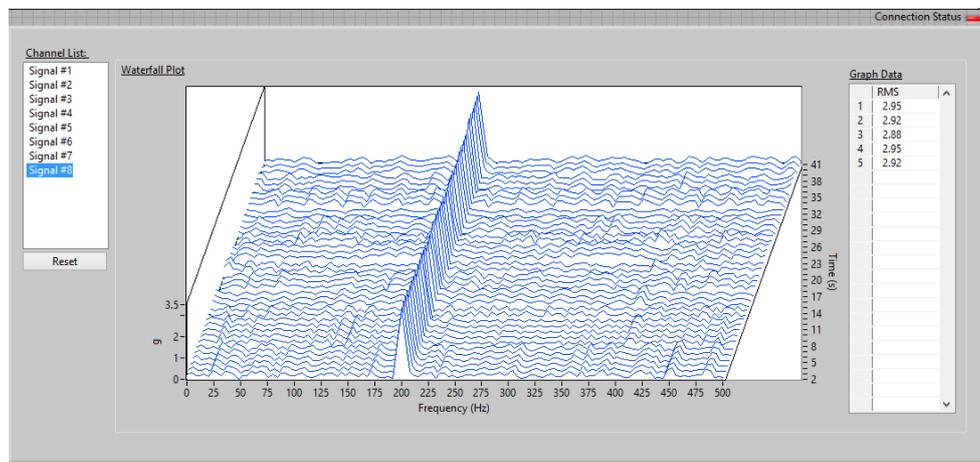
Frequency Spectrum Window

Vibro-Condition Monitoring software

On Peaks table, one may see the frequency & amplitude of maximum FFT points. In overall section, different measured overall values are shown. In the left side of the window user can select the desirable channel to see the plot.

Waterfall Plot

Waterfall plots are designed to display multiple spectra (FFT spectrum) versus time, during run up, run down or constant speed operation. Waterfall plots are 3D plots with time, frequency and amplitude axis. Waterfall plots are commonly used to examine how machine vibration changes with a change in an operating parameter. Waterfall plot clearly shows that the subsynchronous, supersynchronous and asynchronous vibration amplitudes regards to 1X vibration and their changes versus time or speed changes. The table beside the waterfall plot shows the time of the spectrum and the overall vibration of that frame. By choosing reset button user may reset the graph to its initial state and start measurement again.

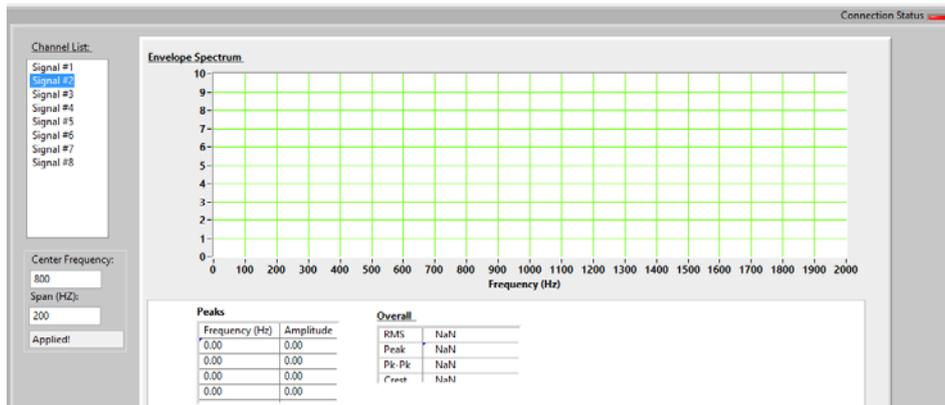


Waterfall Window

Envelope Plot

In envelope plot user may implement an envelope filter to demodulate amplitude modulated signals. This option is very useful in rolling element bearing damage detection. Filter consists of a center frequency and a span both in Hz units. For example if you set center to 2000 Hz and Span of 500 Hz, software will demodulate signals in range 1750 to 2250 Hz and filter out all other components. Always bear in mind that center plus half of the span frequency cannot be over sampling rate otherwise software would return error to the user.

Vibro-Condition Monitoring software

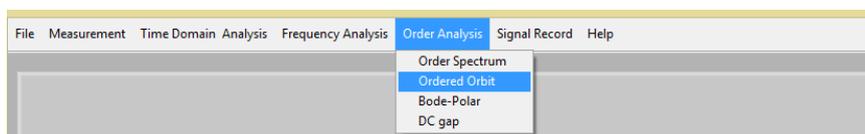


Envelope Spectrum Window

Vibro-Condition Monitoring software

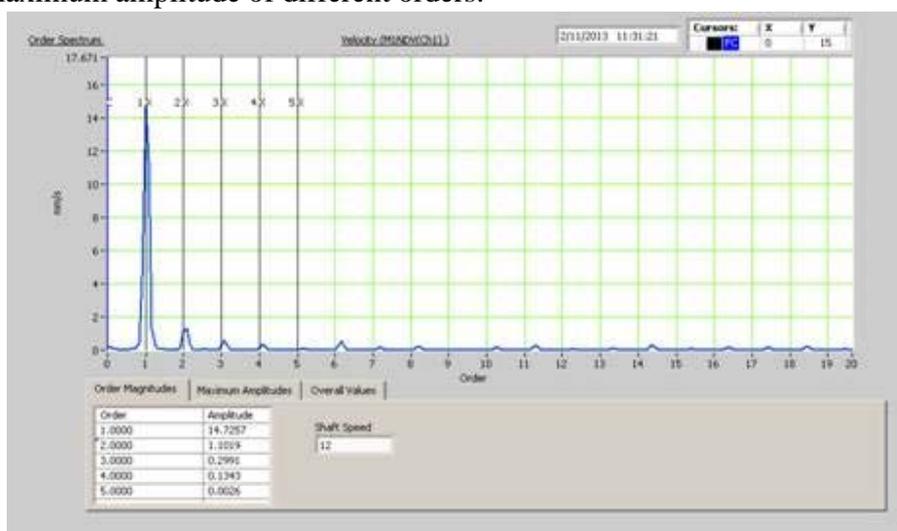
Order analysis

On this menu, functions which are used for order analysis of rotating machine vibration are present. There are four functions on this menu: Order spectrum, ordered orbit, Bode-Polar & DC gap plot.



Ordered spectrum

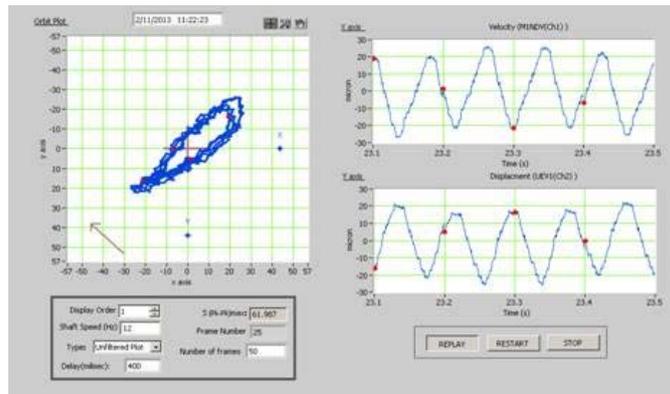
FFT measured from each channel loaded in the software can be used for order analysis in this window. To be able to use this function rotating speed of the shaft should be manually entered in Shaft speed section in Hz unit. A sample window is shown below. The table below the graph shows the maximum amplitude of different orders.



Ordered orbit

For the times when one likes to see the ordered orbit, this function is available. For this one needs a tachometer (KeyPhasor) channel or manually enter the shaft speed. Other buttons are just like the Time base orbit. Sample of this window is shown below.

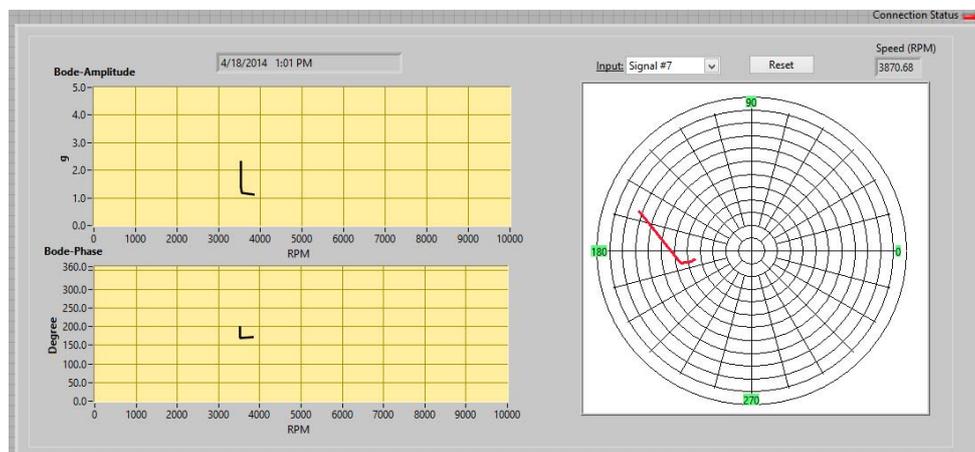
Vibro-Condition Monitoring software



Bode-Polar

This option is only available when there is tachometer / speed sensor connected to channel 1. If speed sensor is connected and graph is rather noisy try resetting the speed sensor settings in measurement setup & configuration editor. This graph is extremely useful for taking run up or rundown tests from rotating machinery. Another usage of the Bode or polar graph is while trying to balance flexible rotors operating near or above at least one of the critical speeds.

On the upper left time and upper right rotational frequency of the shaft is shown. There are three graphs on this page which are amplitude vs. speed, phase vs. speed & amplitude-phase polar diagram. Reset key is used to reset the measurements and start measurements from the beginning again. Input channel selector is to choose the active signal for graph plotting.



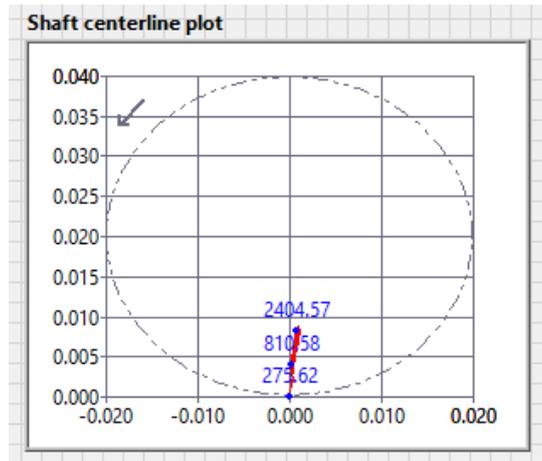
Bode-Polar graph window

DC gap plot

In case of measurements on journal bearings one of the most useful tools for bearing analysis is dc gap plot or average shaft centerline. This plot is created by using one speed sensor and two

Vibro-Condition Monitoring software

orthogonally oriented X , Y displacement transducers. DC output of the displacement transducers indicates the mean distance between the probe and the shafts, this distance is monitored and plotted in planar coordinate systems (X-Y) for different speeds. This plot is helpful in the measurement of bearing clearance in run up / downs or during an arbitrary period of time like a year.

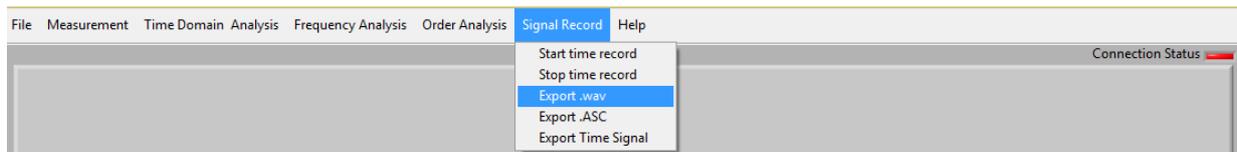


DC gap plot

Vibro-Condition Monitoring software

Signal Record

Signal record menu contains a list of functions for exporting data into different frequently used formats. Functions are associated with .dat measurements which is used by MDS software, .WAV standard sound format for acoustic measurements and analysis, .asc format for operational modal analysis by ARTEMIS® software package. Final option is export time signal which saves the measurement raw time signal into .txt format for further analysis by other 3rd party software such as MATLAB®, Excel® , etc.



Signal record menu

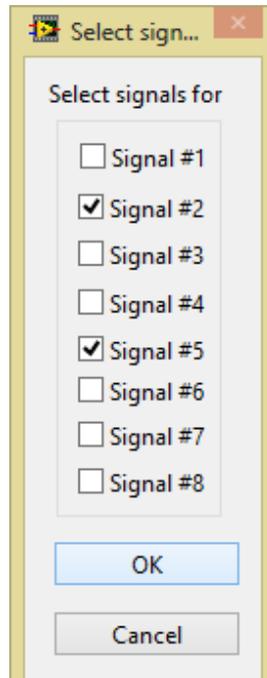
Start/Stop time record

This option is for controlling record action of the measurement files in .dat file formats that is the measurement input file to MDS software. The interval between two consecutive recordings is controlled by “save interval” in measurement settings.

Export .wav

Export .wav is a sound recorder which saves input time signals in .wav standard files. These files may later be used for further processing by sound analysis software applications like Pulse Sound®, MATLAB®, LabVIEW®, etc. This option is usually used when taking measurements by microphones or hydrophones. Please note that the maximum number of data frames for this action is 80 time frames so if you are recording 4096 samples with 2048 Hz sampling rate each frame contains $4096/2048=2$ sec, then user is able to save $80*2=160$ sec in maximum by export .wav.

Vibro-Condition Monitoring software

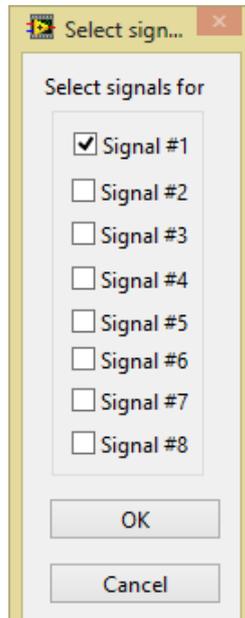


.wav measurement window

Export .ASC

This kind of file export is useful for operational modal analysis by software packages. It records all time signal channels selected by the user into a single standard ASCII format file. Each column of the file is associated with one transducer.

Vibro-Condition Monitoring software



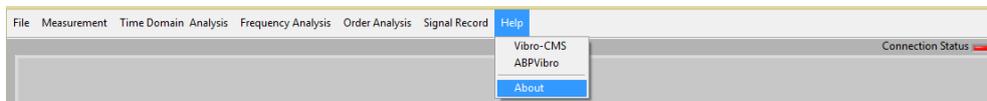
.asc format exporting window

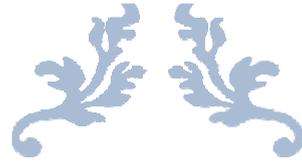
Export time signal

This option is useful when user plans to save recordings into standard text format which may be opened by many software such as Excel®,MATLAB®, ...

Help

Help menu contains access to help menu of the software with access to ABPVibro website.





VIBRO-ROTARY MACHINE DIAGNOSIS SOFTWARE

Software Manual



NOVEMBER 2, 2013

ABP VIBRO

www.ABPVibro.com

Vibro-Rotary machine Diagnosis Software

Introduction to VIBRO-RMDS:

VIBRO-RMDS (Vibro-Rotary Machine Diagnosis Software) is an application which has been developed to enhance usage of condition monitoring systems; It can be used for machinery diagnosis and verification of root cause of vibration problems via off-line data review and analysis. It contains mostly used functions to provide engineers with a collection of the most beneficial tools for analyzing data and finding the malfunctions of machinery.

It gets measurement files of ABPVibro condition monitoring systems as input. It has 3 main inputs which are described in the following:

1) Analyzer Setting File

This file contains condition monitoring system or analyzer channel settings i.e. data required for transducer type & its sensitivity, transducer signal scaling, channel labels, integration type, alarm value ...

So the 1st step in an analysis is to load the analyzer setting file into the software. Figure below shows a setting file data as an example.

Signal	Label	Sensor Type	Sensitivity	Sensitivity Unit	Conversion
Channel 1	UEH1(Ch1)	Displacment	0.008	v	mm/s
Channel 2	UEV1(Ch2)	Displacment	0.008	mil	mm/s
Channel 3	LEH1(Ch3)	Displacment	0.008	mil	mm/s
Channel 4	LEV1(Ch4)	Displacment	0.008	mil	mm/s
Channel 5	TEH1(Ch5)	Displacment	0.008	mil	mm/s
Channel 6	TEV1(Ch6)	Displacment	0.008	mil	mm/s
Channel 7	Spare(Ch7)	Displacment	1.000	v	mm/s
Channel 8	Spare(Ch8)	Displacment	1.000	mil	mm/s
Channel 9	UAH1(Ch9)	Accelerometer	10.000	mm/s	mm/s
Channel 10	UAV1(Ch10)	Accelerometer	10.000	mm/s	mm/s
Channel 11	UAX1(Ch11)	Accelerometer	10.000	mm/s	mm/s
Channel 12	LAH1(CH12)	Accelerometer	10.000	mm/s	mm/s
Channel 13	LAV1(CH13)	Accelerometer	10.000	mm/s	mm/s
Channel 14	TAH1(CH14)	Accelerometer	10.000	mm/s	mm/s
Channel 15	TAV1(CH15)	Accelerometer	10.000	mm/s	mm/s

Sample of a setting file data

2) Measurement File

Measured data is recorded in .dat files by the analyzers. This file contains all the time waveform samples and frames in the way which have been chosen to be saved and recorded. After the setting file is loaded in the program, .dat (measurement) files folder should be introduced to the program to read data. In fact, .dat file contains an array of numbers which include the acquisition data time and acquired waveforms.

Vibro-Rotary machine Diagnosis Software

3) Lay out file

This file is indeed a picture file which is optional and usually is loaded in CMS and contains data from the measurement set up in a pictorial way. It usually shows the plant machinery with sensor locations and tags. This file is optional and is not needed for VIBRO-RMDS to work. Sample of a layout file is shown below.

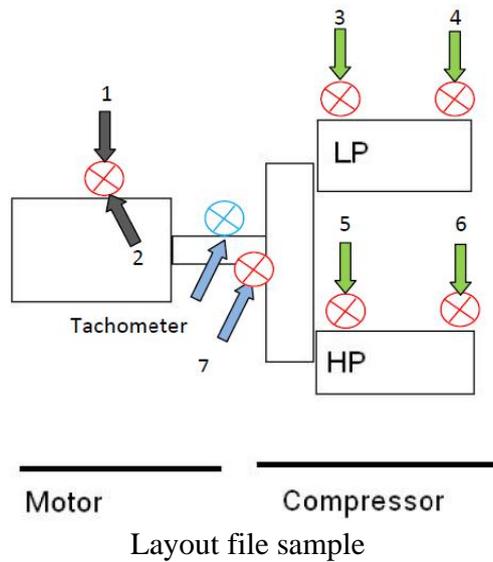
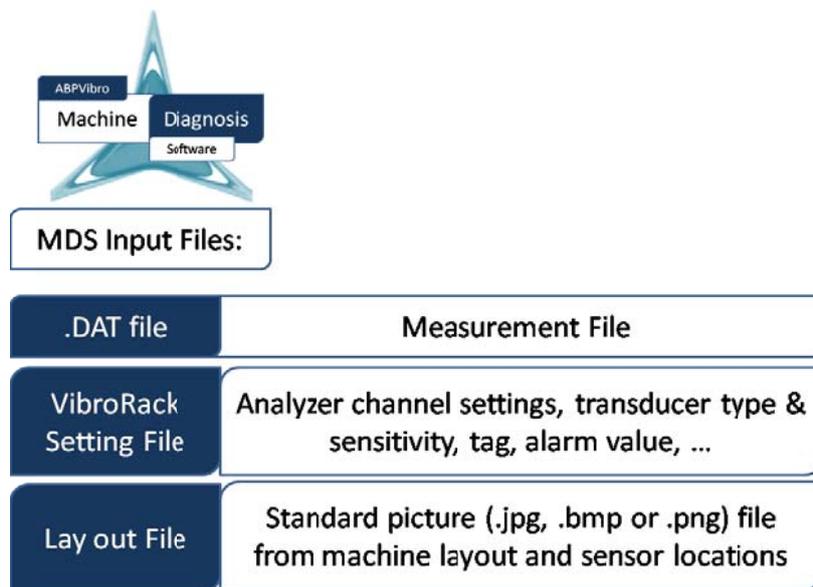


Figure below shows a schematic of data file inputs of VIBRO-RMDS.



VIBRO-RMDS input files

Vibro-Rotary machine Diagnosis Software

File menu

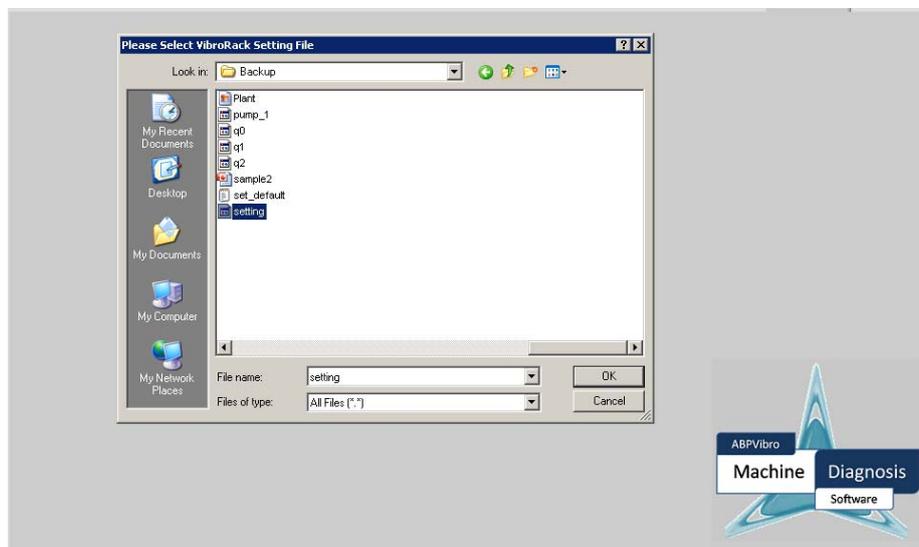
File menu contains menus which are needed for the software to start. It has functions like open analyzer setting, measurement file locations, etc. Its menu configuration is shown below:

File	
Open Analyzer settings	Ctrl+O
Open Layout	Ctrl+1
Set save folder	Ctrl+2
Signal Selector	Ctrl+3
Data Selector	Ctrl+4
Save Machine Route	Ctrl+5
Load Machine Route	Ctrl+6
Print	P
Exit	Ctrl+Q

File menu

Open analyzer settings:

By choosing this option the user may browse the computer for vibration analyzer or condition monitoring system setting file. Every analyzer has its own setting file when installed and connected to the sensors. Ctrl+O shortcut activates this menu.

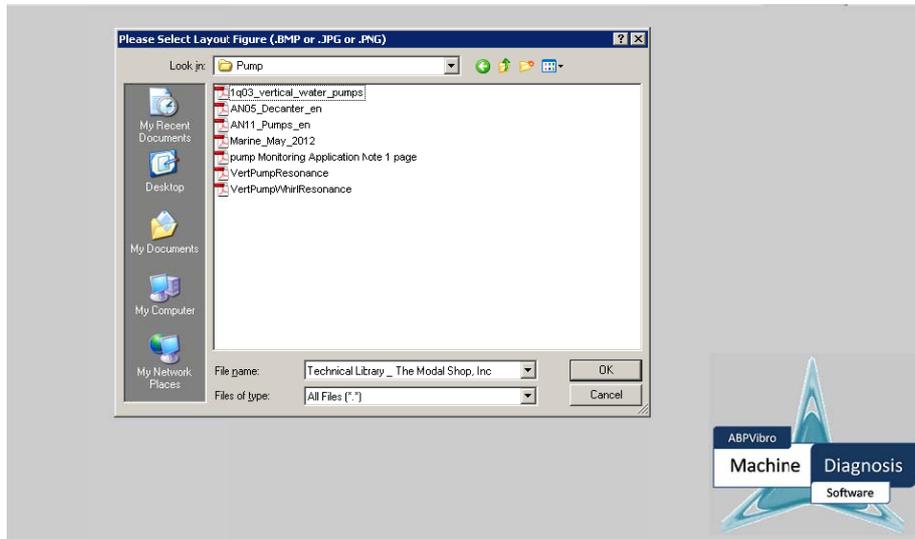


Analyzer setting browse window

Open Layout

By clicking on open layout or pressing Ctrl+1 on the keyboard one gets to a browse window by which the user may select the layout file which is a picture file which is optional and usually is loaded in CMS and contains data from the measurement set up in a pictorial way. It usually shows the plant machinery with sensor locations and tags. This file is optional and is not needed for VIBRO-RMDS to work.

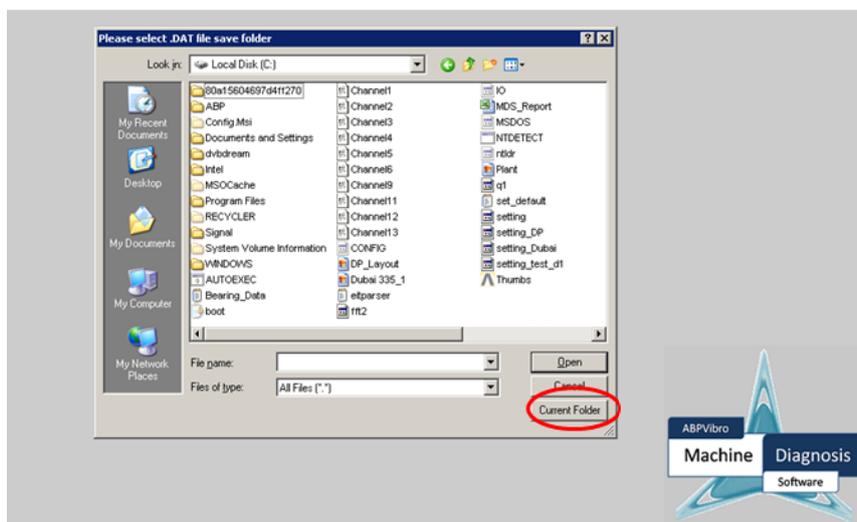
Vibro-Rotary machine Diagnosis Software



Layout file browse window

Set save folder

By choosing this option or pressing Ctrl+2, again comes another browse window which accepts folder. Folder on the computer which has the measurement files i.e. .dat files should be addressed in this section. As shown in the below figure, after browsing for the measurement files folder, “Current Folder” is clicked in the window.



Selection of measurement files folder

Vibro-Rotary machine Diagnosis Software

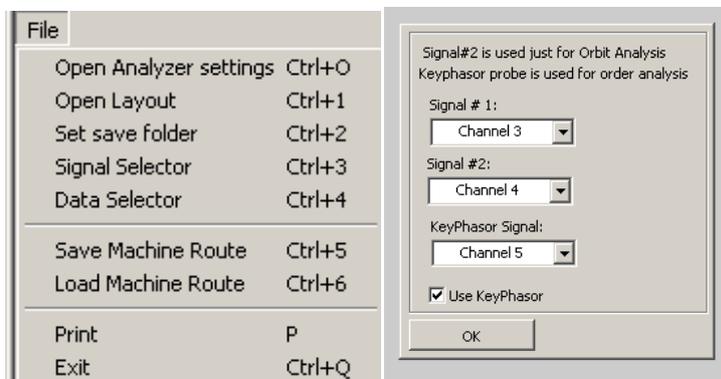
Signal Selector

By choosing “signal selector” or pressing Ctrl + 3, one gets to the following window. Signal#1 is the channel which is used for all the measurement options from time signal to waterfall and etc.

Note 1: If you choose Channel 3 as signal #1 then there should exist Channel3.dat file in the folder you chose as save folder.

Signal #2 selection is related to the channel which is selected for orbit plot section e.g. if 2 X-Y probes are installed as Channel3 and Channel 4, then these 2 channels should be selected for orbit processing.

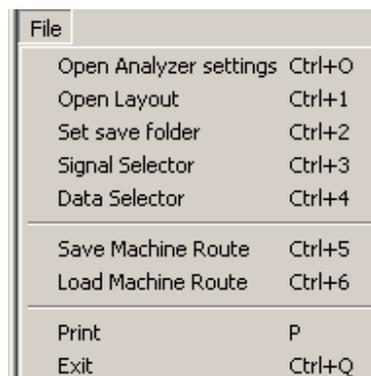
If you have a KeyPhasor or Tachometer installed in front of the shaft you may choose it as KeyPhasor signal to be used for phase and RPM measurements.



Signal selector window

Data Selector

Once analyzer setting file and signals are selected, one may start processing by firstly getting into Data selector window.



Data selector run time menu

Vibro-Rotary machine Diagnosis Software

Choosing data selector would get the user to a window like the one shown below. Top left corner of the window shows all the time frames which have been recorded in .dat measurement file.



Data Selector Window

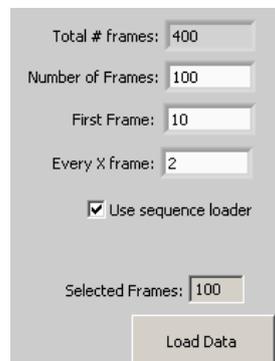
In order to choose data frames which one may analyze, there are two ways:

1) Data time stamps

From the drop list in which all the time stamps recorded are listed, one may choose frames desired for further processing by Ctrl or Shift key.

2) Sequence loader

This option is used when one likes to address data by frame numbers. As an example, suppose there are 400 time frames on the .dat (measurement) file and you want to review 100 data frames, so you enter 100 in number of frames. First frame is the frame number that is used as the first frame of 100 hundred frames and every X frame is a number that is used to define the multiplier of the frames. The below figure shows the user wants to process 100 frames starting from frame 10 and every 2 frame so frames are loaded in the following way:
10, 12, 14, 16...



Note 1: Since the final frame number is equal to:

Vibro-Rotary machine Diagnosis Software

Number of frames * Every X frame + First Frame

This number cannot be greater than total number of frames i.e.

$$100 * 2 + 10 = 210 < 400$$

If this condition is not met, user is prompted as “Invalid Selection” and has to correct his selection.

Note 2: number of selected frames should be a number between 1 to 180 frames

Note 3: To activate sequence loader, it should be selected via the checkbox beside it, otherwise software will load data according to selection on Data time stamps.

Top right corner of the window shows a table which includes analyzer settings like channel label, sensor type, sensitivity and conversion. Bottom left corner of the data selector window shows the layout configuration. When desired data is selected by clicking on “Load Data” button, data is loaded from .dat file into the software.

Signal	Label	Sensor Type	Sensitivity	Sensitivity Unit	Conversion
Channel 1	UEH1(Ch1)	Displacment	0.008	v	mm/s
Channel 2	UEV1(Ch2)	Displacment	0.008	mil	mm/s
Channel 3	LEH1(Ch3)	Displacment	0.008	mil	mm/s
Channel 4	LEV1(Ch4)	Displacment	0.008	mil	mm/s
Channel 5	TEH1(Ch5)	Displacment	0.008	mil	mm/s
Channel 6	TEV1(Ch6)	Displacment	0.008	mil	mm/s
Channel 7	Spare(Ch7)	Displacment	1.000	v	mm/s
Channel 8	Spare(Ch8)	Displacment	1.000	mil	mm/s
Channel 9	UAH1(Ch9)	Accelerometer	10.000	mm/s	mm/s
Channel 10	UAV1(Ch10)	Accelerometer	10.000	mm/s	mm/s
Channel 11	UAX1(Ch11)	Accelerometer	10.000	mm/s	mm/s
Channel 12	LAH1(CH12)	Accelerometer	10.000	mm/s	mm/s
Channel 13	LAV1(CH13)	Accelerometer	10.000	mm/s	mm/s
Channel 14	TAH1(CH14)	Accelerometer	10.000	mm/s	mm/s
Channel 15	TAV1(CH15)	Accelerometer	10.000	mm/s	mm/s

Sample of a setting file data

Save/Load machine route

One may save all the settings which have been set in the software in a file called machine route.

This file includes: channel settings, diagnosis settings (bearing type, belt, electric motor ...), alarm values and all other parametric settings which the user may input to the software once.

This submenu Save is used for saving these data once and using them from load data after that.

File	
Open Analyzer settings	Ctrl+O
Open Layout	Ctrl+1
Set save folder	Ctrl+2
Signal Selector	Ctrl+3
Data Selector	Ctrl+4
Save Machine Route	Ctrl+5
Load Machine Route	Ctrl+6
Print	P
Exit	Ctrl+Q

Vibro-Rotary machine Diagnosis Software

Print menu

This menu prints the current screen.

Time domain menu

Time domain menu consists from the time processing functions frequently used in machine diagnosis.

- 1) Time Signal
- 2) Historic Trend
- 3) Time base orbit

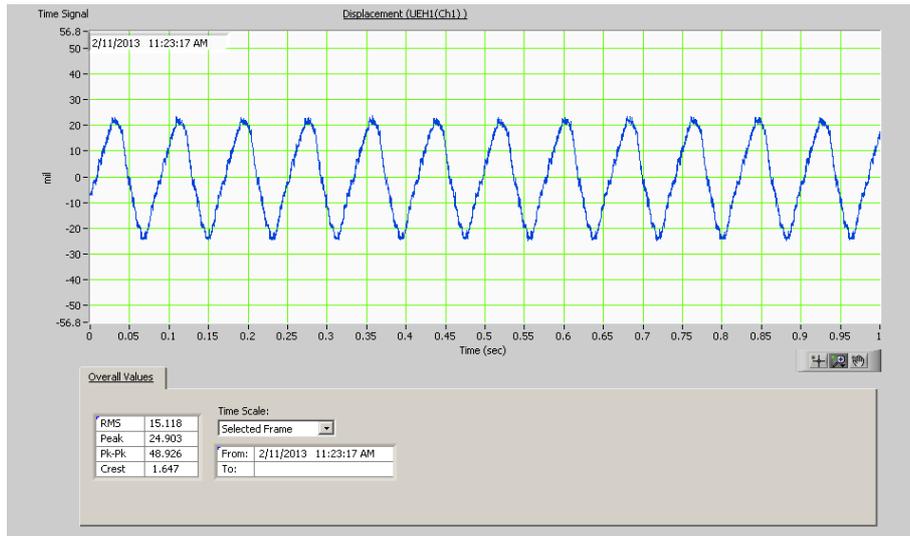
Time Signal

Time waveform is the fundamental graphic presentation of machinery dynamic data. It shows how a single parameter (most often displacement, velocity, or acceleration, but also any other dynamic measurement) from a single transducer changes on a very short time scale, typically a fraction of a second. This is in contrast to trend plots, which display the value of a slowly changing parameter over a much longer time scale, typically hours to months.

A time waveform plot represents a small slice of time in the vibration history of the machine. Usually, the amount of time involves only a few revolutions of the rotor. During this short length of time, the overall behavior of the machine is not likely to change significantly. However, unfiltered time waveform plots can clearly show a change in machine response if sudden events occur in the machine or if the machine is rapidly changing speed (such as an electric motor startup). Time waveform plots have several important uses. They have the advantage in being able to clearly display the unprocessed output from a single transducer. This allows us to look for noise on the signal or to detect the presence of multiple frequency components. An important use of a time waveform plot is to identify the presence and timing of short term transient events like rubs. Large amounts of information such as rub, peak-to-peak amplitude, the filtered vibration frequency, the rotor speed, the nX amplitude and phase of a filtered signal can be obtained from a time waveform plot.

Time signal window shows the time waveform in two types, selected frame and all frames. In selected frame mode graph shows the time frame which has been selected in waterfall tab of frequency domain menu and all frame shows all the data chosen in data selector tab.

Vibro-Rotary machine Diagnosis Software

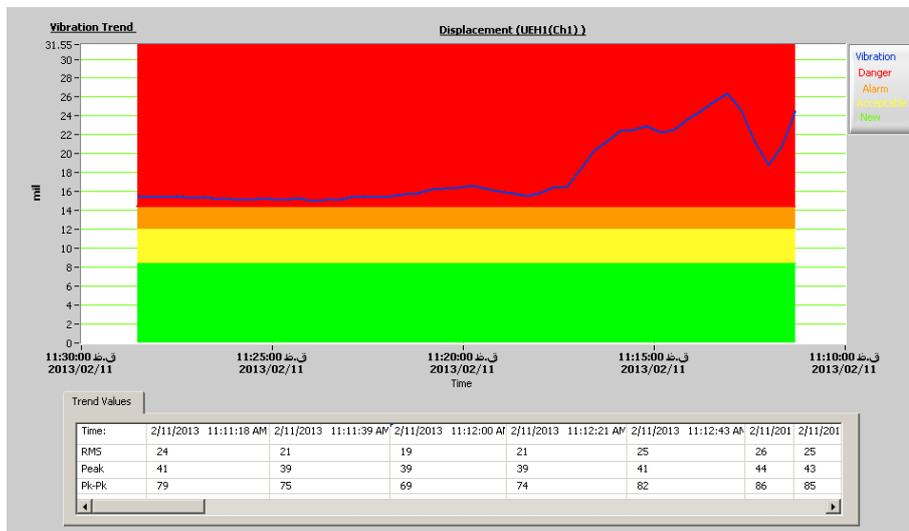


Historic Trend

The trend plot is a rectangular plot on which the value of a measured parameter is plotted versus time. Trend plots can be used to display any kind of data versus time: Displacement, Velocity, Acceleration, gap voltage (radial or thrust position), rotor speed, and process variables, such as pressure, temperature, flow, or power.

Trend plots are used to detect changes in these important parameters. They are used for both long and short term monitoring of machinery in all types of service and are, typically, a kind of a steady state plot. Alarm values which are entered to the program by Report/ Vibration Standard menu, are shown in this graph as green, yellow, orange and red plots corresponding to New, Normal, Alarm and Danger zones, respectively.

Different vibration overall measurements i.e. RMS, Peak and Pk-Pk are shown in a table for every time frame which has been selected on Data Selector tab.



Vibro-Rotary machine Diagnosis Software

Time base orbit

While the time waveform plot can provide important and useful information, it is inherently limited to one dimension of rotor motion. Since, in any lateral plane along the rotor, the rotor moves in a two-dimensional path, or orbit, this one-dimensional picture provided by a single transducer is not adequate. To measure this motion, a second transducer must be installed perpendicular to, and coplanar with, the first transducer. Only then will there be enough information to observe the complete motion of the rotor in that plane. This motion is presented on two separate time waveform plots and one two-dimensional dynamic motion plot called orbit plot. The orbit represents the path of the shaft centerline relative to a pair of orthogonal transducers. These transducers are usually mounted rigidly on the machine casing near a bearing; thus, the orbit typically represents the path of the shaft centerline relative to the bearing clearance of the machine. Because of its ease of interpretation and extensive information content, the orbit is probably the most powerful time domain plot format available to the machinery diagnostician. Orbit analysis is a tool used to detect failures like rubs, unbalance, misalignment or oil whip in journal bearing machines.

There are two orbit plot types available: Time base and Order base orbit

For time base you should have two perpendicular installed transducers, while on ordered orbit one needs a tachometer to be used for phase, speed and order measurements. Controls available in time base orbit are as follows:

Delay (milisec) is the time delay between display of 2 consecutive frames in milliseconds.

Frame number is the currently plotted on the screen frame number

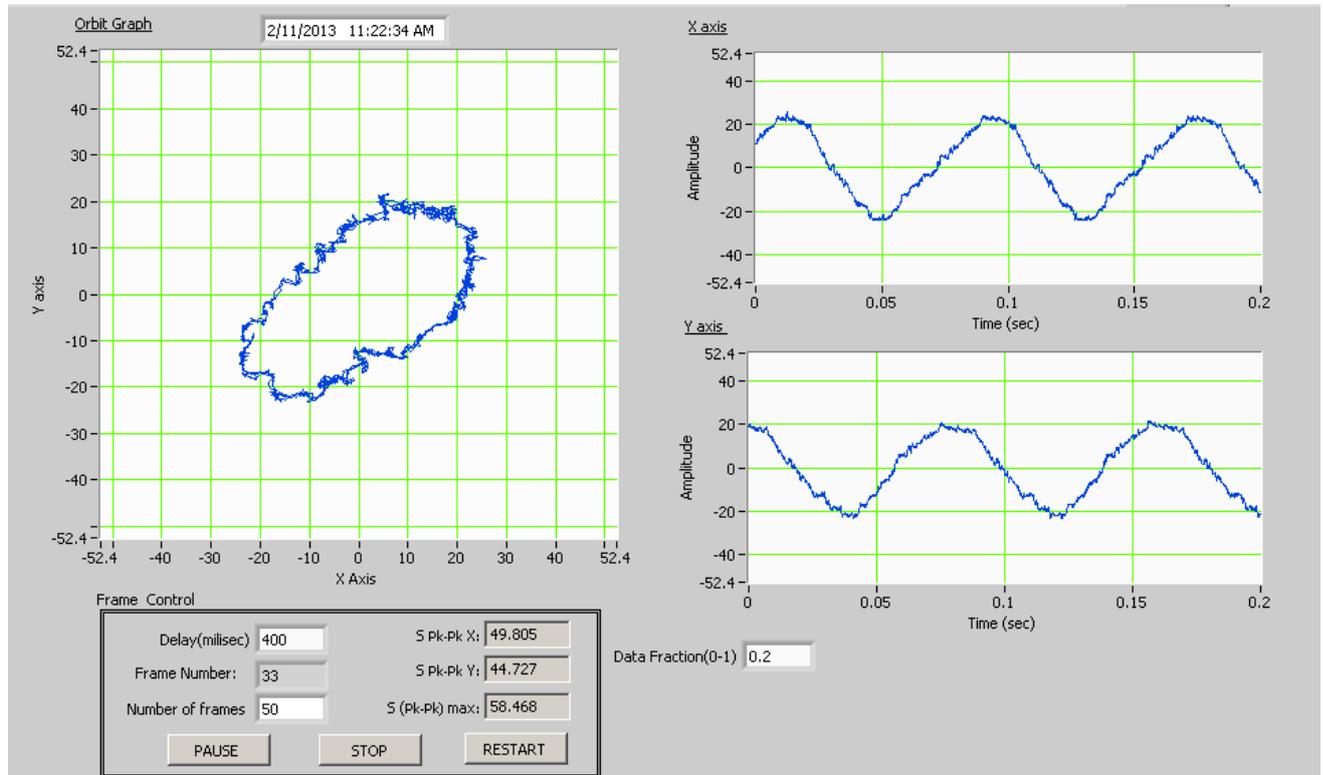
Number of frames is the number of orbit plot frames which have been selected on Data Selector menu.

S pk-Pk X, Y and max are maximum displacement values calculated according to ISO 7919-1.

Data Fraction is a number between 0 to 1 which shows the software what the fraction of data plotted should be, the higher the rotational speed of the shaft the lower this number should be to decrease noise from several revolutions on the screen.

Pause, Stop & Restart buttons are used to freeze on a frame, restart or stop orbit plot display.

Vibro-Rotary machine Diagnosis Software

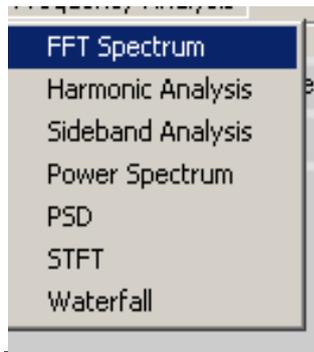


Frequency analysis menu

This menu contains the most useful frequency domain functions for performing a frequency analysis on time signals loaded to the program and it contains:

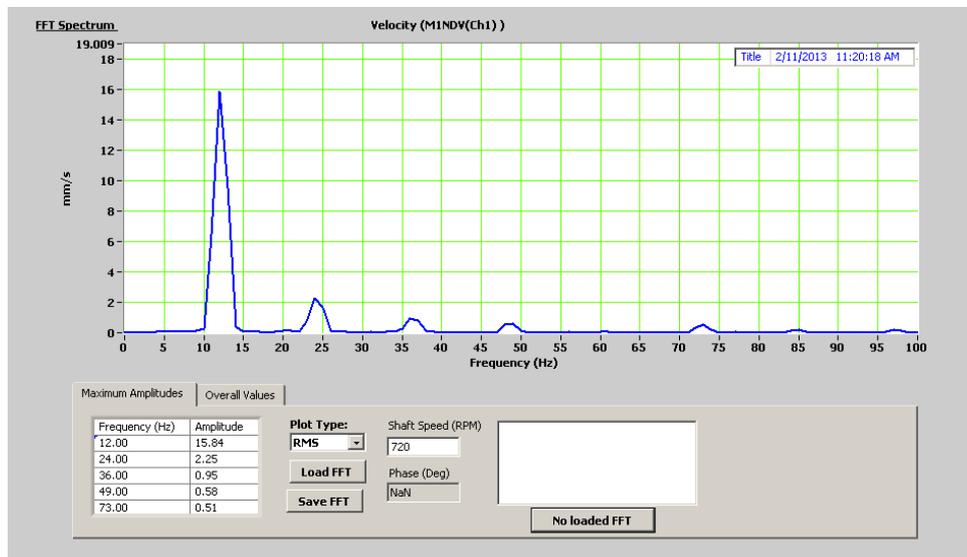
- FFT Spectrum
- Harmonic Analysis
- Sideband Analysis
- Power Spectrum
- PSD (Power Spectral Density)
- STFT (Short Time Fourier Transform)
- Waterfall

Vibro-Rotary machine Diagnosis Software



FFT Spectrum

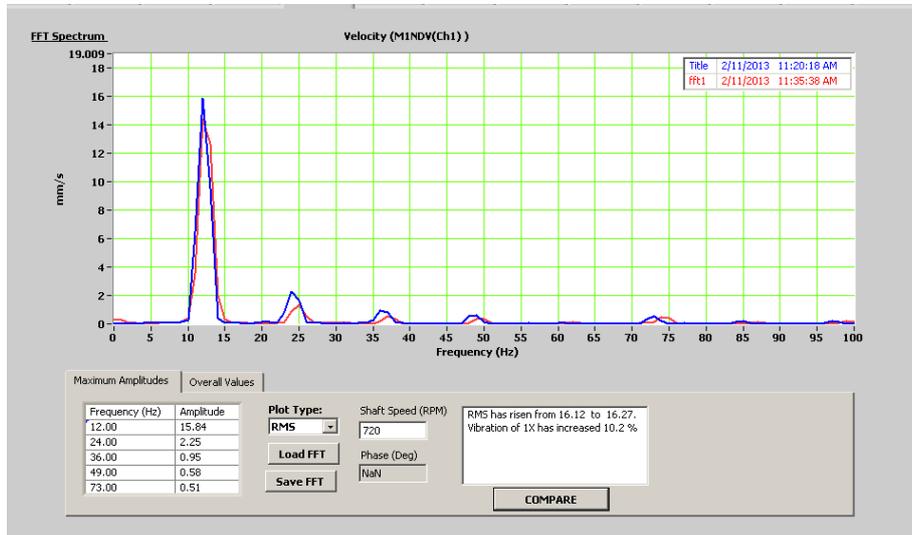
Machines can vibrate at many different frequencies simultaneously. These frequencies can be related or unrelated to running speed and include both subsynchronous and supersynchronous frequencies. Since these frequencies are associated with the operating condition of the machine, the machinery diagnostician must have some way to determine the frequency content of a vibration signal in order to make an accurate diagnosis. Vibration frequencies sometimes appear as a series of harmonics. The series consists of the lowest frequency in the series, called the fundamental, and a number of frequencies at integer multiples of the fundamental. FFT (Fast Fourier Transfer) is used to seize out the frequency contents of a vibration signal. FFT window looks like the figure shown below.



On maximum amplitudes tab, one may see the frequency & amplitude of maximum FFT points. One may change the plot type: RMS, Peak and Pk-Pk. Load FFT & Save FFT is used for comparing FFT plots between other time steps. For FFT amplitude comparison you need to load a previously saved FFT file.

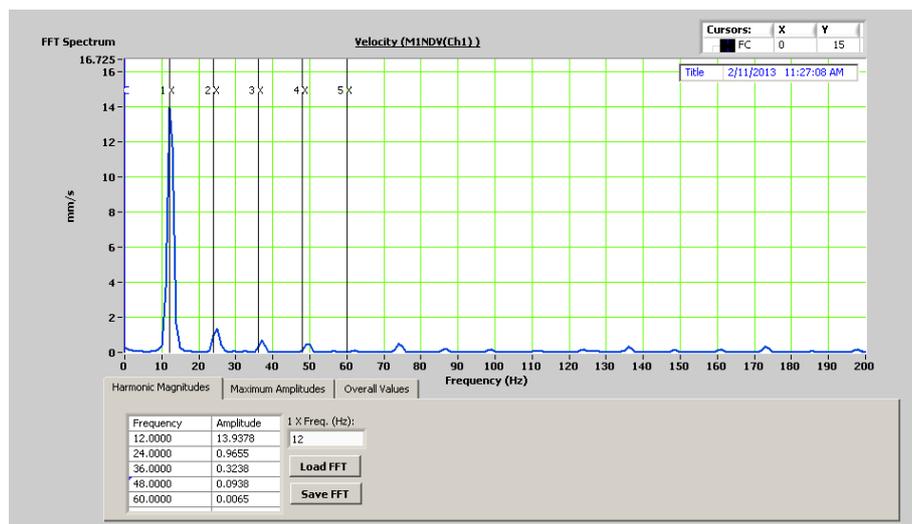
Vibro-Rotary machine Diagnosis Software

An example of comparison is shown below. Shaft speed is read from KeyPhasor probe or entered manually in RPM unit and the normalized results are shown by clicking on “COMPARE” button.



Harmonic Analysis

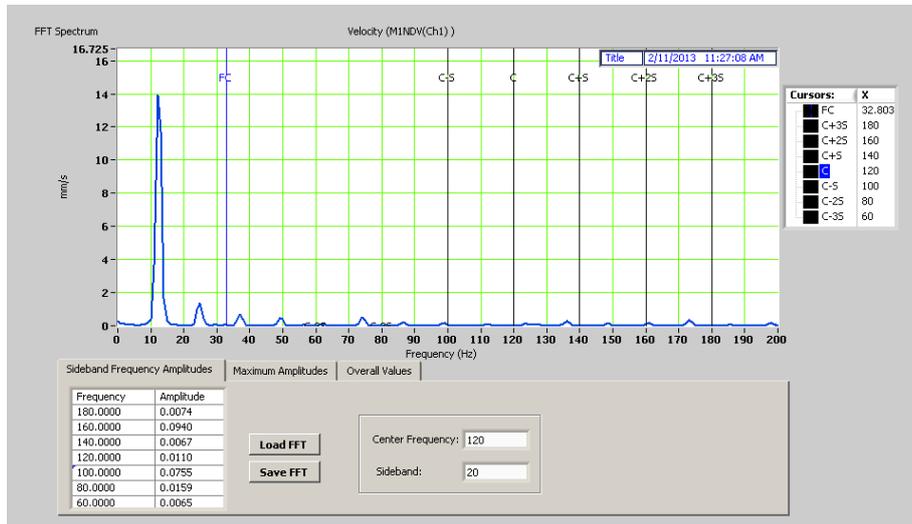
By clicking on harmonic analysis, one may perform harmonic analysis on the FFT loaded. Figure below shows it with an example loaded to the plot. The frequency which its amplitude and harmonics amplitudes are to be calculated should be entered in 1 X Freq. (Hz) and the program would seize out amplitude of harmonics and show them on a table.



Vibro-Rotary machine Diagnosis Software

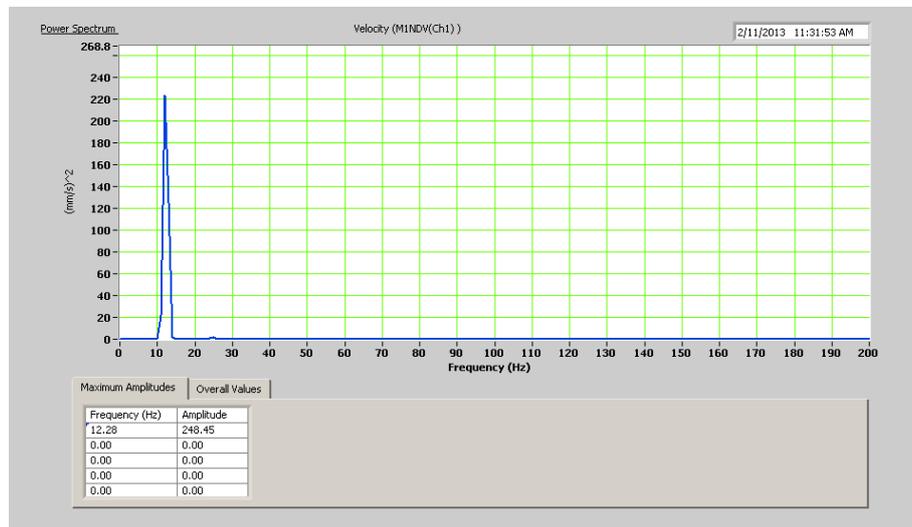
Sideband Analysis

By selecting sideband analysis from frequency analysis menu, user would encounter a window such as below. In this window, one may enter the span (sideband) and center frequency and see their amplitudes and markers on the plot and table below it.



Power Spectrum

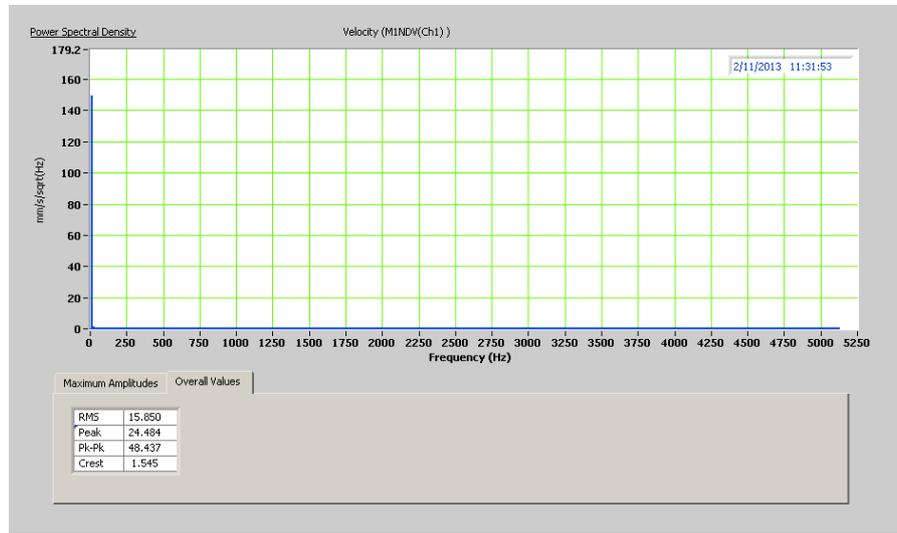
This window shows the Power spectrum of the time signal for the selected frame. Maximum amplitudes and overall values are shown in tables on the bottom of the window.



Vibro-Rotary machine Diagnosis Software

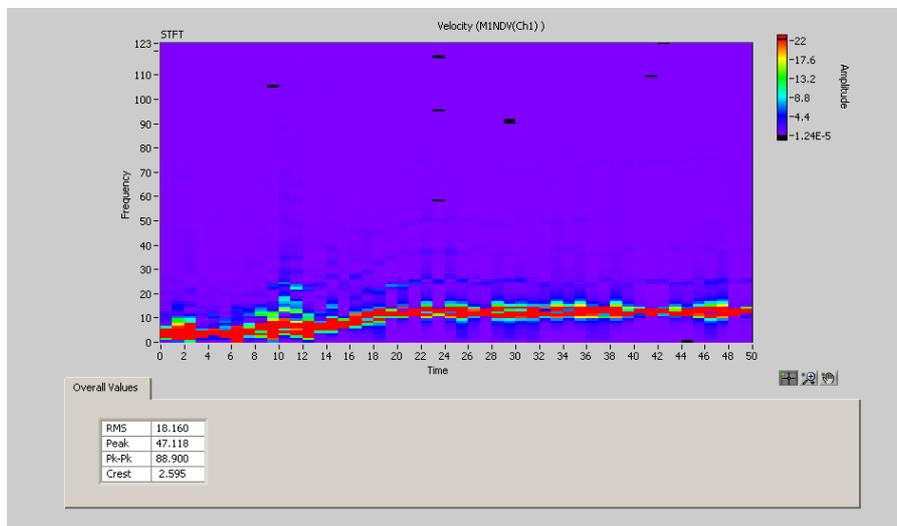
Power Spectral Density (PSD)

This window shows the PSD of the time signal for the selected frame. Maximum amplitudes and overall values are shown in tables on the bottom of the window.



STFT

This window shows the STFT (Short Time Fourier Transform) of the time signal for the selected frames. Overall values are shown in tables on the bottom of the window. This function is useful when there is access to the run up/ run down .dat file and data is loaded in the software.

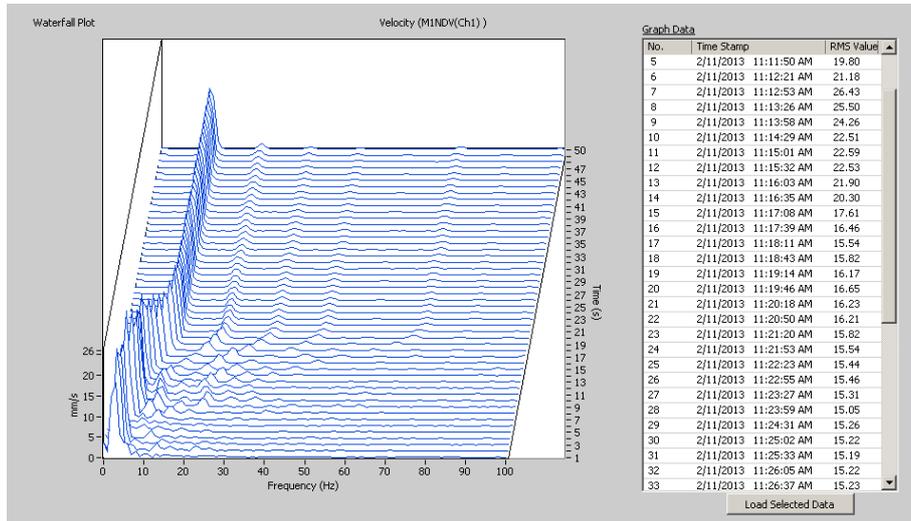


Waterfall Plot

Waterfall plots are designed to display multiple spectra (FFT spectrum) versus time, during run up, run down or constant speed operation. Waterfall plots are 3D plots with time, frequency and amplitude axis. Waterfall plots are commonly used to examine how machine vibration changes with a change in an operating parameter. Waterfall plot clearly shows that the subsynchronous, supersynchronous and

Vibro-Rotary machine Diagnosis Software

asynchronous vibration amplitudes regards to 1X vibration and their changes versus time or speed changes. The table beside the waterfall plot shows the time of the spectrum and the overall RMS vibration of that frame. User may choose one of the frames by clicking on the frame number in the table and selecting “Load Selected Data” button.

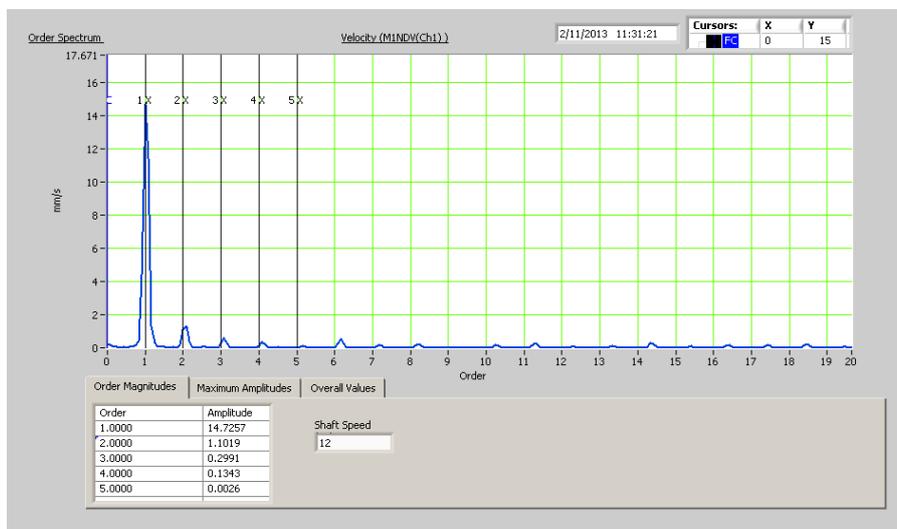


Order analysis

On this menu, functions which are used for order analysis of rotating machine vibration are present. There are three functions on this menu: Order spectrum & Ordered orbit.

Ordered spectrum

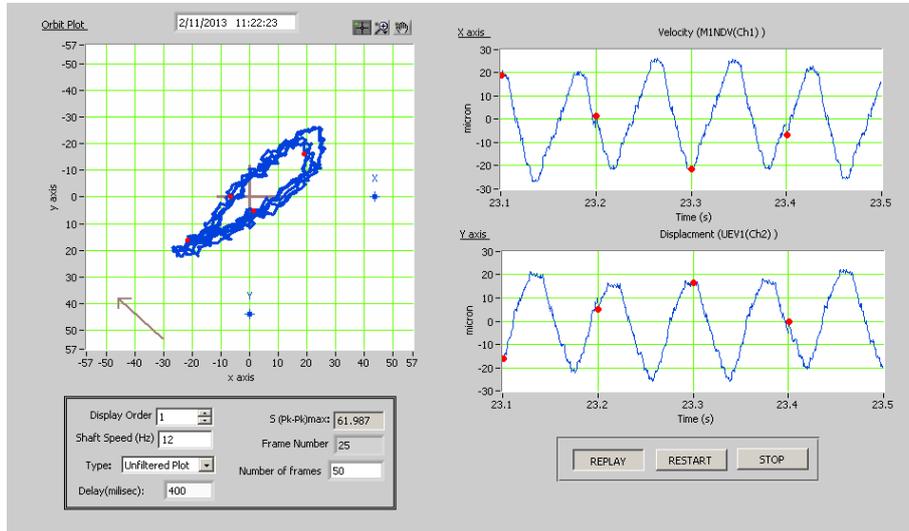
FFT loaded in the software can be used for order analysis in this window. To be able to use this function rotating speed of the shaft should be manually entered in Shaft speed section in Hz unit. A sample window is shown below. The table below the graph shows the maximum amplitude of different orders.



Vibro-Rotary machine Diagnosis Software

Ordered orbit

For the times when one likes to see the ordered orbit, this function is available. For this one needs a tachometer (KeyPhasor) channel or manually enter the shaft speed. Other buttons are just like the Time base orbit. Sample of this window is shown below.



Machine Diagnosis

Machine diagnosis menu contains a list of mostly used frequency calculators which are applied mostly in industry. It includes:

- 1) Belt driven machines
- 2) Anti-friction bearing frequency calculator
- 3) Electric motor frequency calculator
- 4) Gearbox frequency calculator

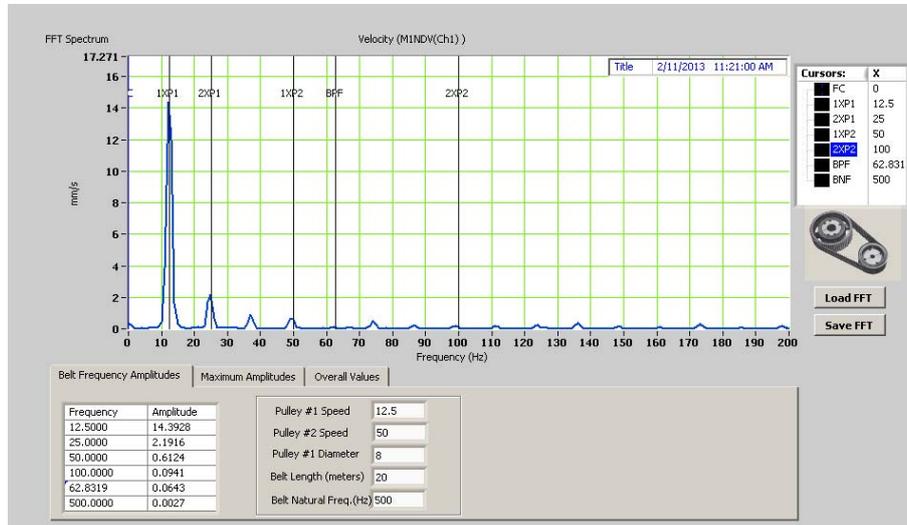
Belt

On this page one may enter main frequencies which are important for frequency analysis of belt driven machines and see their indicators on FFT plot and amplitudes on table results. Data which should be input to the program is as follows.

Rotational speed of the pulleys in hertz unit. Diameter of one pulley # 1 is entered in meter unit. Belt length should be input for the calculation of Belt pass frequency and the belt natural frequency is optional to input. These frequencies are indicated in the graph and tabulated in the bottom of the graph with their correspondent amplitudes.

- 1) 1X of Pulley # 1 (1XP1)
- 2) 2X of Pulley # 2 (2XP1)
- 3) 1X of Pulley # 2 (1XP2)
- 4) 2X of Pulley # 2 (2XP2)
- 5) Belt Pass Frequency (BPF)
- 6) Belt Natural Frequency (BNF)

Vibro-Rotary machine Diagnosis Software



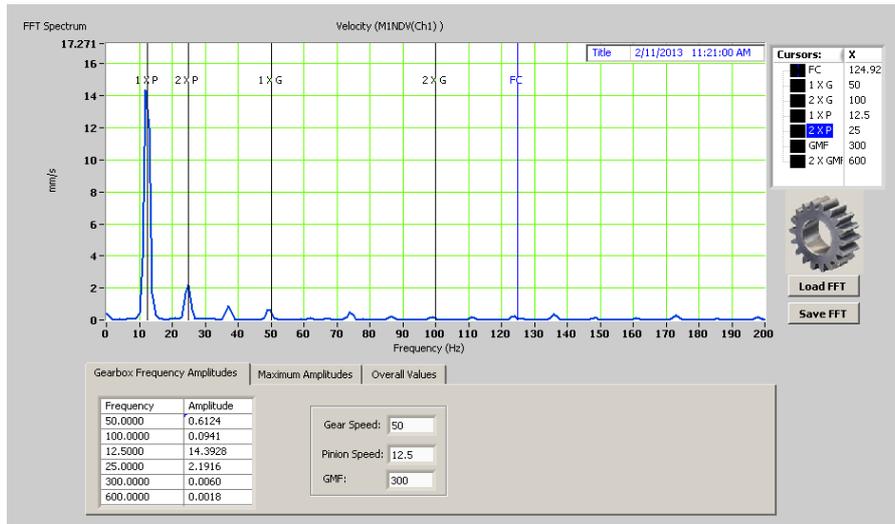
Gearbox

On this page one may enter main frequencies which are important for frequency analysis of gear driven machines and see their indicators on FFT plot and amplitudes on table results. Data which should be input to the program is as follows.

Rotational speed of the pinion and gear in hertz unit. Gear mesh frequency which is the product of pinion speed and its number of teeth or the same about gear. These frequencies are indicated in the graph and tabulated in the bottom of the graph with their correspondent amplitudes.

- 1) 1X of pinion (1 X P)
- 2) 2X of pinion (2 X P)
- 3) 1X of gear (1 X G)
- 4) 2X of gear (2 X G)
- 5) 1X of gear mesh frequency (GMF)
- 6) 2X of gear mesh frequency (2XGMF)

Vibro-Rotary machine Diagnosis Software



Bearing

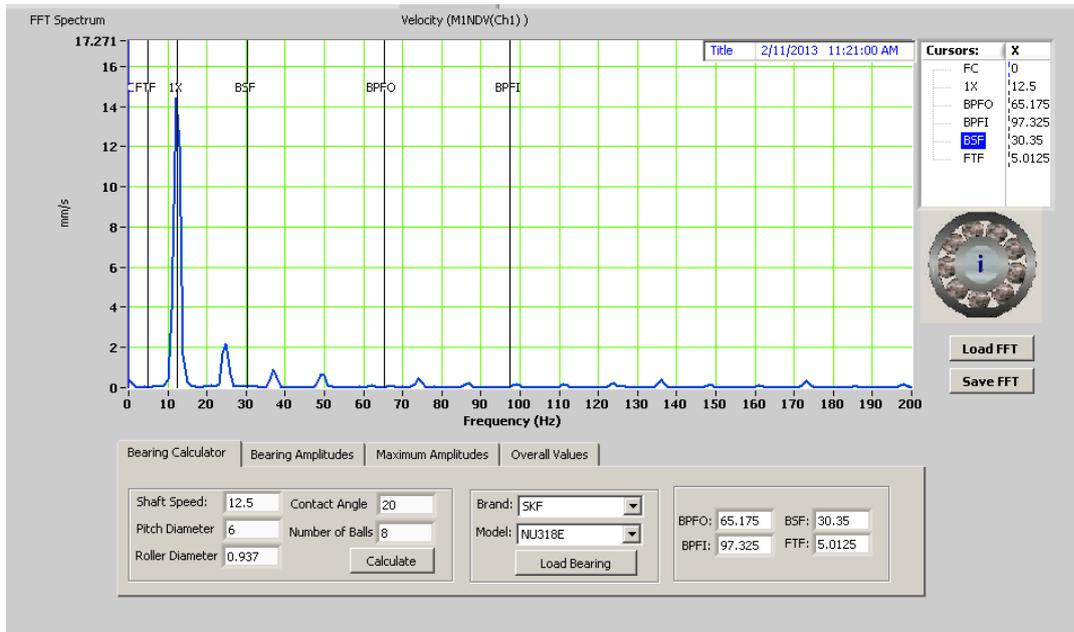
On this page one may enter main frequencies which are important for frequency analysis of anti-friction bearings and see their indicators on FFT plot and amplitudes on table results. Data which should be input to the program is in 2 ways. First you may enter the geometric dimensions of the bearing and press the calculate button. Second way is to choose brand & model of the bearing type and clicking on load bearing button. For both ways one should input the shaft speed in hertz unit. For manually inputting the bearing data, these parameters should be defined:

- 1) Shaft speed (Hz)
- 2) Pitch Diameter (mm)
- 3) Roller Diameter (mm)
- 4) Contact Angle (degrees)
- 5) Number of Rollers

If you know the type of your bearing, you may choose it from Model and Brand sections. Pressing Load Bearing/Calculate button would indicate the following frequencies:

- 1) Rotational speed of the shaft (1X)
- 2) Outer race bearing frequency (BPFO)
- 3) Inner race bearing frequency (BPFI)
- 4) Fundamental train frequency (FTF)
- 5) Ball spin frequency (BSF)

Vibro-Rotary machine Diagnosis Software



Electric Motor

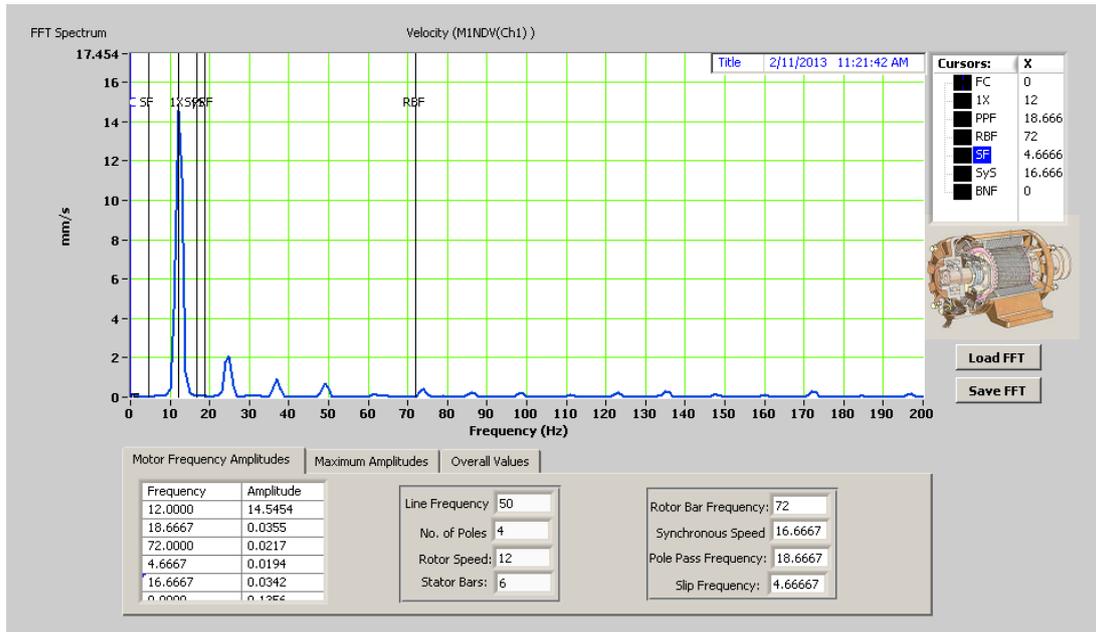
On this page one may enter main frequencies which are important for frequency analysis of electric motors and see their indicators on FFT plot and amplitudes on table results. Data which should be input to the program is as follows.

- 1) Motor speed (Hz)
- 2) Line Frequency (Hz)
- 3) Number of stator bars
- 4) Number of rotor poles

Program would calculate the following frequencies and show their amplitudes in the table.

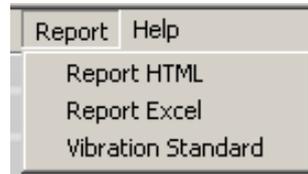
- 1) Synchronous speed (1X)
- 2) Slip frequency (SF)
- 3) Pole pass frequency (PPF)
- 4) Rotor bar frequency (RBF)

Vibro-Rotary machine Diagnosis Software



Report

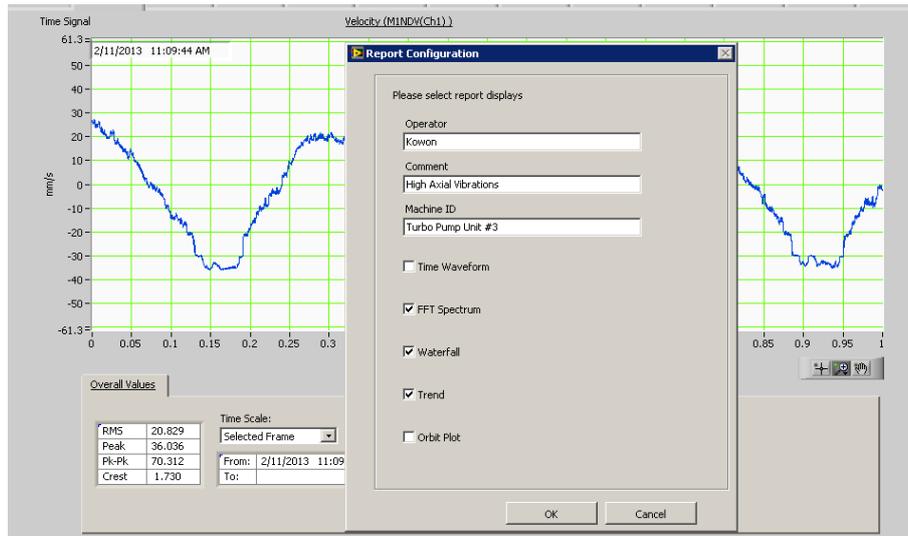
In this menu, there are 3 options. Report HTML and Excel are related to report files which are generated and Vibration standard contains options related to the alarm, normal & danger vibration value of the machine.



Report HTML/Excel

By selecting this option a form like the one below is shown to the user, and the user may fill its records and select the graph types which he likes the report to include and then click on OK button.

Vibro-Rotary machine Diagnosis Software



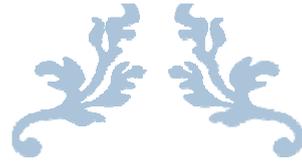
Vibration Standard

On this page ISO 10816-3 or other standard vibration values may be logged to trend page by the user. There are 2 ways to define vibration values for the software. First way is to use ISO 10816 drop menus, which contain Machine group (its definition is shown on the bottom of the page), Output type which may be displacement or velocity in R.M.S. and machine foundation which is related to the way machine is mounted to the base foundation either rigid or flexible.

Second way is to enter manually the vibration values related to Normal, Alarm and Danger operational zones of the machine. When using manual vibration value definition the checkbox of “Use manual input” should be activated. After setting the alarms, by clicking on “Load Values”, numbers are logged to trend graph and trend graph may be plotted via new alarm values.

ISO 10816	Manual Input	Set Alarms
Machine Group: 1	Normal: 4.8	Normal: 45
Output (R.M.S.): Displacement	Alarm: 8.4	Alarm: 90
Machine Foundation: Flexible	Danger: 12	Danger: 140
	<input type="checkbox"/> Use manual input	Load Values

Group 1: Large machines with rated power above 30 kW and not more than 50 MW; electrical machines with shaft height H> 315 mm



IMPACT MODAL TESTING SOFTWARE

Software manual



JULY 26, 2014

ABPVIBRO

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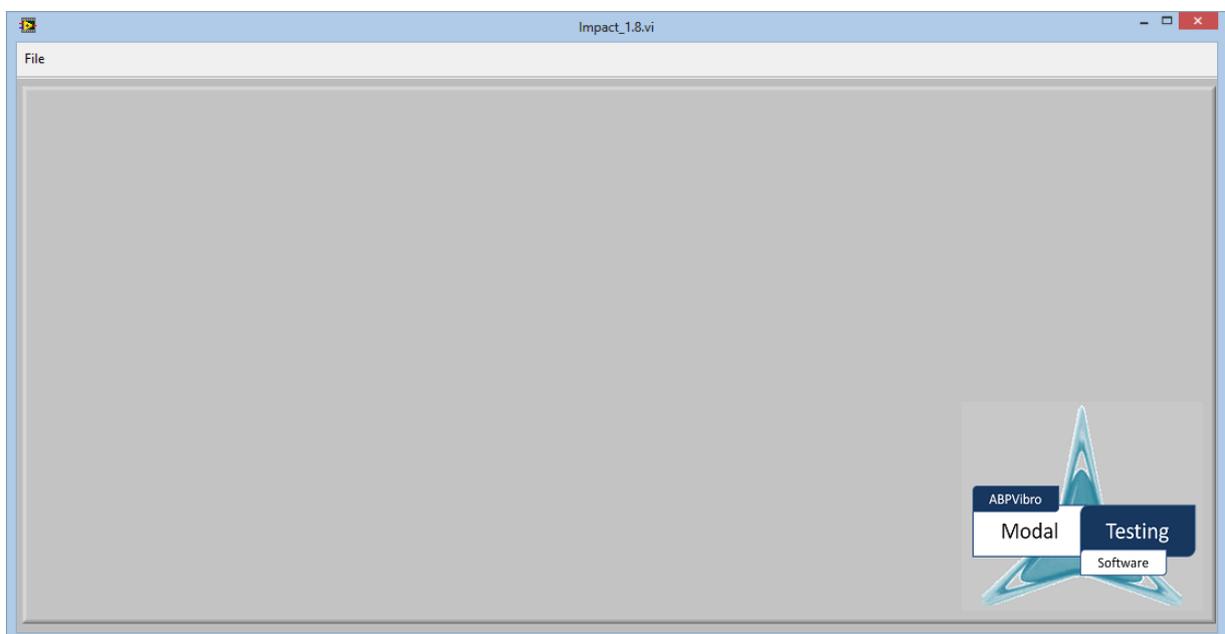
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IMPACT MODAL TESTING software

Introduction to impact modal testing software:

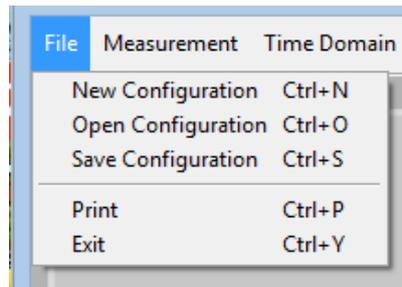
Impact modal testing software is an application which has been developed for the measurement & recording of frequency response functions from transducers/ sensors; it can be used for machinedynamic response analysis, modal analysis, mode shape extraction and model updating. Moreover, it records frequency response functions needed by modal analysis software like ICATS™ for off-line data review and analysis. It contains mostly used functions to provide engineers with a collection of the most beneficial tools like magnitude, phase, real & imaginary FRFs. impact modal testing software connects to VibroRack 1000 data acquisition modules and performs measurements & recordings.



IMPACT MODAL TESTING software

File menu

File menu contains menus which are needed for the configuration of the sensors & transducers which are connected to the analyzer. It has functions like New, Open & Save configuration with print and exit options. File menu is shown below.

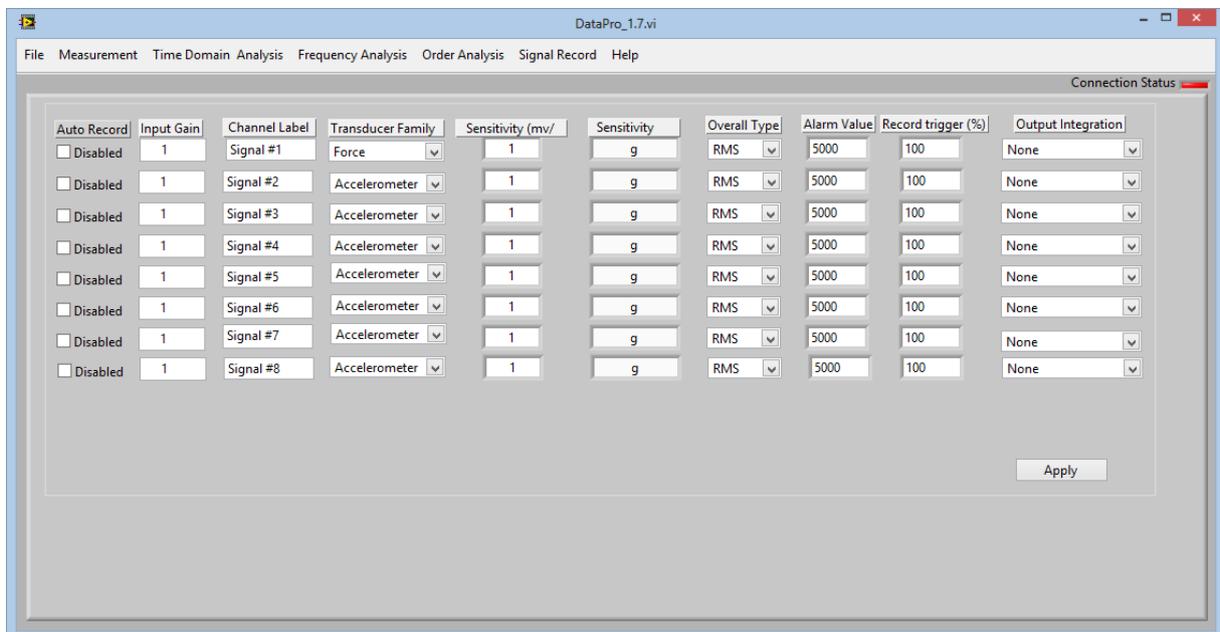


File menu

New Configuration

New configuration is the menu which is used to call the sensor settings and is depicted below.

Note: Impact hammer may only be connected to channel 1.



The first column is auto record enable/disable option and is used when user wants the recording function to start automatic as soon as an input value goes beyond a set value (Record trigger). Second column is input gain. User has to enter this value for each measurement channel from the input gain hardware on the analyzer board. Third column, Channel label is used for signal labeling

IMPACT MODAL TESTING software

and easier use, one may tag it as MDEV for Motor End Drive Vertical direction. Fourth column labeled as Transducer family is used for the determination of type of transducer. It may be displacement, velocity, acceleration, force, tachometer or microphone. Fifth column which is labeled sensitivity is the nominal voltage sensitivity of the sensors e.g. 100 mv/g for a typical accelerometer or 200 mv/mil for a typical displacement transducer. Sixth column is for the setting of sensitivity unit g, mm, mm/sec etc. For example for acceleration measurement there are a number of common units such as: g, m/sec², in/sec².

Column number 7 or overall type is related to the overall value parameter which is used for the status of the machine determination and also for activating the auto record function. There are 3 options RMS, Peak & Peak to Peak for measurement which may be selected separately for overall value calculation of each channel. Usually peak-peak is used for displacement while RMS is used for acceleration signal measurement.

Column 8, Alarm value is for setting the alarm value which is used for overall monitoring page in time domain menu. Moreover it is used for auto record definition.

Column 9, Record trigger (%) is the value in percent which is used for the activation of auto record signal. For example if Alarm is set to 3 g & Record trigger to 70 % and Overall RMS then whenever RMS of the overall vibration acceleration on the corresponding channel is more than $70\% * 3g = 2.1g$ software starts to record vibration signals into .dat measurement file.

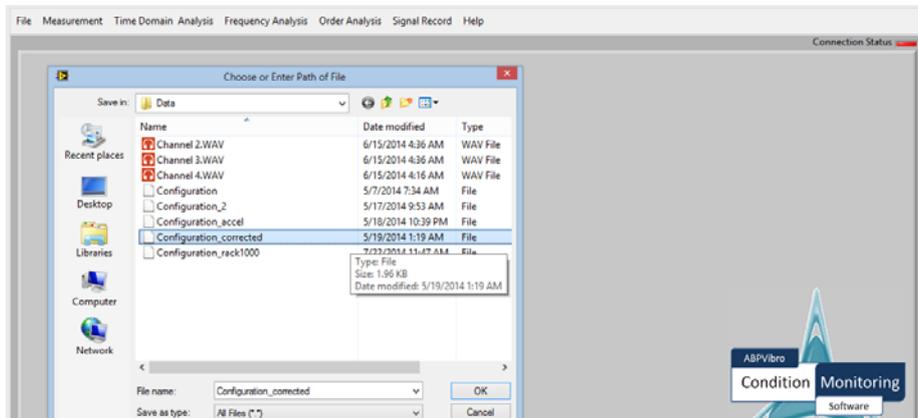
Column 10, Output integration is used for the integration of vibration signal output and is just valid for two kinds of transducers:

- 1) Acceleration signal may be integrated once for velocity calculation and integrated twice to output displacement signal.
- 2) Velocity signal may be integrated once to output displacement signal.

Open Configuration:

By choosing this option the user may browse the computer for VibroRack 1000 / VibroRack 3000 previously saved configuration file. User may save configuration files for different measurement settings i.e. transducer type, sensitivity, etc.

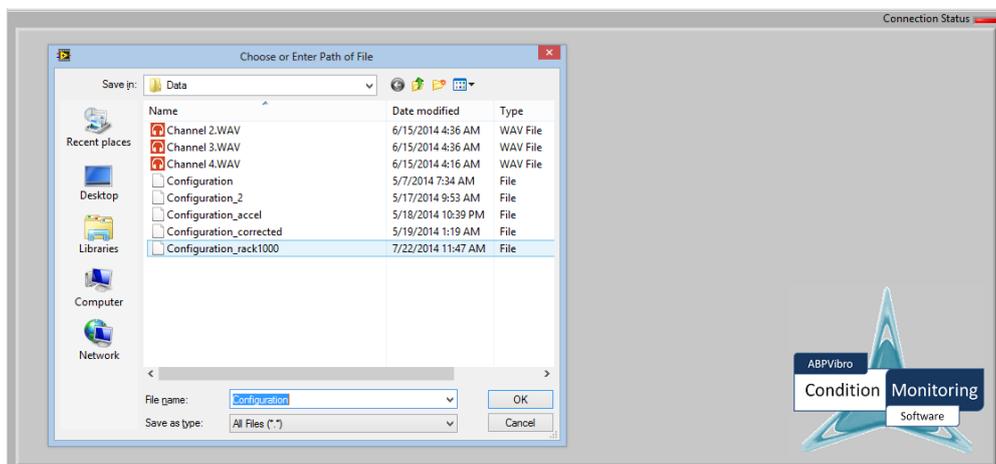
IMPACT MODAL TESTING software



Open configuration browser window

Save configuration

User may save all the sensor settings and measurement settings which have been set in the software in a file called configuration file which may be later used for MDS software or for future calls. This file includes: channel settings, alarm values and all other parametric settings which the user had input to CMS when taking measurements. This submenu Save is used for saving these data once and using them from load data after that.



Save configuration window

Print menu

This menu prints the current screen.

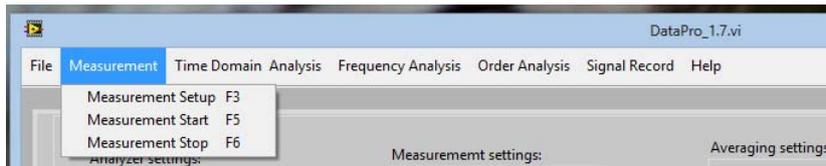
Exit menu

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This option is used for closing the software.

Measurement

Measurement menu contains options related to measurement settings and start/stop triggering of the analyzer. It has 3 options Measurement settings, Measurement start & Measurement stop.



Measurement Setup

By choosing measurement setup option on measurement menu, user is faced with the following window. Measurement parameters are categorized as: Analyzer settings, Measurement settings, Averaging settings & Tachometer settings.

Analyzer settings consists from the following options:

- 1) Analyzer IP which depends on the network which is the network LAN TCP/IP V4IP address of the analyzer like: 192.168.0.101. Please make sure that the ip configuration of the computer on which CMS is installed must be in the range like: 192.168.0.210.
- 2) Port is the port address number and is usually 80 for most VibroRack 1000 and VibroRack 3000 systems. Otherwise, the number may be obtained by contacting the company customer support center.
- 3) Measurement record path: user should select the folder in which .dat measurement record files should be saved in. These files are later used by MDS software.
- 4) Save interval: this option is the time difference between two consecutive signals save. For example if set on 10 minutes save interval, signal is recorded into .dat once in file every 10 minutes.

Measurement settings consists from the following options:

- 1) FFT window which is used for decreasing the spectral leakage of the frequency spectrum while maintaining the maximum possible amplitude accuracy and has different types: hamming, uniform, flat top, force- exponential ...
For FRF measurement in response to impact it should be set to Force-Exponential
- 2) Frequency bandwidth is the maximum frequency bandwidth of interest i.e. 1000 Hz or more. This determines the sampling frequency which is two times the frequency bandwidth. Always remember that this number should be completely consistent with the frequency jumper setting of the hardware board.
- 3) Samples is the number of samples measured from every transducer each time measurement is performed. Always bear in mind that acquisition time is equal to samples divided by 2*

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bandwidth. For the measurement shown in the following window, it is calculated as follows:

$$2000/2*1000=1 \text{ second}$$

Moreover, frequency resolution between 2 consecutive lines of the FFT plot is calculated by inverting the acquisition time so if acquisition time is 2 seconds frequency resolution is $df = 1/2 = 0.5 \text{ Hz}$.

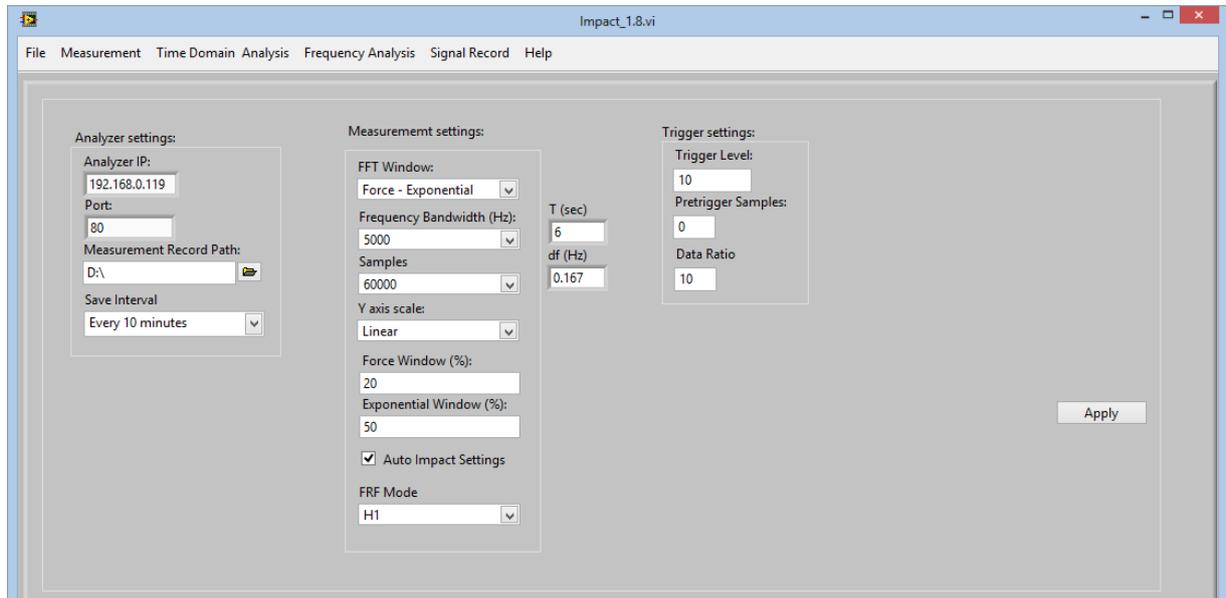
For FRF measurements this option is preferred to be set on 10000Hz, 60000 samples.

- 4) Y axis scale is for the scaling of Y axis (amplitude axis) in different plots which may be set to linear or logarithmic.
- 5) Force Window & Exponential window (%) are the time frame percent window function which is performed in FRF calculation.
- 6) Auto Impact settings chosen makes the software automatically select the best options available for force-exponential window.
- 7) FRF mode may be selected from H1, H2 & H3 which defines the mathematical approach to compute the frequency response function.

Trigger settings consists from the following options:

- 1) Trigger level indicates the force level on channel 1 for the start of measurement i.e. 10 means start calculation when the level of force is above 10 Newton.
- 2) Pretrigger samples: on some tests user needs to start the measurement from a limited number of samples before the impact takes place. On this occasions user may set the number of pre impact samples on this option.
- 3) Data ratio defines how long data to be used for FRF calculation. For example if the measurement period is 6 seconds and you set this option on 3, just 3 seconds after the impact is used for FRF calculation. If this option is set to 10 then maximum signal length available is used for FRF calculation

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Measurement settings window

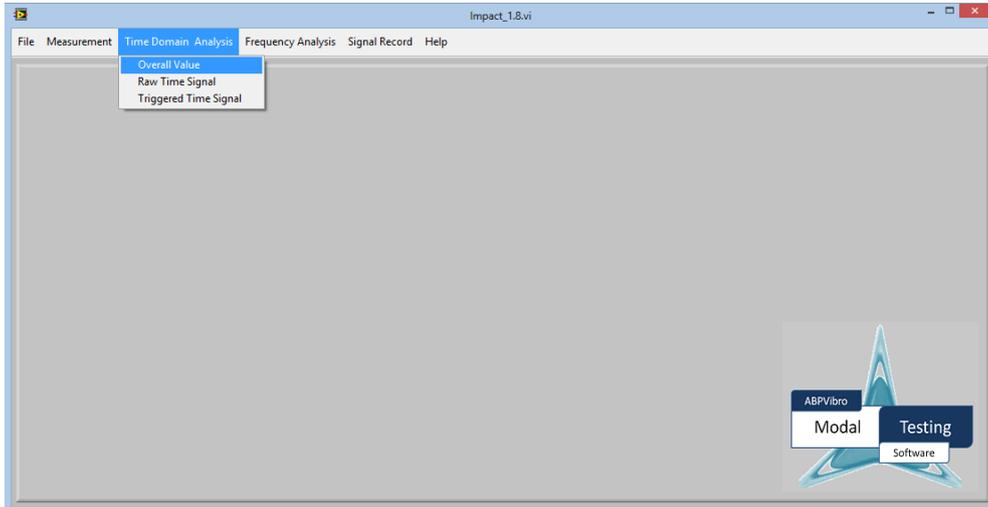
Measurement Start / Stop is for the activation and inactivation of the measurement and may be reached by F5 / F6 shortcut keys from the keyboard.

Note: After selecting Start measurement user has to perform the impact test as soon as possible so that maximum number of measurement samples under the effect of force is recorded

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Time domain analysis

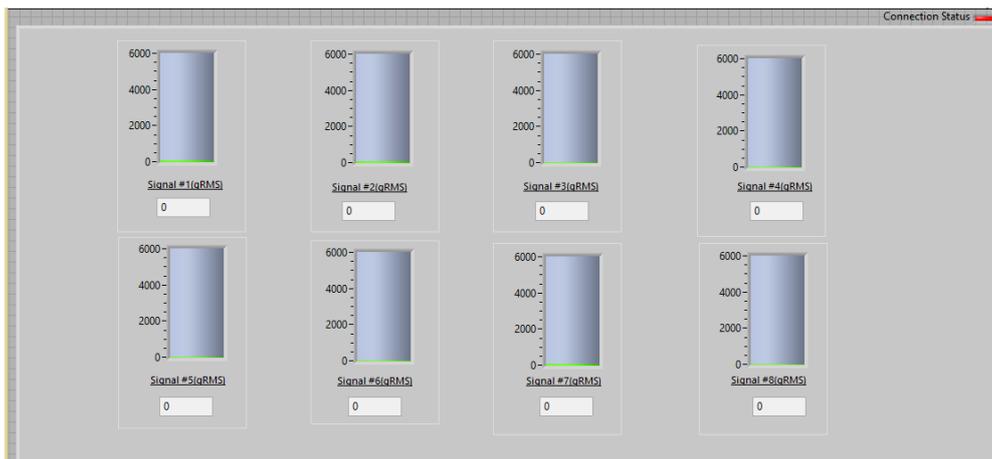
Time domain menu contains functions needed for sensor output analysis in time domain. It contains 3 options Overall value, Raw time signal & Triggered time signal.



Time domain analysis menu

Overall Value

In this page, user can see the overall value of measured parameters in terms of the configuration which has been set for alarm, overall type & sensor type. For each channel label overall value and measurement unit is shown and condition of the machine is plotted in a vertical tank indicator as a graphical layout.



Overall value window

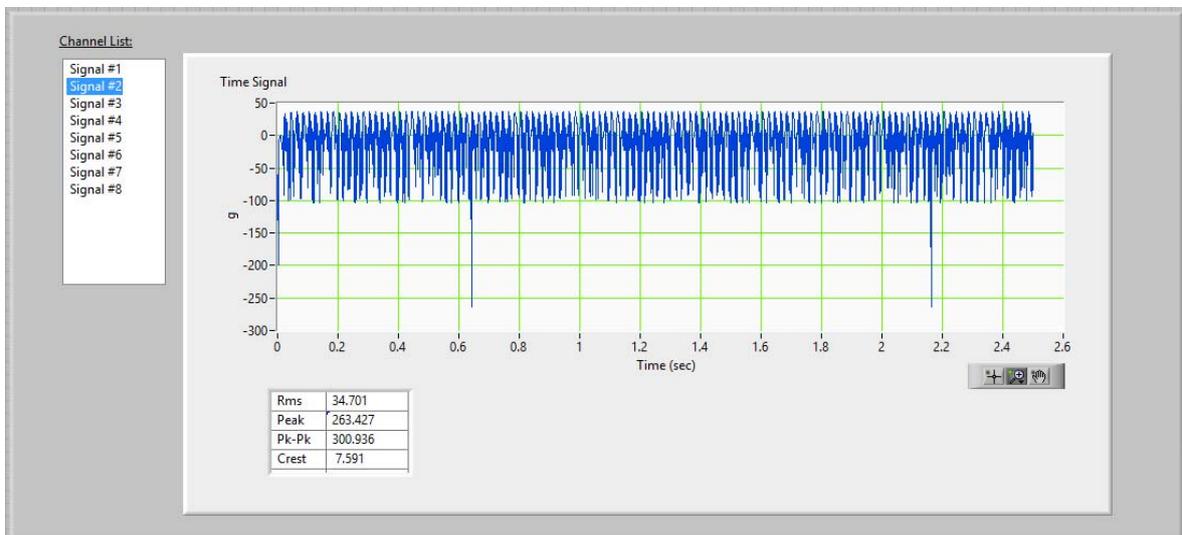
Raw time signal

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Raw time signal shows the complete measurement period time signal i.e. before and after the impact. Time waveform is the fundamental graphic presentation of machinery dynamic data. It shows how a single parameter (most often displacement, velocity, or acceleration, but also any other dynamic measurement) from a single transducer changes on a very short time scale, typically a fraction of a second. This is in contrast to trend plots, which display the value of a slowly changing parameter over a much longer time scale, typically hours to months.

A time waveform plot represents a small slice of time in the vibration history of the machine. Usually, the amount of time involves only a few revolutions of the rotor. During this short length of time, the overall behavior of the machine is not likely to change significantly. However, unfiltered time waveform plots can clearly show a change in machine response if sudden events occur in the machine or if the machine is rapidly changing speed (such as an electric motor startup). Time waveform plots have several important uses. They have the advantage in being able to clearly display the unprocessed output from a single transducer. This allows us to look for noise on the signal or to detect the presence of multiple frequency components. An important use of a time waveform plot is to identify the presence and timing of short term transient events like rubs. Large amounts of information such as rub, peak-to-peak amplitude, the filtered vibration frequency, the rotor speed, the nX amplitude and phase of a filtered signal can be obtained from a time waveform plot.

Time signal window shows the time waveform, channel selection bar in the left and overall value measurements at the bottom of the page.

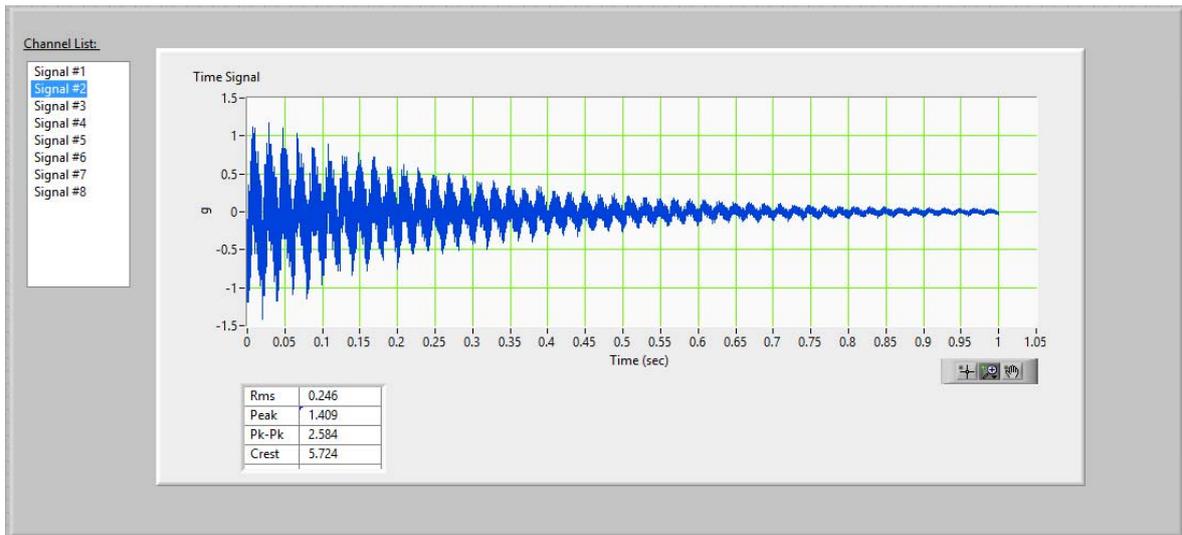


Raw Time Signal Window

Triggered TimeSignal

This window shows only the portion of the measurement after the impact. This part is the only part of data used for FRF calculation.

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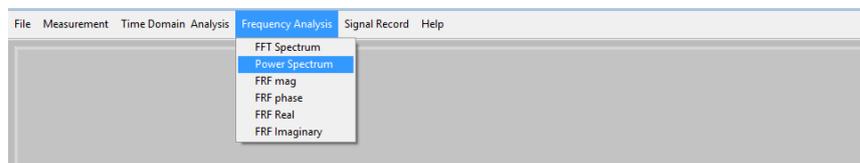
Triggered time signal window

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Frequency Analysis

This menu contains the most useful frequency domain functions for performing a frequency analysis on time signals measured by the analyzer and it contains:

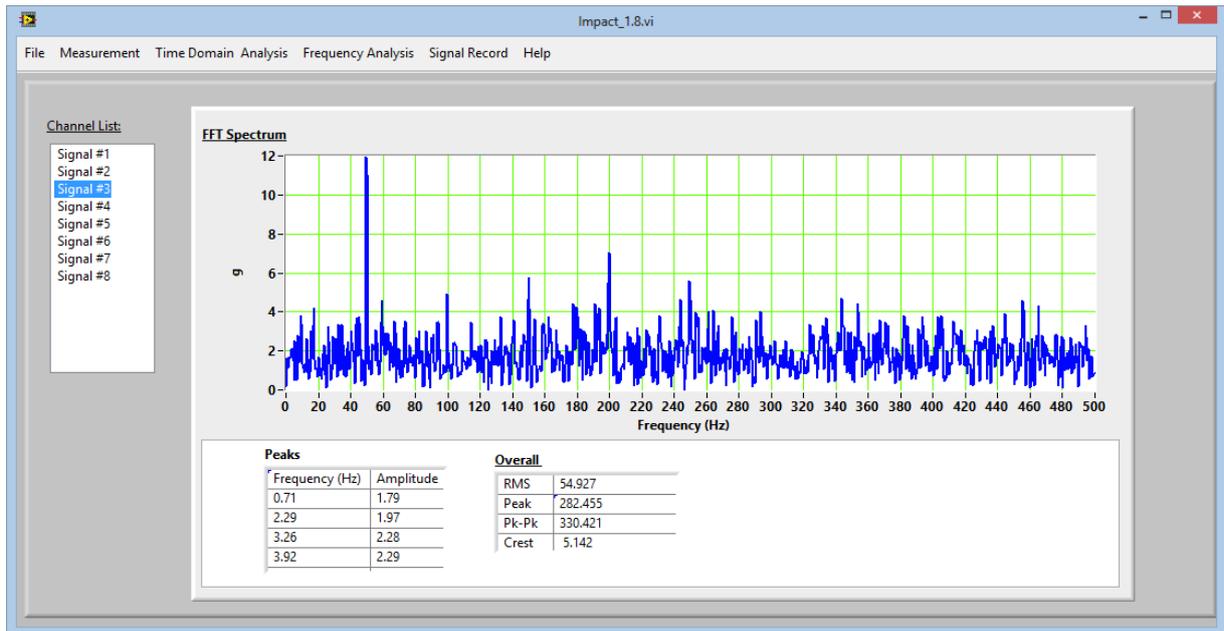
- FFT spectrum
- Power spectrum
- FRF mag
- FRF phase
- FRF real
- FRF imaginary



FFT Spectrum

Machines can vibrate at many different frequencies simultaneously. These frequencies can be related or unrelated to running speed and include both subsynchronous and supersynchronous frequencies. Since these frequencies are associated with the operating condition of the machine, the machinery diagnostician must have some way to determine the frequency content of a vibration signal in order to make an accurate diagnosis. Vibration frequencies sometimes appear as a series of harmonics. The series consists of the rotational frequency of the machine, called the fundamental, and a number of frequencies at integer multiples of the fundamental. FFT (Fast Fourier Transfer) is used to seize out the frequency contents of a vibration signal. FFT window looks like the figure shown below.

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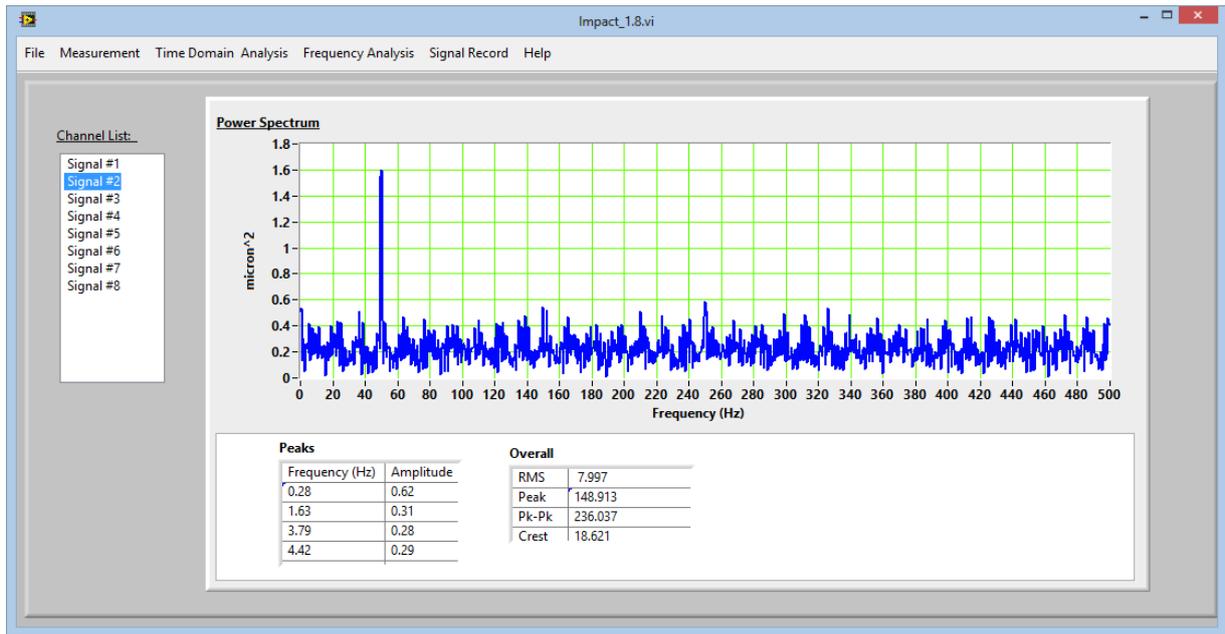
Frequency Spectrum Window

On Peaks table, one may see the frequency & amplitude of maximum FFT points. In overall section, different measured overall values are shown. In the left side of the window user can select the desirable channel to see the plot.

Power spectrum

This window shows the Power spectrum of the time signal for the impact measurement. Maximum amplitudes and overall values are shown in tables on the bottom of the window.

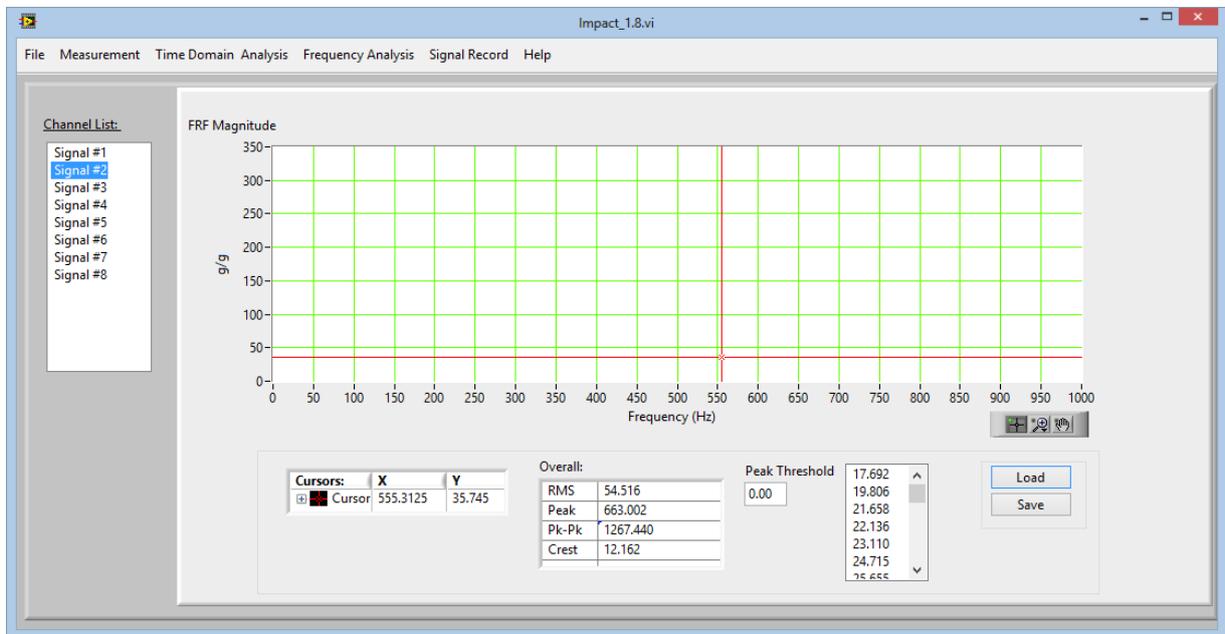
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Power spectrum window

FRF mag

This option shows the magnitude of FRF function for response channels 2 to eight vs. input force on channel one.

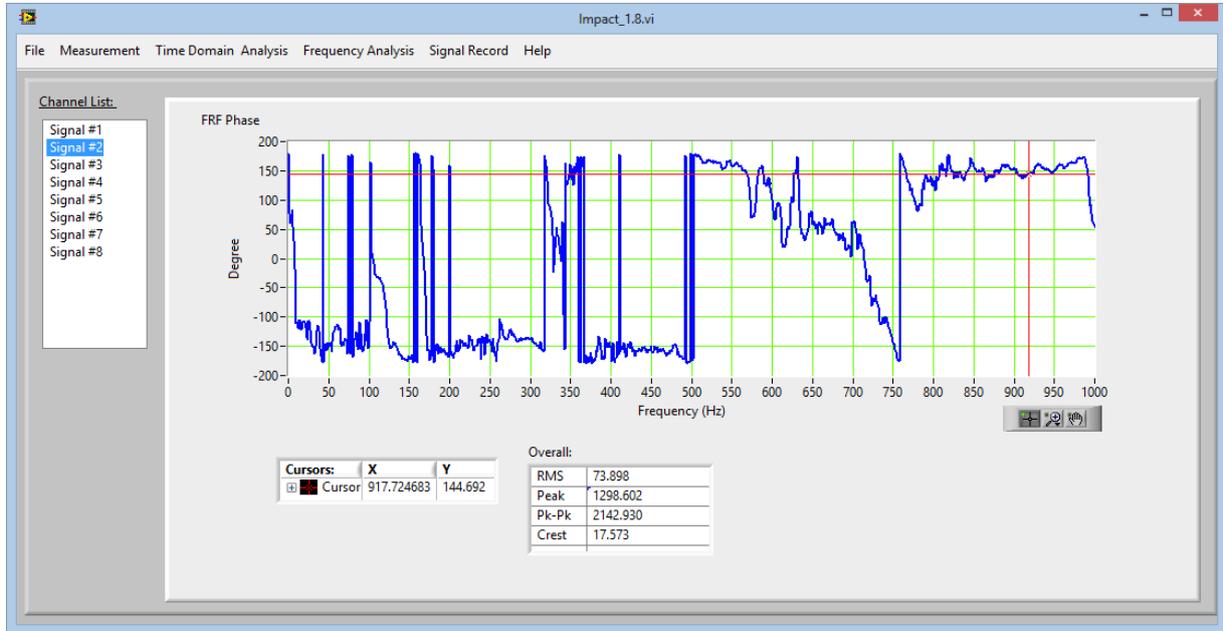


FRF magnitude window

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FRF phase

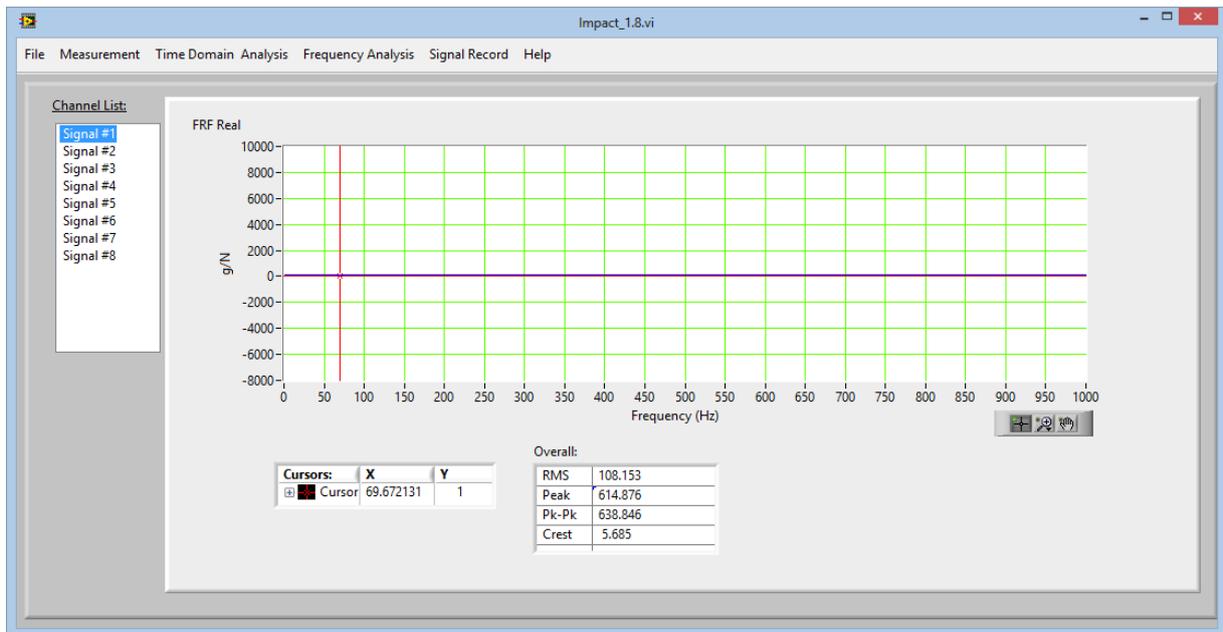
This option shows the relative phase of FRF function for response channels 2 to eight vs. input force on channel one in terms of degrees.



FRF phase window

FRF real

This option shows the real value of the complex FRF function for response channels 2 to eight vs. input force on channel one in terms of degrees.

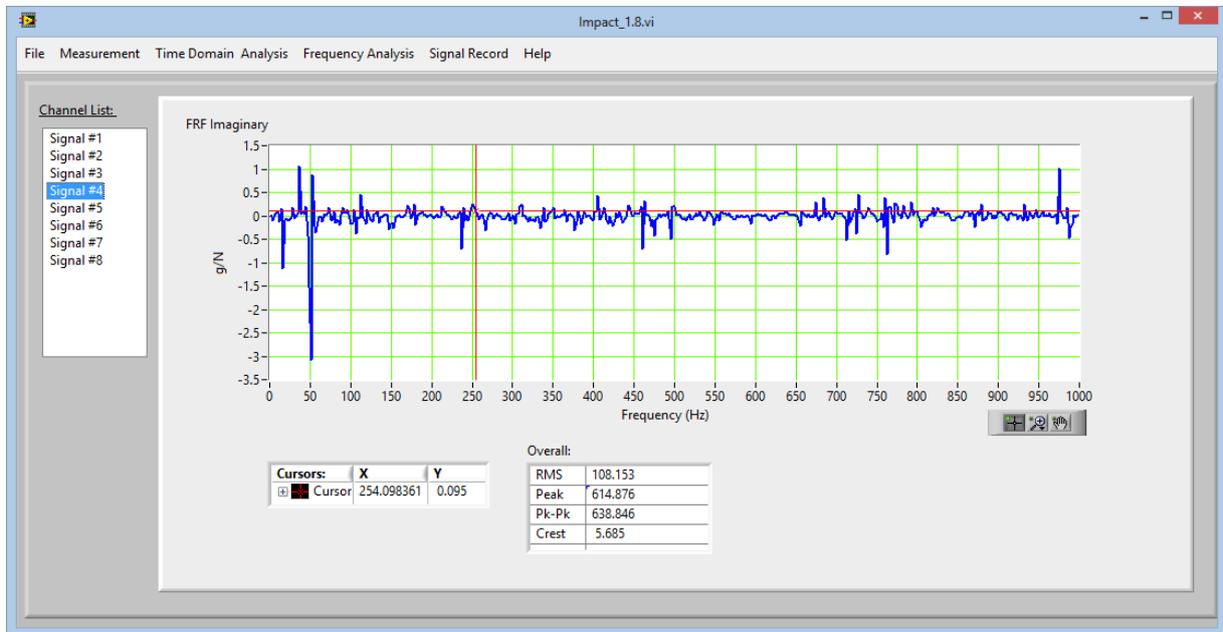


FRF real window

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FRF imag

This option shows the imaginary value of the complex FRF function for response channels 2 to eight vs. input force on channel one in terms of degrees.

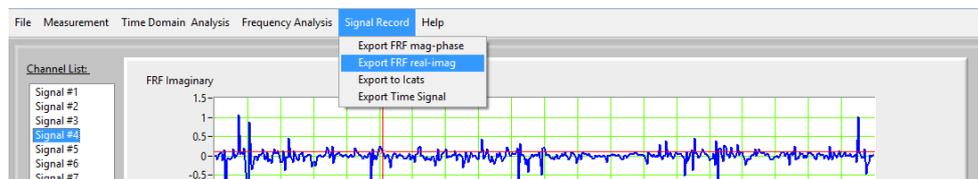


FRF imaginary window

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Signal Record

Signal record menu contains a list of functions for exporting data into different frequently used formats. Functions are associated with ICATS® format measurements which is used by ICATS® modal analysis software, standard text format exporting for time signal, real-imaginary and magnitude-phase measurements which saves the measurement into .txt format for further analysis by other 3rd party software such as MATLAB®, Excel®, etc.



Signal record menu

Export FRF mag-phase

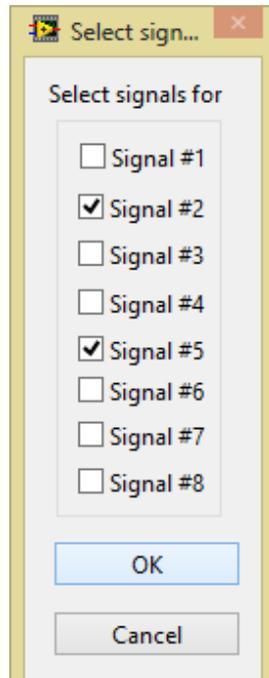
Exports FRF measurements into text files with three columns, column one frequency Hz, column two amplitude and column three phase of the FRF.

Export FRF real-imag

Exports FRF measurements into text files with three columns, column one frequency Hz, column two real part and column three imaginary part of the FRF.

Export time signal

Exports the time signal measurement into standard text files which may be later used by Notepad®, Excel®, MATLAB®, etc.

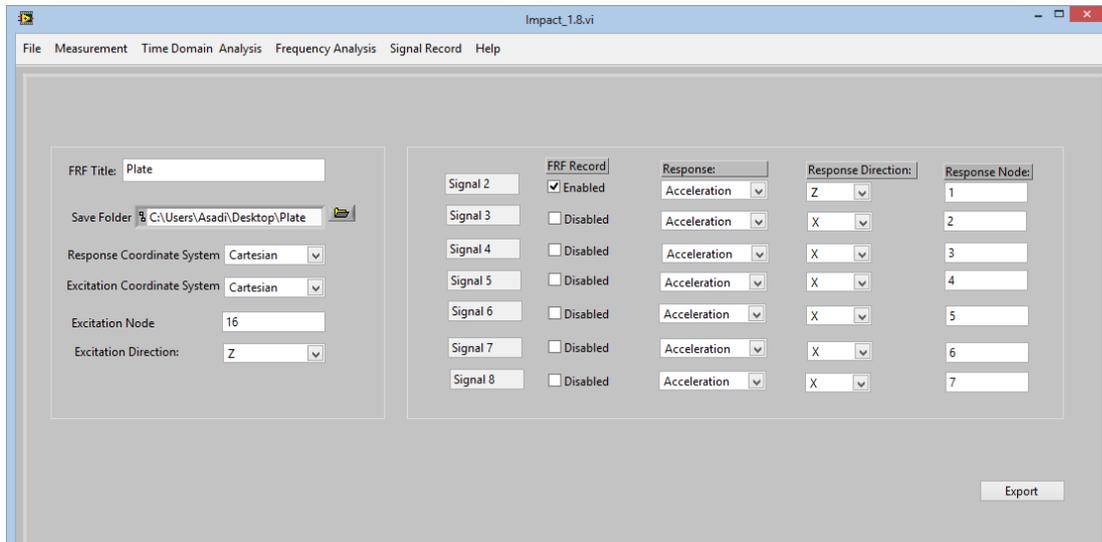


Export time signal window

Export to ICATS

This kind of file export is useful for performing modal analysis and modeshape extraction by 3rd party software packages like ME Scope™ or ICATS™. This window contains a number of options which are located and must be entered correctly for further mode shape analysis. These options include Response / Excitation coordinate systems which may be selected from Cartesian. Polar & spherical. Excitation and response measurement node and direction and FRF record. If FRF record is selected for different input channels, by clicking Export the selected files are generated.

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Export to ICATS window

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Help

Help menu contains access to help menu of the software with access to ABPVibro website.

