

NDT

JAMES INSTRUMENTS

Non Destructive Test Equipment



V-E-400

Emodometer

Operator's Manual

Original Instructions: Revision February 2017



Notice



The James Instruments Emodumeter™ has been tested in accordance with the EU regulations governing Electro-Magnetic compliance and it meets required directives.

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We: James Instruments Inc.

Of: Chicago, IL

In accordance with the following Directive(s):

2006/95/EC Low Voltage Directive

hereby declare that:

Equipment Emodumeter

Model Number V-E-400

is in conformity with the applicable requirements of the following documents

Ref. No.	Title	Edition/date
ASTM C 215	Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Frequencies of Concrete Specimens.	2008
ASTM C 666	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.	2008
EN 61000-6-3	Electromagnetic compatibility (EMC). Generic standards. Emission standard for residential, commercial and light-industrial environments.	2007
EN 61000-6-2	Electromagnetic Compatibility (EMC) Part 6-2: Generic Standards—Immunity for Industrial Environments.	1999

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all applicable Essential Requirements of the Directives.

Signed:



Name: Michael Hoag

Position: President, James Instruments Inc.

Location: Chicago, IL

On: 2/23/2017

Introduction

The Resonant Frequency Tester may be used in the laboratory for research purposes or in the field to assess quality control and concrete stiffness evolution or the damage induced by freezing and thawing of concrete. It is a non-destructive method to determine the longitudinal, torsional, and flexural or transverse resonant frequencies of a variety of materials. The specification complies with ASTM C-215, ASTM C- 666, BS 1991, and JISA 1127 standard for testing concrete specimens by the resonant frequency method. It also meets standards to measure modulus of Elasticity of rocks and other materials.

The instrument consists of the Resonant Frequency Tester, a test bench for longitudinal, flexural and torsional resonance measurements to take specimens up to 28" x 6" x 6", a miniature accelerometer is used as a receiver and a set of 6 hardened steel balls are used to generate the vibrations on the sample by a mechanical impact. In order to obtain the resonance frequency of the sample, the received signal is analyzed in the time domain and the frequency spectrum is displayed on the instrument's screen.

The Emodumeter system comes with 6 different (steel) ball sizes: 6mm, 8mm, 10mm, 12mm, 14mm and 16mm. The maximum frequency that can be generated by each size can be found in the chart below.

Steel ball diameter = Maximum Resonant Frequency possible

6mm = 48.5 kHz max freq.

8mm = 36.4 kHz max freq.

10mm = 29.1 kHz max freq.

12mm = 24.3 kHz max freq.

14mm = 20.8 kHz max freq.

16mm = 18.2 kHz max freq.

(Note: All impactors sold and manufactured at James Instruments, Inc. are made of steel.)

Instrument Contents List

Each Emodometer comes with the following items included in the carrying case.

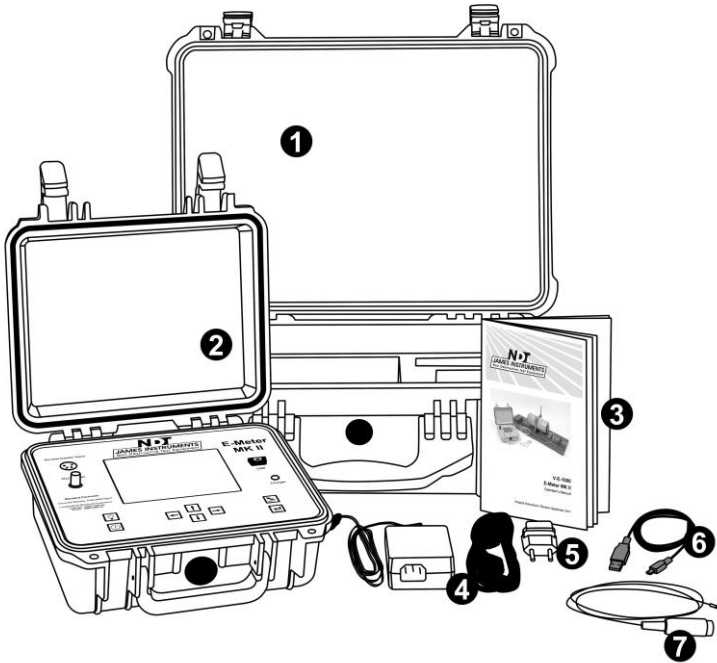


Figure 1: Emodometer Contents

Contents List

Item # Description

- 1 **Case** – Used for carrying the Emodumeter and accessories.
- 2 **Emodumeter Instrument** – Resonant Frequency Tester encased in a durable protective case.
- 3 **Instruction Manual** – Operating instructions for Emodumeter.
- 4 **AC Power Adapter** – Used to power the Emodumeter and recharge the unit.
- 5 **240 VAC Adapter Plug** –
- 6 **USB Cable** – Serial cord used to connect the Emodumeter to a PC to upload data.
- 7 **Accelerometer Pickup Cable** – Connected to Sensor/Accelerometer.

Testing Bench Contents List

Each Emodumeter comes with a testing bench which has the following items included.

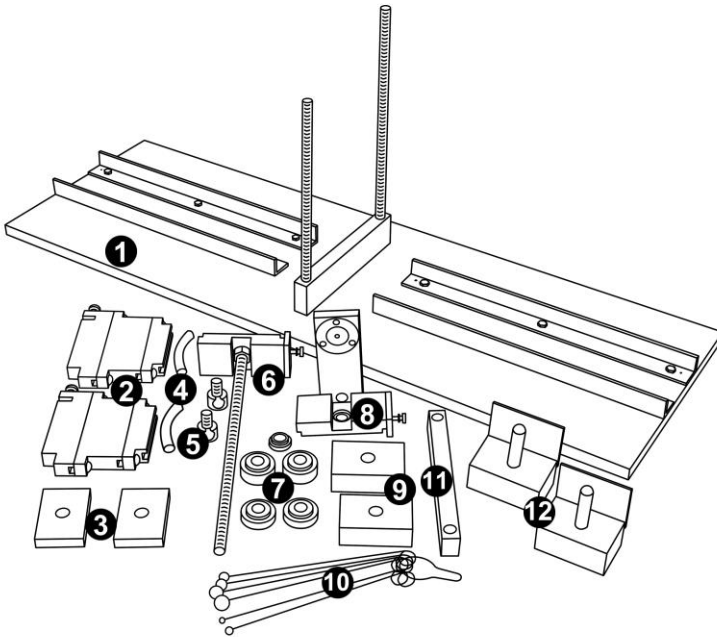


Figure 2: Testing Bench Contents

Contents List

- | Item # | Description |
|---------------|---|
| 1 | Emodometer Test Bench – Base for performing tests. |
| 2 | Flexural Spacer Assembly – Base, #2 and #3. |
| 3 | Torsion Block (#3) – Used with Items 9 and/or 12. |
| 4 | Rubber Cushions – 4”. |
| 5 | Mounting Bolts – Slide on Mounting Rod. |
| 6 | Sensor Mounting Rod – Assembly |
| 7 | Knurled Clamp Nuts – Used to Hold Sample and Item 11. |
| 8 | Pick-Up Mount Bracket Assembly – Used to Hold Sensor (Accelerometer). |
| 9 | Torsion Block (#2) – Used with Item 12. |
| 10 | Impactor Set – 6, 8, 10, 12, 14, and 16mm. |
| 11 | Clamp/Bar – Used to Hold the Sample in Place. |
| 12 | Torsion Block (#1) Base – For Sensor Placement along Concrete Sample. Used with Item #8. |

Emodumeter Overview

The following is an overview of all of the external features of the Emodumeter.

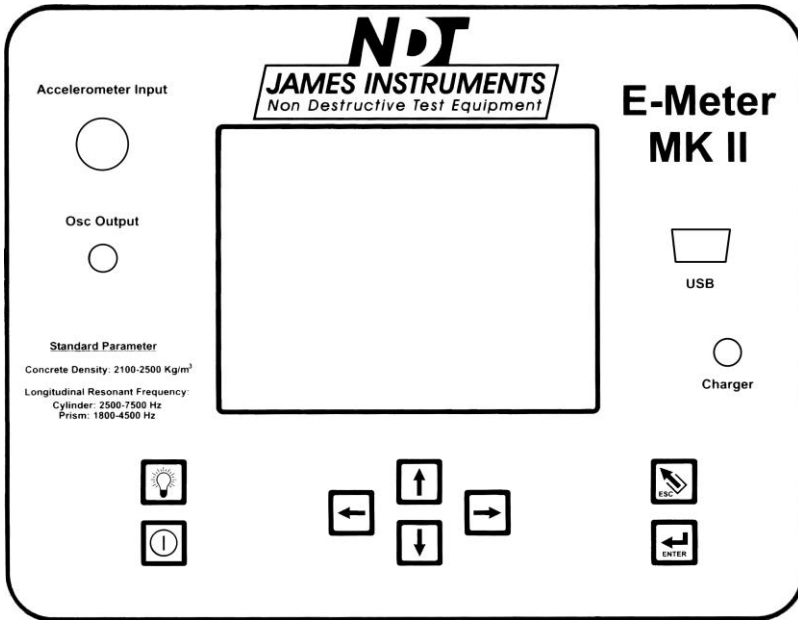










Figure 3: Emodumeter Overview

Control Panel Buttons

Key	Definition
	The power button. Momentarily push this key to turn on the unit. Pressing it again turns off the unit. The unit will power up displaying the main menu screen.
	The up arrow. This key is used to scroll through various settings, wave frames and allows to increase input values needed for calculations.
	The down arrow. This key is used to scroll through various settings, wave frames and allows to decrease input values needed for calculations.
	The left arrow. This key allows you to scroll through various settings.
	The right arrow. This key allows you to scroll through various settings.
	The Enter key. Pressing this key allows you to choose main menu selections. The enter key also allows you to prepare the Vu-Con for testing mode. Pressing the enter key once will give you a message "Emodumeter is Ready". Pressing the key one more time a message "Emodumeter is not Ready" will be displayed.
	The Esc key. Pressing this key allows you to return to the main menu screen from any sub screen.
	The light button. Pressing this key the backlight of the display comes on. Pressing the key again turns the backlight off.

Menu Layout

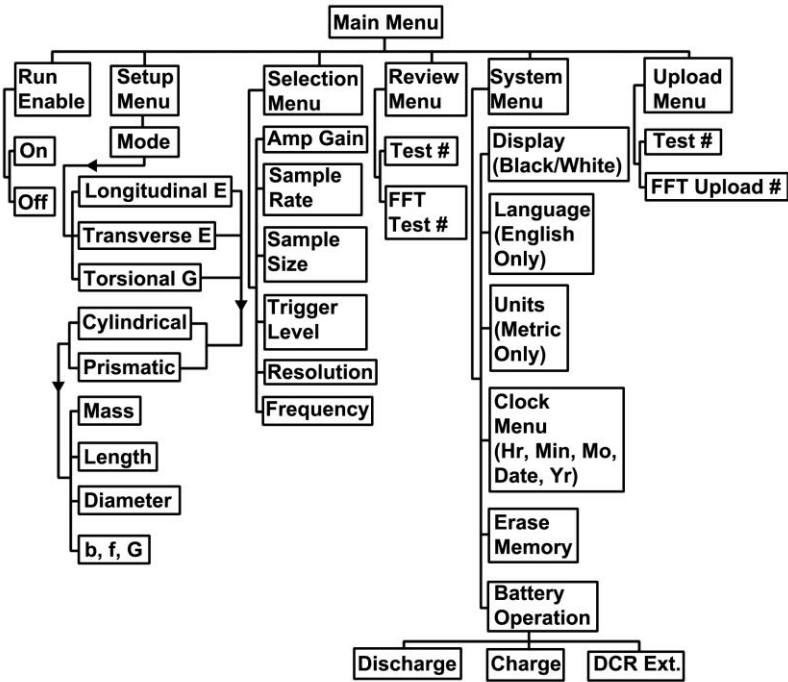


Figure 4: Emodometer Function Flow Chart

Emodumeter Run Mode

In order to run the Emodumeter, you need to press the right or left arrow key. The message will change from “Run enable is OFF” to “Run enable is On”. After the system is in the “Run enable is On” mode, the unit will trigger with the impact of the hardened steel ball on the surface of the sample.

Caution: the system can be triggered with another event, different than the impact of the steel ball on the sample. Once the unit is in the mode “Run enable is On,” any contact with the specimen, cable or accelerometer can trigger the instrument with a meaningless signal.

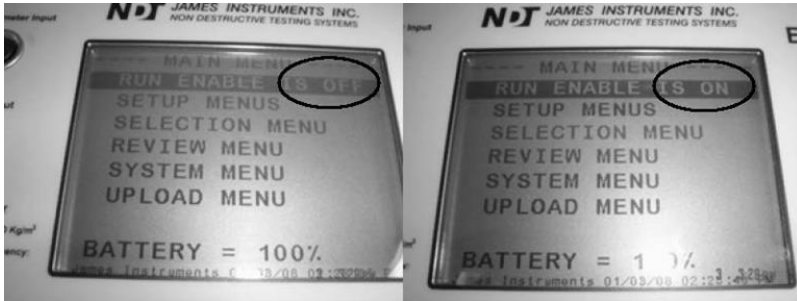


Figure 5: Emodumeter screen showing the “Run Enable Mode”

Emodumeter Setup Menus

By pressing the “Enter” key, the user will be able to change the testing parameters. The first option is the testing Mode. The user can select Longitudinal (E), Transverse (E) or Torsional (G) by using the left and right arrow keys. By pressing “Enter” in one of these modes, the user can manually input the value of G or E, needed to compute Poisson’s ratio. The unit will obtain one of these values according to the testing Mode selected (the output of the test) and will use the user input value for the other variable.

The other option that the user can control in the Setup Menu is the shape of the specimen. According to the user selection, different parameters related to the dimensions of the specimen will appear in the same screen. The user can change the values using the left and right arrow keys by pressing “Enter.” This action opens another screen, allowing the user to control and change parameters before running a test. The dimensions needed are the same that are required by the ASTM C-215.

Emodumeter Selections

The Emodumeter selection menu allows the user to select the parameters for testing according to their needs. The Amplifier Gain and Sample Rate can be adjusted to the user needs. The Sample Size or number of data points recorded can be selected from 1024 to 2048 points. The trigger level can also be adjusted by the user according to specimen characteristics.

Gain

On the main screen, scroll the cursor down using the up or down arrow keys until you get to the Emodumeter selections menu option and press enter. The Emodumeter enters a sub-screen; title of the sub-screen should read Current Selections. Scroll the cursor to the option to be changed. Use the right and left arrow keys to change the values of the selected option. The gain shall be adjusted when testing different specimens. The smaller the sample, the lower the gain shall be. The gain can be adjusted from 1 to 500. The gain is the ratio of an output quantity to an input quantity. The gain options are as follows: 1, 5, 10, 25, 50, 100, 250, and 500.

Sampling rate and number of data points

The user can select the sampling rate and the number of points to sample the signal according to the specific applications or standards requirements. The selection of these parameters affects the frequency resolution and the maximum frequency in the spectrum.

Sampling frequency can be 10 kHz, 20 kHz, 40 kHz or 80 kHz. The number of data points sampled can be 1024 or 2048 points. Figure 6 and 7 show the frequency resolution and the maximum frequency for each combination of selections. In order to achieve the minimum frequency resolution (4.9 Hz), the settings shall be a sampling frequency of 10 kHz and signal length of 2048 data points. Using these settings, a maximum frequency of 5 kHz can be identified, and frequencies higher than 5 kHz are not detected with these sampling parameters.

	1024 points	2048 points
80 kHz	78.1 Hz	39.1 Hz
40 kHz	39.1 Hz	19.5 Hz
20 kHz	19.5 Hz	9.8 Hz
10 kHz	9.8 Hz	4.9 Hz

Figure 6: Frequency resolution for each combination of sampling frequency and number of points

	Maximum Frequency (kHz)
80 kHz	40
40 kHz	20
20 kHz	10
10 kHz	5

Figure 7: Maximum frequency (kHz) for different sampling frequency selections

The selection of sampling frequency and number of points shall allow the user to identify frequencies with the needed accuracy and in the required range of frequencies.

Trigger Level

The Trigger level is adjusted in percentages: 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90%. Pressing the escape keys the system returns to the main menu, so test can be started. Lower trigger level should be used when testing small samples. The Trigger Level should be set to a level that the system records the signal just after the impact and not before. When using low trigger levels, environmental noise could trigger the system. Trigger level should be increased because the system should only be activated by the actual impact of the steel ball.

Review Menu

The review menu allows the user to review previously recorded test results. All the results and parameters used in the test are presented in this menu. The user can review the FFT or the time domain signal as well.

System Setup

The System Menu option on the main menu screen allows the user to make modifications of the system configuration. The user can change the date on the instrument, erase data or change the display colors. It also, allows monitoring the battery operation. The Emodumeter can only be set to use the English language.

Changing Date

Press the up or down key until you get to the system setup menu option.

```
--      SETUP MENU      ---  
  
DISPLAY = BLACK LINES  
LANGUAGE = ENGLISH  
UPLOAD MENU  
CLOCK MENU  
ERASE MEMORY  
BATTERY OPERATION
```

James Instruments 2/27/2008 10:00 AM

Figure 8:

Press "Enter", the setup Menu sub screen should appear.

HOUR = [1 PM]
MINUTE = [0]
MONTH = [10]
DATE = [12]
YEAR = [2003]
Save Changes

Figure 9:

Hour= [1 PM]

- Press the right or left arrow keys to set the proper hour, press the down arrow key when hour has been set.

Minute= [0]

- Press the right or left arrow keys to set the proper minute, press the down arrow key when minute has been set.

Month = [10]

- Press the right or left arrow keys to set the proper month, press the down arrow key when month has been set.

Date = [12]

- Press the right or left arrow keys to set the proper date, press the down arrow key when date has been set.

Year = [2003]

- Press the right or left arrow keys to set the proper year. You have properly set the correct date and time of 10 / 12 / 2003, 1:00 PM, press the down arrow key when date and time are ready to be saved.

HOUR = [1 PM]
MINUTE = [0]
MONTH = [10]
DATE = [12]
YEAR = [2003]

Save Changes

James Instruments 2/27/2003 10:00 AM

Figure 10:

Press "Enter" to save date and time. Then press enter to return you to the main menu screen.

Erase Memory

- Press the up or down key until you get to the system setup menu option. Press Enter. The Setup Menu sub screen should appear.
- Scroll through the Setup menu using the up or down arrow key. Select the Erase Memory option by pressing "Enter". The display should read the following.

-- SETUP MENU ---

DISPLAY = BLACK LINES
LANGUAGE = ENGLISH
UPLOAD MENU
CLOCK MENU
ERASE MEMORY
BATTERY OPERATION

Figure 11:

- Press enter once and a message telling you to press enter again should appear.

```
--      SETUP MENU      ---  
DISPLAY = BLACK LINES  
LANGUAGE = ENGLISH  
UPLOAD MENU  
CLOCK MENU  
PRESS ENTER AGAIN  
BATTERY OPERATION
```

James Instruments 2/27/2003 10:00 AM

Figure 12:

- Pressing enter again will erase all stored memory in the Emodometer. Pressing the “Escape” key will return you to the Main Menu Screen.

Display Cursor

- Press the up or down key until you get to the system setup menu option. Press Enter. The Setup Menu sub screen should appear.
- Scroll through the Setup menu using the up or down arrow key. Select the Display option by pressing enter.
- Pressing the left or right arrow keys will give the option to choose Black Lines or White Lines.

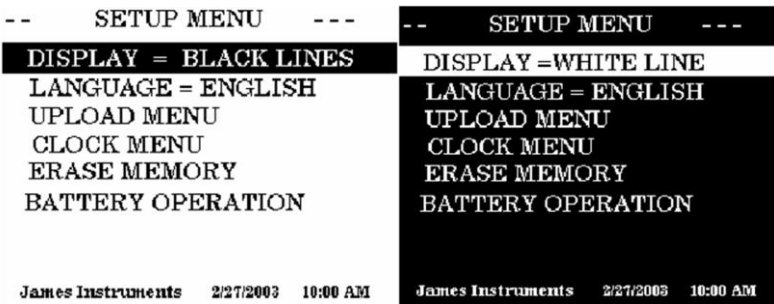


Figure 13:

- Pressing the “Escape” key will return you to the Main Menu Screen.

Battery Operation

The Rebarscope® uses a 14.4V Lithium-Ion battery with a built-in thermo-sensing circuit. This circuit allows for a suitable charge, and maintains the voltage to the cells (< 4.1V). Additionally, this circuit provides the proper charge current to lengthen the battery’s life.

At full charge, the bottom of the display will show **BATTERY=100%**. (**Note:** This value may be inaccurate, if the battery counters were reset without properly charging the unit.)

- The battery status can be viewed in the “**System Menu**”, under the “**Battery Operation**” mode. (Fig.14 & 15)
- When the charger is supplying power to the unit, the battery is charging, and the charge counter (“**Charge CTR**”) will increase.
- When the unit is ON, and the charger is disconnected from the unit, the discharge counter (“**Discharge CTR**”) will increase.
- The battery will continue to charge even after the

microcontroller times out - display and unit turn OFF automatically.



Figure 14: Battery Operation Menu is Highlighted

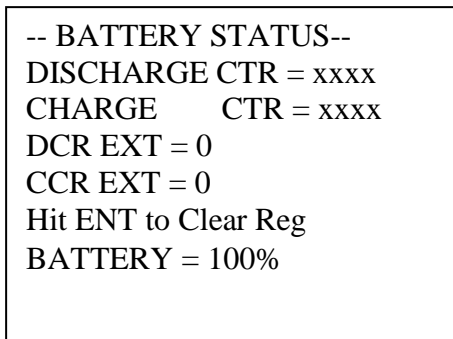


Figure 15: Clearing Charger Register

Battery Charge

1. Connect the charger to a working outlet, and then to the charger input on the unit's front panel. Although, it is recommended for the unit to be OFF during a charge, the user can monitor the charging process in the screen above.

2. If the Charge counter slows to a stop (and does not increase), this is an indication the charge is complete. The battery now has a full charge, and needs to be reset. To do

this, go to: **Main Menu / System Menu / Battery Operation** - press “**Enter**” to zero the counters. This action also resets the battery circuit mentioned above, and will correct any miscounts. (If charging is still an issue, review the Repair Policy on p.61.)

Resetting the battery counters should be done both before and after (at least) a 4hr charge.

When done so, the battery status % on the display will be accurate.

3. When the Battery percentage reaches ~ 40-50%, be sure to charge the unit again. (Go to step 1)
4. A charged battery allows for 4-6 hours of continuous field testing.
5. To extend the battery’s run time in the field, to turn “OFF” the background light.

Simple Guidelines for Battery Maintenance.

1. When allowed to discharge and charge regularly, the end user will experience a better Battery life span (or cycle).
2. Lithium-ion batteries do not need to be fully charged; as the charger can aid its performance.
3. Shallow discharges provide more cycles than deep discharges.
4. It is recommended to fully charge the unit (4-6hrs) before a lengthy field test is performed.
5. As a general rule, it is best to charge the battery both before and after each use. There is no memory effect, so it is a good practice to recharge the unit after each use, or at the end of the day - if used daily.

6. Charge the battery at a moderate temperature. Do not charge below 0deg C (or < 32deg F).

7. Lithium-Ion batteries suffer from stress when exposed to heat. Therefore, to lengthen the life of the battery, avoid elevated temperatures > 30deg C (or > 86deg F).

8. Lithium-Ion batteries may fail when stored for long periods of time in a discharged state. Thus, before a prolonged storage period, be sure to apply a charge to the battery. It's recommended once every 2 months to recharge the battery to keep it fresh. You should store the Unit (and battery) during this period at room temperature.

9. Replacing or repair of the battery should be done by a trained James Instruments technician. Please follow the repair procedure found in the manual.... check the "Table of Contents" in your manual.

Upload Menu

Connect the unit to the correct serial port of the P.C. using the supplied serial cable. Press the up or down key until you get to the system Upload menu option. Press "Enter". The Upload Menu sub screen should appear.

```
--- UPLOAD MENU ---  
TEST UPLOAD = XX  
FFT UPLOAD = XX
```

Figure 16:

Select the upload menu option by pressing "Enter". The display should read the following:

Use the up or down arrow key to select a TEST data or a FFT data. Pressing the left or right arrow key you can select which TEST or FFT data number you want uploaded. Open the Emodumeter software on your PC. Press the Upload key on the tool bar or press

Ctrl + U, the message “Please start Upload” will appear on your PC screen. Then on the Emodumeter unit, press enter on the selected Test and the upload process will begin. You can choose to upload all of the tests stored in memory to the PC, or upload each test one by one.

Note: During the FFT Upload, the Emodumeter will upload the last FFT values to a PC in a few seconds. In order to upload another record, the system will first calculate the Frequency Spectrum, and after that the data will be ready to be transmitted to the PC.

Test Bench

Center support: the basic support has been arranged for the accelerometer to be on the axial center line of a 6” x 12” cylinder or 6” x 6” square section specimen. For 4” dia. or 4” x 4” section a spacer, marked 4, is placed on the basic support and for 3” dia. or 3” x 3” specimens a second spacer, marked 3, is added to the 100 spacer. Torsion spacer blocks, spacer blocks marked 1, 2, and 3 on which the accelerometer supports may be mounted are provided for torsion testing. For 3” dia. and 3” x 3” square section specimens, the accelerometer is mounted on blocks 1 plus 2, for 4” dia. and 4” x 4” specimens use blocks 1 plus 3 and for 6” dia. and 6” x 6” specimens use blocks 1 plus 2 plus 3.

Accelerometer

The accelerometer is used to sense the vibrations of the specimen caused by the impact of a hardened steel ball. In order for the accelerometer to receive the vibrations, it should be in intimate contact with the surface of the specimen. The sensing front of the accelerometer should be touching the specimen. The use of the accelerometer support allows placing the accelerometer at the required location. The accelerometer should be inserted through the rubber ring and then the cable should be connected to the accelerometer microdot connector. The accelerometer does not need to be screwed to the mounting stud base when using it with the accelerometer support. The testing setup using the accelerometer support is shown in Fig.18.

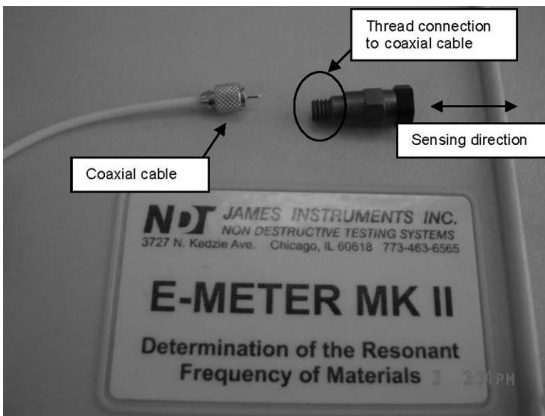


Figure 17: Accelerometer

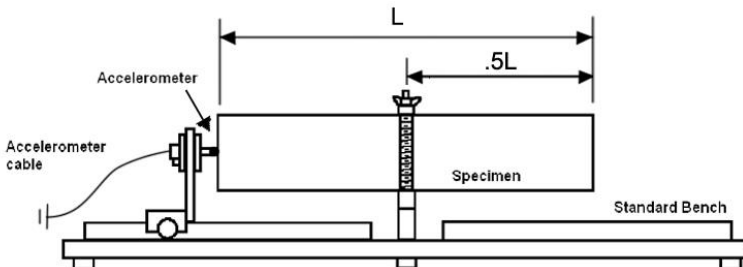


Figure 18: Testing setup using the accelerometer support

Another option is to attach the accelerometer to the surface of the specimen without using the accelerometer support. It can be attached to the specimen using an adhesive mounting base. Wax is usually provided with the system to attach the accelerometer on the surface of the specimen (as shown in Fig. 19).

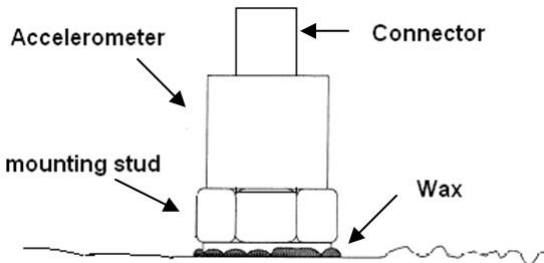


Figure 19: Testing setup using the accelerometer support

Testing Procedure

From the Main menu you can choose among 3 different test modes (or methods):

- Longitudinal frequency (E)
- Transverse frequency (E)
- Torsional (G)

Longitudinal Frequency Mode

The Longitudinal Frequency mode is selected by placing the cursor on the first line, and pressing 'Enter'. For this mode the user can input the desired value of the Modulus of Rigidity (G) that will be used for the Poisson's Ratio calculations.

The user should input the required parameters below using the arrow keys:

Specimen's shape – Cylindrical or Prismatic

M: mass of the specimen (kg)

L: length of the specimen (m)

d: diameter of cylinder (m)

t, b: dimensions of cross section of prism (m), t being the driver (or impact) direction in which it is driven (Note: It is important to distinguish between t and b for transverse frequency).

G: assumed Modulus of Rigidity value in order to compute (μ)

Usually, the user has to input the value of G in G Pa obtained in a previously run Torsional test.

E: assumed Modulus of Elasticity value in order to compute μ .

Usually, the user has to input the value of E in G Pa obtained in a previously run Longitudinal or Flexural test.

The system provides the fundamental longitudinal frequency (n') from the FFT, frequency value of the maximum Amplitude on the FFT, which is applied to a time domain signal obtained by slightly tapping the cylinder with a small hardened steel ball.

The system will calculate the dynamic Young's Modulus of elasticity according to eq. (i), using obtained and computed parameters:

- M= mass of the specimen (kg)
- n'= fundamental longitudinal frequency (Hz.)
- D= 5.093 (L/d²) for a cylinder (N s²/(kg m²)) or
- D= 4 (L/bt) for a prism (N s²/(kg m²))

$$E = D M (n')^2 \quad (i)$$

With these parameters the system will compute the elastic constants of the specimen. If only frequency values are required, the system will assume default values and the elastic constants are not going to have any meaning.

When testing for the fundamental longitudinal resonant frequency, there is one nodal point at the center on the longitudinal direction of a prism or cylinder and the specimen should be placed on the test bed center support at the nodal point (see Fig. 20). The specimen may be simply supported or clamped by the clamping bar provided.

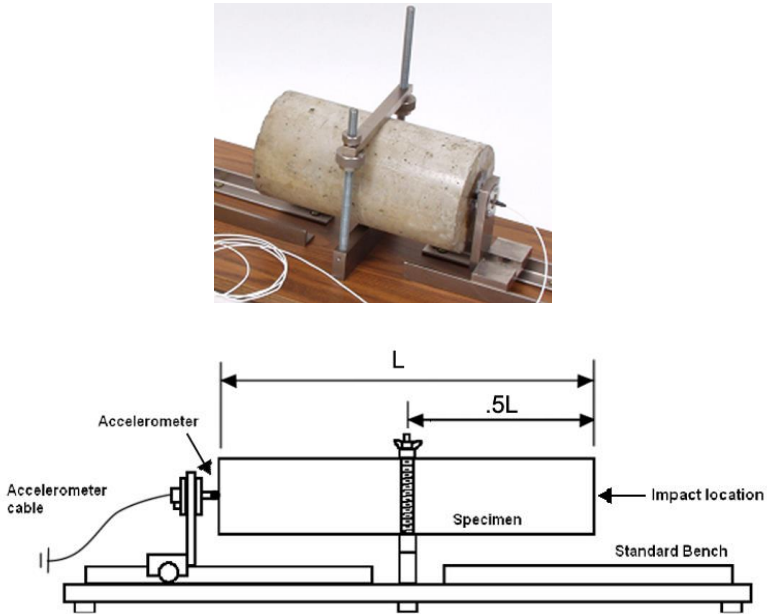


Figure 20: Longitudinal resonance frequency setup

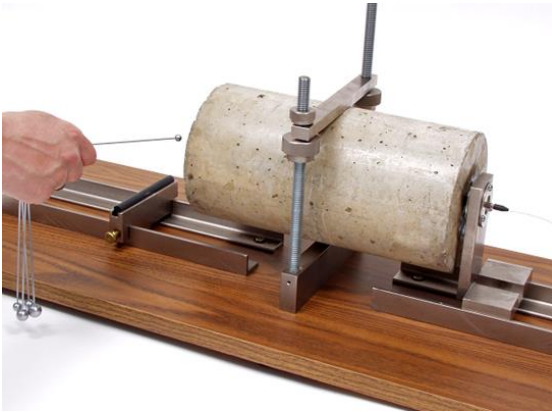


Figure 21: Testing for longitudinal resonance frequency

Place the accelerometer on the required location (contact point at the center of the face), intimate contact between accelerometer and specimen is required. For the ends of the specimens to be free to vibrate in a longitudinal direction, it is essential that minimum restraint is imposed on the ends. The accelerometer is free to move in compliant mountings and it is necessary only to move the accelerometer support along the rails until the contact tip of the accelerometer just make contact with the center of the ends of the specimen. A coupling agent may be used to assure good contact between them (a coupling agent may be required to assure intimate contact). The support may now be locked by using the knurled clamping screws. The accelerometer may also be placed on the surface of the specimen without using its support. It could be attached on the surface of the specimen by using wax and pressing it against the surface (as described in the “Review Menu” chapter). By pressing the right arrow key, the message “Run enable is On” will appear on the screen. Then tap the specimen using a hardened steel ball, causing the instrument to trigger and a signal will appear in the screen. Caution should be taken to apply just one solid impact; otherwise the test should be performed again because the results are not going to be consistent. It is recommended to repeat the test three times to check the consistency of the results.

In order to obtain the spectrum of the signal and the resonance frequency, the Enter key should be pressed. On the screen will appear the message “calculating spectrum please wait”. It will take approximately 45 seconds.

The system will show the fundamental frequency from the FFT, frequency value of the maximum amplitude on the FFT.

The system will obtain the fundamental frequency from the FFT. The fundamental frequency will appear on the first screen with the corresponding value. In order to view the complete frequency spectrum, you can use the left and right arrow key to change from different screens. The frequency spectrum is presented in 2 to 4 different screens.

For concrete specimens the resonance frequency will generally be in the range 1 kHz to 10 kHz depending on the dimensions of the specimen (see Figure 22).

Specimen dimensions (inches)	Approximate range of Frequency (Hz.)
6" x 6" x 30"	1700 – 3000
6" x 6" x 28"	2000 – 3200
4" x 4" x 30"	1700 – 3000
4" x 4" x 20"	3000 – 4500
4" x 4" x 12"	5000 – 7000
6" x 12" cylinder	5000 – 7000

Figure 22: Range of longitudinal fundamental resonant frequencies of concrete prism and cylinder specimens

The system will calculate the dynamic Poisson’s ratio according to eq. (ii), using the obtained value of (E) from the Longitudinal test and assuming a value of (G) that shall be input before to run the Longitudinal test.

In order to obtain a meaningful result of μ , it is recommended to run a Torsional test beforehand to obtain a value of (G) and then input this value as a parameter to compute the Poisson’s ratio.

$$\mu = E/(2G) - 1 \quad (\text{ii})$$

(E): Dynamic Young's Modulus of elasticity (obtained according eq.

(i))

(G): Dynamic modulus of rigidity (input by the user, the recommended value of (G) is the obtained in a previous Torsional test).

Transverse Frequency Mode

In order to obtain the elastic constant of the specimen in the transverse or flexural mode, the user should input some data. By placing the cursor on the first line and pressing the enter key the user can input the desire value of Dynamic Modulus of Rigidity (G) that is going to be used for the computations. The user should also input a Dynamic Poisson's ratio (μ) value, otherwise the default value would be ($\mu = 0.17$).

The system will calculate the dynamic Young's Modulus of elasticity according to e.q. (iii), using obtained and computed parameters:

M= mass of the specimen (kg)

n= fundamental transverse frequency (Hz.)

t, b= dimensions of cross section of prism (m), t being in the direction in which it is driven (distinguish between t and b is important for transverse frequency).

C= 1.6067 (L^3T/d^4), $Ns^2 / (kg \ m^2)$ for a cylinder or

C= 0.9464 (L^3T/bt^3), $Ns^2 / (kg \ m^2)$ for a prism

K= d/4 (m) for cylinder or

K= t/3.464 (m) for prism

T is obtained according to Table 4, using (K/L) and (μ).

$$E = D M n^2 \quad (\text{iii})$$

At the fundamental transverse resonant frequency there are two nodal points, at distances from each end of 0.224 times the length. Position the supports for transverse vibration 0.224 times the specimen length from the ends as shown in Fig. 23. Place the hard rubber circular rods in the grooves of the supports.

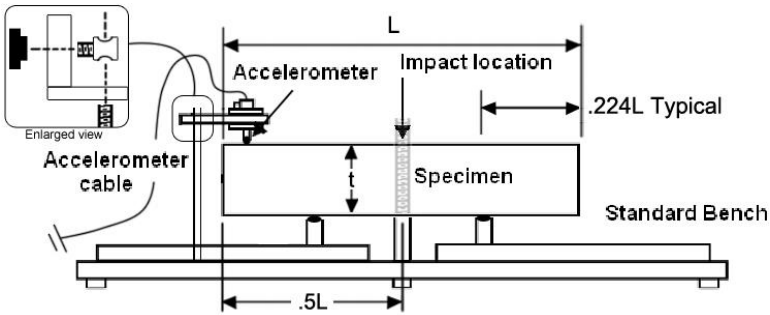


Figure 23: Transverse resonance frequency testing setup

The accelerometer can be placed using the accelerometer support or by placing a spot of wax on the underside of the surface mounting accelerometer onto the top surface at the middle of the specimen. The accelerometer can be placed without the rectangular support or with it as shown in the picture. Connect surface mounting accelerometer to the instrument.

By press the right arrow key, the message “Run enable is On” will appear on the screen. Then tap the specimen using a hardened steel ball, the instrument will trigger and a signal will appear in the screen. In order to obtain the spectrum of the signal and the resonance frequency, the down arrow key should be pressed. On the screen will appear the message “calculating spectrum please wait”. It will take a few seconds. The system will obtain the fundamental transverse frequency (n) from the FFT, frequency value of the maximum amplitude on the FFT (frequency spectrum) will be presented on the top of the screen.

The frequency spectrum is presented in 2 to 4 different screens; you may use the left and right arrow key to change from different screens.

Values of correction factor, T

K/L	Mu=0.17	Mu=0.20	Mu=0.23	Mu=0.26
0	1	1	1	1
0.01	1.01	1.01	1.01	1.01
0.02	1.03	1.03	1.03	1.03
0.03	1.07	1.07	1.07	1.07
0.04	1.13	1.13	1.13	1.14
0.05	1.2	1.2	1.21	1.21
0.06	1.28	1.28	1.29	1.29
0.07	1.38	1.38	1.39	1.39
0.08	1.48	1.49	1.49	1.5
0.09	1.6	1.61	1.61	1.62
0.1	1.73	1.74	1.75	1.76
0.12	2.03	2.04	2.05	2.07
0.14	2.36	2.38	2.39	2.41
0.16	2.73	2.75	2.77	2.8
0.18	3.14	3.17	3.19	3.22
0.2	3.58	3.61	3.65	3.69
0.25	4.78	4.84	4.89	4.96
0.3	6.07	6.15	6.24	6.34

Figure 24: Values of Correction Factor, T

Note: Values for Poisson's ratio for concrete normally vary between about 0.10 dry specimens and 0.25 for saturated specimens.

Size of the specimen (inches)	Approximate range of Frequency (Hz.)
6" x 6" x 30"	550 – 1050
6" x 6" x 28"	600 – 1150
4" x 4" x 36"	400 – 750
4" x 4" x 20"	900 – 1500
4" x 4" x 12"	2500 – 4500
6" x 12" cylinder	2500 – 4500

Figure 25: Range of flexural fundamental resonant frequencies of concrete prism and cylinder specimens

The system will calculate the dynamic Poisson’s ratio according to eq. (ii), using the obtained value of (E) from the Transverse test and assuming a value of (G) that shall be input before to run the Transverse test. In order to obtain a meaningful result of Mu, it is recommended to run a Torsional test before to obtain a value of (G) and then input this value as a parameter to compute the Poisson’s ratio.

$$\text{Mu} = E / (2G) - 1 \tag{ii}$$

(E): Dynamic Young’s Modulus of elasticity (obtained according eq. (iii))

(G): Dynamic modulus of rigidity (input by the user, the recommended value of (G) is the obtained in a previous Torsional test).

Torsional Frequency Mode

The system will obtain the fundamental torsional frequency (n’')

from the FFT (frequency value of the maximum Amplitude on the FFT), which is applied to a time domain signal obtained by slightly tapping the cylinder with a small hardened steel ball.

The configuration of the test varies according to the shape of the specimen. Different standards have specifications about sensor location and impact location.

The system should calculate the dynamic modulus of rigidity according to eq. (iv), using obtained and computed parameters:

$$G = B M (n'')^2 \quad (iv)$$

n'' = fundamental torsional frequency (Hz)

$B = 4LR/A$, (N s²/(kg m²))

$R = 1$ for a circular cylinder

$R = 1.183$ for a square cross section prism,

$R = (a/b + b/a) / (4a/b - 2.52(a/b)^2 + 0.21(a/b)^6)$ for a rectangular prism whose cross-sectional dimensions are a and b (m) with a less than b

A = cross-sectional area of test specimen (m²)

Size of the specimen (inches)	Approximate range of Frequency (Hz.)
6" x 6" x 30"	1150 – 1800
6" x 6" x 28"	1200 – 1920
4" x 4" x 30"	1150 – 1800
4" x 4" x 20"	1800 – 2700
4" x 4" x 12"	3000 – 4200
6" x 12" cylinder	3000 – 4200

Figure 26: Range of torsional fundamental resonant frequencies of concrete prism and cylinder specimens

The system will calculate the dynamic Poisson's ratio according to eq. (ii), using the obtained value of (G) from the test and assuming a value of (E) that shall be input before to run the Torsional test. In

order to obtain meaningful results, it is recommended to run before a Longitudinal or Flexural test to obtain a value of (E) and then input this value as a parameter to compute the Poisson's ratio.

$$\mu = E / (2G) - 1 \quad (ii)$$

(G): Dynamic modulus of rigidity (obtained according eq. (iv))

(E): Dynamic Young's Modulus of elasticity (input by the user, the recommended value of (E) is the obtained in previous Longitudinal or Flexural tests).

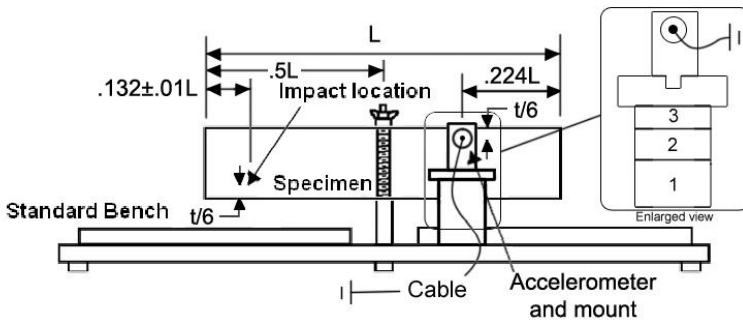


Figure 27: Torsional resonance frequency testing setup (rectangular, side view)

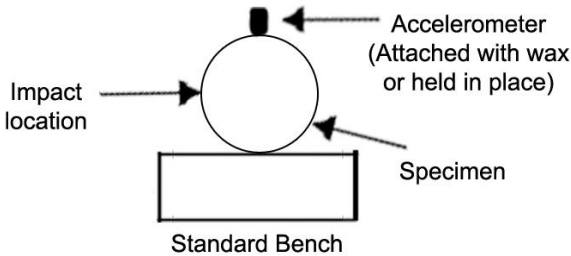


Figure 28: Torsional resonance frequency testing setup (circular, front view)

Emodulinx Introduction

The Emodometer's Emodulinx software enables the user to upload data from the Emodometer device to a PC. The saved data can be read in and graphed. Emodulinx also can be used to control the Emodometer remotely. Configuration settings can be adjusted, and new data sets can be collected, all remotely. When commanded remotely to take a new set of data measurements, the Emodometer will upload the new data to the PC, and Emodulinx will automatically save the data to a file. Existing individual data sets can also be uploaded and graphed to further analyze the Emodometer data. The addition of the remote control functionality makes the Emodometer a very powerful tool.

Features

- The ability to execute a test remotely and graph FFT.
- The ability to review previous test parameters.
- The ability to adjust Test menu, Setup menu, and E/Mu menu parameters. These items include: the amplifier gain, the picture rate, the pulser voltage, the E or Mu calculation method, the material density, the measurement mode, the materials travel distance or time, the cycle time, and the number of pulses per sequence.

Minimum System Requirements

Emodulinx V-E-420

Operating System	Windows Vista or Windows 7
Memory	1 GB RAM
Processor	1 GHz Pentium class processor
Capacity	1 MB hard drive space

Emodulinx Overview

The following is an overview of all of the features of the Emodulinx software. Notice that mostly all menus and settings are the same as the ones found in the Emodumeters menus and settings.

Consequently, the same basic operation and testing procedure mentioned earlier in this manual will be used for Emodulinx.

Additionally, any settings that are changed in Emodulinx will automatically save in the Emodumeter.

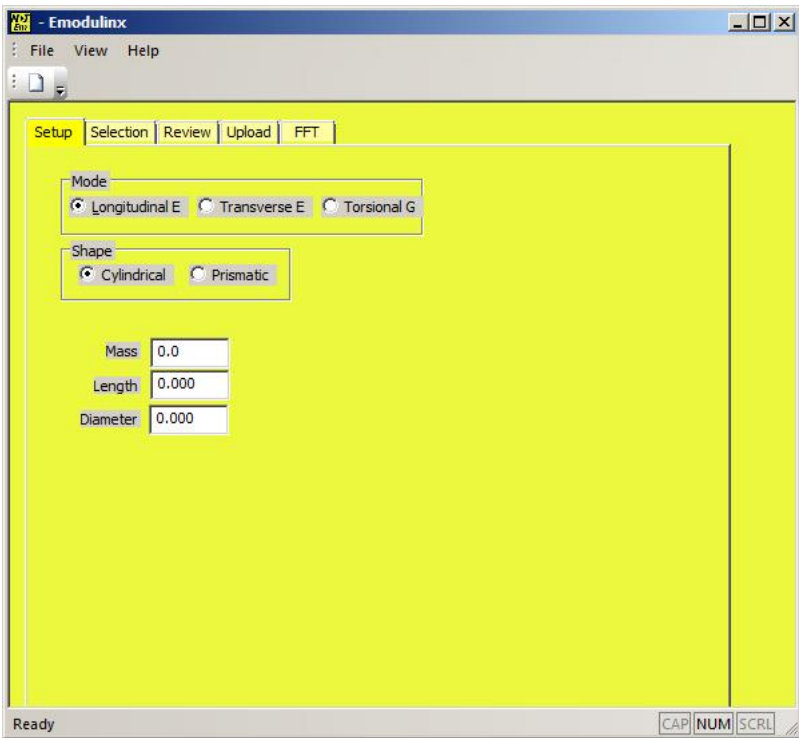


Figure 29: Emodulinx Overview

Menu Descriptions

Name	Description
Setup	Use this menu to specify the type of test to be performed and shape of the concrete sample (see page 10).
Selection	Use this menu to select the testing parameters (see page 11-12).
Review	Use this menu to review previously recorded test results (see page 13).
Upload	Use this menu to upload data from the Emodumeter to a PC (see page 20).
FFT	Use this menu to graph FFT (see page 13).

Software Installation

The PC software that has been developed for the Emodumeter is for data upload purposes. To install the software on your PC follow these instructions.

To install the software:

1. Insert the Emodumeter PC Software CD into the CD-ROM drive.
2. If the CD does not load the setup automatically, go to My Computer, double click on the CD under devices and double click on **setup.exe**.



Name	Size	Type
USB Drivers		File folder
setup.exe	5,059 KB	Application

Figure 30: Installation File Location

3. The InstallShield Wizard checks for the operating system you are using.

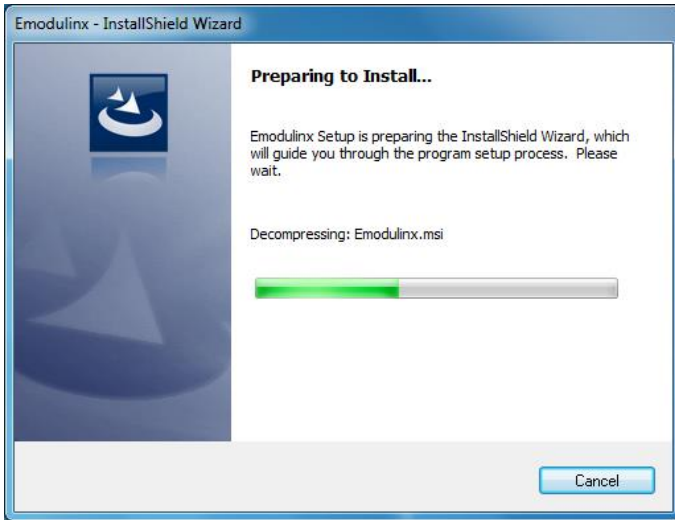


Figure 31: InstallShield Wizard

4. The InstallShield Wizard dialog appears. Click **Next** to proceed.

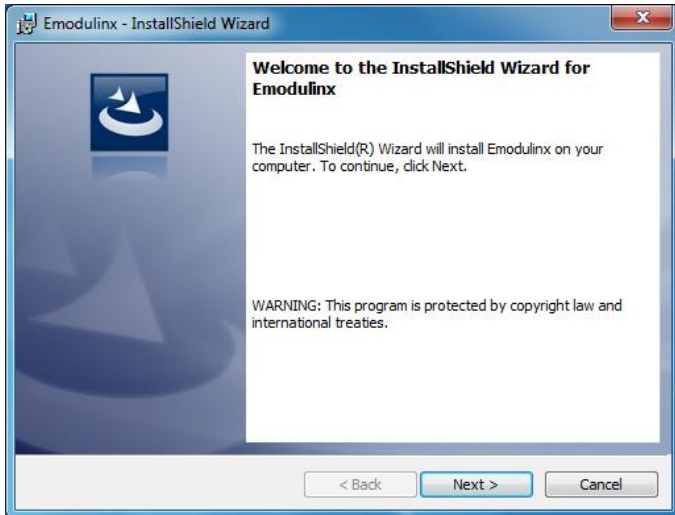


Figure 32: InstallShield Wizard

5. Accept the terms in the license agreement and click **Next**.

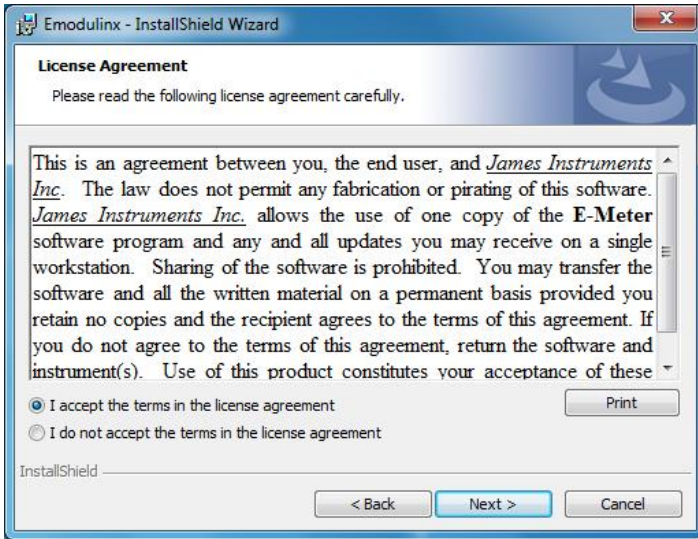


Figure 33: License Agreement Screen

6. Complete the customer information fields and click **Next**.

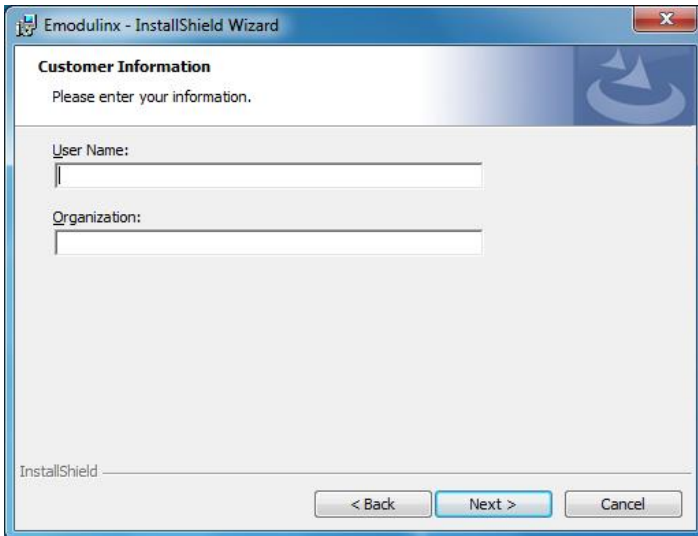


Figure 34: Customer Information Screen

7. The InstallShield Wizard confirms your installation. Click **Install** to continue.

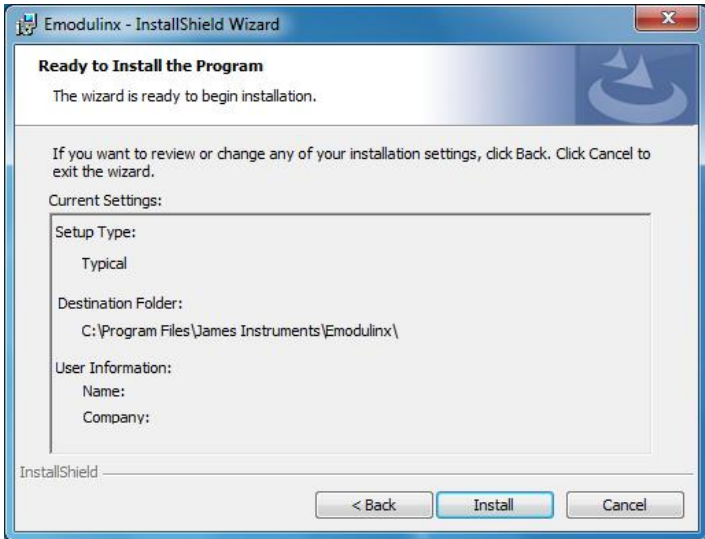


Figure 35: InstallShield Wizard Confirmation

8. The installation progress screen appears.

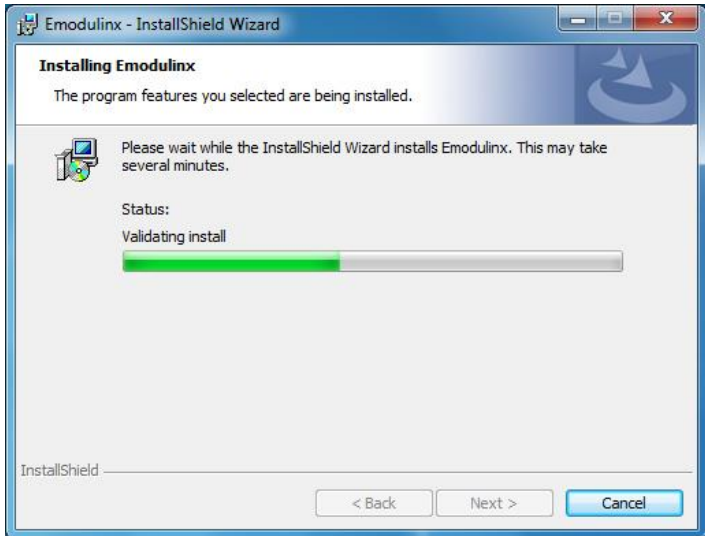


Figure 36: Installation Progress Screen

9. When the installation has completed the following message will appear. Click **Finish** to close the dialog.

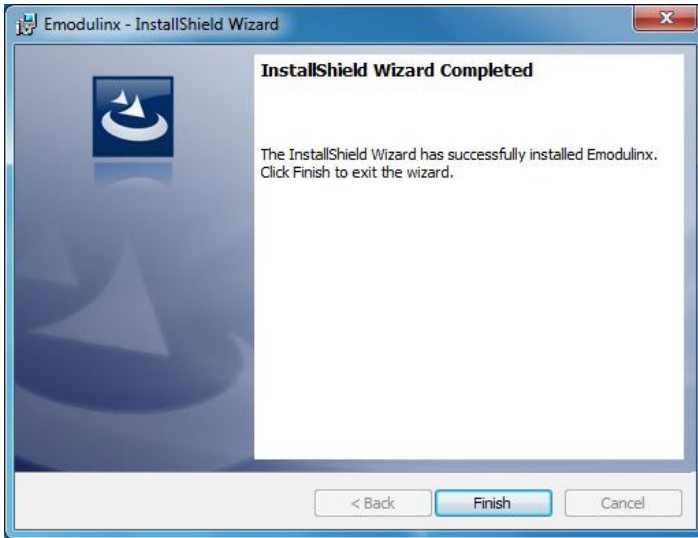


Figure 37: InstallShield Wizard Completed

10. The Emodulinx shortcut appears on the desktop as well as the Start Menu.



Figure 38: Emodulinx Shortcut

Connecting the Emodometer

To run Emodulinx, it is required for the Emodometer to be connected to the PC via the USB cable. Before running Emodulinx, connect one end of the USB cable to the PC and the other end to the Emodometer. When connecting to the Emodometer, push the connector down firmly until it clicks. This will ensure that the Emodometer is properly connected.

After connecting the Emodometer, you may run and use Emodulinx. If you are experiencing difficulties, refer to the “Tips and Troubleshooting” section of this manual (page 51).

Overview of Menus

Setup Menu

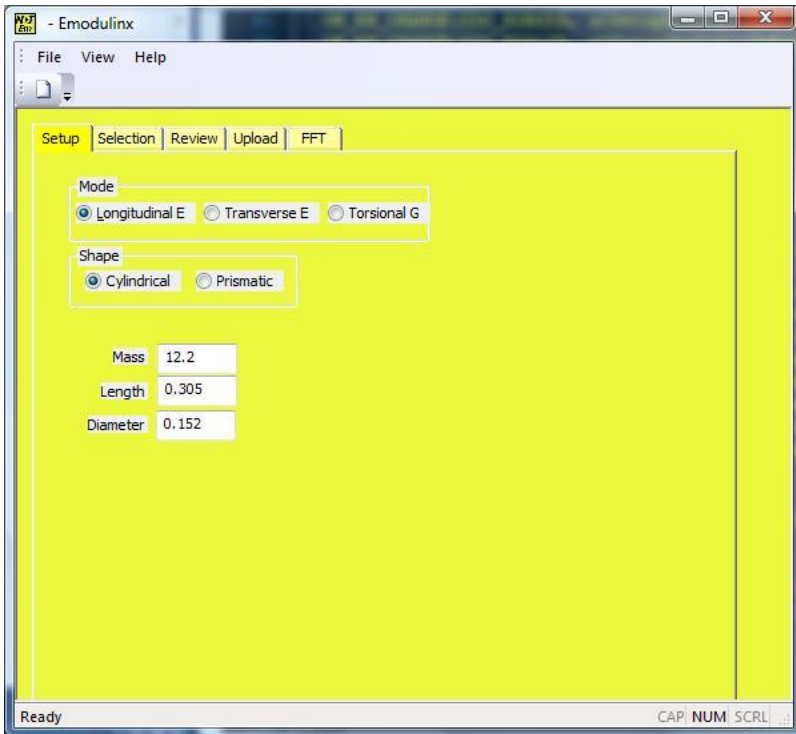


Figure 39: Emodulinx Setup

Mode

Select the radio button of the type of test you wish to perform.

Shape

Select the radio button that best describes the shape of the concrete sample that you wish to test.

Mass

Specify the mass of the specimen here.

Length

Specify the length of the specimen here.

Diameter (Cylindrical Only)

Specify the diameter of the specimen here.

Mu (Transverse E Only)

Specify the Dynamic Poisson's Ratio here (default is .17).

b>a, a<b (Prismatic Torsional G Only)

Specify the cross-sectional dimensions of the prism, where "a" is less than "b".

b, t (Prismatic Longitudinal E and Prismatic Transverse E Only)

Dimensions of the prismatic cross-section, with the "t" dimension being the direction of impact.

Selection Menu

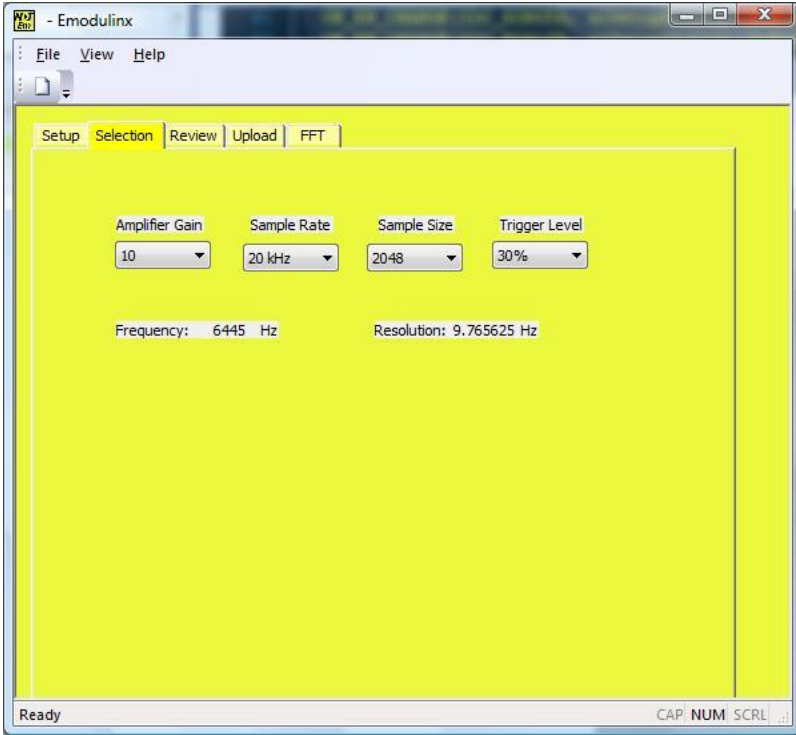


Figure 40: Selection Menu

Amplifier Gain

Use this setting to amplify the received signal. See Tips and Troubleshooting for more information (page 51).

Sample Rate

Use this setting to adjust the sampling frequency.

Sample Size

Use this setting to specify the number of data points sampled.

Trigger Level

Use this setting to adjust the vibration sensitivity of the accelerometer.

Review Menu

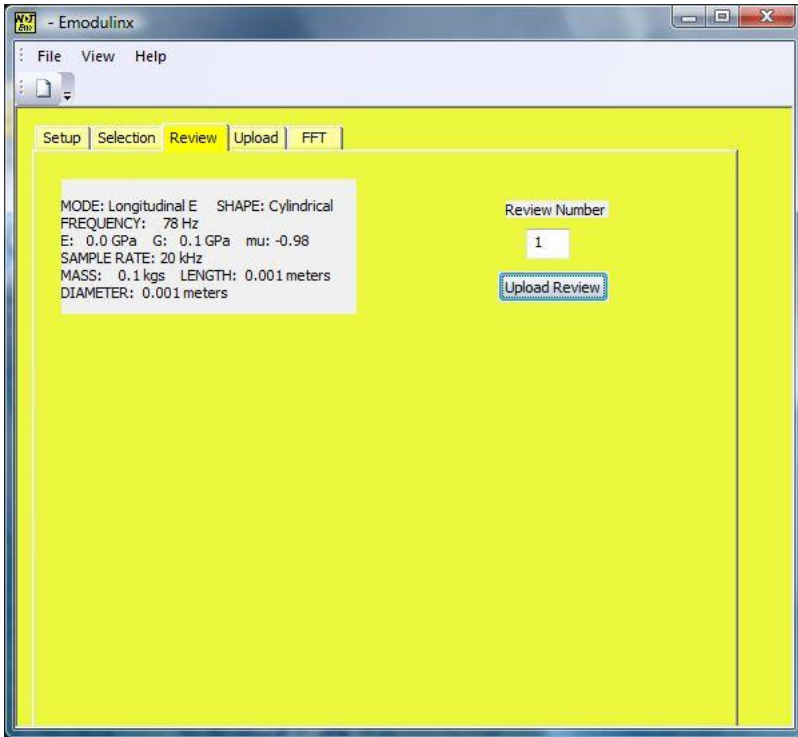


Figure 41: Review Menu

Review Number

Adjust this number to upload a summary of a given test, 1 being the first test that is stored on the Emodumeter.

Upload Review

Click this button after changing the review number to refresh the display window with a review of that particular test.

Upload Menu

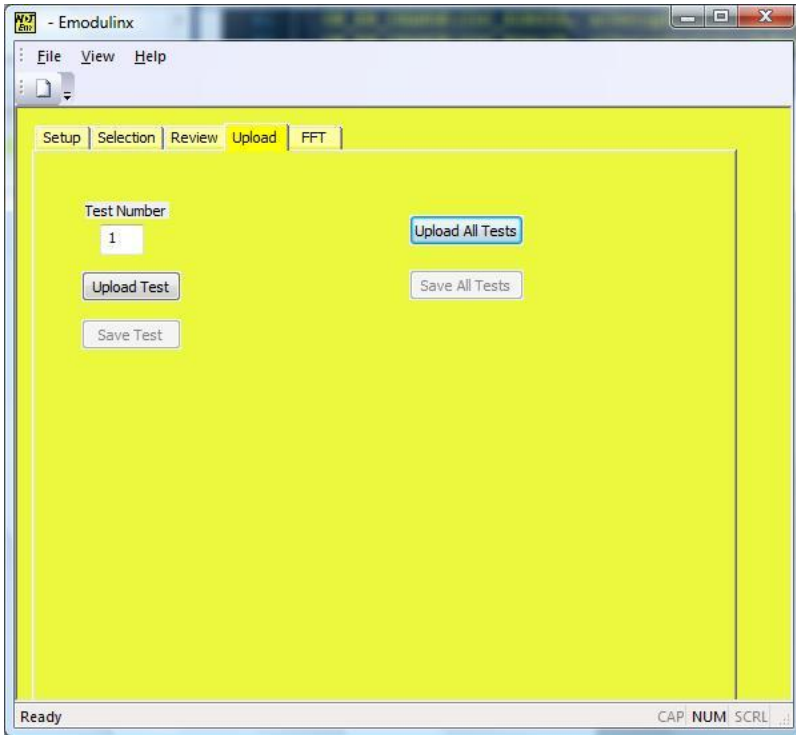


Figure 42: Upload Menu

Test Number

Adjust this number to upload all data of a given test, 1 being the first test that is stored on the Emodumeter.

Upload Test

Click this button after changing the test number to upload the stored data of that particular test. The upload takes a few minutes. A bar will display underneath that shows that the upload is in progress and it will disappear when the upload is complete.

Save Test

Click this button to save the uploaded test to your PC.

Upload All Tests

Click this to upload all stored tests on the Emodumeter.

Save All Tests

Click this to save all tests from the “Upload All Tests” operation to your PC.

FFT Menu

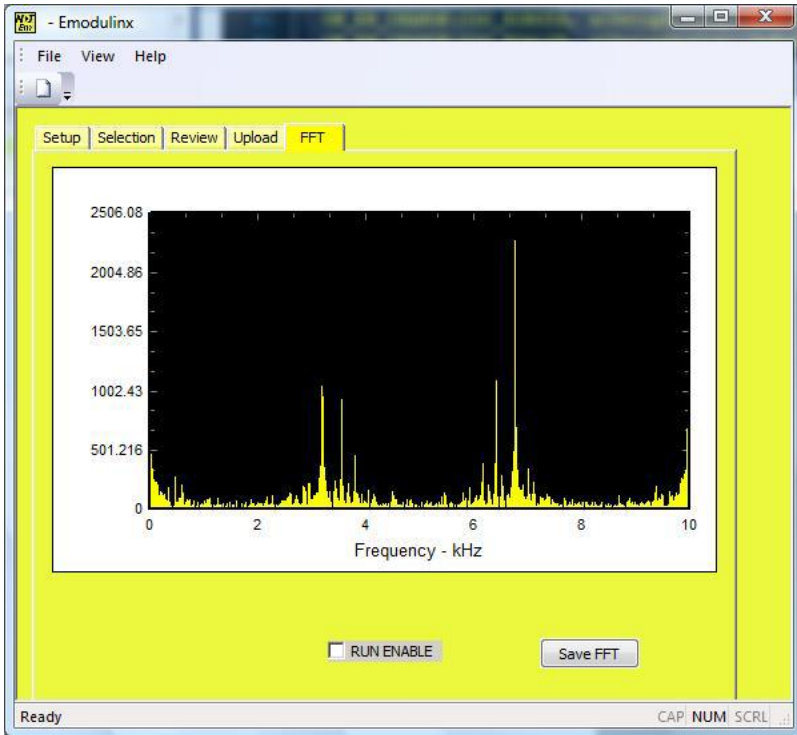


Figure 43: FFT Menu

Run Enable

Check this box right before you are ready to test so the device can begin gathering data. After performing the test, the FFT graph eventually displays in Emodulinx.

Save FFT

Click here to save the current FFT data to your PC.

Tips and Troubleshooting

In this section, some of the problems that could arise with the use of the instrument are mentioned as well as recommendations for solving each of them are described.

Sampling Frequency and frequency resolution

The sampling frequency and the number of collected points will affect the accuracy and precision of your results.

The sampling frequency will determine the maximum frequency that will be useful in the frequency spectrum, which is known as the Nyquist frequency. This value is one half of the sampling frequency and data from the frequency spectrum higher than that are useless. In order to be able to obtain the resonance of the specimen, you need to select a higher sampling frequency than the expected resonance frequency (for concrete usually less than 10 kHz, so sampling frequencies of 20 kHz or higher are recommended).

Contact accelerometer

It is important to place the accelerometer in contact with the specimen. Checking accelerometer contact before impact the specimen with the hardened steel ball is recommended. Coupling between accelerometer and specimen assures proper testing results. For more information, please refer to the recommendations presented in the Operating Instructions chapter.

Trigger level

The trigger level should be adjusted to the particular testing conditions. The level should allow you start recording the vibration of the specimen right after the specimen is hit with the hardened steel ball. A very low trigger level would trigger the system with a different event than the impact of the steel ball. On the other hand, a very high trigger level will not trigger the system even after it is impacted with the steel ball. So, the user shall decide which trigger level is more convenient for the particular testing conditions.

Gain

The gain allows you to control the amplitude of the received signal.

If you select a high gain, the amplitude will get cut-off at higher amplitude values (as presented in Fig. 44) and the obtained frequency result will be different than the actual value. The gain should be selected in order to obtain the best view in the screen of the entire amplitude of the waveform (as presented in Fig. 45). When the beginning of the signal seems to be cut off by the frame of the plot, the gain should be reduced. On the other hand, when the signal on the screen is very small in relationship to the plot frame, the gain should be increased. The ideal gain is the one where the waveform should be horizontally center in the graph and the features of the waveform can be easily seen on the screen.

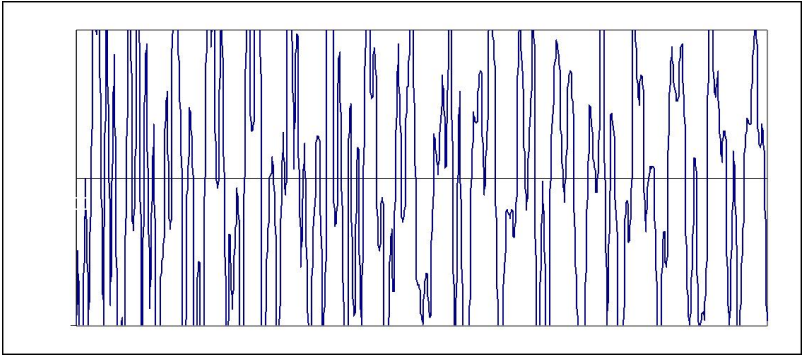


Figure 44: Time domain signal obtained using a high Gain

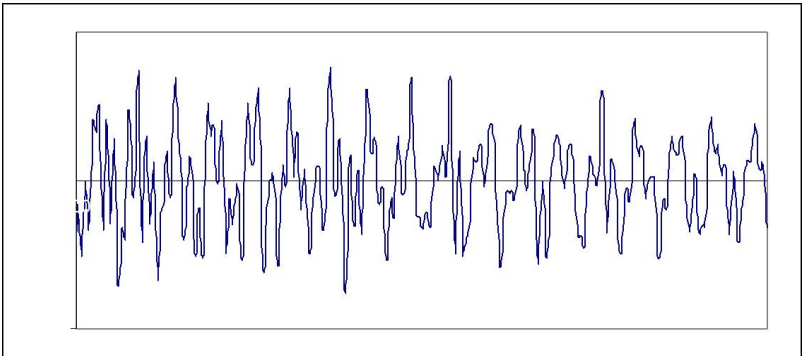


Figure 45: Time domain signal obtained with the proper Gain value

Missing Drivers (Emodulinx)

This is a known issue on some PCs that prevents Emodulinx from

recognizing the Emodumeter while plugged in. If your Emodulinx software brings up a “Emodumeter Not Found” dialog box upon launch, first make sure the USB cable is firmly plugged in (you will hear a click) and make sure the Emodumeter is turned on. If the dialog box still appears, follow these steps:

1. Right click “Computer” in your Start Menu or Desktop and click “Properties”. Select “Device Manager” from the left hand side. The Device Manager will open.
2. With the Emodumeter on, unplug the USB cable and plug it back in. If you see an item on the Device Manager appear with a small yellow exclamation point, this means that the device was detected but there are no supported drivers available on the PC.
3. Make sure the Emodulinx install CD is inserted. Right click the device icon with the exclamation point and select “Update Driver Software”. Select “Browse my computer for driver software”. Click the “Browse” button and navigate to your CD drive. Double click the “USB Drivers” folder and select either the folder called “32-bit” or “64-bit” depending on what operating system you have installed. Click “Next” and your computer will extract the drivers from the CD and install them to the appropriate location on your PC.

The Emodumeter should now be displayed in the Device Manager as “USB Serial Port (COM#)”, as shown in Figure 46.

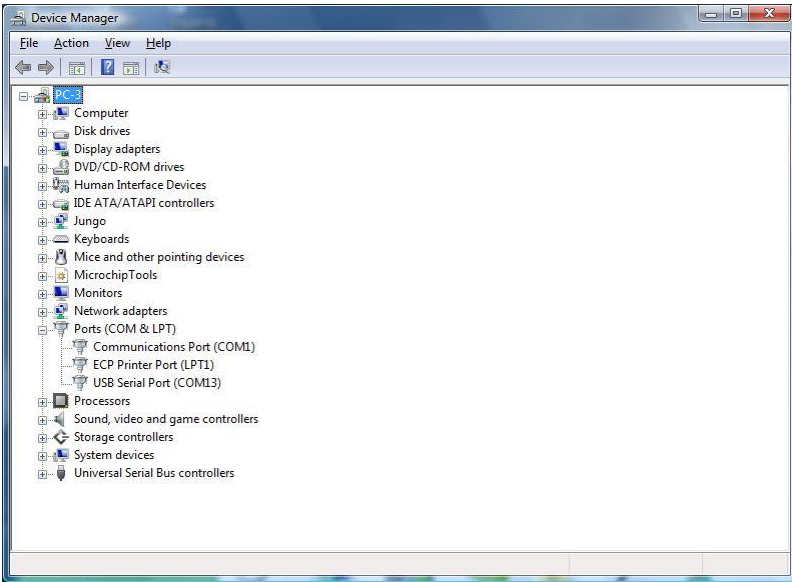


Figure 46: Device Manager

Safety

- Do not submerge unit in water. This can cause electrical shock.

Specifications

Emodumeter V-E-400

Frequency Range	from 10 Hz to 40 kHz
Sampling Frequency	10, 20, 40 or 80 kHz
Frequency Resolution	from 4.9 to 78.1 Hz
Record Length	1024 or 2048 points
Output Bias Level	9.2 V
Accelerometer Sensitivity	9.60 mV/g (0.979 mV/m/s ²)
Battery	14.4 Volt. 4-8 hours - continuous use
Display	320 by 240; backlit for daylight use
Storage	200 plus readings
Software Requirements	Windows compatible 9x/me 32MB RAM
Impactors	Set of 6 hardened steel balls
Operating Temp. Range	0°C to 40°C

Sales Numbers

Part #	Description
V-E-400	Emodumeter Standard Test System
V-E-410	Emodumeter Instrument only
V-E-1020	Accelerometer
V-E-1030	Standard Bench
V-E-1040	Accelerometer and Standard Bench

Warranty Information

1. Contract

Unless otherwise stated all sales transactions are expressly subject to these terms and conditions. Modification or additions will be recognized only if accepted in writing by an authorized Officer of James Instruments Inc. (hereinafter referred to as “James” or the “Company”), or an officially designated representative. PROVISIONS OF BUYER'S PURCHASE ORDER OR OTHER DOCUMENTS THAT ADD TO OR DIFFER FROM THESE TERMS AND CONDITIONS ARE EXPRESSLY REJECTED. NO WAIVER OF THESE TERMS AND CONDITIONS OR ACCEPTANCE OF OTHERS SHALL BE CONSTRUED AS FAILURE OF THE COMPANY TO RAISE OBJECTIONS.

2. Warranties

The Company only warrants the equipment manufactured or supplied by the Company as set forth herein. James makes no other warranties, either expressed or implied (including without limitation, warranties as to merchantability or fitness for a particular purpose). In no event shall James be liable for any type of special, consequential, incidental, or penal damages, whether such damages arise out of or are a result of breach of contract, warranty, negligence, strict liability or otherwise. Warranty shall not apply where the equipment manufactured or supplied has been subject to accident, alteration, misuse, abuse, improper storage, packing, force majeure, improper operation, installation, or servicing. In addition, the following shall constitute the sole and exclusive remedies of Buyer for any breach by James of its warranty hereunder.

a. New Products

James warrants the equipment manufactured or supplied by James as set forth herein. This limited warranty can only be exercised by the original purchaser of the equipment from James or authorized James Agent and is not transferable to any subsequent owner or party. This limited warranty gives you specific legal rights, and you may also have other rights which vary from case to case.

i. For James Equipment

James warrants that James's equipment will be free from defects in materials and workmanship for a period of twenty-four (24) months on the electronic portion and six (6) months on the mechanical portion from the date of shipment of equipment from James to Buyer. Should any defects be found and reported by the Buyer during the applicable limited warranty period, the defect will be corrected upon return of the item to James. James will, during the applicable new equipment warranty period, provide the necessary replacement parts and labor to correct the defect.

Excluded from the new equipment warranty are all consumable and wear and tear items such as impact bodies, penetrators, connection cables, etc. These items are subject to usual wear and tear during usage. Refer to the Consumable, Wear and Tear Items section of this warranty document.

Option For Extended Limited Warranty Coverage

The original purchaser of any new equipment of James which have been identified or labeled by James from time to time in James's sole discretion as being eligible for extended warranty coverage shall have the option to purchase certain extensions of the applicable limited warranty provided hereunder to the electronic portion of any such items for either a twelve (12), twenty-four (24) or thirty-six (36) month period (up to a possible maximum limited warranty coverage period for the electronic portions of such new James equipment of sixty (60) months) by purchasing any such twelve (12), twenty-four (24) or thirty-six (36) month limited warranty extension period either all the time of the purchase of any such item(s) or within ninety (90) days from the date of delivery of the subject item(s) of the original purchaser of such item(s). The price for each such extended limited warranty coverage period shall be as determined by the Company from time to time and all such purchases of any extended warranty coverage periods shall only be effective upon a completed purchase order and payment directly between James and the original purchaser of any such item(s). The extended warranty coverage periods are only valid with respect to the original purchaser of such item(s) from the Company and such extended warranty coverage is not transferable to subsequent owners of the subject item(s) or any other parties. Upon the purchase of any extended limited warranty coverage period, the Company will issue a certificate to Buyer evidencing the details of the applicable extended warranty coverage period purchased by the Buyer.

ii. For Other Manufacturer's Products Supplied by James

Products of other manufacturers supplied as such by James are warranted by James only to the extent of any warranty provided by the original manufacturer, if any.

iii. For Parts and Sub-Assemblies

Parts or sub-assemblies purchased by the Buyer to perform its own repair work etc. are warranted as provided hereunder by James for six (6) months from date of shipment of material from James to Buyer.

iv. For Consumables, Wear and Tear Items

James supplies consumable items and items subject to wear and tear during normal usage of James supplied products. These items are not covered under warranty. Buyer is to check for proper fit, form and function of such items upon receipt of such items. In case of a defect condition, Buyer can return the item to James for evaluation within thirty (30) days of the date of shipment to the Buyer. James reserves the exclusive right to issue full, partial, or no credit to the Buyer based on the condition of the returned item and circumstances related to the return. Examples of items in this category: connection cables, test blocks, impact bodies, penetrators, probes, extraction liquids, calibration liquids, pins, recording paper, test plugs, etc.

b. Calibration and Repair

i. For Calibration Services

James does not warrant the calibration of any equipment. James does however warrant the equipment manufactured by it, in proper working condition, to be capable of being adjusted to meet James printed specifications, if any, for accuracy and performance as to the particular model type during the period of warranty applicable as stated above.

ii. For Repair Services

James warrants repair work performed under the direct control and supervision of James personnel for a period of three (3) months from the date repairs are completed either at James or at the customer site. Should the defect for which the repair work was performed reoccur within this period, James will supply the necessary parts and labor (repair at James facility) or parts (repair at Buyer facility) required to repair the original equipment defect for which the repair parts and labor were required. Additional repair charges that may be incurred in conjunction with any repair service warranty event will be invoiced at the James customer service rates and policies in effect at the time of the event.

Excluded are all consumable and wear and tear items such as impact bodies, probes, connection cables, etc. These items are subject to usual wear and tear during usage. Refer to the Consumable Wear and Tear Item section of this warranty document.

c. Warranty Claims

i. For Warranty Claim Processing

James has established James organizations in the Americas, and Europe. Please visit the James web site www.ndtjames.com for latest address and contact information for the James organization nearest you.

3. Regulatory Laws and/or Standards

The performance of the parties hereto is subject to the applicable laws of the United States. The Company takes reasonable steps to keep its products in conformity with various nationally recognized standards and such regulations, which may affect its products. However, the Company recognizes that its products are utilized in many regulated applications and that from time to time standards and regulations are in conflict with each other. The Company makes no promise or representation that its product will conform to any federal, provincial, state or local laws, ordinances, regulations, codes or standards except as particularly specified and agreed upon for compliance in writing as a part of the contract between Buyer and the Company. The Company prices can not include the cost of any related inspections or permits or inspection fees.

4. Notices

Notice by either the Company or Buyer will be made only by facsimile or similar electronic transmission, effective on the first business day after confirmed receipt, or by letter addressed to the other party at its address as provided in this Agreement, effective three (3) business days after deposit with the U.S. Postal Services, postage prepaid, or one (1) business day after deposit with a recognized overnight express service.

5. Interpretation

Should any term or provision contained in the contract contravene or be invalid under applicable law, the contract shall not fail by reason thereof but shall be construed in the same manner as if such term or provision had not appeared therein.

6. Assignability

Neither this contract nor any claim arising directly or indirectly out of or in connection herewith shall be assignable by Buyer or by operation of law, without the prior written consent of Company. This document shall be binding upon and inure to the benefit of each party hereto and their respective permitted successors and assigns.

7. **Governing Law**

This Agreement shall be governed by and construed in accordance with the internal laws of the State of Illinois, without regard to its conflict of laws provisions. Buyer and the Company expressly agree to submit to the personal jurisdiction of the federal and/or state courts sitting in Chicago, Illinois, U.S.A. and agree that such courts may be utilized if necessary to obtain injunctive or any other relief. The Hague Convention and the United Nations Convention on Contracts for the International Sale of Goods shall not apply to the construction or interpretation of these Standard Terms and Conditions or affect any of its provisions.

END.

Repair Policy

United States | Canada | International

Ship the instrument in a box that meets UPS, Fed Ex, and standard shipping regulations. Enclose a note describing the problem(s) you are having. Include the name and phone number of the contact person in your organization.

The instrument will be evaluated within one week of receipt. The contact person will be notified with an estimate of the cost of the repair.

Upon receipt of your authorization of repair and payment terms, delivery time will be 2 weeks from that day.

If you need the repair back sooner than this, you have the option of paying an express service fee of 10 percent of the purchase price of said instrument, plus the repair cost. With this service, you can receive the instrument back within 3 working days in the USA (5 working days for Europe).

International repair shipments must contain a commercial invoice listing the instrument being returned and must contain the words:

Country of manufacture: USA

Instrument being returned to manufacturer for repair – no value for customs, value for carriage only.

Ship the complete system to:

Attn: Repair Department James Instruments, Inc. - USA 3727 North Kedzie Avenue Chicago, IL 60618-4503 USA	Attn: Repair Department James Instruments, Inc. – Europe Windmolen 22 7609 NN Almelo The Netherlands
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Home page: www.ndtjames.com

E-mail: info@ndtjames.com

europe@ndtjames.eu





James Instruments Inc.

3727 N.Kedzie

Chicago, IL 60618-4503

USA

Tel: (773) 463-6565

Fax: (773) 463-0009

James Instruments Inc. - Europe

Windmolen 22

7609 NN Almelo

The Netherlands

Tel: +31 (0)548 659032

Fax: +31 (0)548 659010

