

Random Vibration Control System

K2+

RANDOM Instruction Manual

IMV CORPORATION

Type of Document : Instruction Manual

System Applied : K2+

Software < RANDOM, SOR/ROR > Later than Version 20.1.0

Japanese Edition

| Version | Date | Contents |
|---------|------------|---|
| 1.0.0 | 2020.10.16 | First edition |
| 1.1.0 | 2021.02.02 | Additional description of 'Pause before transitioning to "In excitation"' of 'Fundamental/Control Condition' and 'Reset timer at 0dB' of 'Data Save Condition'. Additional description of 'Clear history at operation start' and 'Set the data file name automatically' of 'Set up'. |

English Edition

| Version | Date | Contents |
|---------|------------|---|
| 1.0.0 | 2020.10.16 | First edition |
| 1.1.0 | 2021.02.02 | Additional description of 'Pause before transitioning to "In excitation"' of 'Fundamental/Control Condition' and 'Reset timer at 0dB' of 'Data Save Condition'. Additional description of 'Clear history at operation start' and 'Set the data file name automatically' of 'Set up'. |

CONTENS

| | |
|--|------|
| Chapter 1 Outline of the System..... | 1-1 |
| 1.1 Specifications | 1-1 |
| 1.1.1 RANDOM..... | 1-1 |
| 1.1.2 Sine On Random (Option of RANDOM) | 1-3 |
| 1.1.3 Random On Random (Option of RANDOM) | 1-4 |
| 1.1.3.1 Extended Random On Random (Option of Random On Random) | 1-5 |
| 1.1.4 PSD Limit (Option of RANDOM) | 1-5 |
| 1.1.5 Non Gaussian (Option of RANDOM) | 1-5 |
| 1.1.6 Soft-Clipping (Option of RANDOM) | 1-5 |
| Chapter 2 Operation System of K2+ Application..... | 2-1 |
| 2.1 Outline | 2-1 |
| 2.2 Test File | 2-2 |
| 2.3 Test Type | 2-3 |
| Chapter 3 Basic Operation..... | 3-1 |
| 3.1 Random Test | 3-1 |
| 3.2 Simplified Definition | 3-22 |
| Chapter 4 Test Definition..... | 4-1 |
| 4.1 Outline | 4-1 |
| 4.2 Fundamental/Control Condition | 4-2 |
| 4.2.1 Frequency range f_{max} | 4-2 |
| 4.2.2 Control frequency lines | 4-2 |
| 4.2.3 Max. Observation Frequency (Max. Observation Freq.) | 4-3 |
| 4.2.4 Controlled variable | 4-3 |
| 4.2.5 Averaging Parameters | 4-4 |
| 4.2.6 Equalization Mode | 4-5 |
| 4.2.7 Loop check..... | 4-5 |
| 4.2.7.1 Ambient noise upper limit..... | 4-6 |
| 4.2.7.2 Transmissibility check value [in initial excitation] | 4-6 |
| 4.2.7.3 Transmissibility check value [in test operation] | 4-7 |
| 4.2.7.4 Overload check value..... | 4-7 |
| 4.2.8 Test time..... | 4-7 |
| 4.2.9 Initial output level | 4-7 |
| 4.2.10 Level increment | 4-8 |
| 4.2.11 Auto-start | 4-8 |
| 4.2.12 Shutdown time..... | 4-8 |
| 4.2.13 Level Scheduling | 4-9 |
| 4.2.13.1 Level..... | 4-10 |
| 4.2.13.2 Time..... | 4-10 |

| | | |
|-------------|--|------|
| 4.2.13.3 | Tolerance Enlarge..... | 4-10 |
| 4.2.14 | Observation freq. can be set within the Reference freq. range..... | 4-11 |
| 4.2.15 | Pause before transitioning to "In excitation"..... | 4-11 |
| 4.3 | Excitation System Setting..... | 4-12 |
| 4.3.1 | Initial output voltage..... | 4-12 |
| 4.3.2 | Clipping..... | 4-12 |
| 4.3.2.1 | Clipping by crest factor..... | 4-12 |
| 4.3.2.2 | Output voltage limit value..... | 4-13 |
| 4.3.2.3 | Abort Ratio..... | 4-13 |
| 4.3.3 | High Pass Filter (HPF)..... | 4-14 |
| 4.4 | Control Reference..... | 4-15 |
| 4.4.1 | PSD definition..... | 4-15 |
| 4.4.1.1 | Break Point PSD Definition..... | 4-16 |
| 4.4.1.1.1 | Outline..... | 4-16 |
| 4.4.1.1.2 | Frequency..... | 4-17 |
| 4.4.1.1.3 | Level..... | 4-17 |
| 4.4.1.1.4 | Slope..... | 4-18 |
| 4.4.1.1.5 | rms change..... | 4-18 |
| 4.4.1.2 | Measured PSD Definition..... | 4-19 |
| 4.4.1.2.1 | Outline..... | 4-19 |
| 4.4.1.2.2 | PSD Data File Load..... | 4-20 |
| 4.4.1.2.3 | PSD Data Processing..... | 4-21 |
| 4.4.1.2.3.1 | LPF (Low Pass Filter)..... | 4-21 |
| 4.4.1.2.3.2 | HPF (High Pass Filter)..... | 4-22 |
| 4.4.1.2.3.3 | Level Change..... | 4-23 |
| 4.4.1.2.3.4 | rms change..... | 4-24 |
| 4.4.1.2.4 | CSV data file..... | 4-24 |
| 4.4.1.3 | Measured Waveform definition..... | 4-25 |
| 4.4.1.3.1 | Outline..... | 4-25 |
| 4.4.1.3.2 | Waveform Data File loading..... | 4-26 |
| 4.4.1.3.3 | Data edit..... | 4-29 |
| 4.4.1.3.3.1 | Filtering..... | 4-29 |
| 4.4.1.3.3.2 | Edging..... | 4-31 |
| 4.4.1.3.3.3 | Scalar calculation..... | 4-33 |
| 4.4.1.3.3.4 | Data length change..... | 4-35 |
| 4.4.1.3.4 | CSV data file..... | 4-38 |
| 4.4.2 | Tolerance Definition..... | 4-39 |
| 4.4.2.1 | Tolerance..... | 4-40 |
| 4.4.2.2 | Define the alarm line..... | 4-40 |
| 4.4.2.3 | Use the lower limit line..... | 4-40 |

| | |
|---|------|
| 4.4.3 RMS Check | 4-41 |
| 4.5 Input Channel | 4-42 |
| 4.5.1 Outline | 4-42 |
| 4.5.2 Input Channel | 4-42 |
| 4.6 Data Save Condition | 4-43 |
| 4.6.1 Outline | 4-43 |
| 4.6.2 Saving Condition | 4-44 |
| 4.7 Amplitude probability density analysis..... | 4-45 |
| 4.7.1 Outline | 4-45 |
| 4.8 Operation Status | 4-46 |
| 4.9 Safety check | 4-48 |
| 4.9.1 Outline | 4-48 |
| 4.10 Aux. Output | 4-50 |
| 4.10.1 Outline | 4-50 |
| 4.10.2 Fundamental Operation Example | 4-50 |
| Chapter 5 Message and Meanings..... | 5-1 |
| 5.1 K2+ Random Error Message | 5-1 |
| Chapter 6 Supplemental Explanation..... | 6-1 |
| 6.1 Set Up | 6-1 |
| 6.2 Manual Operation | 6-4 |

Chapter 1 Outline of the System

1.1 Specifications

1.1.1 RANDOM

- (1) Control method : PSD control of the random waveform signal with the Gaussian nature
by using the feed-forward method
- (2) Control frequency f_{max} : Maximum 20 kHz (However, it may be limited by conditions.)
- (3) Number of control lines L : Maximum 25600 lines (However, it may be limited by conditions.)
- (4) Control dynamic range : More than 94 dB
- (5) Loop time : 200 ms (120 DOF, $f_{max}=2000$ Hz, $L=400$ line)
- (6) Input channel
 - 1) Number of channels : Maximum 64
 - 2) Channel type : Control channel / Monitor channel (possible to duplicate)
 - 3) Control response averaging method : Average value control / Maximum value control /
Minimum value control
 - 4) Alarm / Abort : For each input channel, the maximum allowance spectrum data (PSD)
or RMS value can be specified for setting of Alarm / Abort.
 - 5) Limit control function : For each input channel, the maximum allowance spectrum data (PSD)
or/and RMS value can be specified. When the response exceeding
over the specified spectrum can be forecasted to be produced at the
concerning channel, the system controls the concerning spectrum not
to produce the exceeded response over the allowance and continues
the testing operation without stopping (however, the linearity of the
controlled system is assumed for the above forecasting). Optional
function of 'PSD Limit' is necessary to execute the operation as in the
above by using PSD data.
- (7) Output channel
 - 1) Number of channels : 1
 - 2) Clipping : Voltage value (specifying by σ can also be added.)
- (8) Analysis / Display data
 - 1) Reference, Controlled response PSD and Tolerance
 - 2) PSD of each input channel, Waveform data
 - 3) Drive spectrum
 - 4) Transmissibility : Controlled system transmissibility (control response / drive)
Transmissibility between input channel and drive
Transmissibility between input channels (amplitude, phase)
 - 5) PSD for Monitoring, Limit control execution ratio
 - 6) Amplitude probability density of each control channel and drive

(9) Data save : Automatic / Manual

Display data save as CSV format

(10) Control operation information save and use

1) Storing of the test operation time information and continuing of test operation

(Partial execution of the test)

2) Storing the control information (Live data in operation) and continuing of the control

(Prompt mode)

(11) Option : PSD Limit

Sine On Random

Random On Random

Extended Random On Random

Non Gaussian

Soft-Clipping

1.1.2 Sine On Random (Option of RANDOM)

(1) Specification for Broad band

Based on K2+/RANDOM (However, '(3) Special mention for SOR' should be referred to.)

(2) Specification for Narrow band

1) Control method : Based on K2+/SINE

2) Base narrow band to be defined : 1

3) Number of higher harmonics in base narrow band to be defined : 32

4) Definition of base narrow band

① Base reference components : specify by level and frequency

② Sweep direction : Log sweep / Linear sweep / Sweep hold

③ Sweep rate : [octave / min] (Log sweep) / [Hz/sec] (Linear sweep) / [min/Single-Sweep]

④ Specifying of break point : possible

5) Definition of each higher harmonic component

① Specifying of Level (Level ratio) : possible

② Specifying of Frequency (Frequency ratio) : possible

③ Specifying of Phase for Output sine waveform : possible

④ Specifying of Tolerance : possible

6) Test time : Sweep cycle of narrow band reference / Infinite / Times

7) Sweep hold / Reverse / Skip / Pause of narrow band : possible

8) Specifying of Sweep pause time : possible

9) Specifying of Sweep start frequency : possible

10) Specifying of Upper / Lower sweep frequency : possible

(3) Special mention for SOR

1) Specifying of Test time : based on the test time of narrow band

2) Level scheduling function : impossible

3) Observing by Observation profile and Limit control : Available only in broad band

1.1.3 Random On Random (Option of RANDOM)

(1) Specification for Broad band

Based on K2+/RANDOM (However, '(3) Special mention for ROR' should be referred to.)

(2) Specification for Narrow band

1) Control method : Based on K2+/RANDOM

2) Base narrow band to be defined : 1

3) Number of higher harmonics in base narrow band to be defined : 32

4) Definition of base narrow band

① Base reference components : specifying by level (1) and frequency range

② Sweep direction : Log sweep / Linear sweep

③ Sweep rate : [octave / min] (Log sweep) / [Hz/sec] (Linear sweep) / [min/Single-Sweep]

④ Specifying of Sweep slope : possible

5) Definition of each higher harmonic component

① Specifying of Level (Level ratio) : possible

② Specifying of Frequency (Frequency ratio) : possible

③ Specifying of Band width : possible

④ Specifying of Tolerance : possible

6) Test time : Sweep cycle of narrow band reference / Infinite / Times

7) Sweep hold / Reverse / Skip / Pause of narrow band : possible

8) Specifying of Sweep pause time : possible

9) Specifying of Sweep start frequency : possible

10) Specifying of Upper / Lower sweep frequency : possible

(3) Special mention for ROR

1) Specifying of Test time : based on the test time of narrow band

2) Level scheduling function : impossible

1.1.3.1 Extended Random On Random (Option of Random On Random)

This is an option to define multiple numbers of base narrow band. The concept of harmonic waves is not included.

To implement this option, it will be necessary to use the Extended Random On Random option in addition to the Random On Random option.

(1) Specification for Broad band

Based on K2+/RANDOM (However, '1.1.3 Random On Random (Option of RANDOM) (3) Special mention for ROR' should be referred to.)

(2) Specification for Narrow band

1) Control method : Based on K2+/RANDOM

2) Base narrow band to be defined : 32

3) Definition of base narrow band

① Base reference components : specifying by level and frequency(break point)

② Sweep direction : Log sweep / Linear sweep / Fixed frequency

③ Sweep rate : [octave / min] (Log sweep) / [Hz/sec] (Linear sweep) /
[min/Single-Sweep]

④ Specifying of Band width : possible

⑤ Specifying of Tolerance : possible

⑥ Test time : Sweep cycle of narrow band reference / Infinite / Times

⑦ Specifying of Sweep pause time : possible

⑧ Specifying of Sweep start frequency : possible

4) Sweep hold / Reverse / Skip / Pause of narrow band : possible

5) Specifying of Upper / Lower sweep frequency : possible

6) Synthesize mode of Base narrow bands : Max / Sum

1.1.4 PSD Limit (Option of RANDOM)

(1) Specifying method : Monitoring level is specified for each limit control channel by PSD.

(2) Number of channels : All the input channels available in the system are usable.
(However, the license setting is required.)

(3) Objective physical quantity : An Input channel having a physical quantity which is different from that of Control Variable is possible to be used as a limit control channel.

1.1.5 Non Gaussian (Option of RANDOM)

Refer to the instruction manual of K2+/NON-GAUSSIAN about the details.

1.1.6 Soft-Clipping (Option of RANDOM)

A functionality of 'Hard-Clipping specified by crest factor' has been provided since the first release of this system. Using this clipping, the spectrum of the clipped drive signal is more or less modified. As a result, the spectrum of the response signal would be more or less different from the

plan.

The Soft-Clipping option is a solution for this disadvantages. Using the Soft-Clipping, it is possible to clip the drive signal without deteriorating the control performance.

Chapter 2 Operation System of K2+ Application

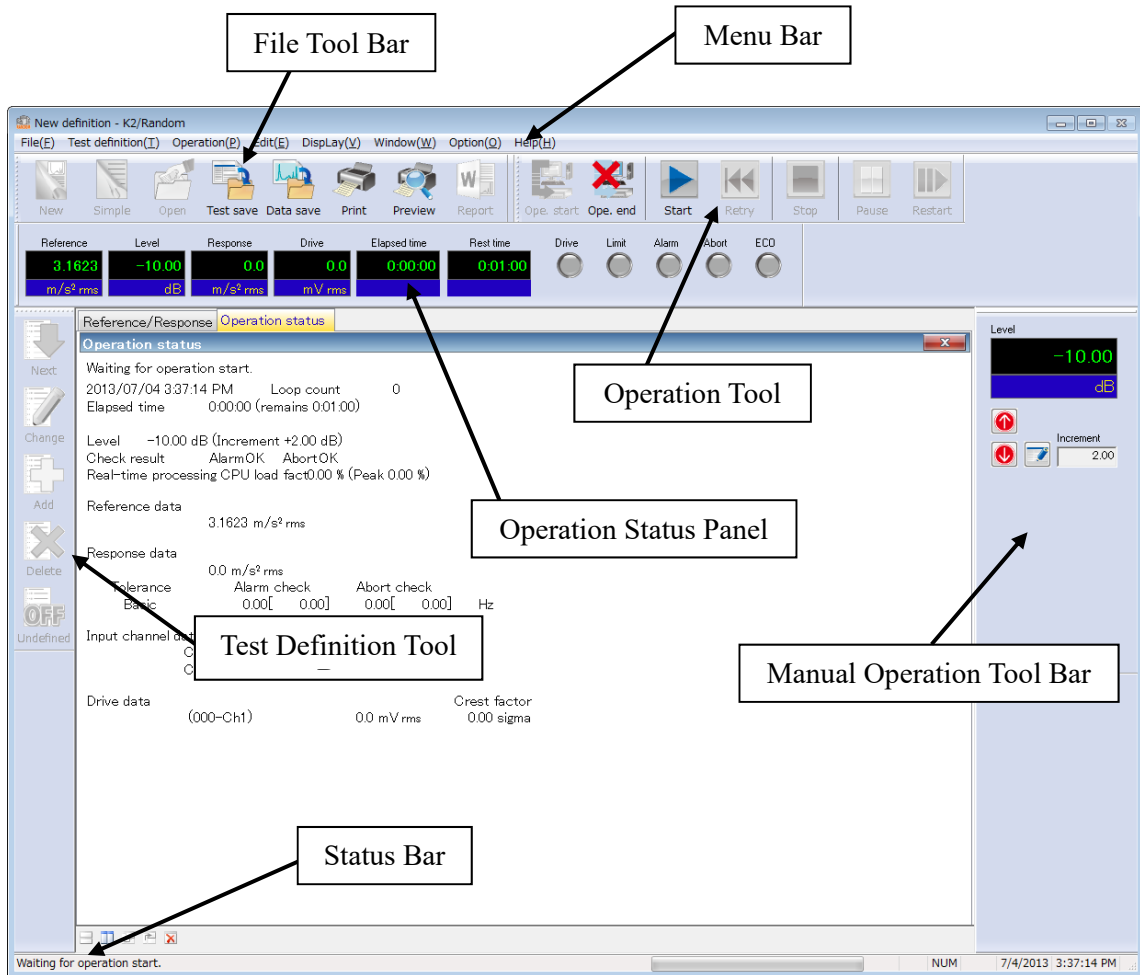
2.1 Outline

In K2+ application, operation after booting up is executed by using a keyboard and a mouse.

When this application is started, a window shown as below appears.

All the names of menu in this application are displayed in Menu bar. Each menu is to be opened by clicking on its name and available commands appears as a list.

The commands used frequently are displayed as icons in each Tool bar. A command is executed or a dialog box corresponding to the command is opened when the icon is clicked. Operation status of K2+ Controller is displayed in Status bar. The state during the excitation operation is displayed in Operation status panel.



K2+ Application Window

2.2 Test File

In K2+ application, necessary information to operate a test is saved in a specified file called 'Test File'. Following kinds of Test File are available in this system.

Necessary Test Files for test operation

- Test Definition File : The file created in Ver.20.0.0.0 or later

K2+/RANDOM (*.ran2, *.sor2,*.ror2,*.rorex2)

The file created in Ver.10.0.0.0 or later

K2/RANDOM (*.ran2, *.sor2,*.ror2,*.rorex2)

The file created before Ver.10.0.0.0

K2/RANDOM (*.ran, *.sor,*.ror)

- Graph Data File : The file created in Ver.10.0.0.0 or later (*.vdf2)
 The file created before Ver.10.0.0.0 (*.vdf)

- Environment setting File

(I/O Module Configuration Information, Excitation System Information, Input channel Information) : SystemInfo.Dat2

Note 1) Saved in '\IMV\K2_Plus' on System Drive. Deleting inhibited.

2.3 Test Type

In K2+/RANDOM, three test types as below are available.

① Random Test

A vibration test operated by the random vibration.

② SOR Test

SOR test is a vibration test composed by adding the random vibration to the sine vibration simultaneously.

The sine vibration is possible to be swept in this test.

③ ROR Test

ROR test is a vibration test composed by superimposing a stationally broad band random vibration with a narrow band random vibration that is swept according to a given condition of sweeping.

④ Extended ROR Test

This is a ROR test that allows the user to define a narrow band random vibration with a greater freedom compared to the ROR tests stated above.

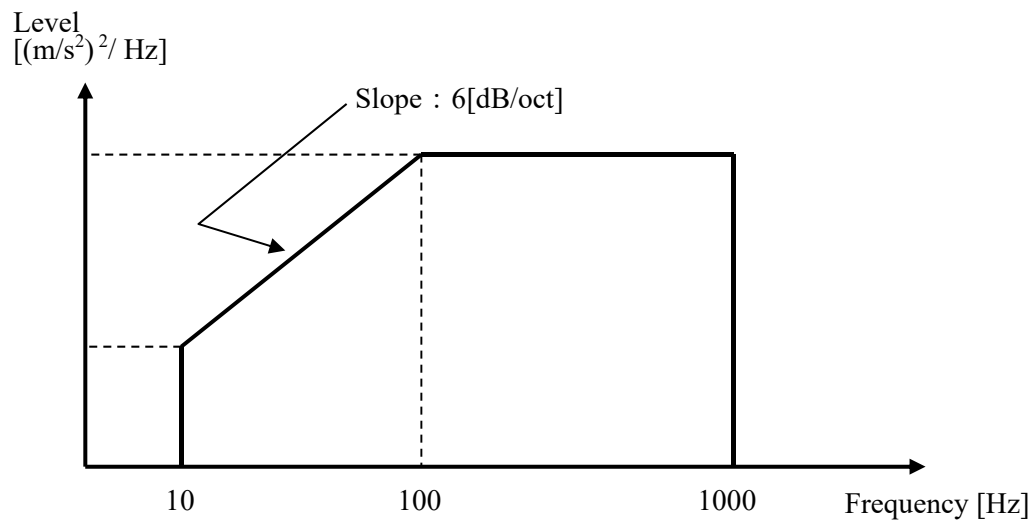
Chapter 3 Basic Operation

3.1 Random Test

< Example >

An example of random test is described as below ;

[Reference pattern]



The PSD is specified to 10 $[(m/s^2)rms]$ having the shape as in the above between 10 [Hz] and 1000 [Hz].

[Test time]

1 minute

[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 $3pC/(m/s^2)$

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

However, these channels must be registered in Input channel information (in this example, 'Input01').

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

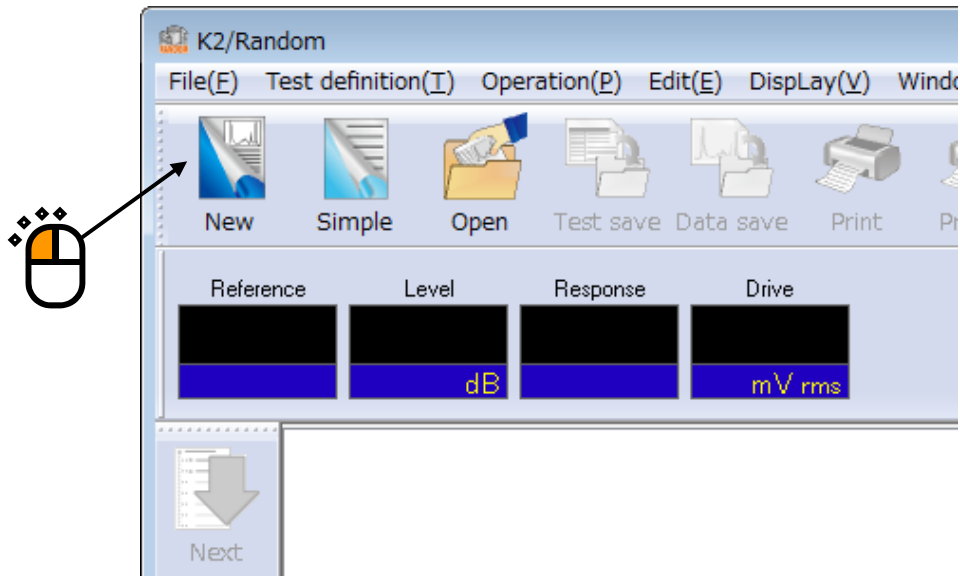
[Information of specimen]

Specimen mass : 10[kg]

< Procedures >

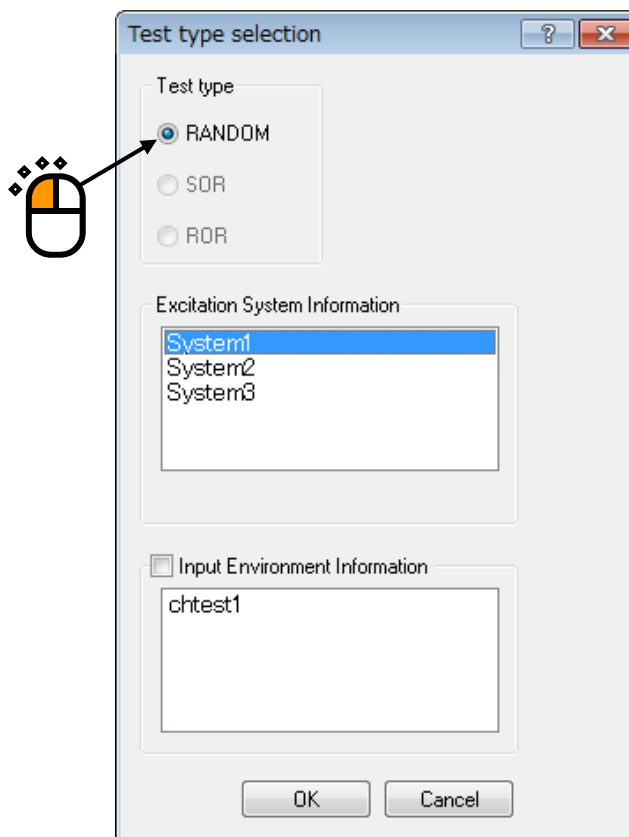
< Step 1 >

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



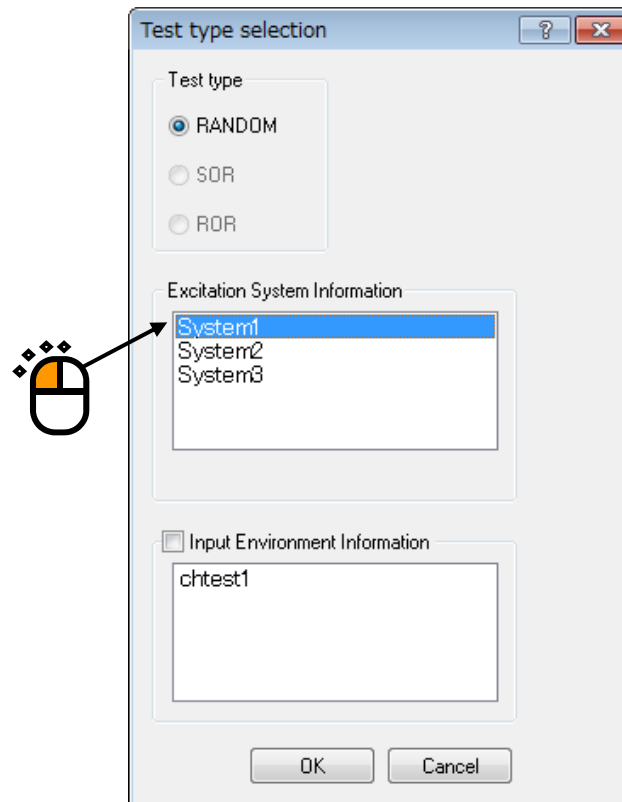
< Step 2 >

Select the item of 'Random test' in Test type. (If SOR, ROR option is not installed, only 'Random test' can be chosen.)



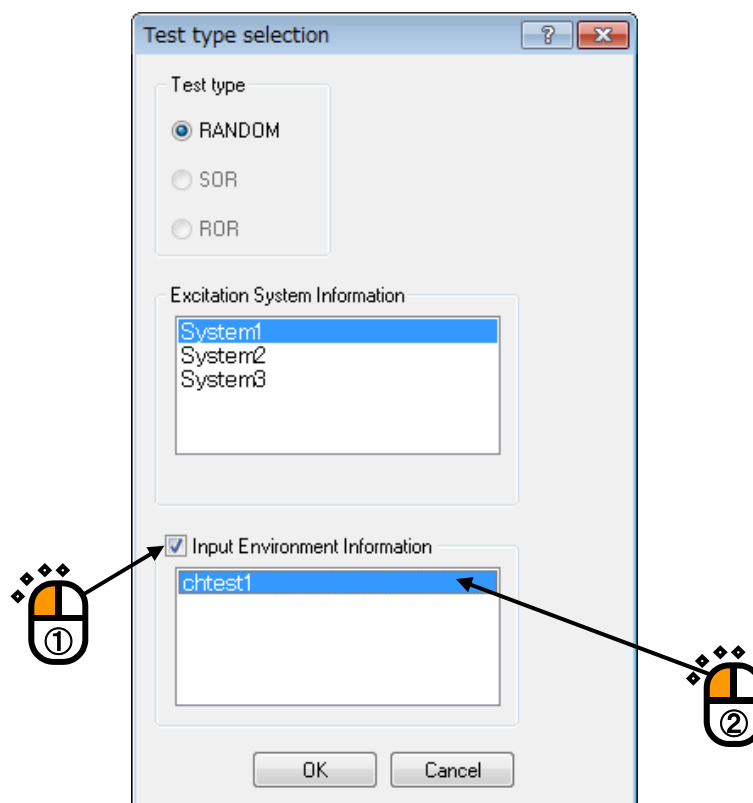
< Step 3 >

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



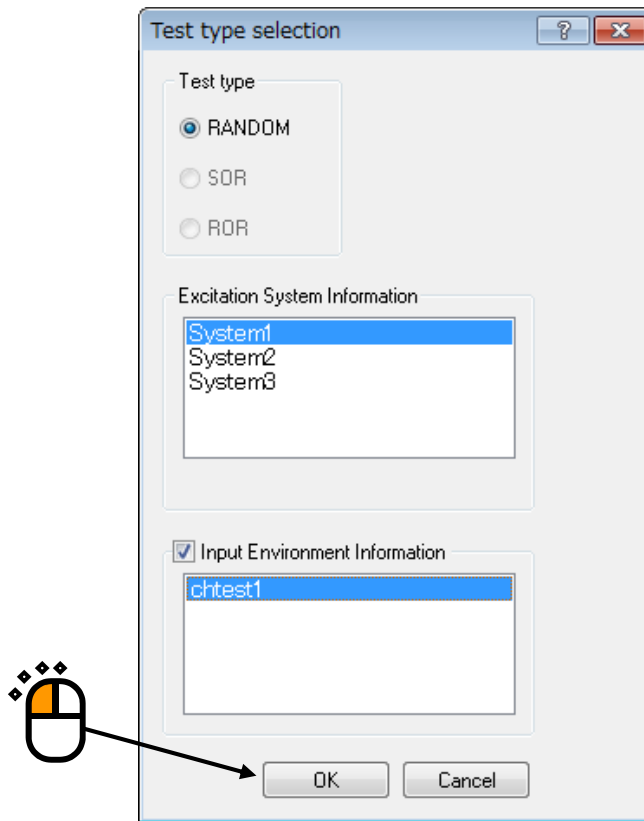
< Step 4 >

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



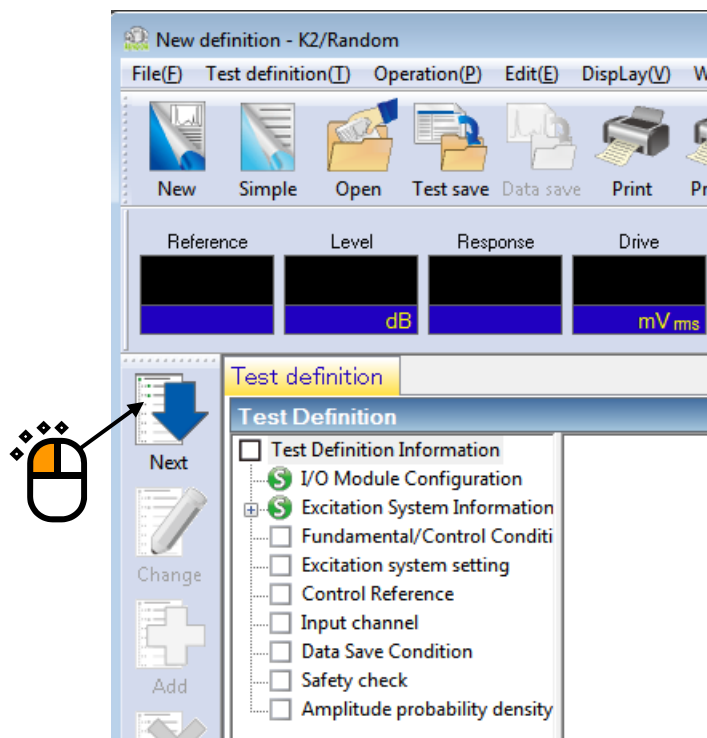
< Step 5 >

Press the button of [OK].



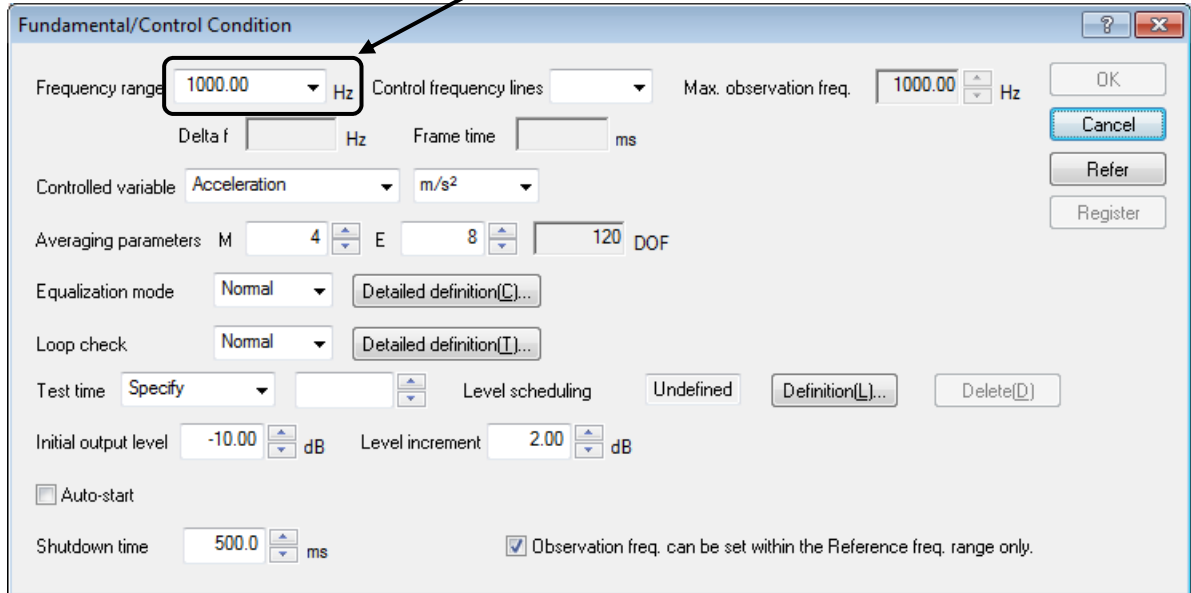
< Step 6 >

Press the button of [Next].



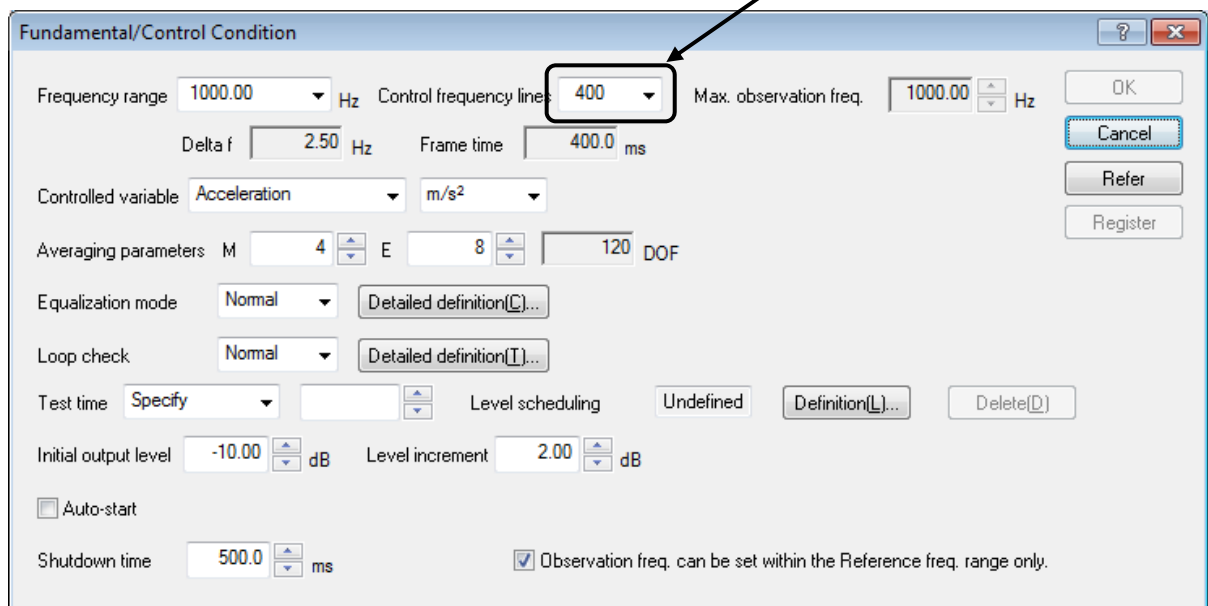
< Step 7 >

Set the Frequency range to '1000Hz'.



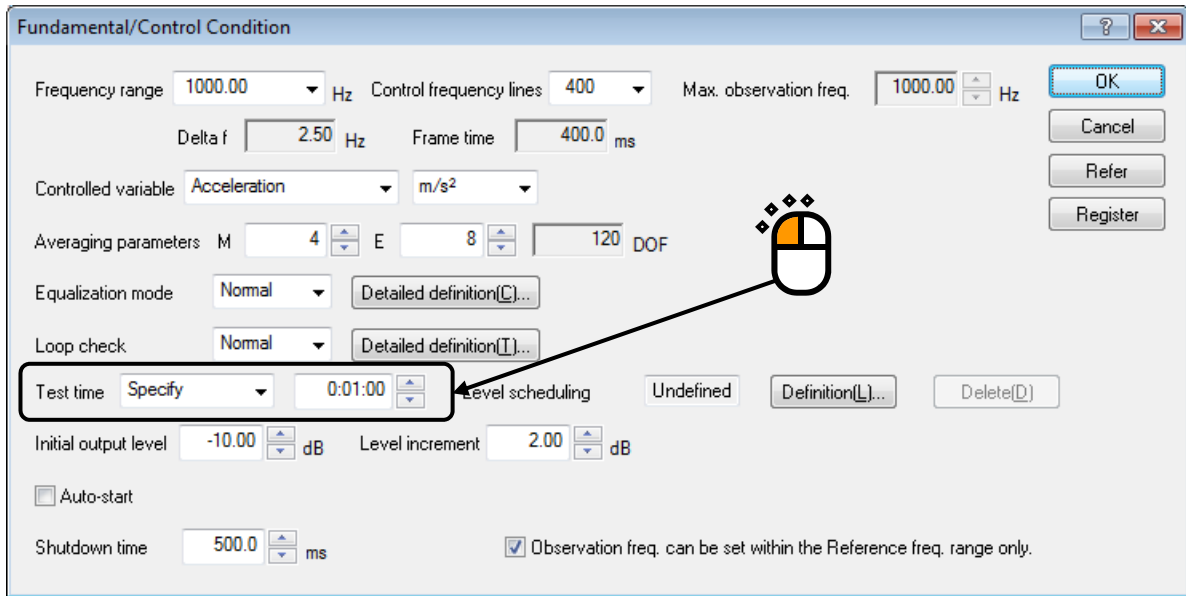
< Step 8 >

Set the Control frequency lines to '400'.



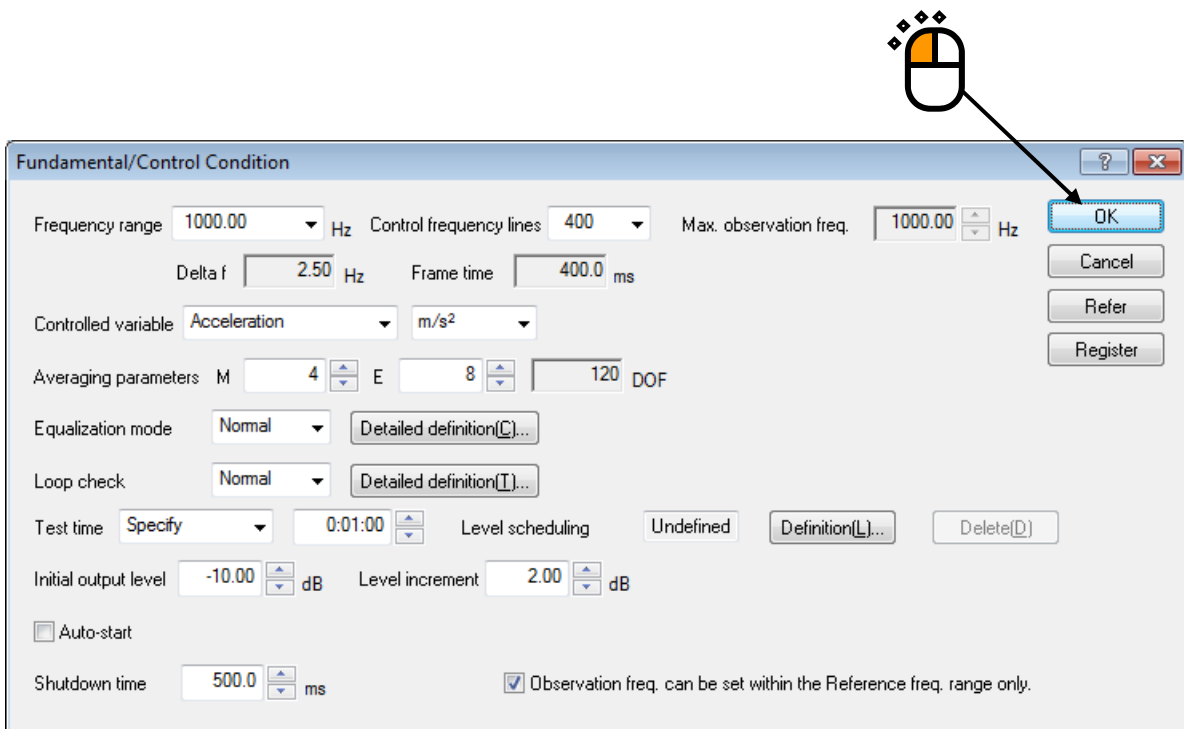
< Step 9 >

Specify the Test time as 'Specify time'. And input the value as 'Test time : 0 : 01 : 00 (60 sec)'.



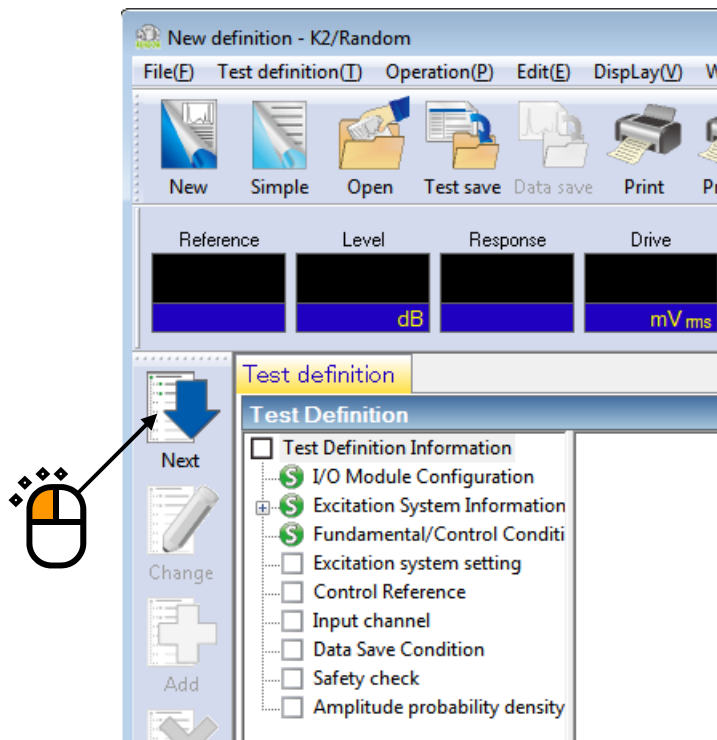
< Step 10 >

Press the button of [OK].



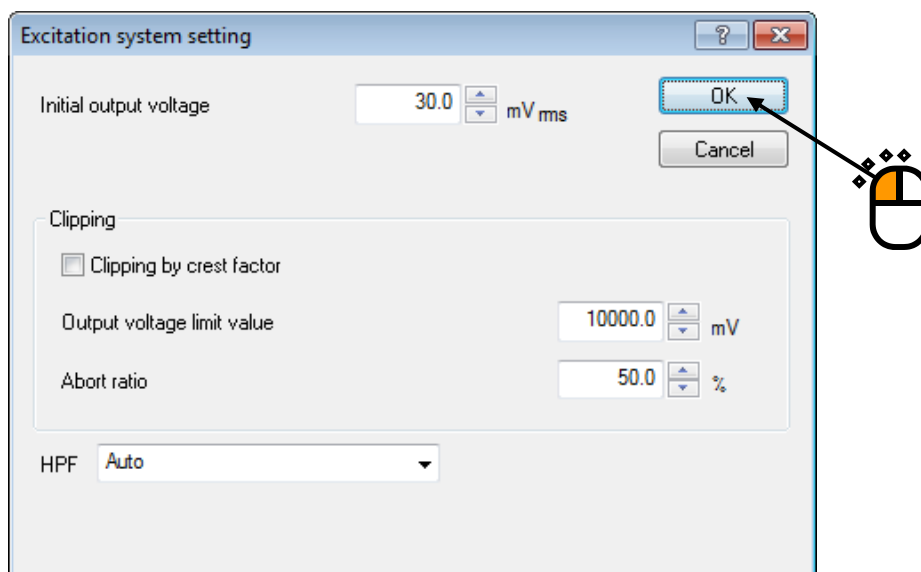
< Step 11 >

Press the button of [Next].



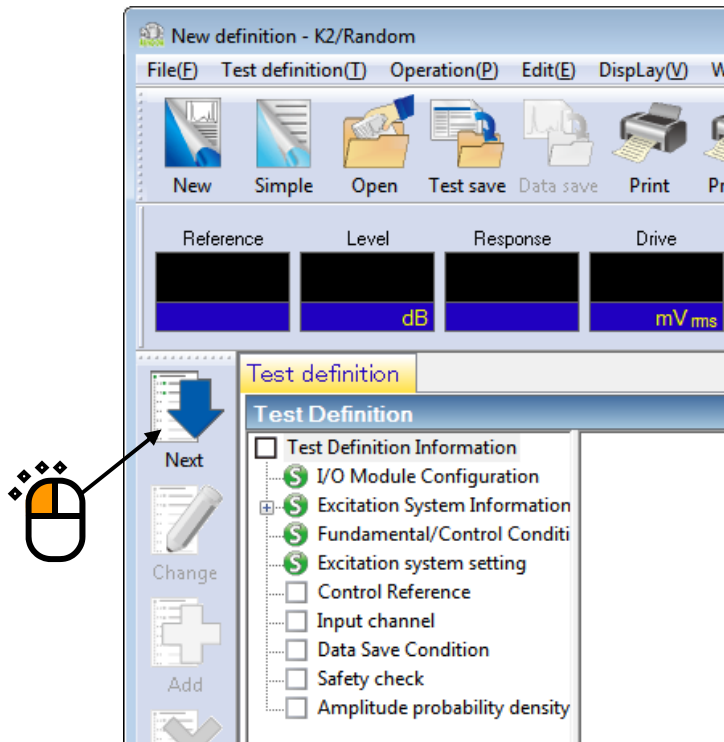
< Step 12 >

Press the button of [OK].



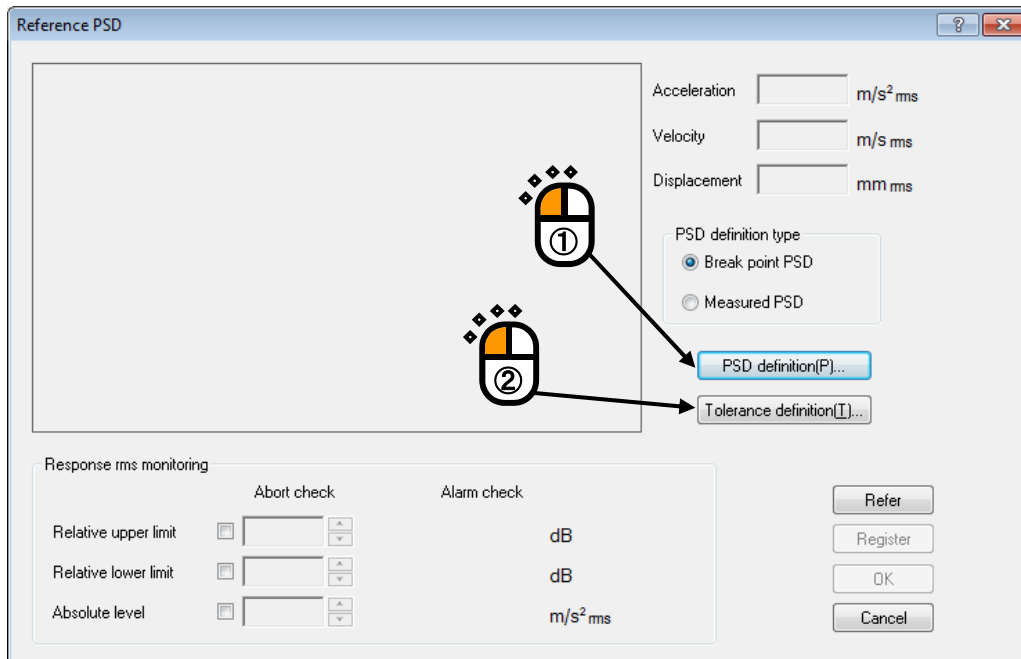
< Step 13 >

Press the button of [Next].



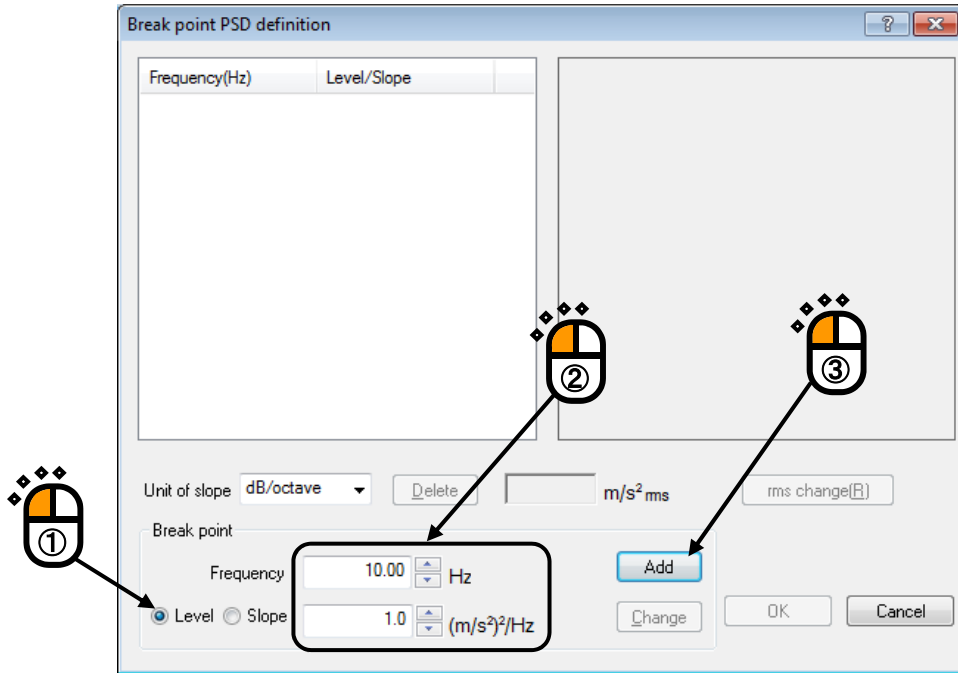
< Step 14 >

Select the item of Break point PSD and press the button of [PSD definition t].



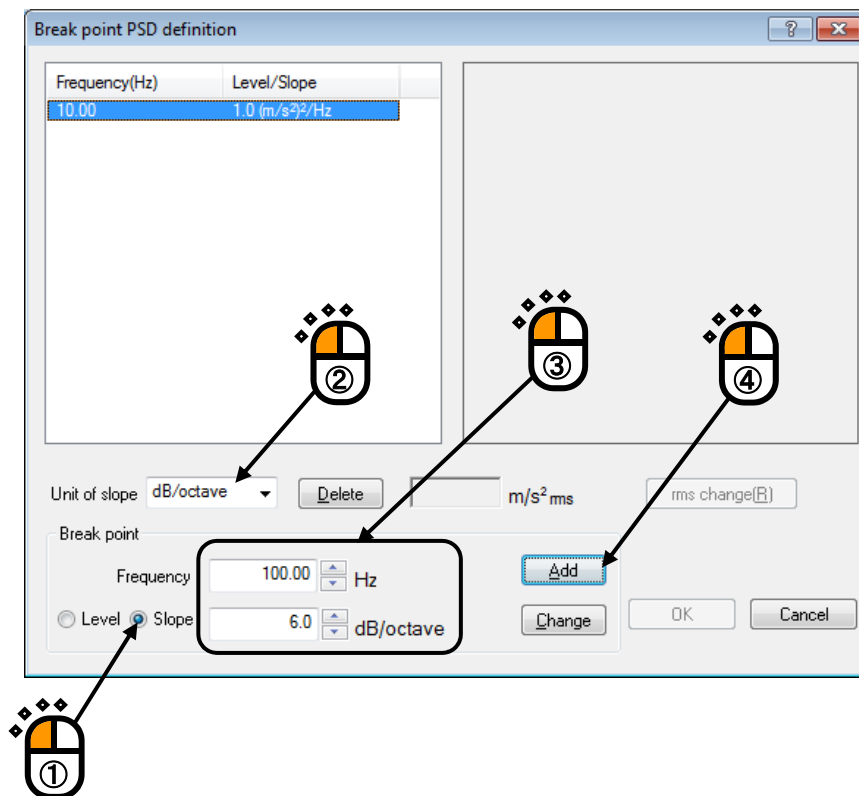
< Step 15 >

Select the item of Level and input the values as ‘Level : 1[(m/s²)²/Hz], Frequency : 10 [Hz]’.
Then, press the button of [Add].



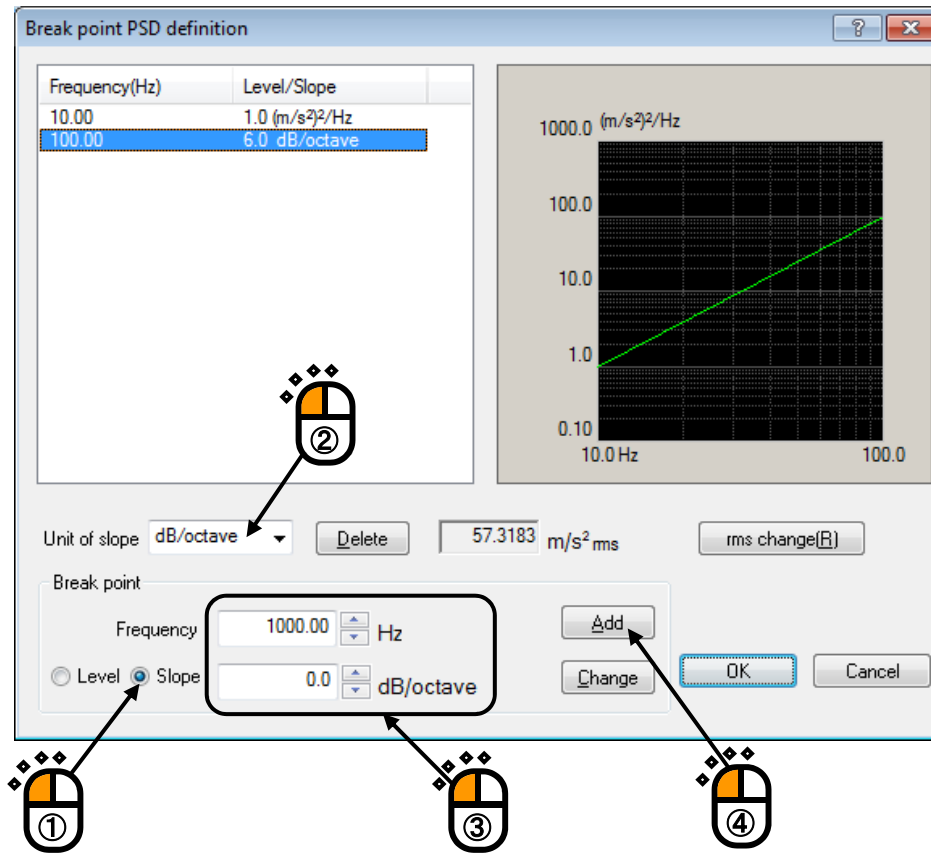
< Step 16 >

Select the item of Slope and specify Unit of Slope as ‘dB/octave’. Input the values as ‘Slope : 6 [dB/octave], Frequency : 100 [Hz]’. Then, press the button of [Add].



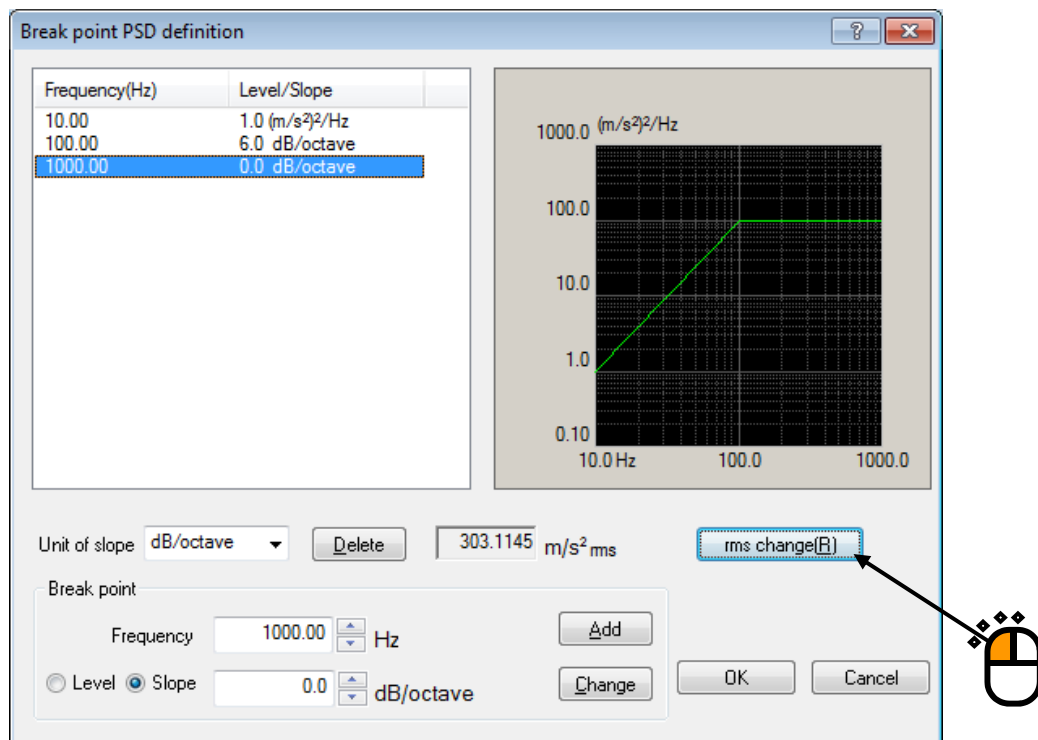
< Step 17 >

As in the same way, select the item of Slope and specify the Unit of Slope as 'dB/octave'. Input the values as 'Slope : 0 [dB/octave], Frequency : 1000 [Hz]'. Then, press the button of [Add].



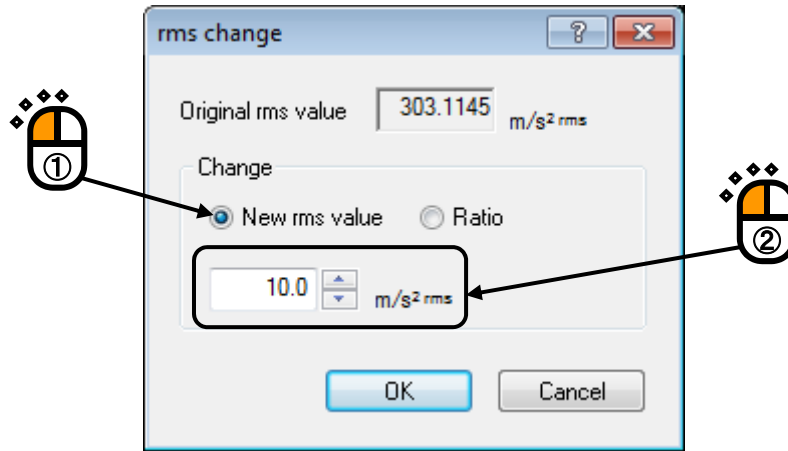
< Step 18 >

Press the button of [rms change].



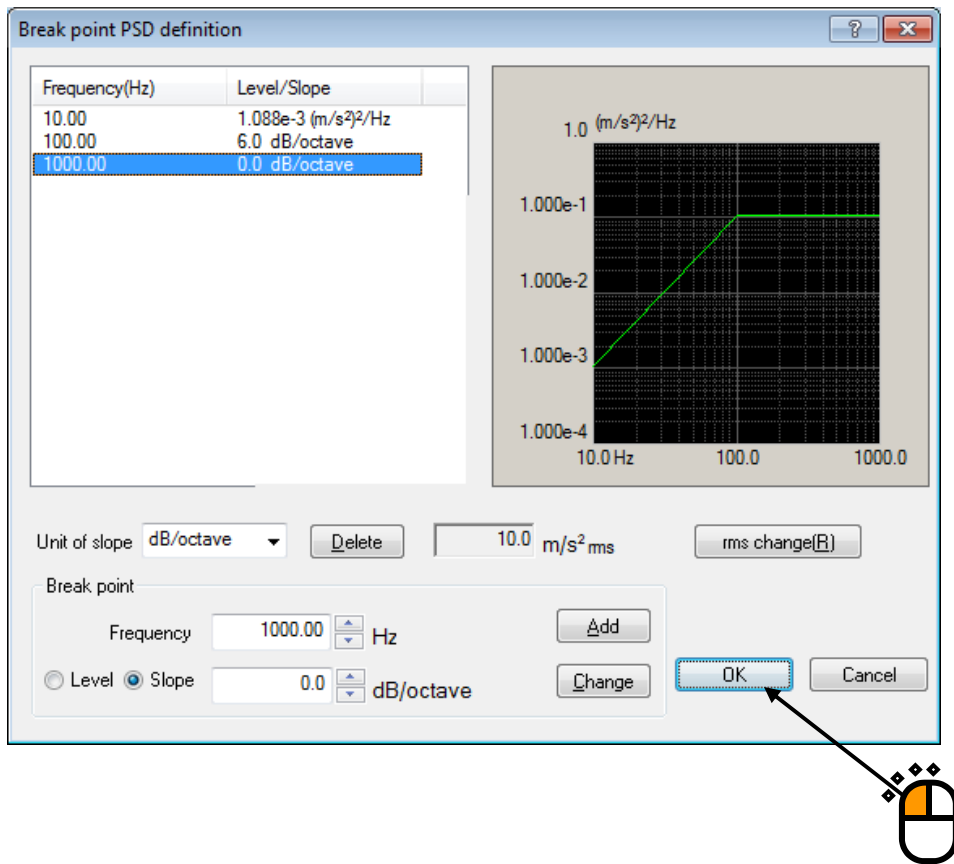
< Step 19 >

Select the item of New rms value and input the value as 'New rms value : 50 [(m/s²) rms].
And press the button of [OK].



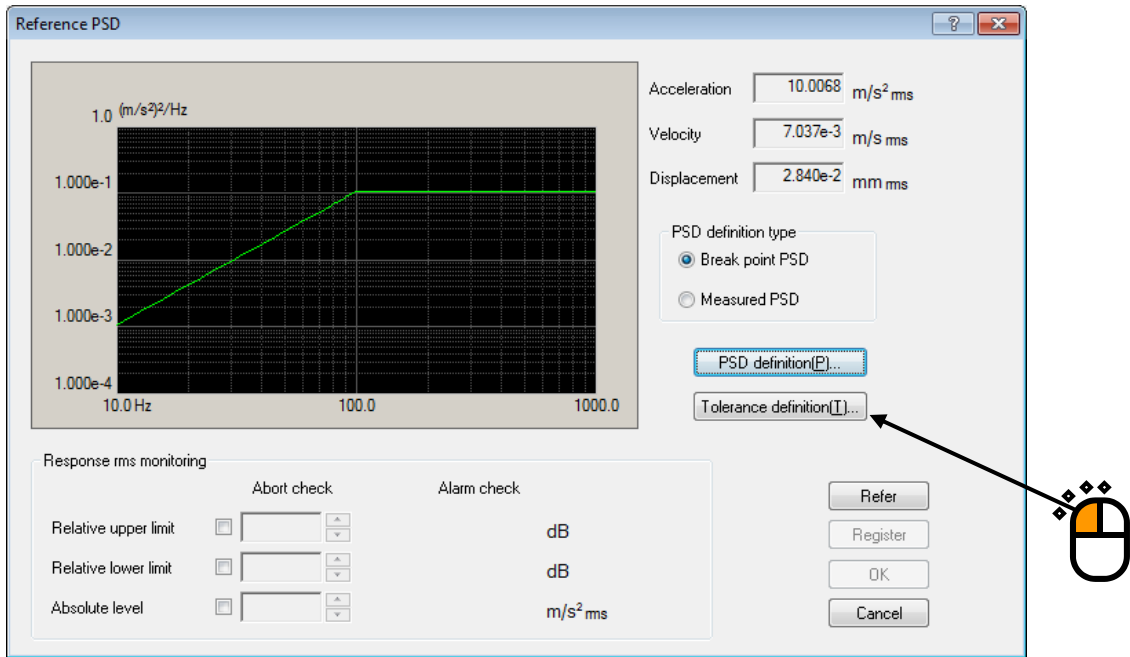
< Step 20 >

Press the button of [OK].



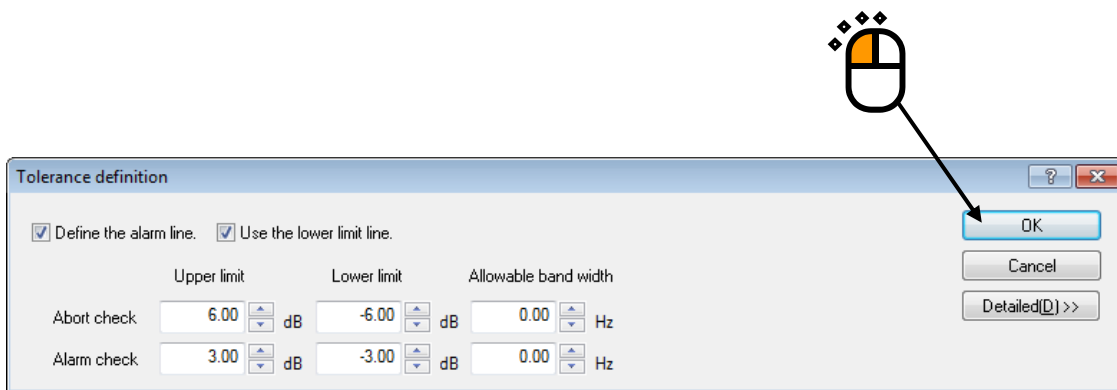
< Step 21 >

Press the button of [Tolerance definition].



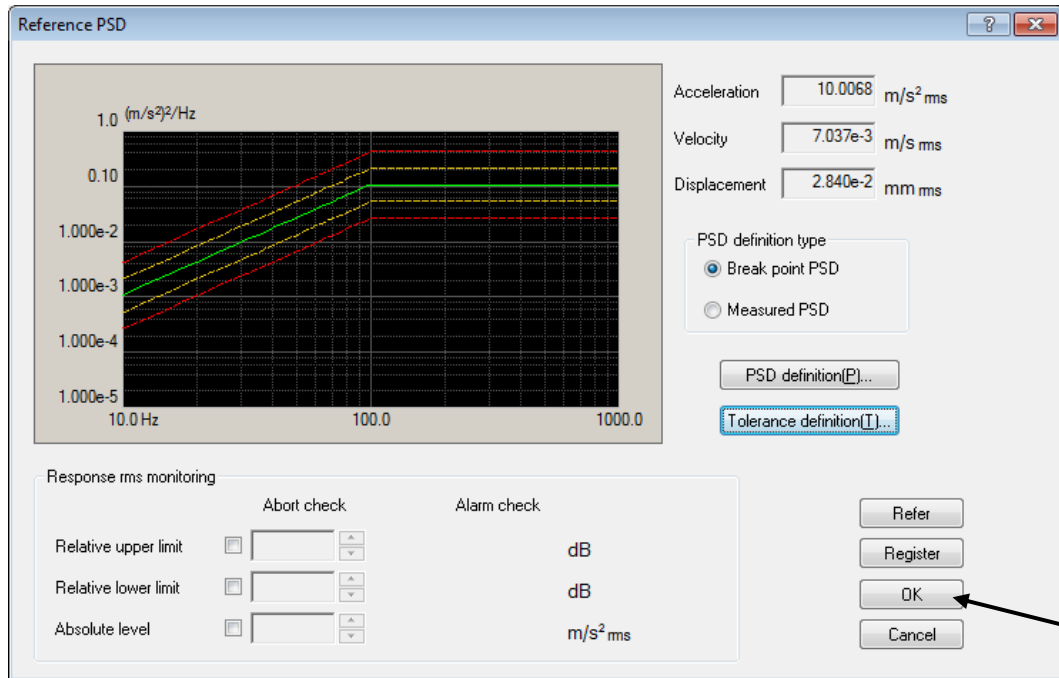
< Step 22 >

Press the button of [OK].



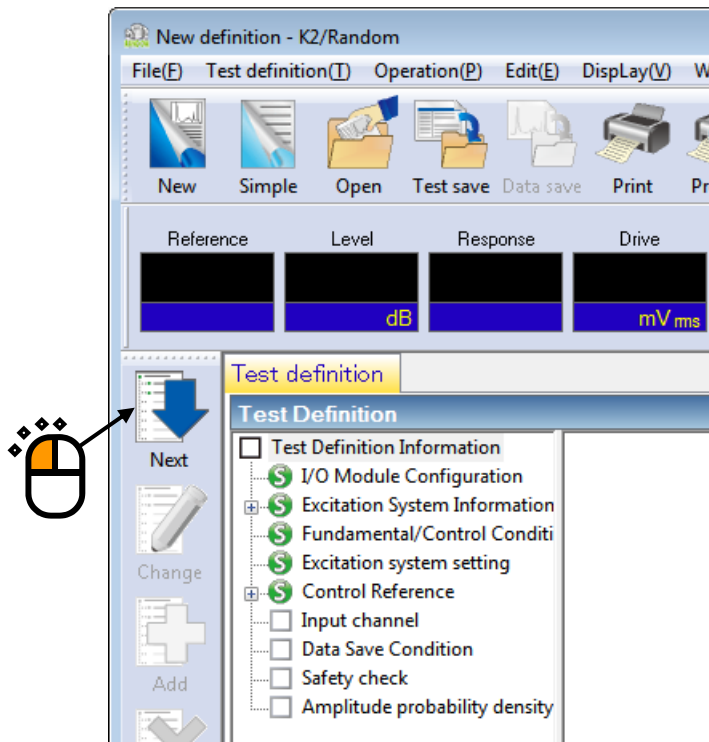
< Step 23 >

Press the button of [OK].



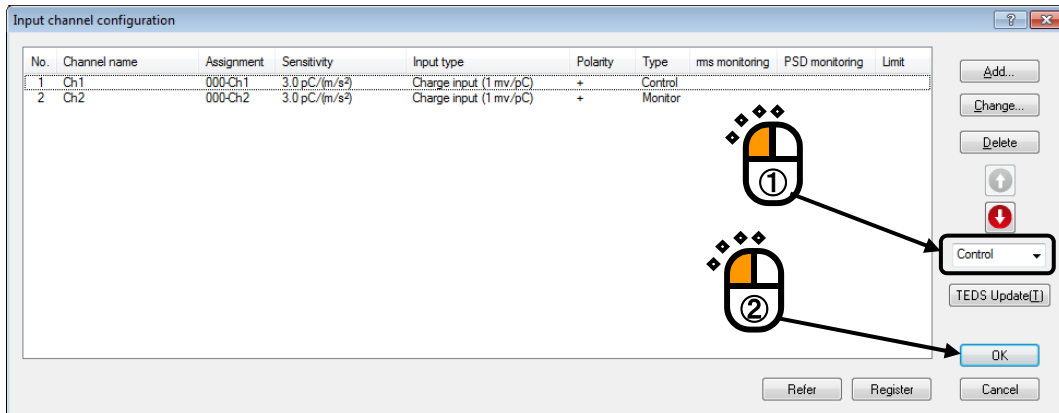
< Step 24 >

Press the button of [Next].



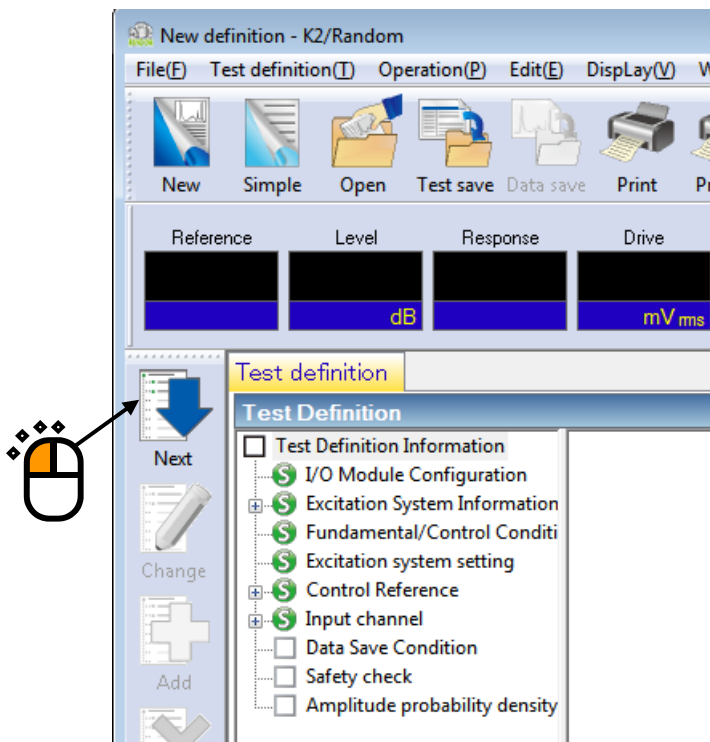
< Step 25 >

Select 'Ch.1' and set as 'Control'. Also, select 'Ch.2' and set as 'Monitor'. Then, press the button of [OK].



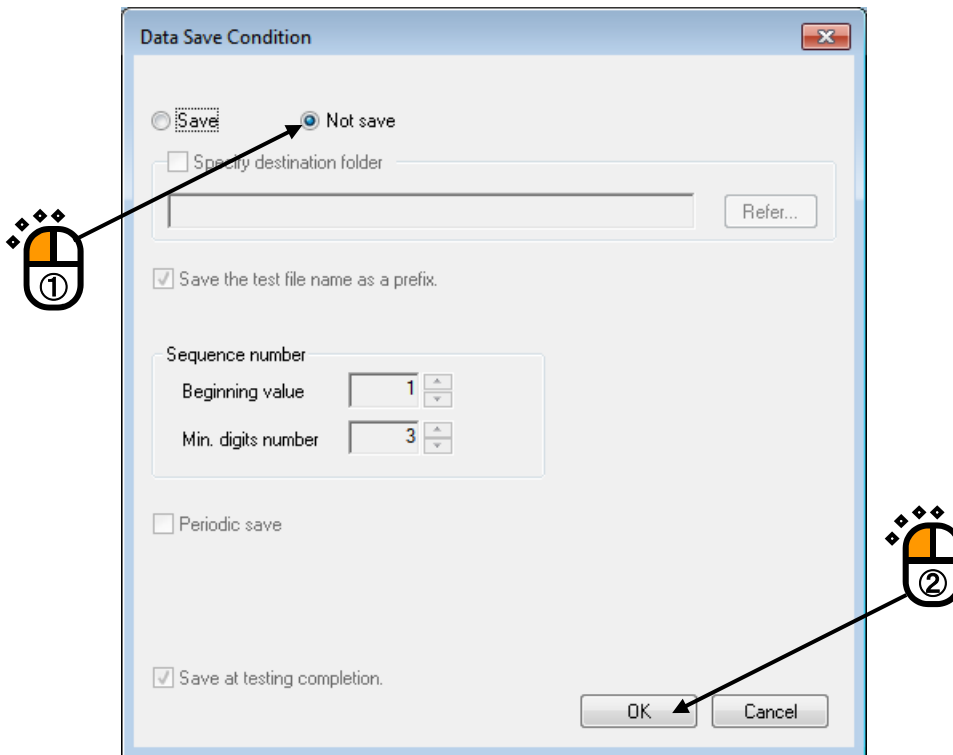
< Step 26 >

Press the button of [Next].



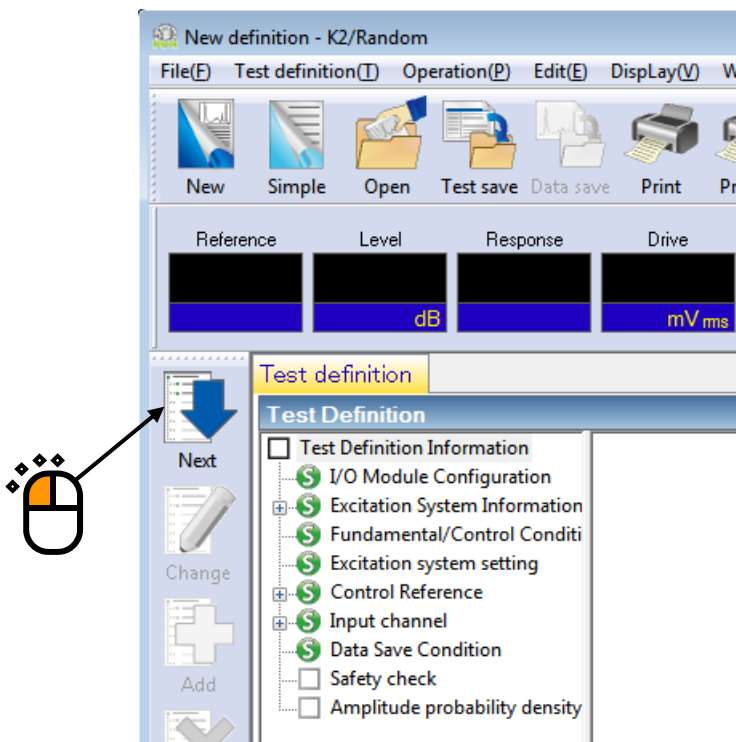
< Step 27 >

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



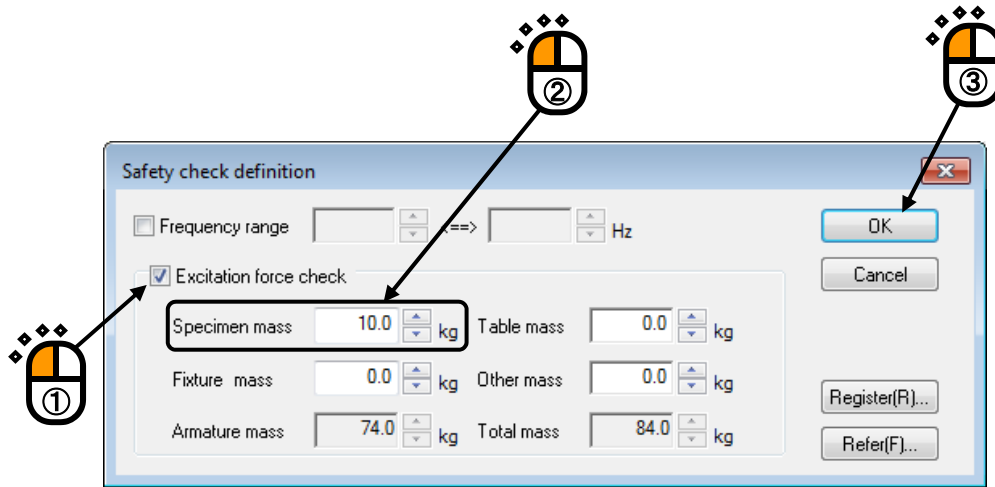
< Step 28 >

Press the button of [Next].



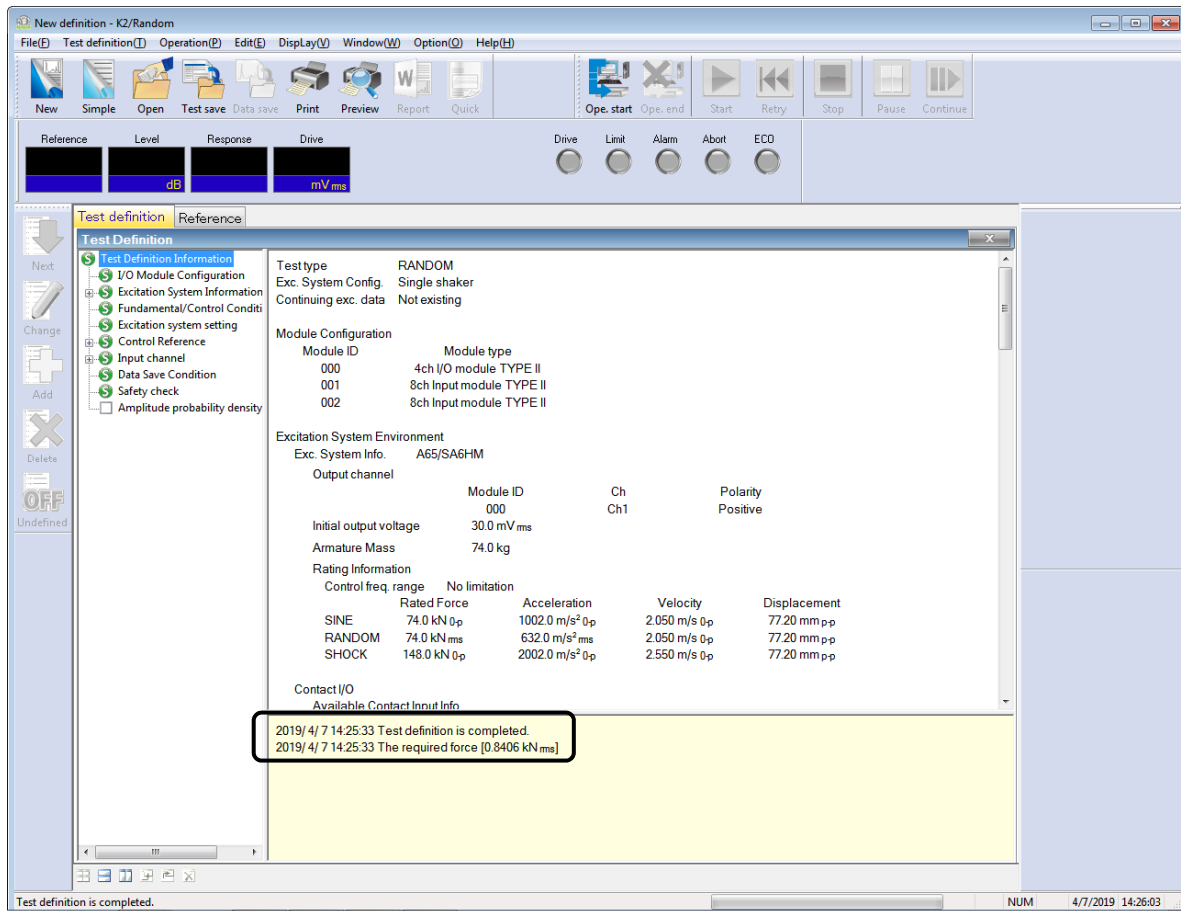
< Step 29 >

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



< Step 30 >

The definition is completed.

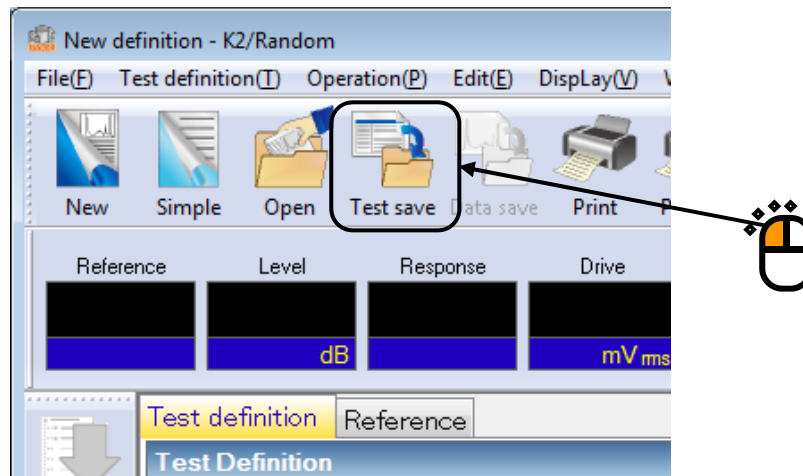


< Save of test >

< Step 1 >

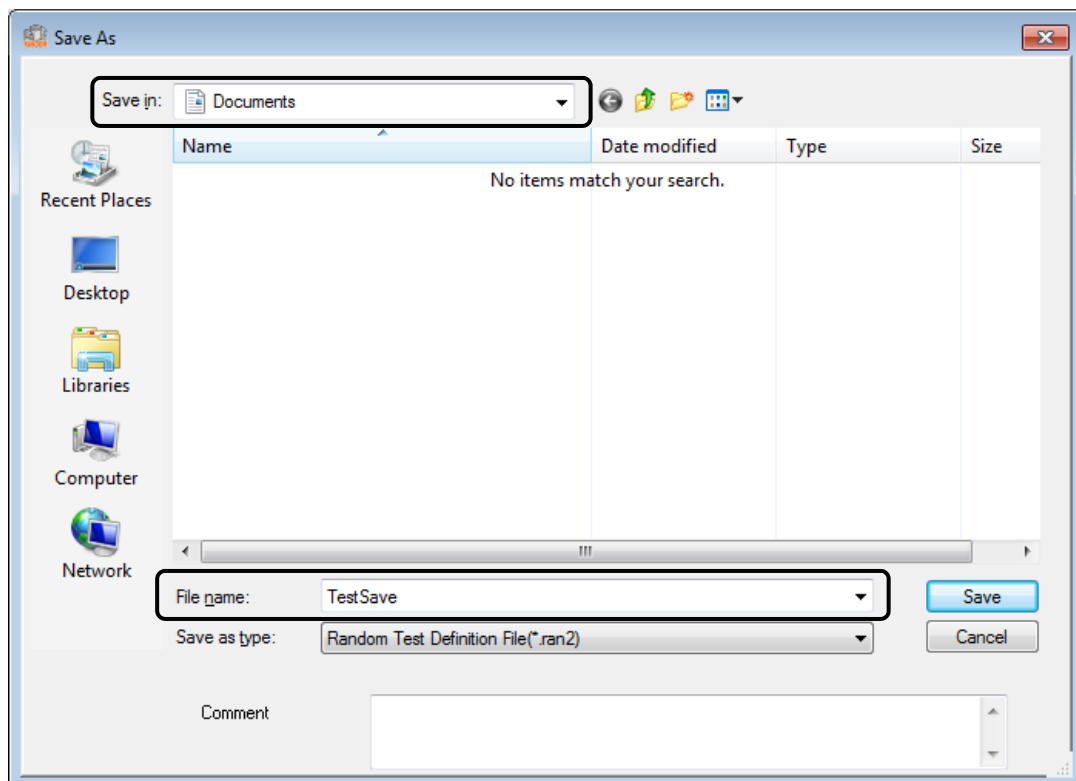
Save the defined test information to a test file.

Click the button of [Save].



< Step 2 >

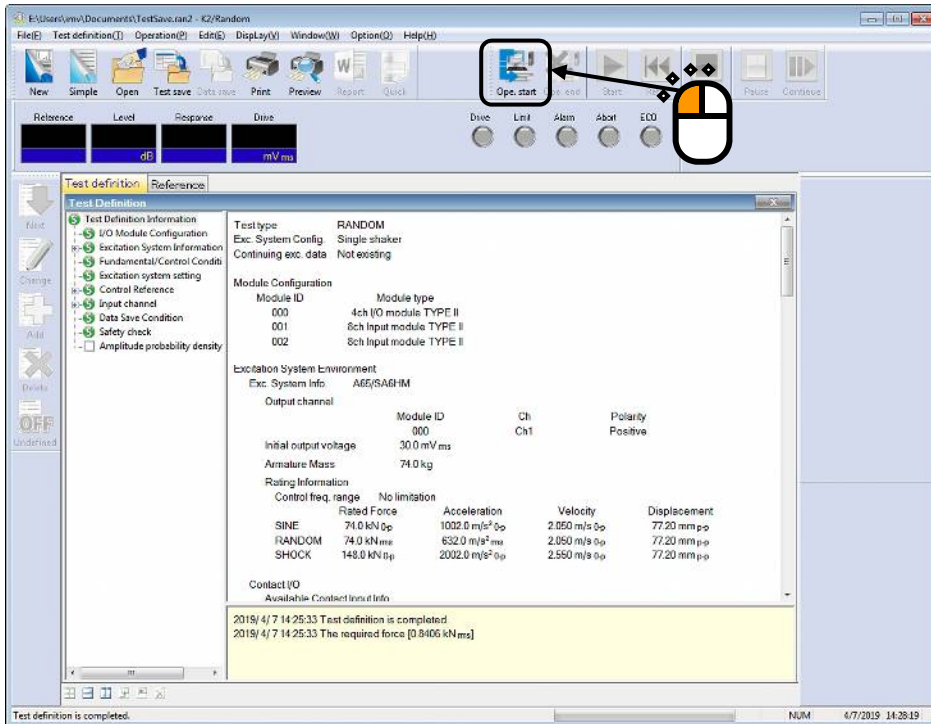
The dialog box as below appears. Specify an arbitrary directory in 'Save in' and input a name to 'File name'.



< Operation of test >

< Step 1 >

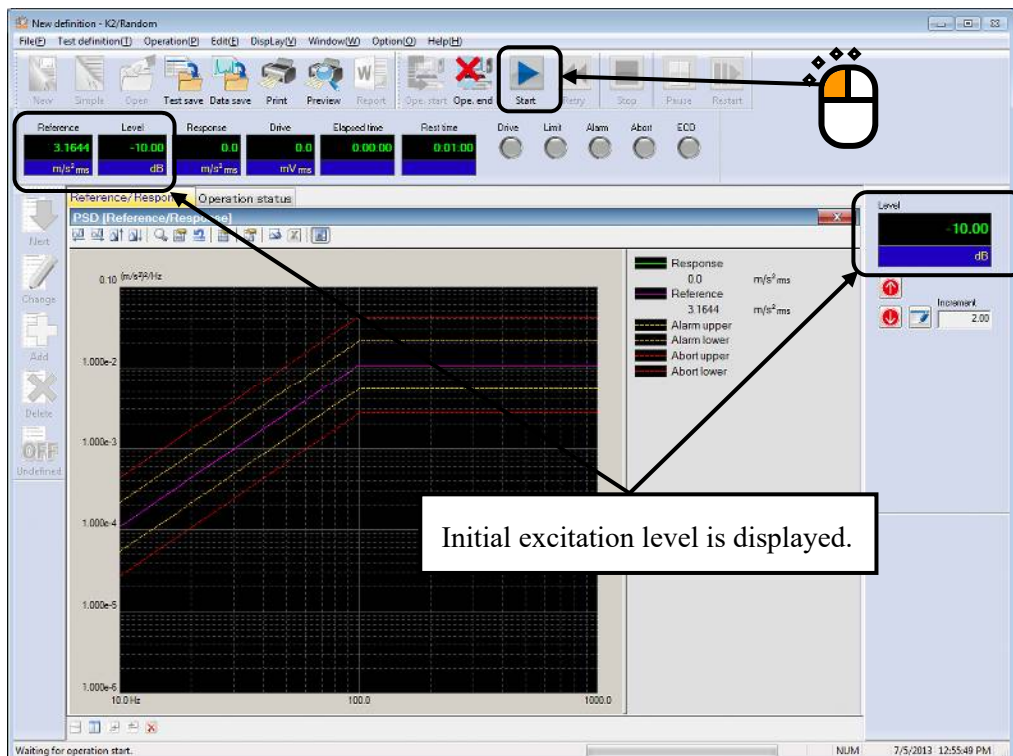
Press the button of [Operation start] for 'Operation start'.



< Step 2 >

Press the button of [Start] for 'Excitation start'.

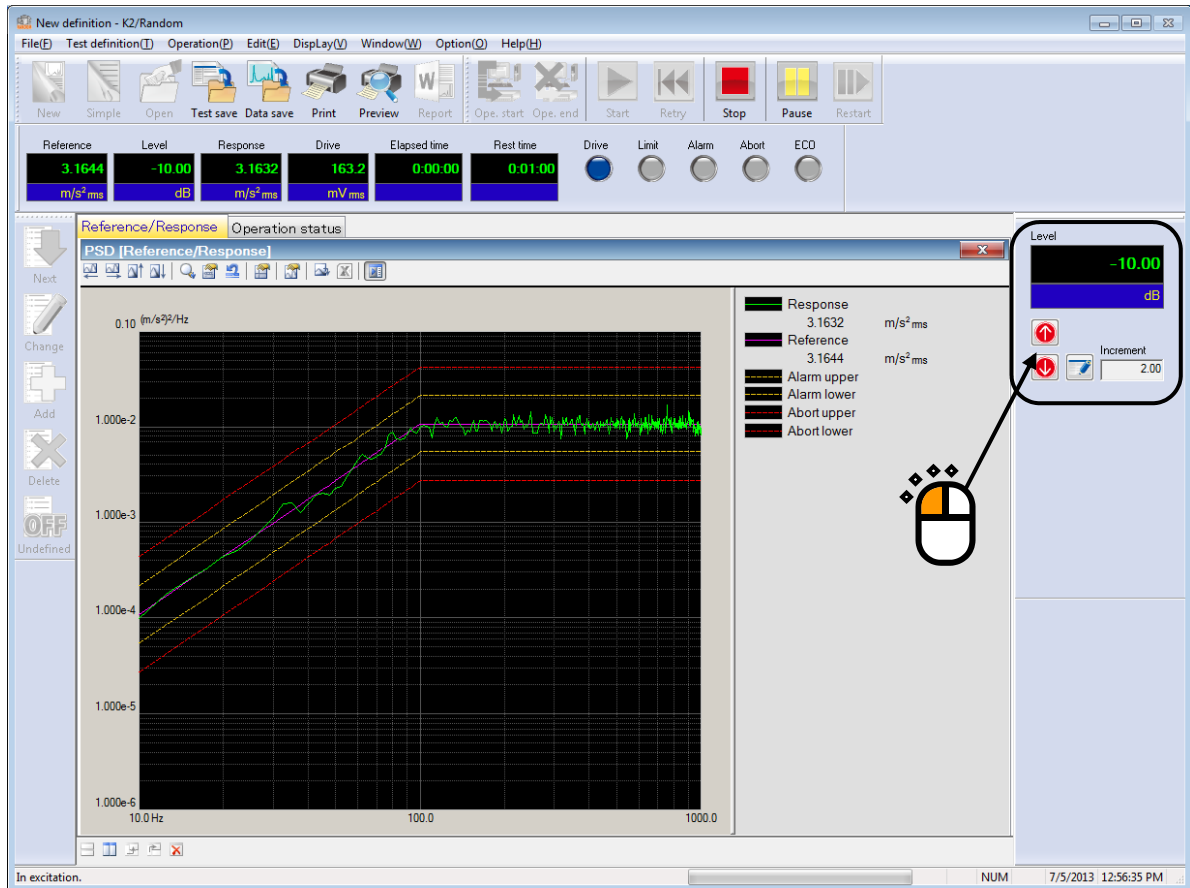
When [Exc. Start] is pressed, Initial Loop Check, and Initial Equalization are automatically operated. Then, the test operation is executed at the initial excitation level (-10 dB in this example).



< Step 3 >

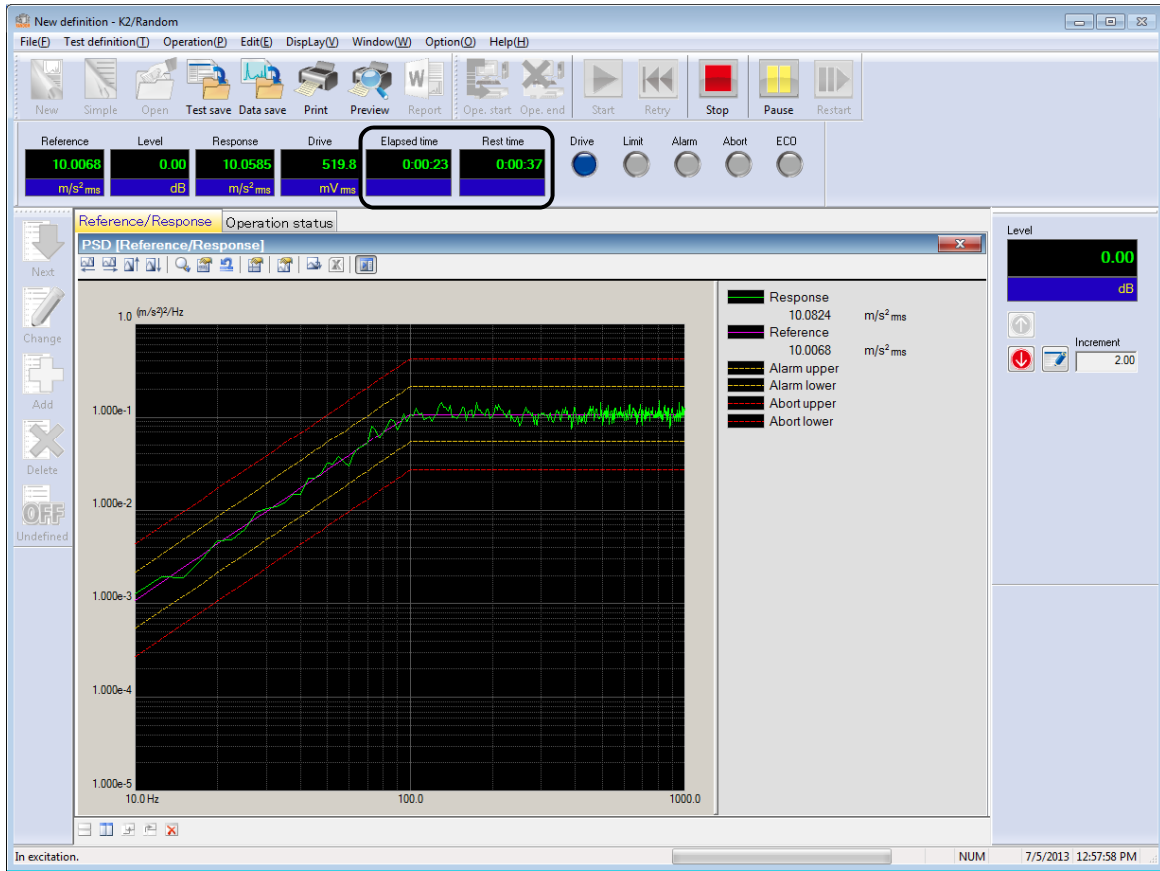
The excitation is operated at the initial excitation level (-10 dB in this example) when the initial equalization is finished.

Set the excitation level to 0 dB by pressing of [Level Up] button.



< Step 4 >

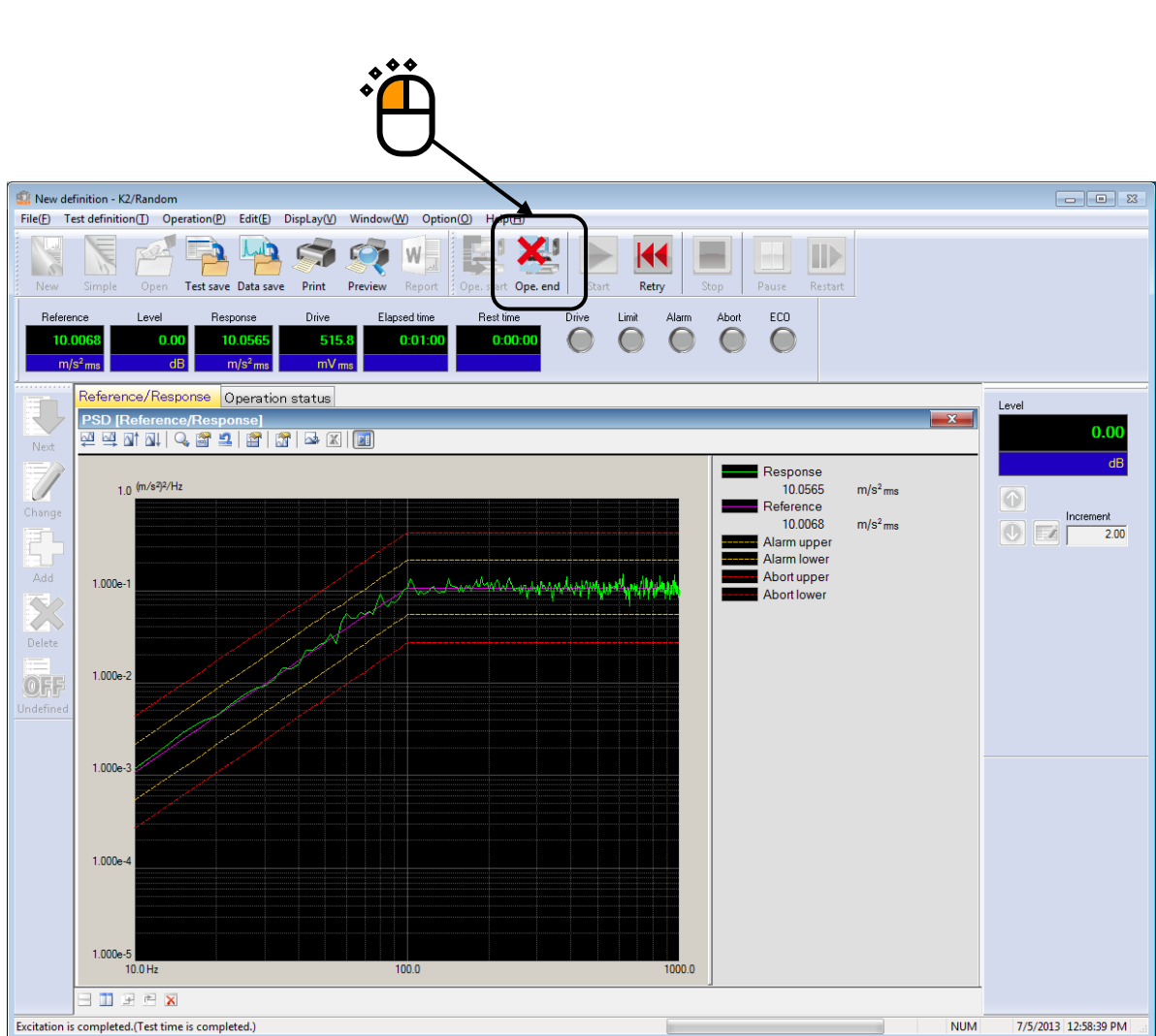
Test time is started to be counted when the excitation level is set to 0 dB.



< Step 5 >

The test operation is completed when the specified test time has passed.

The system returns to Test Definition mode by pressing the button of [Operation end].



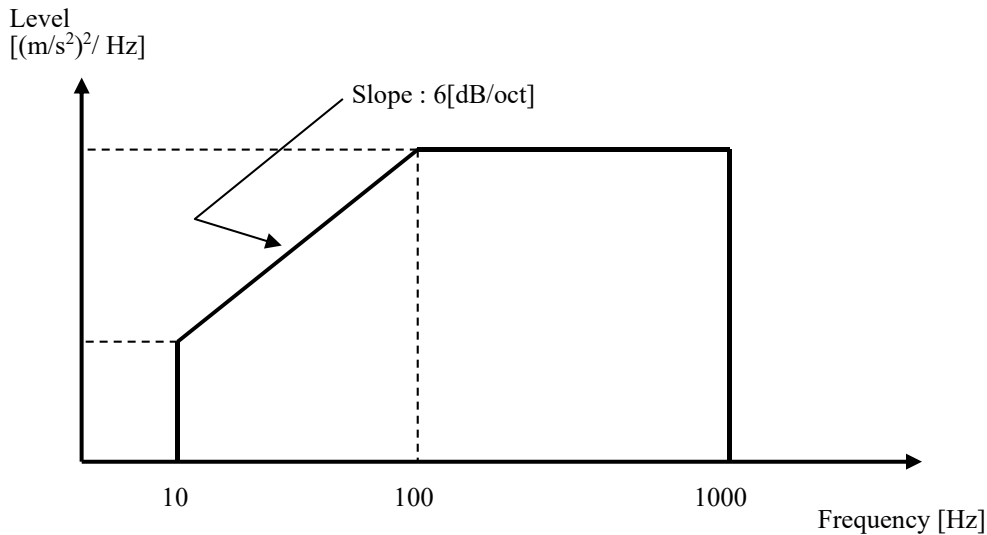
3.2 Simplified Definition

The random test can be operated in simple method by using Simplified Definition mode.

< Example >

An example of random test is described as below ;

[Reference pattern]



The PSD is specified to 10 $[(m/s^2)rms]$ having the shape as in the above between 10 [Hz] and 1000 [Hz].

[Test time]

1 minute

[Information of sensors to be used]

One accelerometer of piezo-electric

Input terminal of K2+ Hardware to be used : Ch.1 of Module ID 0

Channel name : Ch.1 (Sensitivity : 3 pC/(m/s²))

Also, the rating information of excitation system has already been registered in Excitation System Information (in this example, 'System1').

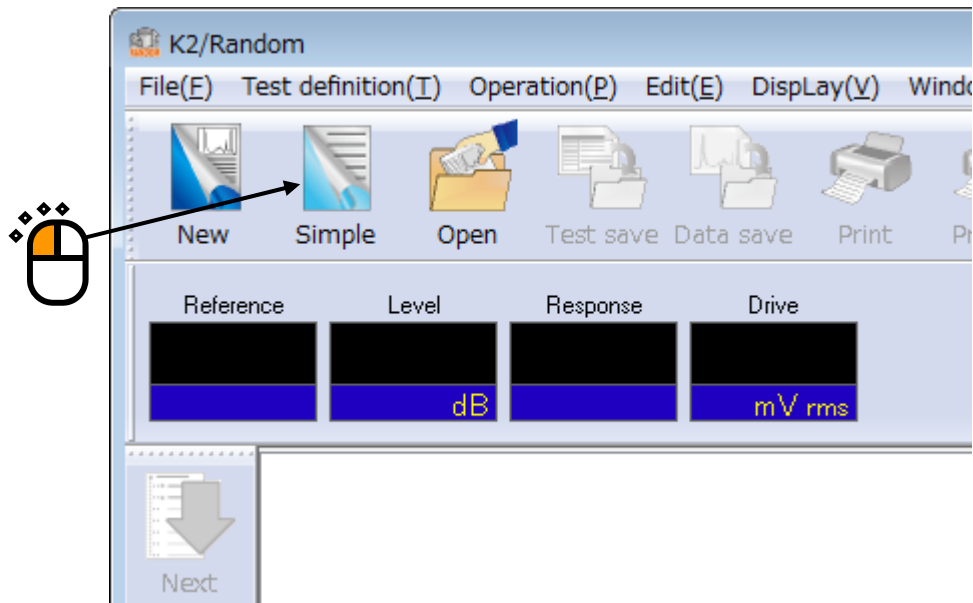
[Information of specimen]

Specimen mass : 10[kg]

< Procedures >

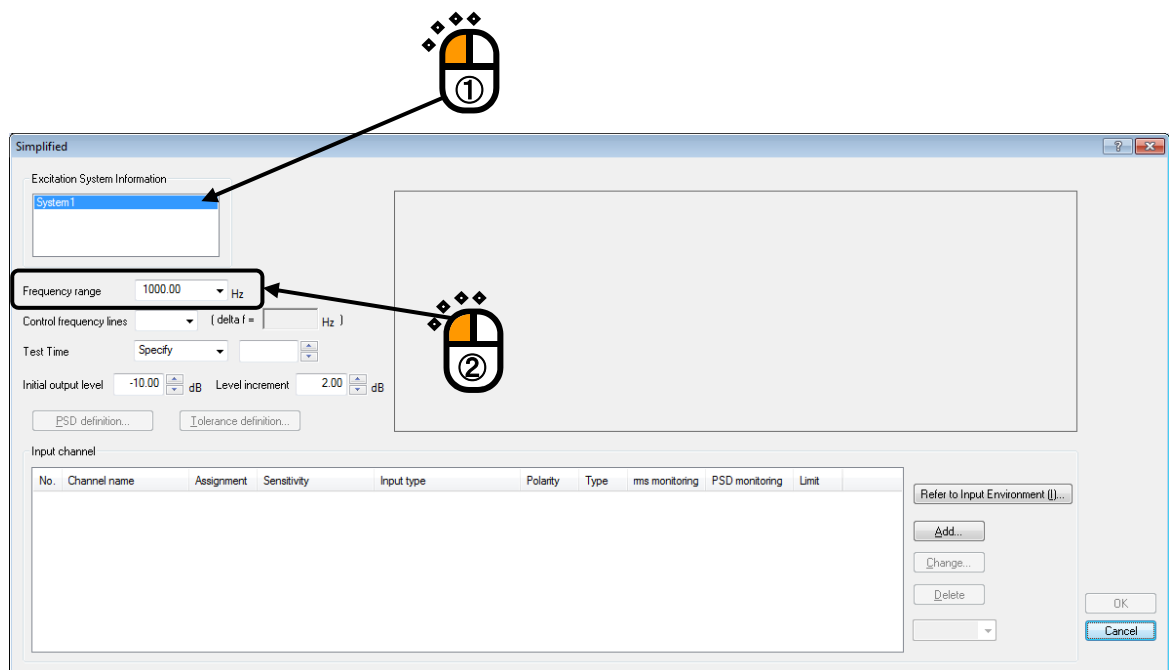
< Step 1 >

Press the button of [Simplified] to start the 'Simplified Definition'.



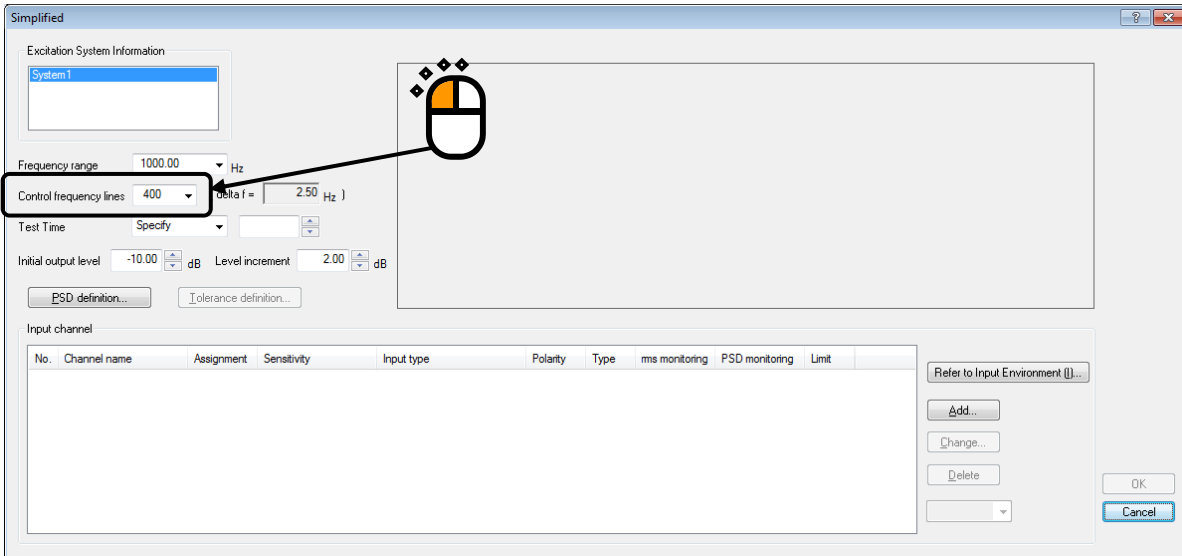
< Step 2 >

Select 'System1' among the items of Excitation System Information. And input the value to 'Frequency range' as 1000 [Hz].



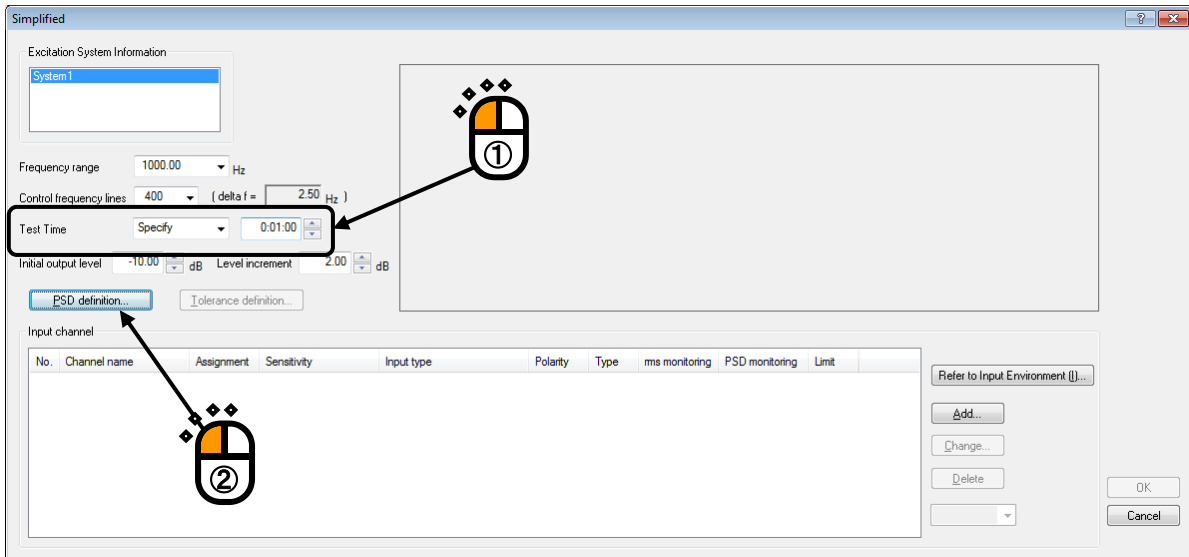
< Step 3 >

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



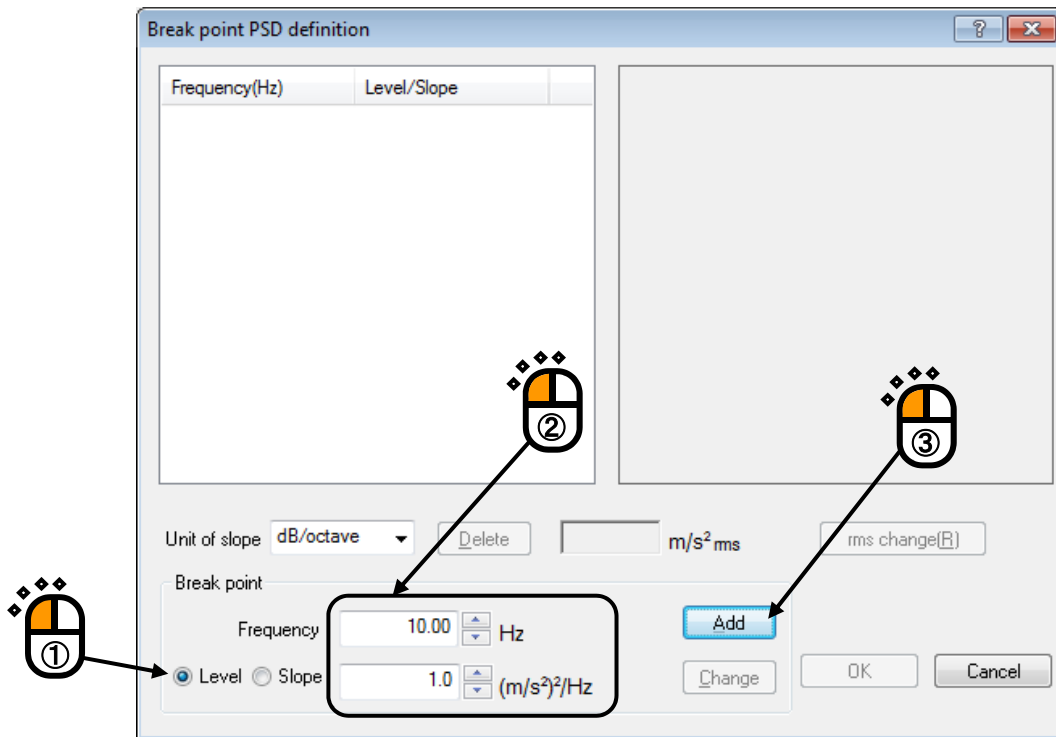
< Step 4 >

Input the value to 'Test time' as 1 [minute] (60 seconds) and press the button of [PSD definition].



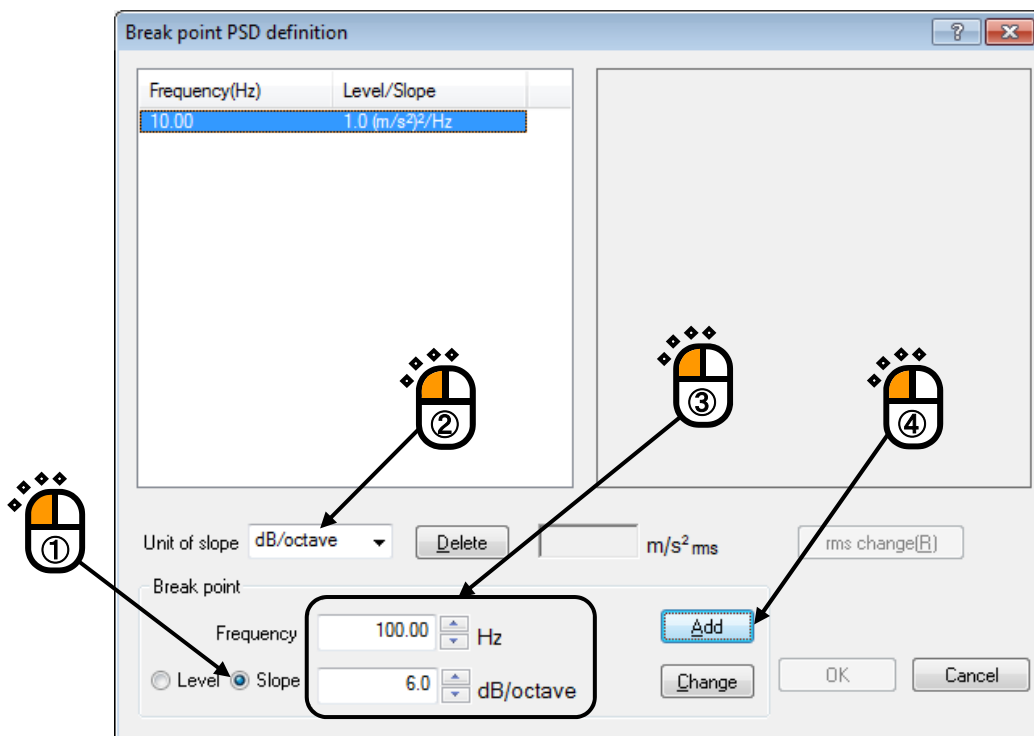
< Step 5 >

Select the item of Level and input the values as 'Frequency : 10 [Hz], Level : 1[(m/s²)²/Hz]'. Then, press the button of [Add].



< Step 6 >

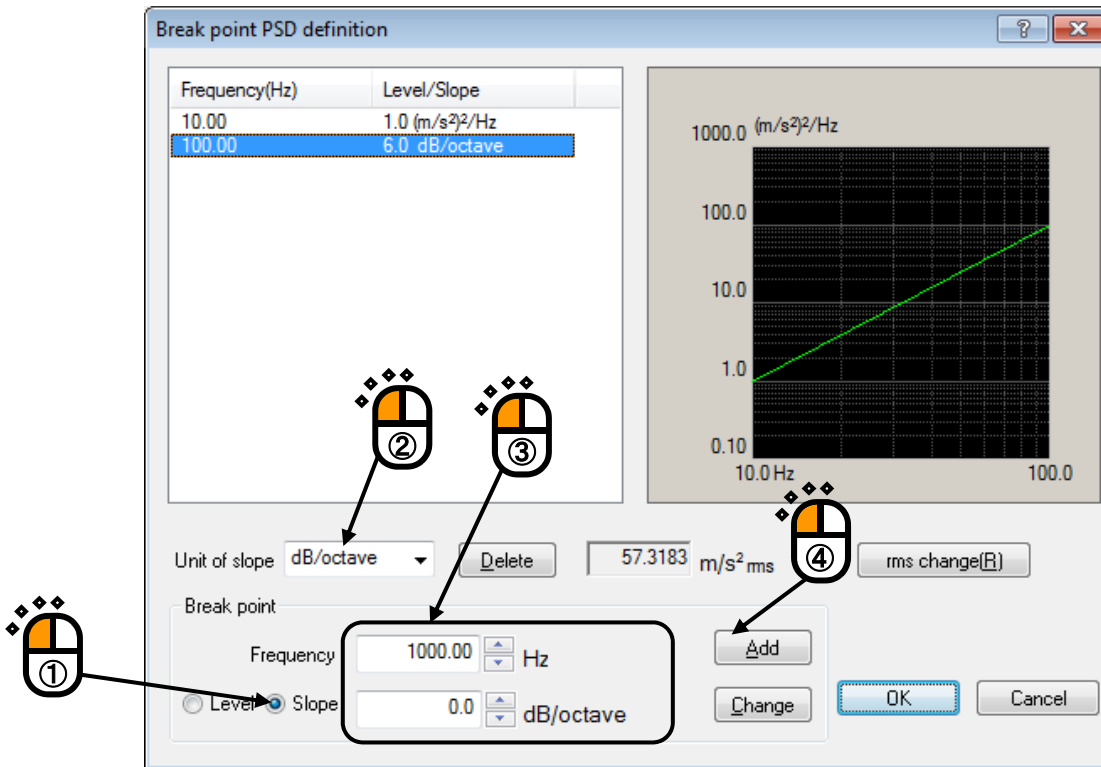
Select the item of Slope and specify Unit of Slope as 'dB/octave'. Input the values as 'Frequency : 100 [Hz], Slope : 6 [dB/octave]'. Then, press the button of [Add].



< Step 7 >

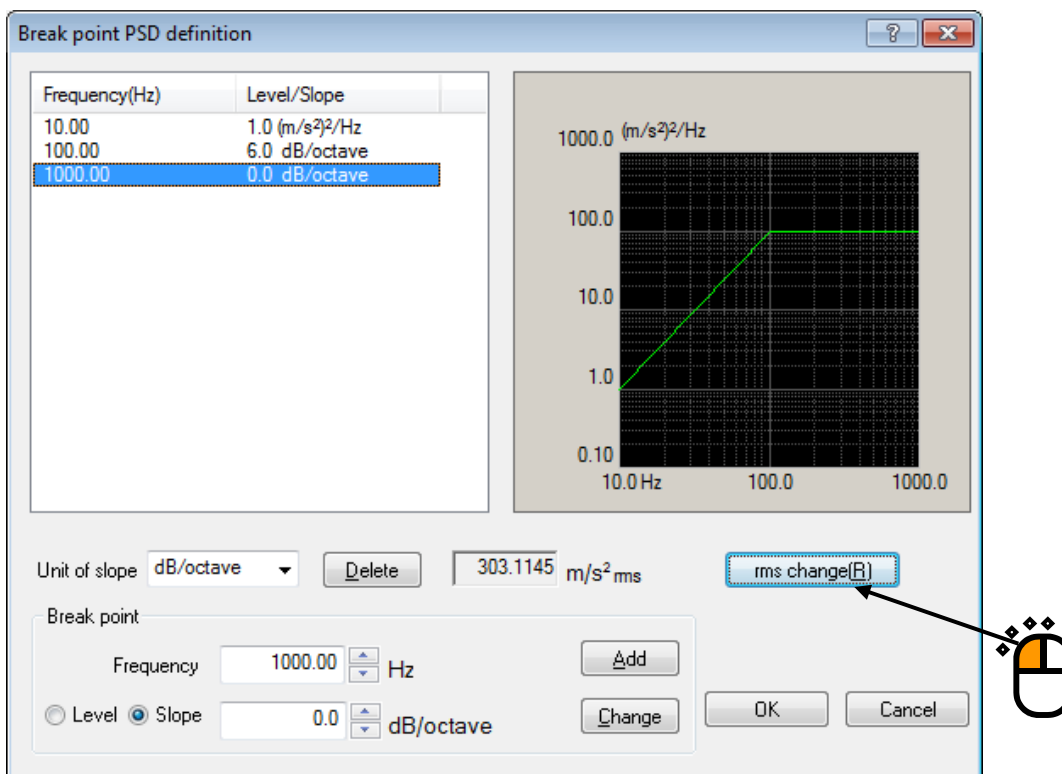
As in the same way, select the item of Slope and specify the Unit of Slope as 'dB/octave'.

Input the values as 'Frequency : 1000 [Hz], Slope : 0 [dB/octave],'. Then, press the button of [Add].



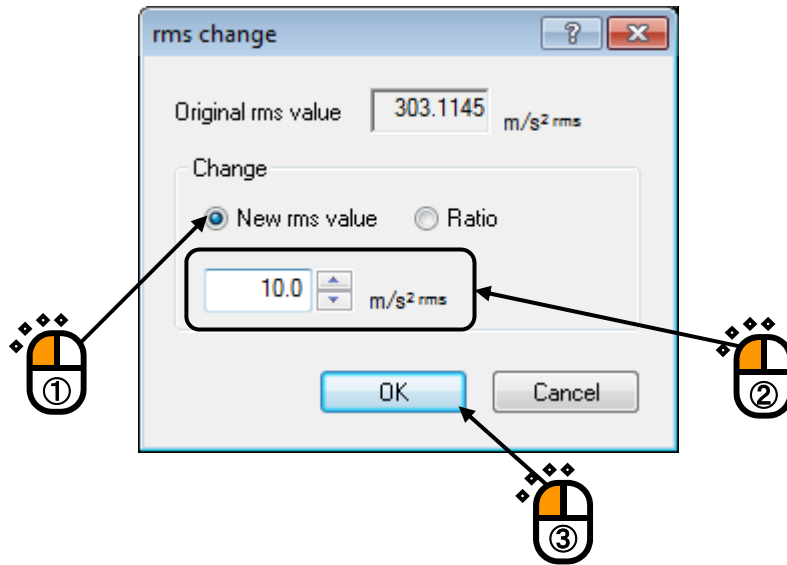
< Step 8 >

Press the button of [rms change].



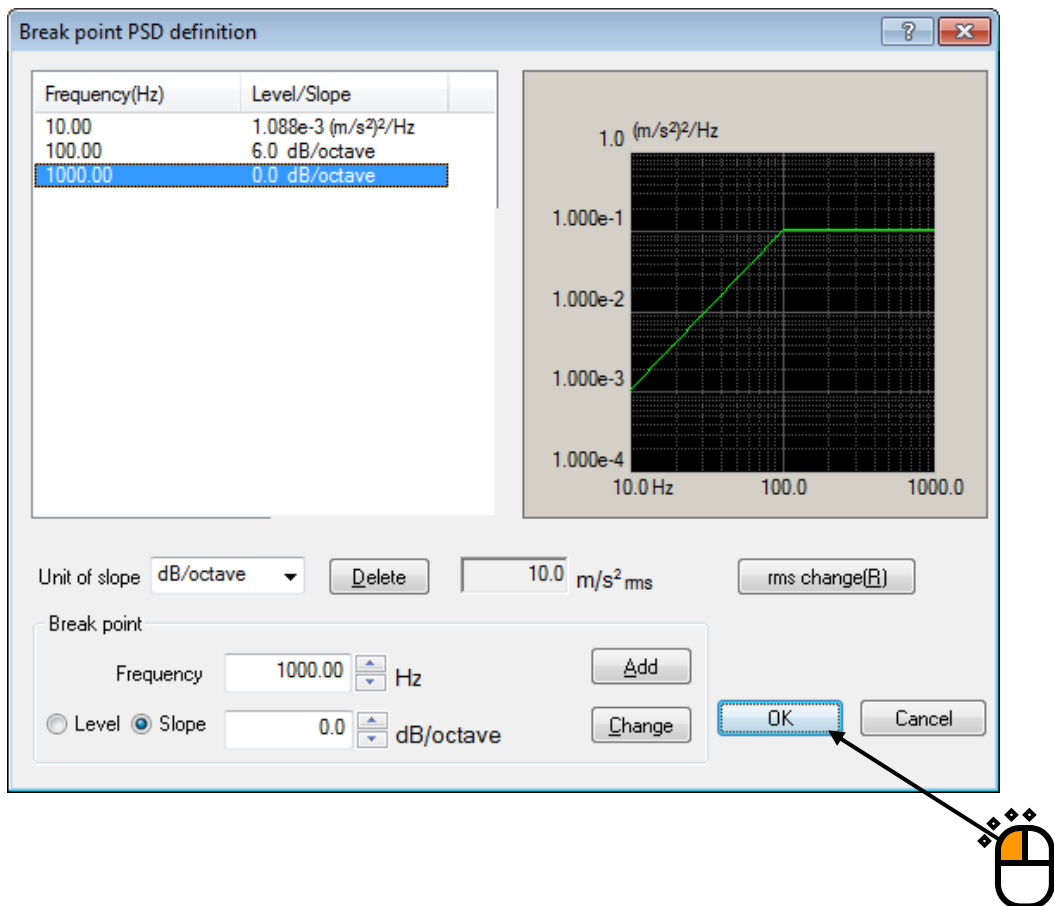
< Step 9 >

Select the item of New rms value and input the value as 'New rms value : 10 [(m/s²) rms].
And press the button of [OK].



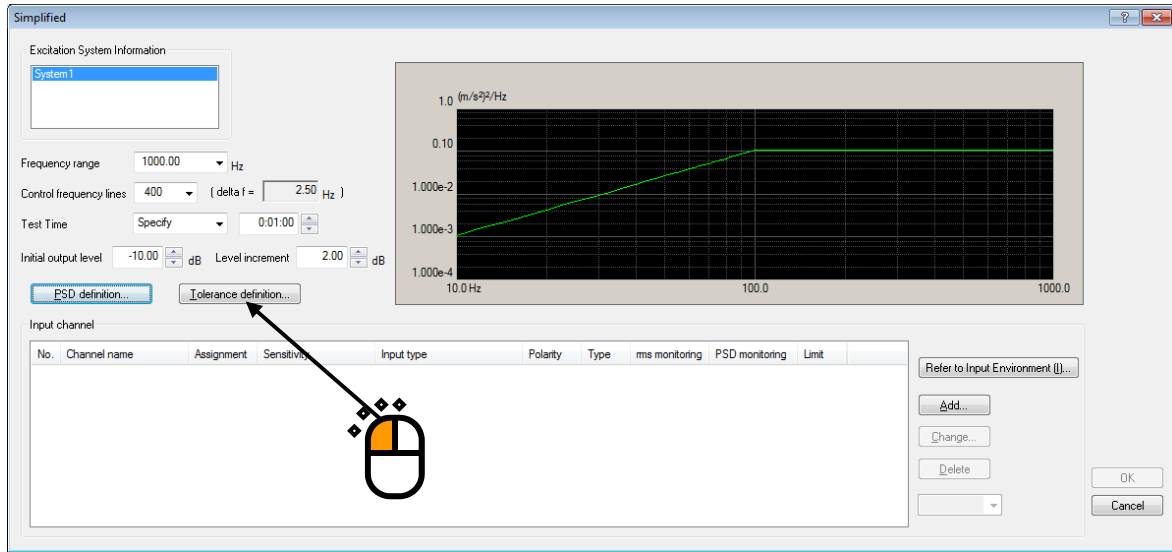
< Step 10 >

Press the button of [OK].



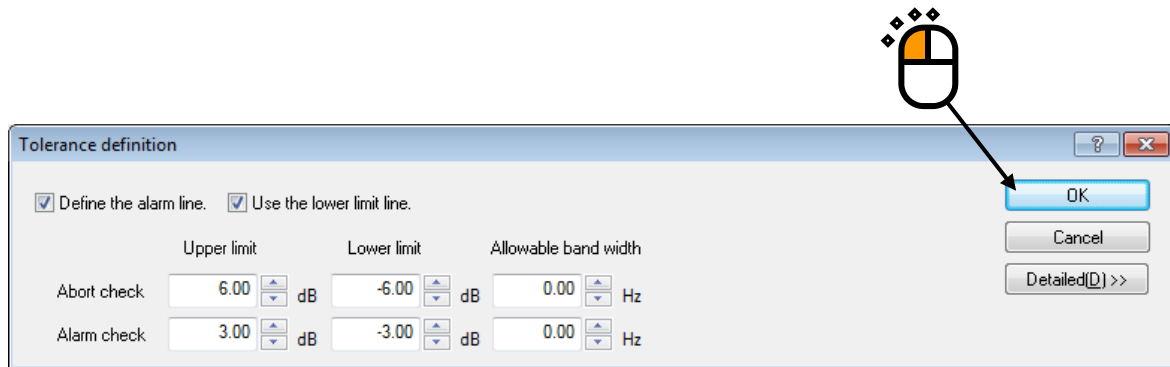
< Step 11 >

Press the button of [Tolerance definition].



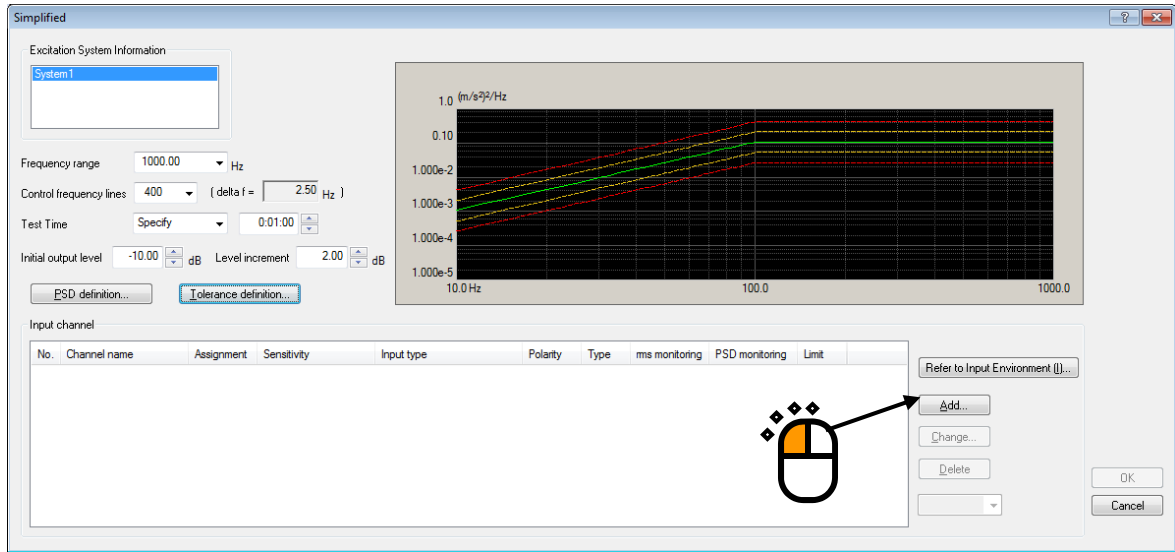
< Step 12 >

Press the button of [OK].



< Step 13 >

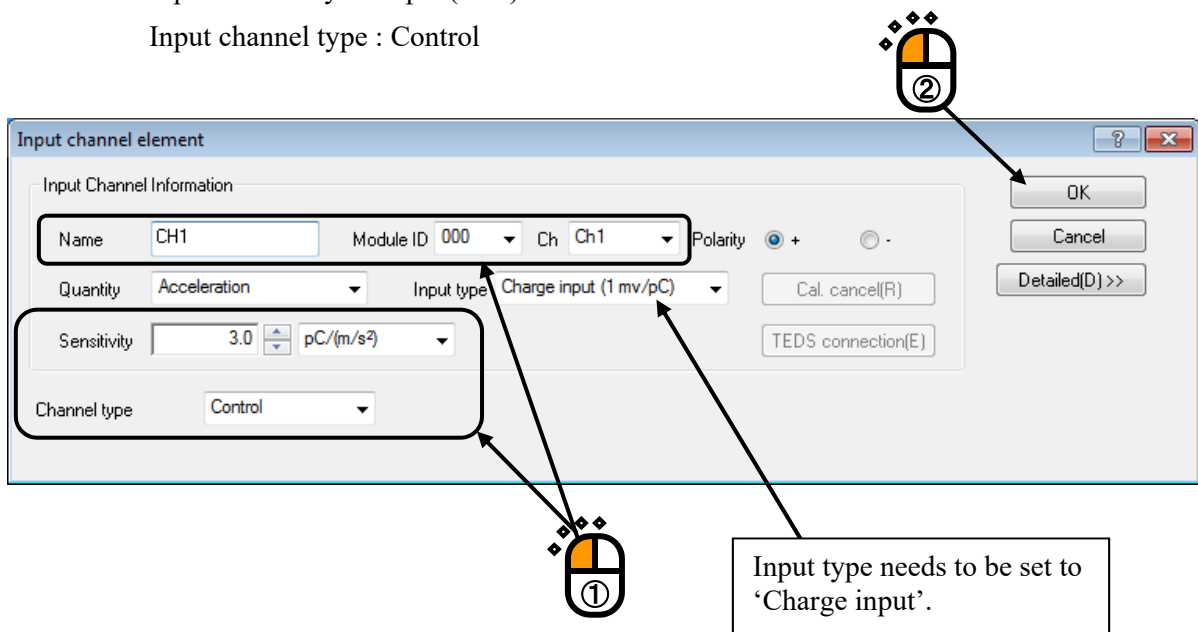
Press the button of [Add] of Input channel.



< Step 14 >

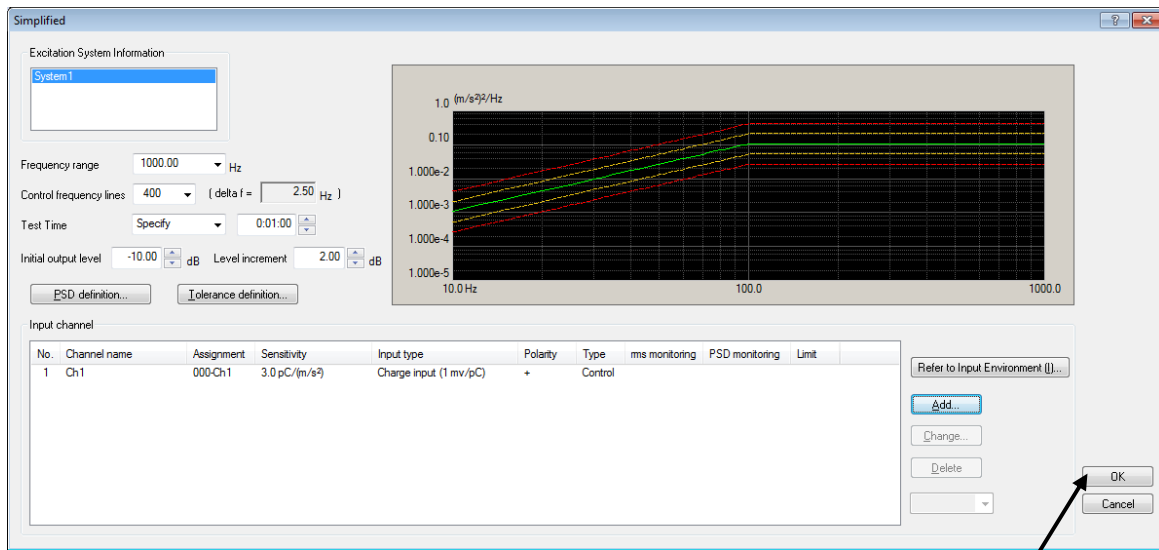
Set the items as below and press the button of [OK].

- Channel name : Ch.1
- Module ID : 000
- Ch : Ch.1
- Input sensitivity : 3.0 pC/(m/s²)
- Input channel type : Control



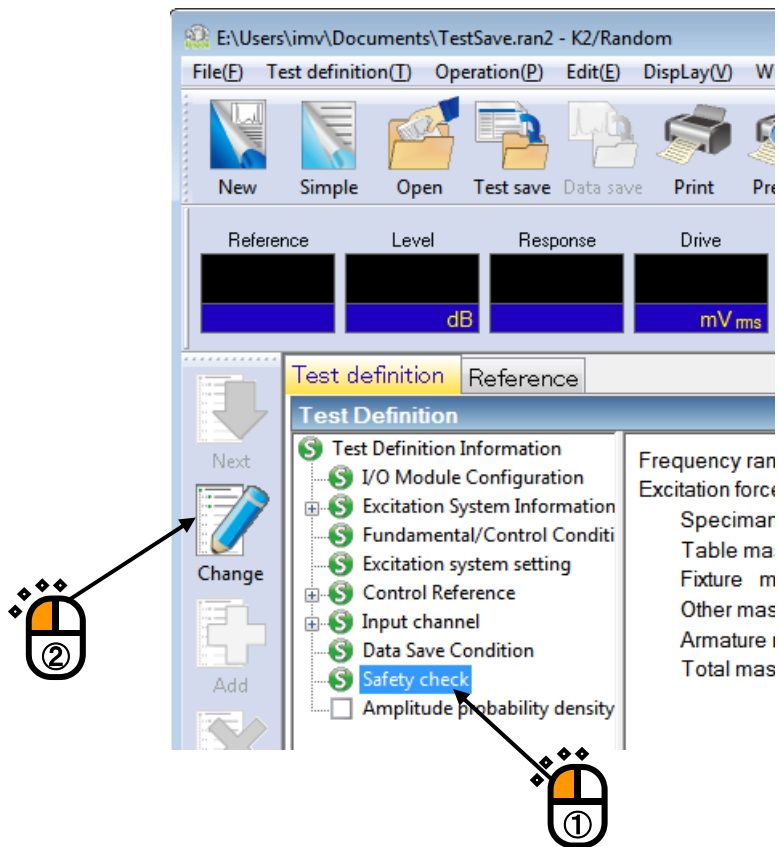
< Step 15 >

Press the button of [OK].



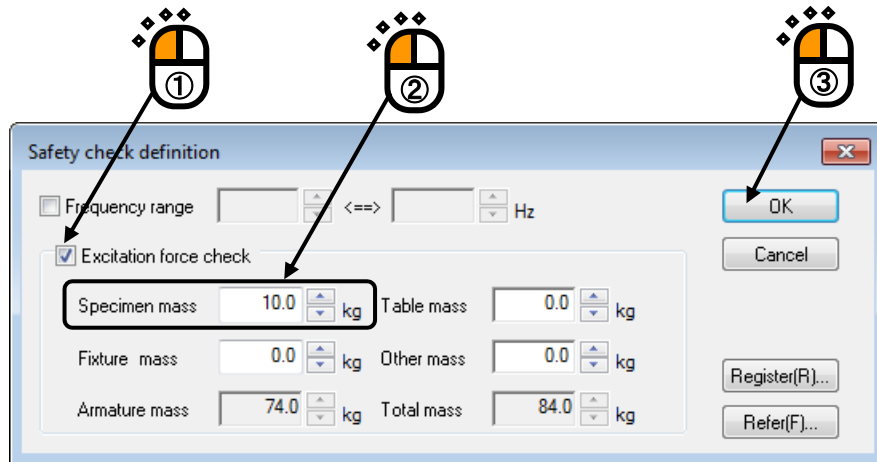
< Step 16 >

Select 'Safety check' and press the button of [Change].



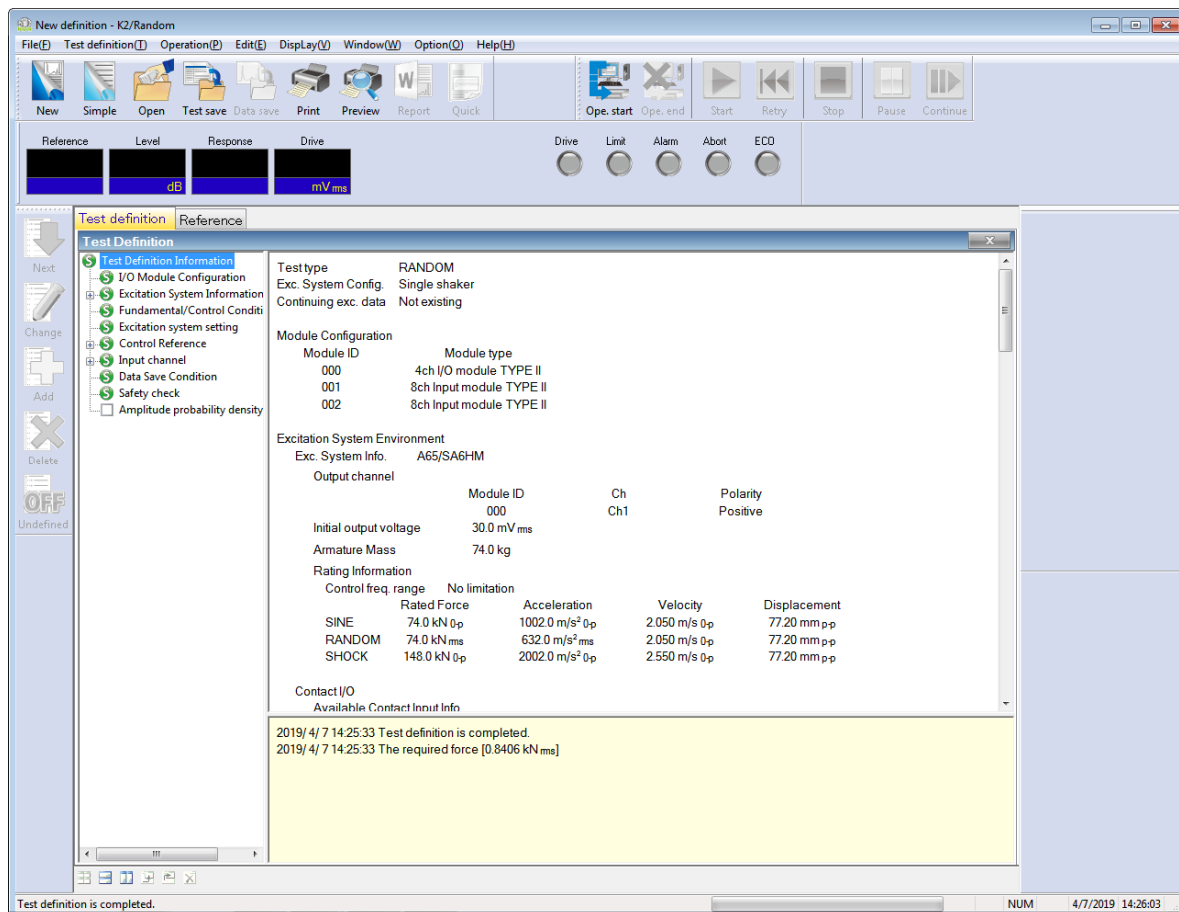
< Step 17 >

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



< Step 18 >

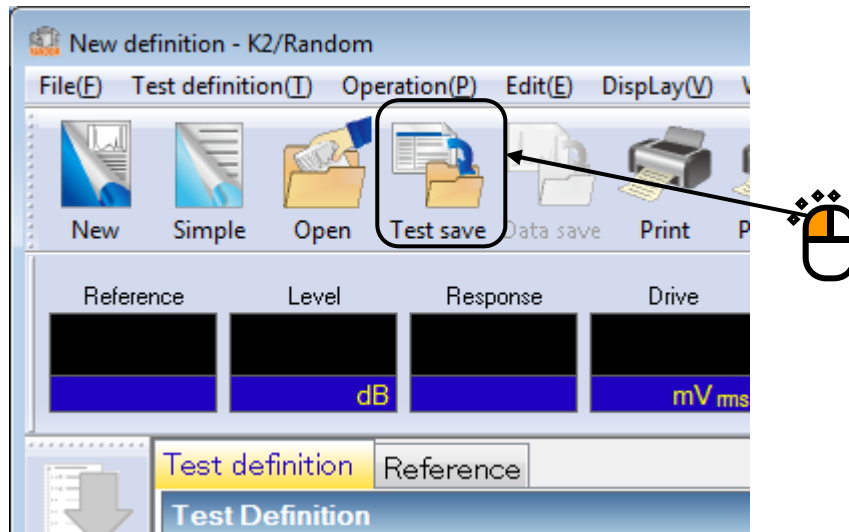
The definition is completed.



< Save of test >

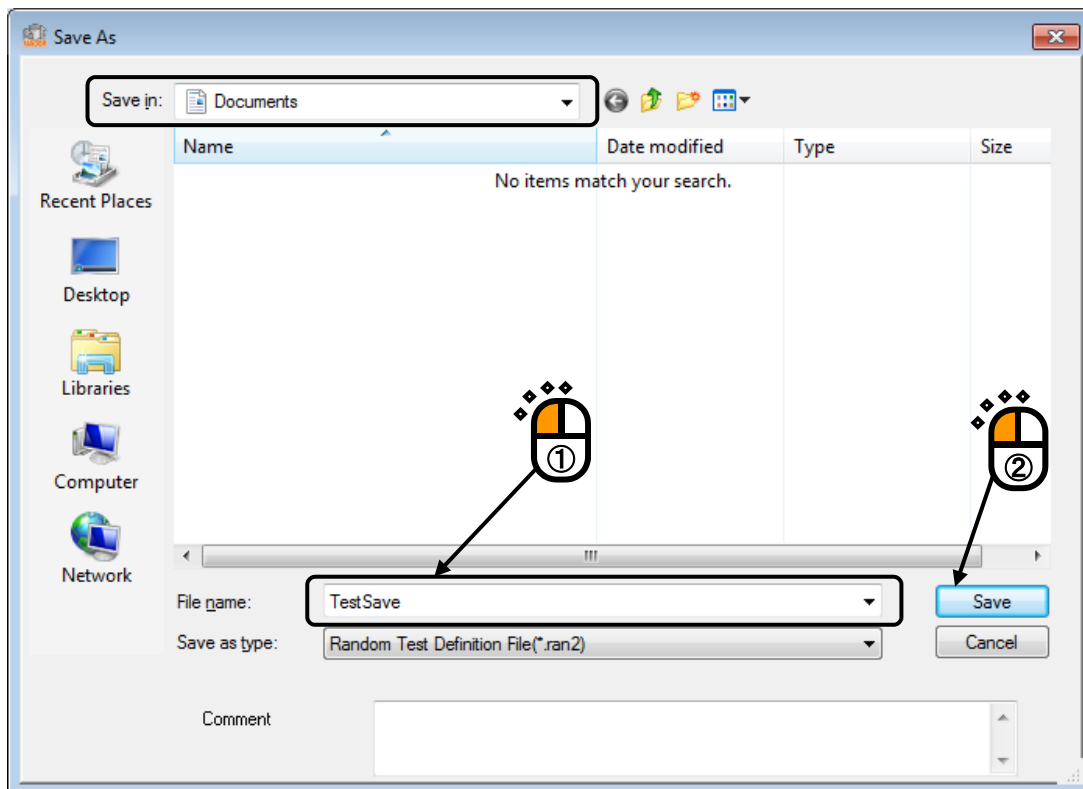
< Step 1 >

Press the button of [Save].



< Step 2 >

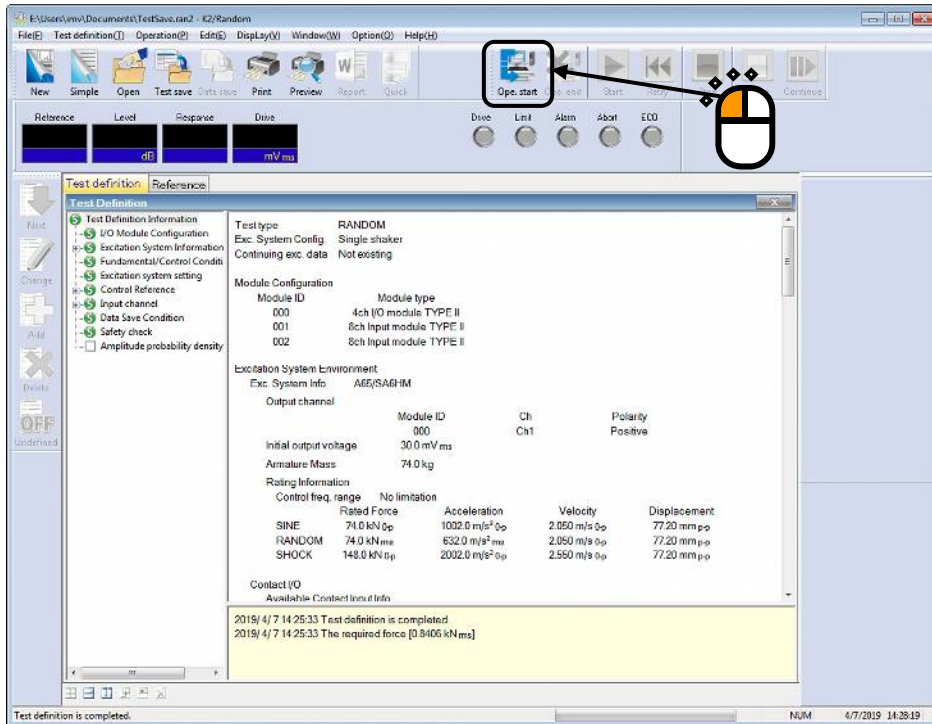
Input the file name and press the button of [Save].



< Operation of test >

< Step 1 >

Press the button of [Operation start].

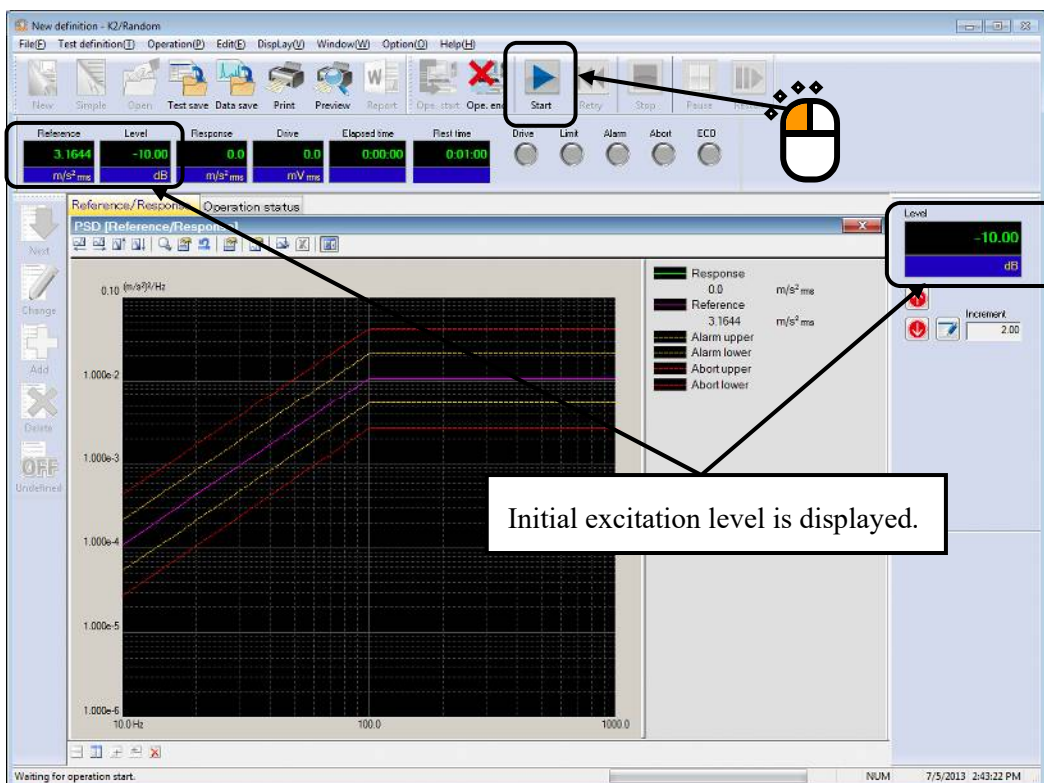


< Step 2 >

Press the button of [Start] (Excitation start).

When [Start] is pressed, Initial loop check and Initial equalization is automatically operated.

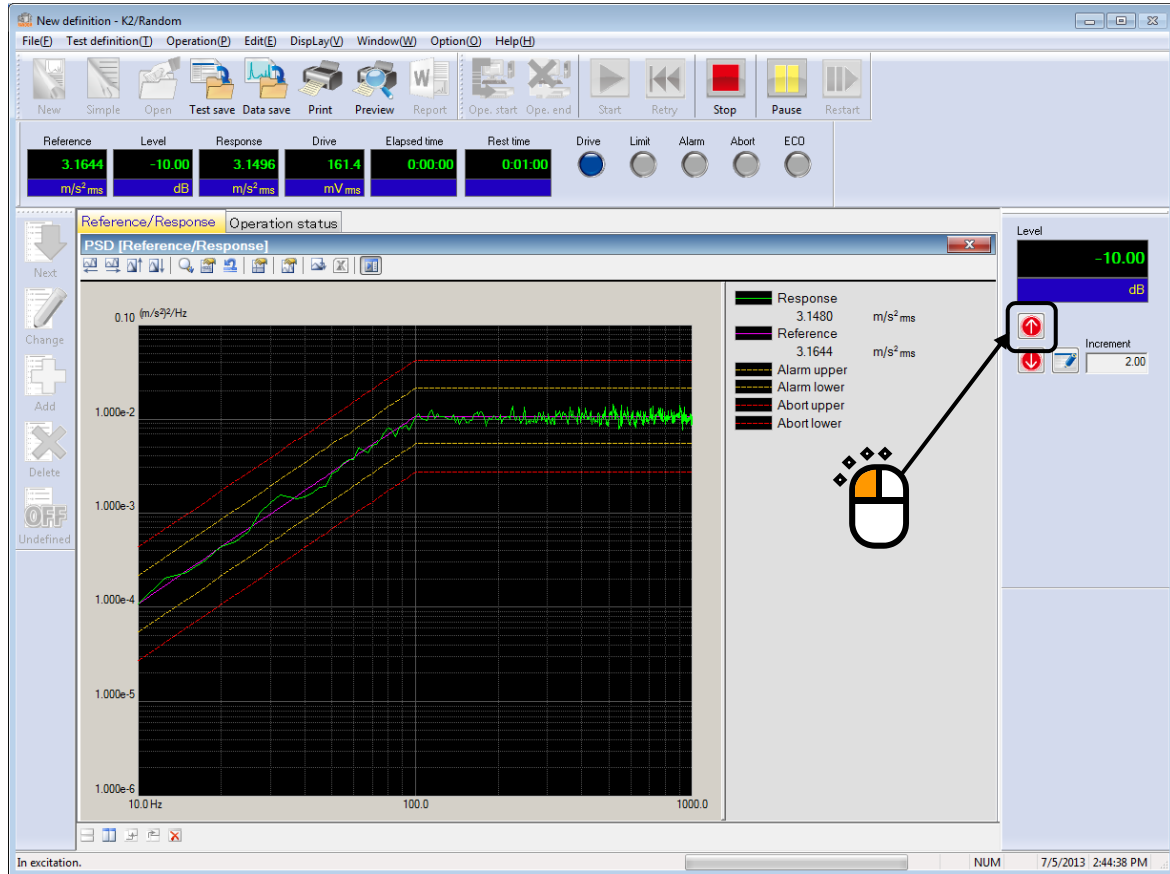
Then, test operation is started at the Initial excitation level (-10dB in this example).



< Step 3 >

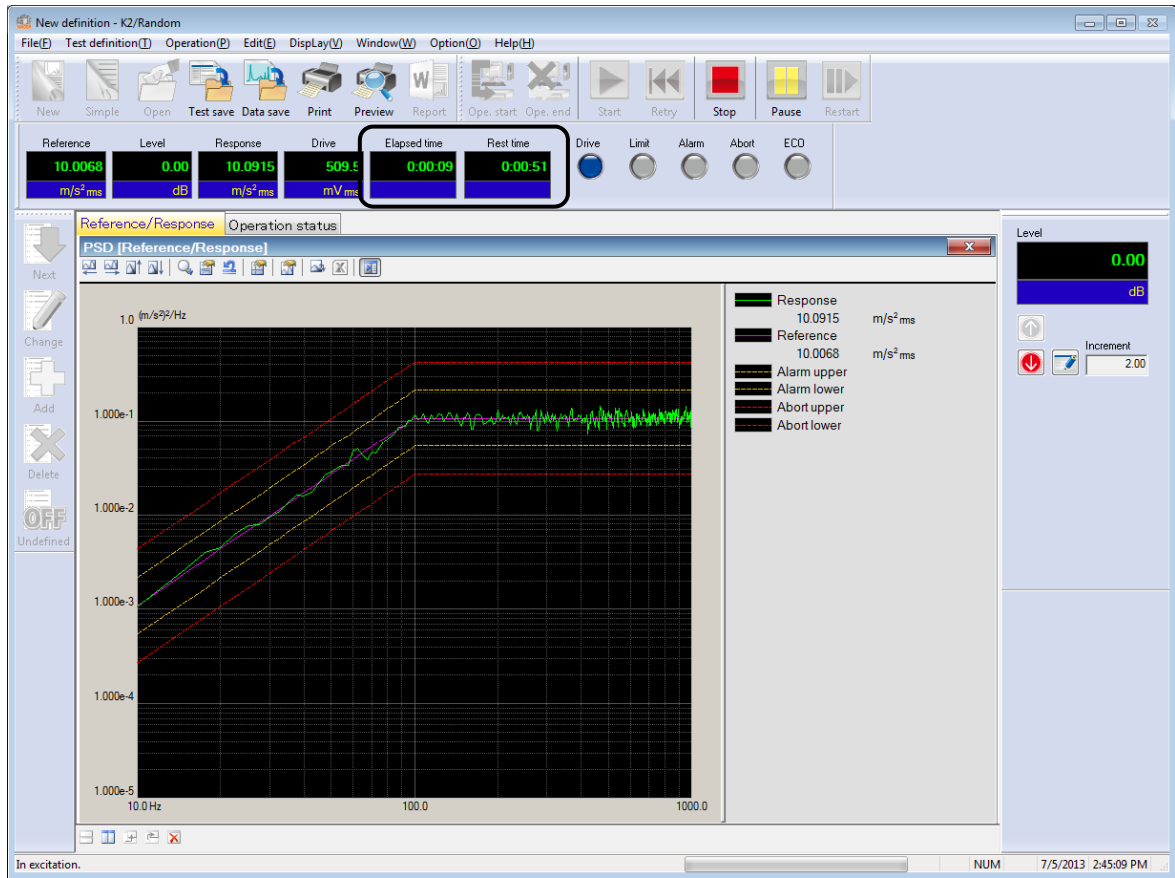
The excitation is started to operate at the Initial excitation level (-10dB in this example) when the Initial equalization operation is finished.

Set the excitation level to 0dB by pressing the button of [Level up].



< Step 4 >

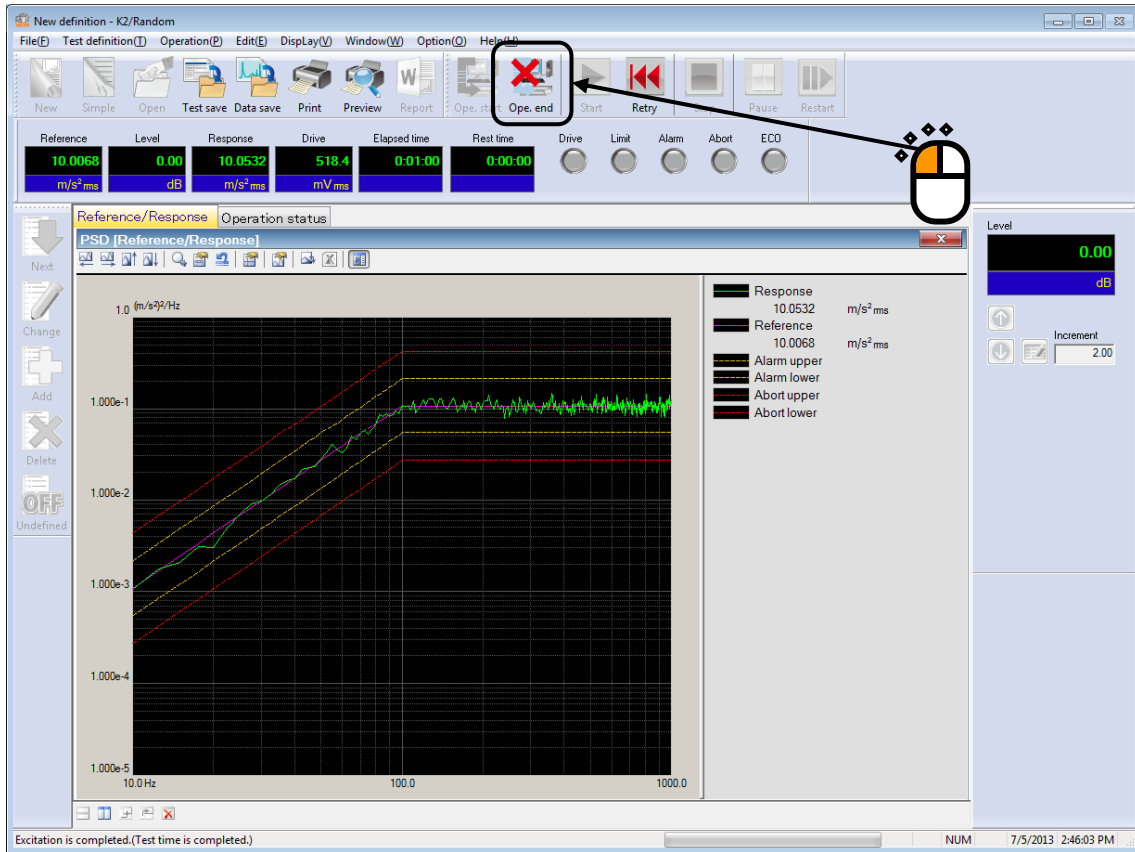
Test time is started to count when the excitation level is set to 0dB.



< Step 5 >

The test operation is completed when the specified test time has passed.

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



Chapter 4 Test Definition

4.1 Outline

In this system, a complete set of information needed for test operation is called 'Test'.

To perform a test, Test must be defined first of all.

This chapter describes the procedure to define the Test.

A Test is defined by the setting of the information in Table 4-1 in order for each Test types.

Table 4-1 Test Types and Definition Information

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

○ : Information that must be defined

△ : Information that is defined if necessary

Information of 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 Test defined beforehand is saved as a Test file.

4.2 Fundamental/Control Condition

Control condition of K2+ controller is defined.

The screenshot shows a dialog box titled "Fundamental/Control Condition" with the following settings:

- Frequency range: 2000.00 Hz
- Control frequency lines: 400
- Max. observation freq.: 2000.00 Hz
- Delta f: 5.00 Hz
- Frame time: 200.0 ms
- Controlled variable: Acceleration (m/s²)
- Averaging parameters: M=4, E=8, 120 DOF
- Equalization mode: Normal
- Loop check: Normal
- Test time: Specify, 0:10:00
- Level scheduling: Undefined
- Initial output level: -11.00 dB
- Level increment: 2.00 dB
- Auto-start:
- Shutdown time: 500.0 ms
- Observation freq. can be set within the Reference freq. range only:

4.2.1 Frequency range fmax

(1) Meaning

This item is for specifying the Frequency range for the spectrum analysis.

An appropriate value should be set in order to cover the frequency elements included in the reference PSD to be reproduced.

When the defined value of this item is too large with comparing other specified items such as the number of input channels, the real time operation may not be available due to the limitations of the ability of the CPU.

Correspondence between Sampling Frequency f_s and Frequency range f_{max} is described as below ;

$$f_s = 2.56 f_{max}$$

4.2.2 Control frequency lines

(1) Meaning

This item is for specifying the resolution of spectrum analysis.

The resolution of spectrum analysis is specified by the number of lines L

In this system, the relation between the number of the lines L and the number of points for spectrum analysis N is described as below ;

$$L = N / 2.56$$

A waveform data for N points corresponding to the control frame length is transformed to the spectral data of complex number for $N/2$ lines in the Frequency range by spectrum analysis. Concerning to the characteristics of anti-aliasing, the valid data for the control operation is specified from the lower frequency side within the spectral data of complex number for $N/2$

lines.

Frequency resolution Δf is described as below ;

$$\Delta f = f_{\max} / L (= f_s / N)$$

< Selection Guide for number of Lines >

The number of lines is to be selected based on the transfer characteristics of the controlled system.

For a successful control, almost all the impulse response of the controlled system must be within the set control frame.

If the result of waveform control is unsuccessful, select a larger line number stepwise.

It is better to do it this way rather than that set an excessively large number.

4.2.3 Max. Observation Frequency (Max. Observation Freq.)

(1) Meaning

This item is for specifying of maximum value of the frequency observed at input channels.

The default setting value of this item is the setting value of Frequency range.

4.2.4 Controlled variable

(1) Meaning

Unit of quantity (controlled variable) used as a control objective for K2+ controller is specified. Control unit defined in this item is treated as a unit in test definition.

A unit specified in 'Other units' is added as a Control unit only when the rating information of 'Other units' is specified in Excitation system information.

4.2.5 Averaging Parameters

(1) Meaning

The Degree-Of-Freedom of measurement, that is, the accuracy of spectrum estimation (averaging operation) is specified in this item.

Averaging operation is necessary to execute an accurate spectrum estimation in the analysis of random signal because the spectrum data obtained in FFT analysis for one time has too large dispersion.

Spectrum analysis of random signal has the characteristics as below;

- ① Spectrum analysis data of random signal can not be obtained as a certain value, but it is obtained as an estimated value having characteristics of probability.
- ② The reliability of the estimated value is expressed as the degree-of-freedom. The larger value of the degree-of-freedom is specified, the more reliable estimation value is obtained.

The degree-of freedom is specified by the parameters as below ;

- ① Averaged time for a loop M

The frame number for operating the response analysis for 1 round of control loop is specified.

- ② Averaging weight parameter of loop E

This parameter is for operating the averaging weight for the response spectrum data obtained at each control loop.

When the value of M and E in the above is determined, the degree-of-freedom K of the response analysis is specified ;

$$K = 2M(2E - 1)$$

For composing the stable control system, it is better to set a larger value of K . Therefore, the values of M and E should be determined in order to specify the value of K according to the following aim ;

$$K > 100$$

However, the control speed (dwelling rate) becomes slower when too large value is set to K .

4.2.6 Equalization Mode

(1) Meaning

This item is for setting of the control speed t the initial equalization during the time from the control operation start (a white-noise-like output start), and through the coincidence of the response spectrum with the reference spectrum (within the Tolerance), to the beginning point of the elapsed time counting start.

1. Fast

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

It is proper to set 'Fast' in this item for the specimen with a stable and a high rigid body.

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 specimen having a non-linear response (for example, the response shows the different characteristics when the excitation level is changed), the setting of 'Slow' may be suitable.

4. Specify (or use the 'Detailed definition' button)

Each parameter of Equalization mode is properly defined according to the setting of 'Fast', 'Normal' and 'Slow'. However, this item 'Specify' is provided for the testing with the specimen which us too difficult to control by the setting of the standard items.

to make a fine adjustment for each control parameter when the testing operation having the difficult specimen to control is operated.

As stated at the top of this clause, the effect of this item appears clearly in the stage of Initial Equalization. However, the set value of this item as the control parameter is also valid during the testing operation after the Test time counting start.

4.2.7 Loop check

(1) Meaning

This item is for specifying of the strictness of the criteria for monitoring abnormal event in the control loop during control operation using loop check function.

Loop check is done in the following two types of operation ;

1. Measurement of Transfer Function
2. Actual for testing

For the Loop Check in measurement of transfer function, each excitation group is given a white-noise output signal of the level defined as Initial output voltage of each excitation group

to the control loop before the measurement. If the control loop is normal, it is followed by the transfer function measurement with abnormal check.

In this item, an abnormal detection criterion for loop check is selected from the followings ;

1. Severe

The severest criterion is set.

It can be used for a specimen with a good linearity.

2. Normal

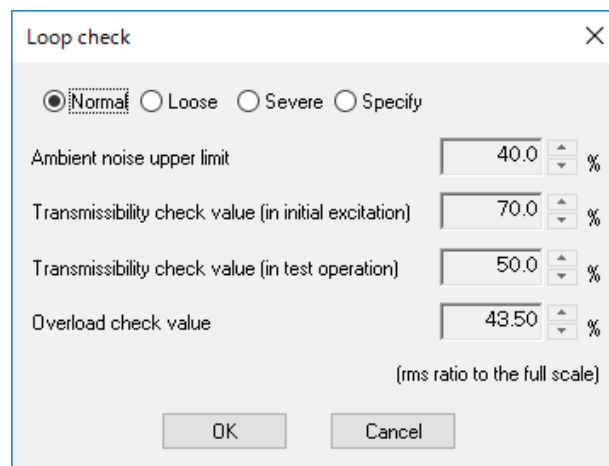
The criterion allows an ordinary level of non-linearity.

3. Loose

The criterion allows a larger non-linearity

4. Specify (or use the 'Detailed definition' button)

Parameters of the loop check in 'Severe', 'Normal' and 'Loose' settings are set up appropriately. However, if the loop check cannot be passed by these settings, tune the parameters by 'Specify'.



4.2.7.1 Ambient noise upper limit

(1) Meaning

This item is intended for the specifying the allowable upper limit of the ambient noise (environmental noise) ratio to the response measured at the initial measurement.

If the measured environmental noise exceeds the specified value, the test is aborted.

4.2.7.2 Transmissibility check value [in initial excitation]

(1) Meaning

This item is intended for specifying the allowance for the transmissibility variations at the initial measurement or initial equalization.

If the transmissibility variations exceed the specified value, the test is aborted.

4.2.7.3 Transmissibility check value [in test operation]

(1) Meaning

This item is intended for specifying the allowance for the transmissibility variations during test operation.

If the transmissibility variations exceed the specified value, the test is aborted.

4.2.7.4 Overload check value

(1) Meaning

This item is intended for the continuance of test even if input signal exceeds the input range to some extent. Note that exact control or measurement is unavailable when input signal always exceeds the input range.

4.2.8 Test time

(1) Meaning

This item is for specifying of the duration of the test operation.

That is, the system automatically stops signal output when the specified time elapses after the start of the test.

< Infinite >

When the Test time is not needed to be set, the value of 'Infinite' should be selected.

In this case, the excitation continues until [Stop] button is pressed except the case of activation of Abort using a predetermined protection function.

< Specify time >

When denoting 'hour' as 'h', 'minute' as 'm' and 'second' as 's', the input format is as below ;

hhh : mm : ss

The conversion such as 'second' to 'minute' is automatically performed.

(Example 1) The entry of '10 : 20 : 30' means '10 hours, 20 minutes and 30 seconds'.

(Example 2) The entry of '50 : 0' means '50 minutes'.

(Example 3) The entry of '1000' is automatically converted to '16 minutes, 40 seconds'.

4.2.9 Initial output level

(1) Meaning

Before testing based on the defined reference spectrum, a trial run of the excitation system (to see behavior of the spectrum, etc.) may be needed : This trial run is done with reproducing the waveform proportional to the reference spectrum at a lower excitation level.

The lower excitation level, which is the ratio of the initial waveform to the original reference,

is called the 'Initial output level'.

This item defines the 'Initial output level', which is defined in the form of a level ratio (dB value) as the standard (0 dB) of the reference waveform level.

The setting of excitation level can be changed (0 dB or less) any time during the testing of actual excitation, but there is a danger to make the mistake of doing excitation at 0 dB from the beginning. This can be avoided by the first setting the required value. This item helps you avoid making this mistake.

< Change in Excitation Level in Operation >

To change the defined excitation level is also possible by clicking a specified button with mouse.

The level increases (decreases) just for the defined 'Level increment' every one press of the keys.

4.2.10 Level increment

(1) Meaning

This item is for specifying increment value of changing excitation level.

By using dialog box of 'Level Change', this setting value can be changed during operation too.

4.2.11 Auto-start

(1) Meaning

When the value less than 0dB is set for the Initial Output Level, the function of level change that automatically executed from the specified Initial Output Level to 0 dB is called 'Auto-start'. This item is for selecting of whether 'Auto-start' is executed or not. If 0 dB is specified for the Initial Output Level, this item can not be selected.

When 'Auto-start' is needed to be executed, the button of this item should be selected (click the check box to be marked). The level is increased automatically for the specified value at each time when the specified time is elapsed, and this action is repeated until the level reaches at 0 dB.

4.2.12 Shutdown time

(1) Meaning

The drive signal output can be aborted by the order of 'Excitation stop' during the drive outputting state in the actual testing. When the response that exceeds over the specified 'Abort level' is detected, the drive signal output is automatically aborted.

However, it is dangerous to cut off the drive output suddenly. To prevent this danger, the

output level should be gradually reduced to zero with taking proper duration.

The time for reducing the output level is called 'Shutdown time' and this quantity can be set in this item.

On the other hand, the same danger of the above may occur at the drive output start. Therefore, for this system, the operation specification that the full level output is produced with taking a specified time of this item is provided.

4.2.13 Level Scheduling

(1) Meaning

This item is for operating a test at the scheduled excitation level.

In the setting of Level schedule, Excitation level / Excitation time / Tolerance are defined.

The setting of Excitation level and Test time in Level Scheduling gets preference over in others. Therefore, when Level Scheduling is set, each definition items of Initial level, Test time and Auto-start become impossible to define or invalid even if it has defined before hand.

Test time in the Level schedule shows the total time of each schedule item.

The definition item of Level scheduling cannot be used in SOR / ROR test.

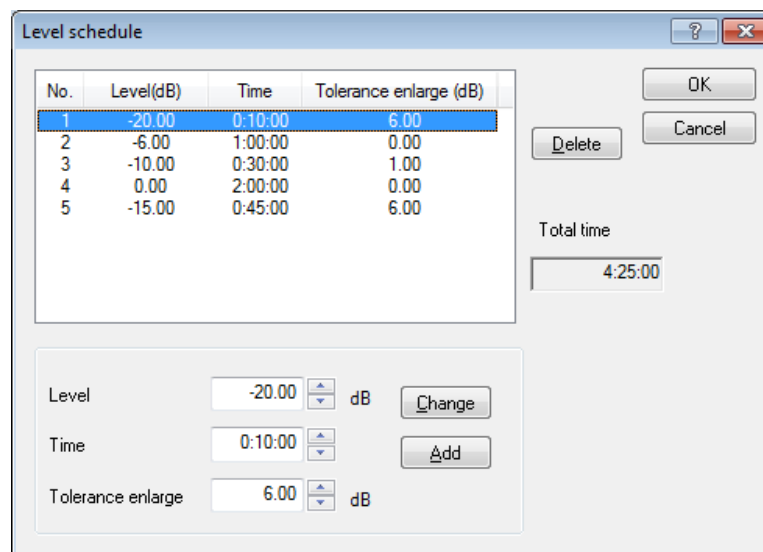
Also, it doesn't have to be defined when it is not necessary.

[Define] : This button is for defining or correcting the Level scheduling. The dialog box of Level schedule definition appears when it is pressed.

[Delete] : This button is for deleting the defined Level scheduling.

< Definition of each scheduling item >

The following buttons are used for setting and registering of each schedule item.



[Add] : This button is for registering a new schedule item
After inputting the values to Level and Time, press this button to register and display the current schedule in the list.

[Change] : This button is for changing the values of a registered schedule.
Selecting a schedule by a mouse, input the values to be changed and press this button.

[Delete] : This button is for deleting the registered schedule.
Selecting a schedule to be deleted by a mouse, press this button to delete it.

4.2.13.1 Level

(1) Meaning

This item is for setting of the excitation level.

Excitation level is specified as a relative level to Reference PSD defined in 'PSD Definition'.

4.2.13.2 Time

(1) Meaning

This item is for setting of the excitation time.

Time is specified by the same method of setting time in 'Test time'.

4.2.13.3 Tolerance Enlarge

(1) Meaning

This item is for setting of Tolerance.

Tolerance is specified as a relative level to the Tolerance defined in 'Tolerance Definition'.

By using this item, Tolerance can be enlarged if it is necessary. For example, the width of Tolerance needs to be enlarged when the too much noise exists in lower excitation level.

When the value of 0dB is set to this item, the value of Tolerance is specified at the same value of the Tolerance defined in 'Tolerance Definition'.

4.2.14 Observation freq. can be set within the Reference freq. range

(1) Meaning

This item is for limiting the observation frequency to set within the reference frequency range*.

When this item “Observation freq. can be set within the Reference freq. range” is checked, the available frequency range for calculating the RMS value and for graph data is limited within the reference frequency range only. Other spectrum data than the reference frequency is regarded as zero data.

This item “Observation freq. can be set within the Reference freq. range” is set valid by default.

*) Control reference lower frequency (the lowest frequency point of Reference PSD)

~ Control reference upper frequency (the highest frequency point of Reference PSD)

4.2.15 Pause before transitioning to "In excitation"

(1) Meaning

After starting the excitation, the response spectrum gradually approaches the reference spectrum by adjusting the drive output signal. And when the response spectrum coincides with the reference spectrum, the test status becomes ‘In excitation’ and the test continues.

When this item is checked, the status becomes ‘Pause’ and the drive output is stopped before the status transitions to "In excitation".

4.3 Excitation System Setting

This item is for setting of the excitation / output system for control.

Excitation system setting

Initial output voltage: 10.0 mV rms

Clipping:

- Soft-Clipping (To minimize the peak output voltage without deteriorating the control performance.)
- Hard-Clipping by crest factor
- None

Peak voltage limiting: Normal 3.0 Sigma

Output voltage limit value: 10000.0 mV

Abort ratio: 50.0 %

HPF: Not used

4.3.1 Initial output voltage

(1) Meaning

‘Initial output voltage’ means the voltage to be outputted to the shaker at the first loop check. The control is always started at this drive voltage when the excitation starts from the state of no drive.

The voltage value is specified in [mV] unit by rms. The value of Initial output voltage (V_{rms}) registered in Excitation System Information is automatically set when this item is not defined.

Note) A proper value for the shaker is needed to be defined in Initial output voltage.

4.3.2 Clipping

(1) Meaning

This item is for setting of the clipping type.

The clipping type is specified as below;

- Soft-Clipping
- Hard-Clipping by crest factor
- Clipping by output voltage

In this system the clipping by output voltage must be specified, but the clipping by crest factor must not be specified in no system needs.

In this system, the default setting is ‘Soft-Clipping’.

4.3.2.1 Clipping by crest factor

(1) Meaning

This item is for selecting whether the function of ‘Clipping by crest factor’ is executed.

When the function of ‘Clipping by crest factor’ is to be executed, this item is checked and the level of Clipping should be specified as a relative ratio to standard deviation σ of the output signal.

1. Soft-Clipping

To use the Soft-Clipping, the Soft-Clipping option is required.

It is possible to clip the drive signal without deteriorating the control performance.

For details, refer to “Soft-Clipping Option Instruction Manual”.

2. Hard-Clipping by crest factor

The spectrum of the clipped drive signal is more or less modified. As a result, the spectrum of the response signal would be more or less different from the plan.

3. None

Clipping by crest factor is not executed.

4.3.2.2 Output voltage limit value

(1) Meaning

This item is for setting of the maximum drive voltage of the system.

The specified voltage level is the clipping level by output voltage.

When each output channel is going to be driven to output the voltage signal which exceeds over the set value of allowable voltage value, the clipping process is done for the drive signal.

4.3.2.3 Abort Ratio

(1) Meaning

In this system, the setting with only ‘Clipping by output voltage’ is provided as a standard. In case of the Clipping by output voltage, when the level close to Output voltage limit value is outputted, almost all the signals are clipped. The execution of the clipping process means a modification of the drive signal spectrum, therefore the clipping process causes the lowering of the spectrum control ability.

For safety, in this system, when the crest factor of the output signal by which clipping is done becomes smaller than a specified value, the system stops the operation.

Operation of abort is judged by the output voltage (rms value). In this case, the abort voltage is specified as below ;

$$\text{Abort voltage [mVrms]} = \text{Abort ratio} \times \text{Output voltage limit value [mV0-p]}$$

4.3.3 High Pass Filter(HPF)

(1) Meaning

This item is for setting of inserting or not-inserting of a high pass filter to the drive signal output circuit which is the concrete mechanism to realize ‘the function of Extra-displacement reduction’.

The following can be chosen for setting of usage of the high pass filter, and for setting of cut-off frequency f_c .

- Not use

This item means that high pass filter is not used.

- Auto-setting of f_c

This item means that high pass filter is used, and the setting of cut-off frequency f_c is automatically operated. Please see < Selection Guide> for the details of the setting.

- Specify cut-off : f_c

This item means that high pass filter is used, and f_c is specified arbitrarily.

< Selection Guide>

Generally, ‘Auto-setting of f_c ’ which is the default value of this system is recommended.

As the selection guide of cut-off frequency f_c setting, it is proper that the relation between the minimum control reference frequency (the frequency at the lower frequency edge of reference PSD) f_{edgeL} and the frequency resolution Δf is about :

$$f_c = f_{\text{edgeL}} + 0.5 \Delta f$$

In the case that the value of f_c estimated as $f_{\text{edgeL}} \geq 5 \Delta f$, using filter is not necessary from the first.

As the actual circuit, a second order characteristic high pass filter with f_c programmable function is implemented. So, you do not have to think of f_c strictly (but in some cases, a definitely important effect of the displacement reduction can be obtained).

<Influence on estimated values of necessary velocity and displacement >

The setting value of this item effects on the estimated rms value of velocity / displacement which is operated with the calculation of the acceleration rms value of the reference spectrum.

Therefore, in the serious case that required displacement is too large to operate a test, it is better for you to change the setting of f_c and think over the calculation value.

On the other hand, to estimate the values of velocity and displacement rms in the above is done on some assumption. Consequently, note that the estimated value may not have absolute accuracy.

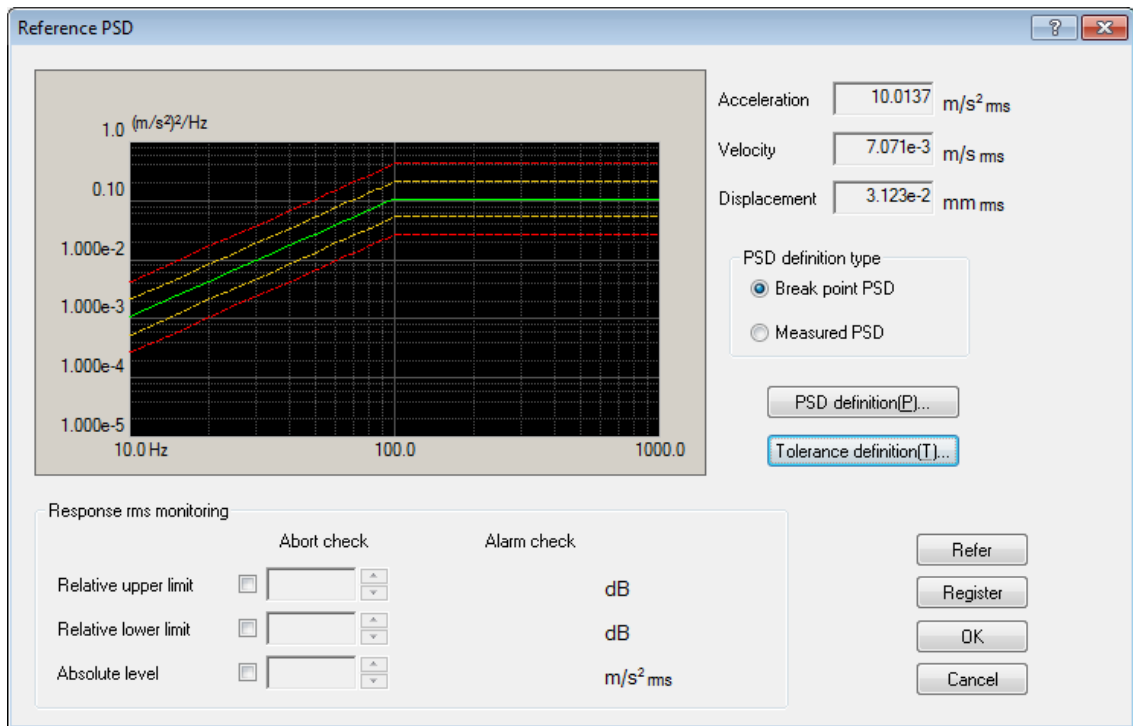
< Indication of f_c set value >

The set value of f_c is to be displayed after completing of the reference PSD definition when ‘Auto-setting of f_c ’ is selected.

4.4 Control Reference

This item is for defining the control reference.

Test pattern is determined by the setting of this definition.



4.4.1 PSD definition

(1) Meaning

This item is for specifying the types of PSD.

In this system, the definition method of PSD data are provided as below ;

- ① Break Point PSD Definition
- ② Measured PSD Definition
- ③ Measured Waveform Definition

Select a definition method of PSD data in PSD definition type.

< Break Point PSD Definition >

The PSD data is defined by the break point.

< Measured PSD Definition >

The data file of PSD data saved in CSV format written as the dedicated format is used as the reference PSD data as it is or with editing properly if necessary.

< Measured Waveform definition >

Calculate PSD data from the data of waveform data file saved by the specified CSV formats without any editing or with appropriate editing as necessary, and use them as reference PSD data.

< RMS value of PSD data >

When PSD data is defined, the RMS value of the defined PSD data is shown in the display. (If the control unit is in acceleration, the RMS values of the velocity and the displacement are also shown.)

The RMS value of the PSD data shown in this definition display is the calculated value which depends on the control line (Δf) specified in Spectrum Analysis Condition.

The RMS value recognized as a control quantity of this system is the RMS value which depends on the control line shown in this definition display. The rating check of the system is also executed with this RMS value.

However, these calculated values may be somewhat different from the 'theoretical value' which is calculated from the defined data shown in the break point definition display (it does not depend of Δf).

The RMS value shown in Measured PSD Definition display is the calculated value which depends on Δf of the PSD data file to be used. And, when both of the Δf do not coincide with each other, the RMS values do not coincide neither.

4.4.1.1 Break Point PSD Definition

4.4.1.1.1 Outline

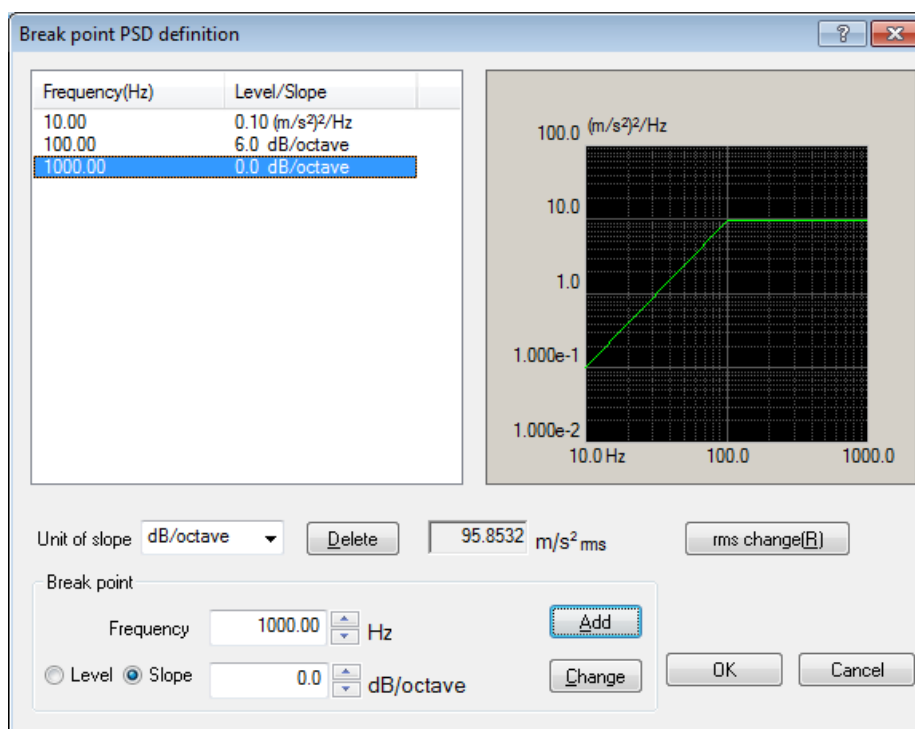
In this dialog, PSD is defined by a pair of the frequency and the level (or the slope).

< Example >

10 [Hz] ~ 100 [Hz] : a spectrum having the slope [6 dB/oct]
with 10 [Hz], 0.1 [(m/s²)²/Hz] as starting point

100 [Hz] ~ 1000 [Hz] : a spectrum having the constant level (the slope [0 dB/oct])

Note) The vertical axis of the graph in Profile is scaled by the control unit.



Break Point PSD Data Definition is independent from the frequency resolution Δf . If the defined break point PSD data has a component of which frequency has a fraction when divided by Δf , the PSD data of each control line is defined as below ;

Draw a straight line between the PSD levels of the frequency adjoining each other in the defined Break Point PSD data. Then, calculate the level at the frequency of the control line on this straight line, and define the PSD data of each control line by this calculated value.

However, the frequency components of the PSD data to be defined should exist in the band between the frequency resolution Δf and the control Frequency range f_{max} .

At least, two lines of the data are needed between Δf and f_{max} .

Break Point (B.P.) data is registered by the following buttons.

B.P. data can be registered for maximum 256.

[Add] : A new B.P. data is registered.

When this button is pressed after inputting of the frequency or the level of B.P. or the value of slope, the current value is shown in the setting frame and registered as a B.P. data.

[Change] : The content of the registered B.P. data is changed.

At first, select the B.P. data line to be changed (by a mouse). Then, change the concerning portion. And, press this button.

[Delete] : The registered B.P. data is deleted.

Press this button at the selected B.P. data line to be deleted.

4.4.1.1.2 Frequency

(1) Meaning

This item is for inputting of B.P. frequency.

The frequency data which is the same or too close a value of the registered B.P. frequency can not be added as a new B.P. data.

4.4.1.1.3 Level

(1) Meaning

At registering of B.P. data, the level data corresponding to the frequency data is inputted in the unit of the PSD value.

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

The PSD value is expressed by 'unit² / Hz'. This 'unit' expresses the control unit that has already determined in Fundamental/Control Condition.

4.4.1.1.4 Slope

(1) Meaning

At registering of B.P. 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.

The unit of slope can be selected from 2 types, that is, 'dB/octave' and 'dB/decade'. One of these units can be used for a PSD data.

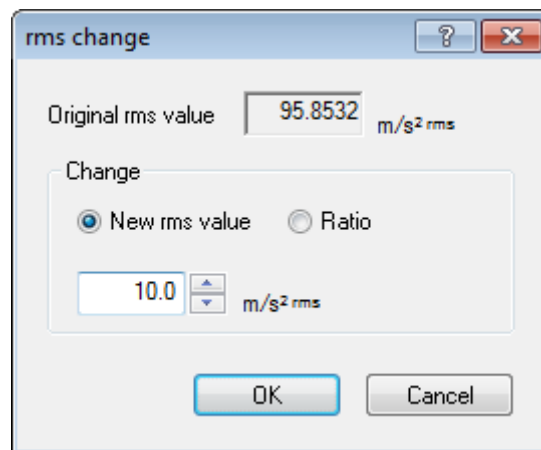
4.4.1.1.5 rms change

(1) Meaning

When the definition of the spectrum stated in the above is completed, the conversion of its RMS value is done.

This function is for proportional converting of Reference PSD, that is, for converting the defined spectrum into the data having the required RMS value by changing only its level without changing its shape.

The dialog box of rms change appears by pressing of the [rms change] button.



The RMS value can be set in the following two methods ;

- New rms value

The changed RMS value is specified in an absolute value.

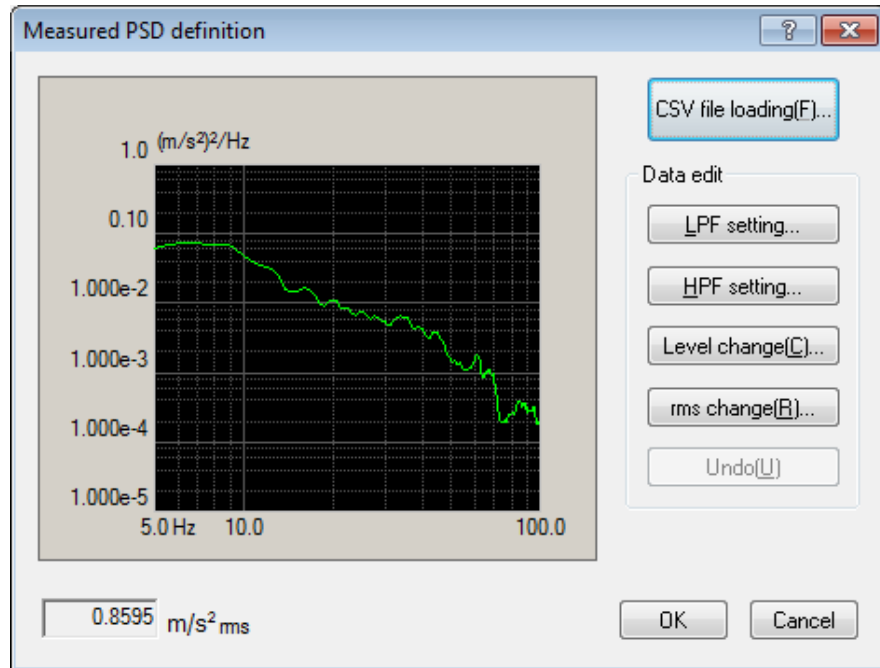
- Ratio

The changed RMS value is specified in a relative value after the change.

4.4.1.2 Measured PSD Definition

4.4.1.2.1 Outline

Reference PSD is defined by using of a measured PSD data.



The measured PSD data to be used should be a CSV file written in the specified format. Refer to “4.4.1.2.4 CSV data file” about the details of this format.

The frequency resolution Δf of the used PSD data file is not necessary to coincide with the Δf defined in Test Definition. If the defined PSD data has a component of which frequency has a fraction when divided by Δf , the PSD data of each control line is defined as follows ;

Draw a straight line between the PSD levels of the frequency adjoining each other in the defined PSD data. Then, calculate the level at the frequency of the control line on this straight line, and define the PSD data of each control line by this calculated value.

However, the frequency components of the PSD data to be defined should exist in the band between the Frequency resolution Δf of Test Definition and the Frequency range f_{max} . When data does not satisfy the above condition this data should be edited to complete the condition. At least, two lines of the data are needed between Δf and f_{max} .

< PSD Data File Selection >

PSD data file is selected by using the button as below ;

[CSV file loading] : The PSD data file is loaded.

< Data Edit >

The loaded data file can be selected by the following buttons ;

[LPF setting] : This item is for operating of low pass filtering or truncating of the data.

[HPF setting] : This item is for operating of high pass filtering or truncating of the data.

[Level change] : The specified level of frequency band is changed.

[rms change] : The RMS value is changed.

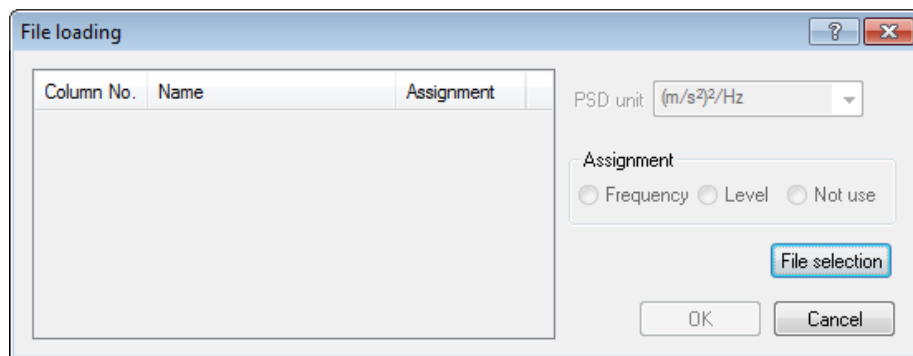
[Undo] / The state of the edited data is returned to the previous state for one step.

4.4.1.2.2 PSD Data File Load

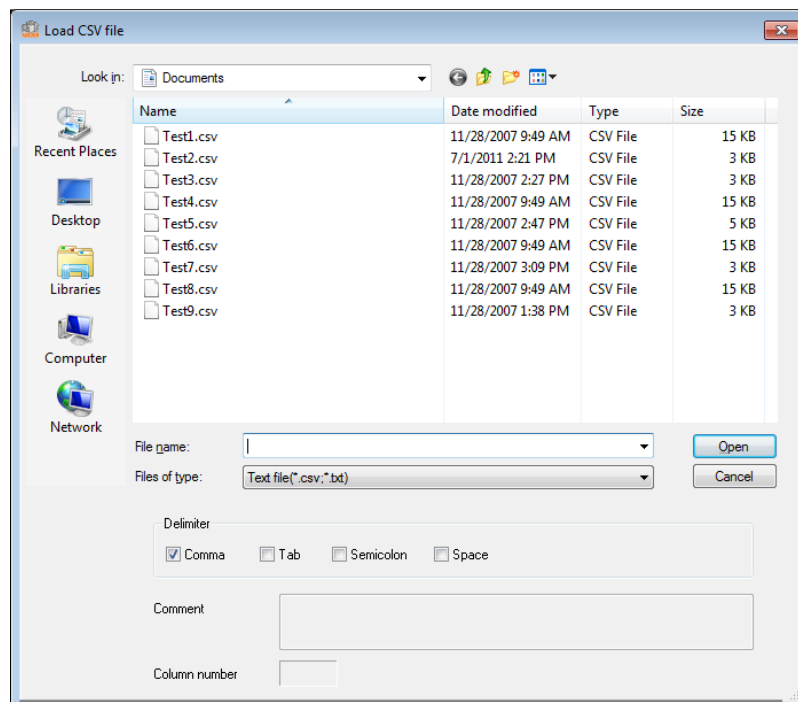
(1) Meaning

This item is for selecting the ‘measured PSD data file’ to be used as the PSD data.

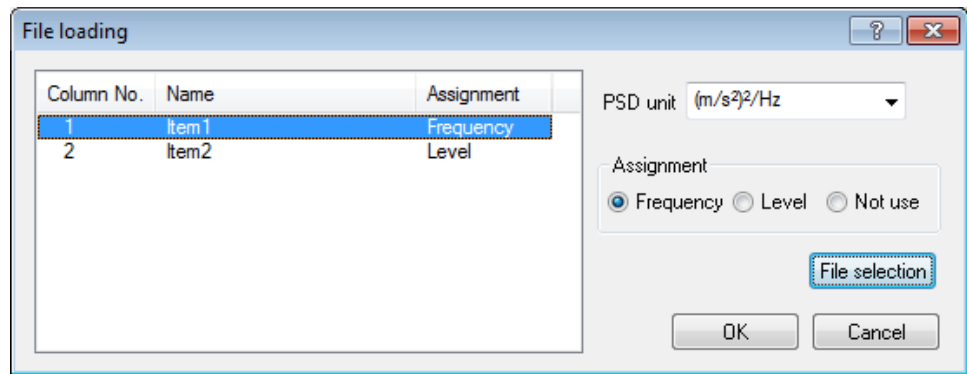
In the dialog of Measured PSD Profile Definition, press the [CSV file loading] button to open ‘File loading dialog box’.



In ‘File loading dialog box’, press the [File selection] button to open a dialog box for CSV file selection.



After the objective data file selection is completed, the data to be used in the definition is to be selected among the data described in the data file.



< PSD Unit selection >

Unit for the level of Data File is selected.

< Configuration of Frequency Data >

The data of column corresponding with the frequency data is selected among the data in Data File.

< Level Data Selection >

The data of column corresponding with the level data is selected among the data in Data File.

4.4.1.2.3 PSD Data Processing

(1) Meaning

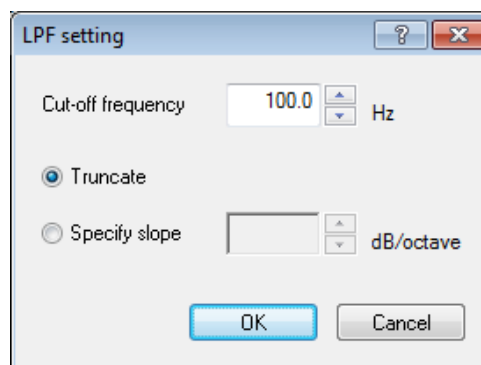
When the PSD data is determined, the selected measured PSD data is displayed and the buttons for 'Data Processing' become valid. The data can be edited by a selected button to be executed on demand.

4.4.1.2.3.1 LPF (Low Pass Filter)

(1) Meaning

This item is for operating of Low Pass Filtering of PSD data or truncating the data in unnecessary frequency band to discard.

A dialog box of LPF setting appears by pressing of the [LPF Setting] button.



The items for setting are as below ;

- Cut-off Frequency

This item is for setting of the Cut-off Frequency for a filtering process.

- Processing Contents

The processing contents of LPF are to be selected ;

[Truncate] : This item is for cutting off the data at the higher band than the specified Cut-off Frequency.

For example, when the frequency components which is higher than the control Frequency range f_{max} exists in PSD data, the higher data should be cut off and discarded from the PSD data.

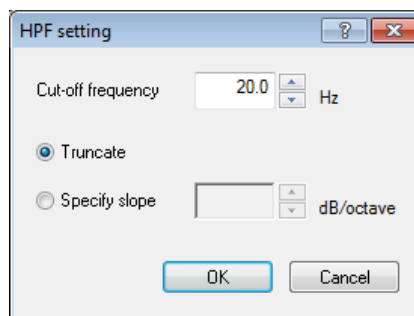
[Specify slope] : This item is for operating of Low Pass Filtering with the specified slope. The unit of slope is 'dB / octave'.

4.4.1.2.3.2 HPF (High Pass Filter)

(1) Meaning

This item is for operating of High Pass Filtering to PSD data at truncating the data in unnecessary frequency band to discard.

A dialog box of HPF setting appears by pressing of the [HPF Setting] button.



The contents and the meaning of these setting items are the same as that of LPF.

- Cut-off Frequency

This item is for setting of the Cut-off Frequency for a filtering process.

- Processing Contents

The processing contents of HPF are to be selected ;

[Truncate] : This item is for cutting off the data at the lower band than the specified Cut-off Frequency.

For example, when the frequency components which is lower than the frequency resolution Δf exists in PSD data, the lower data should be cut off and discarded from the PSD data.

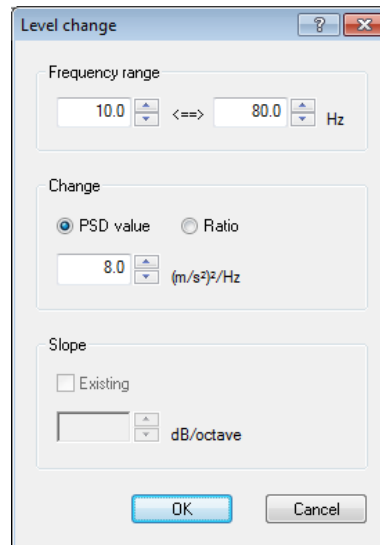
[Specify slope] : This item is for operating of High Pass Filtering with the specified slope. The unit of slope is 'dB / octave'.

4.4.1.2.3.3 Level Change

(1) Meaning

This item is for changing the PSD data level in the specified Frequency range.

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



The items for setting are as below ;

- Frequency range

This item is for setting of the Frequency range for Level Change. The minimum value of the Frequency range to be set is the frequency resolution Δf of PSD data file. The level only for one line can not be changed.

- Change

This item is for selecting of the specifying method of PSD level after the change. The following two methods are provided in HPF characteristics.

‘PSD Value’ : The changed PSD level is specified in an absolute value.

‘Ratio’ : The changed PSD level is specified in a relative value after the change.

- Slope

In case that ‘Ratio’ is selected in the item of Change Method, this item is for specifying whether the slope of transportation band is attached or not.

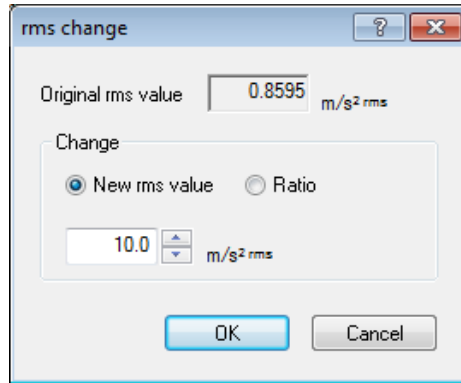
When slope is set to be attached, the slope outside of the specified Frequency range. The unit of slope is ‘dB/octave.’

4.4.1.2.3.4 rms change

(1) Meaning

This item is for converting the defined PSD into the data having the required RMS value by changing only its level without changing its shape.

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



Specifying method of RMS value can be selected among the following two methods ;

- New rms value

The changed RMS value is specified in an absolute value.

- Ratio

The changed RMS value is specified in a relative value after the change.

4.4.1.2.4 CSV data file

(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 | Δf, | ***.***, | ***.**, | ..... |
| | $2\Delta f$, | ***.***, | ***.**, | ..... |
| | : | : | : | : |
| | 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.

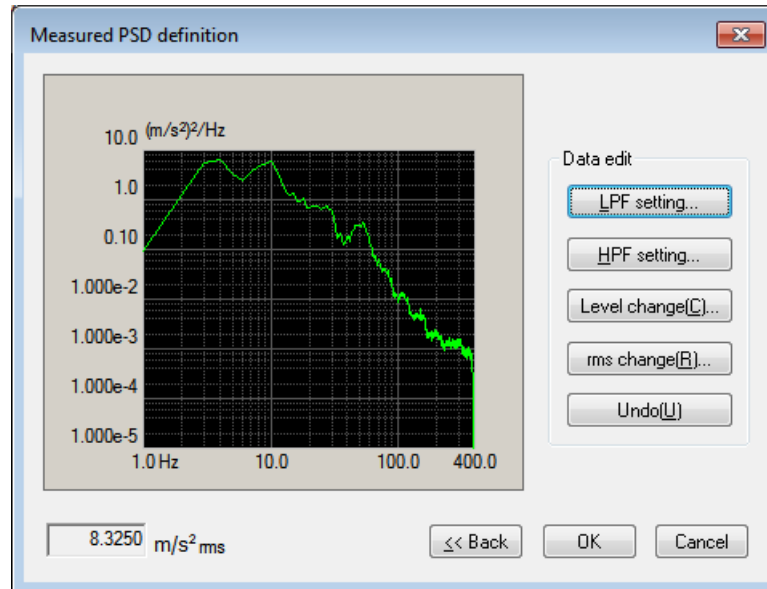
(3) Unit of Data

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

4.4.1.3 Measured Waveform definition

4.4.1.3.1 Outline

Reference PSD is defined by using of a measured waveform data.



First, select waveform data, and edit the waveform as necessary.

Calculate PSD data from the waveform data. Edit the data furthermore as necessary, and use them as reference PSD data.

The measured waveform data to be used should be a CSV file written in the specified format. Refer to “4.4.1.3.4 CSV data file” about the details of this format.

<Data edit>

This item is for editing the PSD.

For details, refer to “4.4.1.2 Measured PSD definition”.

<Back>

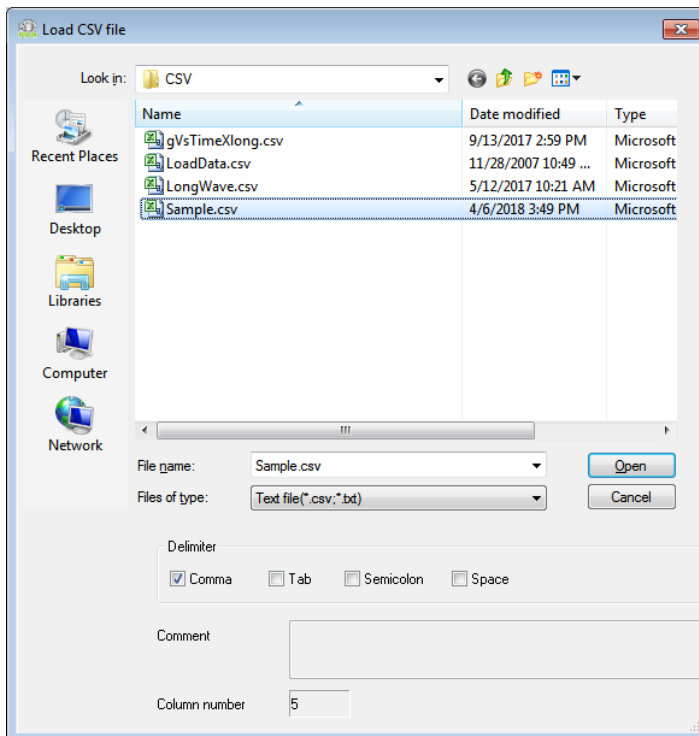
Returns to the screen to select waveform data and data edit.

When this screen reappears after waveform data is changed, data edit which has been conducted already is abandoned.

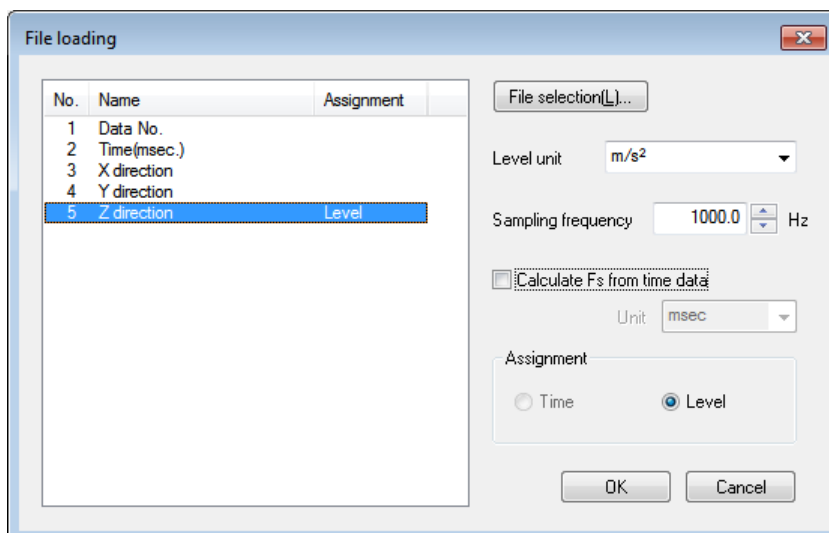
4.4.1.3.2 Waveform Data File loading

(1) Meaning

The 'Measured waveformdata file', the base of PSD data, is selected and edited.
First, a dialogue box to select CSV file is displayed.



After the reference data file is selected, data to be used for definition is selected from the data in the data file.



<File selection>

A dialogue box to select CSV file is displayed, and waveform data file is selected again.

<Selection of level unit>

Unit for the level of data file is selected.

<Sampling frequency>

Sampling frequency of data file is specified.

When sampling frequency is automatically calculated from time data, the calculated sampling frequency is displayed (In this case, changing sampling frequency is not allowed.)

<Calculation of sampling frequency from time data>

Sampling frequency is automatically calculated by the data assigned as time data. Selecting the correct unit of time data is also needed.

<Assignment of level data>

The data of column corresponding with the level data is selected among the data in data file.

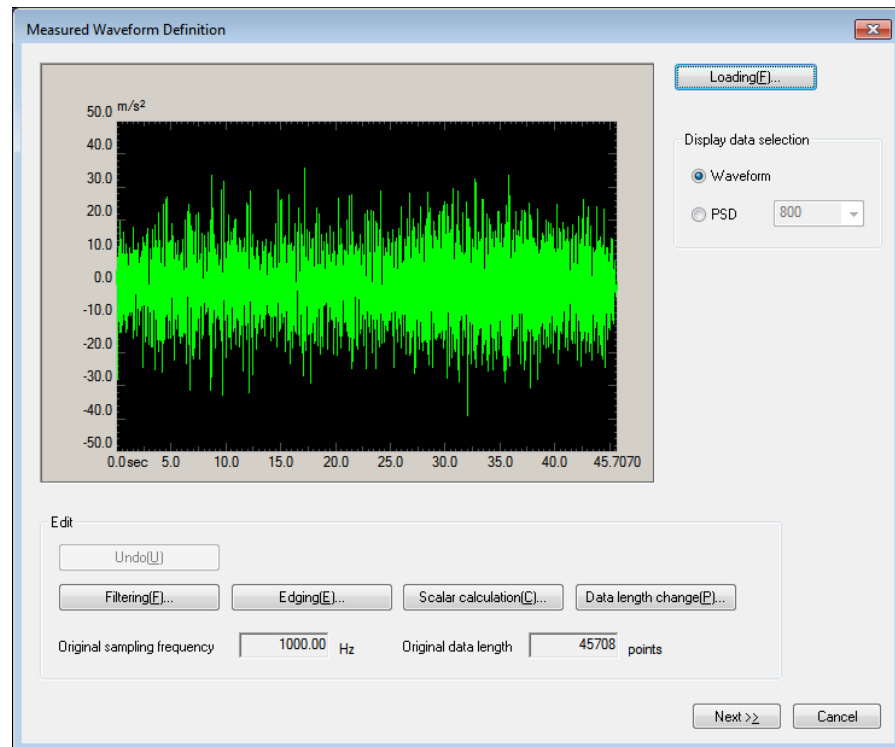
< Assignment of time data>

When sampling frequency is automatically calculated, The data of column corresponding with the time data is selected among the data in data file.

Time data needs to be lined up with constant time intervals.

For details, refer to “4.4.1.3.4 CSV data file”.

When selection of waveform data is completed, the selected waveform measured data is displayed.



<Selection of waveform data file>

Waveform data file is selected by using the buttons shown below.

[File loading]: This button is for loading waveform data files.

<Display data selection>

The graph data can be selected from the items below.

- Waveform display

Waveform graph is displayed.

- PSD display

PSD graph is displayed. The number of lines of PSD can be selected.

<Data editing>

Editing loaded waveform data is allowed by using the buttons shown below.

[Undo]: The state of the edited data is returned to the previous state for one step.

[Filtering]: This item is for operating of filtering.

[Edging]: This item is for operating of Edging, windowing, and clipping.

[Scalar calculation]: This item is for scalar calculation.

[Data length change]: This item is for changing number of data points.

4.4.1.3.3 Data edit

(1) Meaning

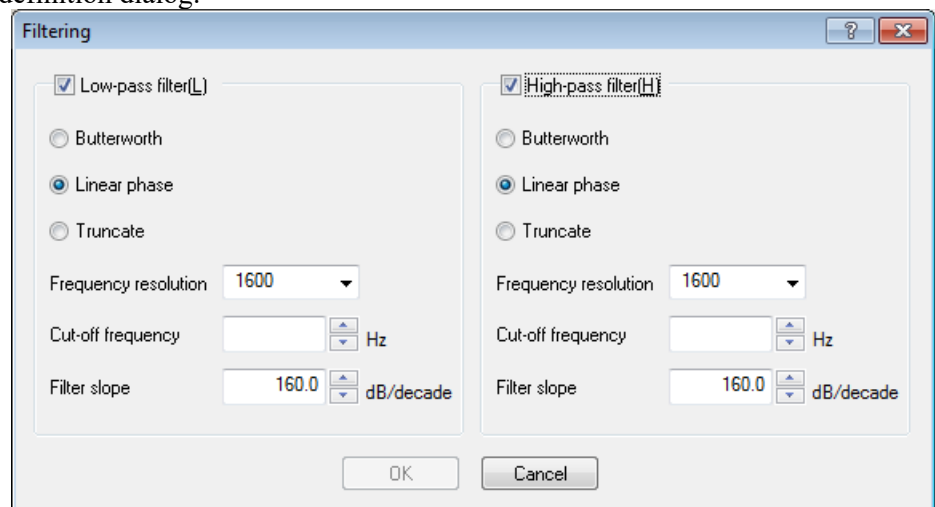
When the PSD data is determined, the selected measured waveform data is displayed and the buttons in 'Data edit' become valid. The data can be edited by a selected button to be executed on demand.

4.4.1.3.3.1 Filtering

(1) Meaning

This item is for operating of Filtering to the waveform data loaded.

The definition dialog of Filtering as below appears by pressing [Filtering] button in the definition dialog.



Setting items are as shown below.

<Type of Filter>

Type of Filter is selected.

- Low-pass filter

In this type, the low frequency component of waveform data is passed.

- High-pass filter

In this type, the high frequency component of waveform data is passed.

<Filter Characteristics>

Filter Characteristic is selected. Generally, the default setting of 'Linear Phase' is used.

- Butterworth

Nth-order Butterworth Filter.

How to specify the order N is described after the next clause.

- Linear phase

The Linear Filter cuts the components without giving any non-linear

phase change to the input signal.

This system adopts the specifications that the slope at the attenuation band can be defined without changing the phase in all the frequency elements at all.

- TRUNCATE

The characteristics of the Frequency range which is the object for the filter processing is truncated to zero bounded by the specified cut-off frequency f_c .

The phase characteristics are the same as the 'Linear Phase' in the previous clause.

<Frequency resolution>

The frequency resolution is specified to carry out Fourier Transform and Inverse Fourier Transform by FFT technique for the filter processing of the waveform data.

Therefore, the input lower Cut-off frequency f_c is determined when frequency resolution is specified.

<Cut-off frequency>

This item specifies the Cut-off frequency for Filtering.

The possible lower value f_{c_min} is determined by the Sampling frequency f_s of the objective waveform data of the Filtering process and the frequency resolution L as follows.

$$f_{c_min} = \Delta f \text{ [Hz]} \qquad \Delta f = f_{max}/L, \quad f_{max} = f_s/2.56$$

<Filter order>

This item is defined only when 'Butterworth' is specified for Filter Characteristics.

The order N is inputted that specifies the Cut-off Characteristics of the Filter.

<Filter slope>

This item is defined only when Filter Characteristic is 'Linear Phase'. The Slope of the attenuation transient band characteristics S [dB/decade] that is correspondent to the order of the Filter is specified.

When this item is defined, Filtering process according to the following formula is executed within the objective range.

$$A'(f) \begin{cases} = A(f) & \Delta f \leq f < f_c \\ = A(f)/(f / f_c)^{S/20} & f_c \leq f \leq f_{max} \end{cases}$$

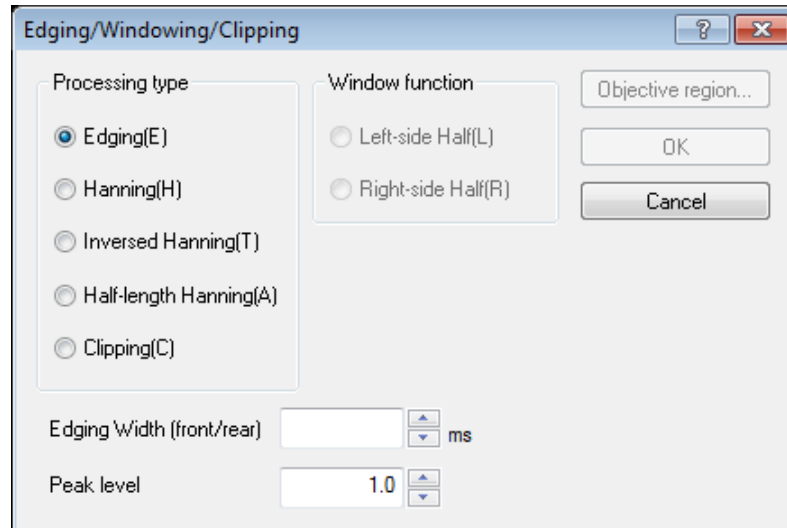
$A(f)$ Amplitude value

4.4.1.3.3.2 Edging

(1) Meaning

This item is for operating the edging process that achieves to smooth the loaded waveform data at the beginning/ending edge to zero. Half-length Hanning Windowing is used in this process.

When [Edging] button is pressed in the definition dialog, the definition dialog of Edging appears as below.



Setting items are as shown below.

<Processing>

Type to be processed can be specified.

- Edging

Half-length-Hanning processing is conducted at front and rear of waveform.

For details of Half-length-Hanning, see below.

- Hanning

Hanning generates the Hanning function of the defined peak value in the defined region, and multiplies the given waveform data by the function.

- Rotated Hanning

Rotated Hanning generates the 'inverse Hanning' function of the defined peak value in the defined region, and multiplies the given waveform data by the function.

- Half-length Hanning

Half-length Hanning generates the half-length Hanning function of the defined peak value in the defined region, and multiplies the given waveform data by the function.

- Clipping

The waveform data in the defined region is clipped by the defined clipping

level.

When the clipping level is positive (+), the data over the level is replaced by the clipping level.

When the level is negative (-), the data below the level is replaced by the clipping level.

Smoothing processing can be achieved to smooth the border between the clipping level.

<Window Function>

This item can be input only if the previous item is set to 'Half-length Hanning'. There are two types ;

- Left-side Half

This type generates the Hanning function on the left, (start-up half-length), and multiplies the given waveform data by the function.

- Right-side Half

This type produces the Hanning function on the right (fall half-length), and multiplies the given waveform data by the function.

< Edging (front and rear)>

- Edging

The time for edging T_e is specified.

Windowing by Half-length Hanning is operated to time data from the beginning to the ending edge.

- Other processing

The objective region in which the processing is conducted is specified. Although the whole region of waveform data is specified normally, an arbitral region can be specified as necessary.

<Peak Level (Clipping Level)>

In the event of Hanning, this item specifies the peak value of the hanning function. The unit is none because the value has no dimension.

The default value is '1'.

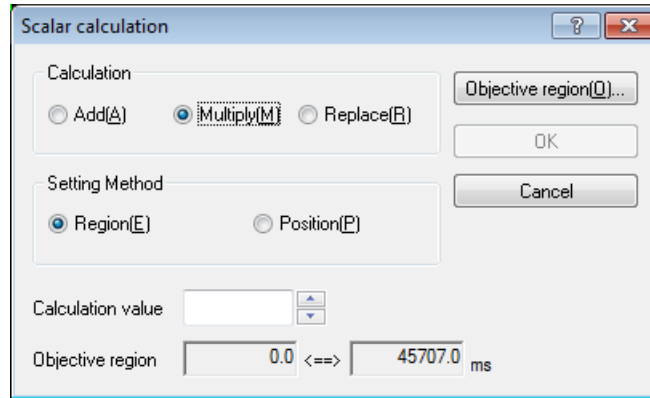
In the event of clipping, this item specifies the clipping level. The unit is the same as the objective waveform data.

4.4.1.3.3.3 Scalar calculation

(1) Meaning

This item is for setting of the calculation between numeral values of the waveform data loaded.

When [Scalar calculation] is pressed in the definition dialog, the definition dialog of Scalar calculation appears as below ;



<Calculation>

This item defines the calculation type between the waveform data and numeric value.

- Add

The defined quantity is uniformly added to the current waveform data.

- Multiply

The waveform data is transformed in proportion to the defined multiplier.

- Replace

The current waveform data is replaced by the defined value.

<Calculation value>

This item defines the value to be calculated.

When the calculation type is specified to 'Multiply', this item is set to the untitled value. When the type is specified to 'Add' or 'Replace', the unit must be the same as that of the current waveform data.

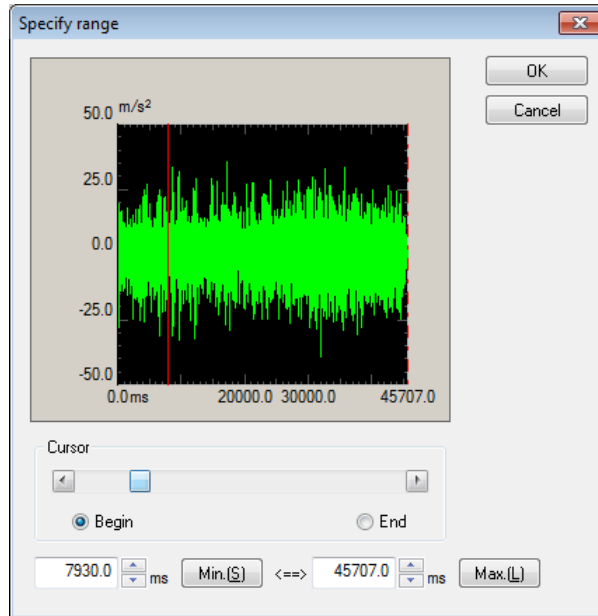
<Setting Method>

This item defines the objective range to be calculated.

- Region

To specify the objective region of the calculation by defining the beginning point and ending point.

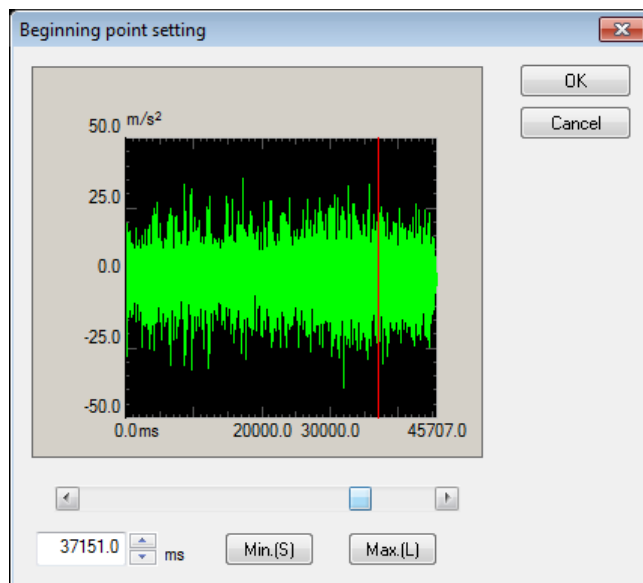
Select [Objective region] to display the dialog as below. And define the beginning and the ending points that become the objects for calculation.



- Position

Only the data of the specified time position is the objective data of the calculation. Namely, only the data for one point on the specified time axis is processed by the calculation.

When [Objective position] is selected, the dialog as below appears. And define the position of the objects for calculation.

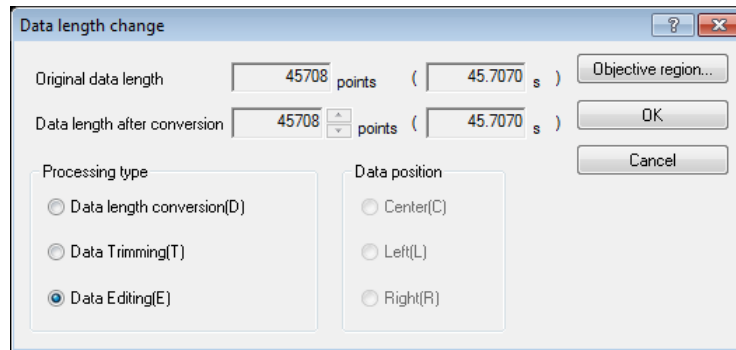


4.4.1.3.3.4 Data length change

(1) Meaning

This item is for changing the waveform data length.

Select [Data length change] in the definition dialog. The definition dialog of Data length change as below appears.



<Processing type>

When Data Length of waveform data is converted, the following methods are available ;

- Data length conversion

The desired Data length which will be converted from the current data length is specified. Data Length can be increased or decreased from the current data length.

- Data trimming

The data in the specified region is trimmed from the objective waveform data and the rest is used as a new waveform data.

Data Length is decreased from the current data length.

- Data editing

The data in the specified region is trimmed from the objective waveform data and the trimmed part is used as a new waveform data.

Data Length is decreased from the current data length.

<Data Length>

This item is specified only when Processing type is specified as Data length conversion and is defined a new Data Length R'.

In this item, the waveform data of a new Data Length is generated, while Sampling frequency fs is kept unchanged.

In other words, the Frame Time T increases or decreases in proportion to the Data Length as follows ;

$$T = R' / f_s \text{ [s]} \quad R' : \text{A new Data Length}$$

- The old Data Length R > The new Data Length R' ;
Part of the old data is discarded in proportion to the decrease of the Frame Time T (the discarded area depends on the defined data position stated later).
- The old Data Length R < The new Data Length R' ;
Zero data is added to the old data in proportion to the increase of the Frame Time T (the added area depends on the defined data position stated later).

<Data Position>

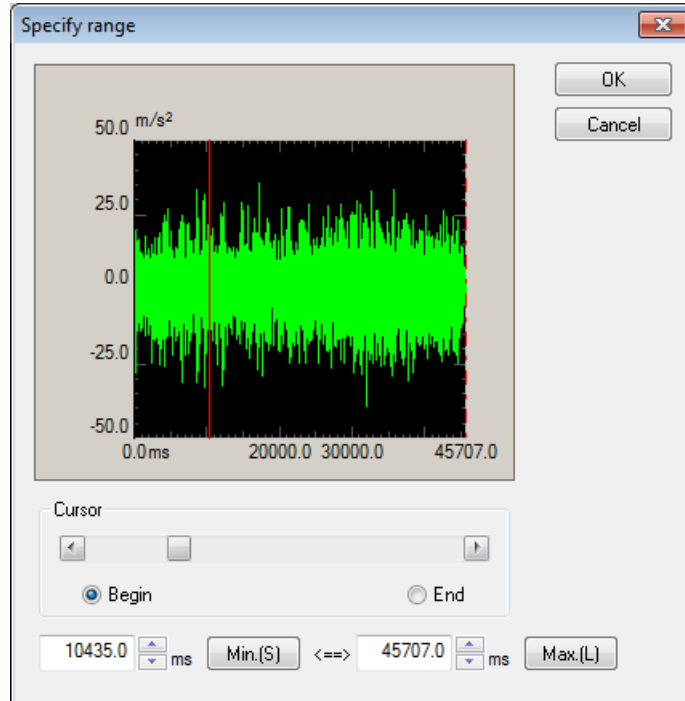
This item should be inputted only when the Processing type is 'Data length conversion' and this item defines the reference position for changing the waveform data, led by changing the data length.

- Center
The data is increased or decreased with keeping the center of the old data as a base. The data is added or discarded uniformly on the right and the left.
- Left
The data is increased or decreased with keeping the left end of the old data fixed. The data is added or discarded from its right end.
- Right
The data is increased or decreased with keeping the right end of the old data fixed. The data is added or discarded from its left end.

<Objective Region>

This item is valid only when 'Data trimming' or 'Data editing' is set in Processing type.

When [Objective Region] is pressed, the dialog box for setting of objective region appears.



4.4.1.3.4 CSV data file

(1) File Format

Text File (MS-DOS format)

(2) Data

Sampling frequency data at each time is described as below in order of time passing.

| | 1st column | 2nd column | 3rd column | | |
|----------|------------------|--------------|--------------|--------------|-------|
| 1st line | <i>Time (ms)</i> | Data Name 1, | Data Name 2, | Data Name 3, | ..... |
| 2nd line | 0.0, | ***.***, | ***.**, | ***.**, | ..... |
| 3rd line | Δt | ***.***, | ***.**, | ***.**, | ..... |
| | $2\Delta t$ | ***.***, | ***.**, | ***.**, | ..... |
| | . | . | . | . | . |
| | T, | ***.***, | ***.***, | ***.**, | ..... |

- It is not necessary to specify the data in a 1st line.
- The order of data (column) are not specified specially.
- Time data is not necessary to me specified.

(3) Unit of Data

Unit of data to be described is determined by selecting a Data File.

(4) Sampling frequency

Sampling frequency of data to be described is specified after selecting the data file.

Sampling frequency can be calculated automatically from time data when time data exists.

4.4.2 Tolerance Definition

(1) Meaning

This item is for defining the condition of Tolerance check.

It may be happened that the response PSD control to be equal to the reference PSD cannot be obtained as you need depending on the condition of specimen (degree of sharpness in resonance characteristics, having the non-linearity elements, etc.) in vibration test operation.

In such a case, it is necessary to decide the conditions for continuing the test operation beforehand. This system has four types of check condition for the control response as below ;

- A ① Alarm allowance band width
- ② Abort allowance band width
- B ① Alarm RMS level
- ② Abort RMS level

Here, 'Alarm' means that this system sounds an alarm (buzzer) when the response quantity which exceeds over the level of the set condition is detected. And, 'Abort' means that the testing operation is aborted (the signal output is stopped) when the response quantity which exceeds over the level of the set condition is detected. The response quantities to be checked are the band width and the RMS value of response spectrum which exceeds over the defined level. Each items in A, B are corresponding to the defined values.

Tolerance is for specifying the item in A.

Monitoring condition of the response RMS is for specifying the item in B.

Tolerance is necessary to be defined. On the other hand, Observation condition of the response RMS is to be defined if necessary.

The definition dialog of Tolerance appears when the button of [Tolerance definition] is pressed in Control Reference definition dialog.

| | Upper limit | Lower limit | Allowable band width |
|-------------|-------------|-------------|----------------------|
| Abort check | 6.00 dB | -6.00 dB | 0.00 Hz |
| Alarm check | 3.00 dB | -3.00 dB | 0.00 Hz |

< Tolerance Check >

The check for the each control line on which whether the response PSD coincides with the reference PSD or not by using the specified Tolerance band as a judgment criterion is called 'Tolerance Check'.

In Tolerance check of this system, alarm level and abort level are provided. However, alarm level does not have to be set if it is not necessary.

4.4.2.1 Tolerance

(1) Meaning

The condition of Tolerance check is defined in the whole band in which the reference PSD exists.

Tolerance must be set for each test definition.

And this Tolerance is called 'Basic Tolerance' in the following description.

Tolerance is defined by the definition items as below ;

< Level >

Alarm / Abort level for monitoring the deviation from the reference PSD are specified. Level is specified by a relative level to the reference PSD.

At the setting of Alarm check, the following relation should be satisfied between Alarm level and Abort level.

$$| \text{Alarm check level} | \leq | \text{Abort check level} |$$

< Allowance >

The frequency width for allowing the deviation from Alarm / Abort level is specified. If the total value of the frequency bands in which the detected deviation from Alarm / Abort level exists is smaller than the set value of allowance, the function of Alarm / Abort is not activated.

If the defined allowance width is larger (including the case of equal) than the band width in which the reference PSD exists, the function of Alarm / Abort is not activated even the deviation is detected at all lines.

4.4.2.2 Define the alarm line

(1) Meaning

This item is for specifying whether alarm check is used or not.

In this system, abort check must be executed. However, alarm check can be used if it is necessary to be executed.

The setting of this item is valid for both of the definitions of Basic Tolerance and Extension Tolerance.

4.4.2.3 Use the lower limit line

(1) Meaning

This item is for specifying whether the lower limit value check is used or not.

In this system, the upper limit value check must be executed. However, the lower limit value check is not used if it is necessary to be executed. For example, the lower limit value check is not used generally when the limit control is executed.

The setting of this item is valid for both of the definitions for Basic Tolerance, Extension Tolerance and RMS check.

4.4.3 RMS Check

This item is for specifying whether the RMS value of the current control response is to be monitored or not during the testing operation.

The following two items are provided for monitoring.

① Alarm Check by Response RMS Value

This system sounds an alarm when the RMS value of the control response exceeds over (or falls below) the defined value of this item.

② Abort Check by Response RMS Value

This system stops the signal output immediately and aborts the testing operation when the RMS value of the control response exceeds over (or falls below) the defined value of this item. The stoppage of the drive signal is done gently. The drive signal is gradually reduced with taking a time that is specified by the set value of 'Shutdown time' in Fundamental/Control Condition.

The method for setting level of the RMS value which is specified to execute 'Alarm/Abort Check' are as follows ;

- Specify the upper level by a relative level to the RMS value of Reference PSD.
- Specify the lower level by a relative level to the RMS value of Reference PSD
- Specify the upper level by an absolute level.

In the case of specifying the level by a relative value, because the level of the RMS value of Reference PSD is changed by the Excitation Level, the level of Alarm/Abort Check is also changed according to it.

4.5 Input Channel

4.5.1 Outline

In this system, there are two types of response input channel ;

- Control channel
- Monitor channel

In this system, all of the used input channels are defined as Monitor channels.

Therefore, Control channels also have the function as Monitor.

Control channels are important one of which response signals are controlled to meet with the control reference.

The physical quantity controlled by each control channel must have the same dimension.

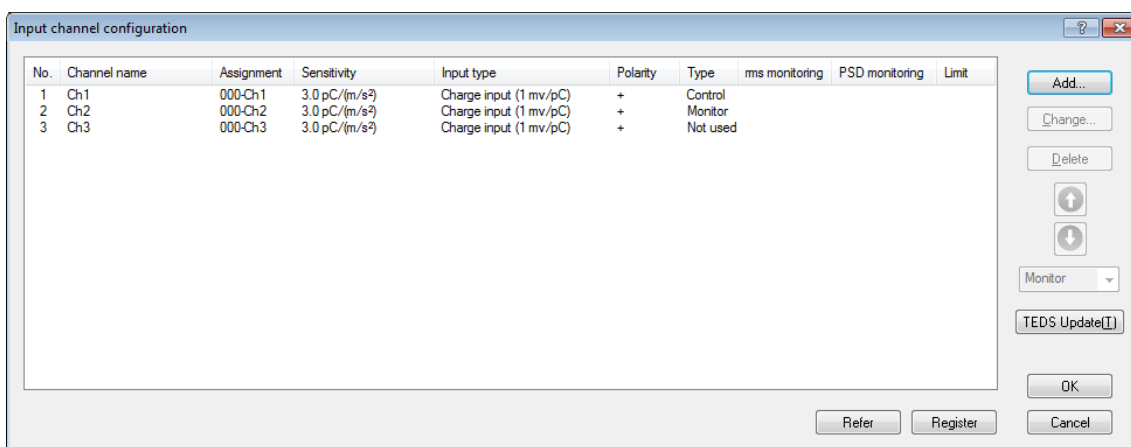
4.5.2 Input Channel

The input channels to be used are set in the definition dialog of Input Channel.

Two setting methods of input channel are available in this system ;

Set the input channel for each test definition

Set the Input Channel Information.



[Add] A new input channel is added.

[Change] The definition contents of an input channel is changed.

[Delete] A selected input channel is deleted from the registration.

[Up] [Down] The registered order of an input channel is corrected. However, the registered order has not much meaning than the order of graph display.

[Not used] The channel is not used.

[Control] The channel is used as a control channel.

[Monitor] The channel is used as a monitor channel.

- [TEDS Update] The input sensitivity is set from the connected TEDS corresponding IEPE sensor automatically. The function is enabled with the TYPEII hardware.
- [Refer] The registered definition contents of input channel configuration is loaded and used.
- [Register] The defined contents of input channel configuration is saved and registered as a file.

4.6 Data Save Condition

4.6.1 Outline

Each item for saving the data measured in test operation to the hard disc is defined.

In

+ system, all the data measured in test operation are saved in a binary file (*.VDF).

Only the data 'In excitation' is storable. The data 'In initial measurement' can not be saved.

Data Save Condition [X]

Save Not save

Specify destination folder

Refer...

Save the test file name as a prefix.

Sequence number

Beginning value

Min. digits number

Periodic save sec

Exc. level dB over

Reset timer at 0dB

Save at testing completion.

OK Cancel

4.6.2 Saving Condition

Saving conditions are described as below ;

1. "Save" & "Not save" buttons

Select "Save" to save the data file automatically and select "Not save" if it is not necessary to save the data.

2. Specify the destination folder

Specify the destination folder for the data file. Press the "Reference" button and specify the folder.

If the destination folder was not specified, the data file will be saved in the folder for the test file.

3. Use the test file name as prefix

A common word can be added as a prefix in the head of the data file name. The default setting of this item is 'Data'. The save file name can be changed by canceling the check of this item.

4. Sequence number

Sequence numbers is given to the data file being added a prefix.

Beginning value : The beginning number of data is specified.

Example) When this item is specified as '1' → 'Data001.VDF'

Min. digits number : The digits number of sequence is specified.

Example) When this item is specified as '2' → 'Data01.VDF'

5. Save after a specified interval

This function is for automatic saving of the data on specified time (seconds).

Time count of periodic saving starts after test status becomes 'In excitation' regardless of excitation level.

(1) Excitation level

Set the excitation level to save the data of testing at the set excitation level or higher levels. Set the excitation level for the data to save. If the excitation level has lowered below the setting, the time count of periodic saving will be reset once, and then counted again from 0 second when the excitation level has reached the set level or higher next time.

(2) Reset timer at 0dB

Check 'Reset timer at 0dB' to reset the periodic saving timer and count from 0 sec when the excitation level has reached 0dB.

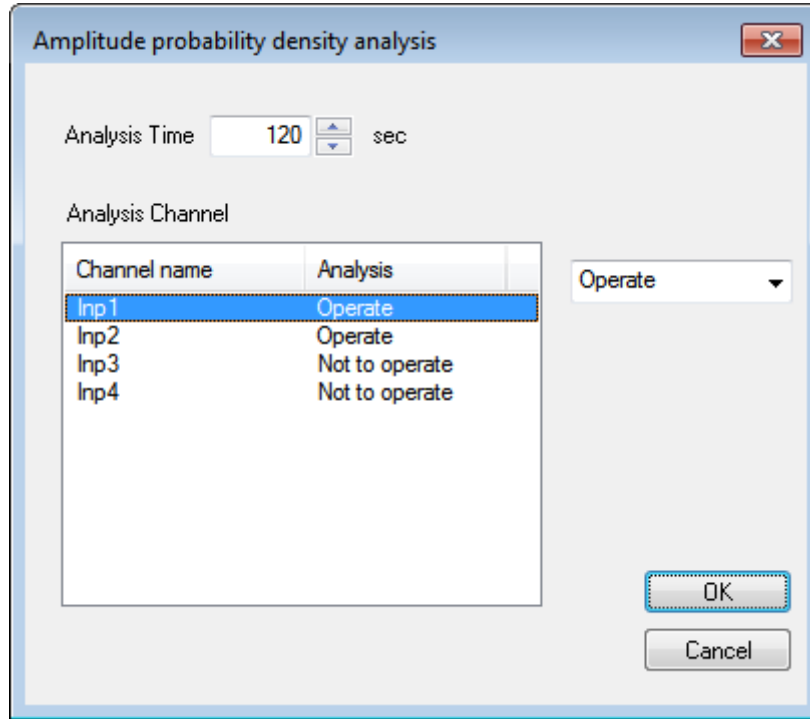
6. Auto-save at testing completion

This function is for automatic saving of the data when the test is completed or when the test is aborted by operator.

4.7 Amplitude probability density analysis

4.7.1 Outline

This item is for setting of analysis time and for selecting input channels to analyze amplitude probability density.



<Analysis Time >

The time of analyzing amplitude probability density is specified.

<Analysis channel>

Input channel to analyze amplitude probability density is selected.

Limitations shown below are applied depending on the input channel type.

| | |
|---------|--|
| Monitor | Only 'Not to operate' is available. |
| Control | Selection between 'Operate' and 'Not to operate' is allowed. |

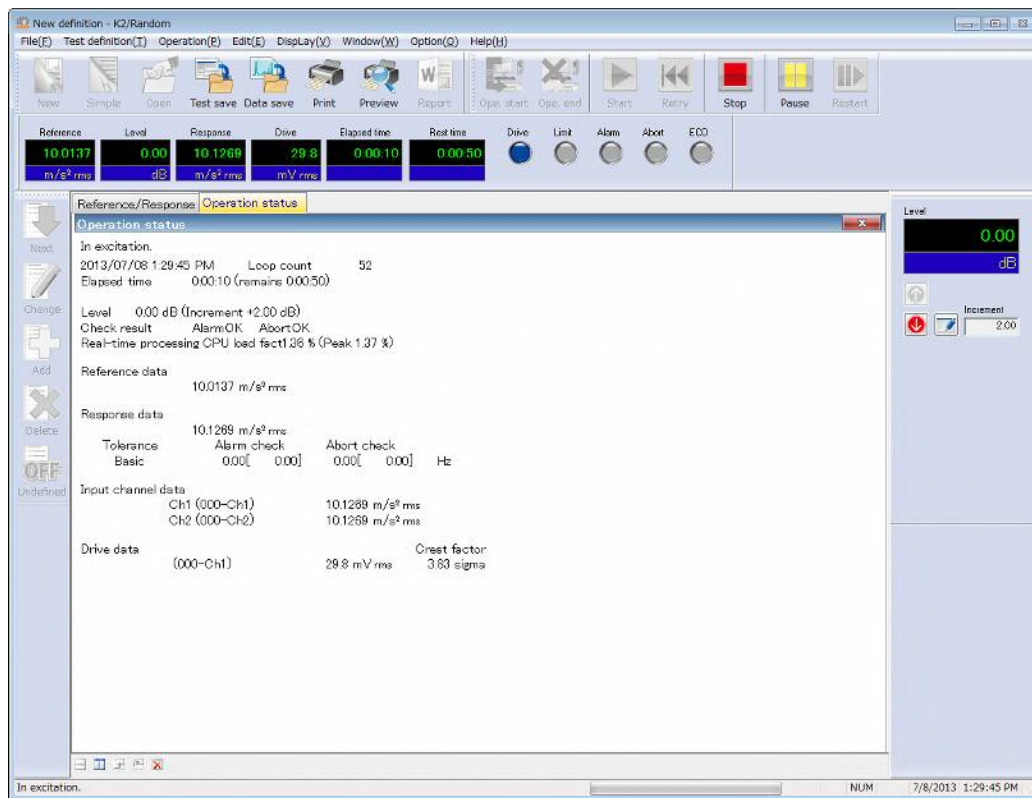
4.8 Operation Status

(1) Meaning

The information concerning to the excitation operation is displayed in this dialog.

Some information in this display are renewed at every control loop time depending on the conditions.

< Random Test >



< Display Contents >

(1) Current status

The message of the current status of the system is displayed.

'In excitation', 'Pause', 'Excitation is completed', [Test is stopped by the command of operator], etc.

(2) Loop count

The count of the control loop is displayed.

(3) Elapsed time

The elapsed time of the test excitation at '0 dB' is displayed. (The time counting is stopped under the '0 dB'.)

(4) Level

The current excitation level is displayed.

(5) Check result

All the results of the checks (such as each checks for the control response, the result of the check for the output drive and each checks for the monitor response) are totally displayed.

(6) Real-time processing CPU load factor

The current CPU load factor is displayed.

(7) Reference data

The current control reference level is displayed.

(8) Response data

The current control response level is displayed.

(9) Response check

The results of Tolerance Check for the control response and the RMS check are displayed.

(10) Input channel data

The information of each input channel data (RMS value, etc.) in the current control loop is displayed. If the limit control is used, the operation status is displayed. Detailed results of each check operated at the input channels are displayed too.

(11) Drive

The drive output voltage generated currently is displayed.

4.9 Safety check

4.9.1 Outline

The screenshot shows a dialog box titled "Safety check definition". It has a close button in the top right corner. The dialog contains the following elements:

- Frequency range: 50.00 <==> 1200.00 Hz
- Excitation force check
 - Specimen mass: 10.0 kg
 - Table mass: 0.0 kg
 - Fixture mass: 0.0 kg
 - Other mass: 0.0 kg
 - Armature mass: 74.0 kg
 - Total mass: 84.0 kg

On the right side of the dialog, there are four buttons: "OK", "Cancel", "Register(R)...", and "Refer(E)...".

The system has the feature of Rating check*¹ to evaluate whether the defined test can be performed on the excitation system as a protective feature. The safety check expands this protective feature and makes it possible to use the excitation system more safely.

(1) Excitation force check

This check is made to evaluate whether the excitation force required for the test is held within the excitation system rating.

The excitation force F required for the test is calculated with the formula shown below.

$$F = M a$$

a : rms value of reference acceleration PSD

M : Total mass

The total mass M is the sum of "Specimen mass, Table mass, Fixture mass and Other mass" entered in this dialog box and the "Armature mass" specified in the system rating information.

The excitation force check is effective only if the controlled variable was the acceleration. Notes on the SOR test)

The excitation force F is calculated based on the total acceleration of broad band random and sine. Because SOR is a combination of a random test and a sine test, a check is made to evaluate whether the peak value of excitation force F and the rms value are within the rated SINE excitation force and the rated RANDOM excitation force, respectively.

Similarly, the rating checks for the velocity and displacement are also performed based on the total value of broad band random and sine.

Notes on the ROR test)

The excitation force F is calculated in rms value of acceleration for the composite PSD of broad band and narrow band random. This composite PSD is equivalent to the reference PSD displayed at the completion of definition.

Similarly, the rating checks for the velocity and displacement are also performed based on the composite PSD.

(2) Frequency range check

This check is made to evaluate whether the frequency range of reference is within the usable frequency range.

Although there is a similar protective feature of “control frequency range” setting in the excitation system information, this is a feature to perform this check for each test.

While the usable frequency range for the excitation system is defined, it may be limited depending on the characteristics of specimen and fixture etc.. Use this feature in such cases.

Notes on the SOR test)

In addition to the broad band random reference, the sine reference is also subjected to the check.

Notes on the ROR test)

In addition to the broad band random reference, the narrow band random reference is also subjected to the check.

[Refer] : The registered definition contents of Safety check is loaded and used.

[Register] : The defined contents of Safety check is saved and registered as a file.

*1 Feature of standard rating check

1) This check is made to evaluate whether the reference level is held within the excitation system rating. If the controlled variable was the acceleration, the velocity and displacement will also be checked.

In case of the SOR and ROR tests, only the broad band random will be subjected to the check.

2) If a “control frequency range” was specified in the excitation system information, a check is made to evaluate whether the frequency range of reference is within the “control frequency range.”

In case of the SOR and ROR tests, only the broad band random will be subjected to the check.

Note)

When specimen and/or fixture is attached to the armature, it may occur that the required acceleration level can not be reproduced within the usable frequency range because of resonance or anti-resonance of the attached specimen and / or fixture.

4.10 Aux. Output

4.10.1 Outline

Aux-output is a function for real-time outputting the information for the control operation as analog signal.

The following output information can be outputted DC voltage which indicates the quantities (Log / Linear) as Aux- output ;

- Control reference level for each input channels[rms]
- Control response level for each input channels[rms]
- Drive voltage level[rms]
- Monitor response level for each input channel[rms]

4.10.2 Fundamental Operation Example

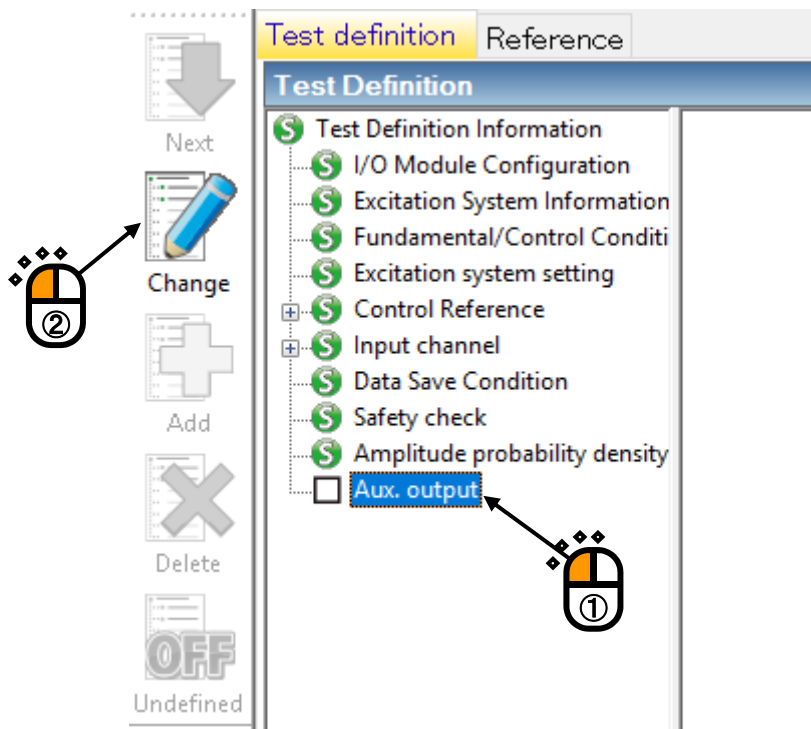
< Example >

Monitor response level (unit : acceleration, range : 1 ~ 100[m/s²]) of input channel Ch2 is to be outputted as DC voltage (range : 1 ~ 100[mV], log) . However, output channel Ch2 is used as an aux-output.

< Procedures >

< Step 1 >

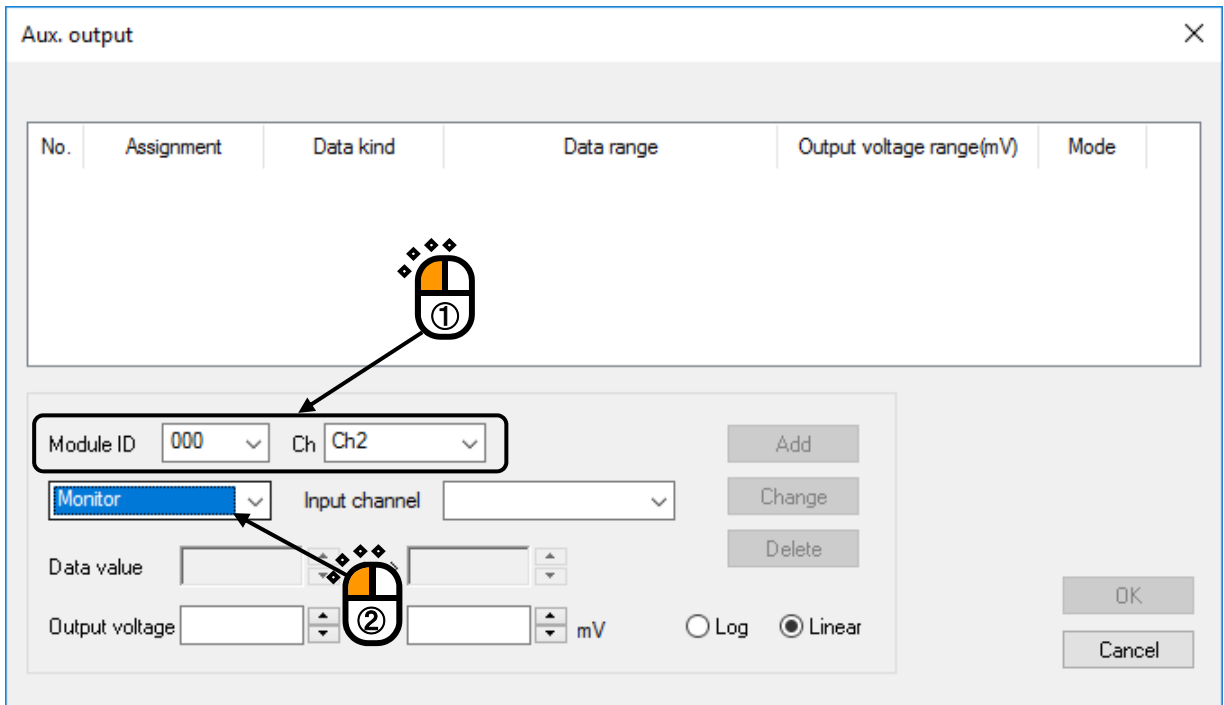
Check the check box of 'Aux. output' and press the button of [Change].



< Step 2 >

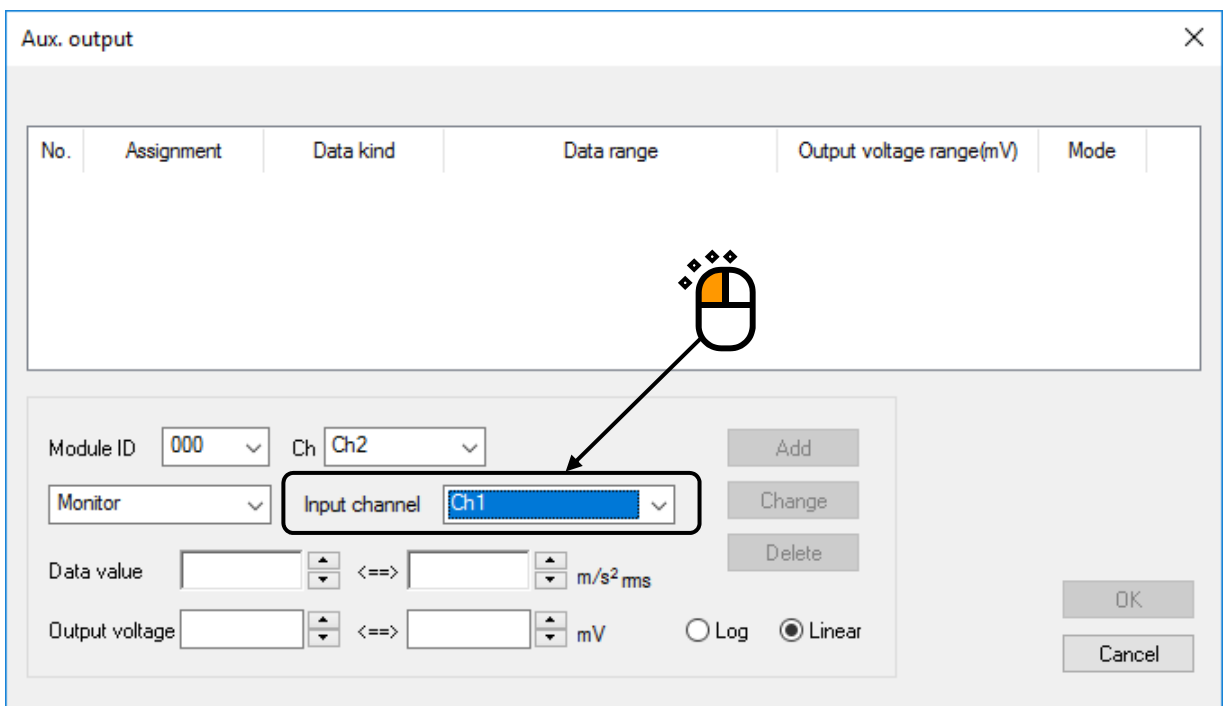
Set the 'Module ID' of I/O board and output channel 'Ch2'.

Select the item of 'Monitor'.



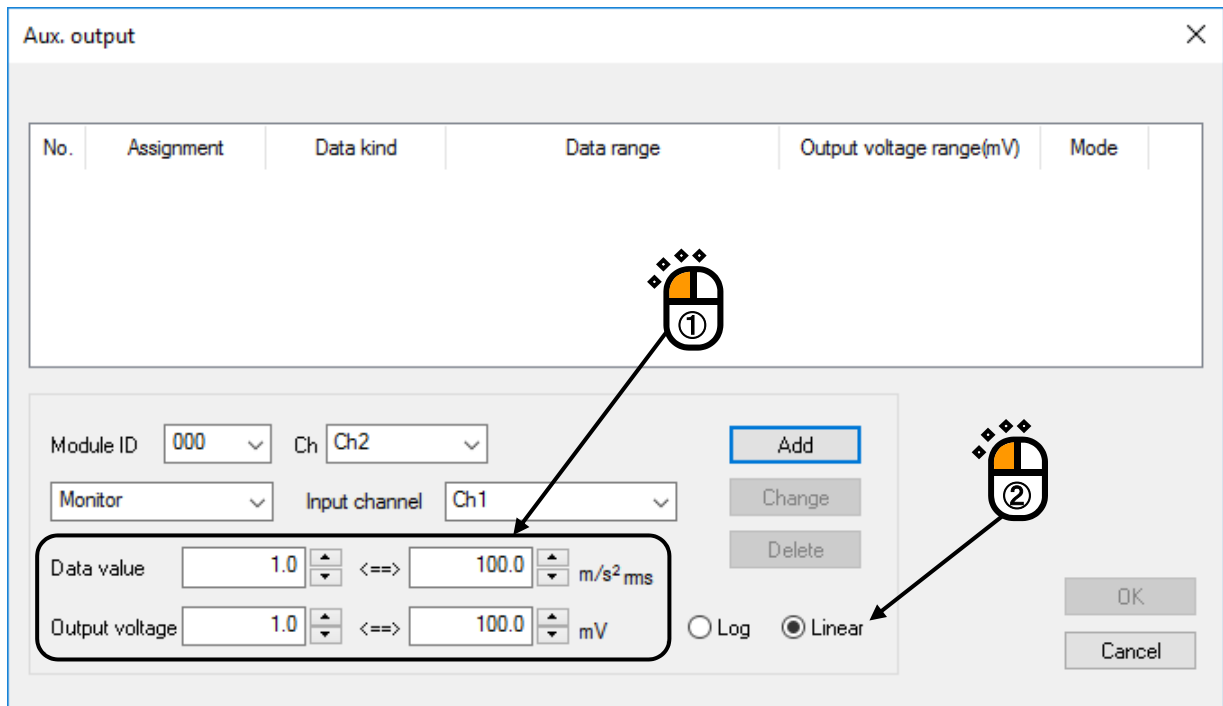
< Step 3 >

Set 'Ch1' to input channel.



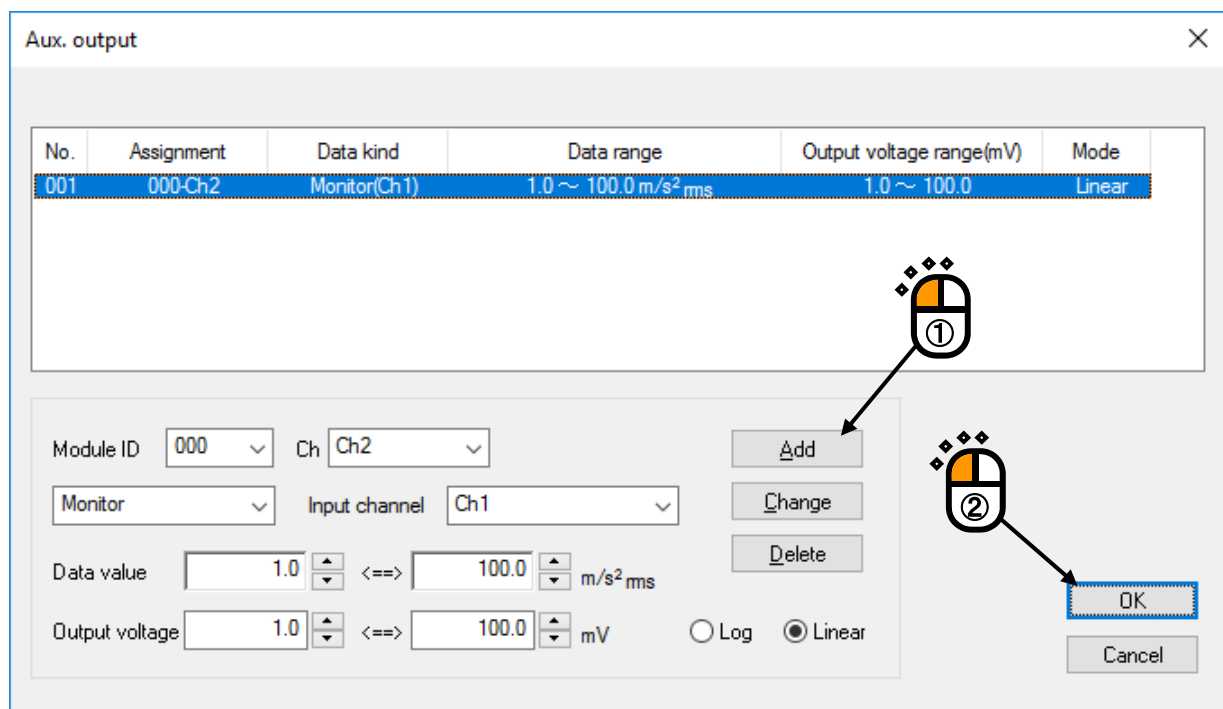
< Step 4 >

Input the values to Data range (1 ~ 100 [m/s²]) and DC Output voltage range (0 ~ 100 [mV]).
Select the item of 'Linear'.



< Step 5 >

Press the button of [Add]. Exit from the definition of Aux-output by pressing the button of [OK].



Chapter 5 Message and Meanings

5.1 K2+ Random Error Message

| Message | Meaning / Action |
|--|--|
| <p>Unusual phenomenon is detected by loop check.</p> | <p>(Meaning)</p> <p>The test operation is aborted due to the error in Initial loop check. The detail about the error is displayed at the input channel in which an error detected in Operation status.</p> <p>A) Too much Environment noise is detected. [1] [2] [4] Too small response in Initial loop check or too much noise in non-excitation is judged as an unusual phenomenon.</p> <p>B) Loop open is detected. [1] [2] [5] Sudden decrease of response characteristics is judged as an unusual phenomenon in operation.</p> <p>C) Too much response is detected. [1] [3] [5] Sudden increase of response characteristics is judged as an unusual phenomenon in operation.</p> <p>D) Over load is detected. [1] [6] [7] [8] A signal having an exceeded level over the maximum input value of the hardware (at voltage input : $\pm 10V$, at charge input : $\pm 10000pC$ or $\pm 1000pC$) is inputted to the input channel.</p> <p>(Action)</p> <p>Check the following points at first.</p> <ul style="list-style-type: none"> • Mistake in system cabling • Incorrect definition of I/O channel information, such as sensitivity and input format. • Cable disconnection • Incorrect installation of the pickups • Unusual condition of the excitation system. • Unusual condition of the specimen. <p>After checking the points in the above, the treatments for each error are to be done according to the specified numbers.</p> <p>[1] Set the Loop check in Fundamental/Control Condition to 'Loose'.</p> <p>[2] Increase the value of initial output voltage in Excitation System setting.(If error occurred in Initial measurement or in Initial equalization)</p> <p>[3] Decrease the value of initial output voltage in Excitation System setting.(If error occurred in Initial measurement or in Initial equalization)</p> <p>[4] Set the Loop check to 'Specify' and increase the Ambient noise</p> |

| Message | Meaning / Action |
|--|---|
| | <p>upper limit value in Fundamental/Control Condition.</p> <p>[5] Set the Loop check to 'Specify' in Fundamental/Control Condition and set as follows.</p> <ul style="list-style-type: none"> • If error occurred in Initial measurement or in Initial equalization Increase the value of 'Transmissibility check value (in initial excitation)'. • If error occurred in excitation Increase the value of 'Transmissibility check value (in test operation)'. <p>[6] At charge input, set the input type of input channel to 'Charge Input (1mV/pC)'.</p> <p>[7] Change the sensor to lower sensibility one.</p> <p>[8] Set the Loop check to 'Specify' and increase the Overload check value in Fundamental/Control Condition.</p> <p>Note: This treatment is done only for not aborting test operation, when the response signal is over the input range a little. In this case, the controlling and measuring has some difficulties for an accuracy.</p> |
| <p>Test is aborted by Abort check.</p> | <p>(Meaning)</p> <p>The test operation is aborted for an error detected by various abort checks in operation. The content of error is displayed in Operation status.</p> <p>A) Test is aborted by Abort check. [1] [2] [3] [5] [6] [7] [8] The test operation is aborted for an error detected by various Tolerance checks.</p> <p>B) Test is aborted by Abort check [Drive]. [4] [5] [6] [7] [8]</p> |

| Message | Meaning / Action |
|---------------------------|--|
| | <p>The test operation is aborted for requiring of the output voltage exceeding over the 'Output voltage limit value' of Excitation System setting in operation.</p> <p>(Action)</p> <p>Check the following points at first.</p> <ul style="list-style-type: none"> • Mistake in system cabling • Incorrect definition of I/O channel information, such as sensitivity and input format. • Cable disconnection • Incorrect installation of the pickups <p>After checking the points in the above, the treatments for each error are to be done according to the specified numbers.</p> <p>[1] Change the set value of Tolerance.</p> <p>[2] Change the setting of Equalization Mode in Fundamental/Control Condition.</p> <p>[3] Change the setting of Averaging Parameters in Fundamental/Control Condition.</p> <p>[4] Change the setting of Output voltage limit value and the Abort ratio in Excitation System Setting.</p> <p>[5] Recheck of Control point.</p> <p>[6] Recheck the pickups used in the system.</p> <p>[7] Recheck the pattern of the test.</p> <p>[8] Recheck the construction of fixture.</p> |
| Failed in initialization. | <p>(Meaning)</p> <p>An error is detected in initialization of I/O unit executed prior to the test operation.</p> <p>(Action)</p> <ul style="list-style-type: none"> • The power of I/O unit is not set ON. • Between the PC and I/O unit is not connected. • Incorrect connection of I/O unit board. • Incorrect connection of K2+ I/F board. • Incorrect action of Driver. <p>Check the above points and retry the testing operation for several times. If these errors occur even after checking the above points, please contact with IMV.</p> |

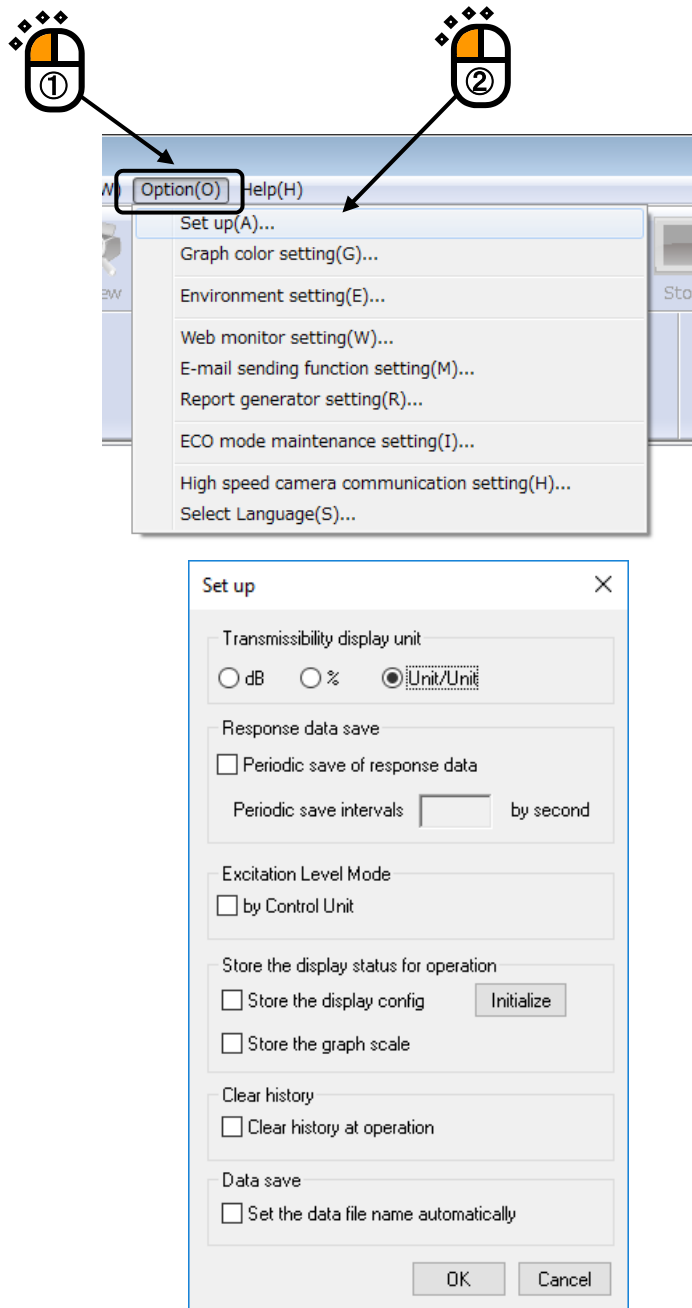
| Message | Meaning / Action |
|--|--|
| The license required for operating the program is not found. | <p>(Meaning) An error is detected in K2+ Protect information check.</p> <p>(Action)</p> <ul style="list-style-type: none"> • License information • Incorrect action of I/O port (COM or LPT) of the PC connected to the protect devise. • Incorrect connection of the protect devise board. <p>Check the above points and retry the testing operation for several times. If these errors occur even after checking the above points, please contact with IMV.</p> |
| Hardware error | <p>(Meaning) An error is detected in the PC or I/O unit.</p> <p>(Action)</p> <ul style="list-style-type: none"> • The power of I/O unit is not set ON. • Between the PC and I/O unit is not connected. • Incorrect connection of I/O unit board. • Incorrect connection of K2+ I/F board. • Incorrect action of Driver. <p>Check the above points and retry the testing operation for several times. If these errors occur even after checking the above points, please contact with IMV.</p> |
| Test is aborted by CPU load. | <p>(Meaning) Test operation is aborted because too much loading is detected in operation.</p> <p>(Action)</p> <ul style="list-style-type: none"> • Exit form the other applications than K2+ executed by the system when they are used. • Decrease the value of Frequency range in Fundamental/Control Condition. • Decrease the value of Control frequency lines in Fundamental/Control Condition. • Decrease the numbers of channel to be used. <p>Check the above points.</p> |

Chapter 6 Supplemental Explanation

6.1 Set Up

<Procedures>

Select [Option] in the menu bar and click [Set up]. A dialog of 'Set up' appears.



[Transmissibility display unit]

This item is for selecting the display unit of amplitude value in Transmissibility Graph.

This unit selected in this item is valid only for the transmissibility graphs calculated from the two data giving the same unit.

In case that the transmissibility graph is calculated from the two data having different units, the display unit of amplitude always appears as 'Unit/Unit'.

[Response data save]

The data of Elapsed time, Excitation level, Reference, Control response and Monitor response are saved as CSV file in time series.

The CSV files are generated according to the rule as below.

Test file name XXX-Y.CSV

XXX : The number of data which is numbered serially in the order of testing operation.

Y : The data lines available to be saved in a file are 65536. When the number of data lines exceed over 65536, the file is automatically generated by incrementing the trailing serial number.

The CSV file format to generated are shown as below.

| | Col. No1 | Col. No.2 | Col. No.3 | Col. No.4 | Col. No.5 | Col. No.6 | |
|----------|-----------------------|---------------------|----------------------|---------------------|----------------------------|---------------------------|-------|
| Row No.1 | <i>Time</i> [Sec.] | <i>Elapsed time</i> | <i>Level</i> [dB] | Reference [Unit] | Control response [Unit] | Monitor channel [Unit] | ..... |
| Row No.2 | ***, | **:*:*:**, | ***, | ***.***, | ***.***, | ***.***, | ..... |
| | ***, | **:*:*:**, | ***, | ***.***, | ***.***, | ***.***, | |
| | : | : | : | : | : | ***.***, | : |
| | ***, | **:*:*:**, | ***, | ***.***, | ***.***, | ***.***, | |

- "Time", "Elapsed time" and "Level" are the fixed characters.
- Time data is substituted in Column No. 1.
- Elapsed time data is substituted in Column No. 2.
- Excitation level data is substituted in Column No. 3.
- Reference data is substituted in Column No. 4.
- Control response data is substituted in Column No. 5.
- Monitor response data is substituted in Column No. 6.

[Excitation Level Mode]

'By Control Unit' check box

Excitation level can be specified by the reference unit when this item is set.

By specifying an excitation level by the reference unit, the unit of Increment is set by the reference unit (rms value). So that, the level can be changed to up or down every '1 m/s²_{rms}'.

[Store the display status for operation]

- ‘Store the display config’ check box

Check ‘Store the display config’ to store the display configuration during testing. Display configuration is stored for each test type. If the display configuration is stored, graphs and others based on the same settings as those for the previous testing will be displayed during next testing. Uncheck ‘Store the display config’ not to store the display configuration modified thereafter.

- ‘Store the graph scale’ check box

Check ‘Store the graph scale’ to store the scale of the displayed graphs during testing. The graph scale is stored for each test type. If the graph scale is stored, graphs based on the same scale as those for the previous testing will be displayed during next testing. Uncheck ‘Store the graph scale’ not to store the graph scale modified thereafter.

- ‘Initialize’ button

Select ‘Initialize’ to format the display configuration and the graph scale.

[Clear history]

- ‘Clear history at operation start’ check box

Check ‘Clear history at operation start’ to clear the history of earlier times at operation start automatically.

[Data save]

- ‘Set the data file name automatically’ check box

Check ‘Set the data file name automatically’ to set the destination folder and the file name automatically. If this item is checked, a dialog of [Save as] doesn’t appear even if [Data save] is selected from the menu or the tool bar. The data file name is set to the name of the test definition file plus a 3-digit sequence number, and is saved in the same folder as the test definition file.

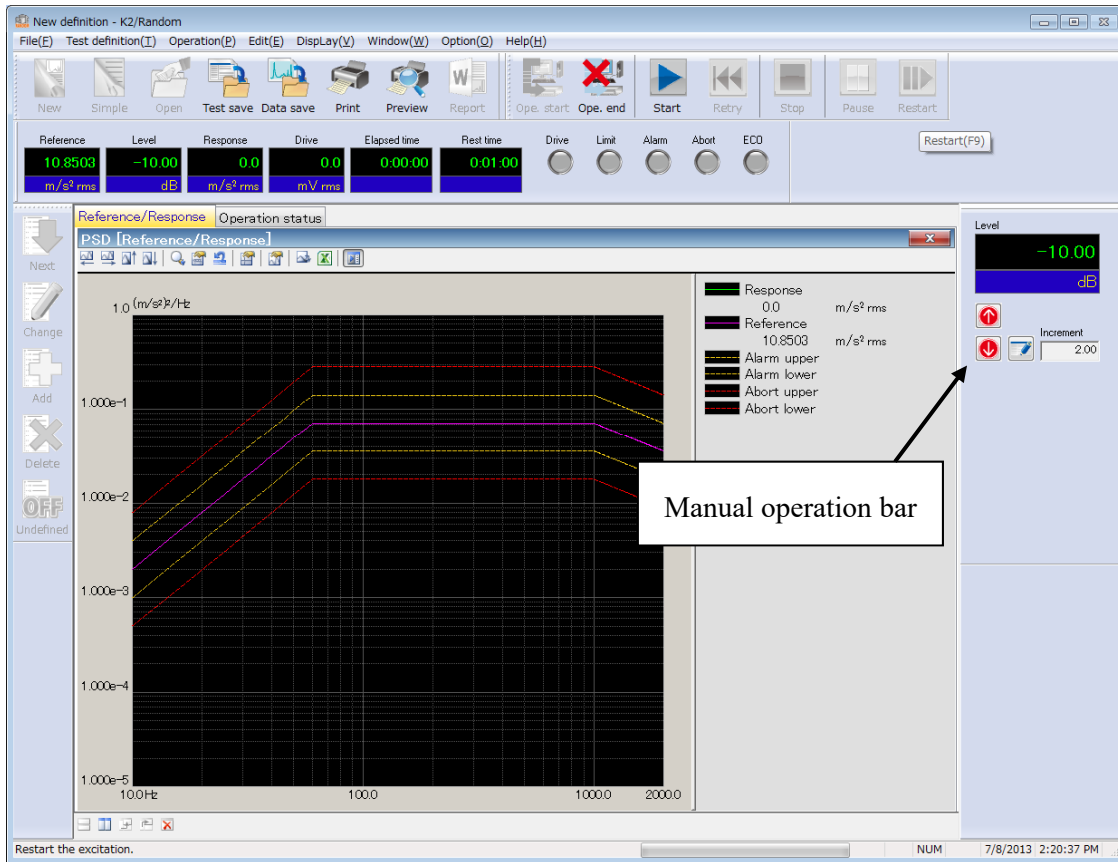
Example) When the test definition file is “C:/K2Data/RandomTest.ran2”,
the data file is saved with the name “C:/K2Data/RandomTest001.vdf2”.

If the same name exists, it is saved with the name increased by one sequence number.

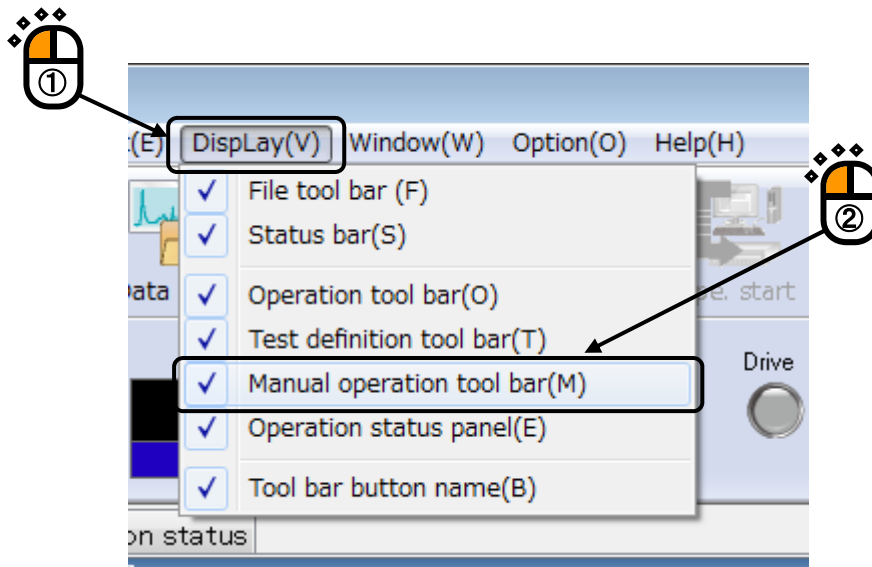
If this item is unchecked, a dialog of [Save as] appears and it is possible to select the folder and the file name as desired.

6.2 Manual Operation

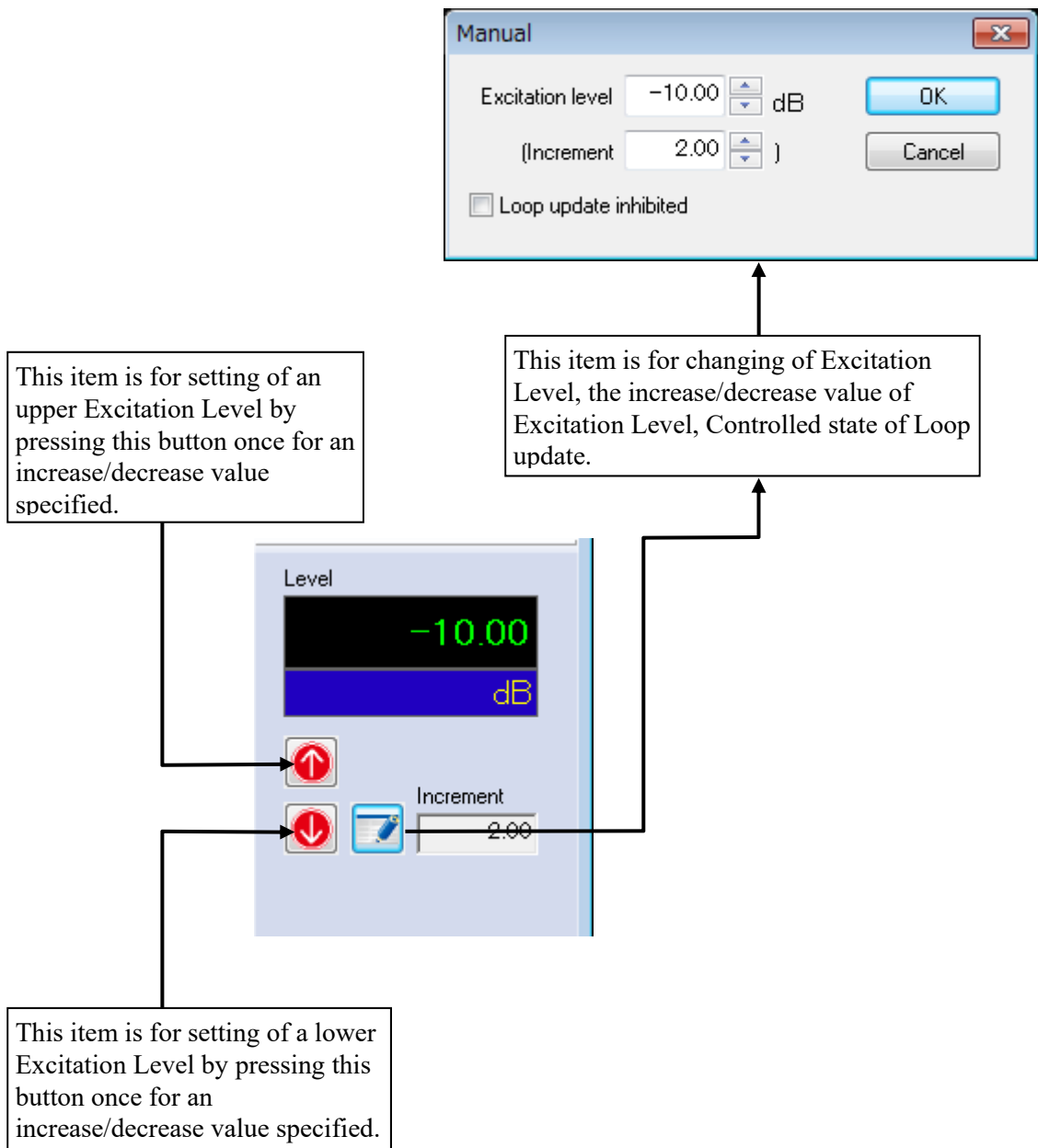
Control Reference can be changed during the excitation operation by using Manual operation bar. Manual operation bar is at right side of window.



If Manual operation bar is not displayed, select [Display] in the menu bar and click [Manual operation tool bar]. Manual operation tool bar appears.



< Items in Manual Operation (RANDOM) >



INDEX

A

| | |
|--|-----------|
| Abort Ratio | 4-13 |
| Ambient noise upper limit | 4-6 |
| Amplitude | 4-30 |
| Amplitude probability density | 4-45 |
| Amplitude probability density analysis | 4-1, 4-45 |
| Analysis Time | 4-45 |
| Auto-start | 4-8 |
| Aux. Output | 4-1, 4-50 |
| Averaging Parameters | 4-4 |

B

| | |
|----------------------------------|------------|
| Band width | 1-4, 1-5 |
| Break Point PSD Definition | 4-15, 4-16 |
| By Control Unit | 6-2 |

C

| | |
|--|---------------|
| Calculation | 4-33 |
| Calculation value | 4-33 |
| Clear history | 6-3 |
| Clear history at operation start | 6-3 |
| Clipping | 4-12 |
| Control frequency lines | 3-5, 4-2, 5-4 |
| Controlled variable | 4-3 |
| CSV data file | 4-24, 4-38 |
| Cut-off frequency | 4-30 |

D

| | |
|------------------------------|------------|
| Data edit | 4-29 |
| Data editing | 4-35, 4-37 |
| Data length change | 4-35 |
| Data length conversion | 4-35, 4-36 |
| Data save | 6-3 |

E

| | |
|---------------------------------|-----------|
| Edging | 4-31 |
| Environment noise | 5-1 |
| Equalization Mode | 4-5, 5-3 |
| Excitation force check | 4-48 |
| Excitation Level Mode | 6-2 |
| Excitation System setting | 5-1 |
| Excitation System Setting | 4-12, 5-3 |

| | |
|--|------------------------------------|
| Extended ROR Test..... | 2-3 |
| F | |
| Filter order..... | 4-30 |
| Filter slope..... | 4-30 |
| Filtering..... | 4-28, 4-29, 4-30 |
| Frequency range..... | 3-5, 4-2, 4-3, 5-4 |
| Frequency range check..... | 4-49 |
| Frequency ratio..... | 1-3, 1-4 |
| Frequency resolution..... | 4-30 |
| Fundamental Operation Example..... | 4-50 |
| Fundamental/Control Condition..... | 4-1, 4-2, 4-17, 5-1, 5-2, 5-3, 5-4 |
| G | |
| Graph Data File..... | 2-2 |
| H | |
| High Pass Filter..... | 4-14 |
| HPF..... | 4-19, 4-22, 4-23 |
| I | |
| Initial loop check..... | 3-33, 5-1 |
| Initial output level..... | 4-7 |
| Initial output voltage..... | 4-12 |
| Input channel..... | 1-1, 1-5, 2-2, 3-1, 3-3, 4-47 |
| L | |
| Level increment..... | 4-8 |
| Level ratio..... | 1-3, 1-4 |
| Loop check..... | 4-5, 4-6 |
| LPF..... | 4-19, 4-21, 4-22 |
| M | |
| Manual Operation..... | 6-4, 6-5 |
| Max. Observation Frequency..... | 4-3 |
| Measured PSD Definition..... | 4-16, 4-19 |
| Measured waveform..... | 4-26, 4-27 |
| Measured waveform definition..... | 4-15, 4-25 |
| Module ID..... | 4-51 |
| O | |
| Observation freq. can be set within the Reference freq. range..... | 4-11 |
| Operation status..... | 2-1 |
| Output voltage limit value..... | 4-13 |
| Overload check value..... | 4-7 |
| P | |
| Pause before transitioning to In excitation..... | 4-11 |

| | |
|--|---|
| Processing type | 4-35, 4-36, 4-37 |
| PSD Data File Load | 4-20 |
| PSD Data Processing | 4-21 |
| PSD definition | 3-8, 4-15 |
| R | |
| Random test | 3-2 |
| Rating check | 4-48, 4-49 |
| Reference PSD | 4-15, 4-25 |
| Response data save | 6-2 |
| rms change | 4-18, 4-24 |
| ROR Test | 2-3 |
| S | |
| Safety check | 4-1, 4-48 |
| Scalar calculation | 4-28, 4-33 |
| Set the data file name automatically | 6-3 |
| Set Up | 6-1 |
| Shutdown time | 4-8, 4-9 |
| Simplified Definition | 3-22 |
| Slope | 3-9, 3-10, 3-25, 3-26, 4-18, 4-23 |
| SOR Test | 2-3 |
| Store the display config | 6-3 |
| Store the display status for operation | 6-3 |
| Store the graph scale | 6-3 |
| Sweep pause time | 1-3, 1-4, 1-5 |
| Sweep rate | 1-3, 1-4, 1-5 |
| Sweep start frequency | 1-3, 1-4, 1-5 |
| T | |
| Test file | 2-2, 4-1 |
| Test time | 1-3, 1-4, 1-5, 3-1, 3-6, 3-20, 4-7 |
| Test type | 3-2, 4-1 |
| Tolerance | 1-1, 1-3, 1-4, 1-5, 4-5, 4-39, 4-40, 4-47, 5-2, 5-3 |
| Transmissibility check value [in initial excitation] | 4-6 |
| Transmissibility check value [in test operation] | 4-7 |
| Transmissibility display unit | 6-1 |
| Type of Filter | 4-29 |
| W | |
| Waveform data file load | 4-26 |