Industrial Maintenance

Vibration Analysis
Pumps Training System

Courseware Sample
89199-F0

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Safety and Common Symbols

The following safety and common symbols may be used in this manual and on the equipment:

Symbol	Description
⚠ DANGER	**DANGER** indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
⚠ WARNING	**WARNING** indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
⚠ CAUTION	**CAUTION** indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
CAUTION	**CAUTION** used without the *Caution, risk of danger* sign ⚠, indicates a hazard with a potentially hazardous situation which, if not avoided, may result in property damage.
	Caution, risk of electric shock
	Caution, hot surface
	Caution, risk of danger
	Caution, lifting hazard
	Caution, hand entanglement hazard
	Notice, non-ionizing radiation
⎓	Direct current
∿	Alternating current
⎓	Both direct and alternating current
3∿	Three-phase alternating current

Safety and Common Symbols

Symbol	Description
	Earth (ground) terminal
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	On (supply)
	Off (supply)
	Equipment protected throughout by double insulation or reinforced insulation
	In position of a bi-stable push control
	Out position of a bi-stable push control

Table of Contents

Preface

The Advanced Vibration Analysis for Pumps training system, Model 46733, is an add-on to the Pumps Training System, Model 46106, which faithfully reproduces an industrial environment where students can develop their skills in the installation and maintenance of industrial pumps.

Due to its modular design, the Pumps Training System can be configured to fit various training needs. The following equipment is available to adjust the curriculum to various training levels:

- Centrifugal Pump - Pedestal
- Centrifugal Pump - Pedestal
- Centrifugal Pump - C-Face
- External Gear Pump
- Vane Pump
- Flexible Impeller Pump
- Progressive Cavity Pump
- Peristaltic Pump
- Pneumatic Diaphragm Pump
- Metering Pump
- Piston Pump
- Centrifugal Pump - Stuffing-Box
- Multi-Stage Centrifugal Pump
- Magnetic-Drive Centrifugal Pump
- Variable Speed Drive
- Upper Reservoir
- Lubrication Kit
- Alignment Kit
- Air Compressor
- Software and configuration software components
- Measuring instruments, including Paddle Wheel Flowmeters, Pressure Gauges, Current Clamp Meter, Pyrometer, Vibration Meter, Tachometer, Stroboscope, and more
- Tools and toolbox
- Hoses and accessories

All of the above components consist of industrial-type equipment and tools for realistic training.

We hope that your learning experience with the Pumps Training System will be the first step of a successful career.

Preface

We invite readers of this manual to send us their tips, feedback, and suggestions for improving the book.

Please send these to did@de.festo.com.

The authors and Festo Didactic look forward to your comments.

About This Manual

The topics covered in this manual are presented in the form of work orders. Each work order includes a brief description of the task, a drawing of the equipment setup when necessary, and the main steps of the work to be done.

To obtain further information about the covered topics, consult the reference material or ask your instructor.

Safety considerations

Safety symbols that may be used in this manual and on the equipment are listed in the Safety Symbols table at the beginning of the manual.

Safety procedures related to the tasks that you will be asked to perform are indicated in each exercise.

Make sure that you are wearing appropriate protective equipment when performing the tasks. You should never perform a task if you have any reason to think that a manipulation could be dangerous for you or your teammates.

It is recommended to complete the safety checklist in Appendix B of this manual at the beginning of any work order.

Reference material

- Introduction to Machine Vibration by Glenn D. White
- User Manual of the vibration analyzer SKF Microlog Advisor Pro
- User Manual of the SKF Analysis and Reporting Module

Prerequisite

To perform the work orders of this manual, you should have completed the manual Single Pump Systems, p/n 37894.

The answers to the questions of this manual can be found in the reference material.

Systems of units

Units are expressed using the International System of Units (SI) followed by the units expressed in the U.S. customary system of units (between parentheses).

To the Instructor

You will find in this Instructor Guide all the elements included in the Student Manual together with the answers to all questions, results of measurements, graphs, explanations, suggestions, and, in some cases, instructions to help you guide the students through their learning process. All the information that applies to you is placed between markers and appears in red.

Accuracy of measurements

The numerical results of the hands-on exercises may differ from one student to another. For this reason, the results and answers given in this manual should be considered as a guide. Students who correctly performed the exercises should expect to demonstrate the principles involved and make observations and measurements similar to those given as answers.

NCCER Accreditation

Contact the National Center for Construction Education and Research (NCCER), at *www.nccer.org*, to obtain the requirements relative to the NCCER accreditation of this course.

Vibration analyzer Microlog

The main menu of the vibration analyzer Microlog shows many icons. The icons represent the modules available with the vibration analyzer Microlog. Most of the icons are dimmed because they represent modules that are not required to perform the exercises in this course. The icons SETUP and ANALYZER should be brightened because they represent the required modules.

Refer to the user manual of the SKF Microlog AdvisorPro® for more details on how to use the vibration analyzer. The user manual is available on the CD supplied with your system.

Sample

Extracted from

Work Orders - Student

FFT Spectrum and Waveform Analyses

OBJECTIVE

To introduce FFT spectrum and waveform analyses. To familiarize yourself with natural frequency and resonance.

PROCEDURE

⚠ CAUTION

Before proceeding with this activity, complete the safety checklist in Appendix B.

Setup

1. Install the Emergency Stop Station, Variable Speed Drive, Pump Universal Base, and motor on the Pump Bench as shown in Figure 7.

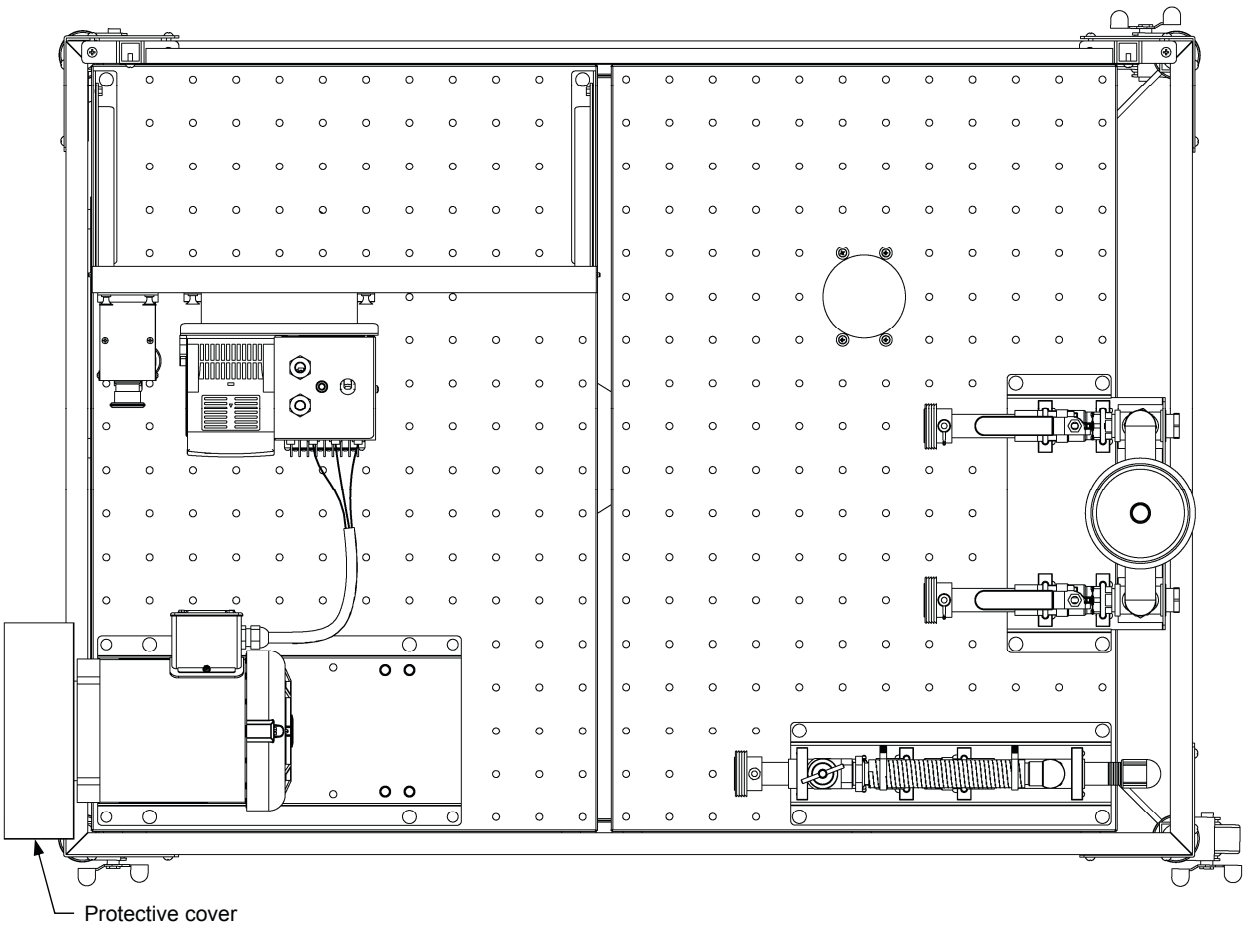


Figure 7. Circuit used to perform FFT spectrum and waveform analyzes.

2. Complete the setup by performing the following steps:

   - Fix the protective cover to the motor.
   - Install the balancing disk on the motor shaft and tighten the setscrew on the shaft key.
   - Install a screw with two Keps nuts in one of the holes of the balancing disk to unbalance the disk.
   - Close the protective cover.

3. On the vibration analyzer, open the *Analyzer - Setup* window, then perform the following settings:

Parameter	Setting
Num Channels	1
Sensor type	Accel. G
Sens.	Enter the vibration transducer sensitivity shown on the calibration chart.
Y-axis units	Time
X-axis units	S
Detection	RMS
Filter	2 Hz
Freq Range	800
Samples	16384
Num. Averages	5
Avg. Type	Exponential
View Signal	Time
Display Y-axis	Linear
Window	Hanning

4. On the Variable Speed Drive, perform the following settings:

   - Set the parameters to default values.
   - Set the acceleration time to 5 seconds.
   - Display the output frequency.
   - Set the direction of rotation to forward.
   - Set the frequency to 25 Hz.

   Start the motor.

   Slightly reduce the speed of the motor if resonance occurs.

Waveform analysis (time domain)

5. Fix the vibration transducer to the motor as shown in Figure 8.

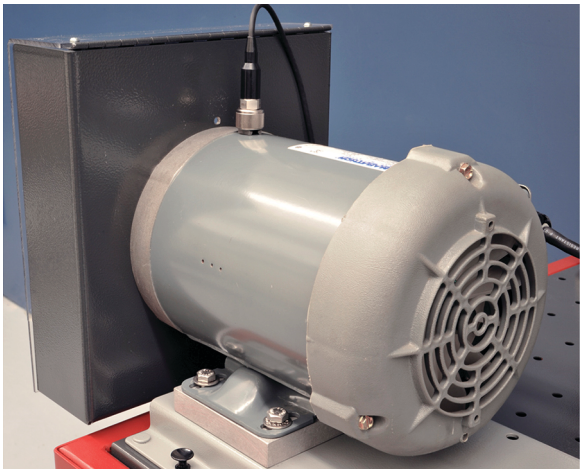


Figure 8. Mount the vibration transducer in the radial axis.

6. On the vibration analyzer, start the data collection.

Once the waveform is displayed, press the *Pause* function button to pause the acquisition process. Make the appropriate *X-Zoom* and *Y-Zoom* settings to observe the waveform.

7. Using the *Harmonic Cursor* and *Peak Find* functions of the vibration analyzer, determine the period (T) of the sinusoidal waveform.

Period of the sinusoidal waveform (T) = _____

8. Using the equation f = 1/T, determine the frequency (f) corresponding to the measured period.

Frequency corresponding to the measured period (f) = _____

9. Is the frequency corresponding to the measured period approximately equal to the output frequency set on the Variable Speed Drive?

❑ Yes ❑ No

10. Name the two domains used to analyze vibration signals.

_____

_____

11. Which domain is best suited to analyze a vibration signal containing a great amount of information? Explain why.

_____

_____

_____

FFT spectrum analysis (frequency domain)

12. What is the meaning of FFT? Describe briefly.

_____

_____

_____

13. On the vibration analyzer, depress the *Spectrum* button to display the vibration signal in the frequency domain.

Make the appropriate *X-Zoom* and *Y-Zoom* settings to observe the frequency spectrum.

Using the *Peak Find* function, determine the dominant frequency (f) in the frequency spectrum.

Dominant frequency (f) in frequency spectrum = _____

14. Does the dominant frequency determined in the previous step correspond to the frequency previously calculated from the measured period?

❑ Yes ❑ No

Resonance

15. Give a brief description of natural frequency.

_____

_____

16. Give a brief description of resonance.

17. Give an example of a highly resonant mechanical system.

18. Describe how the vibration levels vary when resonance occurs.

CAUTION

In the next steps, you will vary the speed of the motor and observe resonance. The high levels of vibration that are produced when resonance occurs can damage the equipment. As soon as you have completed your observations, reduce the motor speed to a value that does not produce such resonance.

19. In the *Analyzer - Setup* window of the vibration analyzer, set the parameters as follows:

Parameter	Setting
Num Channels	1
Sensor type	Accel. G
Sens.	Enter the vibration transducer sensitivity shown on the calibration chart.
Y-axis units	Disp µm (Disp mil)
X-axis units	Hz
Detection	RMS
Filter	2 Hz
Freq Range	2000
Lines	800
Num. Averages	5
Avg. Type	Exponential
View Signal	Spectrum
Display Y-axis	Linear
Window	Hanning

On the vibration analyzer, start the data collection.

20. On the Variable Speed Drive, slowly increase the frequency up to 40 Hz while observing the overall level of displacement on the vibration analyzer display.

Stop the motor.

Describe how the overall level of displacement varies between 25 Hz and 40 Hz.

_____

_____

_____

_____

21. Ask the instructor to check your work.

22. Disassemble the setup, and return the equipment to the storage location.

Name: _____ Date: _____

Instructor's approval: _____

Sample

Extracted from

Work Orders - Instructor

FFT Spectrum and Waveform Analyses

OBJECTIVE

To introduce FFT spectrum and waveform analyses. To familiarize yourself with natural frequency and resonance.

PROCEDURE

⚠ CAUTION

Before proceeding with this activity, complete the safety checklist in Appendix B.

Setup

1. Install the Emergency Stop Station, Variable Speed Drive, Pump Universal Base, and motor on the Pump Bench as shown in Figure 7.

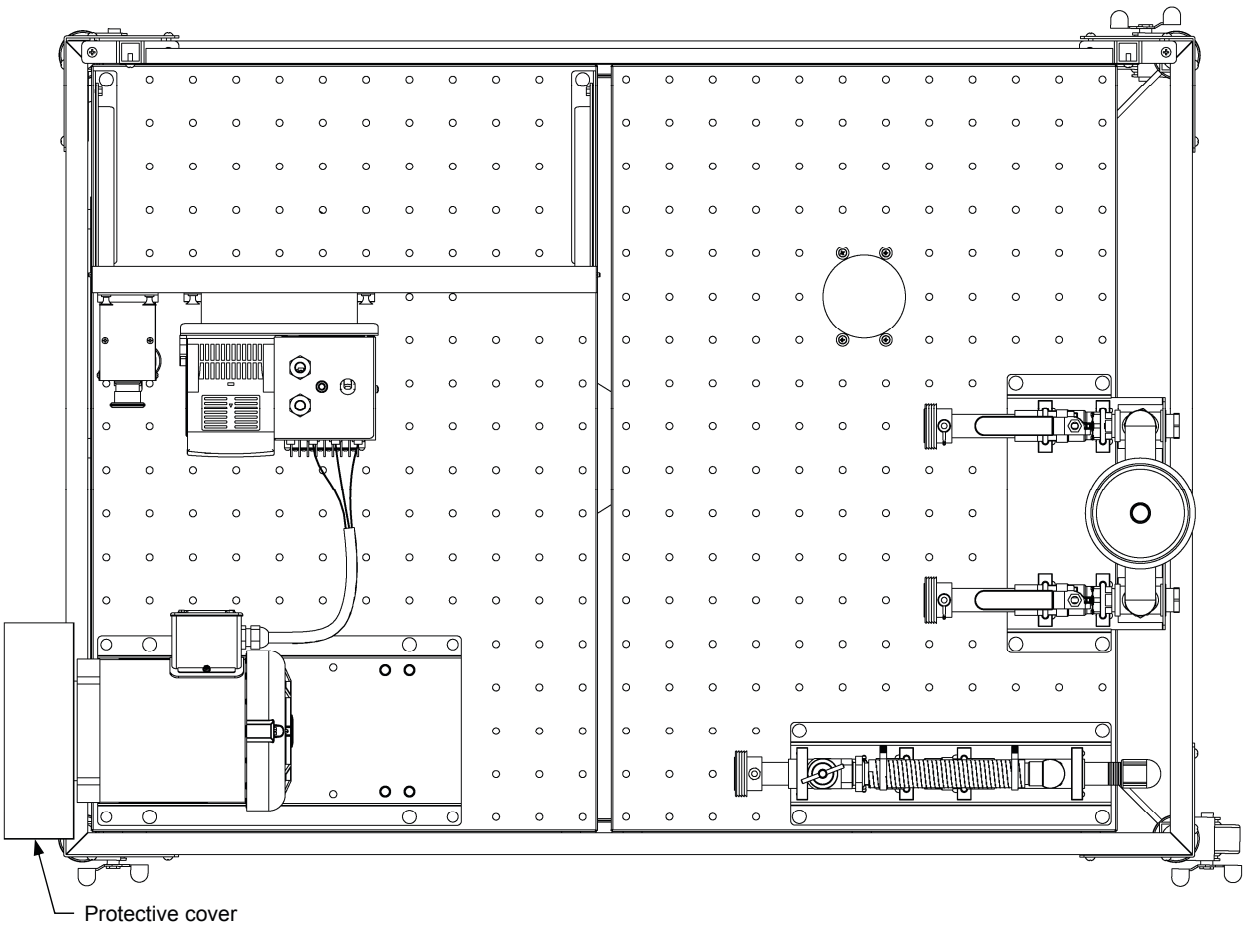


Figure 7. Circuit used to perform FFT spectrum and waveform analyzes.

2. Complete the setup by performing the following steps:

   - Fix the protective cover to the motor.
   - Install the balancing disk on the motor shaft and tighten the setscrew on the shaft key.
   - Install a screw with two Keps nuts in one of the holes of the balancing disk to unbalance the disk.
   - Close the protective cover.

3. On the vibration analyzer, open the *Analyzer - Setup* window, then perform the following settings:

Parameter	Setting
Num Channels	1
Sensor type	Accel. G
Sens.	Enter the vibration transducer sensitivity shown on the calibration chart.
Y-axis units	Time
X-axis units	S
Detection	RMS
Filter	2 Hz
Freq Range	800
Samples	16384
Num. Averages	5
Avg. Type	Exponential
View Signal	Time
Display Y-axis	Linear
Window	Hanning

4. On the Variable Speed Drive, perform the following settings:

   - Set the parameters to default values.
   - Set the acceleration time to 5 seconds.
   - Display the output frequency.
   - Set the direction of rotation to forward.
   - Set the frequency to 25 Hz.

   Start the motor.

   Slightly reduce the speed of the motor if resonance occurs.

Waveform analysis (time domain)

5. Fix the vibration transducer to the motor as shown in Figure 8.

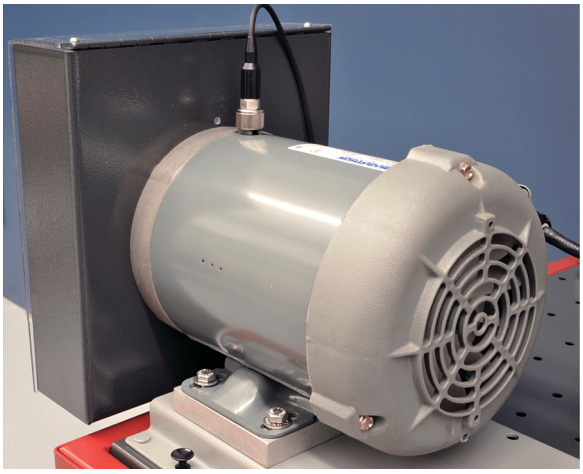
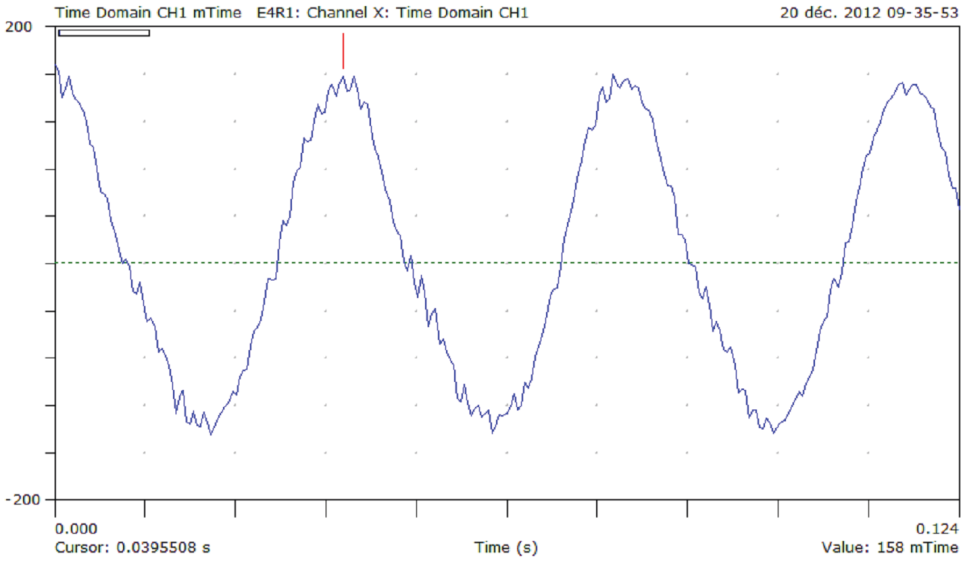


Figure 8. Mount the vibration transducer in the radial axis.

6. On the vibration analyzer, start the data collection.

   Once the waveform is displayed, press the *Pause* function button to pause the acquisition process. Make the appropriate *X-Zoom* and *Y-Zoom* settings to observe the waveform.

The resulting waveform is shown below.



Resulting waveform on the vibration analyzer.

7. Using the *Harmonic Cursor* and *Peak Find* functions of the vibration analyzer, determine the period (T) of the sinusoidal waveform.

Period of the sinusoidal waveform (T) = _____

Measured period of the sinusoidal waveform (T): 0.04 s

8. Using the equation f = 1/T, determine the frequency (f) corresponding to the measured period.

Frequency corresponding to the measured period (f) = _____

Calculated frequency corresponding to the measured period (f): 25 Hz

9. Is the frequency corresponding to the measured period approximately equal to the output frequency set on the Variable Speed Drive?

❑ Yes ❑ No

Yes

10. Name the two domains used to analyze vibration signals.

The two domains used to analyze vibration signals are the time domain and the frequency domain.

11. Which domain is best suited to analyze a vibration signal containing a great amount of information? Explain why.

The frequency domain is best suited to analyze a vibration signal containing a great amount of information. Because it is easier to identify the frequency content in the vibration signature.

FFT spectrum analysis (frequency domain)

12. What is the meaning of FFT? Describe briefly.

FFT means Fast Fourier Transform. It is a computer algorithm that transforms a discrete periodic time signal into a discrete periodic frequency spectrum.

13. On the vibration analyzer, depress the *Spectrum* button to display the vibration signal in the frequency domain.

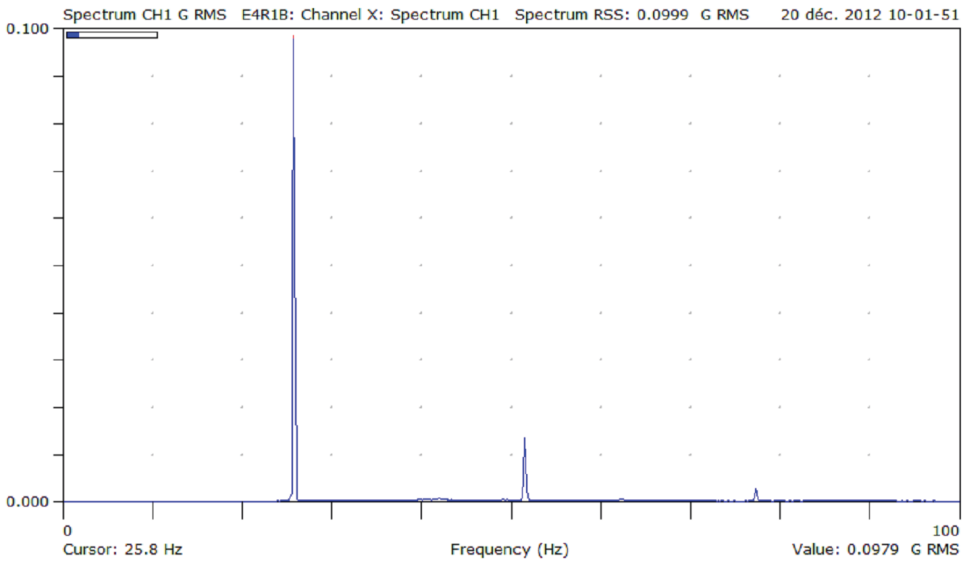
Make the appropriate *X-Zoom* and *Y-Zoom* settings to observe the frequency spectrum.

Using the *Peak Find* function, determine the dominant frequency (f) in the frequency spectrum.

Dominant frequency (f) in frequency spectrum = _____

Dominant frequency in the frequency spectrum: 25.8 Hz

The resulting frequency spectrum is shown below.



Frequency spectrum on the vibration analyzer.

14. Does the dominant frequency determined in the previous step correspond to the frequency previously calculated from the measured period?

❑ Yes ❑ No

Yes

Resonance

15. Give a brief description of natural frequency.

A natural frequency is a frequency at which a mechanical system will continue to vibrate after the excitation signal is removed.

16. Give a brief description of resonance.

A resonance is a vibratory condition where a natural frequency and an excitation frequency coincide. Resonance results in high vibration, and may reach damaging levels. It is important that a machine does not operate at a speed that corresponds to a natural frequency of the structure.

17. Give an example of a highly resonant mechanical system.

Bells or tuning forks are examples of a highly resonant mechanical system.

18. Describe how the vibration levels vary when resonance occurs.

When resonance occurs, the resulting vibration levels can be very high and can rapidly cause damage.

CAUTION

In the next steps, you will vary the speed of the motor and observe resonance. The high levels of vibration that are produced when resonance occurs can damage the equipment. As soon as you have completed your observations, reduce the motor speed to a value that does not produce such resonance.

19. In the *Analyzer - Setup* window of the vibration analyzer, set the parameters as follows:

Parameter	Setting
Num Channels	1
Sensor type	Accel. G
Sens.	Enter the vibration transducer sensitivity shown on the calibration chart.
Y-axis units	Disp µm (Disp mil)
X-axis units	Hz
Detection	RMS
Filter	2 Hz
Freq Range	2000
Lines	800
Num. Averages	5
Avg. Type	Exponential
View Signal	Spectrum
Display Y-axis	Linear
Window	Hanning

On the vibration analyzer, start the data collection.

20. On the Variable Speed Drive, slowly increase the frequency up to 40 Hz while observing the overall level of displacement on the vibration analyzer display.

Stop the motor.

Describe how the overall level of displacement varies between 25 Hz and 40 Hz.

When the excitation frequency (motor speed) reaches the natural frequency of the motor/base assembly, resonance occurs and the vibration levels get very high. Once the excitation frequency exceeds the natural frequency of the motor/base assembly, the vibration levels decrease rapidly.

21. Ask the instructor to check your work.

22. Disassemble the setup, and return the equipment to the storage location.

Name: _____ Date: _____

Instructor's approval: _____