SanDAS
Software Manual

Company:	**Sanline Ltd.** 5F.-3, No.390, Sec. 1, Fuxing S. Rd., Da'an Dist., Taipei City Tel: +886 2 227081730
Author:	**Johnny Yang**
Checked:	**Eno Yu**
Distribution:	**Sanlie Ltd., Customers**

Document Revision

Version Date	Comment
14.02.2020	SanDAS version 1.00

Disclaimer

Sanlien Ltd reserves the right to change the information contained in this document without notice. While the information contained herein is assumed to be accurate, Sanlien Ltd assumes no responsibility for any errors or omissions.

Copyright Notice

No part of this document may be reproduced without the prior written consent of Sanlien Ltd. The software described in this document is furnished under a license and may only be used or copied in accordance with the terms of such a license.

Table of Content

1 The SanDAS Application

1.1 Introduction

This manual describes the Sanlien Data Acquisition System (hereafter SanDAS or just program application). SanDAS is a graphical cross-platform application. All recent Windows versions are supported, down to Windows 10. It may work also on the obsolete Windows 7 but we no longer support it.

This Program is used for instrument configuration 、acquisition of data provided by any standard Sanlien instrument and offline event data analysis.

SanDAS general tasks:

→ Setup of an instrument. One can change config files of an instrument with SanDAS.
→ State of health (SOH) monitoring. SanDAS performs periodical monitoring of instrument status.
→ Downloading of the event files from an instrument working as a recorder
→ Offline event data view and simple data analysis
→ Real-time data viewer for an instrument, which provides a serial data stream.

2 Application Installation
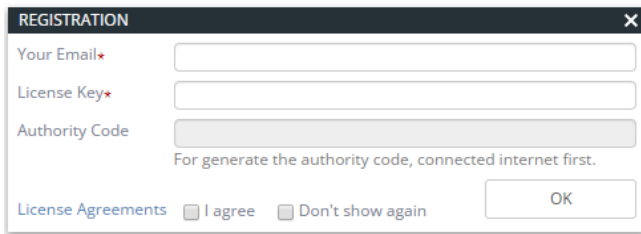
SanDAS is a portable software, after unzipping, right-click the SanDAS.exe file in the folder and select "Properties".
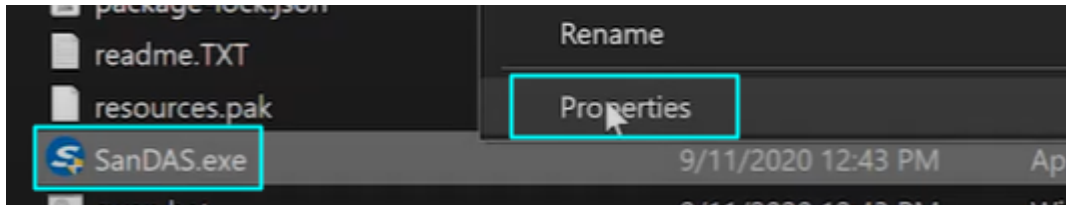
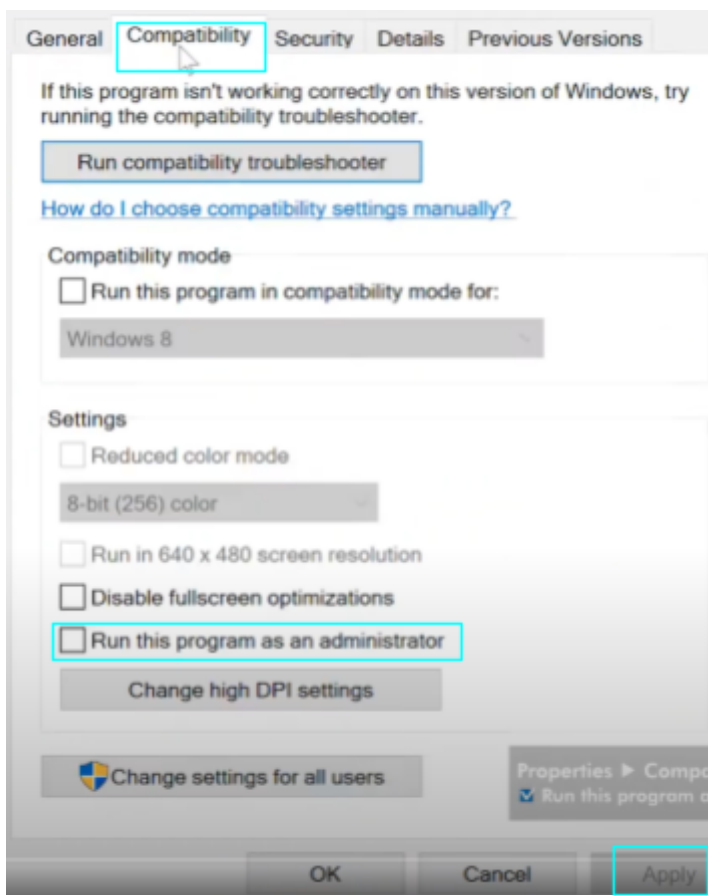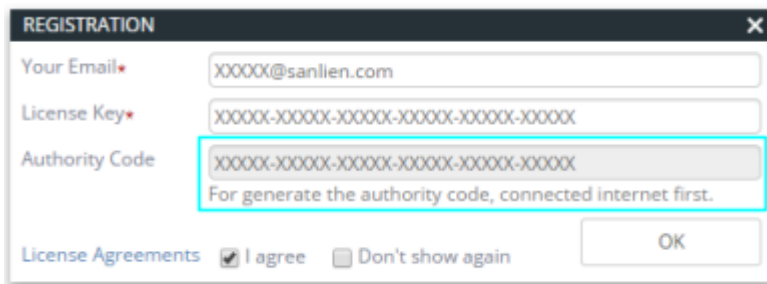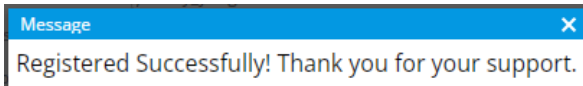In the "Compatibility" tab on properties page, please tick the "Run this program as an administrator" option and click "Apply".
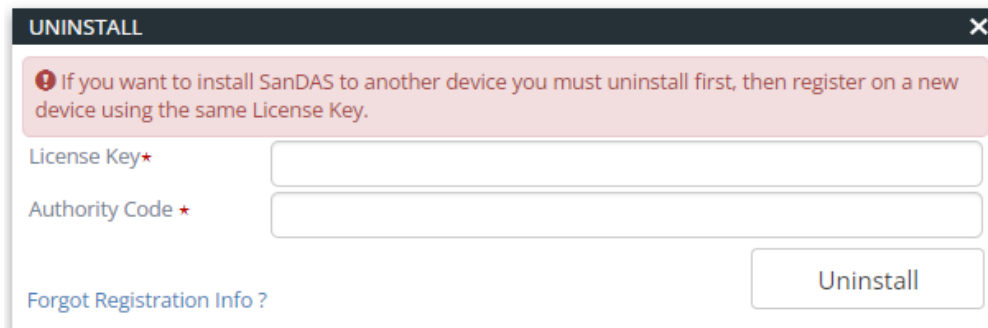
➤ Please note that the "Analyse" functionality is provided as an option. A customer has to order it and receive a valid license key, which must be entered during installation in order to enable access to the "Analyse" menu of SanDAS. The computer must be able to access the internet to generate the authority code.
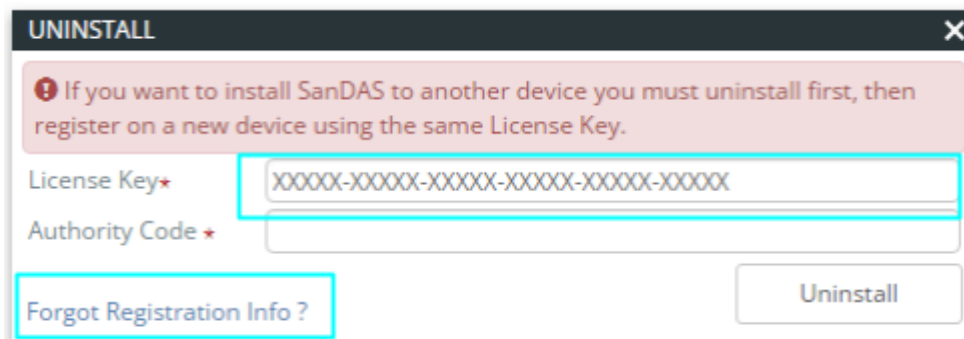
If registration is successful, SanDAS will alert message and fill authority code automatically.

The license is for one computer only at the same time. If you want to use it on another computer, please click "**Help / Uninstall**" from the menu bar, and type in the license key and authority code. Click on "Uninstall" and it will take you back to the registration steps.

If you forgot the registration info, please fill **"License Key"** then click **"Forgot Registration Info?"**,

then you can receive **"License Key"** and **"Authority Code"** in your registered email.

License Key: XXXXX-XXXXX-XXXXX-XXXXX-XXXXX-XXXXX

Authority Code: XXXXX-XXXXX-XXXXX-XXXXX-XXXXX-XXXXX

3 Getting Srarted

3.1 SanDAS Main Screen

The main SanDAS screen is shown in the figure below. The figure also indicates the basic elements of this screen.

The main menu lists the basic categories of functions available: **File, Analyse, Settings** and **Help**. All of them have pull-down submenus and all the references to items of submenus are given hereafter in the form "Main_menu_item/Submenu_item", for instance menu item File/Exit quits the application.

Besides the pull-down menus, there are also **context menus** available in many child windows. Right click in a window, and the corresponding menu will appear, if available. The content of such menu and the accessibility of

its items depend on the current context: whether a parent window displays some information, whether it has at least one item selected, etc. An example of such menu is shown in the picture above for the window "Graph Data Monitor".

There are two toolbars available in SanDAS with the buttons for the main operations: **Station Toolbar** and the **LFV Toolbar**. With the first toolbar one can select a station from the list and perform the basic operations with selected station. The LFV toolbar has buttons for many operations of the Local File Viewer.

The **Status Toolbar** located at the bottom of the main window displays important system messages, progress indicators for the operations, which take a long time and some other status information.

Data Streams Info Window displays various parameters of all the configured stations: general information, status of the data stream, parameters of the communication channels, etc.

Other elements of the SanDAS interactive interface are many dialog windows, which are used to set different working parameters or to monitor some detailed information arriving from an instrument.

When you start SanDAS for the first time, you will see the Registration window only. No other information windows appear on the screen because you did not configure any station yet. Therefore, the next steps after the SanDAS installation is to configure the stations you will work with and set parameters of the instruments.

4 Configuring Stations

The term "station" is used in a different context:
- "Station" refers to the physical device type (such as "pAalert").

☞ Every Station is identified by its unique name.

4.1 Adding stations

The stations are configured manually with the dialog, which is launched either from the Settings/Configured Station.
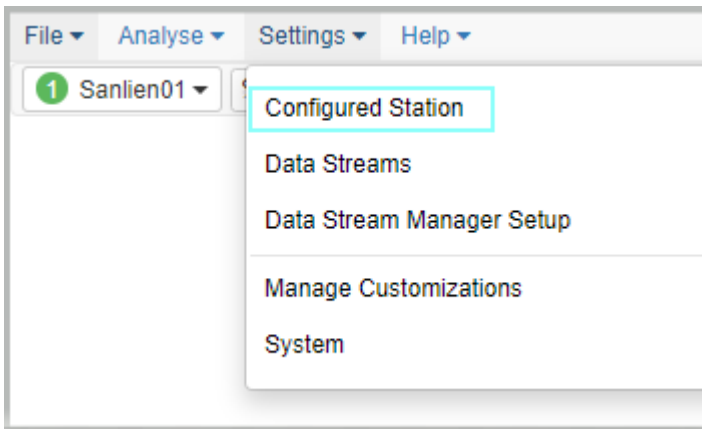
There are two panels in the "Configured Station Setting", "Adding Station" for the station setting, "Configured Station" for managing all configured stations.
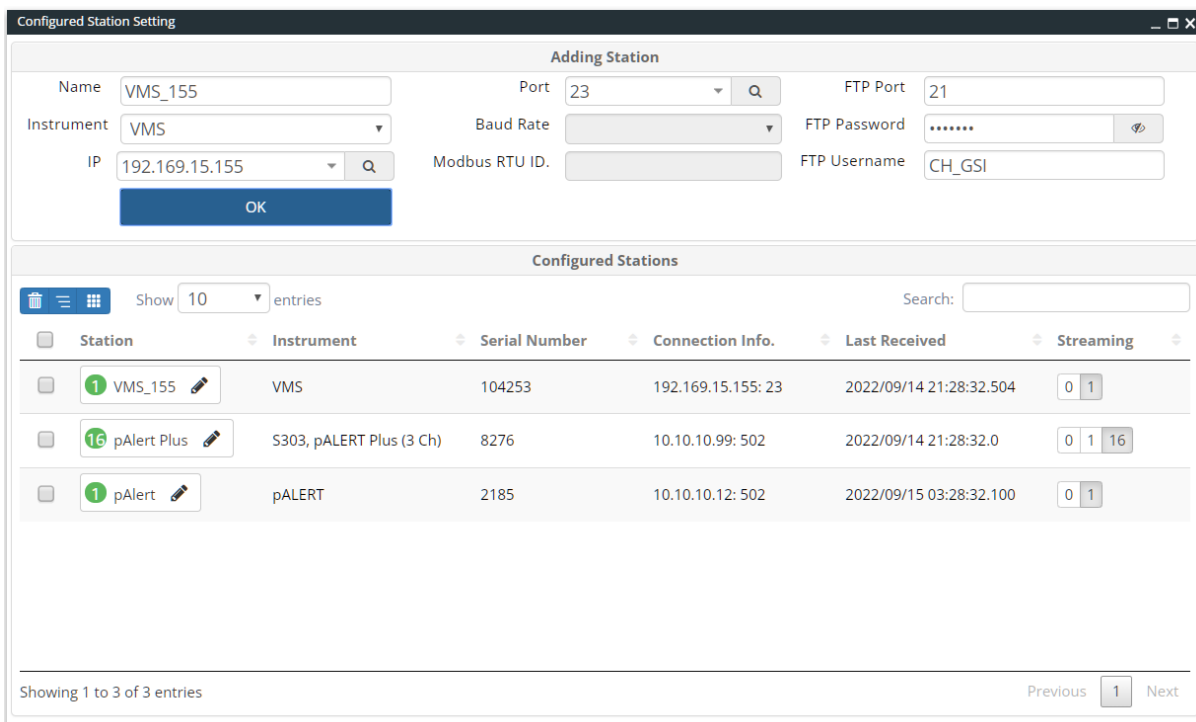
The group of controls indicates some steps, which were performed in order to add a new station.

"Station Name" and "Instrument" are necessary, other controls are not required for some specific instrument, when the "Instrument" combo box is changed they will be disabled automatically.

Generally, all controls will auto-fill when the "Instrument" combo box changes if you didn't change the default setting.

"IP" and "Port" can be entered directly, or use the search button to find out instruments or available serial ports automatically, the search button operation as shown below.
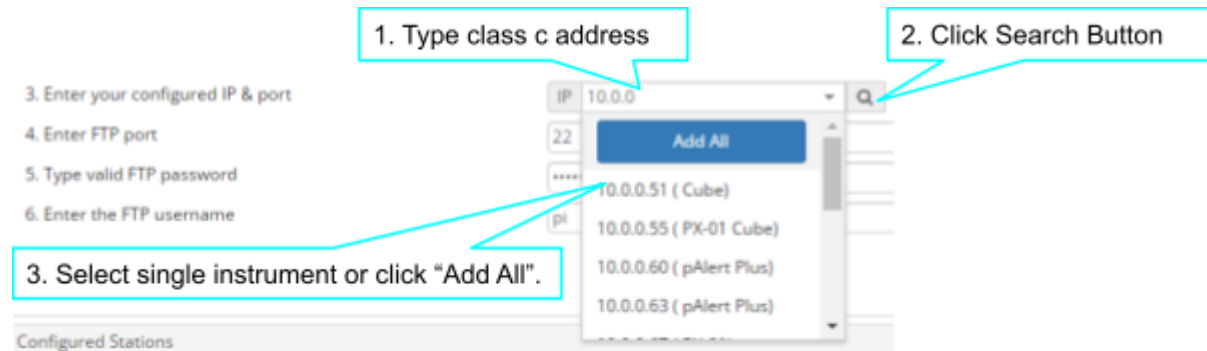
Finally, click "OK" to add the station, it will list at the "Configured Stations" panel.

4.2 Managing stations

The "Configured Stations" panel manages all stations, the functionality of each control as figure below:
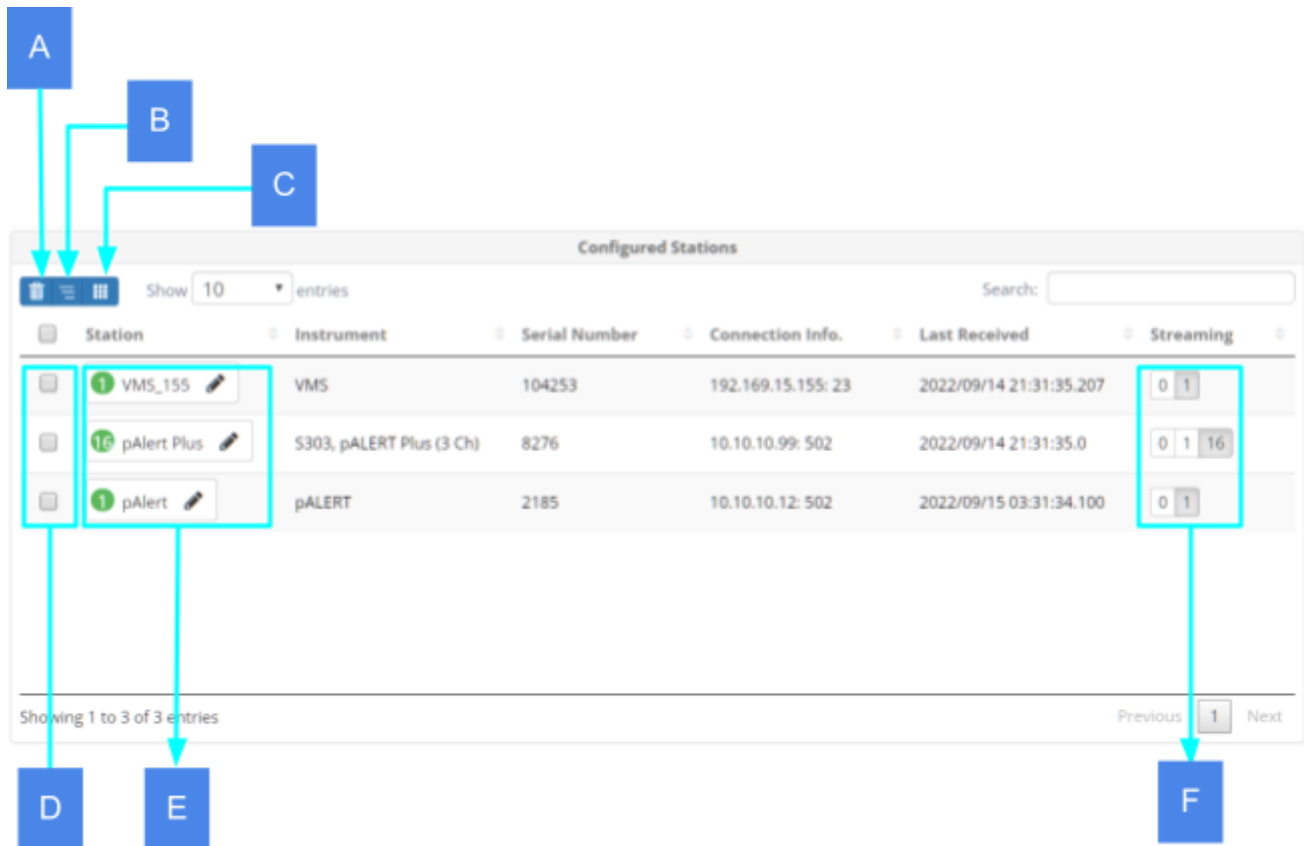
A.   Delete checked stations.
B.   Open the streaming window.
C.   Open channels info window.
D.   Checked for select stations.
E.   Open the Instrument Setup Manager.
      Please refer to the section "**4.3 Instrument Setup Manager"** for more detail.
F.   Switch streaming mode.
- 0 : No streaming.
- 1 : Streaming with 16 bits resolution.
- 2 : Streaming with 16 bits resolution and check sum.
- 16 : Streaming with 24 bits resolution.

4.3 Instrument Setup Manager

The "Instrument Setup Manager" is launched to set up parameters of instruments, The default setting window for most instruments is shown in the figure below, the content somewhat different depending on the selected instrument, and the setting window for special instruments such as SS300 or VMS is different.
There are 4 tabs in the window：
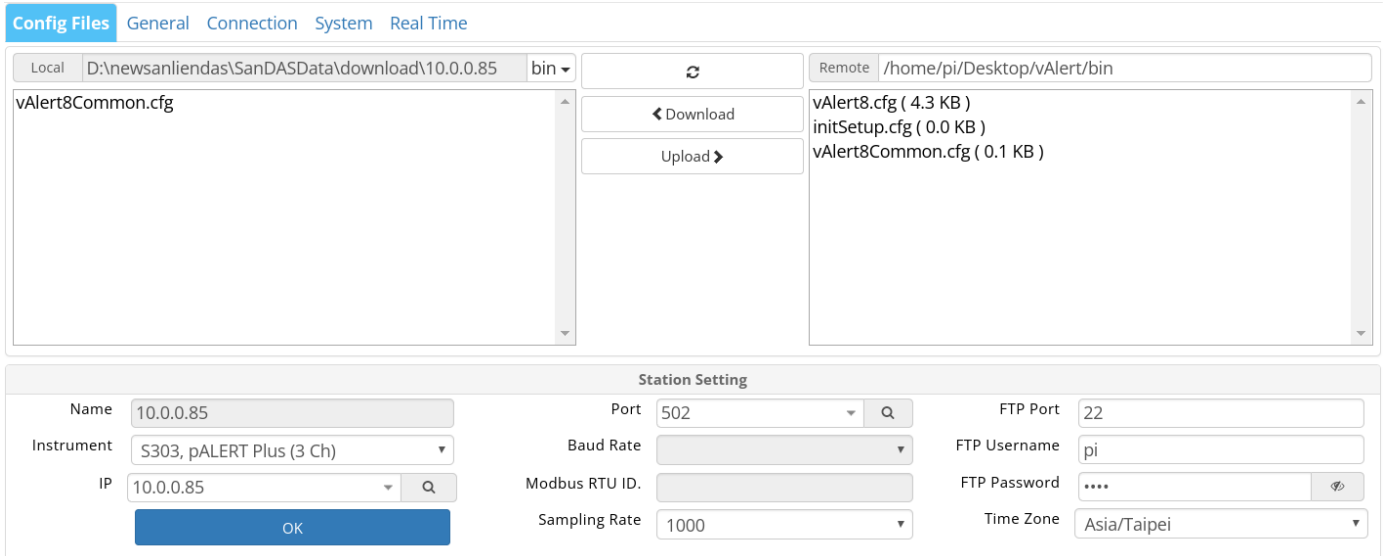
4.3.1 Config Files

Manage configure files, consisting of 3 parts：

1. FTP File Manager

A. File download local storage path.

B. Files filter selector, it will change the content of the "Local File List" (C) while selecting change.

Browse

bin

rec

log

etc

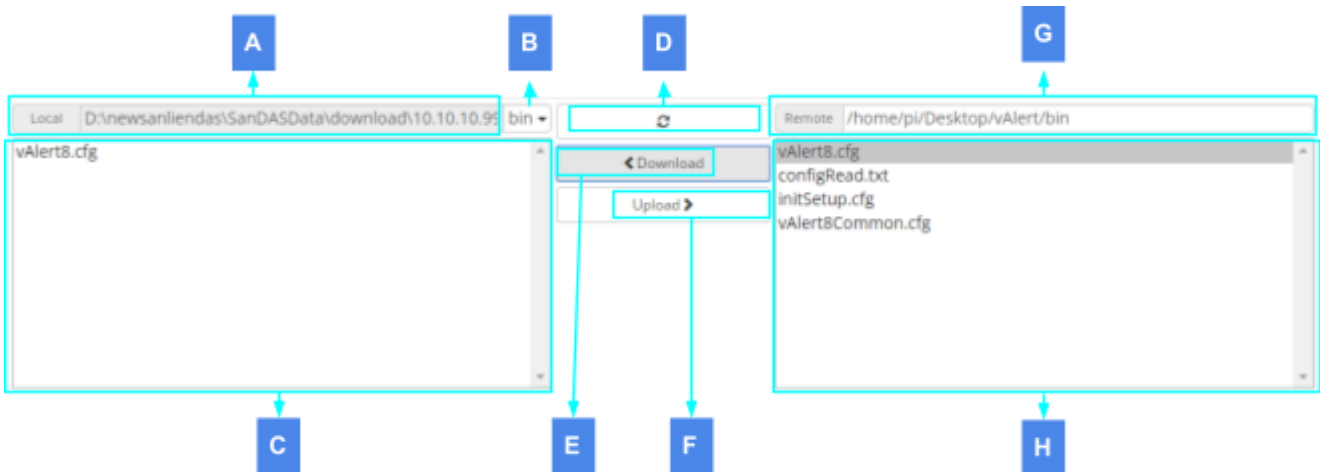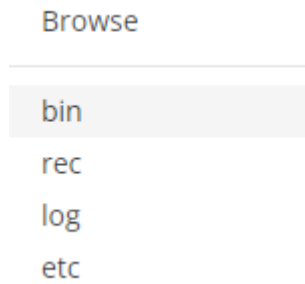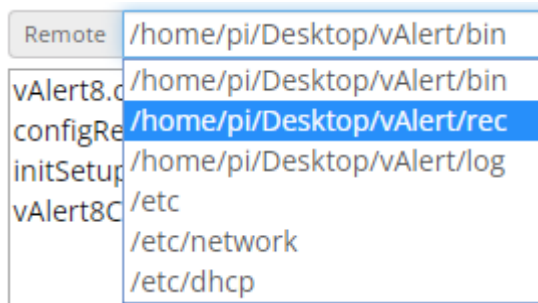- Browse : Change local storage path.
- bin : List the files which download from the bin folder.
- rec : List the files which download from the rec folder.
- log : List the files which download from the log folder.
- etc : List the files which download from the etc folder.

C. List files of local storage paths that filter by the "Files filter selector" (B). File will be opened by double click. There is a specific editor for "vAlert8.cfg" and "vAlert8Common.cfg" please refer to the section of "**4.5 vAlert8 Editor**".

D. Reflash local and remote file lists (C, H).

E. Download the selected file from the remote file list (H).

F. Upload the selected file from the local file list (C).

G. Remote file path selector, it will change the content of the "Remove File List" (H) while selecting change.

H. List files of remote paths that filter by the "Remote file path selector" (G). File will be downloaded then opened by double click.

Remote | /home/pi/Desktop/vAlert/bin
vAlert8.c | /home/pi/Desktop/vAlert/bin
configRe | **/home/pi/Desktop/vAlert/rec**
initSetup | /home/pi/Desktop/vAlert/log
vAlert8C | /etc
        | /etc/network
        | /etc/dhcp

2. Station Setting
This part please refer to the section "**4.1 Adding stations**".

3. Network & NTP Setting
This part is for editing 2 config files of Linux.

The Network Setting Panel on the left side for editing the " /etc/network/interfaces" file. On the panel header on the left side there is the file operation button group. Please refer to the section of "**4.4 File Operation Button Group**".

4.   .
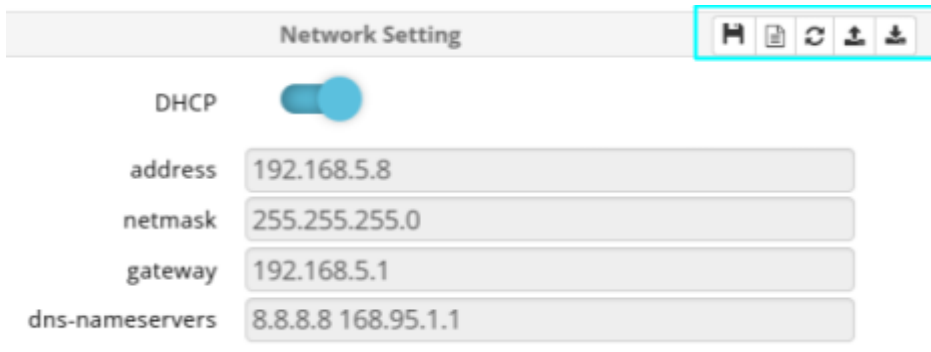
The NTP Setting panel on the right side for editing the " /etc/ntp.conf" file. On the panel header on the left side there is the file operation button group. Please refer to the section of "**4.4 File Operation Button Group**".

The ⊞ button click will create a new text field at the bottom of servers.

4.3.2 General

This panel shows values only while streaming mode is 0. And can change to edit mode only while the instrument is pAlert.

4.3.3 Connection

This panel shows values only while streaming mode is 0. And can change to edit mode only while the instrument is pAlert.

4.3.4 System

This panel shows values only while streaming mode is 0. And can change to edit mode only while the instrument is pAlert.

Config Files	General	Connection	**System**	Real Time

Time Zone	null	
STA Length[0.1 sec]	null	
LTA Length[0.1 sec]	null	
Threshold STA/LTA	null	
Seismic Alarm Time	null	
Offset Records	null	
DO 0 Trig	null	
DO 1 Trig	null	

Default   Write

4.3.5 Real Time

This panel shows values only while streaming mode is 0.

Config Files	General	Connection	System	**Real Time**

Trigger Test   gal 10   count 1000   ⬎

Event	0
Pga_trig_axis	0
Pd	0
Displacement	0
Pga_max_in10s	5.08
Pgv_1s	0.09
Pgd_1s	0.000

STA/LTA

LTA Flag	null
STA / LTA	null
Vecotr -> a Axis	23.39
Vecotr -> b Axis	-1.32
Vecotr -> c Axis	-3.05

Pv	0.0	Pa	0.00000
		TC	0.000

Event Trig

Displacement	false	Pga	false
Pd	false	STA / LTA	false

Digital I/O

	0	1	2	3
DI	○	○	○	○
DO	○	○		

Status

Axis	Instant	Max
a [gal]	0.4185999999999999	23.39
b [gal]	-0.1794	1.79
c [gal]	-0.0598	-3.11
Vector	0	23.6
Intensity	1	3

4.3.6 Trigger Testor

In the top of the "Real Time" panel there is the "Trigger Testor", it can input gal and count which you want to trigger.

Config Files	General	Connection	System	**Real Time**

Trigger Test   gal 10   count 1000   ⬎

You can open the Streaming panel to observe the wave change.
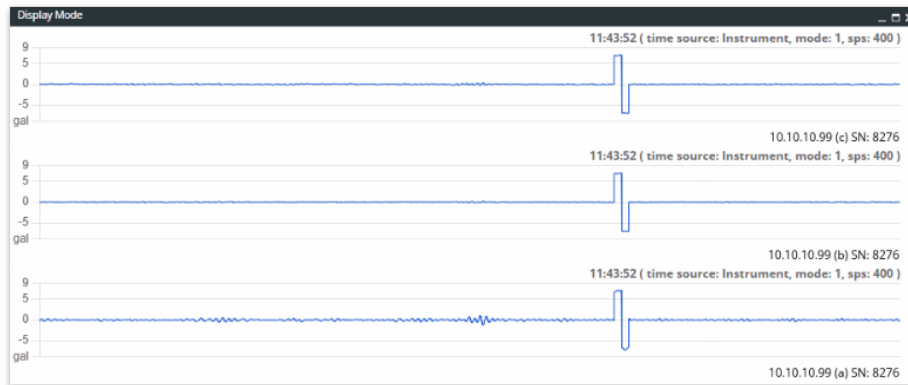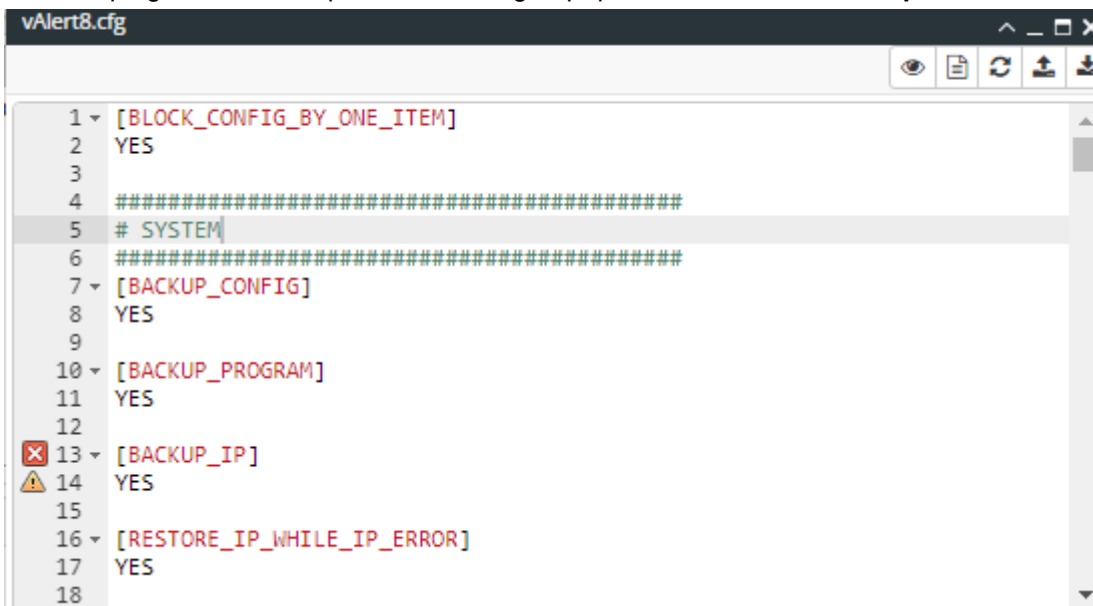
4.4 File Operation Button Group

Save the current setting values to a template file then preview.

Open the original file which was downloaded from the remote.

Reflash all input values from the original file which was downloaded from the remote.

Upload and restart service.

Download a remote file.

Create a new text field.

4.5 vAlert8 Editor

The vAlert8 editor is a specific editor for "vAlert8.cfg" and "vAlert8Common.cfg" and makes it easier to edit files. On the top right is the "file operation button group" please refer to "**4.4 File Operation Button Group**" .

Main functions include：

● WYSIWYG (What You See Is What You Get).

● Autocomplete
   The "Section Title" and description will list automatically by typing "**[**".

```
1 ▼ [BLOCK_CONFIG_BY_ONE_ITEM]
2   YES
3
4   ##########################################
5   # SYSTEM
6   ##########################################
7 ▼ [BACKUP_CONFIG]
8   YES
9
10 ▼ []
11   ADMIN_SERVER_IP  Title          Provide the function of the machine to actively connect to the outside world.
12 ▼ API_CONFIG  Title
13   AUTO RECORD  Title
```

```
Upload >
```
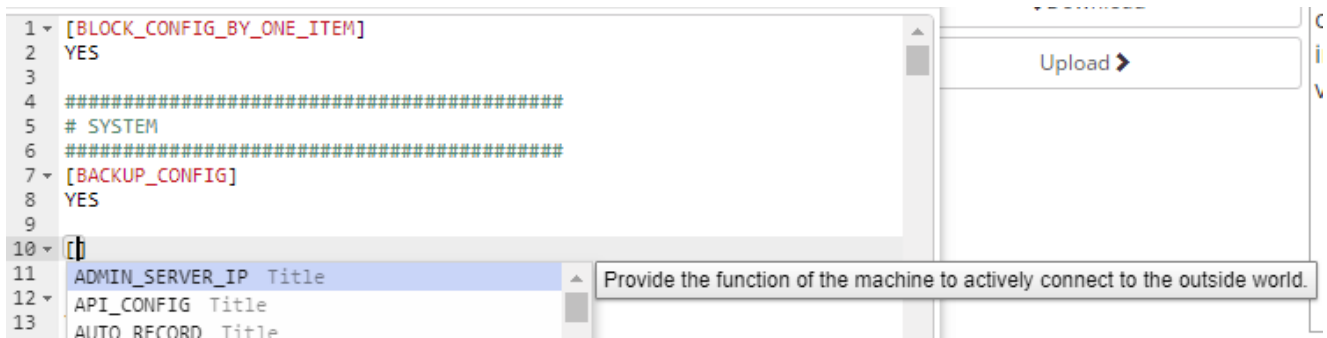
   All parameters of the section will list automatically by typing the blank key below the section title.

```
10 ▼ [API_CONFIG]
11
12   DORTS_FILE_UPLOAD  Parameter
13 ▼ EARTHQUAKE_API  Parameter
14   EARTHQUAKE_FALLING_API  Parameter
15   ISO2631_FILE_UPLOAD  Parameter
16 ▼ PD_API_PARAMETER  Parameter
17
```
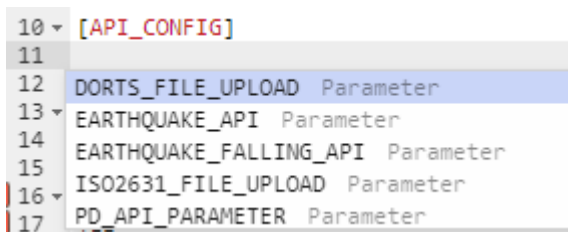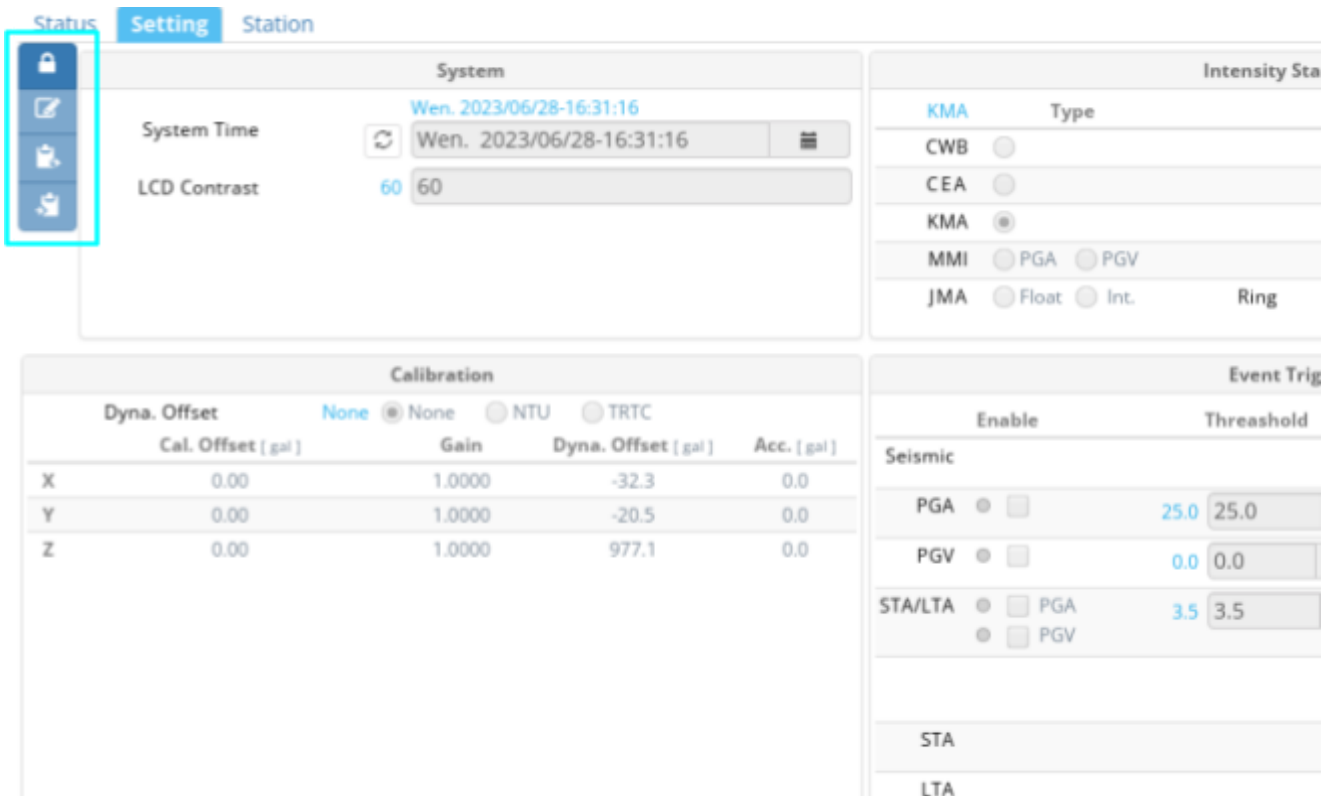
● Format check
   It will show an error icon if something is wrong in the line.

```
   15
⊠ 16 ▼ [BACKUP_IP]
⊠ 17   YES
   18
        No title found.
     S  Unrecognizable Title )
```
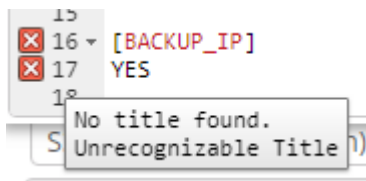
4.6 Modbus Editor

If the instrument supports Modbus read/write settings (e.g., SS300, DATUM...), you will see a "Modbus Edit Button Group " on the Setting tab.

The tab has a protection mechanism, and in order to modify parameters, it must be unlocked. Clicking on

🔒 "Unlock" indicates that it has been unlocked. After modifying the parameters, click on 📝 "Write Parameters" to save the changes.

🔒 Unlock or lock the setting form.

📝 Write changed values to indstrument (ctrl + w).

📋 Save current setting values to a file.

📥 Load the file values to the form.

5 Streaming viewer

SanDAS offers 2 kinds of streaming viewers for displaying real-time streaming data.

Display Mode：
For overview of all channels streaming status, this mode displays up to 108 channel graphs at the same time, but will automatically reduce the graphics resolution according to the computer performance, for full graph please use "Data Streaming".

On the "Station Toolbar" click the "Display Mode Button".
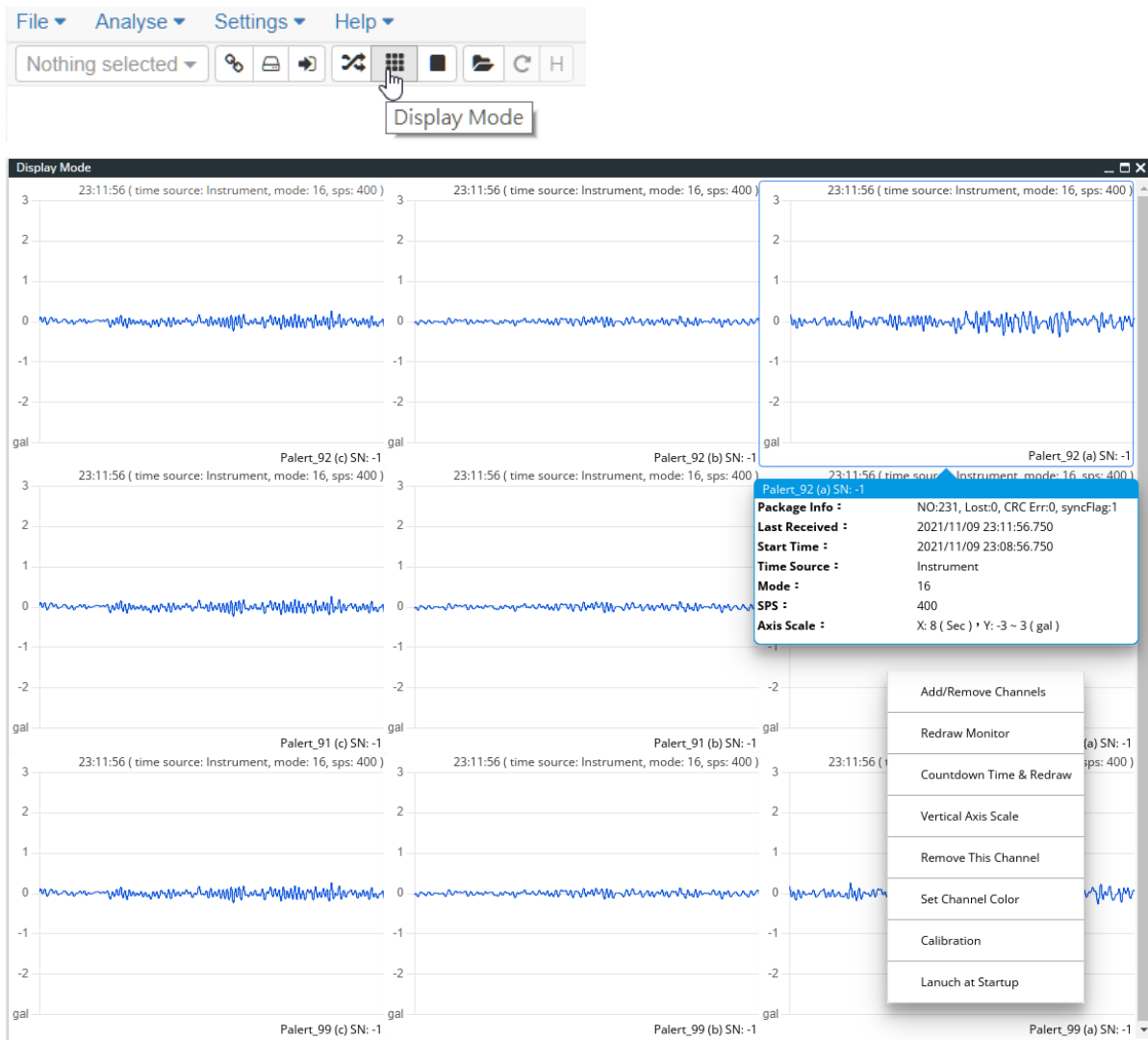
Contextmenu functionality
Add/Remove Channels

Arrange how many columns and rows to display.

Show or hide channels.

Sort channels.

Countdown Time & Redraw

Maximum seconds of horizontal axis

Chart redraw interval

Chart reflash interval
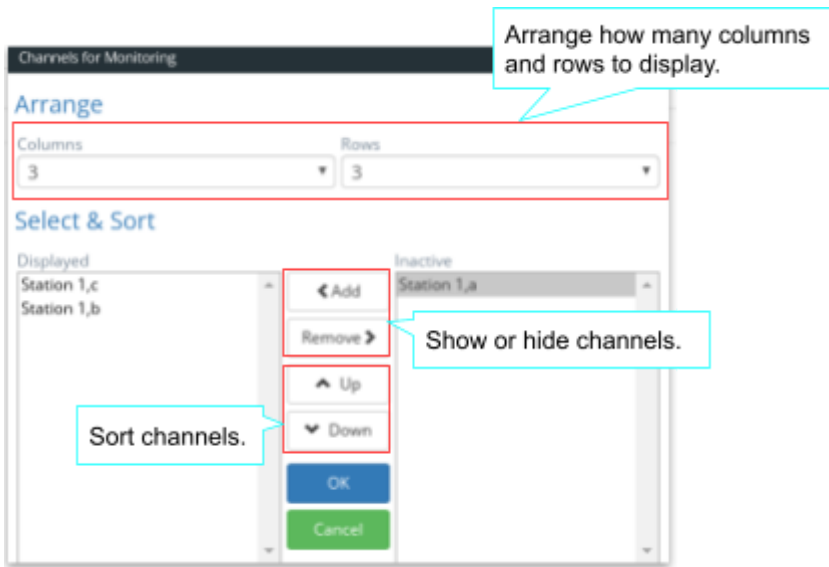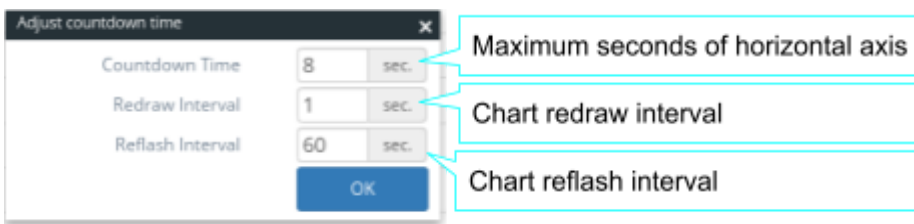
Vertical Axis Scale
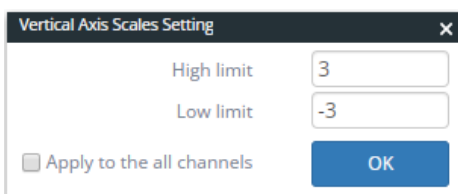
Calibration
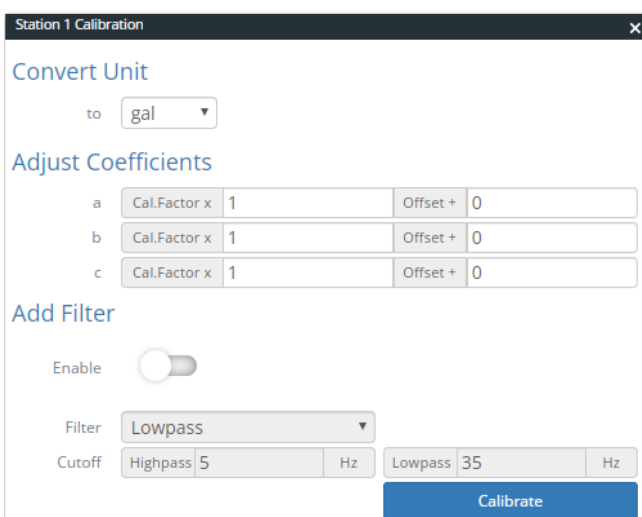
Data Streaming：

This mode displays up to 5 channels full graphs at same time.
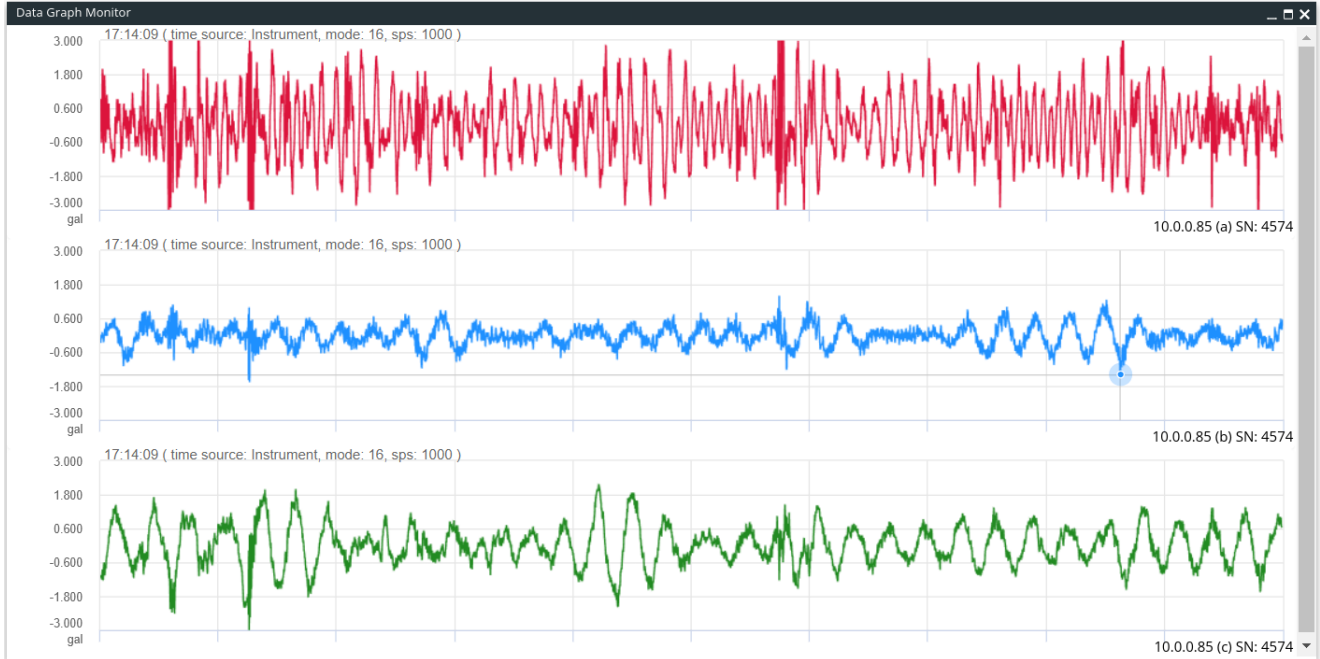
Double-clicking the chart can change to the auto range of the vertical axis and show the function button bar.

Function button bar
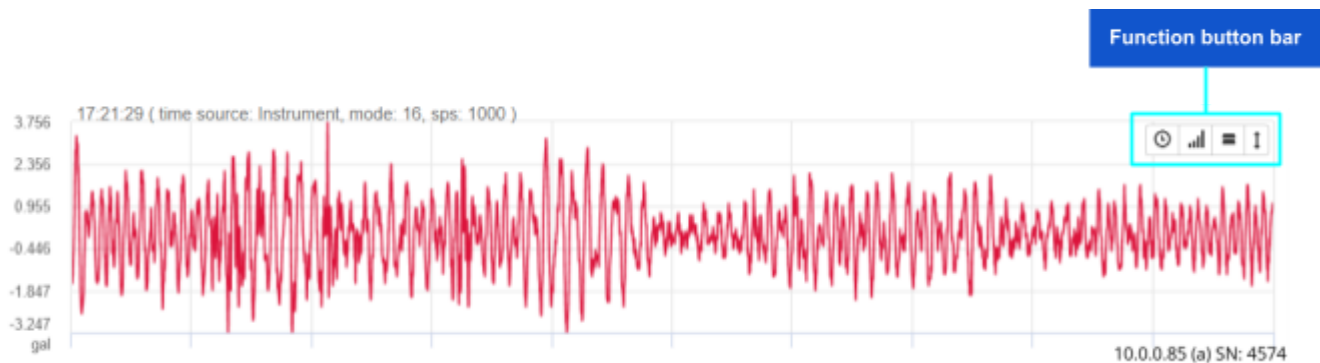
🕐 Show time domain data.

📶 Show frequency domain data.

▬ Show time and frequency domain data both.

↕ Set the current vertical axis scale as default.

On the "Station Toolbar" click the "Data Streaming Button".
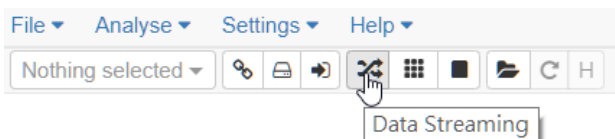
Stop or Start Streaming：

Used to stop or start streaming graph updates.

On the "Station Toolbar" click the "Stop Streaming Button".
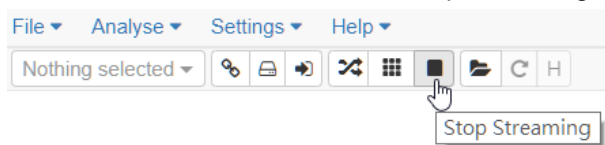
6 Data Recording

Most types of Sanlien instruments can provide the streams of data through the serial communication channel. In general, the data is capable of being recorded as csv files by SanDAS.

The manual recording is the default setting in SanDAS, which means you need to design how long of the recording time of each file, but it can have an advanced setting in the "Data Stream Manager Setup" panel ,for more detail please refer to section 6.2.

6.1 Recording Toolbar

You can very easily start data recording by using the "Recording Toolbar" at bottom of the main window.
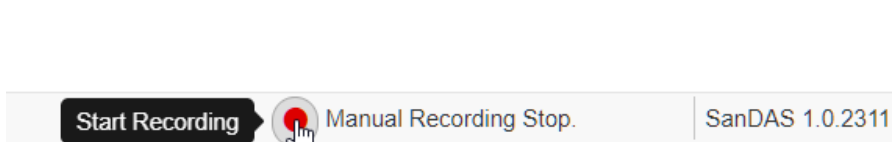
Click the "Recording Button" that will start recording streaming data until you click again.
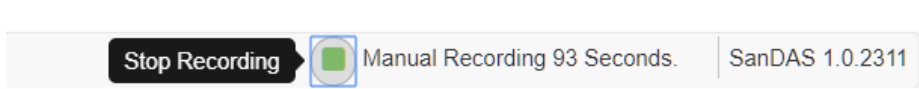
Then popup a dialog window to ask you if you want to open the recorded file.
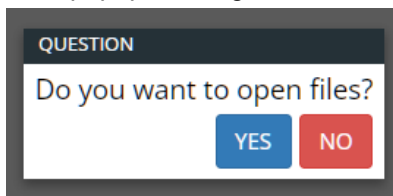
6.2 Data Stream Manager Setup

It is launched either from the Settings/Data Stream Manager Setup.
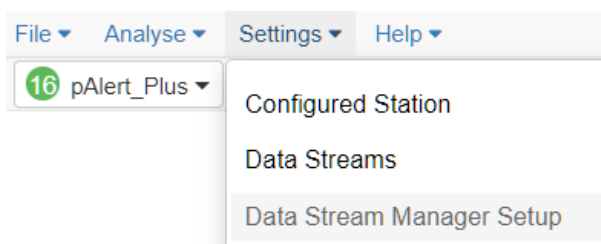
All file record related parameters can be set here.
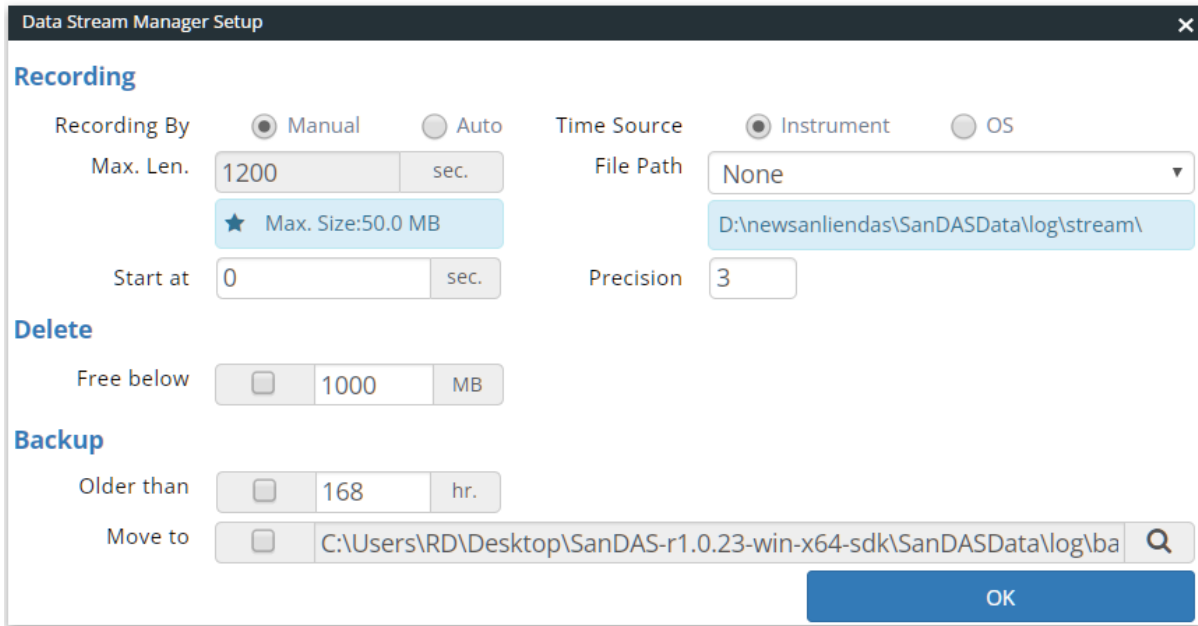
6.2.1 Recording：

Recording By

   Setting data recording mode, the default mode is "Manual", please refer to section 6.1 for how to operate.
   If the "Auto" is selected, the data recording function will be automatically activated when SanDAS is started.

Max. Len.

   Setting the length of recording time in each file unit is second, and it will create a new file automatically while the data recording length reaches the set value or file size over 50 MB, for "Auto" mode only.

Start at

   Setting the number of seconds to start recording.

Time Source

   Setting the data received time, "Instrument" means that it uses package time sent from the instrument, and "OS" means that it is used from the operating system.

File Path

   Setting the save file path format, and it will show the example path when the combobox was changed below.

Precision

   Setting the decimal precision of the record value.

6.2.2 Delete：

Free below

Automatically delete the oldest file when the recording disk size is lower than this value.

6.2.3 Backup：

Older than

Files older than this value are automatically backed up.

Move to

Setting the backup path.

7 Record File Viewer

7.1 Overview

The File Data Viewer (FDV) is a tool of SanDAS intended for visualizing and analysis of the recorded data recorded by Sanlien instruments. The support file extensions are .csv, .dat, .txt, .vms and .mseed.

Opening a record file with SanDAS is as simple as with other Windows applications. Just run the menu item **File->Open.**

The file setting window will popup as below:
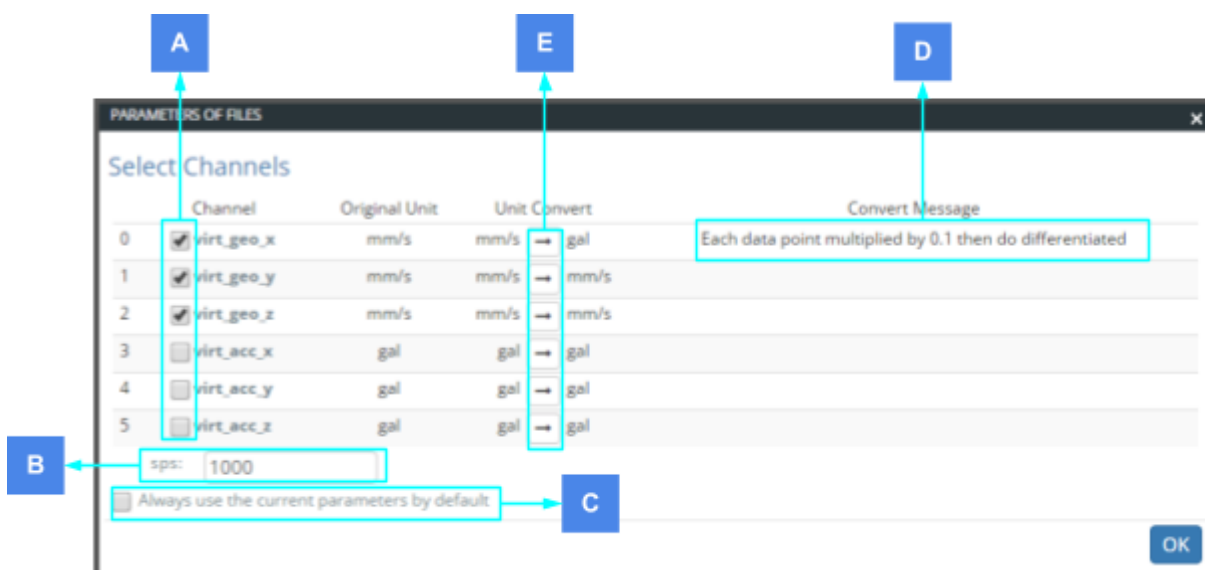
A. Select channels you want to parse.
B. Sampling rate you want to change.
C. Always use the current parameters by default, this window will not popup while the file opens. It can be change by **Analyse->Parameters>File Default Parameter.**
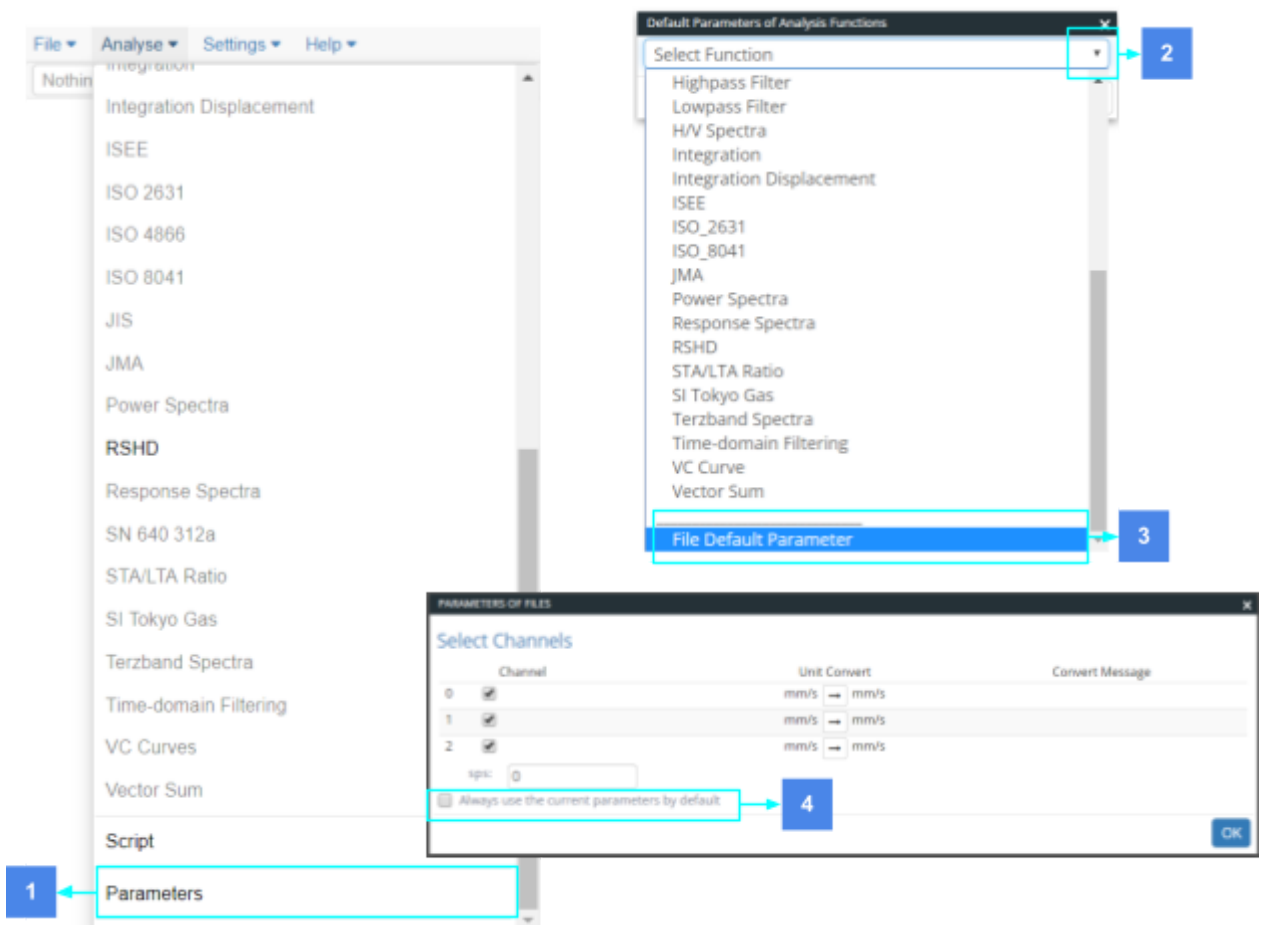
D. Display unit conversion description.
E. The Unit Convert Window will popup while button is clicked.
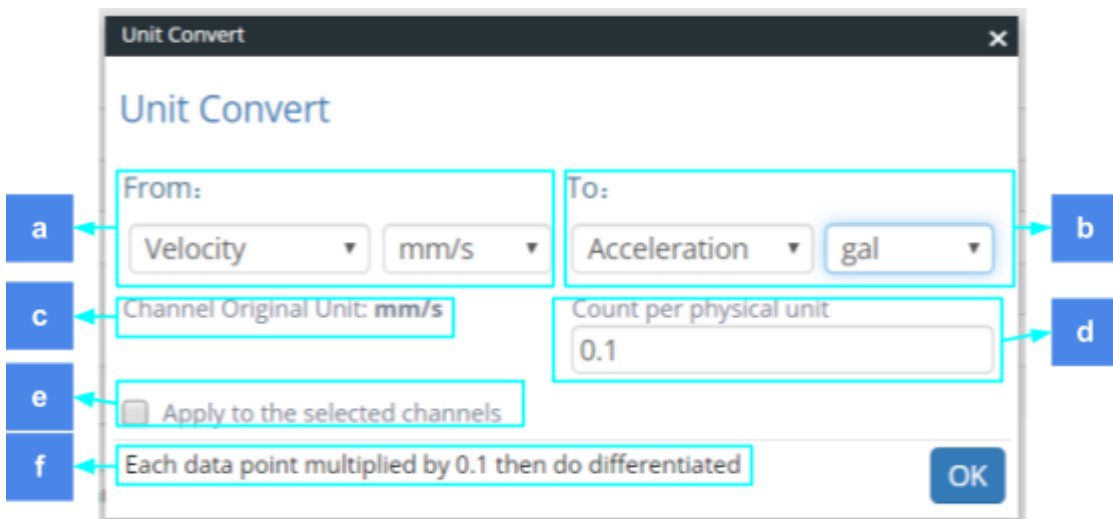
     a. Select original unit of the channel.
     b. Select the unit which you want to change.
     c. Display original unit of the channel.
     d. Count per physical unit.
     e. Apply the setting parameters to all channels.
     f. Display unit conversion description.

7.2 File Menu
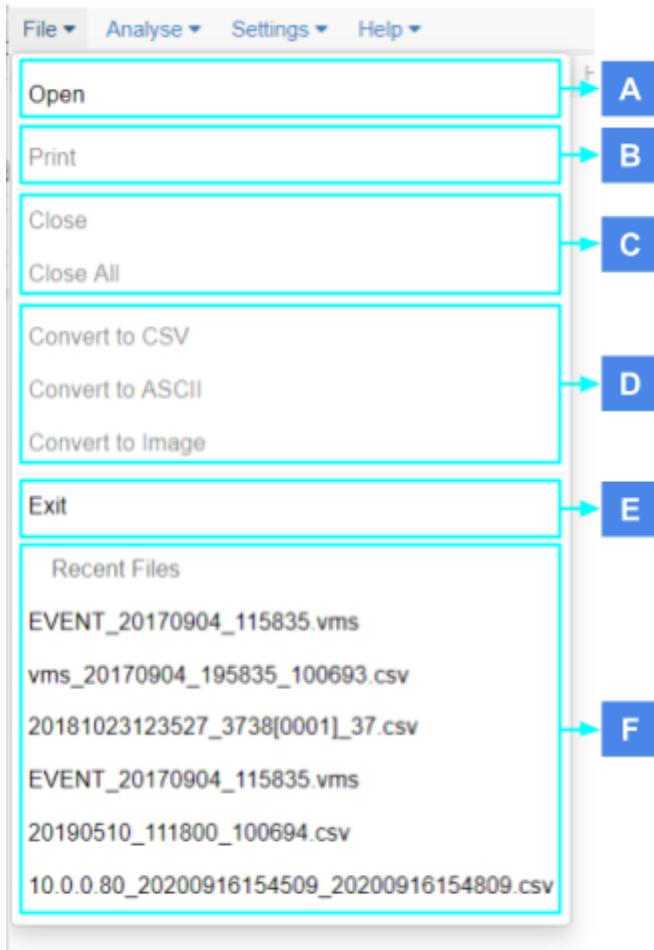
A.   Open the file.
B.   Print the selected FDV.
C.   Close FDV.
    a.   Close selected FDV.
    b.   Close all FDVs.
D.   Convert selected FDV.
    a.   Conver selected FDV to .csv file.
    b.   Conver selected FDV to .txt file.
    c.   Conver selected FDV to .png file.
E.   Exit SanDAS.
F.   Reserve the recent 6 files.

8 Data Aanlysis

This part of SanDAS has been developed by Sanlien especially for the strong motion, earthquake engineering and civil engineering data analysis.

➤ Note that the analysis functions work in the registered SanDAS versions only, which have the valid license key and authority code.

8.1 Data Analysis Menu

All functions are combined in this menu. The operations are performed with the graphs shown in the current FDV window.
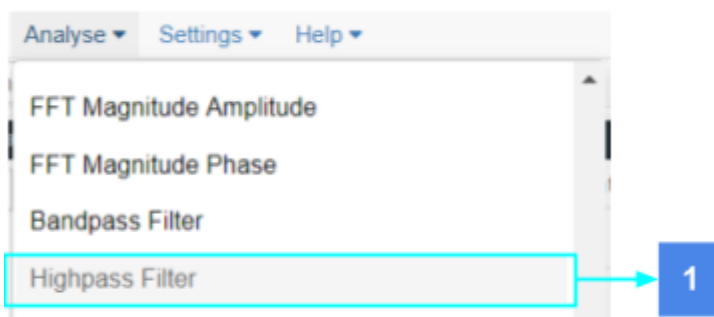
1. Select the function.

The parameters setting window will pop up if it needs to.
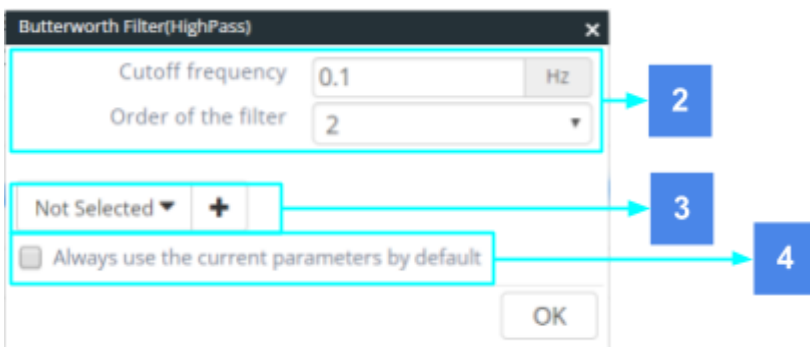
2. Adjust parameters as you want.
3. Use pre-stored parameters, or add the current parameters as pre-stored.
4. Use the current parameters by default, the window will not popup again.It can be change by **Analyse->Parameters**.

When the first math function is applied to the original data set, the current FDV window is split up in to two parts: the upper one displays original datasets and the lower one displays the analysed data. Several previous results are kept in a stack and therefore one can always cancel the results of the latest math operation and to return to the previous analysis results by running the **Undo** item of the Analyse menu.
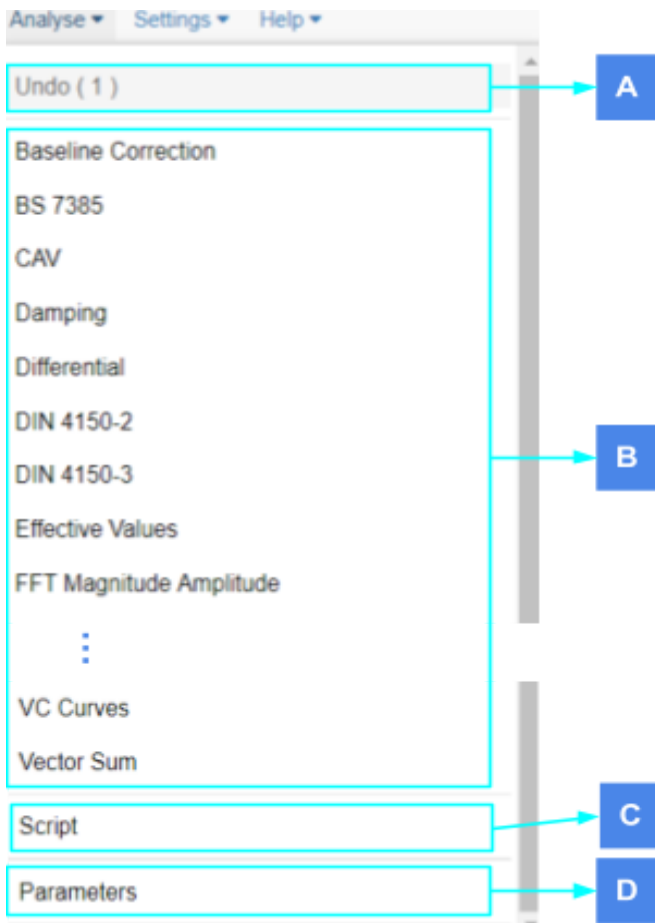
A. Undo the last functoin.
B. Function list : It works when at less one FDV window is open.

C. Script：Scripting the functions that can execute serially.
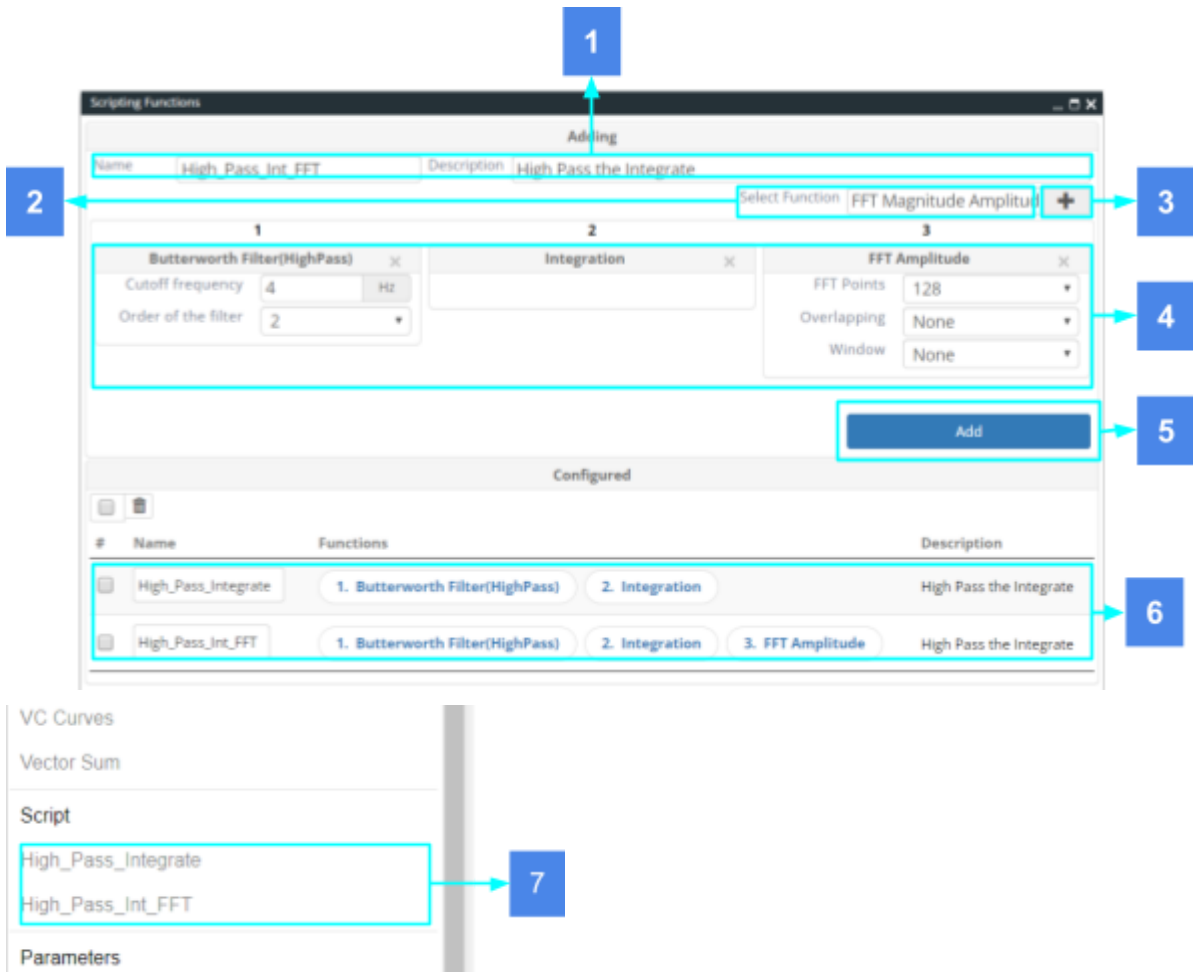
1. Input the name and description.
2. Select the function.
3. Click the "**+**" button, the function parameter setting panel wil be add.
4. This area can set the parameters of each function, and it can be drag and drop to change the order of execution.
5. Click the "**Add**" button the script will be add to the Configured table.
6. This table list all script, and it can be management here, click the name button can pop up script setting window.
7. This script name will be list at "**Analyse>Script**" ready for use.

D. Parameters：Adjust all function parameters.

Select Function
_____

Baseline Correction
BS 7385
CAV
Damping
Differential
DIN_4150_2
DIN_4150_3
Effective Values
FFT Magnitude Amplitude
FFT Magnitude Phase
Bandpass Filter
Highpass Filter
Lowpass Filter
H/V Spectra
Integration
Integration Displacement
ISEE

Select Function ▼

Exit
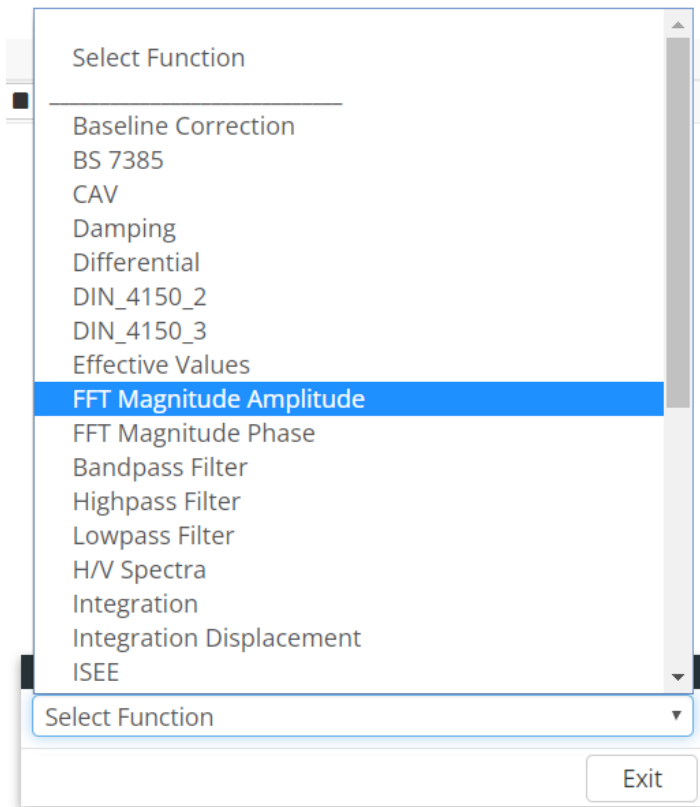
8.2 Functions of the Data Analysis

8.2.1 Baseline correction

This function performs a baseline correction over the whole data set. The correction method can be one of the followings:

1. Using PreEvent samples only. This calculates the average signal level in the pre-event time and subtracts this from the entire data signal. User specifies the number of pre-event samples.

2. Using the whole data record. Default method. This calculates the average signal level of the whole event and subtracts this from the entire data signal.

3. Using PreEvent samples then the whole record. This calculates the average signal level in the first half of the pre-event and subtracts this from the pre-event part of the signal and then calculates the average signal level of the rest of the event and subtracts this from the rest of the data signal. User specifies the number of pre-event samples.

8.2.2 BS 7385

Vibration Standard
- BS 7385-2: 1993, Evaluation and measurement for vibration in buildings
- Part 2: Guide to damage levels from ground-borne vibration

Algorithm
- Integrate acceleration data to velocity data.
- Calculate PV
- Do Vector Sum
- Calculate PPV
- Use the channel with the maximum PV to do PSD & ZC
- Find the dominant frequency

8.2.3 Cumulative Absolute Velocity (CAV)

This function calculates the Cumulative Absolute Velocity of the data by using one-second data windows, with a specified integration level. Note that the input data must be in g units. Only in this case the calculations are performed correctly. The CAV is presented in the units of mm/s or in g-sec units.

User-defined parameters:
1. Integration limit in g
2. Type of the output units

8.2.4 Damping

This function calculates the damping factor and natural frequency of the input signal in the time domain.

8.2.5 Differentiation

This function performs differentiates of the original data set. It is used usually to convert the velocity data to the acceleration.

8.2.6 DIN 4150-2

This standard specifies the evaluation of human exposure to structural vibration (e.g., vibration generated by construction work). The procedures described here can be used to assess the effects of periodic and aperiodic vibration within a frequency range of 1 Hz to 80 Hz.
Here is the flow chart and input parameter:

Parameter:

District: The type of the evaluation site

Time: the data measuring period;

Interval: Fourier sliding window length

Exposure Time: the time of exposure outside rest periods;

Total Time: the assessment period (day 16 h, night 8 h);
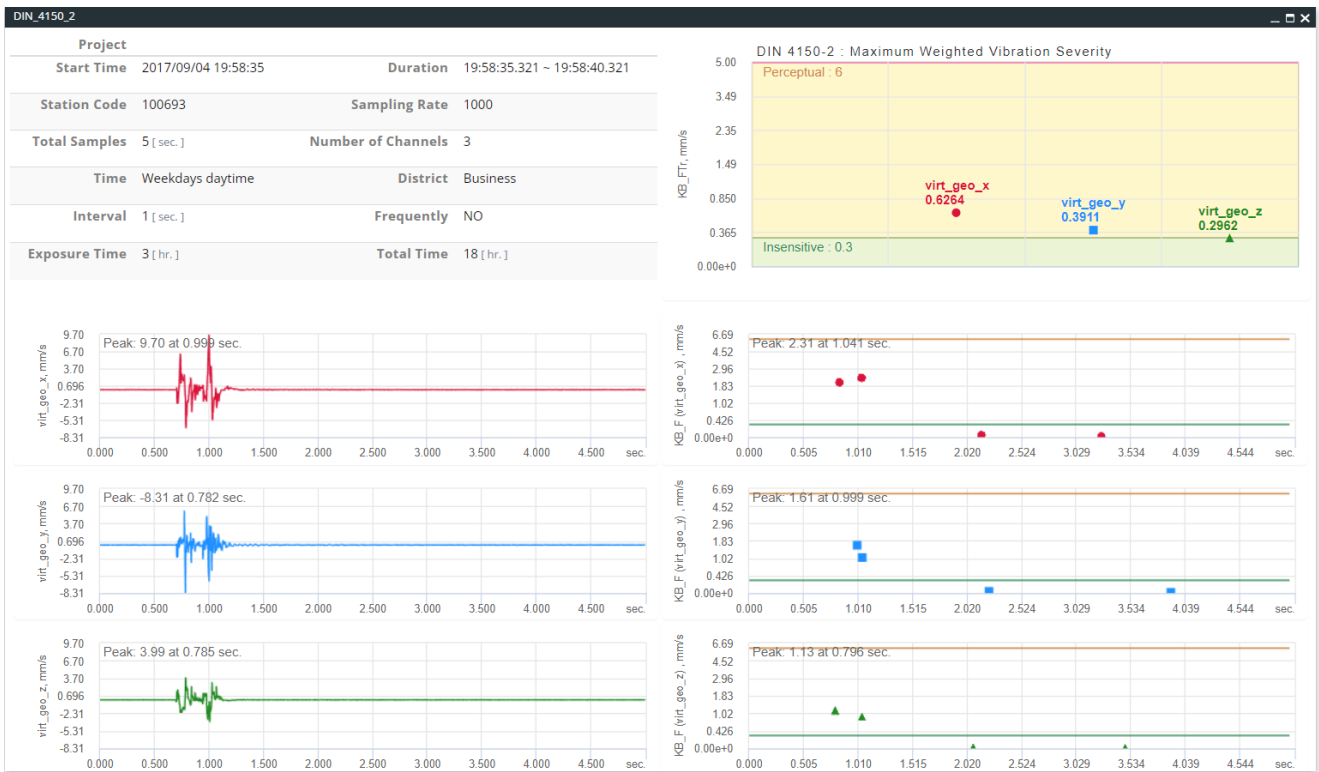
Because a vibration is often non-stationary, the DIN 4150-2 standard proposes the use of a running root-mean square applied to the velocity signal. A weighted time-averaged signal is thus defined by:

$$KB_F(t) = \sqrt{\frac{1}{\tau} \int_0^T KB^2(\xi)\, e^{-\frac{t-\xi}{\tau}} d\xi}$$

where the weighted velocity signal KB(t) is obtained by flowing the original velocity signal through the high-pass filter.

$$KB_{FTr} = \sqrt{\frac{1}{T_r} \sum_j T_{e,j} KB^2_{FTm,j}} \text{ or}$$

$$KB_{FTr} = KB_{FTm} \sqrt{T_e/T_r}$$

where

   T_r is the assessment period (day 16 h, night 8 h);

   T_e is the time of exposure outside rest periods;

   $T_{e,j}$ is the partial time of exposure (time interval i) outside rest periods;

Table: Standard analysis summary for ground-borne vibration assessment.

DIN 4150-2	weighted dose	$0.15\,\mathrm{mm/s}$	residential area
	$KB_{F,\max}$	$0.10\,\mathrm{mm/s}$	sentitive area

8.2.7 DIN 4150-3

The standard specifies a method of measuring and evaluating the effects of vibration on structures designed primarily for static loading. It applies to structures which do not need to be designed to specific standards or codes of practice as regards dynamic loading.

Reference
https://www.researchgate.net/publication/257785745_A_new_damage_criteria_norm_for_blast-induced_ground_vibrations_in_Turkey

8.2.8 Effective Values

This function calculates effective values of the signal by using sliding windows in the time domain according to DIN 45669.
User-defined parameter:
      Time constant defining the sliding window length, in seconds

8.2.9 FFT Magnitude

This calculates the FFT Magnitude. The resulting spectra is normalized either by 1/N factor if no window function is applied or by the corresponding factor of the window function. Input data array is divided into several data chunks, each of them has the specified number of samples (power of 2). The chunks may overlap if specified by the user. The FFT function is applied to every data chunk, and then the result is averaged.

User-defined parameters:
1. Number of samples in every data chunk
2. Overlapping factor: no overlapping, 25%, 50%, 66% or 75%
3. Whether a window function is applied to the input time series, and if yes – which one

8.2.10 FFT Phase

The same parameters with FFT Magnitude and the result showing the FFT Phase.

8.2.11 Bandpass Filter

An even-order Butterworth Bandpass Filter is applied.

User-defined parameters:
1. Cut-off frequency in Hz
2. Order of the filter

8.2.12 High-pass Filter

An even-order Butterworth High-pass Filter is applied.
User-defined parameters:
1. Cut-off frequency in Hz
2. Order of the filter
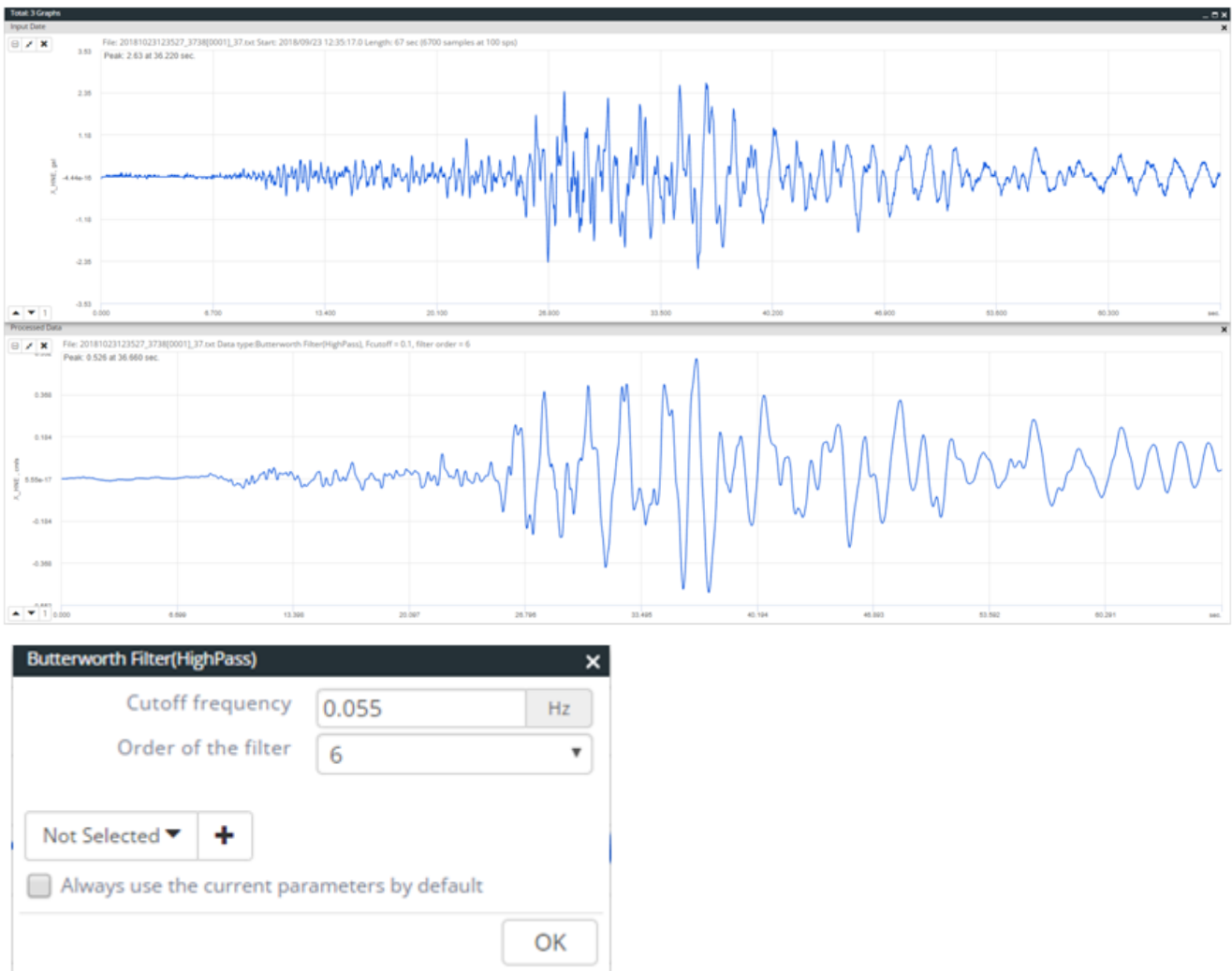
8.2.13 Lowpass Filter

An even-order Butterworth Low-pass Filter is applied.
User-defined parameters:
1. Cut-off frequency in Hz
2. Order of the filter
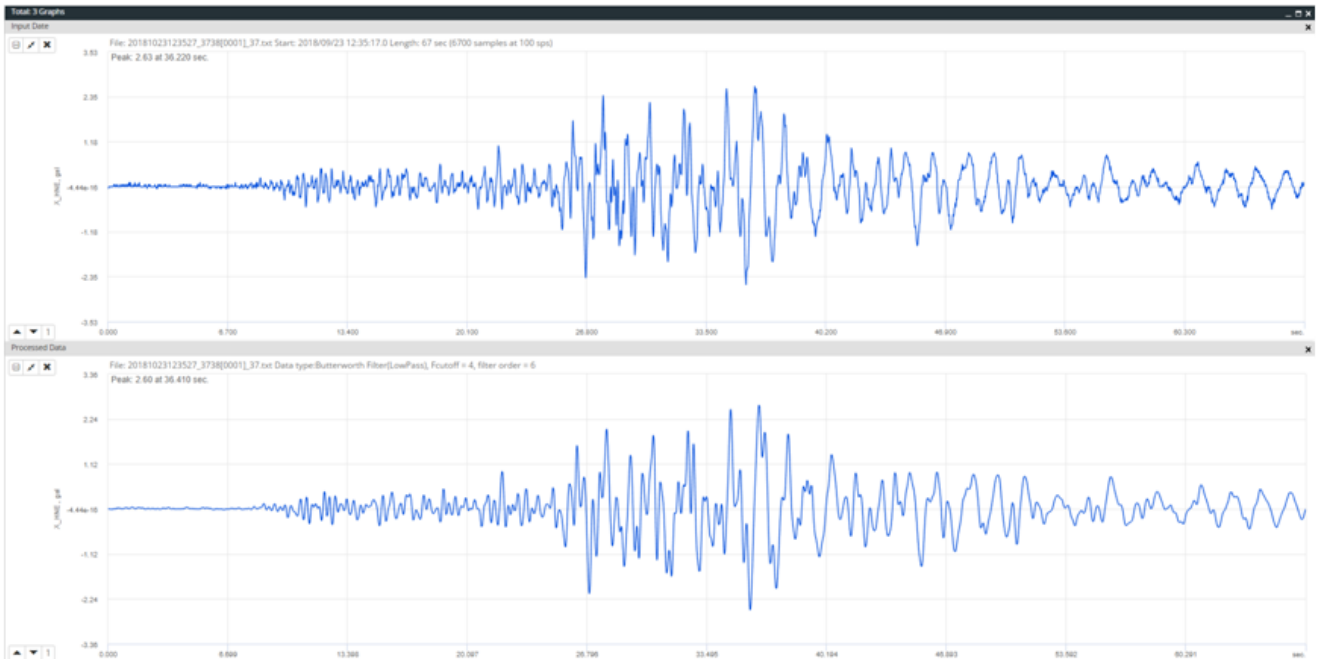
8.2.14 H/V Spectrum

The H/V spectral ratio was found from the strong motion records at various sites in Japan. On the soft ground, horizontal motion is larger than vertical motion. On the other hand, on the hard ground, both horizontal and vertical motions are similar to each other both on the maximum value and waveform.

$$A_m = R/E$$
$$= (A_{hs}/A_{hb})/(A_{vs}/A_{vb})$$
$$= (A_{hs}/A_{vs})/(A_{hb}/A_{vb})$$

The same parameters with FFT Magnitude.

8.2.15 Integration

This function integrates acceleration data to the velocity or from velocity to the displacement. No correction algorithms are used by the integration function; therefore, better results can be obtained by performing the baseline correction or by filtering the data prior to integration.
The result of a double integration (from acceleration to the displacement) must be analyzed rather critically as integration offset levels must be assumed to be zero.

8.2.16 Integration Displacement
Double integration with Butterworth High-pass filter.

8.2.17 ISEE-USBM RI8507

To calculate Peak Particle Velocity and its corresponding dominant frequency.
 Showing on the USBM & OSM safe limit criteria as below.

Reference
https://www.researchgate.net/publication/280494242_Status_quo_and_critical_review_of_PPV_safe_limits_for_subsurface_construction_blasting_close_to_low-rise_buildings

8.2.18 ISO2631

Algorithm
- Sliding Window
- Fourier Transform
- 1/3 Octave Band ([Base, Octave] = [10,3])
- Weighting Type
- RMS for a_w & a_v
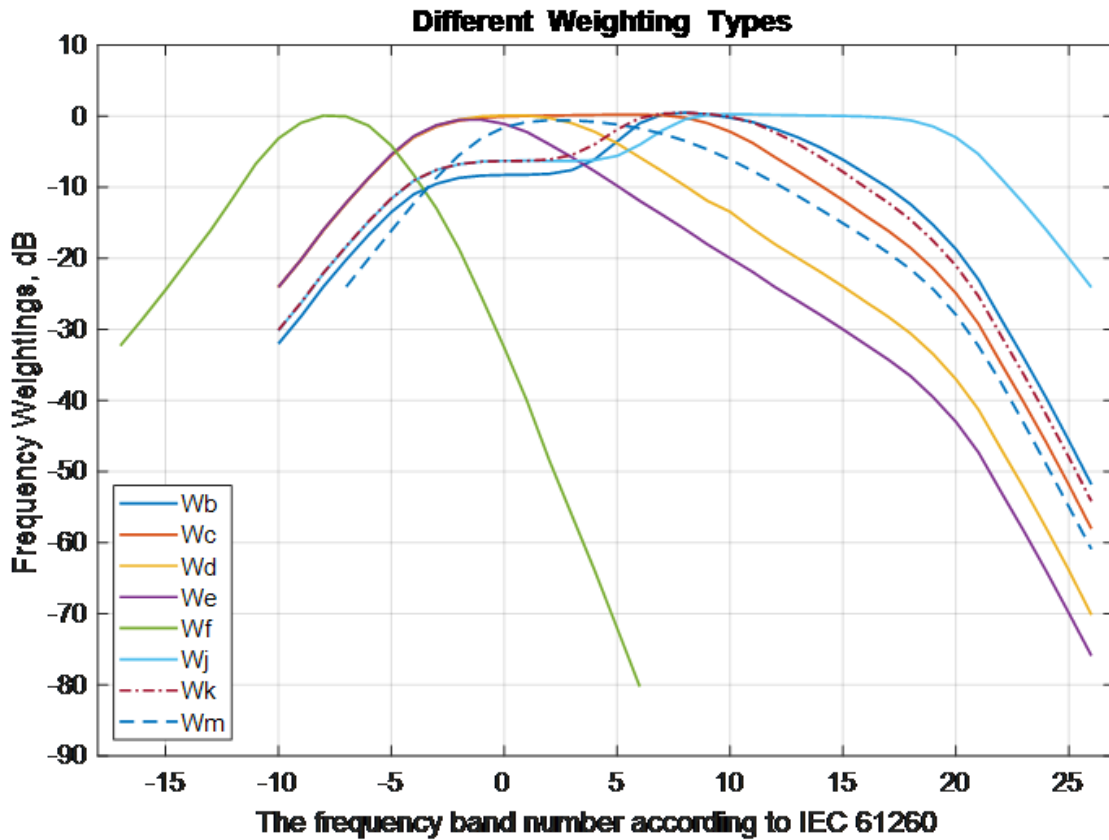
Different Weighting Types

where:

a_w : the Frequency - weighted acceleration;

w_i : the weighting factor for the i th one - third octave band;

a_i : the r.m.s acceleration for the i th one - third octave band.

$$a_w = \left[\sum_i (w_i \, a_i)^2 \right]^{\frac{1}{2}}$$

$$a_v = (k_x^2 \, a_{wx}^2 + k_y^2 \, a_{wy}^2 + k_z^2 \, a_{wz}^2)^{\frac{1}{2}}$$

where:

a_{wx} 、a_{wy} 、a_{wz} : Triaxial Weighted RMS Acceleration;

k_x 、k_y 、k_z : Traixail Factor(For Comfort: choosing 1 for Standing, seat surface, recumbent);

a_v : Combineing vibrations in more than one direciotn.

Table: The Comfort Index of ISO2631

RMS Acceleration (m/s^2)	Comfort Index
< 0.315	Not uncomfortable
0.315-0.63	A little uncomfortable
0.5-1	Fairly uncomfortable
0.8-1.6	Uncomfortable
1.25-2.5	Very uncomfortable
>2	Extremely uncomfortable

8.2.19 ISO4866

ISO 4866:2010, Mechanical vibration and shock. Vibration of fixed structures. Guidelines for the measurement of vibrations and evaluation of their effects on structures (Supersed BS 7385-1)

Weighting: none

Filter: none

Algorithm: Time domain & Frequency Domain

Procedure:
1. If use acceleration, integrate to velocity find peak values Vx.max, Vy.max, Vz.max of each component of Vx(t), Vy(t), Vz(t)
2. Root square of 3 components Vx(t), Vy(t), & Vz(t)
   V(t) = sqrt(Vx(t)^2+Vy(t)^2+Vz(t)^2)
   PPV = max of V(t)

3. Choose Vx(t), Vy(t) of Vz(t) based on max amplitude If Vz(t) has max amplitude, calculate Power Spectral Density (PSD) of Vz(t).

   Find predominant frequency Fp of PSD between 1 to 80 Hz. But, for blasting use zero crossing frequency.

4. Compare (Fp,PPV) to damage levels criteria
   Three damage levels

   1) Domestic: The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in mortar joints of brick/concrete block construction.

      For transient vibration,

Figure 1：Summary of Damage Thresholds for Transient Vibraton on Domestic Structures

For continuous vibration,
Reduce 50% of cosmetic damage levels for transient vibration

2) Minor: The formation of large cracks or loosening and falling of plaster or drywall surfaces, or cracks through bricks/concrete blocks.
   Two times of cosmetic damage levels

3) Major: The damage to structural elements of the structure, cracks in support columns, loosening of joints, splaying of masonry cracks, etc.
   Four times of cosmetic damage levels

8.2.20 ISO8041

1. Purpose
   1) Source: Vibration
   2) Target: Human exposure to vibration
   3) Criteria:
      ISO 5349-1: Hand-transmitted vibration
      ISO 2631-1,-2,-4: Whole-body vibration
      ISO 2631-1: Low-frequency whole-body vibration (0.1~0.5Hz)
   4) Frequency range:

2. Measurement

   Instrument: ISO 8041
   Direction: x, y, z related to structure
   Quantity: acceleration
   Location:
   Posture of occupant: Normally undefined.(Users can specify any posture based on ISO 2631-1)
   Source duration:

   permanent source: day, night, or day and night;

   intermittent source: duration of events and number of events per day and/or night;

   isolated or infrequent source: event duration and number of events per day, week or month.

   Exposure time: time for human in building
   Record Duration: ISO 2631-1

3. Evaluation Method

   1) Max. & min. of weighted acceleration value $a_w(t)$
      $a(t) ==> $ Weighted $ ==> a_w(t)$
      Weighting: ISO 2631-1
      peak vibration value
      maximum modulus of the instantaneous (positive and negative) peak values of the frequency-weighted acceleration

2)

time-averaged weighted acceleration value
frequency-weighted root-mean-square (r.m.s.) vibration acceleration value in a specified axis, a_w, in metres per second squared or radians per second squared, as defined by the expression

$$a_\mathrm{w} = \left(\frac{1}{T} \int_0^T a_\mathrm{w}^2(\xi)\,\mathrm{d}\xi \right)^{1/2}$$

where

    $a_\mathrm{w}(\xi)$ is the translational or rotational, frequency-weighted vibration acceleration in a specified direction or around a specified axis as a function of the instantaneous time, ξ in metres per second squared (m/s^2) or radians per second squared (rad/s^2), respectively;

    T is the duration of the measurement.

3)

time-averaged weighted acceleration level
frequency-weighted r.m.s. vibration acceleration level expressed in decibels, as defined by

$$L_\mathrm{w} = 20\,\lg \frac{a_\mathrm{w}}{a_0}\ \mathrm{dB}$$

where

    a_w is the frequency-weighted r.m.s. acceleration value;

    a_0 is the reference acceleration (in ISO 1683 for translational acceleration defined as 10^{-6} m/s^2).

4)

running r.m.s. acceleration value
frequency-weighted running r.m.s. vibration acceleration, in metres per second squared, defined by the expression

$$a_{\mathrm{w},\theta}(t) = \left(\frac{1}{\theta} \int_{t-\theta}^{t} a_\mathrm{w}^2(\xi)\,\mathrm{d}\xi \right)^{1/2}$$

where

    $a_\mathrm{w}(\xi)$ is the frequency-weighted instantaneous vibration acceleration at time ξ, in metres per second squared or radians per second squared (rad/s^2), respectively;

    θ is the integration time of the measurement;

    t is the instantaneous time.

Note 1 to entry: Exponential averaging may be used for the running r.m.s. method, as an approximation of the linear averaging. The exponential averaging is defined as follows:

$$a_{\mathrm{w},\tau}(t) = \left(\frac{1}{\tau} \int_{-\infty}^{t} a_\mathrm{w}^2(\xi) \exp\left(\frac{\xi - t}{\tau} \right) \mathrm{d}\xi \right)^{1/2}$$

where τ is the time constant.

5)

maximum transient vibration value
MTVV
maximum value of the running r.m.s. vibration acceleration value when the integration time is equal to 1 s

6)

motion sickness dose value
MSDV
integral of the squared frequency-weighted instantaneous vibration acceleration $a_w(t)$ in m/s^{1,5} as defined by the expression

$$MSDV = \left(\int_0^{\Phi} a_w^2 (\xi) \, d\xi \right)^{1/2}$$

where Φ is the total period during which motion could occur

Note 1 to entry: The motion sickness dose value can be obtained from the frequency-weighted r.m.s. vibration acceleration through multiplication by $\Phi^{1/2}$.

Note 2 to entry: For measurement instrumentation, the exposure period, Φ, is likely to be assumed to be equal to the measurement period, T, unless otherwise indicated.

7)

vibration dose value
VDV
integral of the fourth power of the frequency-weighted instantaneous vibration acceleration $a_w(t)$ in m/s^{1,75} as defined by the expression

$$VDV = \left(\int_0^{\Phi} a_w^4 (\xi) \, d\xi \right)^{1/4}$$

where Φ is the total (daily) period for which vibration exposure occurs

Note 1 to entry: The vibration dose value is more sensitive to peaks than is the r.m.s. value.

Note 2 to entry: For measurement instrumentation, the exposure period, Φ, is likely to be assumed to be equal to the measurement period, T, unless otherwise indicated.

8)

vibration total value
combined vibration from three axes of translational vibration, as defined by the expression

$$a_{wv} = \sqrt{k_x^2 a_{wx}^2 + k_y^2 a_{wy}^2 + k_z^2 a_{wz}^2}$$

where

a_{wx}, a_{wy} and a_{wz} are the weighted vibration values in the three orthogonal axes x, y and z;

k_x, k_y and k_z are multiplying constants whose values depend on the measurement application

8.2.21 JMA Intensity

This function performs calculations of the seismic intensity in order to estimate severity of the ground motion at the site of measurements. There are few methods of the intensity scale calculation, the most known are MMI (Modified Mercalli Intensity) and MSK (Medvedev-Sponheuer-Karnik) scales. This particular method utilizes the concept of calculations developed by Japan Meteorological Agency and therefore abbreviated as JMA. Each of three components of the input signal is filtered with a specific band-pass filter and the vector sum of those is taken. Then every point of JMA function is defined as a value of acceleration as a vector taken at some cumulative time offset dt in a sliding time window dT (dT > dt) representing sorted accelerations within this window. The intensity values are calculated from those points using an empirical formula.

User-defined parameters:

1. Length of the time window dT, seconds.
2. Time constant (offset dt in the window), seconds.
3. Type of the output signal, one of the followings:

   1) JMA Function – the set of vector accelerations, as described above.
   2) Empirical Intensity – the resulting JMA intensity.
   3) Vector Sum – square root of the sum of squares of all three filtered components.
   4) Vector Sum Sorted – the same as above but the values are displayed sorted.
   5) 1st Channel Filtered – 1st component of the signal after applying the bandpass filter.
   6) Maximum Acceleration – set of the maximum vector accelerations calculated in each window dT.

4. Output units: either the original units of the input signal or cm/s^2.

8.2.22 Power Spectra

This function performs a power spectrum calculation on the time series.

User-defined parameters:

1. Number of samples in every data chunk.
2. Overlapping factor: no overlapping, 50% or 67%.
3. Whether a window function is applied to the input time series, and if yes – which one default parameters for the implemented Welch's method assume 50% overlapping of the data segments and the Hamming window function applied to each segment before making an FFT. Results of all FFT are averaged to receive the final power spectra, which is then normalized to the sampling frequency in order to receive the PSD, i.e. power per frequency interval.

8.2.23 Response Spectra

This function performs a response spectrum analysis on the data. The output data can be the Response Spectrum Acceleration (RSA) or the Response Spectrum Velocity (RSV) or the Response Spectrum Displacement (RSD). The user can select the integration method for RSV and RSD between integration in the frequency domain and the integration in the time-domain. Integration in the time domain for RSV (double integration for RSD) is performed prior to the response spectra calculation.

User-defined parameters:

1. Start (lowest) frequency of the resulting spectrum in Hz.
2. End (highest) frequency of the resulting spectrum in Hz.
3. Damping factor, always < 1, i.e. damping of 5% is specified as 0.05.
4. How many points per decade are calculated in the resulting signal.
5. Type of the output spectra and the integration method for RSV and RSD selected from the list.

8.2.24 SN 640 312a

The Association of Swiss Highway Engineers distinguished in their Standard four different categories of buildings, mainly according to the type of construction.

Algorithm:
1. Integrate acceleration data to velocity data.
2. Find PV.
3. Vector Sum.
4. Find PPV.
5. Using the channel with the maximum PV to do PSD & ZC.
6. Find the dominant frequency.
7. Compare with the damage index.

8.2.25 STA/LTA Ratio

This function illustrates how the STA/LTA algorithm works. Using the specified short and long time windows for the signal averaging, it calculates the ratio of these two average values and plots it graphically. Note that first LTA seconds the ratio is plotted as zero because no LTA average is calculated yet. If the entire duration of the dataset is less than LTA time window, the function is undefined.

User-defined parameters:

1. STA time window seconds.
2. LTA time window, seconds.

Reference

https://gfzpublic.gfz-potsdam.de/rest/items/item_4097/component/file_4098/content

8.2.26 SI Tokyo Gas

Procedures:
1. Triaxial acceleration data
2. Using the vector sum as input signal for calculating the Pseudo-Spectral Velocity (PSV)

$$PSV = \frac{SA*T}{2\pi} \, or \, \frac{2\pi*SD}{T}$$

3. Calculating SI index

$$SI = \frac{1}{2.4}\int_{0.1}^{2.5} SVdT$$

Parameter
Damping ratio: 20%

Studying the characteristics of the acceleration records from the liquefied sites in Japan
and the United States, the following conditions were employed to judge the occurrence of liquefaction:
1. PGA is larger than 100 cm/s2,
   SI is larger than 20 cm/s.
2. the estimated maximum displacement D
   (D=2SI2/PGA) is larger than 10 cm.
3. The estimated predominant period T by the zero-crossing method is larger than 2.0 seconds.

4. If all the above conditions are satisfied by recorded horizontal accelerations, an alarm signal of liquefaction is issued.

8.2.27 Terzband Spectra

This function calculates peak values of the signal when it is passed through the set of band-pass filters (Class 0) in the time domain. The set of frequency bands and other related issues are specified by the standard IEC 1260.

The type of peak values selected by user can be one of the followings:

1. Max. Amplitude: The maximum value of raw signal is displayed.
2. RMS Amplitude: The RMS value of the raw signal is displayed.
3. Max. Effective Value: The effective value function is applied to the raw signal before calculating of the maximum value.
4. RMS Effective Value: The effective value function is applied to the raw signal before calculating the RMS value.

Other user-defined parameters:

1. Set of filters: either one-third octave bands (default) or the full octave bands
2. Decimal (default) or binary base for the frequency bands
3. Display units: either the actual signal units or dB. In the last case one can specify the reference level or one can use a maximum signal level by default.

8.2.28 Time-domain Filtering

This function applies a window filter to the source data. The window type is one of the followings: Parzen, Hanning, Hamming, Welch, Blackman, Lanczos or Gauss.

8.2.29 VC Curve

- Vibration Criterion (VC) Curves.
- The VC (Vibration Criteria) curves were developed in the early 1980s by Eric Ungar and Colin Gordon.
- Originally developed as a generic vibration criterion for vibration-sensitive equipment for use in the semiconductor, medical and biopharmaceutical industries, but have found application in a wide variety of technological applications.

Procedure:
- Sliding Window
- Fourier Transform
- ⅓ Octave Band ([Base, Octave] = [10,3])
- Weighting Type
- RMS for a_w & a_v

$$a_w = \left[\sum_i (w_i \, a_i)^2 \right]^{\frac{1}{2}}$$

where:

a_w : the Frequency - weighted acceleration;

w_i : the weighting factor for the i th one - third octave band;

a_i : the r.m.s acceleration for the i th one - third octave band.

$$a_v = (a_{wx}^2 + a_{wy}^2 + a_{wz}^2)^{\frac{1}{2}}$$

where:

a_{wx} 、a_{wy} 、a_{wz} : Triaxial Weighted RMS Acceleration;

a_v : Combining vibrations in more than one direction.

Reference

https://www.motioncontroltips.com/what-are-vibration-criteria-and-vc-curves/

8.2.30 Vector Sum

This function calculates the vector sum of three data components.