Vibration Sentry E

User's Manual
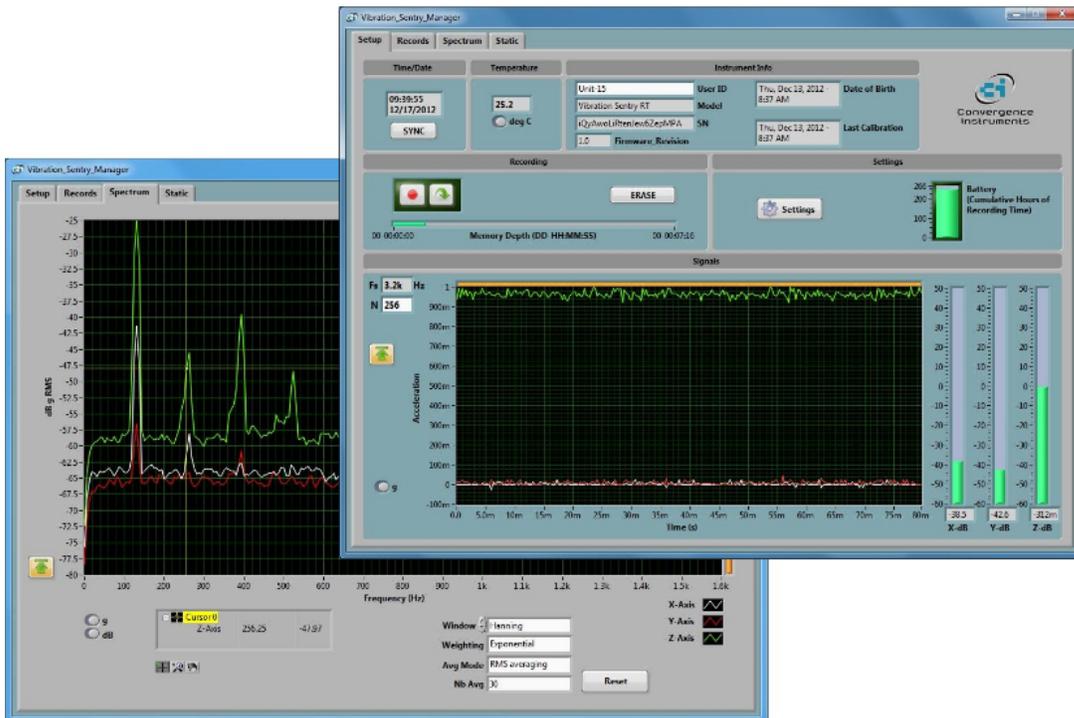
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1   Introduction

Vibration Sentry E is a new generation of smart dataloggers that can record accelerations, vibrations impacts and inclinations. It includes a 3-axis MEMS accelerometer, an accurate date/time clock and a non-volatile 64 Mb or 128 Mb recording memory. Depending on the settings it can record vibration signals and/or RMS vibration levels for months. Its very small size allows it to be attached to, or embedded within, the monitored equipment.

The *E* model is an evolution of the *RT* model. It is implemented mostly by new firmware that can applied to existing RT models. It has the following new features:

- A visual alarm on acceleration threshold (only on new *Vibration Sentry E* hardware)
- A timer that allows the instrument to start the *Record* or the *AutoRec* mode at a specified date and time.
- A new *AutoRec* implementation that performs the triggering in software with much greater precision than on the *RT* model. The new trigger provides at least 80 ms of pre-trig data.
- Management of Time Zones at the instrument level.
- Settings are retained through a reset

The *Vibration Sentry E* includes the following features:

- 3-Axis integral MEMS accelerometer
- Measures and records:
  - Raw acceleration signals
  - Acceleration statistics
  - Vibration levels
  - Inclinations
- All-digital design.
- Integrated oscilloscope function that can show the vibration signals in real time.
- Allows the observation of recorded data while the recording is ongoing.
- Works standalone, or USB connected for setup and data transfer to PC.
- Long life internal rechargeable battery that recharges from USB.
- Self-calibrated using the earth's gravity as a reference.
- Observes and records 100% of the acceleration signals (no missed samples).
- Editable individual custom ID for easier instrument management.
- Completely sealed weatherproof enclosure.
- LabVIEW driver available

2   Applications

- Long-term measurement and recording of accelerations, impacts, vibration signals and RMS vibration levels.
- Over-vibration alarms and emails.
- Monitoring of operation and transport conditions of fragile equipment.
- Continuous monitoring of machinery wear.
- Long term inclination monitoring.

3   Warnings

⚠️   ***Avoid over-discharging the battery***

- *Recharge the instrument immediately if the LED indicates a low-battery condition*

- *Even if the instrument is Idle all or most of the time, recharge it fully at least once every 6 months.*

⚠️   ***Do not store or operate the instrument at temperatures exceeding the following limits***

- *-20 degC to 60 degC (-4 degF to 140 degF)*

4   Getting Started

4.1   Software Installation

Run *Vibration_Sentry_Manager_Installer.exe*. This installs the *Vibration_Sentry_Manager* application, as well as its USB driver and documentation.

> *Note: Perform the software installation above BEFORE connecting the instrument to the PC.*

4.2   Hardware Installation

1. Connect the instrument to an available USB port of the PC

2. Verify that the PC properly detects the instrument and loads the driver. In case of doubt see section ***Troubleshooting***.

4.3   Initial Test and Configuration

1. Upon connection to the PC, the *charge* LED should light-up yellow (charging) or green (charged). The *operating* LED should blink once per second.

2. Go into *Start\All Programs\Vibration_Sentry_E_Management* and run *Vibration_Sentry_Manager.exe*. The front-panel described in ***Figure 5*** appears, and the application tries to connect to the instrument. If it fails to find the instrument it indicates *No Device Found*. If this is the case see section ***Troubleshooting***.

3. Otherwise the application switches-on the *Vibration Sentry E* and starts communicating with it.

4. If the Time and Date in the upper right corner of the application window are not properly adjusted the application asks if you want the time to be synchronized with the PC time. Only say YES if the PC time is correct.

5. In addition, the application detects if the time zone of the instrument is different from the time zone of the PC. If it is, the application asks to set the instrument to the same time zone as the PC.

> Note: If the instrument is not intended to be used in the same time zone as that of the PC, we suggest to temporarily change the PC's time zone to the time zone where the instrument will be recording, let the application set the instrument to the PC's time zone, and change the PC's time zone back after that initial setting. Afterwards if/whenever the application asks to change the instrument time zone back to the PC's time zone, simply choose to cancel the adjustment.

6. In the front-panel of the application you should see the time-domain signals for the three axes display in real-time.

5 Instrument Functions and Description

The instrument connects to a PC on a USB port. The *Vibration_Sentry_Manager* application is used to set its operating parameters and download recorded data.

Figure 1   *Vibration Sentry E*

1. Charge LED
2. Operation LED/Alarm
3. USB Connector
4. Reset Button

6 Principle of Operation

6.1 Power Consumption

The *Vibration Sentry E* is always on. However, when not in operation it only measures time, which only takes a tiny operating current. In that *Idle* state it can stay on for up to one year. When the *Vibration Sentry E* is actively measuring, its power consumption is mostly affected by two factors:

- The accelerometer sampling rate.
- Whether or not a high-pass filter is applied to the signals.

The *Vibration_Sentry_Manager* application automatically calculates and displays the cumulative number of hours that the battery would last while recording, as a function of the instrument settings.

6.2 Battery Charging

The battery charges whenever the following conditions are met:

- The battery has not reached full-charge
- The instrument is connected to a PC's USB port or USB charger
- If connected to a PC, the PC is not in standby

While charging the charge LED is orange. When fully charged the LED changes to green.

The charging time when connected to a PC varies with the amount of power the PC allows the instrument to draw. It is normally around 1 hour. If the PC does not allow the fast charge current, the charging time can increase up to 5 to 6 hours.

> Note: Battery charging from a PC stops while the PC is in standby.

> Note: It is OK to leave the instrument connected to a PC or USB charger all the time. The smart charger inside the instrument will stop charging as soon as the battery reaches full-charge.

6.3 Modes of Operation

The *Vibration Sentry E* has four modes of operation:

Mode	Operation	Power Consumption
Idle	Disconnected from USB and not actively recording - Only keeps time.	Minimal: can stay on for up to 1 year.
Active	Connected to USB – Not recording – Instrument is fully on and measuring	Instrument draws power from USB to power itself, and if necessary recharge its battery. Battery is not depleted.
Recording or Auto-Rec	USB-connected or not - Fully on and recording.	If USB-connected, power comes from USB. If not, power comes from the battery. Battery consumption depends on instrument settings

Table 1

6.4 LED Indicators

The *Vibration Sentry E* has three LED indicators:

6.4.1 Charge LED

The charge LED is always fully on or off.

LED State	Meaning
Off	Instrument is disconnected, or if connected to a PC, the PC is in standby.
Green	Instrument is connected to a PC or USB charger, and the battery is full.
Orange	Instrument is connected to a PC or USB charger, and the battery is charging.

Table 2

6.4.2 Operation LED (Green on *E* model, Yellow on *RT* model)

The operation LED is always blinking.

LED State	Meaning
Off	Instrument is in *Idle* mode.
1-blink/second	Instrument is in *Active* or *Auto-Rec* mode, but is not actively recording.
2-blinks/second	Instrument is actively recording.
4-blinks/second	Battery is low. Recharge as soon as possible. If the battery level becomes critical the instrument will go to *Idle* mode (LED-off) in order to safeguard the battery against over-discharge as much as possible.

Table 3

6.4.3 Alarm LED (Yellow - only on *E* model)

The alarm LED is a high-intensity LED.

LED State	Meaning
Off	Instrument has no alarm.
1-blink/2 second	Instrument has detected an alarm.

Table 4

Note: The alarm is cleared by the following actions:

- Reset button in the *Settings* page of the *Vibration_Sentry_Manager* application

- 5 seconds after disconnecting from USB

- When Record Mode or Auto-Rec Mode is started from the *Vibration_Sentry_Manager* application

6.5 Acceleration Sensor and Signal Processing

6.5.1 Measurement

The 3-axis MEMS accelerometer inside the *Vibration Sentry E* accurately measures static (DC) and dynamic (AC) acceleration signals with an adjustable sampling rate of up to 3.2 kHz.

The accelerometer's dynamic range is either +-16g or +-200g, depending on the model. It does not include any anti-aliasing filters, so to avoid aliasing the sampling frequency should be chosen above twice the frequency content of the measured signal.

An adjustable-frequency high-pass filter can be added to the measurement path. The high-pass filter is required to measure RMS vibration levels. Otherwise the measured RMS levels would be biased by the DC component. On the other hand, inclination measurements require the measurement of the DC component, so DO NOT use the high-pass filter for inclinations.

The instrument's power consumption is proportional to the sampling rate, and dependent upon the presence of the high-pass filter.
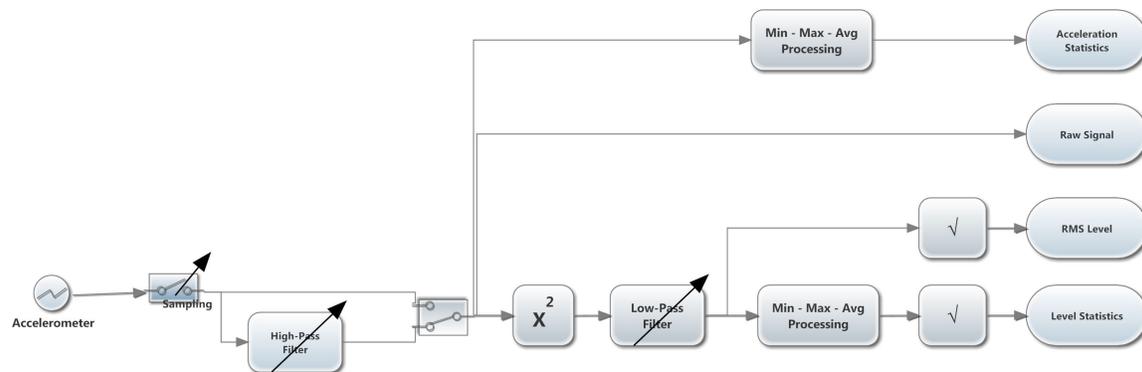
Figure 2   Signal Processing

[Figure 2](#) shows the signal processing flow for one axis of the accelerometer.

The raw acceleration signal is sampled at an adjustable rate. The sampling rate can go up to 3.2 kHz.

The signal is then optionally high-pass filtered to remove the DC and low-frequency components. This is usually required to capture RMS vibration levels. The cutoff of the high-pass filter is adjustable. The high-pass filtering adds a small amount to the power consumption.

- In the *Raw-Signal* branch the signal is recorded at the sampling frequency.

- In the *Acceleration Statistics* branches *Min-Max-Avg* processing captures the min, max and average acceleration signals over an adjustable recording interval. For each new interval the

statistics are cleared, then the statistics are updated during the course of the interval, then at the end of the interval the statistics are recorded, and a new interval is started.

- In the *RMS-Level* branch the signal is squared to calculate the instantaneous power. The instantaneous power is low-pass-filtered with an adjustable time constant to produce an average. A short time constant provides an average that is capable of tracking fast transients, while a longer time constant provides a smoother and less noisy average. A typical fast time constant is around 100ms. While a typical long time constant is around 1s. Finally the square-root of the power is taken to present RMS vibration levels. The RMS vibration levels can be displayed in linear or dB scale.

- In the *Level-Statistics* branch *Min-Max-Avg* processing captures the min, max and average vibration levels over an adjustable recording interval. For each new interval the statistics are cleared, then the statistics are updated during the course of the interval, then at the end of the interval the statistics are recorded, and a new interval is started. The RMS vibration levels can be displayed in linear or dB scale.

Irrespective of the setting, the instrument always observes 100% of the acceleration samples.

6.5.2   Sensor Bandwidth and Frequency Response
6.5.2.1   Upper Frequency Limit

The instrument does not have an anti-aliasing filter. *Figure 3* shows the response of the accelerometer structure and its acquisition chain. This response is the same irrespective of the chosen sampling rate.
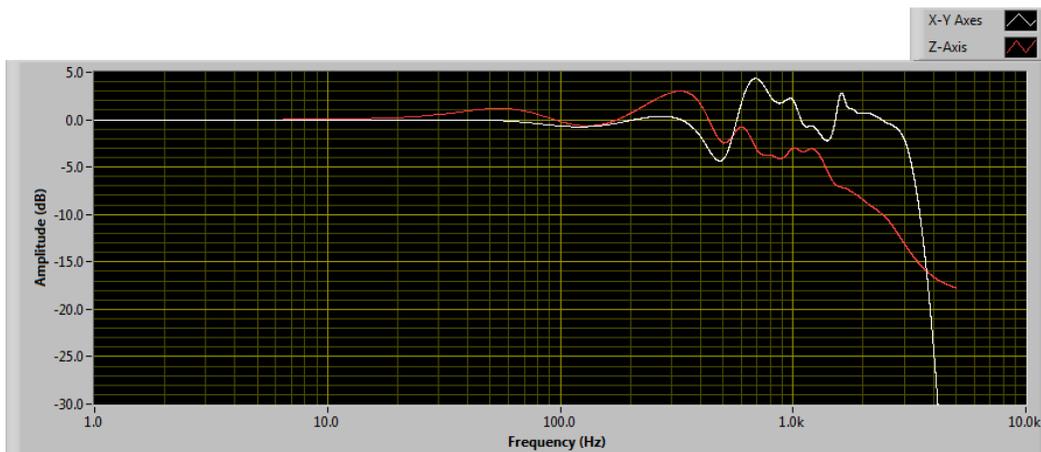
Figure 3

### 6.5.3   Low-Frequency Limit

The low-frequency is limited by the digital high-pass filter. The cutoff frequency is adjustable, and can be adjusted to extremely low frequencies thanks to the filter's exceptionally high resolution. *Figure 4* shows the low-frequency response for a high-pass filter adjusted to 1 Hz, 5 Hz and 10 Hz, and operating at 3.2 kHz sampling frequency.
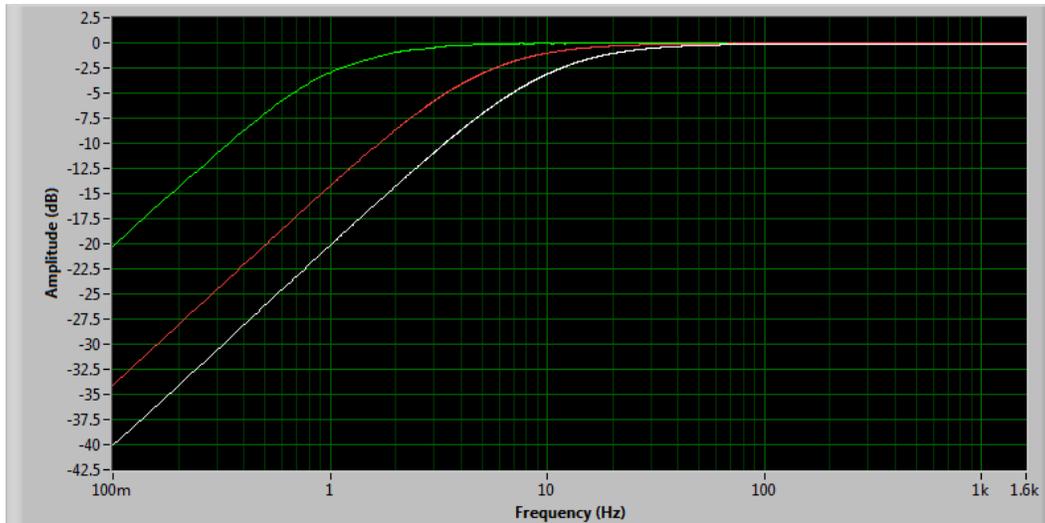
Figure 4

6.5.4   Sensor Noise

The raw sensor noise is dependent on the sampling rate. Higher sampling rates are noisier. Noise on the Z axis is slightly higher than the noise on the X and Y axes. The following table shows typical noise levels.

Sampling Rate	Noise: X Y axes	Noise: Z axis
3.2 kHz	-40 dBg (10 mg RMS)	-36 dBg (16 mg RMS)
1.6 kHz	-40 dBg (10 mg RMS)	-36 dBg (16 mg RMS)
800 Hz	-47 dBg (4.5 mg RMS)	-41 dBg (8.9 mg RMS)
400 Hz	-50 dBg (3.2 mg RMS)	-44 dBg (6.3 mg RMS)
200 Hz	-53 dBg (2.2 mg RMS)	-48 dBg (4 mg RMS)
100 Hz and lower	-54 dBg (2 mg RMS)	-49 dBg (3.6 mg RMS)

Table 5

6.5.5   Sensor Dynamic Range

The sensor's dynamic range extends from -16 g to +16 g for the *-16g* model, and -200g to +200g from the *-200g* model. The precise dynamic range is dependent upon the calibration and varies slightly from an individual instrument to the next.

6.6   Calibration

The calibration uses the earth's gravity as a 1g reference signal. The calibration procedure is completely automated and can be performed at any time. It requires the user to set the instrument in

successive stable positions with its X, Y and Z axes aligned vertically while the instrument takes the reference measurements.

At any time the calibration can be checked by using the static acceleration measurements. The following procedure can be used to check the calibration:

1. Make sure the high-pass filter is off-line, so the instrument is capable of measuring DC values.

2. Place the instrument in a position where the X axis is in the vertical position and axes Y and Z are horizontal. Measure the static acceleration. If the calibration is correct the static acceleration along the X axis should be 1g. The static acceleration along the Y and Z axes should be 0g.

3. Place the instrument in a position where the Y axis is in the vertical position and axes X and Z are horizontal. Measure the static acceleration. If the calibration is correct the static acceleration along the Y axis should be 1g. The static acceleration along the X and Z axes should be 0g.

4. Place the instrument in a position where the Z axis is in the vertical position and axes X and Y are horizontal. Measure the static acceleration. If the calibration is correct the static acceleration along the Z axis should be 1g. The static acceleration along the X and Y axes should be 0g.

The *Vibration Sentry E* records raw uncalibrated data in a scale that is internal to the instrument. The calibration is applied only when the data is extracted from the instrument for viewing or storing to the PC. This way if data was captured with a wrong calibration, the instrument can be recalibrated afterwards, and all the data that is in the instrument's memory becomes well calibrated again.

6.7   Scale

The *Vibration Sentry E* records in a scale that is internal to the instrument. All data is re-scaled for display as selected by the user, whether it is g or m/s^2, dB or linear. This way the data can be displayed in any scale irrespective of the scale selected at the time of the recording.

6.8   Inclinations

The instrument's inclination around the X and Y axes is not measured directly. It is calculated by the *Vibration_Sentry_Manager* application, from the components of the earth's gravity along the three axes. So in order to display inclinations, the instrument must be setup to record <u>acceleration statistics</u>, and at least record the <u>average accelerations</u> along the X, Y and Z axes, with <u>no high-pass filter</u>.

After recording, the average accelerations along the X, Y and Z axes can be displayed by the *Vibration_Sentry_Manager* application as individual-axis accelerations, or as inclinations.

Using the three components of acceleration along the X, Y and Z axes, the inclinations around the X and Y axes can be calculated. These are named:

• Inclination along the X axis: *Theta*

• Inclination along the Y axis: *Phi*

Theta and *Phi* are displayed in the *Static* tab, along with a graphic depiction of the instrument in real time.

In addition to the inclination angles, the instrument measures the norm of the acceleration. If the instrument is stationary, and only subjected to slow changes in inclination, the norm of the acceleration should always be constant and equal to 1*g.*

6.9   Recording

The instrument can record either:

- Raw acceleration signals at the sampling frequency

- Acceleration statistics (min-max-avg) at adjustable intervals.

- Pre-calculated RMS vibration level statistics (min-max-avg) at adjustable intervals

Note: In order to record inclinations the instrument must be set to record Acceleration Statistics, and record the three components X-avg, Y-avg and Z-avg.

Every time recording is started a new record is created in memory and filled until recording is stopped. That record is time-stamped, so the signals can be displayed with respect to absolute date/time if required. Records are stored sequentially in the instrument's memory. There is no limit to the number of records that the memory can contain, only a limit to the total size of the data recorded. The *Vibration_Sentry_Manager* application displays the total memory recording time as a function of the various setup parameters.

After (or while) recording, the records contained in memory can be downloaded from the instrument and observed or exported at any time. In case a recording is ongoing the last record is only displayed up to the present time.

The recording is stopped automatically when the recording memory is exhausted. This way a new record will not over-write an old one.

The recording memory is non-volatile, so there is no risk of losing the data that has already been recorded, even in the case of a battery failure.

Note: It is perfectly legal to find empty records in memory. That occurs typically when recording is started and stopped quickly, before any data could be written to memory. In that case only a time-stamp is written to memory.

6.9.1   Recording Raw Signals

Recording raw signals is very straightforward:

1. Select *Raw-Signal*

2. Select the channels to be recorded (X, Y and/or Z).

3. Select the sampling frequency of interest. Note that recording raw signals uses a lot of memory, so choosing a lower sampling frequency will provide a longer recording time. The total recording time is automatically calculated and displayed by the *Vibration_Sentry_Manager* application, as a function of the sampling frequency and number of selected channels.

4. Select whether or not to cut the DC and low-frequency components. If the high-pass filter is on-line, adjust its cutoff frequency.

5. When ready, simply press the *Record* button. Press *Record* again to stop the recording, or wait until the memory is exhausted.

6.9.2   Recording Acceleration Statistics

Recording acceleration statistics requires slightly more adjustments:

1. Select *Accel-Stats*

2. Select the channels to be recorded (X, Y and/or Z), as well as for each channel the chosen statistic (min, max and/or average).

3. Select the sampling frequency of interest. Contrary to the recording of raw signals, the chosen sampling frequency has no bearing on the amount of memory used. However the noise level and power consumption are both directly affected by the sampling frequency. The power consumption is roughly proportional to the sampling frequency. The noise gets lower as the sampling frequency gets lower (see section *Sensor Noise*).

4. Select the log-interval. After each log-interval has elapsed the instrument writes one point of each selected statistic to memory, so the amount of memory used is inversely proportional to the selected log-interval. Note that the total recording time is automatically calculated and displayed by the *Vibration_Sentry_Manager* application, as a function of the log-interval and types of acceleration statistics and channels selected. The log-interval is adjustable in 125 ms increments, from 125 ms up to 2H.

5. Select whether or not to cut the DC and low-frequency components. If the high-pass filter is on-line, adjust its cutoff frequency.

6. When ready simply press the *Record* button. Press *Record* again to stop the recording.

6.9.3   Recording Inclinations

Inclinations are not measured directly. They are calculated from the components of the earth's gravity along the three axes. Therefore there is not a specific setting to record inclinations.

Inclinations are recorded by recording the acceleration statistics (see *Recording Acceleration Statistics*), making sure that the high-pass filter is off, and that at least the X-avg, Y-avg and Z-avg acceleration components are selected. Then, when the recording is displayed, it can be displayed as individual-axis accelerations, or as inclinations.

6.9.4   Recording RMS Vibration levels

Recording RMS vibration levels requires more adjustments. The high-pass filter is usually required to remove the DC component.

After extracting the signal power, the calculated RMS vibration levels are low-pass filtered (smoothed) using an adjustable time constant. A typical short time constant (around 100ms and lower) allows the RMS vibration levels to track sharp transients, while a longer time constant (around 1s and longer) provides more stable (cleaner) RMS values.

The RMS vibration level statistics (min, max and average) are gathered for an adjustable *log-interval* before being written to the recording memory. The log-interval represents the interval at which the selected statistics are written to memory. Therefore a longer log-interval uses less memory, while a shorter log-interval provides better time resolution and allows the user to distinguish events that occurred close together. The statistics (min, max and average) are reset at the beginning of each log-

interval. Then the statistics are gathered sample-by-sample during the log-interval. At the end of the log interval the calculated statistics are written to memory, and the next log-interval is started.

To record RMS vibration levels proceed as follows:

1. Select *Vib-Level Stats*

2. Switch the high-pass filter on-line and select the cutoff frequency.

3. Select the channels to be recorded (X, Y and/or Z), as well as for each channel the chosen statistic (min, max and/or average).

4. Select the sampling frequency of interest. Contrary to the recording of raw signals, the chosen sampling frequency has no bearing on the amount of memory used. However the noise level and power consumption are both directly affected by the sampling frequency. The power consumption is roughly proportional to the sampling frequency. The noise gets lower as the sampling frequency gets lower (see section *Sensor Noise*).

5. Select the log-interval. After each log-interval has elapsed the instrument writes one point of each selected statistic to memory, so the amount of memory used is inversely proportional to the selected log-interval. Note that the total recording time is automatically calculated and displayed by the *Vibration_Sentry_Manager* application, as a function of the log-interval and types of RMS vibration levels and channels selected. The log-interval is adjustable in 125 ms increments, from 125 ms up to 2H.

6. Select the time constant used to smooth the measured RMS vibration levels. Choose a short time constant (100 ms or lower) to be able to track fast RMS transients. Choose a longer time constant (1 s or higher) to provide smooth RMS vibration levels. The time constant is adjustable in factors of two, and is automatically rounded to the closest available one.

7. When ready simply press the *Record* button. Press *Record* again to stop the recording.

Note: *The Time-Constant parameter only applies to the detection of min and max RMS values. The average RMS value is calculated using a rectangular integration over the log-interval in effect.*

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7   Vibration_Sentry_Manager Application
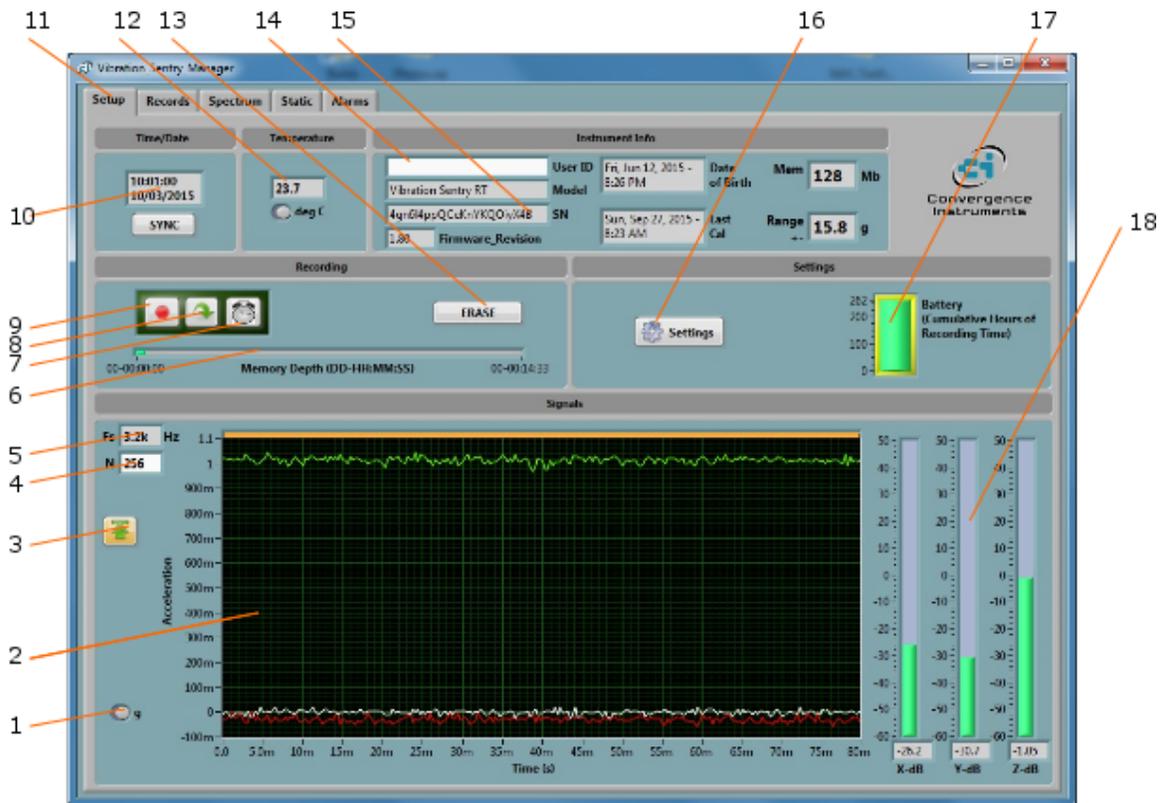
Figure 5   Setup Tab

1.   g – m/s^2 button
2.   Time signals
3.   Auto-Range button
4.   Nb of points control
5.   Sampling Frequency indicator
6.   Memory fill indicator
7.   Timer button
8.   Auto-Rec button
9.   Record button
10. Instrument Time indicator
11. Tab selector
12. Instrument Temperature indicator
13. Erase button
14. Instrument Custom ID
15. Instrument Information
16. Settings button
17. Battery Condition, Charge and Recording Time Field
18. RMS Vibration Levels indicators
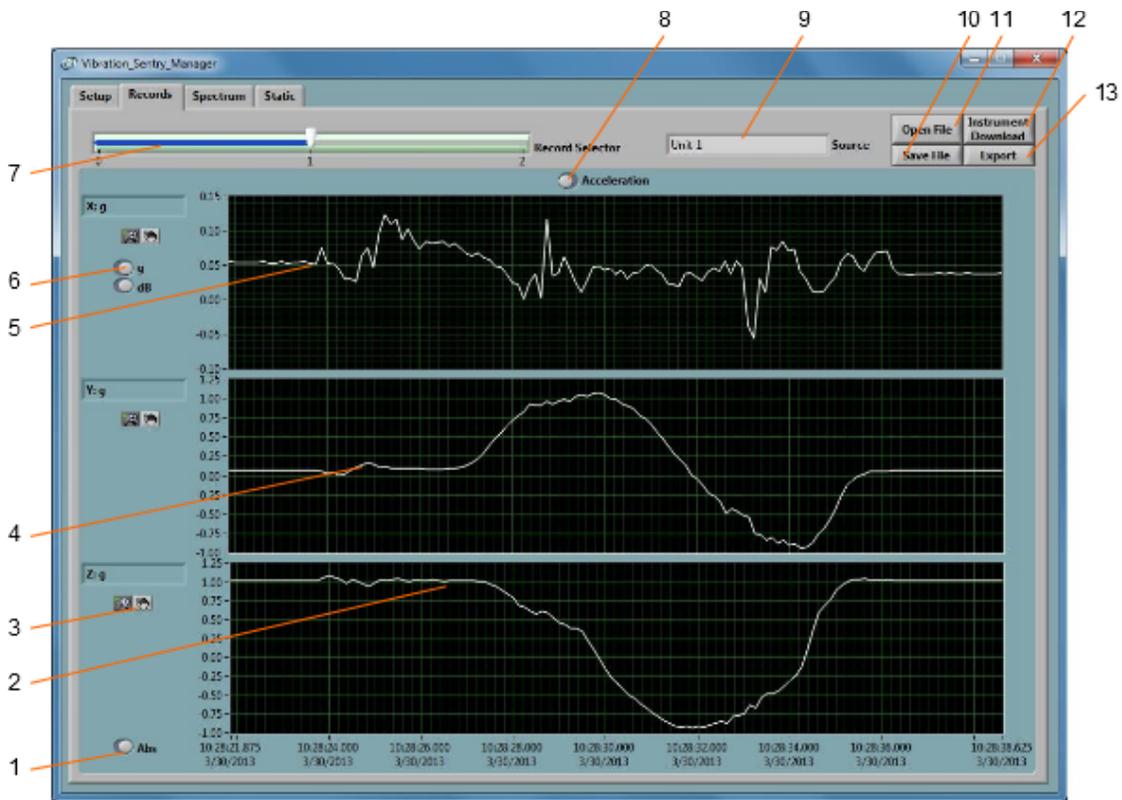
Figure 6   Record Tab

1. Absolute/Relative time scale button
2. Z-axis recorded data
3. Pan and zoom buttons
4. Y-Axis recorded data
5. X-axis recorded data
6. Scale buttons
7. Record number selector
8. Acceleration/Inclination Display Mode
9. Data source
10. File Save button
11. File Open button
12. Instrument Download button
13. Export button
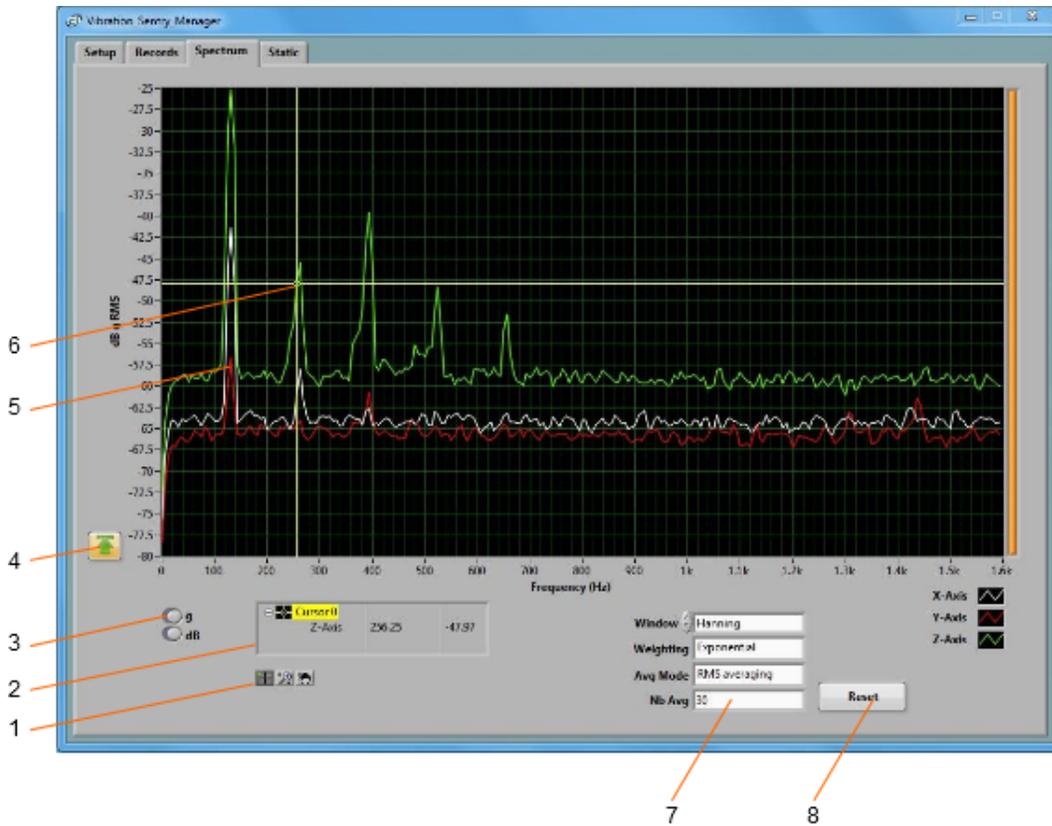
Figure 7   Spectrum Tab

1. Cursor, Zoom and Pan controls
2. Cursor values display
3. Scale buttons
4. Auto-scale button
5. X, Y and Z-axes spectra
6. Cursor
7. Spectral controls
8. Spectra reset button
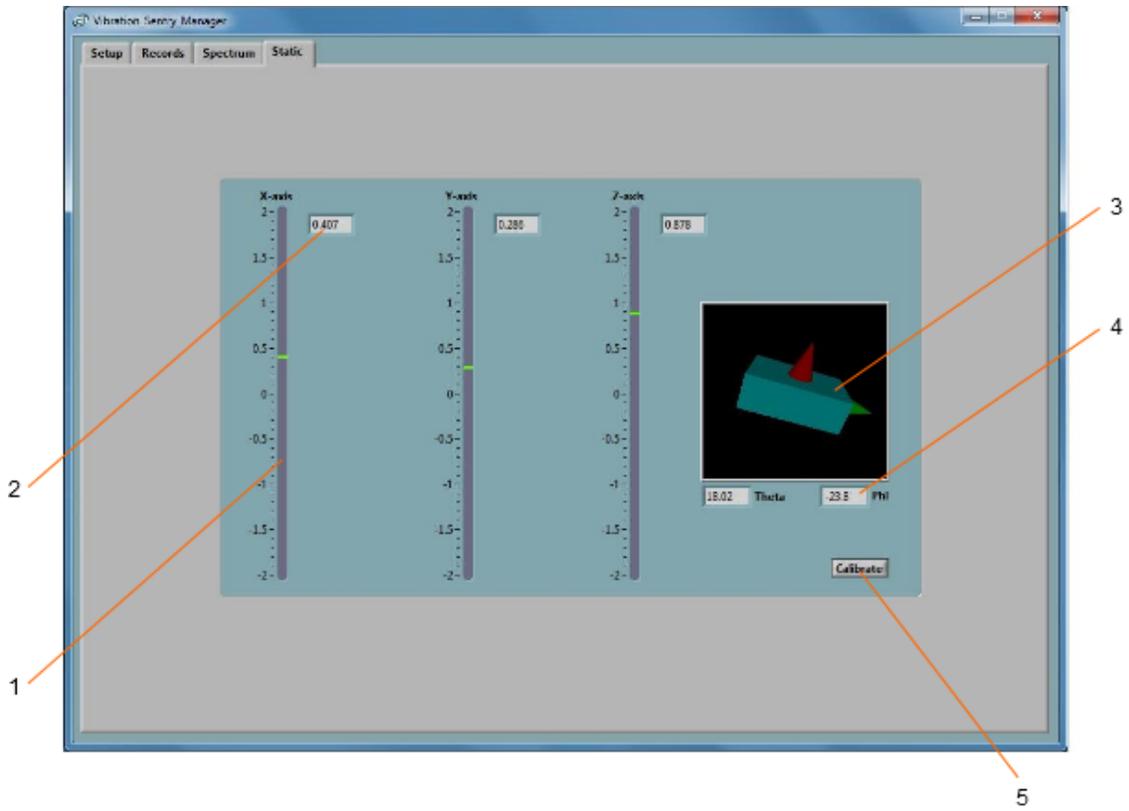
Figure 8　　　Static Tab

1. Static axis indicator
2. Static digital display
3. Inclinometer graphic display
4. Inclinometer angle displays
5. Calibration button
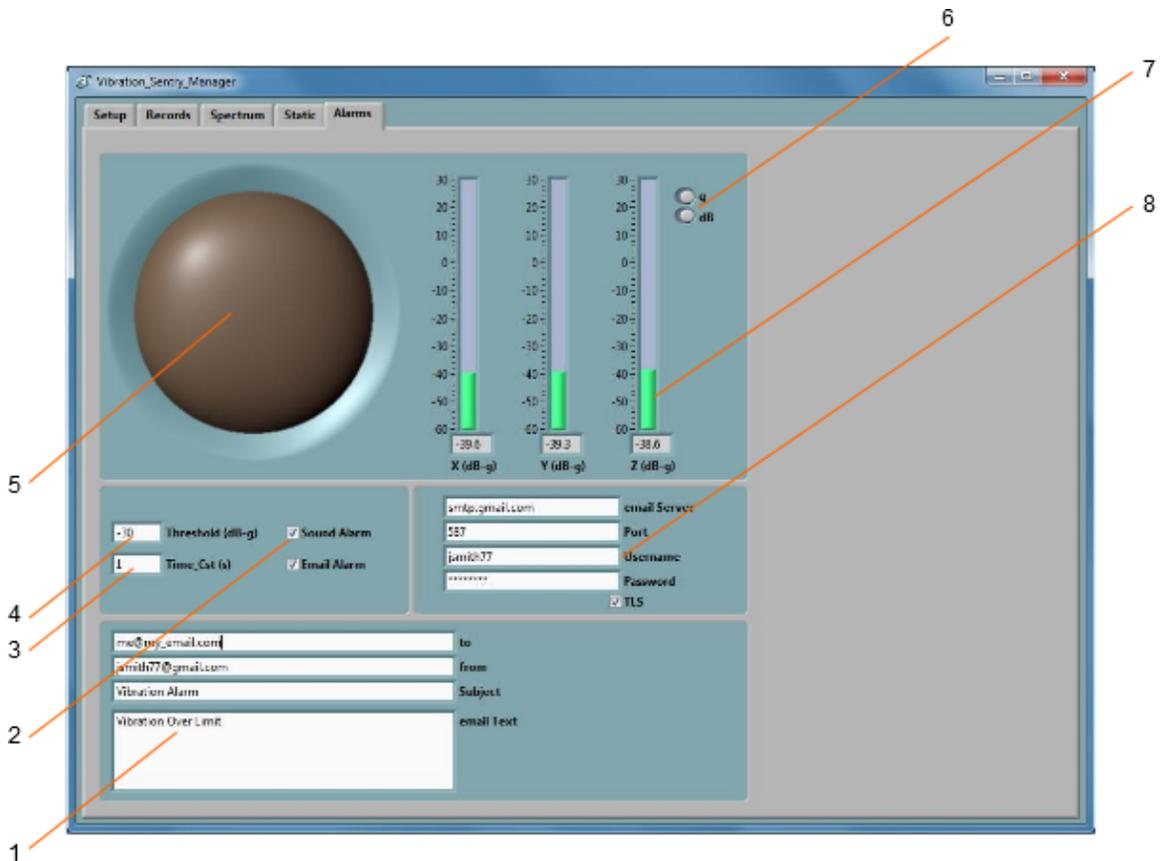
Figure 9   Alarms Tab

1. Email setup
2. Alarm enable controls
3. Alarm time constant
4. Alarm threshold
5. Visual alarm
6. Scale settings
7. Real-time level display
8. Email server setup

7.1   Starting the Application

The application can be run with or without a *Vibration Sentry E* connected. When a *Vibration Sentry E* is not connected the application can only be used to display and analyze a previously saved log file. All the controls and indicators related to the instrument are grayed out.

To control a *Vibration Sentry E* using the *Vibration_Sentry_Manager,* proceed as follows:

1. Connect the instrument to an available USB connector on the PC.

2. Make sure that the charge LED lights-up yellow or green, and that the operation LED starts blinking. If not, review the installation procedure, or see section ***Troubleshooting***.

3. Go into *Start\All Programs\Vibration_Sentry_Manager*, and run *Vibration_Sentry_Manager.exe*.

4. The front-panel described in *Figure 5* appears, and the application tries to connect to the instrument. If it fails to find the instrument it indicates *No Device Found*. If this is the case see section *Troubleshooting*. Otherwise the application immediately starts communicating with the *Vibration Sentry E*.

7.2 Main Functions

The application has five main tabs:

- **The *Setup* Tab:** Is used to setup the instrument and monitor real-time measurements (see *Figure 5*).
- **The Records Tab:** Is used to download, display and export the data from the Vibration Sentry E (see *Figure 6*).
- **The Spectrum Tab:** Is used to display real-time power spectra from the Vibration Sentry E (see *Figure 7*).
- **The *Static* Tab:** Is used to monitor the static accelerations along the three axes and optionally to launch the calibration procedure (see *Figure 8)*.
- **The *Alarm* Tab:** Is used to setup audible and email alarms. The PC must stay connected for the alarms to work (see *Figure 9)*.

7.3 Setup Tab

The setup tab is seen in *Figure 5*. It is divided into six fields.

7.3.1 Time and Date Field

This field displays the internal time of the instrument. If the instrument time is not properly adjusted, press *Synchronize*. This synchronizes precisely the instrument time to the PC time. Make sure the PC time is accurate before synchronizing the instrument.

Note: Time synchronization is not allowed while the instrument is recording. Attempting to synchronize the time while a recording is in progress will trigger an error message to that effect.

7.3.2 Temperature Field

This field is used to display the instrument's internal temperature in degC or degF.

7.3.3 Instrument Info Field

The instrument info field provides instrument information, such as instrument model, serial number and firmware revision. In addition the *User-ID* field may be used to assign a custom identifier to the instrument.

To set, modify or delete the *User-ID*, simply place the cursor in the *User-ID* box and write a new identifier or clear the text. The new identifier is written to the instrument's memory as soon as *return* or *enter* is pressed, or if the mouse is left-clicked outside of the box.

The *User-ID* is written to non-volatile memory, so it is retained even in the event of a battery failure.

7.3.4 Recording Field

The recording field has four buttons:

- **Record**   The *Record* button is used to immediately create a new record and start recording. The new record is placed in memory immediately after the last one. The recording stops when the memory is exhausted, or when the *Record* button is pressed again. The recording parameters, such as number and types of values recorded, sampling frequency…etc. must be adjusted prior to starting the recording.

- **Auto-Rec**   The *Auto-Rec* button is used to place the instrument in or out of the *Auto-Rec* mode. In the *Auto-Rec* mode the instrument stays dormant, sampling the acceleration in the background, as long as it does not detect an acceleration value higher than an adjustable threshold. When the acceleration value goes over the threshold the instrument wakes up and starts recording, using the recording parameters in effect in the instrument's configuration. When the acceleration value goes and stays below the threshold for a set length of time, the recording stops and the instrument goes back to sleep. When the *Auto-Rec* mode is selected, the instrument will first wait for the acceleration signal to rise above the set threshold before starting the first recording. The next period of inactivity will stop the recording, and so on until the user exits the *Auto-Rec* mode, or the memory is exhausted. A new record is created every time activity the threshold is passed and the instrument is not already recording.

Note: *A recording is triggered as soon as the acceleration is detected crossing the threshold for any of the three axes. If the instrument has its high-pass filter off, the axis aligned vertically already sees a 1g acceleration. If the threshold for that axis is set lower than 1 g the recording will never be triggered because the acceleration is permanently above the threshold.*

Note: *The threshold "T" can only be positive. When recording raw signals or acceleration statistics the recording is triggered as soon as the acceleration signal goes higher than +T or lower than -T. When recording RMS levels, the recording is started as soon as the RMS level goes higher than $+T_{RMS}$.*

- **Timer**   The timer button is used to start a recording, or *Auto-Rec* mode at a set date and time in the future. Pressing on the calendar button gives the user more options to set the date and time from a calendar. The action taken (*Record* or *Auto-Rec*) is adjusted in the *Settings* panel.

- **Erase**   The *Erase* button erases unconditionally all the data that has been recorded in the instrument, making room for new records.

The *Memory Depth* bar provides two indications:

- The percentage of memory already used (indicated by the green bar). The bar is completely grey when the memory is empty and completely green when the memory is full.
- The total memory recording time, in Days-Hours-Minutes. The total memory recording time is displayed at the right extremity of the scale. It is calculated as a function of the instrument settings, such as sampling frequency, number of channels selected, type of recording…etc. Therefore it will change dynamically when the settings are modified, to reflect the new overall recording time.

7.3.5 Settings Field

The settings field contains the battery condition indicator and a button to open the instrument settings panel.

This battery condition field indicates the remaining battery capacity. The indicator is surrounded by a yellow indicator that lights-up when the battery is charging.

The battery condition indicator is scaled to indicate the approximate number of hours of recording time remaining in the battery. Since the power consumption varies with the instrument setting, the scale will change to reflect the instrument setting. The number of hours indicated at the upper scale marker indicates the overall number of hours that the battery can last if in continuous *Record* or *AutoRec* mode. The power consumption while the instrument is *Idle* is negligible and allows the instrument to stay on for at least one year. The two factors that have the most impact on power consumption are:

- **Sampling Frequency**   The power consumption is roughly proportional to the sampling frequency. Therefore the number of recording hours is inversely proportional to the sampling frequency.

- **High-Pass Filter**   The increased computational power required to high-pass-filter the signals has a noticeable impact on the power consumption and the number of recording hours.

7.3.6   Instrument Settings Panel

The instrument settings panel opens when the user presses the *Settings* button. Changing the settings is only allowed when the instrument is not actively recording or in *Auto-Rec* mode.
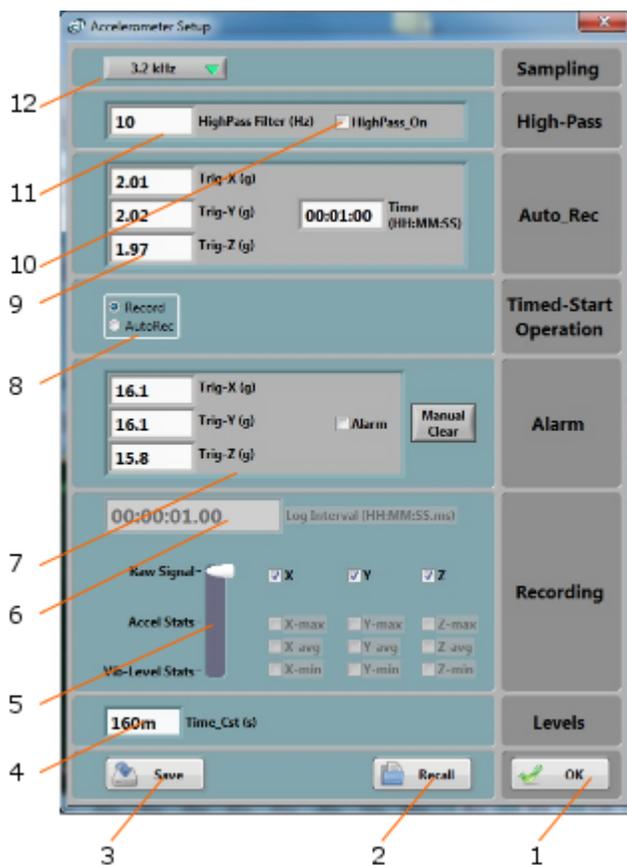

Figure 10   Instrument Settings Panel

1. OK button – Saves the settings and closes the window
2. Recall button – Calls back settings previously saved to a file
3. Save button – Saves to a file the settings presently displayed
4. Time constant for RMS vibration level smoothing (for min and max RMS level detection)
5. Record type selector - Axes to record
6. Log interval setting

7. Alarm thresholds, enable and manual clear
8. Timer action
9. Auto-Rec threshold and inactivity setting
10. High-Pass filter On/Off control
11. High-Pass filter cutoff frequency
12. Sampling Frequency

7.3.6.1 Sampling Frequency

The sampling frequency can be adjusted up to 3.2 kHz. The power consumption while recording is roughly proportional to the sampling frequency. The *Battery* scale in the *Setup* panel indicates how long the instrument can record for as a function of sampling frequency.

When recording raw signals the amount of memory consumed is proportional to the sampling frequency. The *Memory-Depth* indicator in the *Setup* panel automatically calculates the overall recording time as a function of the selection.

7.3.6.2 High-Pass Filter

The high-pass filter can be selected or deselected by clicking on the small green control. The field on the left is used to adjust the cutoff frequency. Thanks to its very high resolution, the high-pass filter can be adjusted to frequencies that are extremely low relative to the sampling frequency.

7.3.6.3 Auto-Rec Settings

These settings adjust the trigger threshold and the inactivity period. Once the instrument is placed in *Auto-Rec* mode it switches between two states:

- **Waiting for activity**   While in inactive mode the instrument waits for activity. Activity is defined as "acceleration that transitions through the threshold on at least one axis". The acceleration must be lower, then greater than the threshold to trigger the recording. When activity is detected the instrument creates a new record and starts recording. The threshold can be different on each axis.

- **Waiting for inactivity**   While in *Record* mode, the instrument waits for inactivity. Inactivity is defined as "acceleration stays lower or equal to the threshold on all three axes for a time longer than the inactivity period". When inactivity is detected the instrument stops the ongoing recording. Therefore the inactivity time defines the minimum amount of time that the instrument will record, once triggered.

7.3.6.4 Timed Start Operation
This control defines the action to take when the timer is engaged. The choices are:

- Record: The recording will start once the timer has reached the specified time and date.

- Auto-Rec: The instrument will go to Auto-Rec mode once the timer has reached the specified time and date.

7.3.6.5 Alarm
These control are used to enable the Alarm function, set the thresholds on each axis and if necessary manually clear an ongoing alarm.

If the alarm is enabled, the alarm LED will start blinking once every two seconds if the acceleration passes through the corresponding threshold on any of the three axes.

The alarm is cleared by the following:

- Manual Clear button is pressed

- 5 seconds after disconnecting from USB

- When Record Mode or Auto-Rec Mode is started from the *Vibration_Sentry_Manager* application

7.3.6.6 Log Interval

The log interval defines the time between two successive recorded points, when the instrument is recording acceleration statistics or RMS vibration level statistics. When recording either type of statistics the min, max and average are reset at the beginning of each log interval. Then the instrument observes the signals or levels for the duration of the log interval, and updates the min, max and averages accordingly. At the end of the log interval the selected statistics are written to memory. Then the next log interval is started… and so on until the recording is stopped or the memory is exhausted.

The log interval is only relevant when recording statistics. When recording raw signals the time between two successive samples is simply the sampling period.

The log interval can be adjusted from 125 ms to 2 H in increments of 125 ms.

When recording statistics the amount of memory consumed is inversely proportional to the log interval. The *Memory-Depth* indicator in the *Setup* panel automatically calculates the overall recording time as a function of the selection.

7.3.6.7 Signal Selectors

The *Record-Type* selector specifies whether raw signals, acceleration statistics or RMS vibration level statistics are being recorded.

In either case the user must choose the axes, and optionally the types of statistics to record. To select or deselect an axis or statistic, simply press on the corresponding checkmark.

Note: In order to record inclinations select "Acceleration Statistics" and select at least the X-avg, Y-avg and Z-avg selectors. The inclinations are calculated from those measurements.

The amount of memory consumed while recording is proportional to the number of channels and statistics selected. The *Memory-Depth* indicator in the *Setup* panel automatically calculates the total recording time as a function of the selection.

7.3.6.8 Low-Pass Time Constant

When measuring RMS vibration levels, the instantaneous RMS levels are low-pass-filtered with an adjustable time constant.

The time constant is adjustable in factors of two, and is automatically rounded to the closest available one.

The time constant is only relevant when recording RMS vibration level statistics, and is only used to detect min and max values. The average is calculated by a rectangular integration over the log interval.

A shorter time constant should be chosen to detect sharp transients. Otherwise the measurements will be smoothed out. On the other hand, when the RMS levels are slowly varying, a longer time constant will provide more precise values.

Typical fast time constants are 100ms and under.

Typical slow time constants are 1s and over.

7.3.6.9   Closing the Window

The adjustments are only implemented when the *OK* button is pressed In order to forego any changes, simply close the window without pressing *OK*.

If any setting requires the user's attention a warning window is open to display the warning. The settings are still in effect though, and the user can either heed the warning and go back and modify the settings, or ignore the warning and leave them as they are.

7.3.7   Signals Field

The vibration levels measurement field provides information about the current acceleration signals and RMS vibration levels.

- The graph presents the instantaneous acceleration signals as they are measured in real-time. The *Fs* indicator to the left of the graph shows the sampling frequency in effect. The *N* control to the left of the graph selects the number of points to display. The maximum is 512. When pressed, the auto-scale button allows the scale to be dynamically adjusted so that all the signals fit in the graph. When released, the scale is fixed. When using a fixed scale, the scale can be adjusted manually by double-clicking and writing new values directly in the top-most and bottom-most marker values of the vertical scale. The acceleration signals can be displayed in *g* or *m/s^2*. The effect of the high-pass filter is taken into account in the display. The orange bar at the top of the graph shows the progressive filling of the capture buffer. When operating at high sampling frequencies the bar is usually always full. However when operating at low sampling frequencies, with a large number of points it may take a long time to fill the buffer for display. The bar provides a visual indication that the buffer is filling-up.
- The three bars to the right of the graph show the RMS vibration levels measured on the X, Y and Z axes. The RMS vibration levels are presented in dB*g* or dB*m/s^2* depending on the scale used to show the time signals. Note that the effect of the high-pass filter is taken into account in the displayed values. RMS vibration levels should not normally include DC levels. In order to exclude the DC levels, the high-pass filter must be activated.

7.4   Records Tab

The *Records* tab is seen in *Figure 6*. It is used to retrieve the recorded information from the *Vibration Sentry E* or from a saved file, and to display and optionally export the recorded logs.

7.4.1   Instrument Download

To download data from the instrument press the *Instrument Download* button. The whole contents of the instruments memory are downloaded, and the newest record is displayed in the graphs.

The *Record Selector* at the top-left of the page indicates how many records have been downloaded. It shows one separate tick per record present.

Use the white slider to select the desired record. When selecting a record the indication *No-Data* is displayed on top of any empty graph. It is legal for a record to contain no data at all. That usually means that the recording was started and stopped before any data had time to be recorded. In such a case the time-stamp is still valid and can be used to determine when that event occurred.

The *Source* indicator shows the *User-ID* of the instrument.

The time scale can be displayed in absolute (date/time) or relative (fractional seconds) format. The absolute format exposes the time-stamp that was written in memory with the record. Relative time is more useful when examining raw signals.

The acceleration scale can be displayed in g or m/s^2, in linear or dB scale.

By default the graphs display acceleration or vibration levels on a per-axis basis. But when the *Acceleration/Inclination* button is set to *Inclination*, and if the recording includes the average acceleration along the three axes, the graphs combine the acceleration components and show:

- The norm of the acceleration on the top-most graph. This is normally 1g if the instrument is stationary and only subjected to changes in inclination.

- The *Theta* angle around the X-axis on the middle graph. The inclination is presented in degrees.

- The *Phi* angle around the Y-axis on the bottom-most graph. The inclination is presented in degrees.

7.4.2   File Save

Pressing the *Save File* button saves all the records downloaded from the instrument to a file on the PC. In addition to the whole contents of the recording memory the file also contains ancillary information, such as calibration, instrument information…etc.

The file is saved in a proprietary format with the extension *.cil*.

By default the file is saved with a name that contains the *User-ID* of the instrument, as well as the present date and time.

7.4.3   File Open

Pressing the *Open File* button recalls all the records previously saved to a *.cil* file. The function works very much like the *Instrument Download* function, except that the data comes from a previously saved file.

The *Source* field shows the *User-ID* of the instrument the data comes from.

That function works even when no instrument is connected to the PC, so it can be used to examine data that was recorded elsewhere and send as a file.

7.4.4   Exporting Data

The data of the record being viewed can be exported for further display or processing. Depending on the type of record two formats can be chosen from:

- If the record contains raw signals, the data can be exported to either *.wav* or *tab-delimited text* format. The *.wav* format is preferred when dealing with a large quantity of data because it provides a smaller, more efficient storage. When exporting as *.wav* a separate file is created for every axis present in the record.

- If the record contains raw signals, the data can also be exported to a tab-delimited text format that can be easily opened by spreadsheet applications such as Excel. In that case the user should be mindful of the quantity of points contained in the record. The text formatting can easily produce files of huge sizes.

- If the record contains RMS vibration levels or acceleration statistics the data can only be exported to a tab-delimited text format.

7.4.5 Graph Controls

All graphs can be adjusted using the following techniques:

7.4.5.1 Zoom Controls

To the left of each graph is a two-button control. The left-most looks like a magnifying glass. It is used to zoom-in and zoom-out the corresponding graph. To use it, simply press the button, and choose one of the following zoom functions:

- Zoom X-Y

- Zoom X

- Zoom Y

- Zoom-Extents

After choosing the function, the cursor changes to a magnifying glass. Click and drag on the graph to apply the required zoom.

Keep in mind that each graph has a separate zoom and pan function. Select the proper function for the particular graph you are interested in before applying it. Make sure that the cursor changes to the proper function when the mouse is hovered on top of the graph.

Note that all three graphs are always synchronized along the X scale. Whatever zoom is applied to the X-scale over one graph is always applied to the other two. This way the X-scale is always the same for the three graphs.

7.4.5.2 Pan Controls

To pan a graph left, right up or down, first press on the *Hand* button to the left of the particular graph you are interested in. Then position the mouse over the graph. Left-click to "grab" the graph, and move the mouse to pan the graph as desired.

7.4.5.3 X-Y-Scale Direct Modification

Another way to zoom a graph is to directly change its scale. To do that, simply click on the value for left-most or right-most marker of the X-scale, and select its value. Type a new value to replace the old one. The scale is adjusted so that that new value is used at the beginning or end of the scale.

The same technique can be applied to the bottom-most or top-most values of the Y-scale of each graph.

7.5   Spectrum Tab

The *Spectrum* tab is shown on *Figure 7*. When that tab is selected the time-domain signals captured by the instrument are presented in the form of averaged power spectra. The processing is as follows:
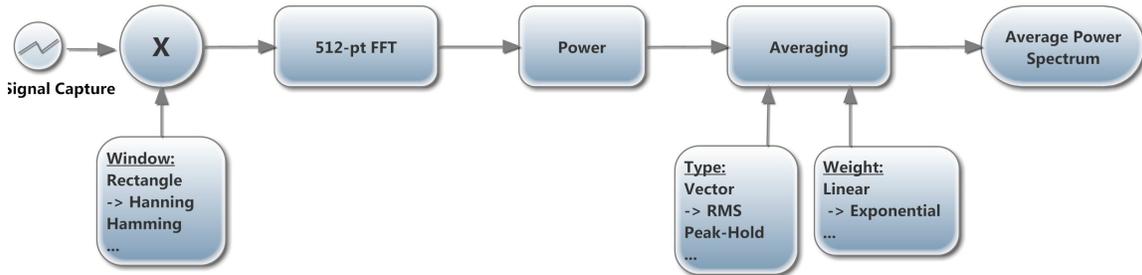

Figure 11   *(-> shows the defaults)*

7.5.1   Window

The type of window chosen has an impact on the spectral resolution. The *Hanning* window is generally a good choice that provides good spectral selectivity.

7.5.2   Weighting

The averaging can be exponential or linear.

- **Exponential Averaging**   is comparable to a low-pass time filtering of the spectrum. In other words each spectral line is low-pass filtered so that the resulting spectrum is smoothed out with time. In that case the *Nb_Avg* represents an equivalent averaging time constant, expressed in number of successive spectra. The averaging is continuous and does not stop. Each successive spectrum is taken into account in the calculation. A larger value of *Nb_Avg* produces a spectrum that is more stable, but also averages-out short-lived transients.

- **Linear Averaging**   takes an equal-weight average of *Nb_Avg* successive spectra. After the *Nb_Avg* spectra have been observed the result is frozen.

In both cases the *Reset* button discards the present display and restarts the averaging from zero.

The *Averaging Mode* can be chosen between several choices:

- **No Averaging**   Only presents instantaneous power spectra, irrespective of the other settings.

- **Vector Averaging**   Vector averaging eliminates noise from synchronous signals. Vector averaging computes the average of complex quantities directly. The real part is averaged separately from the imaginary part. Averaging the real part separately from the imaginary part can reduce the noise floor for random signals because random signals are not phase coherent from one time record to the next. The real and imaginary parts are averaged separately, reducing noise but usually requiring a trigger.

- **RMS Averaging**   RMS averaging reduces signal fluctuations but not the noise floor. The noise floor is not reduced because RMS averaging averages the power of the signal. *RMS Averaging* is the most common type.

- **Peak-Hold**   Peak hold averaging retains the peak levels of the measured spectra. Peak hold averaging is performed at each frequency line separately, retaining peak levels from one FFT record to the next.

Note: All the FFT calculation is performed on the PC. The raw time-signals are transferred from the instrument to the PC, where the FFT and averaging calculations are performed.

7.5.3 Scale

The power spectra can be displayed in *g* or *m/s*^{2} scale, and in linear or dB scale. Changing the scale does not restart the averaging.

7.5.4 Cursor, Zoom and Pan

A cursor can be used to precisely measure the frequency and amplitude of a particular spectral point. In order to use the cursor proceed as follows:

- Press on the button that looks like a cross (see *Figure 7* (1))

- Place the mouse over the point where the X and Y cursor lines meet and left-click. This grabs the cursor.

- Drag the cursor to the spectrum curve and frequency of interest. The cursor can jump from one curve to the other.

- Read the X and Y values in the cursor field underneath the graph.

Zooming and Panning is done the same way as in the *Records* graphs. See section *Graph Controls*. The auto-scale button can be pressed or released to obtain an automatic or fixed scale. When the graph is in fixed scale, writing directly in the values of the end-scale markers sets the scale to fit those values, in the X as well as Y scales.

7.6 Static Tab

The static tab is seen in *Figure 8*. It displays the measured static acceleration along the three axes. This can be used to verify the calibration. When a particular axis is vertical and the instrument is not moving, the measured static acceleration along that axis should be precisely 1g.

The static tab also shows a graphic depiction of the instrument's inclination, as well as the inclination angles along the X and Y axes.

Note: The static values, as well as the graphic depiction can only work when the high-pass filter is off-line. When the high-pass filter is on-line all static values are 0g.

7.6.1 Calibration

Pressing the *Calibrate* button launches the calibration procedure. Once the calibration is started simply follow the on-screen instructions to accurately calibrate the instrument. The calibration can be performed at any time. The calibration requires the instrument to be placed in three different positions, successively placing one of its axes in the vertical position, while the other two stay horizontal.

7.7 Alarms Tab

This alarm function is separate from the instrument's embedded alarm described in *7.3.6.5 Alarm*

It is important to understand that the alarm and email features are functions of the *Vibration_Sentry_Manager* application, not of the instrument itself. So in order to work the instrument must stay connected to a PC, and the PC must be running the *Vibration_Sentry_Manager* application. In order for the email to work, the PC must also be connected to the internet of course.

7.7.1 Alarm Types

There are three main types of alarms:

- Visual Alarms

- Auditory Alarms

- Email Alarms

All except the visual alarm can be disabled or stopped using the *Alarm Enable* controls (2 in *Figure 9*).

7.7.2 Alarm Triggers

Alarms are only triggered when the instantaneous RMS vibration level exceeds a preset threshold. A further limitation is that the same threshold is used on all three axes.

The trigger value is expressed in the same scale as the vibration levels. That scale can be adjusted using the scale settings (6 in in *Figure 9*).

7.7.2.1 Instrument Configuration

The *Vibration Sentry E* is very flexible in what it can measure. Therefore in order to work with alarms it needs the following settings:

- **High-Pass Filter** In order to properly measure RMS levels the high-pass filter needs to be set. Otherwise the DC component from the earth's gravity will bias the measured RMS levels. The cutoff can be chosen as a function of the sampling frequency and the bandwidth of interest (how much low frequency needs to be removed from the signals). A cutoff around 1 Hz is usually a good choice.

- **Sampling Frequency** The choice of sampling frequency is completely application-dependent. For ground-tremor applications, where alarms are often needed, it helps to choose a low sampling frequency in the 100 Hz range, because that lowers the instrument's noise.

- **Time Constant** The instrument's time constant is best adjusted at 100ms or longer. The application detects alarms by monitoring the instantaneous RMS level that the instrument measures. The application reads the instrument 10 times per second at the fastest, so if a time constant shorter than 100ms is chosen there is a risk of missing very short transients.
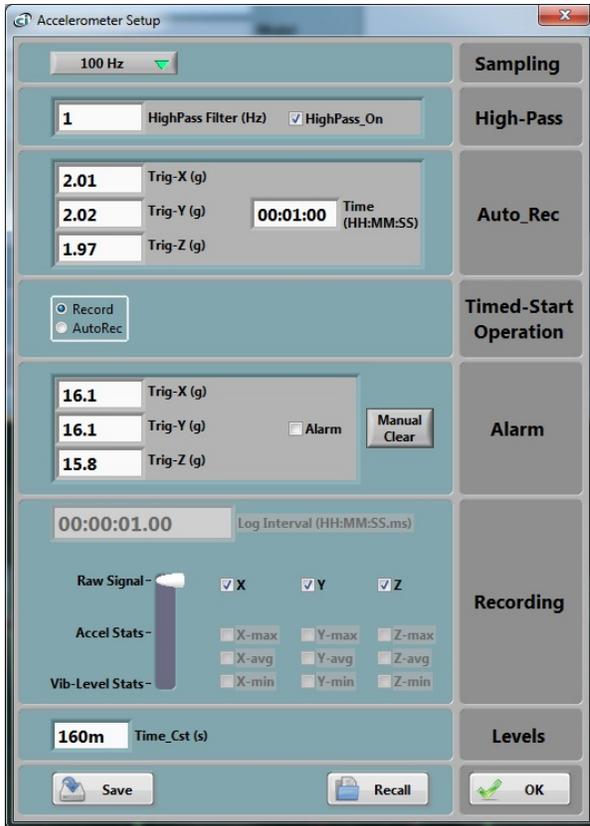
Figure 12

Figure 12 shows a typical *Vibration Sentry E* setup to work with alarms in the context of ground-tremors. Note the low sampling frequency, and the presence of the high-pass filter with a 1 Hz cutoff. The instrument's time-constant is set at 160 ms, which is long enough for even a short transient to not be missed. All other settings have no impact on the operation of alarms.

7.7.3   Alarm Timing

The audible and visual alarms always last for a minimum of three seconds. If the alarm condition is maintained (RMS level is above the threshold) then both alarms will stay active.

In order to avoid filling-up a user's mailbox in case of a maintained alarm condition, the email alarms are only triggered when the alarm has been inactive for at least 1 minute. So when an RMS level exceeds the set threshold and is maintained, an initial email will be sent when the alarm first triggers. A new alarm will only be sent after the level falls back to the inactive level, is maintained below the threshold for at least 1 minute and rises back up above the threshold.

7.7.4   Time Constants

The alarms trigger only on the instantaneous value of the measured RMS level. However in some applications it is useful to filter-out short transients and only trigger when the RMS level is maintained above the threshold for some time. In order to do that, the *Time-Constant* of the alarm needs to be adjusted to a value adequate for the application.

It is worth noting that, contrary to the time constant that is adjusted as part of the instrument settings (see section 7.7.2.1), this "alarm time constant" is implemented at the level of the application, not at the level of the instrument. Therefore it does not affect the data that the instrument may be recording.

For instance *Figure 9* shows a *Time_Cst* of 1 second. That is independent of the instrument's time constant that may be set to a much shorter value, say 100ms.

7.7.5 Email Setup

In order for email alarms to work, the PC that runs the application must of course be connected to the internet. It must be able to connect to an outgoing email server and account. That is usually the email account of your internet service provider, or an email service account, such as *Gmail*.

Emails are sent using the SMTP protocol. The email setup is not always easy. You should know and understand the settings that your outgoing email server requires.

The complete email setup is similar to the configuration of any email application. It includes the following:

- **Email server**   The internet name of the outgoing email server.

- **Port number**   The TCP port number of the email service. This is usually:

  - **25**   for an "open" (no security) account.

  - **465**   for SSL security

  - **587**   for TLS security

- **User-name**   The account name

- **Password**   The account password (leave blank for an "open" (no security) account).

- **TLS**   The security setting. This is the only secure mode supported. Uncheck for an "open" (no security) account.

In addition to these settings, the email alarms settings let you set:

- **One or Several Recipients**   The recipient line (*to* line in *Figure 9*) can hold more than one recipient. Multiple recipient addresses must be separated by space, tab, return or semi-colon.

- **The sender's address**

- **The subject line**

- **The email text**   In addition to the text written in the *email-Text* box, the email text will contain the *User-Name* attributed to the instrument (if one has been set), the detected level and the time and date. This way if multiple instruments are being monitored, the user can determine which of those triggered the alarm by looking at the user name on the first line of the email.

The application by default shows the settings for a fictitious secure *Gmail* account (see *Figure 9*). These settings of course need to be changed to reflect the user's own email account settings.

7.7.6 Sending Alarms While Recording

There is nothing that precludes the instrument from being recording and at the same time monitoring and sending alarms. This way, long after an alarm has been sent, the instrument's data can be downloaded to determine how loud the event that triggered the alarm was.

8 Maintenance

8.1 Battery Care

The following factors affect battery life:

- Prolonged use at extreme temperatures (close to the limits of *-20 degC and +60 degC (-4 degF to 140 degF)* will shorten the life of the battery.
- Over-discharge of the battery will shorten the life of the battery. Always fully recharge the battery when it is low or at least every 6 months, whichever comes first.

8.2 Reset Procedure

In the unlikely case where the instrument's firmware crashes a hardware reset can be performed by inserting a small rod into the reset hole and pushing until a slight click is felt. There is <u>no risk</u> of losing any recorded data or settings by resetting the instrument. The instrument time however will need to be readjusted using the *Vibration_Sentry_Manager* application.

8.3 Operation Outdoors

Thanks to its potted construction, the *Vibration Sentry E* is weather-proof. It can safely be used outdoors provided that the temperature is always within the safe limits. However when using it outdoors with a risk of rain or snow, make sure its USB connector is facing down, so water will not accumulate inside the connector.

8.4 Cleaning

Use a damp sponge or soft cloth.

Note: Do not use solvents. Do not submerge in water.

8.5 Software and Firmware Upgrades

Software upgrades are found on our web site: www.convergenceinstruments.com.

After upgrading the software, if a firmware upgrade is required it will be applied automatically when the upgraded *Vibration_Sentry_Manager* application is started. In that case <u>do not disconnect</u> the instrument until the upgrade is completely over. Failure to do that will put the instrument in a state where it no longer works.

9 Troubleshooting

9.1 USB Power Limitation

In some instances a PC will not allow the instrument to connect to one of its USB port because it cannot provide the battery charge current requested by the instrument. If you suspect that this may be

a factor, try connecting the instrument to the output of an <u>externally-powered</u> USB hub that is capable of providing a full USB load (500 mA). Alternately, recharge the instrument using a USB chager.

9.2 USB Driver Installation

If the *Vibration_Sentry_Manager* application is unable to communicate with the *Vibration Sentry E* it may be because the USB driver failed to install properly. To check the USB driver installation follow the procedure below:

1. Disconnect the USB cable.

2. If necessary take the PC out of stand-by.

3. Reconnect the instrument to an available USB port on the PC.

4. Make sure the charge LED lights-up green (charged) or yellow (charging). If not make sure that the PC's USB port is functional, and that the USB cable is not damaged. If necessary try on a different PC, and/or with a different USB cable. The charge LED is just an indication that the port is powered. It should light-up, even if the USB driver is not installed properly.

5. Make sure that the operation LED starts blinking. If not go to step 6.

6. Open the *Device Manager* on the PC. This is usually found in *Control Panel – System and Maintenance*.

7. Just after connecting the instrument to the PC, observe that the *Device Manager* window refreshes.

8. Verify that an item named *DDCI Platform* or *Vibration Sentry E* has been created in the list of devices.

9. If an unknown item appears, or an item named *DDCI Platform* or *Vibration Sentry E* is found but has an exclamation mark (indicating a problem) beside it, disconnect the device and try re-installing the driver (see step 10).

10. To re-install the driver disconnect the *instrument from the PC*. Then Go into *Start\All Programs\Vibration_Sentry_E_Management\Driver*, and run *DDCI_Driver_Install.exe*. This re-installs the USB driver.

9.3 Connection Problems

Failure to communicate with the PC can also be caused by poor USB cable contacts. Make sure the USB connector is fully inserted into the socket of the *Vibration Sentry E.* Inspect the inside of the socket in the instrument. If dirt is lodged in the socket, use dry compressed air to expel it.

10 Specifications

Category	Specification
Number of Axes	• 3
Acceleration Sensor	• MEMS 3-axes

Acceleration Range	• +-16 g
Bandwidth High Limit	• Adjustable up to 1.6 kHz (@ 3.2 kHz Sampling Rate)
Bandwidth Low Limit	• DC (High-Pass Filter Bypass) • Adjustable from 10 mHz to *Fs/2* (High-Pass Filter On)
Connectivity	• USB
Measurements	• Raw Acceleration (g or m/s^2) • Min, Max and Avg Acceleration values (g or m/s^2) • Inclinations around the X and Y axes • Min, Max and Avg RMS Vibration level (linear or dB, g or m/s^2)
Duty Rate of Signal Capture	• 100% - No Missed Samples
Spectral Display	• 3-Axes 512-point Power Spectrum – dB or Lin Scale.

Modes of Operation	• Idle (Micro-Power)
	• USB-Connected (Active)
	• Recording
	• Auto-Rec
	    o Idle when no activity
	    o Recording while activity is present

Calibration	• Self-Calibration using the earth's gravity as a reference
Battery Type	• Integral Li-Poly - USB-Rechargeable
Recharge Time	• 2 H 30 (Typical)
Battery Autonomy (Full-Charge)	• Up to one year while in *Idle* • 300 H to 6000 H while recording, depending on settings
Battery Life	• > 300 Charge/Discharge Cycles
Temperature Range	• -20 degC to 60 degC (-4 degF to 140 degF)
Noise-Floor X-Y Axes (Typical)	• -54 dBg (2 mg RMS) @ 100 Hz Sampling Rate • -40 dBg (10 mg RMS) @ 3.2 kHz Sampling Rate
Noise-Floor Z Axis (Typical)	• -49 dBg (3.6 mg RMS) @ 100 Hz Sampling Rate • -36 dBg (16 mg RMS) @ 3.2 kHz Sampling Rate
Recording Memory	• Non-Volatile Flash Memory
Recording Memory Capacity (E64 Model)	• 64 Mb • Ex: can continuously record single-axis raw signals for 21 min @ 3.2 kHz Sampling Rate • Ex: can continuously record 3-axes full-statistics levels at 1s intervals for 5 days • Ex: can continuously record 3-axes full statistics levels a 1min intervals for 1 year.

Recording Memory Capacity (E128 Model)	• 128 Mb • Ex: can continuously record single-axis raw signals for 42 min @ 3.2 kHz Sampling Rate • Ex: can continuously record 3-axes full-statistics levels at 1s intervals for 10 days • Ex: can continuously record 3-axes full statistics levels a 1min intervals for 2 years.
Recording/Erasure Cycles	• Greater than 100 000
Data Retention	• Greater than 20 Years
Dimensions	• 76.2 mm x 39.4 mm x 20.6 mm • (3" x 1.55" x 0.81")
Weight	• 65 g
Construction	• Integrally Potted Weather-Proof ABS Enclosure

Table 6

11 Software Specifications

Category	Specification
Compatibility	• Windows XP, Windows Vista, Windows 7
Configuration	• Instrument Internal Time • User ID • Sampling Frequency • High-Pass Filter • Auto-Rec Settings • Recording Interval • Recording Channels and Statistics • Integration Time Constant for RMS vibration levels
Display	• Instrument Internal Time • Instrument Internal Temperature • Instrument Information (Serial Number, User-ID, Calibration…etc.) • Real-Time Signals • Real-Time RMS vibration levels • Real-Time Spectra • Recorded Acceleration Signals or RMS Vibration Levels • Static Acceleration • Battery Level and Charge • All acceleration data can be viewed in g or m/s^2 • All graphs can be viewed in dB or Lin scale
Record	• Record Manual Start/Stop

Management	• Record Auto-Rec Mode • Recording Memory Download (Even while recording) • Recording Memory Clear • Auto-Calculation of Memory Depth
Data Export	• Export to Tab-Delimited Format for Use with Spreadsheet Applications • Export of Raw Data in .wav Format for Post-Processing Applications

Table 7