

# **Sine On Random Vibration Control System**

## **K2 K2Sprint**

## **SOR Instruction Manual**

### Limitation of K2Sprint/SOR

- Maximum numbers of usable input channel are '2' channels.
- Option of LIMIT CONTROL can not be added.

**IMV CORPORATION**

Type of Document : Instruction Manual

System Applied : K2/K2Sprint

Software < RANDOM / SOR > Later than Version 14.3.0

\*K2/RANDOM is necessary to be installed to operate this application.

Japanese Edition

Version	Date	Contents
1.0.0	2004.04.12	Japanese Manual first edition
1.0.1	2006.01.26	Correction of misprints
2.0.0	2008.01.18	Additional description of new functions ; Initial equalization setting, Averaging times setting at transmissibility measurement
10.0.0	2013.08.09	Renewal of screen display
10.0.1	2013.11.29	Correction of misprints
13.6.0	2017.10.02	Additional description of function to start the Sine tones control from 0dB, Correction of misprints
14.1.0	2018.04.27	Description of slope in interpolation type of SOR Sine Reference profile
14.2.0	2018.09.10	Additional description of Measured profile of SOR Sine Reference profile, additional description of "type of interpolation" of SOR Sine Reference profile
14.3.0	2019.04.19	Modified description of Basic operation, additional description of limit control to sine tones, correction of misprints

English Edition

Version	Date	Contents
1.0.0	2004.04.14	English Manual first edition
1.0.1	2006.01.26	Correction of misprints
2.0.0	2008.01.18	Additional description of new functions ; Initial equalization setting, Averaging times setting at transmissibility measurement
2.0.1	2010.12.08	Correction of misprints
10.0.0	2013.08.09	Renewal of screen display
13.6.0	2017.10.02	Additional description of function to start the Sine tones control from 0dB, Correction of misprints
14.1.0	2018.04.27	Description of slope in interpolation type of SOR Sine Reference profile
14.2.0	2018.09.10	Additional description of Measured profile of SOR Sine Reference profile, additional description of "type of interpolation" of SOR Sine Reference profile
14.3.0	2019.04.19	Modified description of Basic operation, additional description of limit control to sine tones, correction of misprints

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# Chapter 1 SOR

## 1.1 Outline

To perform a SOR test, PSD reference for Random vibration of broad band and Peak reference for Sine vibration of narrow band are needed to be defined.

A complete set of information needed for test operation in conjunction with a normal random test is to be described below ;

Table.1-1 Test types and definition information

Information \ Test type	Random	SOR
(1) I/O Module Configuration	○	○
(2) Excitation System Information	○	○
(3) Fundamental/Control Condition	○	○
(4) Excitation System Setting	○	○
(5) Control Reference	○	○
(6) SOR Sine Reference	—	○
(7) Input Channel	○	○
(8) Data Save Condition	○	○
(9) Safety check	○	○
(10) Amplitude probability density analysis	△	△

Information of a test completely defined is to be saved in a file as a specified format of 'Test File'.

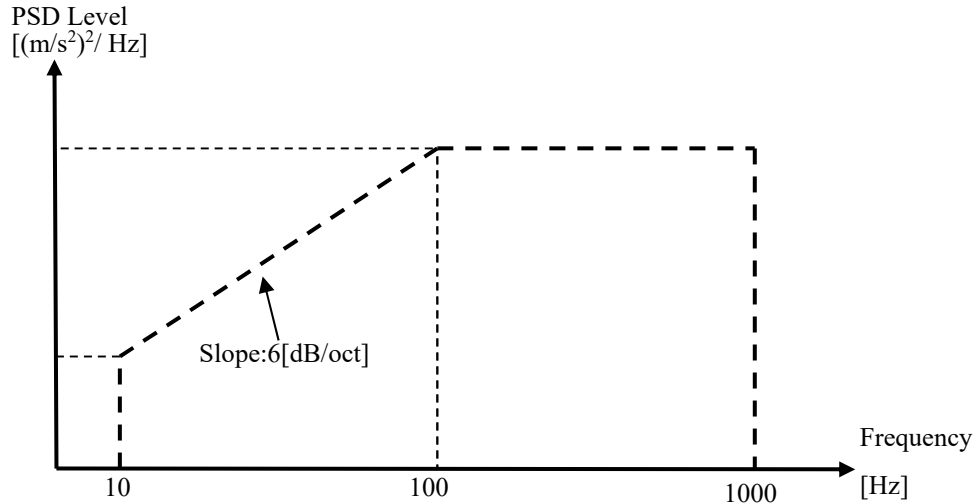
Test operation can be executed by loading a file in which the information of a test defined beforehand is saved as a test file.

## 1.2 SOR Test

< Example >

An example of SOR test is described as below ;

[Reference pattern]



- Broad band random reference

Broad band random is specified to have an intensity of 50  $[(m/s^2)_{rms}]$  having the PSD shape as in the above between 10 [Hz] and 1000 [Hz].

- Narrow band sine reference

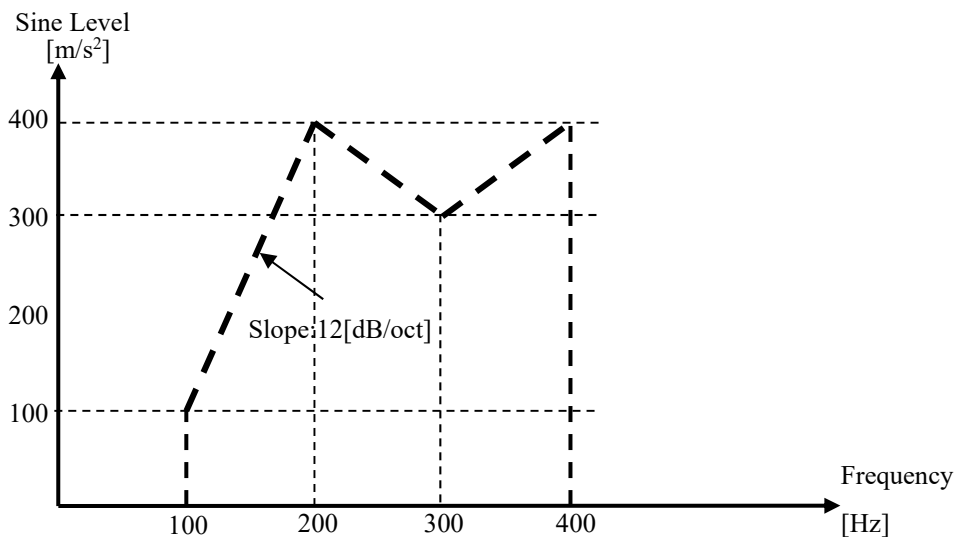
The swept sine waveform composed by a fundamental component and a 2nd harmonic component is used.

(Fundamental component)

A constant swept sine having the profile pattern as below in the swept band between 100 [Hz] and 400 [Hz]. (Initial phase : 0 degree)

(The 2nd harmonic component )

The 2nd harmonics having 80 % of the level for a fundamental component. (Initial phase : 180 degree)



[Test Time]

Sweep rate : 1.000 (octave/min)

Times of double sweep : 5 times from the forward (double-sweep)

[Information of sensors to be used]

Two acceleration pickups of piezoelectric : one is used for control and another for monitor.

Ch. 1 : for control, sensitivity  $3\text{pC}/(\text{m}/\text{s}^2)$

Ch. 2 : for monitor, sensitivity  $3\text{pC}/(\text{m}/\text{s}^2)$

However, these channels must be registered in Input channel information (in this example, 'Input05').

Also, the rating information of excitation system has already been registered in Excitation system information (in this example, 'Exc01').

[Information of specimen]

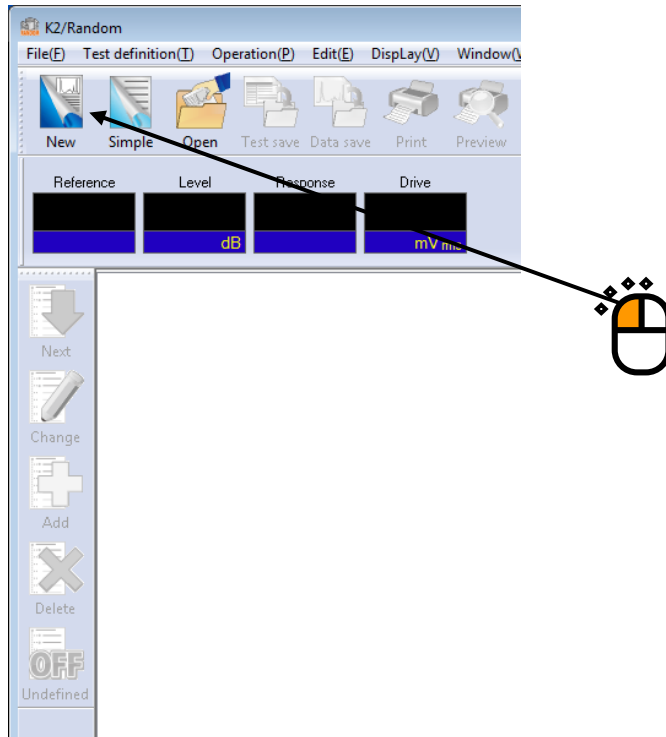
Specimen mass : 10[kg]



< Procedures >

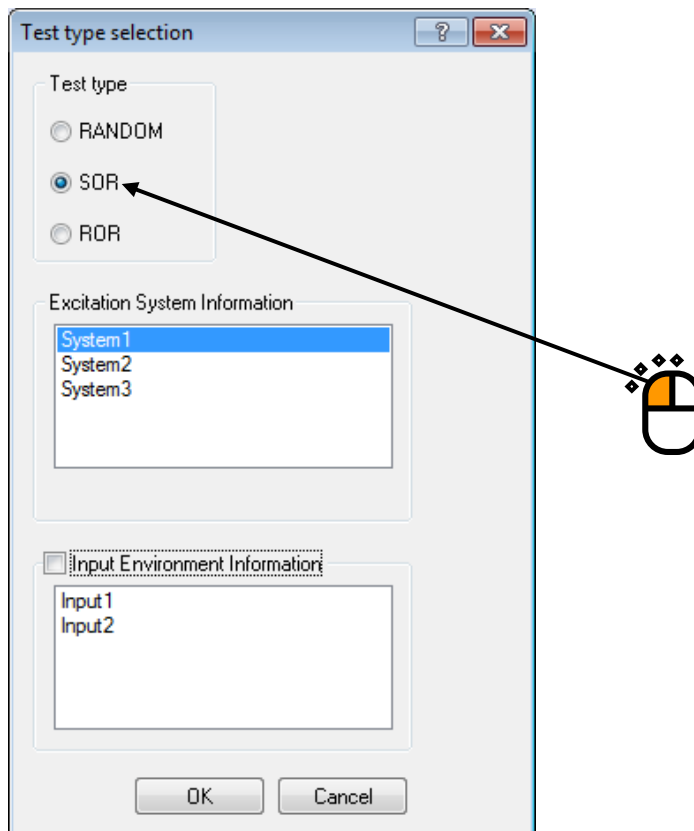
< Step 1 >

Press the button of [New] to start new definition.



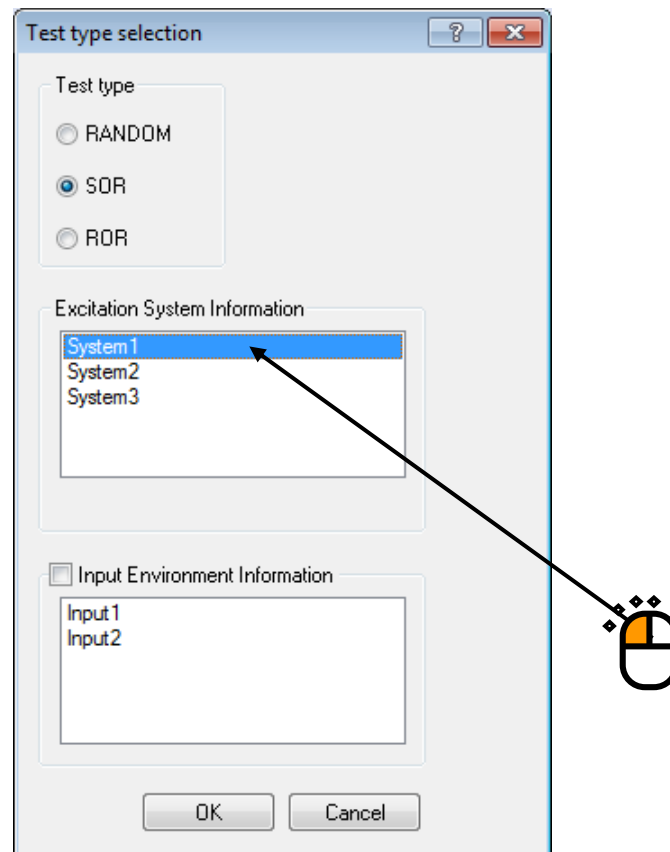
< Step 2 >

Select the item of 'SOR test' in Test type.



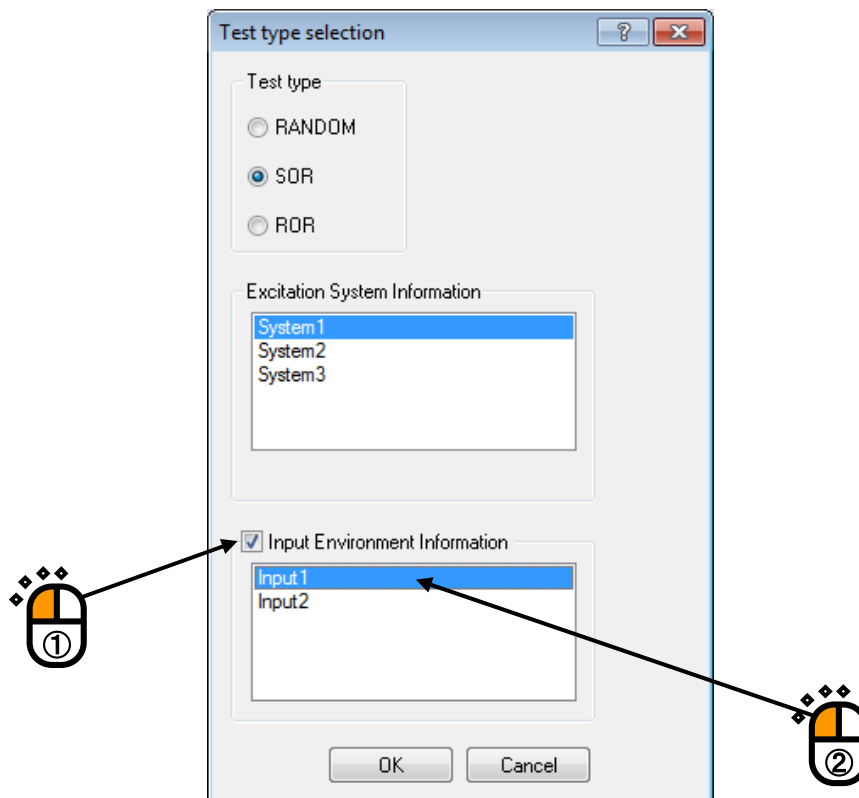
< Step 3 >

Select an Excitation system from the list of 'Excitation system information'.



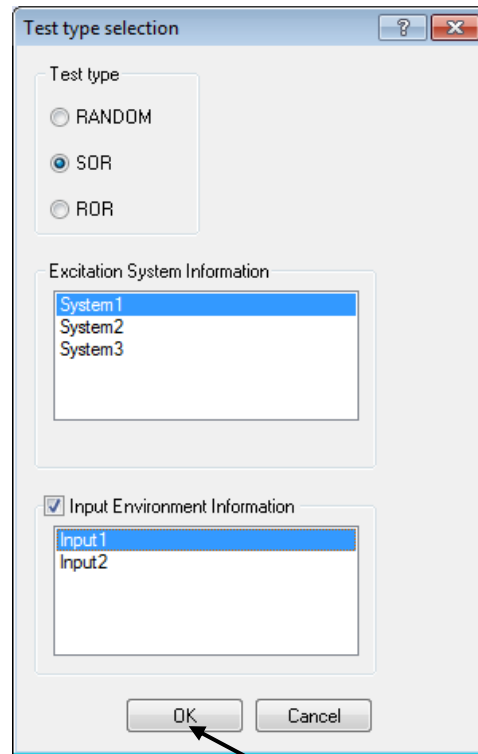
< Step 4 >

Click the checkbox of 'Input channel information selection' and select an Input channel information from the list.



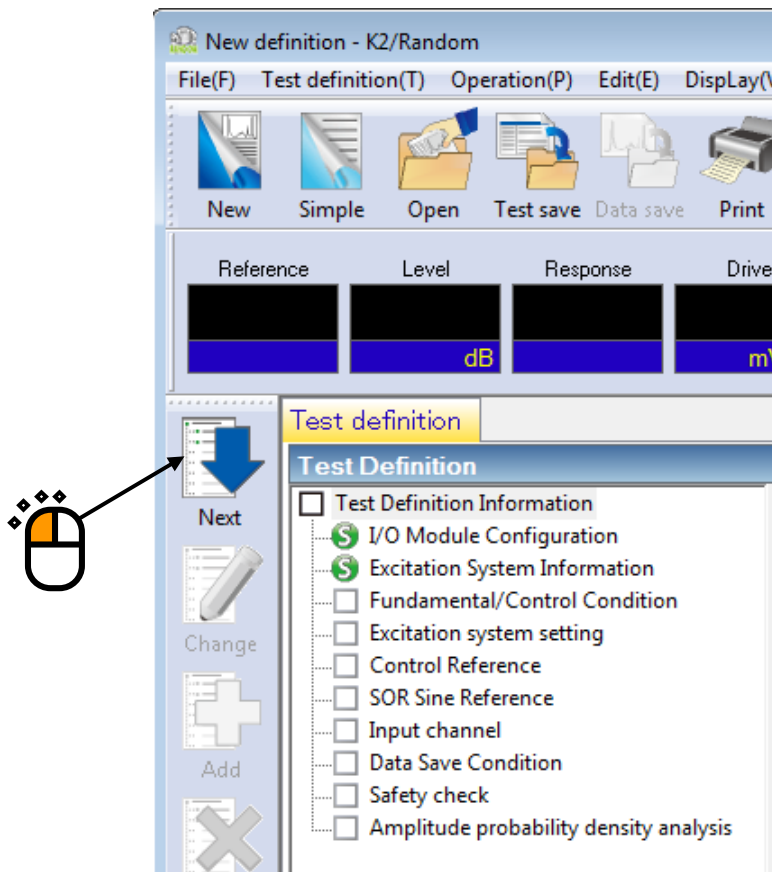
< Step 5 >

Press the button of [OK].



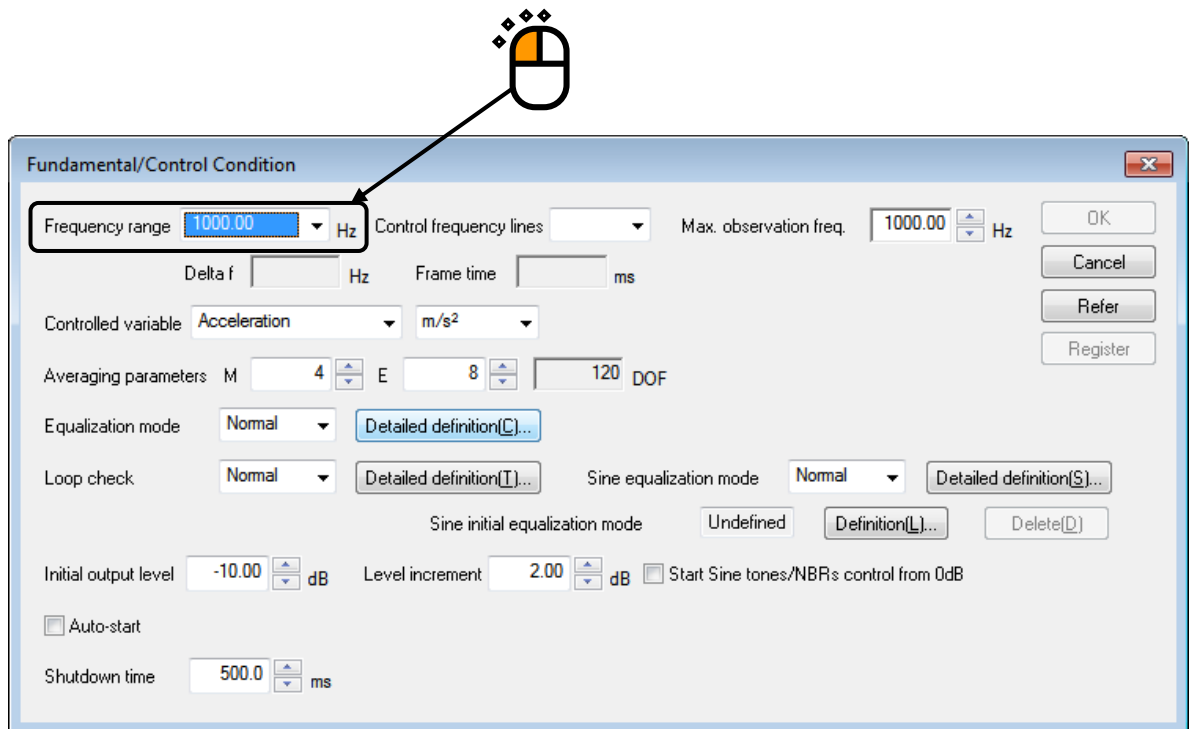
< Step 6 >

Press the button of [Next] to go to the next definition.



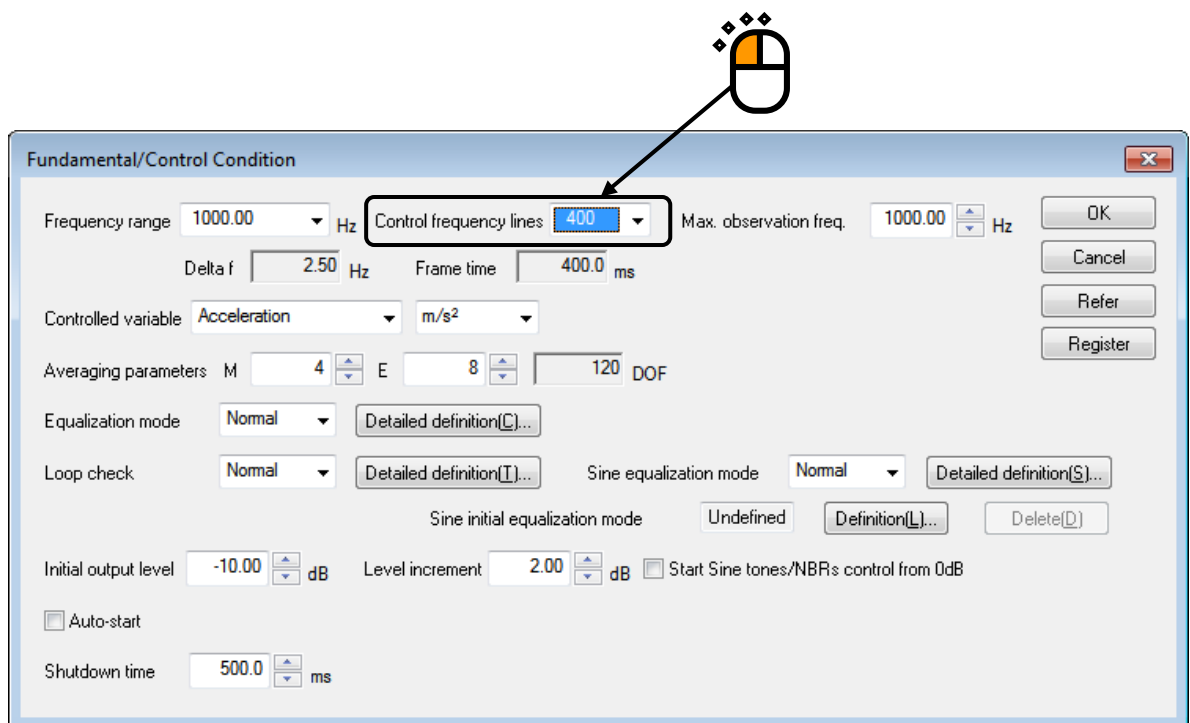
< Step 7 >

Input the value to 'Frequency' as 1000Hz.



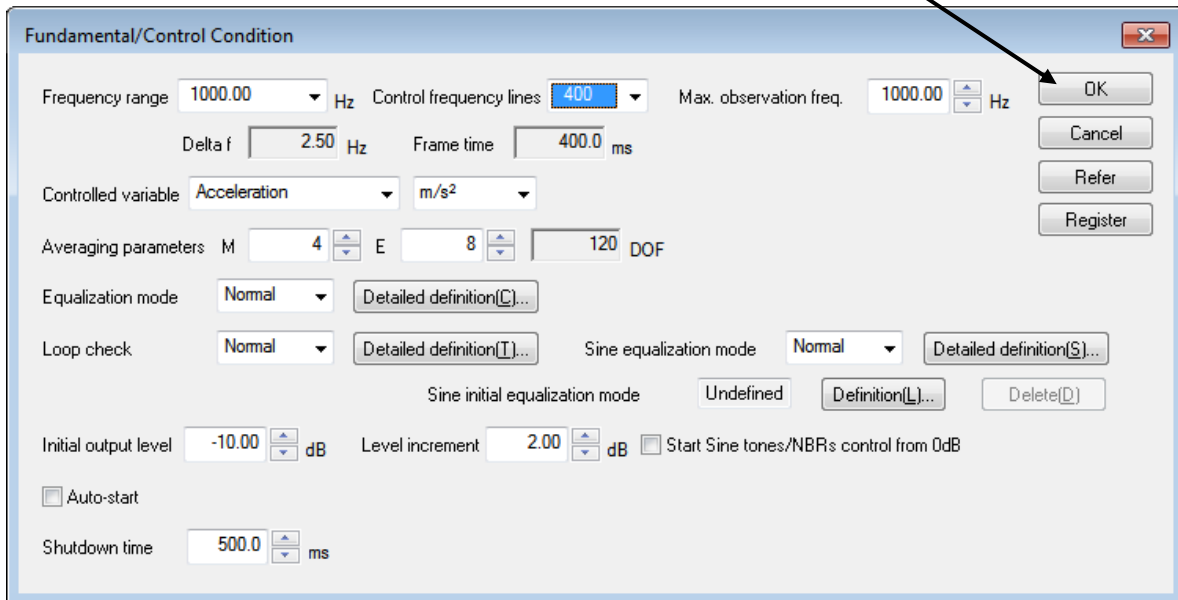
< Step 8 >

Input the value to 'Control frequency lines' as 400.



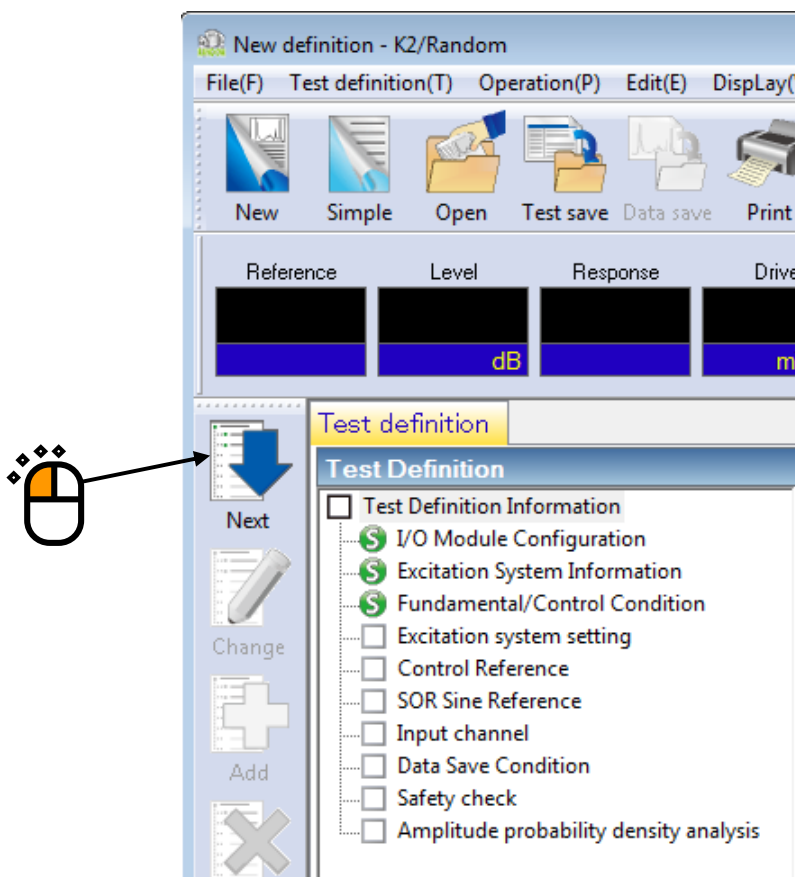
< Step 9 >

Press the button of [OK].



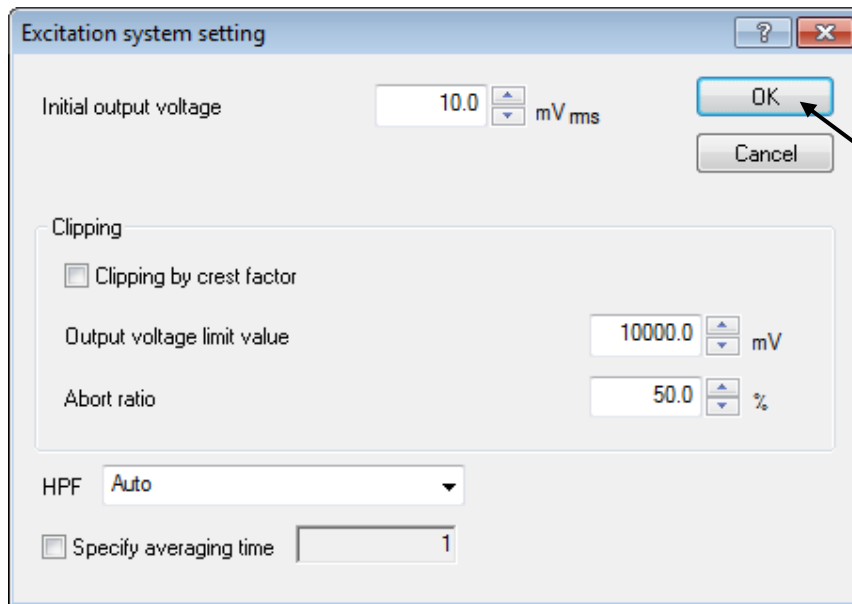
< Step 10 >

Press the button of [Next] to go to the next definition.



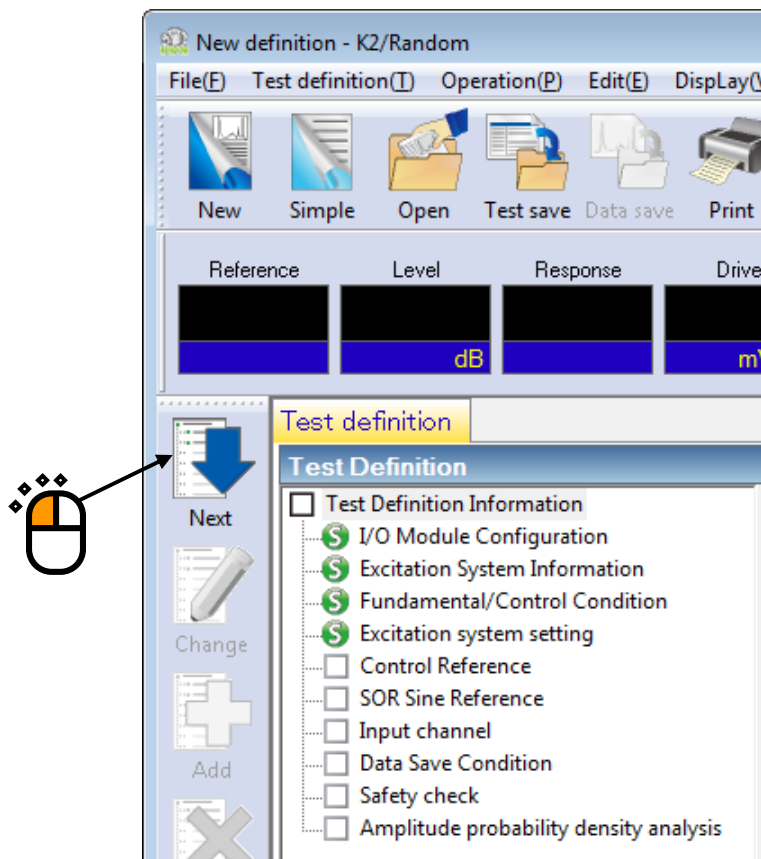
< Step 11 >

Press the button of [OK].



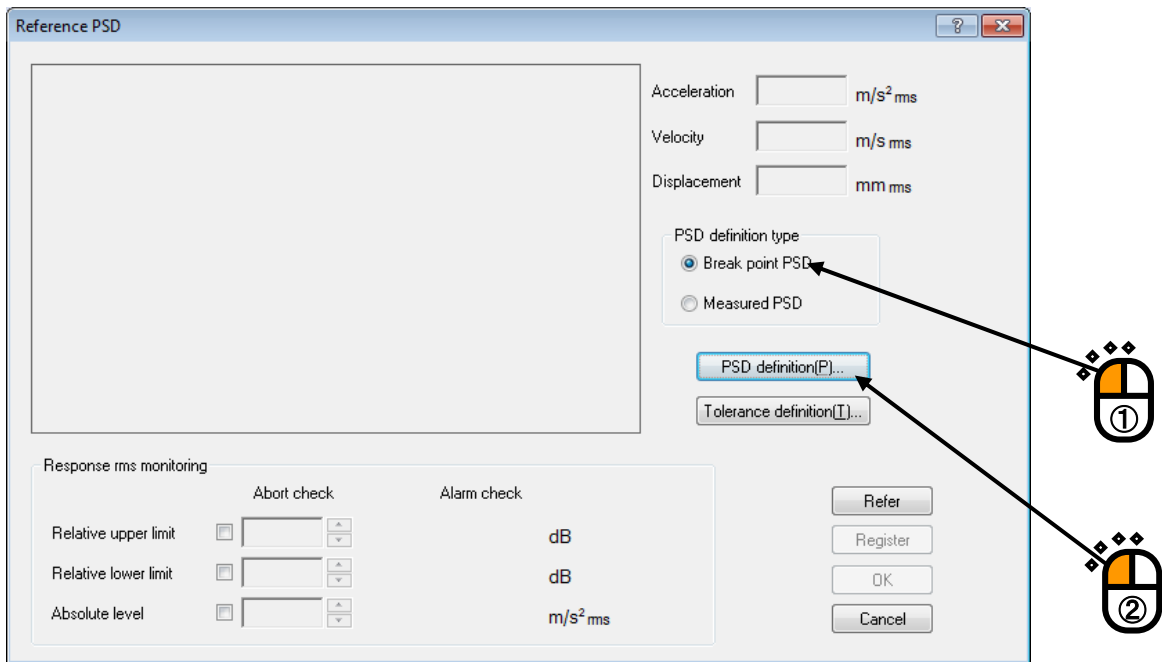
< Step 12 >

Press the button of [Next] to go to the next definition.



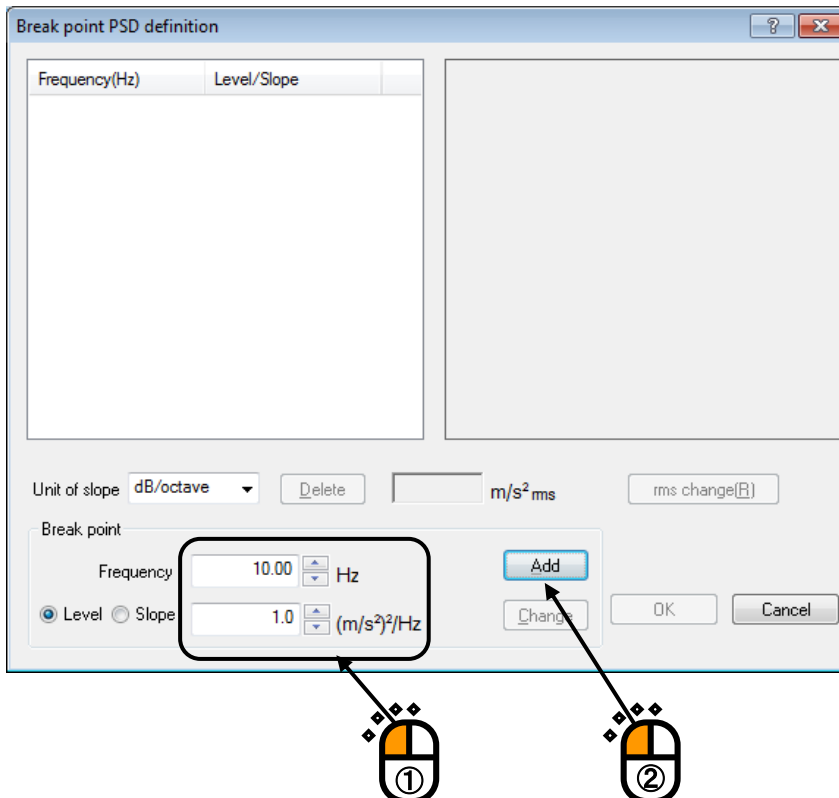
< Step 13 >

Select the item of 'Break point' in PSD definition type. And press the button of [PSD definition].



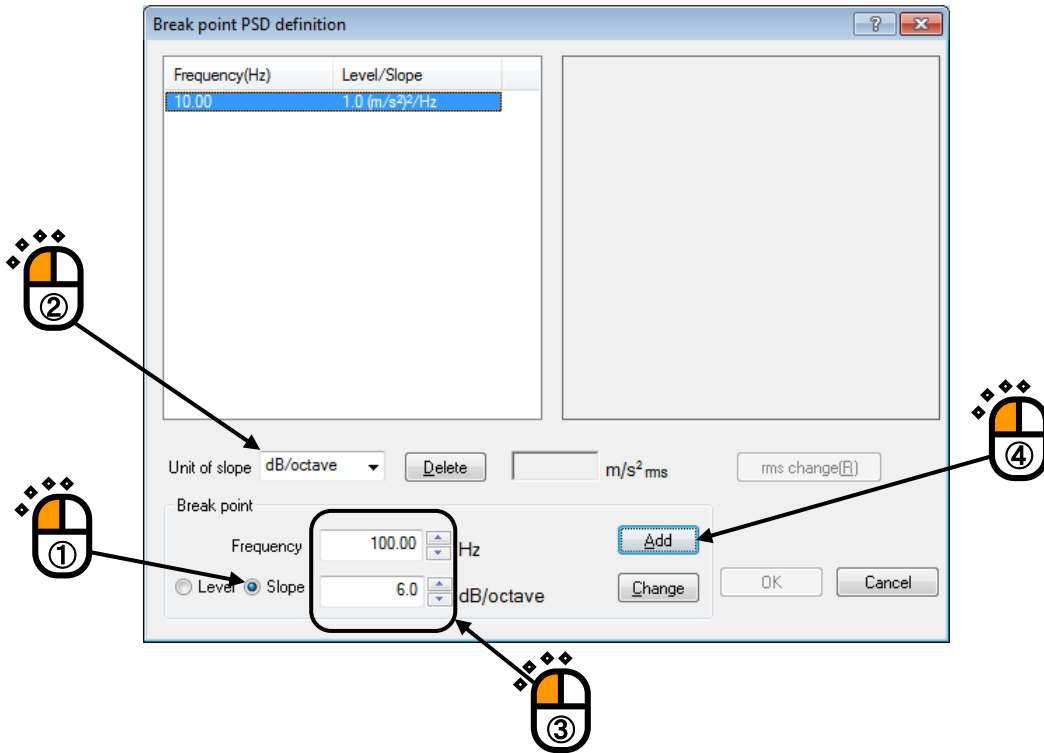
< Step 14 >

Click and select 'Level'. Input the values to 'Frequency' as 10 [Hz] and 'Level' as 1 [(m/s<sup>2</sup>)<sup>2</sup>/Hz]. And press the button of [Add].



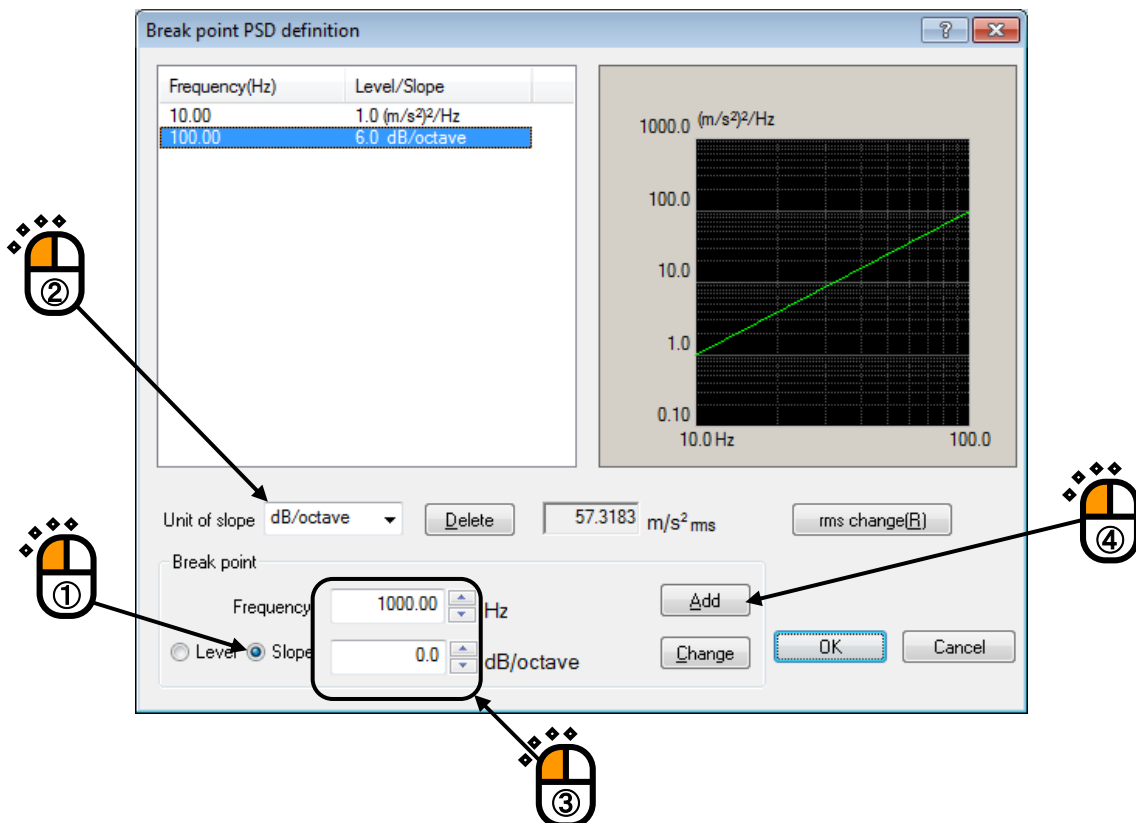
< Step 15 >

Click 'Slope' and select 'dB/octave' as the unit. Input the values to 'Frequency' as 100 [Hz] and 'Slope' as 6 [dB/octave]. Then press the button of [Add].



< Step 16 >

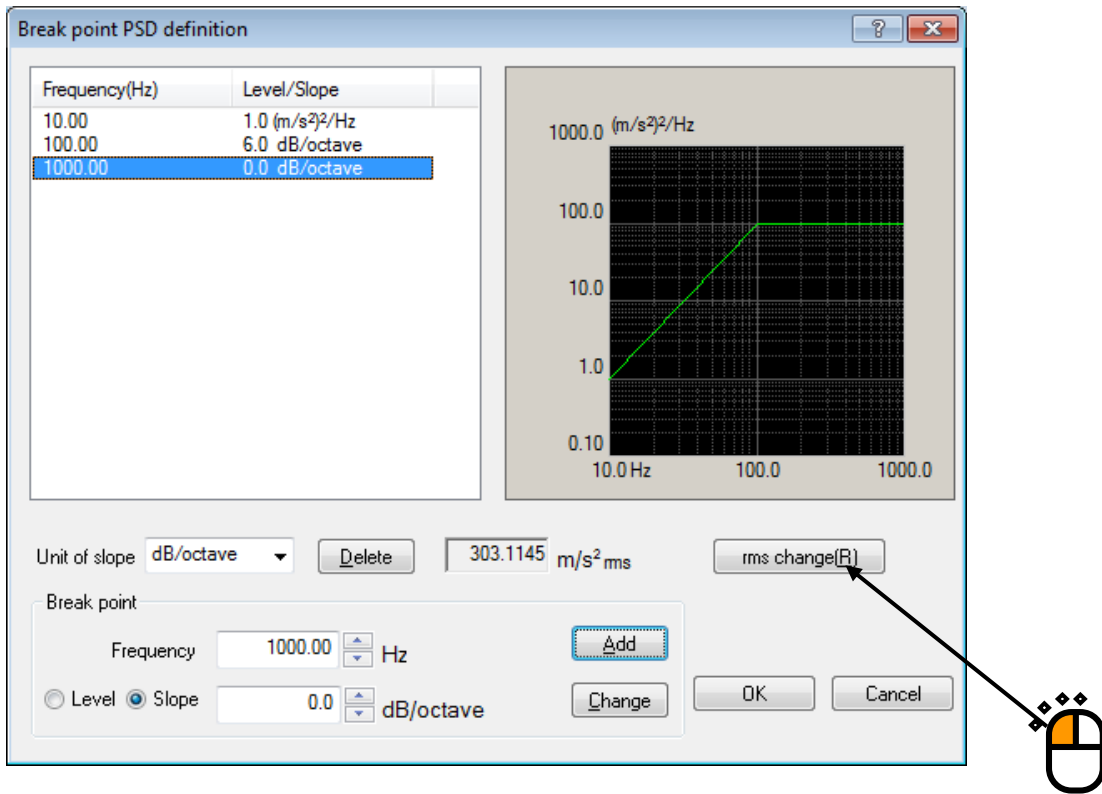
In the same way, click 'Slope' and select 'dB/octave' as the unit. Input the values to 'Frequency' as 1000 [Hz] and 'Slope' as 0 [dB/octave]. Then press the button of [Add].





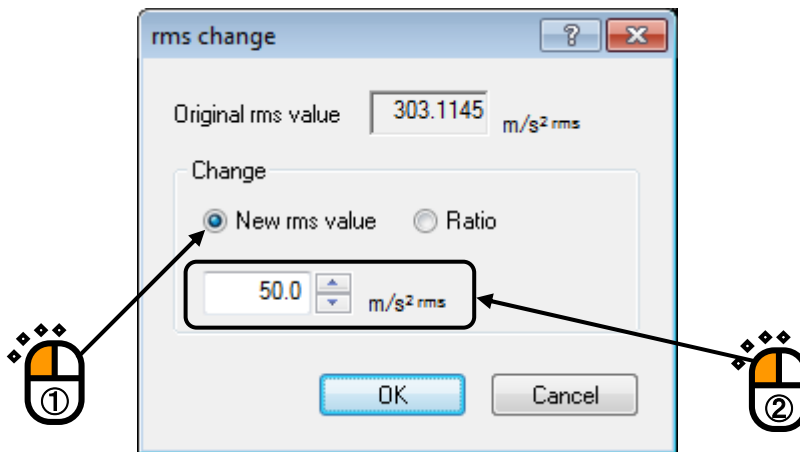
< Step 17 >

Press the button of [rms value change].



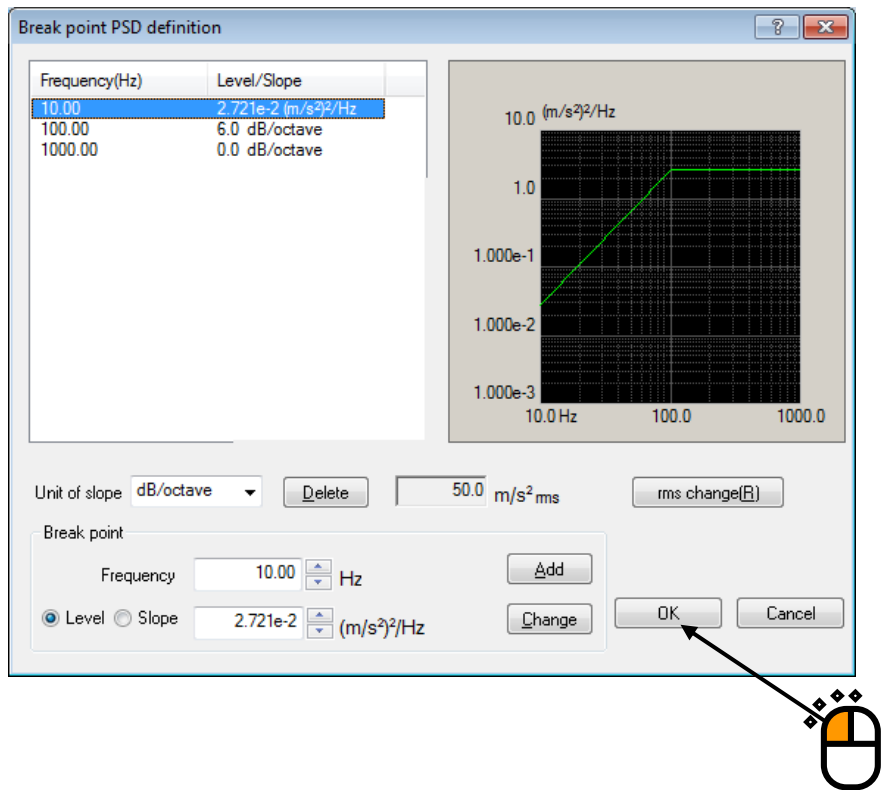
< Step18 >

Click and select 'New rms'. Input the values to 'New rms' as 50 [(m/s<sup>2</sup>) rms] and press the button of [OK].



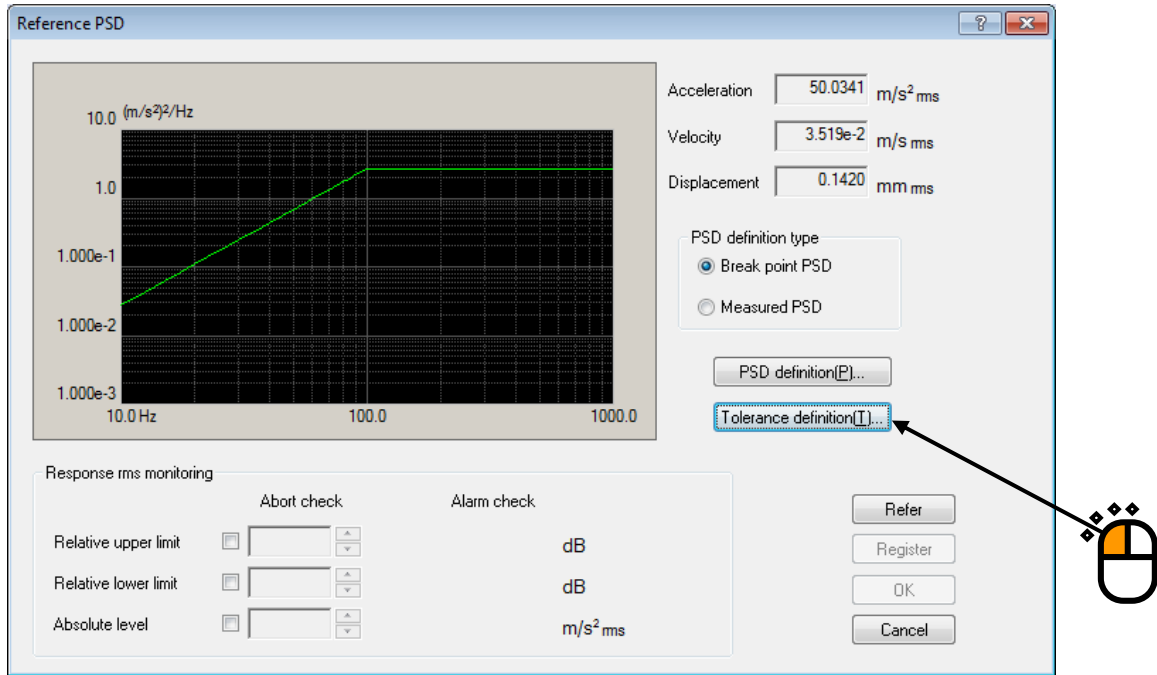
< Step 19 >

Press the button of [OK].



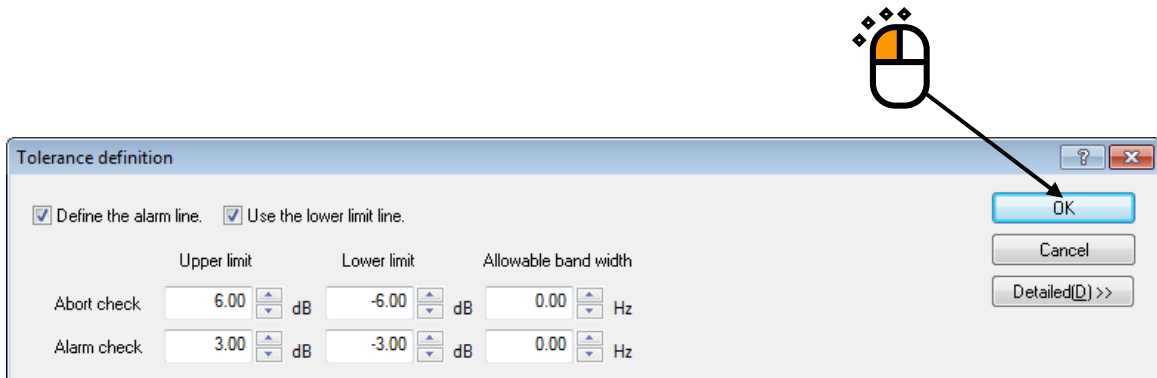
< Step 20 >

Press the button of [Tolerance definition].



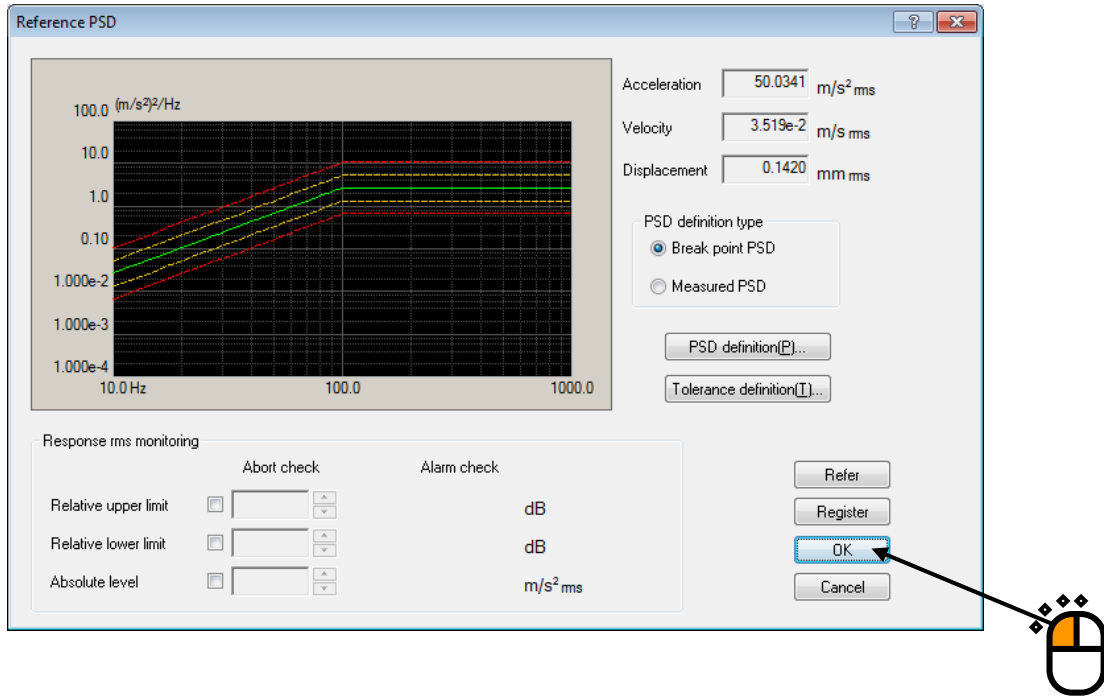
< Step 21 >

Press the button of [OK].



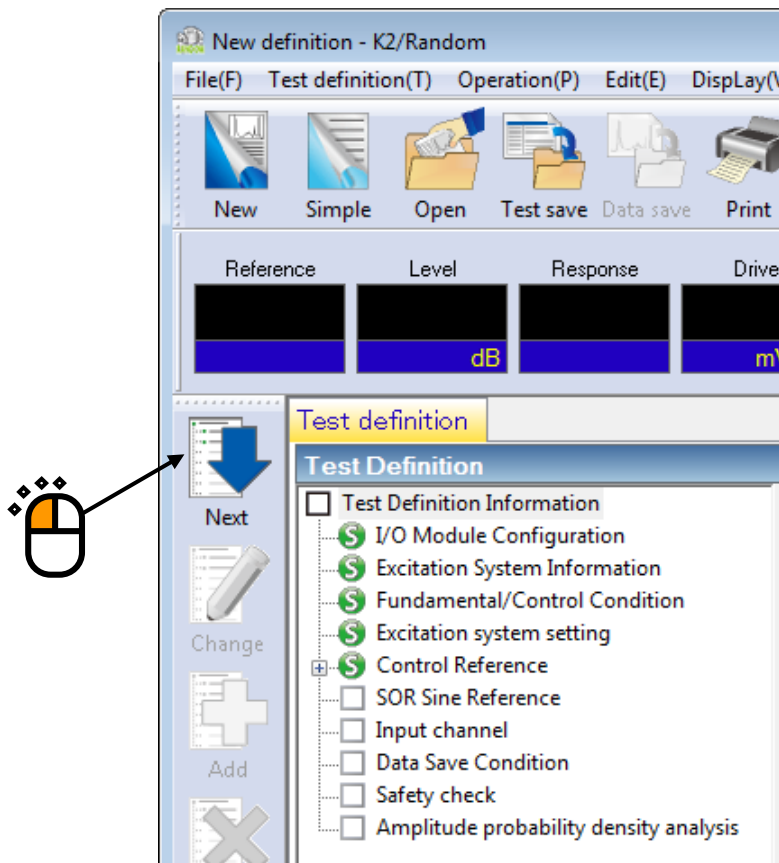
< Step 22 >

Press the button of [OK].



< Step 23 >

Press the button of [Next] to go to the next definition.



< Step 24 >

Define the profile of a swept sine to be operated.

- (1) Sweep mode :                Select 'Log' and 'Forward double' as sweep direction.
- (2) Sweep rate :                Set 1 [octave/min].
- (3) Sweep pause time :        Set to zero.
- (4) Test time :                 Select 'By double sweep counts' and set the times as 5 [double-sweep].
- (5) Press the button of [Profile definition]

The screenshot shows the 'SOR Sine Reference' dialog box. The settings are as follows:

- Sweep mode: Log, Forward-double
- Sweep rate: 1.0 octave/min
- Sweep pause time: 0:00:00
- Test time: By double sweep counts, 5 double-sweep
- Buttons: Profile definition... (highlighted), Profile re-definition(B)...
- Checkboxes: Setting of sweep start freq., Sweep lower limit, Sweep upper limit
- Table:

No.	Freq. ratio(times)	Level ratio	Init. phase(deg)	Abort upper(dB)	Abort lower(dB)	Alarm upper(dB)	Alarm lower(dB)
1	1.0	100.0 %	0.00	6.00	-6.00	3.00	-3.00

Unit of Level ratio: %

Use Alarm: [checked], Use Lower limit: [checked], Symmetric upper/lower limit: [checked]

Buttons: Delete

Unit settings: Freq. ratio: 1.0 times, Level ratio: 100.0 %, Initial phase: 0.00 degree

Abort settings: Upper: 6.00 dB, Lower: -6.00 dB

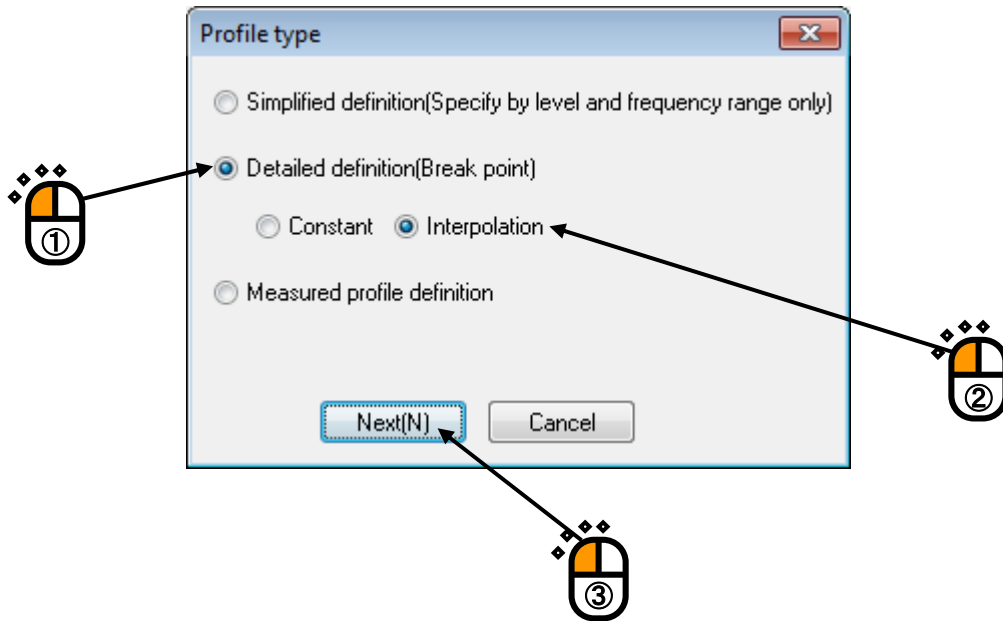
Alarm settings: Upper: 3.00 dB, Lower: -3.00 dB

Buttons: Add, Change

Numbered callouts 1-5 point to: 1. Sweep mode dropdowns, 2. Sweep rate input, 3. Sweep pause time input, 4. Test time dropdown and input, 5. Profile definition button.

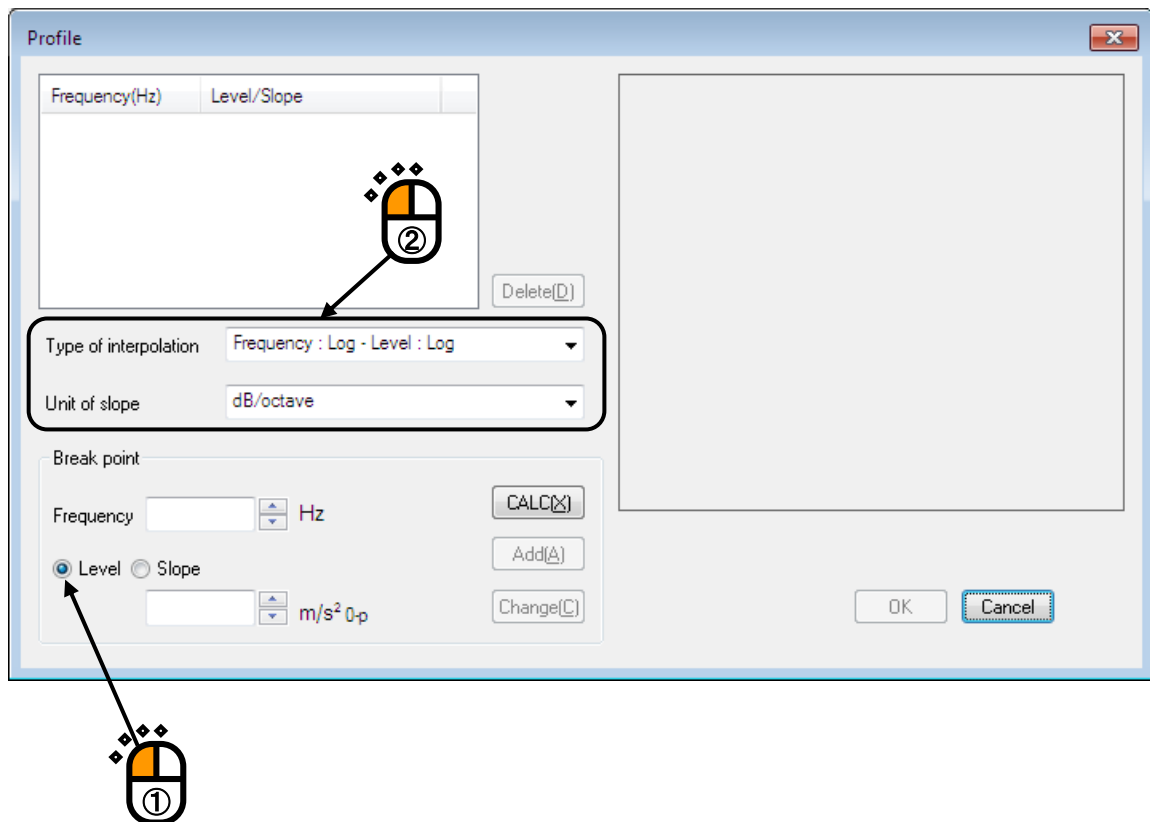
< Step 25 >

Select 'Detailed definition (Break point)' and 'Interpolation'. Press the button of [Next].



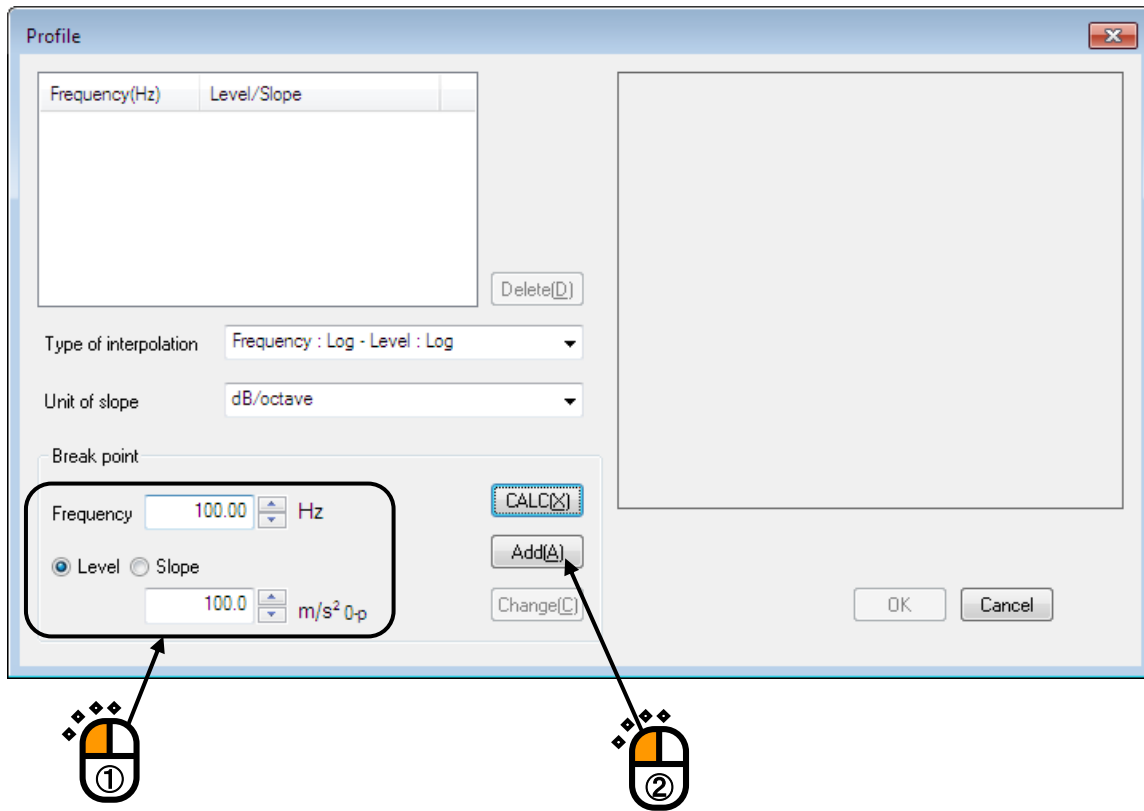
< Step 26 >

Select 'Level'. Specify Type of interpolation as 'Frequency : Log – Level : Log' and Unit of slope as 'dB/octave'.



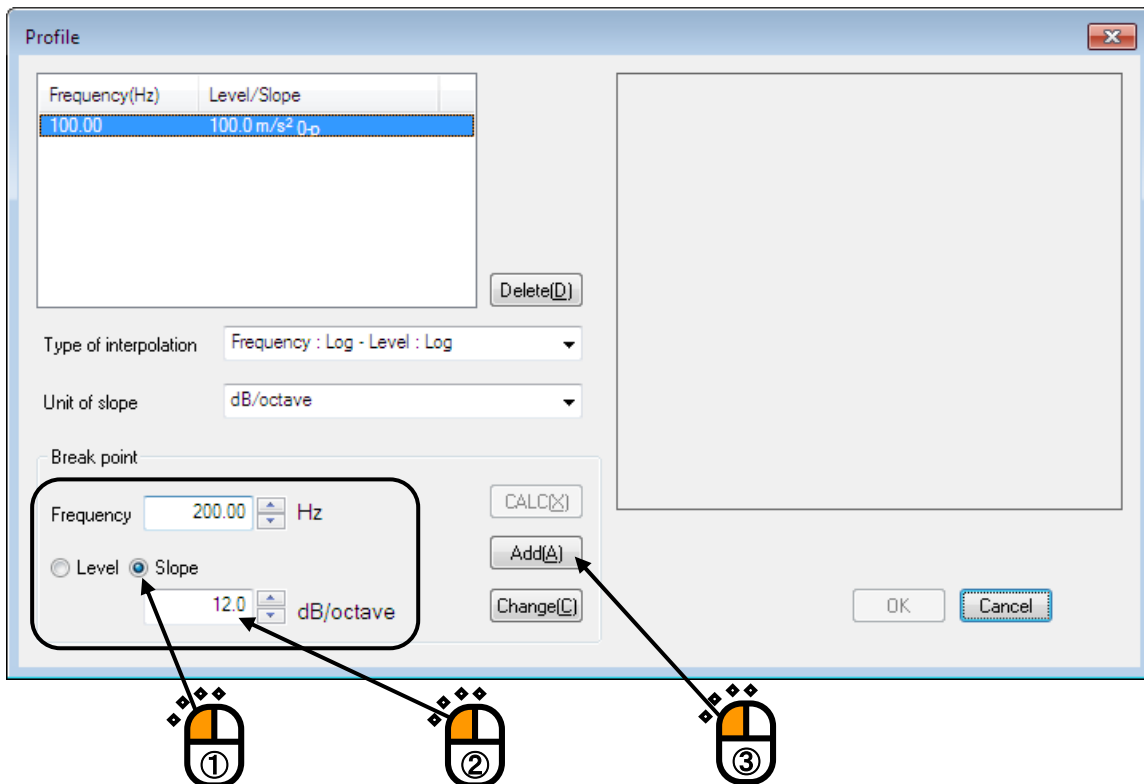
< Step 27 >

Input the values to 'Frequency' as 100.0 [Hz] and 'Level' as 100.0 [m/s<sup>2</sup>].  
Press the button of [Add].



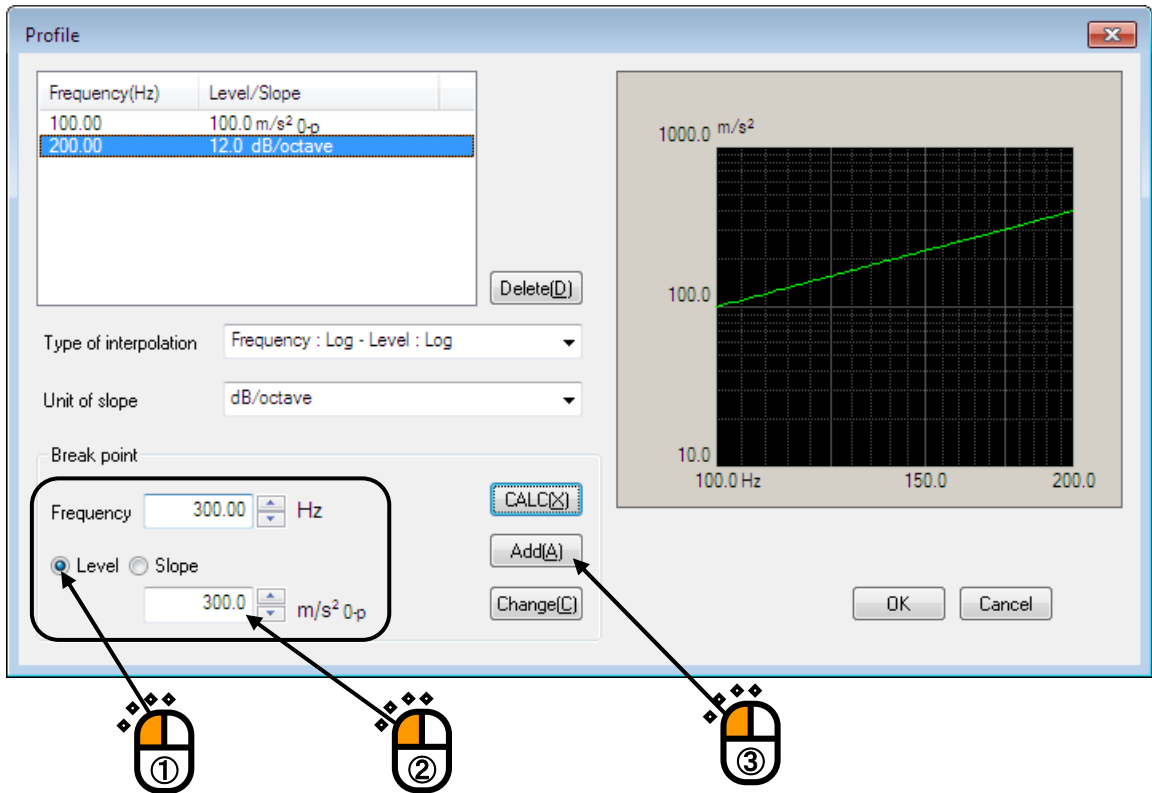
< Step 28 >

Select 'Slope'. Input the values to 'Frequency' as 200.0 [Hz] and 'Slope' as 12.0 [dB/octave].  
Press the button of [Add].



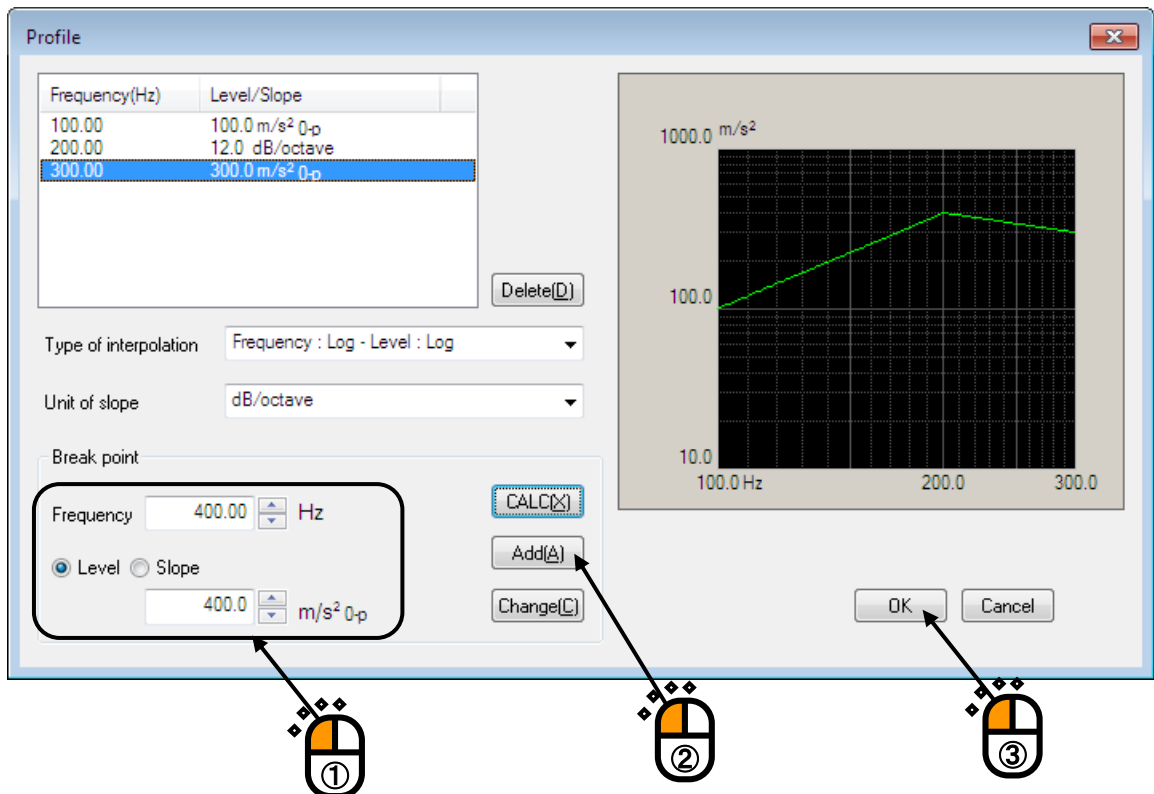
< Step 29 >

Select 'Level'. Input the values to 'Frequency' as 300.0 [Hz] and 'Level' as 300.0 [m/s<sup>2</sup>]. Press the button of [Add].



< Step 30 >

Input the values to 'Frequency' as 400.0 [Hz] and 'Level' as 400.0 [m/s<sup>2</sup>]. Press the button of [Add]. Then press the button of [OK].





< Step 31 >


Set the 'Level ratio' of the reference frequency to 100 [%]. Press the button of [Change].

No.	Freq. ratio(times)	Level ratio	Init. phase(deg)	Abort upper(dB)	Abort lower(dB)	Alarm upper(dB)	Alarm lower(dB)
1	1.0	100.0 %	0.00	6.00	-6.00	3.00	-3.00

Unit of Level ratio %  Use Alarm  Use Lower limit  Symmetric upper/lower limit

Freq. ratio 1.0 times Level ratio 100.0 % Initial phase 0.00 degree

Abort Upper 6.00 dB Lower -6.00 dB Alarm Upper 3.00 dB Lower -3.00 dB



< Step 32 >

The harmonic component of 2 times is needed to be defined.

- (1) Set the 'Frequency ratio' to 2 [times].
- (2) Set the 'Level ratio' to 80 [%].
- (3) Set the 'Initial phase' to 180 [degree].

And press the button of [Add].

After completing the definition, press the button of [OK].

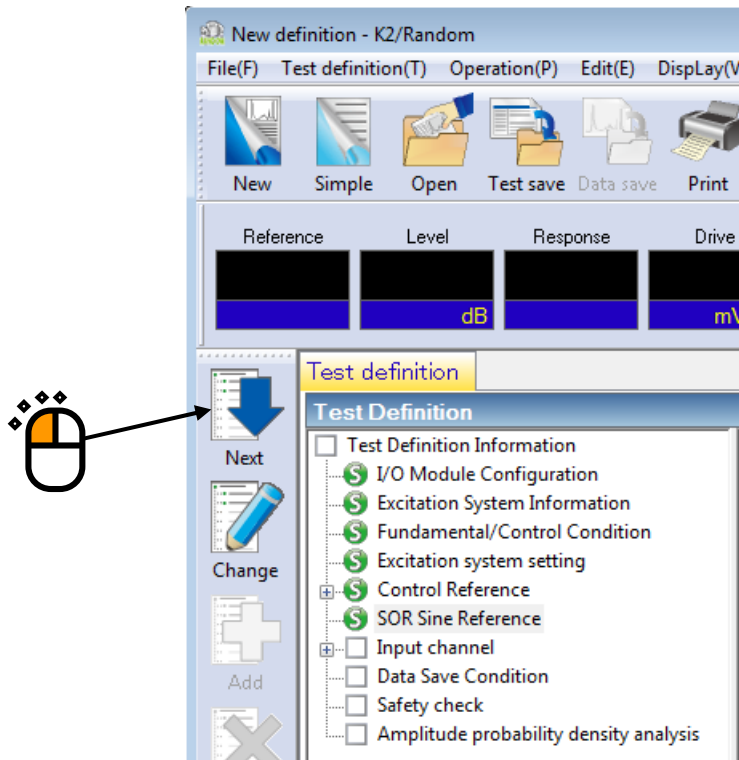
The screenshot shows the 'SOR Sine Reference' window. The graph displays a sine wave with an amplitude of 100.0 m/s² at 100.0 Hz, increasing to 1000.0 m/s² at 200.0 Hz, and then decreasing to 100.0 m/s² at 400.0 Hz. The table below the graph shows the following parameters:

No.	Freq. ratio(times)	Level ratio	Init. phase(deg)	Abort upper(dB)	Abort lower(dB)	Alarm upper(dB)	Alarm lower(dB)
1	1.0	100.0 %	0.00	6.00	-6.00	3.00	-3.00
2	2.0	80.0 %	180.00	6.00	-6.00	3.00	-3.00

The 'Add' button is highlighted, and the 'OK' button is also highlighted. The 'Freq. ratio' is set to 2.0, 'Level ratio' to 80.0 %, and 'Initial phase' to 180.00 degree. The 'Add' button is labeled with a circled '5' mouse cursor. The 'OK' button is labeled with a circled '5' mouse cursor. The 'Freq. ratio' field is labeled with a circled '1' mouse cursor. The 'Level ratio' field is labeled with a circled '2' mouse cursor. The 'Initial phase' field is labeled with a circled '3' mouse cursor. The 'Add' button is labeled with a circled '4' mouse cursor.

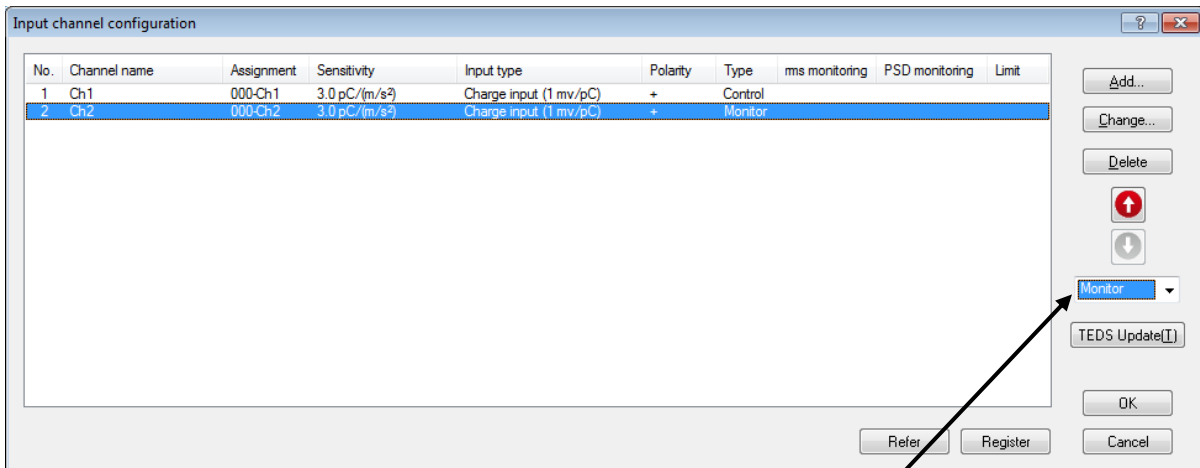
< Step 33 >

Press the button of [Next] to go to the next definition.



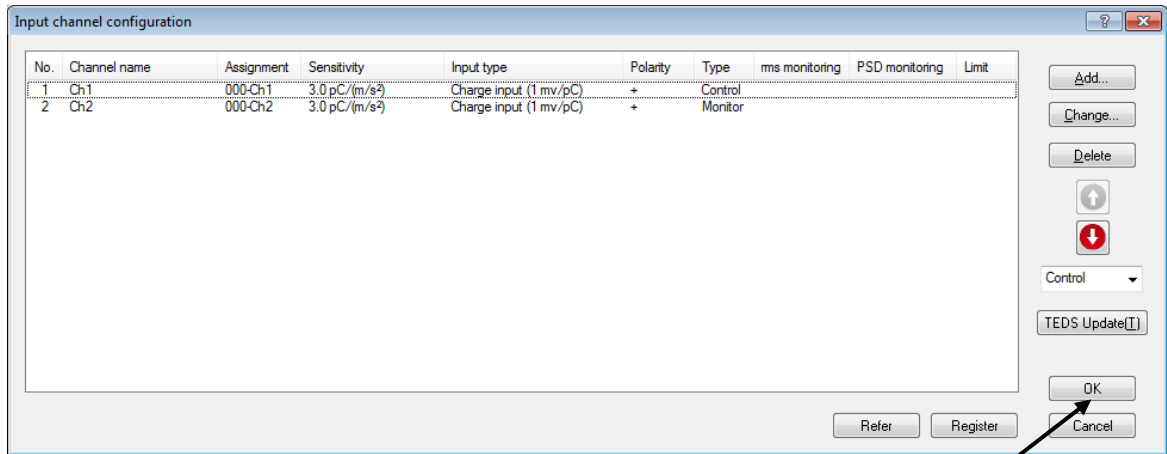
< Step 34 >

Select 'Ch. 1' and specify as 'Control'. And select 'Ch. 2' and specify as 'Monitor'.



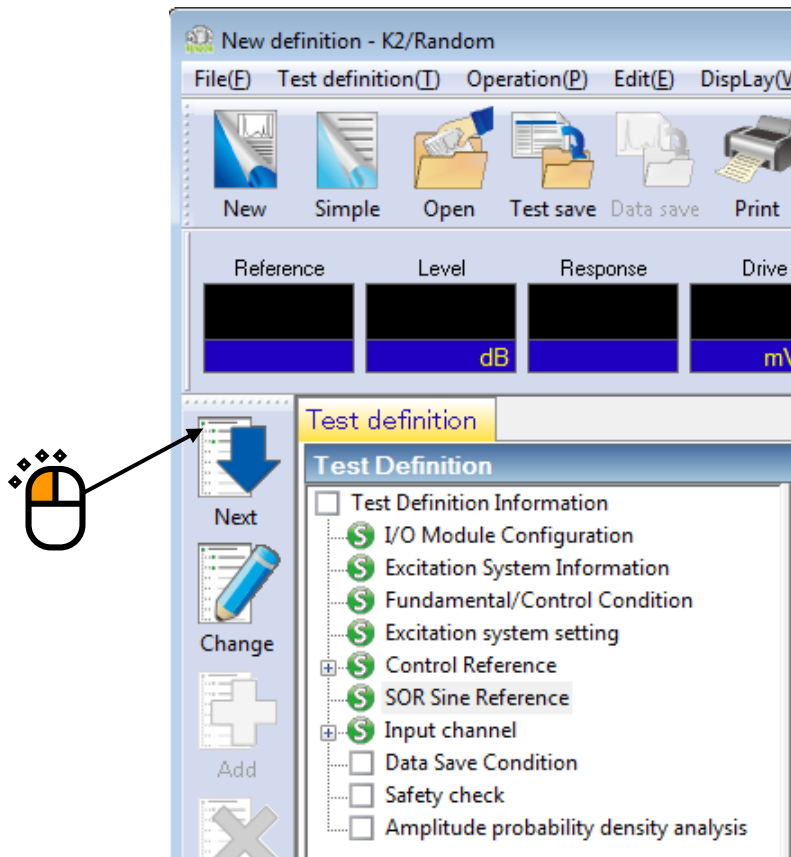
< Step 35 >

After completing the test definition, press the button of [OK].



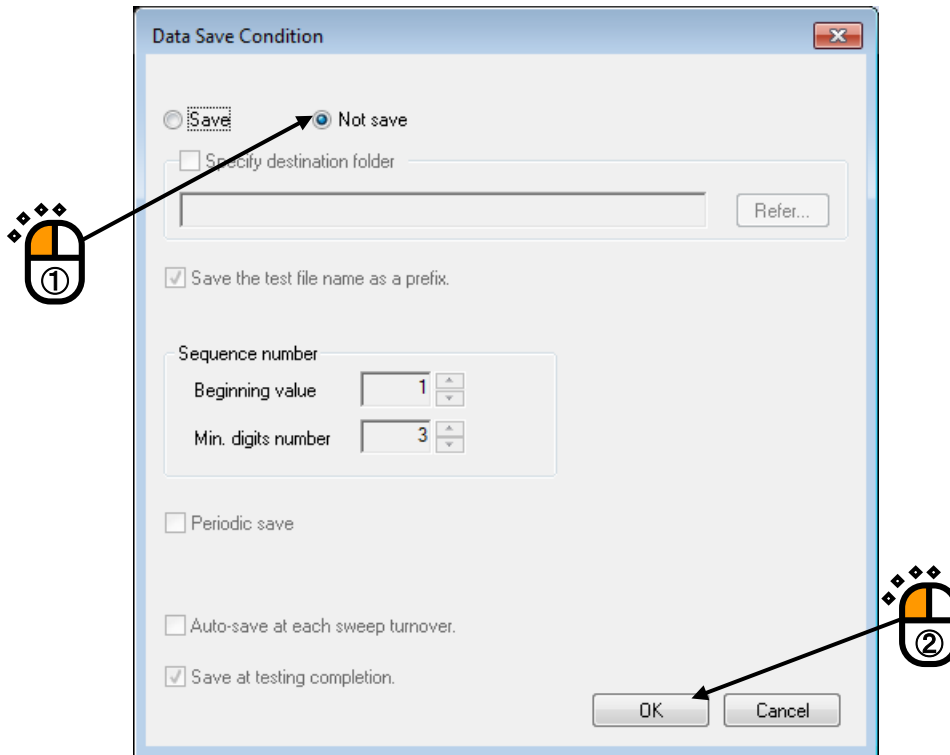
< Step 36 >

Press the button of [Next].



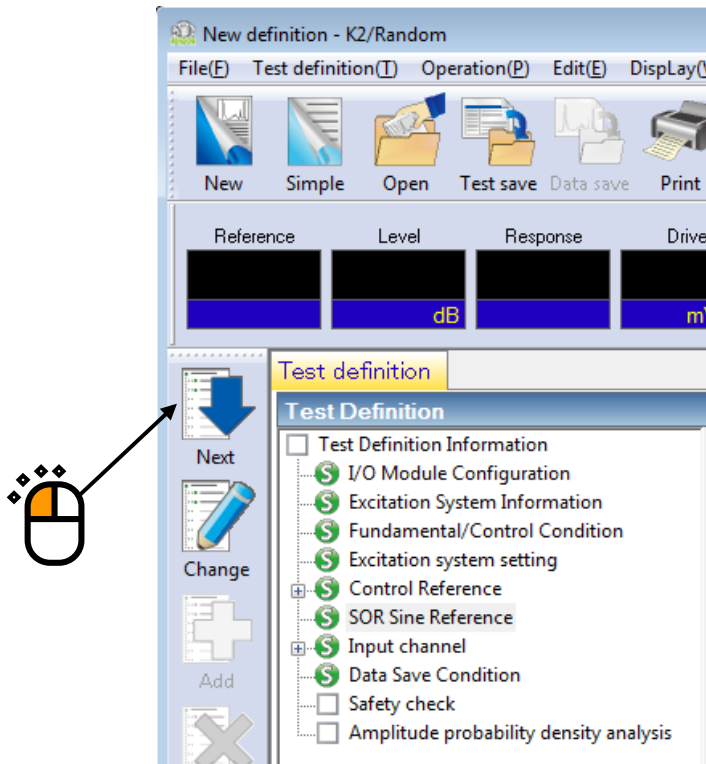
< Step37 >

Select 'Not save' and press the button of [OK].



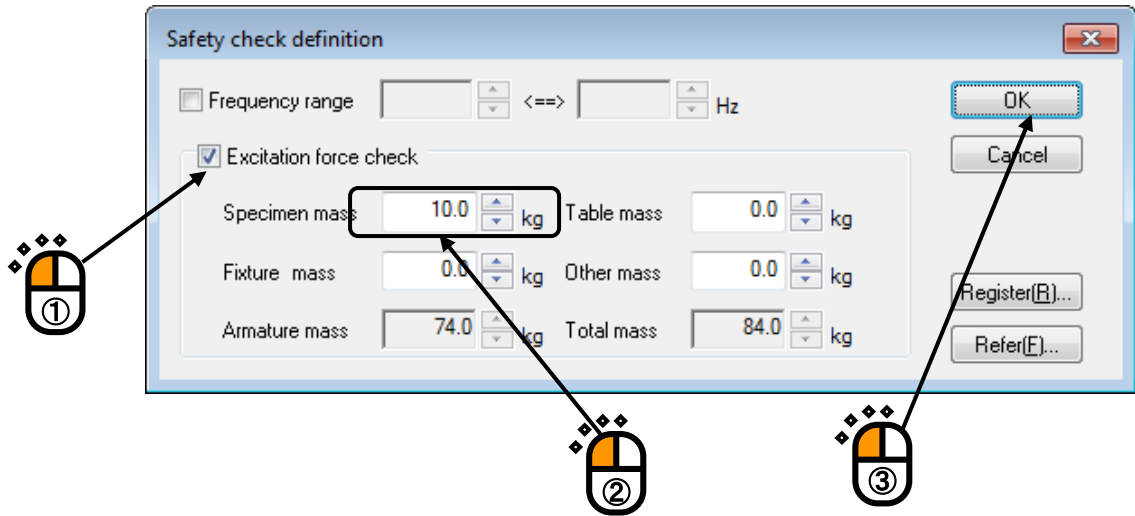
< Step38 >

Press the button of [Next].



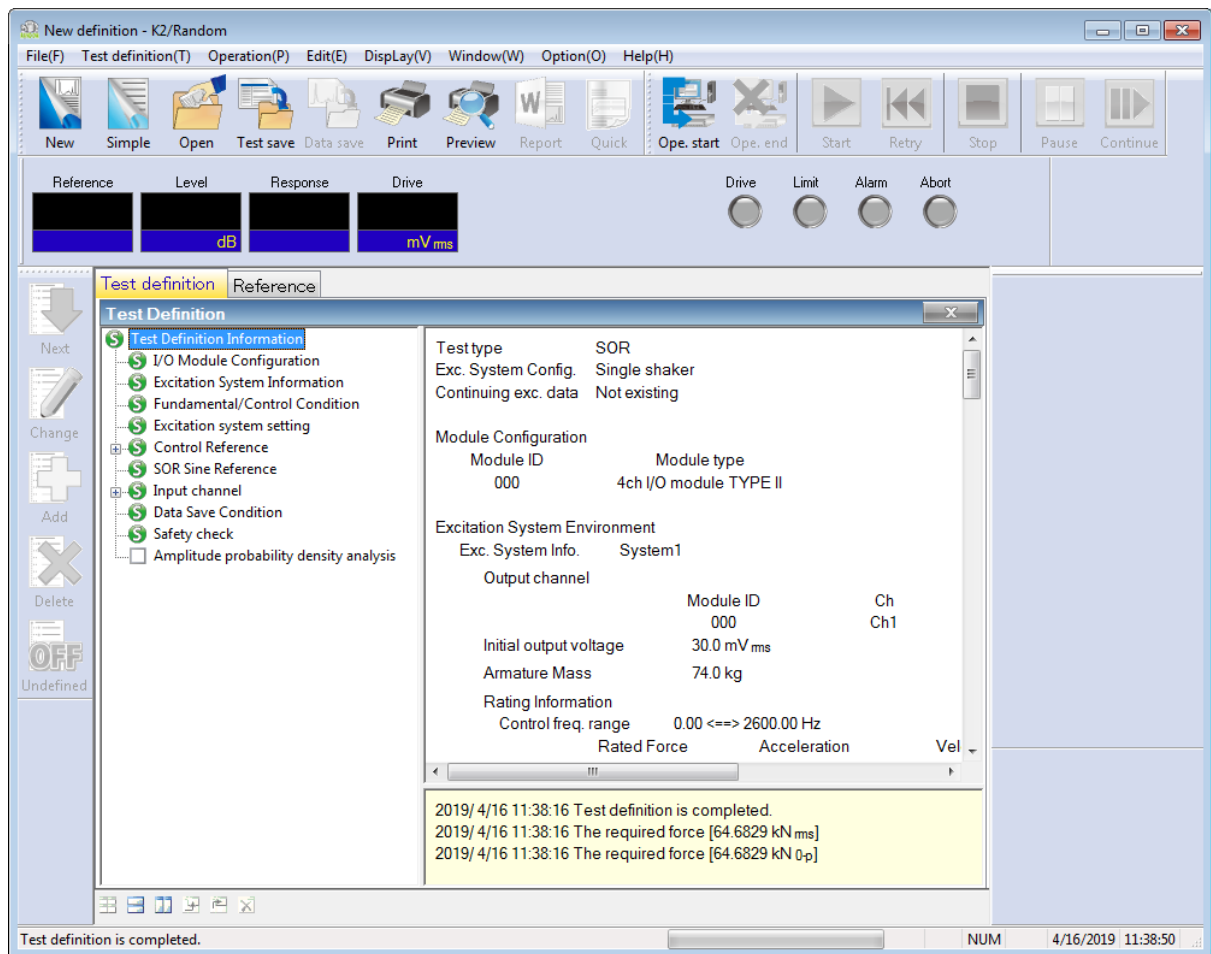
< Step39 >

Select 'Excitation force check' and input the value as 'Specimen mass : 10 [kg]'. And press the button of [OK].



< Step40 >

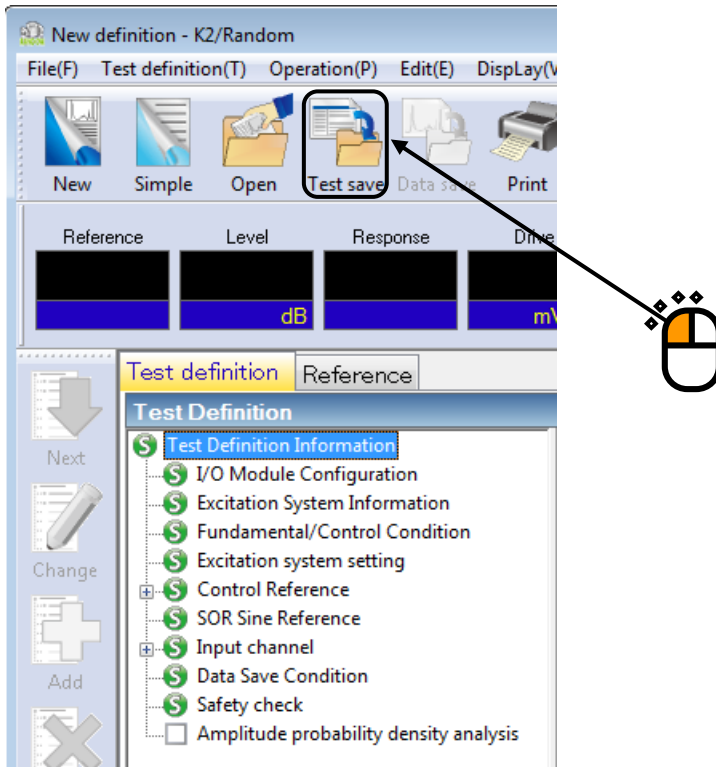
The definition is completed.



< Save of test >

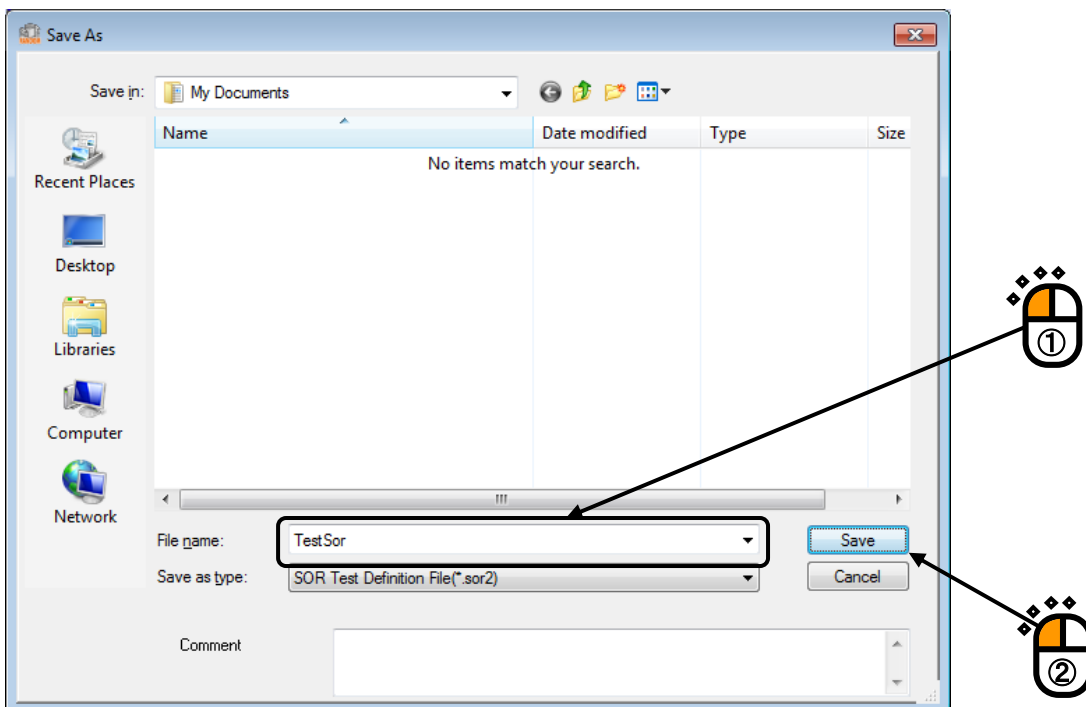
< Step 1 >

Press the button of [Test Save].



< Step 2 >

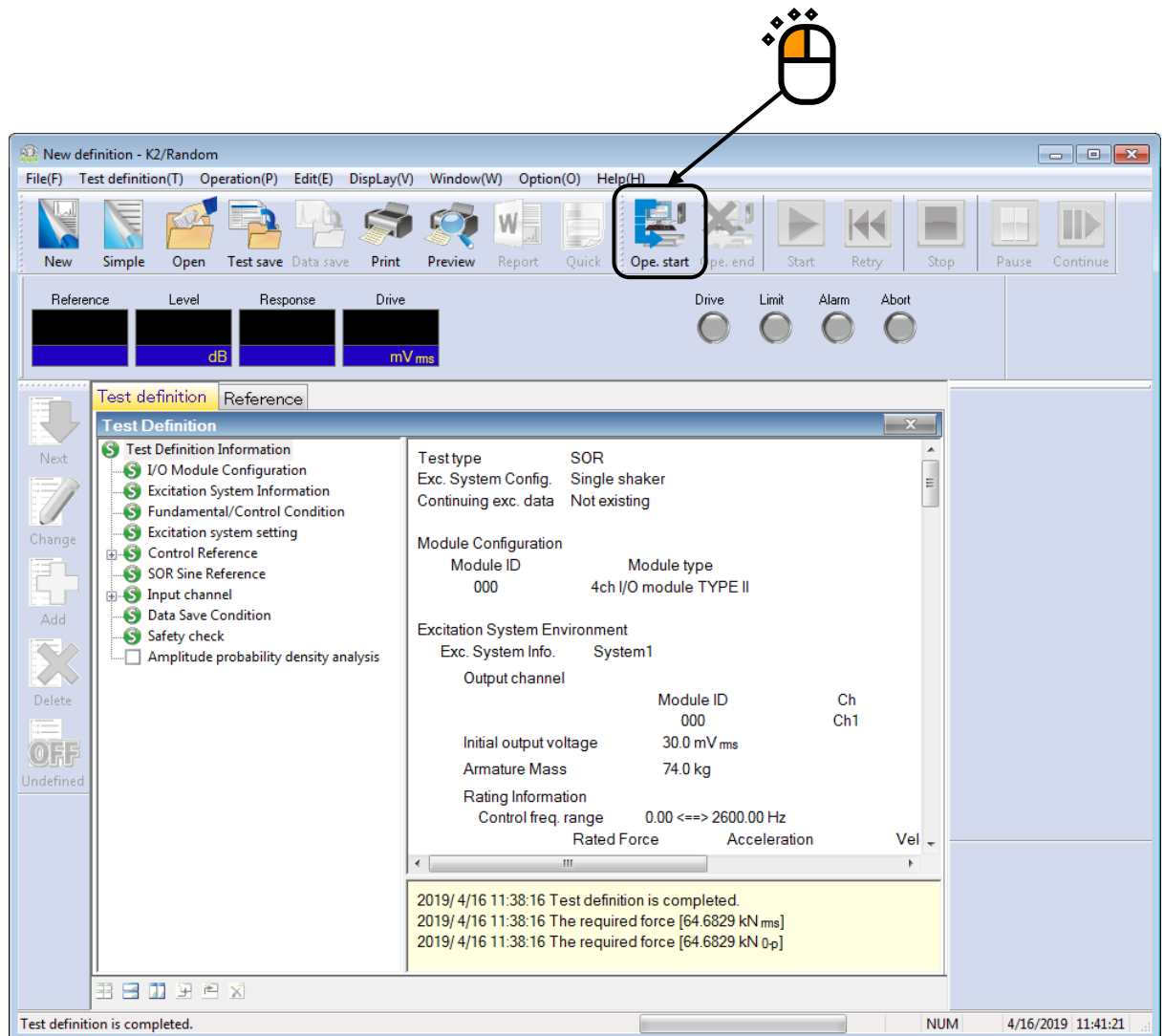
Input a name in 'File name' and press the button of [Save].



< Operation of test >

< Step 1 >

Press the button of [Operation start].

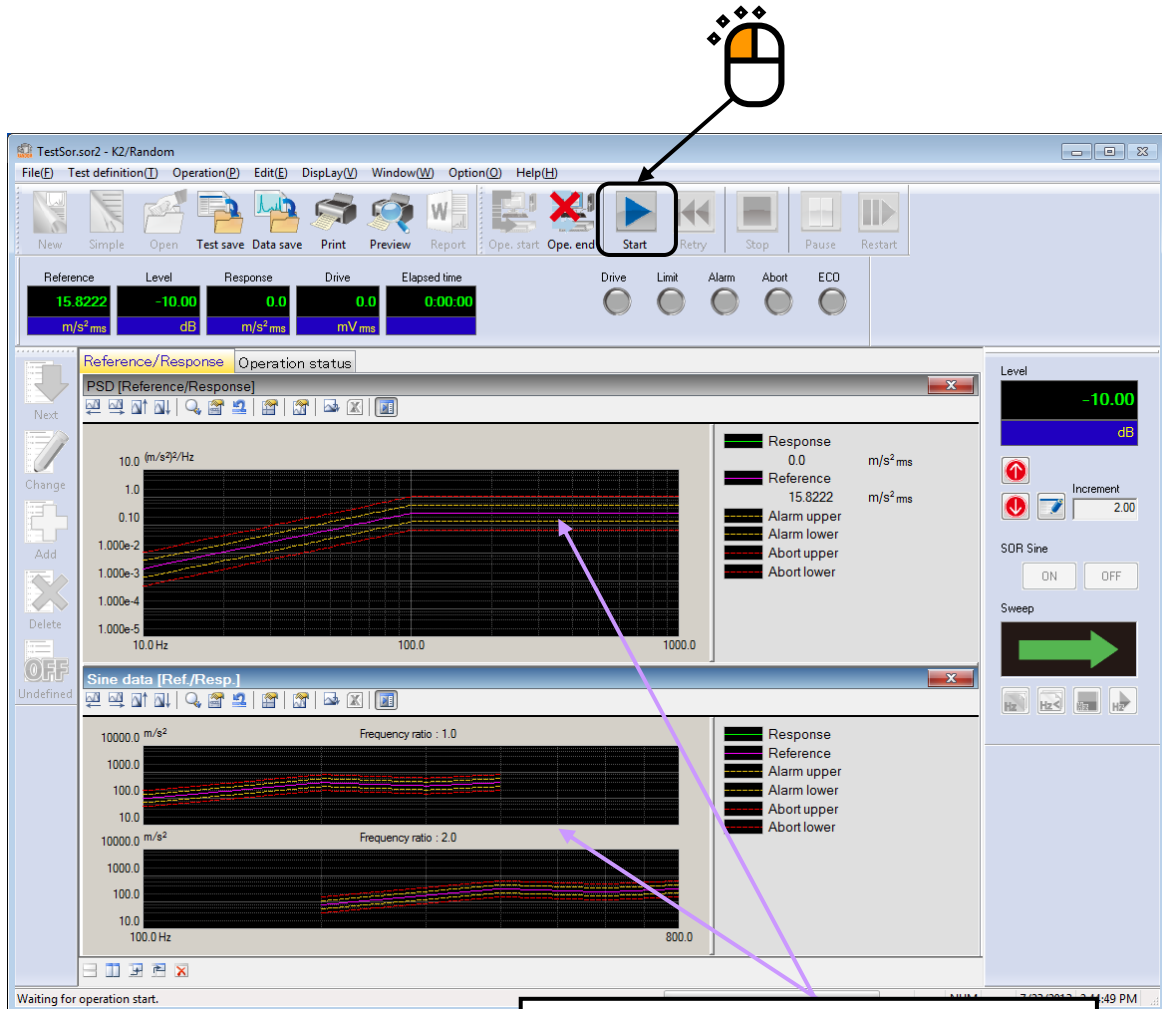




< Step 2 >

Press [Start].

When [Start] is pressed, Initial loop check and Initial equalization are automatically operated. Then, the test operation is executed at the initial excitation level (in this example, at -10 dB).

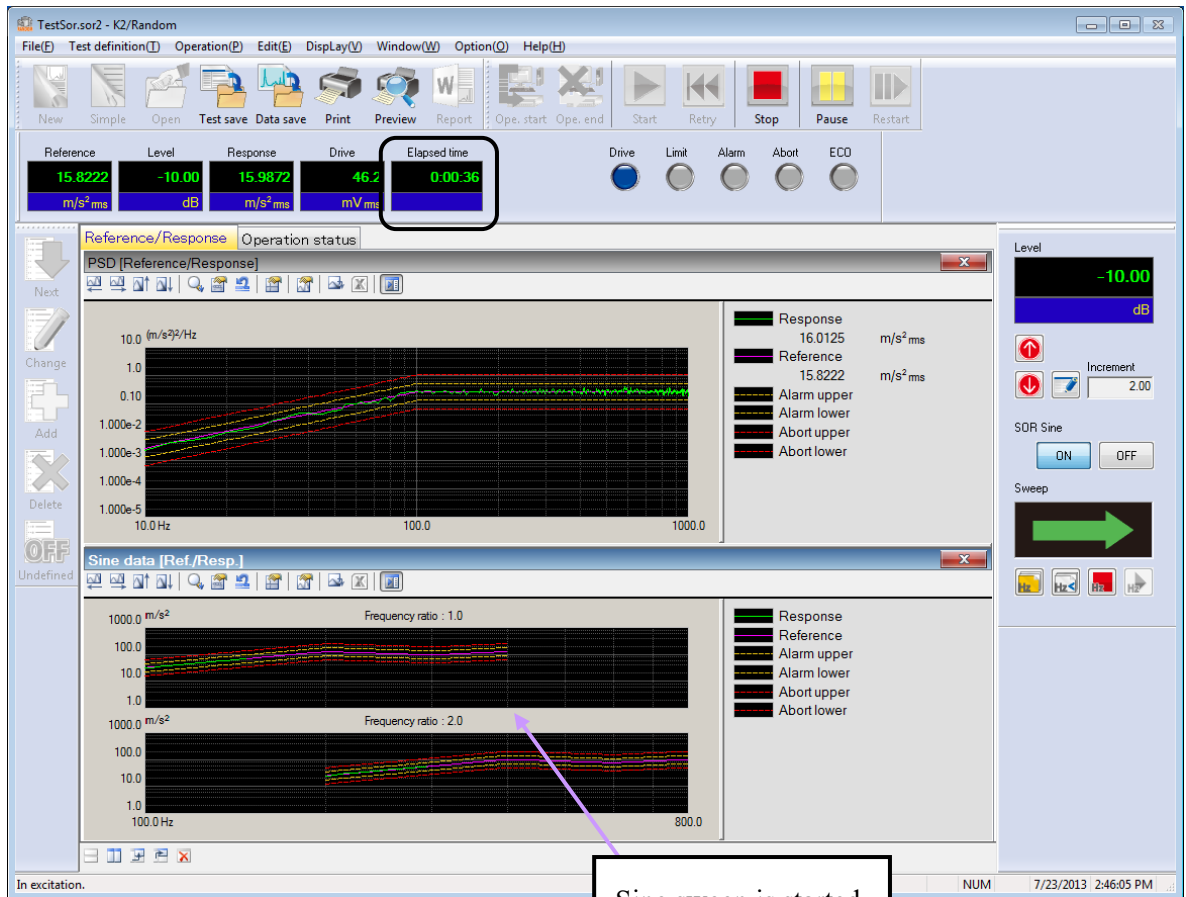


< Step 3 >

When initial equalization is completed, the excitation operation at initial excitation level (in this example, -10 dB) is executed. And the sine waveform is started to be swept.

Test time is started to be counted at the same time when the sweep starts independent of the excitation level.

To start the sine control and timer after the excitation level has reached 0dB, check “Start Sine tones/NBRs control from 0dB” in the Fundamental/Control Condition.



Sine sweep is started.

< Step 4 >

Test operation is completed when the test time passed.

The system returns to the test definition mode by pressing the button of [Operation end].

The screenshot displays the TestSor.sor2 software interface. At the top, a status bar shows test parameters: Reference (15.8222 m/s<sup>2</sup>/ms), Level (-10.00 dB), Response (15.8450 m/s<sup>2</sup>/ms), Drive (46.4 mV/ms), and Elapsed time (0:20:07). A mouse cursor is positioned over the 'Ope. end' button, which is highlighted with a red 'X' and a callout box. Below the status bar, there are control buttons for Drive, Limit, Alarm, Abort, and ECO. The main display area is divided into two sections: 'PSD [Reference/Response]' and 'Sine data [Ref./Resp.]'. The PSD section shows a log-log plot of acceleration power spectral density (m/s<sup>2</sup>/Hz) versus frequency (10.0 Hz to 1000.0 Hz). The Sine data section shows two plots for frequency ratios of 1.0 and 2.0, with acceleration (m/s<sup>2</sup>) versus frequency (100.0 Hz to 800.0 Hz). On the right side, there are control panels for Level (-10.00 dB), SDR Sine (ON/OFF), and Sweep (indicated by a yellow arrow pointing left). The bottom status bar indicates 'Excitation is completed.(Test time is completed.)' and shows the date and time: 7/23/2013 3:10:25 PM.

## Chapter 2 Test Definition

This chapter describes the test definition items required to SOR test.

Refer to “Chapter 4 Test Definition” of K2/RANDOM Instruction Manual about the general definition items of random tests.

### 2.1 Fundamental/Control Condition

#### 2.1.1 Sine equalization mode

##### (1) Meaning

This item is for setting of control parameter concerning to the sine control in SOR test. Also, the parameter concerning to random control is defined in the control mode described as above.

In sine control, level control is executed by adjusting the drive output level to coincide with the response amplitude evaluated value given as a reference level. The control speed of response for the digital feedback control system constructed in the system is defined by the setting of this item.

The set value of this item cannot be proper by itself when the control is difficult to operate by general setting. It is also important to concern about the relation between the control speed and the sweep rate.

##### 1. Fast

This item is for setting of the control at a faster response speed.

When the controlled system has unstable elements of response and too large resonance magnification, the control may be unstable and the system may generate hunting.

##### 2. Normal

This item is for setting of suitable control speed for general cases.

**Generally, the setting of ‘Normal’ is recommended except the case in which the special judging is required.**

##### 3. Slow

This item is for operating the control at a slower response speed.

In case that the control is unstable and generates hunting in the setting of ‘Normal’, the setting of ‘Slow’ may be suitable. For example, ‘Slow’ would be suitable for the control with hydraulic vibration systems.

##### 4. Specify (or use the ‘Detailed definition’ button)

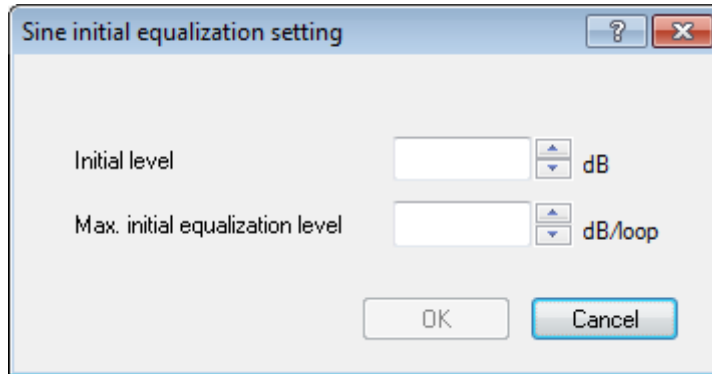
Each parameter of the equalization mode is properly defined according to the setting of ‘Fast’, ‘Normal’ and ‘Slow’. However, this item ‘Specify’ is provided to make a fine adjustment for testing with the specimen that is too difficult to control by the setting of the standard items.

## 2.1.2 Sine initial equalization setting

### (1) Meaning

This item is for setting the operation of initial equalization in sine control.

It is not necessary to be set generally. When the first control operation has some trouble in sine, this item is set to adjust the values for the initial equalization.



### 2.1.2.1 Initial level

#### (1) Meaning

The initial reference level for initial equalization of sine control is specified by a ratio of the reference level for the main test. The main test means that the test to be operated after the initial equalization.

For example; the initial level is set as '-10dB' and the excitation level of the main test is set as '-6dB'. The initial reference level for initial equalization of sine control is specified to '-16dB' based on excitation level '0dB' for the main test.

The value of initial level is '0dB' as the default when the function of "Initial equalization setting" is not set.

### 2.1.2.2 Max. initial equalization level

#### (1) Meaning

This value expressed in dB is the maximum value of the reference level that is renewed at each control loop in initial equalization.

For example; the initial level is set as '-10dB' and the maximum initial equalization level is set as '2dB/loop'. The level is enlarged up to the initial reference level of the main test by operating the control loop for 5 times.

The sine control is started to operate from at the initial reference level of the main test when "Initial equalization setting" is not set. The setting of this item is invalid in this case.

### **2.1.3 Start Sine tones control from 0dB**

(1) Meaning

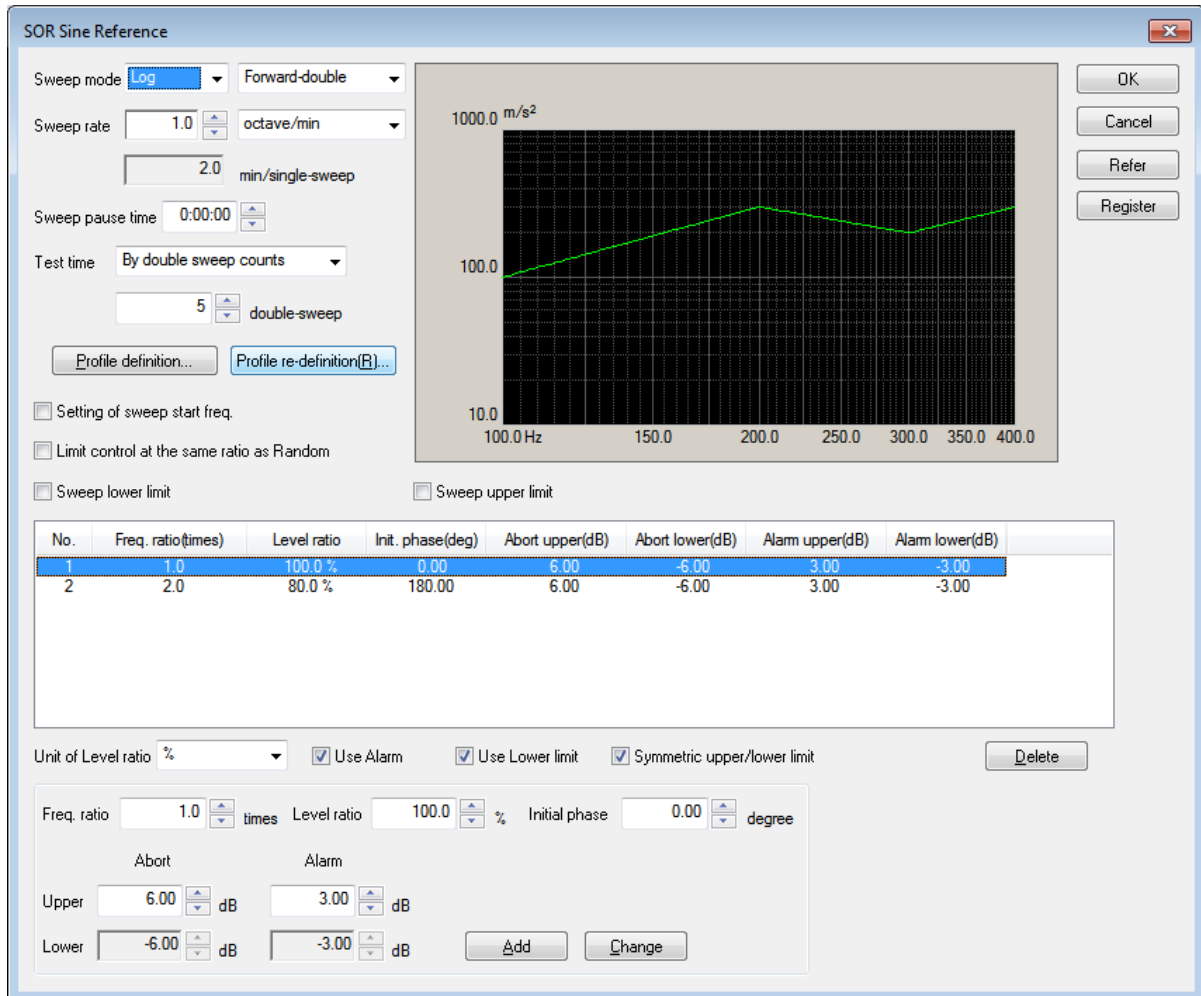
This value allows the specification of the timing to start the sine tones control in SOR test.

Normally, sine tones control and timer are started after the initial equalization is finished regardless of excitation level. To start the sine tones control and timer after the excitation level has reached 0dB, check “Start Sine tones/NBRs control from 0dB”.

## 2.2 SOR Sine Reference

### (1) Meaning

This dialog is for defining the reference of sine waveform in SOR test (Sine On Random test).



SOR test is a vibration test composed by superimposing a random vibration to a sine vibration simultaneously. Therefore, it is necessary to define the references for random vibration and for sine vibration. Here, these references are called the Broad Band Random reference and the narrow Band Sine reference.

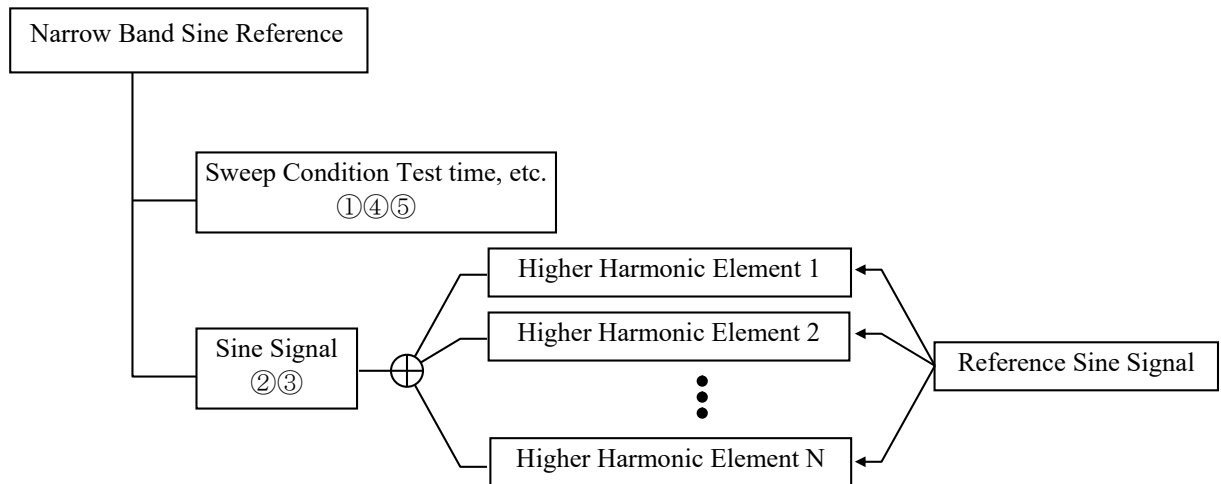
This item is for defining the narrow band sine reference. The definition of the broad band random reference is done in Reference PSD definition as same as in an ordinary random test. However, Test Time is defined in the definition of the narrow band sine reference.

Definition items as below are provided in the narrow band sine reference ;

- ① Whether is sine waveform swept or fixed?
- ② In what range does the frequency component exist between? (Frequency range)
- ③ How much is the level (amplitude)? (Amplitude of sine waveform)
- ④ How fast does the sweeping operation take in case it is swept? (Sweep rate)
- ⑤ How long is the test time specified for? (Test Time)

The narrow band sine waveform is composed by both elements specified according to the idea of the base and the higher harmonic elements.

Each element is needed to be controlled to act regularly at sweeping (frequency ratio of each elements are kept constant in frequency change).



The limitations in a narrow band sine reference definition are described as below ;

- Number of higher harmonic elements are available up to **maximum 32**.
- Each higher harmonic element should be specified to the value under  $f_{\max}$  of frequency range.
- Each higher harmonic element should be specified to the value over  $\Delta f$  of frequency resolution.

< Tolerance Check >

Control and Tolerance check is operated to the broad band random components and the narrow band sine components that are separated from the response signal composed by Random vibration and Sine vibration.

Definition of Tolerance check is specified for each broad band random and narrow band sine. However, Tolerance of the broad band random is defined in Reference PSD as the same as in general random test.

### 2.2.1 Sweep / Fixed frequency

(1) Meaning

This item is for selecting the test method between 'Sweep (Log or Linear) or 'Fixed Frequency'.

### 2.2.2 Fundamental sweep (only for 'Fixed frequency')

(1) Meaning

The frequency of fundamental sine signal as a base for sine waveform of each higher harmonic element is specified.

Frequency of each higher harmonic element is defined by a relative value to this fundamental sweep.

Each parameter as below is denoted for the convenience of explanation ;

$f_1$  : This denotes the lower limit of the frequency when 'Sweep' is selected.

$f_2$  : This denotes the upper limit of the frequency when 'Sweep' is selected.

$f_{\text{fix}}$  : This denotes the fundamental sweep when 'Fixed Frequency' is selected.



### 2.2.3 Fundamental level (only for 'Fixed frequency')

#### (1) Meaning

This item is for specifying the level (amplitude) of sine signal used as a fundamental for each higher harmonic element.

The fundamental level is given as a profile when 'Sweep' is selected.

The parameter in below is denoted for the convenience of explanation ;

$A_b$  : Level of Fundamental sine signal (In the setting of 'Sweep', it is given as a function of frequency.)

### 2.2.4 Swept sine reference (only for 'Sweep')

#### (1) Meaning

This item is for defining the control reference of swept sine.

Main definition items for swept sine reference can fall into three types as below.

- Items relevant to Sweep condition / Test time
- Items relevant to Reference pattern
- Items relevant to Alarm / Abort check for control response

The items relevant to Sweep condition / Test time includes Sweep mode, Sweep direction, Sweep ratio, Sweep pause time, Test time.

Also, reference patterns are defined by Profile and Alarm / Abort check for control response are defined by Tolerance.

#### 2.2.4.1 Sweep mode

##### (1) Meaning

This item is for specifying the action mode of sweep. Two types of sweep mode are provided.

##### 1. Linear

The sweeping having the sweep frequency  $f$  which proportion with the elapsed time  $t$ , that is, the 'Linear' sweep is set to operate ;

$$f = f_0 + R \cdot t$$

Proportional constant  $R$  means 'Sweep rate' and it is defined in 2.2.4.3 Sweep Rate.

##### 2. Log

This item is set to operate the sweeping having the sweep frequency  $f$  that is explained by the exponential function of the elapsed time  $t$ .

$$f = f_0 \cdot \exp(R \cdot t)$$

This type of sweep is called to 'Log' which operates the sweep having the proportion of the elapsed time  $t$  to a logarithm of the sweep frequency  $f$ .

Proportional constant  $R$  means 'Sweep rate' and it is defined in 2.2.4.3 Sweep Rate.

## 2.2.4.2 Sweep direction

### (1) Meaning

When the sweeping operation is done in the specified sweep band [f1, f2], one of the following four directions can be selected.

#### 1. Forward Single

The single sweeping is operated from lower to higher range, as ;

$$f1 \rightarrow f2, f1 \rightarrow f2, f1 \rightarrow f2$$

This item is for setting of a sweeping direction that swept generally just one-way as above in the sweep band. When this item is selected, a 'single-sweep' is used as a unit for setting of the sweep count. A sweeping as 'f1→f2' is treated for one time of sweep count.

#### 2. Backward Single

The single sweeping is operated from higher to lower range, as ;

$$f2 \rightarrow f1, f2 \rightarrow f1, f2 \rightarrow f1$$

This item is for setting of a sweeping direction that swept generally just one-way as above in the sweep band. When this item is selected, a 'single-sweep' is used as a unit for setting of the sweep count. A sweeping as 'f2→f1' is treated for one time of sweep count.

#### 3. Forward Double

The double sweeping is operated from lower range f1, as ;

$$f1 \rightarrow f2 \rightarrow f1 \rightarrow f2 \rightarrow f1 \rightarrow f2 \rightarrow$$

This item is for setting of double way sweep operation in the sweep band.

When this item is selected, a 'single-sweep' or a 'double-sweep' is used as a unit for setting of the sweep count. In case of the setting by 'single-sweep', 'f1→f2' or 'f2→f1' is treated for one time of sweep count. In case of the setting by 'double-sweep', 'f1→f2→f1' is treated for one time of sweep count.

#### 4. Backward Double

The double sweeping is operated from higher range f2, as ;

$$f2 \rightarrow f1 \rightarrow f2 \rightarrow f1 \rightarrow f2 \rightarrow f1 \rightarrow$$

This item is for setting of double way sweep operation in the sweep band.

When this item is selected, a 'single-sweep' or a 'double-sweep' is used as a unit for setting of the sweep count. In case of the setting by 'single-sweep', 'f2→f1' or 'f1→f2' is treated for one time of sweep count. In case of the setting by 'double-sweep', 'f2→f1→f2' is treated for one time of sweep count.

When the function of 'Reverse' is to be used in Manual operation box, the item of 'double-sweep' should be selected.

### 2.2.4.3 Sweep rate

#### (1) Meaning

The setting method of Sweep Rate has the two ways of specifying as below ;

A : Specify the time to complete one sweeping operation.

B : Specify the value for the parameter of a sweep rate, literally.

In the setting method A, Sweep rate is specified by time, so that the same unit can be used either Sweep Mode is set as 'Linear' or 'Log'.

This system takes min (minute) for the time unit. And in this system, 'one time sweep' means 'single-sweep'. That is, the unit of this setting is ;

min / Single-Sweep

The setting method B, each unit is different as follows according to the different Sweep Mode ;

'Linear' : Hz / sec

'Log' : octave / min

When 'Log' is selected, 'decade / min' can be used as a unit of Sweep Rate. In this case, use the following calculation ;

$$1 \text{ decade/min} = 3.3219 \text{ octave/min}$$

$$(\because 1 \text{ decade} = (1/\log 2) \text{ octave} = 3.3219 \text{ octave})$$

The test operation in the setting of a fast Sweep Rate realizes a sweep in a short time. But note that, a too fast sweep can make only an insufficient simulation of specimen at each frequency.

### 2.2.4.4 Sweep pause time

#### (1) Meaning

This item is for specifying the pause time of signal output (sweep pause time) between the ending point of sweep of the narrow band sine waveform and the starting point of next sweep (at the sweep turn).

The excitation of sine is stopped for the time specified in this item at the sweep turn.

However, the excitation of the broad band random waveform is continued.

### 2.2.4.5 Profile definition

#### (1) Meaning

This item is for Break point definition for control reference.

The level unit of a profile is specified by the definition unit in Fundamental / Control Condition.

Refer to "2.2.10 Profile definition" about details.

### 2.2.4.6 Sweep start frequency

#### (1) Meaning

This item is for setting of the frequency at sweep start.

Generally, the sweep operation is started from the lower or higher limit frequency in the fundamental frequency range according to the setting of 'Direction' of sweep. However, an arbitrary value of frequency can be specified for sweep start.

### 2.2.5 Test time

#### (1) Meaning

This item is for setting of the operation time of a testing.

In this system, the following items are provided as the setting methods of Test Time.

#### 1. Specify by the times of single-sweep (only in setting of 'Sweep')

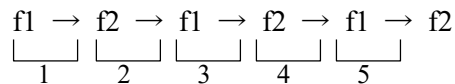
This item is for setting of the test time by the times of single-sweep.

Test time is regulated as an integer number of single-sweep by setting of this item.

A test finishes just at the turning point of the sweep.

Either 'single-sweep' or 'double-sweep' is used as the unit of a sweep.

For example, if a sweeping is operated in the condition that the 'Direction' is set as 'Forward Double' in the sweep band [f1, f2], with specifying 'single-sweep' as the unit of sweeping, the sweeping operated for 5 times



#### 2. Specify by the times of double-sweep (only in setting of 'Sweep')

This item is for setting of the test time by the times of double-sweep.

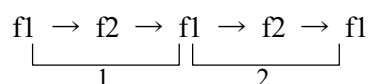
Test time is regulated as an integer number of double-sweep by setting of this item.

A test finishes just at the starting point of the sweep.

'Double-sweep' can be selected only when the 'Direction' is set as 'Forward Double' or 'Backward Double'.

'Double-sweep' is used as the unit of a sweep.

With specifying 'double-sweep' as the unit of sweeping, the sweeping is operated for 2 times as below ;



#### 3. Specify by time

The time for excitation is set.

When the set time elapsed, the test operation is finished even in the middle of a sweep.

The two setting methods by time are usable ;

The example of a test time to be set for 1 hour is described as follows for each methods.

- The case of setting time by seconds ; '3600' is inputted.
- The case of setting time with colons ( : ) as hhh : mm : ss ; '1 : 0 : 0' is inputted.

#### 4. Infinite

'Infinite' means that the finishing condition is not set in this item.

By setting of this item, this system continues the sweep excitation under the set condition until the [Stop] button is pressed or other equivalent operation is carried out.

### 2.2.6 Setting of higher harmonic elements

#### (1) Meaning

Higher harmonic elements are defined with having the defined reference sine signal as a basis.

Higher harmonic elements can be registered up to **32**.

Following buttons are used in the definition of the higher harmonic elements ;

[Add] : A new data of a higher harmonic element is defined and registered.

[Change] : The contents of the higher harmonic element data registered is corrected.

[Delete] : A higher harmonic element data registered is deleted.

#### 2.2.6.1 Frequency ratio

##### (1) Meaning

This item is for specifying the swept frequency range ('Sweep') or the frequency ('Fixed Frequency') by the relative ratio to the fundamental frequency range ('Sweep') or the fundamental frequency ('Fixed Frequency').

The same or close value to the defined higher harmonic element can not be inputted when the new definition of the higher harmonic element or the correction definition of the frequency ratio in the defined higher harmonic element is done.

Denoting the frequency ratio as  $r_f$ , the swept frequency range ('Sweep') or the frequency ('Fixed Frequency') of each higher harmonic element is described as below ;

When 'Sweep' is selected :  $f_1 \times r_f \sim f_2 \times r_f$

When 'Fixed Frequency' is selected :  $f_{fix} \times r_f$

However, the narrow band sine reference should be exist between the frequency resolution  $\Delta f$  and the frequency range  $f_{max}$ .

When 'Sweep' is selected :  $\Delta f \leq f_1 \times r_f \leq f_2 \times r_f \leq f_{max}$

When 'Fixed Frequency' is selected :  $\Delta f \leq f_{fix} \times r_f \leq f_{max}$

### 2.2.6.2 Level ratio

(1) Meaning

This item is for specifying the level (amplitude) of the higher harmonic element by the relative ratio to the fundamental level.

Denoting the level ratio as  $r_{\text{Amp}}$ , the level of each higher harmonic element is described as below ;

$$A_b \times r_{\text{Amp}}$$

The unit of the level ratio is selectable from ‘%’ or ‘dB’.

### 2.2.6.3 Initial phase

(1) Meaning

This item is for specifying the initial phase of the higher harmonic element.

This initial phase is defined by taking the phase of the output sine waveform as the origin.

However, the control is done only for the response level, not for the phase.

### 2.2.6.4 Tolerance

(1) Meaning

Tolerance check as same as that in an ordinal random test is operated for each higher harmonic components of sine waveform.

However, the condition, such as ‘Use Alarm’ or ‘Use Lower Limit’, should be consistent with the Tolerance of the broad band random reference.

## 2.2.7 Sweep lower limit

(1) Meaning

This item is for specifying the lower limit value of frequency which allows the existence of the narrow band sine reference.

For example, thinking of the specimen to which any vibration having lower frequency than the specified value should not be given in any case. When the value is specified in this item, the narrow band sine signal having lower frequency than the specified value is not outputted even if the sweep range of the narrow band sine reference is lower than the specified value. The narrow band sine signal having lower frequency than the specified value is hidden and is not outputted (that is, ‘a fictitious sweeping operation’ is executed in the band below the specified frequency without outputting a signal).

However, the narrow band sine reference must not be lower than the frequency resolution  $\Delta f$ . The narrow band sine reference can be set to the value upper than  $\Delta f$  compulsory when  $\Delta f$  is specified for this item.

## 2.2.8 Sweep upper limit

### (1) Meaning

This item is for specifying the upper limit value of frequency which allows the existence of the narrow band sine reference.

For example, thinking of the specimen to which any vibration having upper frequency than the specified value should not be given in any case. When the value is specified in this item, the narrow band sine signal having upper frequency than the specified value is not outputted even if the sweep range of the narrow band sine reference is upper than the specified value. The narrow band sine signal having upper frequency than the specified value is hidden and is not outputted (that is, 'a fictitious sweeping operation' is executed in the band over the specified frequency without outputting a signal).

However, the narrow band sine reference must not be upper than the frequency range  $f_{\max}$ . The narrow band sine reference can be set to the value lower than  $f_{\max}$  compulsory when  $f_{\max}$  is specified for this item.

## 2.2.9 Limit control at same ratio as Random

### (1) Meaning

When the limit control is executed in Random, the limit control to narrow band sine is executed at same ratio as Random.

When this item is not selected, the limit control to narrow band sine is not executed.

## 2.2.10 Profile definition

### (1) Outline

Reference pattern is defined by 'Profile' in Sweep test.

'Profile' is a table in which the series of break points specified by the frequency data and the level are defined.

In K2 application, three methods of sweep reference definition are available for 'Profile' definition as below ;

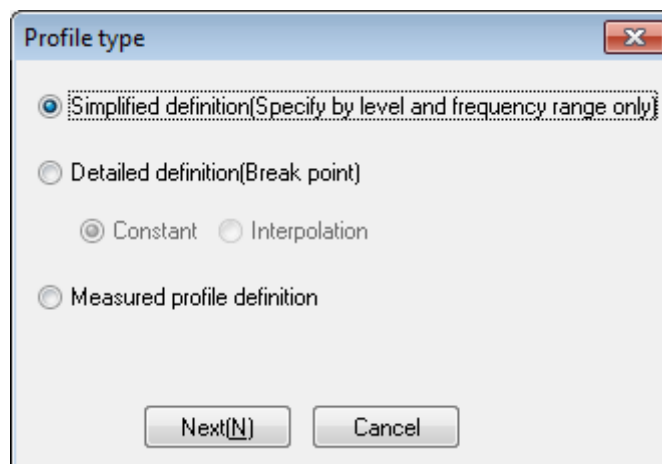
Simplified definition (Specify by level and frequency range only)

Detailed definition (Break point)

And Detailed definition (break point) has two types of the definition method according to the types of data interpolation between the break points as below ;

'Constant' / 'Interpolation'

Maximum **256** of break points are available to register when 'Profile' is defined by the method of detailed definition.





### 2.2.10.1 Simplified definition

#### (1) Meaning

Generally, the Sine vibration test is executed by using the quantity of ‘Acceleration / Velocity / Displacement’ as a reference level, and the reference profile of sweep sine vibration test is defined as follows in the most cases ;

< Example >

A sweep sine vibration test having 1 mm of amplitude and 20 m/s<sup>2</sup> of acceleration value is operated in 10 Hz ~ 2000 Hz of frequency band.

In lower frequency range, the excitation is started from 1 mm of amplitude. When it reaches at a certain frequency, the excitation is proceeded to have 20 m/s<sup>2</sup> of acceleration.

However, in this case, ‘a certain frequency’ as in the above should be the frequency to have 20 m/s<sup>2</sup> of acceleration and just 1 mm of amplitude.

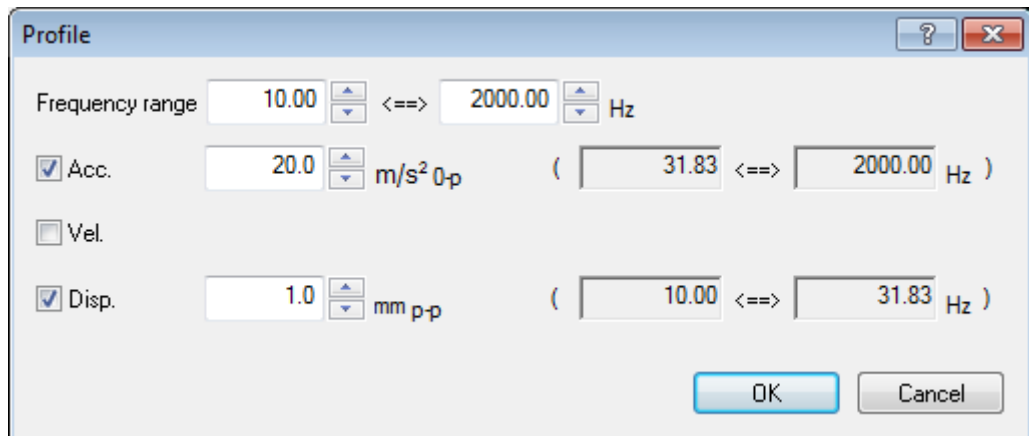
‘A certain frequency’ in the above is generally called ‘cross-over frequency’ or ‘break point frequency’.

In simplified profile definition, the cross-over frequency is automatically obtained to define the profile only by setting the ‘frequency band’ and the level of ‘Acceleration / Velocity / Displacement’.

Cross-over frequency can be obtained by using [CALC] function in general definition. However, it can be defined more easily by using simplified profile definition.

In this example, the level of ‘Acceleration / Displacement’ is specified. All the physical quantities can be set as the level and can be specified as any combination among ‘Acceleration / Velocity / Displacement’. However, at least one physical quantity is needed to be set as the level.

This function is also usable when another physical quantity other than ‘Acceleration / Velocity / Displacement’ is set as the level. In such a case, the profile is defined to have the constant level of the set quantity in the specified frequency band.



### 2.2.10.2 Detailed definition (Constant)

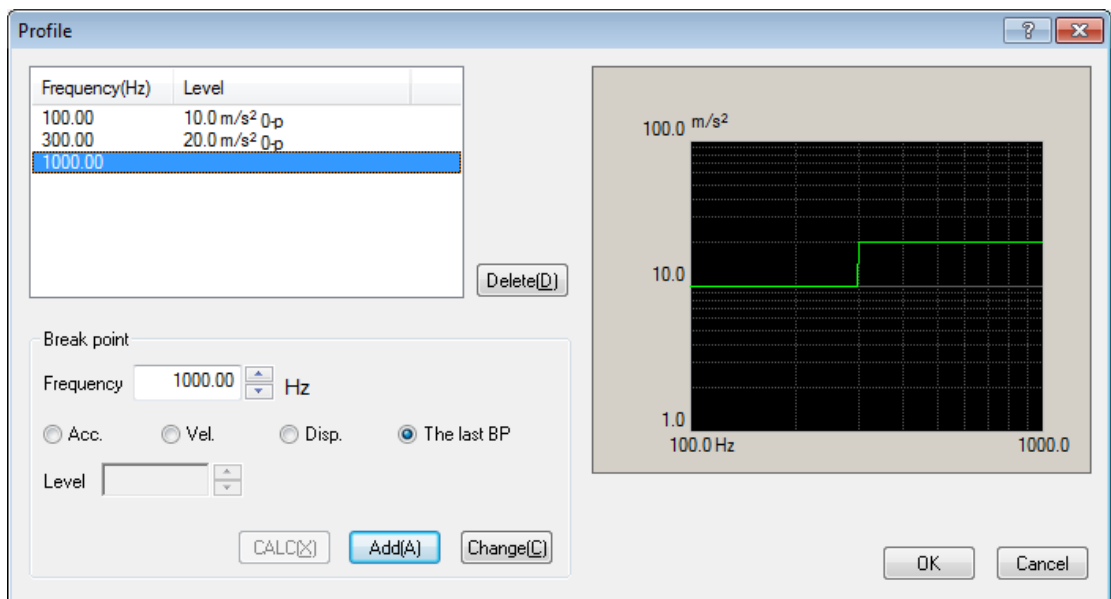
Constant profile is a traditional and the most popular definition method in Sine vibration test, and it defines the level to keep the definition quantity at the constant value in each segment dividing the test range on the frequency axis into some segments.

When a reference level to keep the definition quantity at the constant value in each segment is defined, this level defined at a break point specifies the level in the whole range of the current segment extended to the next break point.

Physical quantity of level can be selected among 'Acceleration / Velocity / Displacement' when the physical quantity is specified one of 'Acceleration / Velocity / Displacement'. However, the same physical quantity as the specified one must be set when the other physical quantity than these values is specified.

<Example 1>

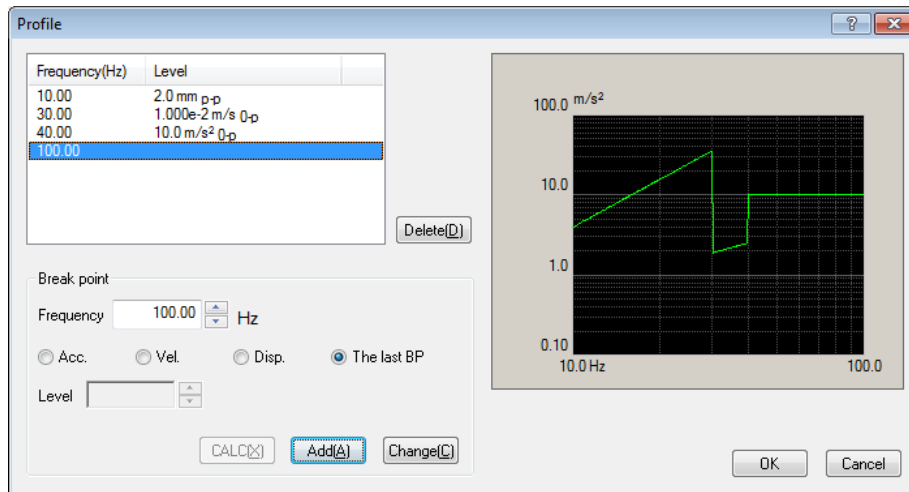
100[Hz]~300[Hz]	: 10 [m/s <sup>2</sup> ] Constant
300[Hz]~1000[Hz]	: 20 [m/s <sup>2</sup> ] Constant
1000[Hz]	: The last break point



< Example 2 >

10[Hz]~30[Hz] : 2.0 [mm] Constant  
30[Hz]~40[Hz] : 1.0 [cm/s] Constant  
40[Hz]~100[Hz] : 10 [m/s<sup>2</sup>] Constant  
100[Hz] : The last break point

**Note) The vertical axis displays the control unit in the graph of profile.**



### 2.2.10.2.1 Break point / Frequency (Constant)

(1) Meaning

A pair of the frequency data and the reference level data that specifies the border of each segment is set from the lower frequency range in order as a break point data.

However, the same break point frequency as the registered one or very close break point frequency to the registered one (within 0.999 ~ 1.001 times) can not be assessed as a break point data.

### 2.2.10.2.2 Break point / Level (Constant)

(1) Meaning

A pair of the level data in each segment and the reference level data in the above is set from the lower frequency range in order as a break point data.

The reference level set in this item is used as the reference value of the segment which has the current break point as the beginning edge and the next one as the ending edge.

When the physical quantity is specified among 'Acceleration / Velocity / Displacement', the physical quantity for the set level can be selected to one among 'Acceleration / Velocity / Displacement'.

The [CALC function] is usable for the conversion calculation between 'Acceleration / Velocity / Displacement'. The [CALC function] can be used by pressing the button of [CALC]. Refer to "2.2.11 CALC Function" about the details.

### 2.2.10.3 Detailed definition (Interpolation)

Interpolation profile has a generalized concept of the constant profile which is popularly used.

The value on the straight line that connects the two adjoining break points in the frequency level plane defines the level for each frequency point in the current segment.

The level is always needed to be set as the same physical quantity. Other physical quantity than the specified one cannot be used.

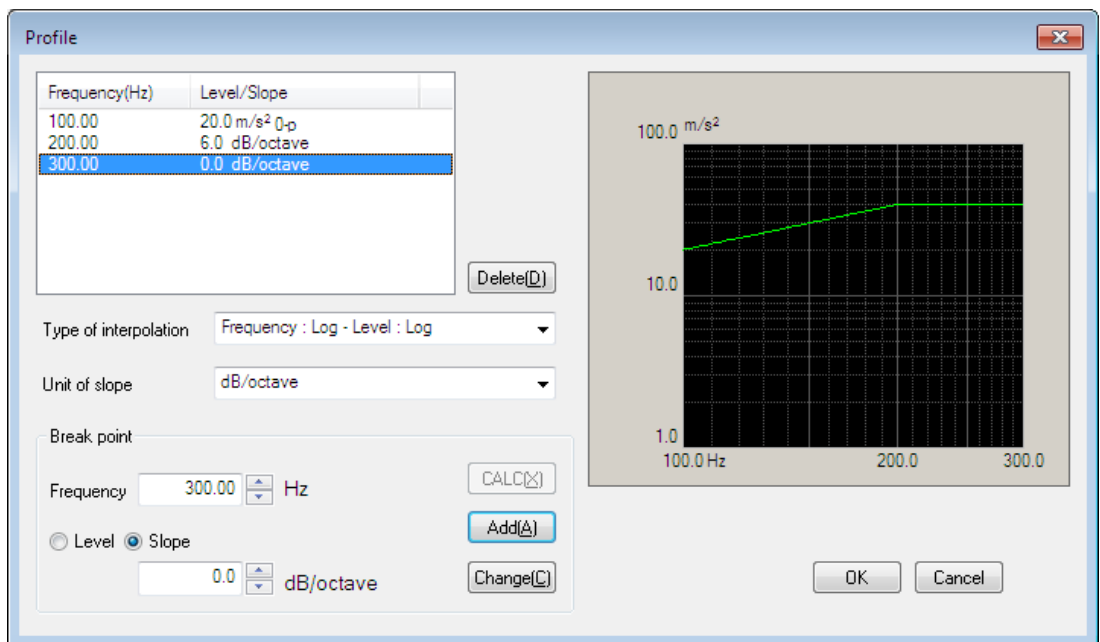
This definition method is similar to the reference definition method in the random vibration test (only the physical quantity of the vertical axis is different).

In the Interpolation profile, different from the constant profile, the last break point has the same meaning as other break points.

The test in which the quantity is defined by acceleration in the B.P. Connect profile is also called 'Acceleration break point test'.

< Example >

100[Hz] : 2.0 [m/s<sup>2</sup>]  
200[Hz] : 6 [dB/octave]  
300[Hz] : 0 [dB/octave]



### 2.2.10.3.1 Type of interpolation

#### (1) Meaning

In this item, interpolation method between the break points is selected among the followings. Also, the initial graph scale (Log or Linear) is set to the same as that of the selected type.

- Frequency : Log – Level : Log
- Frequency : Log – Level : Linear
- Frequency : Linear – Level : Log
- Frequency : Linear – Level : Linear

### 2.2.10.3.2 Unit of slope

#### (1) Meaning

Unit of slope is specified. The available units are different as follows according to the selected type of interpolation.

- Frequency : Log – Level : Log → 'dB/octave', 'dB/decade'
- Frequency : Log – Level : Linear → 'control unit/octave', 'control unit/decade'
- Frequency : Linear – Level : Log → 'dB/Hz'
- Frequency : Linear – Level : Linear → 'control unit/Hz'

### 2.2.10.3.3 Break point / Frequency (Interpolation)

#### (1) Meaning

A pair of the frequency data and the reference data that specify the border of each segment is set from the lower frequency side in order as the break point data.

However, the same break point frequency as the registered one or a very closer break point frequency to the registered one (within 0.999 - 1.001 times) can not be added as a break point data.

### 2.2.10.3.4 Break point / Level (Interpolation)

#### (1) Meaning

The level data in each segment which is treated as the break point data and makes a pair with the frequency data in the above clause is set from the lower frequency range in order.

The level data can be inputted to this item by pressing of the button of [Level].

The reference level set in this item is used as the reference value of the segment which has the current break point as the beginning edge and the next one as the ending edge.

Different from the constant profile, the physical quantity for the set level can be specified as a one of the physical quantities when the physical quantity is specified as

‘Acceleration / Velocity / Displacement’. The [CALC function] is usable for the conversion calculation between ‘Acceleration / Velocity / Displacement’. The [CALC function] can be used pressing the button of [CALC].

Refer to “2.2.11 CALC function” about the details.

### 2.2.10.3.5 Break point / Slope (Interpolation)

(1) Meaning

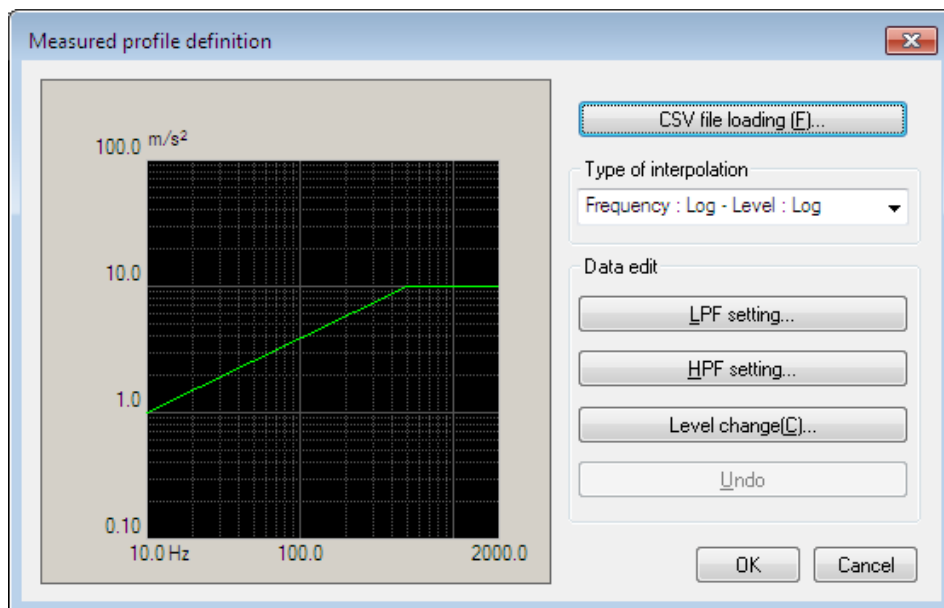
At registering of the break point data, the slope data corresponding to the frequency data is inputted.

The slope value can be inputted to this item by pressing of the [Slope] button.

### 2.2.10.4 Measured Profile Definition

An original data file of CSV format written as the specified format or a properly processed data as the demands is used as the reference data. See the common operation manual about the format in detail.

Reference profile is defined by using measured data.



<Data File Selection>

Data file can be selected by pressing the button [CSV File open].

Selection of data file appears.

<Type of interpolation>

Interpolation method between the loaded data can be selected.

<Data Processing>

Loaded data can be processed by using the buttons for Data processing.

[LPF setting] : This button is for processing the data by Low Pass Filter.

[HPF setting] : This button is for processing the data by High Pass Filter.

[Level change] : This button is for changing Level by ratio.

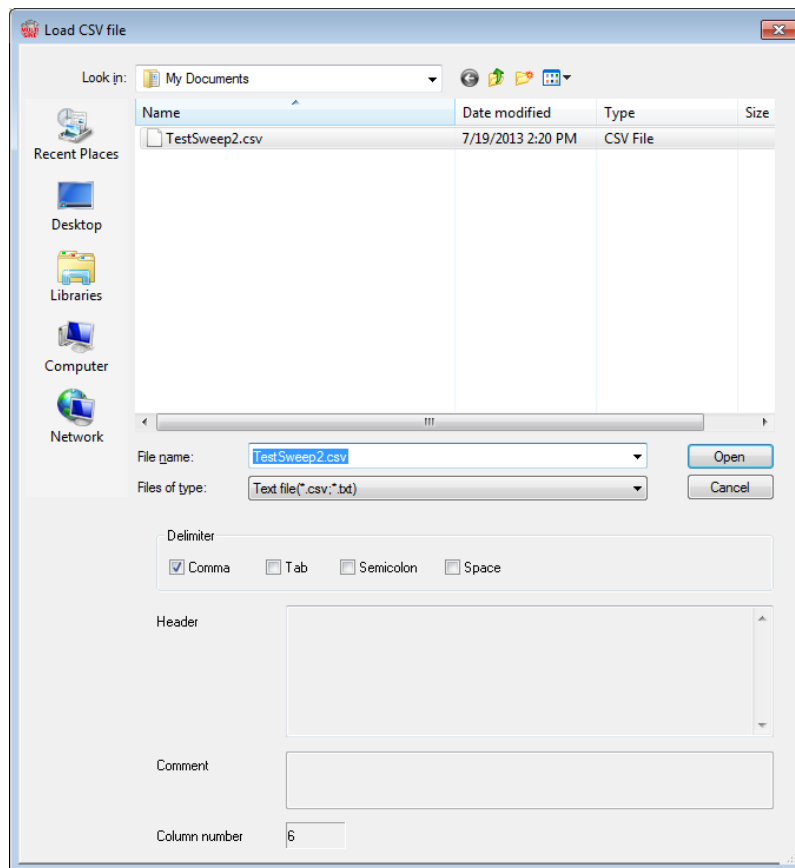
[Undo] : This button is for canceling the editing operation by these buttons in the above and returning to the former state.

#### 2.2.10.4.1 Load the Data File

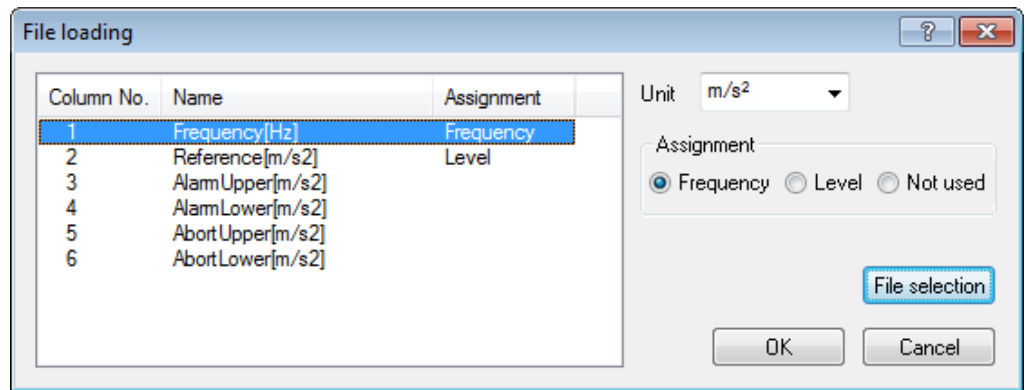
##### (1) Meaning

CSV Data File used as the reference profile is selected.

When the [CSV File open] button in the dialog of Measured Profile Definition is selected, the dialog box for selecting CSV File appears.



Select a data file to be referred to. And select a data to be used for the definition among the data described in the data file.



<Unit>

This item is for selecting the level unit of the data file.

<Configuration>

The data line corresponding to the frequency data is selected among the data.

<Level>

The data line corresponding to the level data is selected among the data.

#### 2.2.10.4.2 Type of interpolation

(1) Meaning

When the data to be used is specified, the measured data is displayed and the type of interpolation can be selected.

In this item, interpolation method between the loaded data is selected among the followings. Also, the initial graph scale (Log or Linear) is set to the same as that of the selected type.

- Frequency : Log – Level : Log
- Frequency : Log – Level : Linear
- Frequency : Linear – Level : Log
- Frequency : Linear – Level : Linear

#### 2.2.10.4.3 Data Processing

(1) Meaning

When the data to be used is specified, the measured data is displayed and the buttons for Data processing turn to valid in the definition dialog.

Select a necessary button to process the data, as you need.

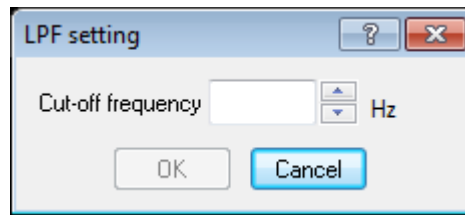


#### 2.2.10.4.4 LPF (Low Pass Filter) Setting

(1) Meaning

This item is for processing the data by Low Pass Filter.

When the [LPF setting] button is pressed, the dialog box of LPF setting appears.



- Cut-off Frequency

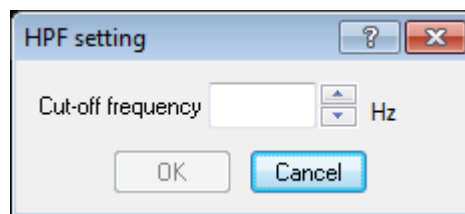
Input the value of cut-off frequency for filtering process.

#### 2.2.10.4.5 HPF (High Pass Filter) Setting

(1) Meaning

This item is for processing the data by High Pass Filter.

When the [HPF setting] button is pressed, the dialog box of HPF setting appears.



- Cut-off Frequency

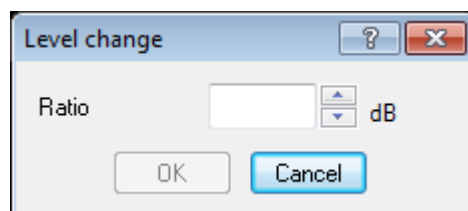
Input the value of cut-off frequency for filtering process.

#### 2.2.10.4.6 Level Change

(1) Meaning

This item is for changing the data level by ratio.

When the [Level change] button is pressed, the dialog box of Level change appears.



- Ratio

Specify the data level by the relative value of the original data.

### 2.2.10.4.7 CSV data file (Measured profile)

(1) File Format

Text File (MS-DOS)

(2) Description formats of Data

The frequency domain data are described as follows.

	1st. column	2nd. column	3rd. column	
1st. line	Frequency[Hz],	Data name 1,	Data name 2,	.....
2nd. line	0.0,	***.***,	***.**,	.....
3rd. line	$\Delta f$ ,	***.***,	***.**,	.....
	$2\Delta f$ ,	***.***,	***.**,	.....
	:	:	:	:
	F,	***.***,	***.**,	.....

- The character-string data of the first line (data name). is not indispensable.
- The order of each Data (row) doesn't have regulations.
- The frequency must be sorted in ascending order.

(3) Unit of Data

The unit of data is specified after the data file is selected.

### 2.2.11 CALC Function

#### (1) Meaning

In the sine vibration test, one vibration state is usually defined by using one of the quantities as Frequency  $f$ , Acceleration  $Acc$  and Displacement  $Disp$ .

Therefore, the conversion calculation between these quantities ( $Acc / Vel / Disp$ ) is needed to be done quickly.

In this program, a convenient function called 'CALCULATOR' is provided for this purpose.

The method for using this function is described as below ;

Denoting the frequency as  $f$  and the amplitude (displacement) as  $D$ , a sine vibration is expressed as below ;

$$x(t) = D \cdot \sin(2 \pi f t)$$

In this expression of the above, the following relations between the acceleration amplitude  $A$ , the velocity amplitude  $V$  and the displacement amplitude  $D$  stand ;

$$V = (2 \pi f)D$$

$$A = (2 \pi f)V$$

The function of CALCULATOR is for calculating easily the other two quantities from the two quantities given arbitrary among the four quantities ( $f, A, V, D$ ).

However, following the custom, the displacement amplitude is expressed by the peak-to-peak (p-p) expression ( $2D$ ) in this system.

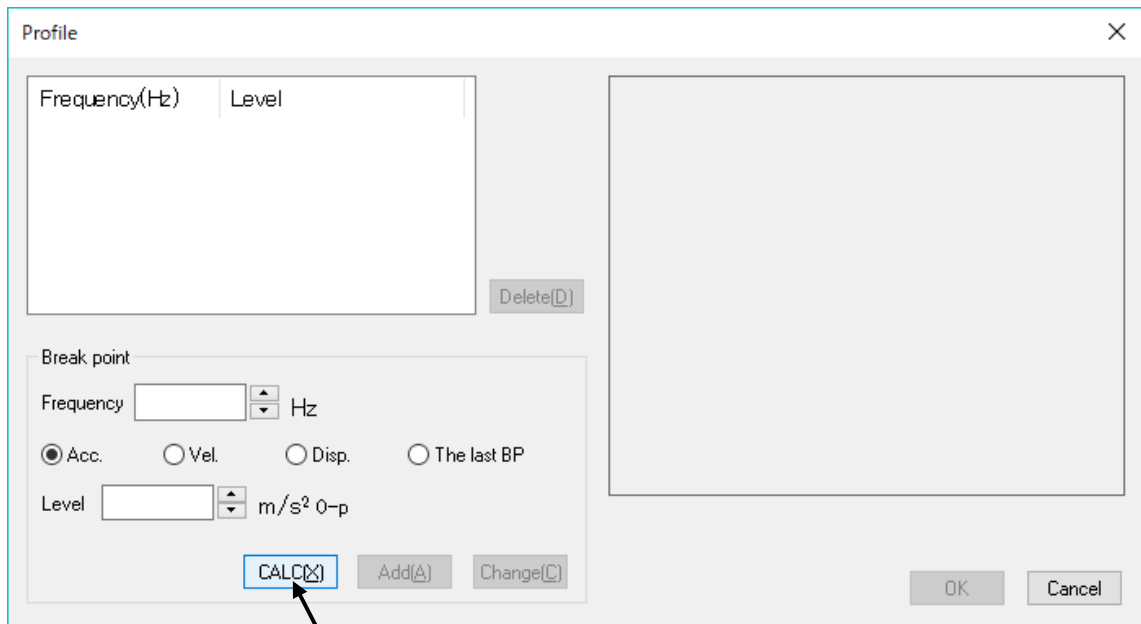
< Example >

The setting of items as ‘Sweep reference – Detailed definition (break point) – Constant’ are executed. When  $f = 100 \text{ Hz}$ ,  $V = 1.2 \text{ m/s}$  are given, the acceleration  $A \text{ [m/s}^2\text{]}$  is to be calculated. And the break point is inputted by the acceleration.

< Procedures >

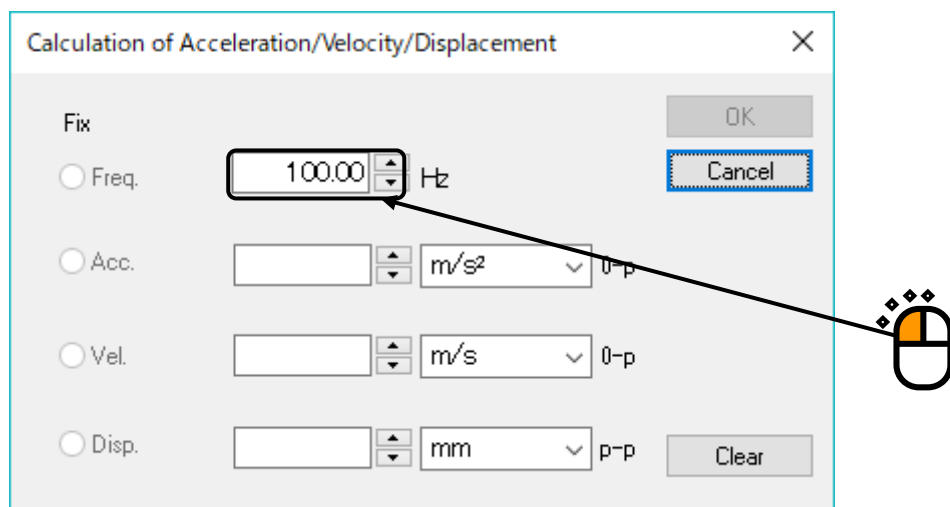
< Step 1 >

Press the button of [CALC].



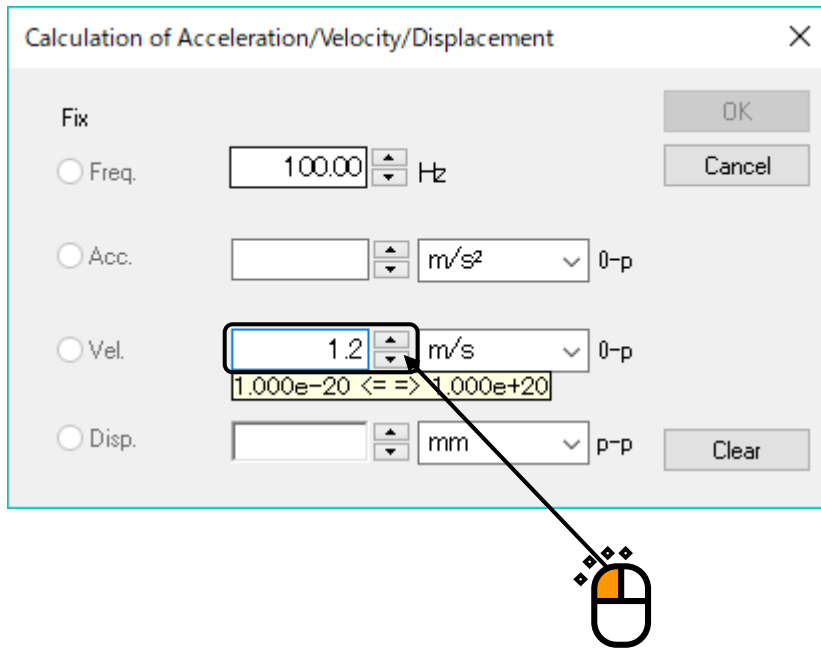
< Step 2 >

Input 100 to the item of Frequency (Freq.).



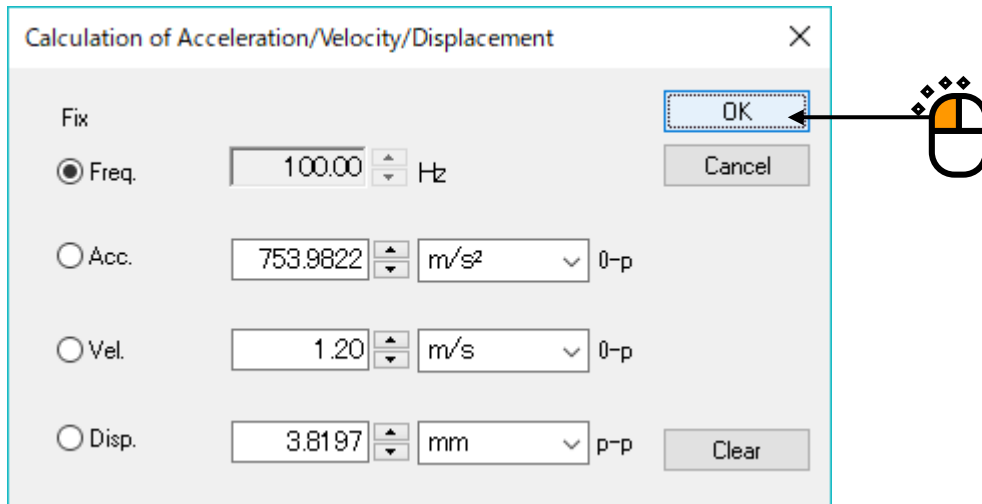
< Step 3 >

Input 1.2 to the item of Velocity (Vel.).



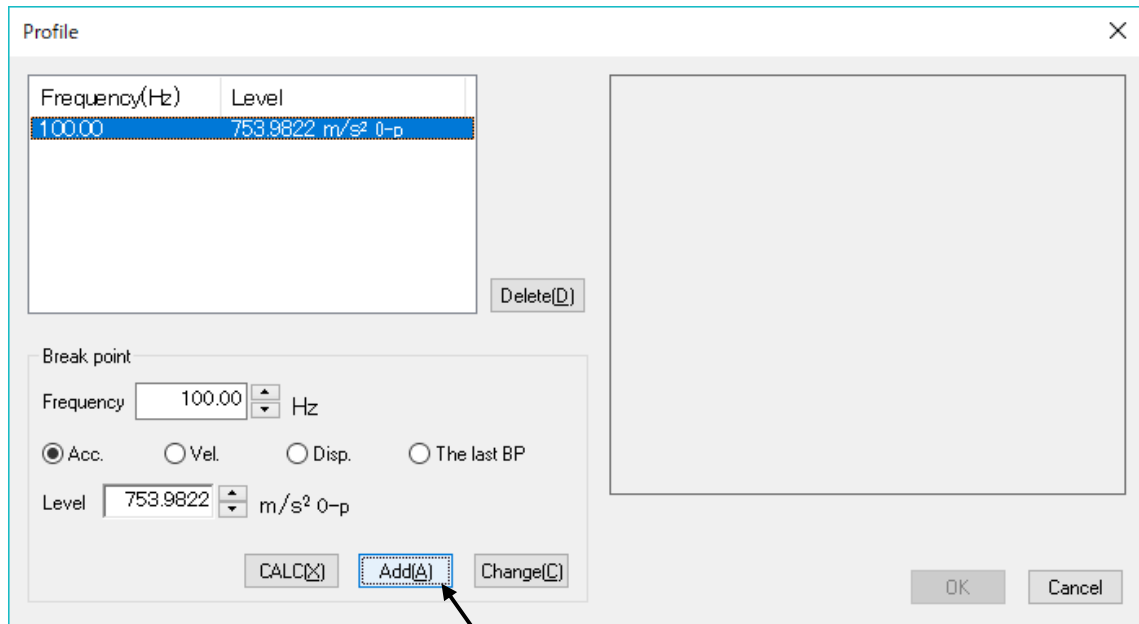
< Step 4 >

Calculation results of Acceleration and Displacement are displayed when the value of Velocity was inputted. Then press [OK].



< Step 5 >

Input the value of the break point by pressing the button of [Add].



## 2.3 Excitation System Setting

Excitation system setting

Initial output voltage: 10.0 mV rms

Clipping

Clipping by crest factor

Output voltage limit value: 10000.0 mV

Abort ratio: 50.0 %

HPF: Auto

Specify averaging time: 16

OK

Cancel

### 2.3.1 Averaging times setting

#### (1) Meaning

Averaging times of transmissibility measurement is specified in the initial measurement. The transmissibility measured in this item is mainly used in the initial control operation. The averaging times is specified '1 time' as the default when this item is not set.

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