Non-Gaussian Random Vibration Control System

K2/ NON-GAUSSIAN
K2Sprint/ NON-GAUSSIAN

Instruction Manual

Limitation of K2Sprint/NON-GAUSSIAN

・Maximum numbers of usable input channel are ‘2’ channels.

・Option of LIMIT CONTROL can not be added.

IMV CORPORATION

Type of Document : Instruction Manual

System Applied : K2/K2Sprint

Software < NON-GAUSSIAN > Later than Version 14.6.0

Japanese Edition

Version	Date	Contents
10.0.0	2016.02.29	First edition
10.0.1	2016.03.02	Correction of a misprint
13.0.0	2016.04.28	Correction of a misprint
14.3.0	2019.04.19	Modified description of Data save condition, correction of misprints
14.6.0	2020.04.15	Correction of a misprint

English Edition

Version	Date	Contents
13.0.0	2016.04.28	First edition
13.0.1	2017.09.28	Correction of misprint
14.3.0	2019.04.19	Modified description of Data save condition, correction of misprints
14.6.0	2020.04.15	Correction of a misprint

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Chapter 1　Outline of the System

1.1 Outline

K2/NON-GAUSSIAN is an option of **K2/RANDOM.**

Vibration test is conducted to verify that the designed performance and functions of a product can be maintained until it is discarded by artificially giving it dynamic stress which is assumed to be given during the life cycle of a product. The test result greatly depends on the type and method of artificial stress to be given to the product. Therefore, vibration to be given artificially in the vibration test is preferable to be similar to that in actual vibration environment. For these reasons, sinusoidal vibration has been used for most of vibration tests for the last few decades. However, random vibration has become mainstream recently, since it is closer to actual vibration.

In this random test, Gaussian random vibration in accordance with Gaussian distribution (normal distribution) is used. However, analysis of measured vibration including vibration during transportation often reveals the vibration to be non-Gaussian random vibrationwhich generates higher peaks, not Gaussian random vibration.

Non-Gaussian random controller reproduces such non-Gaussian random vibrations more precisely. In the non-Gaussian random test, higher peaks are generated than in the conventional random test. Thoroughly understand the nature of non-Gaussian random test, review the protection of specimen and vibration system, considering varied protective functions provided for this system, and conduct the test carefully.

It should be noted that the reproduction of non-Gaussian random vibration having the same characteristics as measured vibration is difficult in general. This is because there are many types of non-Gaussian random vibration having varied characteristics while the characteristics of Gaussian random vibration are uniquely defined.

1.1.1 Index indicating characteristics of random vibration

Following two types of indexes indicating characteristics of random vibration are used in normal random test.

- Power spectral density (PSD)
- rms value

In non-Gaussian random test, following two parameters are added as indexes indicating non-Gaussian.

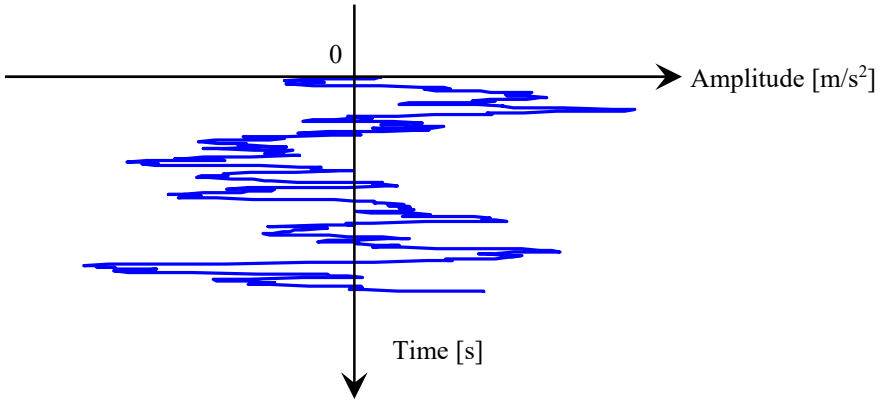
- Kurtosis
- Skewness

‘Kurtosis and Skewness’, a kind of statistic, the same as rms value, is indicated by numerical value as ‘5’. Although rms value is easy to understand immediately as a value to indicate ‘magnitude of vibration’, ‘Kurtosis and Skewness’ may be hard to be understood immediately. To understand ‘Kurotosis and Skewness’, it is necessary to understand how characteristics of random vibration are evaluated.

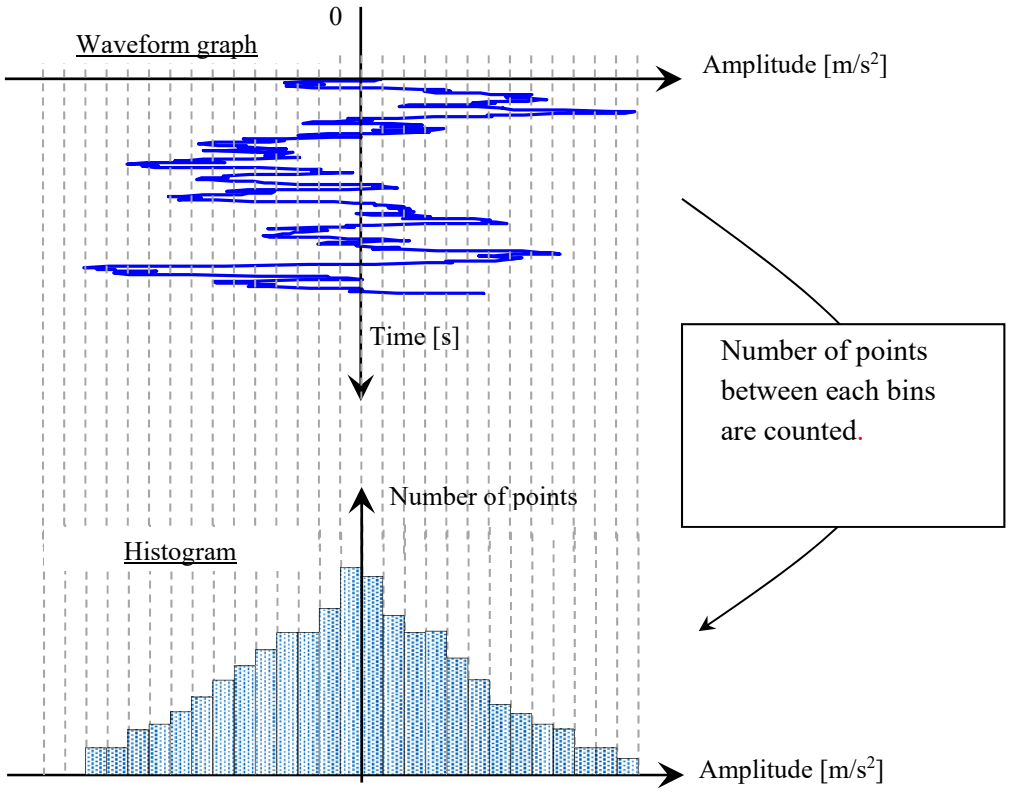
1.1.2 Amplitude probability density

Amplitude probability density (function) indicates the distribution states of random vibration amplitude (magnitude) to evaluate the characteristics of random vibration.

In the graph below, normal waveform graph is turned clockwise by 90°, and amplitude values are on the horizontal axis, while time values are on the vertical axis.



Horizontal axis in this graph is divided into fixed intervals, like scales (grids), as shown below. In the histogram shown below, the number of points counted on the waveform between the bins are plotted for each amplitude level.



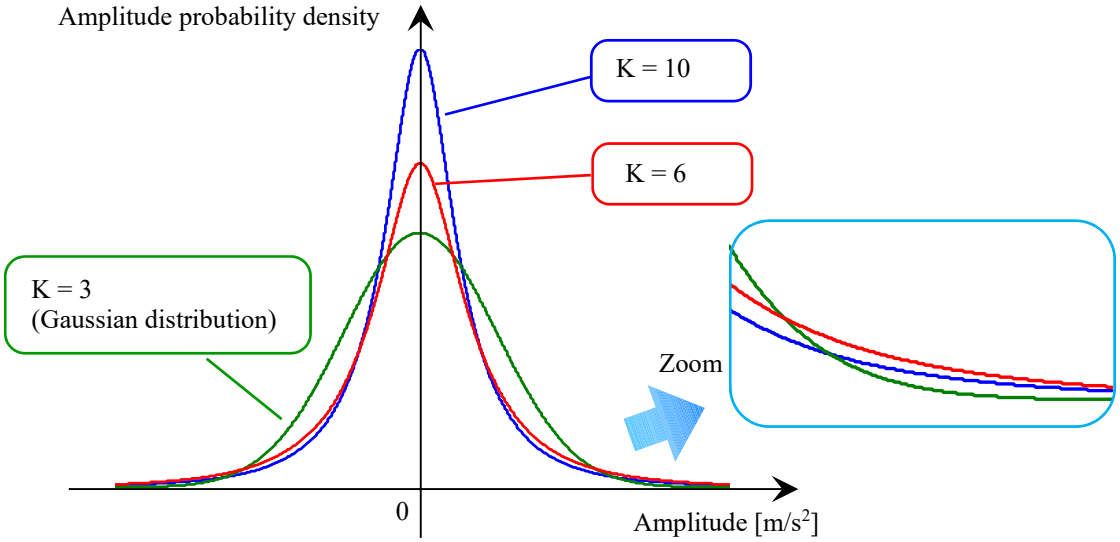
However, shape of histograms cannot be compared because the number of points is greater as the waveform is longer (as the test time is longer). Amplitude probability density is the histogram that the number of points at each amplitude level is normalized by using the total number of points. And amplitude probability density facilitates the comparison of histograms.

1.1.3 Kurtosis

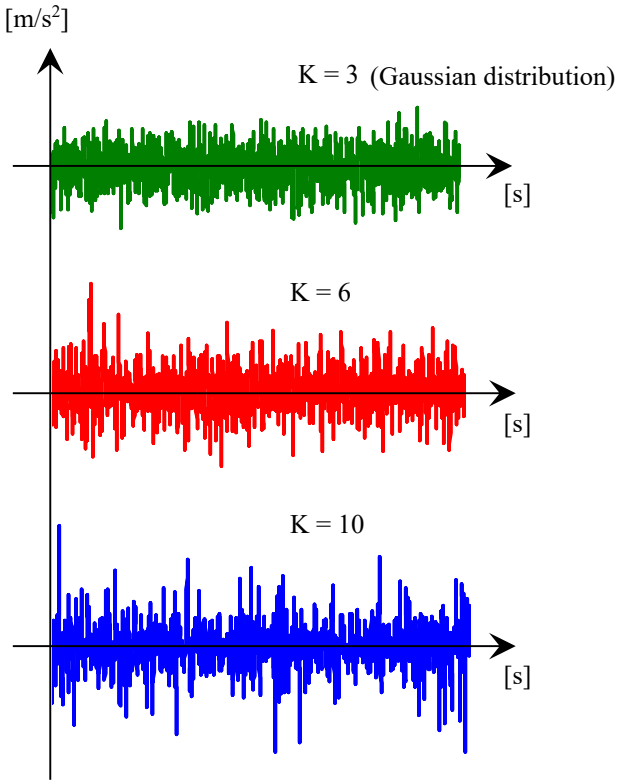
Kurtosis (peakedness) indicates the density extent of amplitude probability density in the vicinity of zero (average value), and it also indicates the peakedness in the area close to zero.

As kurtosis is larger, the peakedness in the area close to zero is enhanced, and the tail is thicker. As the tail is thicker, the peak of random vibration is higher. Kurtosis of Gaussian distribution is "3".

Amplitude probability density examples in the case of Gaussian distribution and, 6 and 10 of kurtosis K are shown below.



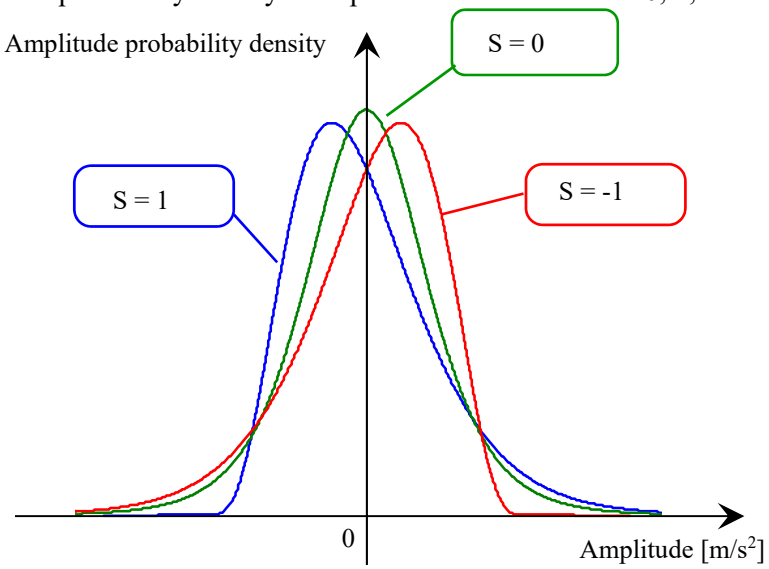
Random vibration examples in the case of Gaussian distribution and, 6 and 10 of kurtosis K are shown below. As kurtosis is larger, the peak of waveform is higher.



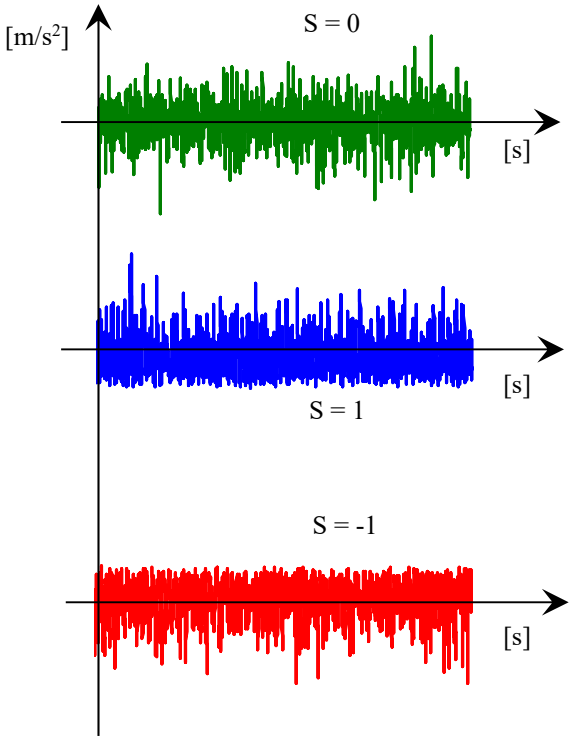
1.1.4 Skewness

Skewness (degree of skew) is an index indicating the asymmetry of amplitude probability density distribution. When skewness is 0, distribution is symmetrical to zero (average value). When skewness is a positive value, the amplitude of which probability is maximum is shifted to the negative side, and the tail of distribution in the positive side is thicker. As the tail of distribution is thicker, the peak of random vibration tends to be biased to the positive side. When skewness is negative conversely, the peak of random waveform tends to be biased to the negative side. Skewness of Gaussian distribution is '0'.

Amplitude probability density examples when skewness S is 0, 1, or -1 are shown below.



Random vibration examples when skewness S is 0, 1, or -1 are shown below. When skewness is 1, the peak in the positive side is higher, while the peak in the negative side is higher when skewness is -1. The average value is also 0 even in this case.



1.1.5 Non-Gaussian random control

Non-Gaussian random controller, like a conventional random controller, controls ‘Power spectral density (PSD) and rms value’ of the control channel to be coincided with the reference values. In addition, it also controls the non-Gaussian parameters ‘Kurtosis and skewness*’ to be coincided with the reference values.

In the non-Gaussian random test, the results of control channel power spectral density is the same as those of the conventional random test. However, the generated peak of response wave of the control channel is higher than that of the conventional random controller.

Because this system has adopted a waveform control function in order to reproduce non-Gaussian parameters precisely, process of measuring the transfer function of controlled system is required prior to the test.

Test procedures of this system are shown below.

1) Transfer function measurement
2) Initial equalization
   Equalization is conducted so that ‘Power spectral density and rms value’ are coincided with the reference values.
3) Initial equalization for Non-Gaussian
   Equalization is conducted so that ‘Kurtosis and skewness*’ are coincided with the reference values.
4) Test start

‘1) Transfer function measurement’ and ‘3) Non-Gaussian initial equalization’ are the processing not conducted with conventional random controllers.

After ‘1) Transfer function measurement’ is finished, the system waits for command from an operator in order to confirm the normality of measured transfer function. Subsequent serial processes are conducted automatically.

* Definition of skewness is not mandatory.

1.1.6 Non-Gaussian characteristic type

Varied types of non-Gaussian random vibration generating methods are available, and the shape of non-Gaussian random vibration cannot be defined uniquely even when kurtoses are identical. This system enables the reproduction of two types of non-Gaussian random vibration having characteristics different from each other.

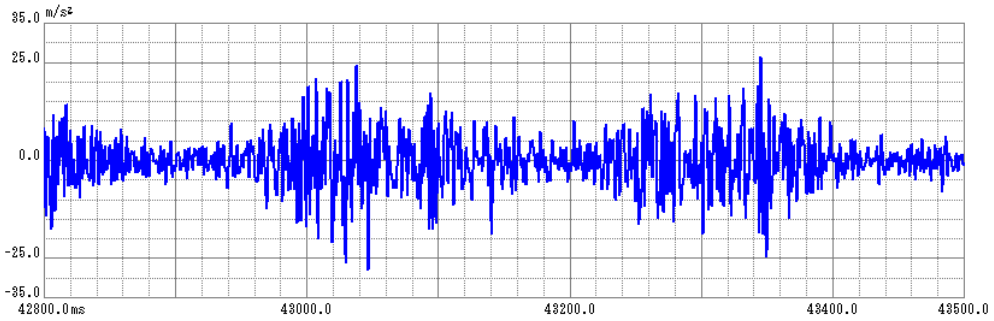
- Sporadic peak type

  This type of Non-Gaussian random vibration is accompanied with higher peaks sporadically. In this type, only kurtosis can be defined.

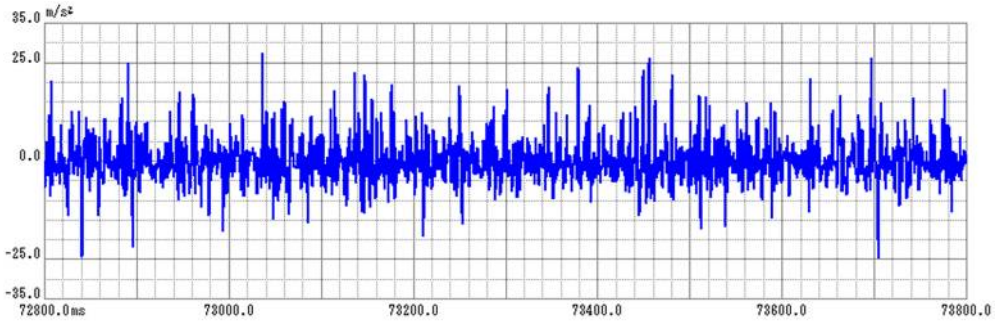
- Stationary peak type

  This type of Non-Gaussian random vibration is accompanied with higher peaks constantly. In this type, kurtosis as well as skewness can be defined.

Random vibration examples of sporadic peak type and stationary peaktype are shown below.



(a) Sporadic peak type example



(b) Stationary peak type example

1.2 Specifications

1.2.1 NON-GAUSSIAN

(1) Control Method： 1) PSD control of the random waveform signal with the Non-Gaussian nature by using the feed-forward method

2) Real time waveform control by using the feed-forward method

(2) Control frequency fmax：Maximum 10 kHz (However, it may be limited by conditions.)

(3) Number of control lines L : Maximum 3200 lines
(However, it may be limited by conditions.)

(4) Control dynamic range： More than 90 dB (Sporadic peak type, in the case of kurtosis 5)

(5) Loop Time ： Within 450 ms (120 DOF, fmax = 2000 Hz, L = 200 line, waveform control average = at 8times/a loop)

(6) Non-gaussian control

1) Non-Gaussian control: Kurtosis / Skewness (Stationary peak type only)

2) Non-Gaussian characteristic type: Sporadic peak type / Stationary peak

(7) Input channel (However, it may be limited by conditions.)

1) Number of channels： Maximum 64
(Non-Gaussian control channel: 1 ch)

2) Channel type: ：
Non-gaussian control channel / 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：Conforms to K2/RANDOM

(8) Output channel

1) Number of channels： 1

2) Clipping： Voltage value (specifying by σ can also be added.)
Response of non-Gaussian control channel.

(9) Analysis / Display data：

1) Reference, Controlled response PSD and Tolerance
2) PSD and Waveform data of each input channel
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 (Non-gaussian control channel, each control channel)
7) Trend Graph (rms value, Kurtosis and Skewness of non-Gaussian control channel)
8) System Data such as Transfer Function or Coherence between Non-Gaussian control channel and Drive output channel

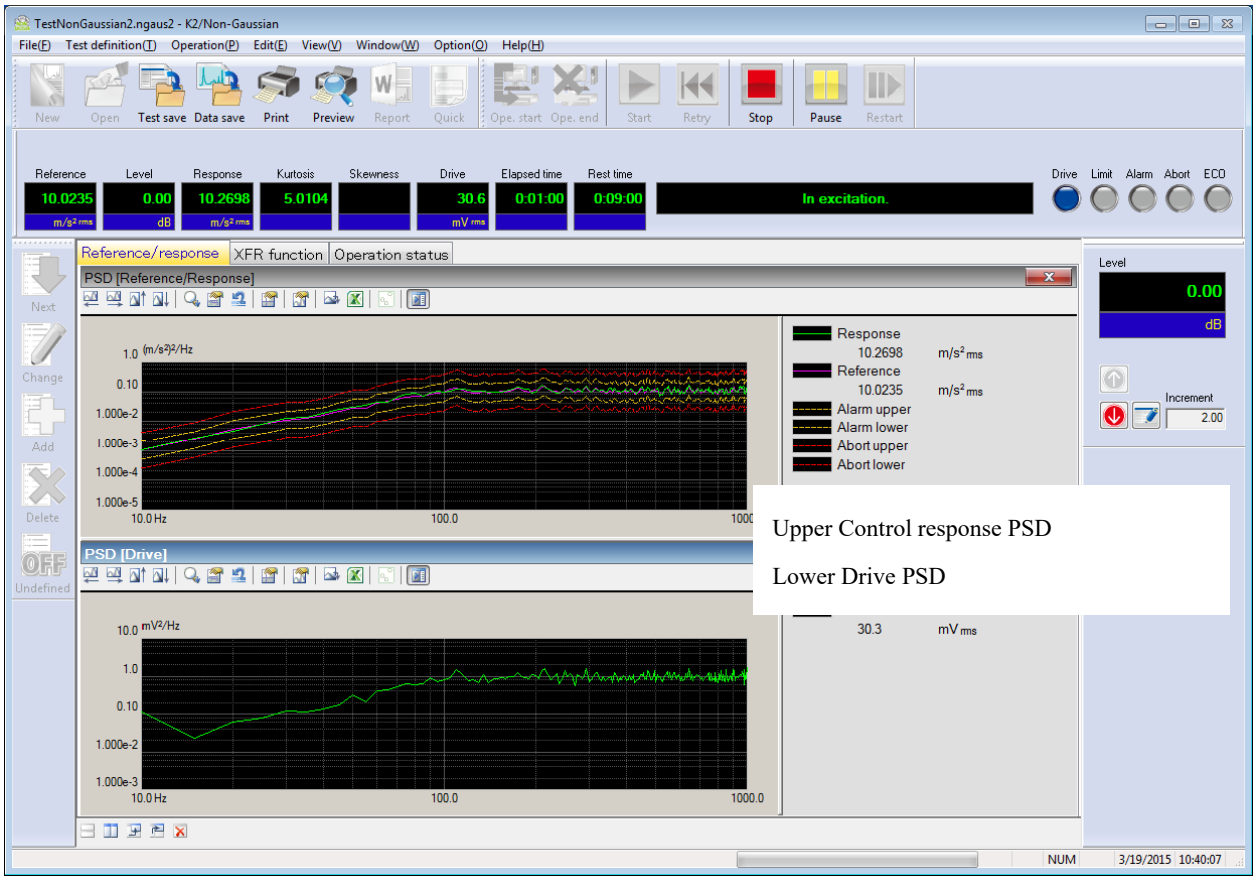
(10) Data save： Automatic / Manual

Display data save as CSV format

(11) 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 and continuing of the control



Example of NON-GAUSSIAN execution screen

Chapter 2　Operation System of K2 Application

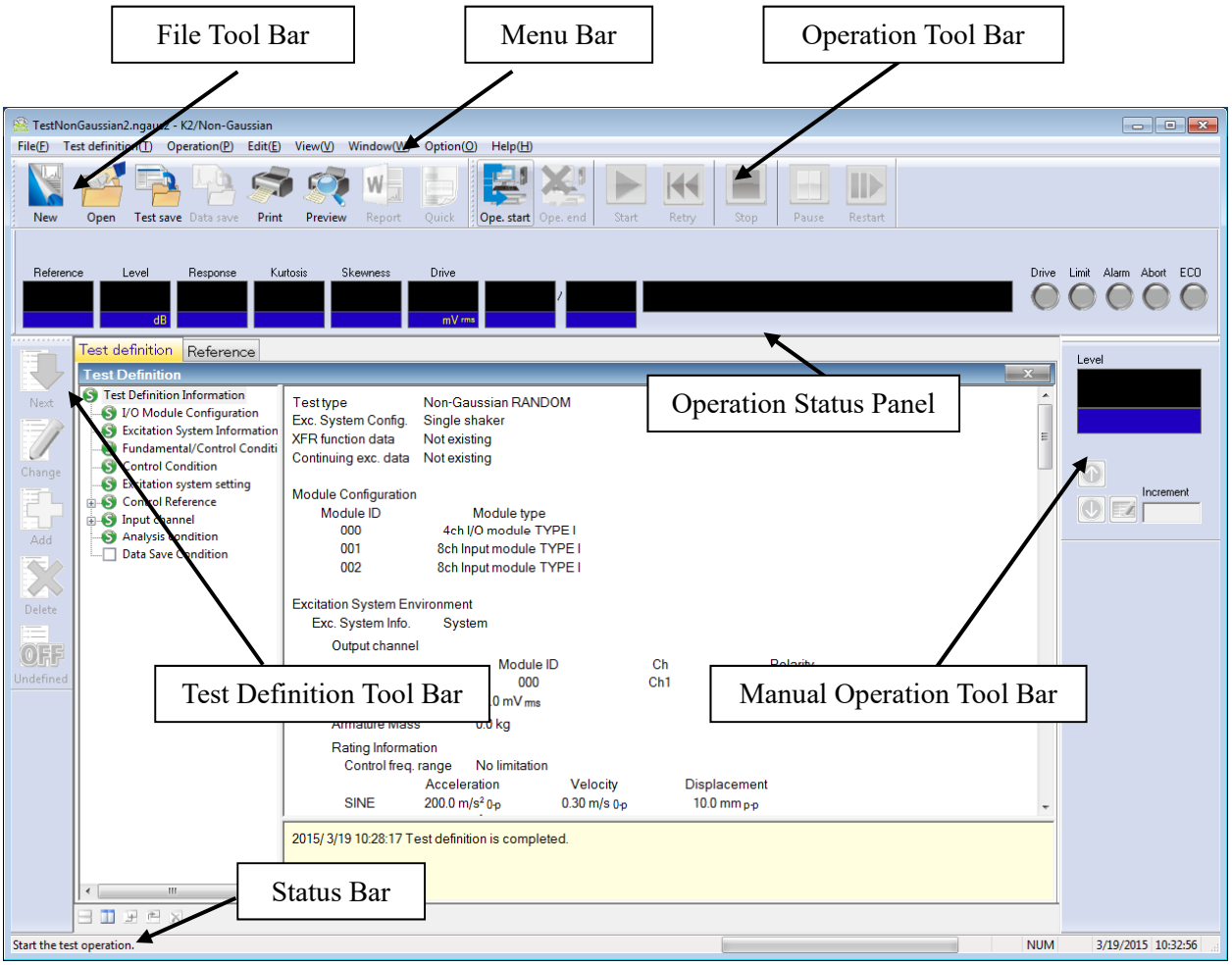
2.1 Outline

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 : K2NON-GAUSSIAN（*.ngaus2）
- Graph Data File : （*.vdf2）

- Environment setting File

  (I/O Module Configuration Information, Excitation System Information, Input channel Information) : SystemInfo.dat2

Note 1) Saved in ‘¥IMV¥K2_2nd’ on System Drive. Deleting inhibited

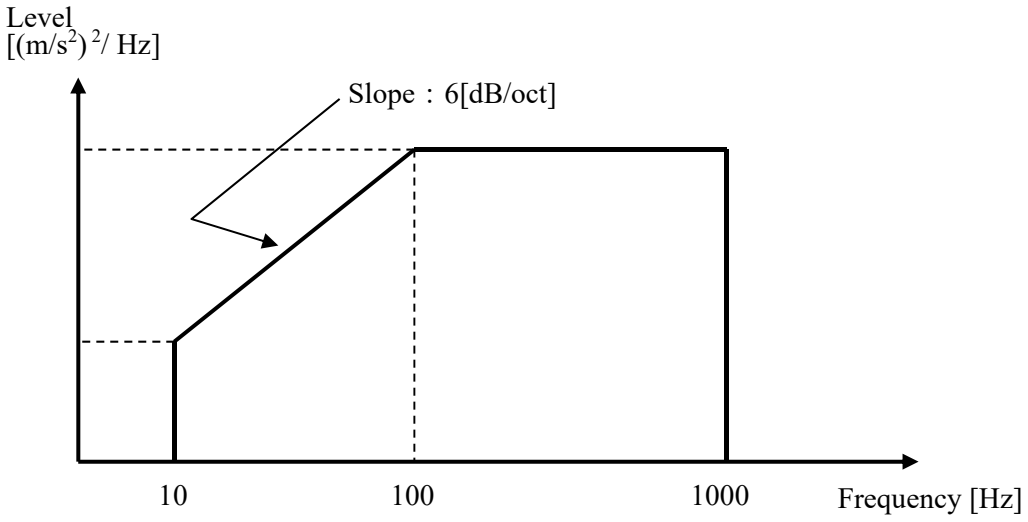
Chapter 3 Basic Operation

3.1 Break point PSD

< Example >

An example of Break point PSD 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].

Non-Gaussian characteristic is set to sporadic peak type, and kurtosis is set to 5.0 during the control.

[Test time]

10 minutes

[Information of sensors to be used]

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

Ch. 1 : for non-gaussian control, sensitivity 3pC/(m/s^2), Break point PSD reference

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

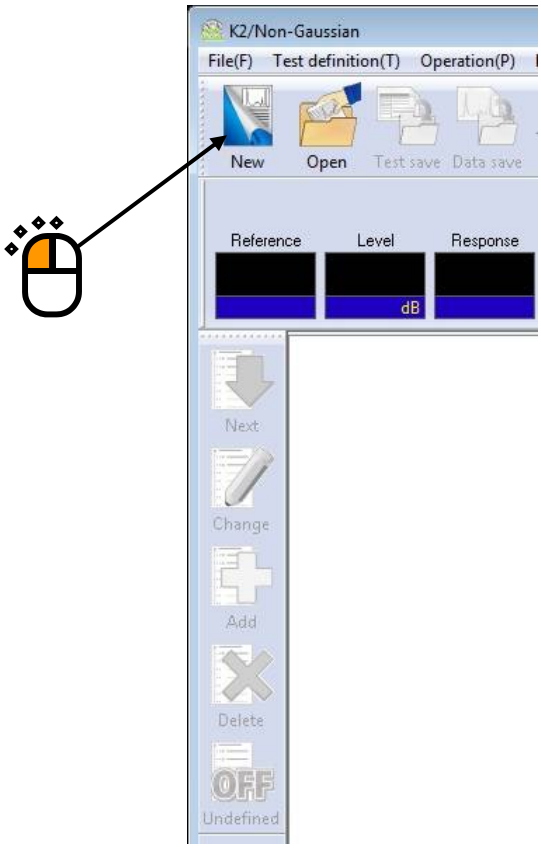
However, these channels must be registered in Input channel information (in this example, 'INPUT').

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

< Procedures >

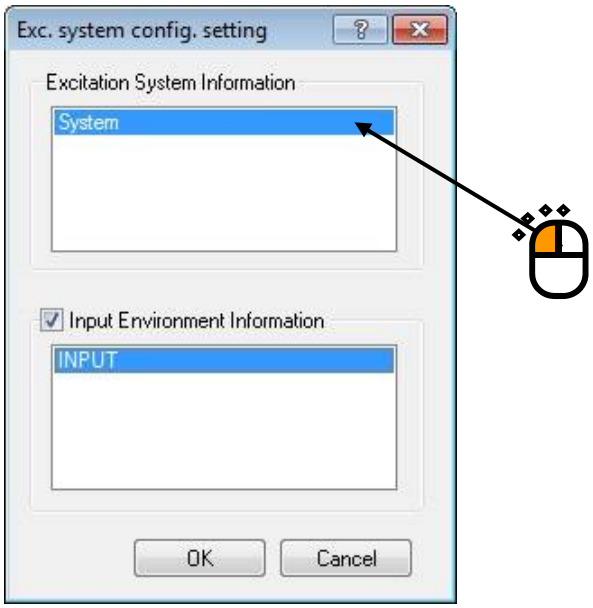
< Step 1 >

Press the button of [New] to start ‘New definition’.



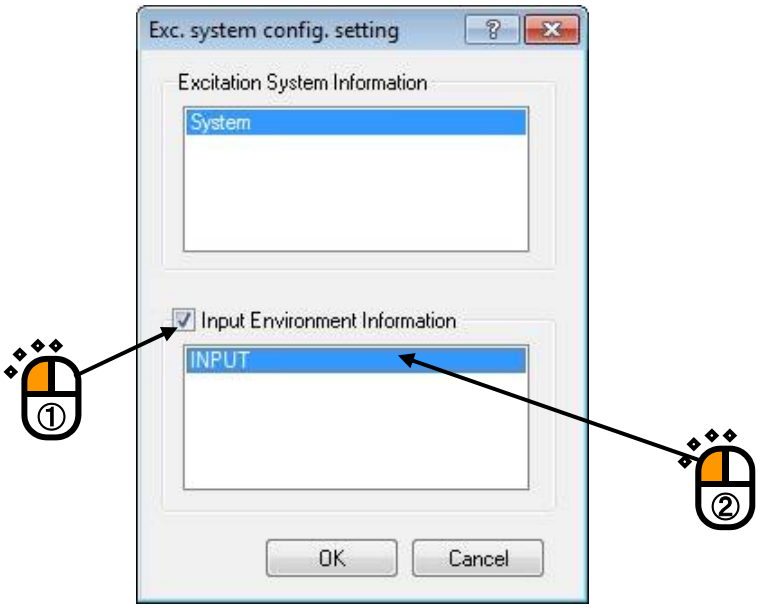
＜Step 2＞

Select an Excitation system from the list of ‘Excitation system information’.



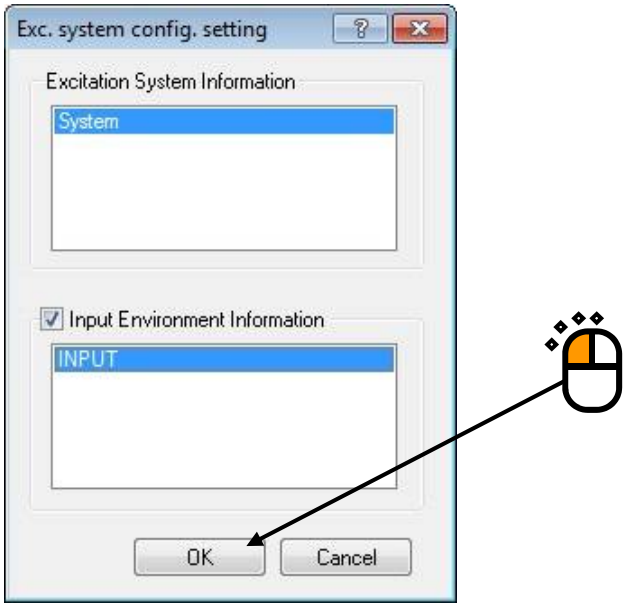
＜Step 3＞

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



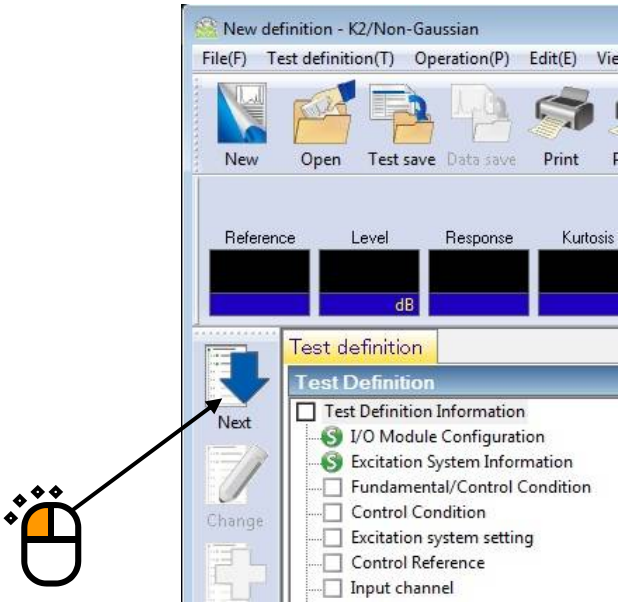
＜Step 4＞

Press the [OK] button.



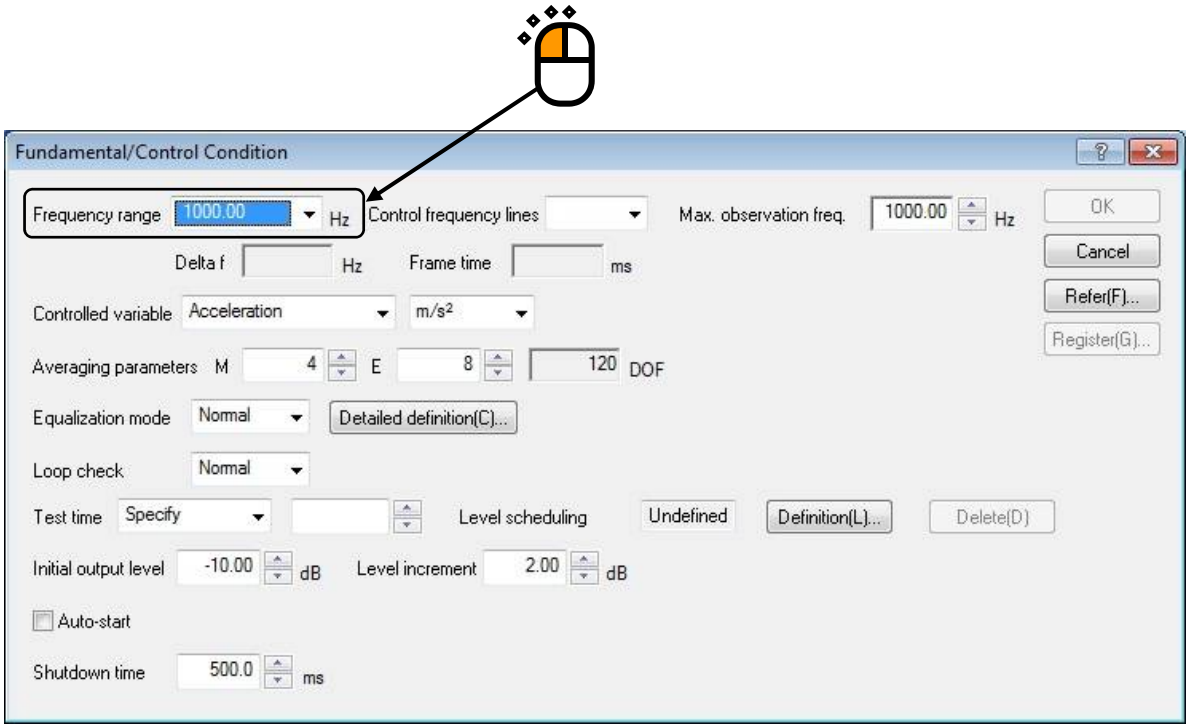
＜Step 5＞

Press the [Next] button.



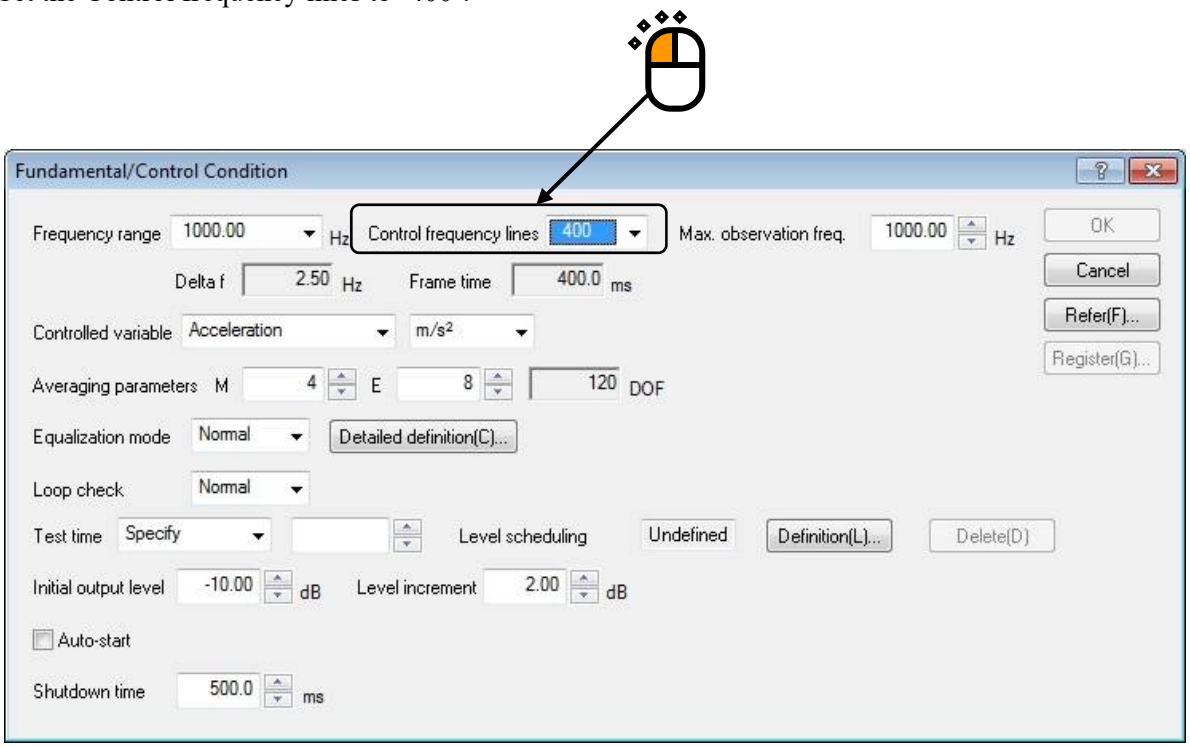
＜Step 6＞

Set the Frequency range to ‘1000Hz’.



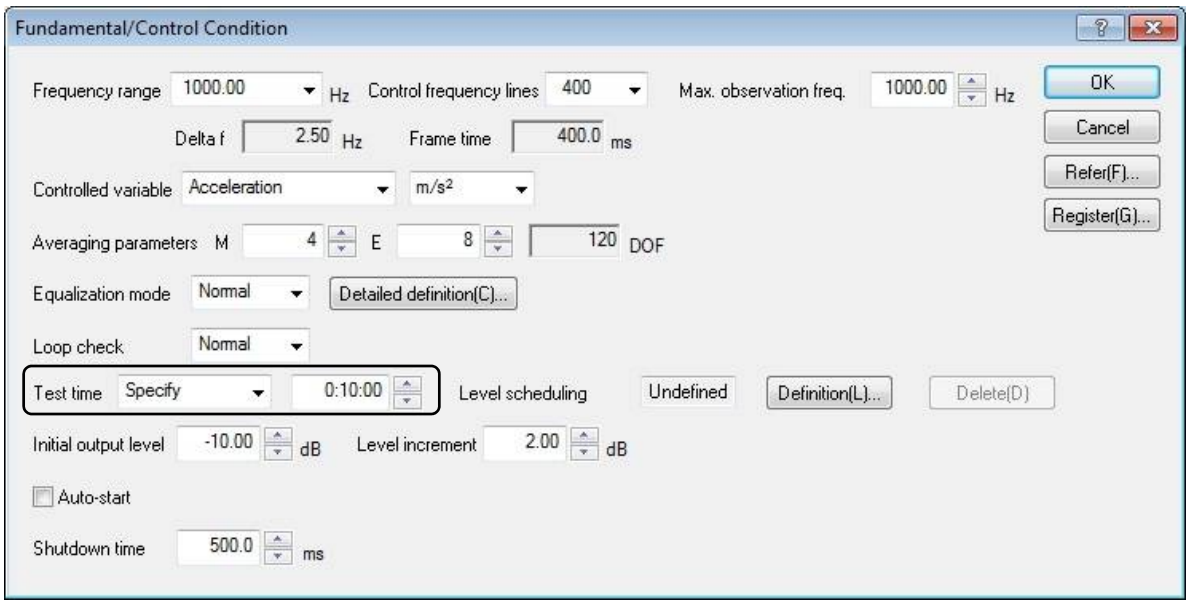
＜Step 7＞

Set the Control frequency lines to ‘400’.



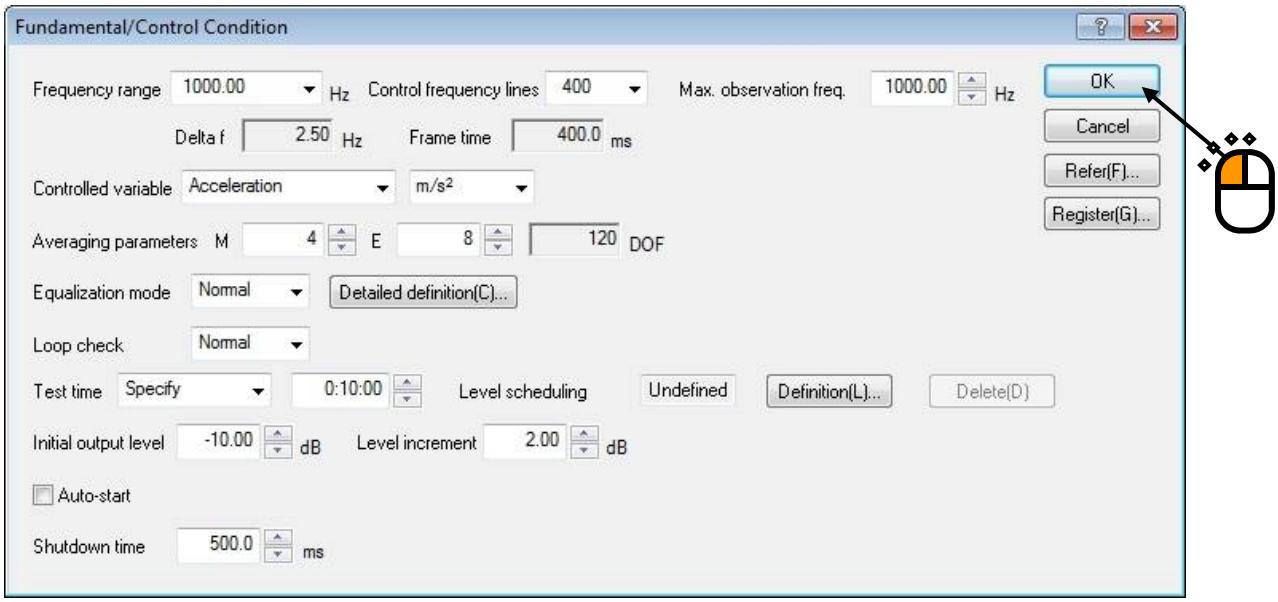
＜Step 8＞

Specify the Test time as ‘Specify time’. And input the value as ‘Test time : 0 : 10 : 00 (600 sec)’.



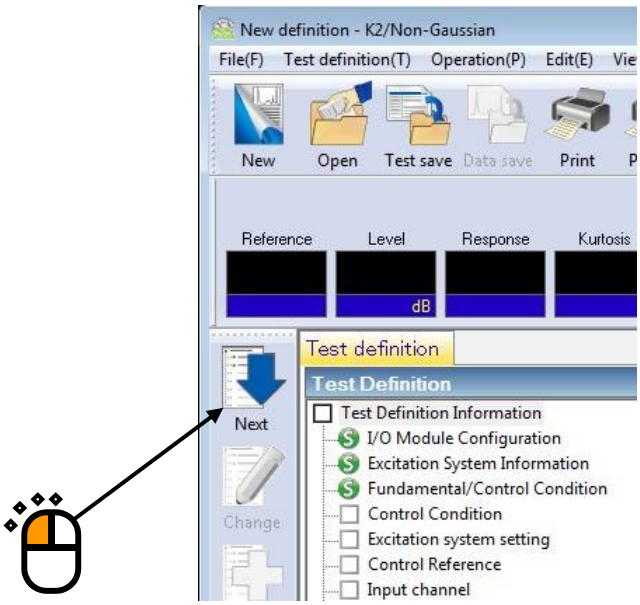
＜Step 9＞

Press the [OK] button.



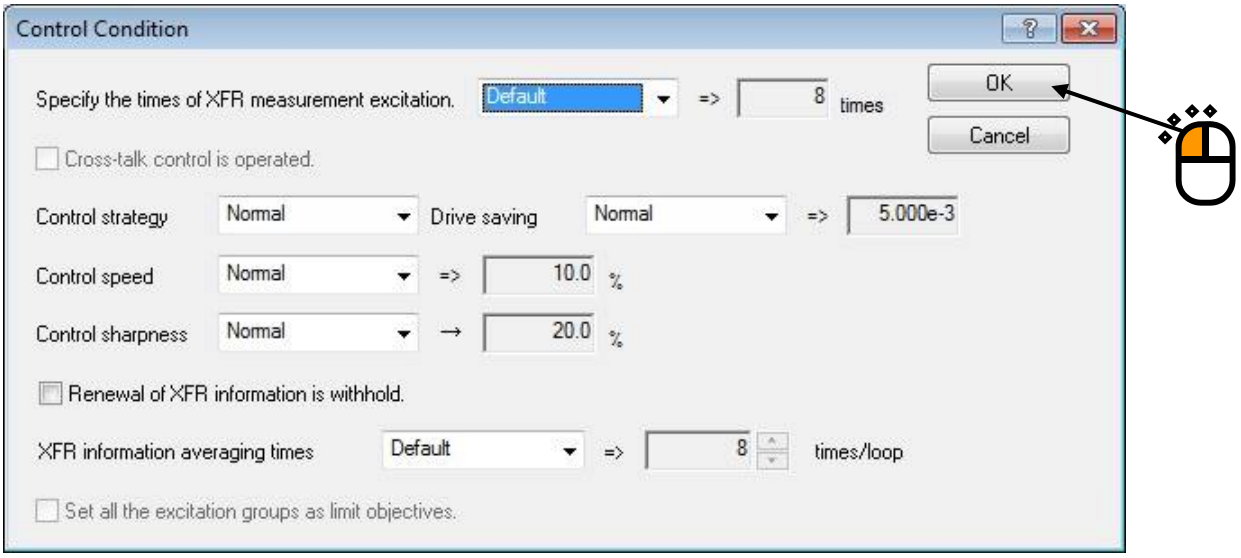
＜Step 10＞

Press the [Next] button.



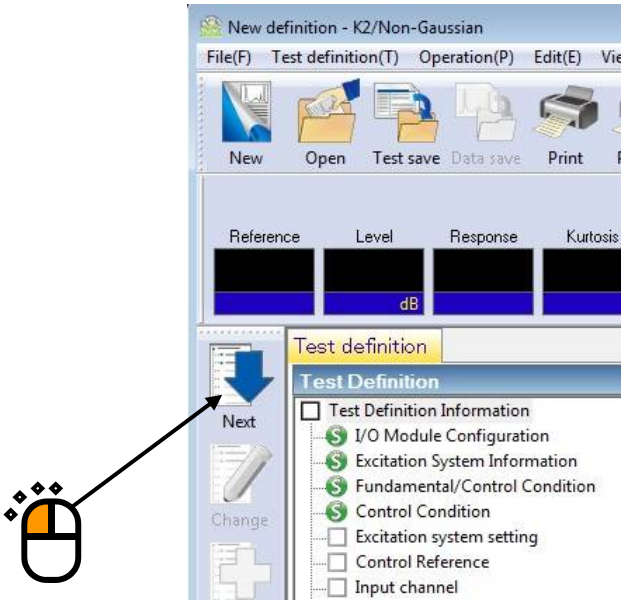
＜Step 11＞

Press the [OK] button.



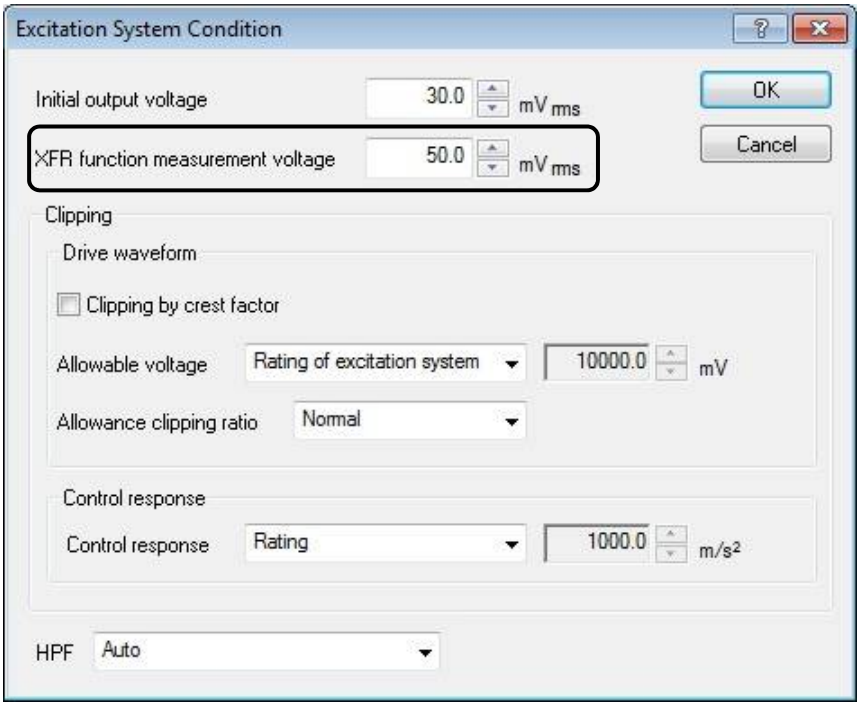
＜Step 12＞

Press the [Next] button.



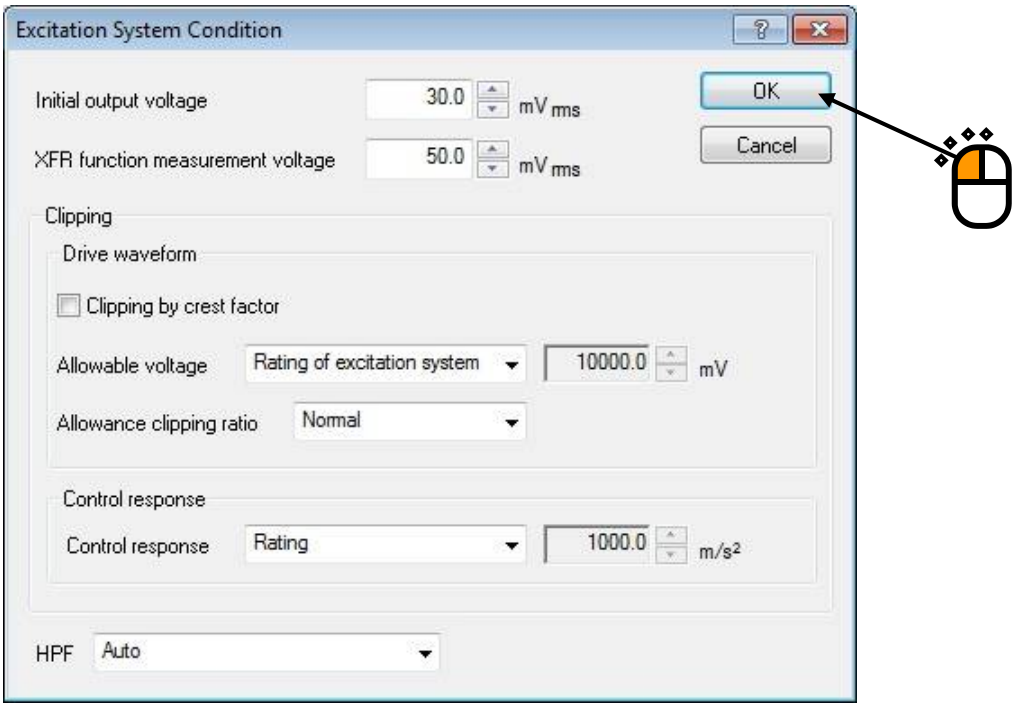
＜Step 13＞

Set the XFR function measurement voltage to 50 (mV_{rms}).



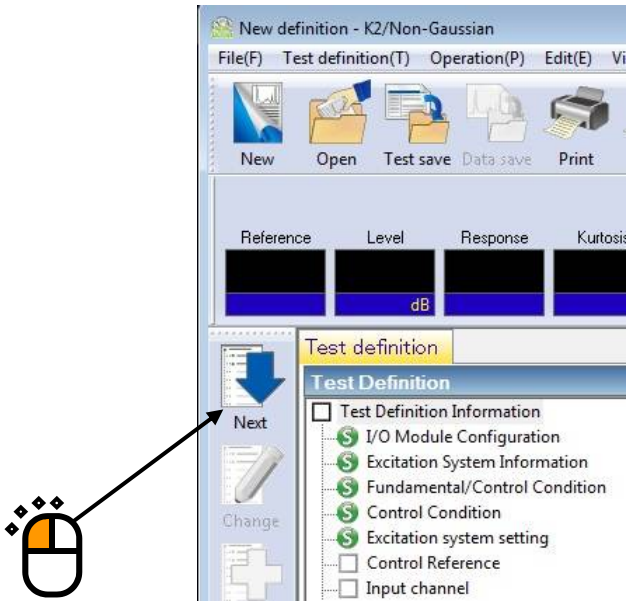
＜Step 14＞

Press the OK button.



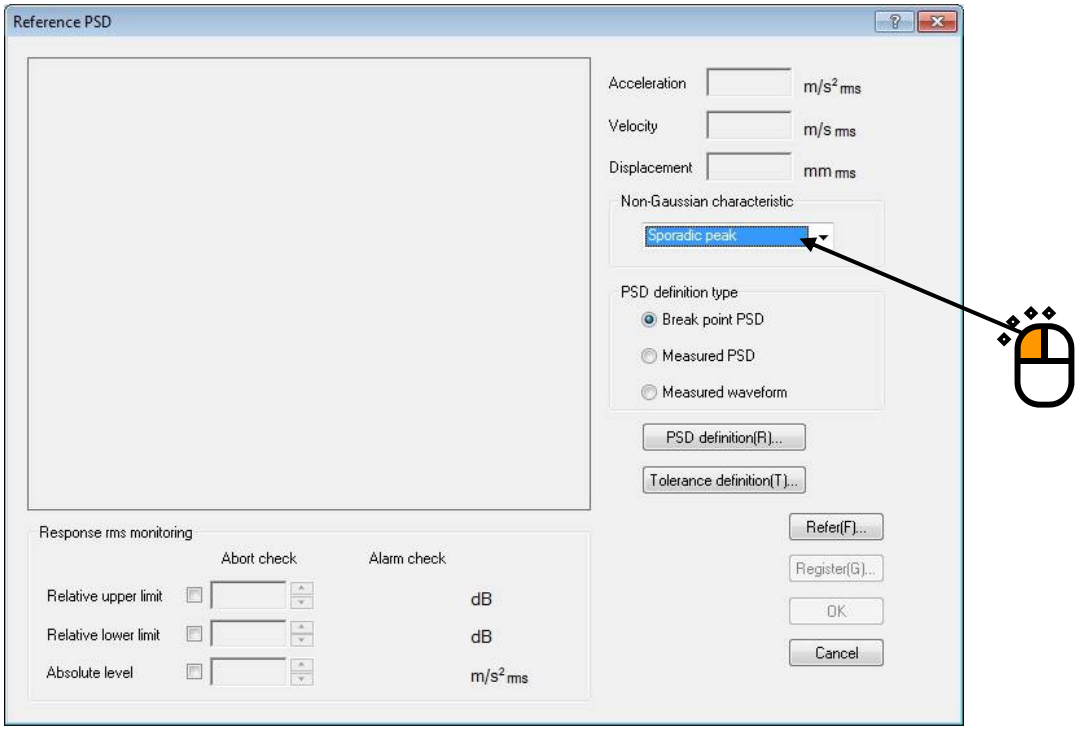
＜Step 15＞

Press the [Next] button.



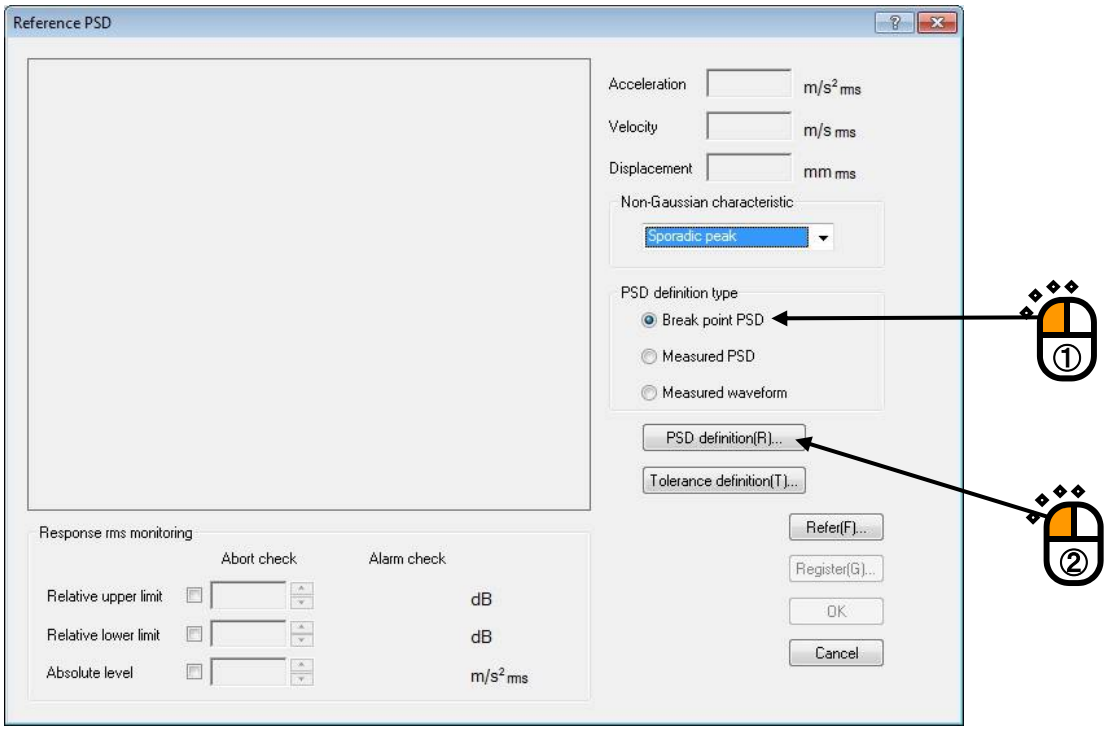
＜Step 16＞

Select ‘Sporadic peak’ in the Non-Gaussian characteristic area.



＜Step 17＞

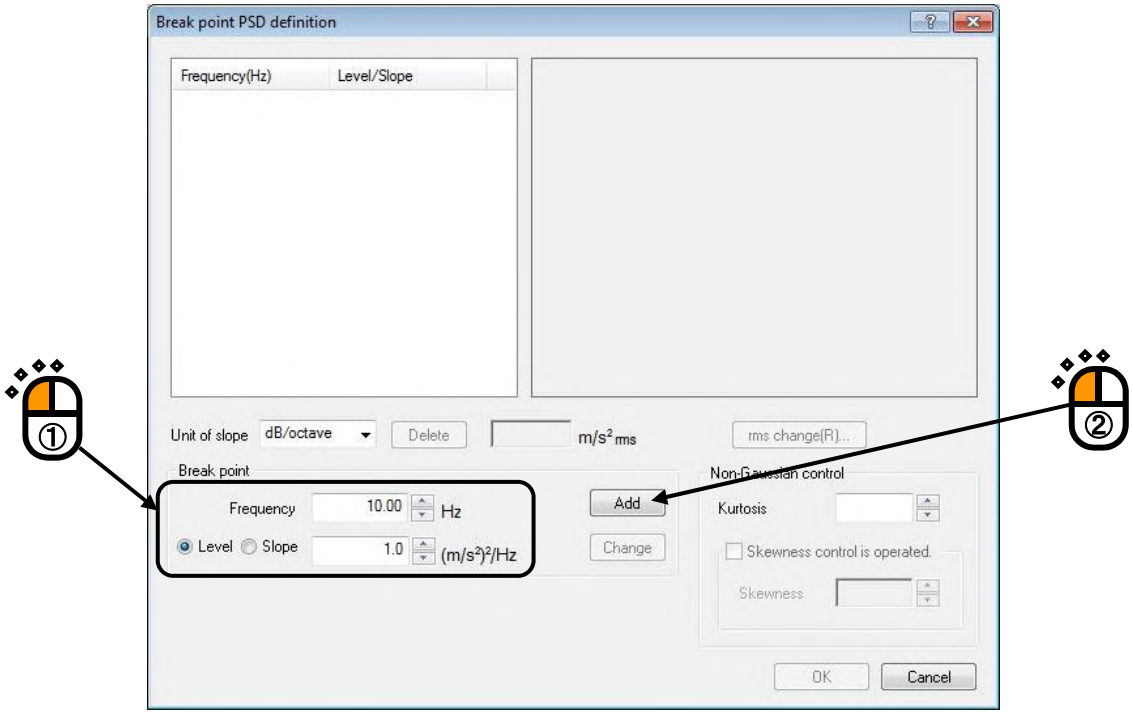
Select the item of Break point PSD and press the [PSD definition] button.



＜Step 18＞

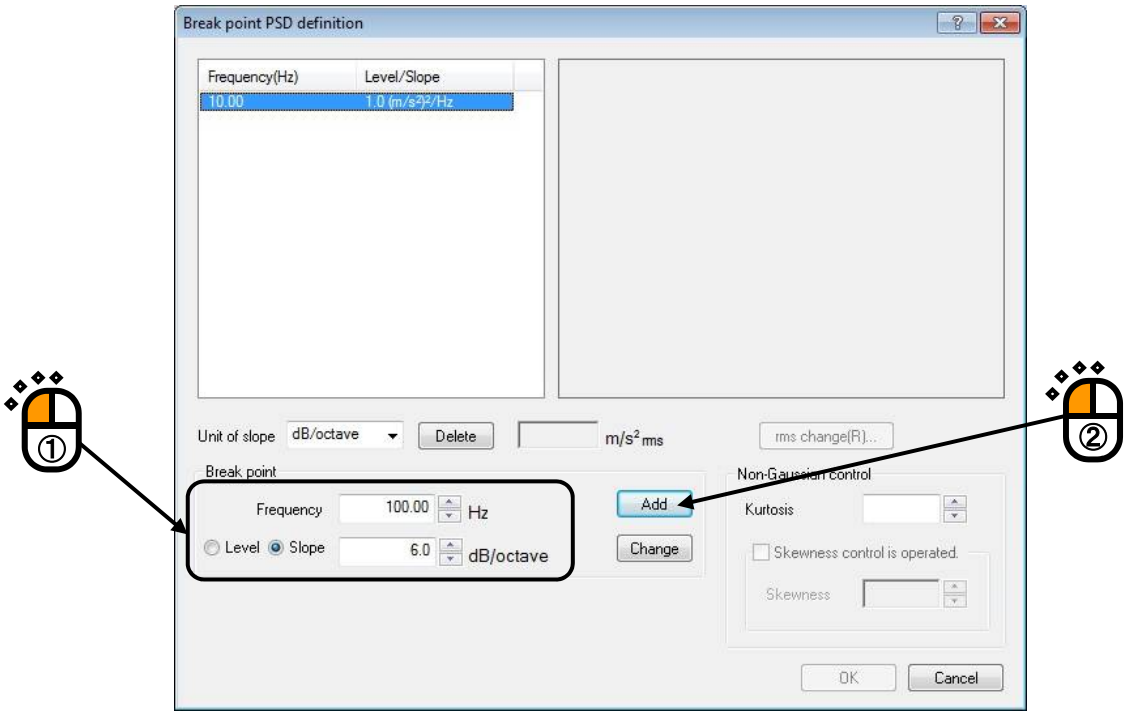
Select the item of level. Input the values for level : 1[$(m/s^2)^2$/Hz] and for frequency : 10 [Hz].

Then press the button to add.



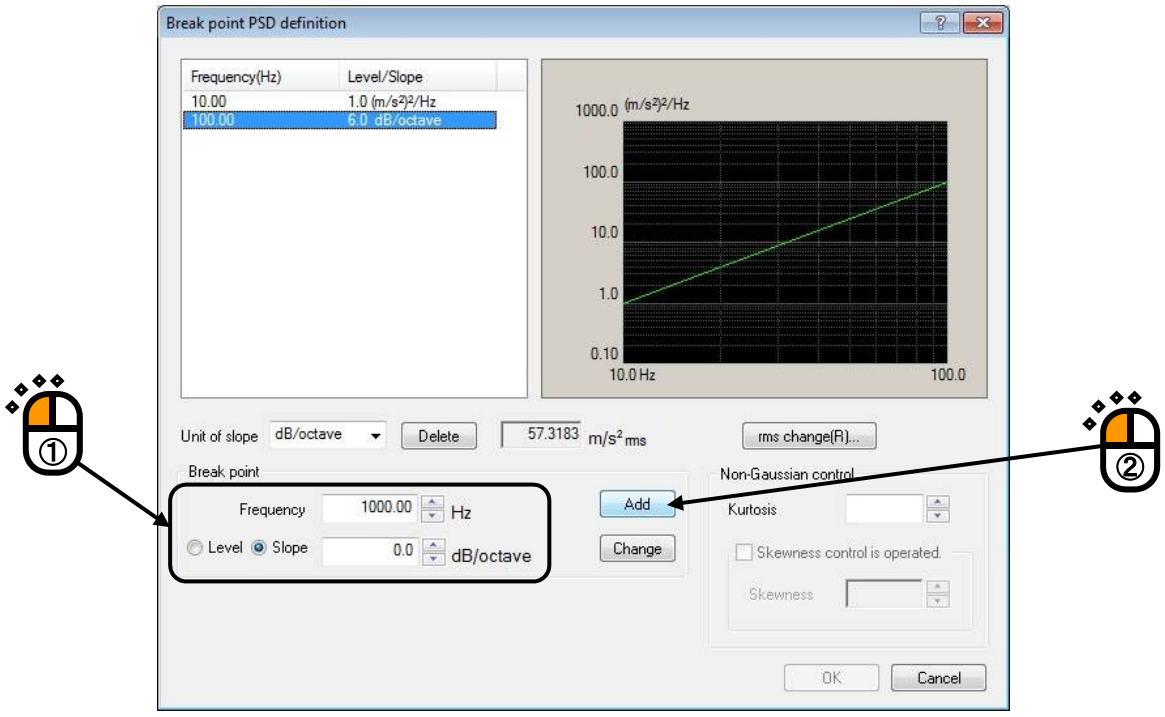
＜Step 19＞

Select the item of the slope and specify the unit of slope as dB/octave. Input the values for slope : 6 [dB/octave] and for frequency : 100 [Hz]. Then press the button to add.



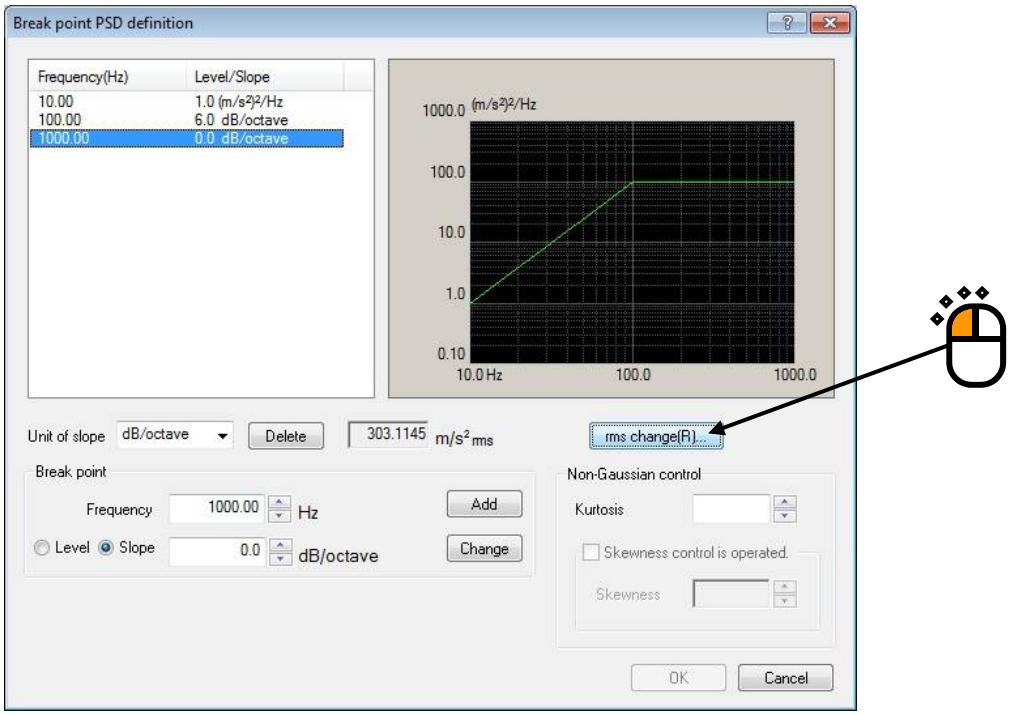
＜Step 20＞

As in the same way, select the item of the slope and specify the unit of slope as dB/octave. Input the values for slope : 0 [dB/octave] and for frequency : 1000 [Hz]. Then press the button to add.



＜Step 21＞

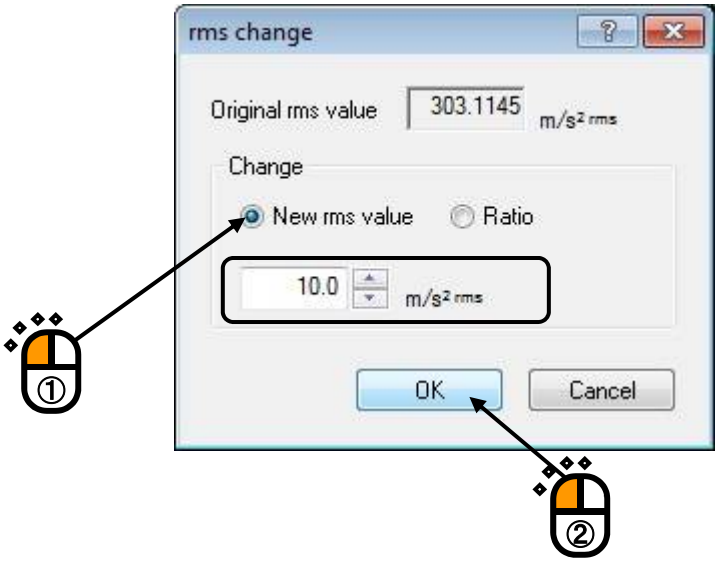
Press the button of [rms change].



＜Step 22＞

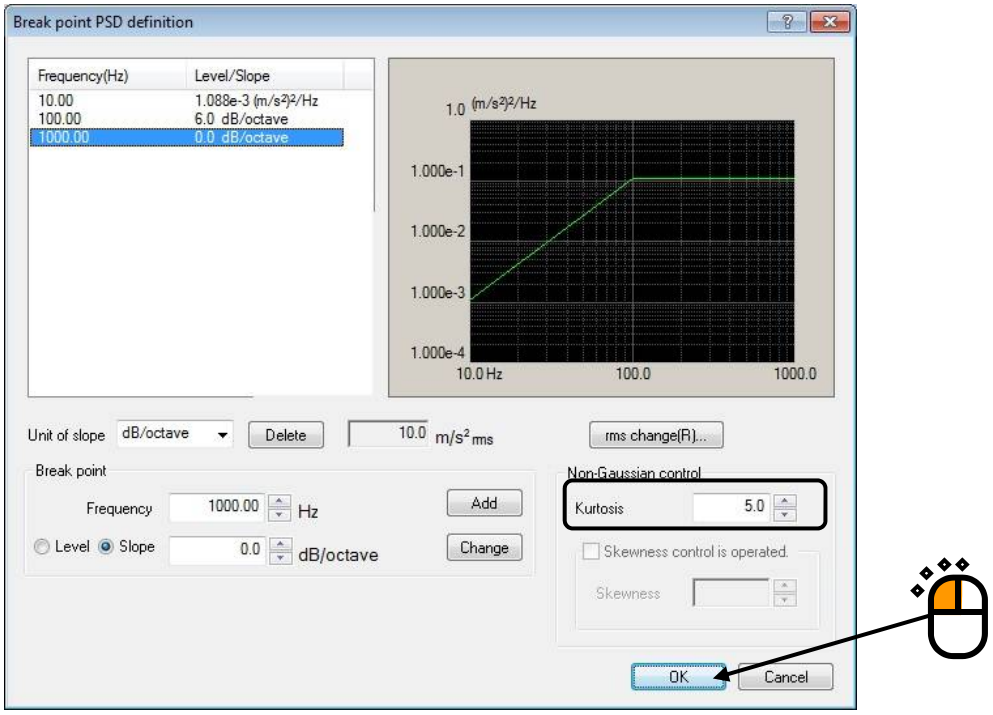
Select the item of New rms value and input the value as ‘New rms value : 10 [(m/s^2) rms].

And press the [OK] button.



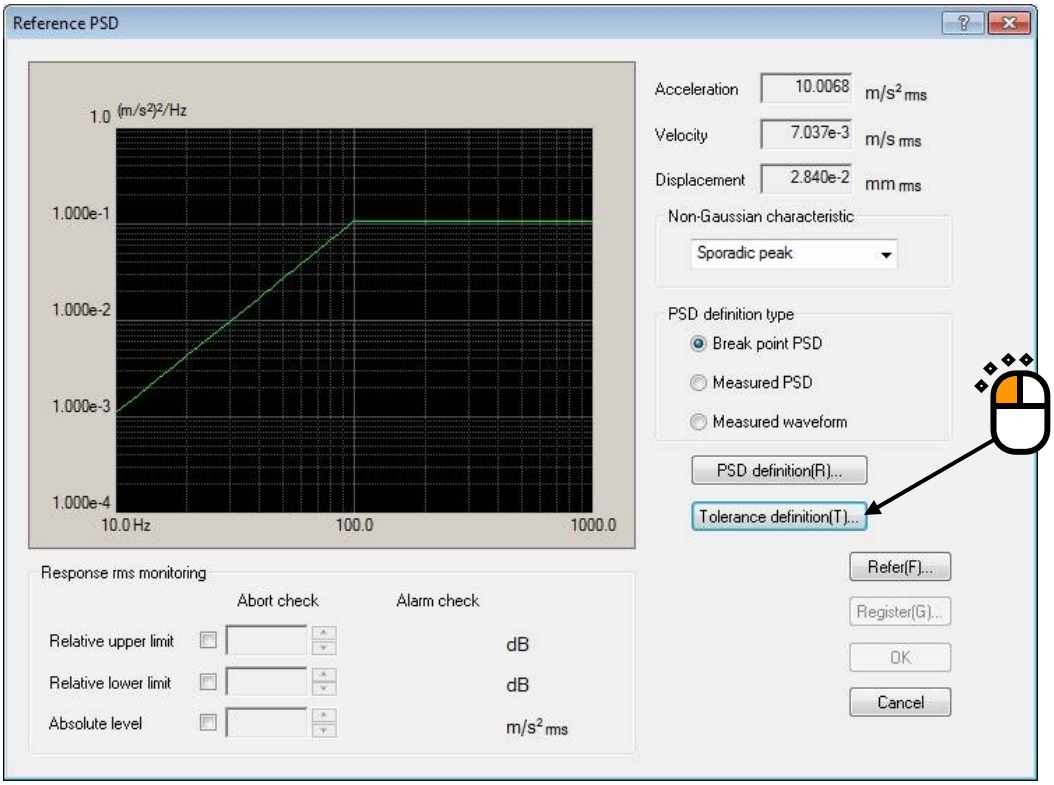
＜Step 23＞

Enter ‘Kurtosis: 5’, and press the [OK] button.



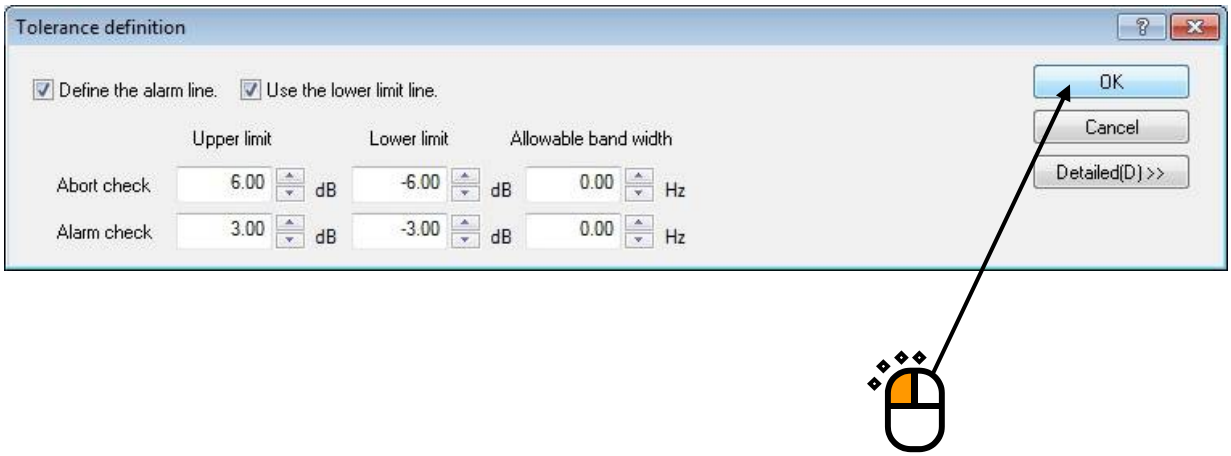
＜Step 24＞

Press the [Tolerance definition] button.



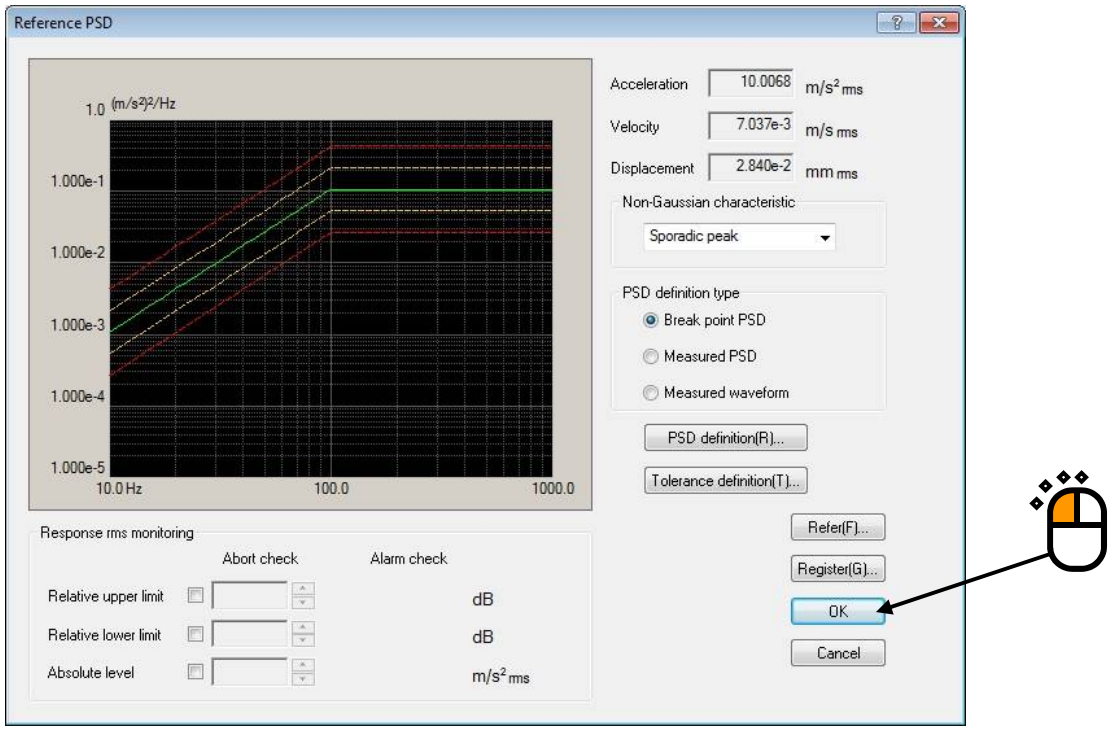
＜Step 25＞

Press the [OK] button.



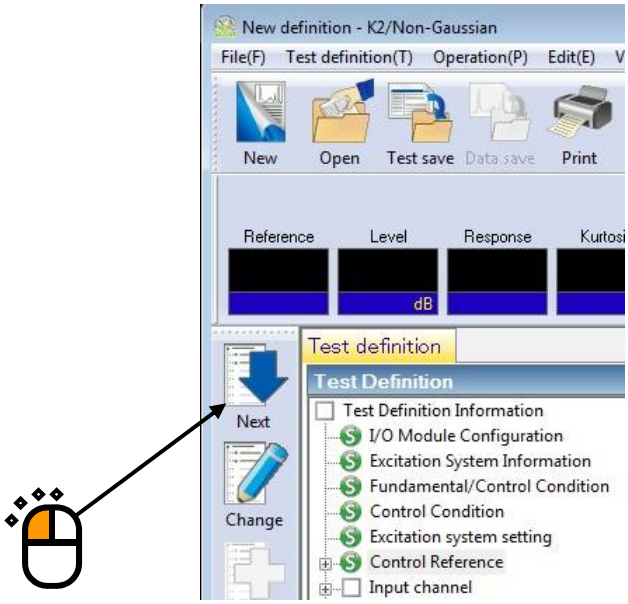
＜Step 26＞

Press the [OK] button.



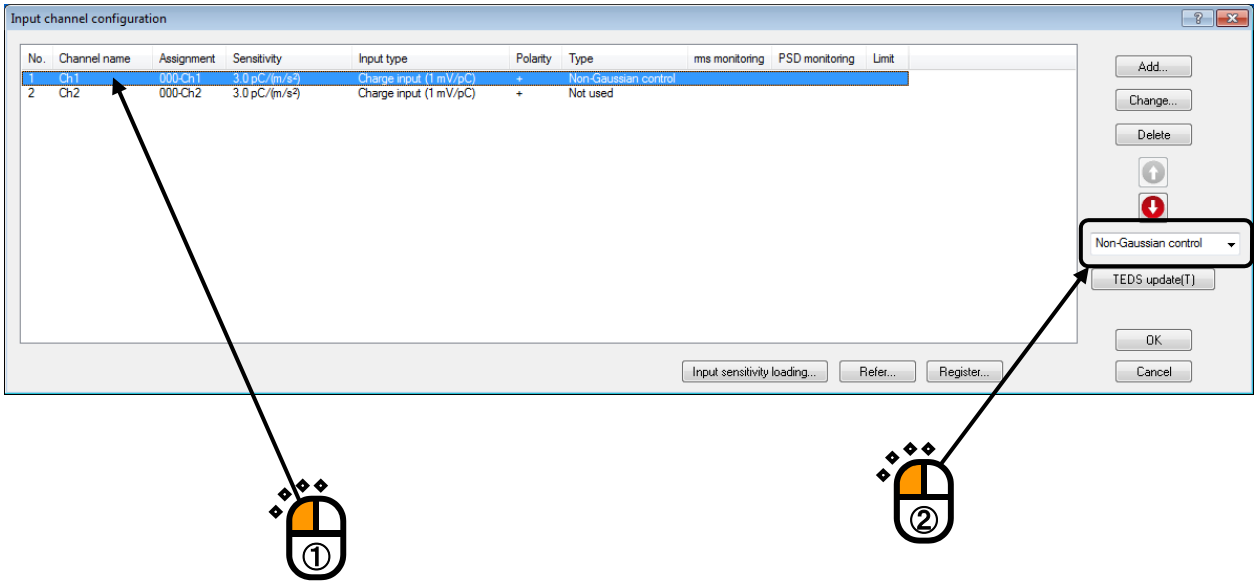
＜Step 27＞

Press the [Next] button.



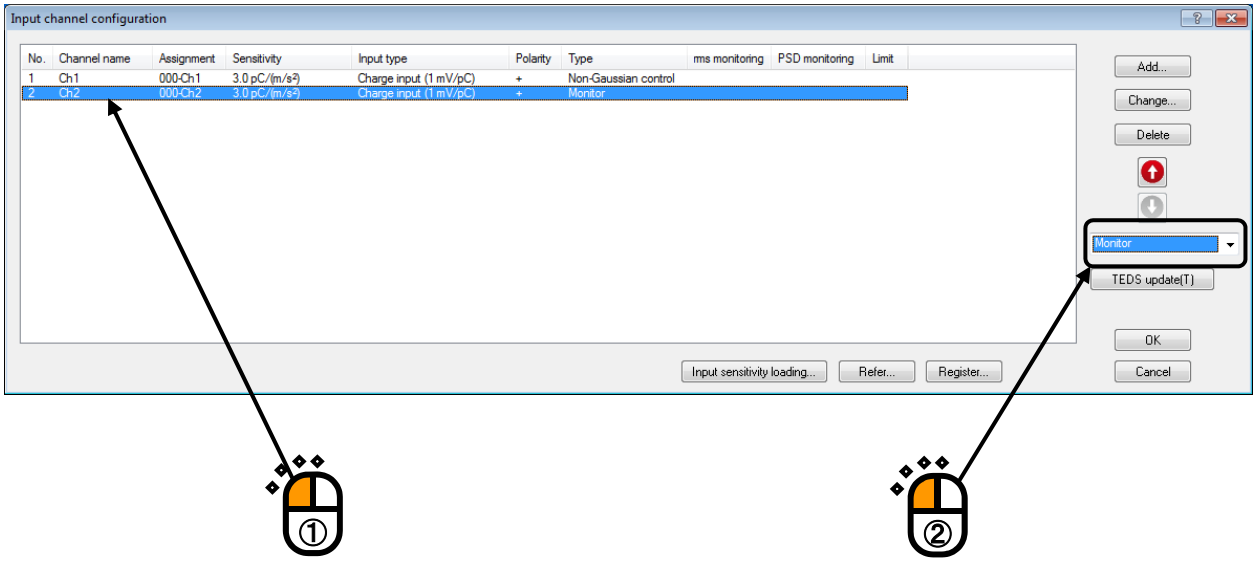
＜Step 28＞

Select ‘Ch.1’ and set as ‘Non-gaussian control’.



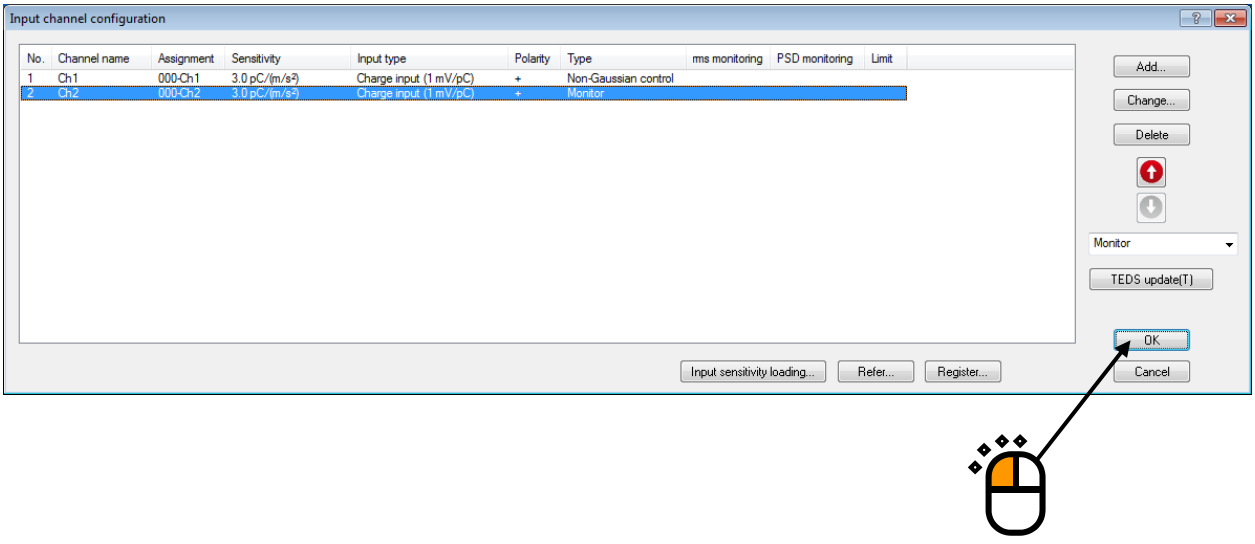
＜Step 29＞

Also, select ‘Ch.2’ and set as ‘Monitor’.



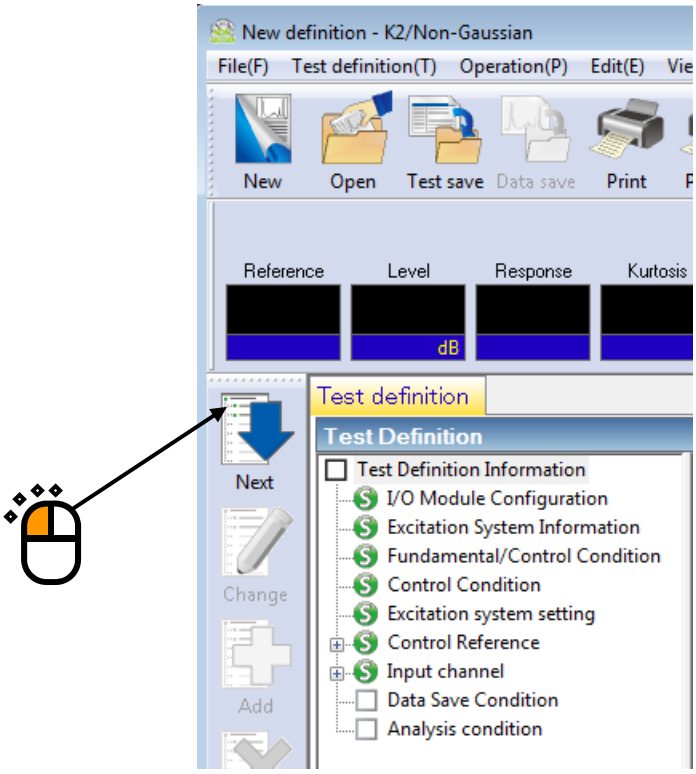
＜Step 30＞

Press the [OK] button.



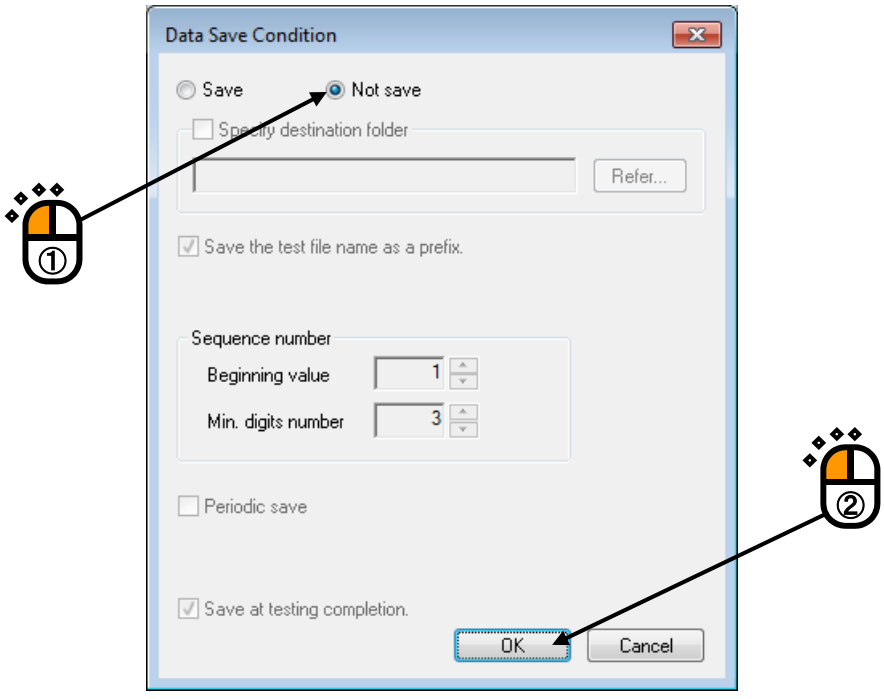
＜Step 31＞

Press the [Next] button.



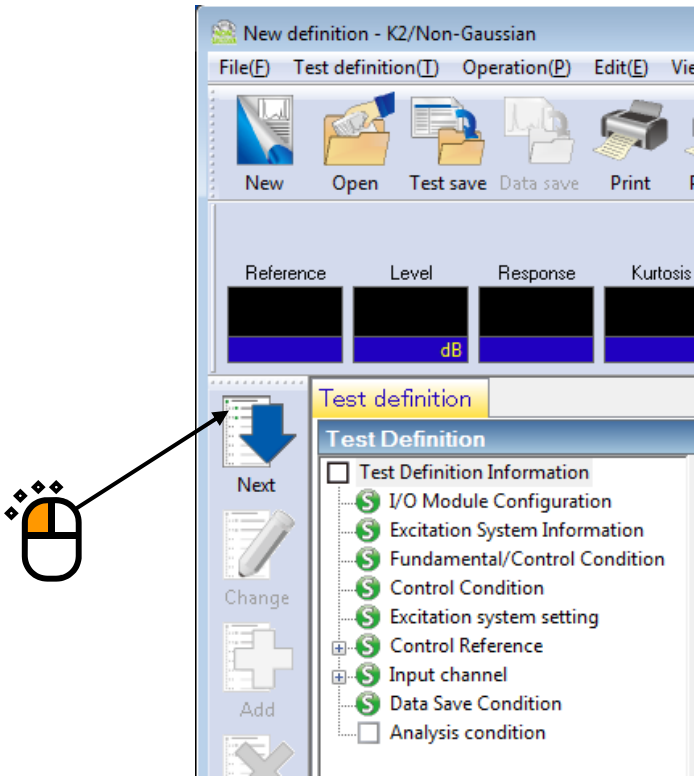
＜Step 32＞

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



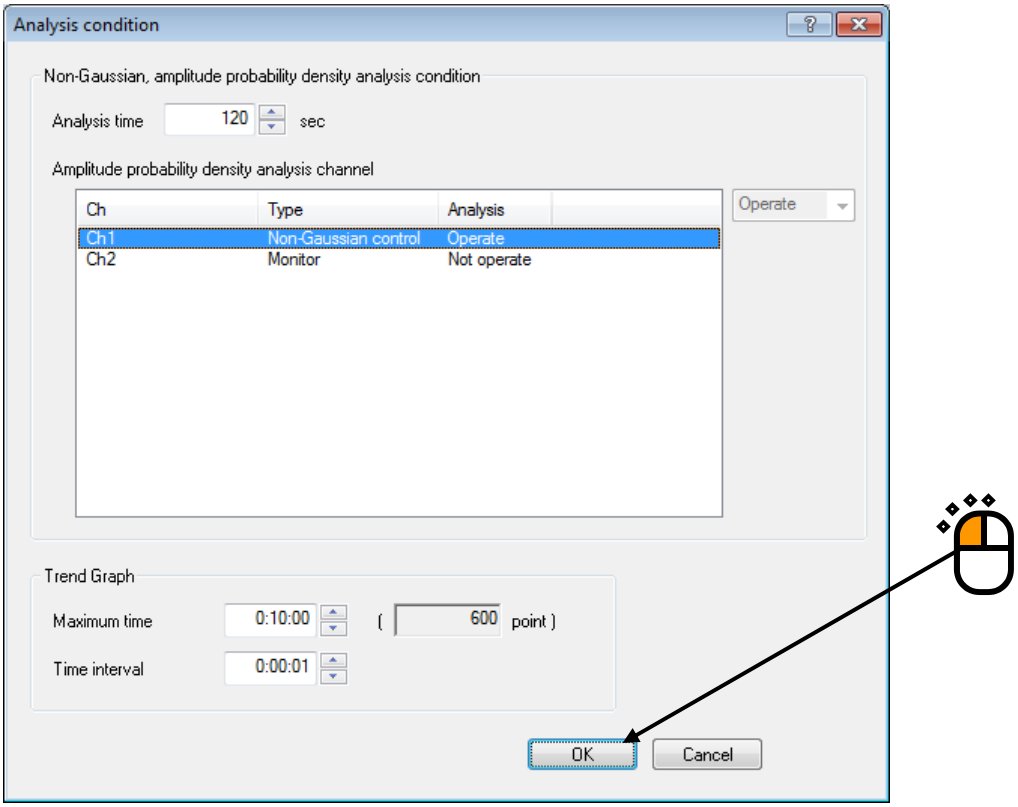
< Step33 >

Press the button of [Next].



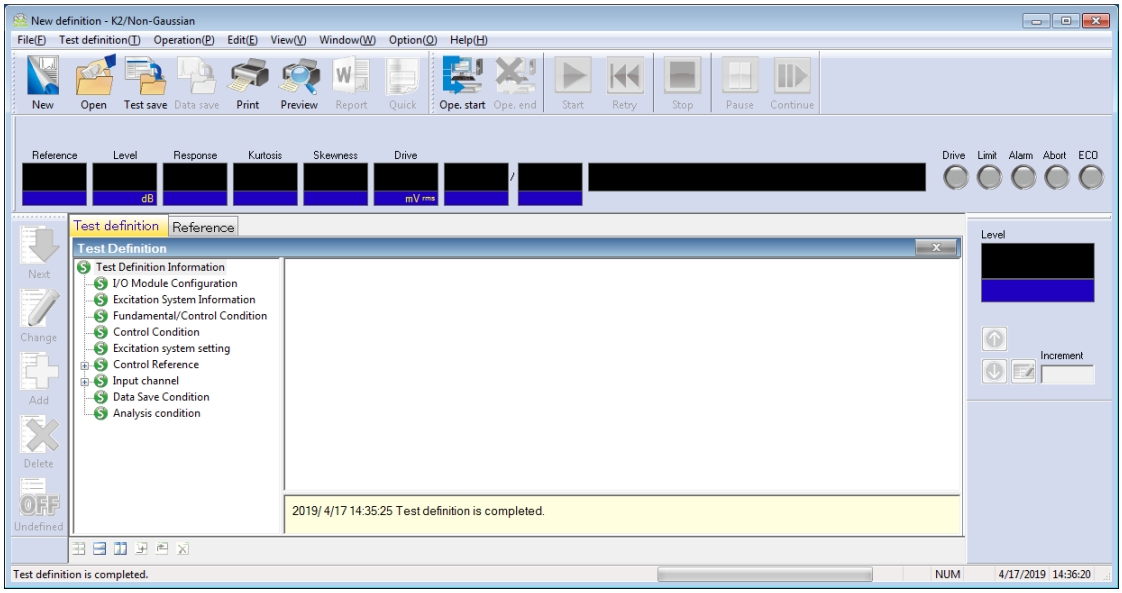
< Step34 >

Press the [OK] button.



< Step 35 >

The definition is completed.

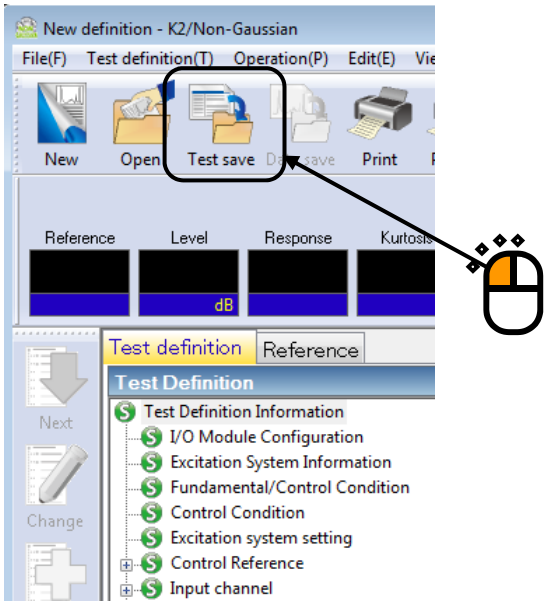


< Save of test>

< Step 1 >

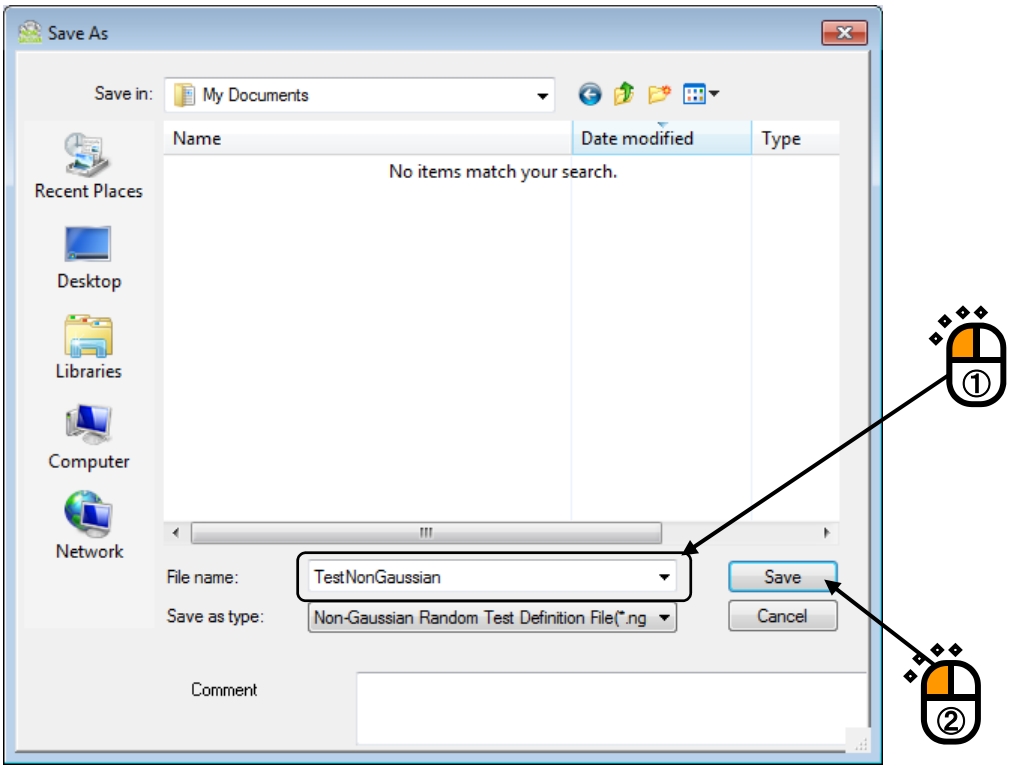
Save the defined test information to a test file.

Click the [Save] button.



＜Step 2＞

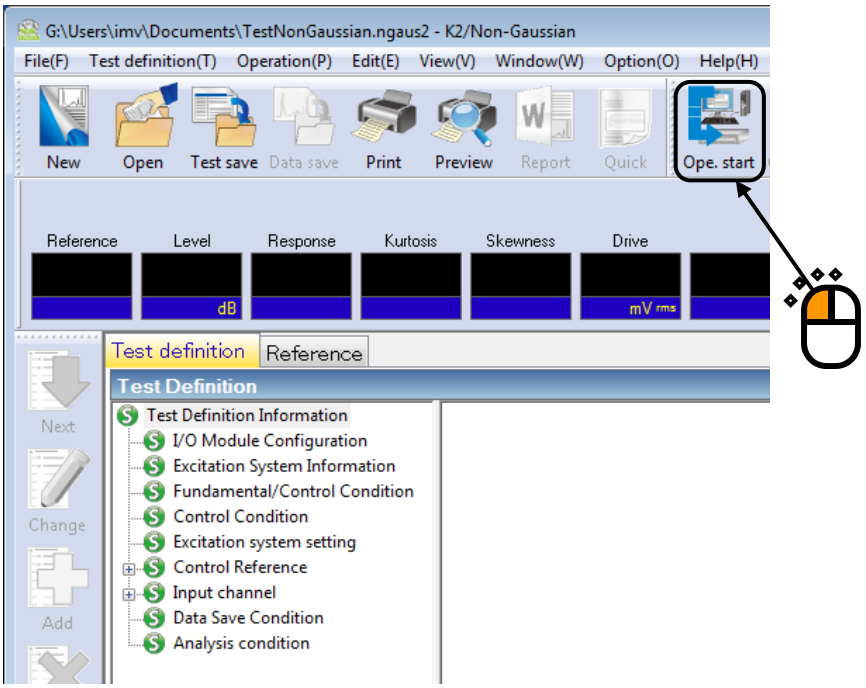
The dialog box as below appears. Specify an arbitrary directory in ‘Save in’ and input a name to ‘File name’.



< Operation of test >

< Step 1 >

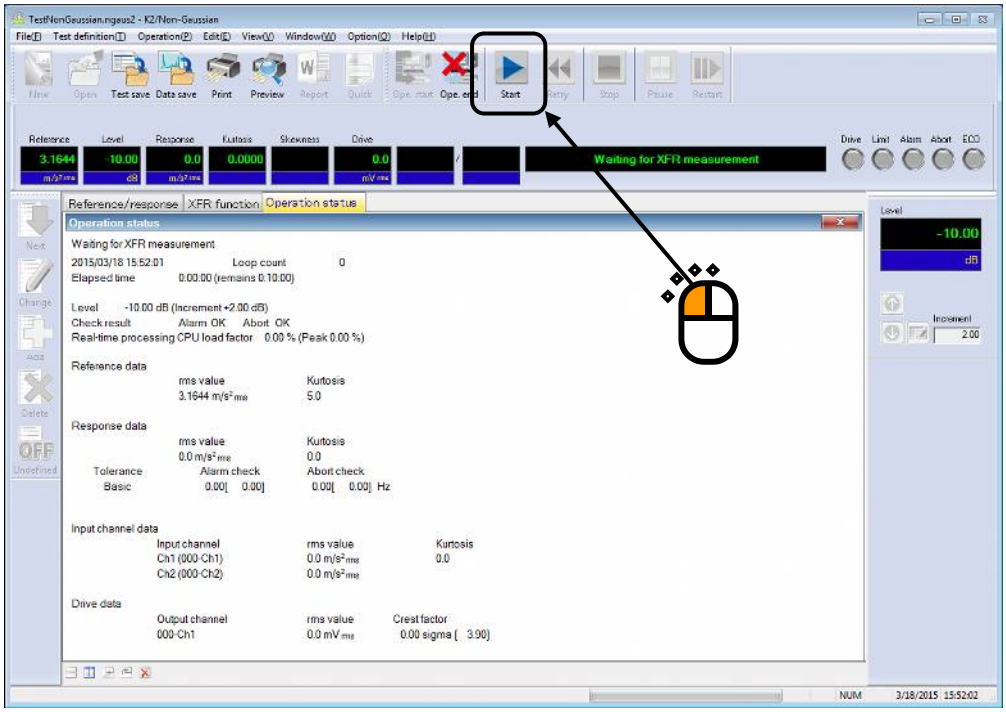
Press the button of [Operation start] for ‘Operation start’.



＜Step 2＞

Press the button of [XFR measurement start].

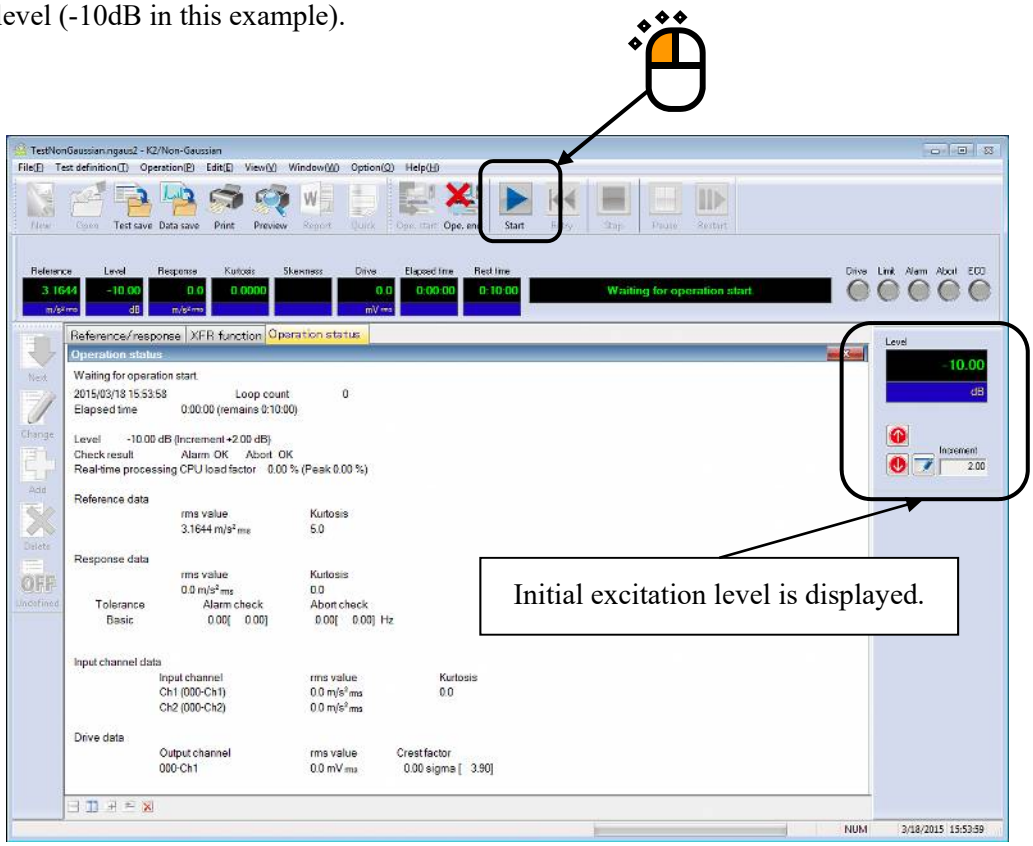
Initial loop check is automatically operated and the XFR measurement is started.



＜Step 3＞

The system proceeds to the state of waiting for operation start when the XFR measurement is finished.

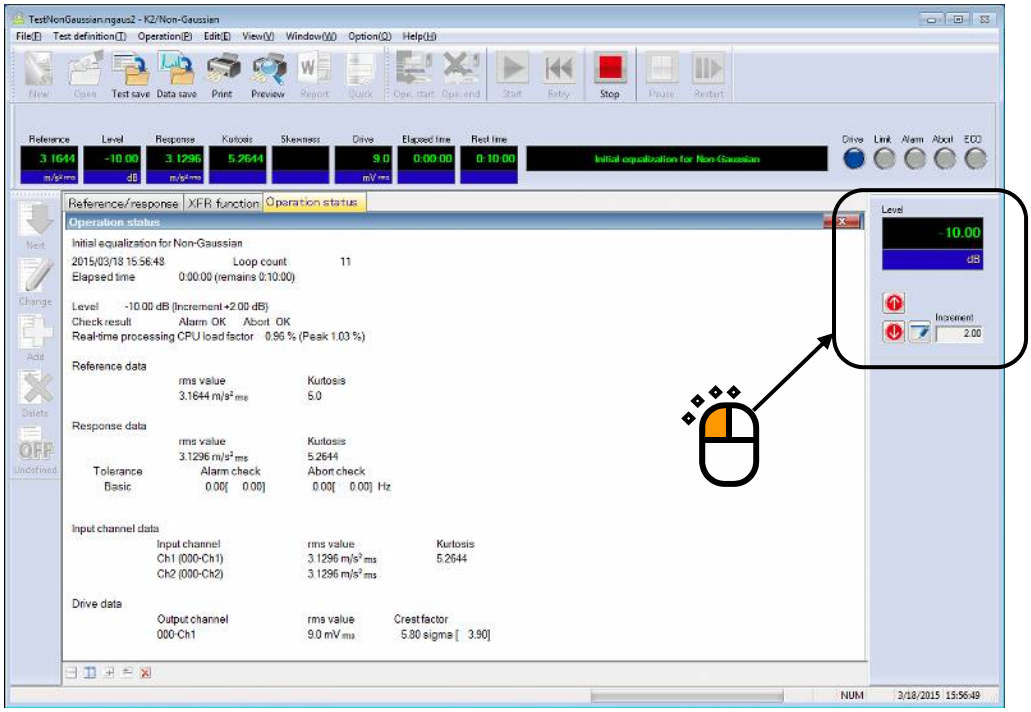
Press the button of [Operation start]. Initial loop check and initial equalization are automatically operated. When initial check and initial equalization are finished, the test operation is started at the initial excitation level (-10dB in this example).



＜Step 4＞

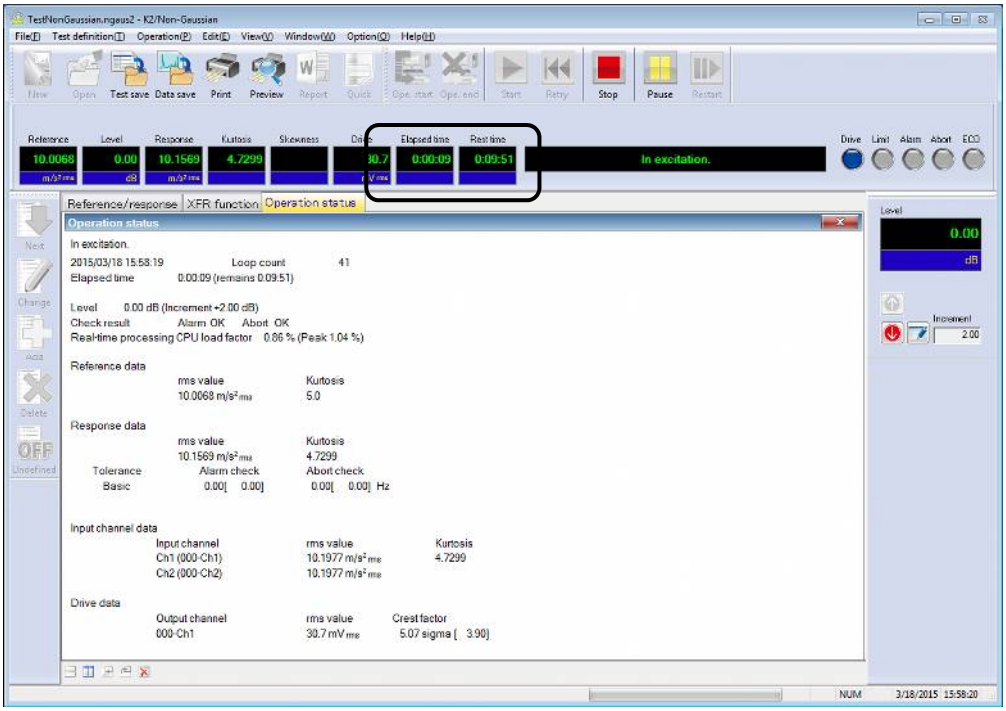
The test operation is started at the initial excitation level (-10dB in this example).

Press the level up button of excitation level and set the value to 0dB.



＜Step 5＞

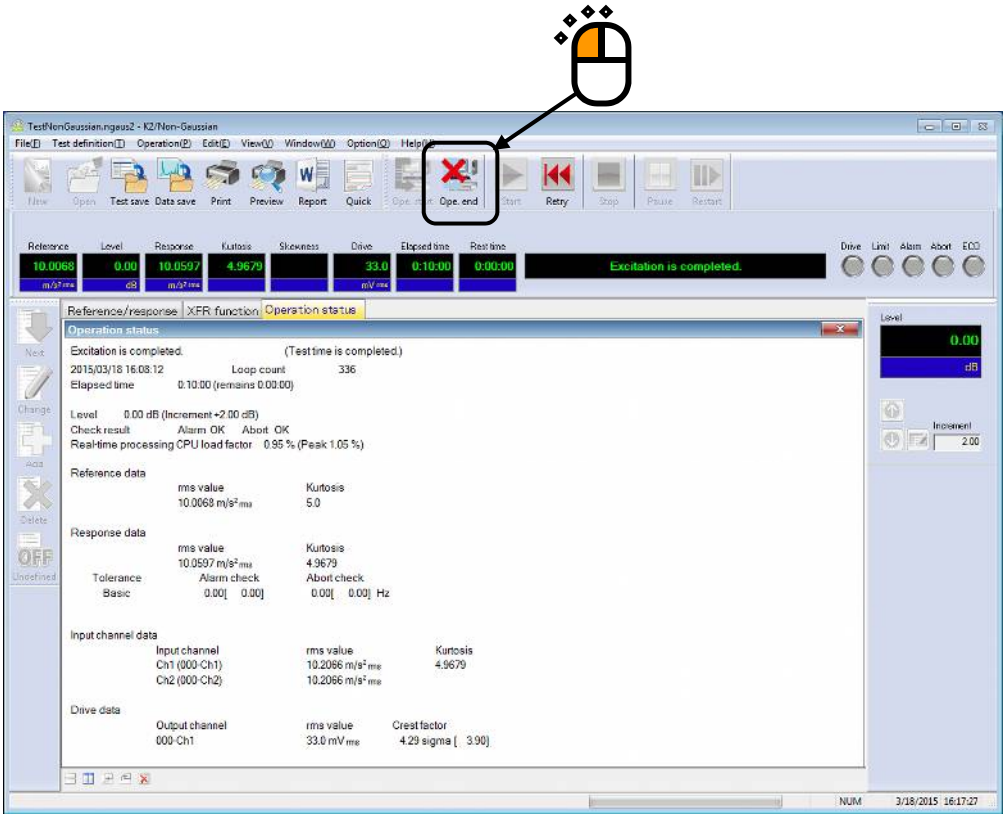
Test time starts to count the elapsed time for test operation when the excitation level is set to 0dB.



＜Step 6＞

Test operation is stopped when the test time ends.

Press the button of [Operation end]. The system proceeds to the display of test definition mode.



3.2 Measured PSD

<Example>

An example of the measured PSD test is described as below.

[Reference pattern]

Measured PSD data

Sporadic peak type is selected, and kurtosis is set to 5.0 during control.

[Control condition]

Frequency range : 2000Hz

Control lines : 400 lines

[Test time]

10 minutes

[Information of sensors to be used]

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

Ch. 1 : for non-gaussian control, sensitivity 3pC/(m/s^2), Measured PSD reference

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

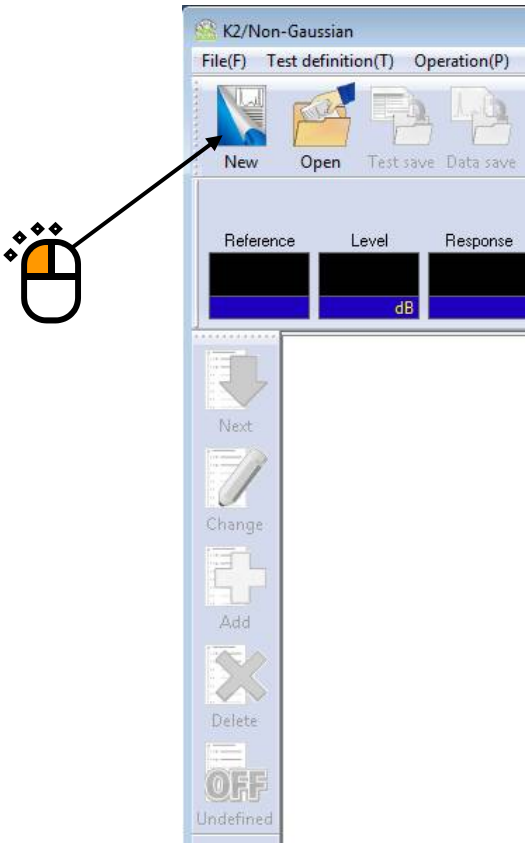
However, these channels must be registered in Input channel information (in this example, 'INPUT').

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

< Procedures >

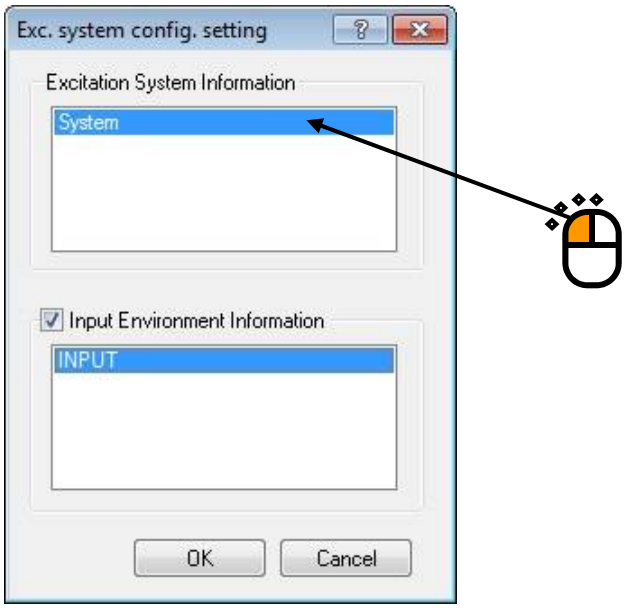
< Step 1 >

Press the button of [New] to start ‘New definition’.



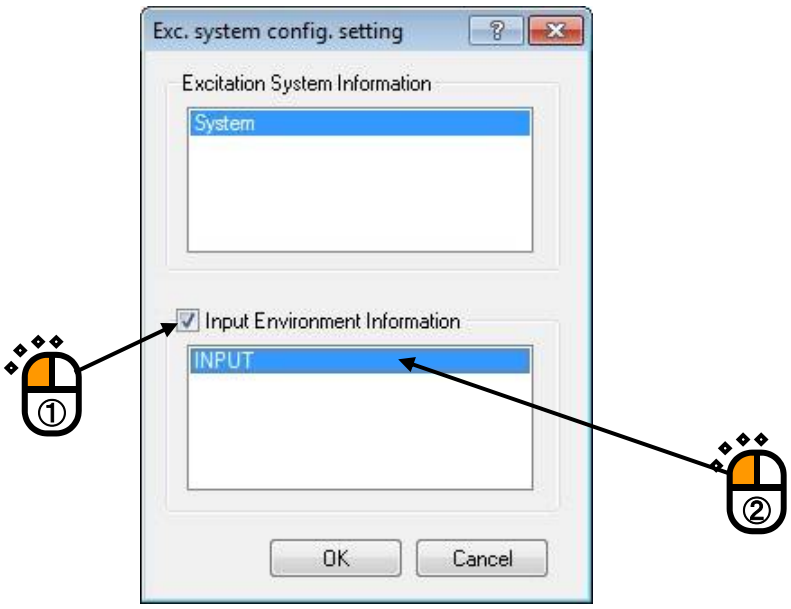
＜Step 2＞

Select an Excitation system from the list of ‘Excitation system information’.



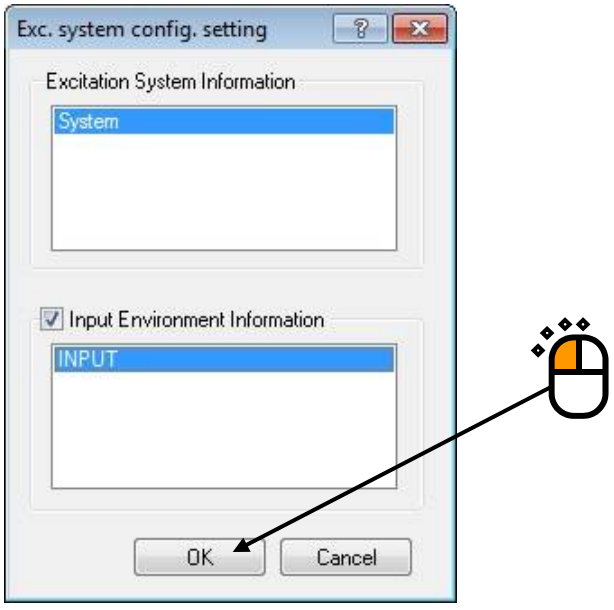
＜Step 3＞

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



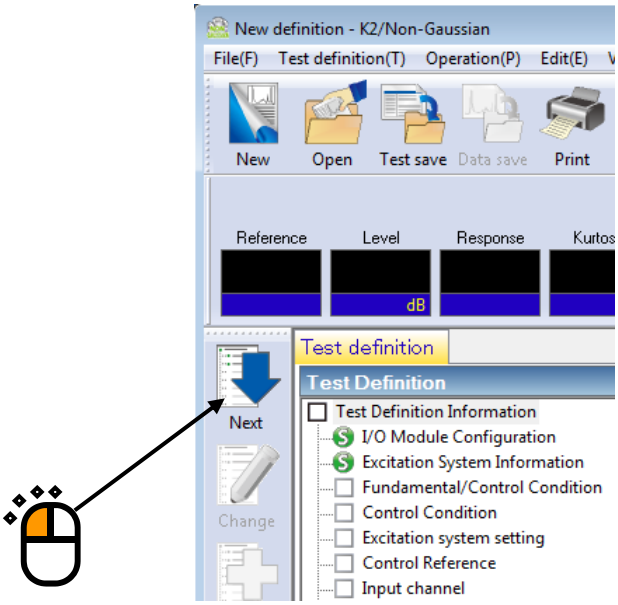
＜Step 4＞

Press the [OK] button.



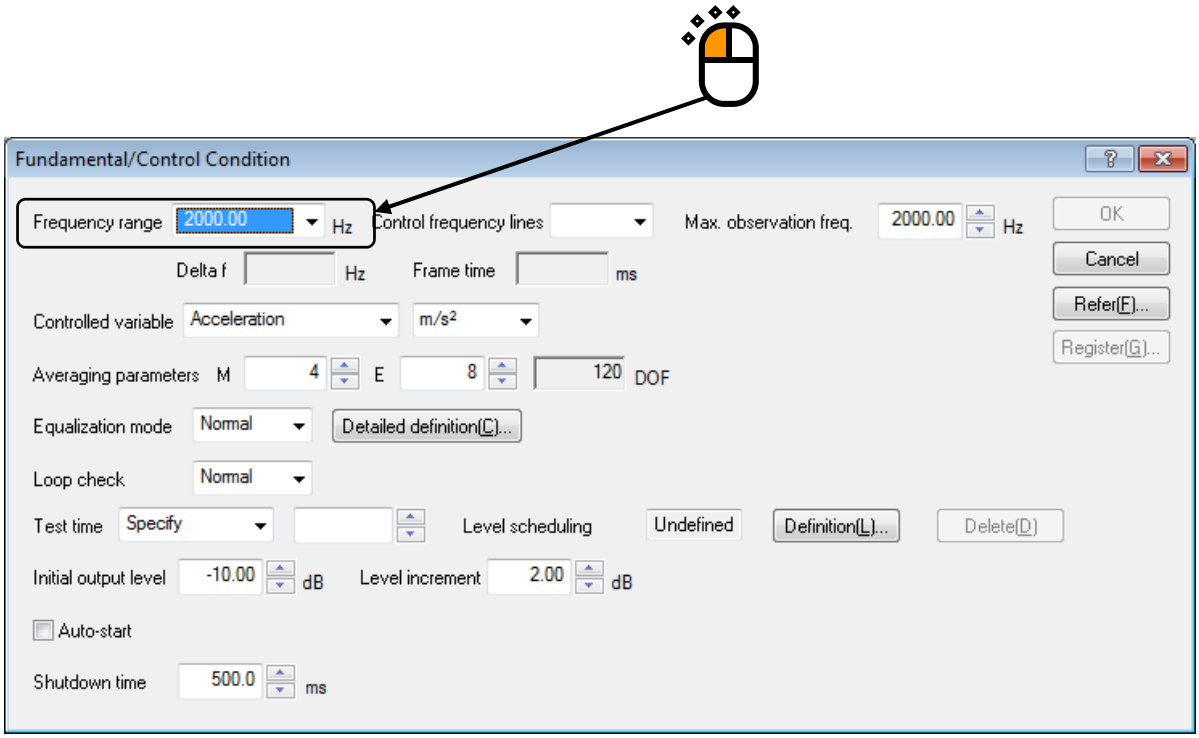
＜Step 5＞

Press the [Next] button.



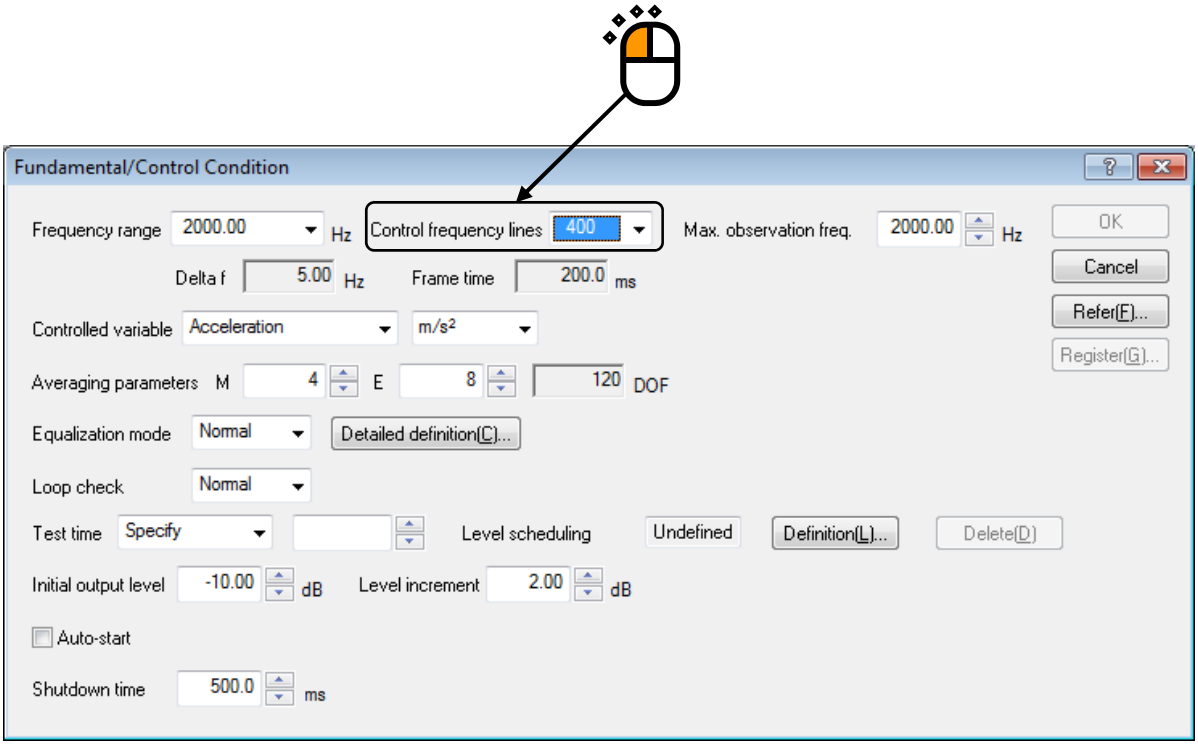
＜Step 6＞

Set the Frequency range to ‘2000Hz’.



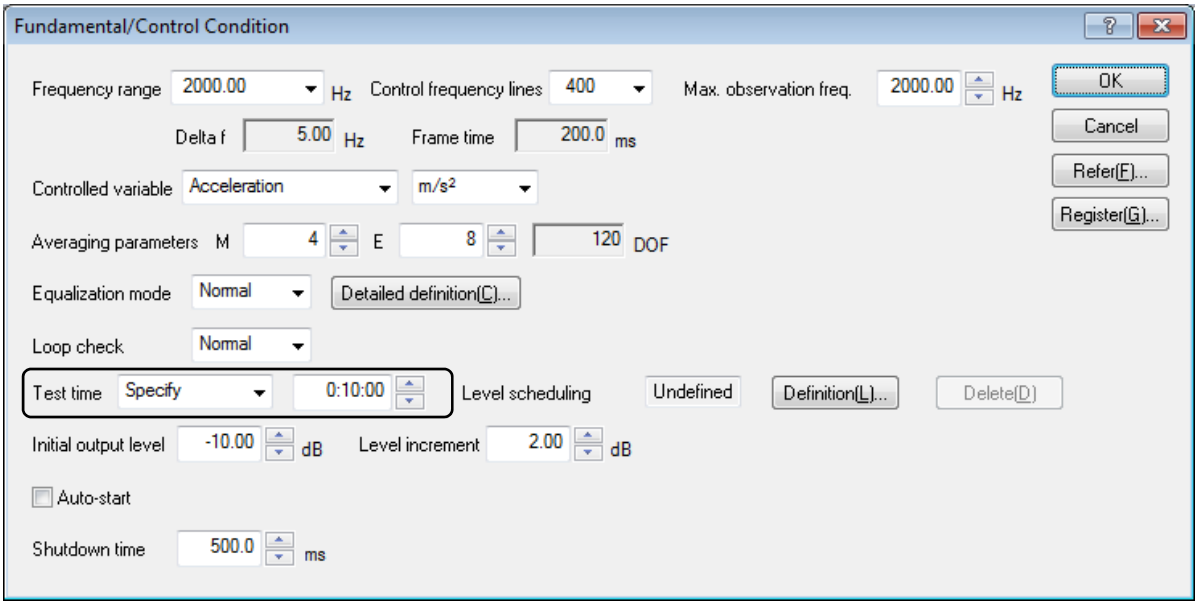
＜Step 7＞

Set the Control frequency lines to ‘400’.



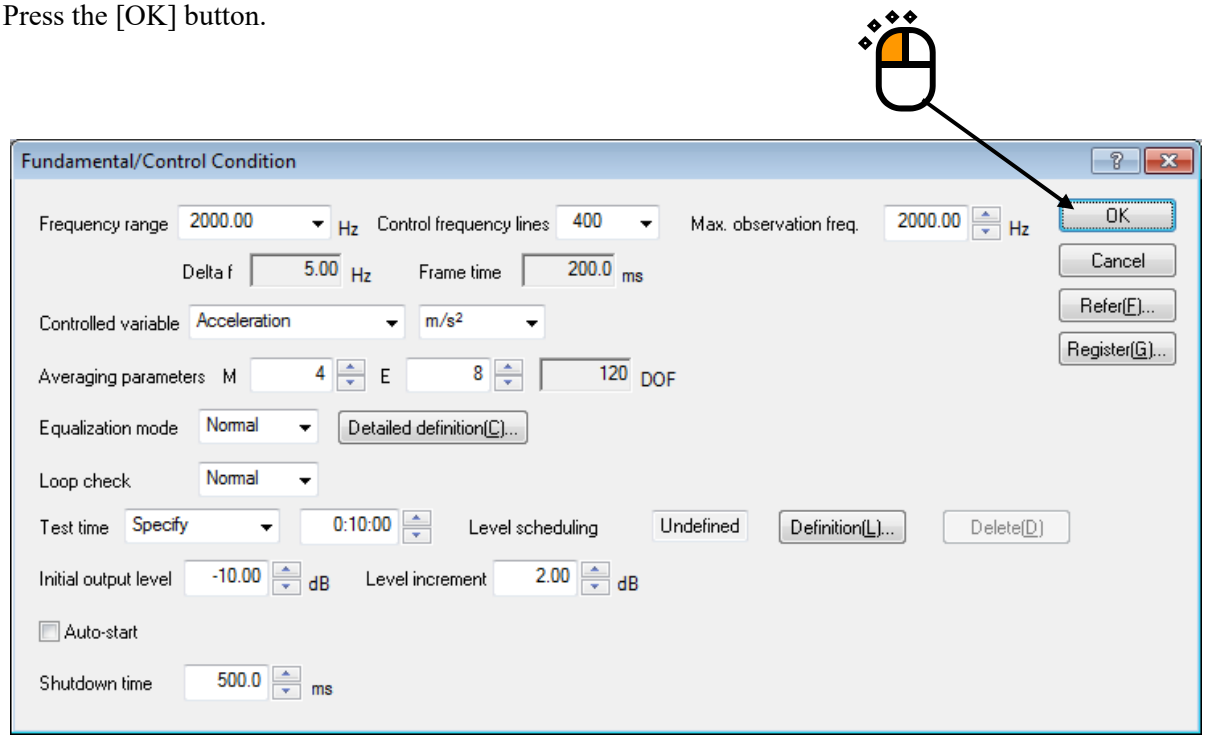
＜Step 8＞

Specify the Test time as ‘Specify time’. And input the value as ‘Test time : 0 : 10 : 00 (600 sec)’.



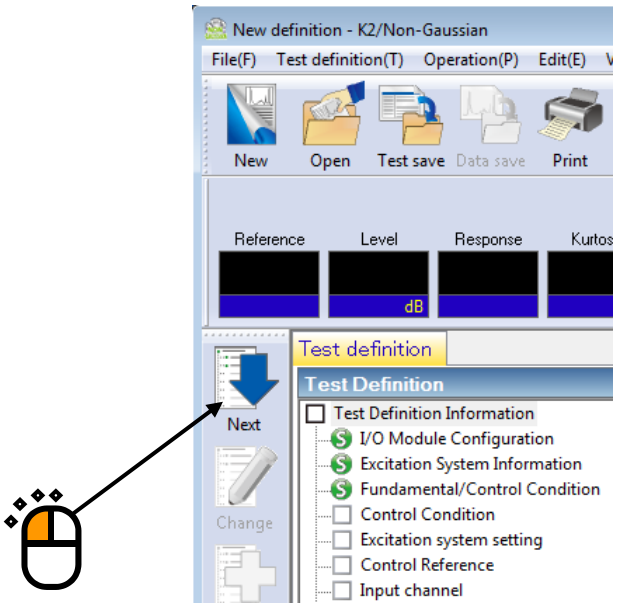
＜Step 9＞

Press the [OK] button.



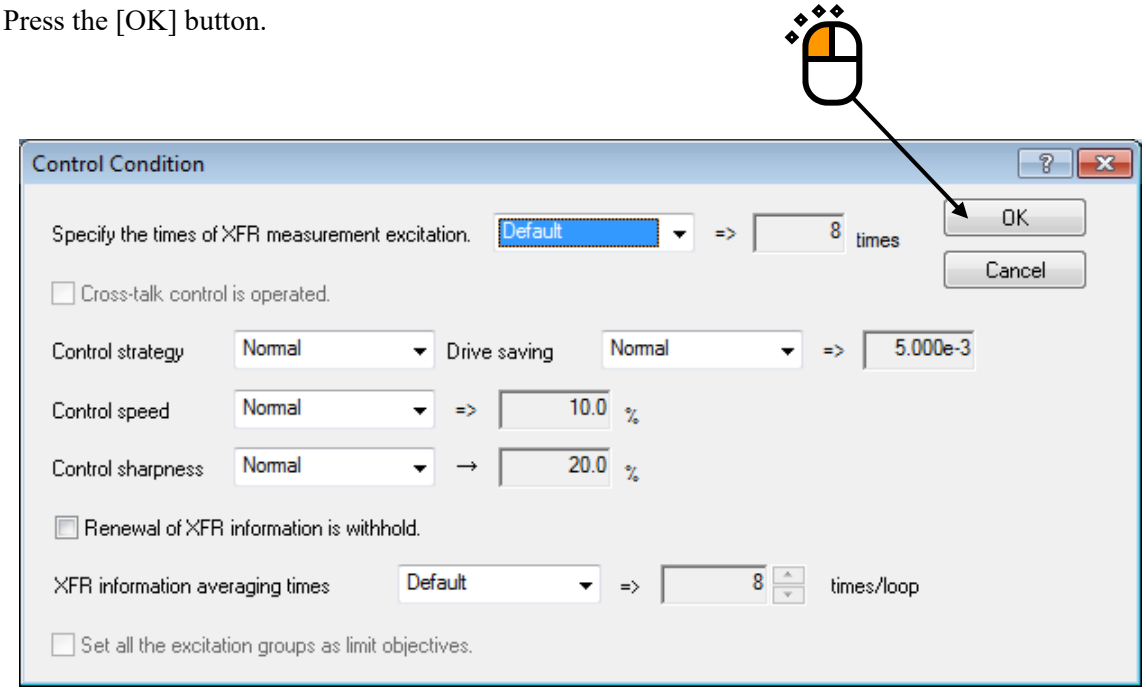
＜Step 10＞

Press the [Next] button.



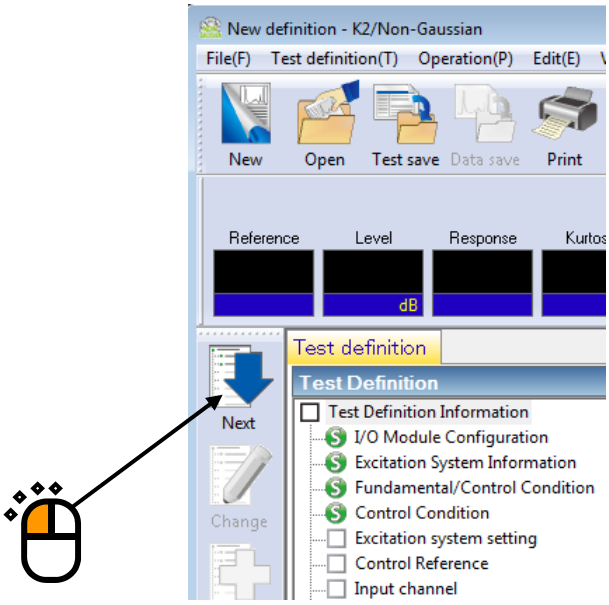
＜Step 11＞

Press the [OK] button.



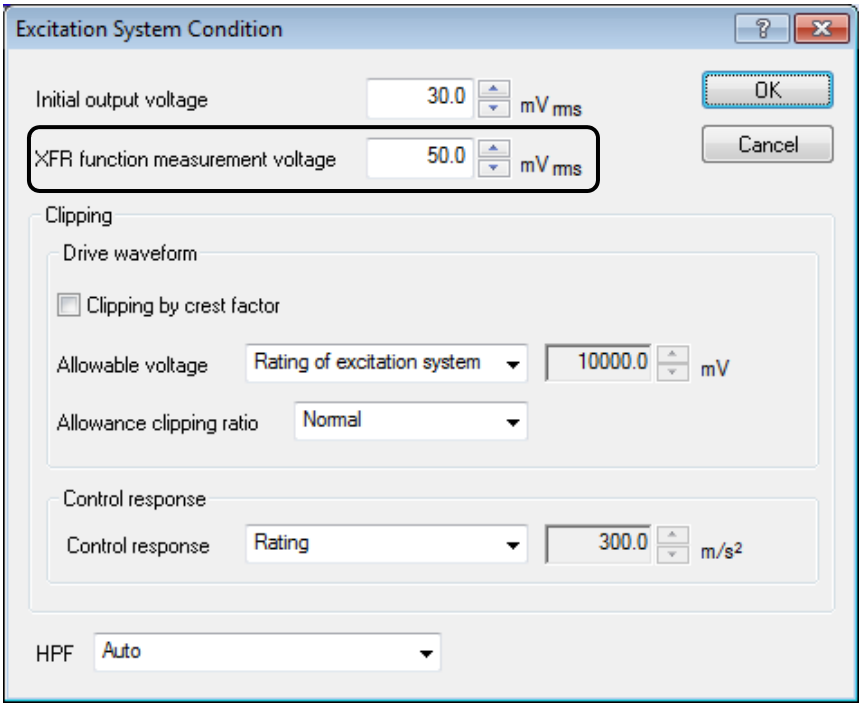
＜Step 12＞

Press the [Next] button.



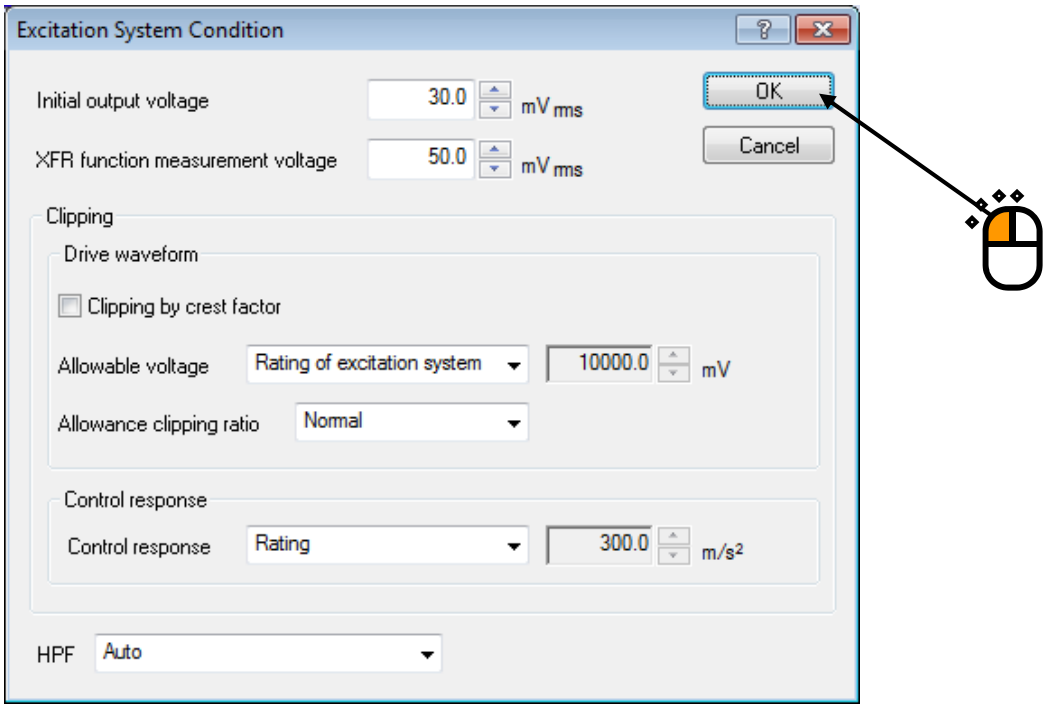
＜Step 13＞

Set the XFR function measurement voltage to 50 (mV_{rms}).



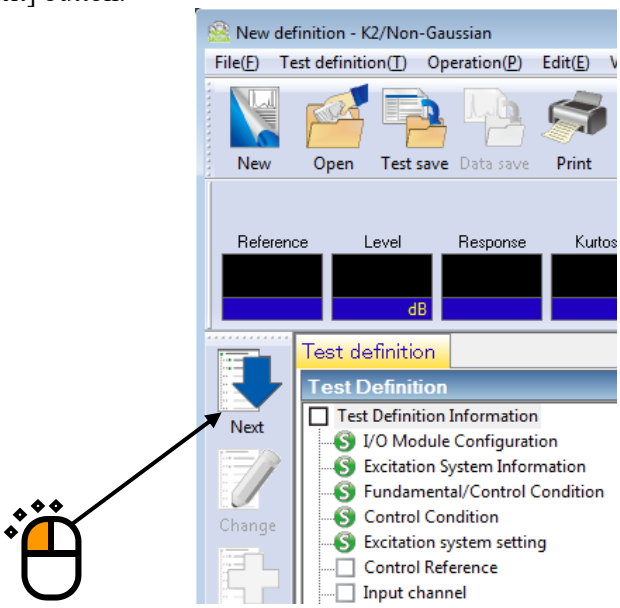
＜Step 14＞

Press the OK button.



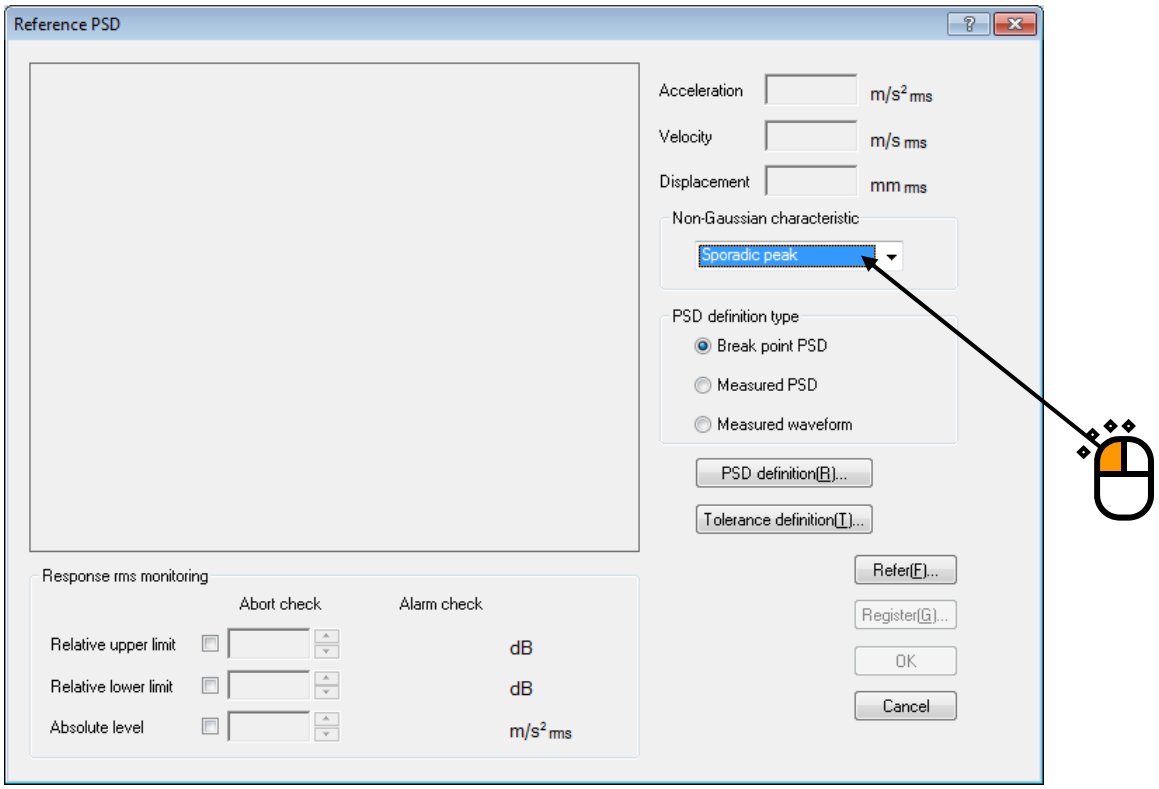
＜Step 15＞

Press the [Next] button.



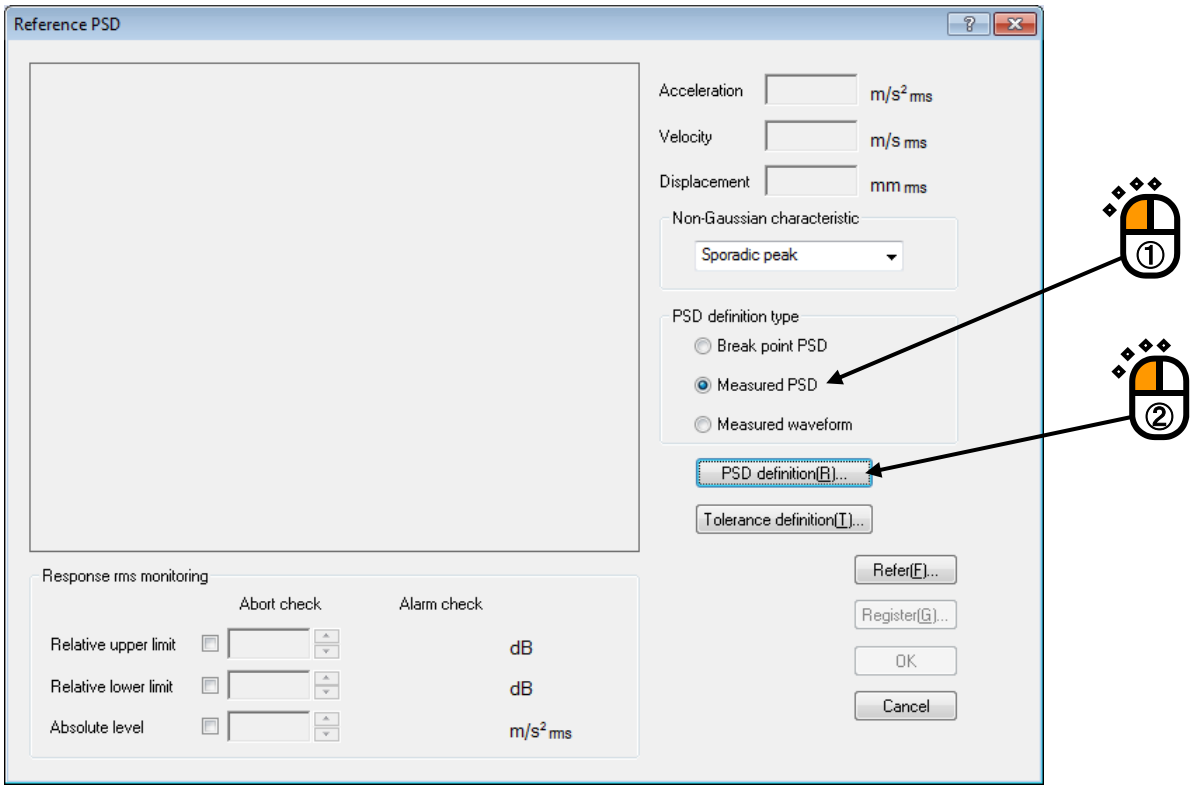
＜Step 16＞

Select ‘Sporadic peak’ in the Non-Gaussian characteristic area.



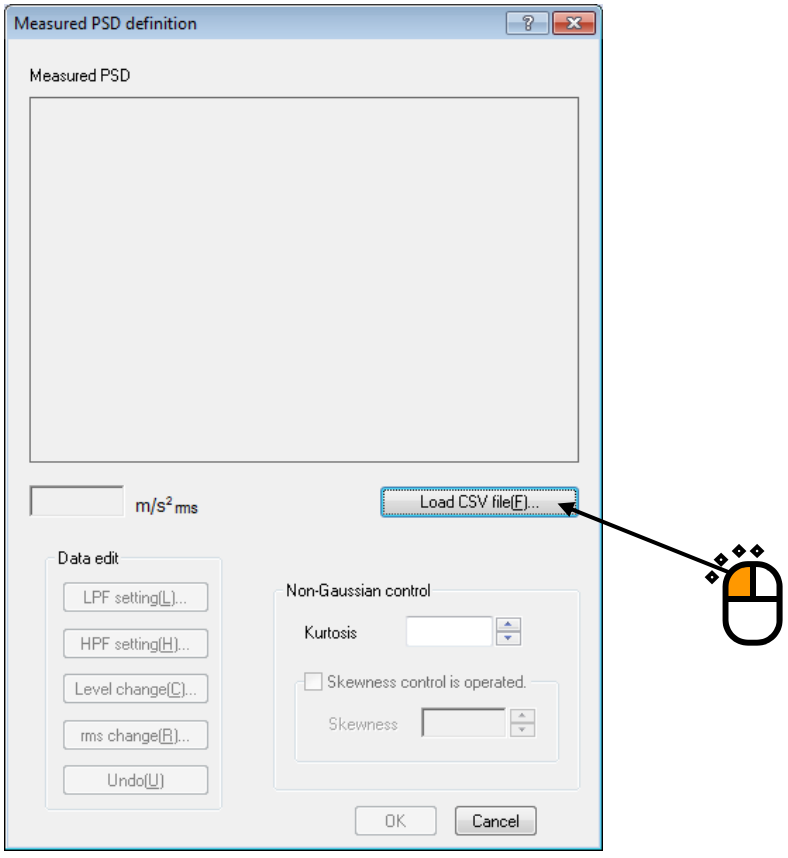
＜Step 17＞

Select the item of Measured PSD and press press the [PSD definition].



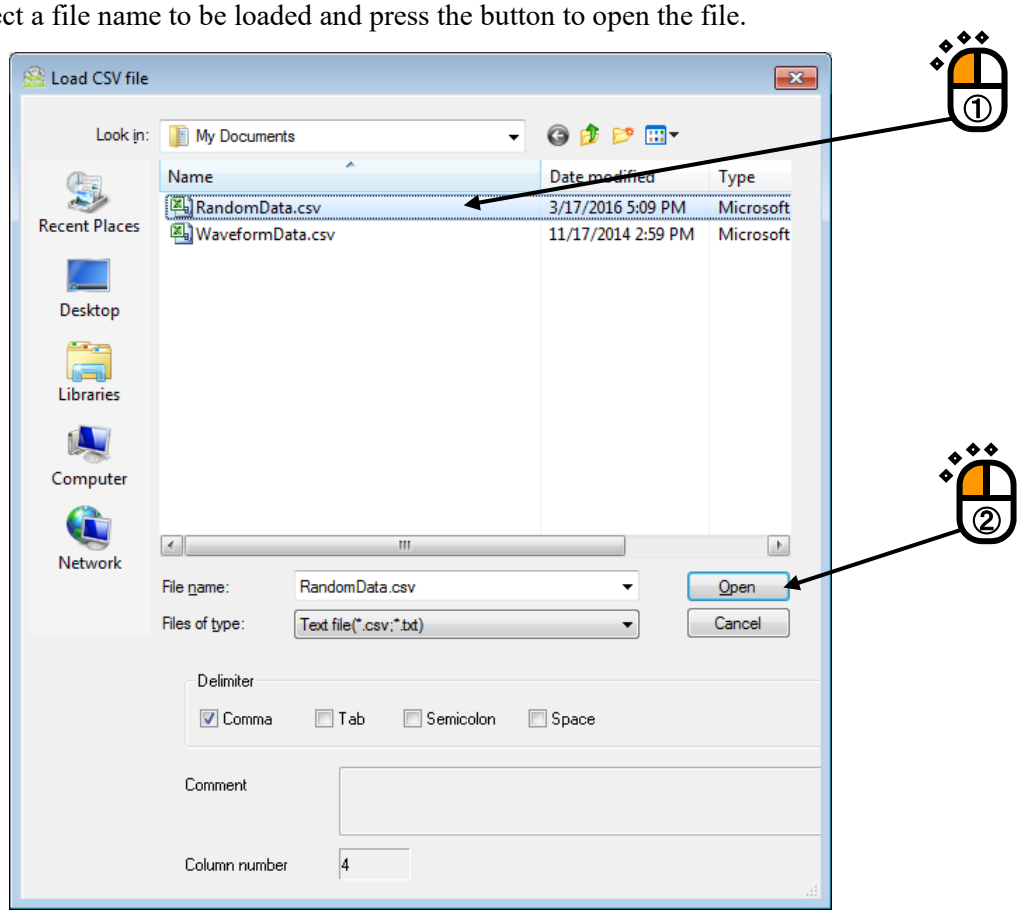
＜Step 18＞

Press the button of [CSV file loading].



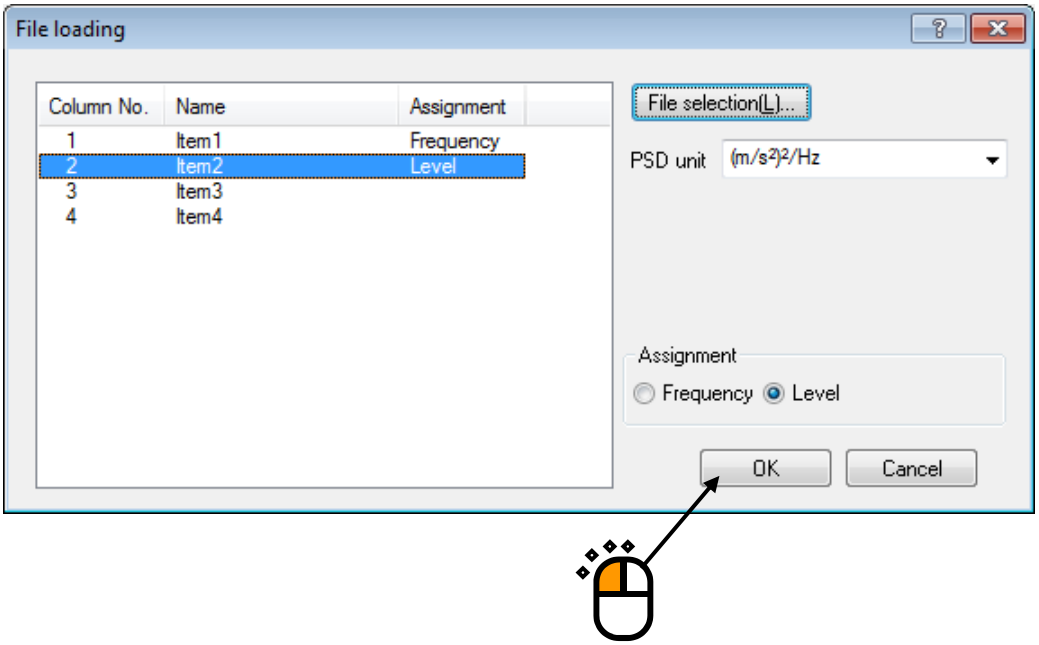
＜Step 19＞

Select a file name to be loaded and press the button to open the file.



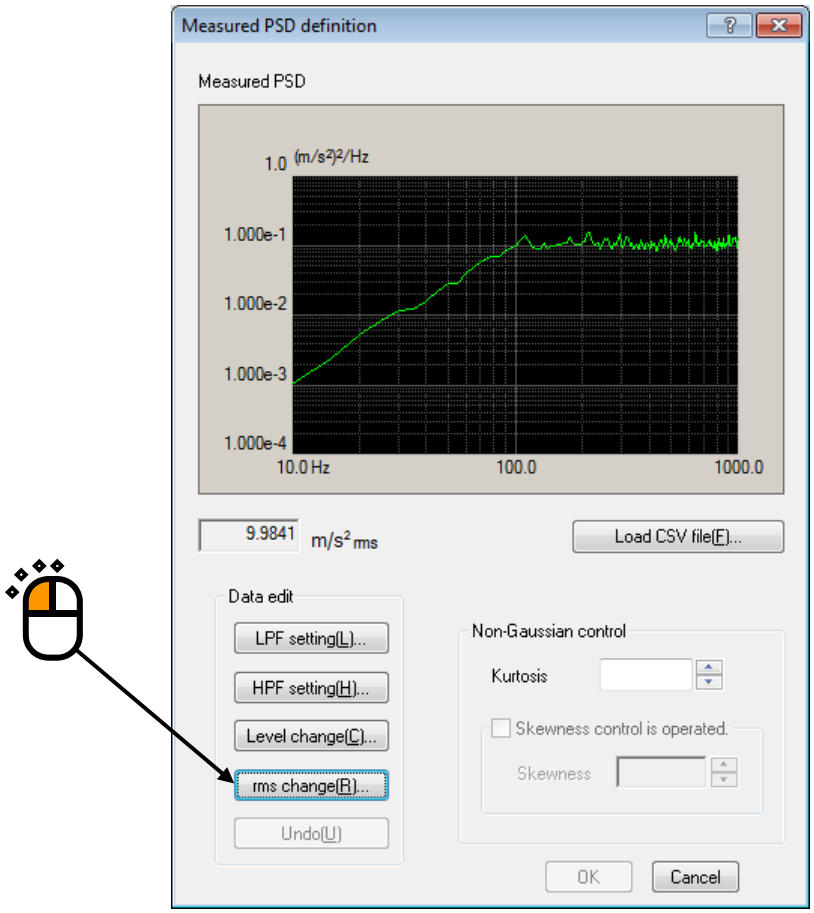
＜Step 20＞

Press the OK button.



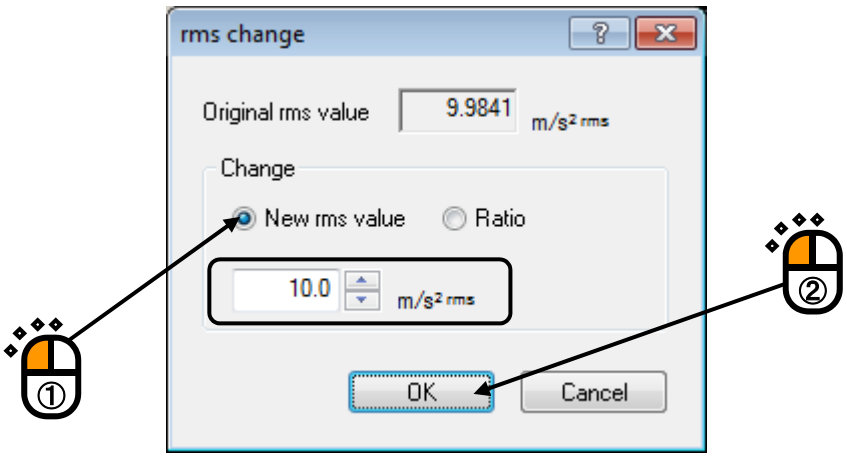
＜Step 21＞

Press the button of [rms change].



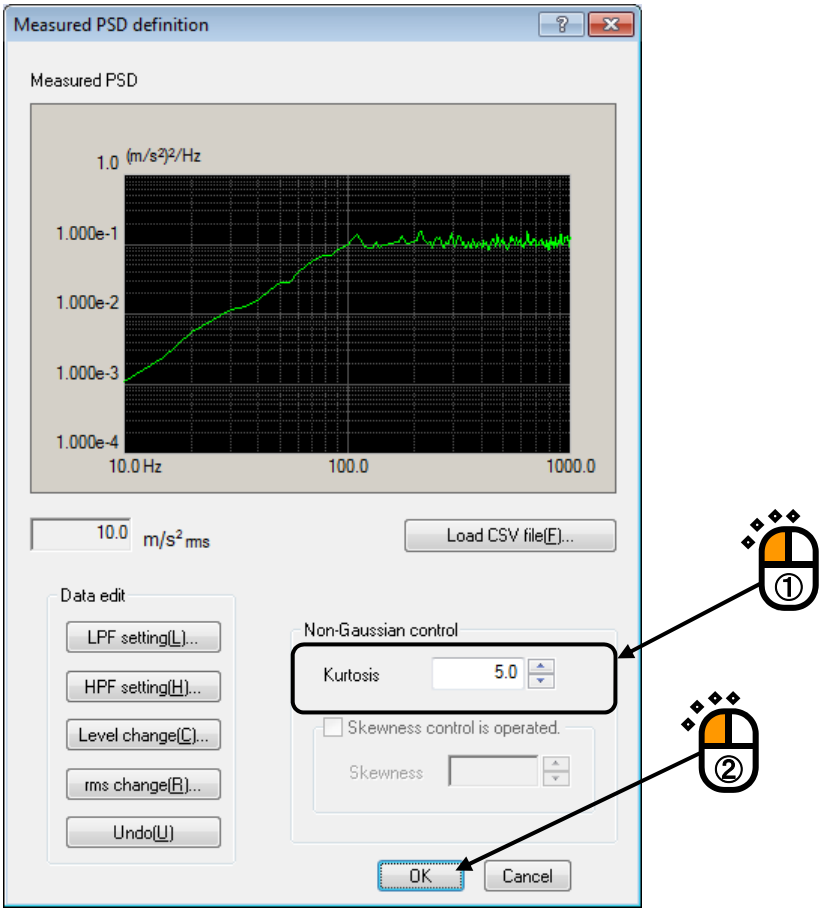
＜Step 22＞

Select the item of New rms value and input the value as ‘New rms value : 10 [(m/s^2) rms]. And press the [OK] button.



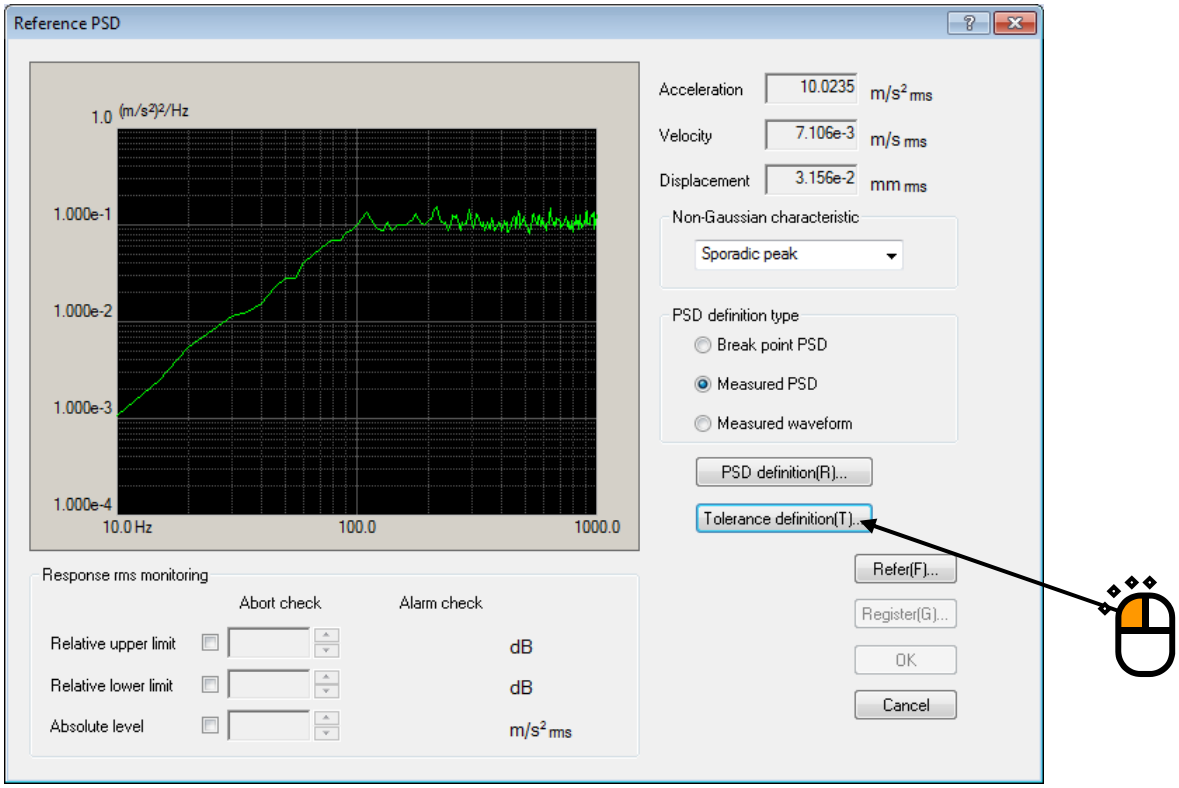
＜Step 23＞

Enter ‘Kurtosis: 5’, and press the [OK] button.



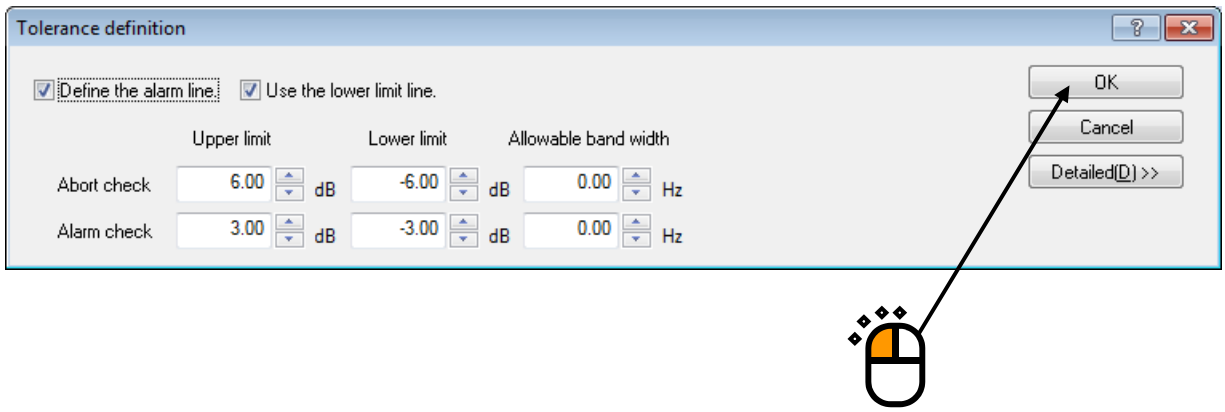
＜Step 24＞

Press the [Tolerance definition] button.



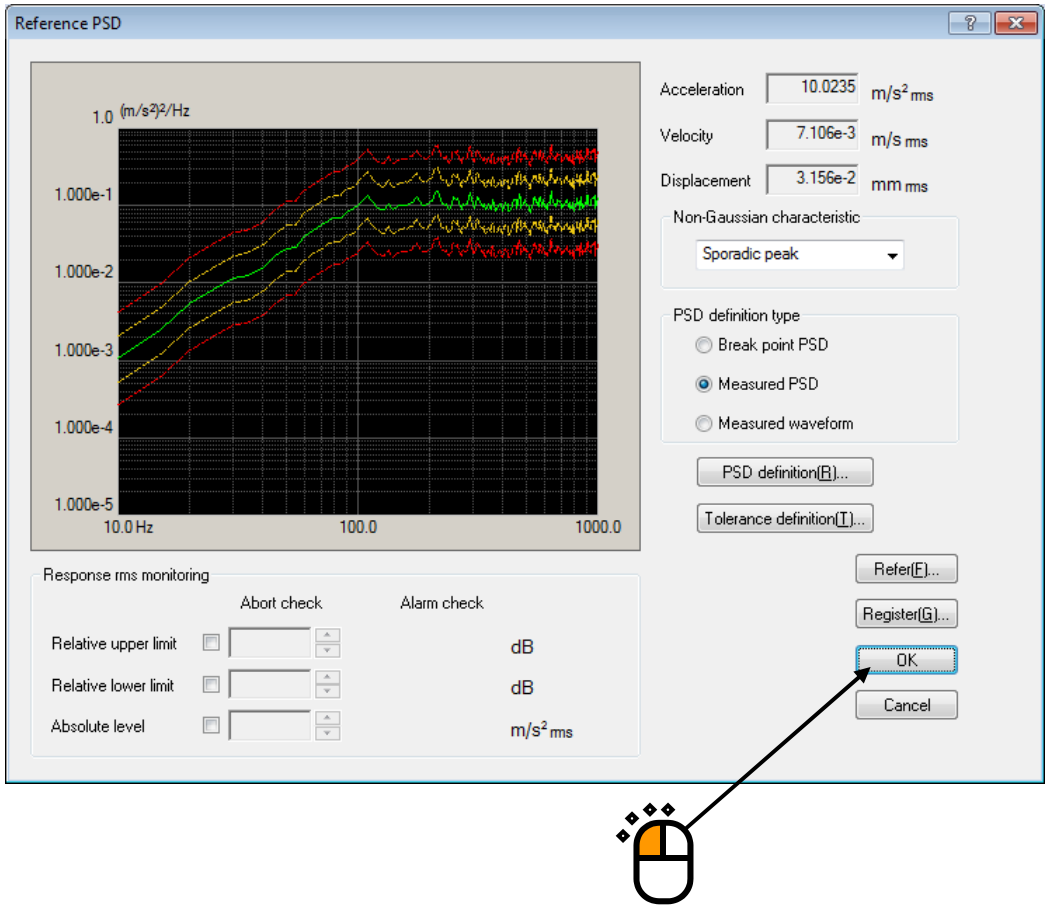
＜Step 25＞

Press the [OK] button.



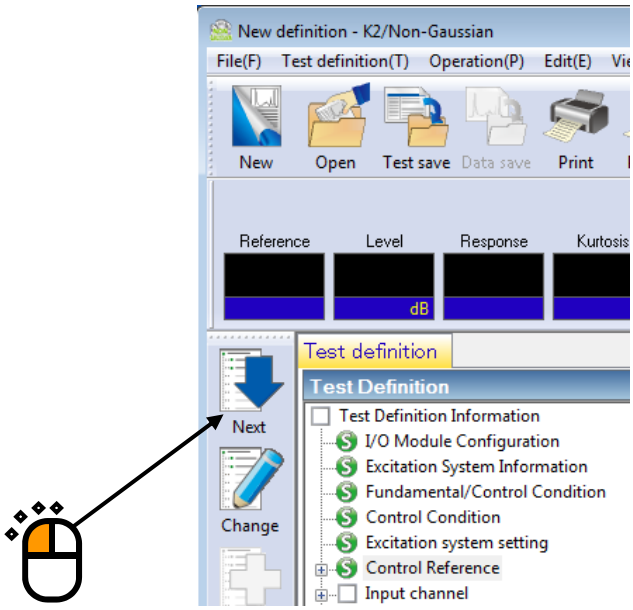
＜Step 26＞

Press the [OK] button.



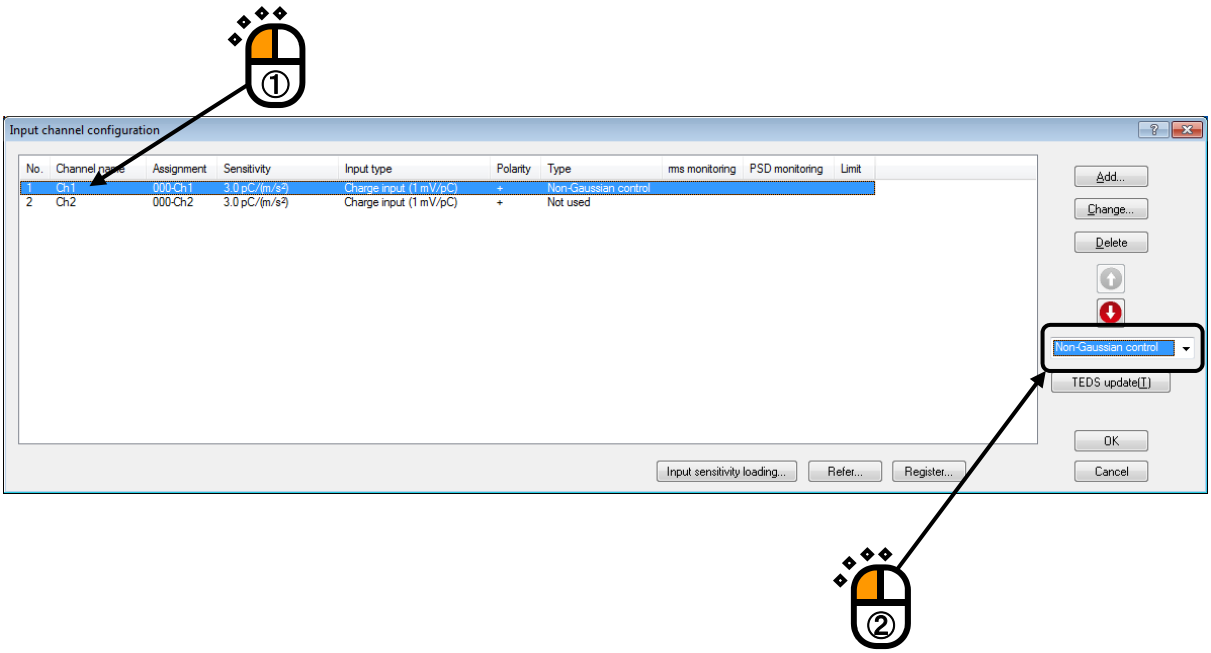
＜Step 27＞

Press the [Next] button.



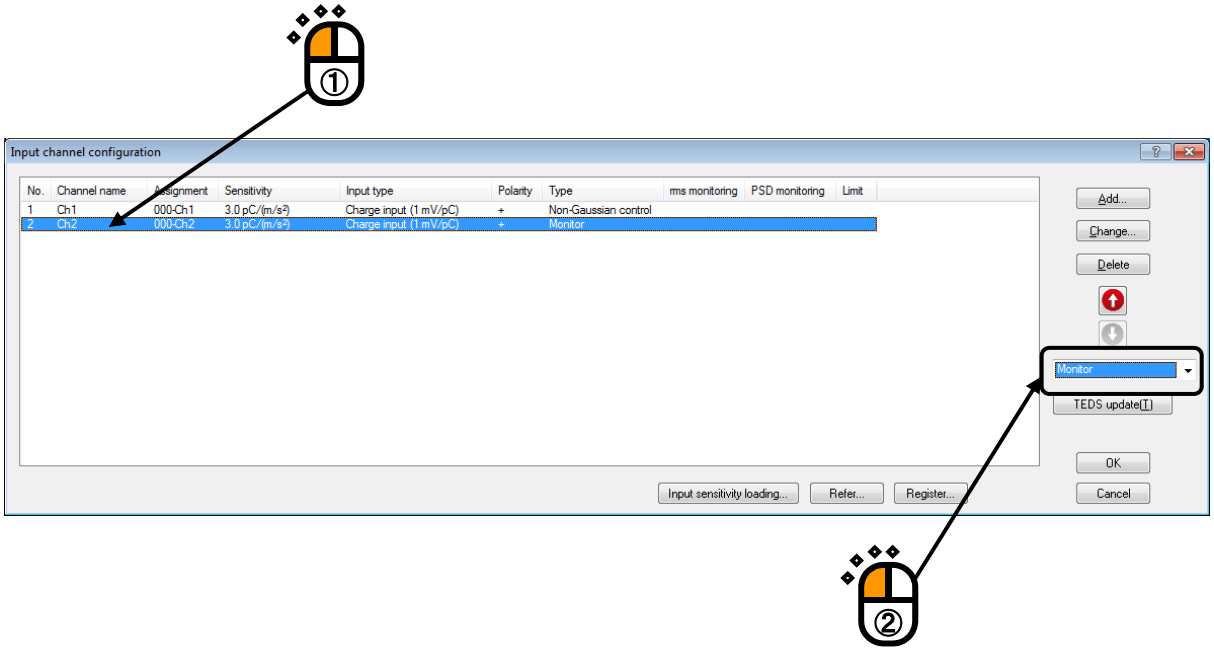
＜Step 28＞

Select ‘Ch.1’ and set as ‘Non-gaussian control’.



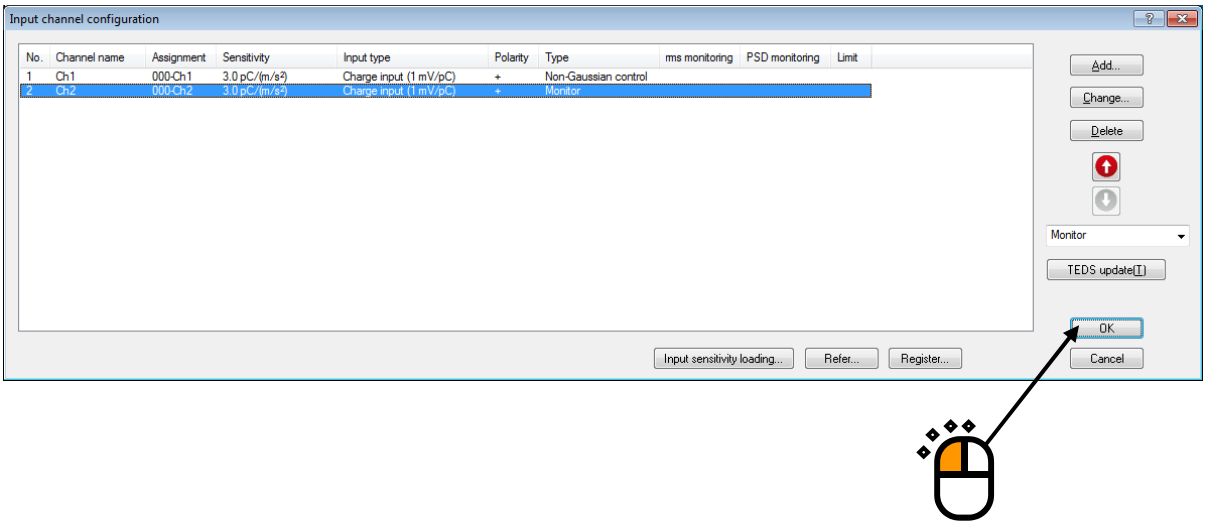
＜Step 29＞

Also, select ‘Ch.2’ and set as ‘Monitor’.



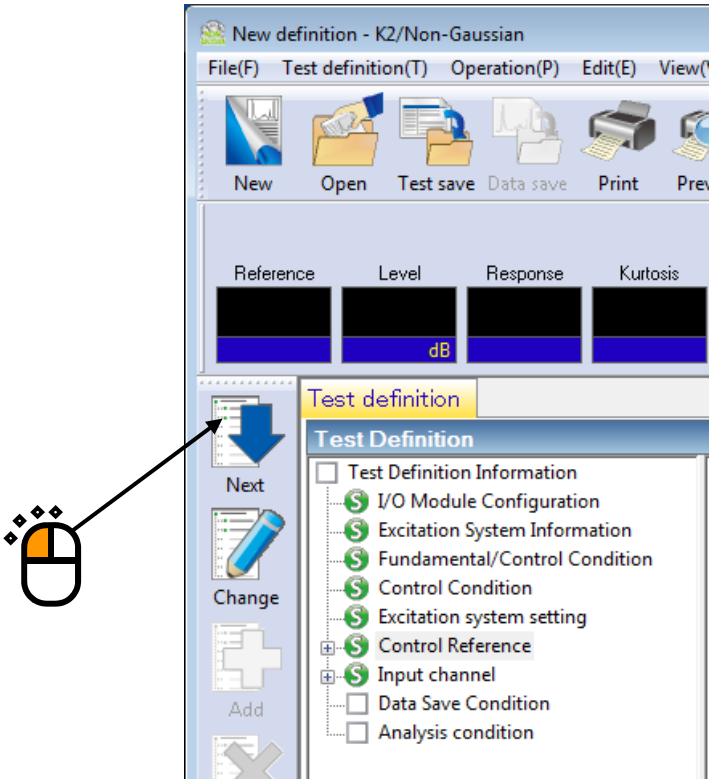
＜Step 30＞

Press the [OK] button.



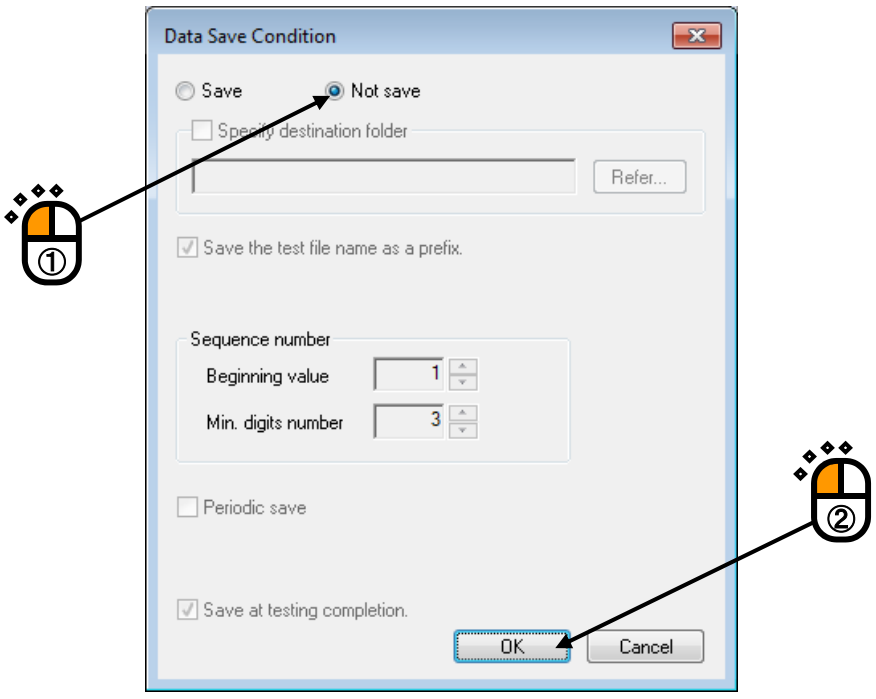
＜Step 31＞

Press the [Next] button.



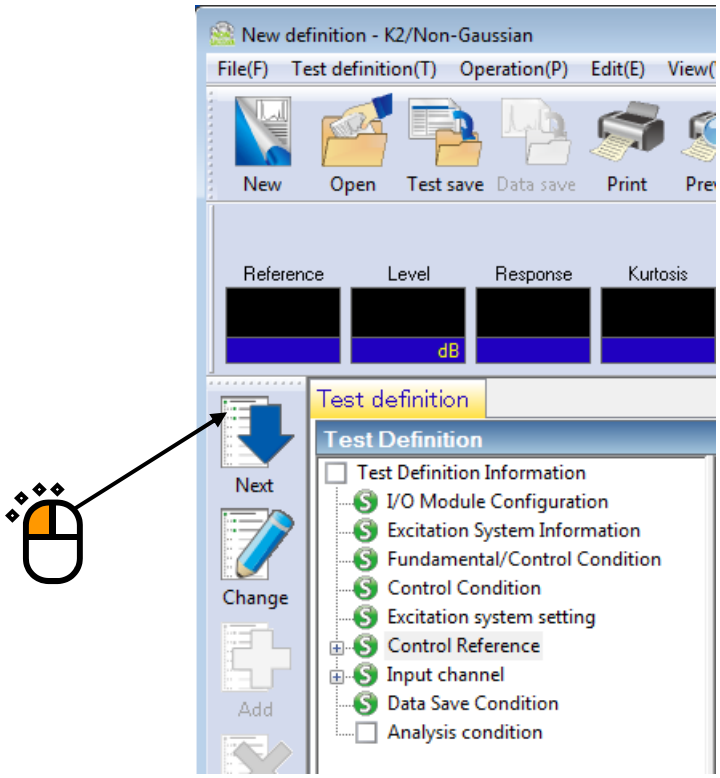
＜Step 32＞

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



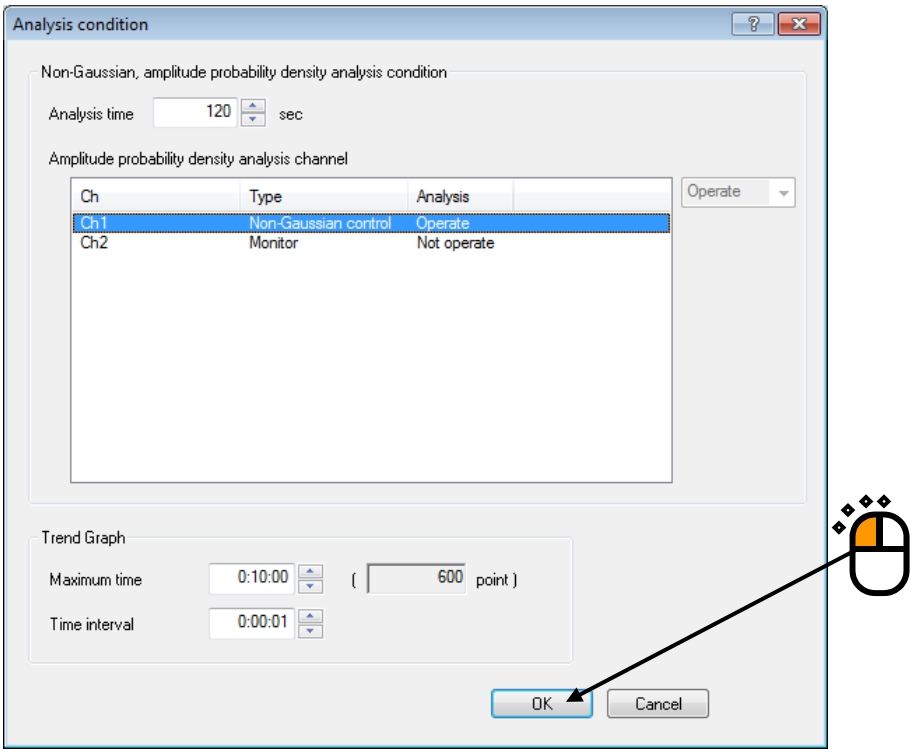
< Step33 >

Press the button of [Next].



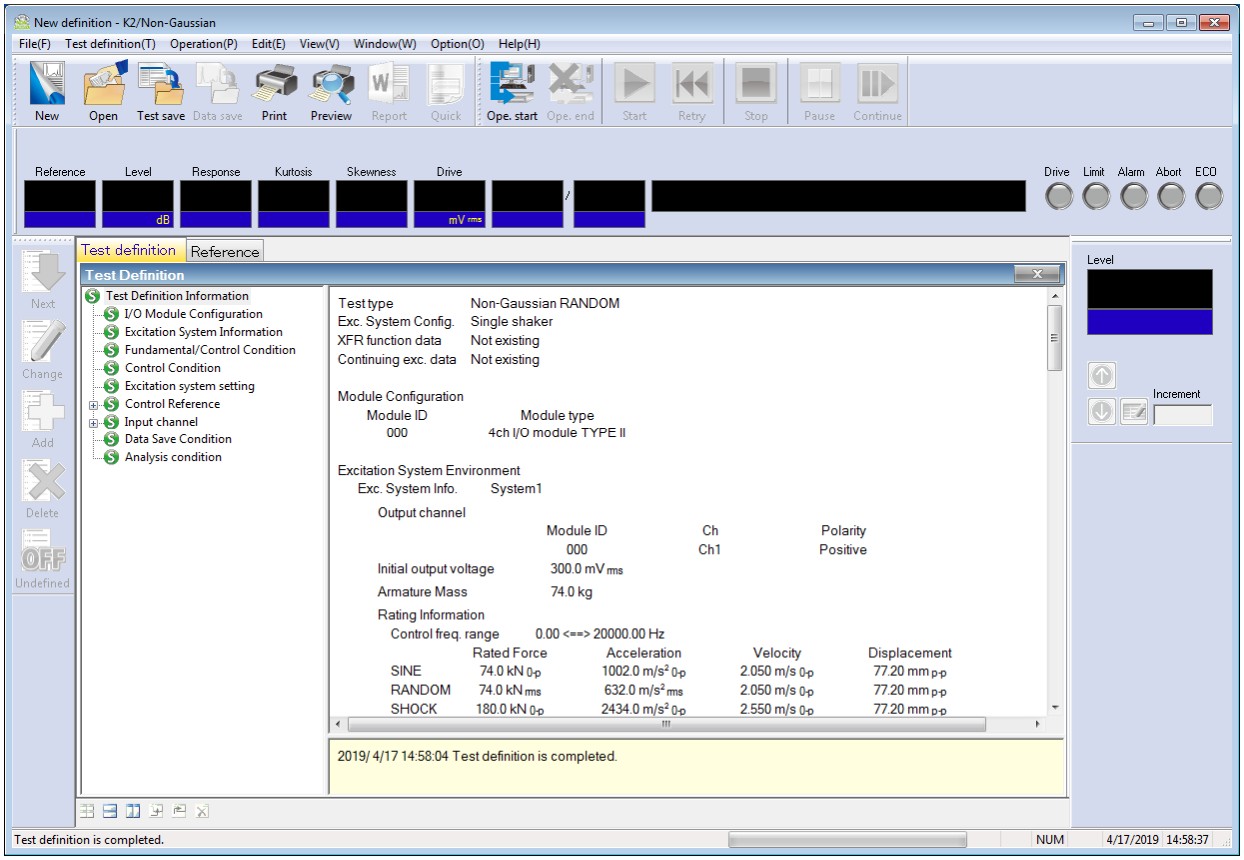
< Step34 >

Press the [OK] button.



< Step35 >

The definition is completed.

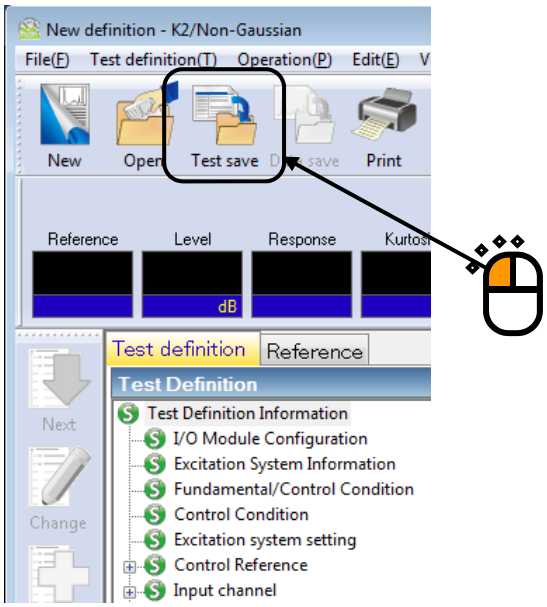


< Save of test>

< Step 1 >

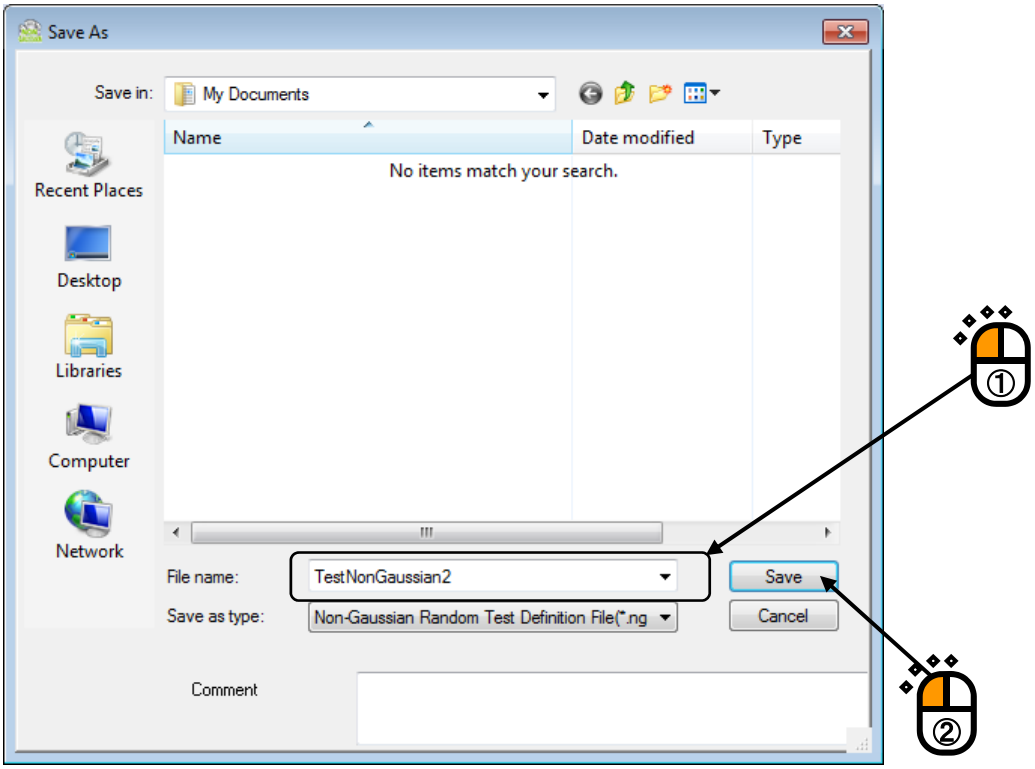
Save the defined test information to a test file.

Click the [Save] button.



＜Step 2＞

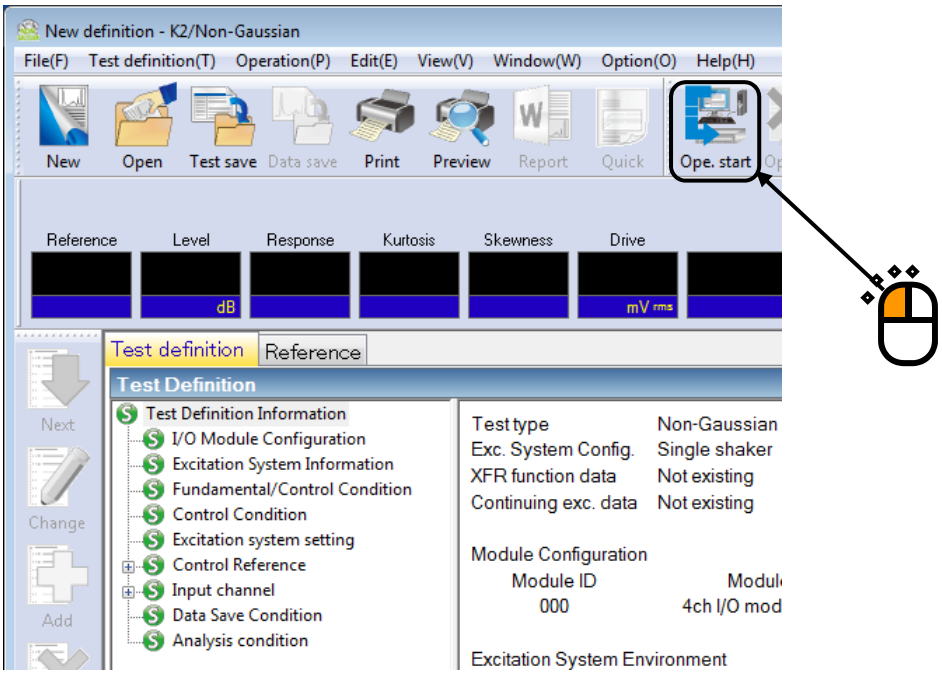
The dialog box as below appears. Specify an arbitrary directory in ‘Save in’ and input a name to ‘File name’.



< Operation of test >

< Step 1 >

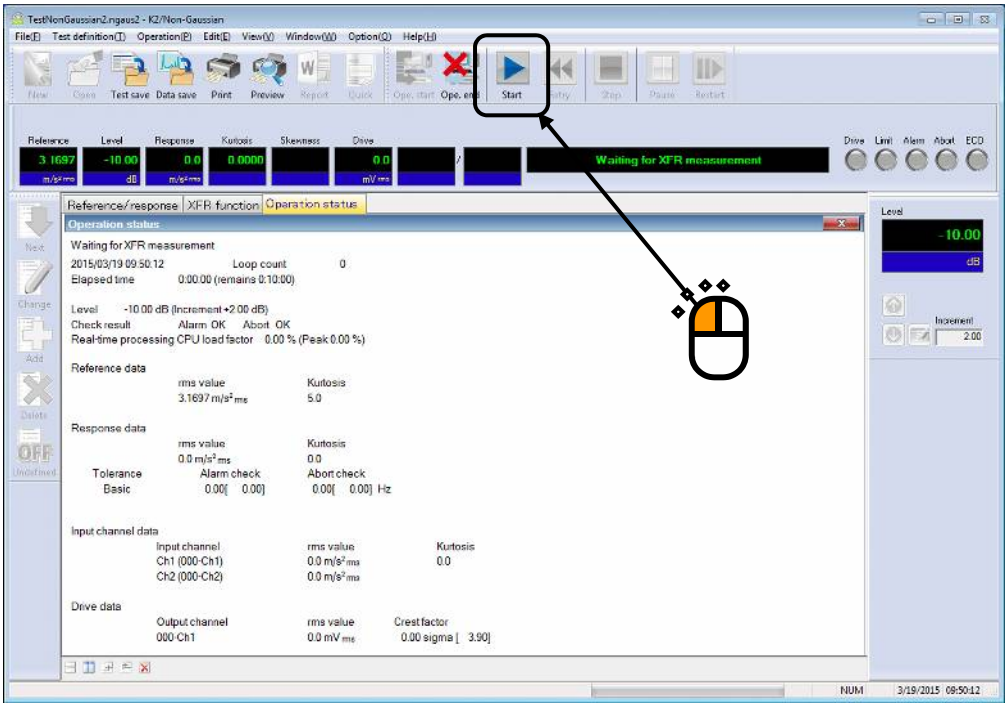
Press the button of [Operation start] for ‘Operation start’.



＜Step 2＞

Press the button of [XFR measurement start].

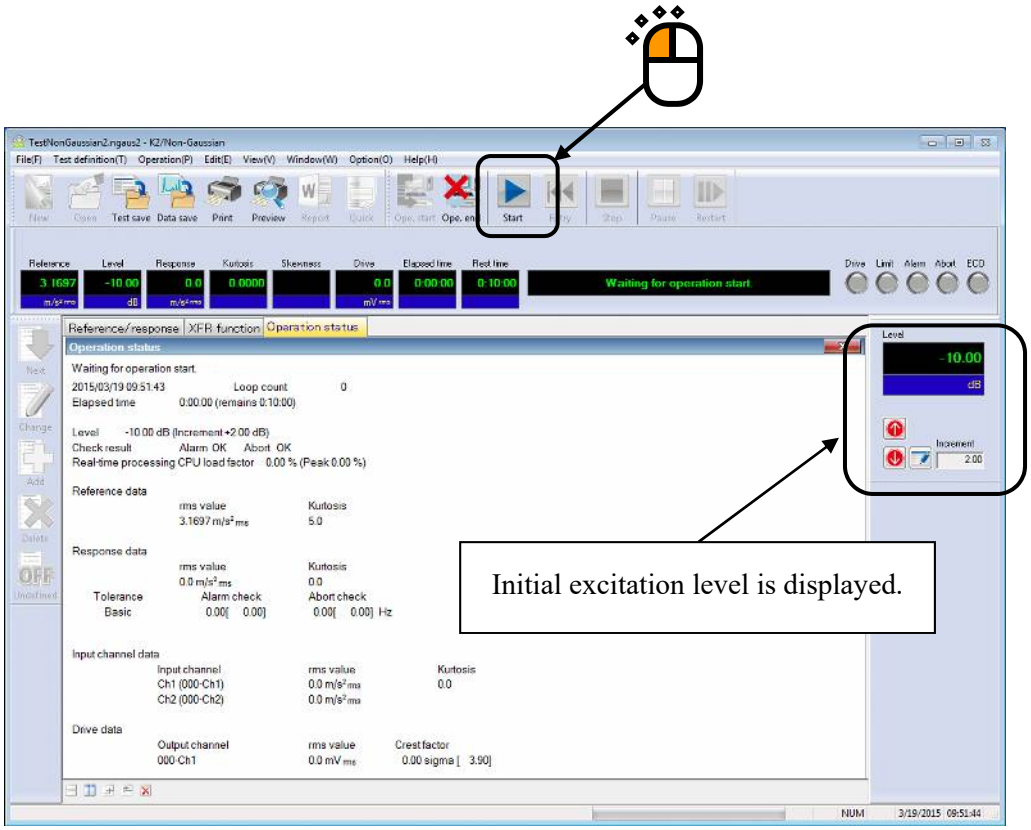
Initial loop check is automatically operated and the XFR measurement is started.



＜Step 3＞

The system proceeds to the state of waiting for operation start when the XFR measurement is finished.

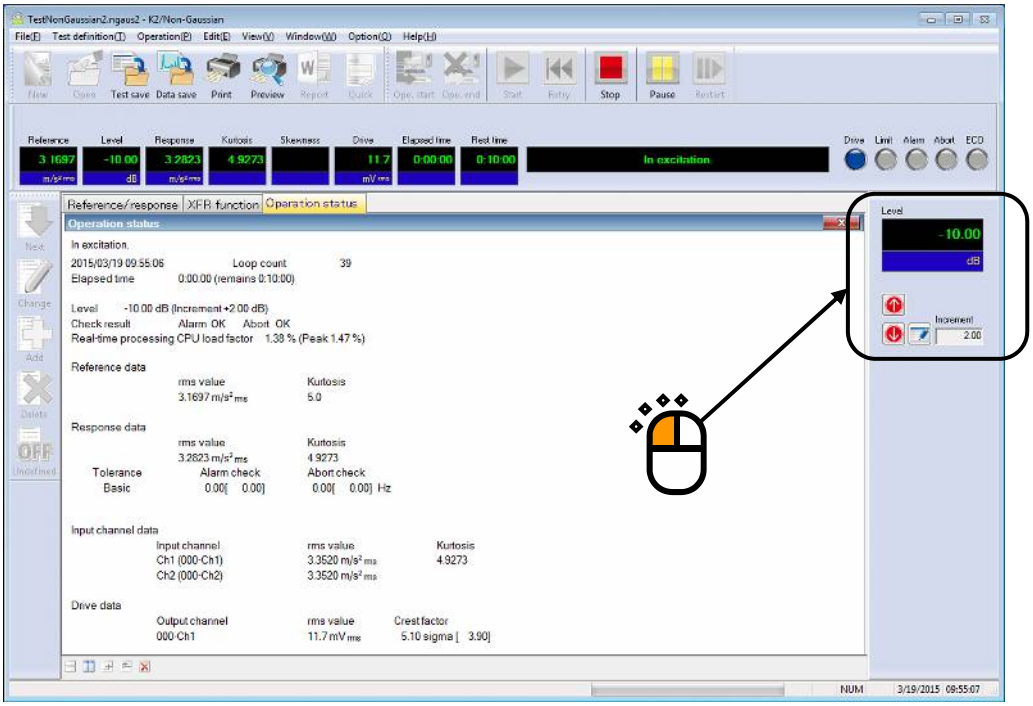
Press the button of [Operation start]. Initial loop check and initial equalization are automatically operated. When initial check and initial equalization are finished, the test operation is started at the initial excitation level (-10dB in this example).



＜Step 4＞

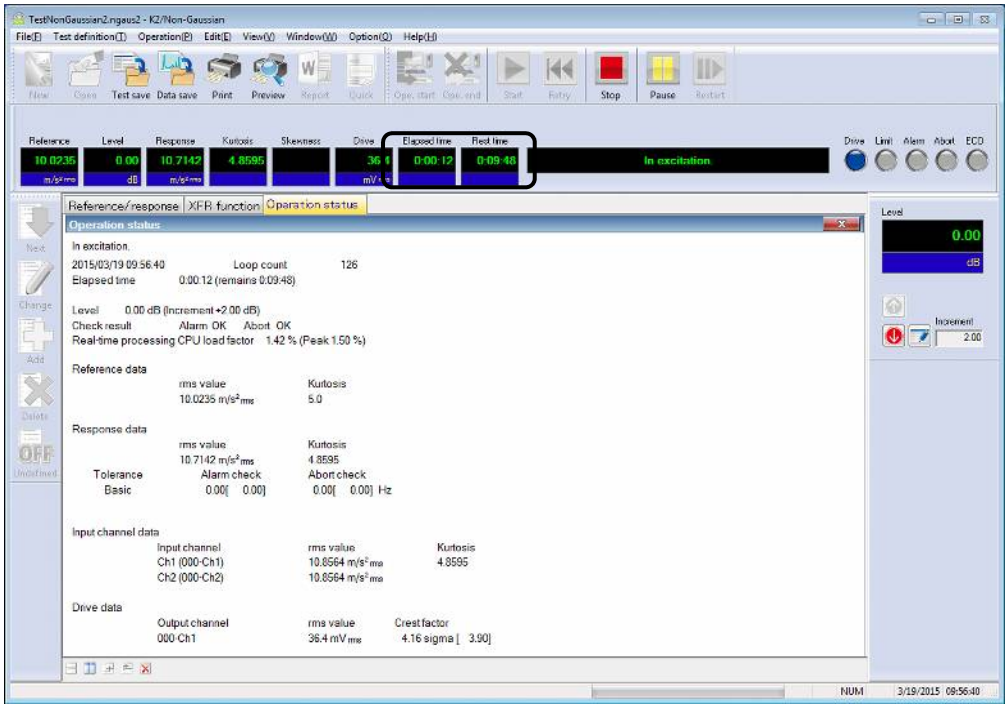
The test operation is started at the initial excitation level (-10dB in this example).

Press the level up button of excitation level and set the value to 0dB.



＜Step 5＞

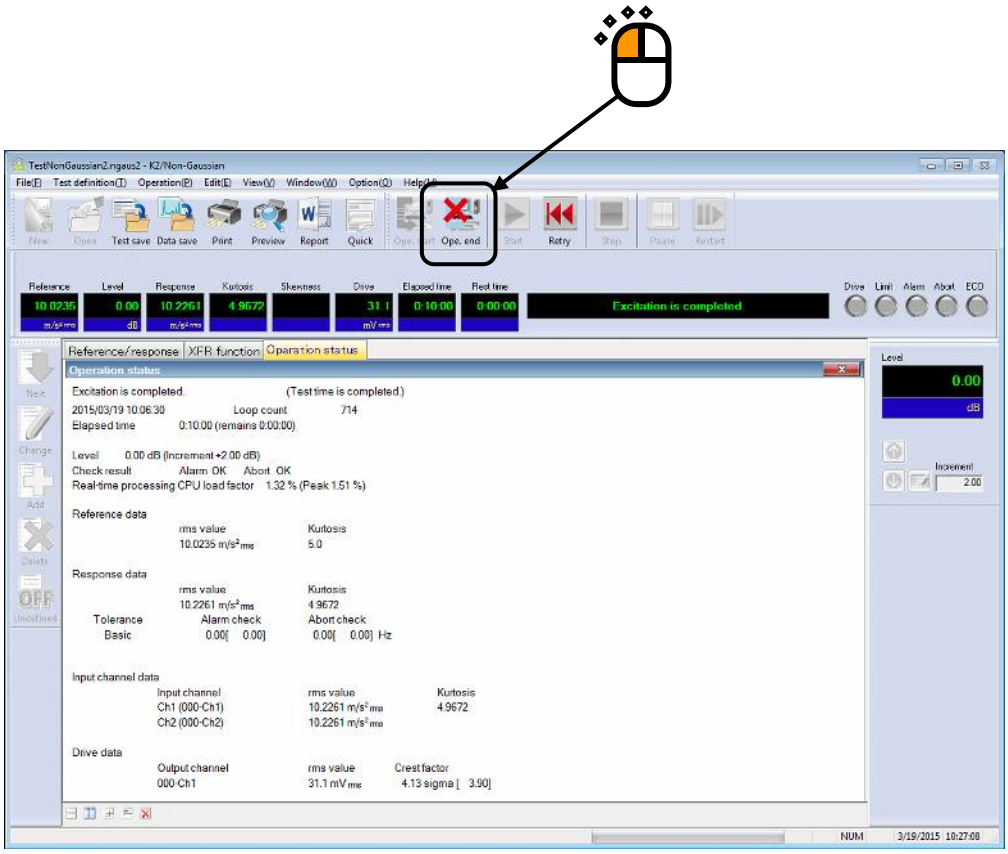
Test time starts to count the elapsed time for test operation when the excitation level is set to 0dB.



＜Step 6＞

Test operation is stopped when the test time ends.

Press the button of [Operation end]. The system proceeds to the display of test definition mode.



3.3 Measured waveform

< Example >

An example of the measured waveform test is described as below ;

[Reference pattern]

PSD calculated from measured waveform data (up to 400 Hz)

Kurtosis and skewness calculated from waveform are used for control.

[Control condition]

Frequency range : 800 Hz

Control lines : 800 lines

[Test time]

10 minutes

[Information of sensors to be used]

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

Ch. 1 : for non-gaussian control, sensitivity 3pC/(m/s^2), Measured waveform reference

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

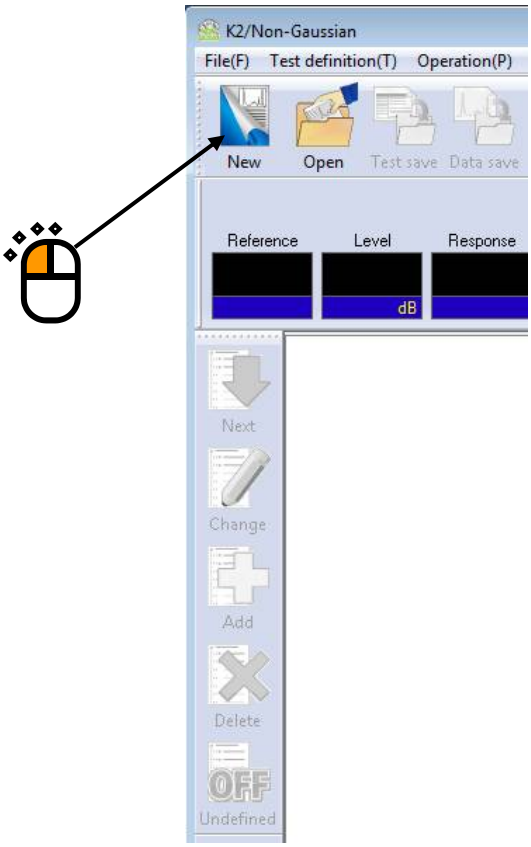
However, these channels must be registered in Input channel information (in this example, 'INPUT').

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

< Procedures >

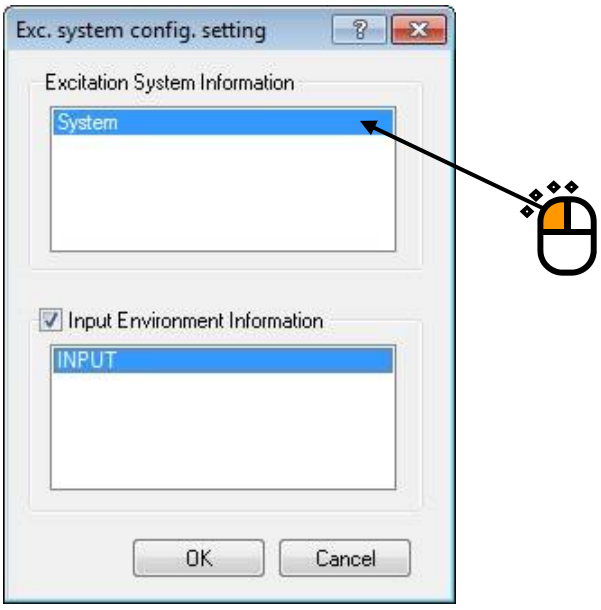
< Step 1 >

Press the button of [New] to start ‘New definition’.



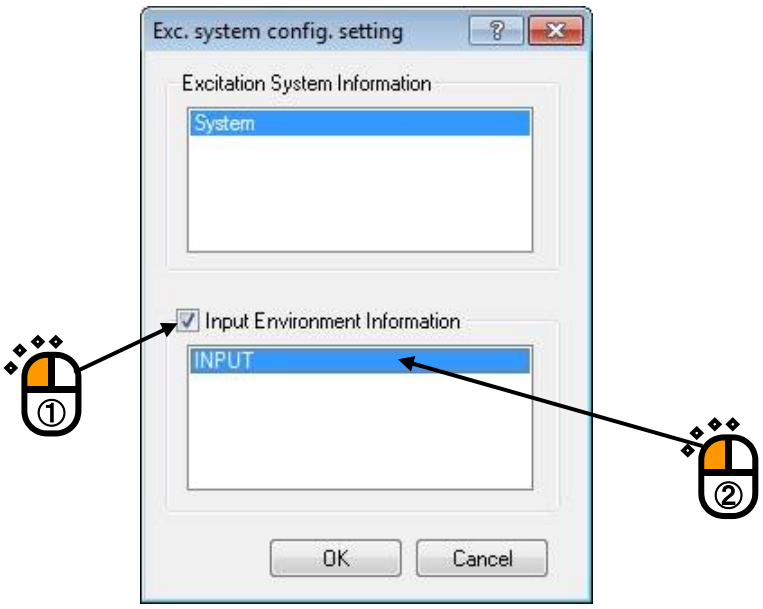
＜Step 2＞

Select an Excitation system from the list of ‘Excitation system information’.



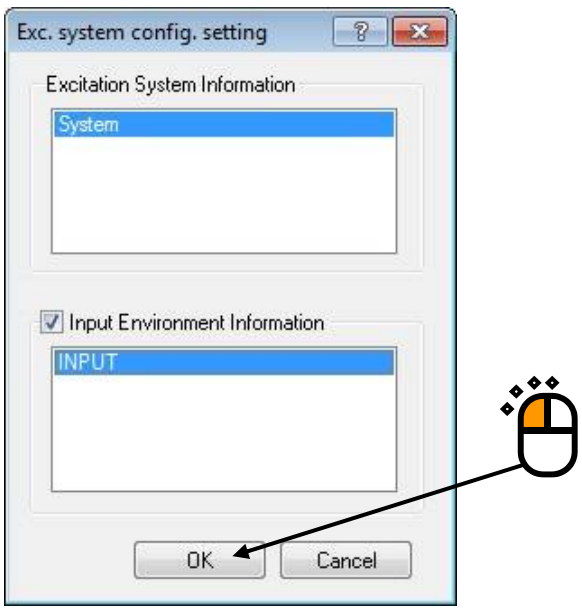
＜Step 3＞

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



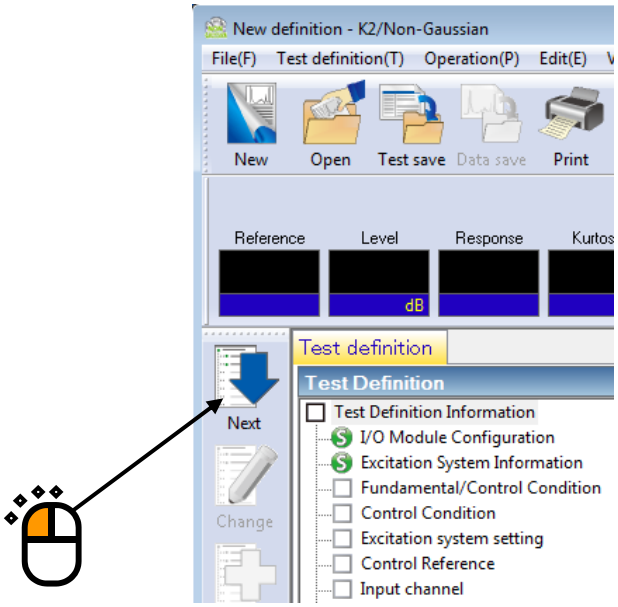
＜Step 4＞

Press the [OK] button.



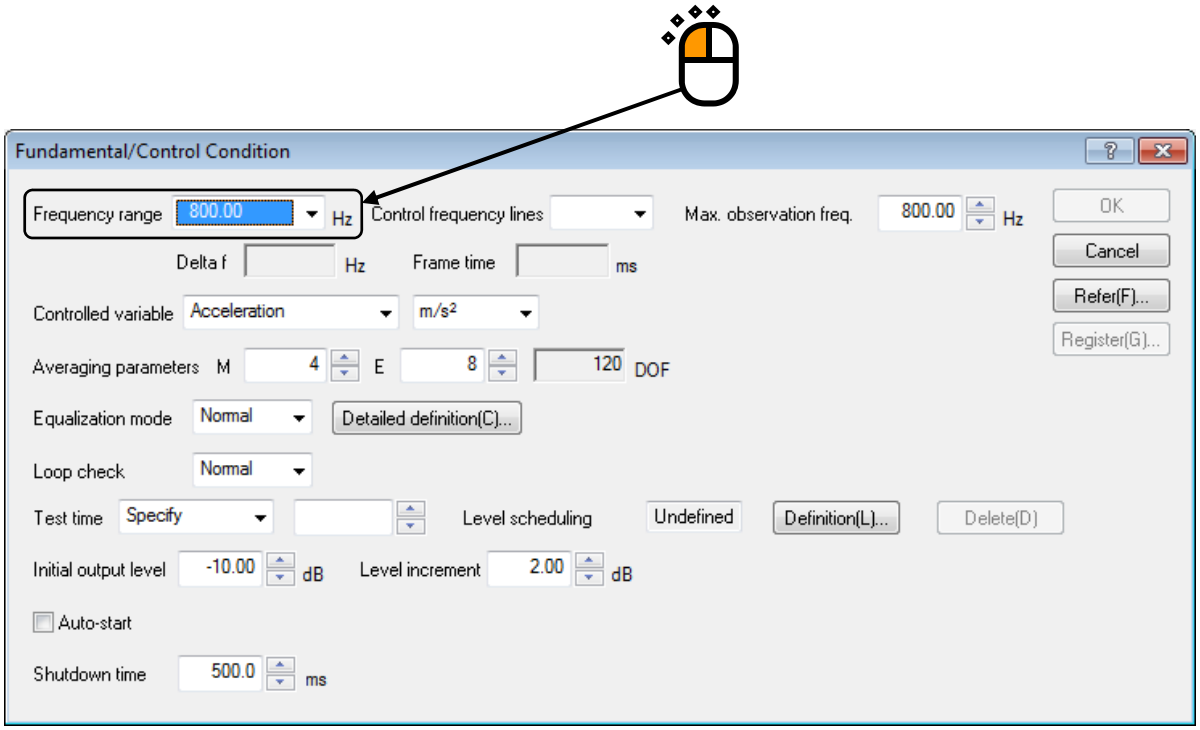
＜Step 5＞

Press the [Next] button.



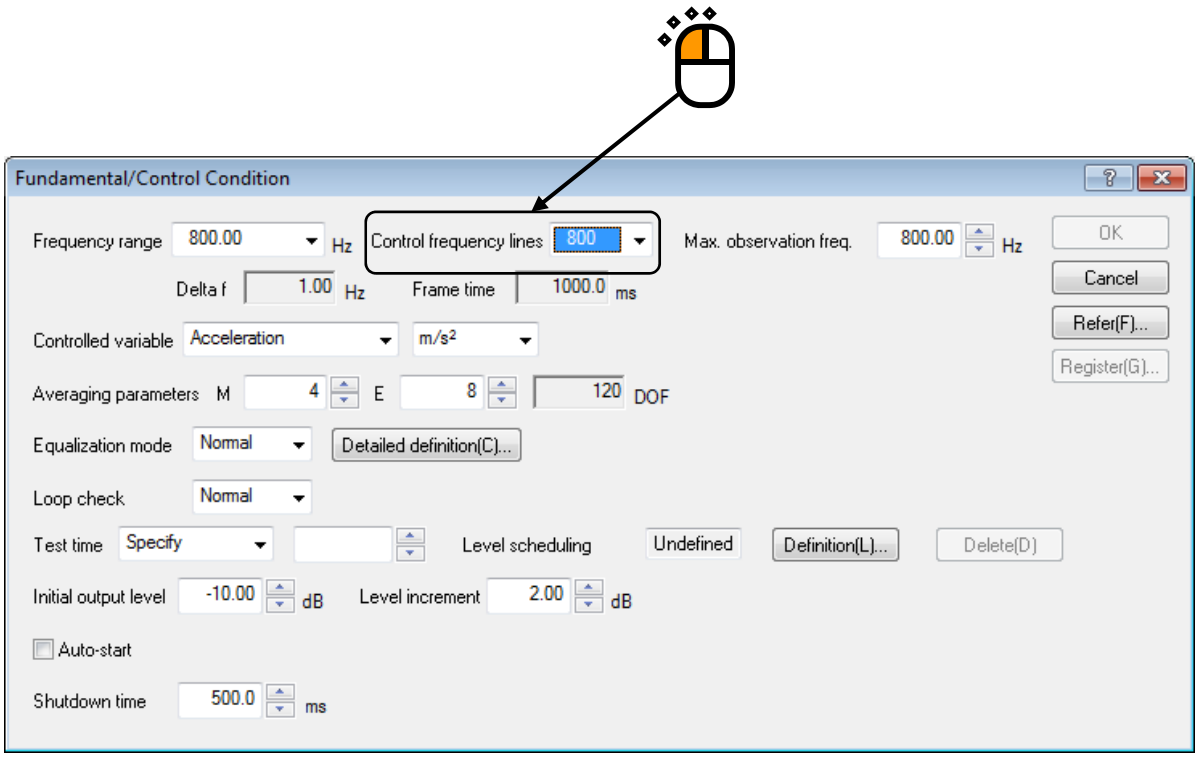
＜Step 6＞

Set the Frequency range to ‘800Hz’.



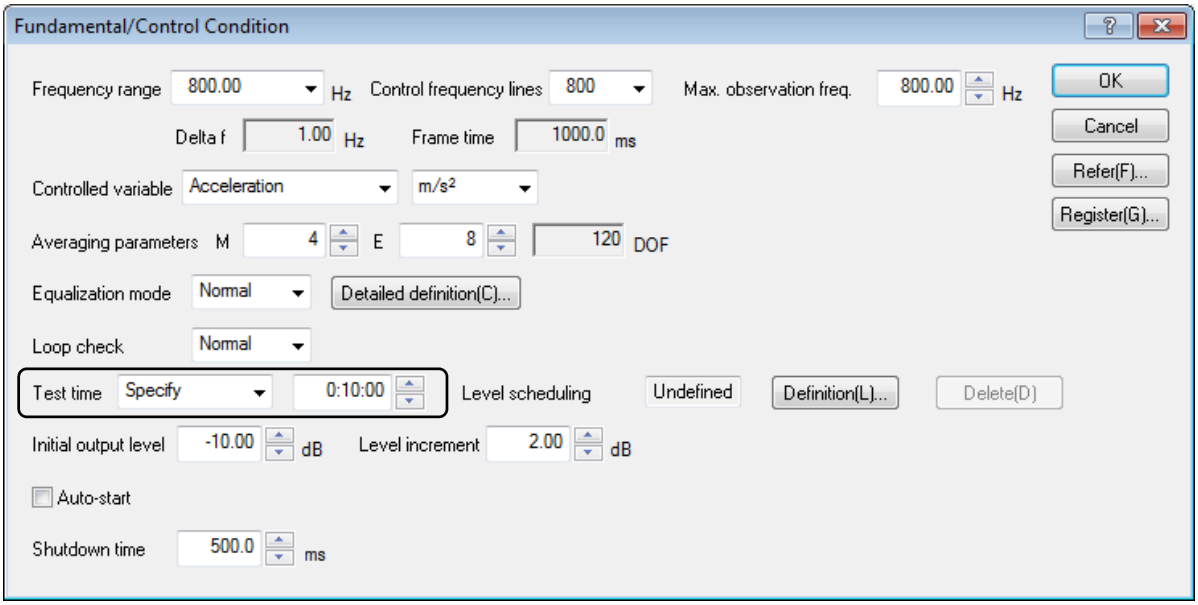
＜Step 7＞

Set the Control frequency lines to ‘800’.



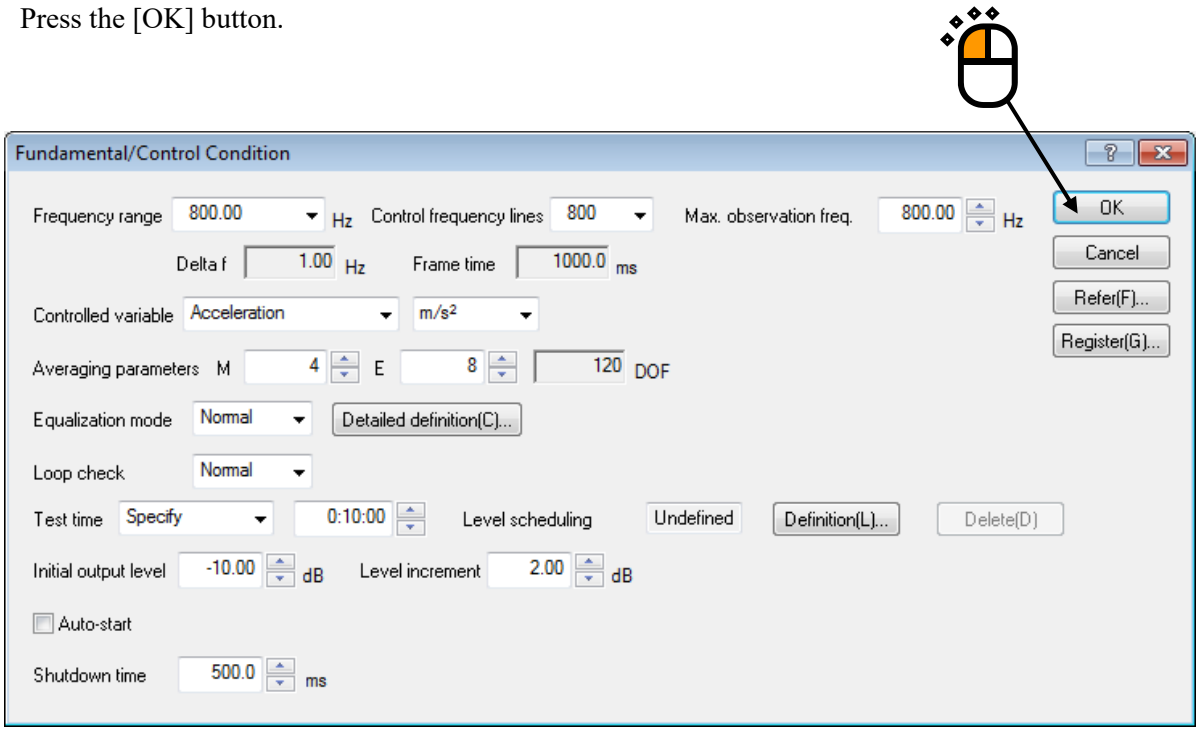
＜Step 8＞

Specify the Test time as ‘Specify time’. And input the value as ‘Test time : 0 : 10 : 00 (600 sec)’.



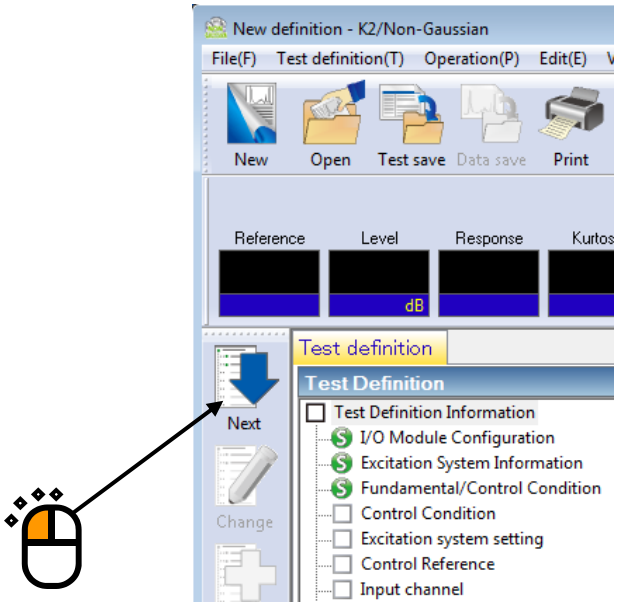
＜Step 9＞

Press the [OK] button.



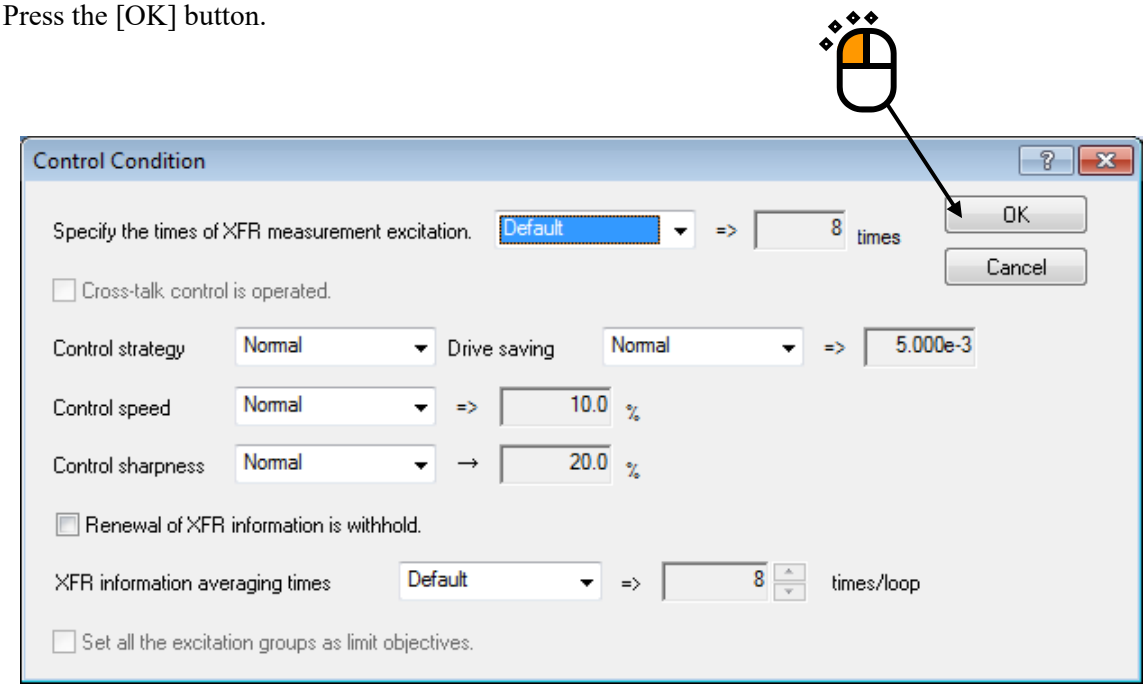
＜Step 10＞

Press the [Next] button.



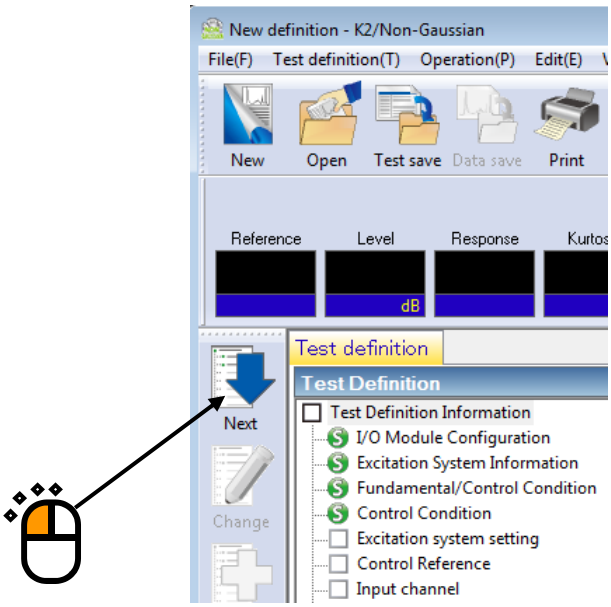
＜Step 11＞

Press the [OK] button.



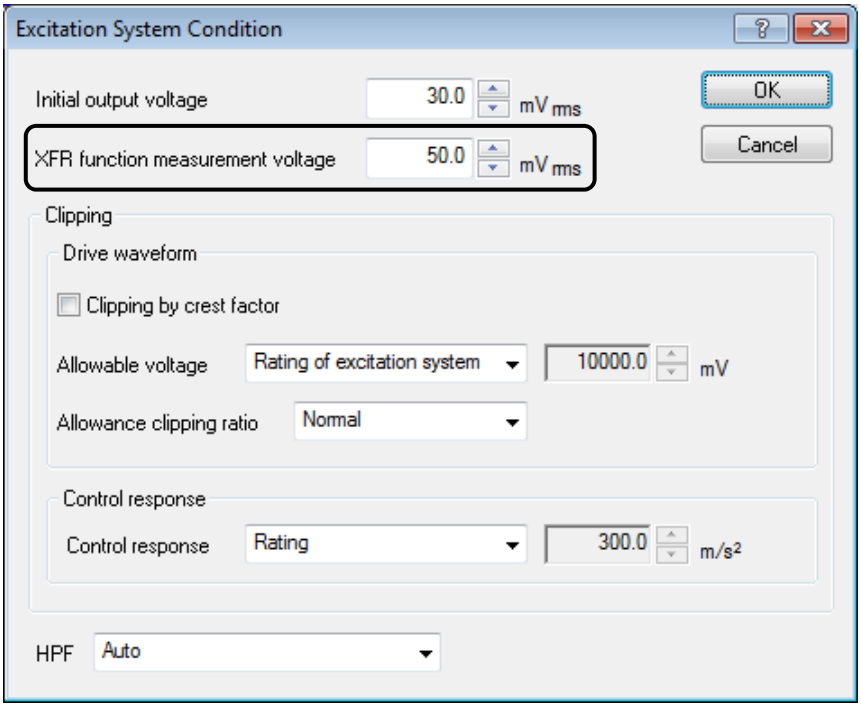
＜Step 12＞

Press the [Next] button.



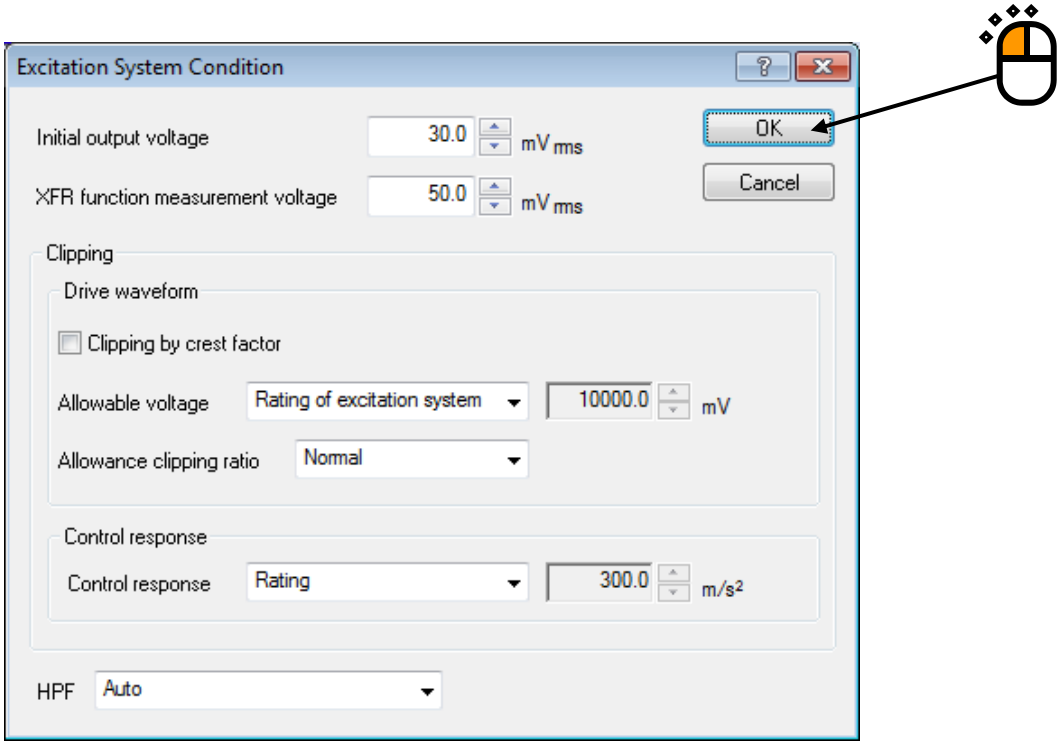
＜Step 13＞

Set the XFR function measurement voltage to 50 (mV_{rms}).



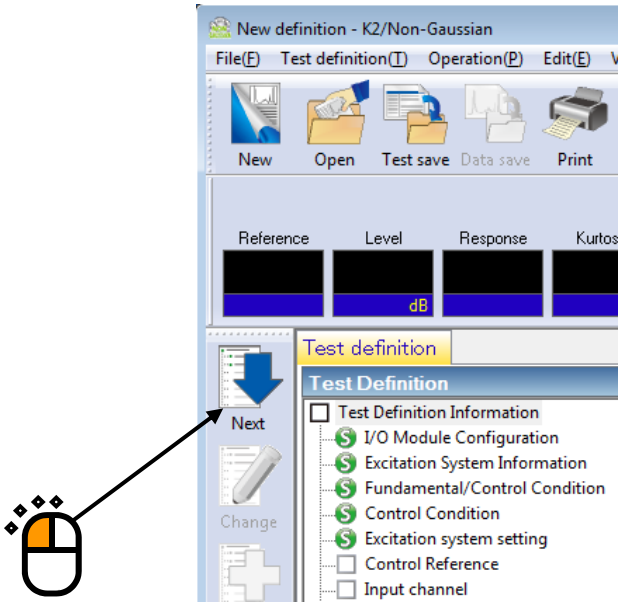
＜Step 14＞

Press the OK button.



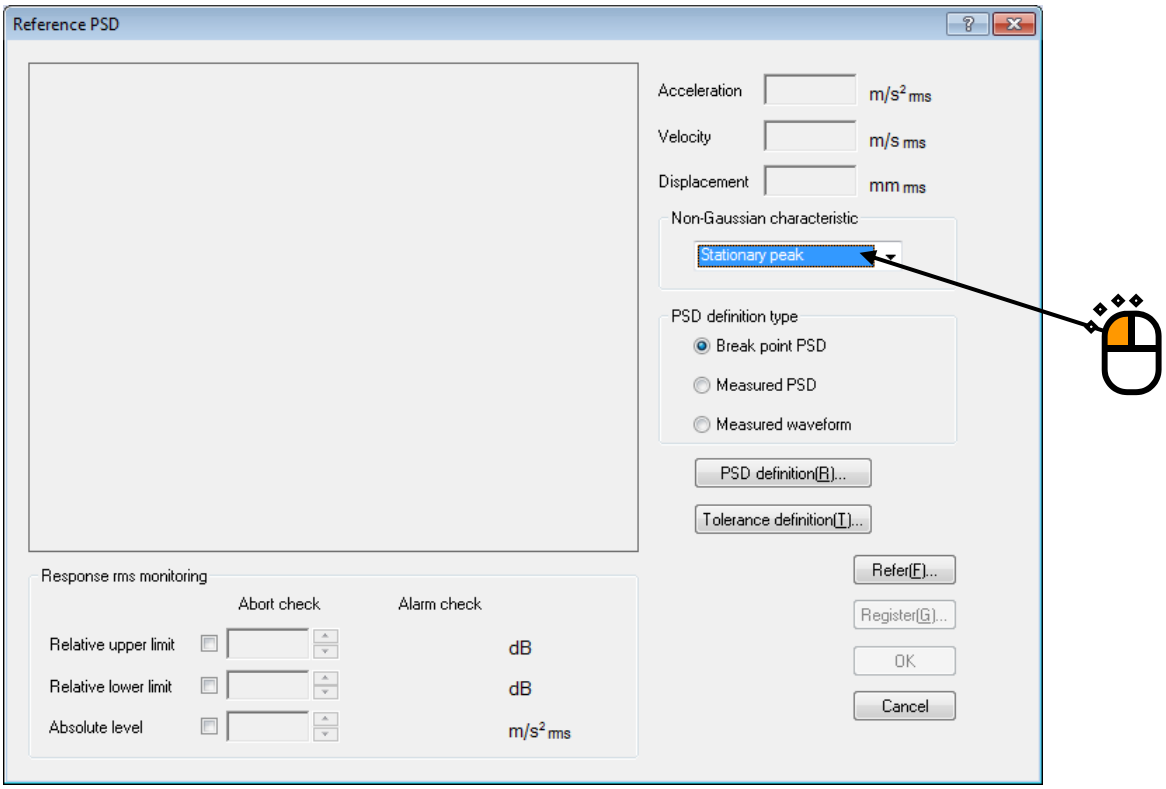
＜Step 15＞

Press the [Next] button.



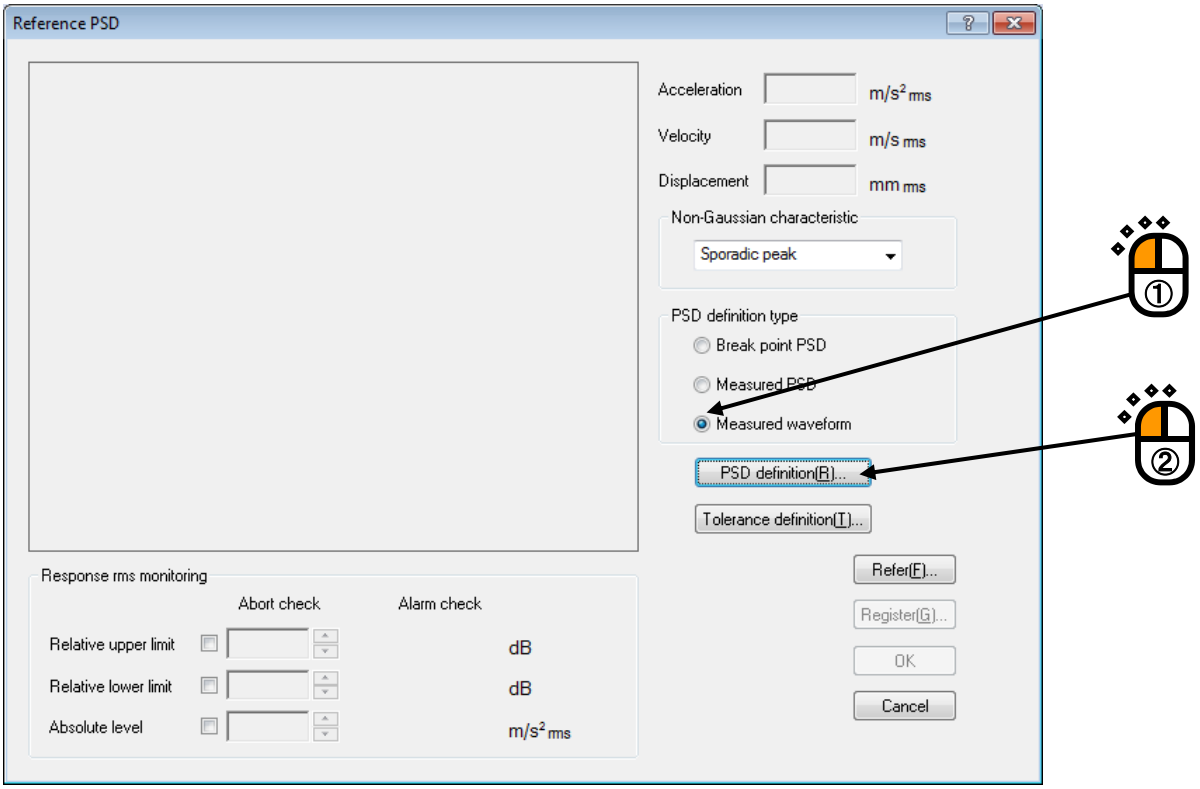
＜Step 16＞

Select ‘Stationary peak’ in Non-Gaussian characteristic area.



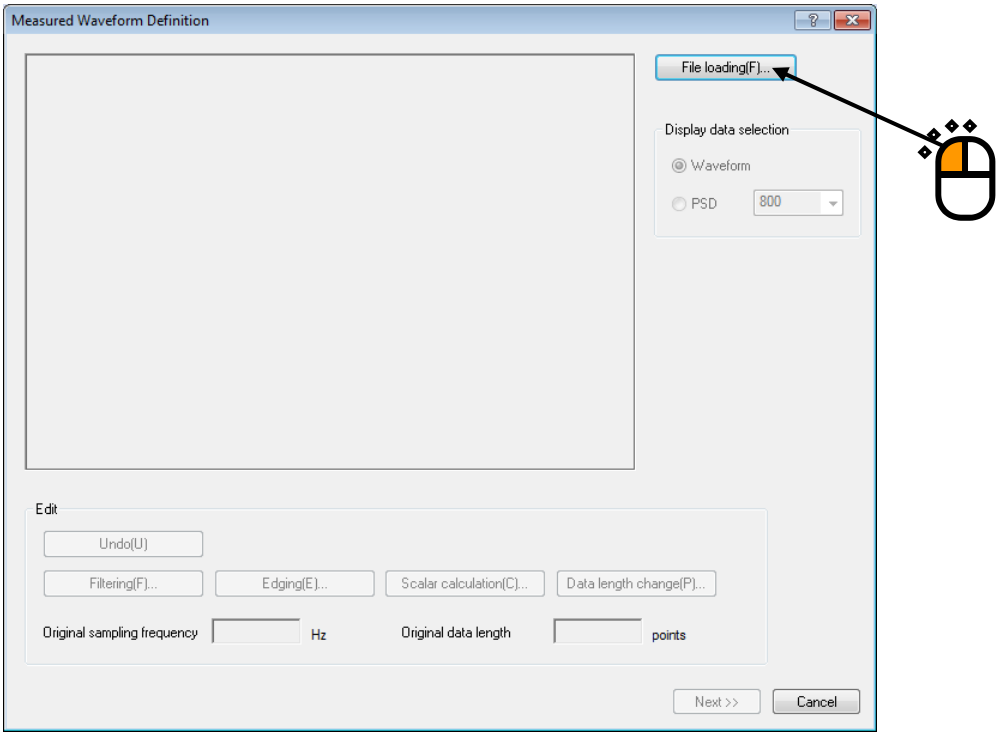
＜Step 17＞

Select the item of Measured waveform and press the [PSD definition] button..



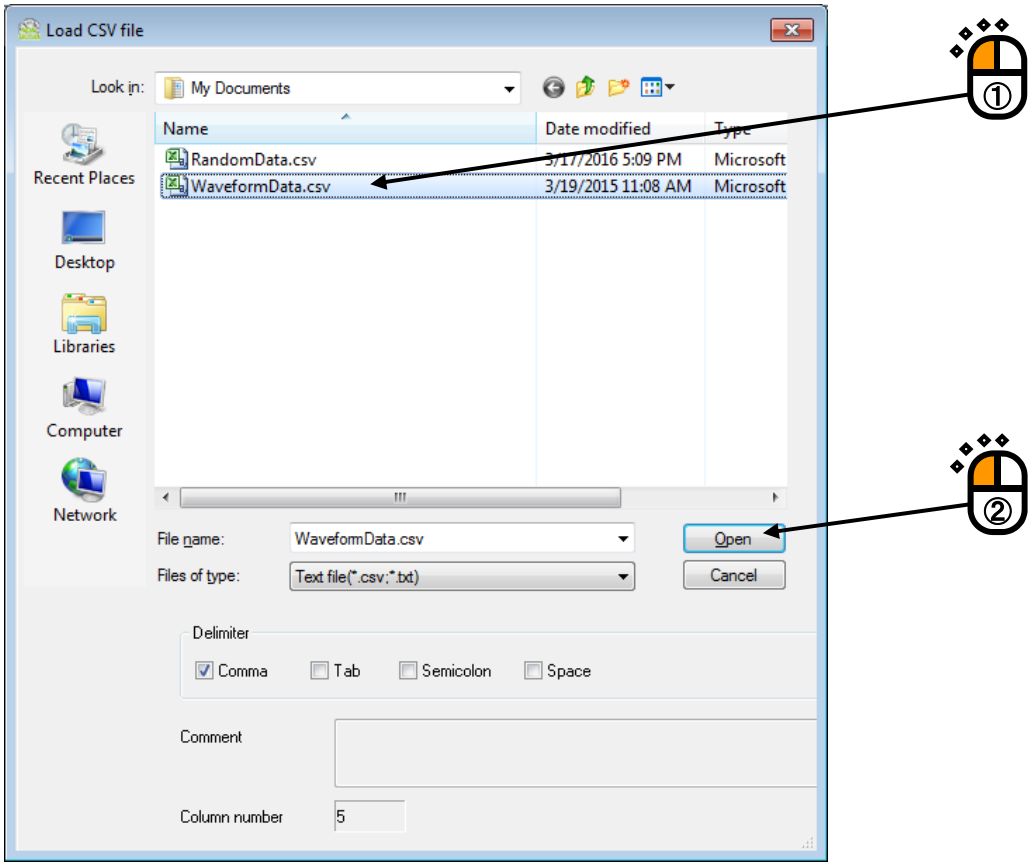
＜Step 18＞

Press the button of [File loading].



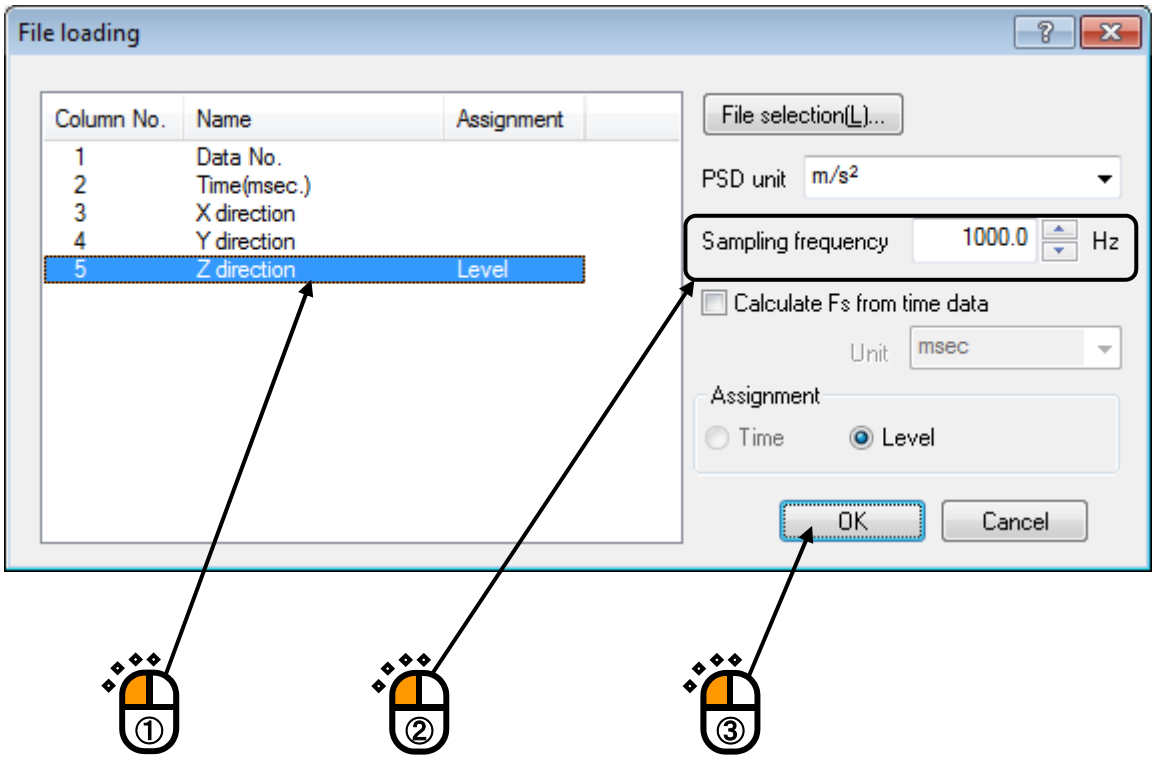
＜Step 19＞

Select a file name to be loaded and press the button to open the file.



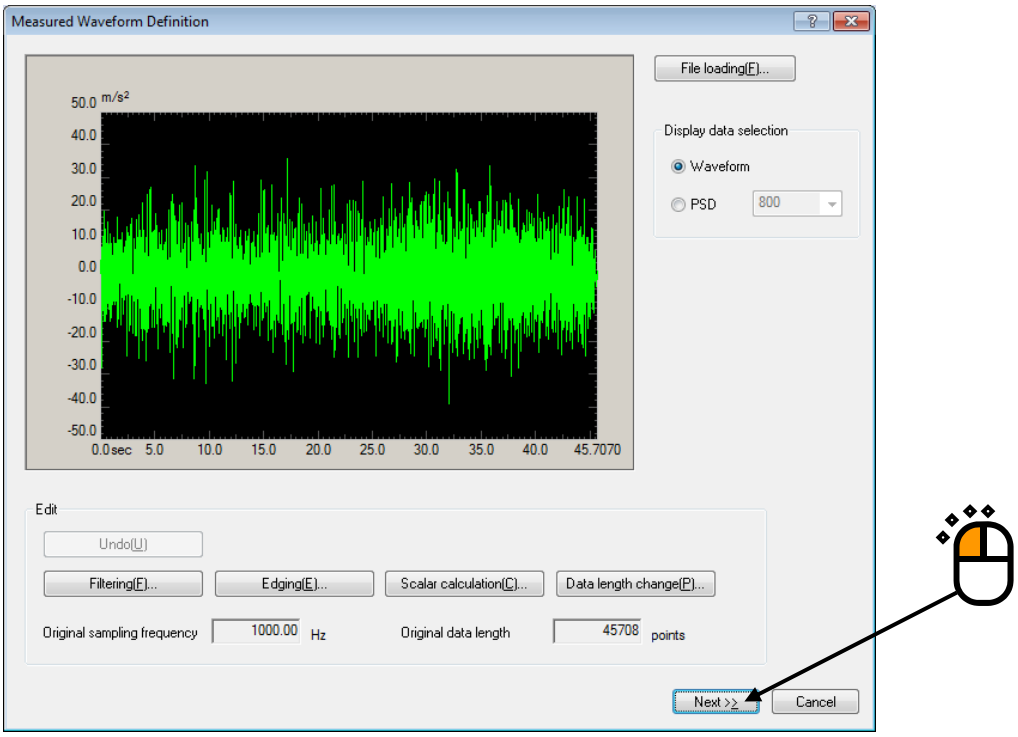
＜Step 20＞

Select your desired level data, enter sampling frequency, and press the [OK] button.



＜Step 21＞

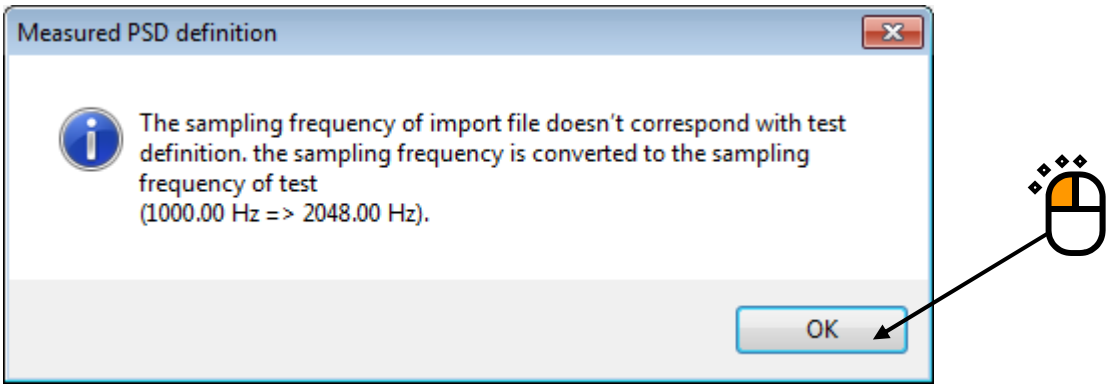
Press the [Next] button.



＜Step 22＞

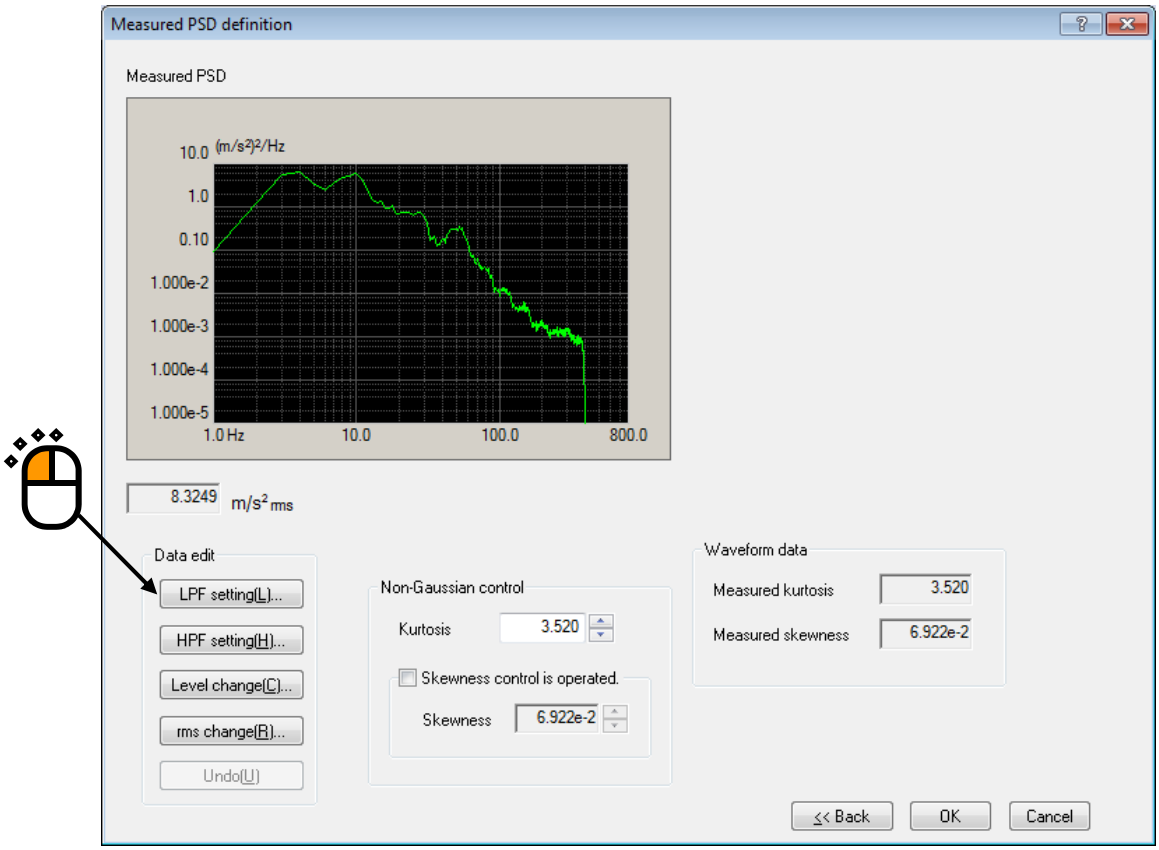
Sampling frequency of waveform is automatically converted into sampling frequency corresponding with frequency range selected in Step 7.

Press the OK button.



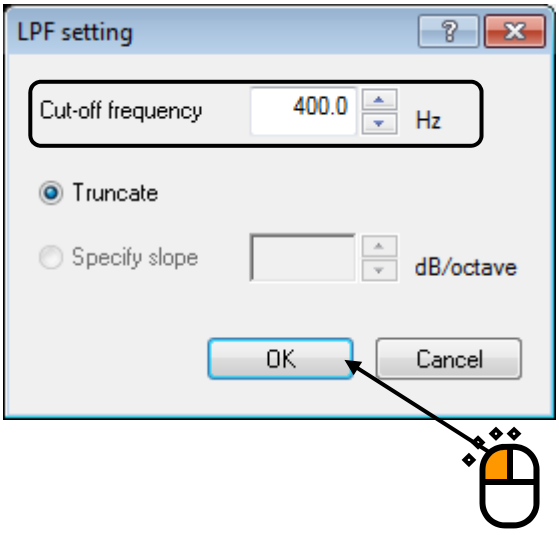
＜Step 23＞

Press ‘LPF setting’ button.



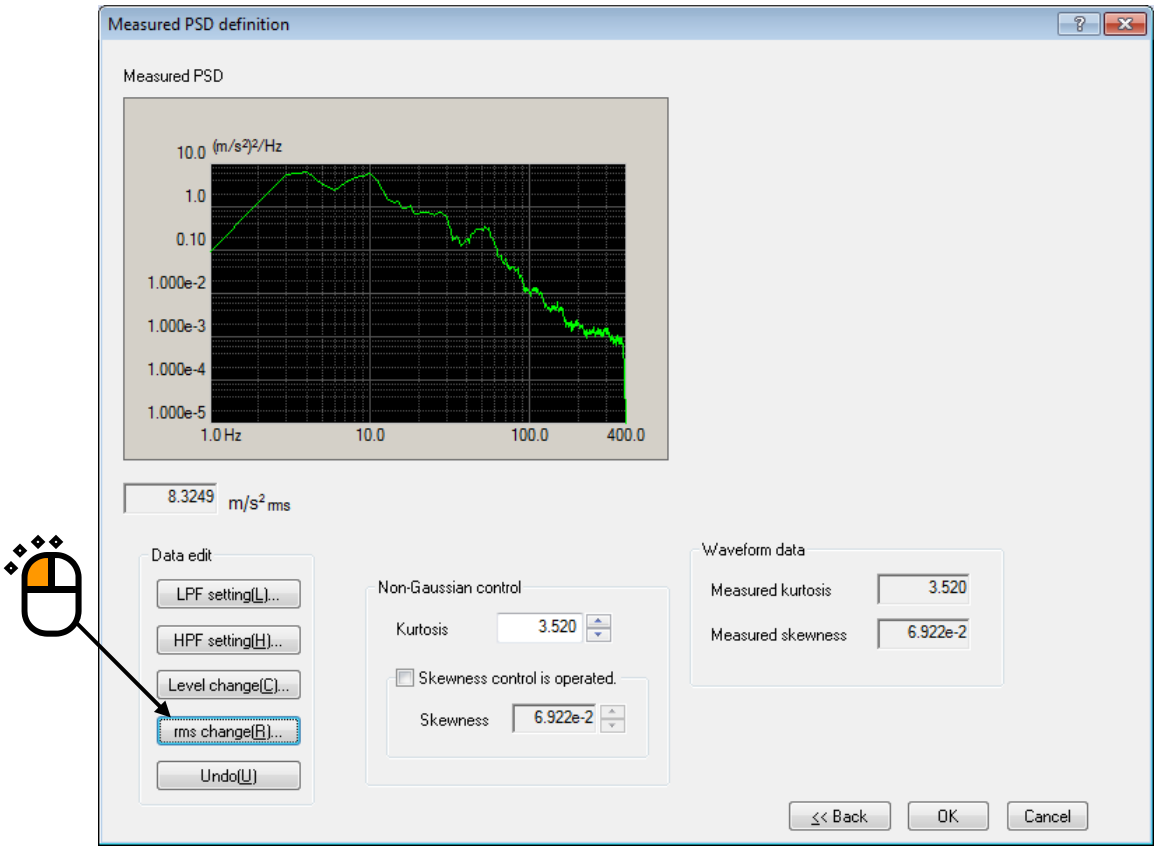
＜Step 24＞

Enter ‘Cut-off frequency: 400.0 Hz’, and press the [OK] button.



＜Step 25＞

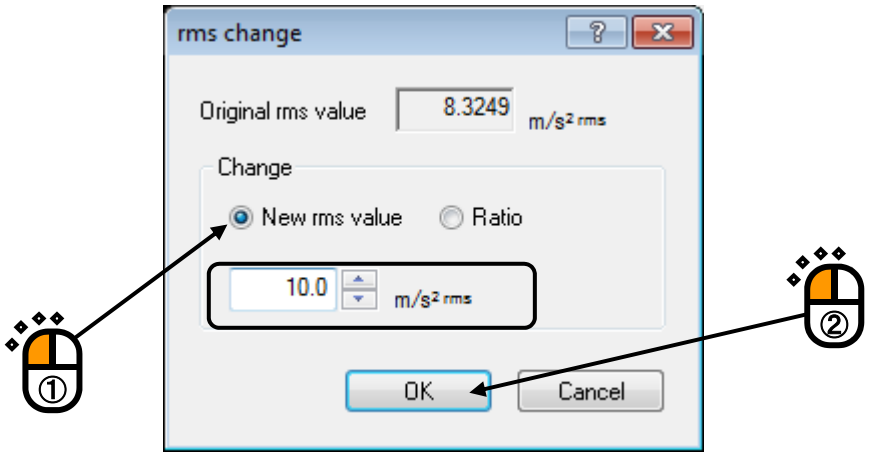
Press the button of [rms change].



＜Step 26＞

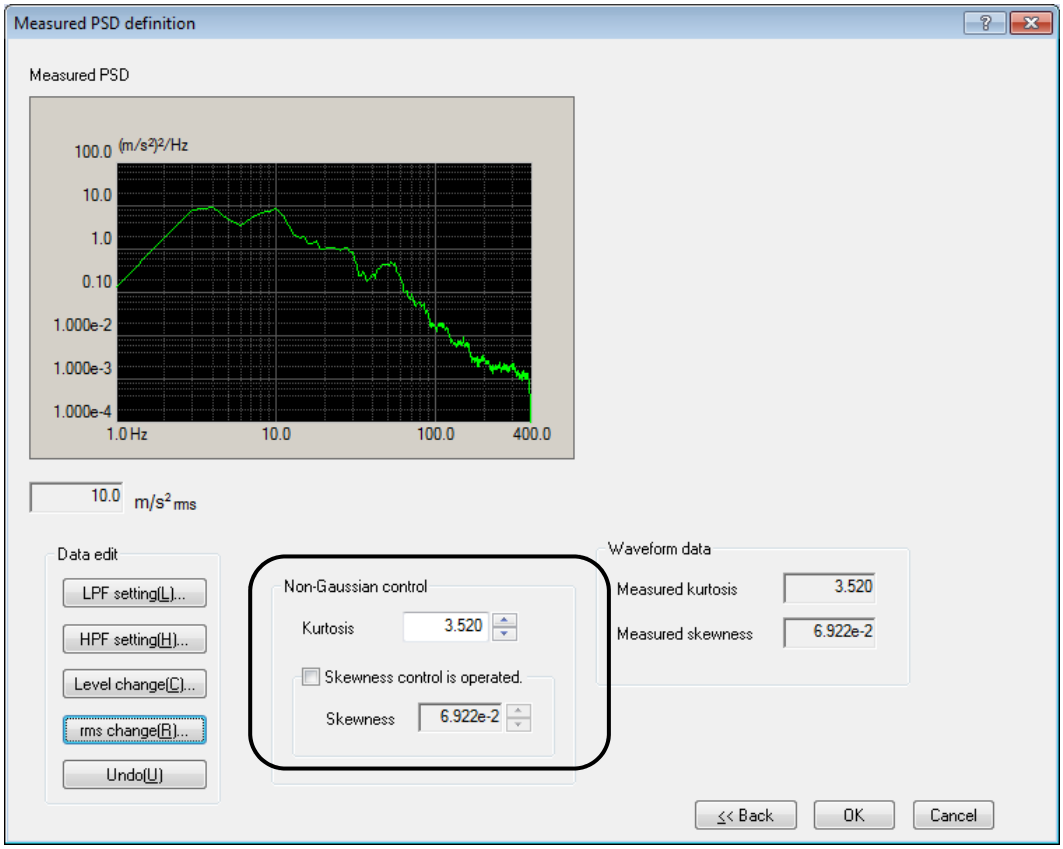
Select the item of New rms value and input the value as ‘New rms value : 10 [(m/s^2) rms].

And press the [OK] button.



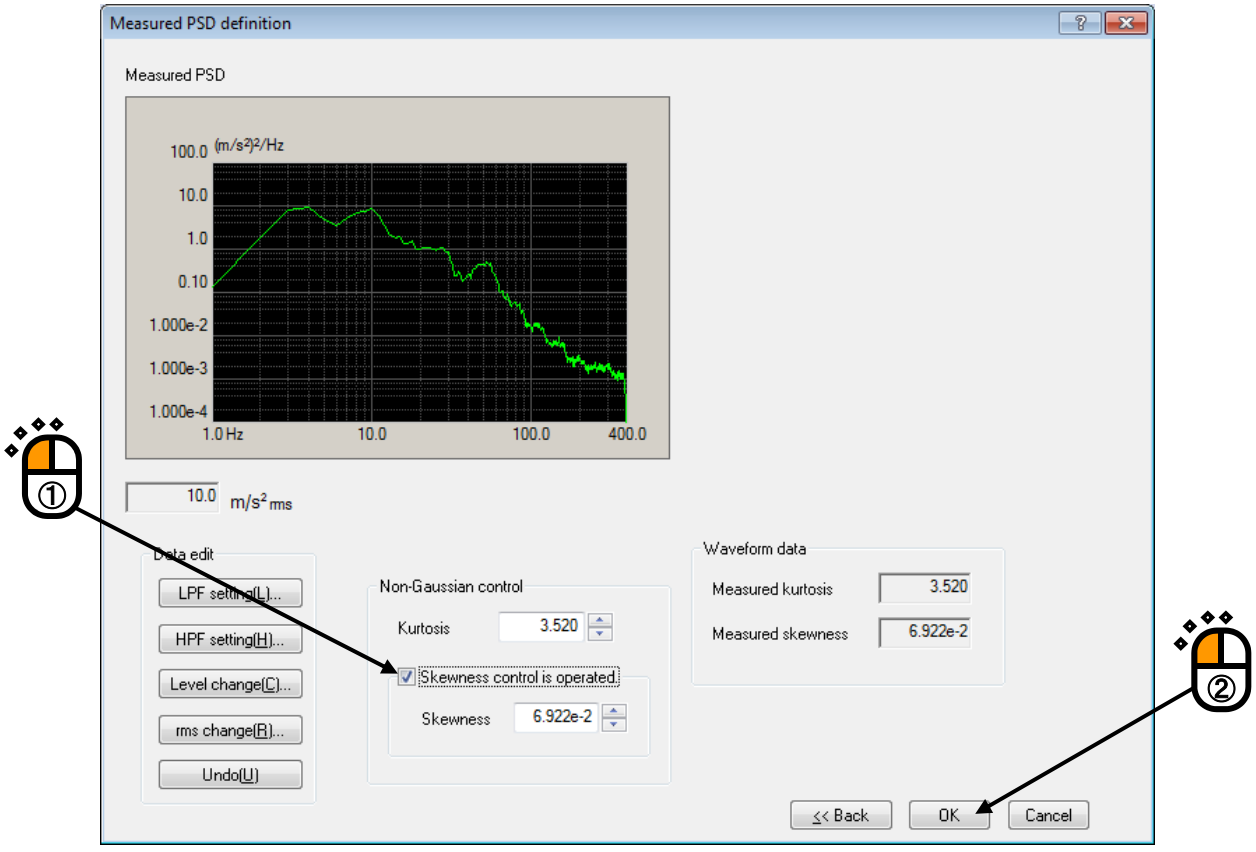
＜Step 27＞

Kurtosis and skewness automatically calculated from waveform are set up.



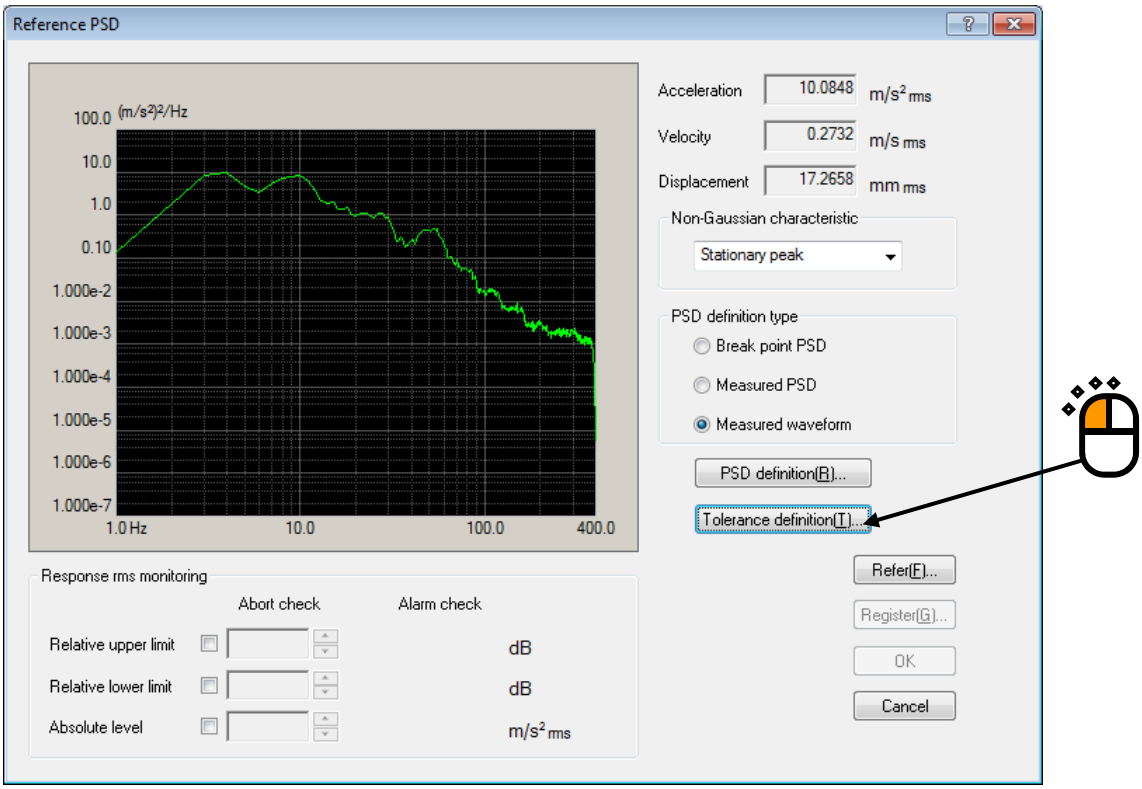
＜Step 28＞

Check ‘Skewness control is operated’, and press the [OK] button.



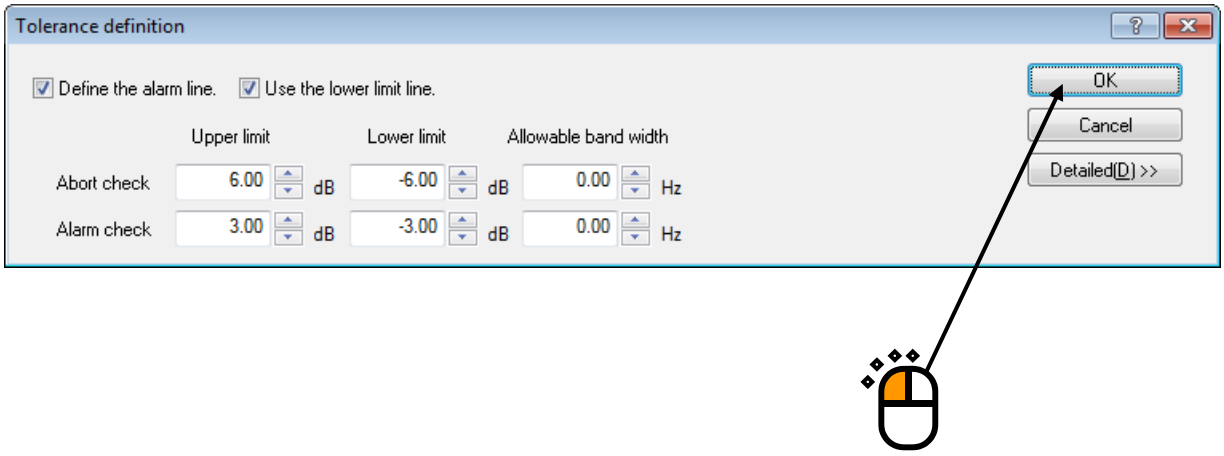
＜Step 29＞

Press the [Tolerance definition] button.



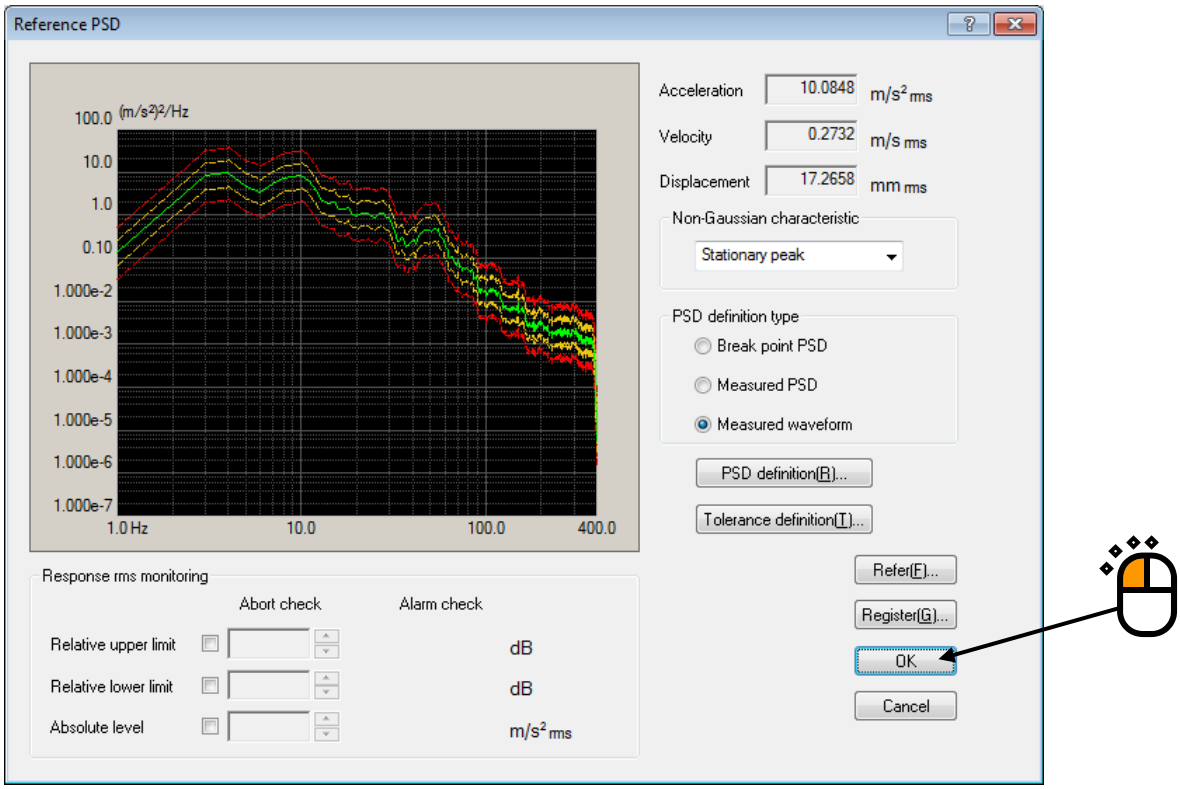
＜Step 30＞

Press the [OK] button.



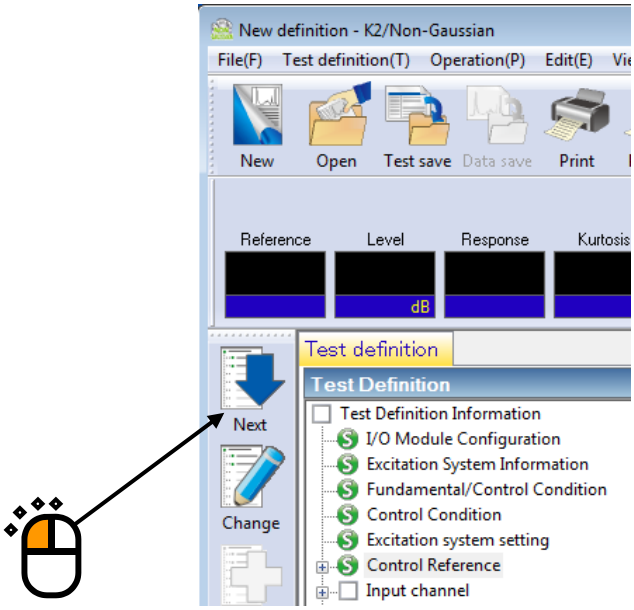
＜Step 31＞

Press the [OK] button.



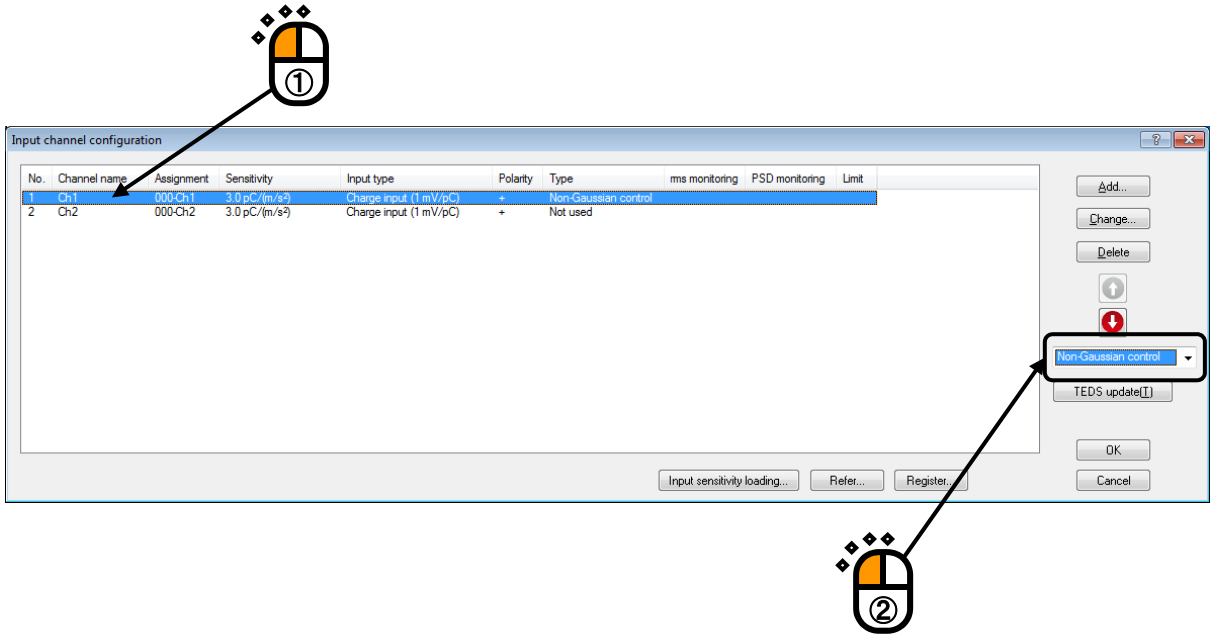
＜Step 32＞

Press the [Next] button.



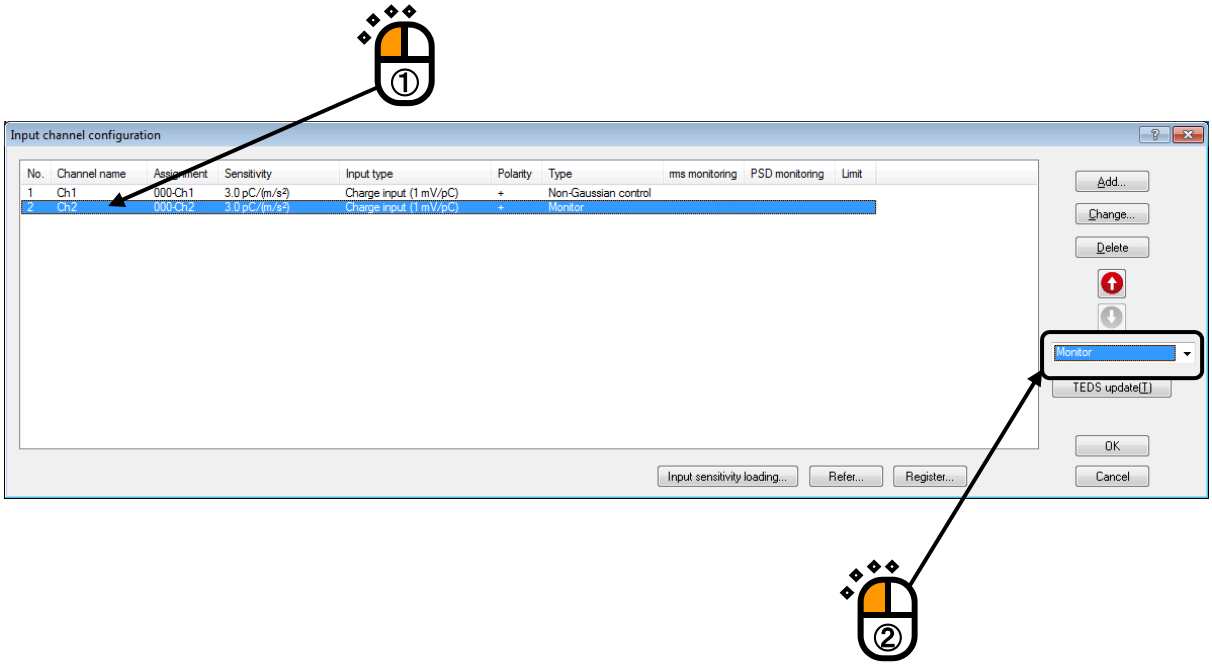
＜Step 33＞

Select ‘Ch.1’ and set as ‘Non-gaussian control’.



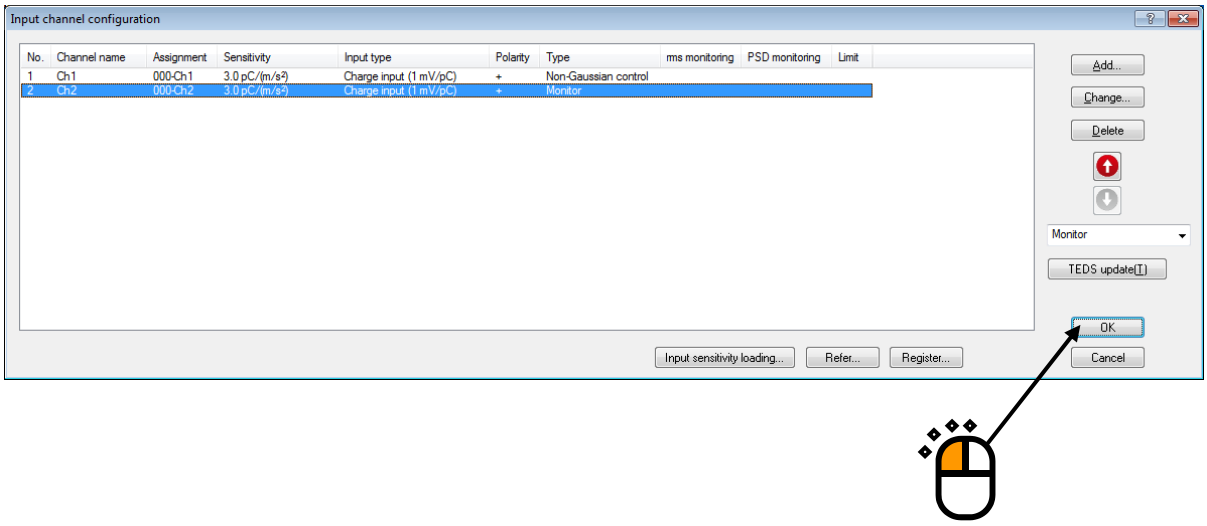
＜Step 34＞

Also, select ‘Ch.2’ and set as ‘Monitor’.



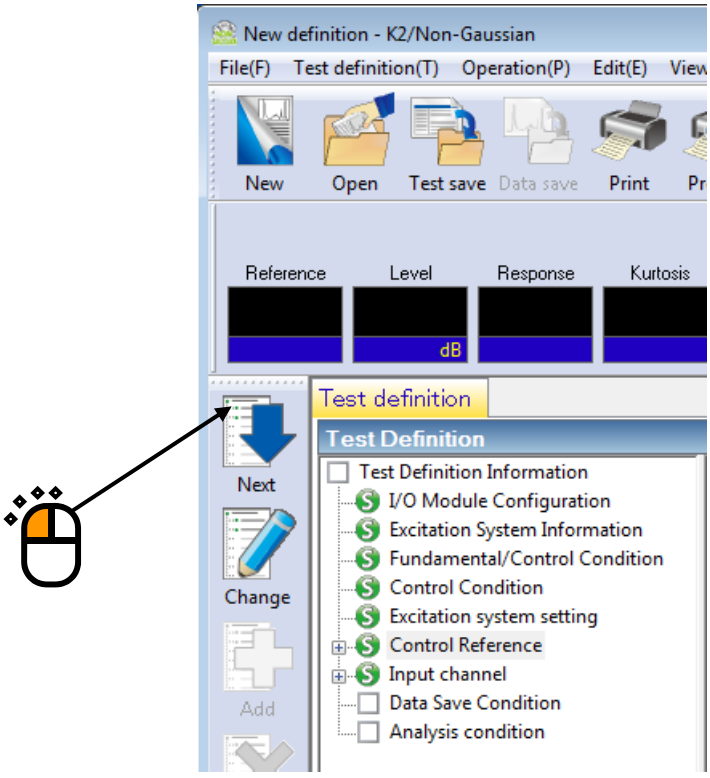
＜Step 35＞

Press the [OK] button.



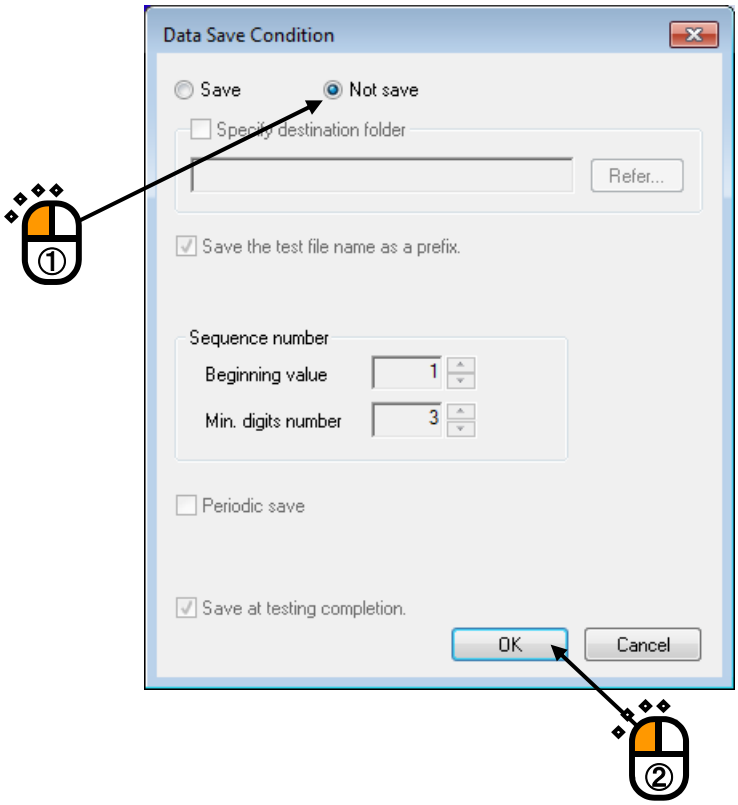
＜Step 36＞

Press the [Next] button.



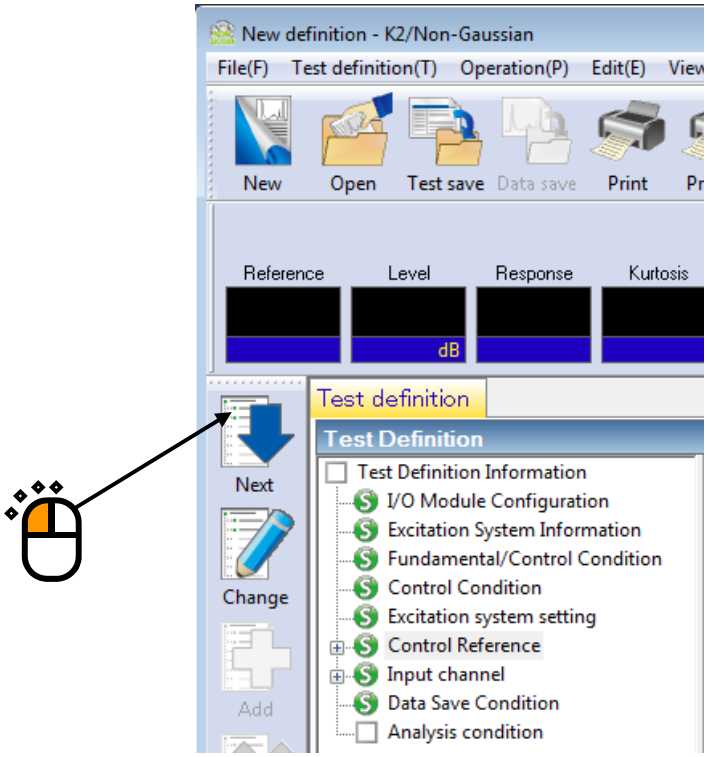
＜Step 37＞

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



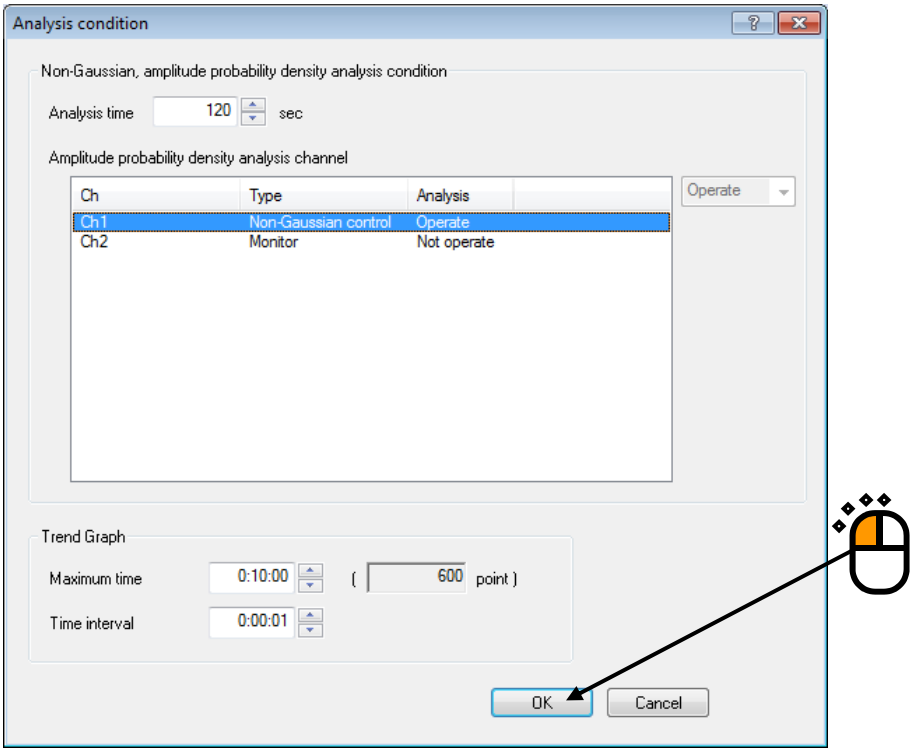
< Step38 >

Press the button of [Next].



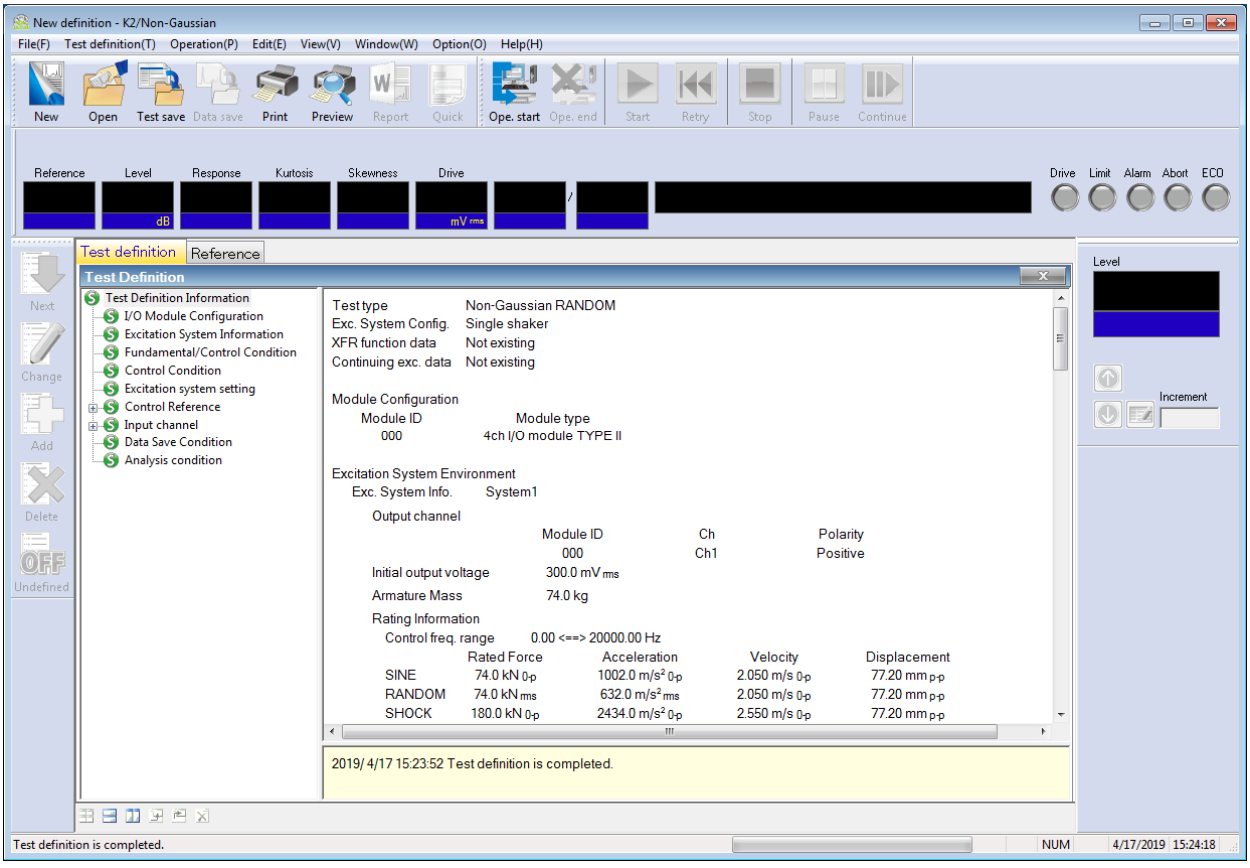
< Step39 >

Press the [OK] button.



< Step 40 >

The definition is completed.

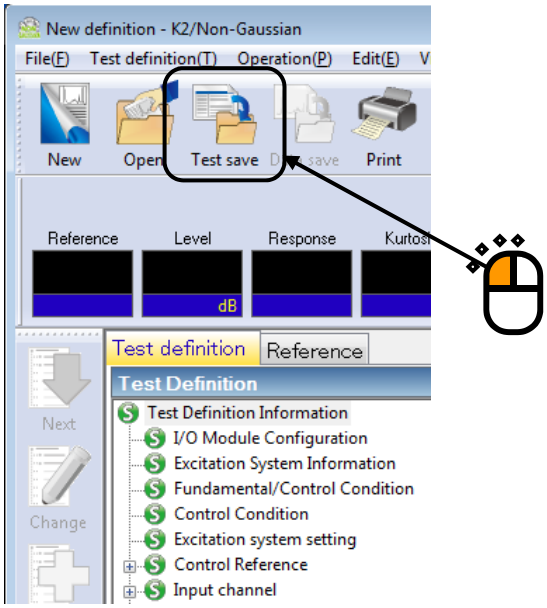


< Save of test>

< Step 1 >

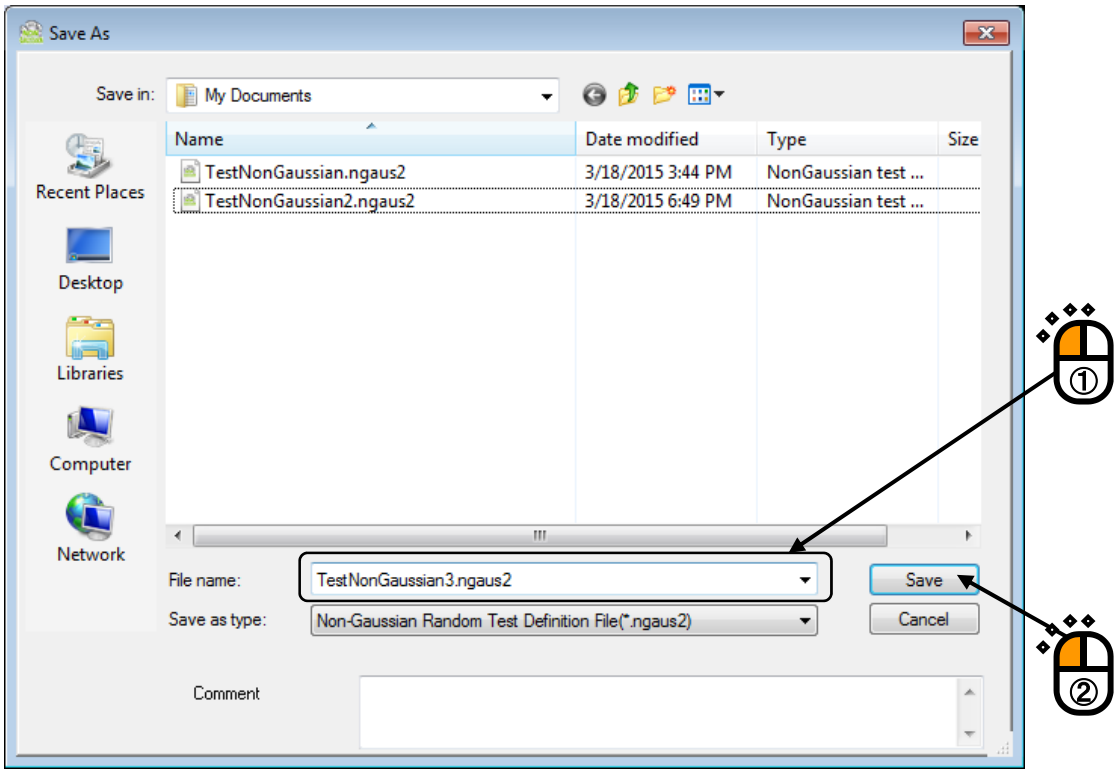
Save the defined test information to a test file.

Click the [Save] button.



＜Step 2＞

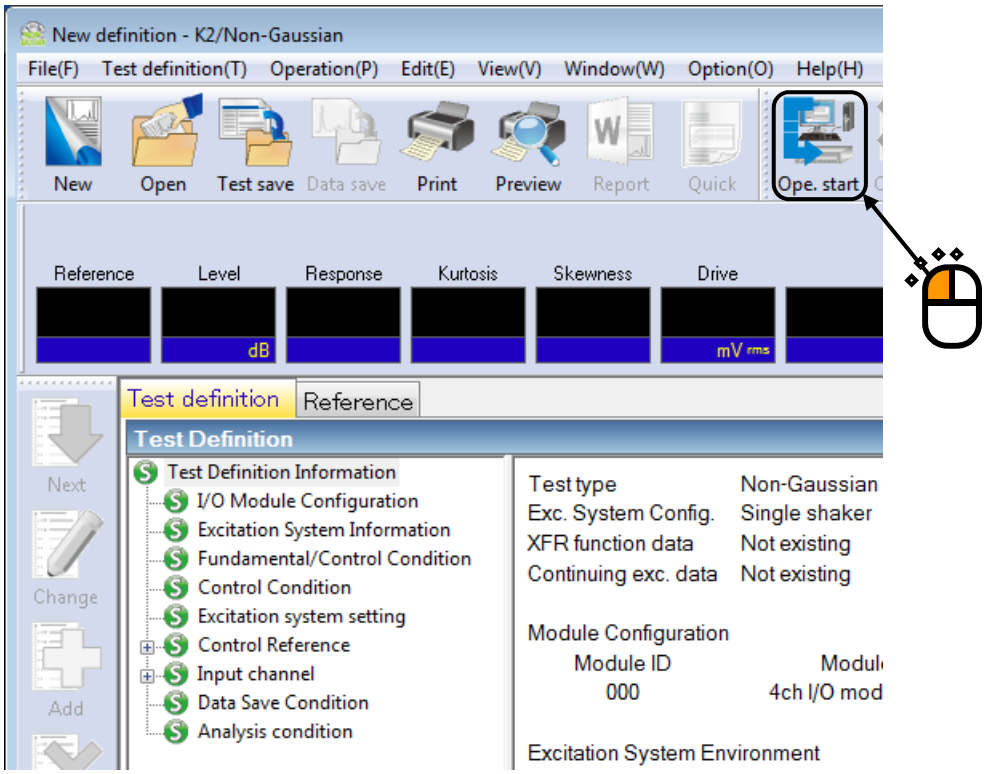
The dialog box as below appears. Specify an arbitrary directory in ‘Save in’ and input a name to ‘File name’.



< Operation of test >

< Step 1 >

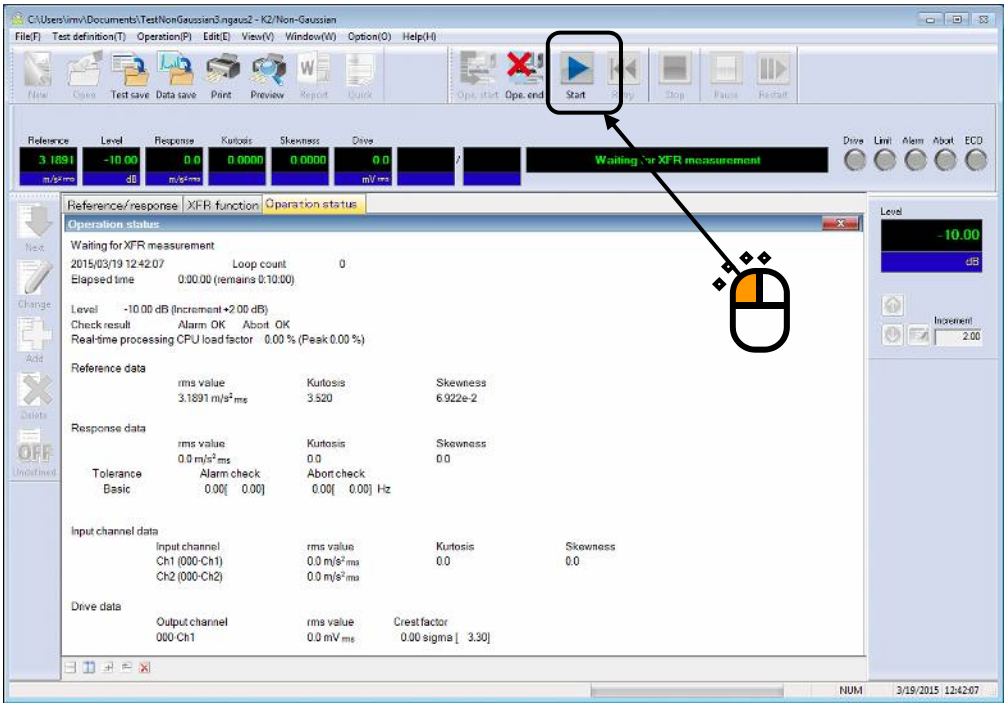
Press the button of [Operation start] for ‘Operation start’.



＜Step 2＞

Press the button of [XFR measurement start].

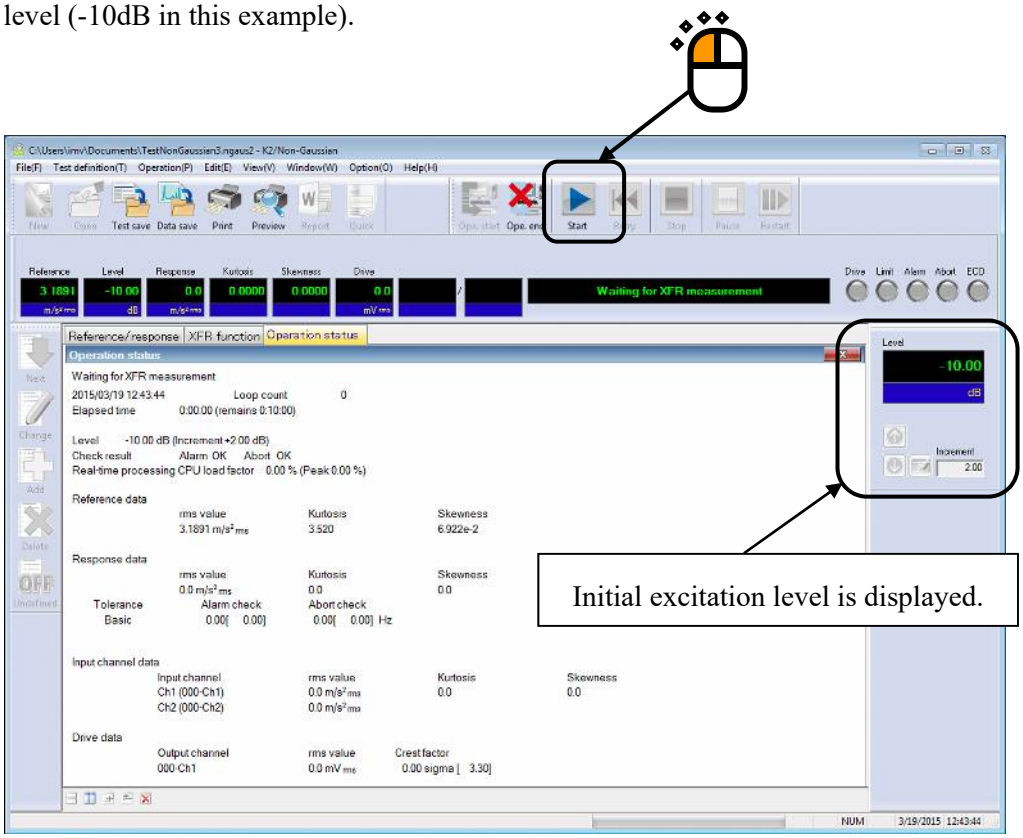
Initial loop check is automatically operated and the XFR measurement is started.



＜Step 3＞

The system proceeds to the state of waiting for operation start when the XFR measurement is finished.

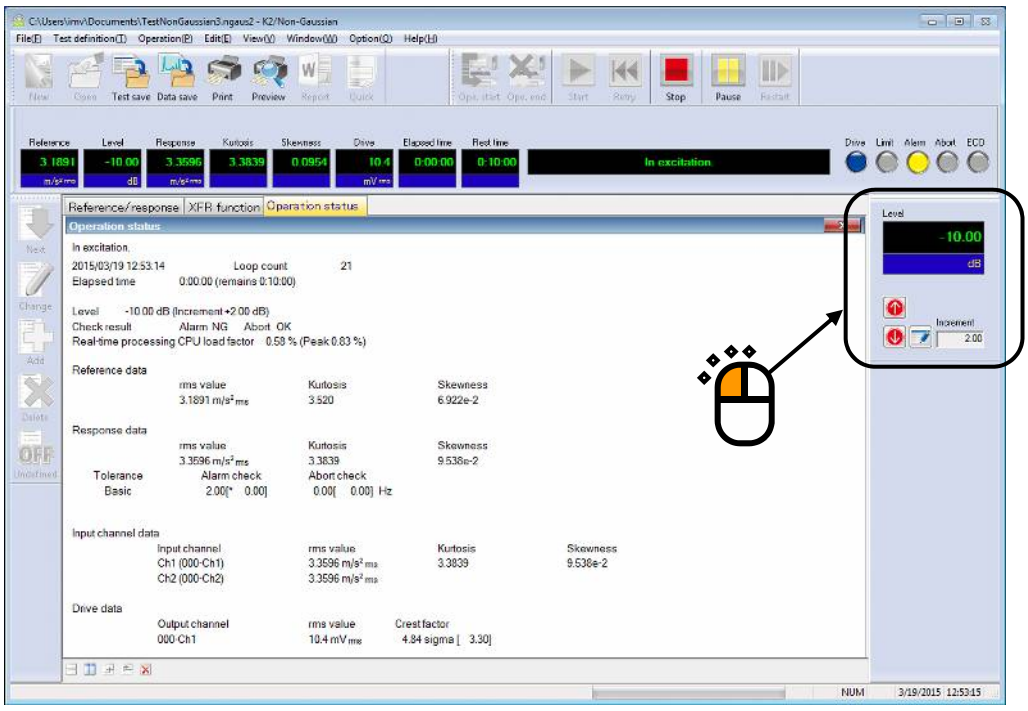
Press the button of [Operation start]. Initial loop check and initial equalization are automatically operated. When initial check and initial equalization are finished, the test operation is started at the initial excitation level (-10dB in this example).



＜Step 4＞

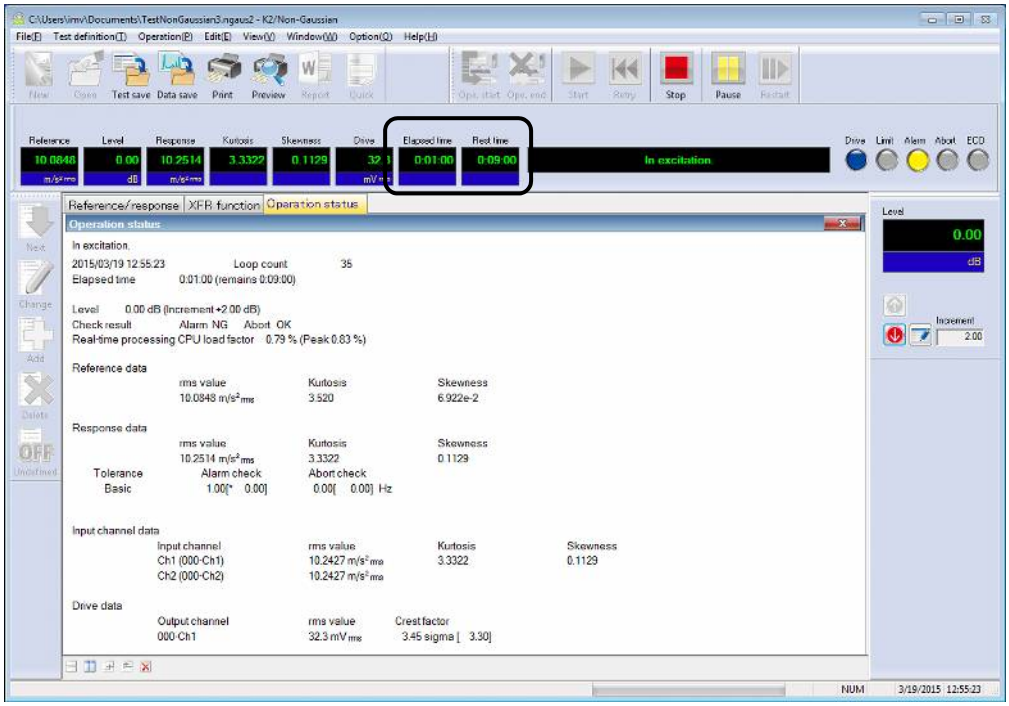
The test operation is started at the initial excitation level (-10dB in this example).

Press the level up button of excitation level and set the value to 0dB.



＜Step 5＞

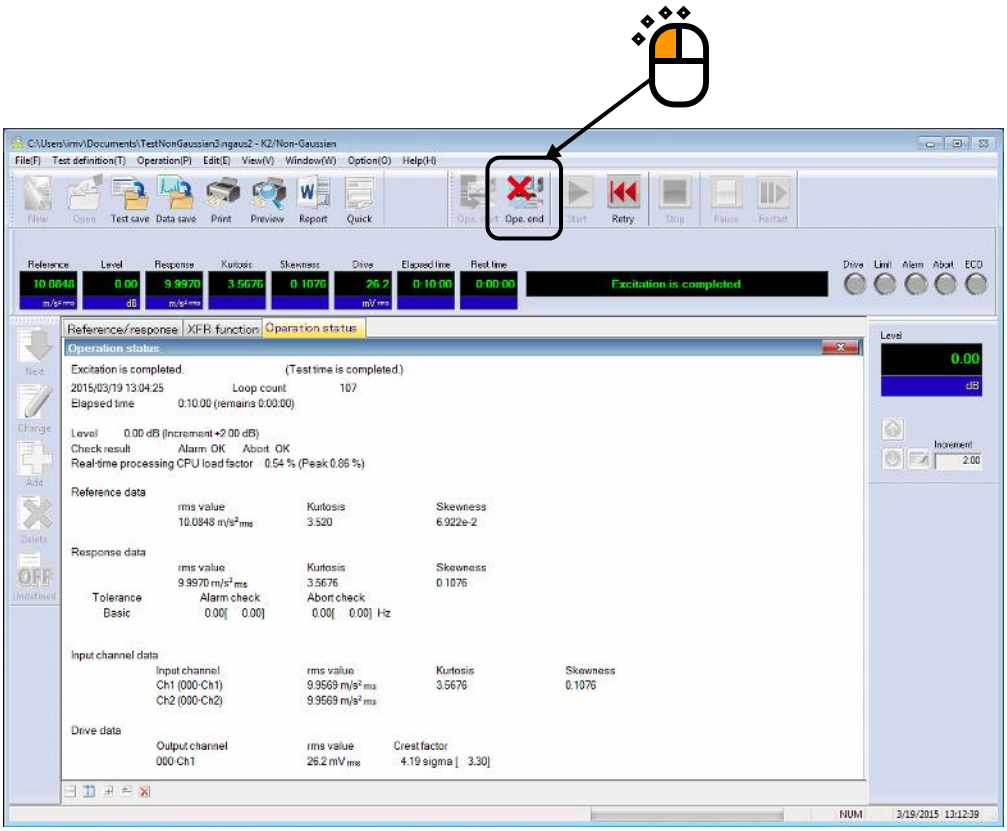
Test time starts to count the elapsed time for test operation when the excitation level is set to 0dB.



＜Step 6＞

Test operation is stopped when the test time ends.

Press the button of [Operation end]. The system proceeds to the display of test definition mode.



Chapter 4 Test Definition

4.1 Outline

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

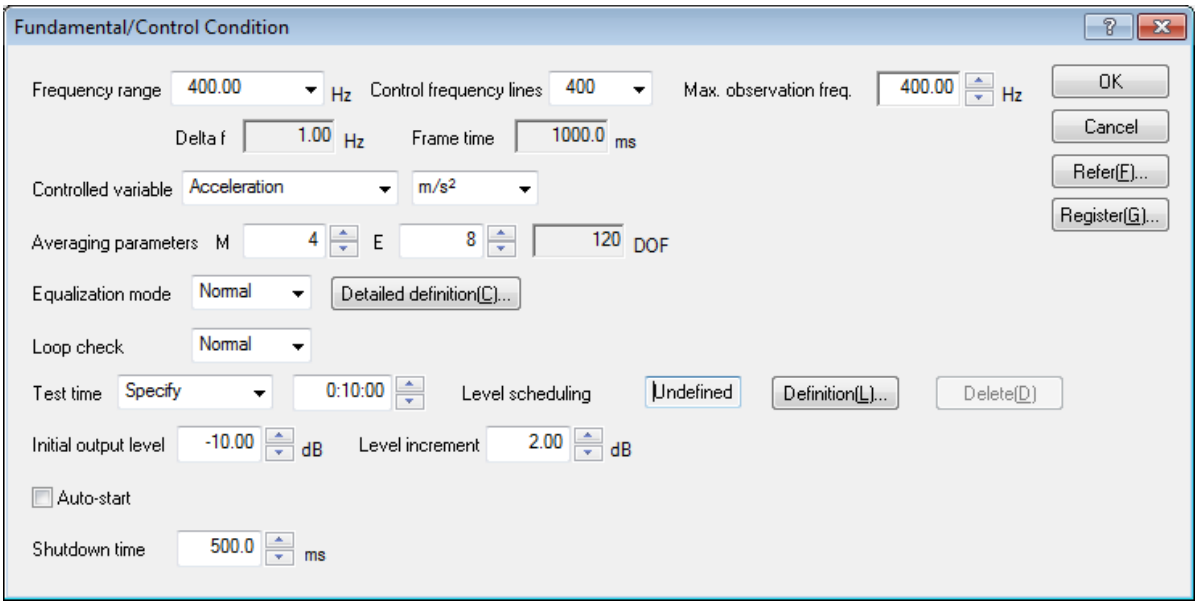
To perform a test, Test must be defined first of all.
This chapter describes the procedure to define the Test.

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.



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 fs and Frequency range fmax is described as below ;

$$fs = 2.56\ fmax$$

<Note>

If non-Gaussian characteristics are of the stationary peak type, it is recommended to set frequency higher than the maximum frequency of reference PSD in order to improve control performance.

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.

<Minimum number of lines>

Non-Gaussian random controller requires the greater number of lines than normal random controller. The minimum number of lines included in the range of reference frequency is limited by krutosis (K) value as shown below.

$3.0 < K \leq 4.0$: Minimum number of lines 50

$4.0 < K \leq 5.0$: Minimum number of lines 80

$5.0 < K \leq 6.0$: Minimum number of lines 100

$6.0 < K \leq 8.0$: Minimum number of lines 150

$8.0 < K \leq 10$: Minimum number of lines 200

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 value s 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 to be operated in the following condition ;

(1) at loop check (before measurement of transfer function)

(2) at initial equalization ,at initial equalization for Non-Gaussian

(3) in control operation

The objective input channels for loop check are ;

- Non-gaussian control channel
- Control channel
- Monitor channel for monitor RMS observing
- Monitor channel having the monitor profile

The loop check before transfer function measurement is operated by white-noise output signals in the excitation of the shakers one by one. The voltage of loop check is defined by "the initial output voltage" specified for each excitation group. Refer to 4.4 Excitation system setting about the details.

The loop check at initial equalization is operated by white-noise output signals that are defined as the initial output voltage in the excitation groups. It checks the abnormality in the control loop and also observes continuously in the control operation.

The abnormal detection level for loop check is selected among the three items below ;

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.
   Use this criterion when loop check is failed in setting ‘Normal’.

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 unit [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' in 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.

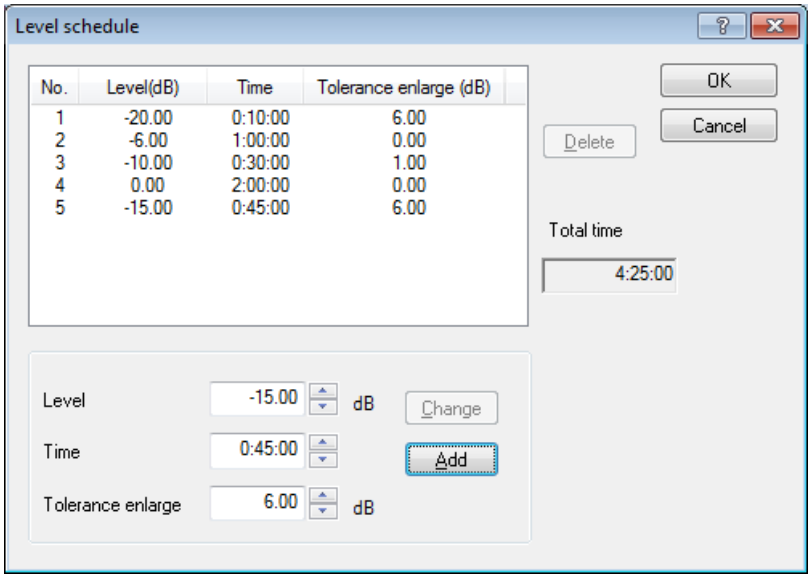
Also, it doesn't have to be defined when it is not necessary.

[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.

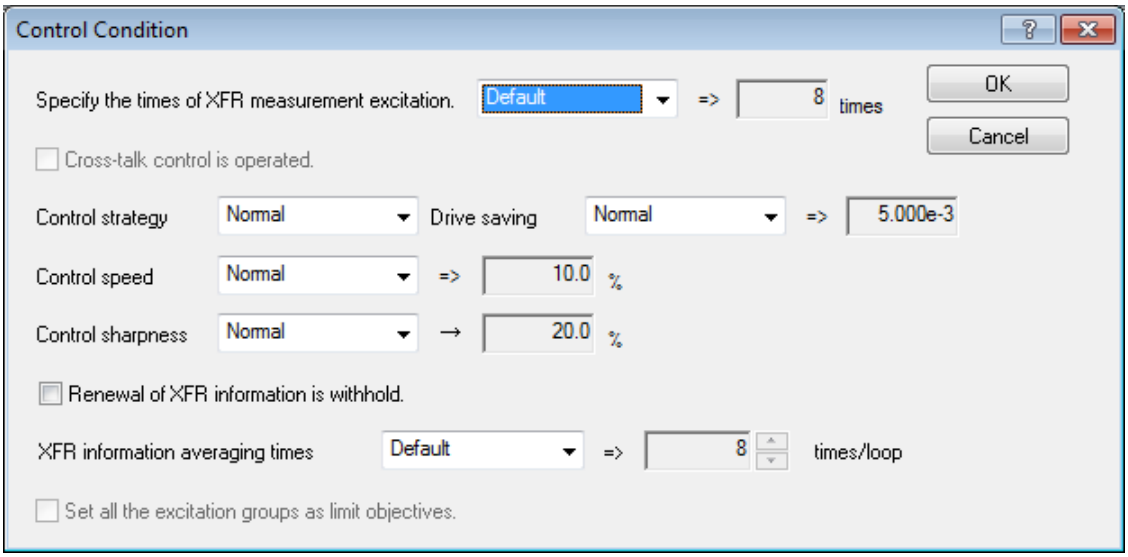
Tolerance is specified as a relative level to the tolerance defined in ‘Tolerance Definition’.

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’.

4.3 Waveform control condition

The items for the condition of waveform control are defined.



4.3.1 Specify the time of XFR measurement excitation

(1) Meaning

This item is for setting the times of excitation / measurement operation in XFR measurement. (The measurement data is to be averaged.)

<Methods of XFR measurement excitation>

1) Initial excitation by white-noise

The loop check before transfer function measurement is operated by white-noise output signals. The voltage of loop check is defined by the initial output voltage specified.

All channels are sure to be checked and the control loop is judged accurately by all the response of the used input channels.

2) XFR measurement excitation

The excitation of transfer function matrix measurement is operated by drive output signals defined as XFR measurement output voltage of the excitation system setting. This item specifies the excitation times for the measurement.

Also, the spectrum of excitation drive signal is controlled for the purpose of utilizing the measurement as much as possible; the transfer characteristic of controlled system is available to know according to the information of drive and response by white-noise excitation of 1). Generate a random signal satisfying the condition according to the information: determine the drive spectrum to have flat spectrum of responses at all input channels as possible, specify the level of drive signal from the specified excitation level. Then the excitation is to be operated.

4.3.2 （This section is left blank intentionally.）

4.3.3 Control strategy

This item is ordinarily to be used in the ‘normal’ mode.

This item is used to partly change the control algorithm when the waveform cannot be controlled by ordinary procedures. The control strategy can be selected from the following three types :

Normal : In this type, the impulse response of the inverse system (in general, non-causal) created on the basis of the transfer function for equalization is handled evenly before and after the time origin (past and future).

This is suitable for the general waveform data which is usually used in this system.

Type A : In this type, the impulse response of the inverse system is handled somewhat unevenly before and after the time origin (emphasis on the future).

Type B : In this type, the impulse response of the inverse system is handled unevenly before and after the time origin (emphasis on the future).

In such a situation better control cannot be achieved or the bad influence may increase, especially when the control method of this system is used for executing the control loop.

However, those types may help in the control of transient waveforms (like that used in a shock test).

4.3.4 Drive saving

(1) Meaning

This item is usually to be set to ‘normal’.

When the linear independence of transfer function matrix H becomes unstable, the equalization matrix G calculated from H also becomes unstable, so some regularization is needed.

This item specifies a parameter for regularization.

In general, the regularization process yields a smaller drive signal (the larger the regularization parameter is set, the smaller the drive signal becomes). The name of this item is derived from this relation.

This item is effective only if the calculation of the equalization matrix G is unstable.

Drive saving is not any kind of actual energy-saving measure to achieve the same result.

In the concerning case, a too small H at a frequency component determines too large value for G as the inverse number of H. The small measured value H includes the measured error caused by noise. However, the influence of this measured error of H appears in the inverse number G as much larger error. This is a very significant problem (because the large G produces large drive voltage signals).

It is needed when the solution (drive) is unstable and unreliable because the simultaneous equations are unstable. In such a situation, the solution may have very large value, but it is not certain whether such large value is correct. Drive saving means using a more reasonable and stable solution (smaller than the original one) after regularization.

When simultaneous equations are stable, Drive saving is not needed.

However, regularization admits a sort of ‘abandonment’ in a shortage of rating of an excitation system; a larger drive signal required for a precise inverse matrix solution cannot be output although the original matrix is not completely bad.

In other words, the required drive voltage can be decreased by giving a larger parameter (instead, the control accuracy is worse, but ‘abandonment’ is useful for achieving excitation).

The selection range is described as follows :

Stricter solution : The regularization stated above is not almost done, but a strict mathematical solution is searched. When the solution is unstable or almost unstable, too large a drive voltage may be given. In this event, actual excitation may be impossible, so Stricter Solution is insubstantial. (Equivalent 0.0002 to regularization parameter)

Normal : Moderate regularization is done. When the solution is stable, there is no regularization effect, so Normal is suitable to the ordinary setting. (Equivalent 0.001 to regularization parameter)

Save : Stronger regularization is done. When the solution is unstable or almost unstable, a rough mathematical calculation is done to avoid generating too large a drive voltage. (Equivalent 0.005 to regularization parameter)

Specify : Regulation parameter is set by a number. When the regularization parameter is set to zero, no regularization is done. This setting does not have any advantage, generally.

4.3.5 Control speed

(1) Meaning

Control speed is usually a concept of follow-up speed with response change of the controlled system (if there is one) during control.

This item is for the transfer information (waveform control information) corresponding to the waveform control. And, the same item for the transfer information corresponding to PSD control is defined in averaging weight parameter of loop E of averaging parameter in fundamental/control conditions.

In this system, the following-up for the characteristic change of the controlled system is achieved by the consequent action such that when the transfer function is renewed at every renewal of control loop, then this system recognizes the change of the controlled system and it leads to the change in equalization matrix.

Based on the definition of this item, the weighting factor for averaging the old and new data in the correction of transfer function data(waveform control information) is varied.

In the procedure to get the averaged data S, the weighting factor e_1 for the new data S^{raw} is adjusted, and S is described as follows

$$S = e_1 \cdot S^{raw} + (1 - e_1)S$$

In the setting of 'Fast', the weighting factor of the new data is large, so the change in the measured transfer function value is quickly reflected to the control.

The numeric value is specified in percentage for the weighting factor e_1 which determines the evaluation ratio of the new data.

For example, the definition of '10 %' means $e_1 = 0.10$.

4.3.6 Control sharpness

(1) Meaning

Random controller shapes drive spectrum so that control response spectrum is coincided with control reference spectrum. Basic data of the shaping includes transfer information and control errors(control response / control reference).

The random controller directly corrects drive spectrum so that it is coincided with control reference spectrum based on errors which could not be controlled by transfer information.

The adjusting quantity of this ‘Error control’ relative to waveform control is specified in this paragraph.

The adjusting quantity of ‘Error control’ relative to PSD control is specified by control acuity of ‘Fundamental/control condition’.

4.3.7 Cross-talk control loop open

(1) Meaning

There are two kinds of control information in the test.

The one is the control information for PSD control and the other is transfer information for the waveform control operation.

Renewing operation of the control loop is defined in ‘cross-talk control loop open’ of the waveform control condition and in ‘open loop operation’ of the level change during the operation.

Renewing process of the control loop varies depending on the defined contents (the setting of open loop operation and cross-talk control loop open). And it is also possible to change the setting for the renewing of the control loop during the testing operation.

The precise description of the renewing activity is summarized as follows :

Definition contents	Open loop operation		Not execute (default)		Execute	
Testing operation	Open loop operation		Not execute (default)	Execute	Not execute (default)	Execute
		PSD control information	○	×	○	×
		Waveform control information	○	×	×	×

○: Control information is renewed.

×: Control information is not renewed.

The default setting of this item is to renew the control information, but by setting this item to ‘Not execute’, the control loop operation is set to ‘open’ as the initial setting.

The renewing of transfer function data is suppressed just after the test start when this item is set to execute. Therefore, this system proceeds to the state of open-loop control based on the transfer function data that is obtained at the initial measurement without changing the equalization matrix data.

4.3.8 Cross-talk information averaging times

(1) Meaning

This system adopts the method of renewing of transfer function data (the transfer information for waveform control) for tracking the changing response of controlled system.

The renewing of transfer function data is executed as below ;

The cross spectrum between the drive data and the response data is calculated as the averaged value obtained by the spectrum analysis for the specified frames. By using these data, a new transfer function data is calculated.

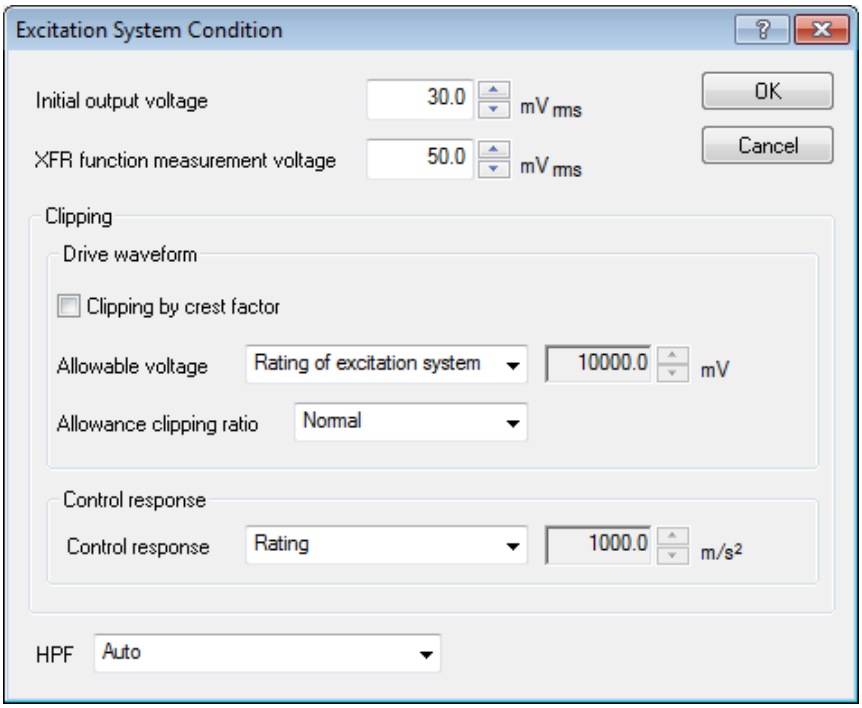
In this item, the times of averaging process is specified. The averaging process is operated by using the data for the fixed numbers of frames equal to the averaging times specified in this item. Then, the renewing of transfer function is executed.

This item is for the renewing of transfer information corresponding to the waveform control. The same item for renewing of transfer information for PSD control is set in ‘Averaging parameter averaging times for a loop M’ of Fundamental/control condition.

4.3.9（This section is left blank intentionally.）

4.4 Excitation System Setting

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



4.4.1 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 (Vrms) 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.

4.4.2 XFR Measure output voltage

(1) Meaning

Following the initial loop check, the voltage level (RMS) of drive signal given to shaker is defined in this item when the excitation for transfer function measurement is executed.

The system operates the constant excitation control at the transfer function measurement and outputs the drive of random signal that is equalized to have a flat (averaged, for multiple channels) characteristic of response frequency at all non-gaussian control channel.

This item defines the level of the drive voltage waveform.

4.4.3 Clipping

(1) Meaning

Setting conditions for ‘Clipping’ to be performed by output channel is allowed.

Clipping is roughly divided in two types shown below.

- Drive waveform clipping
- Control response waveform clipping

4.4.3.1 Clipping of drive waveform

(1) Meaning

Drive waveform clipping can be specified by either of two types of methods shown below.

- Clipping by crest factor
- Clipping by voltage

In this system, the value of clipping by voltage is necessary to be specified. On the other hand, clipping by crest factor is not necessary to be set if it is not needed. It is general that clipping by crest factor is set to ‘not execute’ in this system.

4.4.3.1.1 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.

4.4.3.1.2 Allowable voltage

(1) Meaning

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

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. That is, the specified voltage level of this item has the same meaning of the clipping level by output voltage.

4.4.3.1.3 Allowance clipping ratio

(1) Meaning

In this system, the setting with only 'Allowable 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 ;

Abort voltage [mVrms] = Allowable voltage [mV0-p] ÷ Abort ratio

4.4.3.2 Clipping of control response waveform

(1) Meaning

Setting of the maximum allowable response waveform level with non-Gaussian control channel is allowed.

When control response waveform is presumed to exceed the specified level, clipping process is conducted on the reference waveform of the non-Gaussian control channel not to exceed the specified level.

Please note that the clip level may be fluctuated depending on control status.

The clipping process may lead to unstable control as well as the degradation of control performance. Carefully perform the setting.

SHOCK system rating is set as the initial value.

4.4.4 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 fc.

・Not use

This item means that high pass filter is not used.

・Auto-setting of fc

This item means that high pass filter is used, and the setting of cut-off frequency fc is automatically operated.

・Specify cut-off : fc

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

< Selection Guide>

Generally, 'Auto-setting of fc' which is the default value of this system is recommended.

As the selection guide of cut-off frequency fc 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 :

$$fc = f_edgeL \cdot 0.5\Delta f$$

In the case that the value of fc estimated as $f_edgeL > 5\Delta f$, using filter is not necessary from the first.

As the actual circuit, a second order characteristic high pass filter with fc programmable function is implemented. So, you do not have to think of fc 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 fc and think over the calculation value.

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

< Indication of fc set value >

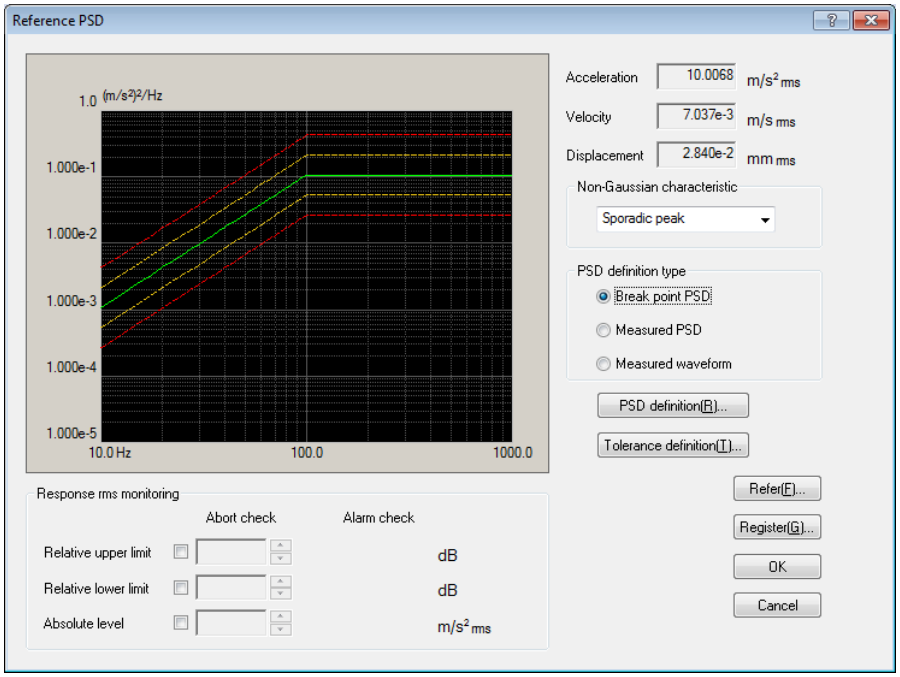
The set value of fc is to be displayed after completing of the reference PSD definition when 'Auto-setting of fc' is selected.

4.5 Control Reference

This item is for defining the control reference.

Test pattern is determined by the setting of this definition.

4.5.1 PSD definition



4.5.1.1 Non-Gaussian characteristic

(1) Meaning

Select any non-Gaussian characteristic. It is not that which of them is superior to another. Select any choice appropriate for the test.

・Sporadic peak

Non-Gaussian random vibration test, applying random vibration with higher sporadic peaks, is conducted. This type allows only kurtosisto be specified.

It is more stable than the stationary peak type in terms of control, and the control dynamic range does not differ from that of normal random controller basically. Use this type usually.

・Stationary peak

Non-Gaussian random vibration test, applying random vibration with higher stationary peaks, is conducted. This type allows kurtosis to be specified as well as skewness.

However, the control dynamic range is less than that of the sporadic peak type due to its principle. Additionally, note the points shown below.

・Control frequency range

To obtain better control results, excitation may also be needed out of the

reference PSD band. Thus, it is recommended to set the control frequency range greater than the maximum frequency of the reference PSD.

・Non-Gaussian equalization time

Time required for kurtosis and skewness to be coincided with their references may be longer than that of the sporadic peak type. It depends on the shape of PSD.

・Tolerance check

In some case, the control response may be out of tolerance after non-Gaussian equalization is finished. It depends on the control situation. In such a case, adjust the setting of tolerance. When test can't be executed due to excessive displacement, decrease the initial level and increase the excitation level after control is stable.

・Level of generated peaks

Higher peaks than the sporadic peak type may be generated under the same kurtosis conditions.

4.5.2 PSD definition type

(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.

Also, select non-Gaussian characteristic.

For details of non-Gaussian characteristic, refer to "4.5.1.1 Non-Gaussian characteristic".

<Beak 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 and non-Gaussian parameters (kurtosis, skewness) 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 if 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 Fundamental/control conditions.

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.

4.5.2.1 Break point PSD definition

4.5.2.1.1 Outline

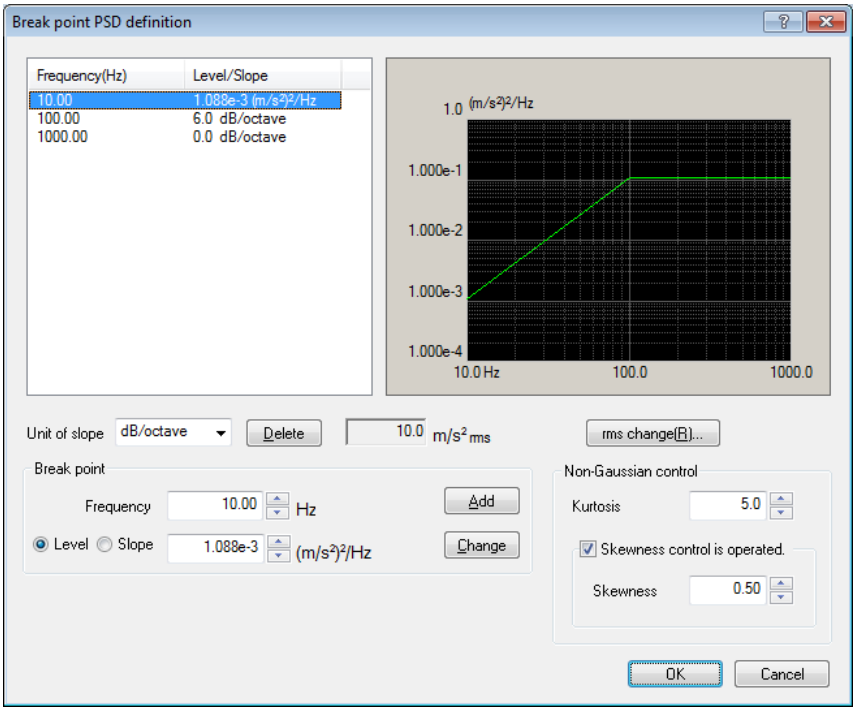
PSD is defined by a pair of the frequency and the level (or the slope).

<Example>

10 [Hz] ~ 100 [Hz] : a spectrum having the slope [6 dB/oct] with 10 [Hz], 0.001 [$(m/s^2)^2$/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 the 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 at dividing by Δf, the PSD data of each control line is defined as; draw a strait 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 fmax.

At least, two lines of the data are needed between Δf and fmax.

Break Point (B.P.) data is registered by using these buttons.
Also the B.P. data can be registered for 256 at the maximum.

[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.
Additional registration of a data having the same or similar frequency of the registered B.P. frequency can not be set.

[Change] : The content of the registered B.P. data is changed.
Select the B.P. data line to be changed by a mouse. Then, change the objective item 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.

4.5.2.1.2 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.

4.5.2.1.3 Level

(1) Meaning

At registering of B.P. data, the level data corresponding to the frequency data is inputted in the unit off the PSD value.
The PSD value can be inputted to this item by pressing of the [Level] button.
The PSD value is expressed by 'unit^2 / Hz'. This 'unit' expresses the control unit. that has already determined in Fundamental/control condition.

4.5.2.1.4 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.

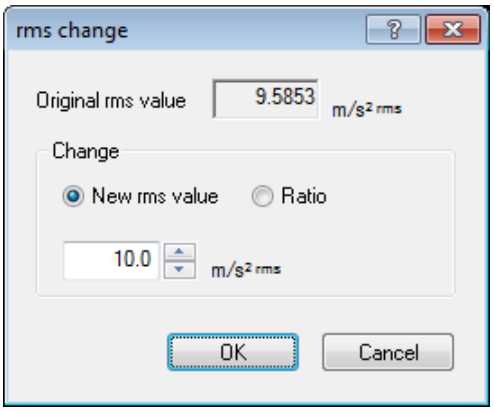
4.5.2.1.5 rms change

(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 these 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.

4.5.2.1.6 Non-Gaussian control

(1) Meaning

Setting control reference of kurtosis and skewness is allowed.

<Kurtosis>

This item is for setting of the control reference of kurtosis.

The input range is: $3.0 < K \leq 10.0$

<Skewness control is operated>

This item is for selecting whether the function of 'skewness control' is executed. This parameter is valid only when 'Stationary peak' is selected in the Non-Gaussian characteristic.

<Skewness>

This item is for setting of the control reference of skewness.

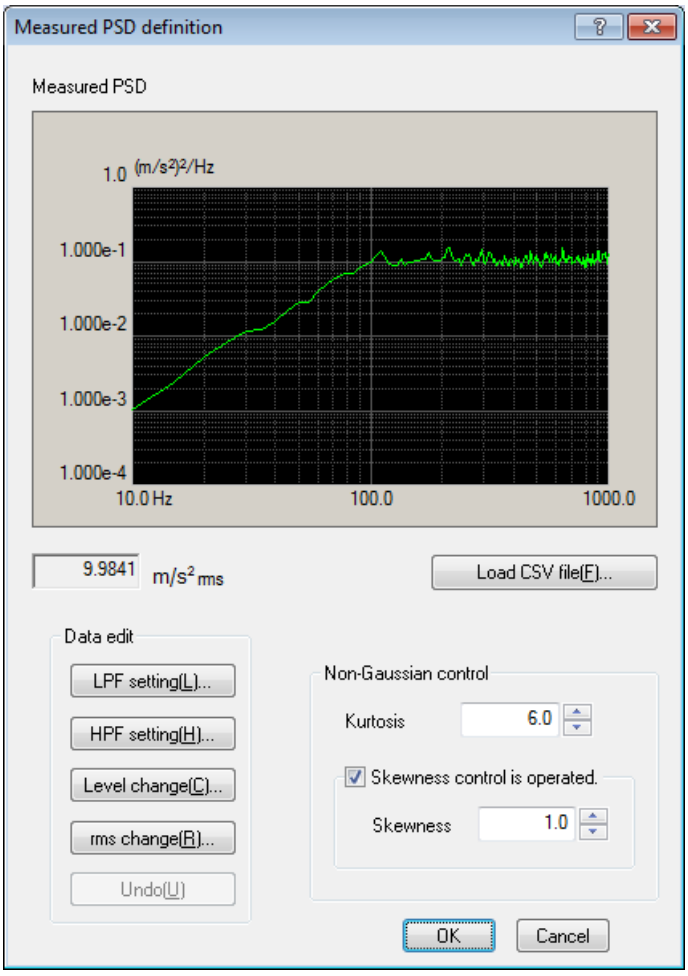
Input range is as shown below, provided that kurtosis is K:

$$-\sqrt{2.0\times\frac{K-3.0}{3.0}}\times 0.8 < S < \sqrt{2.0\times\frac{K-3.0}{3.0}}\times 0.8$$

4.5.2.2 Measured PSD definition

4.5.2.2.1 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 "4.5.2.2.5 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 fmax. 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 fmax.

<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.

<Non-Gaussian control>

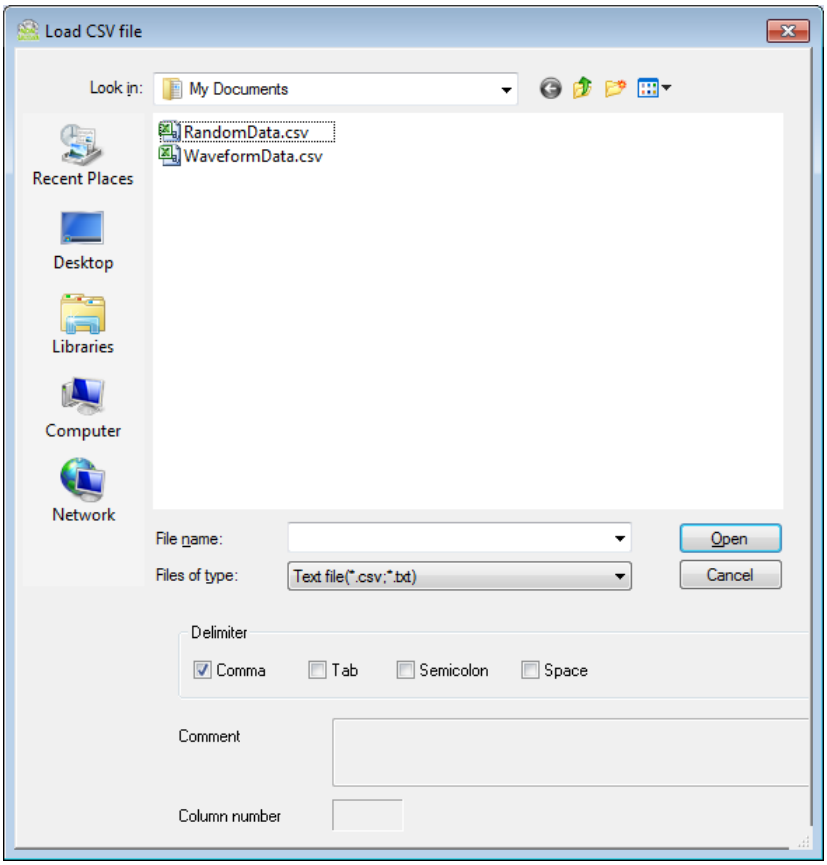
This item is for setting the control reference of kurtosis and skewness.

4.5.2.2.2 PSD Data File loading

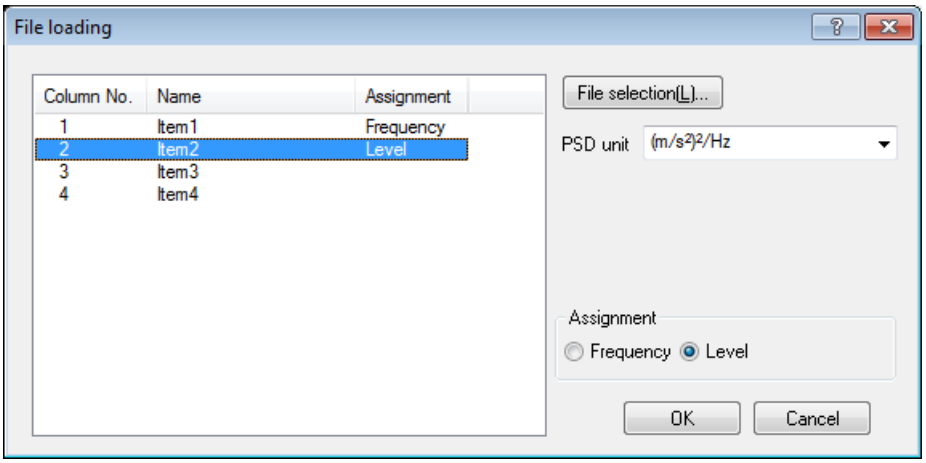
(1) Meaning

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

In the dialog of the measured PSD definition, press the [CSV file loading] button to open the dialog box of File loading.



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.



< File selection >

Dialogue box to select CSV file is displayed, and PSD data file can be selected again.

<PSD unit>

Unit for the level of data file is selected.

<Assignment of frequency data>

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

<Assignment of level data>

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

4.5.2.2.3 Data edit

(1) Meaning

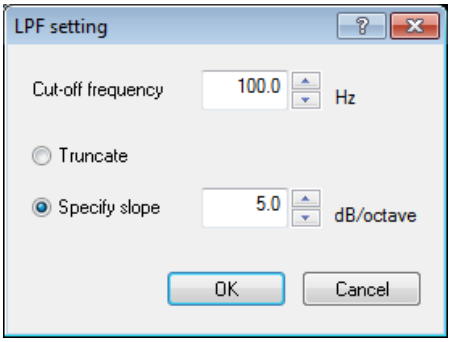
When the PSD data is determined, the selected measured PSD data is displayed and the buttons in 'Data edit' become valid. The data can be edited by a selected button to be executed on demand.

4.5.2.2.3.1 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;

・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;

Truncate : This item is for cutting off the data at the higher band than the specified cut-off frequency. The higher data than fmax should be cut off and discarded from the PSD data when there is higher frequency components than the control frequency range existing.

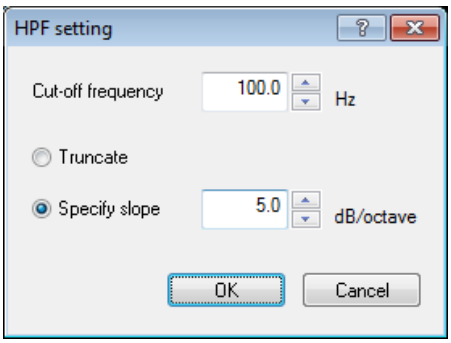
Specify slope : This item is for operating of low pass filtering with the specified slope. The unit of slope is dB/octave.

4.5.2.2.3.2 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;

Truncate : This item is for cutting off the data at the lower band than the specified Cut-off Frequency. The lower data than the frequency resolution Δf should be cut off and discarded from the PSD data when there is lower frequency components than the control frequency resolution existing.

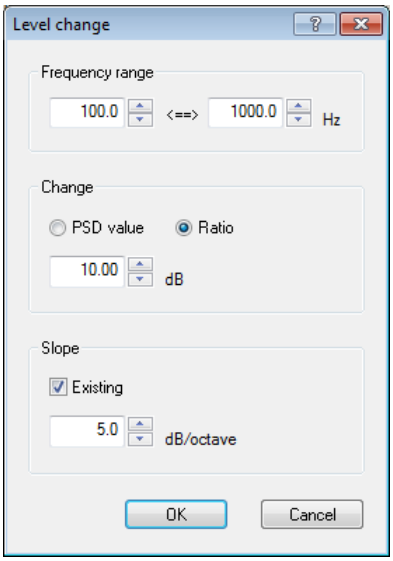
Specify slope : This item is for operating of high pass filtering with the specified slope. The unit of slope is dB/octave.

4.5.2.2.3.3 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;

・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 to be changed.

PSD value : The PSD level to be changed is specified by an absolute value.

Ratio : The PSD level to be changed is specified by a relative value.

・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.

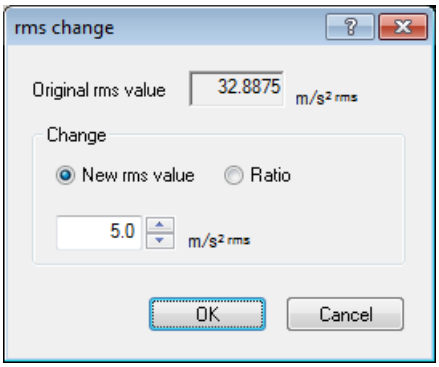
The slope is set outside of the specified frequency range when it is set to be attached. The unit of slope is dB/octave.

4.5.2.2.3.4 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 ;

- Newl rms value

  The RMS value to be changed is specified by an absolute value.

- Ratio

  The RMS value to be changed is specified by a relative value.

4.5.2.2.4 Non-gaussian control

(1) Meaning

This item for setting control reference of kurtosis and skewness.

For details, refer to “4.5.2.1.6 Non-Gaussian control”.

4.5.2.2.5 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,	***.***,	***.**,	……
	2Δf,	***.***,	***.**,	……
	:	:	:	:
	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.

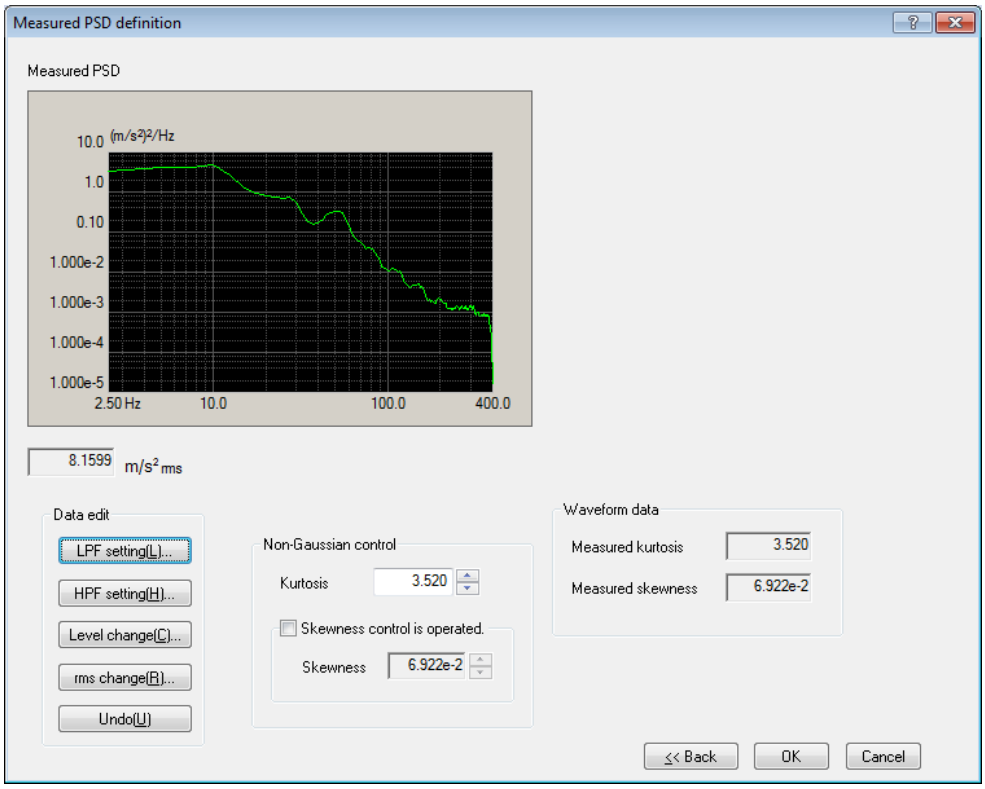
(3) Unit of Data

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

4.5.2.3 Measured Waveform definition

4.5.2.3.1 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 and non-Gaussian parameters (kurtosis, skewness) 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 "4.5.2.3.4 CSV data file" about the details of this format.

<Data edit>

This item is for editing the PSD.

For details, refer to "4.5.2.2 Measured PSD definition".

<Non-gaussian control>

This item is for setting control reference of kurtosis and skewness.

For details, refer to "4.5.2.1.6 Non-Gaussian control".

<Back>

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

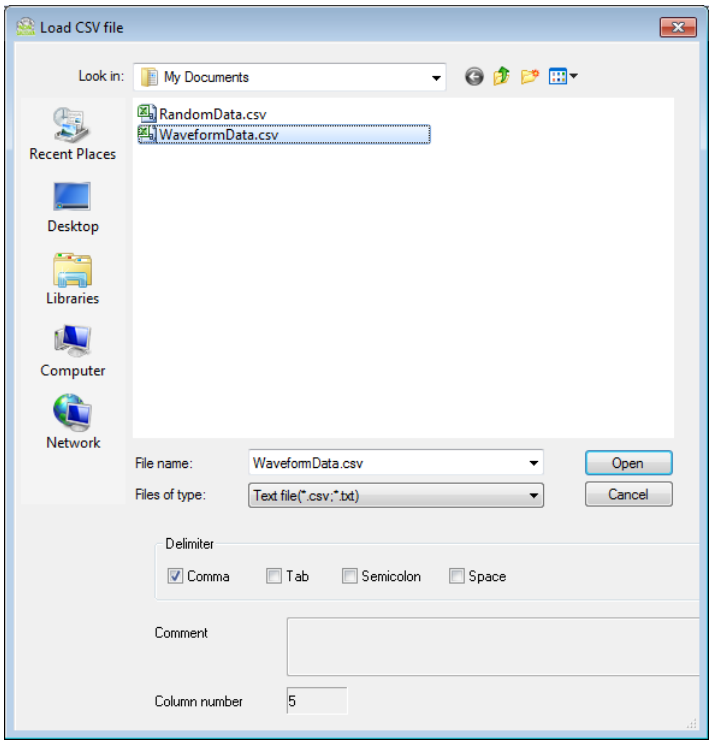
When this screen reappears after waveform data is changed, data edit which has been conducted already is abandoned.

4.5.2.3.2 Waveform Data File loading

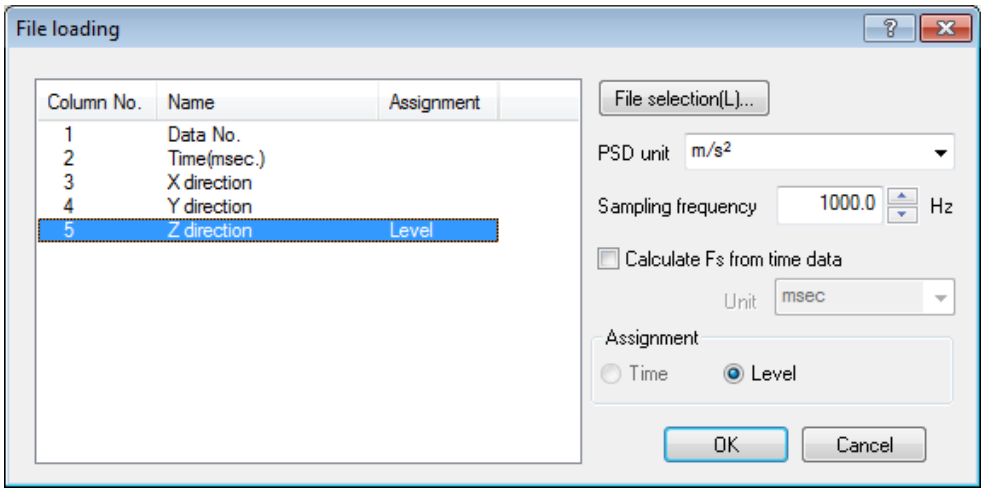
(1) Meaning

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.

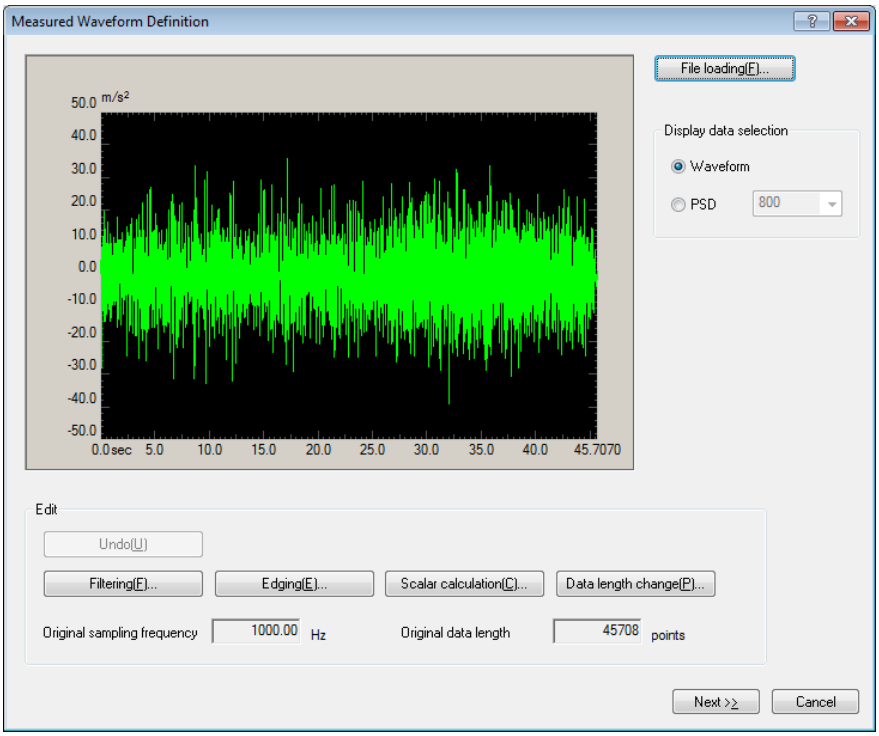
< Assignment of time data>

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 “4.5.2.3.4 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.

4.5.2.3.3 Data edit

(1) Meaning

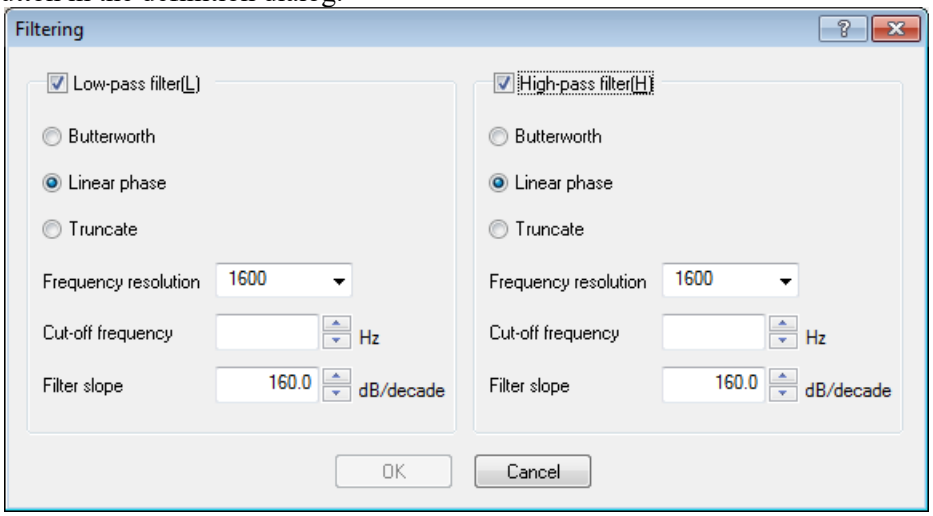
When the PSD data is determined, the selected measured waveform data is displayed and the buttons in 'Data edit' become valid. The data can be edited by a selected button to be executed on demand.

4.5.2.3.3.1 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 fc.

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 fc is determined when frequency resolution is specified.

<Cut-off frequency>

This item specifies the Cut-off frequency for Filtering.

The possible lower value fc_min is determined by the Sampling frequency fs of the objective waveform data of the Filtering process and the frequency resolution L as follows.

$fc_min = \Delta f$ [Hz] $\Delta f = fmax/L, \quad fmax = fs/2.56$

<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.

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

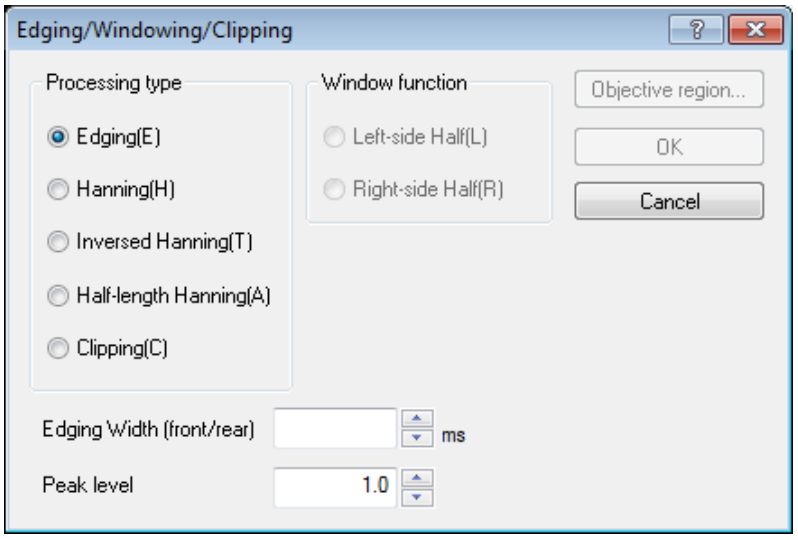
A(f) Amplitude value

4.5.2.3.3.2 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 Te is specifyed.

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'.

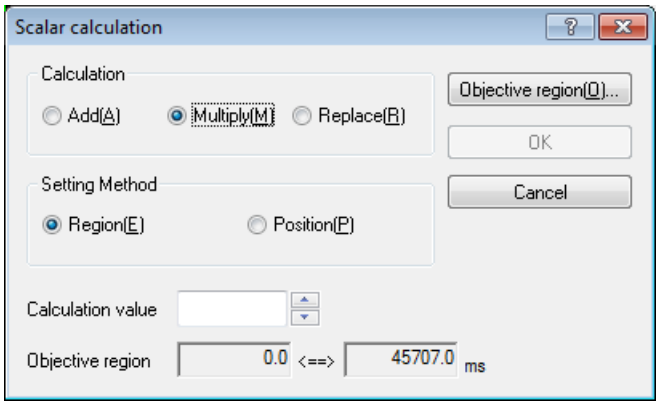
In the event of clipping, this item specifies the clipping level. The unit is the same as the objective waveform data.

4.5.2.3.3.3 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.

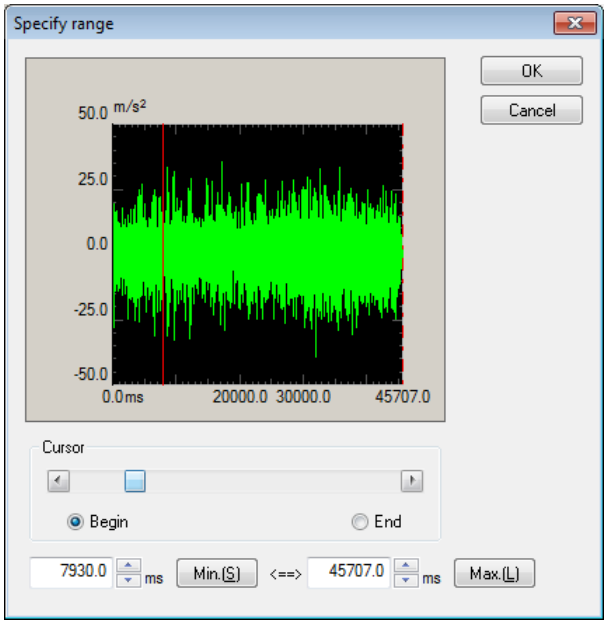
<Setting Method>

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.

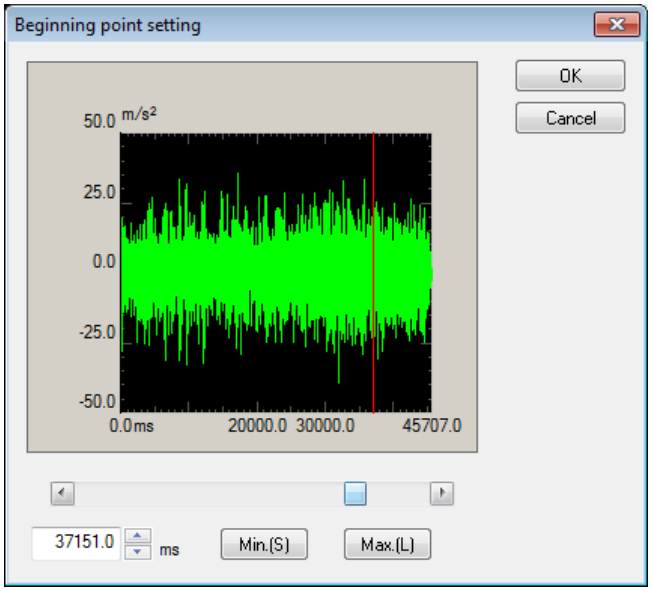
Select [Objective region] to display the dialog as below. And define the beginning and the ending points that become the objects for calculation.



・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.

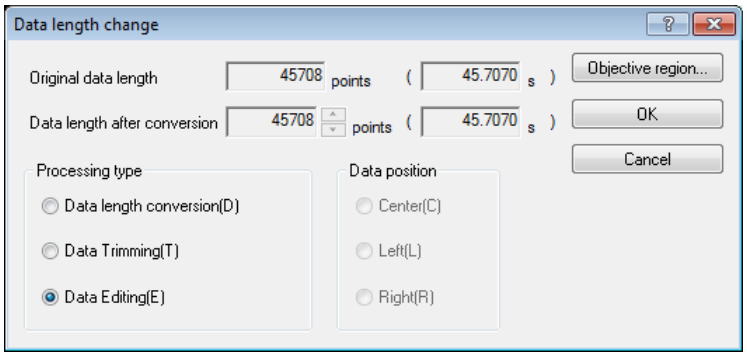


4.5.2.3.3.4 Data length change

(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' / fs [s] R' : 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.

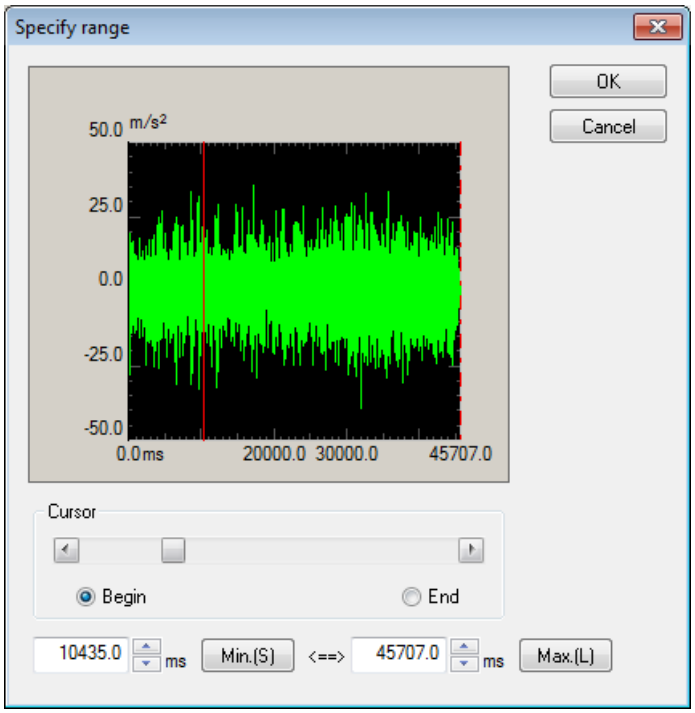
・Right

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.



4.5.2.3.4 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	Time (ms)	Data Name 1,	Data Name 2,	Data Name 3,	……
2nd line	0.0,	***.***,	***.**,	***.**,	……
3rd line	Δt	***.***,	***.**,	***.**,	……
	2Δt	***.***,	***.**,	***.**,	……
	.	.	.	.	.
	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.

4.5.3 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

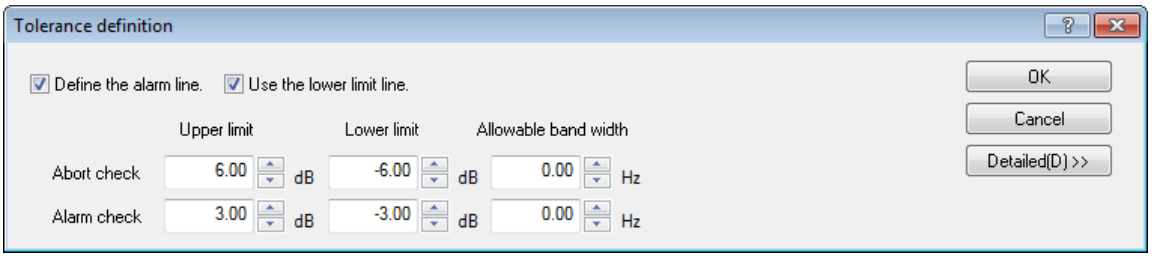
Here, 'Alarm' means that this system sounds an alarm (buzzer) when the response quantity which exceeds over the level of the set condition is detected. And, 'Abort' means that the testing operation is aborted (the signal output is stopped) when the response quantity which exceeds over the level of the 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 he the 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.



< 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.

4.5.3.1 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.

| Alarm check level | ≦ | 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.

4.5.3.2 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.

4.5.3.3 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.

4.5.4 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.

4.6 Input Channel

4.6.1 Outline

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

- Non-gaussian control channel
- Control channel
- Monitor channel

<Non-gaussian control channel>

In this system, the input channel having the role of kurtosis and skewness control among control channels is called ‘Non-Gaussian control channel’.

This Non-Gaussian control channel also has the role of waveform control.

Only one channel must be defined as Non-Gaussian control channel.

<Control channel>

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

<Monitor channel>

Monitor channel is for observing the response at the specified response point independently of the control channels.

The physical quantities of measuring object are available to set to each channel individually.

For example, when a controlled variable is acceleration, one monitor channel can monitor a displacement signal while another can monitor a force signal.

You can also specify RMS value monitoring and PSD spectrum monitoring in the monitor channels. Together with the function stated in the above, for instance, the following types of operation can be done: when the control is done in acceleration, displacement signal of some response point is monitored. And the testing is forced to abort when the displacement exceeds the set limit.

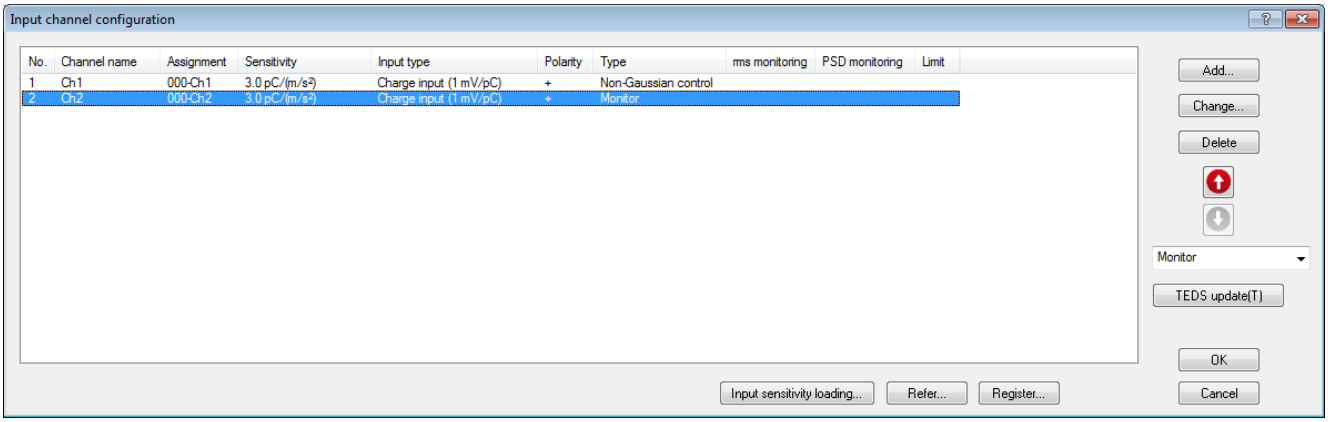
In this system, the used input channels are all defined as monitor channels. So the control channels have the function of monitor channel, too.

Also the same control variables are needed to be used as the objective physical quantities of the non-gaussian control channel and the control channels.

Thus the correspondence between input channels and output channels is determined. Reference PSD of control channel is also decided by this information.

4.6.2 Input channel configuration

The input channels to be used are set in the definition dialog of input channel configuration.



[Add] : A new input channel is added.

[Change] : The definition contents of an input channel are 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.

[Non-Gaussian control] : The channel is used as a non-Gaussian control channel.

[TEDS Update] : The input sensitivity is set from the connected TEDS corresponding IEPE sensor automatically. The function is enabled with the TYPEII hardware

The definition contents of input channel configuration can be registered as a file in this system. The registered definition condition can be used for another test if necessary.

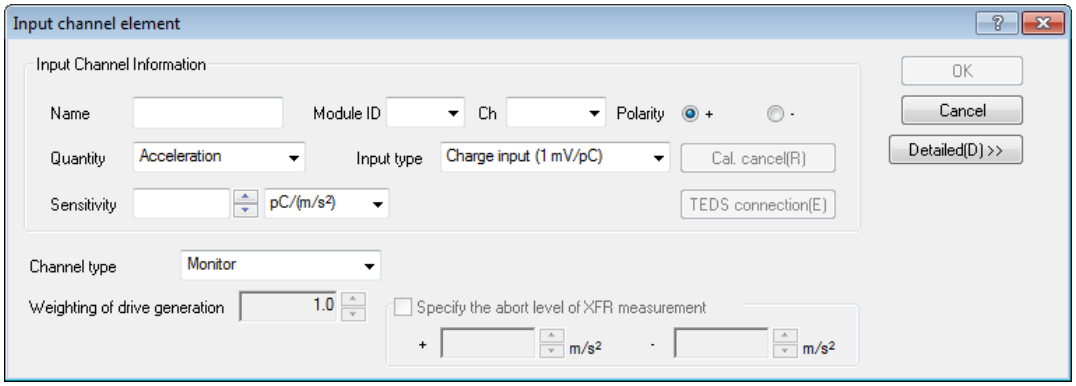
[Refer] : The registered definition contents of input channel configuration is loaded and used.

[Register] : The defined contents of input channel configuration is saved and registered as a file.

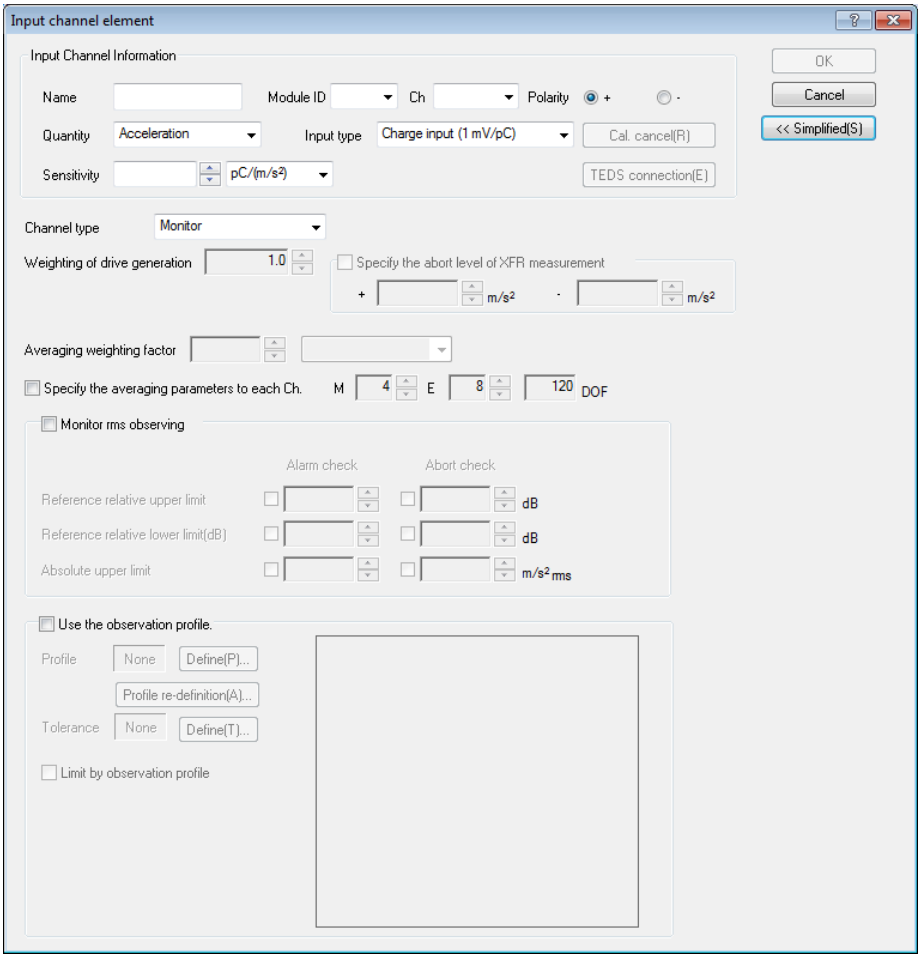
4.6.3 Input channel element

Each input channel element is available to be defined in the display below.

The detailed input channel element is to be defined in the detailed definition display.



Simplified definition display



Detailed definition display

4.6.3.1 （This section is left blank intentionally.）

4.6.3.2 Specify the abort level of XFR measurement

(1) Meaning

This item can be set up only when the channel is specified as ‘Non-Gaussian control channel’ or ‘Control channel’.

Abort level at XFR mesurement can be set arbitrarily.

The default setting value is the 5 times of the peak value of reference.

Test is aborted when the response exceeds over the defined abort level in Loop check or XFR meanirement.

4.6.3.3 Averaging weighting factor

(1) Meaning

This item can be set only when the given channel is specified as the non-gaussian control channel or a control channel.

When the multiple control channels are defined, the response spectrum of these control channels as a whole should be compared with the reference spectrum. For this reason, one representative spectrum as the control response should be obtained from the response spectrum of all the control channels.

The controlling method in which the data obtained by averaging the response spectrum of each control channel for each line is controlled as a control response spectrum is called the average value control.

In this system, when multiple control channels exist, basically the definition of average value control is executed for all the control channels, and the maximum value control or the minimum value control which is explained in the next clause is selected at an arbitrary control channel on demand.

This item is for specifying of weighting factor for each control channel to calculate the average of the control response spectrum for the average value control.

Denoting the response spectrum of the control channel j as $\overline{\phi^{j}}$, the averaging weighting factor as W_j, the control response spectrum $\overline{\phi}$ is expressed as follows ;

$$\overline{\phi} = \frac{1}{W}\sum_{j=1}^{c} W_j \overline{\phi^{j}}$$

Here, c is the number of the control channels which belong to the concerning excitation group. W in the above expression is expressing the following quantity ;

$$W = \sum_{j=1}^{c} W_j$$

Normally, this weight is set for '1' because each channel should be equally estimated.

In this item, the data $\overline{\phi}^{j}$ of each channel uses the averaging parameter M and E defined in the fundamental/control condition and is done the averaging operation for each channel.

4.6.3.4 Maximum Value Control

(1) Meaning

This item can be set only when the given channel is specified as the non-gaussian control channel or a control channel.

This item is for setting of whether the maximum value control of this current control channel is executed or not.

When the maximum value control is executed at control channels, the control response $\overline{\phi}$ is determined as the selected maximum value of the line which is obtained by comparing the each response spectrum $\overline{\phi}^{j}$ of control channels and the averaged response spectrum $\overline{\phi}^{M}$ of all the control channels calculated by the averaging weighting factor of the above clause.

Therefore, in the maximum value control at the current control channel, the response spectrum will not exceed over the level of the reference spectrum.

Denoting the response spectrum of the control channel j as $\overline{\phi}^{j}$, the averaged response spectrum as $\overline{\phi}^{M}$, the control response spectrum $\overline{\phi}$ for the maximum value control is expressed as follows ;

$$\overline{\phi} = MAX\left[\overline{\phi}^{1}, \overline{\phi}^{2}, ..., \overline{\phi}^{c_m}, \overline{\phi}^{M}\right]$$

These 1, 2, c_m are the control channels which belong to the excitation group and is used for executing the maximum value control.

In this item, the data $\overline{\phi}^{j}$ of each channel for executing the maximum value control uses the averaging parameter M and E defined in the fundamental/control condition and is done the averaging operation for each channel.

When this current channel is needed to be used only for the maximum value control without using in the averaging calculation of the averaged response spectrum $\overline{\phi}^{M}$ of all the control channels, the value of the averaging weighting factor W_j explained in the above clause should be set as 0.

The maximum control and minimum control cannot be conducted at a time.

4.6.3.5 Minimum Value Control

(1) Meaning

This item can be set only when the given channel is specified as the non-gaussian control channel or a control channel.

This item is for setting of whether the minimum value control of this current control channel is executed or not.

When the minimum value control is executed at control channels, the control response $\overline{\phi}$ is determined as the selected minimum value of the line which is obtained by comparing the each response spectrum $\overline{\phi}^{j}$ of control channels and the averaged response spectrum $\overline{\phi}^{M}$ of all the control channels calculated by the averaging weighting factor of the above clause.

Therefore, in the minimum value control at the current control channel, the response spectrum will not be below the level of the reference spectrum.

Denoting the response spectrum of the control channel j as $\overline{\phi}^{j}$, the averaged response spectrum as $\overline{\phi}^{M}$, the control response spectrum $\overline{\phi}$ for the minimum value control is expressed as follows ;

$$\overline{\phi} = MIN\left[\overline{\phi}^{1}, \overline{\phi}^{2}, ..., \overline{\phi}^{c_m}, \overline{\phi}^{M}\right]$$

These 1, 2, c_m are the control channels which belong to the excitation group and is used for executing the minimum value control.

In this item, the data $\overline{\phi}^{j}$ of each channel for executing the minimum value control uses the averaging parameter M and E defined in the fundamental/control condition and is done the averaging operation for each channel.

When this current channel is needed to be used only for the minimum value control without using in the averaging calculation of the averaged response spectrum $\overline{\phi}^{M}$ of all the control channels, the value of the averaging weighting factor W_j explained in the above clause should be set as 0.

The maximum control and minimum control cannot be conducted at a time.

4.6.3.6 Specify the averaging parameters to each ch.

(1) Meaning

In this system, all the defined input channels are specified as monitor channels.

The input channel specified as a control channel also has the function of a monitor channel.

Monitor channels are for monitoring the response itself of the current channel. The monitor response is also observed with averaging as in the same way as the observation of the control response (the response data of the current channel for calculating the control response).

This item is for specifying whether the parameter M and E for the averaging process of the response spectrum of the input channel, that is, the monitor spectrum $\overline{\varphi^j}_{MON}$ are independently set or not besides the parameter M, E for the averaging process defined in the fundamental/control condition.

When this averaging parameter specified to each ch. is needed to be defined, the averaging parameter E and M are to be specified by checking the check box of this item. The meaning of E and M are the same as that in the fundamental/control condition.

When this averaging parameter specified to each ch. is not needed to be defined, the averaging parameter of the monitor spectrum for the monitor spectrum of the current channel is specified in the same condition of the fundamental/control.

This item is valid when the current input channel is specified either as the non-gaussian control channel or a control channel.

4.6.3.7 Monitoring RMS observing

(1) Meaning

This item is for specifying whether the RMS value monitoring is executed or not at the current input channel. The meaning of RMS value monitoring is the same as that of reference PSD in the item of test definition.

RMS value monitoring is the function for protecting the system. By setting of this item, the response monitor RMS value of this current channel is monitored and the protecting actions are activated at specified levels according to the RMS value.

These two of protecting actions are provided for the function of RMS value monitoring.

- Abort check
- Alarm check

In the setting of RMS value monitoring, the alarm check does not have to be specified, but the abort check must be specified. Therefore, if the alarm check is executed, the abort check is sure to be specified at the same time. When these checks are executed in compound, the level of RMS value should satisfy the relation below ;

|Alarm check level| ≦ |Abort check level|

When RMS value monitoring is needed to be executed, the check box of this item should be checked. Then, the monitoring actions to be executed are set.

4.6.3.7.1 Abort Check / Alarm Check

(1) Meaning

In this item , the alarm/abort level, the concept of the set value, the definition method and its action are the same as that of RMS value monitoring'. However, these functions treat the different objects for checking. One is the RMS value of the control response $\overline{\phi}$ and another is the monitor spectrum $\overline{\phi}^{j}_{MON}$.

When the alarm/abort check is executed, the RMS value of the analogue input signal to the current input channel (the response of the current input channel) is monitored during the control operation. If this monitor RMS value of the current input channel exceeds over (or falls below) the defined value of this item, this system activates the function of alarm/abort.

In this item, the alarm means that this system sounds an alarm (a buzzer) when the response quantity which exceeds over the level of the set condition is detected. The 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 methods for setting the level which is used as the criteria for the alarm/abort check are as below ;

・Specify the reference relative upper limit
・Specify the reference relative lower limit
・Absolute upper limit

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. However, if the dimension of the physical quantity observed at the input channel is different from that of the controlled variable, the level can be specified only by an absolute value.

The abort check and the alarm check is to be executed by checking the check box of each item. Then, specify the level of the RMS value to the selected items.

4.6.3.8 Use the observation profile

(1) Meaning

This item is for setting the observation profile for monitoring the response

The feature of this item is that the monitor response is not only observed but also operated by limit control.

These three types of observing methods are usable ;

・ Abort check
・ Alarm check
・ Limit by observation profile(*Option)

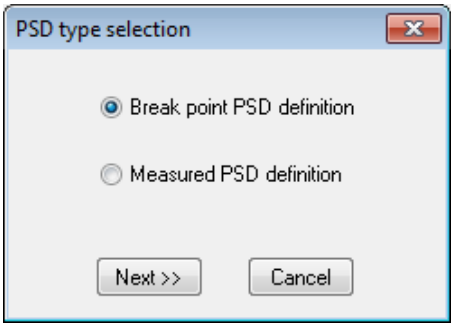
The observation level is defined by the absolute level therefore the observed physical quantity does not have to be the same as the controlled variable. Any observation physical quantities are available to use in this definition.

This function makes it possible to observe one part by a displacement sensor and to observe another by a force sensor while the control variable is defined as the acceleration.

4.6.3.8.1 Profile definition

(1) Meaning

This item is for selecting the PSD type.

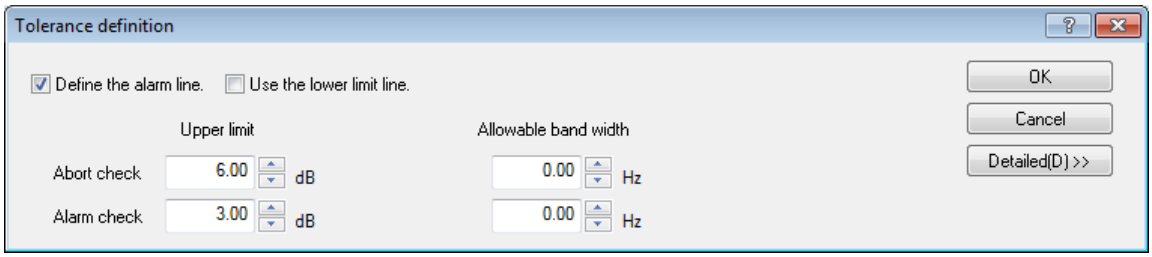


Please refer to "4.5.2 PSD definition type" about the details of PSD definition

4.6.3.8.2 Tolerance definition

(1) Meaning

This item for defining the tolerance.



Please refer to "4.5.3 Tolerance Definition" about the details of tolerance definition.

The values of upper limit and allowable band width are defined in this item.

4.6.3.8.3 Limit by observation profile

(1) Meaning

When limit control is set to be executed, the response PSD for the current input channel is monitored during the control operation. If the response PSD of the current input channel is to exceed over the level of the PSD for monitoring set by the absolute value, the function of limit control is activated. (This item is an option.)

When the limit control is executed, the output drive is controlled so that the monitor PSD may not exceed over the PSD for monitoring set value. To be exact, the drive signal is regulated by setting a smaller value of reference PSD. As a result, the level of the output drive becomes smaller, then the control response PSD and the response of other input channels also become smaller.

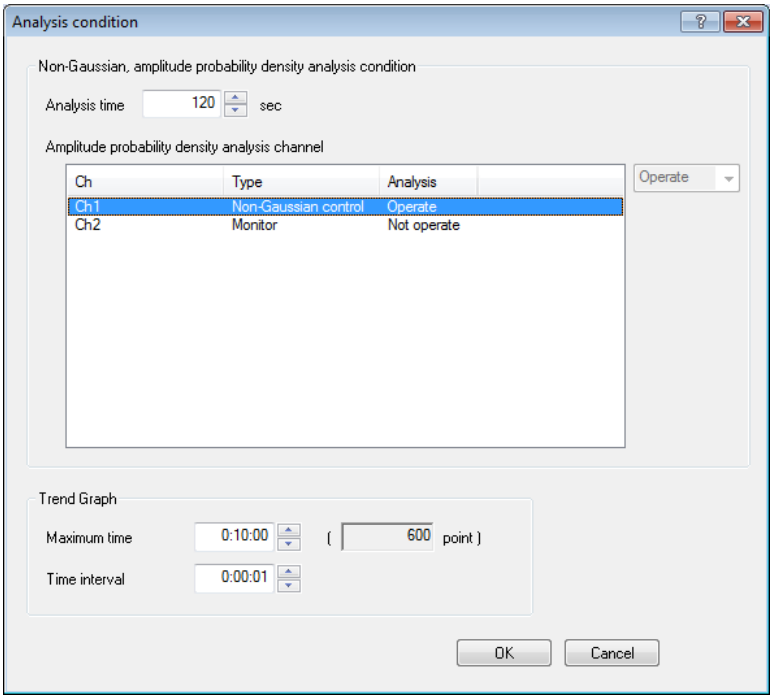
Generally, the limit control is executed for each operation lines.

4.7 Analysis condition

4.7.1 Outline

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

It is also for setting of the maximum display time and interval of trend graph.



4.7.2 Analysis condition

Details of conditions needed for each analysis are shown below.

<Analysis Time >

The time of analyzing kurtosis, skewness, and amplitude probability density is specified.

Input range: $60 < T_a \leq 240$

<NOTE> This setting is related to the control result of kurtosis and skewness.

<Amplitude probability density 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 operate’ is available.
Control	Selection between ‘Operate’ and ‘Not operate’ is allowed.
Non-gaussian control	Only ‘Operate’ is available.

<Maximum time>

The maximum display time of trend graph is specified.

Input range: $00:00:01 < T_m \leq 999:59:59$

Time scale of trend graph is fixed by this setting.

<Time interval>

Setting of trend graph interval is specified.

Input range: 00:00:01 < $\Delta T_m \leq$ 999:59:59

Time interval of trend graph is fixed by this setting.

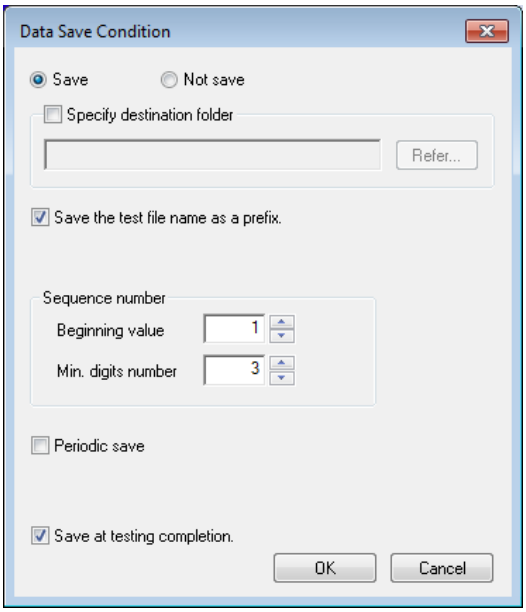
4.8 Data Save Condition

4.8.1 Outline

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

In K2 system, all the data measured in test operation are saved in a binary file (*.VDF).

Only the data ‘In test operation’ is storable. The data ‘In initial measurement’ can not be saved.



4.8.2 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).

(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.

6. Auto-save at testing completion

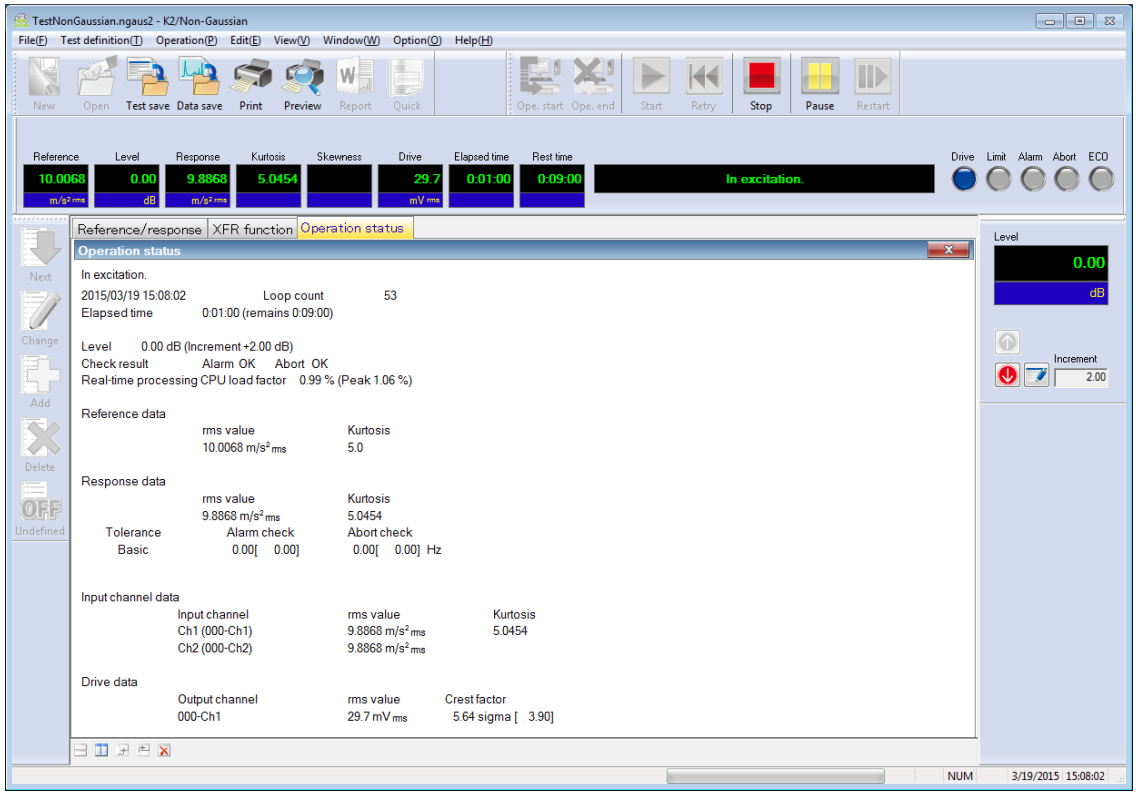
This function is for automatic saving of the data when the test is completed or when the test is aborted by operator.

4.9 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.



< 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 and kurtosis is displayed.

When skewness is controlled, ‘Reference skewness’ is displayed.

(8) Response data

The current control response level and kurtosis is displayed.

When skewness is controlled, ‘Response skewness’ is displayed.

(9) Response check (Tolerance etc.)

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.

Krutosis is displayed as an index of non-Gaussian. When skewness is controlled, it is also displayed.

(11) Drive

The drive output voltage generated currently is displayed.

Chapter 5 Message and Meanings

5.1 K2Non-Gaussian Error Message

Message	Meaning / Action
Unusual phenomenon is detected in XFR measurement.	(Meaning) The test was interrupted because of such reasons as "No response from the control sensor" and "Abnormally great response from the control sensor". The content of error is displayed in Operation status and History window. (Action) Check the following points at first. ・ Ensure that the power supply to the power amplifier is turned on. ・ 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. After checking the points in the above, the treatments for each error are to be done according to the specified numbers. [1] Too small response Increase the value of ‘Initilal output voltage’ or/and ‘XFR function measuremnt output voltage’ in Excitation System setting. [2] Too much response Decrease the value of ‘Initilal output voltage’ or/and ‘XFR function measuremnt output voltage’ in Excitation System setting. [3] Set the loop check in Fundamental/Control Condition to 'Loose' [4] A response having an exceeded level over the abort level Select ‘Specify the abort at XFR measurement’in Input channel setting and increase the value of abort level.(If error occurred in XFR measurement). [5] Recheck of Control point. [6] Recheck the pattern of the test. [7] Recheck the construction of fixture.

Message	Meaning / Action
Unusual phenomenon is detected by loop check.	(Meaning) The test operation is aborted due to the error in loop check. The detail about the error is displayed at the input channel in which an error detected in Operation status. A) Too much Environment noise is detected. [1] [2] Too small response in Initial loop check or too much noise in non-excitation is judged as an unusual phenomenon. B) Loop open is detected. [1] [2] Sudden decrease of response characteristics is judged as an unusual phenomenon in operation. C) Too much response is detected. [1] [3] Sudden increase of response characteristics is judged as an unusual phenomenon in operation. D) Over load is detected. [1] [4] [5] A signal having an exceeded level over the maximum input value of the hardware (at voltage input : ±10V, at charge input : ±10000pC or ±1000pC) is inputted to the input channel. (Action) Check the following points at first. ・ 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. After checking the points in the above, the treatments for each error are to be done according to the specified numbers. [1] Set the Loop check in Fundamental/Control Condition to 'Loose'. [2] Increase the value of initial output voltage in Excitation System setting.(If error occurred in Initial measurement or in Initial equalization) [3] Decrease the value of initial output voltage in Excitation System setting.(If error occurred in Initial measurement or in Initial equalization) [4] At charge input, set the input type of input channel to 'Charge Input(1mV/pC)'. [5] Change the sensor to lower sensibility one.

Message	Meaning / Action
Test is aborted by Abort check.	(Meaning) The test operation is aborted for an error detected by various abort checks in operation. The content of error is displayed in Operation status. (Action) Check the following points at first. ・ Mistake in system cabling ・ Incorrect definition of I/O channel information, such as sensitivity and input format. ・ Cable disconnection ・ Incorrect installation of the pickups After checking the points in the above, the treatments for each error are to be done according to the specified numbers. [1] Change the set value of Tolerance. [2] Change the setting of Equalization Mode in Fundamental/Control Condition. [3] Change the setting of Averaging Parameters in Fundamental/Control Condition. [4] Recheck of Control point. [5] Recheck the pickups used in the system. [6] Recheck the pattern of the test. [7] Recheck the construction of fixture.
Test is aborted by Abort check [Drive].	(Meaning) The test operation is aborted for requiring of the output voltage exceeding over the ‘Allowance clipping ratio’ of Excitation System setting in operation.. (Action) Check the following points at first. ・ Mistake in system cabling ・ Incorrect definition of I/O channel information, such as sensitivity and input format. ・ Cable disconnection ・ Incorrect installation of the pickups After checking the points in the above, the treatments for each error are to be done according to the specified numbers. [1] Change the setting of Allowable voltage and Allowance clipping ratioin Excitation System Setting. [2] Recheck of Control point. [3] Recheck the pickups used in the system. [4] Recheck the pattern of the test. [5] Recheck the construction of fixture.

Message	Meaning / Action
Test is aborted by Abort check [Non-Gaussian].	(Meaning) The test operation is aborted for the non-gaussian control error exceeding over the limit value in operation. (Action) Check the following points at first. ・ Mistake in system cabling ・ Incorrect definition of I/O channel information, such as sensitivity and input format. ・ Cable disconnection ・ Incorrect installation of the pickups After checking the points in the above, the treatments for each error are to be done according to the specified numbers. [1] Set the Loop check in Fundamental/Control Condition to 'Loose'. [2] Change the setting of Equalization Mode in Fundamental/Control Condition. [3] Change the setting of Averaging Parameters in Fundamental/Control Condition. [4] Change the setting of control speed in Waveform Control Condition. [5] Change the setting of analisys time in Analisys Condition. [6] Recheck of Control point. [7] Recheck the pickups used in the system. [8] Recheck the pattern of the test. [9] Recheck the construction of fixture.
Failed in initialization.	(Meaning) An error is detected in initialization of I/O unit executed prior to the test operation. (Action) ・ 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. 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.

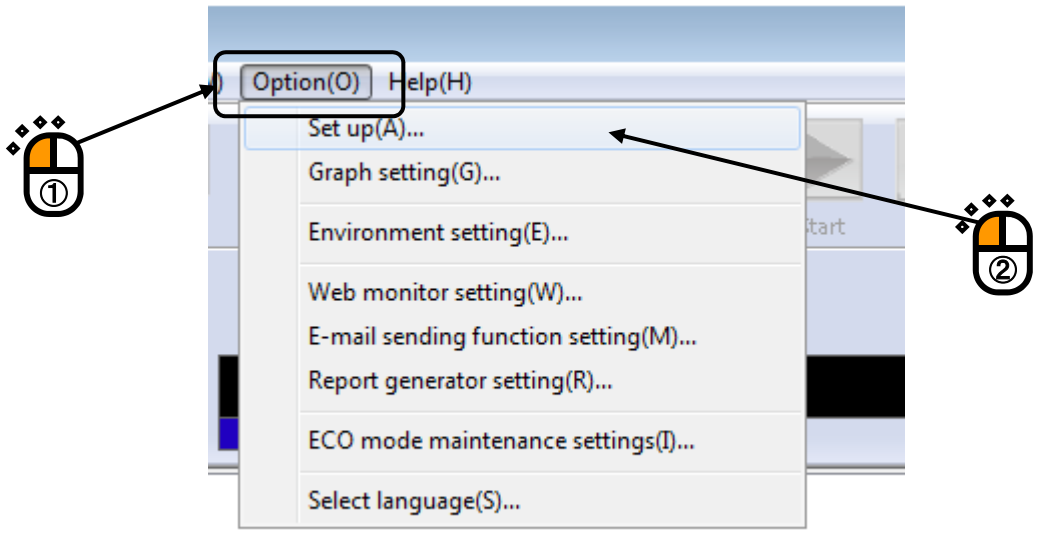
Message	Meaning / Action
The license required for operating the program is not found.	(Meaning) An error is detected in K2 Protect information check. (Action) ・ License information ・ Incorrect action of I/O port (COM ,LPT or USB) of the PC connected to the protect devise. ・ Incorrect connection of the protect devise. 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.
Hardware error	(Meaning) An error is detected in the PC or I/O unit. (Action) ・ 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. 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.
Test is aborted by CPU load.	(Meaning) Test operation is aborted because too much loading is detected in operation. (Action) ・ 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. Check the above points.

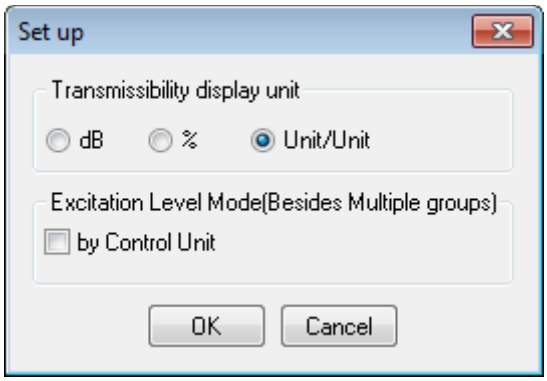
Chapter 6　Supplemental Explanation

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'.

[Excitation Level Mode]

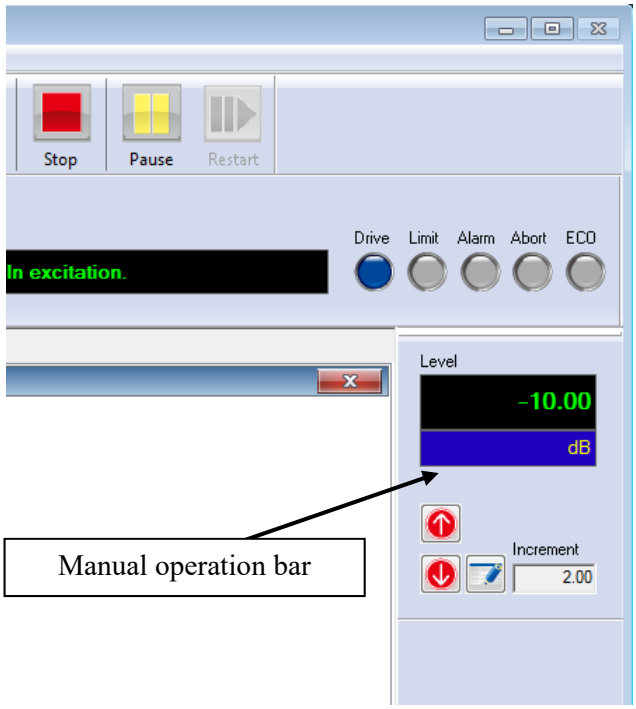
'By Control Unit'

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

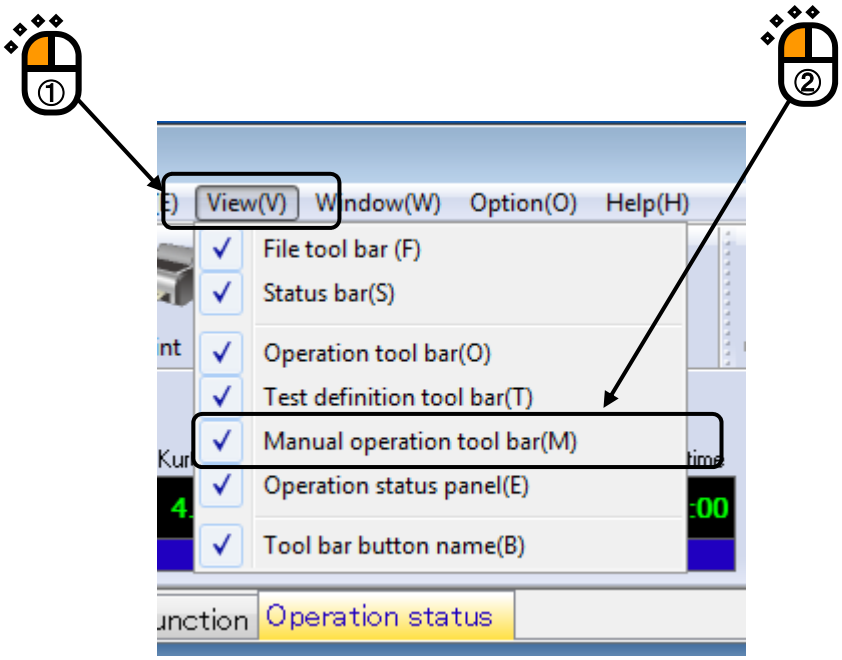
By specifying an excitation level by the reference unit, the unit of Increment is set by the reference unit (rms value). So that, the level can be changed to up or down every '1 m/s^2_{rms}'.

6.2 Manual Operation

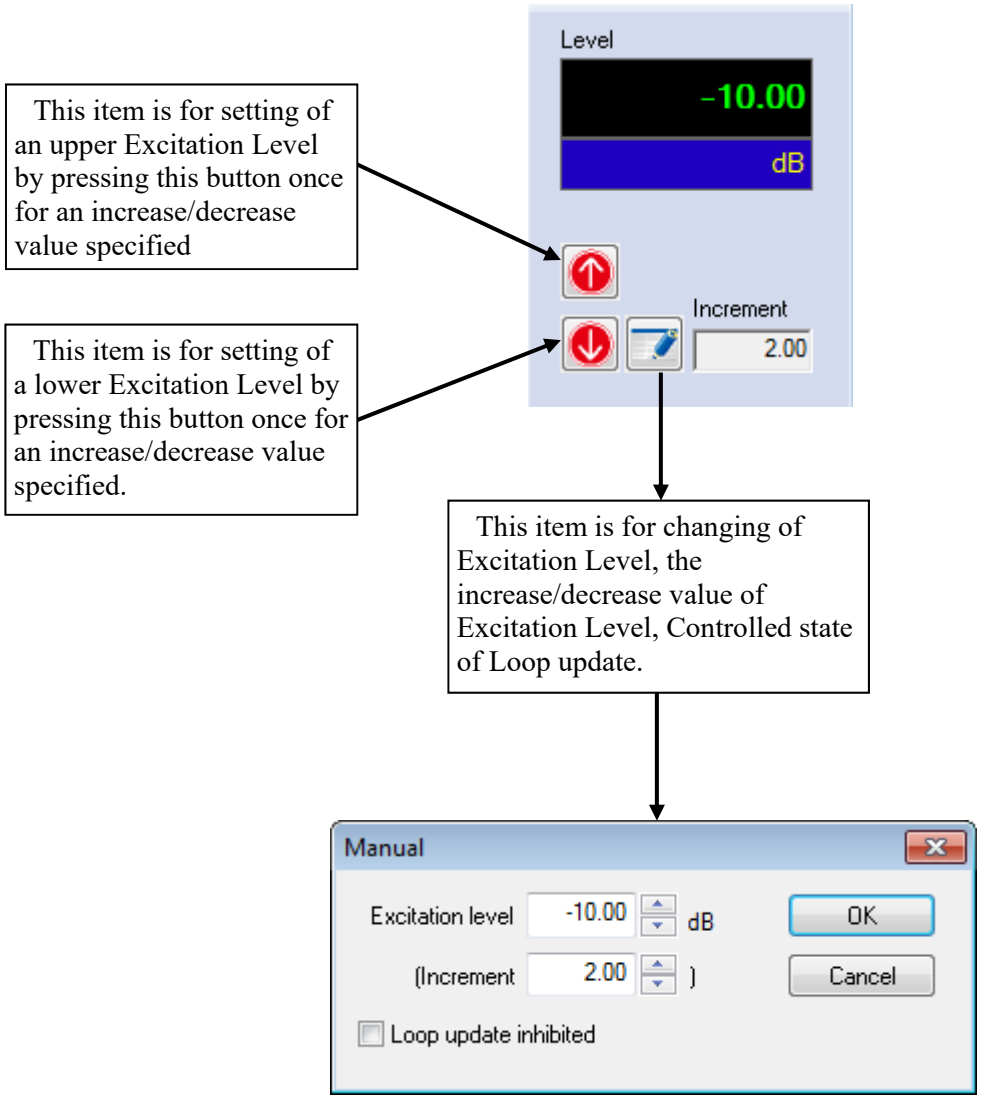
Control Reference can be changed during the excitation operation by using Manual operation bar.
Manual operation bar is at right side of window.



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



< Items in Manual Operation>



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