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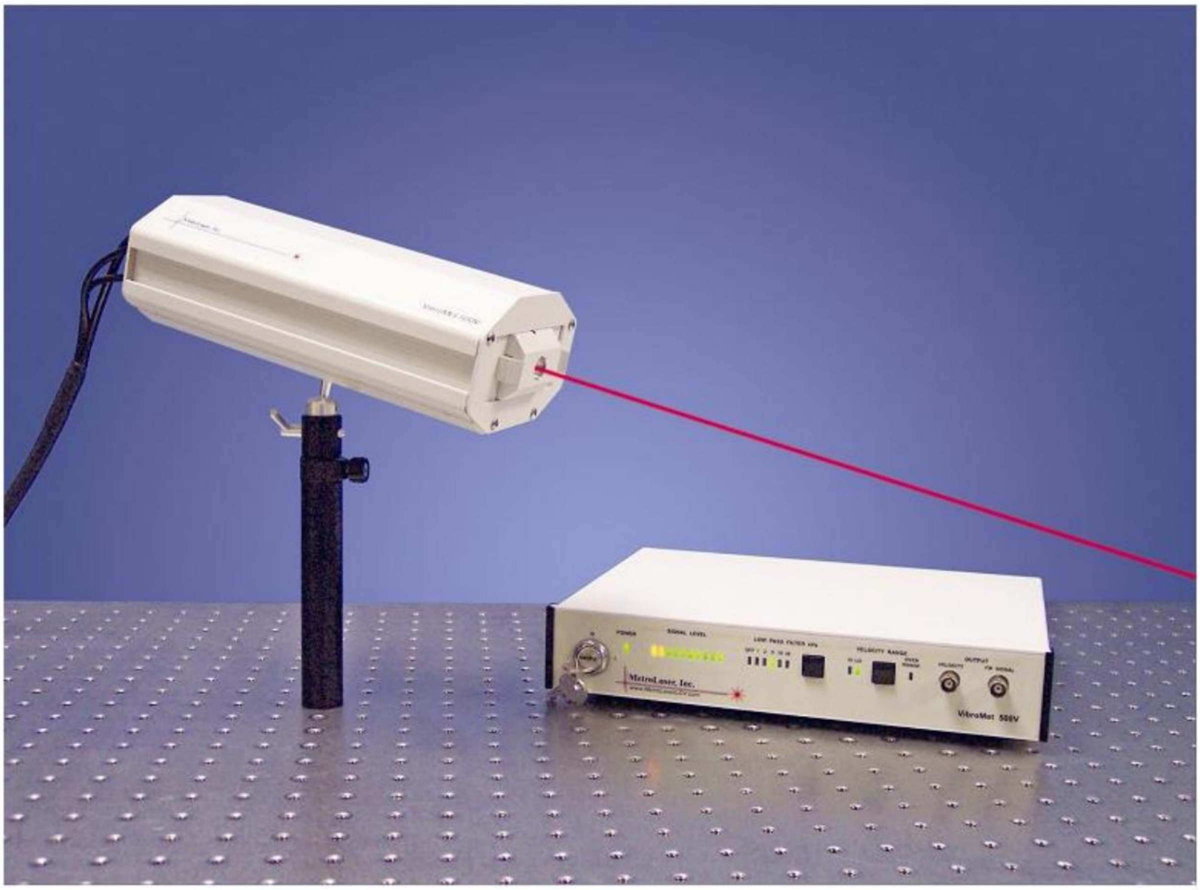
VibroMet™ 500V

Laser Doppler Vibrometer

User Manual

Version 6.0

February 2006



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Introduction

Congratulations on your purchase of the VibroMetTM 500V Single Beam Laser Doppler Vibrometer (LDV) . Designed by MetroLaser Inc., this product represents the latest in vibration measurement technology.

To ensure safe and reliable operation of VibroMetTM for many years, please follow the instructions in this document.

Content

1 Safety precautions when working with a laser

1.1 Safety precautions when working with a class IIIB laser

Use of controls, adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.
irradiation.
The MetroLaser VibroMet™ 500V vibration meter is
Class 3B laser. The outgoing laser beam is a hazardous production factor. To prevent accidental exposure to direct and reflected beams, take precautions.

1.2 Safety regulations

Use of the equipment for other purposes may result in malfunction of the safety devices.

CAUTION - THERE IS A RISK OF ADVERSE EFFECTS LASER ON THE VISUAL ORGANS.

To protect your eyes from exposure to maximum levels of laser radiation, use special protective glasses designed for the required wavelength. Glasses
must be selected to provide protection against laser radiation with a power of 15 mW at a wavelength of 780 nanometers.
Direct exposure of the laser beam to the eyes can cause irreparable damage to vision. It is recommended to provide and use special protective
glasses whenever there is a possibility of exposure to outgoing laser radiation
beam or beam reflected from a mirror surface onto the visual organs of the VibroMet™ user.

Below is a list of safety precautions that must be observed when working with the vibration meter. A full list of references to relevant safety standards can be found in Section 1.5 below.

- Do not look into the laser beam or its reflection as this may cause permanent damage to your eyesight.
- All employees not involved in the work process must be kept away outside the work area.
- The vibration meter should only be used in a clearly designated area with restricted access. Install appropriate signs.
- The vibration meter should only be operated under the supervision of qualified personnel. When not in use, the product should be completely switched off.
- Work with the vibrometer should only be done in well-lit areas so that the worker's pupils are constricted, reducing eye irritation from light and the possibility of damage to the visual organs.
- Directing the laser at living people and moving vehicles is prohibited.
- Never leave the vibration meter in operation unattended.

1.3 VibroMet™ Safety Devices

Below is a list of devices built into VibroMetTM that ensure the product complies with U.S. Federal safety requirements:

- Model number and serial number of the laser of each VibroMetTM vibrometer is registered for the future.
- VibroMet™ Beam Attenuator/Breaker can be used to eliminate the output of laser radiation energy onto the outer part of the product.
- Green LED laser indicator on the controller VibroMet™ and the green LED indicator on the measuring head illuminates for 3 seconds before and during laser energy emission.
- A light spot on the breaker body provides indication when the breaker is open. laser shutter.
- The housing of the VibroMet™ measuring head is sealed, so the energy laser radiation enters only through the laser aperture.
- The VibroMetTM controller and the VibroMetTM measuring head are equipped with signs warning the user of possible risks.

1.3 Warning signs

Below are the warning labels that are attached to the measuring head and to the VibroMetTM controller.

Figure 1 – Warning sign about Located on the aperture. measuring head.

Figure 2 - Laser head warning sign. Located on the rear side of the measuring unit.
heads.

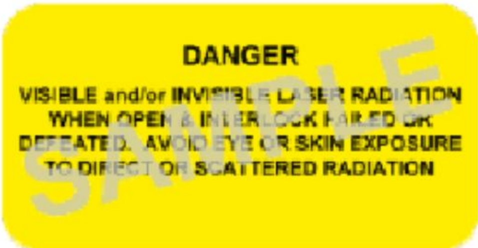

Figure 3 - Enclosure access warning sign.

Figure 4 – Laser radiation warning logo.

1.5 State safety standards

When installing VibroMet™ in the United States, it is recommended to comply with the requirements ANSI Z136.1-1993 *Laser Safety Standard* for Class A Products 3B.

For installations in other countries, please follow the requirements set out in User's Guide, Section 3 of the International Laser Safety Standard IEC 825-1 (or equivalent standard EN60825-1). Document The American National Standards Institute can be requested from the American Laser Institute in Florida at (407) 380-1553, International Electrotechnical Standards (IEC) can be requested from the IEC in Geneva, Switzerland, and European Standards (EN) are available from standards organizations in each European country.

General information about the dangers of laser radiation can be found in *Technical Guidance* (Section III: Chapter 6) of the U.S. Department of Labor, Occupational Safety and Health (OSHA). OSHA Guidance is available at: http://www.osha.gov.

2 Installation and operation

2.1 Instructions for removing packaging

VibroMet™ is transported in a waterproof travel case, in which the device should always be kept during storage and transportation.
Inspect the unit for damage during shipping. Make sure all of the following items are included:

- Measuring head VibroMet™ 500V;
- VibroMet™ 500V controller;
- (2) Cables: a bundle of wires for connecting the controller to the measuring head and the controller power cord;
- Keys, IR card, safety lock (under a small cap).

If parts are damaged or lost, please contact the company immediately.
MetroLaser:

MetroLaser, Inc.
White Road 2572
Irvine, California, 92614, USA
Phone: (949) 553-0688
Fax: (949) 553-0495

2.2 __Preparing VibroMet™ 500V for operation

This section of the manual contains instructions for assembling and preparing your VibroMet™ 500V for operation. To avoid damage to the system Follow the instructions carefully.

2.2.1 Procedure for preparation for work

- **Before** turning on the power, make sure that the VibroMet™ controller is set to the correct voltage and that the device is grounded. Failure to ground may result in system malfunction and/or damage.
systems.
- Connect the safety interlock.
- Connect the multi-pin jumper wire (in the wire bundle controller) to the measuring head and to the back of the controller.
- Connect the RF cable of the controller (RF Power 40 MHz Out) to the measuring head (RF In). Fasten it securely.
- Connect the IF cable of the measuring head (FM out) to the back of the controller (IF Signal In).
- The demodulated speed signal can be obtained from the front panel of the controller via the bayonet output connector labeled "Output". This signal can be displayed on an oscilloscope, spectrum analyzer, or converted to digital form using a data acquisition system (DAS).
- Frequency-modulated IF signal (at a carrier frequency of 10.7 MHz) can be can also be obtained using the bayonet output connector located on the front panel of the controller.

Figure 5 – Rear panel of the VibroMet™ 500V controller with wires.
The safety interlock is shown above and connects to the contact socket below the signal cable.

Figure 6 – Rear panel of the VibroMet™ 500V measuring head.

2.3 __Operation of VibroMet™ 500V

1. Make sure all wires are connected correctly and securely and that the shutter The measuring head is closed.
2. Turn on the controller power by turning the key on the front panel.
3. Before taking measurements, allow the device to warm up for 5 minutes.
4. Make sure the measuring head is pointing in a safe direction, open the shutter and place a white piece of paper on the measuring head's laser beam path to check the laser beam. Turn on the red laser beam switch on the back of the head to check the IR beam direction. Then point the laser head at the test object. The red laser beam does not affect the measurement and can be turned on or off at any time.

5. Check the signal strength indicator (SSI) on the controller panel. The SSI has ten LED lamps (two yellow and eight green) that serve to indicate the level of the incoming signal. An adequate signal level is required to carry out correct and effective measurements. A sufficient level
signal occurs when more than two green SSI LED lamps are lit. If the signal level is insufficient, carefully adjust the object surface (or the VibroMet laser head), if possible, so that at least two LED lamps are lit. The device will perform measurements

with one yellow SSI lamp lit, however, the signal-to-noise ratio will not be optimal.

6. The VibroMet™ controller has two speed ranges: HIGH and LOW. Each setting determines the maximum speed that can be measured. The HIGH range can be used to measure speeds from 100 microns/sec to 800 mm/sec. The LOW range can be used to measure speeds from 5 microns/sec to 50 mm/sec. It is best

use the smallest possible range that can still detect the desired signal.

7. VibroMet™ provides a number of low-pass filters (LPF) that can be used as anti-aliasing filters for digital signal processors. When all filters are turned OFF, the instrument operates in the full range of oscillatory frequencies up to 50 kHz.

8. At high target speeds (v > 400 microns/sec), the velocity value can be easily displayed on an oscilloscope using the following approximate calibration constants:

HIGH speed range: 1 mV = 72 microns/sec;
LOW speed range: 1 mV = 4 microns/sec;

The exact calibration constants are listed on the specification sheet on the back of this manual. The signal at low speeds is best displayed using a spectrum analyzer or data acquisition system.

Figure 7 – Location of instruments on the VibroMet™ 500V controller panel

2.4 Preventive maintenance

VibroMet™ 500V is recommended to be inspected regularly as follows:

- Inspect the protective housings of the measuring head and controller: the panels must be firmly screwed and not deformed. Tighten the screws if necessary. NOTE: Removing the housings or covers will void the VibroMet™ 500V warranty and is a risk factor.

- Make sure that the laser beam outlet is not blocked by anything. NOTE: Always switch off the electronic controller before testing.
  from the power supply network.

- Check the functionality of the laser radiation indicator.

3 Theoretical description of the work

A laser Doppler vibrometer (LDV) is essentially an interference device that mixes the beam from the object (the light reflected from the target) with a reference beam. In the case of the VibroMetTM 500V vibrometer, the reference beam remains in the resonator diode laser, while in systems from other manufacturers the reference beam is separated by an external beam splitter. In both cases, the reflected beam from object beam is mixed with the local reference beam on the coherent sensor. If collected light is scattered from a vibrating object, then it will experience a Doppler shift in its optical frequency caused by the speed of the object's vibration. The frequency shift *f d* is given by the Doppler equation:

f d = 2 *v* cos ÿ / ÿ, (1)

where *v* is the speed of the object, ÿ *is* the optical wavelength, and ÿ is the beam intersection angle light and the object's speed course. For vibrating objects, the signal ratio sensor and vibration values are given below. Let's assume that the position of the object has the form

X = *Xm* cos *(ÿÿ t),* (2)

where *Xm* is the maximum displacement, and *ÿa* is the rotational frequency of vibration. Then the vibration speed *v* is expressed as:

in = - *Xmÿÿsin (ÿÿ* t), (3)

Substituting **Equation (3)** into **Eq. (1),** we obtain the Doppler frequency shift *f d* diffused beam of light:

f d = - 2 *Xm* ÿÿsin *(ÿÿ t)* cos ÿ / *ÿ,* (4)

where ÿ *is* the optical wavelength. Then the electric field of the scattered light beam is receiver can be written as:

Es(t) = *Escos* [2ÿ (f0 + *f d)t* + *Ø1]*

= *Es* cos [2ÿ *(f0 - 2Xmÿÿsin (ÿÿ t)* cos ÿ / *ÿ)* + Ø1], (5)

where *f0 is* the optical frequency. To increase the signal-to-noise ratio (s/n) and the sensitivity of the sensor, the frequency of the reference beam is usually shifted by a constant frequency *f b* using a Bragg cell. The electric field of the reference beam is expressed as:

Er(t) = *Er* cos [2ÿ (f0 + *f b)t* + Ø2], (6)

Mixing the scattered light with the reference beam produces a pulsed signal at the sensor. The optical energy of the sensor is expressed as:

I(t) = 2 *Es Er* cos (2ÿ (fb + *f d)* + *ÿØ)*

= *I* cos (2ÿ *f(t)* + ÿØ), (7a)

And

f(t) = *f b* + *f d* = *f b* - *2 Xm ÿÿ* cos ÿ sin *(ÿÿ t) / ÿ,* (7b)

where ÿØ = *Ø2* - Ø1. **Eq. (7b)** shows that the detected LDV signal is typical FM signal. In general, *f b* >> *f d* and the carrier frequency, *f b,* is modulated vibration with frequency *ÿa* and amplitude *2 Xm ÿa* cos ÿ / *ÿ.* Using the frequency demodulation method, *f b* is subtracted by the phase-locked loop, and the output signal is expressed as:

A(t) = (2 *Xm ÿa* cos ÿ / ÿ) sin *(ÿa* t). (8)

Equation (8) shows that after frequency demodulation the output signal contains only the vibration frequency, *ÿa,* and high-order harmonics are absent. Thus, the frequency demodulation method provides high signal accuracy.
The LDV system is shown schematically in **Figure 8.** It combines a double shear frequencies and random mixing effects, which gives a high signal-to-noise ratio (S/N) when collecting light through a small aperture created by an acousto-optic modulator (AOM). In **Figure 8,** a parallel laser beam from a laser diode enters the acousto-optic modulator. After the AOM, the beam is divided into two separate beams: diffracted and non-diffracted. The non-diffracted beam is blocked screen to interrupt the beam, and the diffracted frequency-shifted beam is used as a probe beam, focused on the object by a lens. The lens collects some of the reflected light, sending it back to the AOM for a second frequency shift. The double-frequency-shifted light beam returns to
laser diode resonator for random mixing. Photodiode built into
laser diode, detects the randomly mixed signal and outputs an electrical signal. The output signal is then processed by electronic circuits
frequency demodulation, which determines the vibration frequency and amplitude.

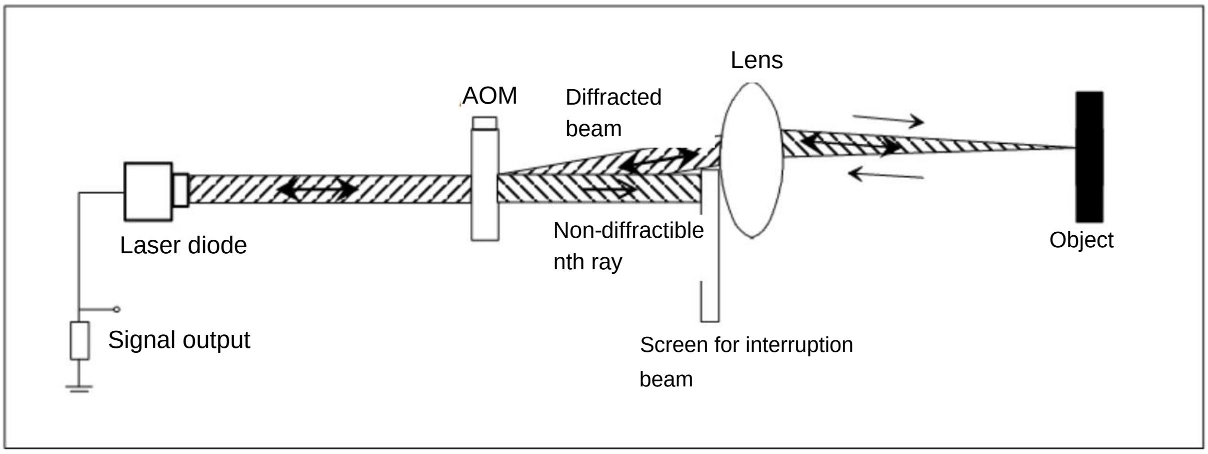

Figure 8 – Schematic representation of the VibroMet™ 500V Measuring Head

3.1 Random Mixing Effect:

Figure **9** shows the principles of the random mixing effect in laser diode. The beam reflected from the object (beam D) upon hitting the laser diode is mixed with the laser beam in the resonator, generating a pulse signal with a frequency of 2fB+fD. The optical pulse signal is then recorded by the built-in photodiode in laser body, resulting in a corresponding electrical signal being generated at the output. Similar to standard LDVs, this signal can be processed using frequency demodulation electronic circuits in order to determine the frequency and amplitude of the object's vibration.

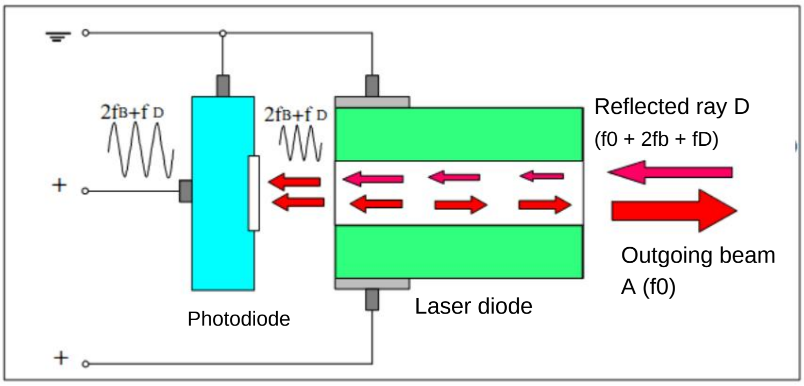

Figure 9 – Random mixing effect

4 Test results using VibroMet™ 500V

The VibroMetTM 500V vibrometer produces a signal that is proportional to the speed of the object. The speed of the object can also be expressed through the Doppler
the shift in the vibration frequency of an object or the displacement of an object. The following expressions can be used to convert one unit of measurement to another:

Let us assume that the object moves periodically with a displacement x(t) = A sin (2ÿft), where
A is the amplitude of the displacement, and f is the frequency. Then the velocity of the object will be the derivative of the magnitude of the displacement and v(t) = dx/dt = 2ÿfA cos(2ÿft). The Doppler shift FD is expressed as as FD = 2v / ÿ, where v is the velocity and ÿ is the laser wavelength, 0.78 µm. Thus, the Doppler shift is expressed by the formula FD = 4ÿfA cos(2ÿft) / ÿ.

The VibroMet™ 500V controller has three operating frequency ranges (configurable on the front panel) that limit the maximum Doppler shift (or velocity) that can be measured. By selecting a lower, narrower operating frequency range, you can
measure the Doppler shift (or velocity) of a smaller object. For each
The maximum possible output voltage setting is +/- 5 volts.

Typical values are shown below:

HIGH speed range (with an estimated object vibration frequency of 1 kHz)			
Doppler Shift (Hz) Signal (mV) 1 MHz 100 kHz 10		Speed (microns/sec) Displacement (nm)	
kHz 1	4000	390000 62070	
kHz 100	400	39000 6207	
Hz	40	3900 621	
	4	390 62.1	
	0.4	39	6.2

LOW speed range (with an estimated object vibration frequency of 1 kHz)			
Doppler Shift (Hz) Signal (mV) 100 kHz 10 kHz 1		Speed (microns/sec) Displacement (nm)	
kHz 100	6400	39000 6207	
Hz 10	640	3900 621	
Hz	64	390 62.1	
	6.4	39 6.2	
	.64	3.9 0.62	

4.1 Test results in HIGH speed range

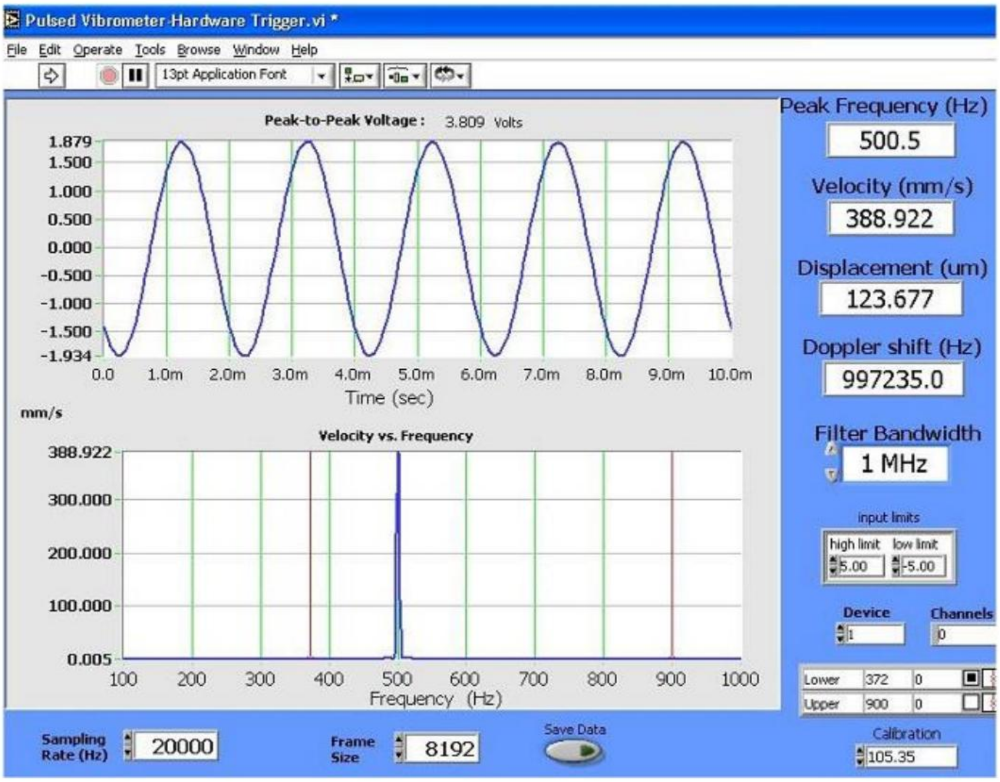

Figure 10 – Discrete signal from an object vibrating at a frequency of 500 Hz with a Doppler frequency shift of 1 MHz. The measured velocity of the object is 388.922 mm/sec, and the displacement value is 123.7 microns.

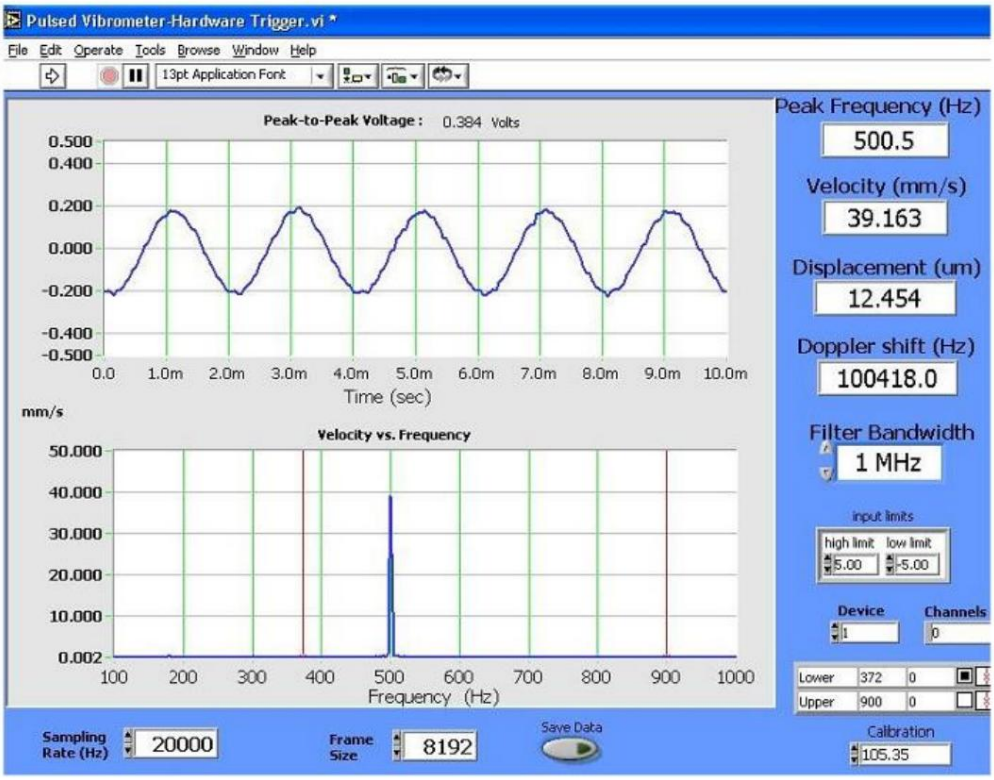

Figure 11 - Discrete signal from an object vibrating at a frequency of 500 Hz with a Doppler frequency shift of 100 kHz. The measured velocity of the object is 39.163 mm/sec, and the displacement value is 12.454 microns.

4.2 Test results in LOW speed range

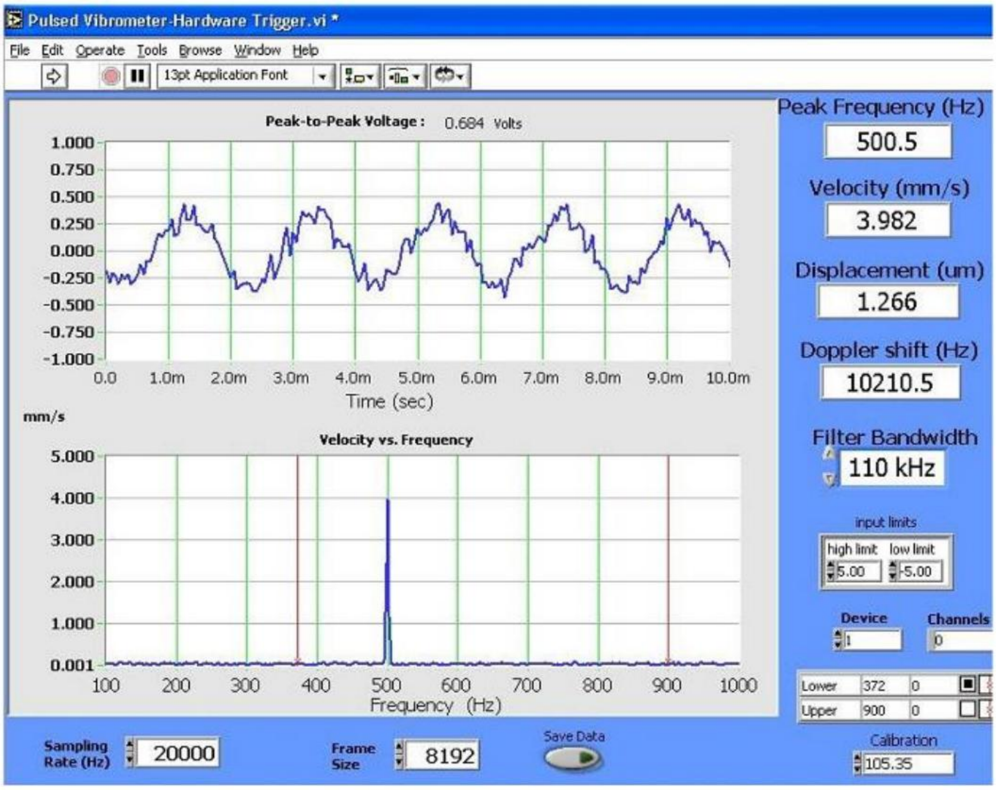

Figure 12 - Discrete signal from an object vibrating at a frequency of 500 Hz with a Doppler frequency shift of 10 kHz. The measured velocity of the object is 3.982 mm/sec, and the displacement value is 1.266 microns.

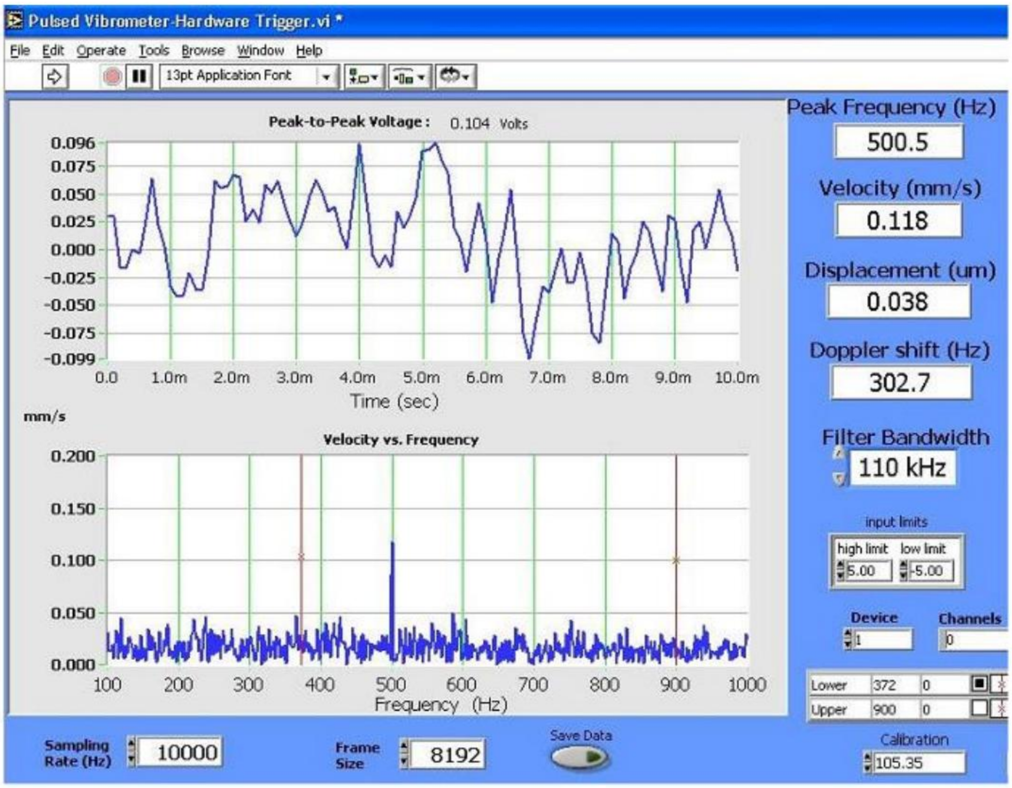

Figure 13 - Discrete signal from an object vibrating at a frequency of 500 Hz with a Doppler frequency shift of 300 Hz. The measured velocity of the object is 118 microns/sec, and the displacement value is 38 nm.

5 Supplement

5.1 Warranty information

MetroLaser guarantees that the purchased VibroMetTM 500V vibration meter (hereinafter referred to as the "Product") is free from defects in material and workmanship for a limited period of time and that the technical characteristics of the Product correspond to the technical characteristics specified in the user manual.

If the Product does not function properly during the warranty period service, we will repair or replace it free of charge. Before returning the Product under MetroLaser's warranty, the Purchaser must obtain a Return Material Authorization (RMA) number from us. The cost of shipping the Product to MetroLaser company for warranty service is paid by the Buyer. If After inspection and verification of the returned Product, MetroLaser specialists conclude that the product is in good working order, the Buyer is notified of this, who pays the costs of returning the Product and the cost of inspecting and checking the Product.

MetroLaser's sole obligation (and sole remedy) Buyer's legal defense) with respect to the above Limited Warranty is (at the discretion of MetroLaser or, where applicable, the Buyer) a refund of the fees paid or repair (replacement) defective Product, provided that MetroLaser receives written notice thereof within the warranty period. In accordance with The terms of the above Limited Warranty do not entitle the Buyer to bring an action to enforce a remedy after one (1) year has passed after the cause of action arose.

5.1.1 Warranty period

The warranty period for new Products sold in the United States is is: one (1) year for the VibroMetTM 500V Measuring Head and Controller and ninety (90) days for the cables. The warranty period for Products sold for outside the United States, is one (1) year from the date of acceptance or fourteen (14) months from the date of delivery, whichever occurs first.

5.1.2 Warranty Limitations

This Limited Warranty is void if damage to the Product is caused by is an accident, improper operation, modification, use not in accordance with intended purpose, operation in an unsuitable physical environment, installation by the Buyer third-party software and/or hardware, not compatible with MetroLaser hardware or software, unauthorized maintenance or repair. The warranty is void if the housing of the Measuring Head or Controller is opened.

Certain components may have a separate warranty period. service, which is specified in the user manual for the Product. For consumables Materials are not covered by the warranty.

DISCLAIMER: The express warranties set forth above are the only MetroLaser warranties for the Product. Any modifications or additions must be in writing and signed by a duly authorized officer of MetroLaser. THE EXPRESS WARRANTIES SET FORTH ABOVE ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE WARRANTIES OF MERCHANTABILITY, NON-INFRINGEMENT, AND FITNESS FOR A PARTICULAR PURPOSE.

LIMITATION OF WARRANTY. METROLASER MAKES NO WARRANTIES OR REPRESENTATIONS REGARDING THE OPERATION OR THE RESULTS OF OPERATION OF THE PRODUCT IN TERMS OF CORRECTNESS, ACCURACY, RELIABILITY, ETC., AND DOES NOT WARRANT THAT THE OPERATION OF THE PRODUCT WILL BE UNINTERRUPTED OR ERROR-FREE.
METROLASER EXPRESSLY DISCLAIMS ALL WARRANTIES OTHER THAN THOSE SET FORTH HEREIN. METROLASER WILL NOT BE LIABLE FOR CONSEQUENTIAL, INCIDENTAL, OR SPECIAL DAMAGES. METROLASER'S TOTAL LIABILITY FOR ANY CLAIM RELATED TO THE USE OF THE PRODUCT IS LIMITED TO THE PRICE PAID BY PURCHASER FOR THE PRODUCT. METROLASER WILL NOT BE LIABLE FOR ANY

RESPONSIBILITY FOR THIRD-PARTY COMPONENTS.

5.2 Information on maintenance and repair

If your VibroMet™ 500V requires recalibration or warranty service, contact your Sales Representative or MetroLaser at the number below to obtain a Return Material Authorization (RMA) number, then return the system with all parts in the original packaging to the following address:

MetroLaser, Inc.
White Road 2572
Irvine, California, 92614, USA
Phone: (949) 553-0688
Fax: (949) 553-0495

For safety reasons, VibroMet™ should always be transported in original protective case. For damages resulting from improper The Buyer is responsible for the transportation of the device.

5.3 General technical characteristics

5.3.1 Electrical characteristics

Supply voltage Power	100-230V AC ±10%, 50-60Hz
dissipation	< 75 W

5.3.2 Performance characteristics

Laser wavelength Laser	780 nm, (650 nm, pointer beam)
power Working	< 15 mW
distance	from 0.02 m to 5 m (or more if the surface is treated)
Displacement sensitivity Vibration	< 1 nm at 1 kHz
frequency range Vibration	from <1 Hz to 20 kHz (at -3dB)
velocity range Dynamic range	3 µm/s – 0.8 m/s
Output FM signal (10.7 MHz)	> 80 dB
Output speed Low-pass filters	1 volt peak to peak
	from 0 to 10 volts
	50 (off), 20, 10, 5, 2, 1 kHz (10th order)
Bandpass filters Voltage	2 MHz, 100 kHz
calibration	HIGH range: 1mV = 72 microns/sec LOW range: 1mV = 4 microns/sec
Maximum error	< 3% at temperatures above 50 °C

5.3.3 Characteristics of environmental conditions

Operating Temperature	10-40 °C
Storage Temperature Warm-	0-50 °C
up Time Humidity	5 minutes to calculated values
Altitude Shock	5-95% non-condensing
Vibration	15,000 m (50,000 ft)
	2 g for 15 ms
	2 g, 10-400 Hz, half sine

5.3.4 Physical characteristics

Weight (laser head) Size	1.4 kg (3 lbs)
(laser head) Weight	7.5cm x 11.4cm x 22.8cm (3" x 4.5" x 9.0")
(controller) Size	3.9kg (8.5lbs)
(controller)	6 ÿÿ x 22 ÿÿ x 30 ÿÿ (2,3" x 8,6" x 11,8")

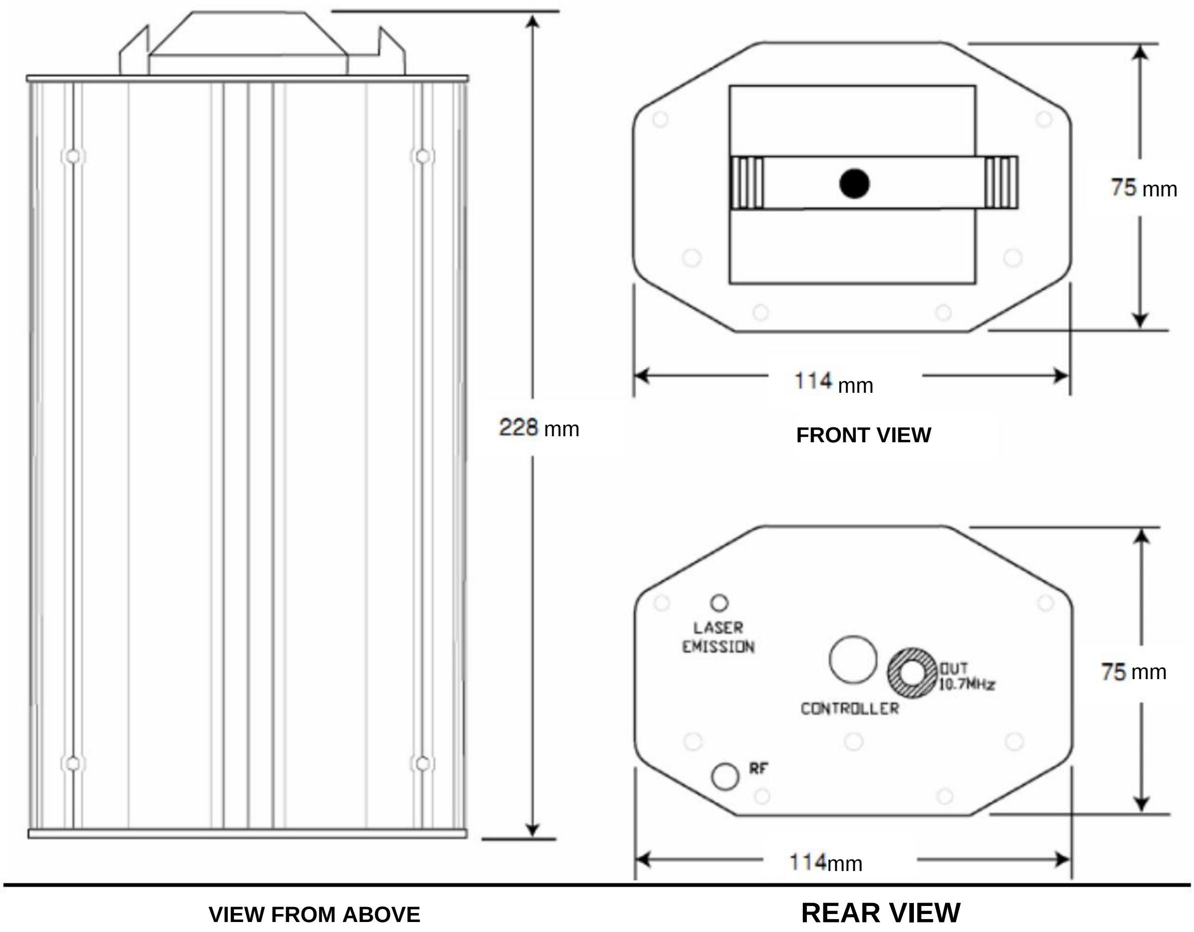

Figure 14 – Physical dimensions of the VibroMet™ 500V measuring head

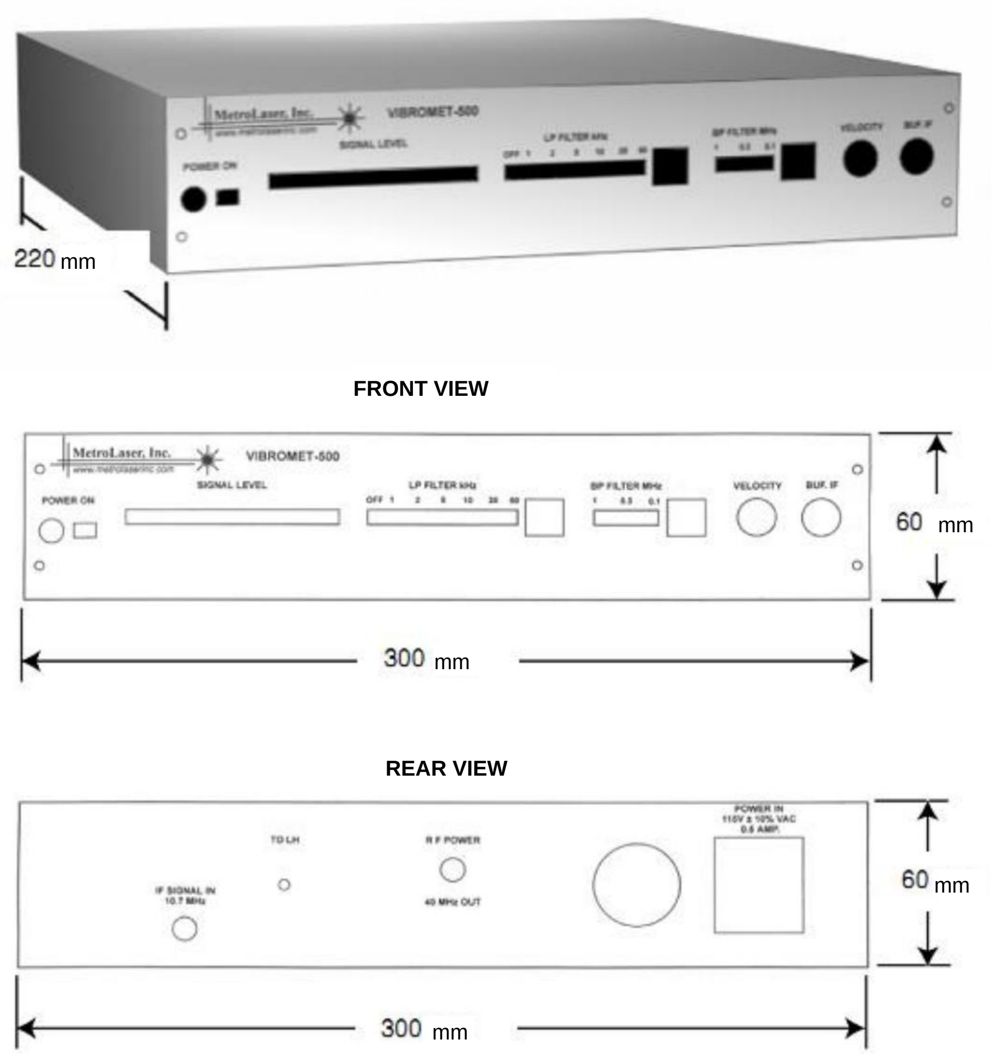

Figure 15 – Physical dimensions of the VibroMet™ 500V Controller

5.4 Diagnostics and troubleshooting

Problem	Solution
No power, LEDs not lit	Check that the control unit is turned on. the socket is live. Make sure that the local voltage corresponds to the system supply voltage (see Section 4.3.1). To obtain the required voltage, power supply may require a power supply. Check for shorted fuses (near line power input). If necessary, Replace them with 750mA slow blow fuses.
The measuring head does not emit a laser beam.	If the LED on the laser head is on, check if the aperture cover is open. Check the beam with a white piece of paper. If the LED is not on, check if the controller cord is connected correctly and the external safety interlock is in place.
Weak signal blocking	The surface of the object should not be mirror-like or highly reflective, otherwise fine adjustment is required. Check the signal blocking with using a white sheet of paper. Move the laser closer to the object.

5.5 Replacement components

COMPONENT NUMBER	COMPONENT NAME
986A0124	VIBROMETER MODEL 500V ASSEMBLY
645-0073	VIBROMET CONTROLLER
645-0072	VIBROMET MEASURING HEAD
269-9396	OPERATING MANUAL VIBROMET 500V
085-999	POWER CORD (1)
085-9615	WIRE HARNESS FOR CONNECTING CONTROLLER TO MEASURING HEAD - (1)
085-7055	5" BAYONET CONNECTOR CONNECTION CORD - (1)
070-9030	FUSE 750MA SLOBLO - (1)
054-9007	VIBROMET SENSOR LENS (1)

5.6 Glossary of Terms

Aperture: The opening through which the laser beam passes.

Beam: beams of laser light that can be parallel, convergent or divergent.

Diffuse reflection: occurs when different parts of the beam incident on the surface, are reflected at different angles according to the cosine law. Intensity reflection is inversely proportional to the square of the distance from the surface.

Radiation: the phenomenon of the release of light energy.

Infrared radiation (IR): invisible electromagnetic radiation with wavelengths ranging from 0.70 to 1000 ÿm. These wavelengths are often broken down into sections: IR-A (0.7-1.4 ÿm), IR-B (1.4-3.0 ÿm), and IR-C (3.0-1000 ÿm).

Direct exposure: viewing conditions in which the eye is under by the action of all or part of a direct laser beam or its reflection from a mirror surface.

Radiant intensity (E): the radiant flux (radiant power) per unit area of a given surface. Units: watts per square centimeter (sometimes the term energy density is used, although this is not entirely correct).

Laser: Short for "light amplification by stimulated emission of radiation". Creates an intense beam of light with unique properties of coherence, collimation and monochromaticity.

Lens: a curved optically transparent material that, depending on its shape, used to focus or diffuse light.

Output power: the amount of energy released per second, measured in watts. laser in the form of coherent light.

Reflectivity: the reflection of radiant energy (incident light) by a surface without changes in wavelength.

Source: The term "source" refers to a laser or a laser-illuminated reflective surface. surface, i.e. the light source.

Wavelength: The length of a light wave, usually measured from peak to peak, which determines its color. Common units of measurement are micrometer (micron), nanometer, and angstrom.

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