FFT & Arithmetic operation Unit (RA23-751)

For RA2000A / DL2800A

INSTRUCTION MANUAL

A&D Company, Limited

1AV7001718R01

Introduction

Thank you very much for purchasing the FFT & Arithmetic operation Unit (RA23-751), which is an accessory to the thermal dot recorder, Omniace-III RA2000A series (RA2300A/RA2800A), Data Logger Station ⅡDL2800A series. The FFT & Arithmetic operation Unit provides an optional capability to the thermal dot recorder. Prior to as well as while using the unit, please carefully read the instruction Manual so that you can correctly use the FFT & Arithmetic operation Unit.
This Instruction Manual is to provide information that is necessary for you to safely and correctly operate the FFT & Arithmetic operation Unit (RA23-751) through reading it while using the unit. Please always place this Instruction Manual together with the FFT & Arithmetic operation Unit whenever you use the unit, so that you can access and refer to the manual at any time.

Please refer to the mainframe Instruction Manual RA2000A/DL2800A Series, for information on the basic functions of the mainframe. If you have questions on the descriptions in this Instruction Manual, please contact marketing/sales personnel of NIPPON AVIONICS CO., LTD.

<Separate-volume manuals>

Manual	Recorder	Document No.	Contents
Instruction Manual Mainframe	RA2300A	7001754R01	The manual involves description of functions and operating instruction of the mainframe
	RA2800A	7001756R01	
	DL2800A	7001757R01A	
Instruction Manual RS-232C, LAN	RA2300A	7006462R01	This manual provides the information necessary to operate the recorder with interfaces such as LAN or RS-232C. It also covers descriptions on interface commands to allow control by a PC.
	RA2800A		
	DL2800A		
Instruction Manual Amplifier Units	RA2300A	7006559R01A	This manual explains how to use and install amp units.
	RA2800A		
	DL2800A		

■ Before Using

- **When Opening Package**
  If opening the package in a warm room during the cold season, open the package after it has reached room temperature to avoid any operational failure due to condensation on the surface of the product.

- **Examining Contents in Package**
  This instrument is delivered after a thorough examination at the factory prior to shipment. However, please examine the product's condition and verify that no obvious shipping damage has occurred after opening the package. Also, examine the specifications of the input units and accessories. If there are any missing or damaged items, please contact our sales representative.

Notice

- Turn off the power when the operation is abnormal.
  If it is impossible to trace the causes of an abnormal operation, please contact our sales representative. In this case, let us know in what way the unit was operating incorrectly and what the environmental conditions are.
- The contents of this manual are subject to change without notice.
- This manual is copyrighted with all rights reserved. No parts of this manual may be transcribed or reproduced without written permission.
- Please let us know if there are any points that are unclear or missing in this manual.

■ Safety Measures - Warning and Cautions

To safely use products

The RA2000A / DL2800A are a product conforming to the IEC standard safety class I. The recorder is manufactured with safety in mind; however, accidents may occur due to misuse by the user. To avoid such accidents, read this manual carefully before use. Observe the following warning and cautions when using the interface and remote control functions. To safely use the input units, the following statements are used in this manual to call the readers' attention.

⚠ WARNING

This indicates a condition or practice that could result in personal injury or loss of life, or may result in light injury or physical damage if this equipment is misused due to neglect of a Warning.

⚠ CAUTION

This indicates a condition or practice that could result in light injury or damage to the equipment or other property if this equipment is misused due to neglect of a Caution.

Be sure to observe the following instructions when using this recorder. The warranty does not cover damages resulting from the actions against instructions, cautions, or warnings mentioned in this manual. Besides, there are a lot of actions that are "cannot" and "do not". It is impossible to write all such descriptions in this manual. Accordingly, assume any actions to be "impossible" except the actions explicitly described as "possible".

■ Warranty - General

We ship our products after conducting quality control, which covers from design to manufacturing. It is, however, possible that failures may occur in the products. If the product does not operate correctly, please make a check of the power supply, cable connections, or other conditions before returning this product to us. For repair or calibration, contact our sales agency. Before returning, be sure to inform us of the model (RA2000A / DL2800A), serial number, and problematic points. The following is our warranty.

■ Limited Warranty

1. Warranty period

One year from our shipment.

2. Warranty period

We will repair the defects of our product free of charge within the warranty period; however, this warranty does not apply in the following cases.

(1) Damage or faults caused by incorrect use.
(2) Damage or faults caused by fire, earthquake, traffic accident, or other natural disasters.
(3) Damage or faults caused by a repair or modification that is carried out by someone other than a service representative of NIPPON AVIONICS CO., LTD.
(4) Damage or faults caused by use or storage in environmental conditions that should be avoided.
(5) Periodical calibration.
(6) Damage or faults caused during transportation.

3. Liability

We do not assume any liabilities for equipment other than NIPPON AVIONICS CO., LTD.

■ Terms and Symbols in This Manual

Terms and symbols used in this manual denote as follows.

Terms and Symbols	Description
⚠ **WARNING**	This indicates a condition or practice that could result in personal injury or loss of life, or may result in light injury or physical damage if this equipment is misused due to neglect of a Warning.
⚠ **CAUTION**	This indicates a condition or practice that could result in light injury or damage to the equipment or other property if this equipment is misused due to neglect of a Caution.
NOTE	This indicates a condition or practice that could result in incorrect operation or damages in data if this equipment is misused due to neglect of Note.
TIPS	This symbol gives setting restrictions and additional descriptions.
☞	Reference page
This recorder	RA2300A / RA2800A / DL2800A
[ ]	Characters enclosed by brackets represent a key name in the operation panel.
Memory	Internal memory of RA2000A / DL2800A When measuring with memory recorder or transient recorder, measured data is recorded in this memory.
k (lower case) K (upper case)	A unit of numerical value "k" is used to represent 1000 such as "10 kg". "K" is used to represent 1024 such as "4 K data"

■ Install

The install and version-up methods of this software are described below. Prior to as well as while installing the software, please carefully read the Instruction Manual so that you can correctly use both FFT and arithmetic calculation units.

► Accessory

The software is stored in the provided USB memory.

T I P S

The provided USB memory must be use to install the software. The other USB memory, in which the data is moved from the provided USB memory, is inapplicable to the install process.

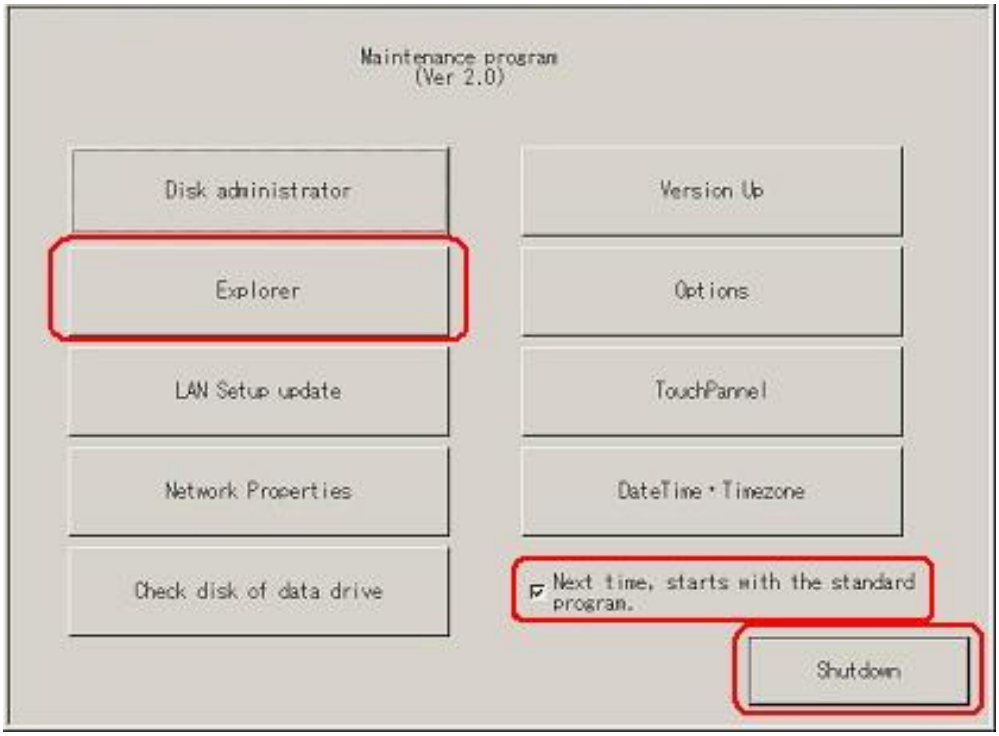
► Install method

1) You boot up RA2000A / DL2800A in maintenance mode. The [Maintenance] tab is displayed in the [SYSTEM] window. After checking the box of <Start next time in Maintenance Mode>, and then shut down by using [Shutdown] key, the maintenance mode is initiated after power is restored.

2) Please insert the provided USB memory into the connector of RA2000A / DL2800A to open the explorer that view automatically the file folders in the USB memory. If the explorer is not open, please refer the USB memory driver with pressing the [Explorer] key in Maintenance Program.

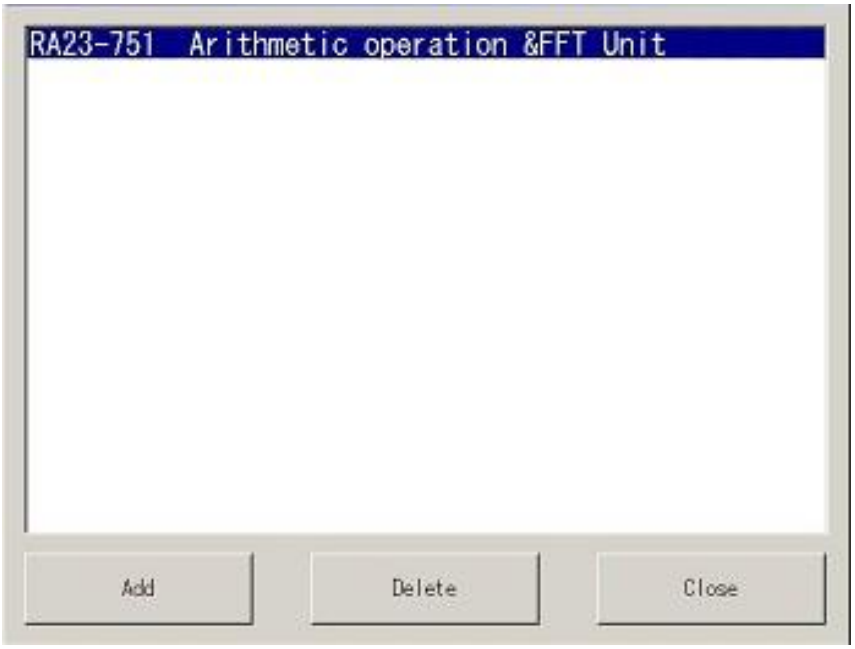
3) Execute the batch file of “RA23-751.bat” to treat both install and option registration collectively.

4) Please shut down RA2000A / DL2800A after checking the <Next Time, starts with the standard program> box. The installation of the software is done after power is restored.



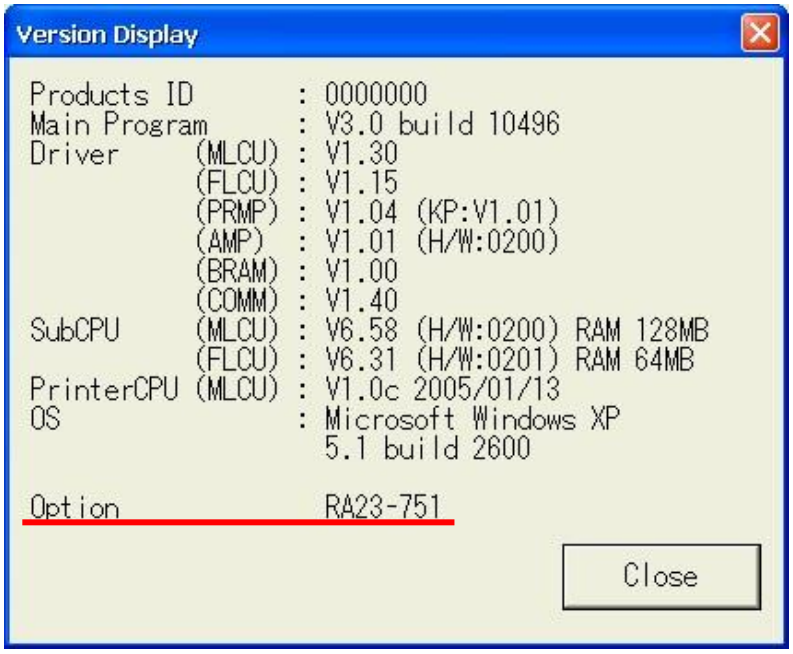
► Uninstallation

Please start RA2000A / DL2800A in the maintenance mode. Press the [Option] key in the [Maintenance tool] box to display the [Options] window. Select an intended option to be deleted, and then press the [Delete] key to delete the desired option file.



► Confirmation of registered contents

Start RA2000A / DL2800A, and press the [Version Display] key on the [Maintenance] tab in the [System] window to display the version information of the RA2000A / DL2800A. If “RA23-751” is shown in the <Option>, the software is installed normally in proper working order.



CONTENTS

1. Interval statistical calculation

1.1. Interval statistical calculation function

The statistical calculations are used for applying statistical operations and processing for each channel data recorded in the memory. The interval statistical calculation involves functions to calculate the maximum, minimum, and average values of the data recorded in the memory for desired interval as specified. The interval statistical operation can be performed during the memory mode under the measurement.

1.2. Operation procedure of interval statistical calculation

Operation procedure is explained for interval statistical calculation.

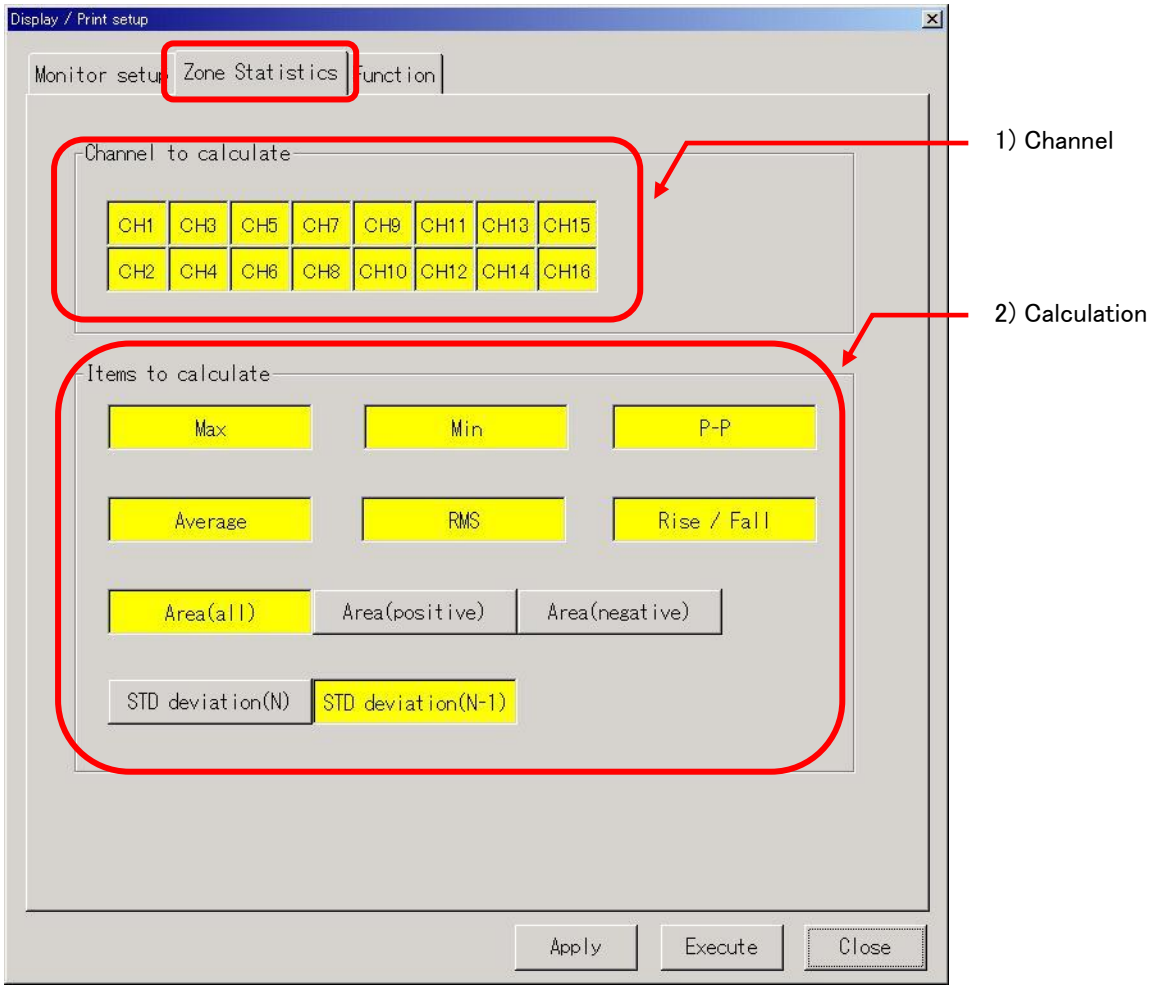
1.2.1. Data selection to be calculated

First press the [REPLAY] button on the display in order to display recorded data to be calculated. Select the data area to be calculated by using [Select Data] on the upper left corner of the display.

☞ Refer to the instruction manual of RA2000A / DL2800A for the details of data selection

1.2.2. Setting of interval statistical calculation

Press the [Diplay/Printing] button on the display to display the diagram below indicates



1) Calculation channel setting
Channel to be calculated are set.

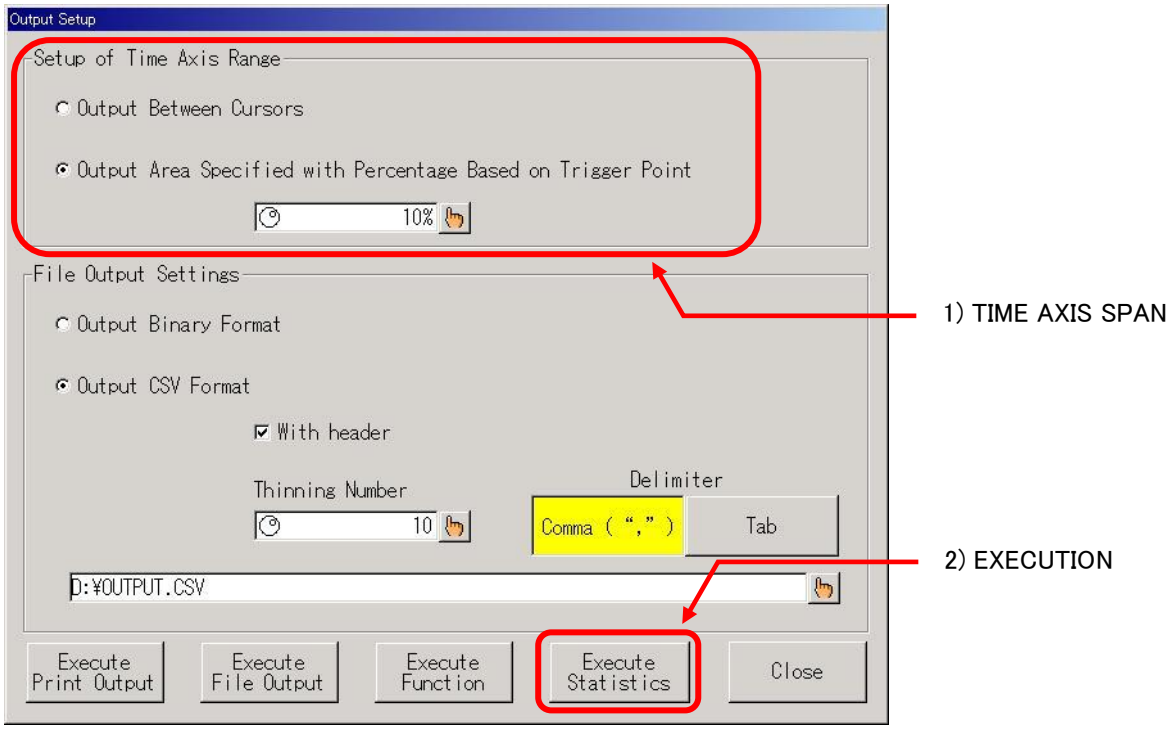
NOTE If there is no data or amplifier on specified channel, calculated result is unable to be display.

2) Calculation content setting
Calculation contents are specified. Area calculation method is selected from among the following three methods.
Calculating the area by using absolute values of measurement data.
Calculating the area by using positive values of measurement data.
Calculating the area by using negative values of measurement data.

Standard deviation calculation method is selected from among the following two methods.
Calculating the standard deviation with N as denominator
Calculating the standard deviation with N-1 as denominator

1.2.3. Executing interval statistical calculation

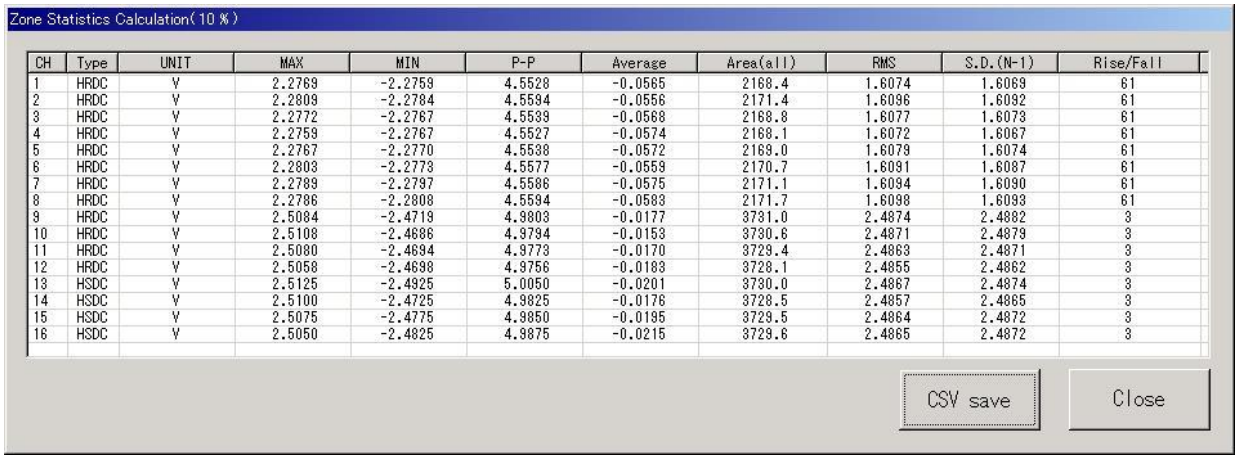
In order to conduct and execute interval statistical calculation, press the [Output Setting] button on the upper left corner of the display to display the diagram below indicates.



1) Time axis span setting
Time axis span is set to conduct and execute interval statistical calculation.

☞ Refer to the instruction manual of RA2000A / DL2800A for the details of time axis span setting.

2) Calculation executing
Press the [Execute Statistics] button to conduct and execute interval statistical calculation, and display the calculated results, as show in below.



CH	Type	UNIT	MAX	MIN	P-P	Average	Area(all)	RMS	S.D.(N-1)	Rise/Fall
1	HRDC	V	2.2769	-2.2759	4.5528	-0.0565	2168.4	1.6074	1.6069	61
2	HRDC	V	2.2809	-2.2784	4.5594	-0.0556	2171.4	1.6096	1.6092	61
3	HRDC	V	2.2772	-2.2767	4.5539	-0.0568	2168.8	1.6077	1.6073	61
4	HRDC	V	2.2759	-2.2767	4.5527	-0.0574	2168.1	1.6072	1.6067	61
5	HRDC	V	2.2767	-2.2770	4.5538	-0.0572	2169.0	1.6079	1.6074	61
6	HRDC	V	2.2803	-2.2773	4.5577	-0.0559	2170.7	1.6091	1.6087	61
7	HRDC	V	2.2789	-2.2797	4.5586	-0.0575	2171.1	1.6094	1.6090	61
8	HRDC	V	2.2786	-2.2808	4.5594	-0.0583	2171.7	1.6098	1.6093	61
9	HRDC	V	2.5084	-2.4719	4.9803	-0.0177	3731.0	2.4874	2.4882	3
10	HRDC	V	2.5108	-2.4686	4.9794	-0.0153	3730.6	2.4871	2.4879	3
11	HRDC	V	2.5080	-2.4694	4.9773	-0.0170	3729.4	2.4863	2.4871	3
12	HRDC	V	2.5058	-2.4698	4.9756	-0.0183	3728.1	2.4855	2.4862	3
13	HSDC	V	2.5125	-2.4925	5.0050	-0.0201	3730.0	2.4867	2.4874	3
14	HSDC	V	2.5100	-2.4725	4.9825	-0.0176	3728.5	2.4857	2.4865	3
15	HSDC	V	2.5075	-2.4775	4.9850	-0.0195	3729.5	2.4864	2.4872	3
16	HSDC	V	2.5050	-2.4825	4.9875	-0.0215	3729.6	2.4865	2.4872	3

1.2.4. CSV saving of interval statistical calculation

To save calculated results as CSV format, press the [CSV save] on the lower right corner of the display.

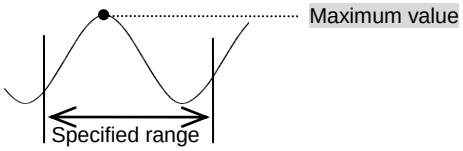
☞ Specification of CSV file and its destination is same as one of CSV save of data recorded, Refer to the instruction manual of RA2000A / DL2800A for the details of CSV save of data recorded.

1.3. Types of interval statistical calculation

Overviews are given below, for the arithmetic types of interval statistical calculations.

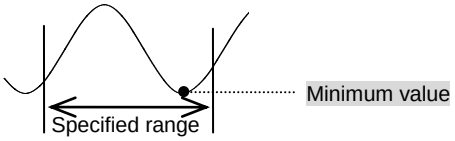
1.3.1. Maximum value (MAX)

The maximum value is shown within the specified data range



1.3.2. Minimum value (MIN)

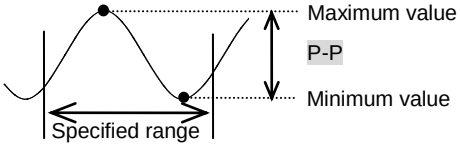
The minimum value is shown within the specified data range.



1.3.3. Peak-to-peak value (P-P)

The difference is computed between the maximum and minimum value.

Equation: P-P=I Maximum value-Minimum value I



1.3.4. Average value (Average)

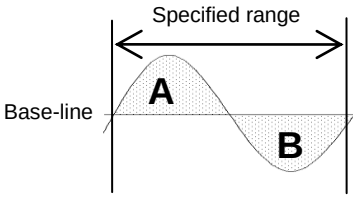
The mean value is computed within the specified data range

Equation: $\mathrm{AVE} = \frac{1}{\mathrm{n}} \sum \mathrm{D}$

D: Sample data in the specified range
n: number of data

1.3.5. Area (AREA)

The area, surrounded by the measured waveform and the base-line within the specified range, is computed.
Area calculation method is selected from among the following three methods.



(1) Area (All)
The area is computed by using absolute values of measurement data.

Equation: $\mathrm{AREA} = \sum |D|$

D: Sample data within the specified range

(2) Area (positive)
The area is computed area by using positive values of measurement data.

Equation: $\mathrm{AREA} = \sum (+\mathrm{D})$

D: Sample data within the specified range

(3) Area (negative)
The area is computed area by using negative values of measurement data.

Equation: $\mathrm{AREA} = \sum (-\mathrm{D})$

D: Sample data within the specified range

1.3.6. Root-mean-square value (RMS)

The root-mean-square value is computed for specified data range.

Equation: $$RMS = \sqrt{\frac{\sum D^2}{n}}$$

D: Sample data within the specified range
n: number of data

1.3.7. Standard deviation (STD)

The standard deviation is computed for the specified data Set the standard deviation parameter to select “n” or “n-1” for the denominator.

1) N: The standard deviation is calculated with parameter on 1/n for the data within the specified range.

Equation: $$SD = \sqrt{\frac{1}{n}\left\{\sum D^2 - \frac{\left(\sum D\right)^2}{n}\right\}}$$

D: Sample data within the specified range
n: number of data

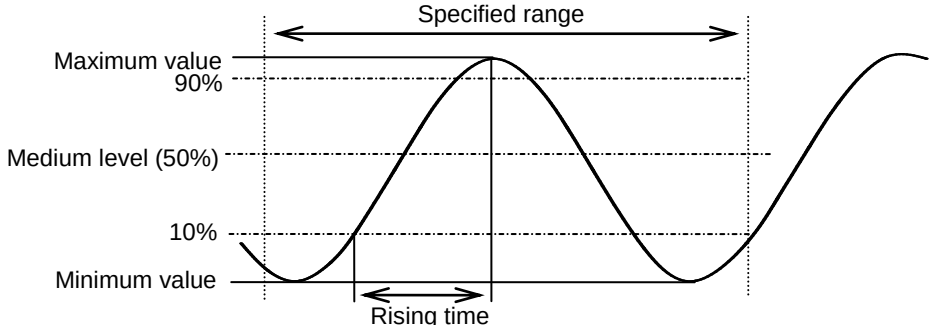
2) N-1: The standard deviation is calculated with parameter on 1/(n-1) for the data within the specified range.

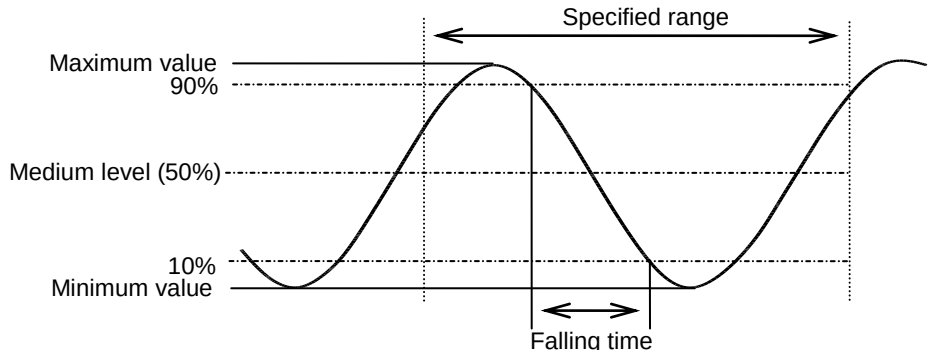
Equation: $$SD = \sqrt{\frac{1}{n-1}\left\{\sum D^2 - \frac{\left(\sum D\right)^2}{n-1}\right\}}$$

D: Sample data within the specified range
n: number of data

1.3.8. Rising or falling time (Rise/Fall)

The rising time or falling time is calculated as follows. Both maximum and minimum values are found within the specified data range, and then the medium level between the maximum and minimum values is defined. Both the rising and falling time are calculated by using 90%and 10% values of absolute value of difference between the maximum and minimum values, as shown in bellows. The calculation results are indicated in terms of the number of sample data. The results are also converted into the time expression by the multiplication of the calculation result and sampling speed.





2. Function calculation

2.1. Function calculation

The function calculation is applied and proceeded for any specified data stored in the memory through the four arithmetic operation, trigonometric function, exponential, and so on. The function operation can be performed only for analogue channel data recorded as sample format.

2.2. Operation procedure of function calculation

Operation procedure is explained for function calculation.

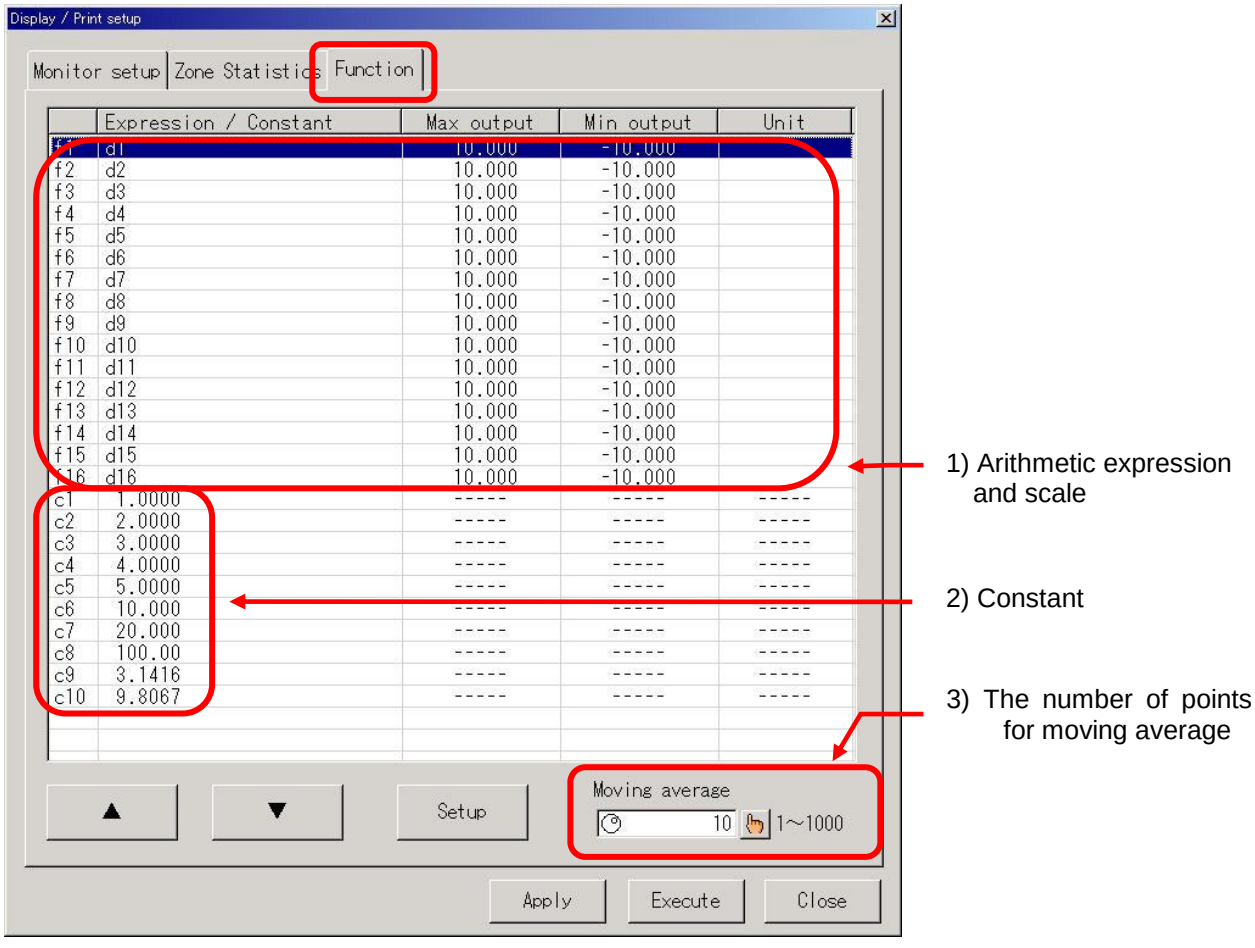
2.2.1. Data selection to be calculated

First press the [REPLAY] button on the display in order to display recorded data to be calculated. Select the data area to be calculated by using [Select Data] on the upper left corner of the display.

☞ Refer to the instruction manual of RA2000A / DL2800A for the details of data selection

2.2.2. Setting of function calculation

Press the [Display/Printing] button, and then press the [FUNCTION] key on the display to display the diagram below indicates



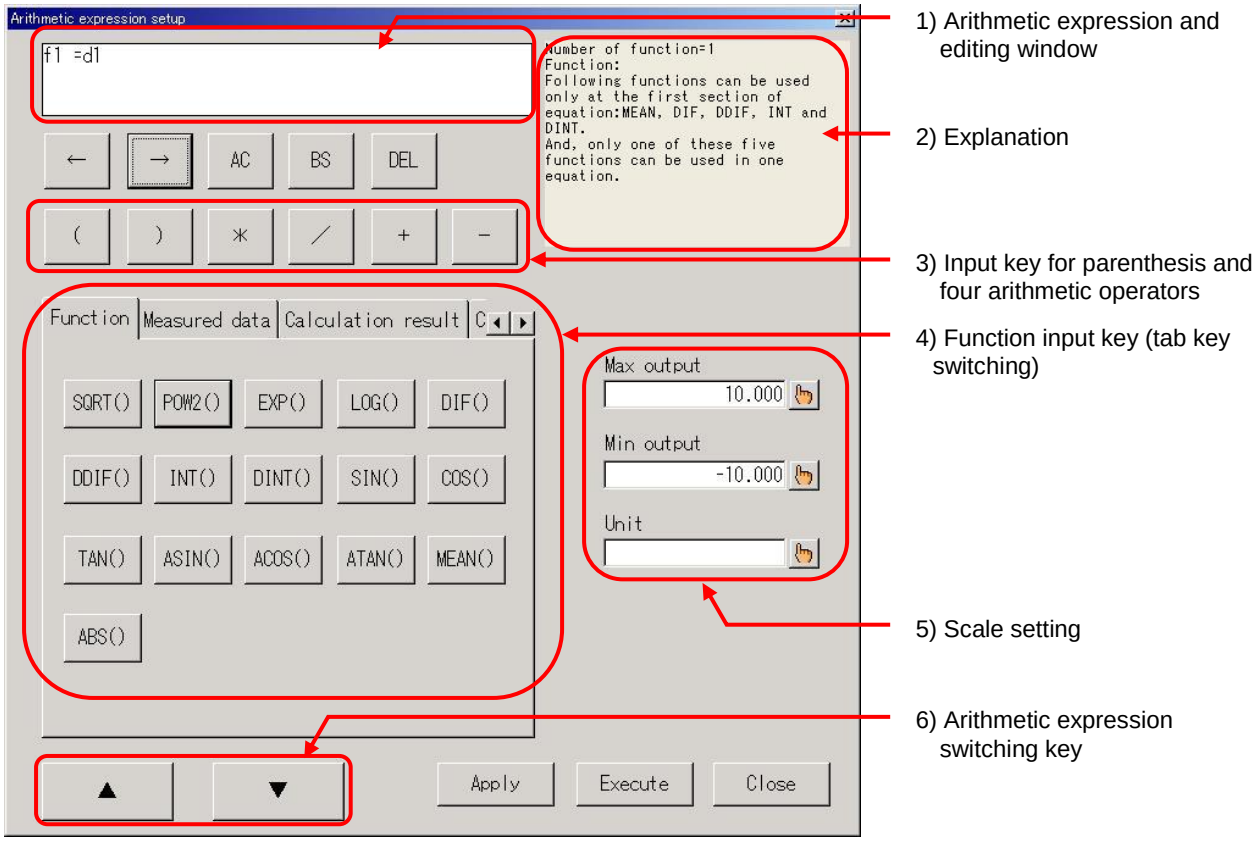
1) Arithmetic expression and scale
Scale setting of “Max output”, “Min output”, or “Unit” is displayed in the case of display for arithmetic expression and waveform of calculation results. Arithmetic expressions are set up to 16 as f1 to f16. To change arithmetic expression setting, select a intended expression by touching the display ,or using [▲] [▼] key. The above setting is performed on the [Arithmetic expression setup] window, which appears by pressing the [Setup] key.

2) Constant
Constant, which is used in the arithmetic expression, is displayed. Constants are set up to 10 as c1 to c10. To change constant setting, select a intended number by touching the display ,or using [▲] [▼] key. The above setting is performed on the [Entry of constant] window, which appears by pressing the [Setup] key.

3) The number of points for moving average
The number of points is displayed when the moving average is specified as arithmetic expression. To change moving average point setting, select a intended point by using jog-dial or [ ] key.

2.2.3. Arithmetic expression setup

To set arithmetic expression, press the [FUNCTION] tab key, and then press the [Setup] button on the [Arithmetic expression setup] window to display the diagram below indicates.



1) Arithmetic expression and editing window
This is a window for current arithmetic expression and its edition.

2) Explanation
Number of input arithmetic expressions and explanation for the input expressions are shown in this window. In addition, If there is any error in registered arithmetic expression, the details of error are shown in this window.

NOTE The total number of numerical values and operators used in one expression is up to 32.

3) Input key for parenthesis and four arithmetic operators
Both parenthesis and four arithmetic operators are input into the arithmetic expression by using these keys.

4) Function input key (tab key switching)
This is a function input key. Function is changed by switching tab key.

TAB KEY	DESCRIPTION
Function	Functions are input into arithmetic expression.
Measured data	Each channel data is input into arithmetic expression as d1 to d16
Calculation result	Calculated results are input into arithmetic expression as f1 to f15. If expression is fn, f1 to fn−1 can be input into fn.
Constant	Constant is input into arithmetic expression.

NOTE First differential, second differential, single integral, and double integral must be used in the first term in the arithmetic expression. In addition, only one of the above four functions is applied to the arithmetic expression

NOTE Only former calculated results are input into the current expression. For example, if the current expression is fn, f1 to fn-1 can be input into fn

NOTE If measured data of d1 to d16 is used in the arithmetic expression, the following data is inapplicable to the expression.

1) Data recorded on the channel in which input setting is off
2) Data recorded on the channel in which event amplifier is set.
3) Data recorded on the channel in which input unit is unset.
Measured data is calculated based on scale preset on Amp Screen window. For example, if desired user scale is applied, calculation is performed based on the user scale.

NOTE Measured data is calculated with conforming physical quantity unit; voltage is V, frequency is Hz, strain is us, acceleration is m/s2 or G.

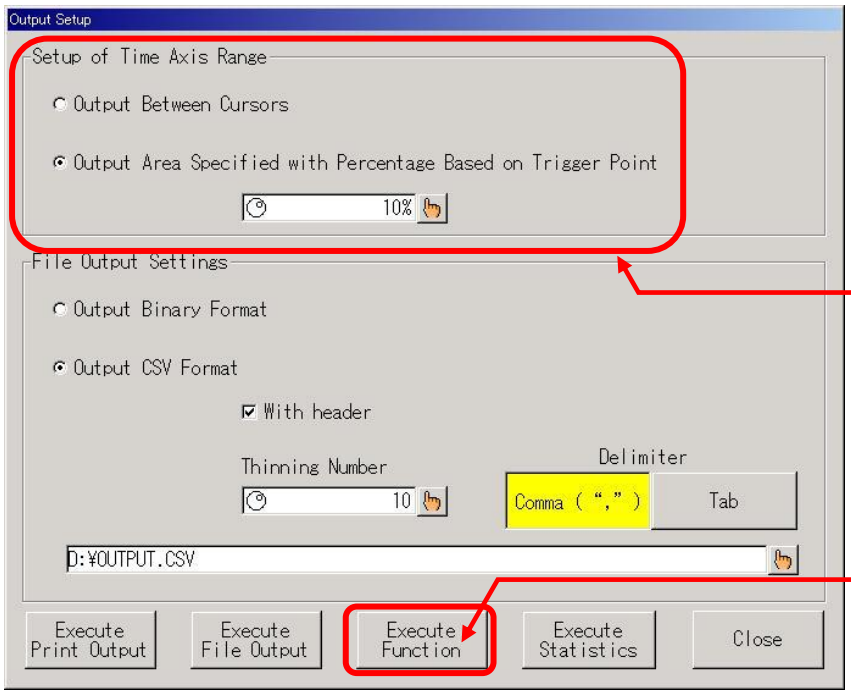
Example: CH1 range: 1V CH2 range: 500mV, arithmetic expression f1=d1+d2
If measured data on CH1 is 0.2V, and measured data on CH2 is 100mV, calculated value F1 is 0.300V (0.2+0.1).

5) Scale setting
Maximum scale, minimum scale and unit are set for waveform output of calculated result. Each item is set by pressing [ ] key.

6) Arithmetic expression switching key
Current compilation is registered by using [▲] [▼] key on the bottom of the display, and you can select next or former equation in a same way.

2.2.4. Execution of function calculation

Press the [Output Setting] key on the upper left corner of the playback monitoring display to execute function calculation and display the following window.



1) Setting of time range

Time axis range is set in the window to execute function calculation.

☞ Refer to the instruction manual of RA2000A / DL2800A for the details of time range setting.

2) Execution of function calculation

Press the [Execute Function] key to execute function calculation, output the calculated result as binary file, and display the result.
Output destination is as follows, depending on data forms.

File data: Calculated result is output as "Path name of the former data file + file extension of CLC"
Memory data: Calculated result is output as "Path name of memory backup file + file extension of CLC"

NOTE Check that available memory capacity for the output destination is enough before execution of function calculation, File size of calculated result is depend on number of arithmetic expression and data volume. If function calculation is performed for whole data, the file size of the calculated result is about 2 times of the former data file size.
File size of calculated result = Number of expression x Data volume x 4 + 4096 (Byte)

2.2.5. Output of function calculation result

Function calculation results are able to be selected as data file. In addition, they are converted into binary or CSV file. They are also recorded on the recording chart.

☞ Refer to the instruction manual of RA2000A / DL2800A for the details of output setting.

2.3. Function calculation item

Outline of function calculation items is described. The arithmetic expression consists of function, valuable number, and fixed number as follows.

Example: f1 = SIN (d1) * c1

f1: Arithmetic expression Function
SIN: Function
d1: Valuable number,
c1: Fixed number

2.3.1. Arithmetic expression

Arithmetic expressions are set up to 16 as f1 to f16. One arithmetic expression contains up to 32 items of function, valuable number, and fixed number. The expression fn contains the expressions from f1 to f (n-1). However, the expression fn dose not involve f (n+1).

2.3.2. Function

The following functions are used and set in this program.

1) The four rules of arithmetic (* , / , + , -)

2) Absolute value (ABS)

3) Square root (SQRT)
Data to be calculated must be positive. If negative value is entered it will be treated as zero.

4) Second power (POW2)

5) Exponential (EXP)
The range of value to be entered is from +38.0 to –45.0. Any value beyond the range entered will be interpreted as +38 or –45.

6) Common logarithmic (LOG)
Data to be calculated must be positive. If zero is entered, the calculated result will be available maximum negative value of -3.4E38. In addition, if negative value is entered, the result is zero.

7) First differential (DIF)

8) Second differential (DDIF)
Calculation of first and second differentials uses Lagrange's interpolation formula of the fifth order, where value of an interesting point is estimated from ten point values on both sides of the interesting point. Designating measured values of n sample points, $t_0,t_1,t_2\ldots,t_n$ to be $y_0,y_1,y_2,\ldots,y_n$, respectively, the arithmetic expressions for the first differential are given as follows:

$$t_0 \quad Y_0 = \frac{1}{12h}\left(-25y_0 + 48y_1 - 36y_2 + 16y_3 - 3y_4\right)$$

$$t_1 \quad Y_1 = \frac{1}{12h}\left(-3y_0 - 10y_1 + 18y_2 - 6y_3 + y_4\right)$$

$$t_2 \quad Y_2 = \frac{1}{12h}\left(y_0 - 8y_1 + 8y_3 - y_4\right)$$

$$\vdots \qquad\qquad \vdots$$

$$t_i \quad Y_I = \frac{1}{12h}\left(y_{i-2} - 8y_{i-1} + 8y_{i+1} - y_{i+2}\right)$$

$$\vdots \qquad\qquad \vdots$$

$$t_{n-2}\ Y_{n-2} = \frac{1}{12h}\left(y_{n-4} - 8y_{n-3} + 8y_{n-1} - y_n\right)$$

$$t_{n-1}\ Y_{n-1} = \frac{1}{12h}\left(-y_{n-4} + 6y_{n-3} - 18y_{n-2} + 10y_{n-1} + 3y_n\right)$$

$$t_n \quad Y_n = \frac{1}{12h}\left(3y_{n-4} - 16y_{n-3} + 36y_{n-2} - 48y_{n-1} + 25y_n\right)$$

Where y is data of calculated result, and h is sampling time.

The arithmetic expressions for the first differential are given as follows:

$$t_0 \quad Y_0 = \frac{1}{12h^2}\left(35y_0 - 104y_1 + 114y_2 - 56y_3 + 11y_4\right)$$

$$t_1 \quad Y_1 = \frac{1}{12h^2}\left(11y_0 - 20y_1 + 6y_2 + 4y_3 - y_4\right)$$

$$t_2 \quad Y_2 = \frac{1}{12h^2}\left(-y_0 + 16y_1 - 30y_2 + 16y_3 - y_4\right)$$

$$\vdots \qquad\qquad \vdots$$

$$t_i \quad Y_I = \frac{1}{12h^2}\left(-y_{i-2} + 16y_{i-1} - 30y_i + 16y_{i+1} - y_{i+2}\right)$$

$$\vdots \qquad\qquad \vdots$$

$$t_{n-2}\ Y_{n-2} = \frac{1}{12h^2}\left(-y_{n-4} + 16y_{n-3} - 30y_{n-2} + 16y_{n-1} - y_n\right)$$

$$t_{n-1}\ Y_{n-1} = \frac{1}{12h^2}\left(-y_{n-4} + 4y_{n-3} + 6y_{n-2} - 20y_{n-1} + 11y_n\right)$$

$$t_n \quad Y_n = \frac{1}{12h^2}\left(11y_{n-4} - 56y_1 + 114y_{n-2} - 104y_{n-1} + 35y_n\right)$$

Where y is data of calculated result, and h is sampling time.

9) Single integral (INT)

10) Double integral (DINT)

Calculation of both single and double integrals uses the trapezoidal rule. The arithmetic expression for the single integral is given as follows.

Point t_0 $I_0 = 0$
Point t_1 $I_1 = 1/2(d0+d1)*h$
Point t_2 $I_2 = 1/2(d0+d1)*h + 1/2(d1+d2)*h = I_1 + 1/2(d1+d2)*h$

$\vdots$

Point t_n $I_n = I_{n-1} + 1/2(d_{n-1} + d_n)*h$

where I0,I1…In are data of calculated result, and h is sampling time.

The arithmetic expression for the double integral is given as follows.

Point t_0 $II_0 = 0$
Point t_1 $II_1 = 1/2(I0+I1)*h$
Point t_2 $II_2 = 1/2(I0+I1)*h = 1/2(I1+I2)*h = II_1 + 1/2(d1+d2)*h$

$\vdots$

Point t_n $II_n = II_{n-1} + 1/2(I_{n-1} + I_n)*h$

where II0, II1…II n are data of calculated result, and h is sampling time.

11) Trigonometric function (SIN,COS,TAN, ASIN,ACOS,ATAN)
Parameters for SIN,COS and TAN are entered in the unit of radian. In the case of both ASIN and ACOS, if an entered value is more than 1 (>1), the value is treated as 1. If an entered value is less than -1 (<-1), the value is treated as -1.

12) Moving average (MEAN)
The number of the points for the moving average can be set at any integer within 1 to 1000. If sample point is less than the number of the points N, the arithmetic expression is

$$\left(\sum_{T=0}^{T=i} D \right) / i$$

If sample points are more than the number of the points N, the arithmetic expression is

$$\left(\sum_{T=i-N}^{T=i} D \right) / N$$

NOTE First differential, second differential, single integral, double integral, and moving average must be used in the first term in the arithmetic expression. In addition, only one of the above five functions is applied to the arithmetic expression.

NOTE If function calculation, such as first differential, second differential, single integral, double integral, is performed for recorded data by using external synchronized clock, sampling time is always used as 1 sec for calculation.

2.3.3. Measured data

Measured data of each channel is set as variable of d1 to d16, where dn is measured data for channel n.

2.3.4. Constant

Ten constants are set as c1 to c10. The range of the fixed value is –9.9999E+12 to 9.9999E+12.

2.4. Output for incorrect calculation

When incorrect calculation, such as restriction of function itself, and impossible calculation in principle, is carried out, following results are output.

2.4.1. Zero division

Zero division gives following results. For f1=d1/d2, and d2=0, the calculated result is dependent upon the value of d2.

If d1 is positive value, f1 is +3.4000E+38
If d1 is negative value, f1 is -3.4000E+38.
If d1 is 0, f1 is 0.

2.4.2. Square root of negative value

Square root of negative value fives the calculated value of 0.0.

2.4.3. Overflow for exponential calculation

Overflow for exponential calculation is presented as follows. For f1=EXP(d1),

d1 is more than 38.0, f1 is 10E+38.
d1 is less than -45.0, f1 is 10E-45.

2.4.4. Common logarithmic of zero or negative value

Common logarithmic of zero or negative value gives following results. For f1=LOG(d1),
if d1 is 0, f1 is –3.4000E+38.
if d1 is negative value, f1 is 0.0000.

2.4.5. ASIN and ACOS for the value of >1 or <-1

Both ASIN and ACOS for the value of >1 or <-1 gives following results. For f1=ASIN(d1) and f2=ACOS(d1),
if d1is less than -1, f1 is ASIN(-1), and f2 is ACOS(-1)
if d1 is more than 1, f1 is ASIN(1), and f2 is ACOS(1).

2.4.6. Differential and integral for recorded data by using external synchronized clock

If function calculation, such as first differential, second differential, single integral, double integrals, is performed for recorded data by using external synchronized clock, sampling time is always used as 1 sec for calculation.

3. FFT analysis

3.1. FFT functions

The FFT functions are used for spectrum analysis of recorded data in both memory recorder and HDD recorder modes FFT. The functions, involve those of time axis waveform, linear spectrum, RMS (Root mean square) spectrum, power spectrum, power spectrum density, transfer function, cross power spectrum, coherence function, and octave analysis. FFT analysis is applied only to the data recorder in sample format. Therefore, the FFT analysis is inapplicable the data in both peak format and recorded data by using external synchronized clock.

3.2. Operation procedure of FFT analysis

Operation procedure is explained for FFT analysis.

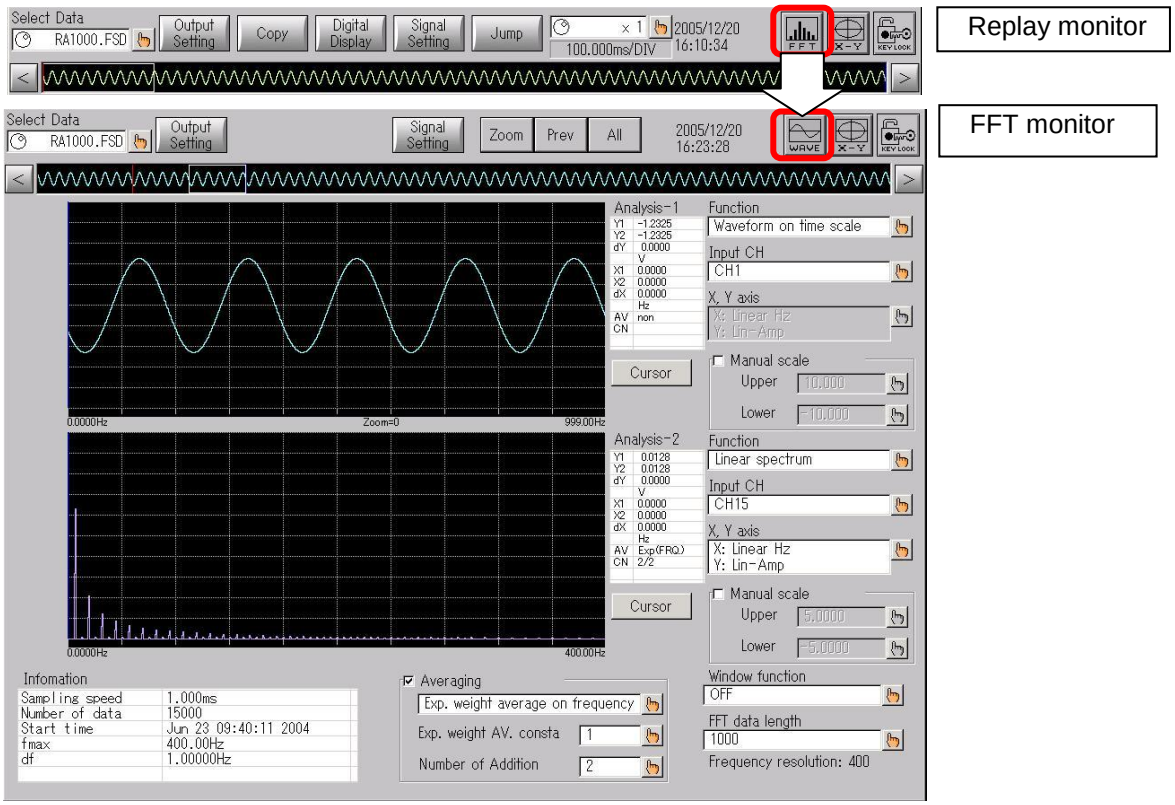
3.2.1. Data selection to be analyzed

First press the [REPLAY] button on the display in order to display recorded data to be calculated. Select the data area to be calculated by using [Select Data] on the upper left corner of the display.

☞ Refer to the instruction manual of RA2000A / DL2800A for the details of data selection

3.2.2. Display of FFT monitor

Operation procedure is explained for FFT monitor.
In order to display FFT monitor, first press the [REPLAY] button on the display. Press the [FFT] key on the upper right corner of the display, the window appears as shown in below



Press the [FFT] key on the upper right corner of the FFT monitor, normal Y-T monitor appears on the display.

NOTE If the peak data or the data recorded by using external synchronized clock, to which FFT analysis is inapplicable, is selected, the [FFT] key is not automatically valid.

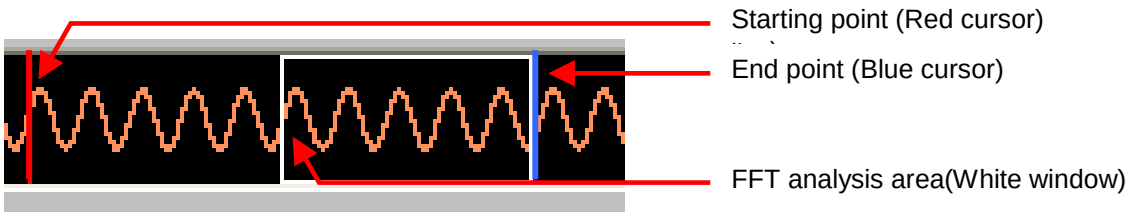
3.2.3. Change of FFT analysis data

The [Select Data] key on the upper right corner of the FFT monitor is used to change recorded data to be FFT-analyzed. FFT analysis is applicable only to the data recorded in the sample format. Information about selected data to be analyzed is shown in the [INFORMATION] window on the bottom left of the FFT monitor.

☞ Refer to the instruction manual of RA2000A / DL2800A for the details of data selection

3.2.4. Starting point of FFT analysis

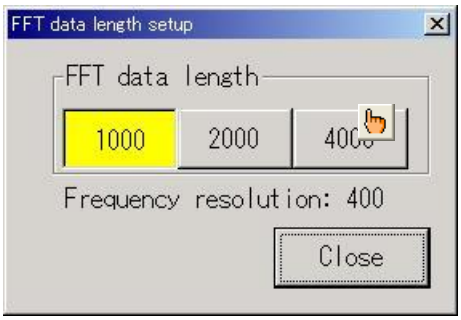
The FFT analysis area is shown as the thumbnail image on the upper side of the FFT monitor.



The starting point is designated by using red cursor1 on the Y-T DISPLAY, and it is also set by touching thumbnail image. Ending point is primarily determined, depending on both data length and averaging number. The white window shows the FFT analysis proceeding. The FFT analysis has already completed in the area from the red cursor to the left edge of the white window, while it is just getting underway in the white window.

3.2.5. Setting of FFT analysis data length

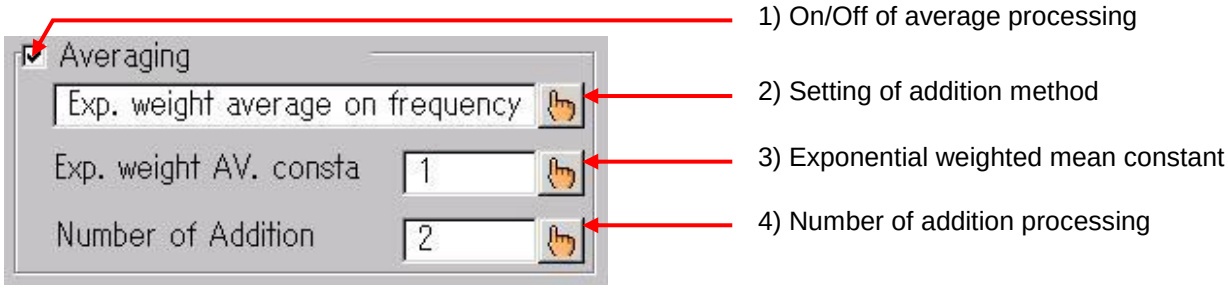
FFT data length is set by using the [DATA LENGTH] key on the lower right corner of the FFT monitor. In order to show the FFT data length setup window, press the [ ] key, and the analyzed data length is set.



NOTE Value set for data length means number of data on time axis. The frequency resolution for FFT analysis is also shown.

3.2.6. Setting of FFT average

FFT average is set by using the [Averaging] key on the bottom center of the FFT monitor.



1) On/Off of average processing
The average processing is switched by checking this box.

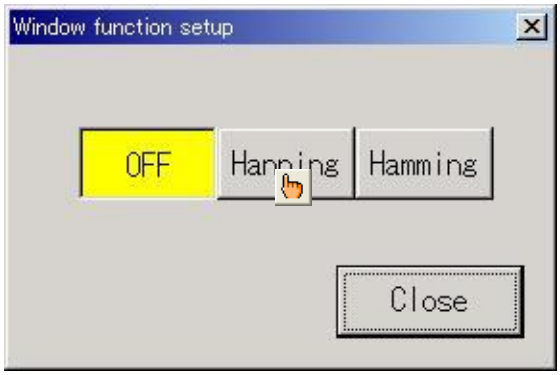
2) Setting of addition method
The addition method is specified in the window of addition method setting by pressing the [ ] key.

3) Exponential weighted mean constant
The exponential weighted mean constant is set in the window of exponential weighted mean constant setting by pressing the [ ] key. The exponential weighted mean constant is available only when the frequency axis exponential weighted average is specified as the addition method.

4) Number of addition processing
The number of addition processing is set in the window of addition number setting by using ten-key by pressing the [ ] key.

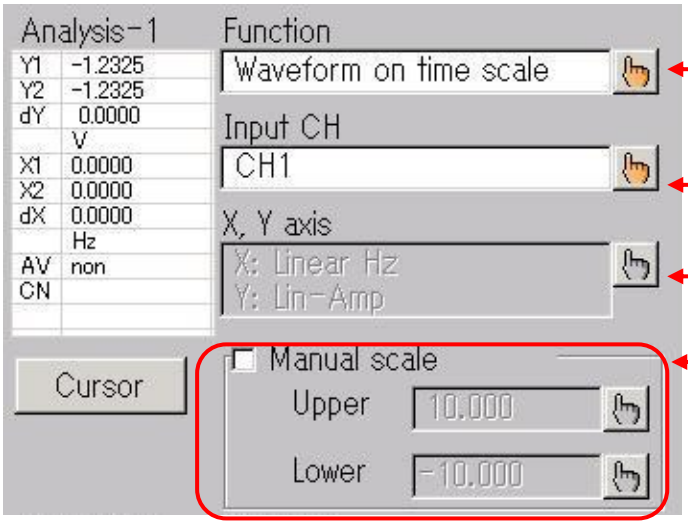
3.2.7. Setting the FFT window function

The window function is set by using the [WINDOW FUNCTION] key on the bottom right corner of the FFT monitor. The right window of the window function setting is displayed by pressing the [ ] key.



3.2.8. Setting the FFT analysis

Two kind of FFT analysis are preformed at a time. Desired FFT analysis functions are input into the two windows of Analysis-1 and Analysis -2, respectively.



1) Analysis function
The analysis functions are set in the window of analysis function setting by pressing the [ ] key

2) Input channel
The input channels are set in the window of input channel setting by pressing the [ ] key. If the analysis function is set as single channel analysis or octave analysis, only one channel can be specified. If the analysis function is set as double channel analysis, two channels can be specified as base channel and reference channel.

NOTE If the input channel is changed on Analysis-1, the thumbnail window is also changed, and the waveform of the base channel (Analysis -1) is displayed on the thumbnail

3) X or Y axis format
The X and Y axis formats is set in the window of X or Y axis format setting by pressing the [ ]key.

NOTE Axis setting is invaluable in certain analysis functions

4) Scale mode of Y-axis
If the box of [MANUAL SCALE] is checked, the scale of Y-axis is determined, depending upon both the upper and Lower values, which are discretionary. If the box is unchecked, the auto-scaling becomes active, and the scale automatically switches, depending on the analysis result. To 1fi function the scale of Y-axis is determined, depending upon both the upper and Lower values.

3.2.9. Display of FFT analysis results

When input of FFT analysis condition is completed, FFT analysis starts, its results are shown in the display. The result is gray during analysis. After the analysis is finished, it changes from gray to the same color with one of the data waveform shown in the display.

3.2.10. Cursor operation

FFT analysis result and frequency value are read by using both cursors X1 and X2, and they are shown in the window of cursor data.

1) Window of cursor data

The FFT analysis results are shown for both cursors X1 and X2. The display color of the analysis result during cursor movement is a reverse of one for the cursor X1 and X2. AV means average function as shown below, and CN means number of average.

Sum (TIME): Time axis averaging process is applied to the display of analysis results.
Sum (FRQ): Frequency averaging process is applied to the display of analysis results.
Exp (FRQ): Frequency exponential weighted mean process is applied to the display of analysis results.
Peak (FRQ): Peak-hold process is applied to the display of analysis results.

2) Cursor change

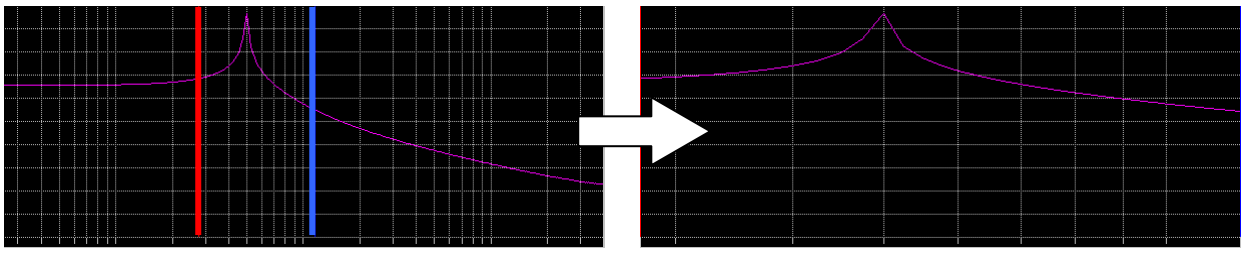
Cursor is changed by pressing the [CURSOR] key.

3) Cursor X1(Red cursor) and Cursor X2(Blue cursor)

Cursor movement is performed by using jog-dial or direct touching on waveform monitor.

3.2.11. Magnification of X-axis

The X-axis area surrounded by the cursors X1 and X2 is magnified by pressing the [ZOOM] key on the FFT monitor.



[Zoom] : The X-axis area surrounded by the cursors X1 and X2 is magnified
[Prev] : Pressing the [Prev] key goes back to the previous screen before pressing the [Zoom] key.
[ALL]: Pressing the [ALL] key goes back to the initial screen with whole X-axis area.

3.2.12. Output of binary file

The FFT analysis result is saved as binary file. The saved binary file can be displayed on the playback monitor or FFT monitor

1) The output-setting screen is displayed by pressing the [Output Setting] key on the upper left corner of the FFT monitor.
2) Check the [OUTPUT BINARY Format] radio button.
3) Direct the output path name. The file extension is fixed as “DFT”.
4) File saving starts by pressing the [Execute File Output] key.

☞ Refer to the instruction manual of RA2000A / DL2800A for the details of output setting

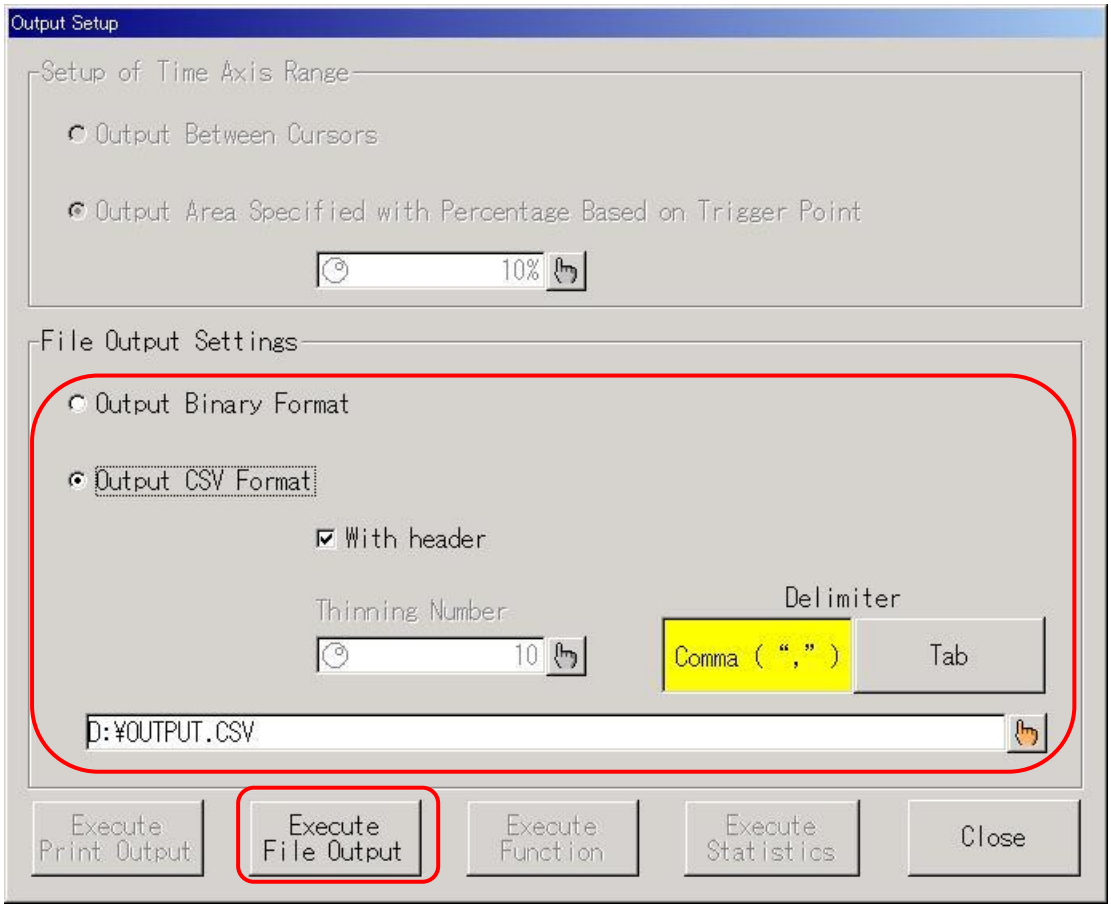
☞ Saved binary file with the extension of “DFT” can be displayed by selecting the data file on the playback monitor. Refer to the instruction manual of RA2000A / DL2800A for the details of output setting

3.2.13. Output of CSV file

The FFT analysis result is saved as CSV file. The saved CSV file can be referred by the text editor. Only the FFT analysis results displayed on the FFT monitor are able to be saved as the CSV file. The numbers of CSV files are two waveforms at most.

1) The output-setting screen is displayed by pressing the [Output Setting] key on the upper left corner of the FFT monitor.
2) Check the [OUTPUT BINARY Format] radio button.
3) Direct the output path name. The file extension is fixed as “CSV”.
4) File saving starts by pressing the [Execute File Output] key.

☞ Refer to the instruction manual of RA2000A / DL2800A for the details of output setting



3.3. FFT analysis function

3.3.1. Waveform on time scale (One signal analysis)

The time-axis waveform is used as input signal.

3.3.2. Linear spectrum (One signal analysis)

Individual frequency component G is defined by the equation; G=R + jI. The linear spectrum analysis gives information about both amplitude and phase for each frequency component

Vertical axis	Computation equation
Real part (Lin-Real)	R
Imaginary part (Lin-Img)	I
Amplitude (Lin-Amp)	$\sqrt{(R^2+I^2)}$
Logarithmic amplitude (Log-Amp)	$20\times\log\sqrt{(R^2+I^2)}$
Phase (Phase)	$\tan^{-1}(I/R)$

3.3.3. RMS spectrum (One signal analysis)

The RMS spectrum analysis gives information about both amplitude (Root-mean-square value) and phase for each frequency component

Vertical axis	Computation equation
Real part (Lin-Rel)	$R/\sqrt{2}$
Imaginary part (Lin-Img)	$I/\sqrt{2}$
Amplitude (Lin-Amp)	$\sqrt{(R^2+I^2)}/\sqrt{2}$
Logarithmic amplitude (Log-Amp)	$20\times\log(\sqrt{(R^2+I^2)}/\sqrt{2})$
Phase (Phase)	$\tan^{-1}(I/R)$

3.3.4. Power spectrum and Density of power spectrum (One signal analysis)

The power spectrum analysis gives only the amplitude information such as the power of input signal (Square value of amplitude). The power spectrum density analysis shows power spectrum per unit frequency.

Vertical axis	Computation equation
Amplitude (Lin-Amp)	(R^2+I^2)
Logarithmic amplitude (Log-Amp)	$10\times\log(R^2+I^2)$

3.3.5. Octave analysis

1/1 octave band or 1/3 octave band can be analyzed. In this software, the octave analysis is done for adding data within individual band ranges after obtaining the power spectrum.

Vertical axis	Computation equation
Amplitude (Lin-Amp)	Oct
Logarithmic amplitude (Log-Amp)	$20\times\log$Oct

3.3.6. Cross power spectrum (Two signal analysis)

The cross power spectrum indicates the power product between two signals. The cross power spectrum is obtained by multiplying two linear spectra of Gx* and Gy*, where Gx* is a conjugate number of the linear spectrum Gx of the reference signal, and Gy is the linear spectrum of a compared signal.

Linear spectrum for the reference signal: $Gx = Rx + jIx, \quad Gx^* = Rx - jIx$

Linear spectrum for a compared signal: $Gy = Ry + jIy$

Therefore, cross power spectrum Gyx: $Gyx = Gy \times Gx^* = (Ry + jIy)(Rx - jIx) = Ryx + jIyx$

where $Ryx = RyRx + IyIx \qquad Iyx = RxIy - RyIx$

Vertical axis	Computation equation
Real part (Lin-Rel)	Ryx
Imaginary part (Lin-Img)	Iyx
Amplitude (Lin-Amp)	$\sqrt{(Ryx^2 + Iyx^2)}$
Logarithmic amplitude(Log-Amp)	$10 \times \log\sqrt{(Ryx^2 + Iyx^2)}$
Phase (Phase)	$\tan^{-1}(Iyx/Ryx)$

3.3.7. Transfer function (Two signal analysis)

The transfer function indicates frequency characteristics between the input and the output of a transfer system. The transfer function is obtained as a ratio of the output linear spectrum Gy to the input linear spectrum Gx.

Output linear spectrum: $Gy = Ry + jIy$

Input linear spectrum: $Gx = Rx + jIx, \quad Gx^* = Rx - jIx$

Transfer function $= Gy/Gx = (Gy \times Gx^*)/(Gx \times Gx^*) = Gyx/Gxx$
$= (Ryx + jIyx)/(Rx^2 + Ix^2)$

where Gx* is the conjugate of the input linear spectrum

Vertical axis	Computation equation
Real part (Lin-Rel)	$Ryx/(Rx^2 + Ix^2)$
Imaginary part (Lin-Img)	$Iyx/(Rx^2 + Ix^2)$
Amplitude (Lin-Amp)	$\sqrt{(Ryx^2 + Iyx^2)}/(Rx^2 + Ix^2)$
Logarithmic amplitude(Log-Amp)	$20 \times \log\sqrt{(Ryx^2 + Iyx^2)}/(Rx^2 + Ix^2)$
Phase (Phase)	$\tan^{-1}(Iyx/Ryx)$

3.3.8. Coherence function (Two signal analysis)

The coherence coefficient function is the ratio of the power generated by the input signal of a certain transfer system to the total output power.

Coherence coefficient function $= Gyx \times Gyx^*/(Gyx \times Gyy)$

Vertical axis	Computation equation
Amplitude (Lin-Amp)	$(Ryx^2 + Iyx^2)/(Gxx \times Gyy)$

TIPS

You will get only one of coherence function over whole frequency range in one-time measurement. By all means, you must perform average processing for the frequency-axis.

3.4. Average processing

Even if average processing is set, the average processing is invalidity if average processing is invalidity on each analysis function specified. The next table lists validity or invalidity of average processing on all analysis functions.

Analysis function	Y-axis form	Average processing		
		Time-axis	Frequency-axis	Peak
waveform on time scale	Amplitude (Lin-Amp)	**Validity**	Invalidity	Invalidity
Linear spectrum	Real part (Lin-Rel)	Invalidity	**Validity**	Invalidity
	Imaginary part (Lin-Img)	Invalidity	**Validity**	Invalidity
	Amplitude (Lin-Amp)	Invalidity	**Validity**	**Validity**
	Logarithmic amplitude (Log-Amp)	Invalidity	**Validity**	**Validity**
	Phase (Phase)	Invalidity	**Validity**	Invalidity
RMS spectrum	Real part (Lin-Rel)	Invalidity	**Validity**	Invalidity
	Imaginary part (Lin-Img)	Invalidity	**Validity**	Invalidity
	Amplitude (Lin-Amp)	Invalidity	**Validity**	**Validity**
	Logarithmic amplitude (Log-Amp)	Invalidity	**Validity**	**Validity**
	Phase (Phase)	Invalidity	**Validity**	Invalidity
Power spectrum	Amplitude (Lin-Amp)	Invalidity	**Validity**	**Validity**
	Logarithmic amplitude (Log-Amp)	Invalidity	**Validity**	**Validity**
Density of power spectrum	Amplitude (Lin-Amp)	Invalidity	**Validity**	**Validity**
	Logarithmic amplitude (Log-Amp)	Invalidity	**Validity**	**Validity**
Cross power spectrum	Real part (Lin-Rel)	Invalidity	**Validity**	Invalidity
	Imaginary part (Lin-Img)	Invalidity	**Validity**	Invalidity
	Amplitude (Lin-Amp)	Invalidity	**Validity**	**Validity**
	Logarithmic amplitude (Log-Amp)	Invalidity	**Validity**	**Validity**
	Phase (Phase)	Invalidity	**Validity**	Invalidity
Transfer function	Real part (Lin-Rel)	Invalidity	**Validity**	Invalidity
	Imaginary part (Lin-Img)	Invalidity	**Validity**	Invalidity
	Amplitude (Lin-Amp)	Invalidity	**Validity**	**Validity**
	Logarithmic amplitude (Log-Amp)	Invalidity	**Validity**	**Validity**
	Phase (Phase)	Invalidity	**Validity**	Invalidity
Coherence function	Amplitude (Lin-Amp)	Invalidity	**Validity**	Invalidity
1/1 octave band	Amplitude (Lin-Amp)	Invalidity	**Validity**	**Validity**
	Logarithmic amplitude (Log-Amp)	Invalidity	**Validity**	**Validity**
1/3 octave band	Amplitude (Lin-Amp)	Invalidity	**Validity**	**Validity**
	Logarithmic amplitude (Log-Amp)	Invalidity	**Validity**	**Validity**

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(3) When operation, proper maintenance, and regular inspection are not done;
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(5) Exhaustion of consumptions and repair parts;
(6) Troubles attributed to third party's conflicts;
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Address inquiries to:

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FFT & Arithmetic operation Unit (RA23-751)
Instruction Manual (7001718-R01)

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