V-Sensor User Manual

Last Updated on 03/05/2015

Contents

1. Application Area and Description

V-Sensor is a compact vibration measurement device designed to automate vibration condition monitoring removing the need of human intervention in the whole measurement & analysis process. The level of automation includes:-

- Automatic recording, balancing and file generation
- Automatic analysis and calculation of vibration RMS, peaks, frequency spectrum, and benchmarking with limits & criteria
- Automatic report generation by station to station RMS, peak, and frequency analysis

It is tailor made for the annual vibration measurement of MTR trains.

V-Sensor is based on the advent of the following modern technologies:-

a) M4-Cortex ARM based microprocessors (used in medical and industrial equipment) that are capable of achieving ultra low power consumption and high speeds (more than a hundreds of millions CPU instructions per second).
b) Nanotechnology accelerometers that can achieve vibration measurements up to 100G in magnitude while maintaining low power without the aid of conventional power amplifiers or power supplies.
c) Realtime operating systems that are faithful to accurate timing which are only used in high end medical equipment and military grade systems.
d) High density PCB design technology which shrinks the entire motherboard to become credit card in size. There are around 80 micro-drilled plated holes and hundreds of wiring implemented in the small board. It was designed using advanced routing technology.

2. Compliance Statement

- All sensors have been pre calibrated in the factory for each axis (X Y Z) and for each sensor range setting (2G, 16G and 100G).
- Type test certificates of calibration are provided and are conducted by an independent laboratory in accordance to equivalent standard of ISO 16063-21:2003.
- All firmware design flow diagram, firmware audit reports by third party scanners, and sensor development tool software certificates are provided as reference or in case that proof is needed to ensure it can be used for reliability critical applications.

3. Hardware Overview

- This manual was updated for V-Sensor Version 2.9807.
- The current guaranteed battery power lifetime of V-Sensor for Duracell standard AAA Alkaline Batteries is 1600 minutes or 26 hours.
- Memory card requirement is a minimum of 1.4 gigabytes (i.e. at least 2 gigs). Use microSD cards with minimum class 4 specification as these are designed for high speed operation.
- Sampling frequency is adjustable from 1 milli seconds or higher. The default setting is 3 milli seconds which is sufficient for most applications and does not produce too many “gigabyte data”.
- The accelerometer sensors are all 3 axis and two sensors operate at the same time – making a total of 6 axis measurements at a time.
- The two sensors have maximum range as follows:- Low G force sensor (2G max or 16G max) and High G force sensor (100G max). Basically, the lower the G range, the higher the accuracy (i.e. lower noise floor).
  - The 2G sensor is used for measuring gentle low magnitude vibrations in the passenger compartment which requires high accuracy/sensitivity and low G range.
  - The 16G sensor is used for measuring axle box vibrations that are relatively high.
  - The 100G sensor is, in contrast, used to measure high magnitude vibrations on track but is more susceptible to electrical noise due to sensitivity.
- Low G (selectable 2G max or 16G max) and High G (100G max) data are recorded simultaneously.
- There is a MicroSD card that can be of up to max 8G in memory size. The recommended brand of MicroSD card is Kingston as it has been tested to show high reliability under low battery power scenarios.
- A high precision crystal clock is used to keep timing in hard realtime.
- The CPU is a M4 Cortex ARM grade which is characterized by high speed and consists of 2 main processors inside – one is a floating point unit for fractional calculations and the other is a digital signal processing unit for communicating with the sensor and MicroSD card.
- The sensors have been chosen to sustain high vibration (10,000 G force survivability) and high temperature (45 degrees C) operation. The batteries are compressed into the case by four M3 screws mounted on flame resistant poly carbonate. The electronic components are light in weight and are soldered securely under strict assembly process.

- Calibration of the sensors is recommended to be done yearly in accordance with the calibration manual which does not require any additional equipment since gravity is used as the reference and calculations are done automatically by the sensor firmware. The formulas complies as close as possible to ISO 16063-21:2003. Although calibration parameters are dependent on temperature coefficient, the parameter drift does not change much through time.
- Batteries are of 3V AAA type which are readily available from the market and should be changed before each datalogging exercise. The CPU can detect loss of power below 1.7V and perform safety reset automatically.

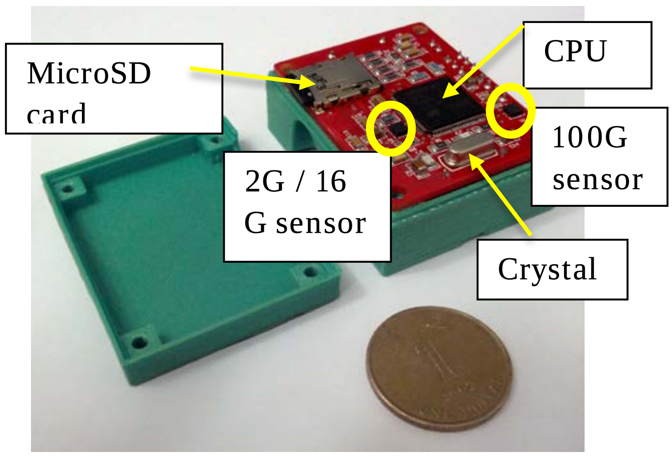


Figure 1 Hardware overview

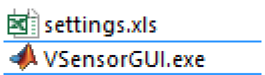
4. Software Overview

- 64 bit application capable of storing and analyzing large datasets.
- Fast data reading.
- Ability to compress large datasets for storage for later.
- Automatic train station detection.
- Fast and user friendly zoom in / zoom out / pan functions.
- Automatic analysis based in Root Mean Squared (RMS) analysis and peak analysis.
- Easy rescaling from seconds -> minutes -> hours -> days.
- Function to compare results with standards and limits.
- Automatic report generation in Microsoft Word with graphs, comparison tables, executive summary generation, and station to station analysis.
- Fourier analysis to find frequency distribution.
- 3D plot to visualize moving train for Z and Y axis against time.

- Ability to synchronize an infinite number of sensors on the same time scale in batch mode

5. Software Download and Installation

1. Contact John Leung through sjleung@mtr.com.hk or seejohnleung@gmail.com
2. (Need administrator rights) Install the executable
3. Restart the computer.
4. Run VSensorGUI:-



6. Onsite Quick Usage Guide

Steps	Check
1) Replace AAA batteries with new ones (recommend Energizer or Duracell)	
2) Take out the micro SD card and set the sensor range in RANGE.txt i.e. 2G 100G or 16G 100G	
3) Delete all data files in the sensor using your laptop/PC or hold onto the user button for >4 seconds to reformat the micro SD card. Then turn the device off and on again.	
4) Install one V-sensor per position of measurement; if benchmarking is required on the same train then more V-sensors are required	
5) Bring helmet for working under the train	
6) Bring hi visibility clothing for working outside the train	
7) Inform relevant parties for installation i.e. email depot control center 1 day earlier and phone them to check for feasibility for site installation, and subsequently require:- a) Competent persons track (safety supervising personnel) b) Driver personnel c) Car number booking	
8) Carbooking form (DCC form)	
9) Permit to work (DCC form)	
10) Phone number of DCC	
11) Double side sticker for installing the sensor on the train (thin type)	
12) Loctite 495 for general installation adhesive (borrow from workshop)	
13) Cable ties and/or electrical tape for redundant security (borrow from workshop)	
14) Hammer to remove sensor (borrow from workshop)	
15) Find level surface for installation of sensor	
16) Photograph installed V-sensor so that you know which axis is longitudinal	
17) Turn on V-sensor	
18) Balance V-sensor by pressing the user button once and record the on-time (day, hour, minute, seconds)	
COMPLETE! The sensor will now be running and recording the Low G and High G vibration at the same time into an Excel file	

7. Battery Replacement

Before using the sensor, replace the batteries by:-

1. Remove the 4 case screws to access the 2 AAA batteries.
2. Remove these and replace with standard cells.

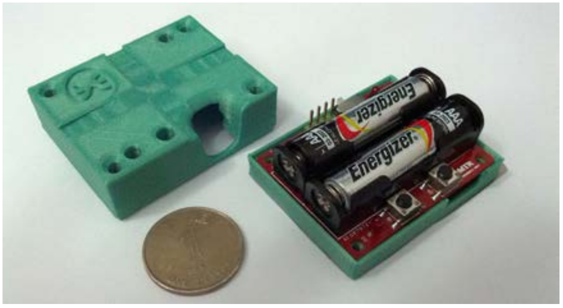


Figure 2 Batteries revealed after screw/case removal

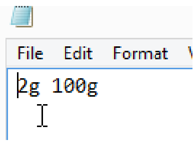
8. Knowing the Device ID

Once you start up the device, a file with the device ID will be generated called ID.txt.

9. Changing the Accelerometer Range

You can change the range by changing the values inside RANGE.txt inside the micro D card.

For example, if you want to select the 16G sensor, change 2g to 16g.



Note that 100g is fixed and you cannot change this.

Note that every time you change the sensor range without deleting the CALIBRATION.txt will result in rapid blinking of 2 LEDs in the device during start up. This indicates that the calibration values in CALIBRATION.txt are wrong and will be set to default values automatically.

10. Onsite Formatting of the MicroSD Card

It is recommended to format the MicroSD card which can be done in the office or onsite using the V-Sensor CPU. The formatting type is FAT 32 file system with partitioning block of 32kb.

For onsite formatting;

1. Ensure there is a MicroSD card inserted.

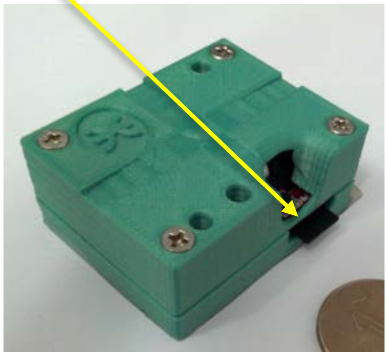


Figure 3 Location of MicroSD card

2. Turn on the device by switching the side-switch:-

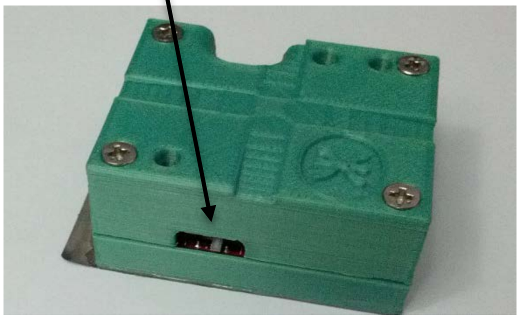


Figure 4 Location of on/off switch

3. Hold onto the user button for 4 seconds until LED2 flickers rapidly. Continue to hold on the user button until LED2 switches off. This indicates that formatting of the MicroSD card has completed.

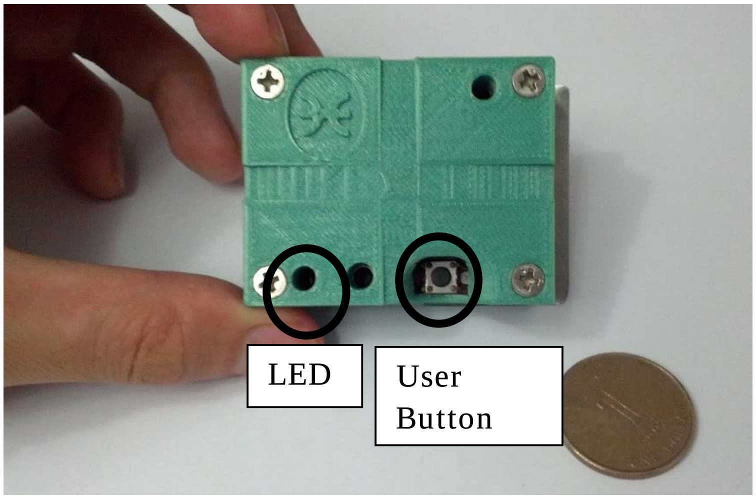


Figure 5 User Button and LED2

11. Balancing / DC Offset Removal

This is normally done before vibration measurements but can be done anytime before i.e. doesn't have to be right before measurements since the balancing parameters are stored inside the MicroSD card.

1. Turn on the device by switching the side-switch:-
2. Place the device on its static condition (zero-level non-vibrating condition).
   2.1. Press the user button to:-
   - Identify the zero vibration level on all X/Y/Z axis
     - Note that it does not matter which axis is X/Y/Z as these can be recognized afterwards using the V-Sensor Windows Software.
     - Note that the zero level position is stored in MicroSD card so you may turn the device off and place it into a different measurement position while retaining the same zero level value.
   - Generate a new Excel file with numbering as follows: VSENSOR<number>.xls
     - Every time the button is pressed, a new file with incremental numbering is generated.
   - Start recording immediately
     - Make sure that LED2 is flashing every 1 second to indicate the recording process in normal.
     - If LED2 is not flashing, ensure that:-
       - MicroSD card has been inserted
       - Battery was renewed or has sufficient power

   2.2. Turn off the device by flicking the side switch

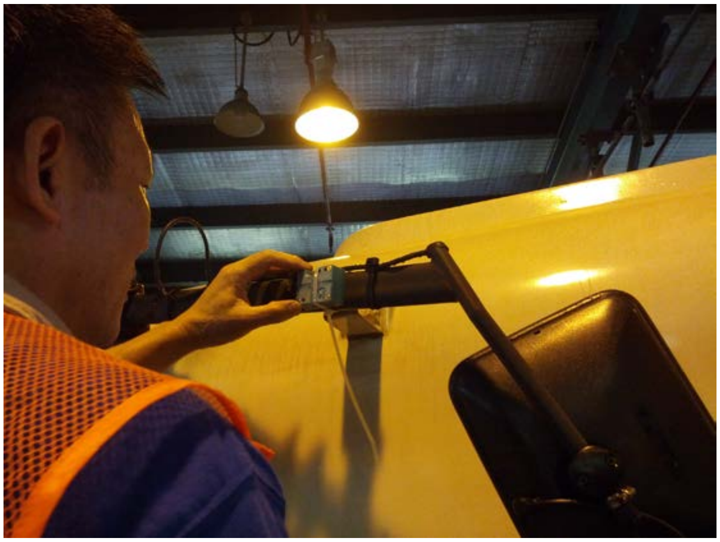
12. Calibration

Refer to the calibration manual for details.

13. Application 1 - General Vibration Measurement

Usually this analysis is performed for the purpose of finding the average vibration and/or peak vibration of a mechanical component – it can be located anywhere not just on the train.

1. Install the sensor on the mechanical component you desire to measure vibration from.
   It is highly recommended to use Loctite 495 or any cyanoacrylate[1] based adhesive at the base of the sensor to stick on your train component surface, however can also use strap ties or both methods of attachment.



[1] Cyanoacrylates are liquid monomers that polymerize forming a hard plastic. This plastic adheres to metal, rubber, glass and various plastics. Room temperature cure; Fast cure time(practically instant); Broad frequency response and good temperature range (From -18°C to +121°C there is no significant change in the response curves.)

Figure 6 An example installation of installing V-Sensor on a mirror arm using strap tie installation method

2. At the non-moving static state, press the user button once to zero-out the offset level and the data collection will start immediately.
3. You may start the dynamic motion for measurement.

14. Application 2 – Outdoors

The installation method is the same as usual however you should protect the device against rain by covering them up with plastic sheath as below:-

15. Application 3 - Onboard Train Structural Vibration Measurement

1. For measuring the carbody structural vibration, position the V-Sensor at the required measurement point – example shown as below:-

Figure 7 Measurements being conducted in the passenger compartment

   1.1. Ensure the contact surfaces are smooth.
   1.2. Apply double sided adhesive tape[2] on the bottom of the V-Sensor so it sticks firmly onto the test location
   1.3. Start the measurements by flicking on the side switch.
   - Measurements are started automatically.
   - A new file with incremental numbering is generated.
2. For measuring train component structural vibration, place the V-Sensor at the location at the underframe at the required measurement point – example shown as below:-

[2] Limited amplitude range and suitable up to +93˚C

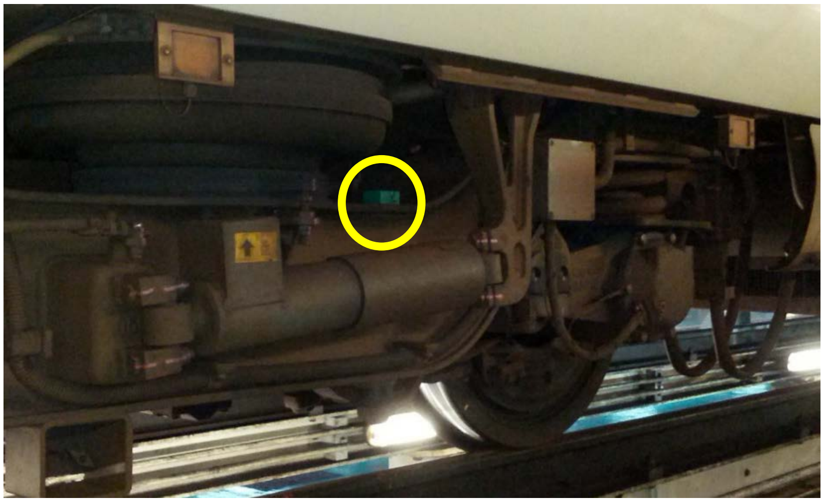


Figure 8 Measurements being conducted at the train underframe

2.1. Ensure the contact surfaces are smooth. Sand and clean the surfaces to clear away any excess dirt or particles.
2.2. Apply Loctite 495 or any cyanoacrylate[3] based adhesive at the metallic surface under the V-Sensor and stick it on the desired measurement location (wait until the adhesive has cured).
2.3. [OPTIONAL] If possible, it is recommended to also apply plastic line tighteners along the grooves of the plastic case and wrap around the measurement location to ensure better security.
2.4. [OPTIONAL] It is also desirable to use Duct tape on top of the V-Sensor to ensure redundant security.

[3] Cyanoacrylates are liquid monomers that polymerize forming a hard plastic. This plastic adheres to metal, rubber, glass and various plastics. Room temperature cure; Fast cure time(practically instant); Broad frequency response and good temperature range (From -18°C to +121°C there is no significant change in the response curves.)

Figure 9 Additional methods of securing V-Sensor - Plastic tightener (left) and Duct tape (right)

2.5. Start the measurements by flicking on the side switch.
- Measurements are started automatically.
- A new file with incremental numbering is generated.

3. Take record of:-

3.1. The time and date (day, hour, minute, second) that the switch was flicked.
- The time is needed if the user wants to estimate the time of peak vibration.

3.2. The route of the train and the train stations that it will pass through.
- The route is needed so that station to station analysis can be conducted afterwards. Note that the stations are automatically recognized by the sensor based on the deceleration and acceleration profiles of the train.

3.3. [OPTIONAL] Ride the train and take down the times of each station arrival.
- Do this if you require manual station detection or wish to eliminate possibility of train stops between stations.

4. After measurements have been conducted, remove the V-Sensor by gently hammering the bottom of the device to detach it from the adhesive. Clean out all remaining adhesive using sand paper.

16. Analysis Preparation – Data Trimming, Loading & Saving

1. Take the MicroSD card out and insert it into a PC through card-reader
    - In the MicroSD card, there will be a series of Excel files which contain the vibration data. Note that a new Excel file was generated to avoid overrunning the maximum row limit of each Excel and also to prevent the risk of one file corrupting affecting the entire dataset.
    - Subsequently, a new Excel file is created with a subnumber as follows (these files belong to the same group of datasets:- VSENSOR<number>_<subnumber>

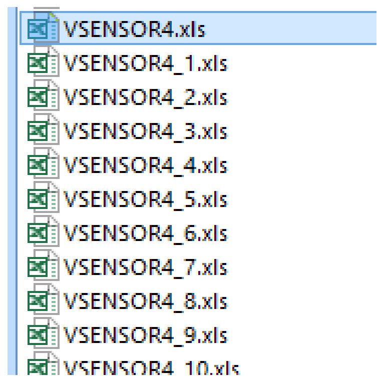
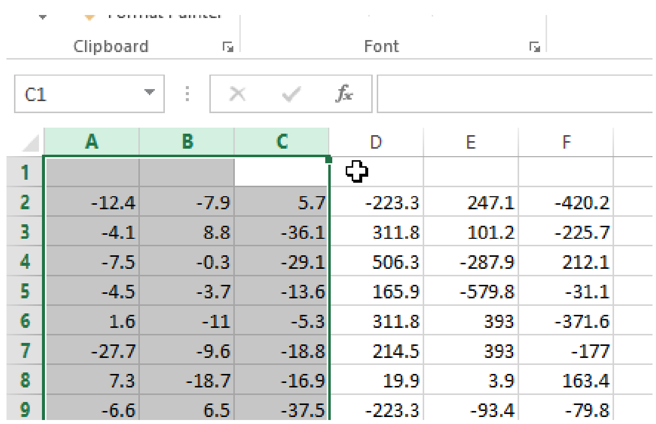


Figure 10 Example set of files generated by V-Sensor

    - Each file will be around 2.05 megs each.
2. Check the datasets – there should be 6 columns, the first 3 columns are the datasets from the 2G sensor and the next 3 columns are the datasets from the 100G sensor.



	A	B	C	D	E	F
1						
2	-12.4	-7.9	5.7	-223.3	247.1	-420.2
3	-4.1	8.8	-36.1	311.8	101.2	-225.7
4	-7.5	-0.3	-29.1	506.3	-287.9	212.1
5	-4.5	-3.7	-13.6	165.9	-579.8	-31.1
6	1.6	-11	-5.3	311.8	393	-371.6
7	-27.7	-9.6	-18.8	214.5	393	-177
8	7.3	-18.7	-16.9	19.9	3.9	163.4
9	-6.6	6.5	-37.5	-223.3	-93.4	-79.8

Figure 11 Example data inside one of the VSENSOR files

3. If there are any unwanted data in a dataset e.g. the starting data which usually consists of waiting period, you can delete them manually by highlighting the initial

files and deleting them. You can also do this in the VSENSOR GUI software however, doing deleting files using Windows Explorer reduces file loading time when using VSENSOR GUI.

REMEMBER TO RENAME THE "FIRST FILE" WHICH DOES NOT CONTAIN FILE SUBNUMBER AS VSENSOR_X.xls AS THE FIRST FILE IS USED FOR IDENTIFICATION REFERENCE.

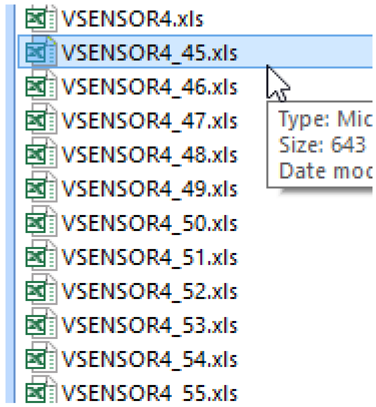
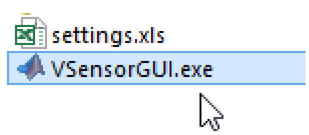


Figure 12 Picture showing initial waiting time data deleted manually

4. Run VSENSOR GUI software by clicking onto the exe file and the user interface will load:-



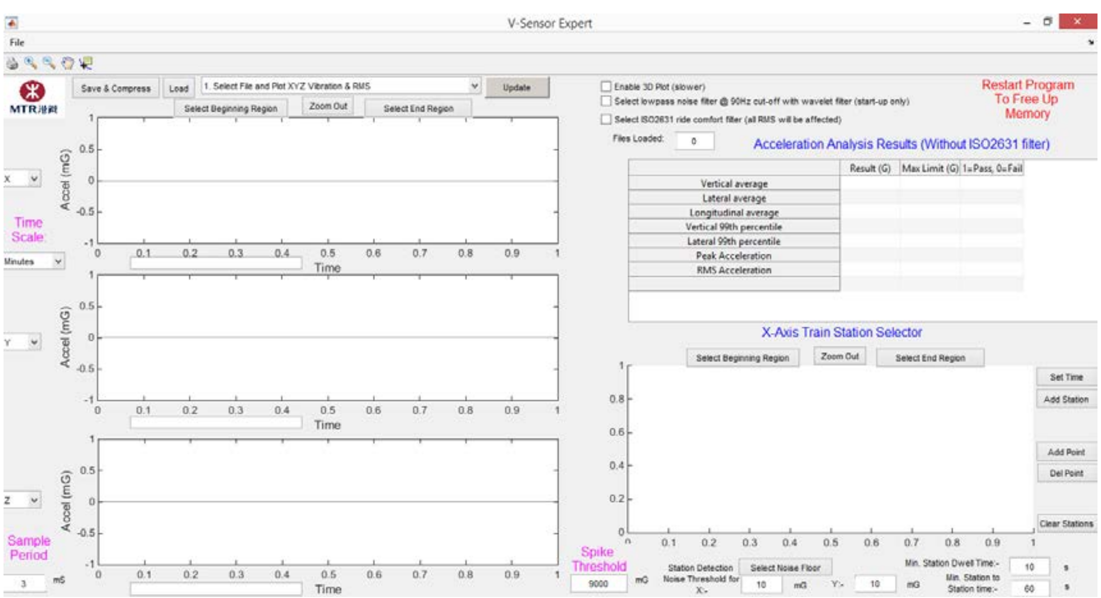


Figure 13 VSENSOR GUI loaded screen

5. After the graphical interface loads, click onto the top drop down menu and select "Select file ..." -> press update. You will be prompted to select the first file of your dataset.

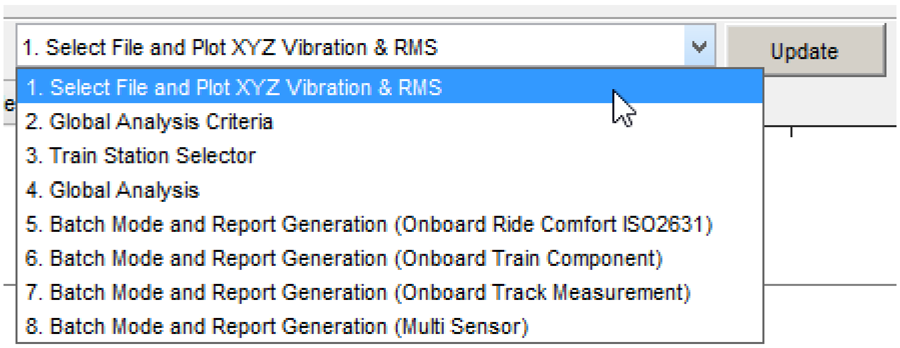


Figure 14 File selection screen

6. Once your dataset has been selected by you, a popup menu will appear and you have the chance to select 2G or 100G sensor data. If the data was taken from a high vibrating component >2G, then you must select the 100G sensor.

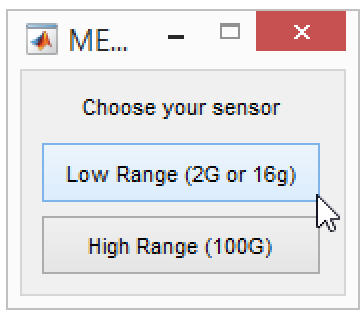


Figure 15 2G and 100G option selection screen

7. Your datasets will be loaded and plotted.

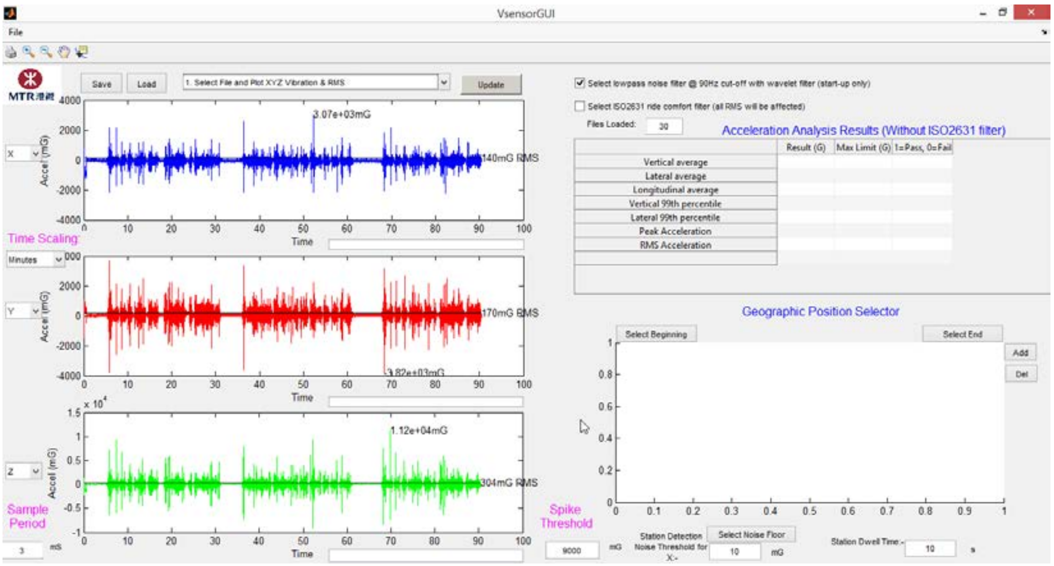


Figure 16 Showing X, Y, Z axis graphs plotted

8. Now instead of loading the Excel datasets all the time which takes a long time, you may save the data in the format of .mat which is much quicker to load next time. Save/load the data as follows:-

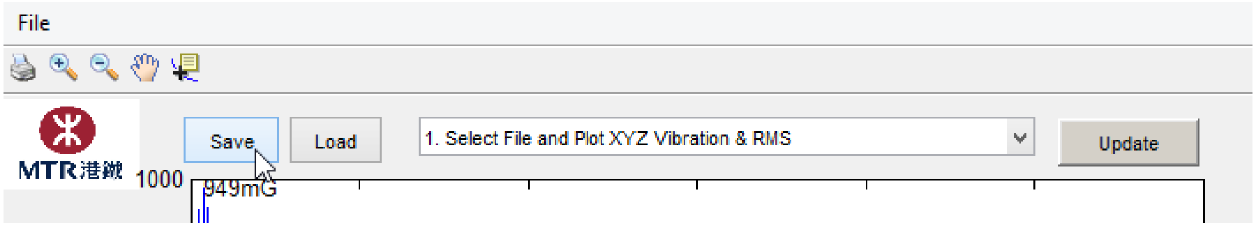
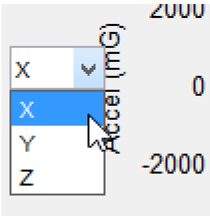
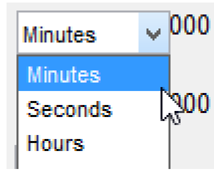


Figure 17 Load/save the data

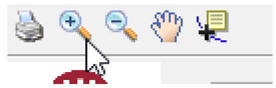
9. Flexible controls – on the far left hand side of the screen, you have the option to:-
   a) Swap the axis of the graph depending on the orientation of the sensor



   b) Change the horizontal scale of the graph from minutes -> seconds etc.



c) Print -> zoom in -> zoom out -> pan -> peak finder



17. Analysis 1- General Analysis (Peak and Average Vibration)

Once you load the data the general analysis is automatically initiated:-

a) The **peak vibration** will be displayed on top of the peak
b) The **average vibration** (in root mean squared) will be displayed at the far right side of the graph

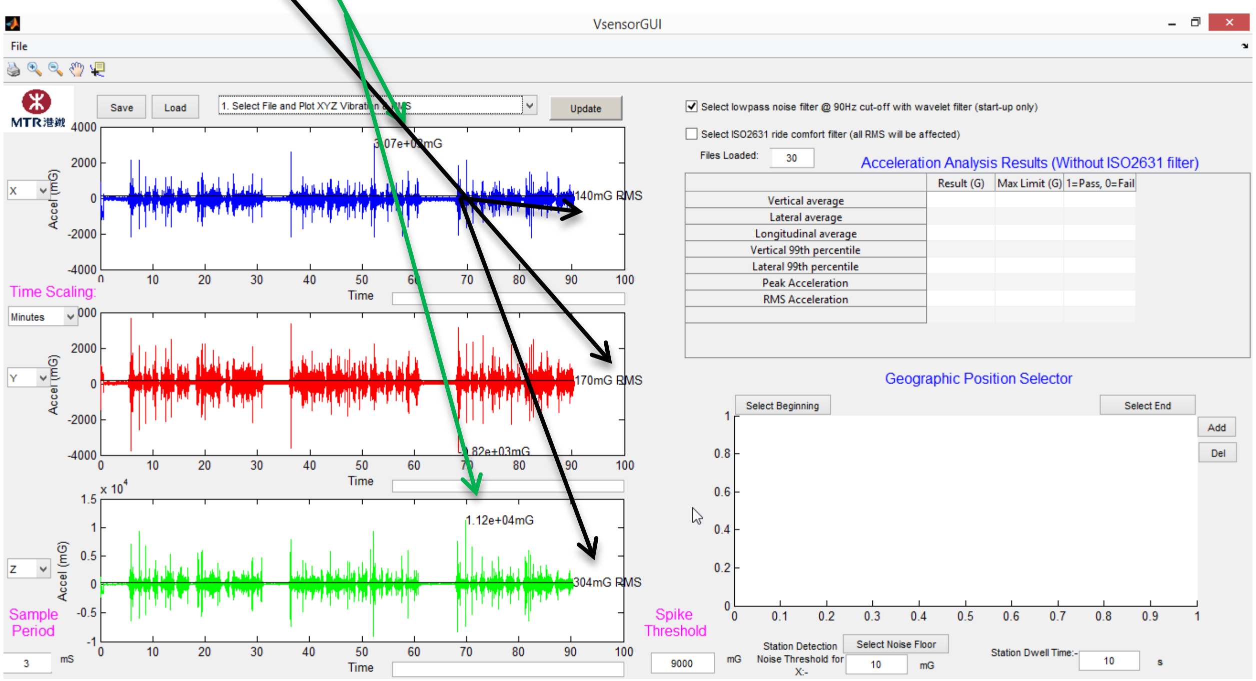
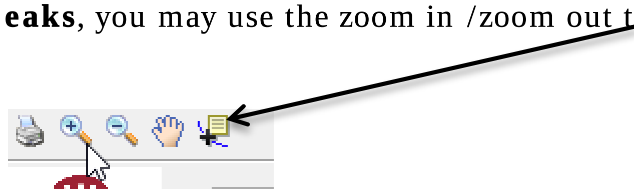


Figure 18 Sample average vibration & peak finder plot

c) If you want to find **local peaks**, you may use the zoom in /zoom out tool along with the peak finder tool:-



d) A **frequency domain plot** will be created in a separate window, you can find in in the task bar. You may also apply the peak finder tool or zoom in/zoom out on this plot. NOTE THAT THERE MUST BE SUFFICIENT DATA (ACCORDING TO NYQUIST VERIFICATION FORMULAS) OTHERWISE THE FREQUENCY PLOT WILL NOT APPEAR.

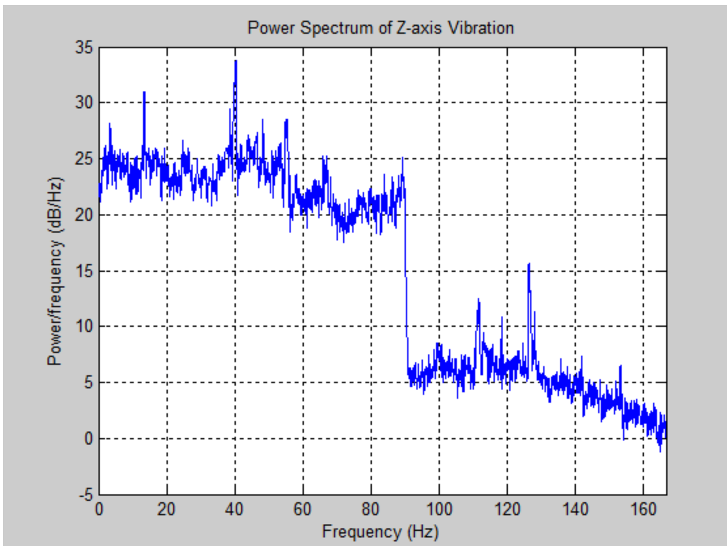


Figure 19 Sample frequency domain plot

18. Analysis 2- Global Analysis (Whole Train Route Analysis)

1. In the top drop down menu, select “Global Analysis Criteria”

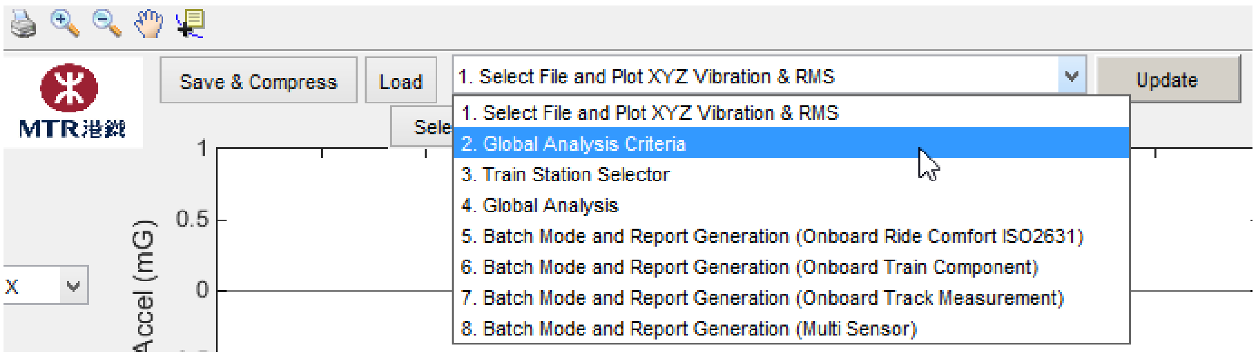


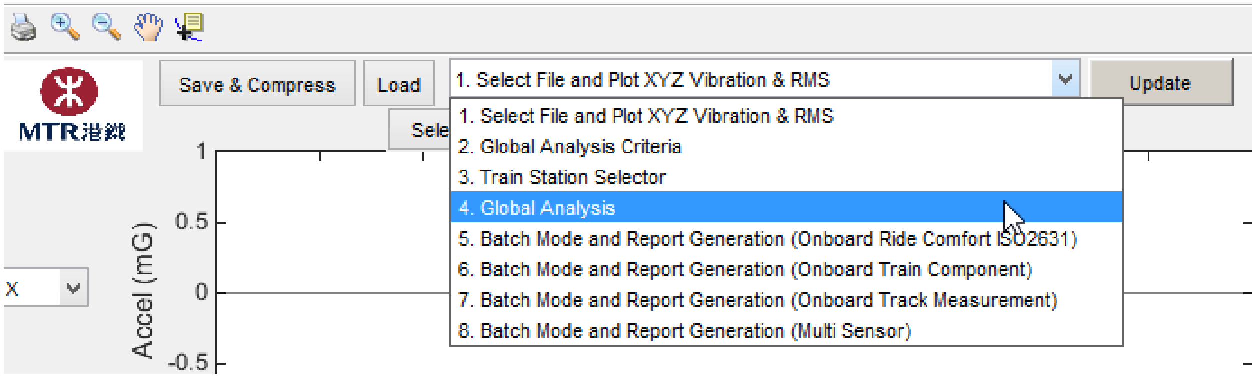
Figure 20 Drop down menu for function selection

2. An Excel file will popup for you to enter the analysis limits based on the train design criteria. The nominal values have already been included into the Excel file:-

	A	B	C
1	**Acceleration Analysis Settings**		
2			
3	**Ride comfort limits**	**Limit**	**Units**
4	Vertical journey average	0.01	g
5	Lateral journey average	0.013	g
6	Longitudinal journey average	0.004	g
7	Vertical 99th percentile	0.02	g
8	Lateral 99th percentile	0.026	g
9			
10	**Structural integrity limits**	**Limit**	**Units**
11	Proof load	2	g
12	Fatigue load (+/-)	0.15	g

Figure 21 Settings that can be changed in Excel “settings.xls”

3. Run the global analysis by selecting “Global Analysis” from the drop down menu:-



4. The table on the right hand side of screen will change to reflect the RMS vibration's calculated for each axis then compare them with the Excel file limits you have previously defined.

Files Loaded: 30

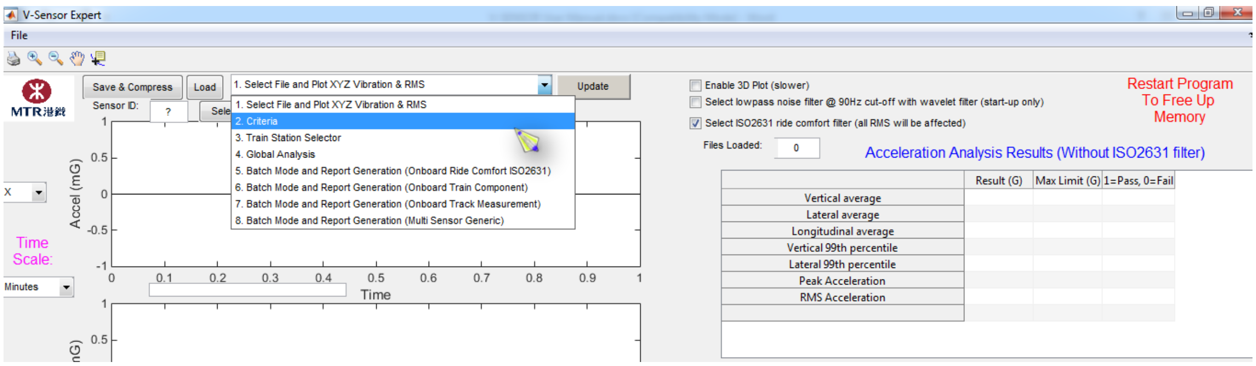
Acceleration Analysis Results (Without ISO2631 filter)

	Result (G)	Max Limit (G)	1=Pass, 0=Fail
Vertical average	0.0354	0.0100	0
Lateral average	0.0712	0.0130	0
Longitudinal average	0.0669	0.0040	0
Vertical 99th percentile	0.8109	0.0200	0
Lateral 99th percentile	0.5223	0.0260	0
Peak Acceleration	11.1943	2	0
RMS Acceleration	0.3037	0.1500	0

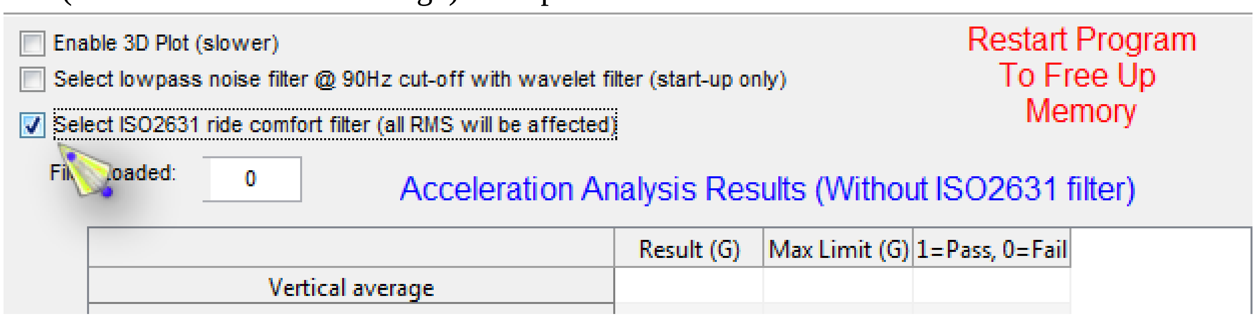
Figure 22 Table for benchmarking calculated results with train structural limits

19. Analysis 3- Station to Station Route Analysis

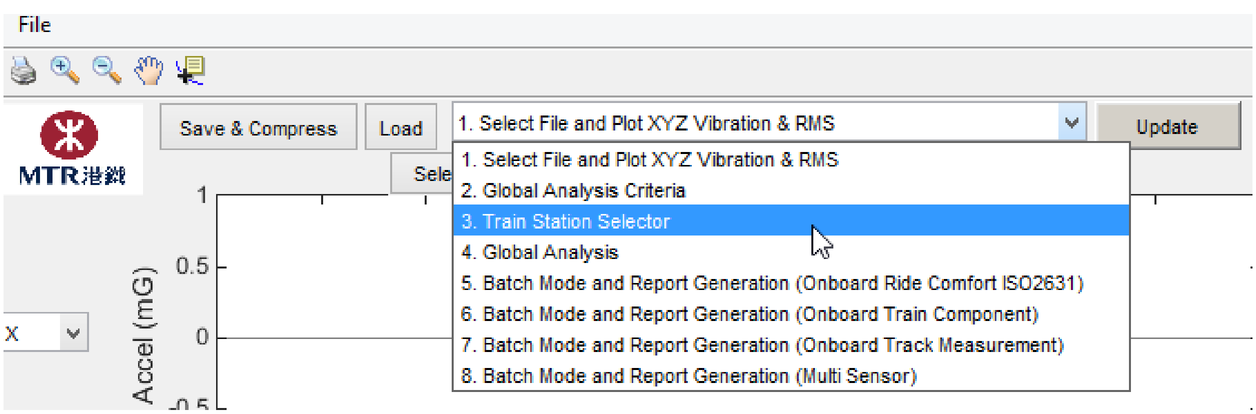
1. Setup
   1.1. If you are planning to do automatic global analysis i.e. update the table on the far right hand side, then set your criteria from the Excel file in the drop down menu at the top of the screen:-



   1.2. If you are planning to use ISO2631 filter for calculating the ride comfort RMS (all RMS values will change) then place a tick on the box shown below:-



2. Automatic station detection
   2.1. In the drop down menu, select option 3 Train Station Selector -> press update



   2.2. In the graph at the bottom right hand side of screen, select "select noise floor"

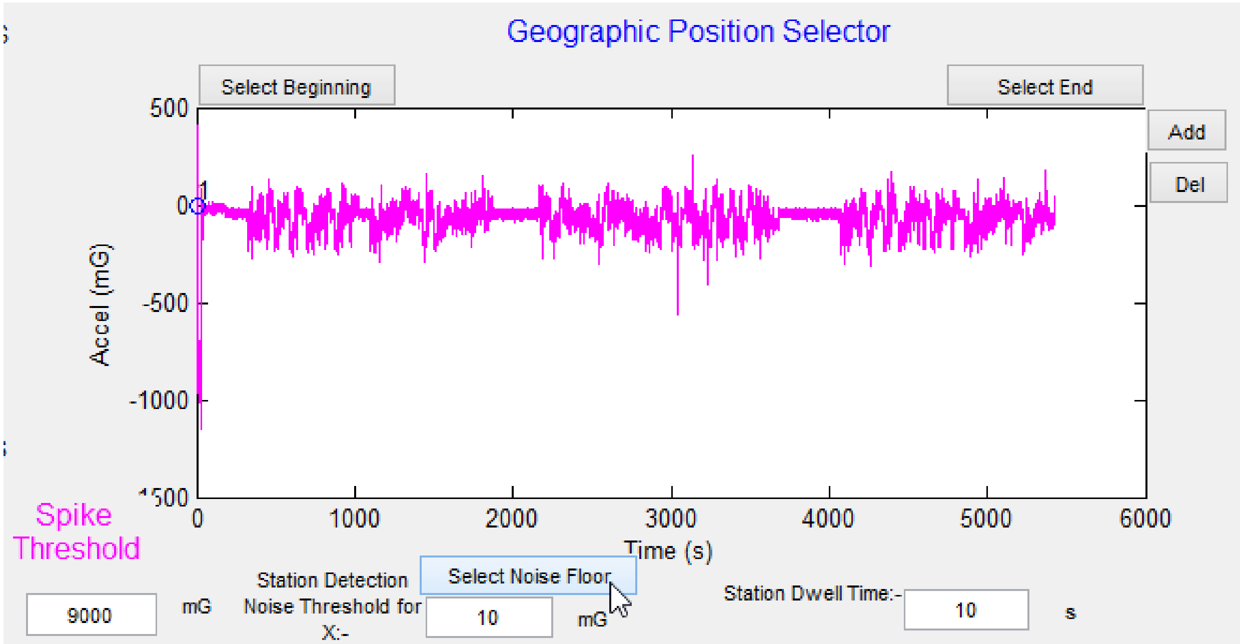


Figure 23 Noise floor selector

2.3. Click twice on the noise area to define its magnitude

Figure 24 Noise floor selector – first mouse click

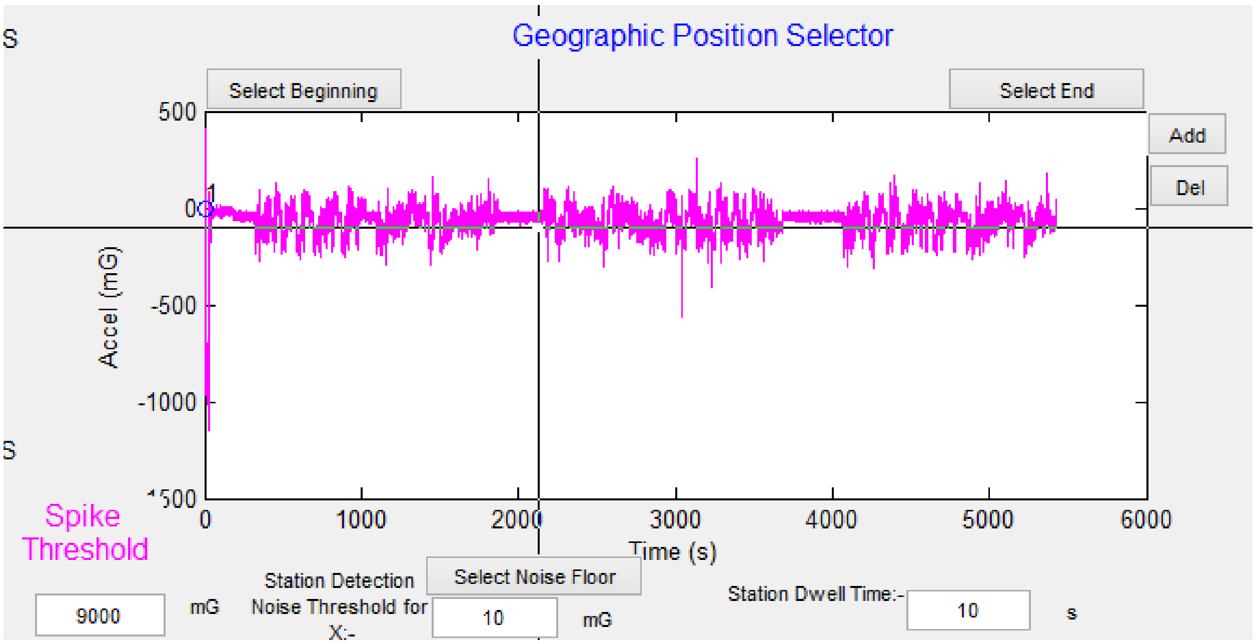


Figure 25 Noise floor selector – second mouse click

The noise floor value now appears in the "Station Detection Noise Threshold for X" cell:-

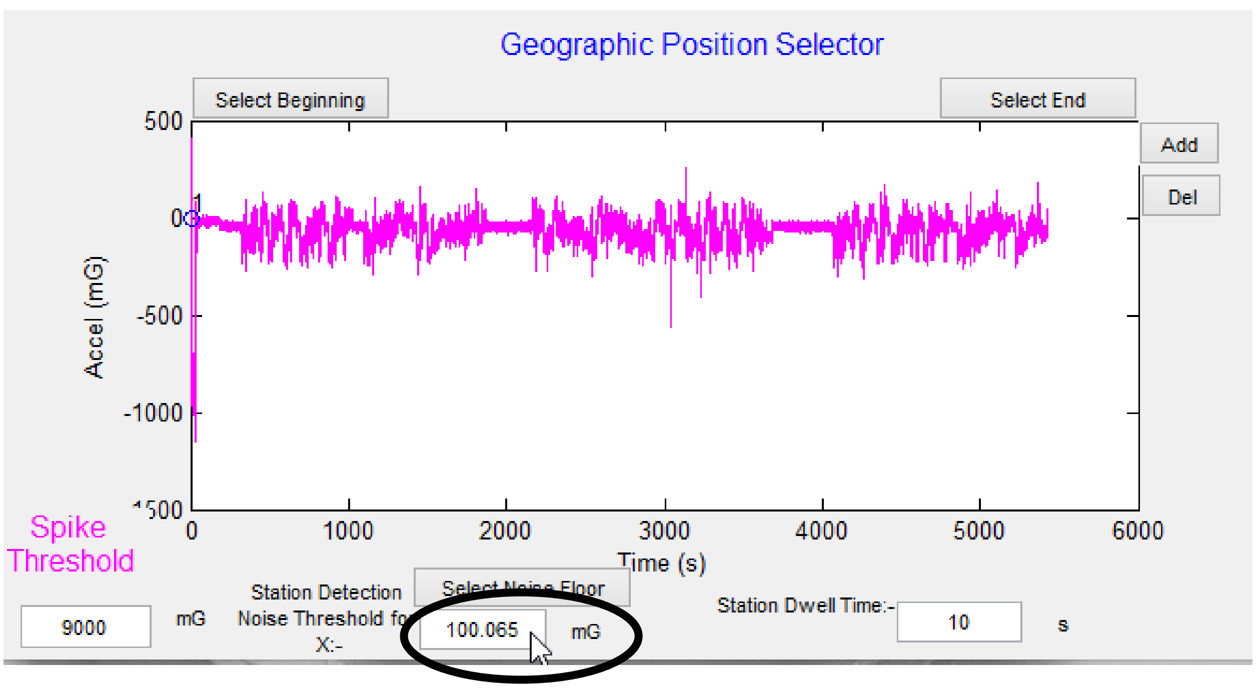


Figure 26 Noise floor selector – value calculated by software

2.4. Press update and all the stations are now automatically detected and circled below:-

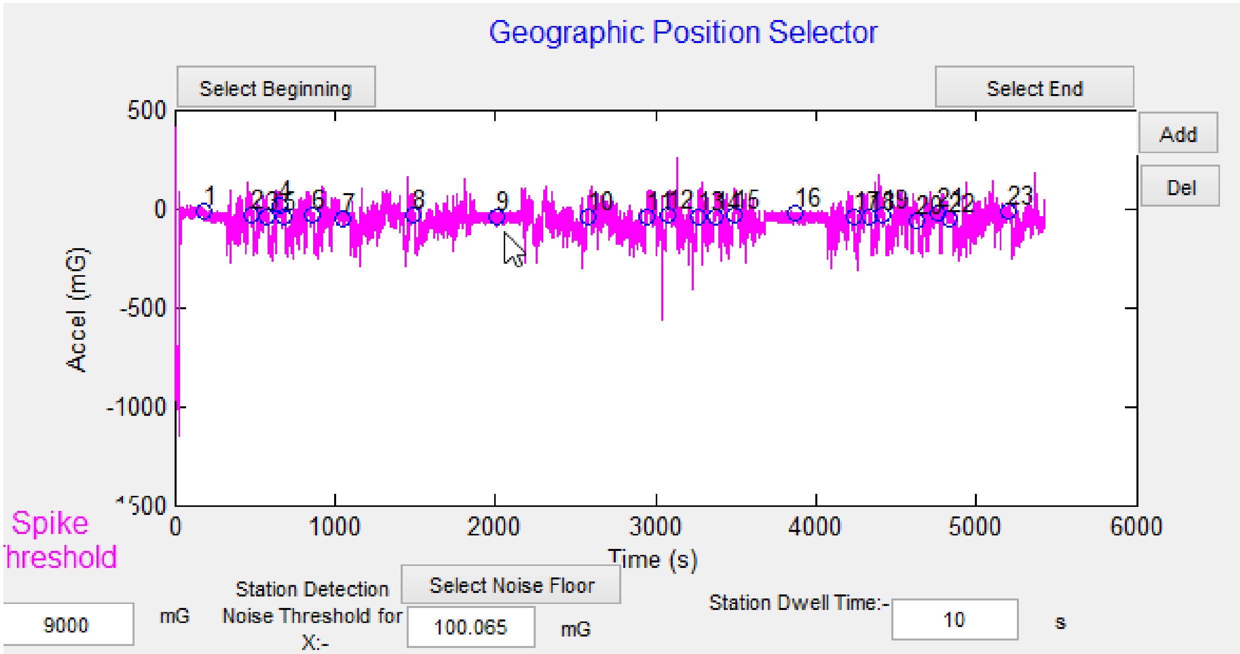
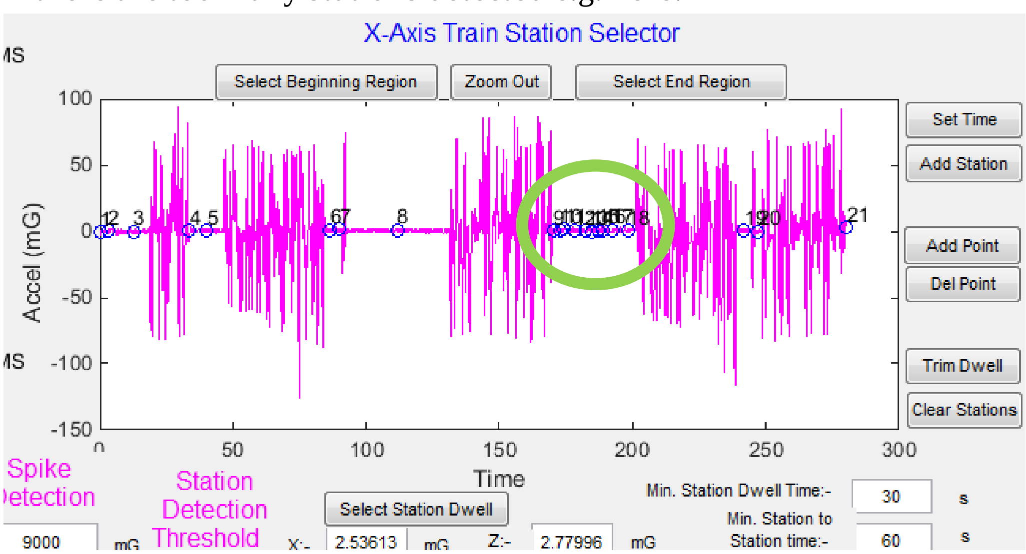


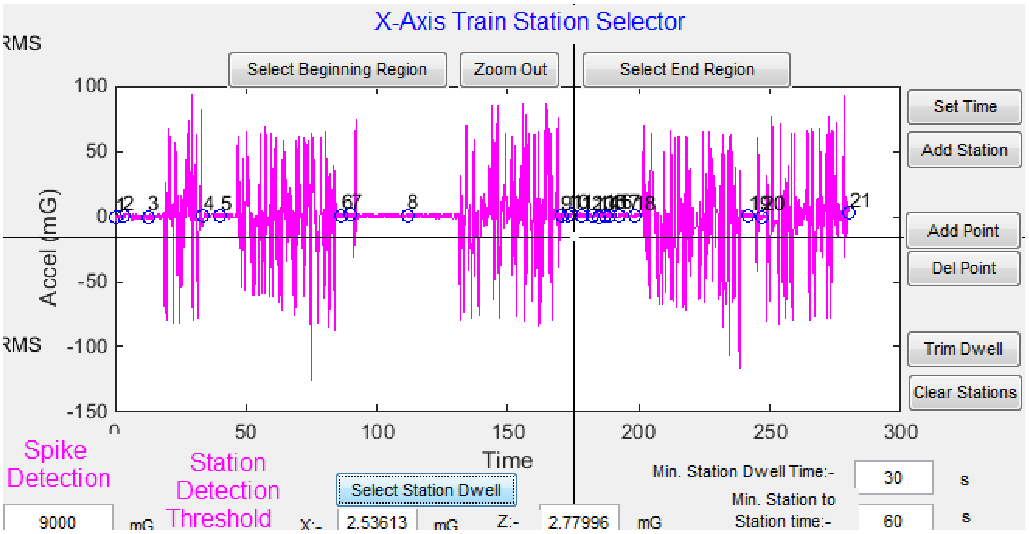
Figure 27 Automatic station selection

If there are too many stations detected e.g. here:-

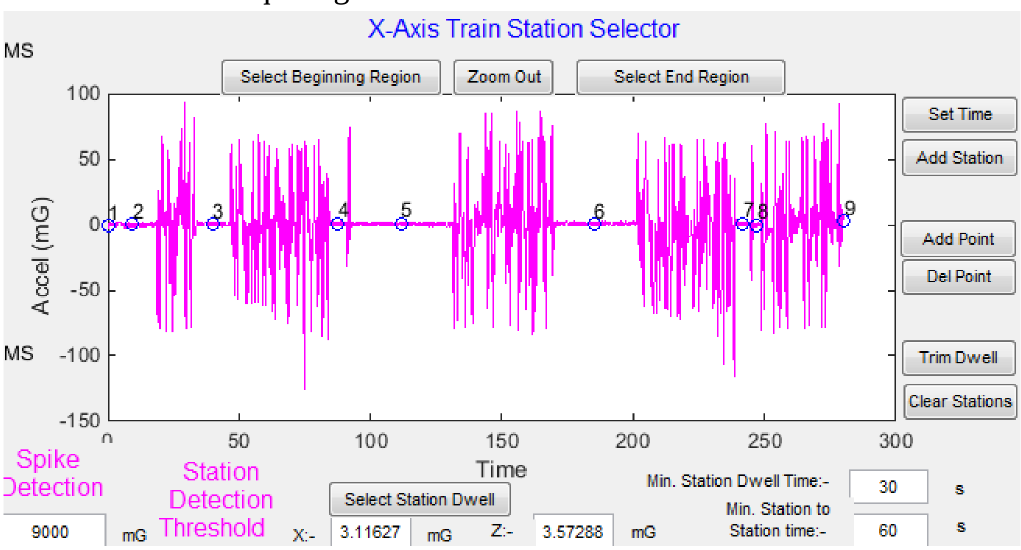


That is due to the threshold being too low.

For this case, you can use the station dwell selector below and select the dwell area with too many stations:-



The result will be quite good:-



2.5. You also have the flexible option to change the threshold value if you consider the number of stations are too many/less and add or delete stations by using the 2 buttons on the far right hand side of screen.

3. Station to station analysis

3.1. Press “select beginning” and select the 1st station in the time interval

3.2. Press “select end” and select the 2nd station in the time interval

3.3. Press update

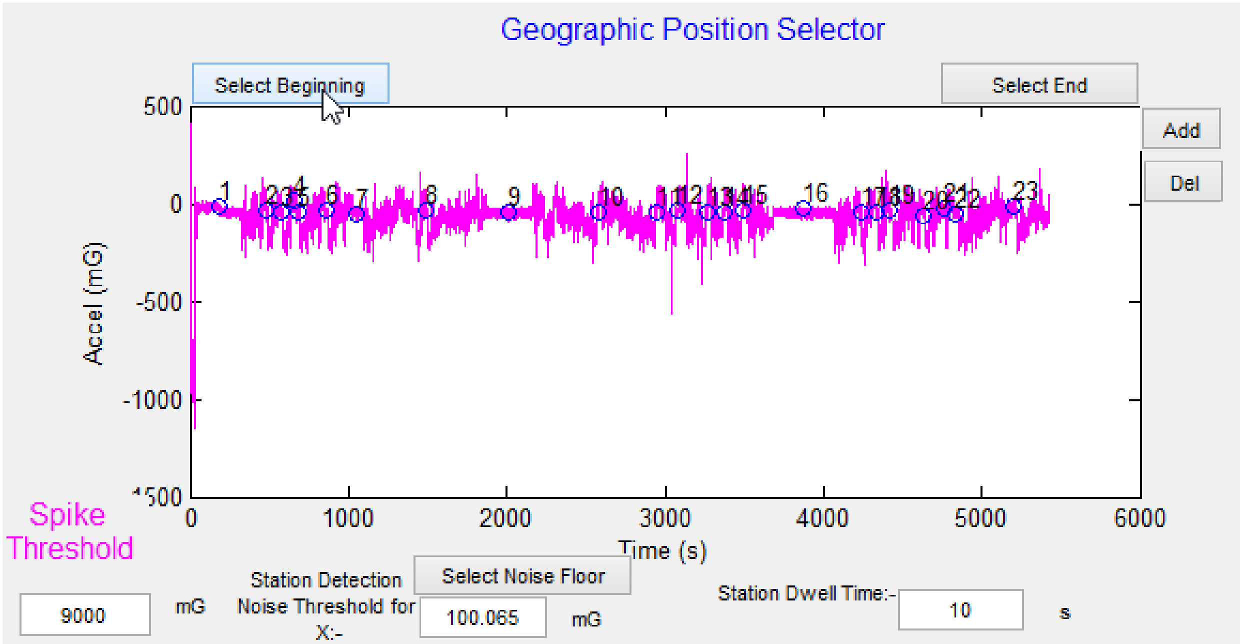


Figure 28 Automatic station selection – first mouse click to select station to station

3.4. Note that if you did tick the ISO2631 filter dialog box, it will ask which pre-filter to choose for the ride comfort analysis (all RMS will change value as a result):

3.4.1. ISO2631 which filters 0.5Hz to 80Hz in accordance with the standard.

3.4.2. MacMinder filter which ranges between 0.05Hz to 20Hz. MacMinder is a internationally used device that measures ride comfort. The values produces are usually around ½ in magnitude as the ISO2631 filter. To compensate for the reduction in magnitude, in Hong Kong trains, they use an acceptance criteria of 10mg and 13mg for vertical and lateral vibration respectively instead of the ISO2631 acceptance criteria.

3.5. You will find the graphs at the left hand side changes and all the calculations are adjusted for the station to station interval you selected. Furthermore, a frequency power spectrum plot is shown that represents the frequency spectrum for that particular analysis interval.

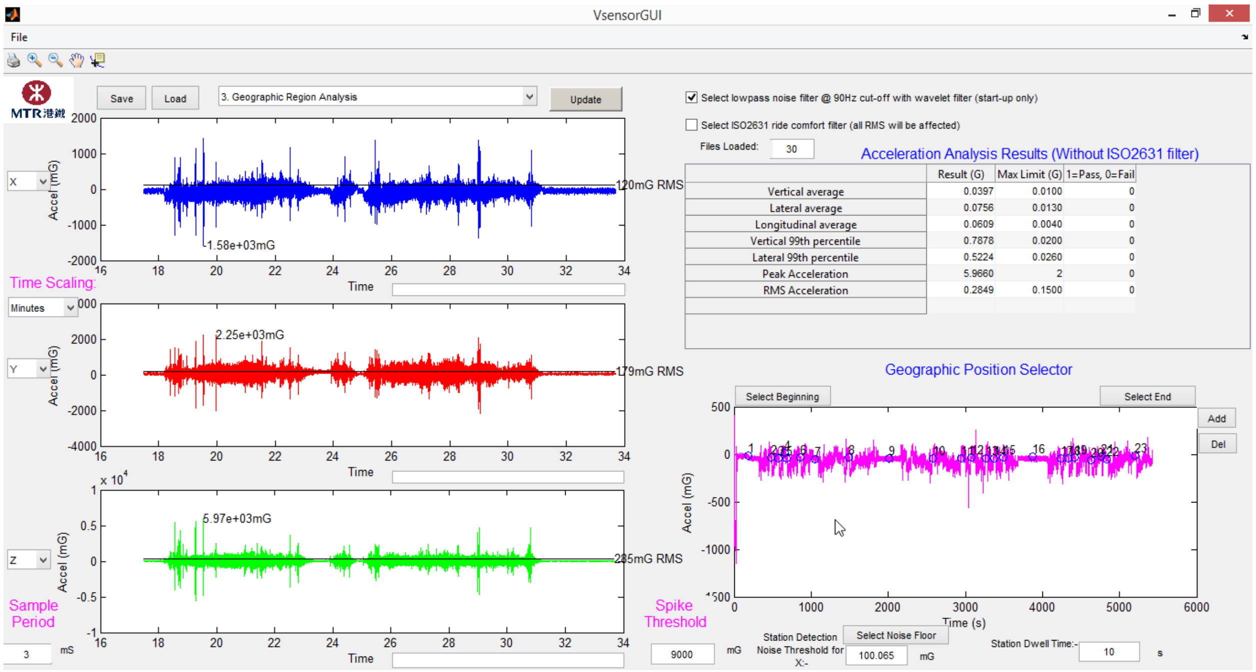


Figure 29 Station to station analysis results – average RMS calculated (example)

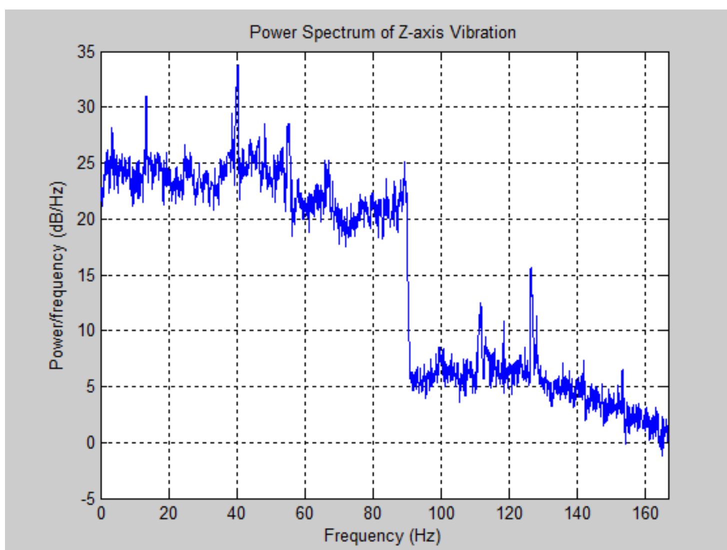
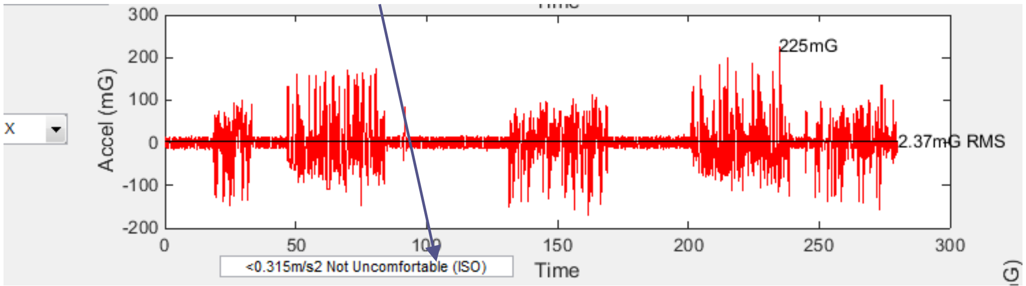
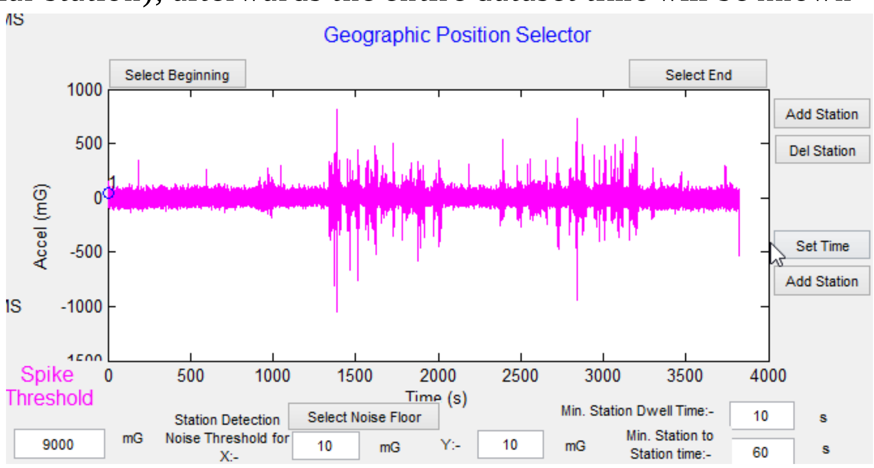


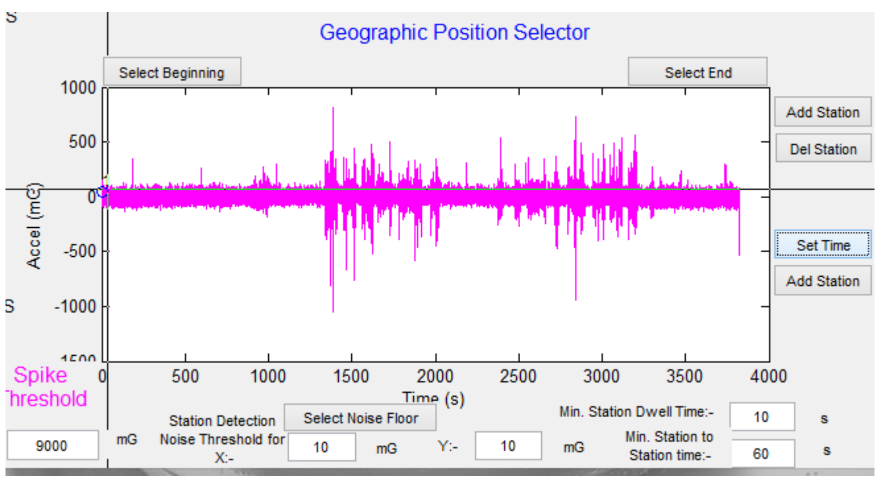
Figure 30 Station to station analysis results – frequency domain calculated (example). Note the Y axis is in dB/Hz

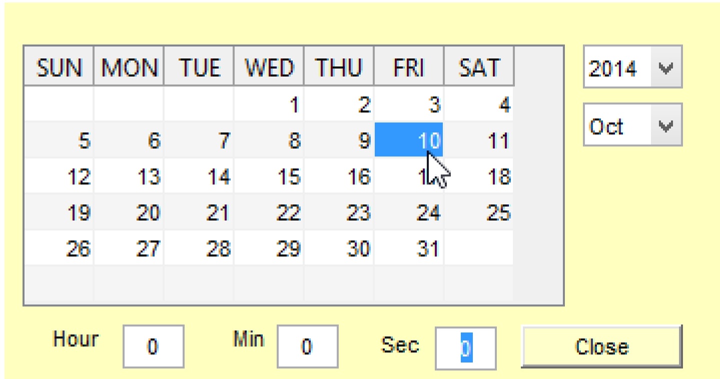
3.6. Now if you selected ISO2631, the RMS values shown on the graph will be the ones post filtered by ISO261. And there will be advice on whether they satisfy the filter criteria or not:-

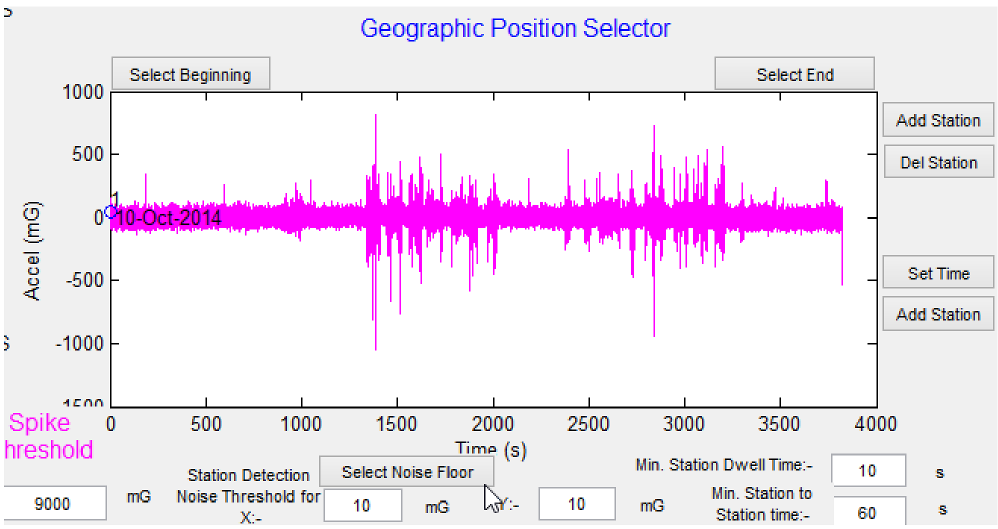


4. Manual station detection – if you have recorded down the station times manually
    4.1. Click "set time" then set any known time (it can be the start time of the data when you switched on the device or the switch off time or the time of a particular station); afterwards the entire dataset time will be known

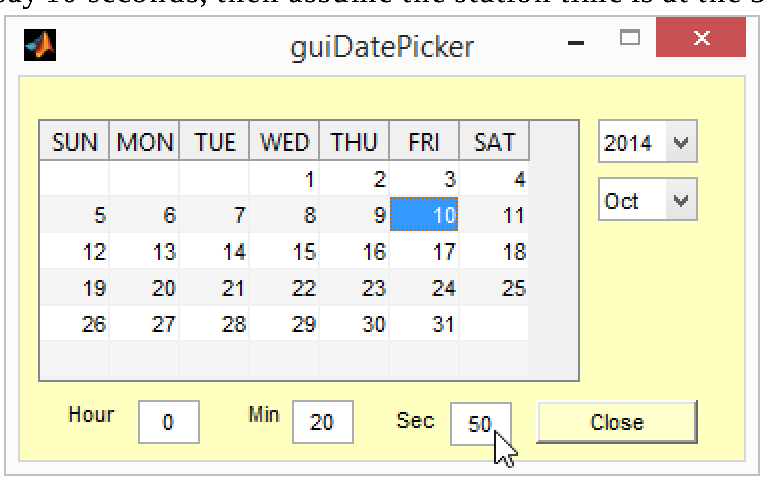


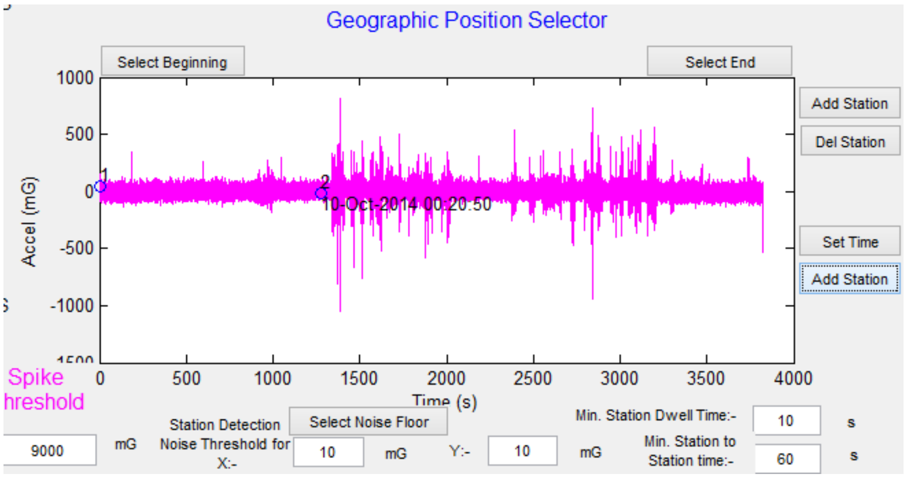






4.2. Click "add station" then set the time of the station(s) that you recorded down, the station(s) will be inserted in the correct time (for a train that stopped at a station for say 10 seconds, then assume the station time is at the 5th second).

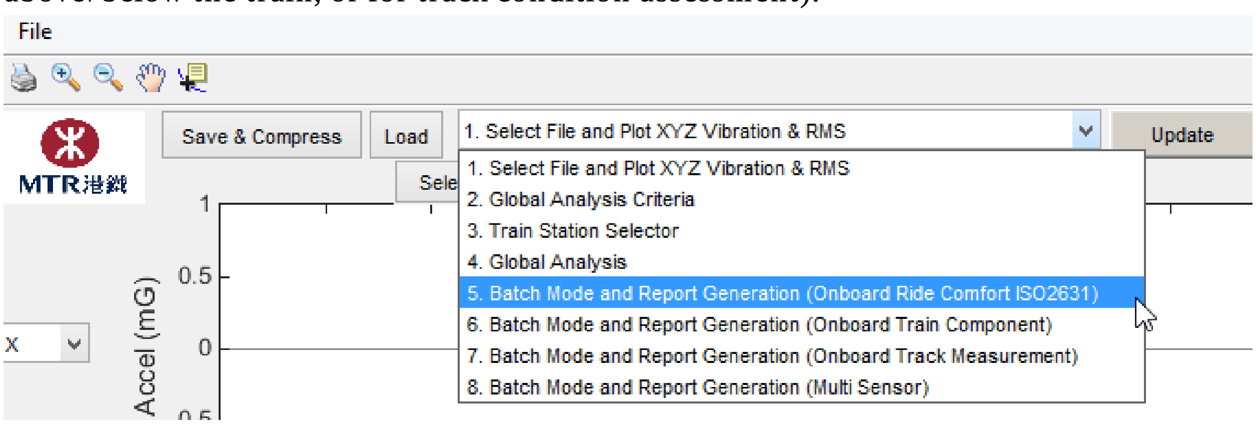




20. Analysis 4- Station to Station Automatic Report Generation

1. This is relevant only to sensors installed onboard the train either above or below the underframe.
2. Ensure you have selected the range of stations to analyze using the train station selector analysis tool. Otherwise the analysis won't run.

3. At the top drop down menu, select Batch mode (either train saloon, train component above/below the train, or for track condition assessment).



   a) Onboard Ride Comfort assessment mainly focused on station to station analysis of **average vibration, peak vibration, and ride comfort level.**
      a. This analysis mode will ask which pre-filter to choose:
         i. ISO2631 which filters 0.5Hz to 80Hz in accordance with the standard.

ii. MacMinder filter which ranges between 0.05Hz to 20Hz. MacMinder is a internationally used device that measures ride comfort. The values produces are usually around ½ in magnitude as the ISO2631 filter. To compensate for the reduction in magnitude, in Hong Kong trains, they use an acceptance criteria of 10mg and 13mg for vertical and lateral vibration respectively instead of the ISO2631 acceptance criteria.

b) Onboard Train component assessment is mainly for station to station analysis of **average vibration and peak detection.**

c) Onboard Track condition assessment is mainly focused on assessing the **average vibration for every 10 second intervals** on the vertical axis then the vibration is ranked from lowest to highest.

4. You will be prompted to save the word file:-

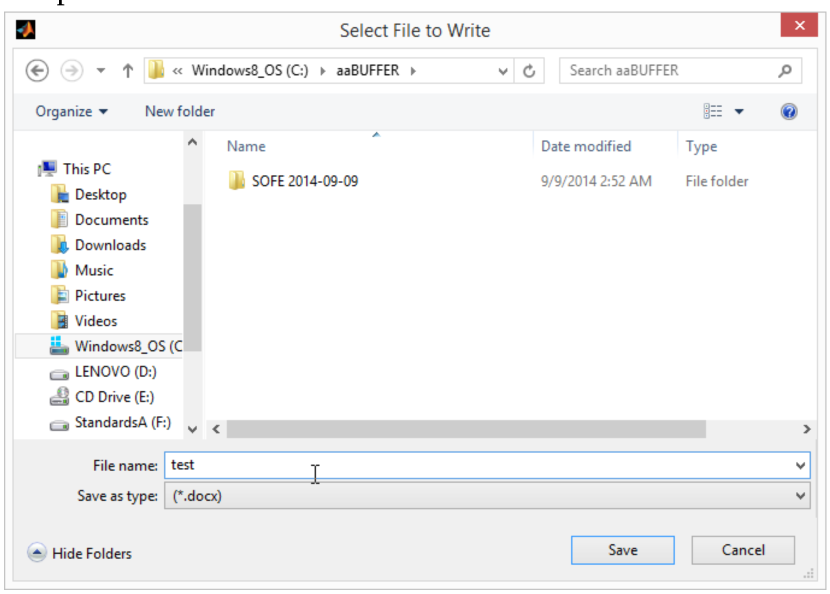
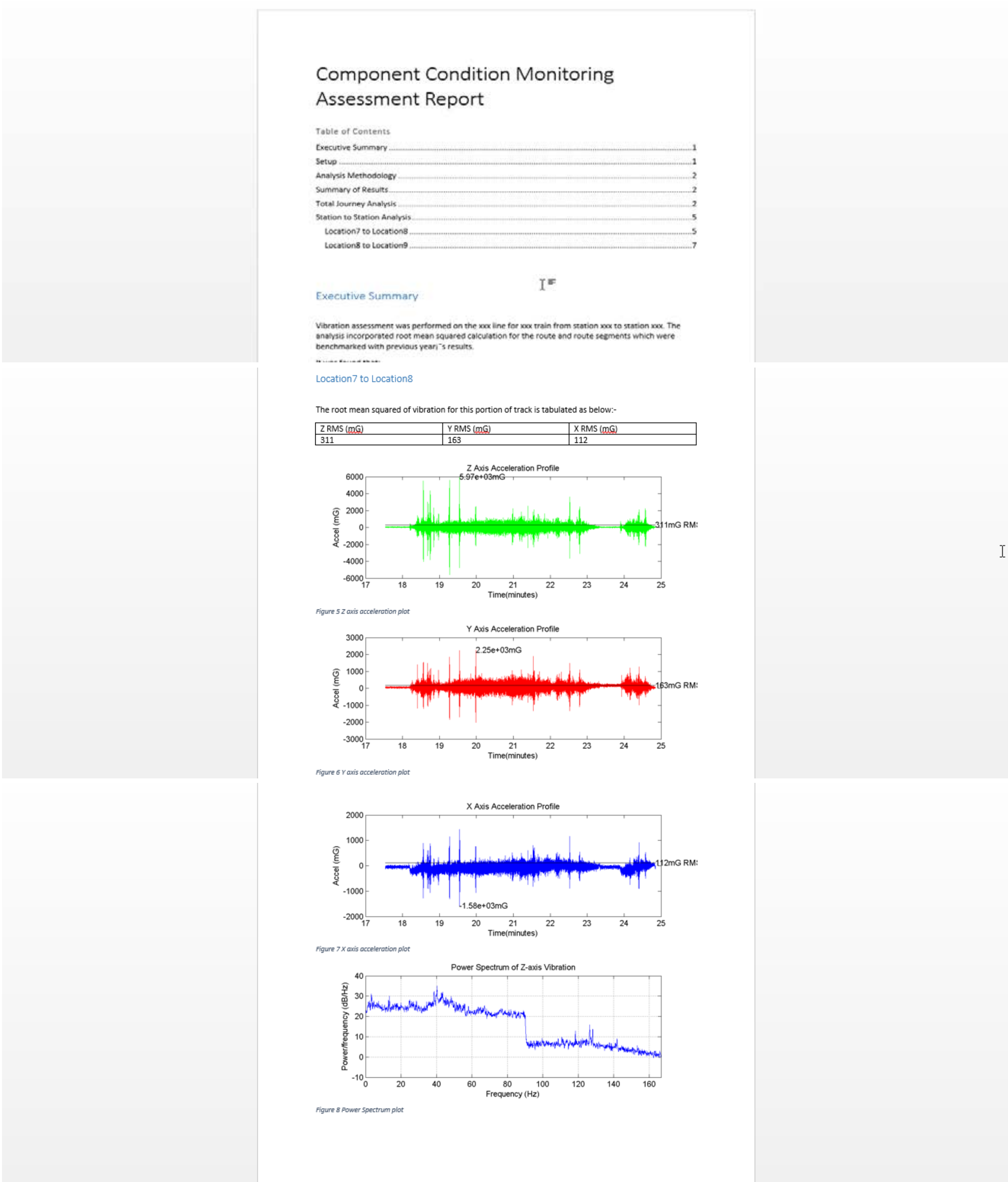


Figure 31 Word file save directory selector

5. Wait until a Microsoft Word file report is generated. The report provides:-
   a) Automatic executive summary generation
   b) An analysis of the whole trip
   c) An analysis of each station to nearby station vibration assessment based on RMS on each 3 axis, peak detection, and frequency spectrum analysis.



Component Condition Monitoring Assessment Report

Table of Contents

Executive Summary

Vibration assessment was performed on the xxx line for xxx train from station xxx to station xxx. The analysis incorporated root mean squared calculation for the route and route segments which were benchmarked with previous year's results.

Location7 to Location8

The root mean squared of vibration for this portion of track is tabulated as below:-

Z RMS (mG)	Y RMS (mG)	X RMS (mG)
311	163	112

Figure 5 Z axis acceleration plot

Figure 6 Y axis acceleration plot

Figure 7 X axis acceleration plot

Figure 8 Power Spectrum plot

Figure 32 Example report being generated (partial screen capture)

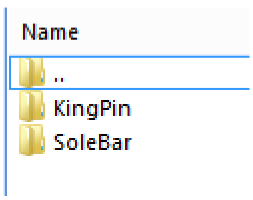
6. Remember to save as .doc NOT .docx otherwise you will lose all the pictures.

21. Analysis 5- Multi Sensor Batch Analysis on Same Time Scale with Automatic Report Generation

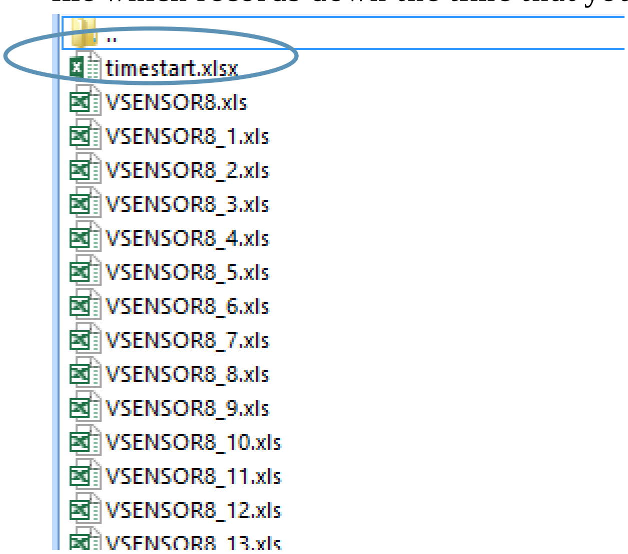
1. This is relevant when you have multiple sensors installed in different locations/positions and want to analyze them on the same timeframe.

2. Install your sensors in different locations, make sure you record the date/time you turn on the sensor. It is highly recommended that you use the Android APP HamtClock to record down the time in "seconds" accuracy.

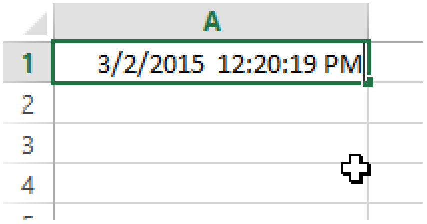
3. Prepare your data by placing your different sensor data into sub folders which you name as the location description (see example as below):-



4. In each subfolder (which represents a sensor dataset/location), add a timestart.xlsx file which records down the time that you turned on the sensor:-

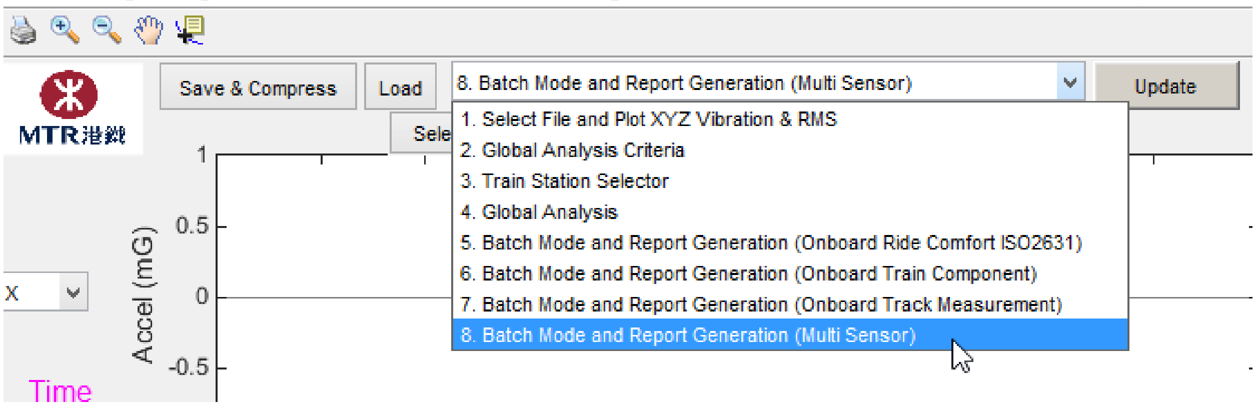


In cell A1, type in the start time of the sensor in the format of:-
2 mar 2015 12:20:19 pm



Do this for every subfolder / dataset

5. At the top drop down menu of V-Sensor Expert, select Batch mode (Multi Sensor).



6. Press update and follow the instructions to generate the analysis report
   - You will be asked to select a time/date range that you want to analyze the data, first select the start time/date -> press ok; then select the end time/date -> press ok again.

7. Report generated has all the plots of multiple sensors on the same time scale:-

Multiple Sensor Vibration Assessment Report

Table of Contents

Executive Summary

Vibration assessment was performed on xxx for multiple sensors. The analysis incorporated root mean squared calculation which were benchmarked with other sensors which are all plotted on the same time frame (same start time and end time).

It was found that:-

a) xxx had the relative highest vertical RMS vibration compared with other sensors.

b) xxx has the relative lowest vertical RMS vibration

Location	Z RMS (mG)	Y RMS (mG)	X RMS (mG)
SoleBar	24	32	40
KingPin	231	45	46

Setup

Test date:

Test train:

Test locations:

1.KingPin

2 SoleBar

VSENSOR 3-axis digital accelerometers were installed.

Photographs:

Analysis Methodology

Vibration is represented by the calculation of the root mean squared without acceleration/deceleration bias. These values are then benchmarked with other measurement locations of the same time frame for comparison purposes.

Summary of Results

On benchmarking with other sensor locations, there was no significant vibrations worth further investigation.

Root mean square vibration ranking for the various tested locations are stipulated below starting from the lowest vertical vibration:-

Location	Z RMS (mG)	Y RMS (mG)	X RMS (mG)
SoleBar	24	32	40
KingPin	231	45	46

KingPin Vibration Analysis Graphs

The vertical vibration in terms of root mean squared was calculated and used for comparison purposes.

Date	Vibration RMS without Acceleration Bias (mG)
06-Mar-2015	231

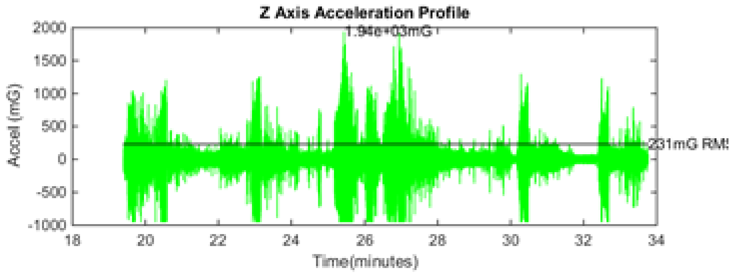


Figure 1 Z axis acceleration plot

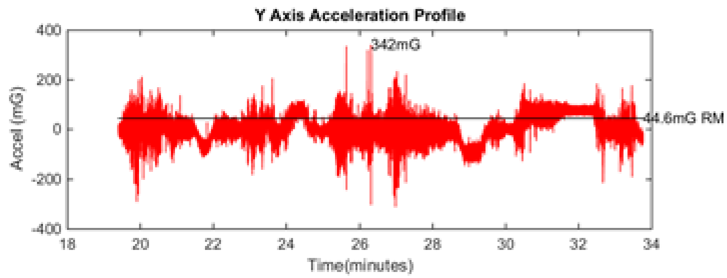


Figure 2 Y axis acceleration plot

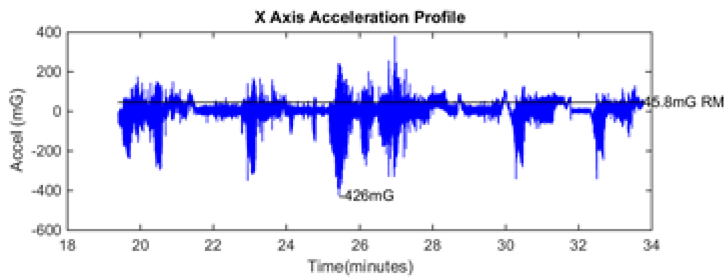


Figure 3 X axis acceleration plot

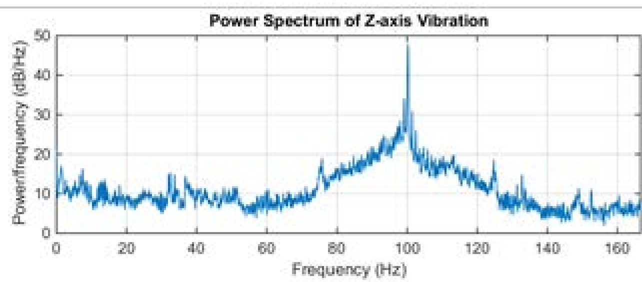


Figure 4 Power Spectrum plot

SoleBar Vibration Analysis Graphs

The vertical vibration in terms of root mean squared was calculated and used for comparizon purposes.

Date	Vibration RMS without Acceleration Bias (mG)
06-Mar-2015	24

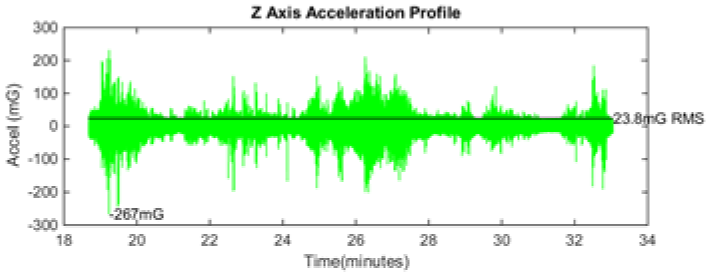


Figure 5 Z axis acceleration plot

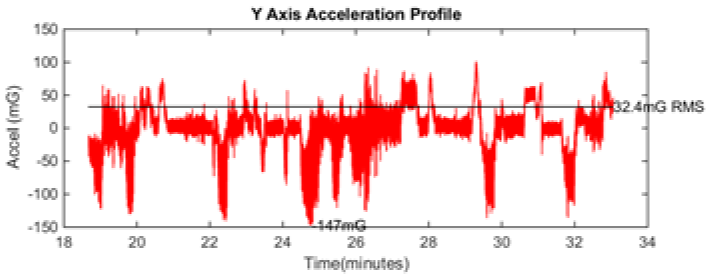


Figure 6 Y axis acceleration plot

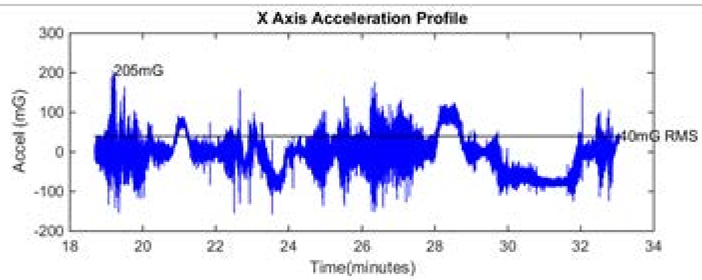


Figure 7 X axis acceleration plot

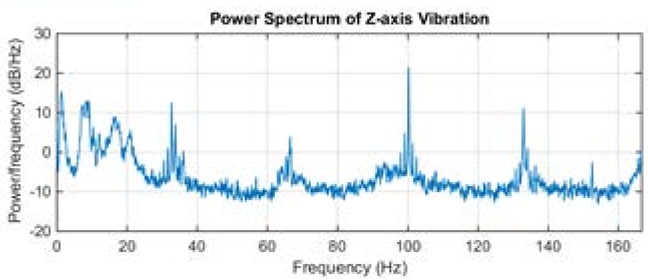


Figure 8 Power Spectrum plot