Vibration Meter Users Guide

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Introduction

The Vibration Meter program is an Android utility that records data from accelerometers installed on most phones and tablets. The software produces a graphical and numerical output of the acceleration data that can be used for vibration testing.

CMM's require an environment that meets specific temperature and vibration requirements. Temperature is frequently monitored and recorded but vibration is rarely tested. When problems from vibration are suspected this utility can be used to perform a quick test to see if additional vibration testing is required.

Vibration Meter Overview

The Vibration Meter program captures acceleration data from the device and generates a visual display of the acceleration and frequency spectrum. Numerical results for each axis is also displayed from the captured data. The data is sampled and stored in a rolling array where the sample time is defined by the capability of the device.
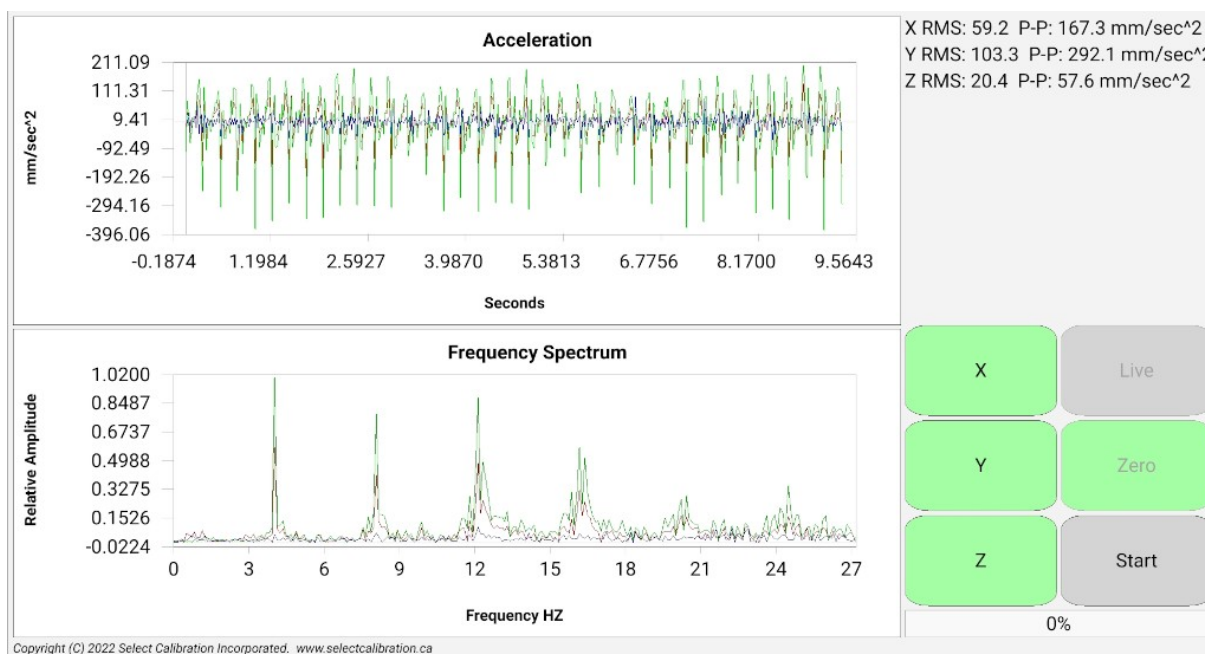

Illustration 1: Screen capture of the Vibration Meter program running on a phone.

The acceleration hardware provides data in three orthogonal directions and are labeled as the X, Y, and Z axis. When the device is sitting flat on a surface the Z axis is up/down and the X and Y axis are in the other two directions of the device. The acceleration graph major axis is amplitude in mm/sec^2 verses time in seconds relative to the initial sample.

The time is always displayed from the initial sample.

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The frequency spectrum shows the result of a Fourier analysis of the acceleration data in order to identify the frequency (or frequencies) of the vibration. The frequency spectrum graph major axis is relative amplitude normalized to 1 verses the frequency (Hz). The highest frequency that can be reported is based on the sample rate of the device. For example, if the device can provide data at intervals of 20 ms then the maximum frequency will be 25 hz.
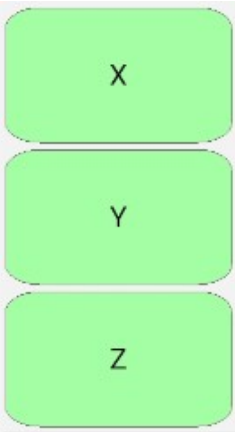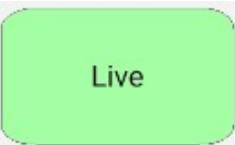
$$max_{frequency} = \frac{1}{(2 * sample_{rate})}$$

The numerical analysis shows the *RMS* and *peak to peak* values for each direction of the accelerometer. The numerical values are calculated from the last full frame of data even if the axis are turned off in the display. The *peak to peak* value is estimated from the *RMS* using the following formula:
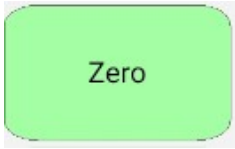
$$\text{Peak to Peak} = RMS * 2\sqrt{(2)}$$

The peak to peak estimate assumes the input is a sine wave without any steady state offset.

The individual axis can be switched on or off in order to view data from each of the three directions individually or in groups. This capability exists for all modes of data collection and when reviewing paused data. The numerical results are always calculated in all three directions regardless if the individual axis are enabled or disabled.

Component	Description
X RMS: 59.2 P-P: 167.3 mm/sec^2 Y RMS: 103.3 P-P: 292.1 mm/sec^2 Z RMS: 20.4 P-P: 57.6 mm/sec^2	The *RMS* and estimated *peak to peak* values from each axis of the devices accelerometer.
X Y Z	Buttons for activation of the X, Y, and Z graphical display of the data.
Live	When enabled the graphical and numerical values are updated in real time. When disabled the data is collected and displayed as a single update for each data frame.

Component	Description
80%	When not running a live view the data is updated only after one complete frame is collected. This progress indicator shows the amount of frame data collected and provides feedback when the operation is complete.
Zero	When enabled the steady state value is removed from the input signal. If not enabled it is expected that one axis (or a combination of axis) will show an approximate acceleration value of 9800 mm/sec^2 due to gravity.
Stop	Allows stopping or starting the collection of data. The text of the button will change between Start and Stop depending on the mode.

Data Zero Offset

The steady state component of the input signals can be removed if the *Zero* option is enabled. The offsets are calculated and applied in a way that has a very fast response time without introducing any kind of instability that is common with closed loop feedback systems.

Data Live View

The live view of the data provides immediate feedback but there is a significant amount of time spent updating the displayed data. For best results collecting data by switching off the live view is recommended as there is only a single update for every data frame.

CMM Vibration Testing

All CMM's have limits to the maximum amount of vibration that is allowed before it starts to have a noticeable affect the machines performance. CMM's that are used in environments with levels of vibration that exceed the manufacturers recommended limits will likely show problems with measurement repeatability (particularly single point measurements).

CMM's are especially sensitive to low frequency vibrations. Most often these are random sources such as a passing fork-lift or the periodic hit of a large press but not always. Illustration 2 shows an example of vibration specification limits for a typical small CMM.
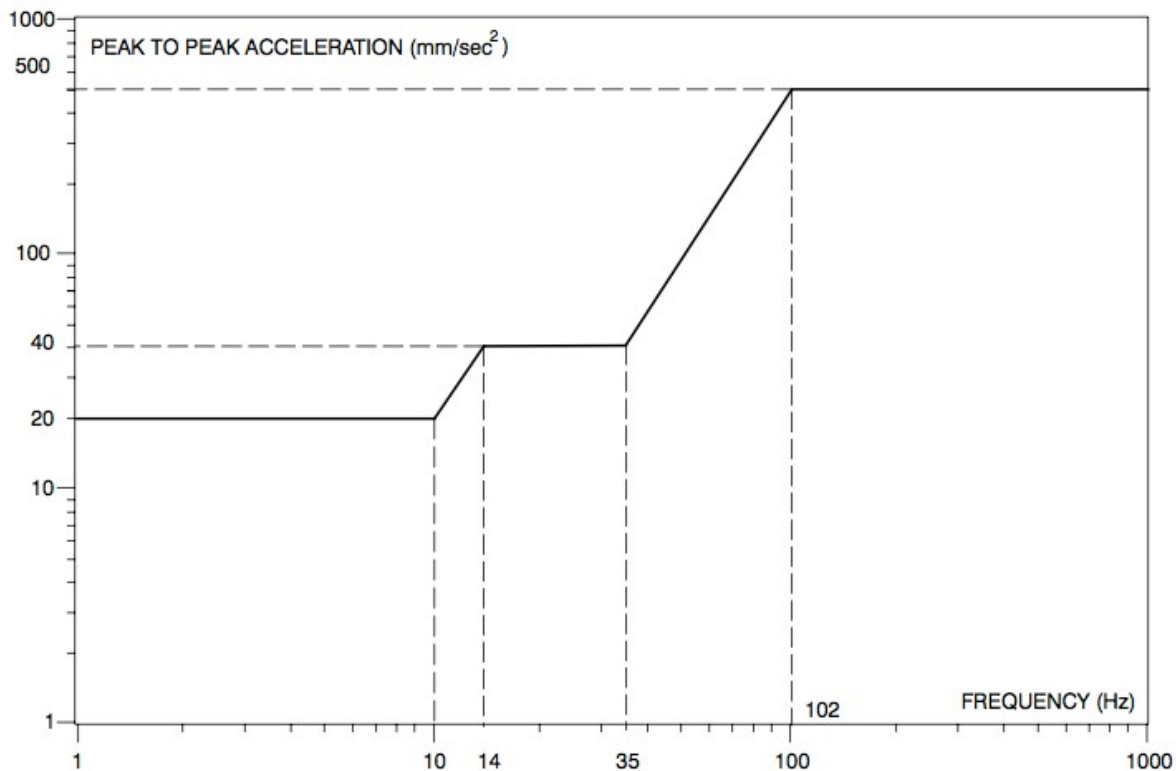
Illustration 2: Example of vibration specifications for a CMM.

Referring to illustration 2 the maximum peak to peak acceleration is 20 mm/sec^2 up to a frequency of 10 Hz and then increases to 40 mm/sec^2 between 14 Hz and 35 Hz and then increases to 450 mm/sec^2 at 100 Hz. The measurement is done at the location the machine is installed and not on the actual machine.

Most CMM's are built on top of a heavy base and further separated from the floor with rubber isolation blocks which provides some level of vibration isolation. The heavy base keeps the table of the machine from moving and the rubber isolation blocks suppress movement of the foundation from reaching the table of the CMM.

Some options that can be used to minimize the effect of vibration on a CMM are:

1) Remove the source of the vibration.

2) Increase the weight of the machines table or base.

3) Use isolation systems that allow more movement between the machine and the environment.

Some machines have concrete or some other heavy fill in the base or lower frame which increases the weight above the isolation system. This is a low cost method to reduce the sensitivity to external vibration. Using an air bag system under the base of the machine is likely the best

method to solve general vibration problems. Removing the source of the vibration is clearly the best option if this is possible. Adding additional rubber isolation pads can help if the material is chosen properly (the weight of the machine and the frequency of the vibration are important factors). Improper selection of isolation pads may cause a resonance in the machine with the vibration source making the situation worse than what it would have been without the isolation pads.

When using an isolation system the CMM must be kept as a single unit. If the machine is modular such as a runway style horizontal arm and a separate inspection table isolation pads will certainty make the situation worse then bolting the two components directly to the same floor.

Vibration Meter Program Limitations

When testing the Vibration Meter utility it seems clear the device is not really ideal for this kind of measurement. It is possible other devices will have superior hardware and therefore perform better. The following is a list of limitations and observations:

- The accelerometer on most devices are not high quality and usually extremely noisy. It is a good idea to establish a base line by measuring the amount of noise when the device is place in a location where vibration doesn't exist.

- The data sample rate may be too low to be able to detect frequencies high enough to be reliable. When testing on one particular tablet computer the maximum sample rate was found to be 20 ms which is a little slower than preferred. With a sample rate of 20 ms the highest frequency that can theoretically be seen by the Vibration Meter is 25 Hz. It is possible that better quality devices will have better accelerometers that can be sampled at a higher rate in which case the upper measurable frequency will change accordingly.

- It was observed that the vertical acceleration reported on the test device was reported at 9.4 m/sec^2 where it should have been 9.8 m/sec^2 (earth gravity). This difference represents an error below 5% which is somewhat standard for electrical components but it does show that the measurement data is not entirely reliable.

- Many devices have rubber feet or are mounted in shock resistant cases. For best results the device should be securely attached to the test surface.

For the reasons mentioned above the reported values are for reference only. If there are concerns about vibration then suitable equipment should be used to measure vibration.

Vibration Meter Installation

The Vibration Meter program has been signed (self signed by SCI) and can be loaded directly by any suitable device running the Android operating system. To install this program transfer the installation APK file onto the device and click it to install.

The default security settings will not allow software to be installed from unknown developers.

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Revision History

Date	Version	Changes
May 15, 2018	1.0	New Program
May 26, 2018	1.1	Changed frequency display from bar to line graph. Frequency display amplitude synchronized for all axis.
Oct 6, 2019	1.2	Autoscale font size in order to run on small screen devices.
Jan 5, 2022	2.0	Changed control options of interface. Amplitude of frequency normalized to non-displayed axis. Amplitude of frequency always shows a minimum value of 1. Compiled with Android API level 25 (Android version 7.1.1).