

Programmable Controller

MELSEC iQ-F
series

MELSEC iQ-F Statistical Analysis Function Block Reference (Basic)

SAFETY PRECAUTIONS

(Read these precautions before use.)

Before using this product, please read this reference and the relevant manuals introduced in this reference carefully and pay full attention to safety in order to handle the product correctly.

Precautions shown in this reference are only for this product. For safety precautions on the programmable controller system, refer to the user's manual (hardware) of the CPU module to be used.

This reference classifies the safety precautions into two categories: [ WARNING] and [ CAUTION].

 WARNING	Indicates that incorrect handling may cause hazardous conditions, resulting in death or severe injury.
 CAUTION	Indicates that incorrect handling may cause hazardous conditions, resulting in minor or moderate injury or property damage.

Depending on the circumstances, procedures indicated by [ CAUTION] may also cause severe injury.

It is important to follow all precautions for personal safety.

Make sure that the end users read this manual and then keep the manual in a safe place for future reference.

INTRODUCTION

Thank you for purchasing the MELSEC iQ-F series.

This reference describes the module FBs for the applicable modules listed below.

Before using this product, please read this reference and the manuals of relevant products carefully and develop familiarity with the specifications to handle the product correctly.

Please make sure that the end users read this reference.

Applicable modules

- FX5UJ CPU module
- FX5U CPU module
- FX5UC CPU module
- FX5S CPU module

Regarding use of this product

- This product has been manufactured as a general-purpose part for general industries, and has not been designed or manufactured to be incorporated in a device or system used in purposes related to human life.
- Before using the product for special purposes such as nuclear power, electric power, aerospace, medicine, or passenger movement vehicles, consult Mitsubishi Electric.
- This product has been manufactured under strict quality control. However, when installing the product where major accidents or losses could occur if the product fails, install appropriate backup or failsafe functions in the system.

Note

- If in doubt at any stage during the installation of the product, always consult a professional electrical engineer who is qualified and trained in the local and national standards. If in doubt about the operation or use, please consult the nearest Mitsubishi Electric representative.
- Since the examples indicated by this reference, technical bulletin, catalog, etc. are used as a reference, please use it after confirming the function and safety of the equipment and system. Mitsubishi Electric will accept no responsibility for actual use of the product based on these illustrative examples.
- This reference content, specification etc. may be changed without a notice for improvement.
- The information in this reference has been carefully checked and is believed to be accurate; however, if you notice a doubtful point, an error, etc., please contact the nearest Mitsubishi Electric representative. When doing so, please provide the manual number given at the end of this reference.

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RELEVANT MANUALS

Manual name	Description
MELSEC iQ-F FX5S/FX5UJ/FX5U/FX5UC User's Manual (Hardware) [SH-082452ENG]	Describes the details of hardware of the CPU module, including performance specifications, wiring, installation, and maintenance.
MELSEC iQ-F FX5 User's Manual (Application) [JY997D55401]	Basic knowledge required for program design, functions of the CPU module, devices/labels, and descriptions of parameters.
MELSEC iQ-F FX5 Programming Manual (Instructions, Standard Functions/ Function Blocks) [JY997D55801]	Specifications of instructions and functions that can be used in programs.
MELSEC iQ-F FX5 Programming Manual (Program Design) [JY997D55701]	Specifications of ladders, ST, FBD/LD, and other programs and labels.
MELSEC iQ-F FX5 User's Manual (Analog Control - CPU module built-in, Expansion adapter) [JY997D60501]	Details of the analog functions of the CPU module built-in and the analog adapter.
GX Works3 Operating Manual [SH-081215ENG]	System configuration, parameter settings, and online function operations of GX Works3.

TERMS

Unless otherwise specified, this reference uses the following terms.

Terms	Description
Box plot	A statistical chart for intelligibly expressing the variation of data. In addition, the degree of variance and skewness can be checked with the shape of the box plot.
Coefficient of determination	An index which indicates how close the predictive value is to the actual measurement value. A value from 0 to 1 is calculated, and it indicates that the closer the value approaches 1, the closer two data are.
Engineering tool	A tool for configuring settings and performing programming, debugging, and maintenance for programmable controllers.
Frequency distribution	Divides a range into several intervals and indicates the distribution of the number of input data which belongs to each interval.
Kurtosis	An index which indicates how skewed the distribution of the input data is with the normal distribution used as the standard. When it is equal to the normal distribution, it is zero. Negative kurtosis indicates "distribution in which data scattered from around the mean", and positive kurtosis indicates "distribution biased toward data with small values".
Moving average	A method for smoothing the input data by taking the average values for the number of data items for moving average.
Skewness	An index which indicates how asymmetric the distribution of the input data is with the normal distribution used as the standard. When it is equal to the normal distribution, it is zero. A negative skewness indicates "distribution biased toward data with large values", and a positive skewness indicates "distribution biased toward data with small values".
Standard deviation	An index which indicates the degree of variation in the input data. The square root of the variance is the standard deviation.
Variance	An index which indicates the degree of variation in the input data. The greater the degree of variation in the input data is, the greater the variance is.

GENERIC TERMS AND ABBREVIATIONS

Unless otherwise specified, this reference uses the following generic terms and abbreviation.

Generic terms and abbreviation	Description
FB	FB is the abbreviation for Function Block. The FB is a generalized circuit block that is repeatedly used in a sequence program and designed to be diverted in the sequence program. This improves the efficiency of the program development and reduces the programming errors, resulting in the improvement in the program quality.
FX5	A generic term for FX5S, FX5UJ, FX5U, and FX5UC programmable controllers.
FX5 CPU module	A generic term for FX5S, FX5UJ, FX5U, and FX5UC CPU modules.

1 OVERVIEW

The function blocks (FBs) in this reference are for performing the statistical analysis.

1.1 FB List

The following table lists the FB libraries in this reference.



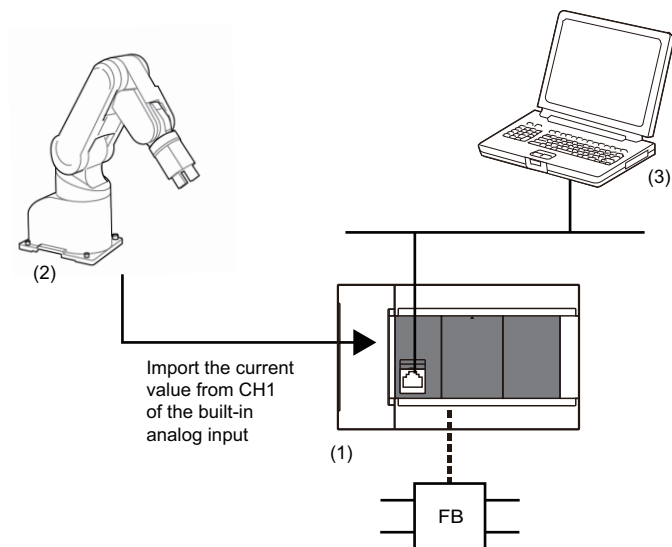
Note that this reference does not describe the FB version information which is displayed such as "_00A" at the end of FB name.

○: Necessary, —: Unnecessary

FB name	Description	Parameter setting necessity
M+DataStatistics_CoeffDetR2_F (Coefficient of determination calculation)	Calculates a coefficient of determination that indicates how close the predictive value is to the actual measurement value.	—
M+DataStatistics_MovingAverage_F (Moving average)	Obtains the moving average of the specified data.	—
M+DataStatistics_StdevSkewKurt_F (Standard deviation/Skewness/kurtosis)	Obtains the results of the standard deviation, kurtosis, and skewness calculation for the specified data.	—
M+DataStatistics_Variance_F (Variance)	Obtains the result of the variance calculation for the specified data.	—
M+DataStatistics_FrequencyDistribution_F (Frequency distribution)	Obtains the result of the frequency distribution calculation for the specified data.	—
M+DataStatistics_Boxplot_F (Box plot)	Obtains the calculation result for each element of the box plot based on the specified data.	—
M+DataStatistics_Different_F (differential)	Obtains the result of the differential calculation for the specified data.	—
M+DataStatistics_Integration_F (integral)	Obtains the result of the integral calculation for the specified data.	—

1.2 System Configuration

The following shows a system configuration example for using the FB described in this reference.



No.	Device
(1)	FX5 CPU module
(2)	Machine
(3)	Personal computer

MEMO

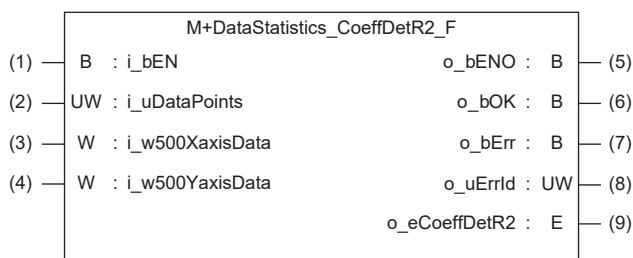
2 DETAILS OF THE FB LIBRARY

2.1 M+DataStatistics_CoeffDetR2_F (Coefficient of Determination Calculation)

2

Overview

By turning on i_bEN (Execution command), the coefficient of determination calculation processing is started.



Label

Input label

No.	Label	Label name	Data type	Setting range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_uDataPoints	Number of data points	Word [Unsigned]/Bit string [16-bit]	2 to 500	Specifies the number of data points for each axis.
(3)	i_w500XaxisData	X-axis data	Word [Signed] (0..499)	—	Specifies the start device No. which stores the predictive value.
(4)	i_w500YaxisData	Y-axis data	Word [Signed] (0..499)	—	Specifies the start device No. which stores the actual measurement value.

Output label

No.	Label	Label name	Data type	Default value	Description
(5)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is off.
(6)	o_bOK	Normal completion	Bit	OFF	When this label is on, it indicates that the coefficient of determination calculation has been completed without error.
(7)	o_bErr	Error completion	Bit	OFF	When this label is on, it indicates that an error has occurred in the FB.
(8)	o_uErrId	Error code	Word [Unsigned]/Bit string [16-bit]	0	The error code that occurred in the FB is stored.
(9)	o_eCoeffDetR2	Coefficient of determination	Single-precision real number	0	Stores the coefficient of determination value calculated from the predictive value and actual measurement value in single-precision real number.

Function overview

Applicable device

■CPU module

Applicable module	Firmware version	Engineering tool
FX5UJ CPU	1.000 or later	GX Works3 Version 1.060N or later
FX5U CPU, FX5UC CPU	1.100 or later	GX Works3 Version 1.047Z or later
FX5S CPU	1.000 or later	GX Works3 Version 1.080J or later

Basic specifications

Item	Description
Programming language	Ladder
Number of steps	476 steps The number of steps of the FB in a program depends on the CPU module used, input and output definition, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Label amount used	- Label: 1.06K points (Word) - Latch label: 0K points (Word) The label amount used in a program depends on the CPU module used, device specified in the argument, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Number of index register points used	- Index register: 0 points - Long index register: 0 points
File register amount used	File register: 0 points
FB dependence	No dependence
FB compiling method	Macro type
FB operation type	Pulsed execution (one scan execution type)

Function description

- The number of data points of the predictive value and actual measurement value with which the coefficient of determination is calculated is set in i_uDataPoints (Number of data points).
- The predictive value is set in i_w500XaxisData (X-axis data).
- The actual measurement value is set in i_w500YaxisData (Y-axis data).
- The coefficient of determination calculation processing is started by turning on i_bEN (Execution command), and the ON state of o_bENO (Execution status) is output. This FB calculates the coefficient of determination by the following expression.
- Covariance calculation

When each item is as follows, the covariance of the predictive value and actual measurement value are calculated by the following expression.

Total number of data	n
ith data value	X_i, Y_i
Average of X	$\bar{X}$
Average of Y	$\bar{Y}$

$$\text{Covariance} = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})$$

- Standard deviation calculation

When each item is as follows, each standard deviation of the predictive value and actual measurement value is calculated by the following expression. The standard deviation of the actual measurement value is calculated by substituting Y for X in the following table and the expression.

Total number of data	n
Value of each data	X_i
Average of data	$\bar{X}$

$$\text{Standard deviation} = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2}$$

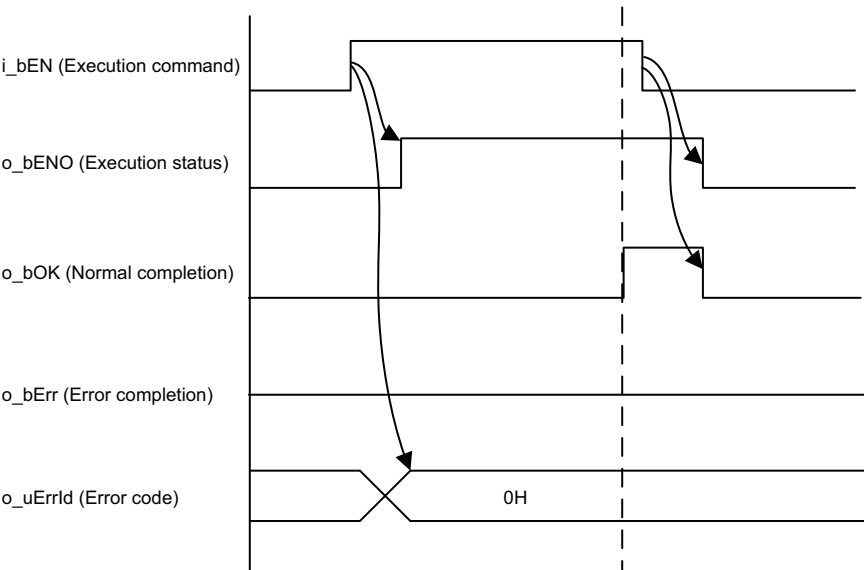
· Coefficient of determination calculation

$$\text{Coefficient of determination} = \left(\frac{\text{Covariance of the X-axis data and Y-axis data}}{\text{Standard deviation of X-axis data} \times \text{Standard deviation of Y-axis data}} \right)^2$$

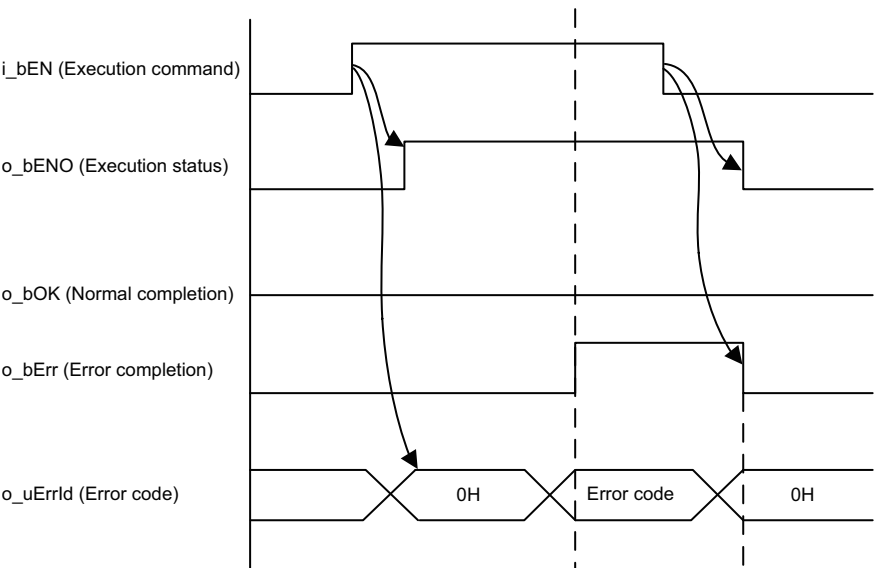
- When the input value is normal, o_bOK (Normal completion) is turned on and o_eCoeffDetR2 (Coefficient of determination) is output.
- When a value out of the range is set in i_uDataPoints (Number of data points), o_bErr (Error completion) turns on and the processing of the FB is interrupted. The error code 100H is stored in o_uErrId (Error code). For details of the error code, refer to [Page 12 Error code](#).
- When the value with which the coefficient of determination cannot be calculated is stored in i_w500XaxisData (X-axis data) or i_w500YaxisData (Y-axis data), o_bErr (Error completion) turns on and the processing of the FB is interrupted. The error code 101H is stored in o_uErrId (Error code). For details of the error code, refer to [Page 12 Error code](#).

Timing chart of I/O signals

■ Normal completion



■ Error completion



Restrictions and precautions

- This FB does not include error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- This FB cannot be used in an interrupt program.
- Using the FB in a program that is to be executed only once, such as a subroutine program or a FOR-NEXT loop, has a problem that i_bEN (Execution command) can no longer be turned off and normal operation is not possible; Always use the FB in a program that is capable of turning off i_bEN (Execution command).

Parameter setting

There is no required parameter setting to use this FB.

Application example

For details of the application example, refer to  Page 66 FB LIBRARY APPLICATION EXAMPLE.

Performance value

CPU	Measurement condition	Process time	Maximum scan time	Number of scans
FX5UJ	Number of data points: 2 points	0.254ms	0.752ms	1 scan
	Number of data points: 250 points	17.9ms	18.2ms	1 scan
	Number of data points: 500 points	35.0ms	35.3ms	1 scan
FX5U, FX5UC ^{*1*2}	Number of data points: 2 points	0.231ms	0.564ms	1 scan
	Number of data points: 250 points	15.5ms	15.9ms	1 scan
	Number of data points: 500 points	30.9ms	31.2ms	1 scan
FX5S	Number of data points: 2 points	0.448ms	1.01ms	1 scan
	Number of data points: 250 points	21.8ms	22.1ms	1 scan
	Number of data points: 500 points	42.6ms	43.0ms	1 scan

*1 When the program capacity is set to 128K steps, the process speed may be decreased.

*2 The standard area is used for the labels.

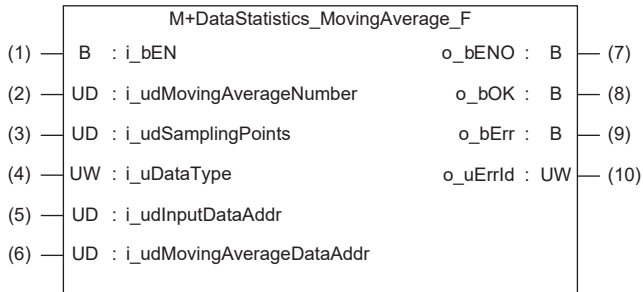
Error code

Error code (hexadecimal)	Description	Action
100H	The setting value of i_uDataPoints (Number of data points) is out of the range. The number of data points is not within the range of 2 to 500.	Review and correct the setting of i_uDataPoints (Number of data points) and then execute the FB again.
101H	The value with which the coefficient of determination cannot be calculated is stored in i_w500XaxisData (X-axis data) or i_w500YaxisData (Y-axis data). The same value is stored in the value of X-axis data or Y-axis data.	Review and correct the setting of i_w500XaxisData (X-axis data) or i_w500YaxisData (Y-axis data) and then execute the FB again.

2.2 M+DataStatistics_MovingAverage_F (Moving Average)

Overview

Obtains the moving average of the specified data.



Label

Input label

No.	Label	Label name	Data type	Setting range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_udMovingAverageNumber	Number of data items for moving average	Double word [Unsigned]/Bit string [32-bit]	1 to 8000	Set the number of data items for moving average to calculate the moving average.
(3)	i_udSamplingPoints	Number of sampling points	Double word [Unsigned]/Bit string [32-bit]	1 to 8000	Set the number of sampling points to be used for the moving average processing.
(4)	i_uDataType	Input data type selection	Word [Unsigned]/Bit string [16-bit]	0, 2	Specify the data type of the input data. 0: Word [Signed] 2: Single-precision real number
(5)	i_udInputDataAddr	Input data start address	Double word [Unsigned]/Bit string [32-bit]	Valid device range* ¹	Specify the start address of the file register (R) where the input data is stored.
(6)	i_udMovingAverageDataAddr	Output data start address	Double word [Unsigned]/Bit string [32-bit]	Valid device range* ¹	Specify the start address of the file register (R) where the result of the moving average calculation. Because the result of the moving average is output as a single-precision real number (2 words), it is output in the range of (number of sampling points × 2) from the file register (R) indicated by the output data start address.

*¹ The setting range differs depending on "Device/Label Memory Area Setting" in "CPU parameter".

Output label

No.	Label	Label name	Data type	Default value	Description
(7)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is off.
(8)	o_bOK	Normal completion	Bit	OFF	When this label is on, it indicates that the moving average calculation has been completed without error.
(9)	o_bErr	Error completion	Bit	OFF	When this label is on, it indicates that an error has occurred in the FB.
(10)	o_uErrId	Error code	Word [Unsigned]/Bit string [16-bit]	0	The error code that occurred in the FB is stored.

Function overview

Applicable device

■CPU module

Applicable module	Firmware version	Engineering tool
FX5UJ CPU	1.020 or later	GX Works3 Version 1.080J or later
FX5U CPU, FX5UC CPU	1.250 or later	GX Works3 Version 1.080J or later
FX5S CPU	1.000 or later	GX Works3 Version 1.080J or later

Basic specifications

Item	Description
Programming language	—(The program in this FB is not open to the public.)
Number of steps	895 steps The number of steps of the FB in a program depends on the CPU module used, input and output definition, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Label amount used	- Label: 0.06K points (Word) - Latch label: 0 points (Word) The label amount used in a program depends on the CPU module used, device specified in the argument, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Number of index register points used	- Index register: 3 points - Long index register: 0 points
File register amount used	Refer to Page 17 Restrictions and precautions .
FB dependence	No dependence
FB compiling method	Subroutine type
FB operation type	Pulsed execution (multiple scan execution type)

Function description

- When i_bEN (execution command) is turned on, the moving average of the specified input data is obtained. For the data for the number of sampling points from the specified input data start address, this FB calculates the average values of data for the number of data items for moving average and stores the values in the devices in the order from the output data start address.

This FB obtains the moving average value by the following expression.

j is the number of calculations, x_i is the i th input data, M is the value for the number of data items for moving average.

Number of calculations (j) < Number of data items for moving average (M)

$$\text{Moving average (j)} = \frac{\sum_{i=1}^j X_i}{j}$$

Number of calculations (j) ≥ Number of data items for moving average (M)

$$\text{Moving average (j)} = \frac{\sum_{i=j-M+1}^j X_i}{M}$$

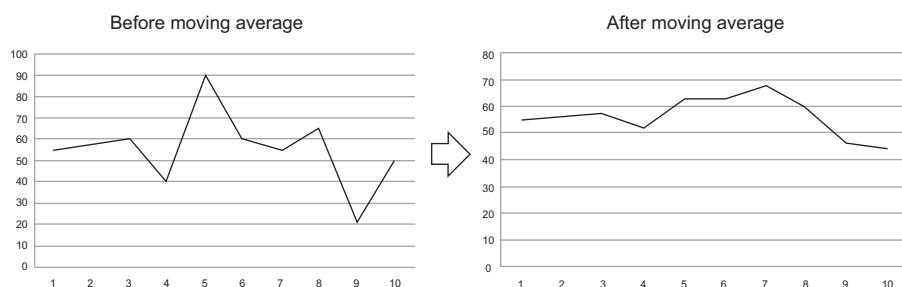
[Calculation example]

Setting example of input label

Label	Label name	Setting value
i_udMovingAverageNumber	Number of data items for moving average	3
i_udSamplingPoints	Number of sampling points	10
i_udInputDataAddr	Input data start address	0(R0)
i_udMovingAverageDataAddr	Output data start address	20(R20)

No.	Input data	No.	Output data	Calculation
1	R0 (Input data start address) 55	1	R20 (Output data start address) 55	Average of No. 1
2	R1 58	2	R22 56.5	Average of No. 1 and No. 2
3	R2 60	3	R24 57.66667	Average of No. 1, No. 2, and No. 3
4	R3 40	4	R26 52.66667	Average of No. 2, No. 3, and No. 4
5	R4 90	5	R28 63.33333	Average of No. 3, No. 4, and No. 5
6	R5 60	6	R30 63.33333	Average of No. 4, No. 5, and No. 6
7	R6 55	7	R32 68.33333	Average of No. 5, No. 6, and No. 7
8	R7 65	8	R34 60	Average of No. 6, No. 7, and No. 8
9	R8 20	9	R36 46.66667	Average of No. 7, No. 8, and No. 9
10	R9 50	10	R38 45	Average of No. 8, No. 9, and No. 10

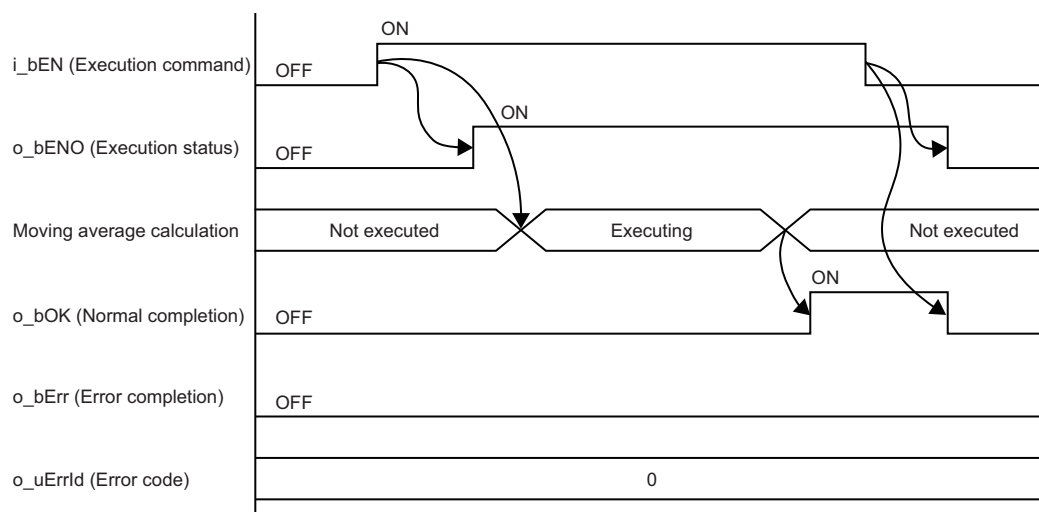
Because the result of the moving average is output as a single-precision real number (2 words), it is output in the range of (number of sampling points × 2) from the file register (R) indicated by the output data start address.



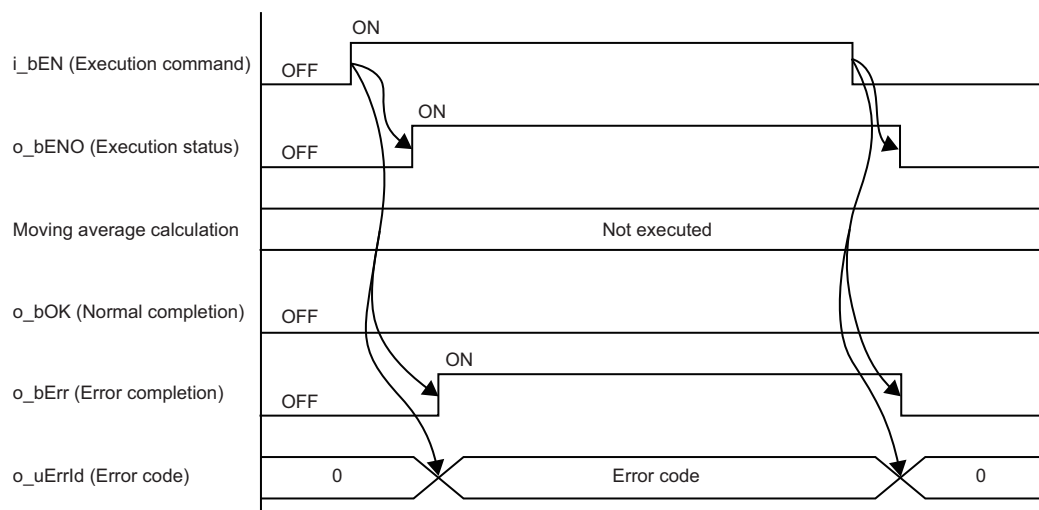
- The input data to be calculated for the moving average is read from the file register (R) whose address has been specified in i_udInputDataAddr (Input data start address). The input data is read for the number of points which has been specified in i_udSamplingPoints (Number of sampling points)
- The calculation result is output to the file register (R) whose address has been specified in i_udMovingAverageDataAddr (Output data start address) in the single-precision real number type. Areas for i_udSamplingPoints (Number of sampling points) × 2 words are occupied in the file register (R).
- It takes several scans to complete the moving average calculation. Therefore, do not change the input data to be calculated until the process is completed. After the moving average calculation is completed, o_bOK (Normal completion) turns on.
- If i_bEN (Execution command) is turned off while o_bOK (Normal completion) or o_bErr (Error completion) is not on, o_bErr (Error completion) turns on during one scan. The error code 205H is stored in o_uErrId (Error code) during one scan. For details of the error code, refer to [Page 19 Error code](#).
- If any other error occurs, o_bErr (Error completion) turns on and the processing of the FB is interrupted. For details of the error code, refer to [Page 19 Error code](#).

Timing chart of I/O signals

■Normal completion



■Error completion



Restrictions and precautions

- This FB does not include error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- This FB uses index registers Z0, Z1, and Z2. Please do not use these index registers in an interrupt program.
- This FB cannot be used in an interrupt program.
- Using the FB in a program that is to be executed only once, such as a subroutine program or a FOR-NEXT loop, has a problem that i_bEN (Execution command) can no longer be turned off and normal operation is not possible; Always use the FB in a program that is capable of turning off i_bEN (Execution command).
- This FB requires the configuration of the ladder for every input label.
- In this FB, the input data must be stored in the file register (R). In addition, the calculation result data must be output to the file register (R). For the file register (R) amount used, refer to the following.

i_uDataType (Input data type selection)	Size
0	i_udSamplingPoints (Number of sampling points) × 3 points
2	i_udSamplingPoints (Number of sampling points) × 4 points

- This FB checks the input data before executing the moving average calculation to prevent an overflow from occurring during the calculation. When an overflow is judged in this check, o_bErr (Error completion) turns on and the error code 203H is stored in o_uErrId (Error code). In the calculation of the single-precision real number, however, an error may be included depending on the combination of input data. In this case, an instruction execution error (calculation error) may occur even after checking.
- When i_bEN (Execution command) of this FB is on and the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module due to an error outside the FB, o_bErr (Error completion) turns on and the processing of the FB is interrupted. The error code 204H is stored in o_uErrId (Error code).
- When two or more of these FBs are used, precaution must be taken to avoid duplication of the area of the file register (R).
- This FB uses pulse commands in the program. Therefore, if the online program change performed while this FB is running, the correct result may not be obtained.

Parameter setting

There is no required parameter setting to use this FB.

Performance value

CPU	Input label			Process time	Maximum scan time	Number of scans
	Number of sampling points	Input data type	Number of data items for moving average			
FX5UJ	100 points	0: Word [Signed]	1	9.05ms	2.25ms	5 scans
			50	9.06ms	1.97ms	5 scans
			100	9.47ms	2.32ms	5 scans
		2: Single-precision real number	1	9.10ms	2.09ms	5 scans
			50	9.50ms	2.06ms	5 scans
			100	9.65ms	1.99ms	5 scans
	4,000 points	0: Word [Signed]	1	338ms	2.14ms	200 scans
			2000	330ms	2.34ms	200 scans
			4000	333ms	2.22ms	200 scans
		2: Single-precision real number	1	446ms	2.47ms	200 scans
			2000	354ms	2.39ms	200 scans
			4000	345ms	2.33ms	200 scans
	8000 points	0: Word [Signed]	1	679ms	2.33ms	400 scans
			4000	662ms	2.32ms	400 scans
			8000	646ms	2.22ms	400 scans
		2: Single-precision real number	1	896ms	2.46ms	400 scans
			4000	700ms	2.29ms	400 scans
			8000	689ms	2.35ms	400 scans
FX5U, FX5UC ^{*1,2}	100 points	0: Word [Signed]	1	7.11ms	1.76ms	5 scans
			50	7.15ms	1.87ms	5 scans
			100	8.07ms	1.64ms	5 scans
		2: Single-precision real number	1	8.75ms	1.93ms	5 scans
			50	8.81ms	2.03ms	5 scans
			100	8.87ms	1.72ms	5 scans
	4000 points	0: Word [Signed]	1	295ms	1.86ms	200 scans
			2000	290ms	1.81ms	200 scans
			4000	284ms	1.79ms	200 scans
		2: Single-precision real number	1	310ms	1.88ms	200 scans
			2000	303ms	1.89ms	200 scans
			4000	298ms	1.84ms	200 scans
	8000 points	0: Word [Signed]	1	590ms	1.81ms	400 scans
			4000	578ms	1.88ms	400 scans
			8000	567ms	1.94ms	400 scans
		2: Single-precision real number	1	621ms	2.05ms	400 scans
			4000	608ms	1.92ms	400 scans
			8000	595ms	1.82ms	400 scans

CPU	Input label			Process time	Maximum scan time	Number of scans
	Number of sampling points	Input data type	Number of data items for moving average			
FX5S	100 points	0: Word [Signed]	1	11.1ms	2.73ms	5 scans
			50	11.1ms	2.58ms	5 scans
			100	1.50ms	2.75ms	5 scans
		2: Single-precision real number	1	12.1ms	2.76ms	5 scans
			50	11.5ms	2.90ms	5 scans
			100	10.0ms	2.37ms	5 scans
	4000 points	0: Word [Signed]	1	420ms	2.58ms	200 scans
			2000	417ms	2.72ms	200 scans
			4000	410ms	2.84ms	200 scans
		2: Single-precision real number	1	442ms	2.71ms	200 scans
			2000	438ms	2.75ms	200 scans
			4000	430ms	2.81ms	200 scans
	8000 points	0: Word [Signed]	1	848ms	2.78ms	400 scans
			4000	826ms	2.52ms	400 scans
			8000	819ms	2.72ms	400 scans
		2: Single-precision real number	1	881ms	2.70ms	400 scans
			4000	874ms	2.80ms	400 scans
			8000	870ms	2.93ms	400 scans

*1 When the program capacity is set to 128K steps, the process speed may be decreased.

*2 The standard area is used for the labels.

Error code

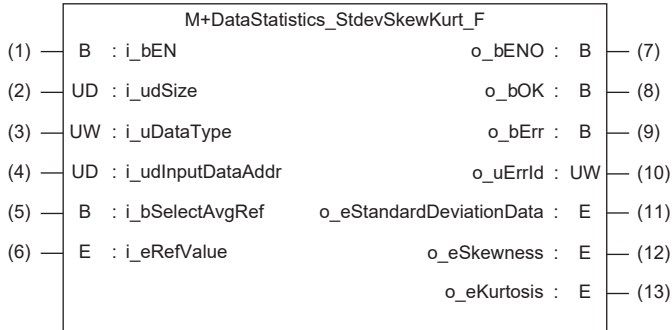
Error code (hexadecimal)	Description	Action
103H	The setting value of i_udDataType (Input data type selection) is out of the range.	Set 0 or 2 in i_udDataType (Input data type selection). Review and correct the setting and then execute the FB again.
105H	The setting value of i_udSamplingPoints (Number of sampling points) is out of the range.	Set a value from 1 to 8000 in i_udSamplingPoints (Number of sampling points). Review and correct the setting and then execute the FB again.
115H	The setting value of i_udMovingAverageNumber (Number of data items for moving average) is out of the range.	For i_udMovingAverageNumber (Number of data items for moving average), set a value that satisfies the following conditions. - i_udMovingAverageNumber (Number of data items for moving average) ≥ 1 - i_udMovingAverageNumber (Number of data items for moving average) $\leq i_udSamplingPoints$ (Number of sampling points) Review and correct the setting and then execute the FB again.
11DH	The ranges of the input data and the output data overlap.	Review and correct the settings below so that the ranges of the input data and the output data do not overlap. - i_udSamplingPoints (Number of sampling points) - i_udInputDataAddr (Input data start address) - i_udMovingAverageDataAddr (Output data start address) Review and correct the setting and then execute the FB again.
11EH	The range of the input or the output data exceeds the range of the file register.	Review and correct the settings below so that the range of the input data or the output data does not exceed the range of the file register. - i_udSamplingPoints (Number of sampling points) - i_udInputDataAddr (Input data start address) - i_udMovingAverageDataAddr (Output data start address) Review and correct the setting and then execute the FB again.
200H	Although the setting value of i_udDataType (Input data type selection) is set to a single-precision real number, the stored input data is not in the single-precision real number format.	Store the value in the file register (R) again in the single-precision real number format. Review and correct the input data and then execute the FB again.

Error code (hexadecimal)	Description	Action
203H	The calculation has overflowed in the FB.	Review and correct the input data stored in the file register (R) and then execute the FB again. When the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module, refer to MELSEC iQ-F FX5 User's Manual (Application) .
204H	Because an overflow has occurred in the calculation other than this FB, the processing of the FB is stopped.	An overflow has occurred in the calculation other than this FB, and the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module. Refer to MELSEC iQ-F FX5 User's Manual (Application) .
205H	i_bEN (Execution command) has been turned off during the processing.	Keep the ON state of i_bEN (Execution command) until o_bOK (Normal completion) or o_bErr (Error completion) turns on.

2.3 M+DataStatistics_StdevSkewKurt_F (Standard deviation/Skewness/kurtosis)

Overview

The results of the standard deviation, kurtosis, and skewness calculation for the specified data are obtained.



Label

Input label

No.	Label	Label name	Data type	Setting range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_udSize	Number of data points	Double word [Unsigned]/Bit string [32-bit]	1 to 16000	Set the number of input data points to calculate the standard deviation.
(3)	i_uDataType	Input data type selection	Word [Unsigned]/Bit string [16-bit]	0, 2	Specify the data type of the input data. 0: Word [Signed] 2: Single-precision real number
(4)	i_udInputDataAddr	Input data start address	Double word [Unsigned]/Bit string [32-bit]	Valid device range ^{*1}	Specify the start address of the file register (R) where the input data is stored.
(5)	i_bSelectAvgRef	Average/reference value selection	Bit	ON, OFF	ON: The standard deviation is calculated according to the input data and i_eRefValue (Reference value). OFF: The standard deviation is calculated according to the average value of the input data. The value in i_eRefValue (Reference value) is ignored.
(6)	i_eRefValue	Reference value	Single-precision real number	• -2^{128} to -2^{-126} ($-3.402823\text{E}+38$ to $-1.175494\text{E}-38$) • 0 • 2^{-126} to 2^{128} ($1.175494\text{E}-38$ to $3.402823\text{E}+38$)	Set the reference value to calculate the standard deviation. When i_bSelectAvgRef (Average/reference value selection) is off, the setting value is ignored.

^{*1} The setting range differs depending on "Device/Label Memory Area Setting" in "CPU parameter".

Output label

No.	Label	Label name	Data type	Default value	Description
(7)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is off.
(8)	o_bOK	Normal completion	Bit	OFF	When this label is on, it indicates that the standard deviation calculation has been completed.
(9)	o_bErr	Error completion	Bit	OFF	When this label is on, it indicates that an error has occurred in the FB.
(10)	o_uErrId	Error code	Word [Unsigned]/Bit string [16-bit]	0	The error code that occurred in the FB is stored.
(11)	o_eStandardDeviationData	Output data	Single-precision real number	0	Stores the result of the standard deviation calculation.
(12)	o_eSkewness	Output data	Single-precision real number	0	Stores the result of the skewness calculation.
(13)	o_eKurtosis	Output data	Single-precision real number	0	Stores the result of the kurtosis calculation.

Function overview

Applicable device

■CPU module

Applicable module	Firmware version	Engineering tool
FX5UJ CPU	1.020 or later	GX Works3 Version 1.080J or later
FX5U CPU, FX5UC CPU	1.250 or later	GX Works3 Version 1.080J or later
FX5S CPU	1.000 or later	GX Works3 Version 1.080J or later

Basic specifications

Item	Description
Programming language	—(The program in this FB is not open to the public.)
Number of steps	895 steps The number of steps of the FB in a program depends on the CPU module used, input and output definition, and option settings of GX Works3. For the option settings of GX Works3, refer to  GX Works3 Operating Manual.
Label amount used	- Label: 0.085K points (Word) - Latch label: 0 points (Word) The label amount used in a program depends on the CPU module used, device specified in the argument, and option settings of GX Works3. For the option settings of GX Works3, refer to  GX Works3 Operating Manual.
Number of index register points used	- Index register: 1 point - Long index register: 0 points
File register amount used	Refer to  Page 27 Restrictions and precautions.
FB dependence	No dependence
FB compiling method	Subroutine type
FB operation type	Pulsed execution (multiple scan execution type)

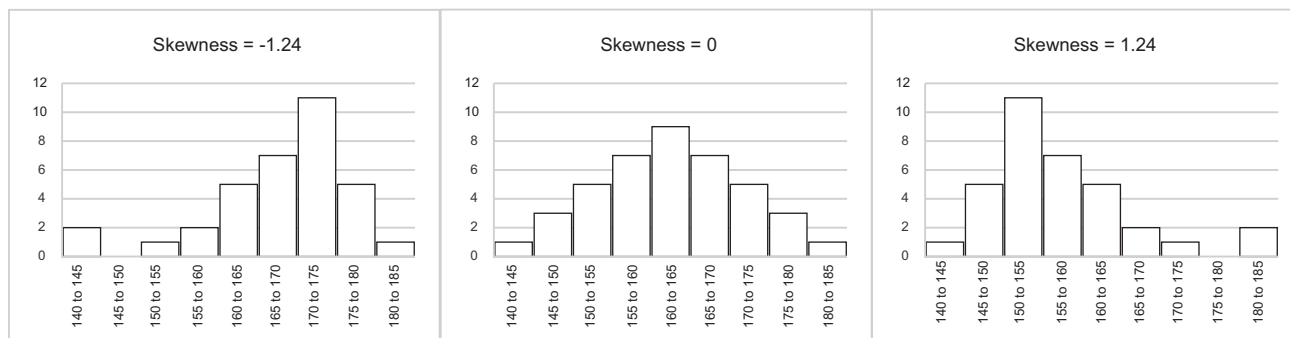
Function description

■Skewness

Skewness is a statistic that indicates how much a distribution is skewed from the normal distribution, and is an index that shows symmetry. When the sample size is n , the average value of each data x_i ($i: 1, 2, \dots, n$) is $\bar{x}$, and the standard deviation is s , the kurtosis can be obtained from the following expression.

$$\frac{n}{(n-1)(n-2)} \times \sum_{i=1}^n \frac{(x_i - \bar{x})^3}{s_i^3}$$

Skewness becomes a positive value when the distribution is "skewed to the right" or "deviated to the left" and a negative value when the distribution is "skewed to the left" or "deviated to the right". When the distribution is symmetrical (normal distribution), the skewness is zero.

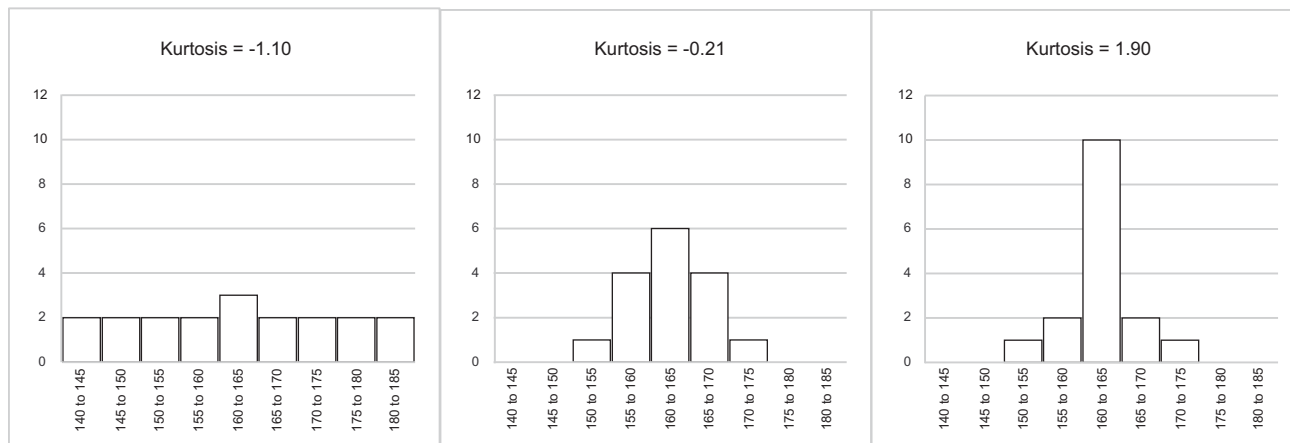


■Kurtosis

Kurtosis is a statistic that indicates how much the distribution is peaked from the normal distribution, and is an index of the peakedness and width of the base of the mountain. When the sample size is n , the average value of each data x_i ($i: 1, 2, \dots, n$) is $\bar{x}$, and the standard deviation is s , the kurtosis can be obtained from the following expression.

$$\frac{n \times (n+1)}{(n-1)(n-2)(n-3)} \times \sum_{i=1}^n \frac{(x_i - \bar{x})^4}{s_i^4} - \frac{3 \times (n-1)^2}{(n-2)(n-3)}$$

Kurtosis becomes a positive value when the distribution is more peaked than the normal distribution, and a negative value when the distribution is flatter than the normal distribution. When the distribution is normal, the kurtosis is zero.



- When i_bEN (Execution command) is turned on, the standard deviation, skewness, and kurtosis of the specified input data are obtained by the following expression.

When i_bSelectAvgRef (Average/reference value selection) is off

The calculation is performed according to the input data and the average value of the input data.

n is the number of data points, x_i is the i-th data, $\bar{x}$ is the average value of data for the number of data points (n) from the input data start address, and s_1 is the standard deviation.

$$s_1 = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2}$$

$$\text{Skewness} = \frac{n}{(n-1)(n-2)} \times \sum_{i=1}^n \frac{(x_i - \bar{x})^3}{s_1^3}$$

$$\text{Kurtosis} = \frac{n \times (n+1)}{(n-1)(n-2)(n-3)} \times \sum_{i=1}^n \frac{(x_i - \bar{x})^4}{s_1^4} - \frac{3 \times (n-1)^2}{(n-2)(n-3)}$$

[Calculation example]

Setting example of input label

Label	Label name	Setting value
i_udSize	Number of data points	5
i_udInputDataAddr	Input data start address	0(R0)
i_uDataType	Input data type selection	0
i_bSelectAvgRef	Average/reference value selection	OFF
i_eRefValue	Reference value	0

Example of input data

Input data	Input value
R0 (Input data start address)	10
R1	20
R2	30
R3	40
R4	55

At this time, $\bar{x}$ is $(10 + 20 + 30 + 40 + 55) / 5 = 31.0$.

If these are applied to the standard deviation, skewness, and kurtosis expressions, the calculation is as follows.

Standard deviation

$$\sqrt{\frac{(R0 - \bar{x})^2 + (R1 - \bar{x})^2 + (R2 - \bar{x})^2 + (R3 - \bar{x})^2 + (R4 - \bar{x})^2}{n}} \approx 15.6$$

Skewness

$$\frac{n}{(n-1)(n-2)} \times \frac{(R0 - \bar{x})^3 + (R1 - \bar{x})^3 + (R2 - \bar{x})^3 + (R3 - \bar{x})^3 + (R4 - \bar{x})^3}{s_1^3} \approx 0.432$$

Kurtosis

$$\frac{n \times (n+1)}{(n-1)(n-2)(n-3)} \times \frac{(R0 - \bar{x})^4 + (R1 - \bar{x})^4 + (R2 - \bar{x})^4 + (R3 - \bar{x})^4 + (R4 - \bar{x})^4}{s_1^4} - \frac{3 \times (n-1)^2}{(n-2)(n-3)} \approx 3.494$$

When i_bSelectAvgRef (Average/reference value selection) is on

The calculation is performed according to the input data and i_eRefValue (Reference value).

n is the number of data points, x_i is the i-th data, s_2 is the standard deviation, and y is the reference value.

$$s_2 = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - y)^2}$$

$$\text{Skewness} = \frac{n}{(n-1)(n-2)} \times \sum_{i=1}^n \frac{(x_i - y)^3}{s_2^3}$$

$$\text{Kurtosis} = \frac{n \times (n+1)}{(n-1)(n-2)(n-3)} \times \sum_{i=1}^n \frac{(x_i - y)^4}{s_2^4} - \frac{3 \times (n-1)^2}{(n-2)(n-3)}$$

[Calculation example]

Setting example of input label

Label	Label name	Setting value
i_udSize	Number of data points	5
i_udInputDataAddr	Input data start address	0(R0)
i_uDataType	Input data type selection	0
i_bSelectAvgRef	Average/reference value selection	ON
i_eRefValue	Reference value	30

Example of input data

Input data	Input value
R0 (Input data start address)	10
R1	20
R2	30
R3	40
R4	55

If these are applied to the standard deviation expression, the calculation is as follows.

Standard deviation

$$\sqrt{\frac{(R0 - y)^2 + (R1 - y)^2 + (R2 - y)^2 + (R3 - y)^2 + (R4 - y)^2}{n}} \approx 15.6$$

Skewness

$$\frac{n}{(n-1)(n-2)} \times \frac{(R0 - y)^3 + (R1 - y)^3 + (R2 - y)^3 + (R3 - y)^3 + (R4 - y)^3}{s_2^3} \approx 0.432$$

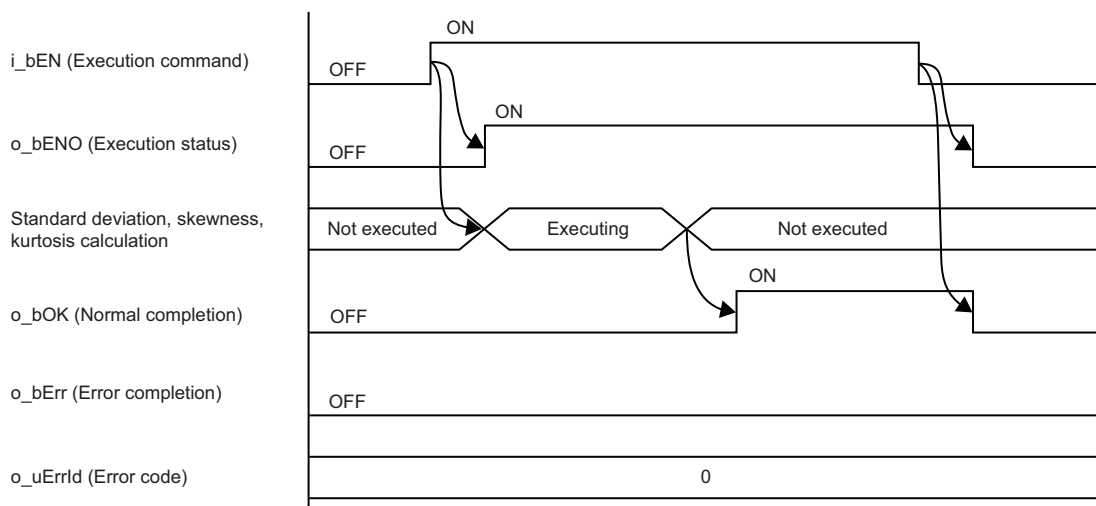
Kurtosis

$$\frac{n \times (n+1)}{(n-1)(n-2)(n-3)} \times \frac{(R0 - y)^4 + (R1 - y)^4 + (R2 - y)^4 + (R3 - y)^4 + (R4 - y)^4}{s_2^4} - \frac{3 \times (n-1)^2}{(n-2)(n-3)} \approx 3.494$$

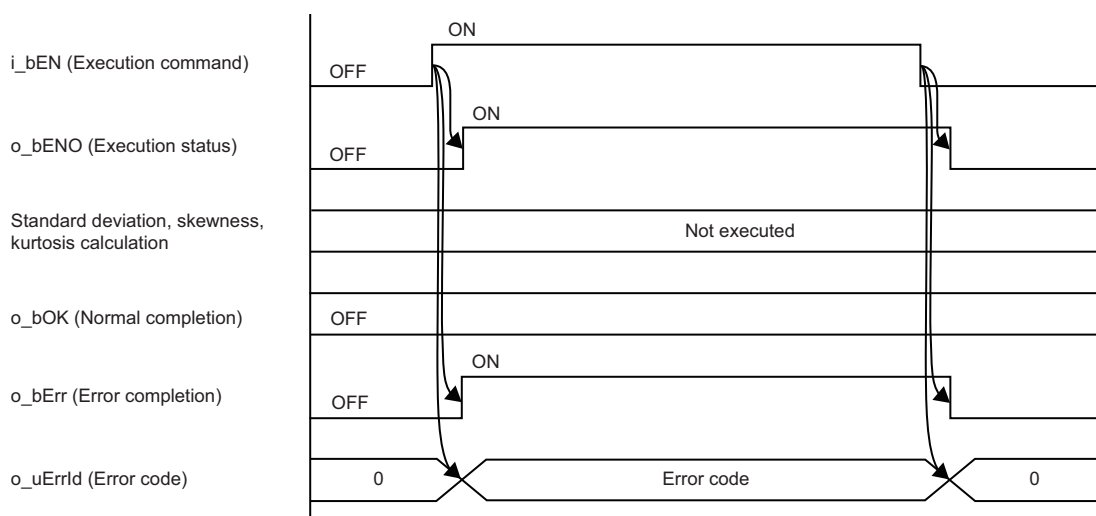
- The input data to be calculated for the standard deviation, skewness, and kurtosis are read from the file register (R) whose address has been specified in i_udInputDataAddr (Input data start address). The input data is read for the number of points which has been specified in i_udSize (Number of data points).
- The calculation results are output to o_eStandardDeviationData (Output data (standard deviation)), o_eSkewness (Output data (skewness)), and o_eKurtosis (Output data (kurtosis)) in the single-precision real number type.
- It takes several scans to complete the standard deviation calculation. Therefore, do not change the input data to be calculated until the process is completed. After the standard deviation calculation is completed, o_bOK (Normal completion) turns on.
- If i_bEN (Execution command) is turned off while o_bOK (Normal completion) or o_bErr (Error completion) is not on, o_bErr (Error completion) turns on during one scan. The error code 205H is stored in o_uErrId (Error code) during one scan. For details of the error code, refer to [Page 29 Error code](#).
- If any other error occurs, o_bErr (Error completion) turns on and the processing of the FB is interrupted. For details of the error code, refer to [Page 29 Error code](#).
- If i_udSize (Number of data points) n is less than 3 points in the skewness calculation, "0" is output to o_eSkewness (Output label). However, it is not treated as an error.
- If i_udSize (Number of data points) n is less than 4 points in the kurtosis processing, "0" is output to o_eKurtosis (Output data). However, it is not treated as an error.

Timing chart of I/O signals

■Normal completion



■Error completion



Restrictions and precautions

- This FB does not include error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- This FB uses index register Z0. Please do not use these index registers in an interrupt program.
- This FB cannot be used in an interrupt program.
- Using the FB in a program that is to be executed only once, such as a subroutine program or a FOR-NEXT loop, has a problem that i_bEN (Execution command) can no longer be turned off and normal operation is not possible; Always use the FB in a program that is capable of turning off i_bEN (Execution command).
- This FB requires the configuration of the ladder for every input label.
- In this FB, the input data must be stored in the file register (R). For the file register (R) amount used, refer to the following.

i_uDataType (Input data type selection)	Size
0	i_udSize (Number of data points) × 1 point
2	i_udSize (Number of data points) × 2 points

- This FB checks the input data before executing standard deviation calculation to prevent an overflow from occurring during the calculation. When an overflow is judged in this check, o_bErr (Error completion) turns on and the error code 203H is stored in o_uErrId (Error code). In the calculation of the single-precision real number, however, an error may be included depending on the combination of input data. In this case, an instruction execution error (calculation error) may occur even after checking.
- When i_bEN (Execution command) of this FB is on and the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module due to an error outside the FB, o_bErr (Error completion) turns on and the processing of the FB is stopped. The error code 204H is stored in o_uErrId (Error code).
- When two or more of these FBs are used, precaution must be taken to avoid duplication of the area of the file register (R).
- This FB uses pulse commands in the program. Therefore, if the online program change performed while this FB is running, the correct result may not be obtained.

Parameter setting

There is no required parameter setting to use this FB.

Performance value

CPU	Input label			Process time	Maximum scan time	Number of scans
	Number of sampling points	Input data type	Average/ reference value selection			
FX5UJ	2 points	0: Word [Signed]	OFF: Average value	1.46ms	1.04ms	2 scans
			ON: Reference value	0.54ms	1.04ms	1 scan
		2: Single-precision real number	OFF: Average value	1.47ms	1.04ms	2 scans
			ON: Reference value	0.554ms	1.04ms	1 scan
	8000 points	0: Word [Signed]	OFF: Average value	4.80s	1.46ms	5333 scans
			ON: Reference value	10.5s	1.47ms	18664 scans
		2: Single-precision real number	OFF: Average value	4.84s	1.51ms	5333 scans
			ON: Reference value	10.6s	1.53ms	18664 scans
	16000 points	0: Word [Signed]	OFF: Average value	9.59s	1.47ms	10666 scans
			ON: Reference value	20.9s	1.54ms	37331 scans
		2: Single-precision real number	OFF: Average value	9.59s	1.53ms	10666 scans
			ON: Reference value	21.1s	1.56ms	37331 scans
FX5U, FX5UC ^{*1*2}	2 points	0: Word [Signed]	OFF: Average value	1.29s	0.798ms	2 scans
			ON: Reference value	0.50ms	0.835ms	1 scan
		2: Single-precision real number	OFF: Average value	1.29ms	0.801ms	2 scans
			ON: Reference value	0.507ms	0.873ms	1 scan
	8000 points	0: Word [Signed]	OFF: Average value	4.19s	1.22ms	5333 scans
			ON: Reference value	9.02s	1.22ms	18664 scans
		2: Single-precision real number	OFF: Average value	4.23s	1.22ms	5333 scans
			ON: Reference value	9.12s	1.24ms	18664 scans
	16000 points	0: Word [Signed]	OFF: Average value	8.38s	1.22ms	10666 scans
			ON: Reference value	18.1s	1.22ms	37331 scans
		2: Single-precision real number	OFF: Average value	8.45s	1.22ms	10666 scans
			ON: Reference value	18.3s	1.24ms	37331 scans
FX5S	2 points	0: Word [Signed]	OFF: Average value	1.78ms	1.22ms	2 scans
			ON: Reference value	1.8ms	1.28ms	1 scan
		2: Single-precision real number	OFF: Average value	0.675ms	1.28ms	2 scans
			ON: Reference value	0.695ms	1.28ms	1 scan
	8000 points	0: Word [Signed]	OFF: Average value	6.46s	1.84ms	5333 scans
			ON: Reference value	13.8s	1.85ms	18665 scans
		2: Single-precision real number	OFF: Average value	6.54s	1.85ms	5333 scans
			ON: Reference value	13.9s	1.87ms	18665 scans
	16000 points	0: Word [Signed]	OFF: Average value	13.0s	1.84ms	37331 scans
			ON: Reference value	27.6s	1.86ms	37331 scans
		2: Single-precision real number	OFF: Average value	13.1s	1.88ms	37331 scans
			ON: Reference value	27.8s	1.93ms	37331 scans

*1 When the program capacity is set to 128K steps, the process speed may be decreased.

*2 The standard area is used for the labels.

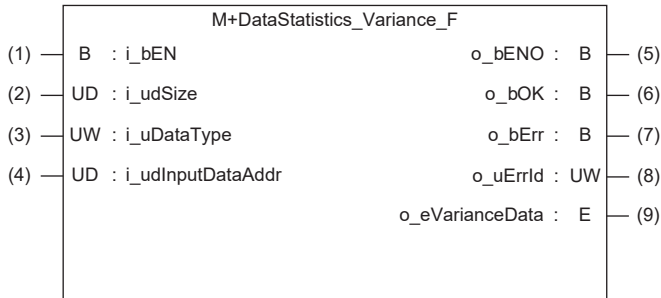
Error code

Error code (hexadecimal)	Description	Action
103H	The setting value of i_uDataType (Input data type selection) is out of the range.	Set 0 or 2 in i_uDataType (Input data type selection). Review and correct the setting and then execute the FB again.
105H	The setting value of i_udSize (Number of data points) is out of the range.	Set a value from 1 to 16000 in i_udSize (Number of data points). Review and correct the setting and then execute the FB again.
11EH	The range of the input data exceeds the range of the file register.	Review and correct the settings below so that the range of the input data does not exceed the range of the file register. • i_udSize (Number of data points) • i_udInputDataAddr (Input data start address) Review and correct the setting and then execute the FB again.
200H	Although the setting value of i_uDataType (Input data type selection) is set to a single-precision real number, the stored input data is not in the single-precision real number format.	Store the value in the file register (R) again in the single-precision real number format. Review and correct the input data and then execute the FB again.
203H	The calculation has overflowed in the FB.	Review and correct the input data stored in the file register (R) and then execute the FB again. When the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module, refer to MELSEC iQ-F FX5 User's Manual (Application).
204H	Because an overflow has occurred in the calculation other than this FB, the processing of the FB is stopped.	An overflow has occurred in the calculation other than this FB, and the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module. Refer to MELSEC iQ-F FX5 User's Manual (Application).
205H	i_bEN (Execution command) has been turned off during the processing.	Keep the ON state of i_bEN (Execution command) until o_bOK (Normal completion) or o_bErr (Error completion) turns on.
206H	The setting value of i_eRefValue (Reference value) is not in the single-precision real number format.	In i_eRefValue (Reference value), store a value in the single-precision real number format. Review and correct the setting and then execute the FB again.

2.4 M+DataStatistics_Variance_F (Variance)

Overview

The results of the variance calculation for the specified data are obtained.



Label

Input label

No.	Label	Label name	Data type	Setting range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_udSize	Number of data points	Double word [Unsigned]/Bit string [32-bit]	1 to 16000	Set the number of input data points to calculate the variance.
(3)	i_uDataType	Input data type selection	Word [Unsigned]/Bit string [16-bit]	0, 2	Specify the data type of the input data. 0: Word [Signed] 2: Single-precision real number
(4)	i_udInputDataAddr	Input data start address	Double word [Unsigned]/Bit string [32-bit]	Valid device range ^{*1}	Specify the start address of the file register (R) where the input data is stored.

^{*1} The setting range differs depending on "Device/Label Memory Area Setting" in "CPU parameter".

Output label

No.	Label	Label name	Data type	Default value	Description
(5)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is off.
(6)	o_bOK	Normal completion	Bit	OFF	When this label is on, it indicates that the variance calculation has been completed.
(7)	o_bErr	Error completion	Bit	OFF	When this label is on, it indicates that an error has occurred in the FB.
(8)	o_uErrId	Error code	Word [Unsigned]/Bit string [16-bit]	0	The error code that occurred in the FB is stored.
(9)	o_eVarianceData	Output data	Single-precision real number	0	Stores the result of the variance calculation.

Function overview

Applicable device

■CPU module

Applicable module	Firmware version	Engineering tool
FX5UJ CPU	1.020 or later	GX Works3 Version 1.080J or later
FX5U CPU, FX5UC CPU	1.250 or later	GX Works3 Version 1.080J or later
FX5S CPU	1.000 or later	GX Works3 Version 1.080J or later

Basic specifications

Item	Description
Programming language	—(The program in this FB is not open to the public.)
Number of steps	828 steps The number of steps of the FB in a program depends on the CPU module used, input and output definition, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Label amount used	- Label: 0.05K points (Word) - Latch label: 0 points (Word) The label amount used in a program depends on the CPU module used, device specified in the argument, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual.
Number of index register points used	- Index register: 1 point - Long index register: 0 points
File register amount used	Refer to Page 33 Restrictions and precautions .
FB dependence	No dependence
FB compiling method	Subroutine type
FB operation type	Pulsed execution (multiple scan execution type)

Function description

- When i_bEN (Execution command) is turned on, the variance of the specified input data is obtained. This FB calculates the variance by the following expression. N is the number of data points, x_i is the i-th data, and $\bar{x}$ is the average value of data for the number of data points (N) from the input data start address.

$$\text{Variance} = \frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^2$$

[Calculation example]

Setting example of input label

Label	Label name	Setting value
i_udSize	Number of data points	3
i_udInputDataAddr	Input data start address	0(R0)
i_udDataType	Input data type selection	0

Example of input data

Input data	Input value
R0 (Input data start address)	10
R1	20
R2	30

At this time, $\bar{x}$ is $(10 + 20 + 30) / 3 = 20$.

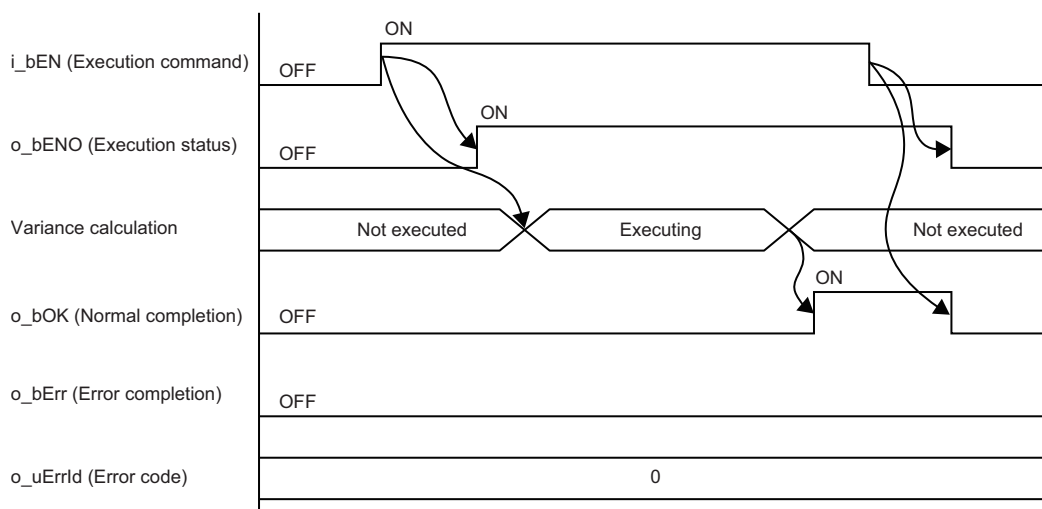
If these are applied to the variance expression, the calculation is as follows.

$$\frac{(10 - 20)^2 + (20 - 20)^2 + (30 - 20)^2}{3} \approx 66.66$$

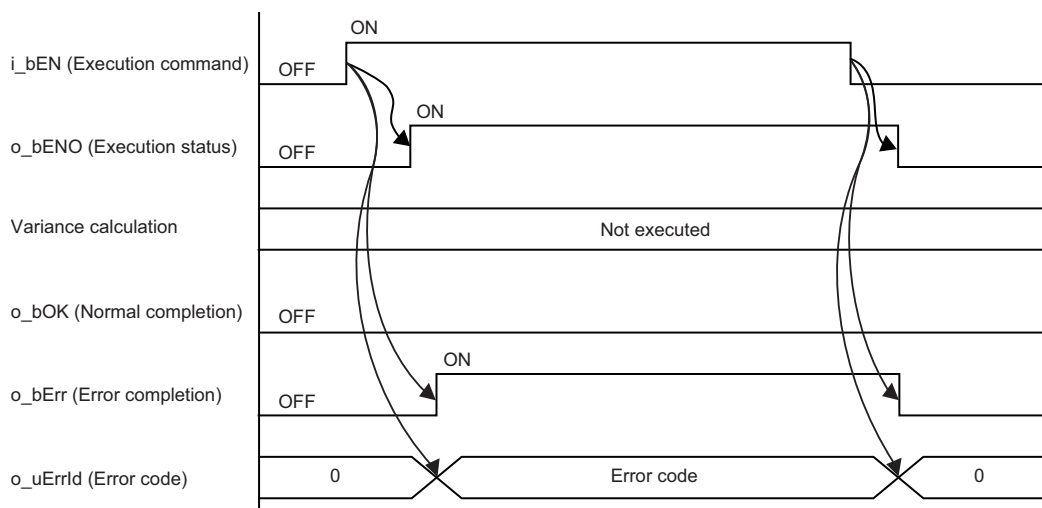
- The input data to be calculated for the variance is read from the file register (R) whose address has been specified in `i_udInputDataAddr` (Input data start address). The input data is read for the number of points which has been specified in `i_udSize` (Number of data points).
- The calculation result is output to `o_eVarianceData` (Output data) in the single-precision real number type.
- It takes several scans to complete the variance calculation. Therefore, do not change the input data to be calculated until the process is complete. After the variance calculation is complete, `o_bOK` (Normal completion) turns on.
- If `i_bEN` (Execution command) is turned off while `o_bOK` (Normal completion) or `o_bErr` (Error completion) is not on, `o_bErr` (Error completion) turns on during one scan. The error code 205H is stored in `o_uErrId` (Error code) during one scan. For details of the error code, refer to [Page 34 Error code](#).
- If any other error occurs, `o_bErr` (Error completion) turns on and the processing of the FB is interrupted. For details of the error code, refer to [Page 34 Error code](#).

Timing chart of I/O signals

■Normal completion



■Error completion



Restrictions and precautions

- This FB does not include error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- This FB uses index register Z0. Please do not use these index registers in an interrupt program.
- This FB cannot be used in an interrupt program.
- Using the FB in a program that is to be executed only once, such as a subroutine program or a FOR-NEXT loop, has a problem that i_bEN (Execution command) can no longer be turned off and normal operation is not possible; Always use the FB in a program that is capable of turning off i_bEN (Execution command).
- This FB requires the configuration of the ladder for every input label.
- In this FB, the input data must be stored in the file register (R). For the file register (R) amount used, refer to the following.

i_uDataType (Input data type selection)	Size
0	i_udSize (Number of data points) × 1 point
2	i_udSize (Number of data points) × 2 points

- This FB checks the input data before executing the variance calculation to prevent an overflow from occurring during the calculation. When an overflow is judged in this check, o_bErr (Error completion) turns on and the error code 203H is stored in o_uErrId (Error code). In the calculation of the single-precision real number, however, an error may be included depending on the combination of input data. In this case, an instruction execution error (calculation error) may occur even after checking.
- When i_bEN (Execution command) of this FB is on and the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module due to an error outside the FB, o_bErr (Error completion) turns on and the processing of the FB is interrupted. The error code 204H is stored in o_uErrId (Error code).
- When two or more of these FBs are used, precaution must be taken to avoid duplication of the area of the file register (R).
- This FB uses pulse commands in the program. Therefore, if the online program change performed while this FB is running, the correct result may not be obtained.

Parameter setting

There is no required parameter setting to use this FB.

Performance value

CPU	Input label		Process time	Maximum scan time	Number of scans
	Number of sampling points	Input data type			
FX5UJ	2 points	0: Word [Signed]	0.761ms	0.772ms	2 scans
		2: Single-precision real number	0.784ms	0.792ms	2 scans
	8000 points	0: Word [Signed]	1290ms	2.36ms	799 scans
		2: Single-precision real number	1320ms	2.30ms	799 scans
	16000 points	0: Word [Signed]	2560ms	2.37ms	1599 scans
		2: Single-precision real number	2630ms	2.30ms	1599 scans
FX5U, FX5UC ^{*1*2}	2 points	0: Word [Signed]	0.608ms	0.589ms	2 scans
		2: Single-precision real number	0.617ms	1.03ms	2 scans
	8000 points	0: Word [Signed]	1140ms	1.95ms	799 scans
		2: Single-precision real number	1290ms	1.86ms	799 scans
	16000 points	0: Word [Signed]	2260ms	1.91ms	1599 scans
		2: Single-precision real number	2630ms	1.84ms	1599 scans
FX5S	2 points	0: Word [Signed]	1.01ms	1.10ms	2 scans
		2: Single-precision real number	1.03ms	1.13ms	2 scans
	8000 points	0: Word [Signed]	1610ms	2.81ms	799 scans
		2: Single-precision real number	1660ms	2.76ms	799 scans
	16000 points	0: Word [Signed]	3220ms	2.84ms	1599 scans
		2: Single-precision real number	3320ms	2.81ms	1599 scans

*1 When the program capacity is set to 128K steps, the process speed may be decreased.

*2 The standard area is used for the labels.

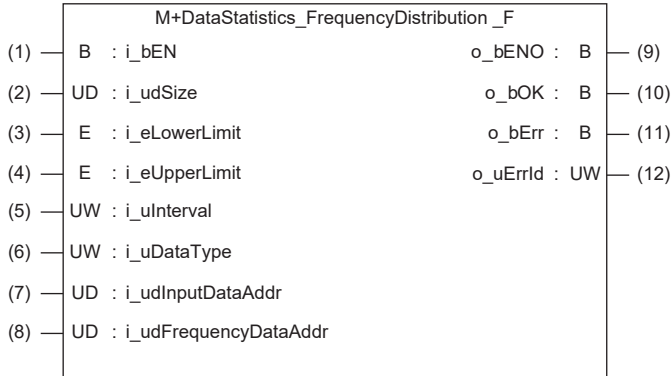
Error code

Error code (hexadecimal)	Description	Action
103H	The setting value of i_uDataType (Input data type selection) is out of the range.	Set 0 or 2 in i_uDataType (Input data type selection). Review and correct the setting and then execute the FB again.
105H	The setting value of i_udSize (Number of data points) is out of the range.	Set a value from 1 to 16000 in i_udSize (Number of data points). Review and correct the setting and then execute the FB again.
11EH	The range of the input data exceeds the range of the file register.	Review and correct the settings below so that the range of the input data does not exceed the range of the file register. • i_udSize (Number of data points) • i_udInputDataAddr (Input data start address) Review and correct the setting and then execute the FB again.
200H	Although the setting value of i_uDataType (Input data type selection) is set to a single-precision real number, the stored input data is not in the single-precision real number format.	Store the value in the file register (R) again in the single-precision real number format. Review and correct the input data and then execute the FB again.
203H	The calculation has overflowed in the FB.	Review and correct the input data stored in the file register (R) and then execute the FB again. When 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module, refer to  .
204H	Because an overflow has occurred in the calculation other than this FB, the processing of the FB is stopped.	An overflow has occurred in the calculation other than this FB, and the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module. Refer to  .
205H	i_bEN (Execution command) has been turned off during the processing.	Keep the ON state of i_bEN (Execution command) until o_bOK (Normal completion) or o_bErr (Error completion) turns on.

2.5 M+DataStatistics_FrequencyDistribution_F (Frequency Distribution)

Overview

The results of the frequency distribution calculation for the specified data is obtained.



Label

Input label

No.	Label	Label name	Data type	Setting range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_udSize	Number of data points	Double word [Unsigned]/Bit string [32-bit]	1 to 16000	Set the number of input data points to calculate the frequency distribution.
(3)	i_eLowerLimit	Interval minimum value	Single-precision real number	-2^{128} to -2^{-126} (-3.4028235E+38 to -1.175494E-38) 0 2^{-126} to 2^{128} (1.175494E-38 to 3.4028235E+38)	Specify the interval minimum value for performing the frequency distribution. Specify a value smaller than i_eUpperLimit (Interval maximum value).
(4)	i_eUpperLimit	Interval maximum value	Single-precision real number	-2^{128} to -2^{-126} (-3.4028235E+38 to -1.175494E-38) 0 2^{-126} to 2^{128} (1.175494E-38 to 3.4028235E+38)	Specify the interval maximum value for performing the frequency distribution. Specify a value larger than i_eLowerLimit (Interval minimum value).
(5)	i_uInterval	Number of intervals	Word [Unsigned]/Bit string [16-bit]	1 to 200	Specify the number of intervals for performing the frequency distribution.
(6)	i_uDataType	Input data type selection	Word [Unsigned]/Bit string [16-bit]	0, 2	Specify the data type of the input data. 0: Word [Signed] 2: Single-precision real number
(7)	i_udInputDataAddr	Input data start address	Double word [Unsigned]/Bit string [32-bit]	Valid device range ^{*1}	Specify the start address of the file register (R) where the input data is stored.
(8)	i_udFrequencyDataAddr	Output data start address	Double word [Unsigned]/Bit string [32-bit]	Valid device range ^{*1}	Specify the start address of the file register (R) where the output data is stored.

*1 The setting range differs depending on "Device/Label Memory Area Setting" in "CPU parameter".

Output label

No.	Label	Label name	Data type	Default value	Description
(9)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is off.
(10)	o_bOK	Normal completion	Bit	OFF	When this label is on, it indicates that the frequency distribution calculation has been completed.
(11)	o_bErr	Error completion	Bit	OFF	When this label is on, it indicates that an error has occurred in the FB.
(12)	o_uErrId	Error code	Word [Unsigned]/Bit string [16-bit]	0	The error code that occurred in the FB is stored.

Function overview

Applicable device

■CPU module

Applicable module	Firmware version	Engineering tool
FX5UJ CPU	1.020 or later	GX Works3 Version 1.080J or later
FX5U CPU, FX5UC CPU	1.250 or later	GX Works3 Version 1.080J or later
FX5S CPU	1.000 or later	GX Works3 Version 1.080J or later

Basic specifications

Item	Description
Programming language	—(The program in this FB is not open to the public.)
Number of steps	1108 steps The number of steps of the FB in a program depends on the CPU module used, input and output definition, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Label amount used	- Label: 0.07K points (Word) - Latch label: 0 points (Word) The label amount used in a program depends on the CPU module used, device specified in the argument, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Number of index register points used	- Index register: 2 points - Long index register: 0 points
File register amount used	Refer to Page 39 Restrictions and precautions .
FB dependence	No dependence
FB compiling method	Subroutine type
FB operation type	Pulsed execution (multiple scan execution type)

Function description

- When i_bEN (Execution command) is turned on, the frequency distribution of the specified input data is obtained. For the data for the number of points from the specified input data start address, this FB stores the number of data items that exist in the interval in the devices in the order from the output data start address.

[Calculation example]

Setting example of input label

Label	Label name	Setting value
i_udSize	Number of data points	5
i_eLowerLimit	Interval minimum value	0
i_eUpperLimit	Interval maximum value	50
i_ulInterval	Number of intervals	5
i_uDataType	Input data type selection	0 (Word [Signed])
i_udInputDataAddr	Input data start address	0(R0)
i_udFrequencyDataAddr	Output data start address	10(R10)

Example of input data

Input data	Input value
R0 (Input data start address)	10
R1	20
R2	30
R3	-10
R4	60

When the frequency distribution calculation is executed on these data, the output is as follows.

File register	Minimum value (equal to or higher than this value)	Maximum value (lower than this value)	Stored value
R10	—	0.0	1
R12	0.0	10.0	0
R14	10.0	20.0	1
R16	20.0	30.0	1
R18	30.0	40.0	1
R20	40.0	50.0	0
R22	50.0	—	1

The width of each interval is calculated by the following expression: (Interval maximum value - Interval minimum value) ÷ Number of intervals,

Since the output data is output in the double-word type, the file register (R) for (i_ulInterval (Number of intervals) + 2) × 2 points is required for storing the output data. In the above example, (5 + 2) × 2, that is, 14 words are required.

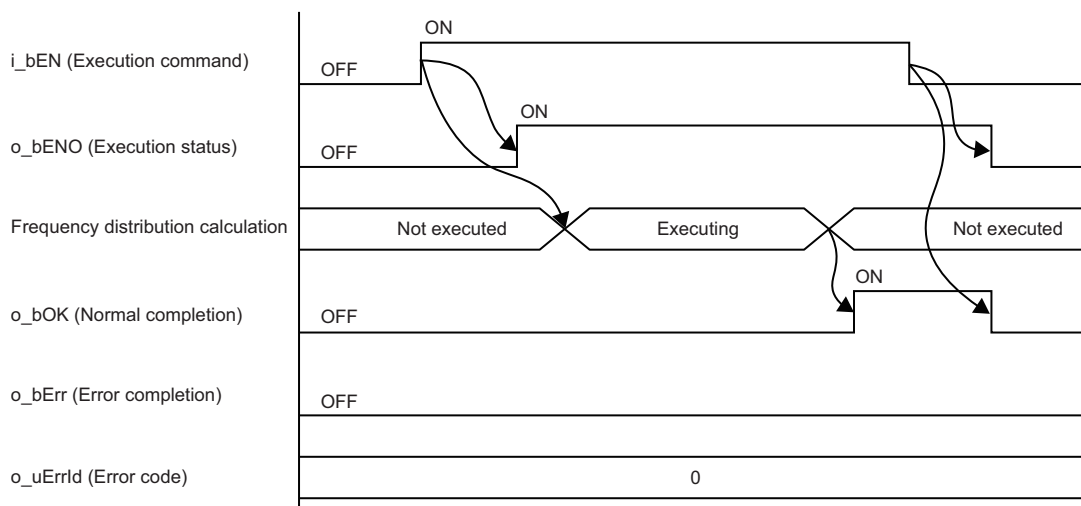
The number of values smaller than i_eLowerLimit (Interval minimum value) is stored in R10 and R11 (double word).

The number of values equal to or larger than i_eUpperLimit (Interval maximum value) is stored in R22 and R23 (double word).

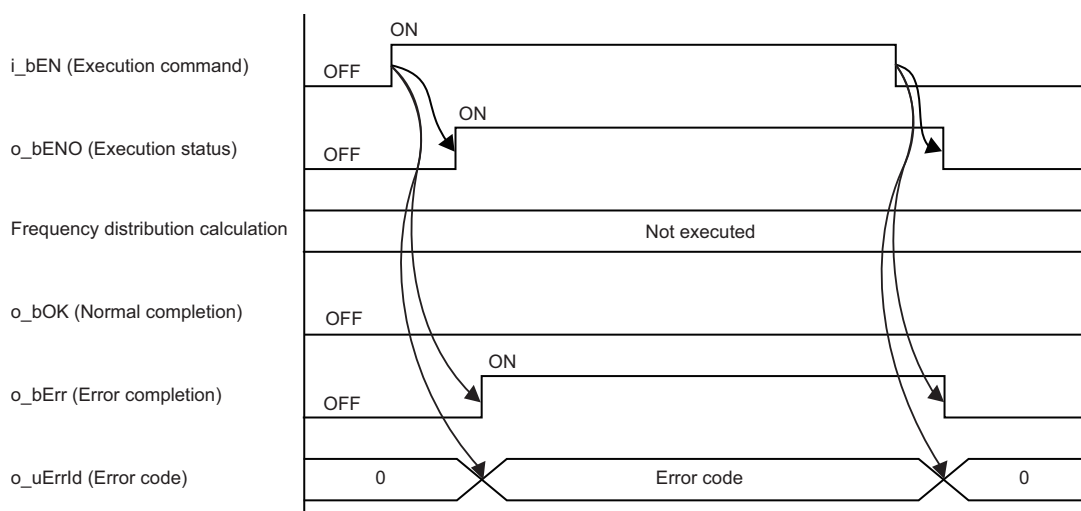
- The input data to be calculated for the frequency distribution is read from the file register (R) whose address has been specified in i_udInputDataAddr (Input data start address). The input data is read for the number of points which has been specified in i_udSize (Number of data points).
- Even when 0: Word [Signed] is set in i_uDataType (Input data type selection), the value is converted into a single-precision real number in this FB to perform the frequency distribution calculation.
- Set single-precision real numbers in i_eLowerLimit (Interval minimum value) and i_eUpperLimit (Interval maximum value).
- The calculation result is output to the file register (R) whose address has been specified in i_udFrequencyDataAddr (Output data start address) in the double-word type. Areas for $(i_uInterval \text{ (Number of intervals)} + 2) \times 2$ words are occupied in the file register (R).
- It takes several scans to complete the frequency distribution calculation. Therefore, do not change the input data to be calculated until the process is completed. After the frequency distribution calculation is completed, o_bOK (Normal completion) turns on.
- If i_bEN (Execution command) is turned off while o_bOK (Normal completion) or o_bErr (Error completion) is not on, o_bErr (Error completion) turns on during one scan. The error code 205H is stored in o_uErrId (Error code) during one scan. For details of the error code, refer to [Page 40 Error code](#).
- If any other error occurs, o_bErr (Error completion) turns on and the processing of the FB is interrupted. For details of the error code, refer to [Page 40 Error code](#).

Timing chart of I/O signals

■Normal completion



■Error completion



Restrictions and precautions

- This FB does not include error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- This FB uses index registers Z0 and Z1. Please do not use these index registers in an interrupt program.
- This FB cannot be used in an interrupt program.
- Using the FB in a program that is to be executed only once, such as a subroutine program or a FOR-NEXT loop, has a problem that i_bEN (Execution command) can no longer be turned off and normal operation is not possible; Always use the FB in a program that is capable of turning off i_bEN (Execution command).
- This FB requires the configuration of the ladder for every input label.
- In this FB, the input data must be stored in the file register (R). In addition, the output data must be double-word type and output to the file register (R). For the file register (R) amount used, refer to the following.

i_uDataType (Input data type selection)	Size
0	i_udSize (Number of data points) + (i_ulInterval (Number of intervals) + 2) × 2 points
2	i_udSize (Number of data points) + (i_ulInterval (Number of intervals) + 2) × 2 points

- In this FB, a value equal to the maximum value of one interval is considered to be in the next interval. For example, if there are an interval of 0.0 or more to less than 1.0 and another interval of 1.0 or more to less than 2.0, the stored value of 1.0 is included in the interval of 1.0 or more to less than 2.0.
- This FB checks the input data before executing the frequency distribution calculation to prevent an overflow from occurring during the calculation. When an overflow is judged in this check, o_bErr (Error completion) turns on and the error code 203H is stored in o_uErrId (Error code). In the calculation of the single-precision real number, however, an error may be included depending on the combination of input data. In this case, an instruction execution error (calculation error) may occur even after checking.
- When i_bEN (Execution command) of this FB is on and the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module due to an error outside the FB, o_bErr (Error completion) turns on and the processing of the FB is stopped. The error code 204H is stored in o_uErrId (Error code).
- When two or more of these FBs are used, precaution must be taken to avoid duplication of the area of the file register (R).
- This FB uses pulse commands in the program. Therefore, if the online program change performed while this FB is running, the correct result may not be obtained.

Parameter setting

There is no required parameter setting to use this FB.

Performance value

CPU	Input label		Process time	Maximum scan time	Number of scans
	Number of sampling points	Input data type			
FX5UJ	2 points	0: Word [Signed]	0.200ms	0.806ms	1 scan
		2: Single-precision real number	0.304ms	0.806ms	1 scan
	8000 points	0: Word [Signed]	604ms	2.04ms	399 scans
		2: Single-precision real number	634ms	2.16ms	399 scans
	16000 points	0: Word [Signed]	1210ms	2.05ms	799 scans
		2: Single-precision real number	1280ms	2.15ms	799 scans
FX5U, FX5UC ^{*1*2}	2 points	0: Word [Signed]	0.190ms	0.598ms	1 scan
		2: Single-precision real number	0.201ms	0.590ms	1 scan
	8000 points	0: Word [Signed]	534ms	1.69ms	399 scans
		2: Single-precision real number	560ms	1.75ms	399 scans
	16000 points	0: Word [Signed]	1060ms	1.67ms	799 scans
		2: Single-precision real number	1120ms	1.75ms	799 scans
FX5S	2 points	0: Word [Signed]	0.287ms	0.953ms	1 scan
		2: Single-precision real number	0.304ms	0.958ms	1 scan
	8000 points	0: Word [Signed]	734ms	2.40ms	399 scans
		2: Single-precision real number	734ms	2.40ms	399 scans
	16000 points	0: Word [Signed]	1470ms	2.39ms	799 scans
		2: Single-precision real number	1570ms	2.51ms	799 scans

*1 When the program capacity is set to 128K steps, the process speed may be decreased.

*2 The standard area is used for the labels.

Error code

Error code (hexadecimal)	Description	Action
103H	The setting value of i_uDataType (Input data type selection) is out of the range.	Set 0 or 2 in i_uDataType (Input data type selection). Review and correct the setting and then execute the FB again.
105H	The setting value of i_udSize (Number of data points) is out of the range.	Set a value from 1 to 16000 in i_udSize (Number of data points). Review and correct the setting and then execute the FB again.
11BH	The setting value of i_eUpperLimit (Interval maximum value) is out of the range.	For i_eUpperLimit (Interval maximum value), specify a value larger than i_eLowerLimit (Interval minimum value). Review and correct the setting and then execute the FB again.
11CH	The setting value of i_ulInterval (Number of intervals) is out of the range.	Set a value from 1 to 200 in i_ulInterval (Number of intervals). Review and correct the setting and then execute the FB again.
11DH	The ranges of the input data and the output data overlap.	Review and correct the settings below so that the ranges of the input data and the output data do not overlap. • i_udSize (Number of data points) • i_ulInterval (Number of intervals) • i_udInputDataAddr (Input data start address) • i_udFrequencyDataAddr (Output data start address) Review and correct the setting and then execute the FB again.

Error code (hexadecimal)	Description	Action
11EH	The range of the input or the output data exceeds the range of the file register.	Review and correct the settings below so that the range of the input data or the output data does not exceed the range of the file register. • i_udSize (Number of data points) • i_udInputDataAddr (Input data start address) • i_udFrequencyDataAddr (Output data start address) Review and correct the setting and then execute the FB again.
200H	Although the setting value of i_uDataType (Input data type selection) is set to a single-precision real number, the stored input data is not in the single-precision real number format.	Store the value in the file register (R) again in the single-precision real number format. Review and correct the input data and then execute the FB again.
203H	The calculation has overflowed in the FB.	Review and correct the input data stored in the interval minimum value, interval maximum value, and file register (R), and then execute the FB again. When the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module, refer to MELSEC iQ-F CPU Module User's Manual (Application).
204H	Because an overflow has occurred in the calculation other than this FB, the processing of the FB is stopped.	An overflow has occurred in the calculation other than this FB, and the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module. Refer to MELSEC iQ-F FX5 User's Manual (Application).
205H	i_bEN (Execution command) has been turned off during the processing.	Keep the ON state of i_bEN (Execution command) until o_bOK (Normal completion) or o_bErr (Error completion) turns on.
206H	Either of the following setting values is not in the single-precision real number format. • i_eLowerLimit (Interval minimum value) • i_eUpperLimit (Interval maximum value)	In the following input labels, store values in the single-precision real number format. • i_eLowerLimit (Interval minimum value) • i_eUpperLimit (Interval maximum value) Review and correct the setting and then execute the FB again.

2.6 M+DataStatistics_Boxplot_F (Box Plot)

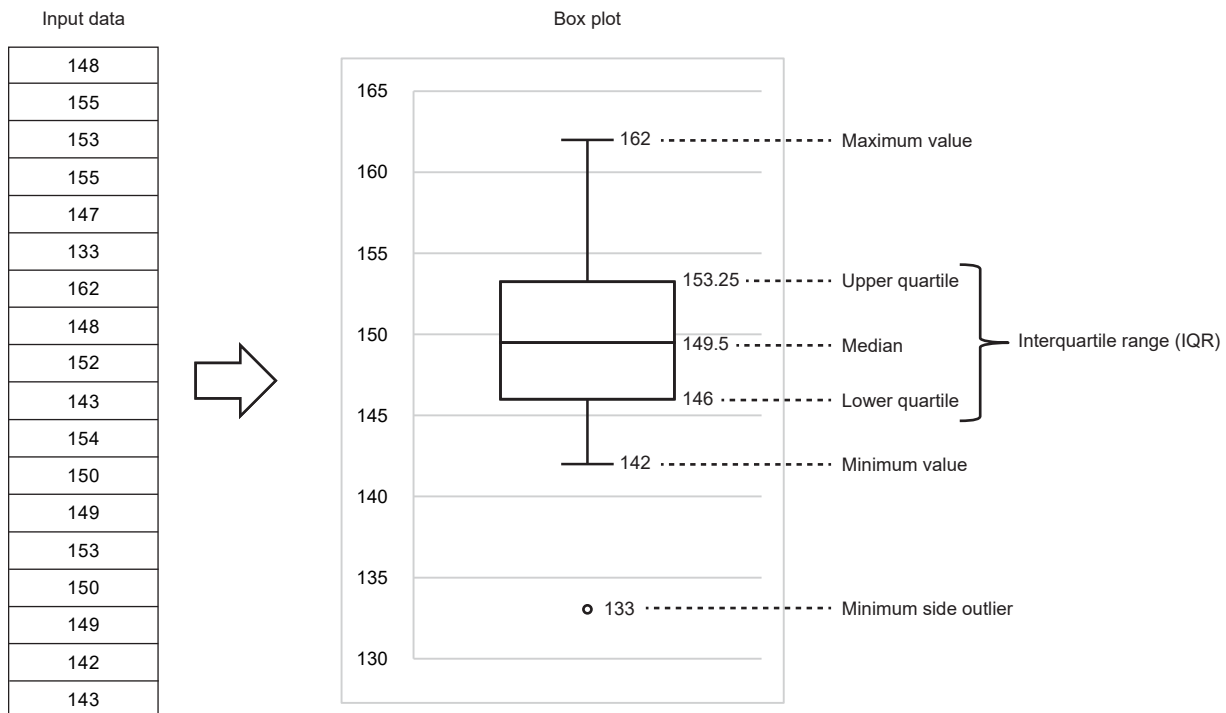
Overview

The calculation result for each element of the boxplot is obtained based on the specified data.

M+DataStatistics_Boxplot_F			
(1)	B : i_bEN	o_bENO : B	(7)
(2)	UD : i_udSize	o_bOK : B	(8)
(3)	UW : i_uDataType	o_bErr : B	(9)
(4)	E : i_eOutlierCriterion	o_uErrId : UW	(10)
(5)	UD : i_udInputDataAddr		
(6)	UD : i_udBoxplotDataAddr		

Box plot

A box plot is a statistical chart for intelligibly expressing the variation of data.



■ Quartile

A box plot consists of quartiles.

Quartiles are numbers that are at positions to divide the data into quarters when the data is arranged in ascending order.

When the data is arranged in ascending order, the elements have the following relationship.

- Lower quartile: Data at the position of 25% of the number of data items
- Median (second quartile): Data at the position of 50% of the number of data items
- Upper quartile: Data at the position of 75% of the number of data items

■ Interquartile range (IQR)

The range from the lower quartile to the upper quartile is called the interquartile range (IQR). The IQR contains approximately half of all the data gathered around the median.

When any extreme deviation is included in the input data, indexes that treat the entire data, such as an average value, are greatly affected. However, the IQR is barely affected.

■Outlier

Data exceeding a certain range (defined by the percentage of the IQR) from the first and upper quartiles can be considered as "outliers" and excluded from the box plot. Generally, most outlier judgments are made under the following conditions, but the criteria can be changed depending on the user's purpose.

- Minimum value side outlier: Data less than the one calculated by the following expression: Lower quartile - (IQR × 1.5)
- Maximum value side outlier: Data greater than the one calculated by the following expression: Upper quartile + (IQR × 1.5)

Label

Input label

No.	Label	Label name	Data type	Setting range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_udSize	Number of data points	Double word [Unsigned]/Bit string [32-bit]	5 to 8000	Specify the number of input data points to be calculated for each element related to the box plot.
(3)	i_uDataType	Input data type selection	Word [Unsigned]/Bit string [16-bit]	0, 2	Specify the data type of the input data. 0: Word [Signed] 2: Single-precision real number
(4)	i_eOutlierCriterion	Outlier criterion	Single-precision real number	• -2^{128} to -2^{-126} ($-3.402823E+38$ to $1.175494E-38$) • 0 • 2^{-126} to 2^{128} ($1.175494E-38$ to $3.402823E+38$)	Less than 1: For the input data, the outlier judgment is not performed. 1 or more: The following input data is judged as outliers. • Maximum value side outlier Input data larger than the one calculated by the following expression: Upper quartile + (IQR^{*1} × i_eOutlierCriterion (Outlier criterion)) • Minimum side outlier Input data less than the one calculated by the following expression: Lower quartile - (IQR^{*1} × i_eOutlierCriterion (Outlier criterion))
(5)	i_udInputDataAddr	Input data start address	Double word [Unsigned]/Bit string [32-bit]	Valid device range ^{*1}	Specify the start address of the file register (R) where the input data is stored.
(6)	i_udBoxplotDataAddr	Output data start address	Double word [Unsigned]/Bit string [32-bit]	Valid device range ^{*1}	Specify the start address of the file register (R) where the output data is stored.

*1 The setting range differs depending on "Device/Label Memory Area Setting" in "CPU parameter".

Output label

No.	Label	Label name	Data type	Default value	Description
(7)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is off.
(8)	o_bOK	Normal completion	Bit	OFF	When this label is on, it indicates that the calculation related to each element of the box plot has been completed.
(9)	o_bErr	Error completion	Bit	OFF	When this label is on, it indicates that an error has occurred in the FB.
(10)	o_uErrId	Error code	Word [Unsigned]/Bit string [16-bit]	0	The error code that occurred in the FB is stored.

Function overview

Applicable device

■CPU module

Applicable module	Firmware version	Engineering tool
FX5UJ CPU	1.020 or later	GX Works3 Version 1.080J or later
FX5U CPU, FX5UC CPU	1.250 or later	GX Works3 Version 1.080J or later
FX5S CPU	1.000 or later	GX Works3 Version 1.080J or later

Basic specifications

Item	Description
Programming language	—(The program in this FB is not open to the public.)
Number of steps	3675 steps The number of steps of the FB in a program depends on the CPU module used, input and output definition, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Label amount used	- Label: 0.16K points (Word) - Latch label: 0 points (Word) The label amount used in a program depends on the CPU module used, device specified in the argument, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Number of index register points used	- Index register: 2 points - Long index register: 0 points
File register amount used	Refer to Page 52 Restrictions and precautions .
FB dependence	No dependence
FB compiling method	Subroutine type
FB operation type	Pulsed execution (multiple scan execution type)

Function description

- For the data for i_udSize (Number of data points) from i_udInputDataAddr (Input data start address), the sort result of the input data and each element related to the box plot are stored in the devices in the order from i_udBoxplotDataAddr (Output data start address) by turning on i_bEN (Execution command).

To obtain each element of the box plot, follow the procedure below.

Step 1: Copy the input data.

Step 2: Sort the data.

Step 3: Obtain the upper quartile, median, and lower quartile.

Step 4: If the outlier criterion is 1 or more, obtain the percentage of the outlier.

Step 5: Obtain the maximum and minimum values from the data excluding the outliers.

[Details of each step]

The following terms are used to describe the details of each step.

Term	Description
(s)	File register (R) whose address has been specified in i_udInputDataAddr (Input data start address)
(d)	File register (R) whose address has been specified in i_udBoxplotDataAddr (Output data start address)
(o)	Number of data points which has been set in i_udSize (Number of data points)
x(i)	ith data value (1...i...(o))

1. Copy the data in (s) and after to (d) + 14 and after.

The number of data points to be copied is as follows.

i_uDataType (Input data type selection)	Number of data points
0 (Word [Signed])	(o)
2 (Single-precision real number)	(o) × 2

(s)	148	Copy ➡	(d)+14	148
(s+1)	155		(d)+15	155
⋮	⋮		⋮	⋮
(s) + (o) - 1 or (s) + (o) × 2 - 1	143		(d) + 14 + (o) - 1 or (d) + 14 + (o) × 2 - 1	143

2. Sort the copied data in (d) + 14 and after in descending order and overwrite it.

(d)+14	148	Sort 	(d)+14	162
(d)+15	155		(d)+15	155
⋮	⋮		⋮	⋮
(d) + 14 + (o) - 1 or (d) + 14 + (o) × 2 - 1	143		(d) + 14 + (o) - 1 or (d) + 14 + (o) × 2 - 1	133

3. Obtain the upper quartile, median, and lower quartile from the sorted data.

Element	Expression
Upper quartile	$x(((o) + 1) / 4)$
Median	$x(2((o) + 1) / 4)$
Lower quartile	$x(3((o) + 1) / 4)$

If the element number of each quartile is not an integer, use the linear interpolation to obtain the value.

When the quotient of the element number is j , the following calculation is performed depending on the remainder of the element number.

Remainder of element number	Expression
1	$(3x(j) + x(j + 1)) / 4$
2	$(2x(j) + 2x(j + 1)) / 4$
3	$(x(j) + 3x(j + 1)) / 4$

Store the calculation results in (d) + 4 and after in the data type of single-precision real number.

Element	Storage destination*1
Upper quartile	(d) + 4
Median	(d) + 6
Lower quartile	(d) + 8

*1 Regardless of the setting of i_uDataType (Input data type selection), the result is stored in the data type of single-precision real number.

4. When $i_eOutlierCriterion$ (Outlier criterion) is 1 or more, obtain the interquartile range (IQR) from the upper quartile and lower quartile obtained in Step 3.

· $IQR = \text{Upper quartile} - \text{Lower quartile}$

Obtain the outlier criterion based on the IQR.

· Maximum value side outlier criterion: Input data larger than the one calculated by the following expression: $\text{Upper quartile} + (IQR \times i_eOutlierCriterion (\text{Outlier criterion}))$

· Minimum value side outlier criterion: Input data less than the one calculated by the following expression: $\text{Lower quartile} - (IQR \times i_eOutlierCriterion (\text{Outlier criterion}))$

Count the outlier data on the maximum and minimum value sides and calculate the percentage of outliers.

· Percentage of maximum value side outlier (%) = $\text{Number of maximum value side outlier} \div (o) \times 100$

· Percentage of minimum value side outlier (%) = $\text{Number of minimum side outlier} \div (o) \times 100$

Store the calculation results in (d) and (d) + 12 in the data type of single-precision real number.

Percentage of outlier	Storage destination ^{*1}
Percentage of maximum value side outlier (%)	(d)
Percentage of minimum value side outlier (%)	(d) + 12

^{*1} Regardless of the setting of $i_uDataType$ (Input data type selection), the result is stored in the data type of single-precision real number.

5. Exclude the outliers obtained in Step 4 from the data sorted in Step 2, and obtain the maximum and minimum values.

Element	Storage destination ^{*1}
Maximum value	(d) + 2
Minimum value	(d) + 10

^{*1} Regardless of the setting of $i_uDataType$ (Input data type selection), the result is stored in the data type of single-precision real number.
[Calculation example]

Setting example of input label

Label	Label name	Setting value
i_udSize	Number of data points	18
$i_uDataType$	Input data type selection	0
$i_eOutlierCriterion$	Outlier criterion	1.5
$i_udInputDataAddr$	Input data start address	0(R0)
$i_udFrequencyDataAddr$	Output data start address	20(R20)

Example of input data

Input data	Input value
R0 (Input data start address)	148
R1	155
R2	153
R3	155
R4	147
R5	133
R6	162
R7	148
R8	152
R9	143
R10	154
R11	150
R12	149
R13	153
R14	150
R15	149
R16	142
R17	143

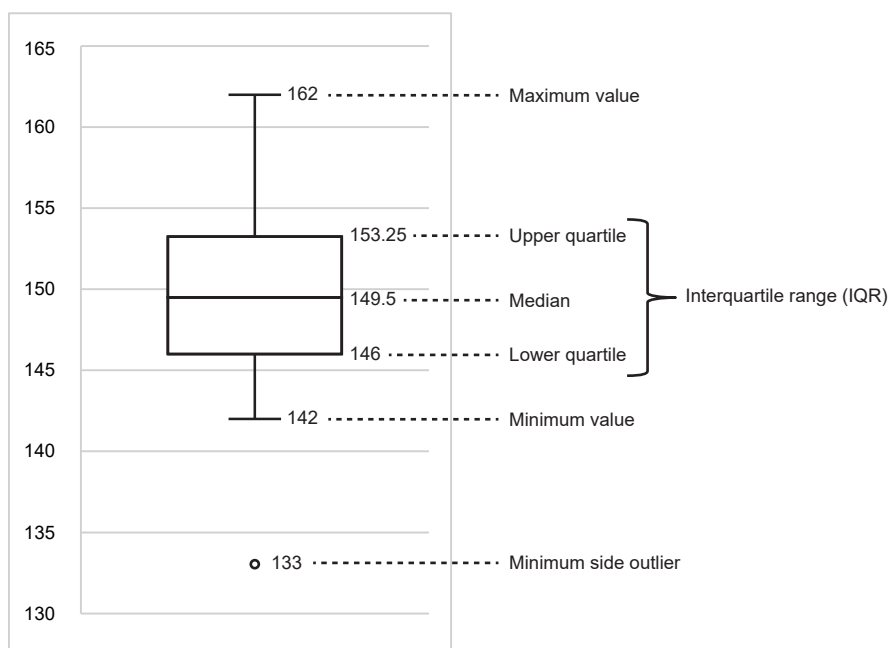
When this FB is executed, the output is as follows.

Output item	Output data	Data type	Output value
Percentage of maximum value side outlier (%)	R20 (Output data start address)	Single-precision real number	0.000 ^{*2}
Maximum value	R22		162.000 ^{*2}
Upper quartile value	R24		153.250 ^{*2}
Median	R26		149.500 ^{*2}
Lower quartile value	R28		146.000 ^{*2}
Minimum value	R30		142.000 ^{*2}
Percentage of minimum value side outlier (%)	R32		5.556 ^{*2}
Ascending sort result of input data	R34	Word [Signed] ^{*1}	162
	R35		155
	R36		155
	R37		154
	R38		153
	R39		153
	R40		152
	R41		150
	R42		150
	R43		149
	R44		149
	R45		148
	R46		148
	R47		147
	R48		143
	R49		143
	R50		142
	R51		133

*1 The data type is the same as i_uDataType (Input data type selection).

*2 The single-precision real number values in the example are rounded to four decimal places for convenience.

The following shows a box plot based on the calculation results obtained by using the FB.



[Image of calculation results for each element of a box plot]
 The calculation results for each element of a boxplot are as follows.

1. Copy the input data.

R0	148	Copy →	R34	148
R1	155		R35	155
⋮	⋮		⋮	⋮
R17	143		R51	143

2. Sort the data.

R34	148	Sort →	R34	162
R35	155		R35	155
R36	153		R36	155
R37	155		R37	154
R38	147		R38	153
R39	133		R39	153
R40	162		R40	152
R41	148		R41	150
R42	152		R42	150
R43	143		R43	149
R44	154		R44	149
R45	150		R45	148
R46	149		R46	148
R47	153		R47	147
R48	150		R48	143
R49	149		R49	143
R50	142		R50	142
R51	143		R51	133

3. Obtain the upper quartile, median, and lower quartile.

Upper quartile = x (4 and a remainder of 3)

(By linear interpolation $(3x[j] + x[j + 1]) / 4 = 153.250$)

Median = x (9 and a remainder of 2)

(By linear interpolation $(2x[j] + 2x[j + 1]) / 4 = 149.500$)

Lower quartile = x (14 and a remainder of 1)

(By linear interpolation $(x[j] + 3x[j + 1]) / 4 = 146.000$)

R34	162
R35	155
R36	155
R37	154
R38	153
R39	153
R40	152
R41	150
R42	150
R43	149
R44	149
R45	148
R46	148
R47	147
R48	143
R49	143
R50	142
R51	133

Calculate the upper quartile

R24 (Upper quartile)	153.250
----------------------	---------

Calculate the median

R26 (Median)	149.500
--------------	---------

Calculate the lower quartile

R28 (Lower quartile)	146.000
----------------------	---------

4. If the outlier criterion is 1 or more, obtain the percentage of the outlier.

$IQR = \text{Upper quartile} - \text{Lower quartile} = 7.25$

Maximum value side outlier criterion = Lower quartile + $(IQR \times i_eOutlierCriterion \text{ (Outlier criterion)}) = 164.125$

Minimum value side outlier criterion = Upper quartile + $(IQR \times i_eOutlierCriterion \text{ (Outlier criterion)}) = 135.125$

Maximum value side outlier criterion 164.125	→	
		R34 162
		R35 155
		R36 155
		R37 154
		R38 153
		R39 153
		R40 152
		R41 150
		R42 150
		R43 149
		R44 149
		R45 148
		R46 148
		R47 147
		R48 143
		R49 143
		R50 142
Minimum value side outlier criterion 135.125	→	R51 133

Outlier	Q'ty
Maximum value side	0
Minimum value side	1

Percentage of maximum value side outlier (%) = Number of maximum value side outlier ÷ (o) × 100 = 0.000

Percentage of minimum value side outlier (%) = Number of minimum value side outlier ÷ (o) × 100 = 5.556

R20	0.000
R32	5.556

5. Obtain the maximum and minimum values from the data excluding the outliers.

R34	162
R35	155
R36	155
R37	154
R38	153
R39	153
R40	152
R41	150
R42	150
R43	149
R44	149
R45	148
R46	148
R47	147
R48	143
R49	143
R50	142
R51	133



R22 (Maximum value)	162.000
R30 (Minimum value)	142.000

- The input data to be calculated for box plot is read from the file register (R) whose address has been specified in i_udInputDataAddr (Input data start address). The input data is read for the number of points which has been specified in i_udSize (Number of data points).
- Even when 0: Word [Signed] is set for i_uDataType (Input data type selection), the value is converted into a single-precision real number in this FB to perform the calculation.
- In i_eOutlierCriterion (Outlier criterion), set a value in the single-precision real number.

The calculation result is output to the file register (R) whose address has been specified in i_udBoxplotDataAddr (Output data start address).

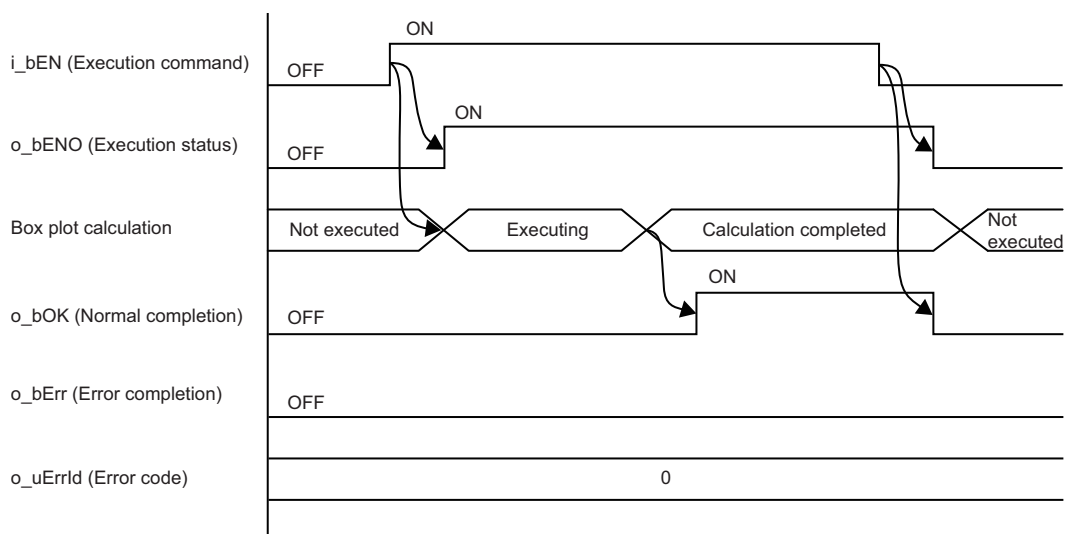
Areas for the following number of output points × 1 word are occupied in the file register (R)..

i_uDataType (Input data type selection)	Output point
0	i_udSize (Number of data points) + 14 points
2	i_udSize (Number of data points) × 2 + 14 points

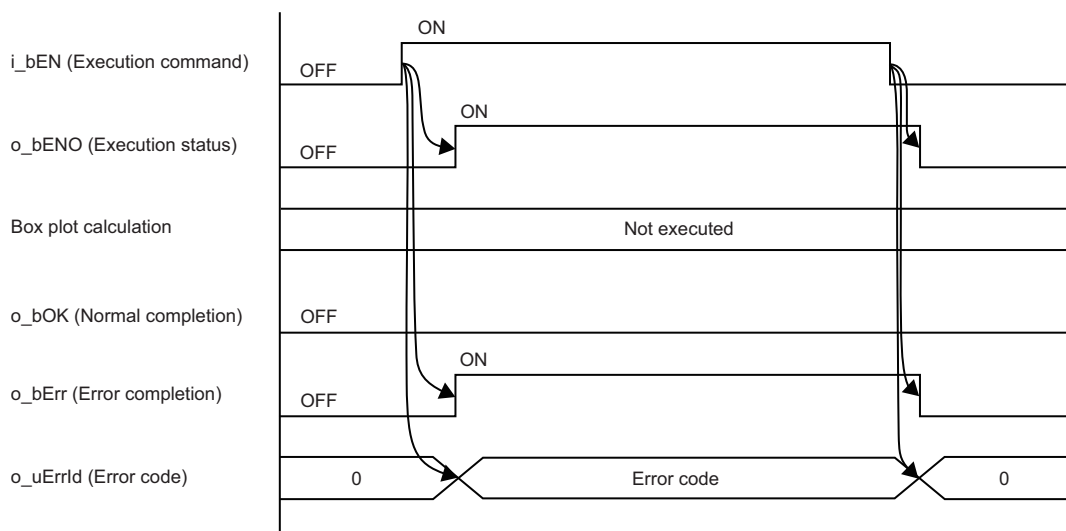
- This FB requires multiple scans to complete the calculation. Therefore, do not change the input data to be calculated until the process is completed. After the calculation is completed, o_bOK (Normal completion) turns on.
- When i_bEN (execution command) is changed from on to off, if o_bOK (Normal completion) and o_bErr (Error completion) are off, o_bErr (Error completion) turns on during one scan. 205H is stored in o_uErrId (Error code) during one scan. For details of the error code, refer to [Page 53 Error code](#).
- If any other error occurs, o_bErr (Error completion) turns on and the processing of the FB is interrupted. For details of the error code, refer to [Page 53 Error code](#).

Timing chart of I/O signals

■ Normal completion



■ Error completion



Restrictions and precautions

- This FB does not include error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- This FB uses index registers Z0 and Z1. Please do not use these index registers in an interrupt program.
- This FB cannot be used in an interrupt program.
- Using the FB in a program that is to be executed only once, such as a subroutine program or a FOR-NEXT loop, has a problem that i_bEN (Execution command) can no longer be turned off and normal operation is not possible; Always use the FB in a program that is capable of turning off i_bEN (Execution command).
- This FB requires the configuration of the ladder for every input label.
- This FB checks the input data before executing the calculation to prevent an overflow from occurring during the calculation. When an overflow is judged in this check, o_bErr (Error completion) turns on and the error code 203H is stored in o_uErrId (Error code). In the calculation of the single-precision real number, however, an error may be included depending on the combination of input data. In this case, an instruction execution error (calculation error) may occur even after checking.
- When i_bEN (Execution command) of this FB is on and the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module due to an error outside the FB, o_bErr (Error completion) turns on and the processing of the FB is stopped. The error code 204H is stored in o_uErrId (Error code).
- When two or more of these FBs are used, precaution must be taken to avoid duplication of the area of the file register (R).
- This FB uses pulse commands in the program. Therefore, if the online program change performed while this FB is running, the correct result may not be obtained.

Parameter setting

There is no required parameter setting to use this FB.

Performance value

CPU	Input label		Process time	Maximum scan time	Number of scans
	Number of sampling points	Input data type			
FX5UJ	5 points	0: Word [Signed]	3.36ms	1.03ms	7 scans
		2: Single-precision real number	3.47ms	1.04ms	7 scans
	4000 points	0: Word [Signed]	3.84s	3.21ms	4067 scans
		2: Single-precision real number	6.19s	5.36ms	4067 scans
	8000 points	0: Word [Signed]	11.6s	6.14ms	8134 scans
		2: Single-precision real number	20.5s	10.5ms	8134 scans
FX5U, FX5UC ^{*1*2}	5 points	0: Word [Signed]	2.83ms	0.962ms	7 scans
		2: Single-precision real number	2.89ms	1.43ms	7 scans
	4000 points	0: Word [Signed]	3.17s	2.32ms	4067 scans
		2: Single-precision real number	5.20s	3.89ms	4067 scans
	8000 points	0: Word [Signed]	9.46s	3.92ms	8134 scans
		2: Single-precision real number	17.4s	7.13ms	8134 scans
FX5S	5 points	0: Word [Signed]	4.27ms	1.24ms	7 scans
		2: Single-precision real number	4.37ms	1.26ms	7 scans
	4000 points	0: Word [Signed]	4.45s	3.38ms	4067 scans
		2: Single-precision real number	7.26s	5.76ms	4067 scans
	8000 points	0: Word [Signed]	13.0s	6.09ms	8134 scans
		2: Single-precision real number	23.7s	10.8ms	8134 scans

*1 When the program capacity is set to 128K steps, the process speed may be decreased.

*2 The standard area is used for the labels.

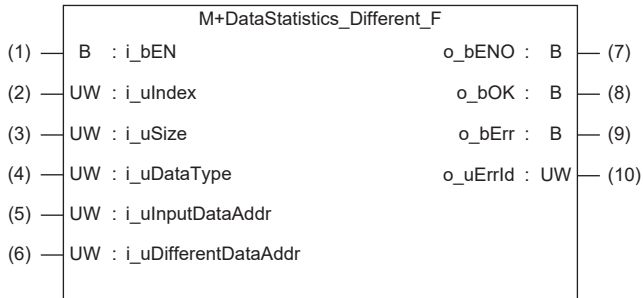
Error code

Error code (hexadecimal)	Description	Action
103H	The setting value of i_udDataType (Input data type selection) is out of the range.	Set 0 or 2 in i_udDataType (Input data type selection). Review and correct the setting and then execute the FB again.
105H	The setting value of i_udSize (Number of data points) is out of the range.	Set a value from 5 to 8000 in i_udSize (Number of data points). Review and correct the setting and then execute the FB again.
11DH	The ranges of the input data and the output data overlap.	Review and correct the settings below so that the ranges of the input data and the output data do not overlap. • i_udSize (Number of data points) • i_ulInterval (Number of intervals) • i_udInputDataAddr (Input data start address) • i_udFrequencyDataAddr (Output data start address) Review and correct the setting and then execute the FB again.
11EH	The range of the input or the output data exceeds the range of the file register.	Review and correct the settings below so that the range of the input data or the output data does not exceed the range of the file register. • i_udSize (Number of data points) • i_udInputDataAddr (Input data start address) • i_udFrequencyDataAddr (Output data start address) Review and correct the setting and then execute the FB again.
200H	Although the setting value of i_udDataType (Input data type selection) is set to a single-precision real number, the stored input data is not in the single-precision real number format.	Store the value in the file register (R) again in the single-precision real number format. Review and correct the input data and then execute the FB again.
203H	The calculation has overflowed in the FB.	Review and correct the input data stored in the interval minimum value, interval maximum value, and file register (R), and then execute the FB again. When the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module, refer to MELSEC iQ-F FX5 User's Manual (Application).
204H	Because an overflow has occurred in the calculation other than this FB, the processing of the FB is stopped.	An overflow has occurred in the calculation other than this FB, and the error code 3403H is stored in the special register SD0 (Latest self-diagnostics error code) of the CPU module. Refer to MELSEC iQ-F FX5 User's Manual (Application).
205H	i_bEN (Execution command) has been turned off during the processing.	Keep the ON state of i_bEN (Execution command) until o_bOK (Normal completion) or o_bErr (Error completion) turns on.
206H	The setting value of i_eOutlierCriterion (Outlier criterion) is not in the single-precision real number format.	In i_eOutlierCriterion (Outlier criterion), store a value in the single-precision real number format. Review and correct the setting and then execute the FB again.

2.7 M+DataStatistics_Different_F (Differential)

Overview

The result of the differential calculation for the specified data is obtained.



Label

Input label

No.	Label	Label name	Data type	Setting range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_uIndex	Comparison data index	Word [Unsigned]	0 to 7999	Specify how many points the comparison input data is away from the target input data for difference calculation.
(3)	i_uSize	Number of data points	Word [Unsigned]	1 to 8000	Specify the number of data points (1 to 8000 points).
(4)	i_uDataType	Input data type selection	Word [Unsigned]	0, 2	Specify the data type of the input data. 0: Word [Signed] 2: Single-precision real number
(5)	i_uInputDataAddr	Input data start address	Word [Unsigned]	0 to 32767	Specify the start address of the file register (R) where the input data is stored.
(6)	i_uDifferentDataAddr	Output data start address	Word [Unsigned]	0 to 32767	Specify the start address of the file register (R) where the differential calculation result is stored. Because the result of the differential calculation is output as a single-precision real number (2 words), it is output in the range of ((number of data points - comparison data index) × 2) from the file register (R) indicated by the output data start address.

Output label

No.	Label	Label name	Data type	Default value	Description
(7)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is off.
(8)	o_bOK	Normal completion	Bit	OFF	When this label is on, it indicates that the differential calculation has been completed without error.
(9)	o_bErr	Error completion	Bit	OFF	When this label is on, it indicates that an error has occurred in the FB.
(10)	o_uErrId	Error code	Word [Unsigned]	0	The error code that occurred in the FB is stored.

Function overview

Applicable device

■CPU module

Applicable module	Firmware version	Engineering tool
FX5UJ CPU	1.050 or later	GX Works3 Version 1.090U or later
FX5U CPU, FX5UC CPU	1.290 or later	GX Works3 Version 1.090U or later
FX5S CPU	1.010 or later	GX Works3 Version 1.090U or later

Basic specifications

Item	Description
Programming language	Ladder
Number of steps	997 steps The number of steps of the FB in a program depends on the CPU module used, input and output definition, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Label amount used	- Label: 0.040K points (Word) - Latch label: 0 points (Word) The label amount used in a program depends on the CPU module used, device specified in the argument, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual.
Number of index register points used	- Index register: 3 points - Long index register: 0 points
File register amount used	File register: 32768 points (Words) (R0 to R32767) For the option settings of GX Works3, refer to GX Works3 Operating Manual .
FB dependence	No dependence
FB compiling method	Subroutine type
FB operation type	Pulsed execution (multiple scan execution type)

Function description

- The differential of the specified input data is calculated.
- The data in the file register (R) areas are used, starting from the area specified by the input data start address, for the specified number of data points.
- The difference between the target data and the data that is away from the target data by the number of points specified in the comparison data index is calculated, and the results are stored in the device in order, starting from the area of output data start address.
- The differential values are obtained by the following expression.*1

$$\text{Differential (i)} = X_{(i+d)} - X_i$$

*1 X_i is the i-th input data, and d is the number set in the comparison data index.

- The input data to be used for differential calculation is read starting from the file register (R) area whose address is specified in i_uInputDataAddr (Input data start address), for the number of points specified in i_uSize (Number of data points).
- The calculation results are output to the file register (R) as a single-precision real number, starting from the area whose address is specified in i_uDifferentDataAddr (Output data start address), for the number of points calculated by the following: (i_uSize (Number of data points) - i_uIndex (Comparison data index)) × 2.
- It takes several scans to complete the differential calculation. Therefore, do not change the input data to be calculated until the process is completed. After the calculation is completed, o_bOK (Normal completion) turns on.
- If an error occurs, the execution of the FB is interrupted and o_bErr (Error completion) turns on. The error code of the error that occurred for the FB is stored in o_uErrId (Error code). For details of the error code, refer to [Page 59 Error code](#).

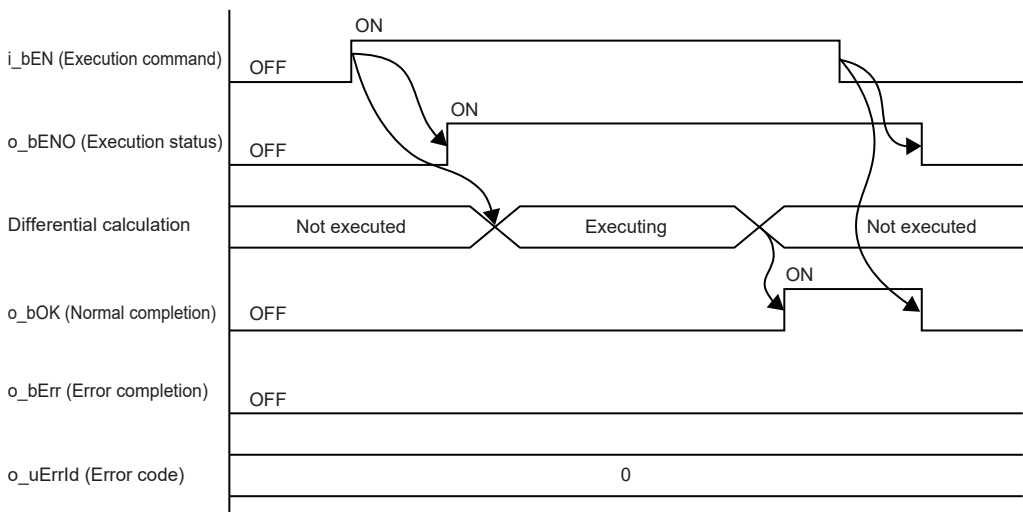
[Calculation example]
 Setting example of input label

Label	Label name	Setting value
i_ulIndex	Comparison data index	3
i_uSize	Number of data points	10
i_ulInputDataAddr	Input data start address	0
i_uDifferentDataAddr	Output data start address	20

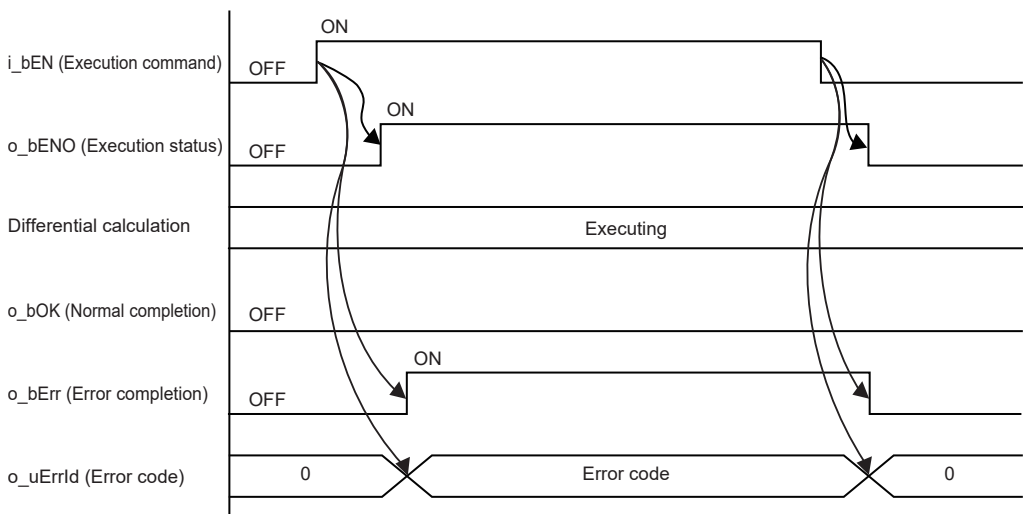
No.	Input data				
1	R0 (Input data start address)	945	→	1	R20 (Output data start address)
2	R1	948			
3	R2	978			
4	R3	1011			
5	R4	1035	→	2	R22
6	R5	1189			
7	R6	1263			
8	R7	1304			
9	R8	1401	→	3	R24
10	R9	1584			
			→	4	R26
			→	5	R28
			→	6	R30
			→	7	R32

Timing chart of I/O signals

■Normal completion



■Error completion



Restrictions and precautions

- This FB does not include error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- This FB uses index registers Z0, Z1, and Z2. Set the index (Z) to three points or greater in "Index Register Setting" of "CPU Parameter". For details, refer to  MELSEC iQ-F FX5 User's Manual (Application). Please do not use these index registers in an interrupt program.
- This FB cannot be used in an interrupt program.
- Using the FB in a program that is to be executed only once, such as a subroutine program or a FOR-NEXT loop, has a problem that i_bEN (Execution command) can no longer be turned off and normal operation is not possible; Always use the FB in a program that is capable of turning off i_bEN (Execution command).
- This FB requires the configuration of the ladder for every input label.
- In this FB, the input data must be stored in the file register (R). In addition, the calculation result data must be output to the file register (R). For the file register (R) amount used, refer to the following.

i_uDataType (Input data type selection)	Size
0	$(i_uSize \text{ (Number of data points)} \times 3) - (i_uIndex \text{ (Comparison data index)} \times 2)$ points
2	$(i_uSize \text{ (Number of data points)} \times 4) - (i_uIndex \text{ (Comparison data index)} \times 2)$ points

- If multiple instances of this FB are called by the same input/output data start address, redundant operation will be performed for the same data point.
- To prevent an incorrect result from being obtained when multiple instances of this FB are called, pay attention when setting the input/output data address range.

Parameter setting

There is no required parameter setting to use this FB.

Performance value

CPU	Measurement condition			Process time	Maximum scan time	Number of scans
	Number of data points	Input data type selection	Comparison data index			
FX5UJ	100 points	0: Word [Signed]	99	0.478ms	0.853ms	1 scan
			50	17.200ms	0.853ms	50 scans
			0	31.000ms	0.853ms	100 scans
		2: Single-precision real number	99	0.900ms	0.809ms	1 scan
			50	17.000ms	0.835ms	50 scans
			0	34.000ms	0.835ms	100 scans
	4000 points	0: Word [Signed]	3999	1.250ms	0.853ms	1 scan
			2000	611.000ms	0.853ms	2000 scans
			0	1200.000ms	0.853ms	4000 scans
		2: Single-precision real number	3999	0.478ms	0.837ms	1 scan
			2000	632.000ms	0.834ms	2000 scans
			0	1240.000ms	0.834ms	4000 scans
	8000 points	0: Word [Signed]	7999	1.250ms	1.880ms	1 scan
			4000	1200.000ms	0.830ms	4000 scans
			0	2360.000ms	0.830ms	8000 scans
		2: Single-precision real number	7999	0.478ms	0.834ms	1 scan
			4000	1240.000ms	0.834ms	4000 scans
			0	2410.000ms	0.834ms	8000 scans
FX5U, FX5UC ^{*1*2}	100 points	0: Word [Signed]	99	1.870ms	0.587ms	1 scan
			50	13.500ms	0.587ms	50 scans
			0	26.400ms	0.587ms	100 scans
		2: Single-precision real number	99	1.870ms	0.586ms	1 scan
			50	15.500ms	0.586ms	50 scans
			0	27.600ms	0.586ms	100 scans
	4000 points	0: Word [Signed]	3999	1.250ms	0.591ms	1 scan
			2000	469.000ms	0.591ms	2000 scans
			0	972.000ms	0.591ms	4000 scans
		2: Single-precision real number	3999	1.990ms	0.599ms	1 scan
			2000	516.000ms	0.599ms	2000 scans
			0	973.000ms	0.601ms	4000 scans
	8000 points	0: Word [Signed]	7999	1.200ms	0.591ms	1 scan
			4000	968.000ms	0.591ms	4000 scans
			0	1900.000ms	0.591ms	8000 scans
		2: Single-precision real number	7999	1.940ms	0.598ms	1 scan
			4000	990.000ms	0.598ms	4000 scans
			0	1980.000ms	0.600ms	8000 scans

CPU	Measurement condition			Process time	Maximum scan time	Number of scans
	Number of data points	Input data type selection	Comparison data index			
FX5S	100 points	0: Word [Signed]	99	1.250ms	1.140ms	1 scan
			50	21.100ms	1.140ms	50 scans
			0	37.100ms	1.150ms	100 scans
		2: Single-precision real number	99	1.320ms	1.080ms	1 scan
			50	20.800ms	1.080ms	50 scans
			0	39.100ms	1.080ms	100 scans
	4000 points	0: Word [Signed]	3999	1.250ms	1.150ms	1 scan
			2000	728.000ms	1.150ms	2000 scans
			0	1440.000ms	1.150ms	4000 scans
		2: Single-precision real number	3999	1.290ms	1.080ms	1 scan
			2000	752.000ms	1.080ms	2000 scans
			0	1470.000ms	1.080ms	4000 scans
	8000 points	0: Word [Signed]	7999	1.250ms	1.150ms	1 scan
			4000	1440.000ms	1.230ms	4000 scans
			0	2840.000ms	1.190ms	8000 scans
		2: Single-precision real number	7999	0.900ms	1.160ms	1 scan
			4000	1480.000ms	1.070ms	4000 scans
			0	2920.000ms	0.995ms	8000 scans

*1 When the program capacity is set to 128K steps, the process speed may be decreased.

*2 The standard area is used for the labels.

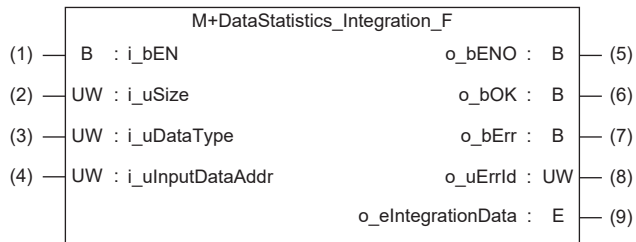
Error code

Error code (hexadecimal)	Description	Action
103H	The setting value of i_uDataType (Input data type selection) is out of the range.	Set 0 or 2 in i_uDataType (Input data type selection). Review and correct the setting and then execute the FB again.
105H	The setting value of i_uSize (Number of data points) is out of the range.	Set a value of 1 to 8000 in i_uSize (Number of data points). Review and correct the setting and then execute the FB again.
116H	The setting value of i_ulIndex (Comparison data index) is out of the range.	For i_ulIndex (Comparison data index), set a value that satisfies the following conditions. - i_ulIndex (Comparison data index) ≥ 0 - i_ulIndex (Comparison data index) $< i_uSize$ (Number of data points) Review and correct the setting and then execute the FB again.
11DH	Some areas of input data and output data are overlapped.	Review the following settings so that the input data areas and the output data areas are not overlapped. - i_uSize (Number of data points) - i_ulInputDataAddr (Input data start address) - i_uDifferentDataAddr (Output data start address) Review and correct the settings and then execute the FB again.
11EH	Any of input or output data areas exceed the range of the file register (R).	Review the following settings so that the input data areas and the output data areas do not exceed the range of the file register (R). - i_uSize (Number of data points) - i_ulInputDataAddr (Input data start address) - i_uDifferentDataAddr (Output data start address) Review and correct the settings and then execute the FB again.
200H	Although the setting value of i_uDataType (Input data type selection) is set to a single-precision real number, the stored input data is not in the single-precision real number format.	Store the value in the file register (R) again in the single-precision real number format. Review and correct the input data and then execute the FB again.
205H	i_bEN (Execution command) has been turned off during the processing.	Keep the ON state of i_bEN (Execution command) until o_bOK (Normal completion) or o_bErr (Error completion) turns on.

2.8 M+DataStatistics_Integration_F (Integral)

Overview

The result of the integral calculation for the specified data is obtained.



Label

Input label

No.	Label	Label name	Data type	Setting range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_uSize	Number of data points	Word [Unsigned]	1 to 16000	Specify the number of data points (1 to 16000 points).
(3)	i_uDataType	Input data type selection	Word [Unsigned]	0, 2	Specify the data type of the input data. 0: Word [Signed] 2: Single-precision real number
(4)	i_uInputDataAddr	Input data start address	Word [Unsigned]	0 to 32767	Specify the start address of the file register (R) where the input data is stored.

Output label

No.	Label	Label name	Data type	Default value	Description
(5)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is off.
(6)	o_bOK	Normal completion	Bit	OFF	When this label is on, it indicates that the integral calculation has been completed without error.
(7)	o_bErr	Error completion	Bit	OFF	When this label is on, it indicates that an error has occurred in the FB.
(8)	o_uErrId	Error code	Word [Unsigned]	0	The error code that occurred in the FB is stored.
(9)	o_eIntegrationData	Output data	Single-precision real number	0	The integral calculation result is stored.

Function overview

Applicable device

■CPU module

Applicable module	Firmware version	Engineering tool
FX5UJ CPU	1.050 or later	GX Works3 Version 1.090U or later
FX5U CPU, FX5UC CPU	1.290 or later	GX Works3 Version 1.090U or later
FX5S CPU	1.010 or later	GX Works3 Version 1.090U or later

Basic specifications

Item	Description
Programming language	Ladder
Number of steps	803 steps The number of steps of the FB in a program depends on the CPU module used, input and output definition, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual .
Label amount used	- Label: 0.028K points (Word) - Latch label: 0 points (Word) The label amount used in a program depends on the CPU module used, device specified in the argument, and option settings of GX Works3. For the option settings of GX Works3, refer to GX Works3 Operating Manual.
Number of index register points used	- Index register: 1 point - Long index register: 0 points
File register amount used	File register: 32768 points (Words) (R0 to R32767)
FB dependence	No dependence
FB compiling method	Subroutine type
FB operation type	Pulsed execution (multiple scan execution type)

Function description

- The integrated value of the specified input data is calculated.
- When the start number is the same as the end number, the integrated value of all the input data is output.
- The integrated value is obtained by the following expression.*1

$$\text{Integral} = \sum_{i=0}^{N-1} (x_i)$$

*1 X_i is the i -th input data, N is the number of data points, and 0 is the 0th element from the input start address.

- The input data to be used for integral calculation is read starting from the file register (R) area whose address is specified in `i_uInputDataAddr` (Input data start address), for the number of points specified in `i_uSize` (Number of data points).
- The calculation result is output to `o_eIntegrationData` (Output data) as a single-precision real number.
- It takes several scans to complete the integral calculation. Therefore, do not change the input data to be calculated until the process is completed. After the integral calculation is completed, `o_bOK` (Normal completion) turns on.
- If an error occurs, the execution of the FB is interrupted and `o_bErr` (Error completion) turns on. The error code of the error that occurred for the FB is stored in `o_uErrId` (Error code). For details of the error code, refer to [Page 65 Error code](#).

[Calculation example 1: When the input data type is WORD]

Setting example of input label

Label	Label name	Setting value
i_uSize	Number of data points	10
i_uDataType	Input data type selection	0 (Word [Signed])
i_ulInputDataAddr	Input data start address	10

No.	Input data	
0	R10 (Input data start address)	10
1	R11	20
2	R12	30
3	R13	40
4	R14	50
5	R15	60
6	R16	70

The calculation result of the following expression is output to o_eIntegrationData (Output data).

$$\begin{aligned}
 \sum_{i=0}^{N-1} (x_i) &= x_0 + x_1 + x_2 + x_3 + x_4 + x_5 + x_6 \\
 &= 10 + 20 + 30 + 40 + 50 + 60 + 70 \\
 &= 280
 \end{aligned}$$

[Calculation example 2: When the input data type is single-precision real number]

Setting example of input label

Label	Label name	Setting value
i_uSize	Number of data points	7
i_uDataType	Input data type selection	2 (Single-precision real number)
i_ulInputDataAddr	Input data start address	10

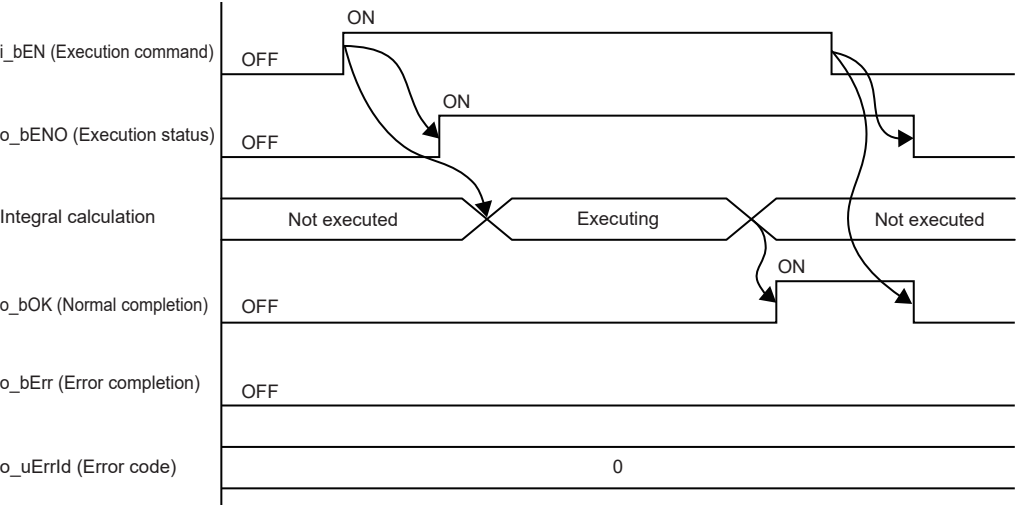
No.	Input data	
0	R10 (Input data start address)	1.1
	R11	
1	R12	1.2
	R13	
2	R14	1.3
	R15	
3	R16	1.4
	R17	
4	R18	1.5
	R19	
5	R20	1.6
	R21	
6	R22	1.7
	R23	

The calculation result of the following expression is output to o_eIntegrationData (Output data).

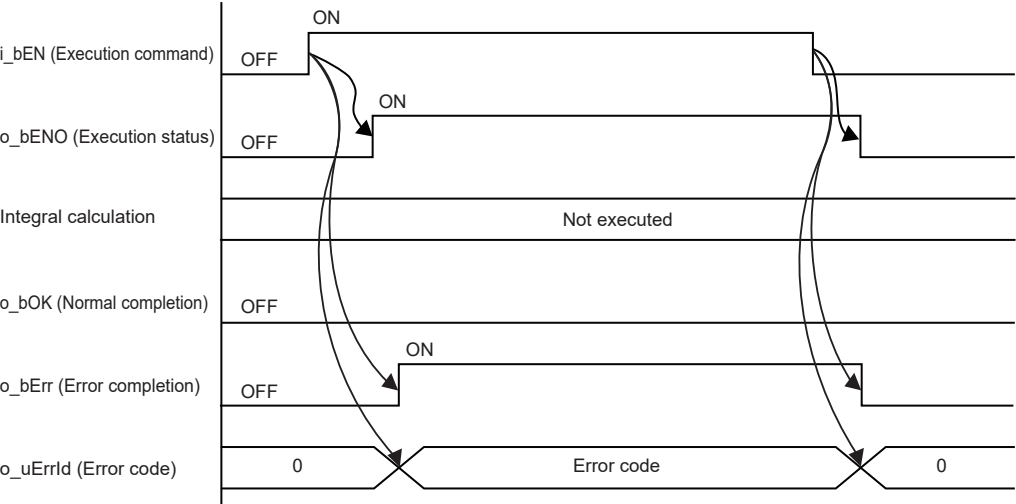
$$\begin{aligned}
 \sum_{i=0}^{N-1} (x_i) &= x_0 + x_1 + x_2 + x_3 + x_4 + x_5 + x_6 \\
 &= 1.1 + 1.2 + 1.3 + 1.4 + 1.5 + 1.6 + 1.7 \\
 &= 9.8
 \end{aligned}$$

Timing chart of I/O signals

■Normal completion



■Error completion



Restrictions and precautions

- This FB does not include error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- This FB uses the long index register Z0. Please do not use this index register in an interrupt program.
- This FB cannot be used in an interrupt program.
- Using the FB in a program that is to be executed only once, such as a subroutine program or a FOR-NEXT loop, has a problem that i_bEN (Execution command) can no longer be turned off and normal operation is not possible; Always use the FB in a program that is capable of turning off i_bEN (Execution command).
- This FB requires the configuration of the ladder for every input label.
- In this FB, the input data must be stored in the file register (R). For the file register (R) amount used, refer to the following.

i_uDataType (Input data type selection)	Size
0	i_uSize (Number of data points) × 1 point
2	i_uSize (Number of data points) × 2 points

Parameter setting

There is no required parameter setting to use this FB.

Performance value

CPU	Measurement condition		Process time	Maximum scan time	Number of scans
	Number of data points	Input data type selection			
FX5UJ	100 points	0: Word [Signed]	27.200ms	0.891ms	100 scans
		2: Single-precision real number	27.200ms	0.891ms	100 scans
	8000 points	0: Word [Signed]	2220.000ms	0.891ms	8000 scans
		2: Single-precision real number	2230.000ms	0.891ms	8000 scans
	16000 points	0: Word [Signed]	4420.000ms	0.891ms	16000 scans
		2: Single-precision real number	4490.000ms	0.891ms	16000 scans
FX5U, FX5UC ^{*1*2}	100 points	0: Word [Signed]	36.400ms	0.594ms	100 scans
		2: Single-precision real number	35.900ms	0.652ms	100 scans
	8000 points	0: Word [Signed]	1840.000ms	0.645ms	8000 scans
		2: Single-precision real number	1880.000ms	0.645ms	8000 scans
	16000 points	0: Word [Signed]	3640.000ms	0.645ms	16000 scans
		2: Single-precision real number	3720.000ms	0.647ms	16000 scans
FX5S	100 points	0: Word [Signed]	43.800ms	1.060ms	100 scans
		2: Single-precision real number	35.200ms	1.150ms	100 scans
	8000 points	0: Word [Signed]	2690.000ms	1.130ms	8000 scans
		2: Single-precision real number	2780.000ms	1.130ms	8000 scans
	16000 points	0: Word [Signed]	5410.000ms	1.130ms	16000 scans
		2: Single-precision real number	5500.000ms	1.130ms	16000 scans

*1 When the program capacity is set to 128K steps, the process speed may be decreased.

*2 The standard area is used for the labels.

Error code

Error code (hexadecimal)	Description	Action
103H	The setting value of i_uDataType (Input data type selection) is out of the range.	Set 0 or 2 in i_uDataType (Input data type selection). Review and correct the setting and then execute the FB again.
105H	The setting value of i_uSize (Number of data points) is out of the range.	Set a value of 1 to 16000 in i_uSize (Number of data points). Review and correct the setting and then execute the FB again.
11EH	Input data areas exceed the range of the file register (R).	Review the following settings so that the input data areas do not exceed the range of the file register (R). • i_uSize (Number of data points) • i_ulInputDataAddr (Input data start address) Review and correct the settings and then execute the FB again.
200H	Although the setting value of i_uDataType (Input data type selection) is set to a single-precision real number, the stored input data is not in the single-precision real number format.	Store the value in the file register (R) again in the single-precision real number format. Review and correct the input data and then execute the FB again.
205H	i_bEN (Execution command) has been turned off during the processing.	Keep the ON state of i_bEN (Execution command) until o_bOK (Normal completion) or o_bErr (Error completion) turns on.

3 FB LIBRARY APPLICATION EXAMPLE

This chapter shows application examples of this FB.

3.1 Application Example of M+DataStatistics_CoeffDetR2_F

Overview

Set five data points values as the predictive values for the device, and calculate the coefficients of determination with the actual measurement values using M+DataStatistics_CoeffDetR2_F.

For the actual measurement values, import the current values for the five data points from the equipment using the FX5 CPU module's built-in analog function.

Set the threshold value for the coefficient of determination for judging the occurrence of equipment error to 0.5. When the coefficient of determination is 0.5 or less, it is judged that the equipment has an error.

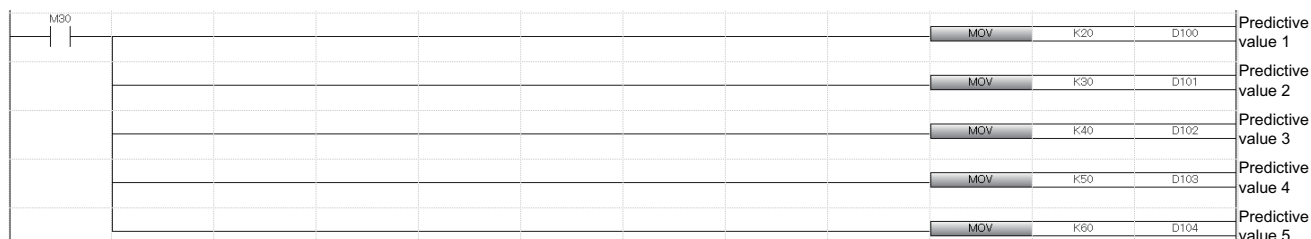
System configuration

For the system configuration example, refer to  Page 7 System Configuration.

Program example

■Setting the predictive value

Set the predictive values to D100 to D104.

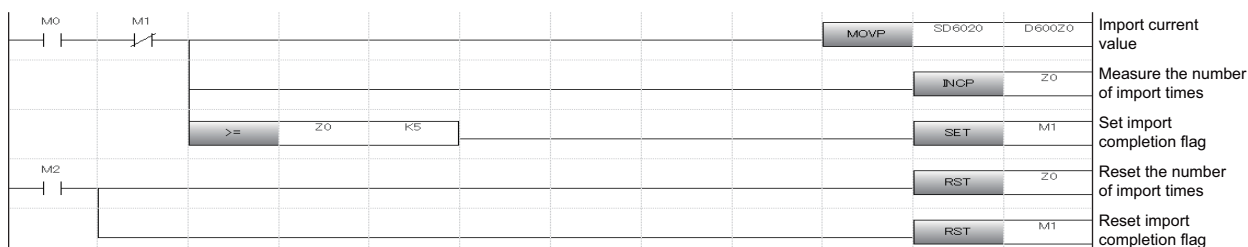


■Importing the current value as the actual measurement value

Import the current into D600 to D604 as the actual measurement values from the FX5 CPU module built-in analog CH1.

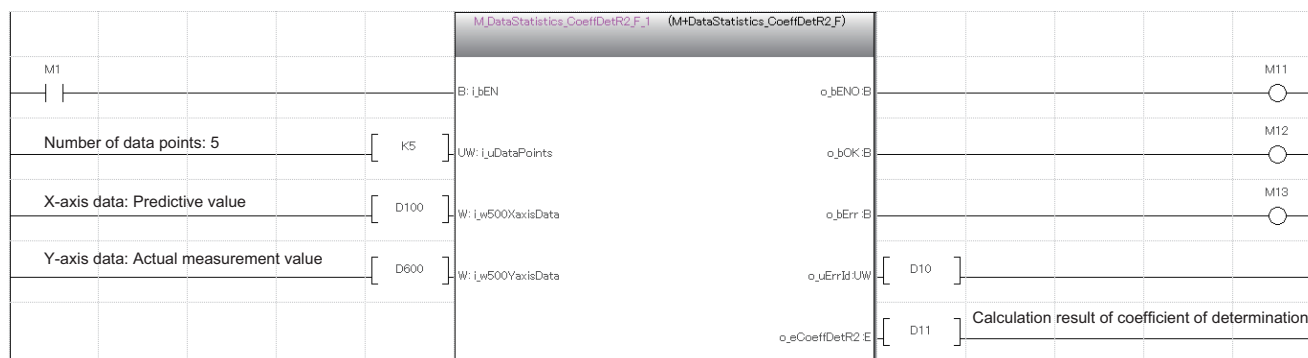
For the setting method to import the current from the built-in analog input, refer to "How to use analog inputs built in CPU module for current inputs" in the following.

 MELSEC iQ-F FX5 User's Manual (Analog Control - CPU module built-in, Expansion adapter)



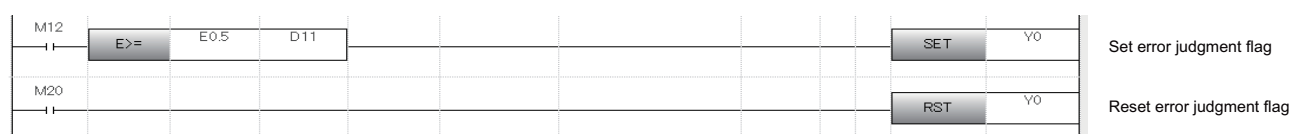
■Coefficient of determination calculation

The coefficient of determination is calculated from the set predictive value and actual measurement value. The calculation results of the coefficient of determination are stored in D11 and D12.



■Judgment for the coefficient of determination

Whether the coefficient of determination calculated in the FB for coefficient of determination calculation is 0.5 (threshold value) or less is judged.



Coefficient of determination calculation example

• Normal judgment

When the combinations of the predictive values and actual measurement values are as shown in the following table, the coefficient of determination becomes 0.974599, which is larger than 0.5 (threshold value), and is judged as normal.

Predictive value	Actual measurement value
20	19
30	33
40	38
50	49
60	65

• Abnormal judgment

When the combinations of the predictive values and actual measurement values are as shown in the following table, the coefficient of determination becomes 0.465249, which is equal to or less than 0.5 (threshold value), and is judged as abnormal.

Predictive value	Actual measurement value
20	29
30	13
40	36
50	57
60	42

3.2 Application Example of M+DataStatistics_Different_F

Overview

Assume that the number of data points for the input data is 100, and calculate the difference between values separated by the comparison data index.

System configuration

For the system configuration example, refer to  Page 7 System Configuration.

Program example

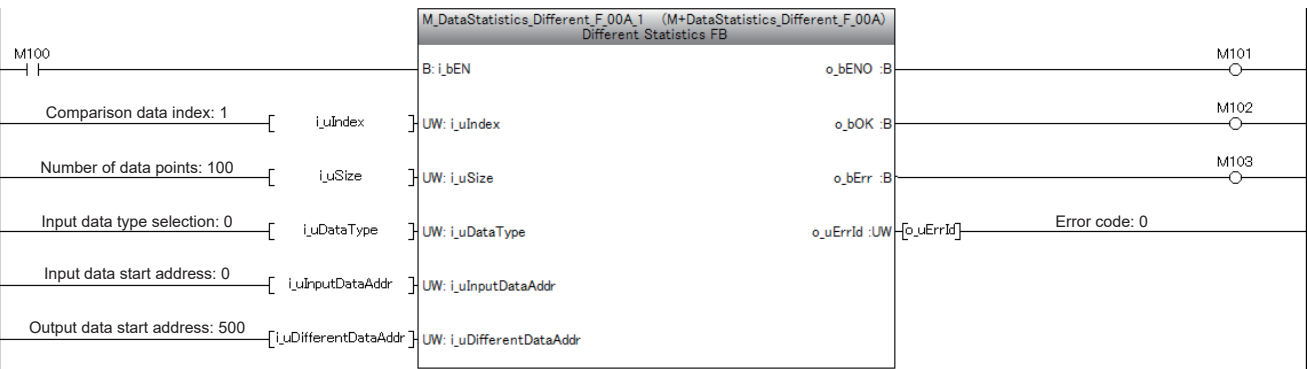
Input value setting

Set the input values for i_uIndex, i_uSize, i_uDataType, i_uInputDataAddr, and i_uDifferentDataAddr.



Differential calculation

Execute differential calculation for the set input values. The differential calculation results are stored as a real number in the file register (R) for the output data.



3.3 Application Example of M+DataStatistics_Integration_F

Overview

Assume that the number of data points for the input data is 7, and calculate the sum of all the input data.

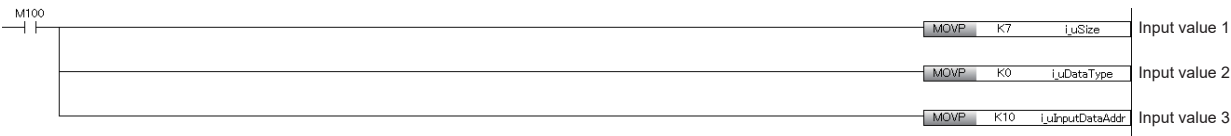
System configuration

For the system configuration example, refer to  Page 7 System Configuration.

Program example

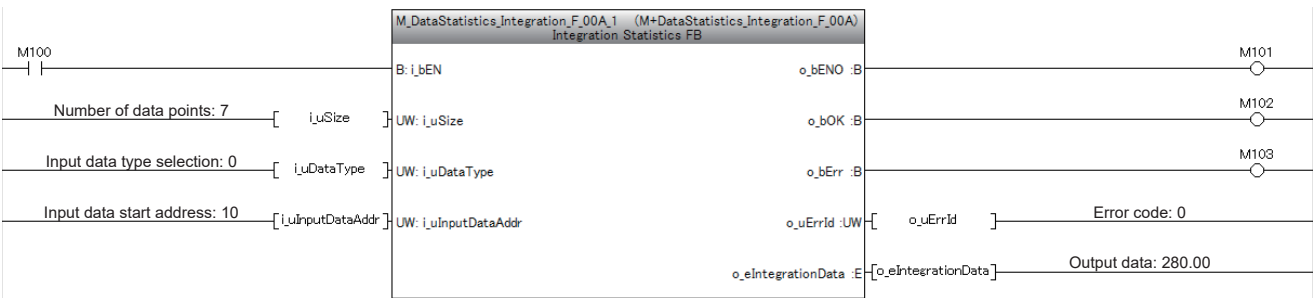
Input value setting

Set the input values for i_uSize, i_uDataType, and i_uInputDataAddr.



Integral calculation

Execute integral calculation for the set input values. The integral calculation result is stored as a real number in o_eIntegrationData (Output data).



APPENDIX

Appendix 1 M+DataStatistics_FrequencyDistribution_F (Frequency Distribution) Sample Project

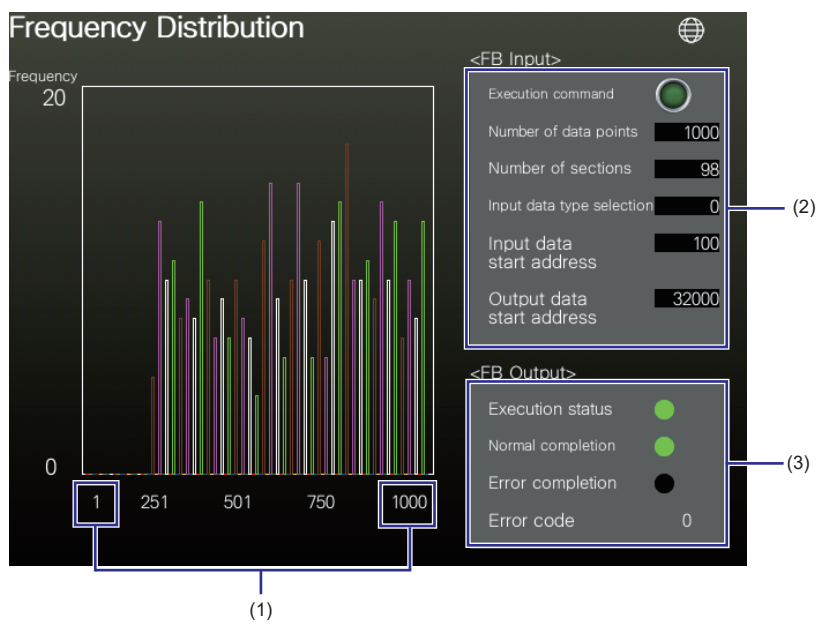
Function

Obtains the result of the frequency distribution calculation for the specified data and displays the frequency distribution on the GOT screen.

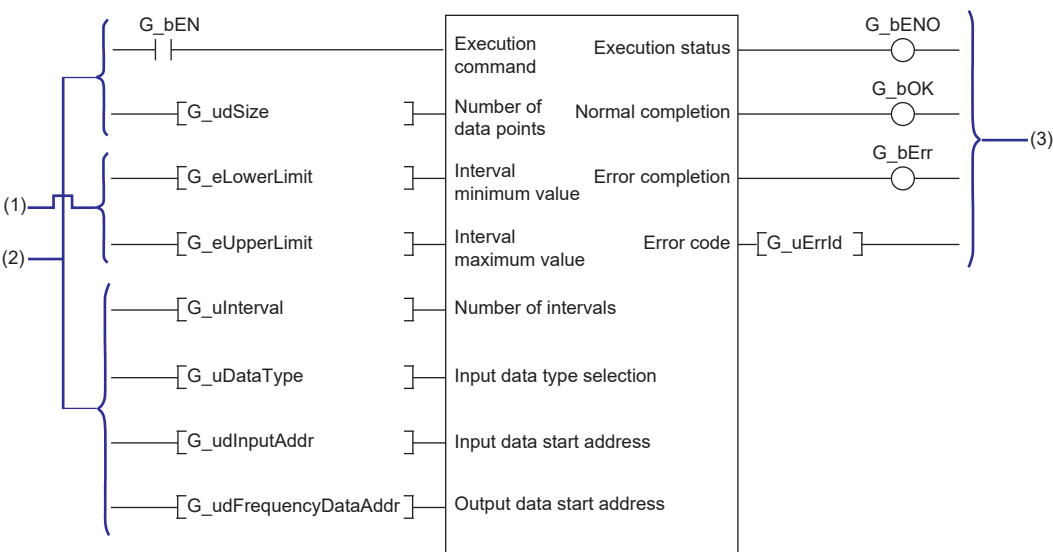
Correspondence between the GOT screen and FB

The following shows the correspondence between each item on the GOT screen and the input/output of the FB.

GOT screen

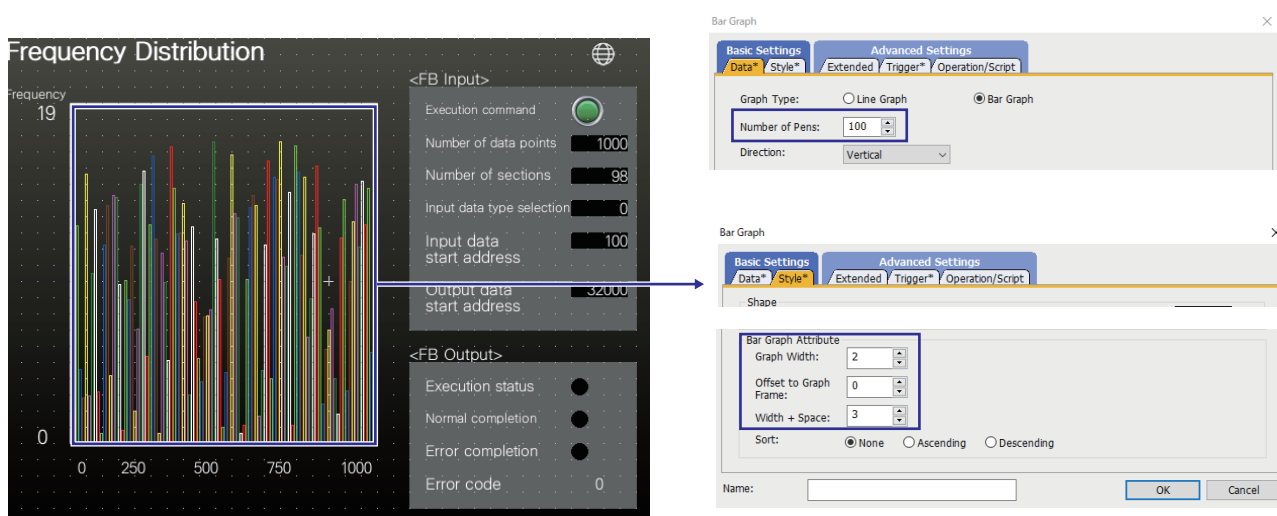


FB I/O



Note

To change the number and width of bars in the bar chart displayed on the GOT screen, double-click the bar chart on the Frequency Distribution screen in the GOT sample project. Then, change the value of "Number of Pens" in the [Data] tab and values of "Bar Graph Attribute" in the [Style] tab.



Because the sample project does not import sample data only by the RUN operation after writing the project to the programmable controller, follow the procedure below.

Operating procedure

1. Click [Online]⇒[Write to PLC]⇒[Parameter + Program]⇒[Execute] from the menu to write the sample program.
2. After writing is completed, reset the CPU module.
3. After setting the RUN/STOP/RESET switch to STOP, click [Online]⇒[Write to PLC]⇒[Deselect All].
4. Write the device memory with only [Device Memory] and [MAIN] selected.
5. After writing is completed, set the RUN/STOP/RESET switch to RUN.

Point

If the reset operation is performed during Step 3 to 5, the programmable controller is initialized and thus the sample data is cleared. To operate this sample project, do not perform the reset operation midway.

A

Global label, device assignment

The following table shows the assignment of the global labels and devices used in this sample project.

No.	Label	Label name	Data type	Assigned device	Input/output label corresponding to M+DataStatistics_FrequencyDistribution_F (Frequency distribution FB)
(1)	G_bEN	Execution command	Bit	M100	Execution command (i_bEN)
(2)	G_udSize	Number of data points	Double word [Unsigned]/Bit string [32-bit]	D100 to D101	Number of data points (i_udSize)
(3)	G_uDataType	Input data type selection	Word [Unsigned]/Bit string [16-bit]	D107	Input data type selection (i_uDataType)
(4)	G_uInterval	Number of intervals	Word [Unsigned]/Bit string [16-bit]	D106	Number of intervals (i_uInterval)
(5)	G_udInputDataAddr	Input data start address	Double word [Unsigned]/Bit string [32-bit]	D108 to D109	Input data start address (i_udInputDataAddr)
(6)	—*1	Input data	Word [Unsigned]/Bit string [16-bit]	R100 to R1099	—
			Single-precision real number	R100 to R2198	
(7)	G_udFrequencyDataAddr	Output data start address	Double word [Unsigned]/Bit string [32-bit]	D100 to D101	Output data start address (i_udFrequencyDataAddr)
(8)	—*2	Output data	Word [Unsigned]/Bit string [16-bit]	R32000 to R32099	—
(9)	G_eLowerLimit	Interval minimum value	Single-precision real number	D102 to D103	Interval minimum value (i_eLowerLimit)
(10)	G_eUpperLimit	Interval maximum value	Single-precision real number	D104 to D105	Interval maximum value (i_eUpperLimit)
(11)	G_bENO	Execution status	Bit	M110	Execution status (o_bENO)
(12)	G_bOK	Normal completion	Bit	M111	Normal completion (o_bOK)
(13)	G_bErr	Error completion	Bit	M112	Error completion (o_bErr)
(14)	G_uErrId	Error code	Word [Unsigned]/Bit string [16-bit]	D112	Error code (o_uErrId)
(15)	G_uVerticAlaxis_Max	Axis maximum value	Word [Unsigned]/Bit string [16-bit]	D114 to D115	—
(16)	G_uAbscissa_Middle	Frequency distribution horizontal axis middle value	Single-precision real number	D117 to D118	
(17)	G_uAbscissa_Quarter	Frequency distribution horizontal axis quarter value	Single-precision real number	D119 to D120	
(18)	G_uAbscissa_threeQuarter	Frequency distribution horizontal axis three-quarter value	Single-precision real number	D121 to D122	

*1 Because the input data is used only in the sequence program, no global label is defined and only the device is assigned.

*2 Because some of the output data is used only in the sequence program, no global label is defined and only the device is assigned.

Appendix 2 M+DataStatistics_Boxplot_F (Box Plot) Sample Project

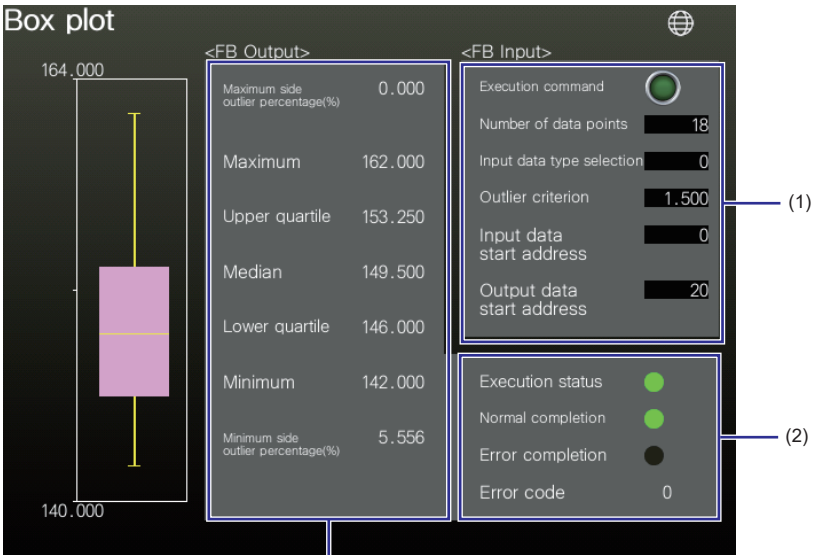
Function

Obtains the calculation result for each element of the box plot based on the specified data and displays it on the GOT screen.

Correspondence between the GOT screen and FB

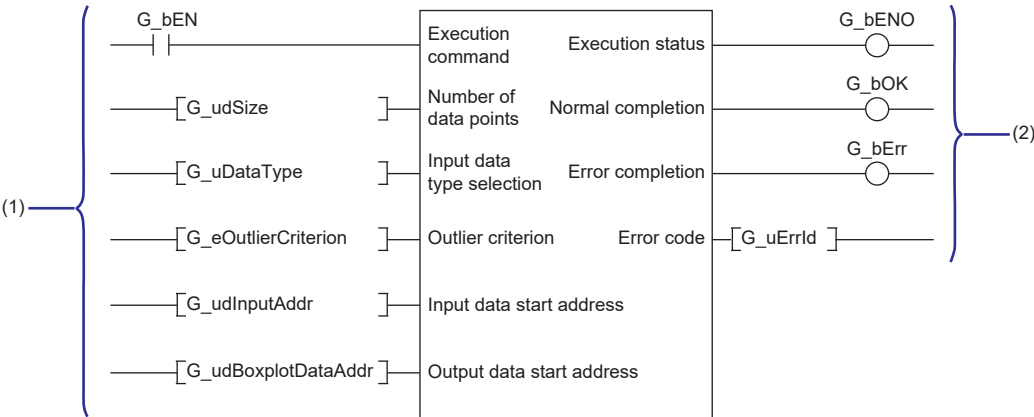
The following shows the correspondence between each item on the GOT screen and the input/output of the FB.

GOT screen



FB execution result
Each element of the box plot to be stored in the file register (R)
whose address has been specified in i_udBoxplotDataAddr (Output data start address)

FB I/O



Note

- The box plot is displayed while i_bOK (Normal completion) of M+DataStatistics_Boxplot_F (Boxplot FB) is on.
- Outliers are not displayed on the GOT screen.

Global label, device assignment

The following table shows the assignment of the global labels and devices used in this sample project.

No.	Label	Label name	Data type	Assigned device	Input/output label corresponding to M+DataStatistics_Boxplot_F (Box plot FB)
(1)	G_bEN	Execution command	Bit	M200	Execution command (i_bEN)
(2)	G_udSize	Number of data points	Double word [Unsigned]/Bit string [32-bit]	D150 to D151	Number of data points (i_udSize)
(3)	G_uDataType	Input data type selection	Word [Unsigned]/Bit string [16-bit]	D152	Input data type selection (i_uDataType)
(4)	G_eOutlierCriterion	Outlier criterion	Single-precision real number	D154 to D155	Outlier criterion (i_eOutlierCriterion)
(5)	G_udInputDataAddr	Input data start address	Double word [Unsigned]/Bit string [32-bit]	D156 to D157	Input data start address (i_udInputDataAddr)
(6)	—*1	Input data	Word [Unsigned]/Bit string [16-bit]	R0-R17	—
(7)	G_udBoxplotDataAddr	Output data start address	Double word [Unsigned]/Bit string [32-bit]	D158 to D159	Output data start address (i_udFrequencyDataAddr)
(8)	G_e7BoxplotData	Output data	Single-precision real number (0..6)	R20 to R33	—
	—*2		Word [Unsigned]/Bit string [16-bit]	R34 to R51	—
(9)	G_bENO	Execution status	Bit	M210	Execution status (o_bENO)
(10)	G_bOK	Normal completion	Bit	M211	Normal completion (o_bOK)
(11)	G_bErr	Error completion	Bit	M212	Error completion (o_bErr)
(12)	G_uErrId	Error code	Word [Unsigned]/Bit string [16-bit]	D160	Error code (o_uErrId)
(13)	G_eAxisMax	Axis maximum value	Single-precision real number	D162 to D163	—
(14)	G_eAxisMin	Axis minimum value	Single-precision real number	D164 to D165	—

*1 Because the input data is used only in the sequence program, no global label is defined and only the device is assigned.

*2 Because some of the output data is used only in the sequence program, no global label is defined and only the device is assigned.

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MEMO

REVISIONS

*The manual number is given on the bottom left of the back cover.

Revision date	*Manual number	Description
October 2018	SH(NA)-082093ENG-A	First edition
October 2019	SH(NA)-082093ENG-B	■Added or modified parts Chapter 2, 3
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HEAD OFFICE: TOKYO BLDG., 2-7-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN
NAGOYA WORKS: 1-14, YADA-MINAMI 5-CHOME, HIGASHI-KU, NAGOYA 461-8670, JAPAN

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