

# **DS-0321 FFT Analysis Software**

**Operation manual**

**Damping factor measurement using Hilbert transform**

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The DS-0321 FFT Analysis software has the Hilbert operation function. A time envelope of a time-domain waveform can be displayed by means of Hilbert transform.

This manual describes measurement procedure of damping ratio from vibration damping waveform by means of Hilbert transform function in the DS-0321 FFT Analysis software.

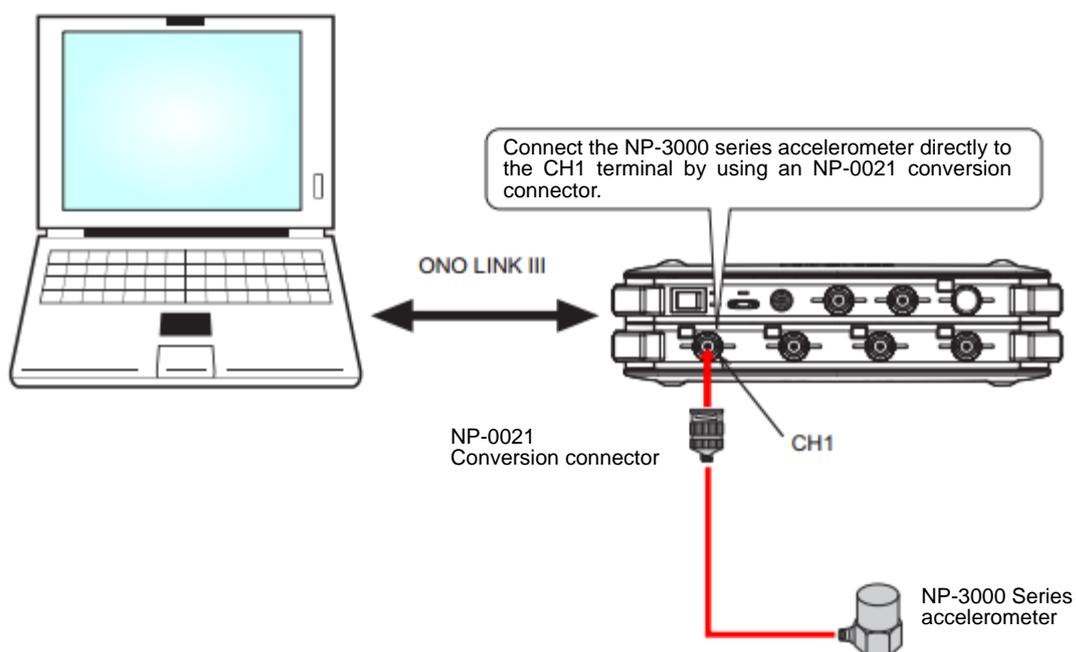
As in the system configuration in the figure below, with the accelerometer connected to Ch2 of DS-3000 (with Ch1 unused), FFT Analysis is executed using DS-0321 FFT Analysis software.

This manual describes functions with the focus on what behavior will result from a single operation, and you are recommended to try various actions on the instrument.

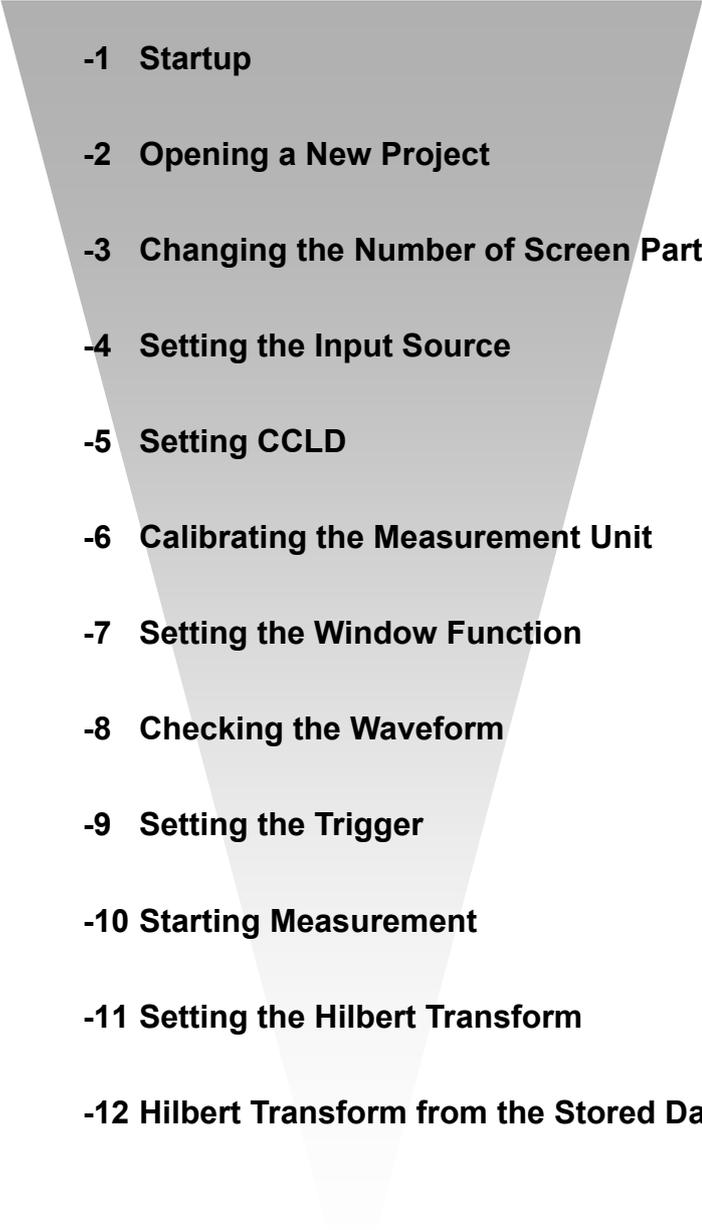
Basic operations of the DS-3000 software are mostly executed in the Configuration window. As the operations in the Configuration window are correspondent with those of the Main menu, the Main menu operations are not included in this manual. For details on the Configuration window operations, refer to the respective procedure manuals (“Basic operation procedure for Configuration Setting” and “Basic operation for display of Configuration Window”).

In this instruction manual, a series of clicking operations is described, for example, as follows; "Click "File" > "Project File"> "New Project" > "  ".

## ■ System Configuration



**■ Operation Flow**

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- 1 Startup**
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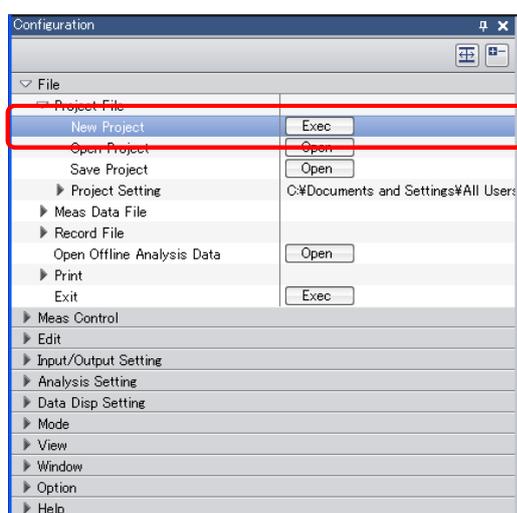
## ■ Operation Procedures

### -1 Startup

Connect each device as described in the System Configuration, turn the power on, and start the DS-0321 FFT Analysis software.

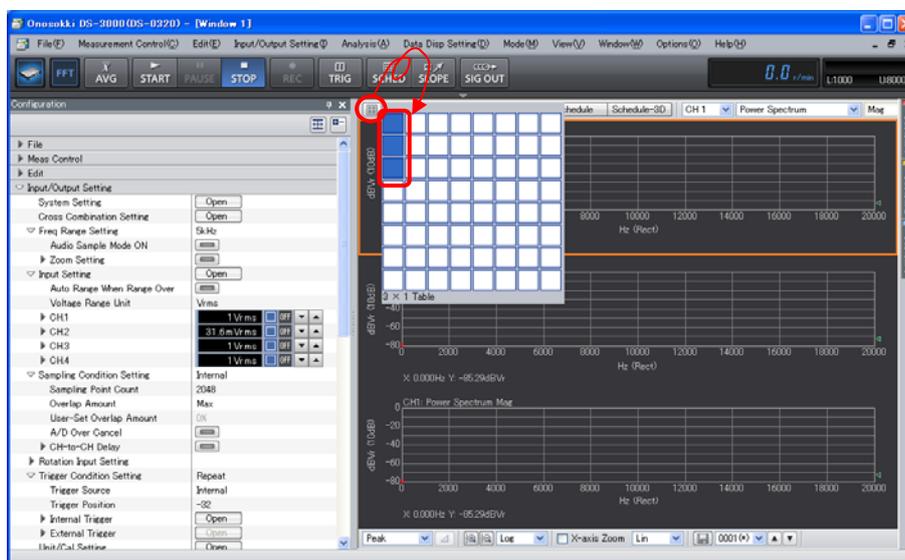
### -2 Opening a New Project

- ① From the main menu, click "View" > "Configuration" to open the "Configuration" window.
- ② In the "Configuration" window, click "File" > "Project File" > "New Project" > "Exec". This operation erases the current settings and opens a new project with initial settings.



### -3 Changing the Number of Screen Partitions

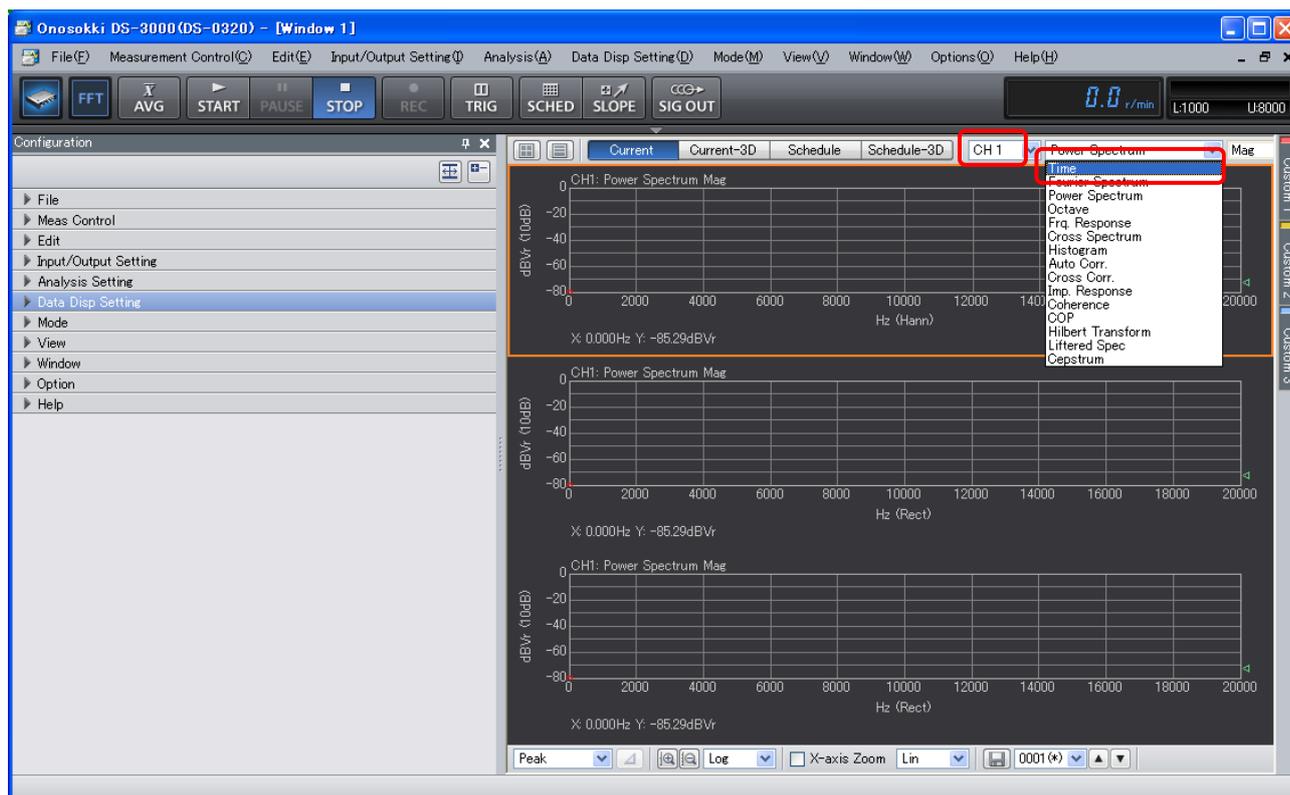
- ① Click the Selecting partition numbers tool "☐" at the upper part of the graph window and, here, set the triple-partition display mode as shown below.



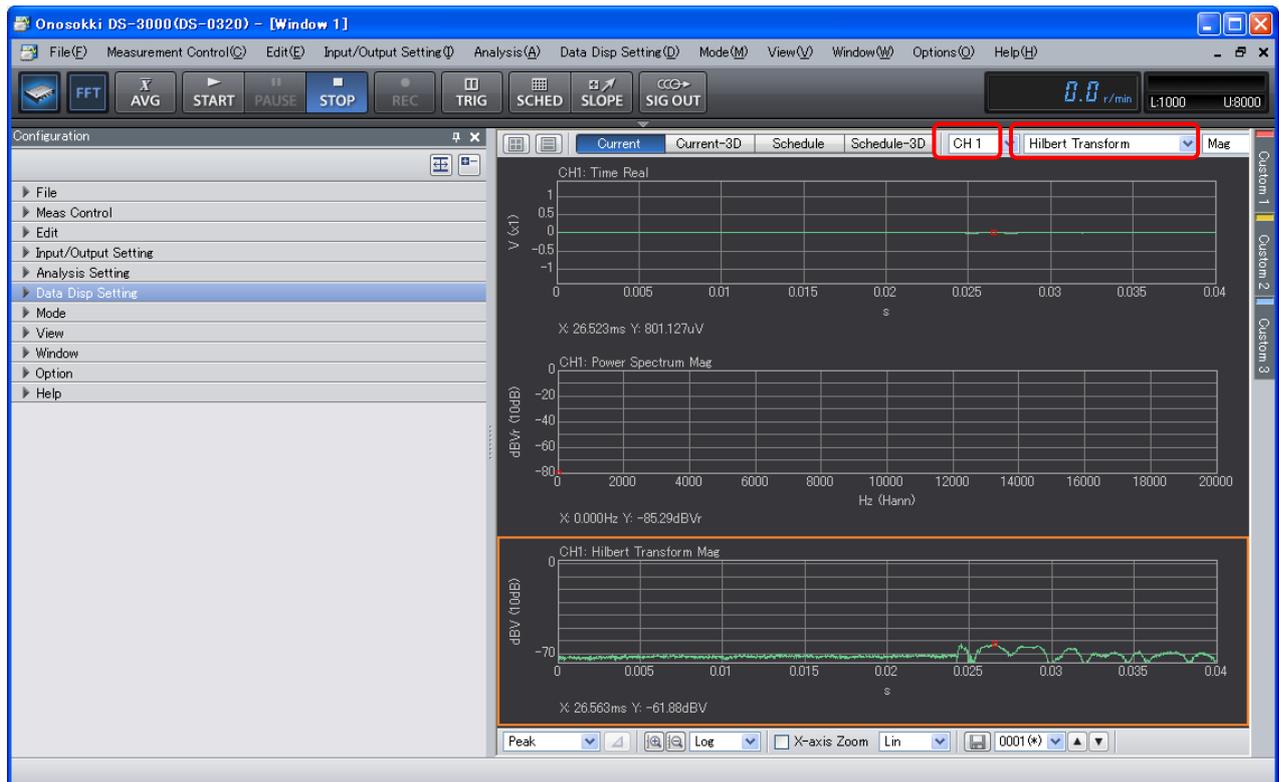
#### 4 Setting the Input Source

Set the graph in the upper screen partition to the "CH1 Time" view. Set that in the middle screen partition to the "CH1 Power Spectrum" view, and set that in the lower partition to the "CH1 Hilbert Transform" view.

- ① Click in the upper graph to activate it. The graph is enclosed with orange box lines.
- ② Select "CH1" using the tool for selecting an input source above the graph window. From the pull-down menu on the right to it, select "Time".



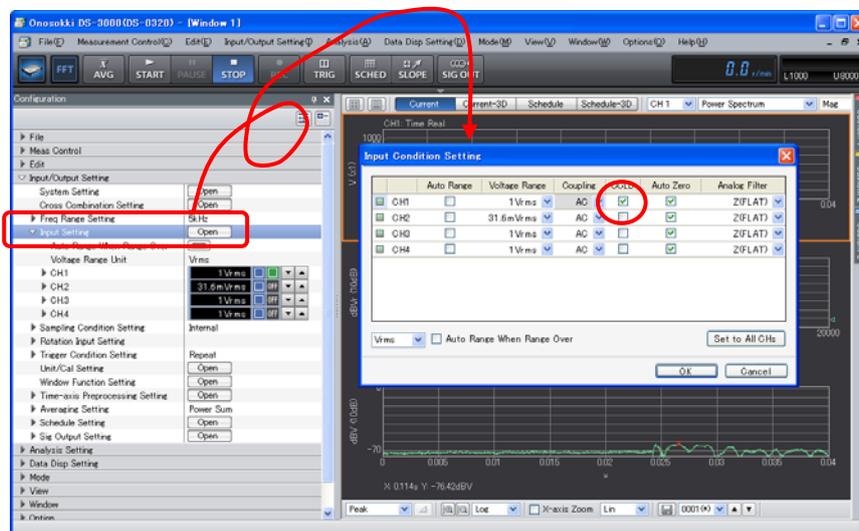
- ③ In a similar manner, click in the middle graph, select "CH1" for input source, and select "Power Spectrum" for the display waveform.
- ④ In a similar manner, click in the lower graph, select "CH1" for input source, and select "Hilbert Transform" for the display waveform.



- When you click in the graph, it is enclosed with orange box lines to show that it is active.
- The settings in the "Configuration" window are reflected in the active screen partition, except for the measurement items related to all the channels, including the frequency and voltage ranges.

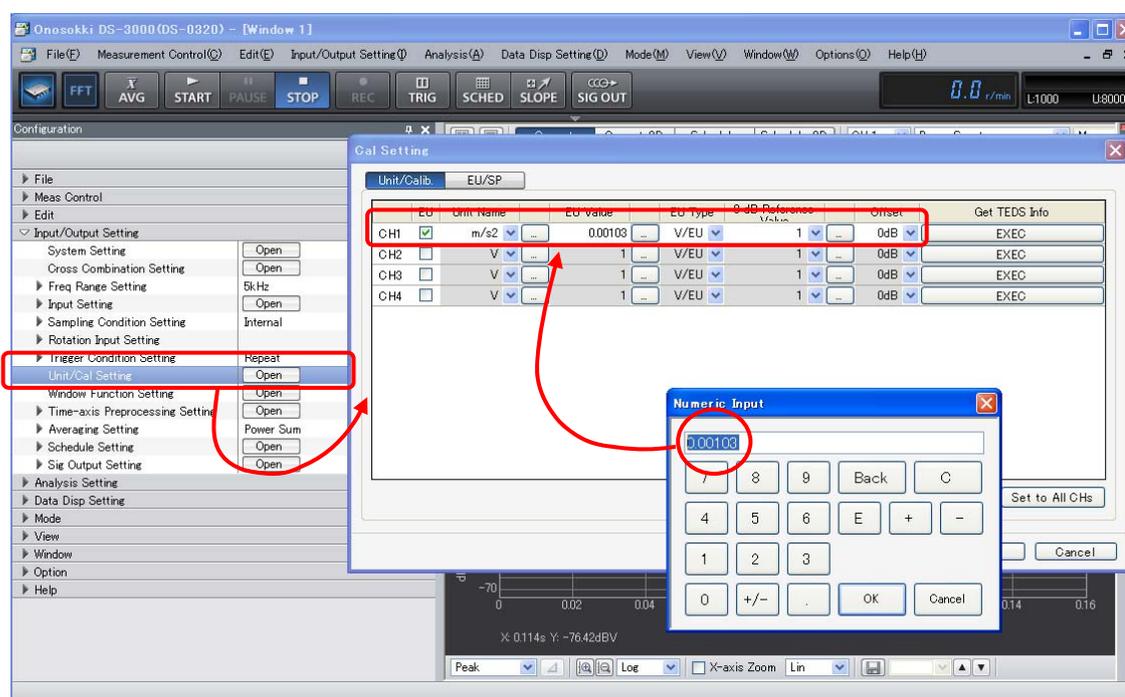
## -5 Setting CCLD

- ① In the "Configuration" window, click "Input/Output Setting" > "Input Setting" > "Open". The "Input Condition Setting" dialog box opens.
- ② In the "Input Condition Setting" dialog box, put a check mark in the "CCLD" box of "CH1". This allows power of "+24V/4mA" to be supplied from CH1 to the accelerometer. The signal will be input properly.



## -6 Calibrating the Measurement Unit

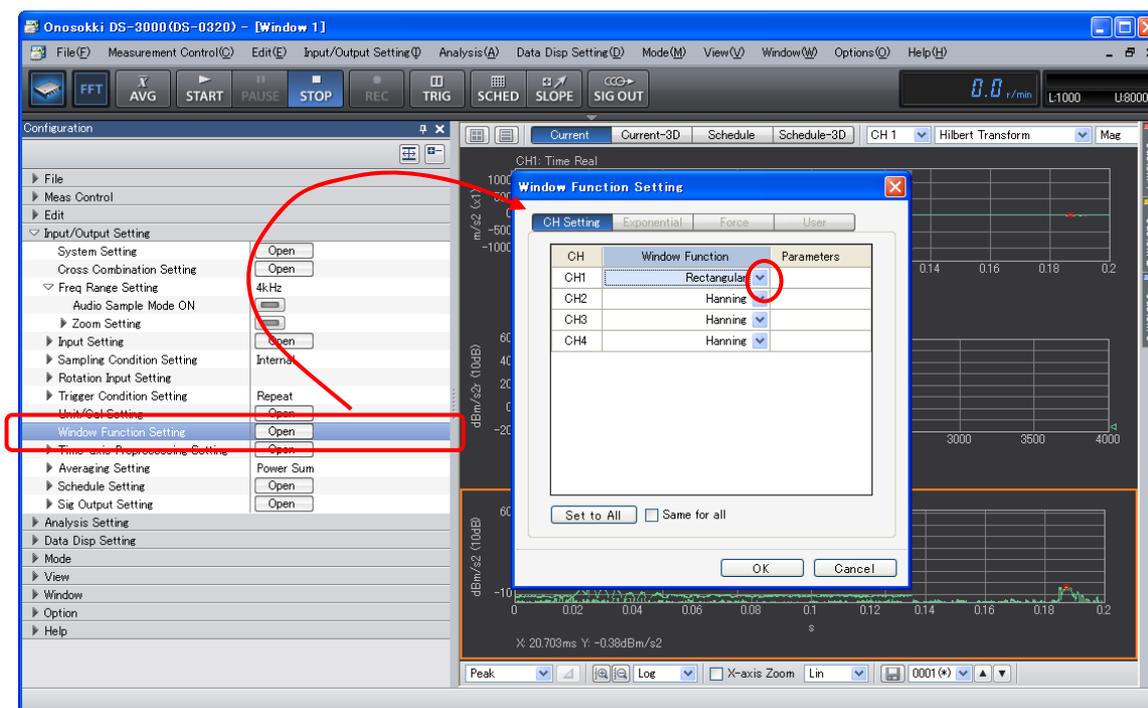
- ① Calibrate the measurement unit so that the reading along the Y axis can be directly read in the vibration unit ( $m/s^2$ ). (When the measurement for the purpose of damping ratio, unit calibration is not required.)
- ② For example, read "Voltage Sensitivity:  $1.03 mV/ms^{-2}$ " from the Calibration Chart attached to the accelerometer you use.
- ③ In the "Configuration" window, click "Input/Output Setting" > "Unit/Cal Setting" > "Open". The "Cal Setting" dialog box opens.
- ④ Put a check mark in the "EU" box of "CH1" in the "Cal Setting" dialog box. Then, set the "Unit Name:  $m/s$ ", "EU value: 0.00103" and "EU Type: V/EU".



## -7 Setting the Window Function

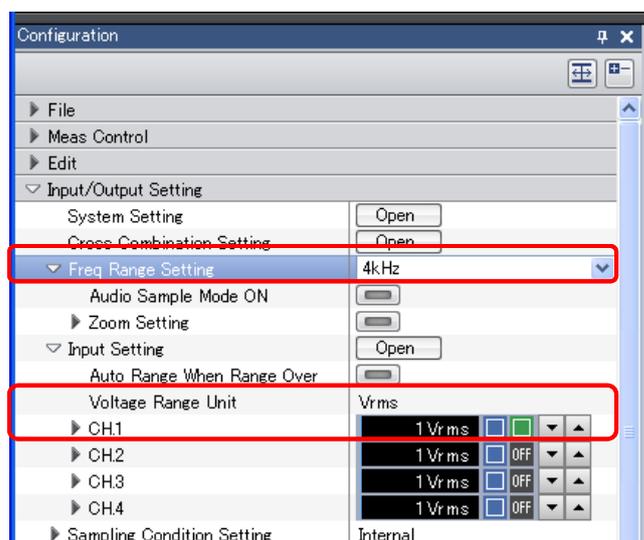
Set the window function "Rectangular" to obtain the damping ratio from vibration damping waveform using Hilbert Transform function.

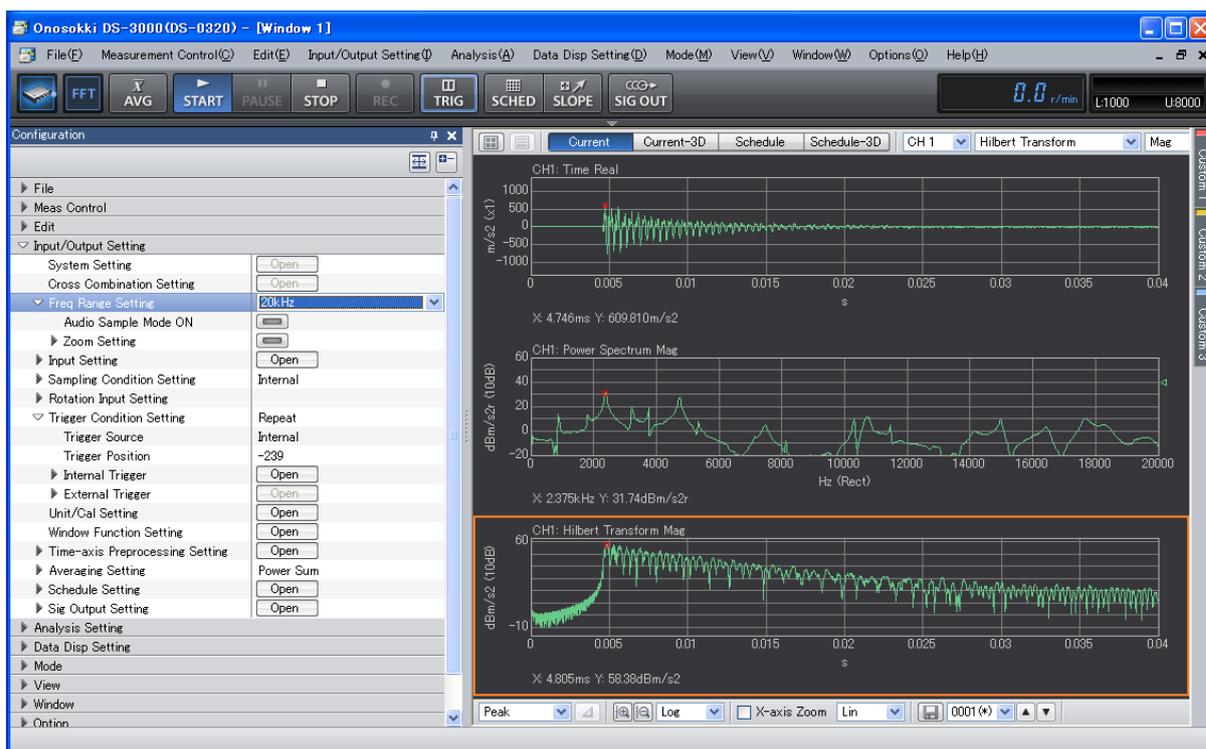
- ① In the "Configuration" window, click "Input/Output Setting" > "Window Function Setting" > "Open". The "Window Function Setting" dialog box opens.
- ② Select "CH1: Rectangular" from the pull-down menu on the "Window Function Setting" dialog box



## -8 Checking the Waveform

Push “Start” button and apply impact as a trial to check the acceleration time axis waveform and its power spectrum are displayed properly. Also adjust the frequency range and voltage range properly. In this example, the frequency range is set to 4 kHz, voltage range is set to 1 Vrms according to the 1-order of basic frequency.



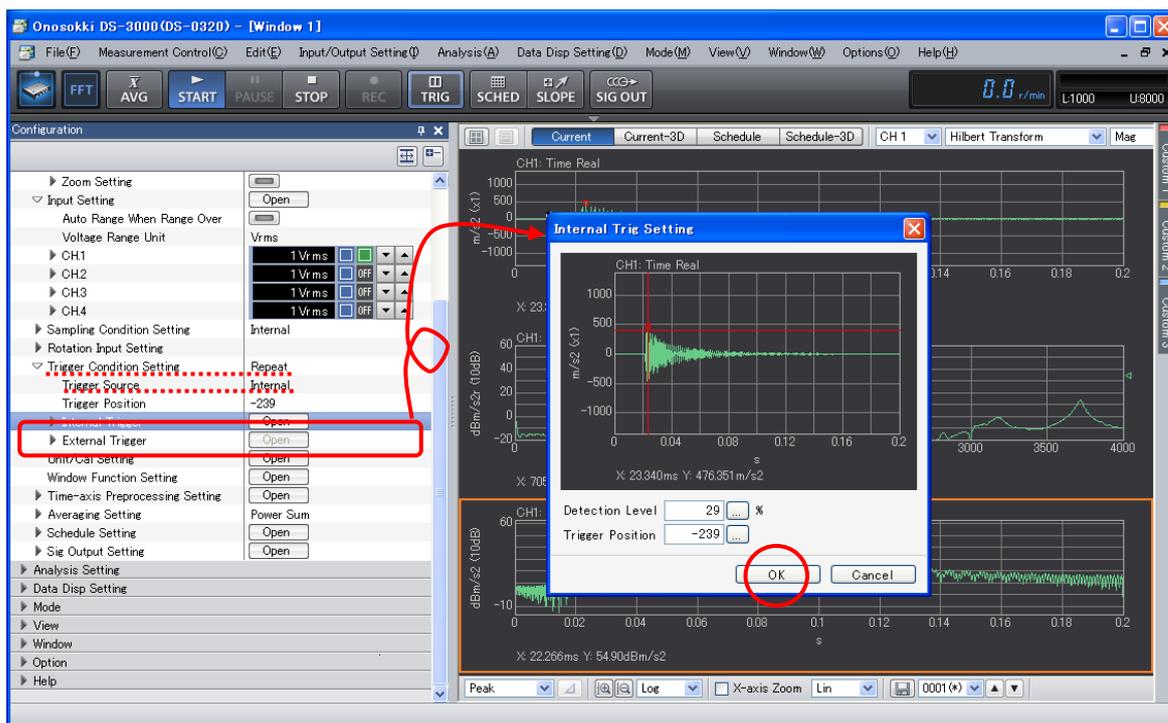


## -9 Setting the Trigger

Trigger function is a function which starts waveform sampling based on a certain trigger level of a signal. This function makes it possible to display whole of free vibration damping waveform on a screen after hitting a desired waveform portion.

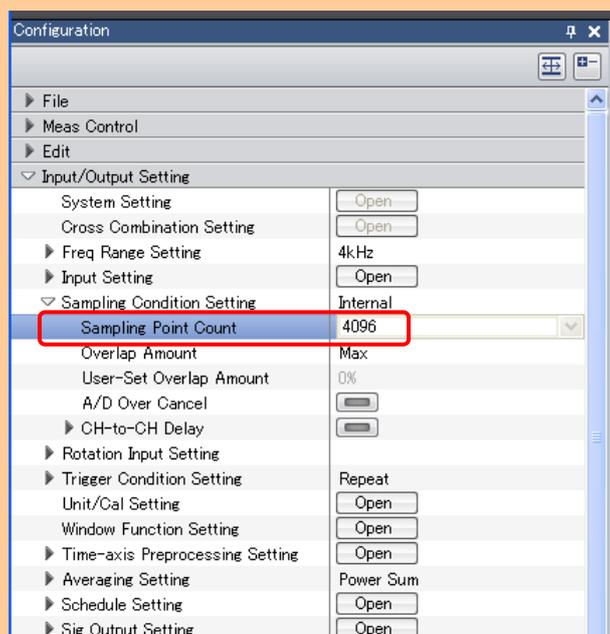
Under [START] status, take trial excitation repeatedly switching [TRIG] button ON/OFF. While seeing the waveform amplitude, set the trigger level.

- ① In the “Configuration” window, click “Input/Output Setting”>”Trigger Condition Setting” and set “Trigger Condition Setting: Repeat”, “Trigger Source: Internal”.  
By this setting, the waveform is sampled every time the trigger is applied.
- ② ”Trigger Condition Setting”> “Internal Trigger” >  to open “Internal Trig Setting” dialog box.
- ③ Red cross line will appear when you click within the waveform graph in “Internal Trig Setting” dialog box. The intersection point is a position of the trigger point. With taking trial excitations, set the trigger point temporarily so that the damping waveform is within the graph as follows.



④ After the setting completes, press “OK” button to close “Internal Trig Setting” dialog box.

- When the damping time is long and the waveform is not completed within the graph, change the number of samplings. In the “Configuration” window, click “Input/Output Setting”>“Sampling Condition Setting”>“Sampling Point Count” and change to the larger value such as 4096.



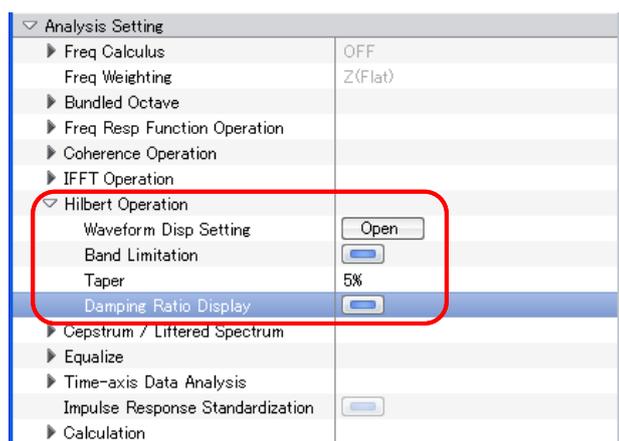
## -10 Starting Measurement

- ① With [START] button ON, turn the [TRIG] button ON to start measurement.
- ② Hit the measurement object several times and turn the [STOP] button ON when the desired waveform is obtained. However, it may not operate correctly, set again the trigger referring the section 9 [Setting the Trigger]. Be careful not to hit too strongly so that the signal does not go over the voltage range, the waveform does not get distorted.

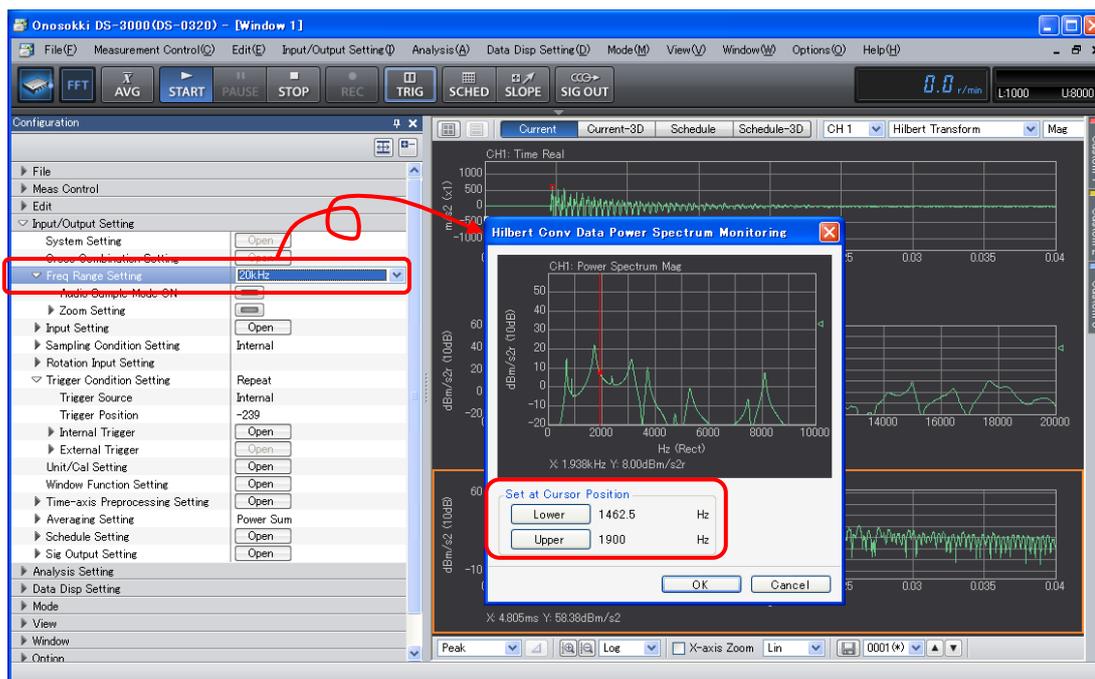
## -11 Setting Hilbert Transform

Specify the band to interpose the basic frequency and perform Hilbert transform to obtain the damping ratio.

- ① Click the Hilbert transform data graph to activate.
- ② In the “Configuration” window, click “Analysis Setting”>”Hilbert Operation”, and click the right button of “Band Limitation” to set it ON. The Hilbert transform data may become nearly straight line because the [Band Limitation] or [Taper] is set.



- ③ “Hilbert Operation” > “Waveform Disp Setting” > ”Open” to open the “Hilbert Conv Data Power Spectrum Monitoring” dialog box.
- ④ In “Hilbert Conv Data Power Spectrum Monitoring” dialog box, click “Lower” button and set the red line cursor to the lower limit of the basic frequency (natural frequency).
- ⑤ In the same manner, click “Upper” button and set the red line cursor to the upper limit of the basic frequency (natural frequency).  
Finally the frequency band interposed between upper and lower limit frequencies is limited, Hilbert transform is performed.
- ⑥ After setting is complete, click “OK” button to close “Hilbert Conv Data Power Spectrum Monitoring” dialog box.

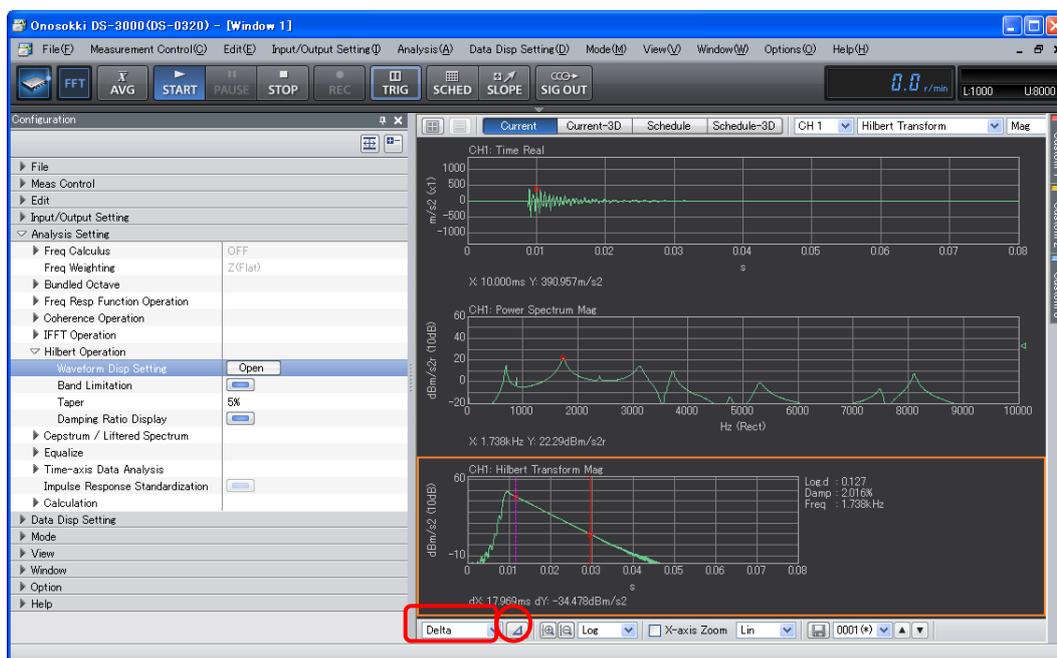


⑦ Set the cursor setup tool in the lower graph window "Delta", click the lower position that you want to perform damping ratio transform, and click [ ] button.

The line color changed from red to pink.

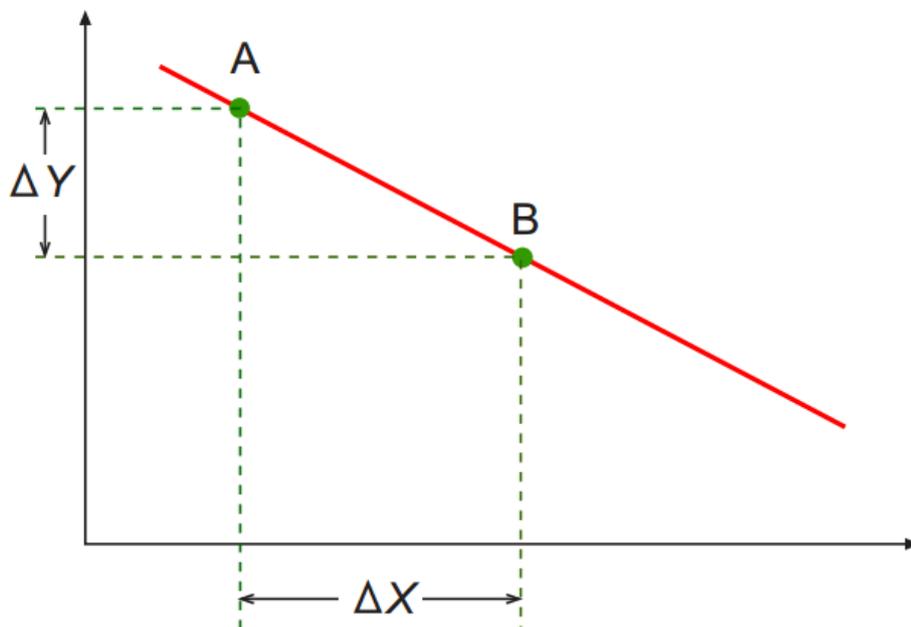
Next, click the upper limit position to display red line. The damping ratio is obtained from the upper and lower limit positions, and [Log.d], [Damp], and [Freq] are displayed. If the Hilbert conversion data is not linear, try to change the band frequency following the above procedure ③ to ⑤.

The measurement will be difficult when Hilbert conversion data does not become straight line for several reasons; there is no peak (not apparent natural frequency) in the power spectrum or there are several peaks in the power spectrum because the shape of the measurement object is complicated.



< Remarks >

The way to calculate the damping ratio from Hilbert conversion data



$$\text{Logarithmic decrement } (\log D) \quad \delta = \left| \frac{\Delta Y(\text{dB})}{\Delta X} \right| * \frac{\ln 10}{20} * \frac{1}{f_n} = 0.1151 * \left| \frac{\Delta Y}{\Delta X} \right| * \frac{1}{f_n}$$

$$\text{Damping ratio } (\text{Damp}) \quad \zeta = \frac{\delta}{2. \pi} = 0.01832 * \left| \frac{\Delta Y}{\Delta X} \right| * \frac{1}{f_n}$$

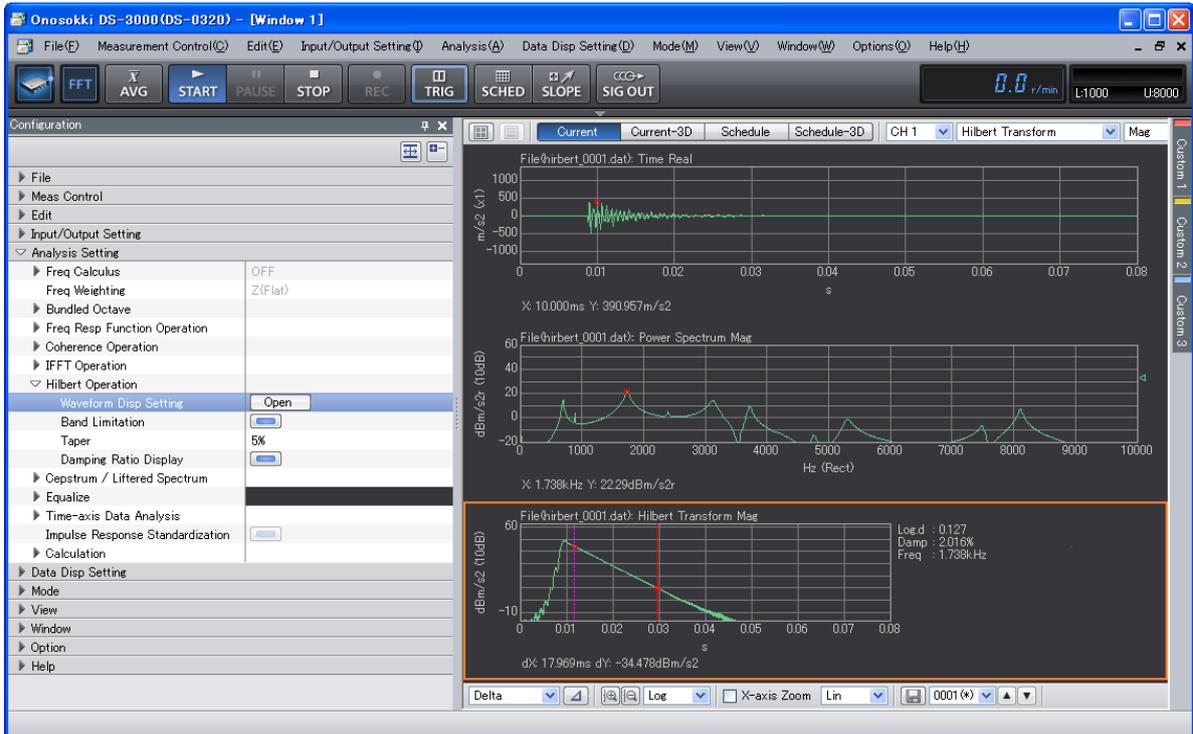
$f_n$  :Resonance frequency

$\Delta X$  and  $\Delta Y$  : X and Y axes values of two points specified by delta cursor.

## -12. Hilbert transform from the stored data

The damping time-axis waveform stored in DAT format can be used for Hilbert transform.

Store the time-axis waveform data of section-11 in DAT format, and reproduce the DAT file (hirbert\_001.dat) on the upper, middle, and lower screen. The following screen shows the time-axis waveform, power spectrum and Hilbert transform data.



End