instructions for

VI-100
Vibration Meter

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UKAS QUALITY MANAGEMENT 015

QUEST®
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TABLE OF CONTENTS

INTRODUCTION

The VI-100 is a wide band vibration meter that measures how much vibration is present in units of either displacement, velocity, or acceleration. Such wide band measurements give a quick and simple indication of a machine's health when related to previously measured base line levels. An increase in vibration typically indicates deteriorating health.

UNIT FUNCTIONS

RMS UNITS: This 3 position switch determines which of ACCeleration, VELocity, or DISPlacement is being displayed. ACCeleration is measured in g's (g = 9.81 meters per second^2). VELocity is measured in centimeters per second. DISPlacement is measured in x10^{-5} meters (10 micrometers).

RANGE: The range switch has 2 positions: HIGH and LOW. Switching the range key will cause the decimal point to shift over in the display. Measurement ranges are 0.0 - 199.9 on the HIGH range and 0.00 to 19.99 on the LOW range.

RESET/HOLD/RUN: For normal operation, the switch should be in the RUN position. In the HOLD position, the maximum value measured is held in the display until a higher value occurs. The maximum value from HOLD can be RESET by momentarily pushing the switch upwards. The RESET position is spring loaded so that when you release the button, it automatically returns to the HOLD position.

ON/OFF: To operate the VI-100, it must be switched ON. When not in use, move the switch to the OFF position to conserve the battery power.

OVERLOAD LED: The overload indicator is a red LED located to the right of the display. If an incoming signal is larger than the electronics are meant to handle (the incoming signal is 'clipped'), then the red LED will momentarily be turned on. If the measured vibration signal returns to lower levels, then the LED will automatically turn back off.

LOW BATTERY: When the batteries are weak, "LO BAT" will appear in the upper left corner of the display. Both batteries should be replaced with new 9-volt alkaline batteries (NEDA 1604).

AC OUTPUT: The AC output is primarily used for determining frequency components of vibration. The buffered signal from the accelerometer is presented at the AC OUT jack for potential use with an outside device such as an oscilloscope. The accelerometer signal passes through an amplifier stage, a bandpass filter, and possibly integrator stages if velocity or displacement is selected.

DC OUTPUT: After the AC signal is converted to a DC (rms) level, it is presented at the DC OUT jack. Outside devices such as chart recorders or data acquisition circuits may be able to use the DC output signal.

CALIBRATION

Because of the long term stability of the accelerometers used, daily field calibration of the VI-100 is not necessary. Quest recommends that annual calibration be done at the Quest factory.

The VI-100 will accept accelerometer sensitivities between the range of 8 and 14 millivolts per g. Any time an accelerometer is replaced, the VI-100 should be calibrated to match the new sensor.

UNDERSTANDING VIBRATION

A weight suspended on a spring can be used to illustrate the fundamentals of vibration. Refer to figure 1.

At rest, the weights hangs stationary at point "0". If the weight is raised to point "A" and then released, it would drop to point "B" where it would reverse direction and return to point "A". In an ideal (frictionless) system, this cycle would continue forever.

The graphs below the weight and spring diagram show displacement, velocity, and acceleration as they change over time (one full cycle is shown). The resulting pattern is described as being sinusoidal.

For any of the measurement modes, point "0" to point "A" is called the PEAK. Point "A" to point "B" is called PEAK to PEAK and is equal to twice the PEAK. The RMS (root-mean-square) value equals 0.707 times the PEAK. The VI-100 always gives RMS values. Note that points "0", "A", and "B" are relative locations and have no specific values associated with them.

Displacement is the distance of the weight from the center point, "0" at a given point in time. The VI-100 measures displacement in 10^{-5} meters rms.

Velocity of the weight is the speed at which it is travelling at a given point in time. At the instant before the weight is released from point "A", the velocity is zero. The maximum velocity in the downward (negative) direction occurs when it crosses the "0" point. As the spring stretches, the velocity slows and becomes zero at point "B" and then reverses direction. The VI-100 measures velocity in centimeters per second rms.

Acceleration is the rate of change in velocity. When the weight is released from point "A", gravity is quickly accelerating the weight downward. The velocity is constant as the weight passes through point "0" and therefore its acceleration goes to zero. As the spring stretches and the weight approaches point "B", the rate of change in velocity (acceleration) is at a maximum. The weight then changes direction and is pulled upward by the spring. The VI-100 measures acceleration in g's rms where 1 g is equivalent to the earth's gravitational pull of 9.81 m/sec^2.

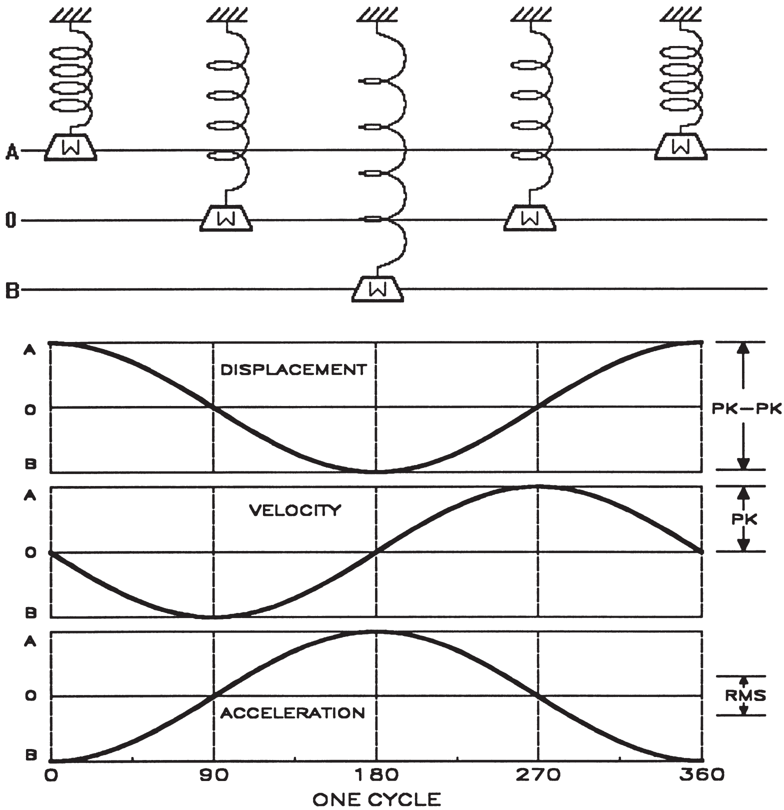

Figure 1.

MEASUREMENT UNITS

The frequency of vibration typically determines whether acceleration, velocity, or displacement is the most appropriate mode of measurement.

DISPLACEMENT: Some low frequency vibrations (typically between five and several hundred hertz) may be measured using displacement. This mode may be particularly useful if part clearance is a consideration.

VELOCITY: Velocity is related to the amount of energy dissipated in a machine due to the vibration and is therefore a very common mode of measurement. [Kinetic energy = 1/2 * mass * velocity^2.] Velocity can be used over a fairly large frequency range from a few hertz to several thousand hertz.

ACCELERATION: The output of the accelerometer of the VI-100 is directly related to acceleration. Acceleration is a measurement of the force applied to the machine due to the vibration. [Force = mass * acceleration.] While acceleration is used over a very large frequency range, it is especially useful for high frequencies.

FREQUENCY RESPONSE

Figure 2 shows the frequency response of each of the measurement modes of the VI-100: acceleration, velocity, and displacement. The input is held to a constant level of 10 millivolts which corresponds to a constant 1 g acceleration.

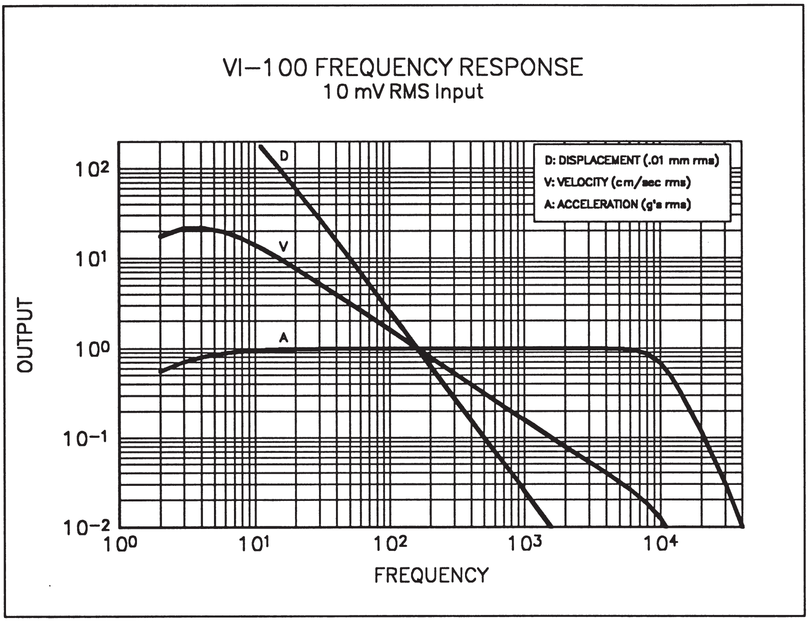

Figure 2.

MOUNTING METHODS

The mounting location should be smooth and clean and the mass of the accelerometer should not notably affect the object it is mounted to. For repeat measurements, the exact mounting location should be marked and used every time because small variations in location could significantly affect the readings.

The accelerometer can be mounted using a stud, permanent magnet, adhesives, or wax, or it can be used with a hand held probe. Each of these methods have their own characteristics and care must be taken in determining which is best for a given application.

STUD MOUNTING: Stud mounting to a tapped hole in the test object is the best mounting method and should be used whenever possible. Be sure that the accelerometer base is in direct contact with the mounting base or erroneous readings may occur. Stud mounting allows repeatable measurements over the full frequency range of the VI-100.

PERMANENT MAGNETS: Using a permanent magnet for mounting can be reliable provided that the base material is ferro-magnetic and that the mass of the magnet does not affect the structure that it is mounted on. Although not as effective as stud mounting, magnetic mounting can be used over most of the frequency range of the VI-100. For very high frequencies (>6KHz) stud mounting would be more reliable.

ADHESIVES: Adhesive mounting of the accelerometer allows good overall frequency response where stud mounting is not a viable option. The primary disadvantage with using adhesives is that it may be difficult to remove and clean the accelerometer.

WAXES: Some waxes, such as Beeswax, may be used as temporary adhesives for mounting the accelerometer. It is often used as a quick and easy method and it provides good coupling over the full frequency range of the VI-100. The waxes, however, may not hold secure for high vibrations and even moderately warm temperatures can cause the wax to soften and reduce coupling.

HAND PROBES: To use the hand probe, the probe must be securely attached to the accelerometer, the tip must be placed perpendicular to the measuring surface, and it must be held with enough force to keep it coupled with the measuring surface but not so hard as to influence the vibration. Although this method is quick and easy, it has several limitations. It is only useful for low frequency measurements below several hundred hertz because the hand can not reliably couple the probe to the surface for higher frequencies. Repeatability is also quite poor for hand probes. This method should be avoided whenever possible and is only recommended for quick spot checks on low frequency vibrations.

NOTE: The VI-100's accelerometer is directly grounded to the instrument's case. To avoid ground loop errors, it is good practice to either hand hold or tripod mount the VI-100 rather than setting it down on a surface which may be at a different ground potential than the one being measured.

CABLE PLACEMENT

Under some conditions, cable placement can affect vibration measurements. Because the cable has mass, movement can affect the output from the accelerometer either by actually moving the accelerometer or by producing a slight strain on the connector. The readings most affected by cable placement are low level displacement measurements.

To minimize cable effect, it is recommended to tape or clamp the cable to the object that the accelerometer is mounted to. Clamp the cable at a point roughly two inches (5cm) from the accelerometer.

GLOSSARY

Acceleration: is the rate of change in velocity with respect to time. It is typically measured in g's. 1 g represents the acceleration due to the earth's gravity (9.806 meters/sec^2).

Accelerometer: directly measures acceleration of the object it is mounted to. By integrating the accelerometer signal, velocity can be measured. By integrating a second time, displacement is determined. The VI-100's accelerometer measures vibration along the axis of the mounting stud.

Displacement: refers to the distance that an object moves.

PEAK: is the maximum value obtained over a given time period.

RMS: is a common method of measuring the magnitude of a signal by the Root-Mean-Square. The rms value is related to the vibration energy and therefore its damage potential. For a true sinusoidal signal, it is equal to 0.707 times the peak value.

Velocity: is the rate of change in displacement with respect to time.

EQUATIONS

Vibration can be measured in terms of displacement, velocity, or acceleration. Assuming the vibration is sinusoidal in nature, the three measurement modes can be shown with the following equations: (time related equations - not rms values)

TIME DOMAIN EQUATIONS FOR SINUSOIDAL SIGNALS
$D = X \sin wt$ (meters) $V = wX \cos wt$ (meters / second) $A = -w^2X \sin wt$ (meters / second^2)
X : peak displacement w : frequency of vibration (radians/sec) t : time D : instantaneous displacement. V : instantaneous velocity. A : instantaneous acceleration.

If the frequency (f) is known, the measured rms values can be related to each other through the following equations:

RMS VALUES
$V = 6.28\ Df$ $V = 1.56\ g/f$ $g = 4.03\ Df^2$ $g = 0.641\ Vf$ $D = 0.159\ V/f$ $D = 0.248\ g/f^2$
D : meters rms V : meters/second f : Hertz (Hz) g : 9.806 meters/sec^2

The following table provides some of the commonly used vibration conversion factors.

TO CONVERT	MULTIPLY BY	TO OBTAIN
g's	9.806	meters/sec^2
g's	32.17	feet/sec^2
cm/sec	0.0328	feet/sec
10^{-5} meters	0.3937	mils
rms values	1.414	peak values

SPECIFICATIONS

RANGE (All values in RMS units)

LOW

Acceleration	0.01 - 19.99 g's
Velocity	0.01 - 19.99 cm/sec
Displacement	0.01 - 19.99 meters x 10^{-5}

HIGH

Acceleration	0.1 - 199.9 g's
Velocity	0.1 - 199.9 cm/sec
Displacement	0.1 - 199.9 meters x 10^{-5}

FREQUENCY RANGE

Acceleration	5 - 10,000 Hertz
Velocity	7 - 10,000 Hertz
Displacement	10 - 10,000 Hertz

ACCURACY

Calibrated at 159Hz and 10m/sec^2 to +/- 5%.

ACCELEROMETER

The accelerometer is internally amplified and case grounded.
Sensitivity: 10 millivolts per g. (8 - 14mV calibration range)
Mounting threads: 10-32 screw stud.

OVERLOAD INDICATOR

The red LED turns on when the input signal exceeds +/- 5 volts. If the range is set to low and the led stays on, then switch to the high range.

AC OUTPUT

Signal (tip of plug) maximum of +/- 5 volts relative to signal ground. 10 millivolts of rms signal per count of 1.0 in the display on the high range. 100 millivolts of rms signal per count of 1.0 in the display on the low range.

Accepts 1/8 inch phone jack.

1000 ohm output impedance.

DC OUTPUT

Signal (tip of plug) of + 2.0 volts relative to signal ground corresponds to full scale in the display. 10 millivolts of rms signal per count of 1.0 in the display on the high range. 100 millivolts of rms signal per count of 1.0 in the display on the low range.

Accepts 1/8 inch phone jack.

1000 ohm output impedance.

TEMPERATURE RANGE

VI-100: 0 - +60°C.
Accelerometer: -50 - +120°C.

RELATIVE HUMIDITY

0 - 95% non condensing.

BATTERIES

Two alkaline 9 volt batteries (NEDA 1604, IEC 6LR61) provide roughly 40 hours of operation. Replace BOTH batteries when the low battery indicator appears in the display.

TRIPOD MOUNT

A threaded insert on back of the unit accepts a standard 1/4-20 tripod mounting screw.

SIZE

Unit: 2.75 x 8.5 x 1.0 inches (7.0 x 21.6 x 2.5 cm).
Accelerometer: 0.87 x 0.6(diameter) inches (2.2 x 1.5 cm).
Cable: 16 inches (41 cm) coiled; 6 feet (183 cm) stretched.

WEIGHT

Unit: 14.6 ounces (414 g) including batteries.
Accelerometer: 0.42 ounces (12 g).
Cable: 1.2 ounces (34 g).

ACCESSORIES

Accelerometer
VI-100 Cable Assembly
Hand Probe
Tripod (large)
Tripod (small)

QUEST SERVICE AND WARRANTY POLICY

Service Policy

The Quest product you have purchased is one of the finest acoustic instruments available. It is backed by our full one year warranty which seeks complete customer satisfaction. This is your assurance that you can expect prompt courteous service for your equipment from the entire Quest service organization.

Should your Quest equipment need to be returned for repair or recalibration, please contact the Service Department at (800) 245-0779 (USA) or Fax (414) 567-4047 for a Return Authorization Number. The RA number is valid for 30 days, and must be shown on the shipping label and purchase order/cover letter. If you are unable to return instruments in that time call for a new RA number. Send it prepaid and properly packed in the original shipping carton directly to Quest Technologies, 1060 Corporate Center Drive, Oconomowoc, WI 53006 U.S.A.

Repair or replacement work done under warranty will be performed free of charge, and the instrument will be returned to you prepaid. Your copy or a photocopy of the Quest Registration Card will serve as proof of warranty should the factory require this information.

If for any reason you should find it necessary to contact the factory regarding service or shipping damage, please direct your calls or letters to the attention of the Service Manager, Quest Technologies, (414) 567-9157 or (800) 245-0779. Office hours are from 7 AM to 6 PM (Central Standard Time) Monday through Friday.

For service or recalibration outside the U.S.A., please contact your local Quest Dealer or fax Quest U.S.A. at 1-414-567-4047.

Warranty Policy

Quest Technologies warrants our instruments to be free from defects in materials and workmanship for one year under normal conditions of use and service. For U.S.A. customers we will replace or repair (our option) defective instruments at no charge, excluding batteries, abuse, misuse, alterations, physical damage, or instruments previously repaired by other than Quest Technologies. Microphones, sensors, and printers may have shorter warranty periods. This warranty states our total obligation in place of any other warranties expressed or implied. Our warranty does not include any liability or obligation directly resulting from any defective instrument or product or any associated damages, injuries, or property loss, including loss of use or measurement data.

For warranty outside the U.S.A., a minimum one year warranty applies to the same limitation and exceptions as above with service provided or arranged through the authorized Quest distributor or our Quest European Service Laboratory. Foreign purchasers should contact the local Quest distributor for details.

— NOTES —

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