MITSUBISHI ELECTRIC

Programmable Controller

MELSEC iQ-R series

MELSEC iQ-R Statistical Analysis Function Block Library Reference (Basic)

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1 OVERVIEW

The FB library in this manual is for statistical analysis.

1.1 FB Library List

The following table lists the FB library in this manual.

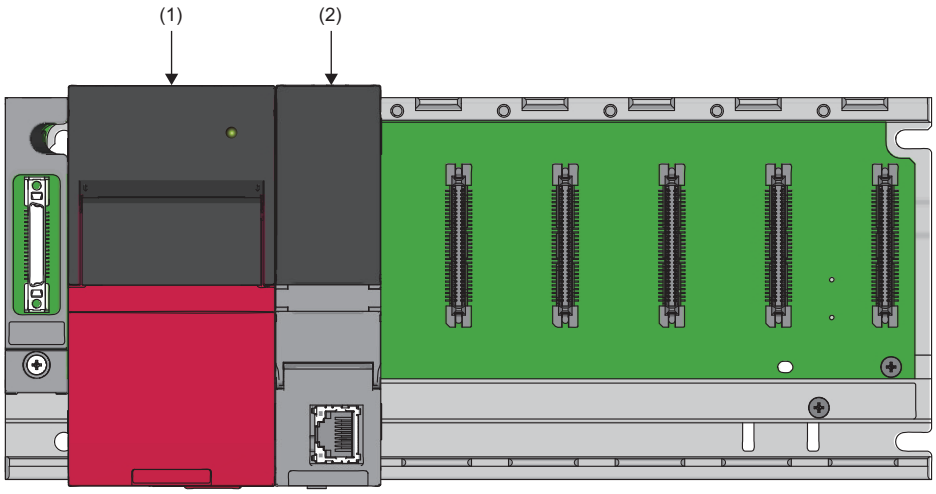
Name	Description
M+DataStatistics_MovingAverage_R	Calculates the moving average of the specified data.
M+DataStatistics_StandardDeviation_R	Obtains the standard deviation operation result of the specified data.
M+DataStatistics_StandardDeviationEx_R	Calculates the standard deviation from the specified data and a reference value.
M+DataStatistics_Variance_R	Obtains the distributed arithmetic operation result of the specified data.
M+DataStatistics_FrequencyDistribution_R	Obtains the frequency distribution operation result of the specified data.
M+DataStatistics_CalcCoefficient_R	Calculates the coefficient of correlation and the coefficient of determination from predicted values and observed values.

For the FB library, please consult your local Mitsubishi representative.

For how to register the FB library, refer to the GX Works3 Operating Manual.

1.2 System Configuration Example

The following figure shows a system configuration example to use the FB library in this manual.



(1) Power supply module

(2) CPU module

For the specifications of the modules, refer to the user's manual for the module used.

MEMO

2 DETAILS OF THE FB LIBRARY

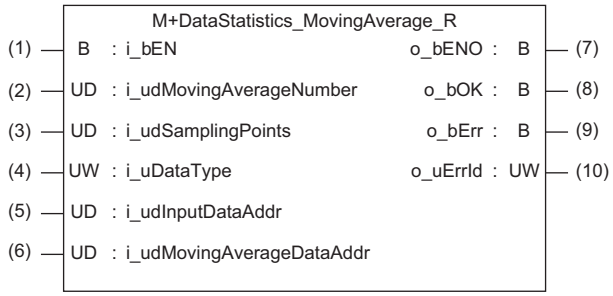
This chapter describes the details of the FB library.

2.1 M+DataStatistics_MovingAverage_R

Name

M+DataStatistics_MovingAverage_R

Overview

Item	Description
Functional overview	Calculates the moving average of the specified data.
Symbol	

Labels to use

■Input labels

No.	Variable name	Name	Data type	Scope	Description
(1)	i_bEN	Execution command	Bit	On or off	On: The FB is activated. Off: The FB is not activated.
(2)	i_udMovingAverageNumber	Number of moving average	Double Word [unsigned]	1 to 90000	Sets the number of moving average for the moving average operation.
(3)	i_udSamplingPoints	Number of sampling points	Double Word [unsigned]	1 to 90000	Sets the number of sampling points used for the moving average processing.
(4)	i_uDataType	Input data type selection	Word [unsigned]	0, 2	Specifies 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]	Valid device range*1	Specifies the start address of the file register (ZR) where input data is stored.
(6)	i_udMovingAverageDataAddr	Output data start address	Double Word [unsigned]	Valid device range*1	Specifies the start address of the file register (ZR) where the moving average result is stored. As the moving average results are output as single-precision real numbers (2-word), they are stored in file register within the range of "number of sampling points × 2", starting from the file register (ZR) specified with the output data start address.

*1 The valid range varies depending on "File Register Setting" of "CPU Parameter".

■Output labels

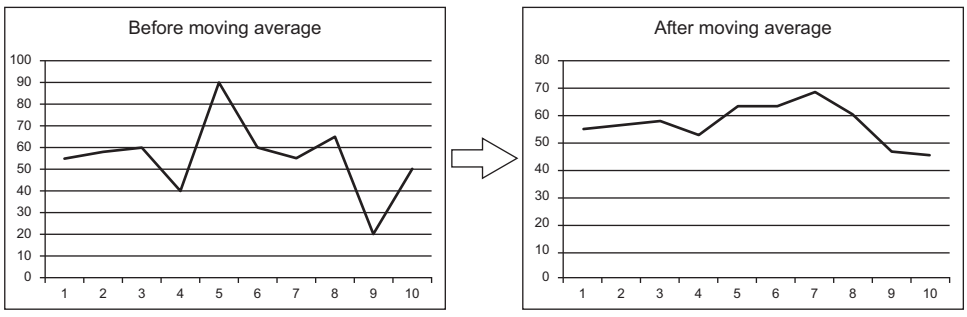
No.	Variable name	Name	Data type	Default value	Description
(7)	o_bENO	Execution status	Bit	Off	On: The execution command is on. Off: The execution command is off.
(8)	o_bOK	Normal completion	Bit	Off	The on state indicates that the moving average operation has been completed.
(9)	o_bErr	Error completion	Bit	Off	The on state indicates that an error has occurred in the FB.
(10)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error that occurred in the FB is returned.

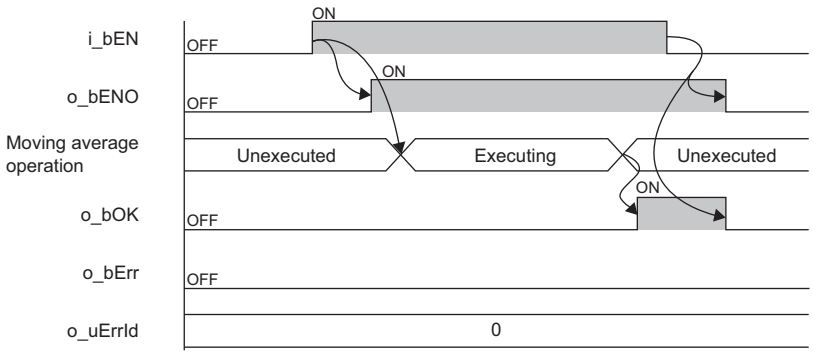
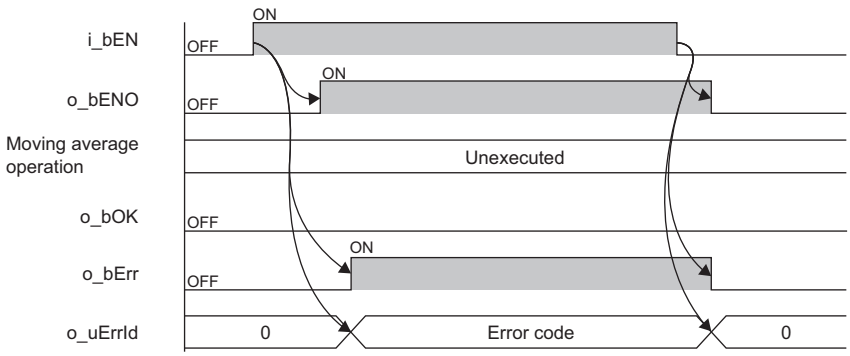
FB details

Item	Description	
Relevant devices	CPU module	MELSEC iQ-R series
	Engineering tool	GX Works3 of version 1.055H or later
Language to use	— (The internal program of this FB is not open to the public.)	
Number of steps	515 steps The number of steps of the FB embedded in a program depends on the CPU module used, the input/output definitions, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
Label usage	• Label: 0.12K points (Word) • Latch label: 0.01K points (Word) The usage of labels embedded in a program depends on the CPU module used, the devices specified as an argument, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
FB dependence	No dependence	
Functional description	(1) As i_bEN (execution command) turns on, this FB calculates the moving average of the specified input data values. This FB uses data in file register areas for the number of sampling points starting from the one specified with the input data start address. The FB calculates the average of input data values in the areas of the range specified by the number of moving average. And then the FB stores the result in file register areas in order starting from the output data start address. This FB calculates the moving average with the following formula. "j" stands for the number of calculations, "x_i" for i-th input data, and "M" for the number of moving average. ■Number of calculations (j) < Number of moving average (M) $\text{Moving average (j)} = \frac{\sum_{i=1}^{j} x_i}{j}$ ■Number of calculations (j) ≥ Number of moving average (M) $\text{Moving average (j)} = \frac{\sum_{i=j-M+1}^{j} x_i}{M}$ ■Example The following figure shows an operation example of when values of each input label are as follows. • i_udMovingAverageNumber (moving average): 3 • i_udSamplingPoints (number of sampling points): 10 • i_udInputDataAddr (input data start address): 0 (ZR0) • i_udMovingAverageDataAddr (output data start address): 20 (ZR20)	

No.	Input data		No.	Output data		Operation
1	ZR0 (input data start address)	55	1	ZR20 (output data start address)	55	Average of No.1
2	ZR1	58	2	ZR22	56.5	Average of No.1 and No.2
3	ZR2	60	3	ZR24	57.66667	Average of No.1, No.2, and No.3
4	ZR3	40	4	ZR26	52.66667	Average of No.2, No.3, and No.4
5	ZR4	90	5	ZR28	63.33333	Average of No.3, No.4, and No.5
6	ZR5	60	6	ZR30	63.33333	Average of No.4, No.5, and No.6
7	ZR6	55	7	ZR32	63.33333	Average of No.5, No.6, and No.7
8	ZR7	65	8	ZR34	60	Average of No.6, No.7, and No.8
9	ZR8	20	9	ZR36	46.66667	Average of No.7, No.8, and No.9
10	ZR9	50	10	ZR38	45	Average of No.8, No.9, and No.10

As the moving average results are output as single-precision real numbers (2-word), they are stored in file register areas within the range of "number of sampling points × 2", starting from the file register area (ZR) specified with the output data start address.



Item		Description
Functional description		(2) The input data used for the moving average operation are read from the file register (ZR), starting from the area of the address specified by i_udInputDataAddr (input data start address). This FB reads input data for the number of points set in i_udSamplingPoints (number of sampling points). (3) Operation results are stored in the file register (ZR), starting from the area of the address specified by i_udMovingAverageDataAddr (output data start address). The operation results are output as single-precision real numbers, within the range of "i_udSamplingPoints (number of sampling points) × 2". (4) It takes multiple scans until the moving average operation is completed. Thus, do not change the input data values used for the operation until the processing is completed. When the moving average operation is completed, o_bOK (normal completion) turns on. (5) If a value out of the range is set in i_udSamplingPoints (number of sampling points), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 105H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 8 List of error codes) (6) If i_udMovingAverageNumber (number of moving average) is greater than i_udSamplingPoints (number of sampling points), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 115H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 8 List of error codes) (7) If a value out of the range is set in i_uDataType (input data type selection), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 103H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 8 List of error codes) (8) If an overflow occurs during the moving average operation, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 203H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 8 List of error codes) (9) If i_bEN (execution command) is turned off before o_bOK (normal completion) or o_bErr (error completion) turns on, o_bErr (error completion) turns on in one scan. In addition, 205H is stored in o_uErrId (error code) in one scan. For the error code, refer to the list of error codes. (☞ Page 8 List of error codes) (10)When a single-precision real number is set in i_uDataType (input data type selection) and the value stored in the file register (ZR) is not a single-precision real number, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 200H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 8 List of error codes) (11)Some of the areas specified by i_udInputDataAddr (input data start address) and i_udMovingAverageDataAddr (output data start address) are overlapped. In such a case, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 11DH is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 8 List of error codes)
FB compilation method		Subroutine type
FB operation		Pulse execution type (multiple scan execution type)
Timing chart of I/O signals	Normal completion	
	Error completion	

Item	Description
Restrictions and precautions	(1) This FB does not include the error recovery processing. Prepare the error recovery processing separately to suit the user's system and the expected operation. (2) This FB uses the long index registers LZ0, LZ1, and LZ2. Set the long index (LZ) to three points or greater in "Index Register Setting" of "CPU Parameter". (📖 MELSEC iQ-R CPU Module User's Manual (Application)) When using interrupt programs, do not use the corresponding index registers. (3) The FB cannot be used in an interrupt program. (4) 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 the execution command. (5) The FB requires the configuration of the ladder for every input label. (6) The FB requires the input data to be stored in the file register (ZR). In addition, an operation result data is output in the file register (ZR). Refer to the following examples and set the file register (ZR) capacity. For the setting method, refer to the MELSEC iQ-R CPU Module User's Manual (Application). ■When 0 is set in i_uDataType (input data type selection) Set the capacity of "i_udSamplingPoints (number of sampling points) × 3" for the file register (ZR). ■When 2 is set in i_uDataType (input data type selection) Set the capacity of "i_udSamplingPoints (number of sampling points) × 4" for the file register (ZR). (7) This FB checks the input data values before the moving average operation execution to prevent an overflow from occurring during the operation. If a possibility of an overflow is detected at this check, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). For the operation with the single-precision real number, an error may occur depending on the combination of input data values. Even after the input data values are checked, the instruction execution fault (operation error) may occur at the operation execution. In such a case, if "RAS Setting" of "CPU Parameter" is set to continue the processing even after an operation error occurs, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). (8) If 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module due to an error outside FB while i_bEN (execution command) of this FB is on, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 204H is stored in o_uErrId (error code). However, if "RAS Setting" of "CPU Parameter" is set to stop the processing after an operation error occurs, 204H is not stored in o_uErrId (error code).

Performance value

The following table lists the performance values of this FB under the following conditions.

- CPU module: R16CPU
- File register storage location: CPU built-in memory
- FB compilation method: Subroutine type

Input label			Time required for the processing*1	Maximum scan time	Number of the scans required for the processing
Number of sampling points	Input data type	Number of moving average			
100 points	0: Word [signed]	1	0.474ms	0.21ms	5 scans
		50	0.488ms	0.209ms	
		100	0.473ms	0.211ms	
	2: Single-precision real number	1	0.473ms	0.211ms	
		50	0.486ms	0.209ms	
		100	0.476ms	0.209ms	
45000 points	0: Word [signed]	1	254ms	0.22ms	2250 scans
		22500	255ms	0.211ms	
		45000	254ms	0.213ms	
	2: Single-precision real number	1	256ms	0.213ms	
		22500	258ms	0.22ms	
		45000	256ms	0.216ms	
90000 points	0: Word [signed]	1	508ms	0.215ms	4500 scans
		45000	510ms	0.215ms	
		90000	507ms	0.216ms	
	2: Single-precision real number	1	512ms	0.219ms	
		45000	516ms	0.221ms	
		90000	511ms	0.219ms	

*1 The time required from start to end of the processing

List of error codes

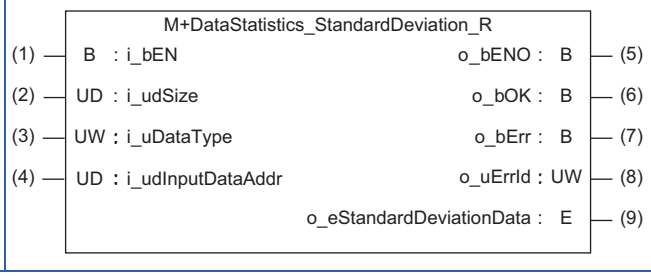
Error code	Description	Action
103H	A value out of the range is set in i_uDataType (input data type selection).	Set 0 or 2 in i_uDataType (input data type selection). Review and correct the setting and then execute the FB again.
105H	A value out of the range is set in i_udSamplingPoints (number of sampling points).	Set a value of 1 to 90000 in i_udSamplingPoints (number of sampling points). Review and correct the setting and then execute the FB again.
115H	A value out of the range is set in i_udMovingAverageNumber (number of moving average).	Set the value that satisfies the following conditions in i_udMovingAverageNumber (number of moving average). • i_udMovingAverageNumber (number of moving average) ≥ 1 • i_udMovingAverageNumber (number of moving average) ≤ i_udSamplingPoints (number of sampling 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_udSamplingPoints (number of sampling points) • i_udInputDataAddr (input data start address) • i_udMovingAverageDataAddr (output data start address) Review and correct the settings and then execute the FB again.
200H	Although the value set in i_uDataType (input data type selection) is Single-precision real number, the stored input data is not a single-precision real number.	Store the input data as a single-precision real number in the file register (ZR). Review and correct the input data and then execute the FB again.
203H	An overflow has occurred in the FB during the operation.	Review and correct the input data stored in the file register (ZR) and then execute the FB again. When 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module, refer to the MELSEC iQ-R CPU Module User's Manual (Application).
204H	The processing of the FB has been interrupted due to an overflow in an operation other than that of this FB.	An overflow has occurred in the operation other than that of this FB, and 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module. Refer to the MELSEC iQ-R CPU Module User's Manual (Application).
205H	i_bEN (execution command) has been turned off during the processing.	Do not turn off i_bEN (execution command) until o_bOK (normal completion) or o_bErr (error completion) turns on.

2.2 M+DataStatistics_StandardDeviation_R

Name

M+DataStatistics_StandardDeviation_R

Overview

Item	Description
Functional overview	Obtains the standard deviation operation result of the specified data.
Symbol	

Labels to use

■Input labels

No.	Variable name	Name	Data type	Scope	Description
(1)	i_bEN	Execution command	Bit	On or off	On: The FB is activated. Off: The FB is not activated.
(2)	i_udSize	Number of data points	Double Word [unsigned]	1 to 90000	Sets the number of input data points for the standard deviation operation.
(3)	i_uDataType	Input data type selection	Word [unsigned]	0, 2	Specifies 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]	Valid device range*1	Specifies the start address of the file register (ZR) where input data is stored.

*1 The valid range varies depending on "File Register Setting" of "CPU Parameter".

■Output labels

No.	Variable name	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	The on state indicates that the standard deviation operation has been completed.
(7)	o_bErr	Error completion	Bit	Off	The on state indicates that an error has occurred in the FB.
(8)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error that occurred in the FB is returned.
(9)	o_eStandardDeviationData	Output data	Single-precision real number	0	The standard deviation operation result is stored.

FB details

Item	Description	
Relevant devices	CPU module	MELSEC iQ-R series
	Engineering tool	GX Works3 of version 1.055H or later
Language to use	— (The internal program of this FB is not open to the public.)	
Number of steps	474 steps The number of steps of the FB embedded in a program depends on the CPU module used, the input/output definitions, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
Label usage	• Label: 0.1K points (Word) • Latch label: 0.01K points (Word) The usage of labels embedded in a program depends on the CPU module used, the devices specified as an argument, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
FB dependence	No dependence	
Functional description	(1) As i_bEN (execution command) turns on, this FB calculates a standard deviation of the specified input data values. This FB calculates the standard deviation with the following formula. "N" stands for the number of data points, "x_i" for i-th data, and "$\bar{x}$" for the average of input data values in file register areas for the number of data points (N) starting from the one specified with the input data start address. $\text{Standard deviation} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}$ ■Example The following figures show an operation example of when values of each input label are as follows. • i_udSize (number of data points): 3 • i_udInputDataAddr (input data start address): 0 (ZR0) • i_uDataType (input data type selection): 0	

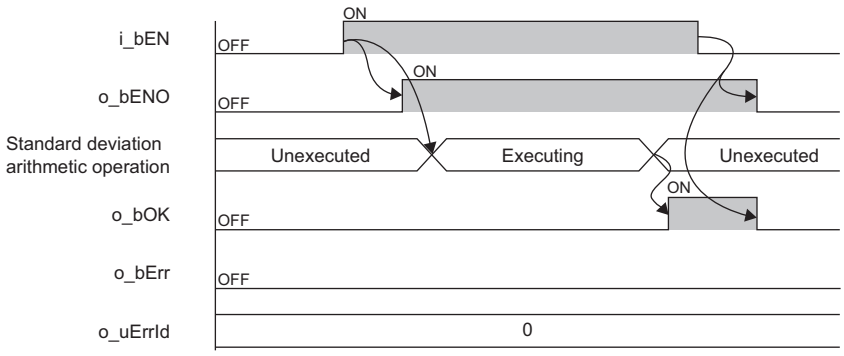
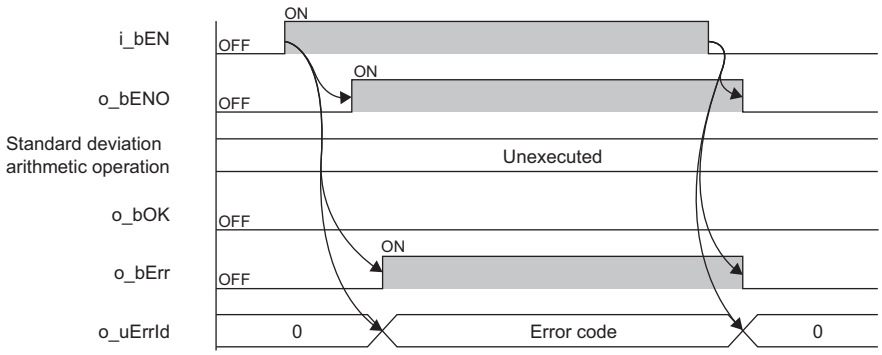
No.	Input data	
1	ZR0 (input data start address)	10
2	ZR1	20
3	ZR2	30

In this case, $\bar{x}$ is (10 + 20 + 30)/3 = 20.
The following value is obtained by applying the above values to the formula to calculate the standard deviation.

$$\sqrt{\frac{(10 - 20)^2 + (20 - 20)^2 + (30 - 20)^2}{3}} \fallingdotseq 8.16$$

(2) The input data used for the standard deviation operation are read from the file register (ZR), starting from the area of the address specified by i_udInputDataAddr (input data start address). This FB reads input data for the number of points set in i_udSize (number of data points).
(3) The operation result is output as a single-precision real number to o_eStandardDeviationData (output data).
(4) It takes multiple scans until the standard deviation operation is completed. Thus, do not change the input data values used for the operation until the processing is completed. When the standard deviation operation is completed, o_bOK (normal completion) turns on.
(5) If a value out of the range is set in i_udSize (number of data points), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 105H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 12 List of error codes)
(6) If a value out of the range is set in i_uDataType (input data type selection), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 103H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 12 List of error codes)
(7) If an overflow occurs during the standard deviation operation, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 203H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 12 List of error codes)
(8) If i_bEN (execution command) is turned off before o_bOK (normal completion) or o_bErr (error completion) turns on, o_bErr (error completion) turns on in one scan. In addition, 205H is stored in o_uErrId (error code) in one scan. For the error code, refer to the list of error codes. (☞ Page 12 List of error codes)
(9) When a single-precision real number is set in i_uDataType (input data type selection) and the value stored in the file register (ZR) is not a single-precision real number, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 200H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 12 List of error codes)

FB compilation method	Subroutine type
FB operation	Pulse execution type (multiple scan execution type)

Item		Description
Timing chart of I/O signals	Normal completion	
	Error completion	
Restrictions and precautions		(1) This FB does not include the error recovery processing. Prepare the error recovery processing separately to suit the user's system and the expected operation. (2) This FB uses the long index register LZ0. When using interrupt programs, do not use the corresponding index register. (3) The FB cannot be used in an interrupt program. (4) 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 the execution command. (5) The FB requires the configuration of the ladder for every input label. (6) The FB requires the input data to be stored in the file register (ZR). Refer to the following examples and set the file register (ZR) capacity. For the setting method, refer to the MELSEC iQ-R CPU Module User's Manual (Application). ■When 0 is set in i_uDataType (input data type selection) Set the capacity of i_udSize (number of data points) for the file register (ZR). ■When 2 is set in i_uDataType (input data type selection) Set the capacity of "i_udSize (number of data points) × 2" for the file register (ZR). (7) This FB checks the input data values before the standard deviation operation execution to prevent an overflow from occurring during the operation. If a possibility of an overflow is detected at this check, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). For the operation with the single-precision real number, an error may occur depending on the combination of input data values. Even after the input data values are checked, the instruction execution fault (operation error) may occur at the operation execution. In such a case, if "RAS Setting" of "CPU Parameter" is set to continue the processing even after an operation error occurs, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). (8) If 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module due to an error outside FB while i_bEN (execution command) of this FB is on, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 204H is stored in o_uErrId (error code). However, if "RAS Setting" of "CPU Parameter" is set to stop the processing after an operation error occurs, 204H is not stored in o_uErrId (error code).

Performance value

The following table lists the performance values of this FB under the following conditions.

- CPU module: R16CPU
- File register storage location: CPU built-in memory
- FB compilation method: Subroutine type

Input label		Time required for the processing[*1]	Maximum scan time	Number of the scans required for the processing
Number of data points	Input data type			
2 points	0: Word [signed]	0.148ms	0.21ms	2 scans
	2: Single-precision real number	0.138ms	0.206ms	
45000 points	0: Word [signed]	643ms	0.28ms	4500 scans
	2: Single-precision real number	647ms	0.275ms	
90000 points	0: Word [signed]	1290ms	0.278ms	9000 scans
	2: Single-precision real number	1300ms	0.28ms	

*1 The time required from start to end of the processing

List of error codes

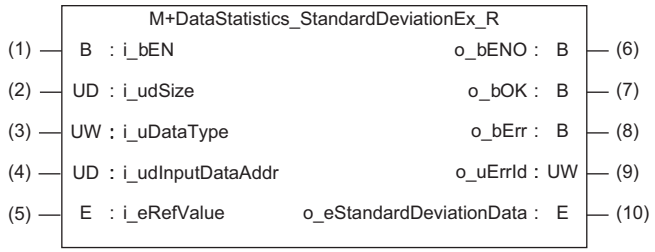
Error code	Description	Action
103H	A value out of the range is set in i_uDataType (input data type selection).	Set 0 or 2 in i_uDataType (input data type selection). Review and correct the setting and then execute the FB again.
105H	A value out of the range is set in i_udSize (number of data points).	Set a value of 1 to 90000 in i_udSize (number of data points). Review and correct the setting and then execute the FB again.
200H	Although the value set in i_uDataType (input data type selection) is Single-precision real number, the stored input data is not a single-precision real number.	Store the input data as a single-precision real number in the file register (ZR). Review and correct the input data and then execute the FB again.
203H	An overflow has occurred in the FB during the operation.	Review and correct the input data stored in the file register (ZR) and then execute the FB again. When 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module, refer to the MELSEC iQ-R CPU Module User's Manual (Application).
204H	The processing of the FB has been interrupted due to an overflow in an operation other than that of this FB.	An overflow has occurred in the operation other than that of this FB, and 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module. Refer to the MELSEC iQ-R CPU Module User's Manual (Application).
205H	i_bEN (execution command) has been turned off during the processing.	Do not turn off i_bEN (execution command) until o_bOK (normal completion) or o_bErr (error completion) turns on.

2.3 M+DataStatistics_StandardDeviationEx_R

Name

M+DataStatistics_StandardDeviationEx_R

Overview

Item	Description
Functional overview	Calculates the standard deviation from the specified data and a reference value.
Symbol	

Labels to use

■Input labels

No.	Variable name	Name	Data type	Scope	Description
(1)	i_bEN	Execution command	Bit	On or off	On: The FB is activated. Off: The FB is not activated.
(2)	i_udSize	Number of data points	Double Word [unsigned]	1 to 90000	Sets the number of input data points for the standard deviation operation.
(3)	i_uDataType	Input data type selection	Word [unsigned]	0, 2	Specifies 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]	Valid device range*1	Specifies the start address of the file register (ZR) where input data is stored.
(5)	i_eRefValue	Reference value	Single-precision real number	• -2^{128} to -2^{-126} (E-3.40282347+38 to E-1.17549435-38) • 0 • 2^{-126} to 2^{128} (E1.17549435-38 to E3.40282347+38)	Sets a reference value for the standard deviation operation.

*1 The valid range varies depending on "File Register Setting" of "CPU Parameter".

■Output labels

No.	Variable name	Name	Data type	Default value	Description
(6)	o_bENO	Execution status	Bit	Off	On: The execution command is on. Off: The execution command is off.
(7)	o_bOK	Normal completion	Bit	Off	The on state indicates that the standard deviation operation has been completed.
(8)	o_bErr	Error completion	Bit	Off	The on state indicates that an error has occurred in the FB.
(9)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error that occurred in the FB is returned.
(10)	o_eStandardDeviationData	Output data	Single-precision real number	0	The standard deviation operation result is stored.

FB details

Item	Description	
Relevant devices	CPU module	MELSEC iQ-R series
	Engineering tool	GX Works3 of version 1.055H or later
Language to use	— (The internal program of this FB is not open to the public.)	
Number of steps	1121 steps The number of steps of the FB embedded in a program depends on the CPU module used, the input/output definitions, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
Label usage	• Label: 0.01K points (Word) • Latch label: 0.01K points (Word) The usage of labels embedded in a program depends on the CPU module used, the devices specified as an argument, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
FB dependence	No dependence	
Functional description	(1) As i_bEN (execution command) turns on, this FB calculates a standard deviation from the specified input data and a reference value. This FB calculates the standard deviation with the following formula. "N" stands for the number of data points, "x_i" stands for i-th data, and "y" stands for the reference value. $\text{Standard deviation} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{y})^2}$ ■Example The following figures show an operation example of when values of each input label are as follows. • i_udSize (number of data points): 3 • i_udInputDataAddr (input data start address): 0 (ZR0) • i_uDataType (input data type selection): 0 • i_eRefValue (reference value): 20	

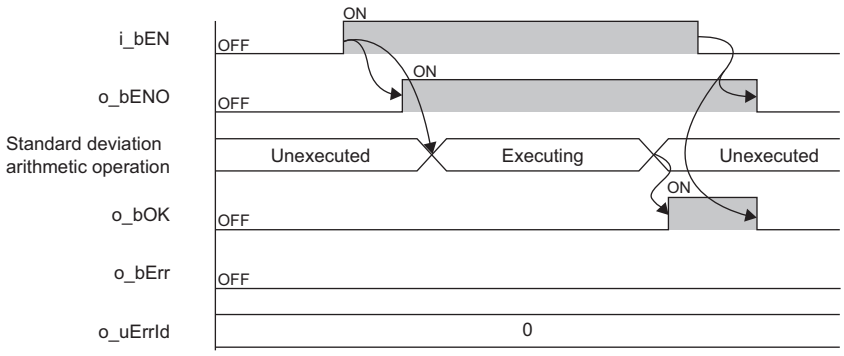
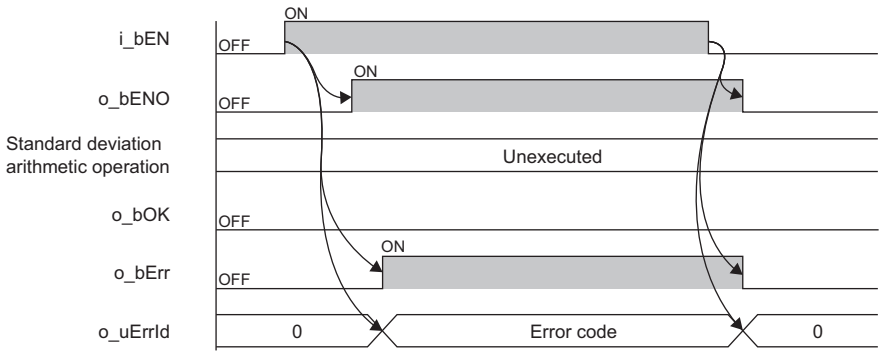
No.	Input data	
1	ZR0 (input data start address)	10
2	ZR1	20
3	ZR2	30

In this case, $\bar{x}$ is (10 + 20 + 30)/3 = 20.
The following value is obtained by applying the above values to the formula to calculate the standard deviation.

$$\sqrt{\frac{(10 - 20)^2 + (20 - 20)^2 + (30 - 20)^2}{3}} \fallingdotseq 8.16$$

(2) The input data used for the standard deviation operation are read from the file register (ZR), starting from the area of the address specified by i_udInputDataAddr (input data start address). This FB reads input data for the number of points set in i_udSize (number of data points).
(3) The operation result is output as a single-precision real number to o_eStandardDeviationData (output data).
(4) It takes multiple scans until the standard deviation operation is completed. Thus, do not change the input data values used for the operation until the processing is completed. When the standard deviation operation is completed, o_bOK (normal completion) turns on.
(5) If a value out of the range is set in i_udSize (number of data points), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 105H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 16 List of error codes)
(6) If a value out of the range is set in i_uDataType (input data type selection), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 103H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 16 List of error codes)
(7) If an overflow occurs during the standard deviation operation, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 203H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 16 List of error codes)
(8) If i_bEN (execution command) is turned off before o_bOK (normal completion) or o_bErr (error completion) turns on, o_bErr (error completion) turns on in one scan. In addition, 205H is stored in o_uErrId (error code) in one scan. For the error code, refer to the list of error codes. (☞ Page 16 List of error codes)
(9) When a single-precision real number is set in i_uDataType (input data type selection) and the value stored in the file register (ZR) is not a single-precision real number, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 200H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 16 List of error codes)

FB compilation method	Subroutine type
FB operation	Pulse execution type (multiple scan execution type)

Item		Description
Timing chart of I/O signals	Normal completion	
	Error completion	
Restrictions and precautions		(1) This FB does not include the error recovery processing. Prepare the error recovery processing separately to suit the user's system and the expected operation. (2) This FB uses the long index register LZ0. When using interrupt programs, do not use the corresponding index register. (3) The FB cannot be used in an interrupt program. (4) 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 the execution command. (5) The FB requires the configuration of the ladder for every input label. (6) The FB requires the input data to be stored in the file register (ZR). Refer to the following examples and set the file register (ZR) capacity. For the setting method, refer to the MELSEC iQ-R CPU Module User's Manual (Application). ■When 0 is set in i_uDataType (input data type selection) Set the capacity of i_udSize (number of data points) for the file register (ZR). ■When 2 is set in i_uDataType (input data type selection) Set the capacity of "i_udSize (number of data points) × 2" for the file register (ZR). (7) This FB checks the input data values before the standard deviation operation execution to prevent an overflow from occurring during the operation. If a possibility of an overflow is detected at this check, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). For the operation with the single-precision real number, an error may occur depending on the combination of input data values. Even after the input data values are checked, the instruction execution fault (operation error) may occur at the operation execution. In such a case, if "RAS Setting" of "CPU Parameter" is set to continue the processing even after an operation error occurs, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). (8) If 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module due to an error outside FB while i_bEN (execution command) of this FB is on, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 204H is stored in o_uErrId (error code). However, if "RAS Setting" of "CPU Parameter" is set to stop the processing after an operation error occurs, 204H is not stored in o_uErrId (error code).

Performance value

The following table lists the performance values of this FB under the following conditions.

- CPU module: R120CPU
- File register storage location: CPU built-in memory
- FB compilation method: Subroutine type

Input label		Time required for the processing*1	Maximum scan time	Number of the scans required for the processing
Number of data points	Input data type			
2 points	0: Word [signed]	0.217ms or less	0.217ms	1 scan
	2: Single-precision real number	0.217ms or less	0.217ms	
45000 points	0: Word [signed]	402.000ms	0.280ms	2250 scans
	2: Single-precision real number	405.000ms	0.283ms	
90000 points	0: Word [signed]	804.000ms	0.281ms	4500 scans
	2: Single-precision real number	809.000ms	0.282ms	

*1 The time required from start to end of the processing

List of error codes

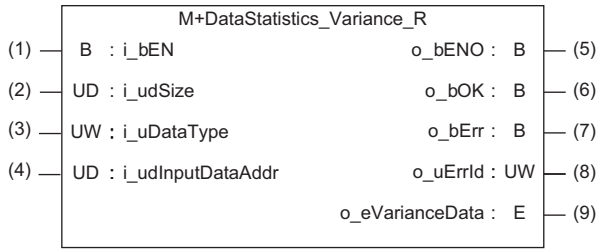
Error code	Description	Action
103H	A value out of the range is set in i_uDataType (input data type selection).	Set 0 or 2 in i_uDataType (input data type selection). Review and correct the setting and then execute the FB again.
105H	A value out of the range is set in i_udSize (number of data points).	Set a value of 1 to 90000 in i_udSize (number of data points). Review and correct the setting and then execute the FB again.
200H	Although the value set in i_uDataType (input data type selection) is Single-precision real number, the stored input data is not a single-precision real number.	Store the input data as a single-precision real number in the file register (ZR). Review and correct the input data and then execute the FB again.
203H	An overflow has occurred in the FB during the operation.	Review and correct the input data stored in the file register (ZR) and then execute the FB again. When 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module, refer to the MELSEC iQ-R CPU Module User's Manual (Application).
204H	The processing of the FB has been interrupted due to an overflow in an operation other than that of this FB.	An overflow has occurred in the operation other than that of this FB, and 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module. Refer to the MELSEC iQ-R CPU Module User's Manual (Application).
205H	i_bEN (execution command) has been turned off during the processing.	Do not turn off i_bEN (execution command) until o_bOK (normal completion) or o_bErr (error completion) turns on.

2.4 M+DataStatistics_Variance_R

Name

M+DataStatistics_Variance_R

Overview

Item	Description
Functional overview	Obtains the distributed arithmetic operation result of the specified data.
Symbol	

Labels to use

■Input labels

No.	Variable name	Name	Data type	Scope	Description
(1)	i_bEN	Execution command	Bit	On or off	On: The FB is activated. Off: The FB is not activated.
(2)	i_udSize	Number of data points	Double Word [unsigned]	1 to 90000	Sets the number of input data points for the distributed arithmetic operation.
(3)	i_uDataType	Input data type selection	Word [unsigned]	0, 2	Specifies 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]	Valid device range*1	Specifies the start address of the file register (ZR) where input data is stored.

*1 The valid range varies depending on "File Register Setting" of "CPU Parameter".

■Output labels

No.	Variable name	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	The on state indicates that the distributed arithmetic operation has been completed.
(7)	o_bErr	Error completion	Bit	Off	The on state indicates that an error has occurred in the FB.
(8)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error that occurred in the FB is returned.
(9)	o_eVarianceData	Output data	Single-precision real number	0	The distributed arithmetic operation result is stored.

FB details

Item	Description	
Relevant devices	CPU module	MELSEC iQ-R series
	Engineering tool	GX Works3 of version 1.055H or later
Language to use	— (The internal program of this FB is not open to the public.)	
Number of steps	471 steps The number of steps of the FB embedded in a program depends on the CPU module used, the input/output definitions, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
Label usage	• Label: 0.1K points (Word) • Latch label: 0.01K points (Word) The usage of labels embedded in a program depends on the CPU module used, the devices specified as an argument, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
FB dependence	No dependence	
Functional description	(1) As i_bEN (execution command) turns on, this FB calculates variance of the specified input data values. This FB calculates the variance with the following formula. "N" stands for the number of data points, "x_i" for i-th data, and "$\bar{x}$" for the average of input data values in file register areas for the number of data points (N) starting from the one specified with the input data start address. $\text{Variance} = \frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2$ ■Example The following figures show an operation example of when values of each input label are as follows. • i_udSize (number of data points): 3 • i_udInputDataAddr (input data start address): 0 (ZR0) • i_uDataType (input data type selection): 0	

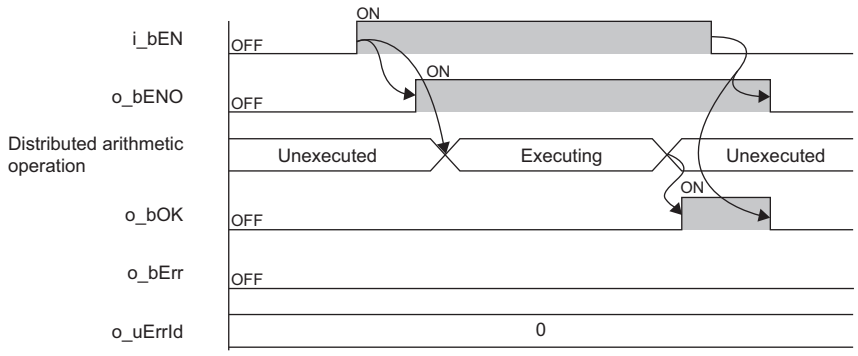
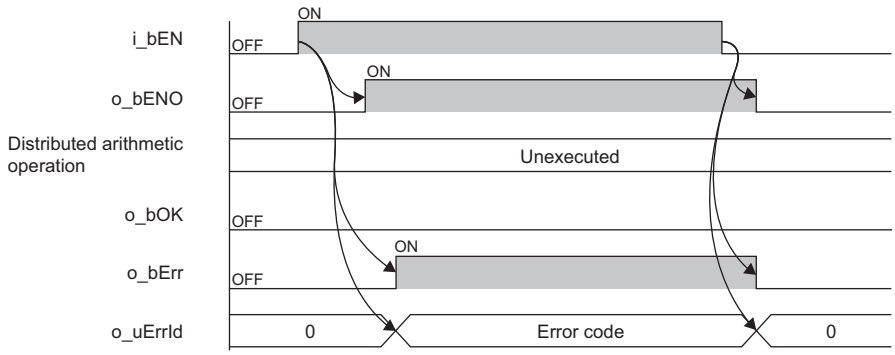
No.	Input data	
1	ZR0 (input data start address)	10
2	ZR1	20
3	ZR2	30

In this case, $\bar{x}$ is (10 + 20 + 30)/3 = 20.
The following value is obtained by applying the above values to the formula to calculate the variance.

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

(2) The input data used for the distributed arithmetic operation are read from the file register (ZR), starting from the area of the address specified by i_udInputDataAddr (input data start address). This FB reads input data for the number of points set in i_udSize (number of data points).
(3) The operation result is output as a single-precision real number to o_eVarianceData (output data).
(4) It takes multiple scans until the distributed arithmetic operation is completed. Thus, do not change the input data values used for the operation until the processing is completed. When the distributed arithmetic operation is completed, o_bOK (normal completion) turns on.
(5) If a value out of the range is set in i_udSize (number of data points), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 105H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 20 List of error codes)
(6) If a value out of the range is set in i_uDataType (input data type selection), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 103H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 20 List of error codes)
(7) If an overflow occurs during the distributed arithmetic operation, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 203H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 20 List of error codes)
(8) If i_bEN (execution command) is turned off before o_bOK (normal completion) or o_bErr (error completion) turns on, o_bErr (error completion) turns on in one scan. In addition, 205H is stored in o_uErrId (error code) in one scan. For the error code, refer to the list of error codes. (☞ Page 20 List of error codes)
(9) When a single-precision real number is set in i_uDataType (input data type selection) and the value stored in the file register (ZR) is not a single-precision real number, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 200H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 20 List of error codes)

FB compilation method	Subroutine type
FB operation	Pulse execution type (multiple scan execution type)

Item		Description
Timing chart of I/O signals	Normal completion	
	Error completion	
Restrictions and precautions		(1) This FB does not include the error recovery processing. Prepare the error recovery processing separately to suit the user's system and the expected operation. (2) This FB uses the long index register LZ0. When using interrupt programs, do not use the corresponding index register. (3) The FB cannot be used in an interrupt program. (4) 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 the execution command. (5) The FB requires the configuration of the ladder for every input label. (6) The FB requires the input data to be stored in the file register (ZR). Refer to the following examples and set the file register (ZR) capacity. For the setting method, refer to the MELSEC iQ-R CPU Module User's Manual (Application). ■When 0 is set in i_uDataType (input data type selection) Set the capacity of i_udSize (number of data points) for the file register (ZR). ■When 2 is set in i_uDataType (input data type selection) Set the capacity of "i_udSize (number of data points) × 2" for the file register (ZR). (7) This FB checks the input data values before the distributed arithmetic operation execution to prevent an overflow from occurring during the operation. If a possibility of an overflow is detected at this check, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). For the operation with the single-precision real number, an error may occur depending on the combination of input data values. Even after the input data values are checked, the instruction execution fault (operation error) may occur at the operation execution. In such a case, if "RAS Setting" of "CPU Parameter" is set to continue the processing even after an operation error occurs, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). (8) If 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module due to an error outside FB while i_bEN (execution command) of this FB is on, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 204H is stored in o_uErrId (error code). However, if "RAS Setting" of "CPU Parameter" is set to stop the processing after an operation error occurs, 204H is not stored in o_uErrId (error code).

Performance value

The following table lists the performance values of this FB under the following conditions.

- CPU module: R16CPU
- File register storage location: CPU built-in memory
- FB compilation method: Subroutine type

Input label		Time required for the processing*1	Maximum scan time	Number of the scans required for the processing
Number of data points	Input data type			
2 points	0: Word [signed]	0.132ms	0.207ms	2 scans
	2: Single-precision real number	0.131ms	0.209ms	
45000 points	0: Word [signed]	640ms	0.277ms	4500 scans
	2: Single-precision real number	645ms	0.278ms	
90000 points	0: Word [signed]	1280ms	0.278ms	9000 scans
	2: Single-precision real number	1290ms	0.276ms	

*1 The time required from start to end of the processing

List of error codes

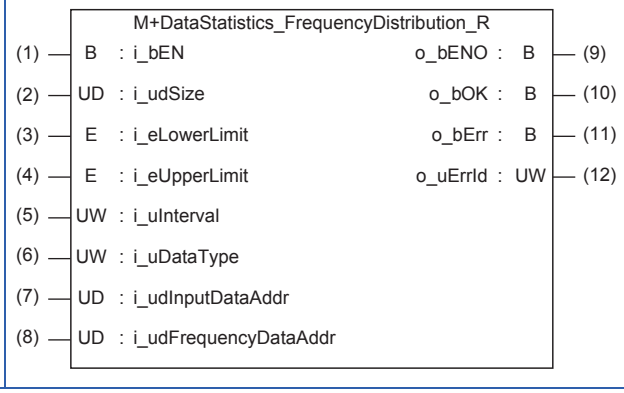
Error code	Description	Action
103H	A value out of the range is set in i_uDataType (input data type selection).	Set 0 or 2 in i_uDataType (input data type selection). Review and correct the setting and then execute the FB again.
105H	A value out of the range is set in i_udSize (number of data points).	Set a value of 1 to 90000 in i_udSize (number of data points). Review and correct the setting and then execute the FB again.
200H	Although the value set in i_uDataType (input data type selection) is Single-precision real number, the stored input data is not a single-precision real number.	Store the input data as a single-precision real number in the file register (ZR). Review and correct the input data and then execute the FB again.
203H	An overflow has occurred in the FB during the operation.	Review and correct the input data stored in the file register (ZR) and then execute the FB again. When 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module, refer to the MELSEC iQ-R CPU Module User's Manual (Application).
204H	The processing of the FB has been interrupted due to an overflow in an operation other than that of this FB.	An overflow has occurred in the operation other than that of this FB, and 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module. Refer to the MELSEC iQ-R CPU Module User's Manual (Application).
205H	i_bEN (execution command) has been turned off during the processing.	Do not turn off i_bEN (execution command) until o_bOK (normal completion) or o_bErr (error completion) turns on.

2.5 M+DataStatistics_FrequencyDistribution_R

Name

M+DataStatistics_FrequencyDistribution_R

Overview

Item	Description
Functional overview	Obtains the frequency distribution operation result of the specified data.
Symbol	

Labels to use

■Input labels

No.	Variable name	Name	Data type	Scope	Description
(1)	i_bEN	Execution command	Bit	On or off	On: The FB is activated. Off: The FB is not activated.
(2)	i_udSize	Number of data points	Double Word [unsigned]	1 to 90000	Sets the number of input data points for the frequency distribution operation.
(3)	i_eLowerLimit	Lower limit value in whole intervals	Single-precision real number	• -2^{128} to -2^{-126} (E-3.40282347+38 to E-1.17549435-38) • 0 • 2^{-126} to 2^{128} (E1.17549435-38 to E3.40282347+38)	Specifies the lower limit value in whole intervals for the frequency distribution. Set a smaller value than i_eUpperLimit (upper limit value in whole intervals).
(4)	i_eUpperLimit	Upper limit value in whole intervals	Single-precision real number	• -2^{128} to -2^{-126} (E-3.40282347+38 to E-1.17549435-38) • 0 • 2^{-126} to 2^{128} (E1.17549435-38 to E3.40282347+38)	Specifies the upper limit value in whole intervals for the frequency distribution. Set a larger value than i_eLowerLimit (lower limit value in whole intervals).
(5)	i_uInterval	Number of intervals	Word [unsigned]	1 to 200	Specifies the number of intervals for the frequency distribution.
(6)	i_uDataType	Input data type selection	Word [unsigned]	0, 2	Specifies 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]	Valid device range*1	Specifies the start address of the file register (ZR) where input data is stored.
(8)	i_udFrequencyDataAddr	Output data start address	Double Word [unsigned]	Valid device range*1	Specifies the start address of the file register (ZR) where output data is to be stored.

*1 The valid range varies depending on "File Register Setting" of "CPU Parameter".

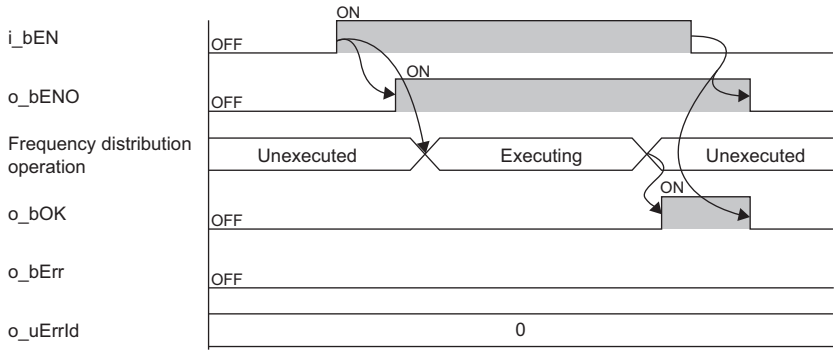
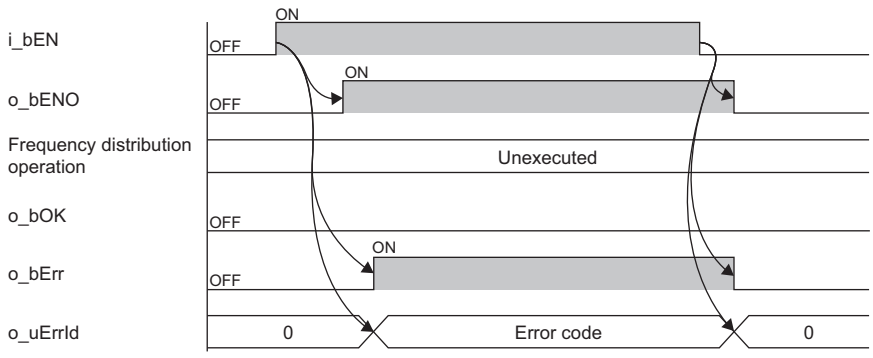
■Output labels

No.	Variable name	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	The on state indicates that the frequency distribution operation has been completed.
(11)	o_bErr	Error completion	Bit	Off	The on state indicates that an error has occurred in the FB.
(12)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error that occurred in the FB is returned.

FB details

Item	Description	
Relevant devices	CPU module	MELSEC iQ-R series
	Engineering tool	GX Works3 of version 1.055H or later
Language to use	— (The internal program of this FB is not open to the public.)	
Number of steps	603 steps The number of steps of the FB embedded in a program depends on the CPU module used, the input/output definitions, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
Label usage	• Label: 0.07K points (Word) • Latch label: 0K points (Word) The usage of labels embedded in a program depends on the CPU module used, the devices specified as an argument, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
FB dependence	No dependence	

<table>
<tr><th>Item</th><th>Description</th></tr>
<tr><td>Functional description</td><td>
(1) As i_bEN (execution command) turns on, this FB calculates frequency distribution of the specified input data values. This FB uses data in file register areas for the number of data points starting from the one specified with the input data start address. The FB calculates how many data (input values) fall within a range (a minimum value to a maximum value) of each interval. And then the FB stores the result in file register areas in order starting from the output data start address.
■Example
The following figures show an operation example of when values of each input label are as follows.
• i_udSize (number of data points): 5
• i_eLowerLimit (lower limit value in whole intervals): 0
• i_eUpperLimit (upper limit value in whole intervals): 50
• i_uInterval (number of intervals): 5
• i_uDataType (input data type selection): 0 (Word [signed])
• i_udInputDataAddr (input data start address): 0 (ZR0)
• i_udFrequencyDataAddr (output data start address): 10 (ZR10)
<table>
<tr><th>No.</th><th colspan="2">Input data</th></tr>
<tr><td>1</td><td>ZR0
(input data start address)</td><td>10</td></tr>
<tr><td>2</td><td>ZR1</td><td>20</td></tr>
<tr><td>3</td><td>ZR2</td><td>30</td></tr>
<tr><td>4</td><td>ZR3</td><td>-10</td></tr>
<tr><td>5</td><td>ZR4</td><td>60</td></tr>
</table>
When the frequency distribution operation is executed for these data, the result is output as follows.
<table>
<tr><th>—</th><th>ZR10</th><th>ZR12</th><th>ZR14</th><th>ZR16</th><th>ZR18</th><th>ZR20</th><th>ZR22</th></tr>
<tr><td>Minimum value
(including the value)</td><td>—</td><td>0.0</td><td>10.0</td><td>20.0</td><td>30.0</td><td>40.0</td><td>50.0</td></tr>
<tr><td>Maximum value
(excluding the value)</td><td>0.0</td><td>10.0</td><td>20.0</td><td>30.0</td><td>40.0</td><td>50.0</td><td>—</td></tr>
<tr><td>Stored value</td><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
</table>
• A width of the value range for the interval is calculated from "(Upper limit value in whole intervals - Lower limit value in whole intervals) ÷ Number of intervals".
• Since the result is output in double word, the required areas of the file register (ZR) to store the output data are "(i_uInterval (number of intervals) + 2) × 2 points". For the above example, a total of 14 words ((5 + 2) × 2) are required.
• The number of input values that are smaller than i_eLowerLimit (lower limit value in whole intervals) is stored in ZR10 and ZR11 (double word).
• The number of input values that are equal to or larger than i_eUpperLimit (upper limit value in whole intervals) is stored in ZR22 and ZR23 (double word).
(2) The input data used for the frequency distribution operation are read from the file register (ZR), starting from the area of the address specified by i_udInputDataAddr (input data start address). This FB reads input data for the number of points set in i_udSize (number of data points).
(3) Even if 0: Word [signed] is set in i_uDataType (input data type selection), this FB executes the frequency distribution operation after converting input data to a single-precision real number.
</td></tr>
</table>

Item		Description
Functional description		(4) Set a single-precision real number in i_eLowerLimit (lower limit value in whole intervals) and i_eUpperLimit (upper limit value in whole intervals). (5) The operation result is stored in the file register (ZR), starting from the area of the address specified by i_udFrequencyDataAddr (output data start address). Data for "(i_uInterval (number of intervals) + 2) × 2 points" is output as the operation result. The address area to which the operation result is output is initialized (0 clear) at FB execution. (6) It takes multiple scans until the frequency distribution operation is completed. Thus, do not change the input data values used for the operation until the processing is completed. When the frequency distribution operation is completed, o_bOK (normal completion) turns on. (7) If a value out of the range is set in i_udSize (number of data points), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 105H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 26 List of error codes) (8) If a value out of the range is set in i_uDataType (input data type selection), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 103H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 26 List of error codes) (9) If a value out of the range is set in i_eUpperLimit (upper limit value in whole intervals), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 11BH is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 26 List of error codes) (10)If a value out of the range is set in i_uInterval (number of intervals), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 11CH is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 26 List of error codes) (11)If an overflow occurs during the frequency distribution operation, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 203H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 26 List of error codes) (12)If i_bEN (execution command) is turned off before o_bOK (normal completion) or o_bErr (error completion) turns on, o_bErr (error completion) turns on in one scan. In addition, 205H is stored in o_uErrId (error code) in one scan. For the error code, refer to the list of error codes. (☞ Page 26 List of error codes) (13)Some of the areas specified by i_udInputDataAddr (input data start address) and i_udFrequencyDataAddr (output data start address) are overlapped. In such a case, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 11DH is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 26 List of error codes) (14)When a single-precision real number is set in i_uDataType (input data type selection) and the value stored in the file register (ZR) is not a single-precision real number, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 200H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 26 List of error codes)
FB compilation method		Subroutine type
FB operation		Pulse execution type (multiple scan execution type)
Timing chart of I/O signals	Normal completion	
	Error completion	

Item	Description
Restrictions and precautions	(1) This FB does not include the error recovery processing. Prepare the error recovery processing separately to suit the user's system and the expected operation. (2) This FB uses the long index registers LZ0 and LZ1. Set the long index (LZ) to two points or greater in "Index Register Setting" of "CPU Parameter". (📖 MELSEC iQ-R CPU Module User's Manual (Application)) When using interrupt programs, do not use the corresponding index registers. (3) The FB cannot be used in an interrupt program. (4) 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 the execution command. (5) The FB requires the configuration of the ladder for every input label. (6) For the operation of this FB, a value equal to a maximum value in one interval is regarded to fit in the next interval. ■Example When two intervals exist and one interval has a range of 0.0 (including 0.0) to 1.0 (excluding 1.0) and another has a range of 1.0 (including 1.0) to 2.0 (excluding 2.0), a value of 1.0 is regarded to fit in the latter interval that has the range of 1.0 (including 1.0) to 2.0 (excluding 2.0). (7) The FB requires the input data to be stored in the file register (ZR). In addition, output data in double word is output in the file register (ZR). Refer to the following examples and set the file register (ZR) capacity. For the setting method, refer to the MELSEC iQ-R CPU Module User's Manual (Application). ■When 0 is set in i_uDataType (input data type selection) Set the capacity of "i_udSize (number of data points) + (i_uInterval (number of intervals) + 2) × 2" for the file register (ZR). ■When 2 is set in i_uDataType (input data type selection) Set the capacity of "(i_udSize (number of data points) + i_uInterval (number of intervals) + 2) × 2" for the file register (ZR). (8) This FB checks the input data values before the frequency distribution operation execution to prevent an overflow from occurring during the operation. If a possibility of an overflow is detected at this check, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). For the operation with the single-precision real number, an error may occur depending on the combination of input data values. Even after the input data values are checked, the instruction execution fault (operation error) may occur at the operation execution. In such a case, if "RAS Setting" of "CPU Parameter" is set to continue the processing even after an operation error occurs, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). (9) If 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module due to an error outside FB while i_bEN (execution command) of this FB is on, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 204H is stored in o_uErrId (error code). However, if "RAS Setting" of "CPU Parameter" is set to stop the processing after an operation error occurs, 204H is not stored in o_uErrId (error code). (10)The input data of the single-precision real number has a rounding error. Therefore, when the data for frequency distribution has an error, the intended operation result may not be obtained.

Performance value

The following table lists the performance values of this FB under the following conditions.

- CPU module: R16CPU
- File register storage location: CPU built-in memory
- FB compilation method: Subroutine type

Input label		Time required for the processing*1	Maximum scan time	Number of the scans required for the processing
Number of data points	Input data type			
2 points	0: Word [signed]	0.213ms or less	0.213ms	1 scan
	2: Single-precision real number	0.213ms or less	0.213ms	
45000 points	0: Word [signed]	250ms	0.218ms	2250 scans
	2: Single-precision real number	253ms	0.221ms	
90000 points	0: Word [signed]	499ms	0.222ms	4500 scans
	2: Single-precision real number	505ms	0.22ms	

*1 The time required from start to end of the processing

List of error codes

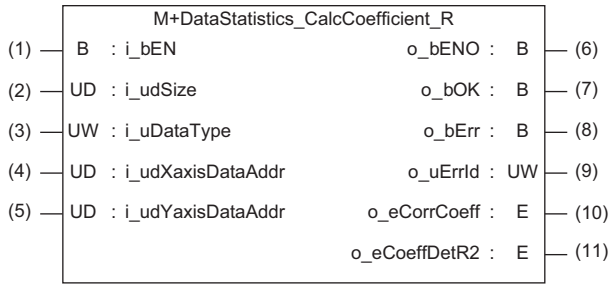
Error code	Description	Action
103H	A value out of the range is set in i_uDataType (input data type selection).	Set 0 or 2 in i_uDataType (input data type selection). Review and correct the setting and then execute the FB again.
105H	A value out of the range is set in i_udSize (number of data points).	Set a value of 1 to 90000 in i_udSize (number of data points). Review and correct the setting and then execute the FB again.
11BH	A value out of the range is set in i_eUpperLimit (upper limit value in whole intervals).	Set a larger value than i_eLowerLimit (lower limit value in whole intervals) for i_eUpperLimit (upper limit value in whole intervals). Review and correct the setting and then execute the FB again.
11CH	A value out of the range is set in i_uInterval (number of intervals).	Set a value of 1 to 200 in i_uInterval (number of intervals). 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_udSize (number of data points) • i_uInterval (number of intervals) • i_udInputDataAddr (input data start address) • i_udFrequencyDataAddr (output data start address) Review and correct the settings and then execute the FB again.
200H	Although the value set in i_uDataType (input data type selection) is Single-precision real number, the stored input data is not a single-precision real number.	Store the input data as a single-precision real number in the file register (ZR). Review and correct the input data and then execute the FB again.
203H	An overflow has occurred in the FB during the operation.	Review and correct the lower limit value in whole intervals, upper limit value in whole intervals, and input data stored in the file register (ZR), and then execute the FB again. When 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module, refer to the MELSEC iQ-R CPU Module User's Manual (Application).
204H	The processing of the FB has been interrupted due to an overflow in an operation other than that of this FB.	An overflow has occurred in the operation other than that of this FB, and 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module. Refer to the MELSEC iQ-R CPU Module User's Manual (Application).
205H	i_bEN (execution command) has been turned off during the processing.	Do not turn off i_bEN (execution command) until o_bOK (normal completion) or o_bErr (error completion) turns on.

2.6 M+DataStatistics_CalcCoefficient_R

Name

M+DataStatistics_CalcCoefficient_R

Overview

Item	Description
Functional overview	Calculates the coefficient of correlation and the coefficient of determination from predicted values and observed values.
Symbol	

Labels to use

■Input labels

No.	Variable name	Name	Data type	Scope	Description
(1)	i_bEN	Execution command	Bit	On or off	On: The FB is activated. Off: The FB is not activated.
(2)	i_udSize	Number of data points	Double Word [unsigned]	1 to 90000	Sets the number of input data points for the operation to calculate a coefficient of correlation and a coefficient of determination.
(3)	i_uDataType	Input data type selection	Word [unsigned]	0, 2	Specifies the data type of the input data. 0: Word [signed] 2: Single-precision real number
(4)	i_udXaxisDataAddr	Start address of data of predicted values (X-axis)	Double Word [unsigned]	Valid device range*1	Specifies the start address of the file register (ZR) where data of predicted values are stored.
(5)	i_udYaxisDataAddr	Start address of data of observed values (Y-axis)	Double Word [unsigned]	Valid device range*1	Specifies the start address of the file register (ZR) where data of observed values are stored.

*1 The valid range varies depending on "File Register Setting" of "CPU Parameter".

■Output labels

No.	Variable name	Name	Data type	Default value	Description
(6)	o_bENO	Execution status	Bit	Off	On: The execution command is on. Off: The execution command is off.
(7)	o_bOK	Normal completion	Bit	Off	The on state indicates that the operation to calculate a coefficient of correlation and a coefficient of determination has been completed.
(8)	o_bErr	Error completion	Bit	Off	The on state indicates that an error has occurred in the FB.
(9)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error that occurred in the FB is returned.
(10)	o_eCorrCoeff	Coefficient of correlation	Single-precision real number	0	The coefficient of correlation calculated from the data of predicted values and the data of observed values is returned.
(11)	o_eCoeffDetR2	Coefficient of determination	Single-precision real number	0	The coefficient of determination calculated from the data of predicted values and the data of observed values is returned.

FB details

Item	Description	
Relevant devices	CPU module	MELSEC iQ-R series
	Engineering tool	GX Works3 of version 1.055H or later
Language to use	— (The internal program of this FB is not open to the public.)	
Number of steps	2893 steps The number of steps of the FB embedded in a program depends on the CPU module used, the input/output definitions, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
Label usage	• Label: 4.09K points (Word) • Latch label: 0K points (Word) The usage of labels embedded in a program depends on the CPU module used, the devices specified as an argument, and the options setting of GX Works3. For the options setting of GX Works3, refer to the GX Works3 Operating Manual.	
FB dependence	No dependence	
Functional description	(1) As i_bEN (execution command) turns on, this FB calculates a coefficient of correlation and a coefficient of determination from specified data of predicted values and observed values. The FB stores a calculated coefficient of correlation in o_eCorrCoeff (coefficient of correlation), and a calculated coefficient of determination in o_eCoeffDetR2 (coefficient of determination). (2) This FB calculates the coefficient of correlation and the coefficient of determination with the following formulas. Coefficient of determination (R^2) = Coefficient of correlation (R) × Coefficient of correlation (R)	

$$\text{Coefficient of correlation (R)} = \frac{\text{Covariance}}{\text{(Standard deviation of data of predicted values)} \times \text{(Standard deviation of data of observed values)}}$$

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

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

"N" stands for the number of data points, "x_i" for i-th data of predicted values (X-axis), "$\bar{x}$" for the mean value of data of predicted values (X-axis), "y_i" for i-th data of observed values (Y-axis), and "y" for the mean value of data of observed values (Y-axis).

(3) The following is a calculation example of a coefficient of correlation and a coefficient of determination.

■Example

The following figures show an operation example of when values of each input label are as follows.

- i_udSize (number of data points): 5
- i_uDataType (input data type selection): 0
- i_udXaxisDataAddr (start address of data of predicted values (X-axis)): 0
- i_udYaxisDataAddr (start address of data of observed values (Y-axis)): 10

Measured value	Data of predicted values (X-axis)		Data of observed values (Y-axis)	
	File register	Stored value	File register	Stored value
1st time	ZR0	20	ZR10	19
2nd time	ZR1	30	ZR11	33
3rd time	ZR2	40	ZR12	38
4th time	ZR3	50	ZR13	49
5th time	ZR4	60	ZR14	65

The mean value of data of predicted values (X-axis): (20 + 30 + 40 + 50 + 60) ÷ 5 = 40

The mean value of data of observed values (Y-axis): (19 + 33 + 38 + 49 + 65) ÷ 5 = 40.8

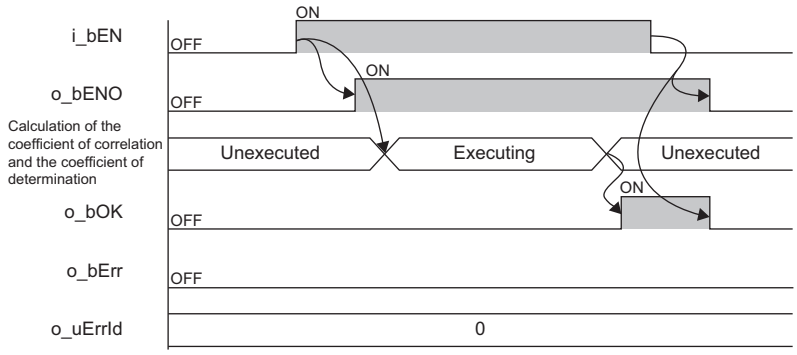
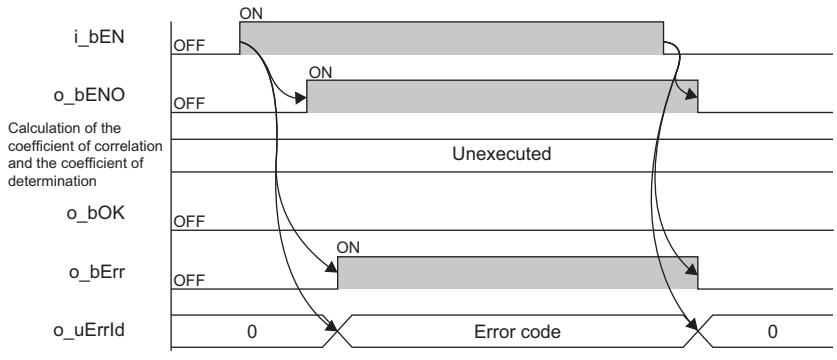
The following values are obtained by applying the above values to the formulas to calculate standard deviations and a covariance.

$$\text{Standard deviation of predicted values} = \sqrt{\frac{(20-40)^2 + (30-40)^2 + (40-40)^2 + (50-40)^2 + (60-40)^2}{5}} \fallingdotseq 14.142$$

$$\text{Standard deviation of observed values} = \sqrt{\frac{(19-40.8)^2 + (33-40.8)^2 + (38-40.8)^2 + (49-40.8)^2 + (65-40.8)^2}{5}} \fallingdotseq 15.4713$$

$$\text{Covariance} = \frac{(20-40)(19-40.8) + (30-40)(33-40.8) + (40-40)(38-40.8) + (50-40)(49-40.8) + (60-40)(65-40.8)}{5}$$

$$= 216$$

Item		Description
Functional description		The following value is obtained by applying the covariance and the standard deviations to the formula to calculate a coefficient of correlation. Coefficient of correlation $= \frac{216}{14.142 \times 15.4713} \fallingdotseq 0.9872$ The following value is obtained by applying the coefficient of correlation to the formula to calculate a coefficient of determination. Coefficient of determination = 0.9872 × 0.9872 ≒ 0.9746 (4) The calculated coefficient of correlation is output to o_eCorrCoeff (coefficient of correlation) as a single-precision real number. And the calculated coefficient of determination is output to o_eCoeffDetR2 (coefficient of determination) as a single-precision real number. (5) It takes multiple scans until the operation to calculate a coefficient of correlation and a coefficient of determination is completed. Thus, do not change the input data values used for the operation until the processing is completed. When the operation is completed, o_bOK (normal completion) turns on. (6) If a value out of the range is set in i_udSize (number of data points), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 105H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 31 List of error codes) (7) If a value out of the range is set in i_uDataType (input data type selection), o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 103H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 31 List of error codes) (8) If an overflow occurs during the operation to calculate a coefficient of correlation and a coefficient of determination, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 203H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 31 List of error codes) (9) If i_bEN (execution command) is turned off before o_bOK (normal completion) or o_bErr (error completion) turns on, o_bErr (error completion) turns on in one scan. In addition, 205H is stored in o_uErrId (error code) in one scan. For the error code, refer to the list of error codes. (☞ Page 31 List of error codes) (10)Some of the areas specified by i_udXaxisDataAddr (start address of data of predicted values (X-axis)) and i_udYaxisDataAddr (start address of data of observed values (Y-axis)) are overlapped. In such a case, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 11DH is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 31 List of error codes) (11)When 2 (single-precision real number) is set in i_uDataType (input data type selection) and input data is not a single-precision real number, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 200H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 31 List of error codes) (12)If neither a coefficient of correlation nor a coefficient of determination can be calculated because values stored as data of predicted values or data of observed values are inappropriate, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 210H is stored in o_uErrId (error code). For the error code, refer to the list of error codes. (☞ Page 31 List of error codes)
FB compilation method		Subroutine type
FB operation		Pulse execution type (multiple scan execution type)
Timing chart of I/O signals	Normal completion	
	Error completion	

Item	Description
Restrictions and precautions	(1) This FB does not include the error recovery processing. Prepare the error recovery processing separately to suit the user's system and the expected operation. (2) The FB cannot be used in an interrupt program. (3) 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 the execution command. (4) The FB requires the configuration of the ladder for every input label. (5) Change "Memory/Device Setting" of "CPU Parameter" so that the memory capacity required to use this FB is secured. If "Memory/Device Setting" is not changed, an error may occur on GX Works3. (6) This FB checks the input data values before the operation execution to calculate a coefficient of correlation and a coefficient of determination to prevent an overflow from occurring during the operation. If a possibility of an overflow is detected at this check, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). For the operation with the single-precision real number, an error may occur depending on the combination of input data values. Even after the input data values are checked, the instruction execution fault (operation error) may occur at the operation execution. In such a case, if "RAS Setting" of "CPU Parameter" is set to continue the processing even after an operation error occurs, o_bErr (error completion) turns on and 203H is stored in o_uErrId (error code). (7) If 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module due to an error outside FB while i_bEN (execution command) of this FB is on, o_bErr (error completion) turns on and the processing of the FB is interrupted. In addition, 204H is stored in o_uErrId (error code). However, if "RAS Setting" of "CPU Parameter" is set to stop the processing after an operation error occurs, 204H is not stored in o_uErrId (error code).

Performance value

The following table lists the performance values of this FB under the following conditions.

- CPU module: R120CPU
- File register storage location: CPU built-in memory
- FB compilation method: Subroutine type

Input label		Time required for the processing*1	Maximum scan time	Number of the scans required for the processing
Number of data points	Input data type			
2 points	0: Word [signed]	0.162ms	0.221ms	2 scans
	2: Single-precision real number	0.151ms	0.223ms	
45000 points	0: Word [signed]	607.000ms	0.999ms	1125 scans
	2: Single-precision real number	659.000ms	0.996ms	
90000 points	0: Word [signed]	1220.000ms	0.999ms	2250 scans
	2: Single-precision real number	1320.000ms	0.999ms	

*1 The time required from start to end of the processing

List of error codes

Error code	Description	Action
103H	A value out of the range is set in i_uDataType (input data type selection).	Review and correct the setting and then execute the FB again. Set 0 or 2 in i_uDataType (input data type selection).
105H	A value out of the range is set in i_udSize (number of data points).	Set a value of 2 to 90000 in i_udSize (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_udSize (number of data points) • i_udXaxisDataAddr (start address of data of predicted values (X-axis)) • i_udYaxisDataAddr (start address of data of observed values (Y-axis)) Review and correct the settings and then execute the FB again.
200H	Although the value set in i_uDataType (input data type selection) is Single-precision real number, the stored input data is not a single-precision real number.	Store the input data as a single-precision real number in the file register (ZR). Review and correct the input data and then execute the FB again.
203H	An overflow has occurred in the FB during the operation.	Review and correct the input data stored and then execute the FB again. When 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module, refer to the MELSEC iQ-R CPU Module User's Manual (Application).
204H	The processing of the FB has been interrupted due to an overflow in an operation other than that of this FB.	An overflow has occurred in the operation other than that of this FB, and 3403H is stored in the special register SD0 (Latest self-diagnostic error code) of the CPU module. Refer to the MELSEC iQ-R CPU Module User's Manual (Application).
205H	i_bEN (execution command) has been turned off during the processing.	Do not turn off i_bEN (execution command) until o_bOK (normal completion) or o_bErr (error completion) turns on.
210H	Neither a coefficient of correlation nor a coefficient of determination can be calculated since the values stored either as data of predicted values (X-axis) or as data of observed values (Y-axis) are all the same.	Check that either data of predicted values or data of observed values stored in the file register are not all the same values, then execute the FB again.

INSTRUCTION INDEX

M

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M+DataStatistics_StandardDeviationEx_R 13
M+DataStatistics_StandardDeviation_R 9
M+DataStatistics_Variance_R 17

MEMO

REVISIONS

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

Revision date	*Manual number	Description
May 2017	BCN-P5999-0835-A	First edition
January 2018	BCN-P5999-0835-B	■Additional FB M+DataStatistics_FrequencyDistribution_R ■Added or modified parts Section 1.1, 2.4
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