MITSUBISHI ELECTRIC

Programmable Controller

MELSEC iQ-R series

MELSEC iQ-R C Intelligent Function Module Function Block Reference

SAFETY PRECAUTIONS

(Read these precautions before using this product.)

Before using the products described under "Relevant products", please read this manual and the relevant manuals carefully and pay full attention to safety to handle the products correctly.

The precautions given in this manual are concerned with the products only. For the safety precautions of the programmable controller system, refer to the MELSEC iQ-R Module Configuration Manual.

In this manual, the safety precautions are classified into two levels: " ⚠ 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.

Under some circumstances, failure to observe the precautions given under " ⚠ CAUTION" may lead to serious consequences.

Observe the precautions of both levels because they are important for personal and system safety.

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

CONDITIONS OF USE FOR THE PRODUCT

(1) Mitsubishi programmable controller ("the PRODUCT") shall be used in conditions;

i) where any problem, fault or failure occurring in the PRODUCT, if any, shall not lead to any major or serious accident; and

ii) where the backup and fail-safe function are systematically or automatically provided outside of the PRODUCT for the case of any problem, fault or failure occurring in the PRODUCT.

(2) The PRODUCT has been designed and manufactured for the purpose of being used in general industries.
MITSUBISHI SHALL HAVE NO RESPONSIBILITY OR LIABILITY (INCLUDING, BUT NOT LIMITED TO ANY AND ALL RESPONSIBILITY OR LIABILITY BASED ON CONTRACT, WARRANTY, TORT, PRODUCT LIABILITY) FOR ANY INJURY OR DEATH TO PERSONS OR LOSS OR DAMAGE TO PROPERTY CAUSED BY the PRODUCT THAT ARE OPERATED OR USED IN APPLICATION NOT INTENDED OR EXCLUDED BY INSTRUCTIONS, PRECAUTIONS, OR WARNING CONTAINED IN MITSUBISHI'S USER, INSTRUCTION AND/OR SAFETY MANUALS, TECHNICAL BULLETINS AND GUIDELINES FOR the PRODUCT.
("Prohibited Application")

Prohibited Applications include, but not limited to, the use of the PRODUCT in;

• Nuclear Power Plants and any other power plants operated by Power companies, and/or any other cases in which the public could be affected if any problem or fault occurs in the PRODUCT.

• Railway companies or Public service purposes, and/or any other cases in which establishment of a special quality assurance system is required by the Purchaser or End User.

• Aircraft or Aerospace, Medical applications, Train equipment, transport equipment such as Elevator and Escalator, Incineration and Fuel devices, Vehicles, Manned transportation, Equipment for Recreation and Amusement, and Safety devices, handling of Nuclear or Hazardous Materials or Chemicals, Mining and Drilling, and/or other applications where there is a significant risk of injury to the public or property.

Notwithstanding the above restrictions, Mitsubishi may in its sole discretion, authorize use of the PRODUCT in one or more of the Prohibited Applications, provided that the usage of the PRODUCT is limited only for the specific applications agreed to by Mitsubishi and provided further that no special quality assurance or fail-safe, redundant or other safety features which exceed the general specifications of the PRODUCTs are required. For details, please contact the Mitsubishi representative in your region.

(3) Mitsubishi shall have no responsibility or liability for any problems involving programmable controller trouble and system trouble caused by DoS attacks, unauthorized access, computer viruses, and other cyberattacks.

INTRODUCTION

Thank you for purchasing the Mitsubishi Electric MELSEC iQ-R series programmable controllers.

This manual describes the module function blocks for the relevant products listed below.

Before using the products, please read this manual and the relevant manuals carefully and develop familiarity with the functions and performance of the MELSEC iQ-R series programmable controller to handle the products correctly.

Please make sure that the end users read this manual.

Relevant products

RD55UP06-V, RD55UP12-V

CONTENTS

RELEVANT MANUALS

Manual name [manual number]	Description	Available form
MELSEC iQ-R C Intelligent Function Module Function Block Reference [BCN-P5999-1037] (this reference)	Specifications, functions, and input/output labels of function blocks for a C intelligent function module	e-Manual PDF

Point

e-Manual refers to the Mitsubishi Electric FA electronic book manuals that can be browsed using a dedicated tool.

e-Manual has the following features:

• Required information can be cross-searched in multiple manuals.

• Other manuals can be accessed from the links in the manual.

• The hardware specifications of each part can be found from the product figures.

• Pages that users often browse can be bookmarked.

• Sample programs can be copied to an engineering tool.

TERMS

Unless otherwise specified, this reference uses the following terms.

Term	Description
Engineering tool	A tool used for setting up programmable controllers, programming, debugging, and maintenance.
Module label	A label that represents one of memory areas (I/O signals and buffer memory areas) specific to each module in a given character string. For the module used, GX Works3 automatically generates this label, which can be used as a global label.

GENERIC TERMS AND ABBREVIATIONS

Unless otherwise specified, this reference uses the following generic terms and abbreviations:

Generic term and abbreviation	Description
C intelligent function module	An abbreviation for a MELSEC iQ-R C intelligent function module.

1 OVERVIEW

The FBs listed in this reference are module FBs (for GX Works3) to use the C intelligent function module.

1.1 FUNCTION BLOCK (FB) LIST

This section shows the module FB list of 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.

○: Required, ×: Not required

Name	Description	Necessity of parameter setting
M+model_DANLDigitalFilter	To perform digital filter operation for the specified wave.	×
M+model_DANLEnvelopeCalculation	To calculate the envelope of the specified wave.	×
M+model_DANLFFTSpectrum	To perform spectrum calculation using fast Fourier transform (FFT) for the specified wave.	×
M+model_DANLLeastSquare	To calculate a coefficient and a constant of a polynomial, and a multiple correlation coefficient using a least-squares method for the specified data.	×
M+model_DANLMTUnit	To determine a unit space that is used in the MT method based on the specified normal data.	×
M+model_DANLMTMD	To calculate a Mahalanobis distance of the specified signal data.	×
M+model_DANLMultiRegression	To calculate a coefficient, constant, and regression statistics for multiple regression analysis.	×

1.2 How to Obtain

Module FBs are installed at the same time as installing GX Works3; however, the module FBs in this reference may not be installed with some versions of GX Works3. It is recommended to install the latest version of GX Works3.

1.3　System Configuration

The following shows the system configuration for using the module FBs in this reference.
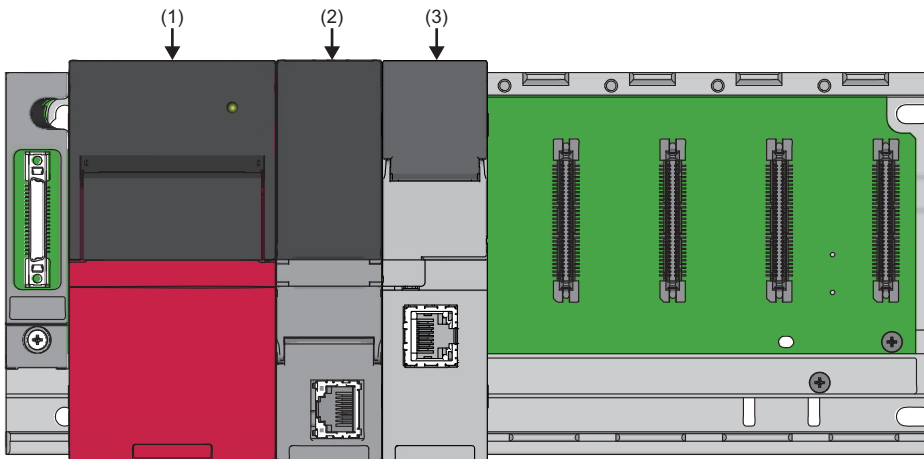
(1) Power supply module

(2) CPU module

(3) C intelligent function module

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

2 C Intelligent Function Module FBs
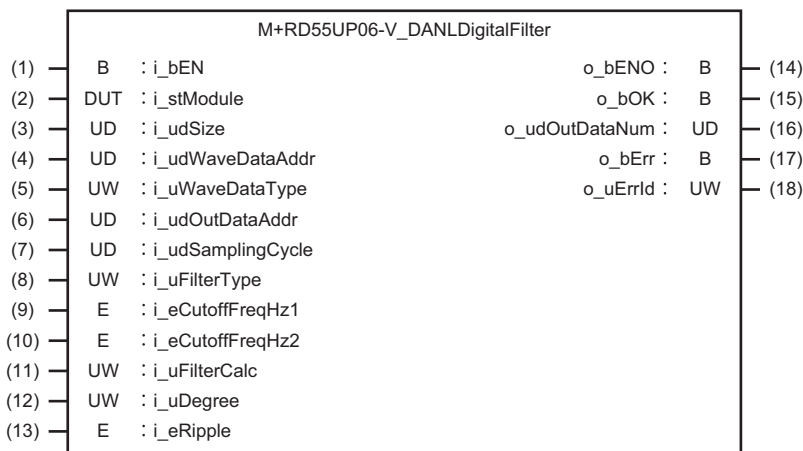
2.1 M+model_DANLDigitalFilter

Name

The module names of the FB are based on the module used and are as follows.

Target module	Name
RD55UP06-V	M+RD55UP06-V_DANLDigitalFilter
RD55UP12-V	M+RD55UP12-V_DANLDigitalFilter

Overview

To perform digital filter operation for the specified wave.

```
                    M+RD55UP06-V_DANLDigitalFilter
(1) ─── B    : i_bEN                          o_bENO ：   B  ─── (14)
(2) ─── DUT  : i_stModule                      o_bOK ：   B  ─── (15)
(3) ─── UD   : i_udSize              o_udOutDataNum ：  UD  ─── (16)
(4) ─── UD   : i_udWaveDataAddr                o_bErr ：   B  ─── (17)
(5) ─── UW   : i_uWaveDataType                o_uErrId ：  UW  ─── (18)
(6) ─── UD   : i_udOutDataAddr
(7) ─── UD   : i_udSamplingCycle
(8) ─── UW   : i_uFilterType
(9) ─── E    : i_eCutoffFreqHz1
(10) ─── E   : i_eCutoffFreqHz2
(11) ─── UW  : i_uFilterCalc
(12) ─── UW  : i_uDegree
(13) ─── E   : i_eRipple
```

Labels

Input label

No.	Label	Label name	Data type	Range	Description
(1)	i_bEN	Execution command	bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_stModule	Module label	Structures	The range varies depending on the module label.	Specify the module label of the C intelligent function module.
(3)	i_udSize	Number of data points	Double Word [unsigned]	16 to 1000000	Specify the number of data points of the wave to be calculated.
(4)	i_udWaveDataAddr	Wave data start address	Double Word [unsigned]	16384 to 2097151	Specify a start address of the buffer memory of a C intelligent function module where wave data to be calculated is stored. • Data for the specified number of data points is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the wave data to be calculated in the buffer memory.
(5)	i_uWaveDataType	Wave data type selection	Word [unsigned]	0 to 2	Specify a data type of the wave data to analyze. 0: Word [signed] 1: Double Word [signed] 2: Single-precision real number

No.	Label	Label name	Data type	Range	Description
(6)	i_udOutDataAddr	Start address of output data	Double Word [unsigned]	16384 to 2097150	Specify a start address of the buffer memory of a C intelligent function module to store an operation result. • Data for the specified number of data points is stored to the specified start address and its consecutive address in the buffer memory as an operation result.
(7)	i_udSamplingCycle	Sampling cycle	Double Word [unsigned]	1 to 1000000 (1us to 1000000us)	Specify a sampling cycle [×1us].
(8)	i_uFilterType	Filter type	Word [unsigned]	0 to 3	Specify a filter type. 0: Low-pass filter (LPF) 1: High-pass filter (HPF) 2: Band-pass filter (BPF) 3: Band elimination filter (BEF)
(9)	i_eCutoffFreqHz1	Cutoff frequency 1	Single-precision real number	A value greater than '0'[*1]	Specify a cutoff frequency 1 [Hz].
(10)	i_eCutoffFreqHz2	Cutoff frequency 2	Single-precision real number	A value greater than '0'[*1,*2]	Specify a cutoff frequency 2 [Hz]. This label is enabled only when either band-pass filter (BPF) or band elimination filter (BEF) is specified to i_uFilterType (filter type). If low-pass filter (LPF) or high-pass filter (HPF) is specified, this will be ignored.
(11)	i_uFilterCalc	Filter operation type	Word [unsigned]	0 to 2	Specify a filter operation type. 0: FIR filter 1: IIR filter (Butterworth) 2: IIR filter (Chebyshev) IIR filter can be used only when either a low-pass filter (LPF) or high-pass filter (HPF) is specified to i_uFilterType (filter type). When a band-pass filter (BPF) or a band elimination filter (BEF) is specified, it operates as an FIR filter.
(12)	i_uDegree	Degree	Word [unsigned]	FIR filter: 2 to 200 (even number only) [*3] IIR filter: 2 to 40 [*3]	Specifies the degree of a digital filter.
(13)	i_eRipple	Ripple	Single-precision real number	0.015625 to1.0	Specify a ripple [dB]. This label is enabled only when IIR filter (Chebyshev) is specified to i_uFilterCalc (filter operation type). If FIR filter or IIR filter (Butterworth) is specified, this will be ignored.

*1   Specify a value less than the one obtained by dividing the sampling cycle by 2.
*2   Specify a value greater than or equal to the one set for i_eCutoffFreqHz1 (cutoff frequency 1).
*3   Specify a value less than or equal to the one set for the i_udSize (number of data points).

Output label

No.	Label	Label name	Data type	Default value	Description
(14)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is OFF.
(15)	o_bOK	Normal completion	Bit	OFF	The ON state indicates that a digital filter operation is completed.
(16)	o_udOutDataNum	Number of output data points	Double Word [unsigned]	0	The number of points of output data is stored when a calculation is completed.
(17)	o_bErr	Error completion	Bit	OFF	The ON state indicates that an error has occurred in the FB.
(18)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error occurred in the FB is returned.

FB details

Available device

■ C intelligent function module

Target module	Firmware version	Engineering tool
RD55UP06-V	07 or later	GX Works3 of version 1.050C or later
RD55UP12-V	01 or later	GX Works3 of version 1.065T or later

■ CPU module

MELSEC iQ-R series programmable controller CPU

> **Point**
>
> For the CPU modules classified as programmable controller CPUs, refer to the MELSEC iQ-R Module Configuration Manual.

Basic specifications

Item	Description
Language	— (The internal program of this FB is not open to the public.)
Number of steps	150 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.
FB dependence	No dependence
FB compilation method	Macro type
FB operation	Pulse execution (multiple scan execution type)

Processing

- As i_bEN (execution command) turns ON, a digital filter operation is performed for wave data for the number of data points specified to the i_udSize (number of data points) from the start address specified to i_udWaveDataAddr (start address of wave data). Depending on the set filter operation type and degree, the output wave varies. (☞ Page 12 Output wave)
- Specify the data type of input wave data for i_uWaveDataType (wave data type selection).
- Data for the number of points set to i_udSize (number of data points) is stored to the start address specified to i_udOutDataAddr (start address of output data) and its consecutive address in the buffer memory as an operation result.
- Input wave data is read for the number of data points set for i_udSize (number of data points). Depending on the data type set for i_uWaveDataType (wave data type selection), the range of the buffer memory to be read varies. (☞ Page 12 Buffer memory points required for each wave data type)
- An operation result is stored to the buffer memory as a single-precision real number. Additionally, an area for 'i_udSize (number of data points) × 2' words is used in the buffer memory.
- This FB supports the frequency response filter types, such as low-pass filter, high-pass filter, band-pass filter, and band elimination filter.
- This FB supports FIR filter, IIR filter (Butterworth), and IIR filter (Chebyshev).
- Multiple scans are taken until the operation is completed; therefore, do not change the wave data before the completion of the process. When the process is completed, o_bOK (normal completion) turns ON.
- If an error occurs, o_bErr (error completion) turns ON and the processing of the FB is interrupted, and then an error code is stored to o_uErrId (error code). For error codes, refer to the error code list. (☞ Page 17 Error code)
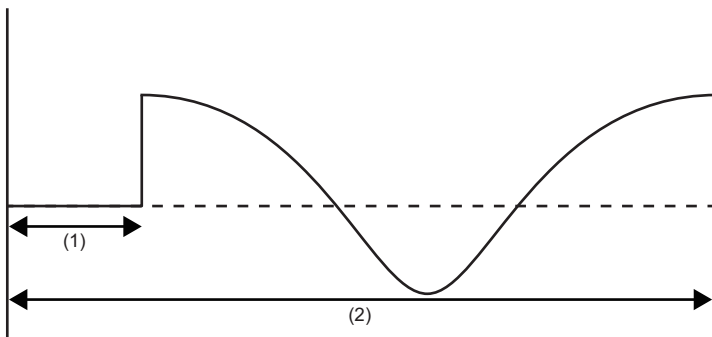
■ Output wave

● FIR

The wave after a digital filter operation is output from the set degree point. (The wave output value from the start of the output wave to the degree point will be '0.')

Ex.

Number of output data points (2):1000 points, degree (1): 200 points

● IIR

Regardless of the set degree, the wave after a digital filter operation is always output from the start.

■ Buffer memory points required for each wave data type

i_uWaveDataType (wave data type selection)	Required buffer memory points (word)
0: Word [signed]	i_udSize (number of data points)
1: Double Word [signed]	i_udSize (number of data points) × 2
2: Single-precision real number	

■ Operation example on the frequency response filter

The following shows an example when each filter is applied to the synthetic wave (2) which consists of three waves shown in the composed wave (1). (The actual results may be different from the following example.)

In the following figure, the horizontal axis indicates time and the vertical axis indicates amplitude.

(1)　　　　　　　　　　　　　　(2)
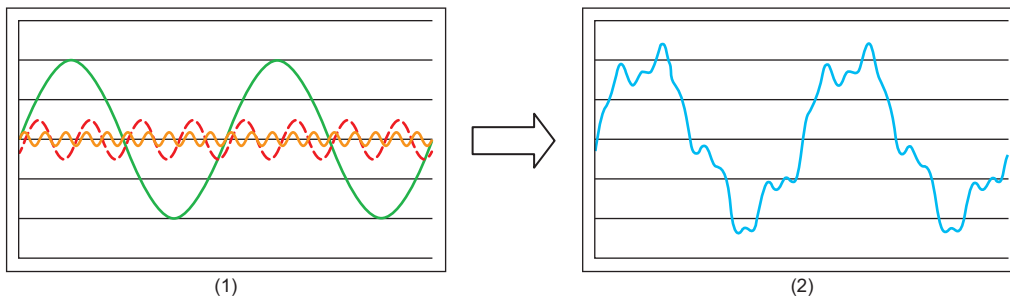
| Filter type	Feature
Low-pass filter	Attenuates and terminates signals with frequencies higher than the specified frequency to pass only low frequency signals.
High-pass filter	Attenuates and terminates signals with frequencies lower than the specified frequency to pass only high frequency signals.
Band-pass filter	Passes only signals with frequencies within the specified range.
Band elimination filter	Eliminates frequency signals within the specified range.

● Low-pass filter

A low-pass filter attenuates and terminates signals with a frequency higher than the one specified to the cutoff frequency 1 to pass only low frequency signals.
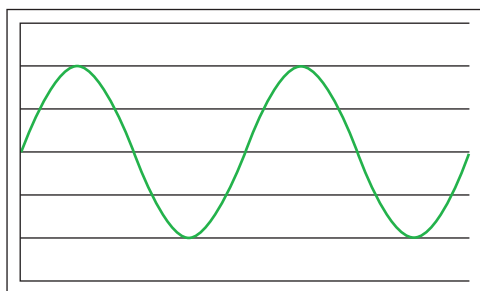
● High-pass filter

A high-pass filter attenuates and terminates signals with a frequency lower than the one specified to the cutoff frequency 1 to pass only high frequency signals.
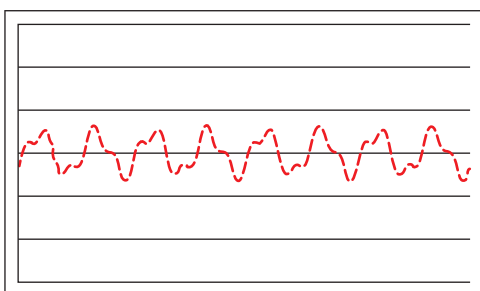
●Band-pass filter

A band-pass filter passes signals with a frequency higher than the one specified to the cutoff frequency 1 and lower than the one specified to the cutoff frequency 2.
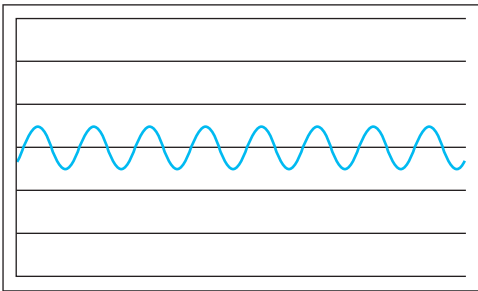
● Band elimination filter

A band elimination filter eliminates signals with a frequency higher than the one specified to the cutoff frequency 1 and lower than the one specified to the cutoff frequency 2.
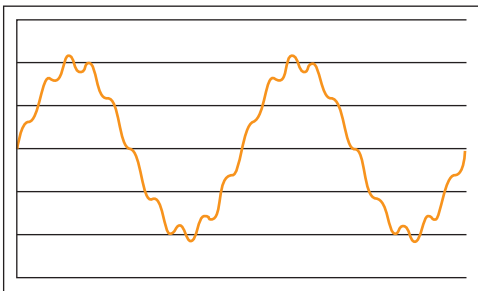
Timing chart of I/O signals

■ Normal completion (number of data points: 1000 points)

i_bEN	
o_bENO	
Operation processing	Not performed / Perform / Not performed
o_udOutDataNum	0 / 1000 / 0
o_bOK	
o_bErr	OFF
o_uErrId	0

■ Error completion

i_bEN	
o_bENO	
Operation processing	Not performed
o_udOutDataNum	0
o_bOK	OFF
o_bErr	
o_uErrId	0 / Error code / 0

Restrictions or precautions

- This FB does not include the error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- A long index register (LZ0) is used for this FB. When creating an interrupt program, do not use the index register.
- This FB cannot be used in an interrupt program.
- If a program which is executed only once, such as a subroutine program or FOR-NEXT instruction, is used in this FB, the i_bEN (execution command) cannot be turned OFF, and as a result the program does not operate properly. This FB should be used in a program in which the i_bEN (execution command) can be turned OFF.
- Setting a circuit is required for all the input labels of this FB.
- i_bEN (execution command) should be turned OFF after o_bOK (normal completion) or o_bErr (error completion) is turned ON. Otherwise, o_bOK (normal completion) or o_bErr (error completion) turns OFF, and as a result o_uErrId (error code) will be cleared to '0'.
- This FB operates on a C intelligent function module which is specified for i_stModule (module label). Even when i_bEN (execution command) turns OFF during an operation, it continues on the module until the processing ends. When the i_stModule (module label) turns OFF during the operation and the operation is completed successfully, the result is output to the buffer memory of the C intelligent function module; however, it is not output to the output label of this FB.
- The input and output data type of a data analysis library that is executed by this FB is single-precision real number; therefore, specifying double-word type for i_uWaveDataType (wave data type selection) may lead to a loss of trailing digits.
- During the execution of this FB, neither a dedicated instruction nor an FB can be executed for the same C intelligent function module. The operation under the situation as previously noted is not guaranteed; therefore, arrange a program that executes a dedicated instruction or an FB after o_bOK (normal completion) or o_bErr (error completion) is turned ON.

parameter settings

No parameter settings are required for using this FB.

Error code

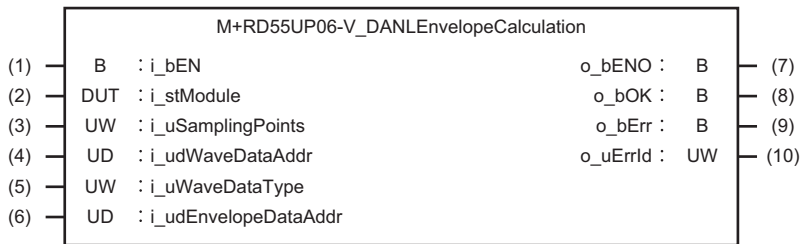| Error code	Description	Corrective action
103H	The value set for the i_uWaveDataType (wave data type selection) is out of the range. Set 0 to 2 for i_uWaveDataType (wave data type selection).	After checking the setting, execute the FB again.
105H	The value set for the i_udSize (number of data points) is out of the range. Set 16 to 1000000 for i_udSize (number of data points).	After checking the setting, execute the FB again.
109H	The value set for the i_udSamplingCycle (sampling cycle) is other than 1 to 1000000.	After checking the setting, execute the FB again.
10AH	The value set for the i_uFilterType (filter type) is other than 0 to 3.	After checking the setting, execute the FB again.
10BH	The value set for the i_eCutoffFreqHz1 (cutoff frequency 1) is 0 or less, or greater than or equal to the one obtained by dividing the sampling frequency by 2.	After checking the setting, execute the FB again.
10CH	The value set for the i_eCutoffFreqHz2 (cutoff frequency 2) is 0 or less, greater than or equal to the one obtained by dividing the sampling frequency by 2, or less than the one set to the i_eCutoffFreqHz1 (cutoff frequency 1).	After checking the setting, execute the FB again.
10DH	The value set for the i_uFilterCalc (filter operation type) is other than 0 to 2.	After checking the setting, execute the FB again.
10EH	The value set for the i_uDegree (degree) is out of the range.	Specify an even number from 2 to 200 when "0: FIR filter" is specified to the i_uFilterCalc (filter operation type). When "1: IIR filter (Butterworth)" or "2: IIR filter (Chebyshev)" is specified, specify 2 to 40, and execute the FB again.
110H	The value set for the i_eRipple (ripple) is other than 0.015625 to 1.0.	After checking the setting, execute the FB again.
120H	A value greater than the one set to the i_uDegree (degree) is set for the i_udSize (number of data points).	Check that the value set for the i_uDegree (degree) is less than or equal to the one set for the i_udSize (number of data points).
121H	• The value set for the i_udWaveDataAddr (start address of wave data) is out of the range. • The values set for the i_udWaveDataAddr (start address of wave data) and i_udSize (number of data points) are out of the range.	• Set 16384 to 2097151 for i_udWaveDataAddr (start address of wave data). • Check the values set for the i_udWaveDataAddr (start address of wave data) and i_udSize (number of data points).
20EH	A memory reservation error occurred in the C intelligent function module.	Reduce the number of processings that run simultaneously in the C intelligent function module.
211H	• The value set for the i_udOutDataAddr (start address of output data) is out of the range. • The values set for the i_udOutDataAddr (start address of output data) and i_udSize (number of data points) are out of the range.	• Set 16384 to 2097150 for i_udOutDataAddr (start address of output data). • Check the values set for the i_udOutDataAddr (start address of output data) and i_udSize (number of data points).

2.2 M+model_DANLEnvelopeCalculation

Name

The module names of the FB are based on the module used and are as follows.

Target module	Name
RD55UP06-V	M+RD55UP06-V_DANLEnvelopeCalculation
RD55UP12-V	M+RD55UP12-V_DANLEnvelopeCalculation

Overview

To calculate the envelope of the specified wave.

```
             M+RD55UP06-V_DANLEnvelopeCalculation
(1) ─  B    : i_bEN                      o_bENO ：  B  ─ (7)
(2) ─  DUT  : i_stModule                 o_bOK ：   B  ─ (8)
(3) ─  UW   : i_uSamplingPoints          o_bErr ：  B  ─ (9)
(4) ─  UD   : i_udWaveDataAddr           o_uErrId ： UW ─ (10)
(5) ─  UW   : i_uWaveDataType
(6) ─  UD   : i_udEnvelopeDataAddr
```

Labels

Input label

No.	Label	Label name	Data type	Range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_stModule	Module label	Structures	The range varies depending on the module label.	Specify the module label of the C intelligent function module.
(3)	i_uSamplingPoints	Number of sampling points	Word [unsigned]	6 to 15	Set the number of sampling points (within 64 to 32768). When the number of sampling points is taken as N, the formula, i_uSamplingPoints = $\log_2 N$, should be satisfied. Example: i_uSamplingPoints = 6 : 64 points i_uSamplingPoints = 7 : 128 points ⋮ i_uSamplingPoints=15: 32768 points
(4)	i_udWaveDataAddr	Wave data start address	Double Word [unsigned]	16384 to 2097151	Specify a start address of the buffer memory of a C intelligent function module where wave data to be calculated is stored. • Data for the specified number of sampling points is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the wave data to be calculated in the buffer memory.
(5)	i_uWaveDataType	Wave data type selection	Word [unsigned]	0 to 2	Specify a data type of the wave data to analyze. 0: Word [signed] 1: Double Word [signed] 2: Single-precision real number

No.	Label	Label name	Data type	Range	Description
(6)	i_udEnvelopeDataAddr	Start address of output envelope data	Double Word [unsigned]	16384 to 2097150	Specify a start address of the buffer memory of a C intelligent function module to store an analysis result (envelope). • Data for the specified number of sampling points is stored to the specified start address and its consecutive address in the buffer memory as an operation result.

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	The ON state indicates that an envelope processing is 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 occurred in the FB is returned.

FB details

Available device

■ C intelligent function module

Target module	Firmware version	Engineering tool
RD55UP06-V	07 or later	GX Works3 of version 1.050C or later
RD55UP12-V	01 or later	GX Works3 of version 1.065T or later

■ CPU module

MELSEC iQ-R series programmable controller CPU

Point

For the CPU modules classified as programmable controller CPUs, refer to the MELSEC iQ-R Module Configuration Manual.

Basic specifications

Item	Description
Language	— (The internal program of this FB is not open to the public.)
Number of steps	74 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.
FB dependence	No dependence
FB compilation method	Macro type
FB operation	Pulse execution (multiple scan execution type)

Processing

- As i_bEN (execution command) turns ON, an envelope operation is performed for wave data for the number of data points specified to the i_uSamplingPoints (number of sampling points) from the start address specified to i_udWaveDataAddr (start address of wave data).
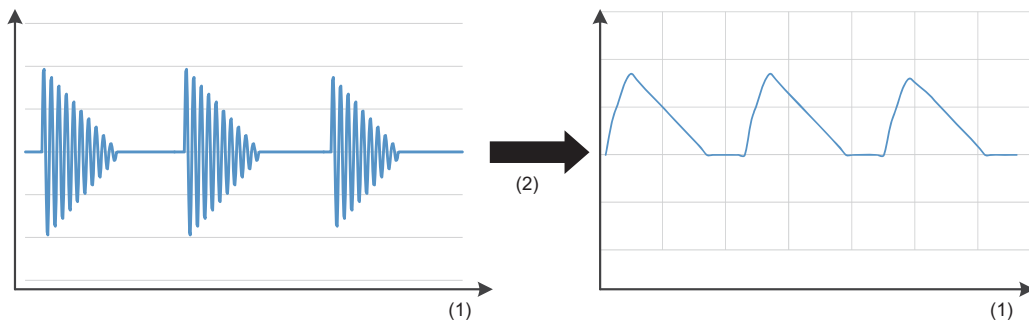
(1) Time

(2) Envelope calculation

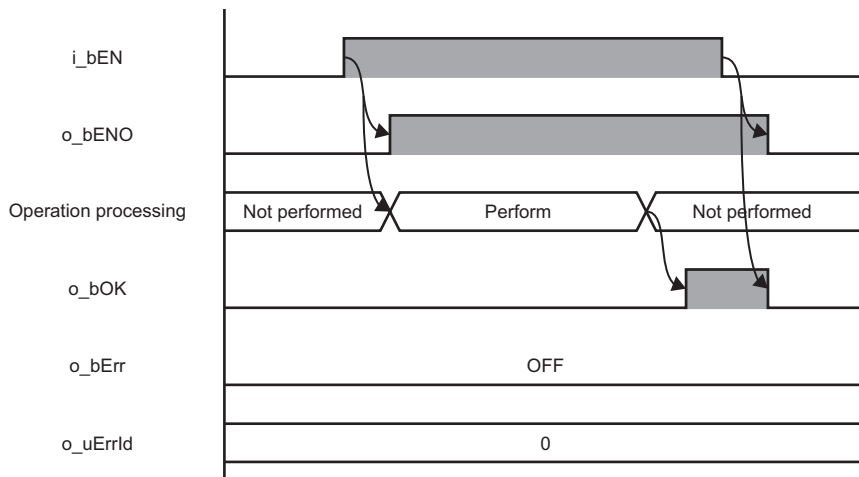- Specify the data type of input wave data for i_uWaveDataType (wave data type selection).
- Input wave data is read for the number of data points set for i_uSamplingPoints (number of sampling points). Depending on the data type set for i_uWaveDataType (wave data type selection), the range of the buffer memory to be read varies. (☞ Page 20 Buffer memory points required for each wave data type)
- Data for the number of points set to i_uSamplingPoints (number of sampling points) is stored to the start address specified to i_udEnvelopeDataAddr (start address of output envelope data) and its consecutive address in the buffer memory as an operation result.
- An operation result is stored to the buffer memory as a single-precision real number. Additionally, an area for 'i_uSamplingPoints (number of sampling points) × 2' words is used in the buffer memory.
- If an overflow occurs during operation, review the input data. A value stored at the occurrence of an overflow varies depending on each engineering tool. Check the specification of the engineering tool used.
- Multiple scans are taken until the operation is completed; therefore, do not change the wave data before the completion of the process. When the process is completed, o_bOK (normal completion) turns ON.
- If an error occurs, o_bErr (error completion) turns ON and the processing of the FB is interrupted, and then an error code is stored to o_uErrId (error code). For error codes, refer to the error code list. (☞ Page 22 Error code)

■ Buffer memory points required for each wave data type
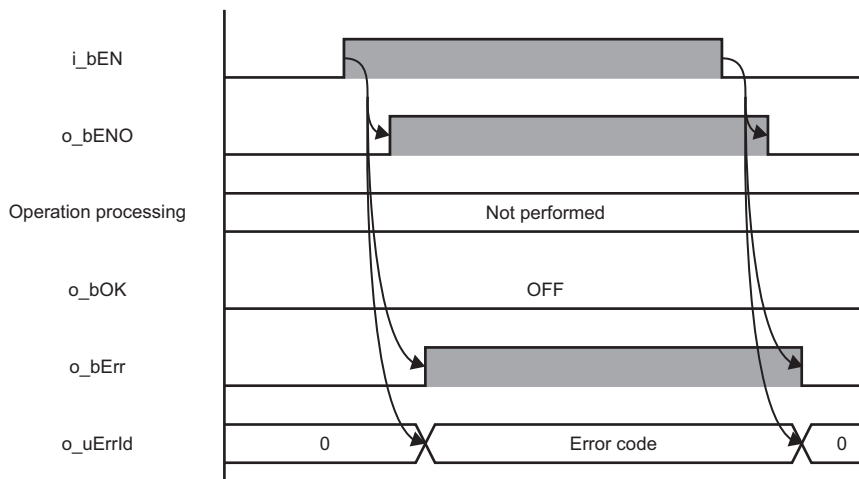
i_uWaveDataType (wave data type selection)	Required buffer memory points (word)
0: Word [signed]	i_uSamplingPoints (number of sampling points)
1: Double Word [signed]	i_uSamplingPoints (number of sampling points) × 2
2: Single-precision real number	

Timing chart of I/O signals

■ Normal completion

■ Error completion

Restrictions or precautions

- This FB does not include the 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.
- If a program which is executed only once, such as a subroutine program or FOR-NEXT instruction, is used in this FB, the i_bEN (execution command) cannot be turned OFF, and as a result the program does not operate properly. This FB should be used in a program in which the i_bEN (execution command) can be turned OFF.
- Setting a circuit is required for all the input labels of this FB.
- i_bEN (execution command) should be turned OFF after o_bOK (normal completion) or o_bErr (error completion) is turned ON. Otherwise, o_bOK (normal completion) or o_bErr (error completion) turns OFF, and as a result o_uErrId (error code) will be cleared to '0'.
- This FB operates on a C intelligent function module which is specified for i_stModule (module label). Even when i_bEN (execution command) turns OFF during an operation, it continues on the module until the processing ends. When the i_stModule (module label) turns OFF during the operation and the operation is completed successfully, the result is output to the buffer memory of the C intelligent function module; however, it is not output to the output label of this FB.
- The input and output data type of a data analysis library that is executed by this FB is single-precision real number; therefore, specifying double-word type for i_uWaveDataType (wave data type selection) may lead to a loss of trailing digits.
- During the execution of this FB, neither a dedicated instruction nor an FB can be executed for the same C intelligent function module. The operation under the situation as previously noted is not guaranteed; therefore, arrange a program that executes a dedicated instruction or an FB after o_bOK (normal completion) or o_bErr (error completion) is turned ON.

parameter settings

No parameter settings are required for using this FB.

Error code

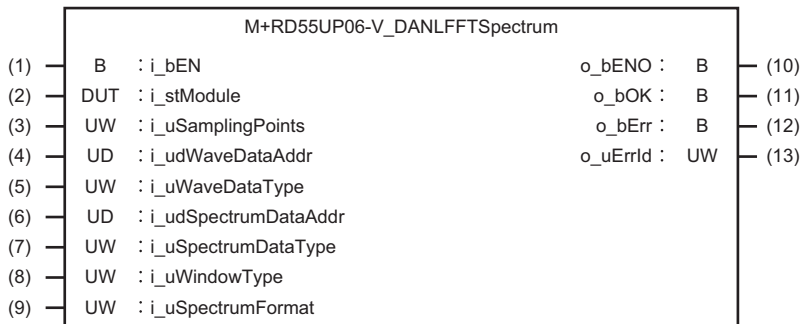| Error code	Description	Corrective action
100H	The value set for the i_uSamplingPoints (number of sampling points) is out of the range. Set 6 to 15 for i_uSamplingPoints (number of sampling points).	After checking the setting, execute the FB again.
103H	The value set for the i_uWaveDataType (wave data type selection) is out of the range. Set 0 to 2 for i_uWaveDataType (wave data type selection).	After checking the setting, execute the FB again.
121H	• The value set for the i_udWaveDataAddr (start address of wave data) is out of the range. • The values set for the i_udWaveDataAddr (start address of wave data) and i_uSamplingPoints (number of sampling points) are out of the range.	• Set 16384 to 2097151 for i_udWaveDataAddr (start address of wave data). • Check the values set for the i_udWaveDataAddr (start address of wave data) and i_uSamplingPoints (number of sampling points).
20EH	A memory reservation error occurred in the C intelligent function module.	Reduce the number of processings that run simultaneously in the C intelligent function module.
211H	• The value set for the i_udEnvelopeDataAddr (start address of output envelope data) is out of the range. • The values set for the i_udEnvelopeDataAddr (start address of output envelope data) and i_uSamplingPoints (number of sampling points) are out of the range.	• Set 16384 to 2097150 for i_udEnvelopeDataAddr (start address of output envelope data). • Check the values set for the i_udEnvelopeDataAddr (start address of output envelope data) and i_uSamplingPoints (number of sampling points).

2.3 M+model_DANLFFTSpectrum

Name

The module names of the FB are based on the module used and are as follows.

Target module	Name
RD55UP06-V	M+RD55UP06-V_DANLFFTSpectrum
RD55UP12-V	M+RD55UP12-V_DANLFFTSpectrum

Overview

To perform spectrum calculation using fast Fourier transform (FFT) for the specified wave.

```
                 M+RD55UP06-V_DANLFFTSpectrum
(1) —   B    : i_bEN                    o_bENO ：  B  — (10)
(2) — DUT   : i_stModule                 o_bOK ：  B  — (11)
(3) — UW    : i_uSamplingPoints          o_bErr ：  B  — (12)
(4) — UD    : i_udWaveDataAddr          o_uErrId ： UW  — (13)
(5) — UW    : i_uWaveDataType
(6) — UD    : i_udSpectrumDataAddr
(7) — UW    : i_uSpectrumDataType
(8) — UW    : i_uWindowType
(9) — UW    : i_uSpectrumFormat
```

Labels

Input label

No.	Label	Label name	Data type	Range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_stModule	Module label	Structures	The range varies depending on the module label.	Specify the module label of the C intelligent function module.
(3)	i_uSamplingPoints	Number of sampling points	Word [unsigned]	4 to 15	Set the number of sampling points (within 16 to 32768). When the number of sampling points is taken as N, the formula, i_uSamplingPoints = $\log_2 N$, should be satisfied. Example: i_uSamplingPoints=4: 16 points i_uSamplingPoints=5: 32 points ⋮ i_uSamplingPoints=15: 32768 points
(4)	i_udWaveDataAddr	Wave data start address	Double Word [unsigned]	16384 to 2097151	Specify a start address of the buffer memory of a C intelligent function module where wave data to be calculated is stored. • Data for the specified number of sampling points is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the wave data to be calculated in the buffer memory.
(5)	i_uWaveDataType	Wave data type selection	Word [unsigned]	0 to 2	Specify a data type of the wave data to analyze. 0: Word [signed] 1: Double Word [signed] 2: Single-precision real number

No.	Label	Label name	Data type	Range	Description
(6)	i_udSpectrumDataAddr	Start address of output spectrum	Double Word [unsigned]	16384 to 2097151	Specify a start address of the buffer memory of a C intelligent function module to store an operation result. • Data for the specified number of sampling points is stored to the specified start address and its consecutive address in the buffer memory as an operation result.
(7)	i_uSpectrumDataType	Output spectrum data type selection	Word [unsigned]	0 to 2	Specify the data type of an analysis result (spectrum). 0: Word [signed] 1: Double Word [signed] 2: Single-precision real number
(8)	i_uWindowType	Window function	Word [unsigned]	0 to 3	Specify a window function used for fast Fourier transform (FFT). 0: Rectangular window 1: Hanning window 2: Hamming window 3: Blackman window
(9)	i_uSpectrumFormat	Output spectrum format	Word [unsigned]	0 to 3	Specify an output spectrum format for fast Fourier transform (FFT). 0: Power 1: P (Peak) 2: P-P (Peak to Peak) 3: RMS (Root Mean Square)

Output label

No.	Label	Label name	Data type	Default value	Description
(10)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is OFF.
(11)	o_bOK	Normal completion	Bit	OFF	The ON state indicates that an FFT spectrum calculation is completed.
(12)	o_bErr	Error completion	Bit	OFF	The ON state indicates that an error has occurred in the FB.
(13)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error occurred in the FB is returned.

FB details

Available device

■ C intelligent function module

Target module	Firmware version	Engineering tool
RD55UP06-V	07 or later	GX Works3 of version 1.050C or later
RD55UP12-V	01 or later	GX Works3 of version 1.065T or later

■ CPU module

MELSEC iQ-R series programmable controller CPU

Point⌕

> For the CPU modules classified as programmable controller CPUs, refer to the MELSEC iQ-R Module Configuration Manual.

Basic specifications

Item	Description
Language	— (The internal program of this FB is not open to the public.)
Number of steps	108 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.
FB dependence	No dependence
FB compilation method	Macro type
FB operation	Pulse execution (multiple scan execution type)

Processing

- As i_bEN (execution command) turns ON, an FFT spectrum operation using fast Fourier transform (FFT) is performed for wave data for the number of data points specified to the i_uSamplingPoints (number of sampling points) from the start address specified to i_udWaveDataAddr (start address of wave data).
- By performing the fast Fourier transform (FFT), the time axis of a wave is converted to a frequency axis.
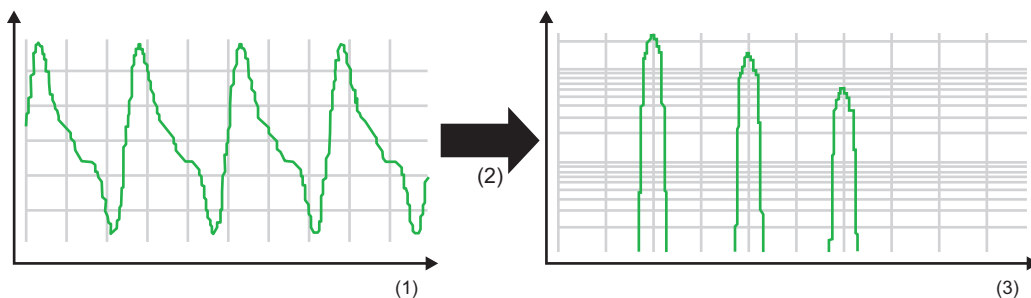
(1) Time

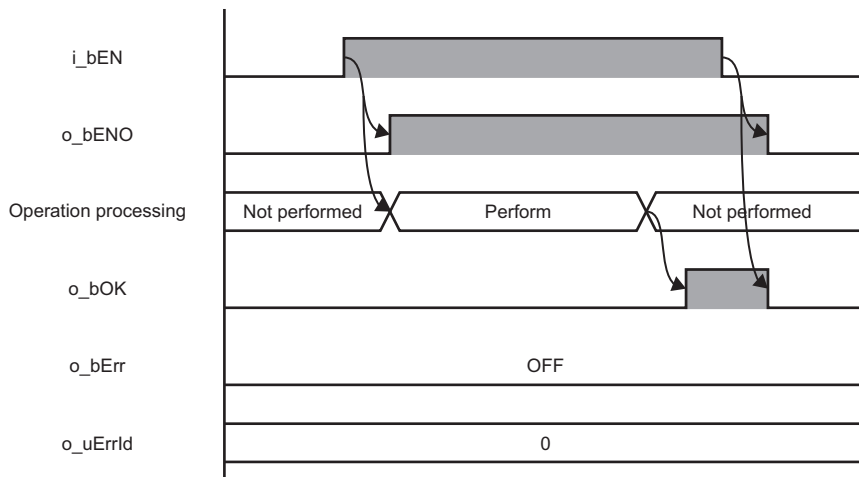(2) FFT operation

(3) Frequency

- This FB supports window functions (rectangular, hanning, hamming, and blackman).
- This FB supports output spectrum formats (power, P (Peak), P-P (Peak to Peak), and RMS (Root Mean Square)).
- Input wave data for Fourier transform (FFT) analysis is read from the buffer memory address specified to i_udWaveDataAddr (start address of wave data).
- Specify the data type of input wave data for i_uWaveDataType (wave data type selection).
- Input wave data is read for the number of data points set for i_uSamplingPoints (number of sampling points). Depending on the data type set for i_uWaveDataType (wave data type selection), the range of the buffer memory to be read varies. (☞ Page 26 Buffer memory points required for each wave data type)
- Data for the number of points set to i_uSamplingPoints (number of sampling points) is stored to the start address specified to i_udSpectrumDataAddr (start address of output spectrum) and its consecutive address in the buffer memory as an operation result.
- Depending on the data type set for i_uSpectrumDataType (output spectrum data type selection), the range of the buffer memory to store data varies.
  Word [signed]: Data for 'i_uSamplingPoints (number of sampling points)' words
  Double word [signed] or single-precision real number: Data for 'i_uSamplingPoints (number of sampling points) $\times$ 2' words
- When Word [signed] or Double Word [signed] is specified for i_uSpectrumDataType (output spectrum data type selection), all analysis results are normalized with the maximum value of the specified data type.
- Multiple scans are taken until the operation is completed; therefore, do not change the wave data before the completion of the process. When the process is completed, o_bOK (normal completion) turns ON.
- If an error occurs, o_bErr (error completion) turns ON and the processing of the FB is interrupted, and then an error code is stored to o_uErrId (error code). For error codes, refer to the error code list. (☞ Page 29 Error code)

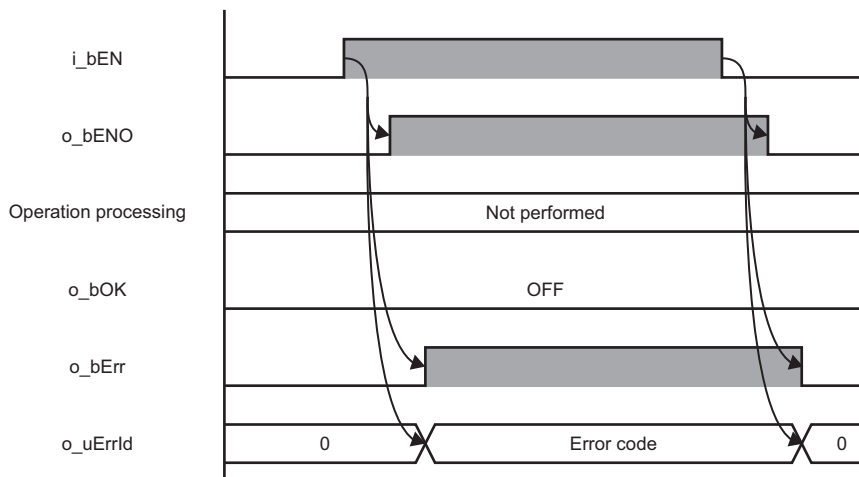### ■ Buffer memory points required for each wave data type

i_uWaveDataType (wave data type selection)	Required buffer memory points
0: Word [signed]	i_uSamplingPoints (number of sampling points)
1: Double Word [signed]	i_uSamplingPoints (number of sampling points) $\times$ 2
2: Single-precision real number	

Timing chart of I/O signals

■ Normal completion

i_bEN	
o_bENO	
Operation processing	Not performed / Perform / Not performed
o_bOK	
o_bErr	OFF
o_uErrId	0

■ Error completion

i_bEN	
o_bENO	
Operation processing	Not performed
o_bOK	OFF
o_bErr	
o_uErrId	0 / Error code / 0

Restrictions or precautions

- This FB does not include the 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.
- If a program which is executed only once, such as a subroutine program or FOR-NEXT instruction, is used in this FB, the i_bEN (execution command) cannot be turned OFF, and as a result the program does not operate properly. This FB should be used in a program in which the i_bEN (execution command) can be turned OFF.
- Setting a circuit is required for all the input labels of this FB.
- i_bEN (execution command) should be turned OFF after o_bOK (normal completion) or o_bErr (error completion) is turned ON. Otherwise, o_bOK (normal completion) or o_bErr (error completion) turns OFF, and as a result o_uErrId (error code) will be cleared to '0'.
- This FB operates on a C intelligent function module which is specified for i_stModule (module label). Even when i_bEN (execution command) turns OFF during an operation, it continues on the module until the processing ends. When the i_stModule (module label) turns OFF during the operation and the operation is completed successfully, the result is output to the buffer memory of the C intelligent function module; however, it is not output to the output label of this FB.
- The input and output data type of a data analysis library that is executed by this FB is single-precision real number; therefore, specifying double-word type for i_uWaveDataType (wave data type selection) may lead to a loss of trailing digits.
- During the execution of this FB, neither a dedicated instruction nor an FB can be executed for the same C intelligent function module. The operation under the situation as previously noted is not guaranteed; therefore, arrange a program that executes a dedicated instruction or an FB after o_bOK (normal completion) or o_bErr (error completion) is turned ON.

parameter settings

No parameter settings are required for using this FB.

Error code

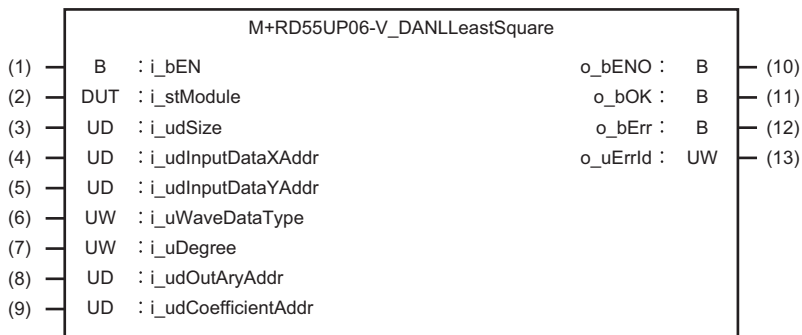| Error code	Description	Corrective action
100H	The value set for the i_uSamplingPoints (number of sampling points) is out of the range. Set 4 to 15 for i_uSamplingPoints (number of sampling points).	After checking the setting, execute the FB again.
101H	The value set for the i_uWindowType (window function) is out of the range. Set 0 to 3 for i_uWindowType (window function).	After checking the setting, execute the FB again.
102H	The value set for the i_uSpectrumFormat (output spectrum format) is out of the range. Set 0 to 3 for i_uSpectrumFormat (output spectrum format).	After checking the setting, execute the FB again.
103H	The value set for the i_uWaveDataType (wave data type selection) is out of the range. Set 0 to 2 for i_uWaveDataType (wave data type selection).	After checking the setting, execute the FB again.
104H	The value set for the i_uSpectrumDataType (output spectrum data type selection) is out of the range. Set 0 to 2 for i_uSpectrumDataType (output spectrum data type selection).	After checking the setting, execute the FB again.
121H	• The value set for the i_udWaveDataAddr (start address of wave data) is out of the range. • The values set for the i_udWaveDataAddr (start address of wave data) and i_uSamplingPoints (number of sampling points) are out of the range.	• Set 16384 to 2097151 for i_udWaveDataAddr (start address of wave data). • Check the values set for the i_udWaveDataAddr (start address of wave data) and i_uSamplingPoints (number of sampling points).
20EH	A memory reservation error occurred in the C intelligent function module.	Reduce the number of processings that run simultaneously in the C intelligent function module.
211H	• The value set for the i_udSpectrumDataAddr (start address of output spectrum) is out of the range. • The values set for the i_udSpectrumDataAddr (start address of output spectrum) and i_uSamplingPoints (number of sampling points) are out of the range.	• Set 16384 to 2097151 for i_udSpectrumDataAddr (start address of output spectrum). • Check the values set for the i_udSpectrumDataAddr (start address of output spectrum) and i_uSamplingPoints (number of sampling points).
213H	An FFT operation error occurred in the C intelligent function module.	Check if data available for FFT operation is stored in the input data.

2.4   M+model_DANLLeastSquare

Name

The module names of the FB are based on the module used and are as follows.

Target module	Name
RD55UP06-V	M+RD55UP06-V_DANLLeastSquare
RD55UP12-V	M+RD55UP12-V_DANLLeastSquare

Overview

To calculate a coefficient and a constant of a polynomial, and a multiple correlation coefficient using a least-squares method for the specified data.

```
                    M+RD55UP06-V_DANLLeastSquare
(1) ─   B    : i_bEN                    o_bENO :   B   ─ (10)
(2) ─  DUT   : i_stModule               o_bOK :    B   ─ (11)
(3) ─   UD   : i_udSize                 o_bErr :   B   ─ (12)
(4) ─   UD   : i_udInputDataXAddr       o_uErrId : UW   ─ (13)
(5) ─   UD   : i_udInputDataYAddr
(6) ─   UW   : i_uWaveDataType
(7) ─   UW   : i_uDegree
(8) ─   UD   : i_udOutAryAddr
(9) ─   UD   : i_udCoefficientAddr
```

Labels

Input label

No.	Label	Label name	Data type	Range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_stModule	Module label	Structures	The range varies depending on the module label.	Specify the module label of the C intelligent function module.
(3)	i_udSize	Number of data points	Double Word [unsigned]	3 to 500000	Specify the number of data points of X coordinate data and Y coordinate data to be calculated.
(4)	i_udInputDataXAddr	Start address of X coordinate data	Double Word [unsigned]	16384 to 2097151	Specify a start address of the buffer memory of a C intelligent function module where X coordinate data to be calculated is stored. • Data for the specified number of data points is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the wave data to be calculated in the buffer memory.

No.	Label	Label name	Data type	Range	Description
(5)	i_udInputDataYAddr	Start address of Y coordinate data	Double Word [unsigned]	16384 to 2097151	Specify a start address of the buffer memory of a C intelligent function module where Y coordinate data to be calculated is stored. • Data for the specified number of data points is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the wave data to be calculated in the buffer memory.
(6)	i_uWaveDataType	Wave data type selection	Word [unsigned]	0, 2	Specify a data type of the wave data to analyze. 0: Word [signed] 2: Single-precision real number
(7)	i_uDegree	Degree	Word [unsigned]	1 to 10	Specify a degree to be calculated.
(8)	i_udOutAryAddr	Start address of output array data	Double Word [unsigned]	16384 to 2097150	Specify a start address of the buffer memory of a C intelligent function module to store an operation result. • Data for the number of points specified for (i_uDegree (degree + 1)) is stored to the specified start address and its consecutive address in the buffer memory as an operation result. • The result is output as a single-precision real number.
(9)	i_udCoefficientAddr	Start address of multiple correlation coefficient output result storage destination	Double Word [unsigned]	16384 to 2097150	Specify a start address of the buffer memory of a C intelligent function module to store a multiple correlation coefficient. • An operation result is output as a single-precision real number. • Data for two words worth of data is stored to the specified start address and its consecutive address of the buffer memory as an operation result.

Output label

No.	Label	Label name	Data type	Default value	Description
(10)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is OFF.
(11)	o_bOK	Normal completion	Bit	OFF	The ON state indicates that a least-squares method operation is completed.
(12)	o_bErr	Error completion	Bit	OFF	The ON state indicates that an error has occurred in the FB.
(13)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error occurred in the FB is returned.

FB details

Available device

■ C intelligent function module

Target module	Firmware version	Engineering tool
RD55UP06-V	07 or later	GX Works3 of version 1.050C or later
RD55UP12-V	01 or later	GX Works3 of version 1.065T or later

■ CPU module

MELSEC iQ-R series programmable controller CPU

Point

For the CPU modules classified as programmable controller CPUs, refer to the MELSEC iQ-R Module Configuration Manual.

Basic specifications

Item	Description
Language	— (The internal program of this FB is not open to the public.)
Number of steps	100 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.
FB dependence	No dependence
FB compilation method	Macro type
FB operation	Pulse execution (multiple scan execution type)

Processing

- As i_bEN (execution command) turns ON, a coefficient and a constant of a polynomial, and a multiple correlation coefficient are calculated using a least-squares method for the number of data points specified to the i_udSize (number of data points) from the start address specified to i_udInputDataXAddr (start address of X coordinate data) and i_udInputDataYAddr (start address of Y coordinate data).
- Input data is read for the number of data points set to i_udSize (number of data points). Depending on the data type set for i_uWaveDataType (wave data type selection), the range of the buffer memory to be read varies.
  (☞ Page 33 Buffer memory points required for each wave data type)
- Operation results (coefficient and constant) are stored to the buffer memory address specified for i_udOutAryAddr (start address of output array data). For the buffer memory address specified to the i_udOutAryAddr (start address of output array data) and its consecutive address, reserve an area larger than or equal to the size specified to the degree + 1 because the number of units of data in the operation result will be the degree + 1. Additionally, the operation result is output as a single-precision real number.
- A multiple correlation coefficient is stored to the buffer memory specified for i_udCoefficientAddr (start address of multiple correlation coefficient output result storage destination) for two words worth of data as a single-precision real number.
- If an overflow occurs during operation, review the input data. A value stored at the occurrence of an overflow varies depending on each engineering tool. Check the specification of the engineering tool used.
- For an operation result, each coefficient is stored from the start in the order of {constant, first-order coefficient, second-order coefficient, third-order coefficient...} for the degree specified to the degree. (☞ Page 34 Example for storing results)
- A multiple correlation coefficient has the following characteristics:
  '$-1 \leq$ multiple correlation coefficient ≤ 1'
  Close to 1: Positive correlation (with a straight line having a positive slope)
  Close to 0: No correlation
  Close to -1: Negative correlation (with a straight line having a negative slope)
- Multiple scans are taken until the operation is completed; therefore, do not change the wave data before the completion of the process. When the process is completed, o_bOK (normal completion) turns ON.
- If an error occurs, o_bErr (error completion) turns ON and the processing of the FB is interrupted, and then an error code is stored to o_uErrId (error code). For error codes, refer to the error code list. (☞ Page 36 Error code)

■ Buffer memory points required for each wave data type

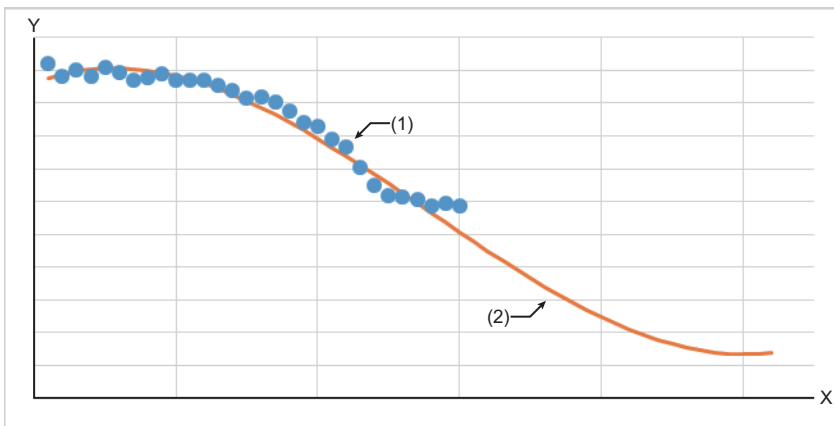| Type of input data	i_uWaveDataType (wave data type selection)	Required buffer memory points (word)
X coordinate data	0: Word [signed]	i_udSize (number of data points)
	2: Single-precision real number	i_udSize (number of data points) $\times$ 2
Y coordinate data	0: Word [signed]	i_udSize (number of data points)
	2: Single-precision real number	i_udSize (number of data points) $\times$ 2

■ Example for storing results

When '5' is specified for the degree, the number of data points stored to i_udOutAryAddr (start address of output array data) will be '6'. (Coefficients (a to e) and a constant (f) of a fifth-order polynomial are calculated.)

Prediction data Y to the X coordinate can be calculated by using the operation result obtained above (coefficients (a to e) and a constant (f) of a fifth-order polynomial) and by specifying an arbitrary value to 'X' in the polynomial 'Y = aX^5 + bX^4 + cX^3 + dX^2 + eX +f'.

When nth data of the i_udOutAryAddr (start address of output array data) is Output[n], the following data is stored to each array element.

Number of points	Data item	Corresponding coefficient
Output[0]	Constant	f
Output[1]	First-order coefficient	e
Output[2]	Second-order coefficient	d
Output[3]	Third-order coefficient	c
Output[4]	Fourth-order coefficient	b
Output[5]	Fifth-order coefficient	a

(1) Input data
(2) Prediction data Y

Timing chart of I/O signals

■ Normal completion

i_bEN	
o_bENO	
Operation processing	Not performed / Perform / Not performed
o_bOK	
o_bErr	OFF
o_uErrId	0

■ Error completion

i_bEN	
o_bENO	
Operation processing	Not performed
o_bOK	OFF
o_bErr	
o_uErrId	0 / Error code / 0

Restrictions or precautions

- This FB does not include the 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.
- If a program which is executed only once, such as a subroutine program or FOR-NEXT instruction, is used in this FB, the i_bEN (execution command) cannot be turned OFF, and as a result the program does not operate properly. This FB should be used in a program in which the i_bEN (execution command) can be turned OFF.
- Setting a circuit is required for all the input labels of this FB.
- i_bEN (execution command) should be turned OFF after o_bOK (normal completion) or o_bErr (error completion) is turned ON. Otherwise, o_bOK (normal completion) or o_bErr (error completion) turns OFF, and as a result o_uErrId (error code) will be cleared to '0'.
- This FB operates on a C intelligent function module which is specified for i_stModule (module label). Even when i_bEN (execution command) turns OFF during an operation, it continues on the module until the processing ends. When the i_stModule (module label) turns OFF during the operation and the operation is completed successfully, the result is output to the buffer memory of the C intelligent function module; however, it is not output to the output label of this FB.
- During the execution of this FB, neither a dedicated instruction nor an FB can be executed for the same C intelligent function module. The operation under the situation as previously noted is not guaranteed; therefore, arrange a program that executes a dedicated instruction or an FB after o_bOK (normal completion) or o_bErr (error completion) is turned ON.

parameter settings

No parameter settings are required for using this FB.

Error code

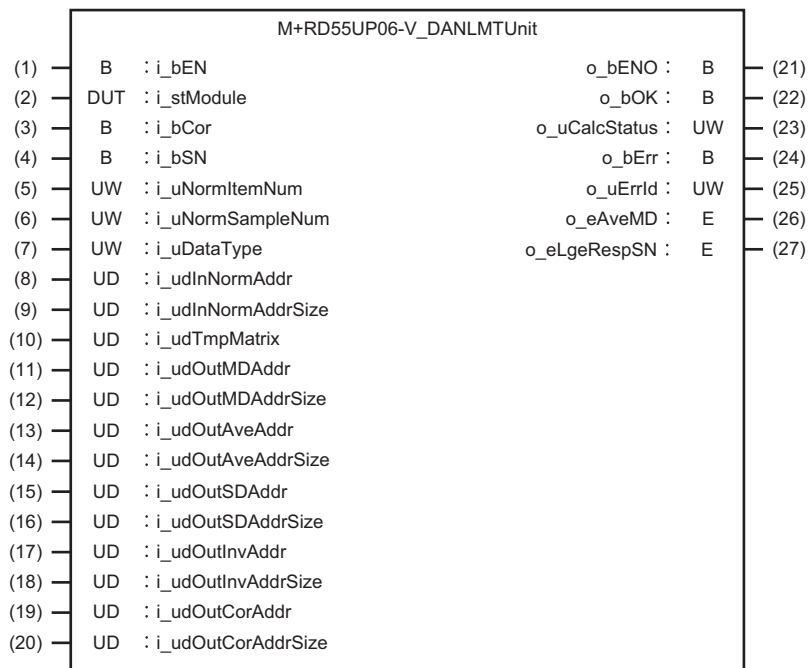| Error code	Description	Corrective action
103H	The value set for the i_uWaveDataType (wave data type selection) is out of the range. Set 0 or 2 for i_uWaveDataType (wave data type selection).	After checking the setting, execute the FB again.
105H	The value set for the i_udSize (number of data points) is out of the range. Set 3 to 500000 for i_udSize (number of data points). (Specify a value greater than or equal to the one specified to the i_uDegree (degree) + 2.)	After checking the setting, execute the FB again.
10EH	The value set for the i_uDegree (degree) is out of the range. Set 1 to 10 for i_uDegree (degree).	After checking the setting, execute the FB again.
125H	• The value set for the i_udInputDataXAddr (start address of X coordinate data) is out of the range. • The values set for the i_udInputDataXAddr (start address of X coordinate data) and i_udSize (number of data points) are out of the range.	• Set 16384 to 2097151 for i_udInputDataXAddr (start address of X coordinate data). • Check the values set for the i_udInputDataXAddr (start address of X coordinate data) and i_udSize (number of data points).
126H	• The value set for the i_udInputDataYAddr (start address of Y coordinate data) is out of the range. • The values set for the i_udInputDataYAddr (start address of Y coordinate data) and i_udSize (number of data points) are out of the range.	• Set 16384 to 2097151 for i_udInputDataYAddr (start address of Y coordinate data). • Check the values set for the i_udInputDataYAddr (start address of Y coordinate data) and i_udSize (number of data points).
140H	The value set for the i_udCoefficientAddr (start address of multiple correlation coefficient output result storage destination) is out of the range.	Set 16384 to 2097150 for i_udCoefficientAddr (start address of multiple correlation coefficient output result storage destination).
20DH	A least-squares method operation error occurred in the C intelligent function module.	Check that the variance (dispersion between input data) of the input data (X coordinate data or Y coordinate data) is not '0'. An overflow may have occurred during operation. Check the input data.
20EH	A memory reservation error occurred in the C intelligent function module.	Reduce the number of processings that run simultaneously in the C intelligent function module.
211H	• The value set for the i_udOutAryAddr (start address of output array data) is out of the range. • The values set for the i_udOutAryAddr (start address of output array data) and (i_uDegree (degree + 1)) are out of the range.	• Set 16384 to 2097150 for i_udOutAryAddr (start address of output array data). • Check the values set for the i_udOutAryAddr (start address of output array data) and (i_uDegree (degree + 1)).

2.5 M+model_DANLMTUnit

Name

The module names of the FB are based on the module used and are as follows.

Target module	Name
RD55UP06-V	M+RD55UP06-V_DANLMTUnit
RD55UP12-V	M+RD55UP12-V_DANLMTUnit

Overview

To determine a unit space that is used in the MT method based on the specified normal data.

```
                    M+RD55UP06-V_DANLMTUnit
(1) —  B   : i_bEN                      o_bENO ：  B   — (21)
(2) — DUT  : i_stModule                  o_bOK ：  B   — (22)
(3) —  B   : i_bCor              o_uCalcStatus ：  UW  — (23)
(4) —  B   : i_bSN                       o_bErr ：  B   — (24)
(5) — UW   : i_uNormItemNum             o_uErrId ：  UW  — (25)
(6) — UW   : i_uNormSampleNum           o_eAveMD ：  E   — (26)
(7) — UW   : i_uDataType             o_eLgeRespSN ：  E   — (27)
(8) — UD   : i_udInNormAddr
(9) — UD   : i_udInNormAddrSize
(10) — UD  : i_udTmpMatrix
(11) — UD  : i_udOutMDAddr
(12) — UD  : i_udOutMDAddrSize
(13) — UD  : i_udOutAveAddr
(14) — UD  : i_udOutAveAddrSize
(15) — UD  : i_udOutSDAddr
(16) — UD  : i_udOutSDAddrSize
(17) — UD  : i_udOutInvAddr
(18) — UD  : i_udOutInvAddrSize
(19) — UD  : i_udOutCorAddr
(20) — UD  : i_udOutCorAddrSize
```

Labels

Input label

No.	Label	Label name	Data type	Range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_stModule	Module label	Structures	The range varies depending on the module label.	Specify the module label of the C intelligent function module.
(3)	i_bCor	Correlation matrix of a unit space	Bit	ON, OFF	ON: Output the correlation matrix of a unit space OFF: Not to output the correlation matrix of a unit space.
(4)	i_bSN	SN ratio	Bit	ON, OFF	ON: Output the SN ratio (larger-is-better characteristic) of normal data MD. OFF: Not to output the SN ratio (larger-is-better characteristic) of normal data MD.
(5)	i_uNormItemNum	Number of normal data items	Word [unsigned]	2 to 300	Specify the number of normal data items.

No.	Label	Label name	Data type	Range	Description
(6)	i_uNormSampleNum	Number of normal data samples	Word [unsigned]	2 to 3000	Specify the number of normal data samples. Set a value greater than or equal to the one set for i_uNormItemNum (number of normal data items) and less than or equal to the one set for i_uNormSampleNum (number of normal data samples).
(7)	i_uDataType	Data type selection	Word [unsigned]	0 to 2	Specify a data type of normal data. 0: Word [signed] 1: Double Word [signed] 2: Single-precision real number
(8)	i_udInNormAddr	Start address of normal data storage destination	Double Word [unsigned]	16384 to 2096127	Specify a start address of the buffer memory of a C intelligent function module where normal data to be calculated is stored. • Data for the number of data items set for "i_uNormItemNum (number of normal data items)" × number of samples set for "i_uNormSampleNum (number of normal data samples)" is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the normal data to be calculated in the buffer memory. • Store a value with the same data type as the one selected in i_uDataType (data type selection).
(9)	i_udInNormAddrSize	Normal data storage destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uNormItemNum (number of normal data items)" × "i_uNormSampleNum (number of normal data samples)" × "Number of bytes required for the data type specified for i_uDataType (data type selection)"	Specify a size of the buffer memory of a C intelligent function module where normal data to be calculated is stored in byte. • Set a value greater than or equal to "i_uNormItemNum (number of normal data items)" × "i_uNormSampleNum (number of normal data samples)" × "number of bytes required for the data type specified for i_uDataType (data type selection)" as a buffer memory size.
(10)	i_udTmpMatrix	Start address of an area for matrix operation	Double Word [unsigned]	Specify '0'. No error occurs if a value other than '0' is specified.	It is not used in this FB. Specify a dummy device.
(11)	i_udOutMDAddr	Start address of normal data MD output destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory of a C intelligent function module to store an output result (Mahalanobis distance of normal data). • Data for the number of samples specified for "i_uNormSampleNum (number of normal data samples)" is stored to the specified start address and its consecutive address in the buffer memory as an operation result. • The Mahalanobis distance of normal data is output as a single-precision real number.

No.	Label	Label name	Data type	Range	Description
(12)	i_udOutMDAddrSize	Normal data MD output destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uNormSampleNum (number of normal data samples)" × "number of bytes required for single-precision real number"	Specify a size of the buffer memory to store a Mahalanobis distance of normal data in byte. • Set a value greater than or equal to "i_uNormSampleNum (number of normal data samples)" × "number of bytes required for single-precision real number" as a buffer memory size.
(13)	i_udOutAveAddr	Start address of average value output destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory of a C intelligent function module to store an output result (average value of items). • Data for the number of items specified for "i_uNormItemNum (number of normal data items)" is stored to the specified start address and its consecutive address in the buffer memory as an operation result. • The average value of items is output as a single-precision real number.
(14)	i_udOutAveAddrSize	Average value output destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uNormItemNum (number of normal data items)" × "number of bytes required for single-precision real number"	Specify a size of the buffer memory to store average values for each item in byte. • Set a value greater than or equal to "i_uNormItemNum (number of normal data items)" × "number of bytes required for single-precision real number" as a buffer memory size.
(15)	i_udOutSDAddr	Start address of standard deviation output destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory of a C intelligent function module to store an output result (standard deviation of items). • Data for the number of items specified for "i_uNormItemNum (number of normal data items)" is stored to the specified start address and its consecutive address in the buffer memory as an operation result. • The standard deviation of items is output as a single-precision real number.
(16)	i_udOutSDAddrSize	Standard deviation output destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uNormItemNum (number of normal data items)" × "number of bytes required for single-precision real number"	Specify a size of the buffer memory to store standard deviations for each item in byte. • Set a value greater than or equal to "i_uNormItemNum (number of normal data items)" × "number of bytes required for single-precision real number" as a buffer memory size.
(17)	i_udOutInvAddr	Start address of inverse matrix output destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory of a C intelligent function module to store an output result (inverse matrix of the correlation matrix of a unit space). • Data for the number of items specified for "i_uNormItemNum (number of normal data items)" × " i_uNormItemNum (number of normal data items)" is stored to the specified start address and its consecutive address in the buffer memory as an operation result. • The inverse matrix of the correlation matrix of a unit space is output as a single-precision real number.

No.	Label	Label name	Data type	Range	Description
(18)	i_udOutInvAddrSize	Inverse matrix output destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uNormItemNum (number of normal data items)" × "i_uNormItemNum (number of normal data items)" × "number of bytes required for single-precision real number"	Specify a size of the buffer memory to store the inverse matrix of the correlation matrix of a unit space in byte. • Set a value greater than or equal to "i_uNormItemNum (number of normal data items)" × " i_uNormItemNum (number of normal data items)" × "number of bytes required for single-precision real number" as a buffer memory size.
(19)	i_udOutCorAddr	Start address of correlation matrix output destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory of a C intelligent function module to store an output result. • The correlation matrix of a unit space is output while the i_bCor (correlation matrix of a unit space) is ON. No result is returned when it is OFF. • Data for the number of items specified for "i_uNormItemNum (number of normal data items)" × " i_uNormItemNum (number of normal data items)" is stored to the specified start address and its consecutive address in the buffer memory as an operation result. • The correlation matrix of a unit space is output as a single-precision real number.
(20)	i_udOutCorAddrSize	Correlation matrix output destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uNormItemNum (number of normal data items)" × "i_uNormItemNum (number of normal data items)" × "number of bytes required for single-precision real number"	Specify a size of the buffer memory to store the correlation matrix of a unit space in byte. • Set a value greater than or equal to "i_uNormItemNum (number of normal data items)" × " i_uNormItemNum (number of normal data items)" × "number of bytes required for single-precision real number" as a buffer memory size.

Output label

No.	Label	Label name	Data type	Default value	Description
(21)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is OFF.
(22)	o_bOK	Normal completion	Bit	OFF	The ON state indicates that the calculation of a Mahalanobis distance of normal data and SN ratio is completed.
(23)	o_uCalcStatus	Operation status	Word [unsigned]	0	'0' is output.
(24)	o_bErr	Error completion	Bit	OFF	The ON state indicates that an error has occurred in the FB.
(25)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error occurred in the FB is returned.
(26)	o_eAveMD	Average value of normal data MD	Single-precision real number	0	The average value of a Mahalanobis distance is returned.
(27)	o_eLgeRespSN	SN ratio (larger-is-better characteristic) of normal data MD	Single-precision real number	0	The SN ratio (larger-is-better characteristic) of Mahalanobis distance is returned while i_bSN (SN ratio) is ON. No result is returned when it is OFF.

FB details

Available device

■ C intelligent function module

Target module	Firmware version	Engineering tool
RD55UP06-V	07 or later	GX Works3 of version 1.050C or later
RD55UP12-V	01 or later	GX Works3 of version 1.065T or later

■ CPU module

MELSEC iQ-R series programmable controller CPU

Point

For the CPU modules classified as programmable controller CPUs, refer to the MELSEC iQ-R Module Configuration Manual.

Basic specifications

Item	Description
Language	— (The internal program of this FB is not open to the public.)
Number of steps	352 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.
FB dependence	No dependence
FB compilation method	Macro type
FB operation	Pulse execution (multiple scan execution type)

Processing

- As i_bEN (execution command) turns ON, a unit space[*1] that is used in the MT method is determined based on the normal data for the number of units of data specified to i_uNormItemNum (number of normal data items) × i_uNormSampleNum (number of normal data samples) from the start address specified to i_udInNormAddr (start address of normal data storage destination) and its consecutive address.

[*1] In a unit space, a correlation matrix and its inverse matrix, which are determined based on normal data, are included.

- Besides determination of a unit space, the following data can also be obtained with this FB.

  Average values for each item

  Standard deviations for each item

  Mahalanobis distances for each sample

  Average value of a Mahalanobis distance

  SN ratio (larger-is-better characteristic)

- Normal data is read from the buffer memory address specified for i_udInNormAddr (start address of normal data storage destination). For the buffer memory address specified for i_udInNormAddr (start address of normal data storage destination) and its consecutive address, data for the same number of units of data specified for i_uNormItemNum (number of normal data items) × i_uNormSampleNum (number of normal data samples) should be stored in advance.

Ex.

i_uNormSampleNum (number of normal data samples): 100 samples, i_uNormItemNum (number of normal data items): 10 items

(1)	1	2	3	~	10
1	Data[0]	Data[1]	Data[2]	~	Data[9]
2	Data[10]	Data[11]	Data[12]	~	Data[19]
~	~	~	~	~	~
100	Data[990]	Data[991]	Data[992]	~	Data[999]

Data[n]: nth data in the buffer memory address specified for i_udInNormAddr (start address of normal data storage destination) and its consecutive address.

(1) Number of data points

- Specify the data type of normal data for i_uDataType (data type selection).
- Normal data is read for the number of units of data specified for i_uNormItemNum (number of normal data items) × i_uNormSampleNum (number of normal data samples). Depending on the data type set for i_uDataType (data type selection), the range of buffer memory to be read varies.
  (☞ Page 44 Buffer memory points required for each data type)
- A calculation result is stored to the buffer memory as a single-precision real number. Additionally, an area for 'number of output points × 2' words is used in the buffer memory. For the number of output points for each result, refer to the following section. (☞ Page 44 Start addresses and number of output points for each calculation result)
- The calculation result of the average value of a Mahalanobis distance is stored to o_eAveMD (average value of normal data MD). If the value is not an approximate value of 1, a multiple collinearity error may occur.
- When i_bSN (SN ratio) is ON, the calculation result of the SN ratio (larger-is-better characteristic) is output to o_eLgeRespSN (SN ratio (larger-is-better characteristic) of normal data MD). The larger SN ratio (larger-is-better characteristic) corresponds to the better performance characteristic.
- Multiple scans are taken until a unit space determination is completed; therefore, do not change the normal data before the completion of the process. When the process is completed, o_bOK (normal completion) turns ON.

- If all the values of a specific item are the same, the standard deviation of the item will be '0' and therefore a Mahalanobis distance cannot be obtained. In that case, the processing will be terminated and an error will be returned.
- Before the execution of an operation, this FB checks input values so as not to cause an overflow during operation. If any of the input value is recognized as overflow, an error will occur in this FB.
  However, in the calculation of single-precision real numbers, an error may occur depending on the combination of input values even though the check has been conducted. A value stored at the occurrence of an overflow varies depending on each engineering tool. Check the specification of the engineering tool used.
- Multiple scans are taken until the operation is completed; therefore, do not change the normal data before the completion of the process. When the process is completed, o_bOK (normal completion) turns ON.
- If an error occurs, o_bErr (error completion) turns ON and the processing of the FB is interrupted, and then an error code is stored to o_uErrId (error code). For error codes, refer to the error code list. (☞ Page 47 Error code)

■ Buffer memory points required for each data type

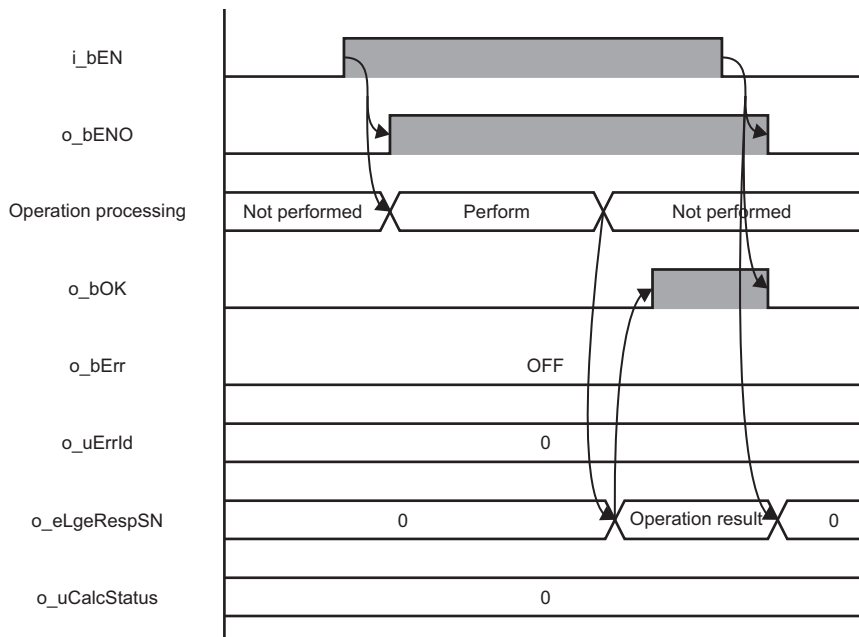| i_uDataType (data type selection)	Required buffer memory points (word)
0: Word [signed]	i_uNormItemNum (number of normal data items) × i_uNormSampleNum (number of normal data samples)
1: Double Word [signed]	i_uNormItemNum (number of normal data items) × i_uNormSampleNum (number of normal data samples) × 2
2: Single-precision real number	

■ Start addresses and number of output points for each calculation result

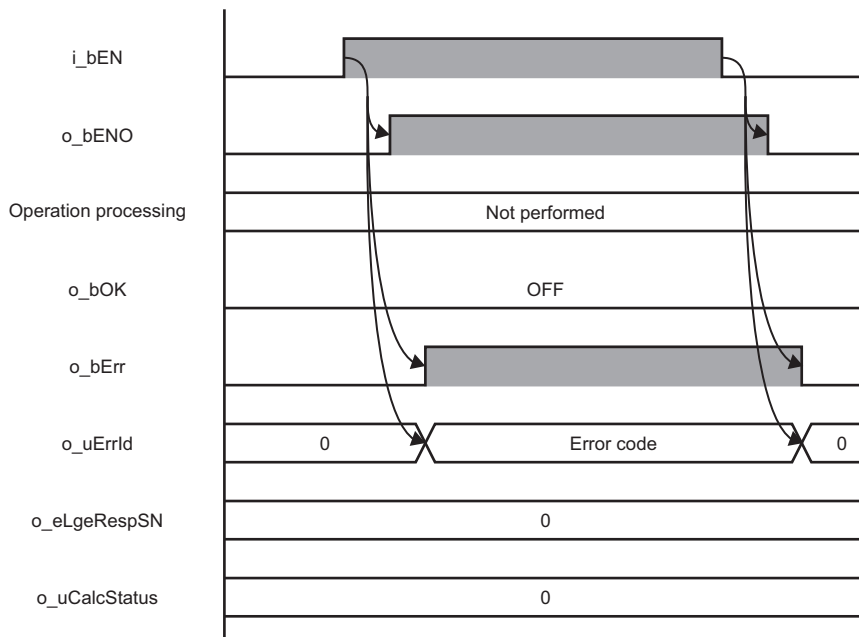| Type of calculation result	Start address	Number of output points
Mahalanobis distance of normal data	An address specified for i_udOutMDAddr (start address of normal data MD output destination).	The number of points specified for the i_uNormSampleNum (number of normal data samples)
Average value of items	An address specified for i_udOutAveAddr (start address of average value output destination).	The number of points specified for the i_uNormItemNum (number of normal data items)
Standard deviation of items	An address specified for i_udOutSDAddr (start address of standard deviation output destination).	
Inverse matrix of the correlation matrix of a unit space	An address specified for i_udOutInvAddr (start address of inverse matrix output destination).	Number of points specified for i_uNormItemNum (number of normal data items) × number of points specified for i_uNormItemNum (number of normal data items)
Correlation matrix of a unit space[1]	An address specified for i_udOutCorAddr (start address of correlation matrix output destination).	

[1] It is output while the i_bCor (correlation matrix of a unit space) is ON.

Timing chart of I/O signals

■ Normal completion

i_bEN	
o_bENO	
Operation processing	Not performed / Perform / Not performed
o_bOK	
o_bErr	OFF
o_uErrId	0
o_eLgeRespSN	0 / Operation result / 0
o_uCalcStatus	0

■ Error completion

i_bEN	
o_bENO	
Operation processing	Not performed
o_bOK	OFF
o_bErr	
o_uErrId	0 / Error code / 0
o_eLgeRespSN	0
o_uCalcStatus	0

Restrictions or precautions

- This FB does not include the error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- A long index register (LZ0) is used for this FB. When creating an interrupt program, do not use the index register.
- This FB cannot be used in an interrupt program.
- If a program which is executed only once, such as a subroutine program or FOR-NEXT instruction, is used in this FB, the i_bEN (execution command) cannot be turned OFF, and as a result the program does not operate properly. This FB should be used in a program in which the i_bEN (execution command) can be turned OFF.
- Setting a circuit is required for all the input labels of this FB.
- i_bEN (execution command) should be turned OFF after o_bOK (normal completion) or o_bErr (error completion) is turned ON. Otherwise, o_bOK (normal completion) or o_bErr (error completion) turns OFF, and as a result o_uErrId (error code) will be cleared to '0'.
- When a unit space is determined successfully based on sufficient number of samples without having a multicollinearity error, the value of o_eAveMD (average value of normal data MD) will be '1'. If a Mahalanobis distance of signal data is calculated using an output result (inverse matrix of correlation matrix) other than '1', an accurate result may not be obtained.
- During the execution of this FB, buffer memory addresses from 2096128 to 2097151 are not available.
- This FB operates on a C intelligent function module which is specified for i_stModule (module label). Even when i_bEN (execution command) turns OFF during an operation, it continues on the module until the processing ends. When the i_stModule (module label) turns OFF during the operation and the operation is completed successfully, the result is output to the buffer memory of the C intelligent function module; however, it is not output to the output label of this FB.
- The input and output data type of a data analysis library that is executed by this FB is single-precision real number; therefore, specifying double-word type for i_uDataType (data type selection) may lead to a loss of trailing digits.
- When the total size of input data and output data exceeds the buffer memory size (2079743 word), set the start address of input data storage destination and start address of output data storage destination so as to intentionally overlap each other.
- During the execution of this FB, neither a dedicated instruction nor an FB can be executed for the same C intelligent function module. The operation under the situation as previously noted is not guaranteed; therefore, arrange a program that executes a dedicated instruction or an FB after o_bOK (normal completion) or o_bErr (error completion) is turned ON.

parameter settings

No parameter settings are required for using this FB.

Error code

Error code	Description	Corrective action
103H	The value set for the i_uDataType (data type selection) is out of the range.	Set 0 to 2 for i_uDataType (data type selection). After changing the setting, execute the FB again.
11EH	The value set for the i_uNormItemNum (number of normal data items) is out of the range.	Set 2 to 300 for i_uNormItemNum (number of normal data items). After changing the setting, execute the FB again.
11FH	The value set for the i_uNormSampleNum (number of normal data samples) is out of the range.	Set 2 to 3000 for i_uNormSampleNum (number of normal data samples). After changing the setting, execute the FB again.
127H	• The value set for the i_udOutMDAddr (start address of normal data MD output destination) is out of the range. • The values set for the i_udOutMDAddr (start address of normal data MD output destination) and i_udOutMDAddrSize (normal data MD output destination size) are out of the range.	• Set 16384 to 2096126 for i_udOutMDAddr (start address of normal data MD output destination). • Check the values set for the i_udOutMDAddr (start address of normal data MD output destination) and i_udOutMDAddrSize (normal data MD output destination size).
128H	• The value set for the i_udOutAveAddr (start address of average value output destination) is out of the range. • The values set for the i_udOutAveAddr (start address of average value output destination) and i_udOutAveAddrSize (average value output destination size) are out of the range.	• Set 16384 to 2096126 for i_udOutAveAddr (start address of average value output destination). • Check the values set for the i_udOutAveAddrv (start address of average value output destination) and i_udOutAveAddrSize (average value output destination size).
129H	• The value set for the i_udOutSDAddr (start address of standard deviation output destination) is out of the range. • The values set for the i_udOutSDAddr (start address of standard deviation output destination) and i_udOutSDAddrSize (standard deviation output destination size) are out of the range.	• Set 16384 to 2096126 for i_udOutSDAddr (start address of standard deviation output destination). • Check the values set for the i_udOutSDAddr (start address of standard deviation output destination) and i_udOutSDAddrSize (standard deviation output destination size).
12AH	• The value set for the i_udOutInvAddr (start address of inverse matrix output destination) is out of the range. • The value set for the i_udOutInvAddr (start address of inverse matrix output destination) and the square of the value set for the i_udOutInvAddrSize (inverse matrix output destination size) are out of the range.	• Set 16384 to 2096126 for i_udOutInvAddr (start address of inverse matrix output destination). • Check the value set for the i_udOutInvAddr (start address of inverse matrix output destination) and the square of the value set for the i_udOutInvAddrSize (inverse matrix output destination size).
12BH	• The value set for the i_udOutCorAddr (start address of correlation matrix output destination) is out of the range. • The values set for the i_udOutCorAddr (start address of correlation matrix output destination) and i_udOutCorAddrSize (correlation matrix output destination size) are out of the range.	• Set 16384 to 2096126 for i_udOutCorAddr (start address of correlation matrix output destination). • Check the values set for the i_udOutCorAddr (start address of correlation matrix output destination) and i_udOutCorAddrSize (correlation matrix output destination size).
13AH	The value set for the i_udInNormAddrSize (normal data storage destination size) is out of the range.	For i_udInNormAddrSize (normal data storage destination size), specify a value greater than or equal to the one set for i_uNormItemNum (number of normal data items) × i_uNormSampleNum (number of normal data samples) × number of bytes required for the data type specified for i_uDataType (data type selection).
13BH	The value set for the i_udOutMDAddrSize (normal data MD output destination size) is out of the range.	For i_udOutMDAddrSize (normal data MD output destination size), specify a value greater than or equal to the one set for i_uNormSampleNum (number of normal data samples) × number of bytes required for single-precision real number.
13CH	The value set for the i_udOutAveAddrSize (average value output destination size) is out of the range.	For i_udOutAveAddrSize (average value output destination size), specify a value greater than or equal to the one set for i_uNormItemNum (number of normal data items) × number of bytes required for single-precision real number.
13DH	The value set for the i_udOutSDAddrSize (standard deviation output destination size) is out of the range.	For i_udOutSDAddrSize (standard deviation output destination size), specify a value greater than or equal to the one set for i_uNormItemNum (number of normal data items) × number of bytes required for single-precision real number.
13EH	The value set for the i_udOutInvAddrSize (inverse matrix output destination size) is out of the range.	For i_udOutInvAddrSize (inverse matrix output destination size), specify a value greater than or equal to the one set for i_uNormItemNum (number of normal data items) × i_uNormItemNum (number of normal data items) × number of bytes required for single-precision real number.

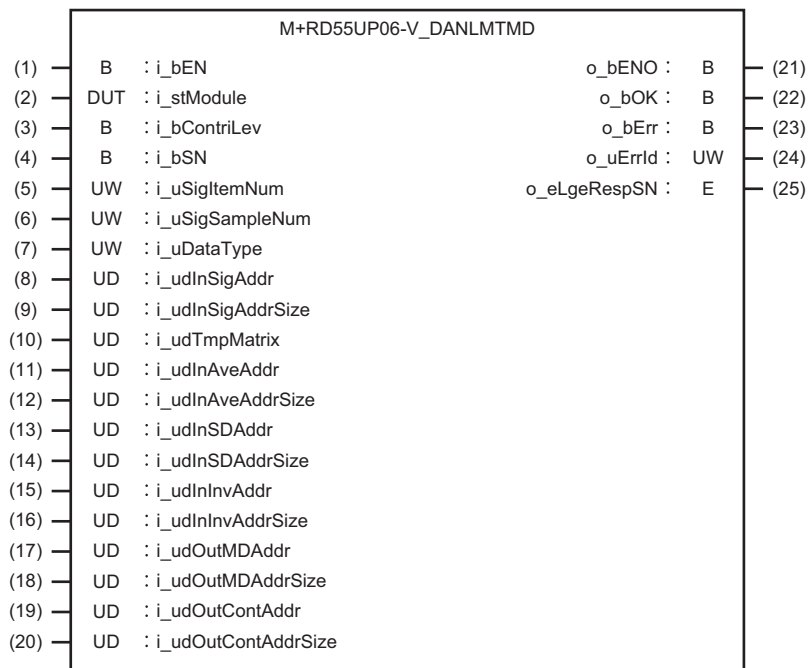| Error code	Description	Corrective action
13FH	The value set for the i_udOutCorAddrSize (correlation matrix output destination size) is out of the range.	For i_udOutCorAddrSize (correlation matrix output destination size), specify a value greater than or equal to the one set for i_uNormItemNum (number of normal data items) × i_uNormItemNum (number of normal data items) × number of bytes required for single-precision real number.
141H	• The value set for the i_udInNormAddr (start address of normal data storage destination) is out of the range. • The values set for the i_udInNormAddr (start address of normal data storage destination) and i_udInNormAddrSize (normal data storage destination size) are out of the range.	• Set 16384 to 2096127 for i_udInNormAddr (start address of normal data storage destination). • Check the values set for the i_udInNormAddr (start address of normal data storage destination) and i_udInNormAddrSize (normal data storage destination size).
203H	An arithmetic overflow occurred in the FB.	After checking the input data, execute the FB again.
20AH	The value set for i_uNormSampleNum (number of normal data samples) is less than the one set for i_uNormItemNum (number of normal data items).	Set a value less than or equal to the one set for i_uNormSampleNum (number of normal data samples) and greater than or equal to the one set for i_uNormItemNum (number of normal data items). After changing the setting, execute the FB again.
20BH	Unable to calculate due to a multicollinearity error.	Delete the data which are strongly correlated each other. After deleting the data, execute the FB again.
20EH	A memory reservation error occurred in the C intelligent function module.	Reduce the number of processings that run simultaneously in the C intelligent function module.
1000H+nH	Unable to calculate because standard deviation of item n is 0. (n = 1, 2, 3, ...)	All contents of item n are the same value. Delete the contents of item n, review the data, then execute the FB again.

2.6   M+model_DANLMTMD

Name

The module names of the FB are based on the module used and are as follows.

Target module	Name
RD55UP06-V	M+RD55UP06-V_DANLMTMD
RD55UP12-V	M+RD55UP12-V_DANLMTMD

Overview

To calculate a Mahalanobis distance of the specified signal data.

```
                    M+RD55UP06-V_DANLMTMD
(1) —    B    : i_bEN                        o_bENO ：   B   — (21)
(2) — DUT    : i_stModule                    o_bOK ：    B   — (22)
(3) —    B    : i_bContriLev                 o_bErr ：    B   — (23)
(4) —    B    : i_bSN                        o_uErrId ：  UW  — (24)
(5) —   UW   : i_uSigItemNum            o_eLgeRespSN ：  E   — (25)
(6) —   UW   : i_uSigSampleNum
(7) —   UW   : i_uDataType
(8) —   UD   : i_udInSigAddr
(9) —   UD   : i_udInSigAddrSize
(10) —  UD   : i_udTmpMatrix
(11) —  UD   : i_udInAveAddr
(12) —  UD   : i_udInAveAddrSize
(13) —  UD   : i_udInSDAddr
(14) —  UD   : i_udInSDAddrSize
(15) —  UD   : i_udInInvAddr
(16) —  UD   : i_udInInvAddrSize
(17) —  UD   : i_udOutMDAddr
(18) —  UD   : i_udOutMDAddrSize
(19) —  UD   : i_udOutContAddr
(20) —  UD   : i_udOutContAddrSize
```

Labels

Input label

No.	Label	Label name	Data type	Range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_stModule	Module label	Structures	The range varies depending on the module label.	Specify the module label of the C intelligent function module.
(3)	i_bContriLev	Contribution level	Bit	ON, OFF	ON: Output a contribution level. OFF: Not to output a contribution level.
(4)	i_bSN	SN ratio	Bit	ON, OFF	ON: Output the SN ratio (larger-is-better characteristic) of signal data MD. OFF: Not to output the SN ratio (larger-is-better characteristic) of signal data MD.
(5)	i_uSigItemNum	Number of signal data items	Word [unsigned]	2 to 300	Specify the number of signal data items. Set the same value as the one set for i_uNormItemNum (number of normal data items) in M+model_DANLMTUnit.
(6)	i_uSigSampleNum	Number of signal data samples	Word [unsigned]	1 to 3000	Specify the number of signal data samples.

No.	Label	Label name	Data type	Range	Description
(7)	i_uDataType	Data type selection	Word [unsigned]	0 to 2	Specify a data type of signal data. 0: Word [signed] 1: Double Word [signed] 2: Single-precision real number
(8)	i_udInSigAddr	Start address of signal data storage destination	Double Word [unsigned]	16384 to 2096127	Specify a start address of the buffer memory of a C intelligent function module where signal data is stored. • Data for the number of units of data specified for "i_uSigItemNum (number of signal data items)" × "i_uSigSampleNum (number of signal data samples)" is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the signal data to be calculated in the buffer memory. • Store a value with the same data type as the one selected in i_uDataType (data type selection).
(9)	i_udInSigAddrSize	Signal data storage destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uSigItemNum (number of signal data items)" × "i_uSigSampleNum (number of signal data samples)" × "Number of bytes required for the data type specified for i_uDataType (data type selection)"	Specify a size of the buffer memory of a C intelligent function module where signal data to be calculated is stored in byte. • Set a value greater than or equal to "i_uSigItemNum (number of signal data items)" × " i_uSigSampleNum (number of signal data samples)" × "number of bytes required for the data type specified for i_uDataType (data type selection)" as a buffer memory size.
(10)	i_udTmpMatrix	Start address of an area for matrix operation	Double Word [unsigned]	Specify '0'. No error occurs if a value other than '0' is specified.	It is not used in this FB. Specify a dummy device.
(11)	i_udInAveAddr	Start address of average value storage destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory of a C intelligent function module where the average value of normal data is stored. • Data for the number of items specified for "i_uSigItemNum (number of signal data items)" is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the average value of items calculated by M+model-V_DANLMTUnit to the buffer memory.
(12)	i_udInAveAddrSize	Average value storage destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uSigItemNum (number of signal data items)" × "number of bytes required for single-precision real number"	Specify the size of the buffer memory where the average value of normal data is stored in byte. • Set a value greater than or equal to "i_uSigItemNum (number of signal data items)" × "number of bytes required for single-precision real number" as a buffer memory size.

No.	Label	Label name	Data type	Range	Description
(13)	i_udInSDAddr	Start address of standard deviation storage destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory of a C intelligent function module where the standard deviation of normal data is stored. • Data for the number of items specified for "i_uSigItemNum (number of signal data items)" is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the value of a standard deviation calculated by M+model_DANLMTUnit.
(14)	i_udInSDAddrSize	Standard deviation storage destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uSigItemNum (number of signal data items)" × "number of bytes required for single-precision real number"	Specify the size of the buffer memory where the standard deviation of normal data is stored in byte. • Set a value greater than or equal to "i_uSigItemNum (number of signal data items)" × "number of bytes required for single-precision real number" as a buffer memory size.
(15)	i_udInInvAddr	Start address of inverse matrix storage destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory of a C intelligent function module where the inverse matrix of the correlation matrix of a unit space is stored. • Data for the number of items specified for "i_uSigItemNum (number of signal data items)" × "i_uSigItemNum (number of signal data items)" is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store a value of the inverse matrix calculated by M+model_DANLMTUnit.
(16)	i_udInInvAddrSize	Inverse matrix storage destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uSigItemNum (number of signal data items)" × "i_uSigItemNum (number of signal data items)" × "number of bytes required for single-precision real number"	Specify the size of the buffer memory where the inverse matrix of the correlation matrix of a unit space is stored in byte. • Set a value greater than or equal to "i_uSigItemNum (number of signal data items)" × "i_uSigItemNum (number of signal data items)" × "number of bytes required for single-precision real number" as a buffer memory size.
(17)	i_udOutMDAddr	Start address of signal data MD output destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory of a C intelligent function module to store an output result (Mahalanobis distance of signal data). • Data for the number of samples specified for "i_uSigSampleNum (number of signal data samples)" is stored to the specified start address and its consecutive address in the buffer memory as an operation result. • The Mahalanobis distance of signal data is output as a single-precision real number.

No.	Label	Label name	Data type	Range	Description
(18)	i_udOutMDAddrSize	Signal data MD output destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uSigSampleNum (number of signal data samples)" × "number of bytes required for single-precision real number"	Specify a size of the buffer memory to store a Mahalanobis distance of signal data in byte. • Set a value greater than or equal to "i_uSigSampleNum (number of signal data samples)" × "number of bytes required for single-precision real number" as a buffer memory size.
(19)	i_udOutContAddr	Start address of contribution level output destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory of a C intelligent function module to store an output result (contribution level). • Data for the number of units of data specified for "i_uSigItemNum (number of signal data items)" × "i_uSigSampleNum (number of signal data samples)" is stored to the specified start address and its consecutive address in the buffer memory as an operation result. • A contribution level is output as a single-precision real number.
(20)	i_udOutContAddrSize	Contribution level output destination size (byte)	Double Word [unsigned]	A value greater than or equal to "i_uSigItemNum (number of signal data items)" × "i_uSigSampleNum (number of signal data samples)" × "number of bytes required for single-precision real number"	Specify a size of the buffer memory to store a contribution level in byte. • Set a value greater than or equal to "i_uSigItemNum (number of signal data items)" × " i_uSigSampleNum (number of signal data samples)" × "number of bytes required for single-precision real number" as a buffer memory size.

Output label

No.	Label	Label name	Data type	Default value	Description
(21)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is OFF.
(22)	o_bOK	Normal completion	Bit	OFF	The ON state indicates that the calculation of a Mahalanobis distance of signal data and SN ratio is completed.
(23)	o_bErr	Error completion	Bit	OFF	The ON state indicates that an error has occurred in the FB.
(24)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error occurred in the FB is returned.
(25)	o_eLgeRespSN	SN ratio (larger-is-better characteristic) of signal data MD	Single-precision real number	0.0	The SN ratio (larger-is-better characteristic) of Mahalanobis distance is returned while i_bSN (SN ratio) is ON. No result is returned when it is OFF.

FB details

Available device

■ C intelligent function module

Target module	Firmware version	Engineering tool
RD55UP06-V	07 or later	GX Works3 of version 1.050C or later
RD55UP12-V	01 or later	GX Works3 of version 1.065T or later

■ CPU module

MELSEC iQ-R series programmable controller CPU

> **Point**
>
> For the CPU modules classified as programmable controller CPUs, refer to the MELSEC iQ-R Module Configuration Manual.

Basic specifications

Item	Description
Language	— (The internal program of this FB is not open to the public.)
Number of steps	331 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.
FB dependence	No dependence
FB compilation method	Macro type
FB operation	Pulse execution (multiple scan execution type)

Processing

- As i_bEN (execution command) turns ON, Mahalanobis distances for each sample are calculated for the number of units of signal data[*1] specified to i_uSigItemNum (number of signal data items) × i_uSigSampleNum (number of signal data samples) from the stat address specified to i_udInSigAddr (start address of signal data storage destination) and its consecutive address.

*1 Signal data indicates data that determines error level. The distance between the data and the unit space is calculated as a Mahalanobis distance.

- Besides calculation of a Mahalanobis distance, the following data can also be obtained with this FB.
  Contribution levels for each item
  SN ratio (larger-is-better characteristic)
- By comparing contribution levels of each item, an error cause can be assumed.
- When i_bSN (SN ratio) is ON, the calculation result of the SN ratio (larger-is-better characteristic) is output to o_eLgeRespSN (SN ratio (larger-is-better characteristic) of signal data MD). The larger SN ratio (larger-is-better characteristic) corresponds to the better performance characteristic.
- Input data for calculating a Mahalanobis distance is read from the buffer memory address specified for i_udInSigAddr (start address of signal data storage destination). For the buffer memory address specified for i_udInSigAddr (start address of signal data storage destination) and its consecutive address, the data for the same number of units of data specified for i_uSigItemNum (number of signal data items) × i_uSigSampleNum (number of signal data samples) should be stored in advance.

Ex.

i_uSigSampleNum (number of signal data samples): 100 samples, i_uSigItemNum (number of signal data items): 10 items

	i_uSigItemNum				
(1)	1	2	3	~	10
1	Data[0]	Data[1]	Data[2]	~	Data[9]
2	Data[10]	Data[11]	Data[12]	~	Data[19]
~	~	~	~	~	~
100	Data[990]	Data[991]	Data[992]	~	Data[999]

Data[n]: nth data in the buffer memory address specified for i_udInSigAddr (start address of signal data storage destination) and its consecutive address.
(1) Number of data points

- Specify a data type of the signal data for i_uDataType (data type selection).
- Signal data is read for the number of units of data specified for i_uSigItemNum (number of signal data items) × i_uSigSampleNum (number of signal data samples). Depending on the data type set for i_uDataType (data type selection), the range of buffer memory to be read varies.
  (☞ Page 56 Buffer memory points required for each data type)
- Apply an average value, a standard deviation, and an inverse matrix calculated by M+model_DANLMTUnit.
- A calculation result is stored to the buffer memory as a single-precision real number. Additionally, an area for 'number of output points × 2' words is used in the buffer memory. For the number of output points for each result, refer to the following section. (☞ Page 56 Start addresses and number of output points for each calculation result)
- Multiple scans are taken until the calculation of a Mahalanobis distance is completed; therefore, do not change the signal data before the completion of the process. When the process is completed, o_bOK (normal completion) turns ON.
- When the values in the inverse matrix of the correlation matrix of a unit space are all '0', an error occurs in this FB.
- If '0' is included in the standard deviation of items, an error will occur in this FB.

- Before the execution of an operation, this FB checks input values so as not to cause an overflow during operation. If any of the input value is recognized as overflow, an error will occur in this FB.
However, in the calculation of single-precision real numbers, an error may occur depending on the combination of input values even though the check has been conducted. A value stored at the occurrence of an overflow varies depending on each engineering tool. Check the specification of the engineering tool used.
- Multiple scans are taken until the operation is completed; therefore, do not change the signal data before the completion of the process. When the process is completed, o_bOK (normal completion) turns ON.
- If an error occurs, o_bErr (error completion) turns ON and the processing of the FB is interrupted, and then an error code is stored to o_uErrId (error code). For error codes, refer to the error code list. (☞ Page 59 Error code)

■ Buffer memory points required for each data type

i_uDataType (data type selection)	Required buffer memory points (word)
0: Word [signed]	i_uSigItemNum (number of signal data samples) × i_uSigSampleNum (number of signal data samples)
1: Double Word [signed]	i_uSigItemNum (number of signal data items) × i_uSigSampleNum (number of signal data samples) × 2
2: Single-precision real number	

■ Start addresses and number of output points for each calculation result

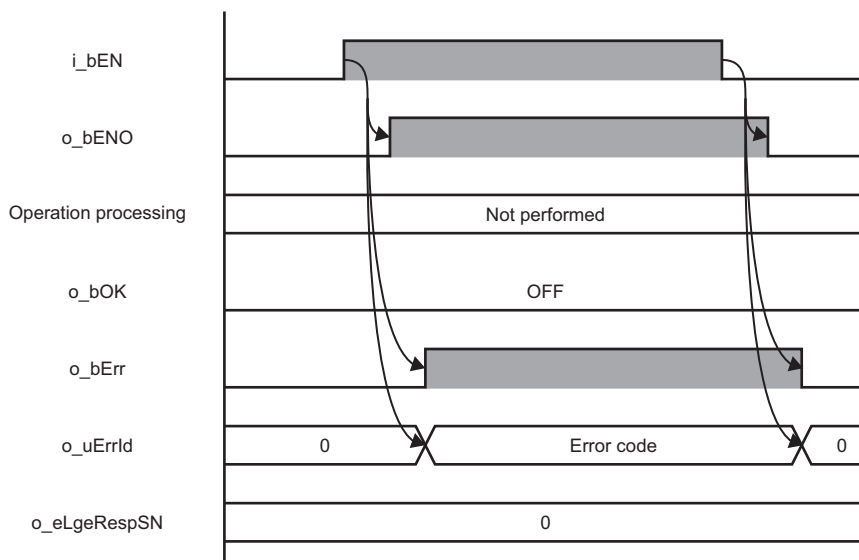| Type of calculation result	Start address	Number of output points
Mahalanobis distance of signal data	An address specified for i_udOutMDAddr (start address of signal data MD output destination).	The number of points specified for the i_uSigSampleNum (number of signal data samples)
Contribution level[1]	An address specified for i_udOutContAddr (start address of contribution level output destination).	The number of points specified to i_uSigItemNum (number of signal data items) × the number of points specified to i_uSigSampleNum (number of signal data samples)

*1   It is output while the i_bContriLev (contribution level) is ON.

Timing chart of I/O signals

■ Normal completion

■ Error completion

Restrictions or precautions

- This FB does not include the error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- A long index register (LZ0) is used for this FB. When creating an interrupt program, do not use the index register.
- This FB cannot be used in an interrupt program.
- If a program which is executed only once, such as a subroutine program or FOR-NEXT instruction, is used in this FB, the i_bEN (execution command) cannot be turned OFF, and as a result the program does not operate properly. This FB should be used in a program in which the i_bEN (execution command) can be turned OFF.
- Setting a circuit is required for all the input labels of this FB.
- i_bEN (execution command) should be turned OFF after o_bOK (normal completion) or o_bErr (error completion) is turned ON. Otherwise, o_bOK (normal completion) or o_bErr (error completion) turns OFF, and as a result o_uErrId (error code) will be cleared to '0'.
- During the execution of this FB, buffer memory addresses from 2096128 to 2097151 are not available.
- This FB operates on a C intelligent function module which is specified for i_stModule (module label). Even when i_bEN (execution command) turns OFF during an operation, it continues on the module until the processing ends. When the i_stModule (module label) turns OFF during the operation and the operation is completed successfully, the result is output to the buffer memory of the C intelligent function module; however, it is not output to the output label of this FB.
- The input and output data type of a data analysis library that is executed by this FB is single-precision real number; therefore, specifying double-word type for i_uDataType (data type selection) may lead to a loss of trailing digits.
- When the total size of input data and output data exceeds the buffer memory size (2079743 word), set the start address of input data storage destination and start address of output data storage destination so as to intentionally overlap each other.
- During the execution of this FB, neither a dedicated instruction nor an FB can be executed for the same C intelligent function module. The operation under the situation as previously noted is not guaranteed; therefore, arrange a program that executes a dedicated instruction or an FB after o_bOK (normal completion) or o_bErr (error completion) is turned ON.

parameter settings

No parameter settings are required for using this FB.

Error code

Error code	Description	Corrective action
103H	The value set for the i_uDataType (data type selection) is out of the range.	Set 0 to 2 for i_uDataType (data type selection). After checking the setting, execute the FB again.
11EH	The value set for the i_uSigItemNum (number of signal data items) is out of the range.	Specify 2 to 300 for i_uSigItemNum (number of signal data items). After changing the setting, execute the FB again.
11FH	The value set for the i_uSigSampleNum (number of signal data samples) is out of the range.	Specify 1 to 3000 for i_uSigSampleNum (number of signal data samples). After changing the setting, execute the FB again.
12CH	• The value set for the i_udOutContAddr (start address of contribution level output destination) is out of the range. • The values set for the i_udOutContAddr (start address of contribution level output destination) and i_udOutContAddrSize (contribution level output destination size) are out of the range.	• Set 16384 to 2096126 for i_udOutContAddr (start address of contribution level output destination). • Check the values set for the i_udOutContAddr (start address of contribution level output destination) and i_udOutContAddrSize (contribution level output destination size).
133H	• The value set for the i_udInSigAddr (start address of signal data storage destination) is out of the range. • The values set for the i_udInSigAddr (start address of signal data storage destination) and i_udInSigAddrSize (signal data storage destination size) are out of the range.	• Set 16384 to 2096127 for i_udInSigAddr (start address of signal data storage destination). • Check the values set for the i_udInSigAddr (start address of signal data storage destination) and i_udInSigAddrSize (signal data storage destination size).
134H	The value set for the i_udInSigAddrSize (signal data storage destination size) is out of the range.	For i_udInSigAddrSize (signal data storage destination size), specify a value greater than or equal to the one set for i_uSigItemNum (number of signal data items) × i_uSigSampleNum (number of signal data samples) × number of bytes required for the data type specified for i_uDataType (data type selection).
135H	The value set for the i_udInAveAddrSize (average value storage destination size) is out of the range.	For i_udInAveAddrSize (average value storage destination size), specify a value greater than or equal to i_uSigItemNum (number of signal data items) × number of bytes required for single-precision real number.
136H	The value set for the i_udInSDAddrSize (standard deviation storage destination size) is out of the range.	For i_udInSDAddrSize (standard deviation storage destination size), specify a value greater than or equal to i_uSigItemNum (number of signal data items) × number of bytes required for single-precision real number.
137H	The value set for the i_udInInvAddrSize (inverse matrix storage destination size) is out of the range.	For i_udInInvAddrSize (inverse matrix storage destination size), specify a value greater than or equal to i_uSigItemNum (number of signal data items) × i_uSigItemNum (number of signal data items) × number of bytes required for single-precision real number.
138H	The value set for the i_udOutMDAddrSize (signal data MD output destination size) is out of the range.	For i_udOutMDAddrSize (signal data MD output destination size), specify a value greater than or equal to i_uSigSampleNum (number of signal data samples) × number of bytes required for single-precision real number.
139H	The value set for the i_udOutContAddrSize (contribution level output destination size) is out of the range.	For i_udOutContAddrSize (contribution level output destination size), specify a value greater than or equal to i_uSigItemNum (number of signal data items) × i_uSigSampleNum (number of signal data samples) × number of bytes required for single-precision real number.
143H	• The value set for the i_udInAveAddr (start address of average value storage destination) is out of the range. • The values set for the i_udInAveAddr (start address of average value storage destination) and i_udInAveAddrSize (average value storage destination size) are out of the range.	• Set 16384 to 2096126 for i_udInAveAddr (start address of average value storage destination). • Check the values set for the i_udInAveAddr (start address of average value storage destination) and i_udInAveAddrSize (average value storage destination size).
144H	• The value set for the i_udInSDAddr (start address of standard deviation storage destination) is out of the range. • The values set for the i_udInSDAddr (start address of standard deviation storage destination) and i_udInSDAddrSize (standard deviation storage destination size) are out of the range.	• Set 16384 to 2096126 for i_udInSDAddr (start address of standard deviation storage destination). • Check the values set for the i_udInSDAddr (start address of standard deviation storage destination) and i_udInSDAddrSize (standard deviation storage destination size).
145H	• The value set for the i_udInInvAddr (start address of inverse matrix storage destination) is out of the range. • The values set for the i_udInInvAddr (start address of inverse matrix storage destination) and i_udInInvAddrSize (inverse matrix storage destination size) are out of the range.	• Set 16384 to 2096126 for i_udInInvAddr (start address of inverse matrix storage destination). • Check the values set for the i_udInInvAddr (start address of inverse matrix storage destination) and i_udInInvAddrSize (inverse matrix storage destination size).

Error code	Description	Corrective action
146H	• The value set for the i_udOutMDAddr (start address of signal data MD output destination) is out of the range. • The values set for the i_udOutMDAddr (start address of signal data MD output destination) and i_udOutMDAddrSize (signal data MD output destination size) are out of the range.	• Set 16384 to 2096126 for i_udOutMDAddr (start address of signal data MD output destination). • Check the value set for the i_udOutMDAddr (start address of signal data MD output destination) and i_udOutMDAddrSize (signal data MD output destination size).
203H	An arithmetic overflow occurred in the FB.	After checking the input data, execute the FB again.
20CH	The values in the inverse matrix of the correlation matrix of a unit space are all '0'.	Check the inverse matrix of the correlation matrix of a unit space specified to the i_udInInvAddr (start address of inverse matrix storage destination). After checking the data, execute the FB again.
20EH	A memory reservation error occurred in the C intelligent function module.	Reduce the number of processings that run simultaneously in the C intelligent function module.
2000H+nH	Unable to calculate because the standard deviation of the signal data of item n is '0'. (n = 1, 2, 3, ...)	Check the standard deviation of the signal data of item n. After checking the data, execute the FB again.

2.7 M+model_DANLMultiRegression

Name

The module names of the FB are based on the module used and are as follows.

Target module	Name
RD55UP06-V	M+RD55UP06-V_DANLMultiRegression
RD55UP12-V	M+RD55UP12-V_DANLMultiRegression

Overview

To calculate a coefficient, constant, and regression statistics for multiple regression analysis.

```
                    M+RD55UP06-V_DANLMultiRegression
(1)  —  B    : i_bEN                        o_bENO :    B  — (16)
(2)  — DUT   : i_stModule                    o_bOK :    B  — (17)
(3)  — UD    : i_udInputDataXAddr            o_bErr :    B  — (18)
(4)  — UD    : i_udInputDataXAddrSize      o_uErrId :   UW  — (19)
(5)  — UD    : i_udInputDataYAddr         o_eBConst :    E  — (20)
(6)  — UD    : i_udInputDataYAddrSize     o_eBStdErr :   E  — (21)
(7)  — UW    : i_uDataType              o_eDetermCoef :  E  — (22)
(8)  — UD    : i_udSize                 o_eYEstStdErr :  E  — (23)
(9)  — UW    : i_uDataItem                 o_eFStats :   E  — (24)
(10) —  B    : i_bConst                       o_eDF :    E  — (25)
(11) —  B    : i_bState                     o_eSSreg :    E  — (26)
(12) — UD    : i_udMCoef                   o_eSSresid :   E  — (27)
(13) — UD    : i_udMCoefSize
(14) — UD    : i_udMStdErr
(15) — UD    : i_udMStdErrSize
```

Labels

Input label

No.	Label	Label name	Data type	Range	Description
(1)	i_bEN	Execution command	Bit	ON, OFF	ON: The FB is activated. OFF: The FB is not activated.
(2)	i_stModule	Module label	Structures	The range varies depending on the module label.	Specify the module label of the C intelligent function module.
(3)	i_udInputDataXAddr	Start address of X coordinate data	Double Word [unsigned]	16384 to 2096127	Specify a start address of the buffer memory of a C intelligent function module where X coordinate data to be calculated is stored. • Data for the number of data points specified for "i_udSize (number of data points)" × number of data items set for "i_uDataItem (number of data items)" is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the wave data to be calculated in the buffer memory.
(4)	i_udInputDataXAddrSize	X coordinate data start address size	Double Word [unsigned]	A value greater than or equal to the one set for the number of data points × number of data items × number of bytes required for the data type specified for the input data type selection	Specify the data size of an X coordinate to be calculated. • Specify a value greater than or equal to the one set for the number of data points × number of data items × number of bytes required for the data type specified for the input data type selection.
(5)	i_udInputDataYAddr	Start address of Y coordinate data	Double Word [unsigned]	16384 to 2096127	Specify a start address of the buffer memory of a C intelligent function module where Y coordinate data to be calculated is stored. • Data for the number of data points specified for "i_udSize (number of data points)" is read from the specified start address and its consecutive address in the buffer memory, and is used for operation. • Before executing this FB, store the wave data to be calculated in the buffer memory.
(6)	i_udInputDataYAddrSize	Y coordinate data start address size	Double Word [unsigned]	A value greater than or equal to the number of data points × number of bytes required for the data type specified for the input data type selection	Specify a size of the Y coordinate data to be calculated. • Specify a value greater than or equal to the one set for the number of data points × number of bytes required for the data type specified for the input data type selection
(7)	i_uDataType	Input data type selection	Word [unsigned]	0 to 2	Specify a data type of the wave data to analyze. 0: Word [signed] 1: Double Word [signed] 2: Single-precision real number

No.	Label	Label name	Data type	Range	Description
(8)	i_udSize	Number of data points	Double Word [unsigned]	2 to 3000	Specify the number of data points of the wave to be calculated. A value can be specified within the following range. i_bConst = 0: 2 to 3000 i_bConst = 1: 3 to 3000 • i_bConst = 0: Specify a value greater than or equal to i_uDataItem + 1. • i_bConst = 1: Specify a value greater than or equal to i_uDataItem + 2.
(9)	i_uDataItem	Number of data items	Word [unsigned]	1 to 64	Specify the number of X coordinates to be calculated. (Example) When X coordinates to be calculated are X_0, X_1, ..., X_{n-1}, the number of data items is n.
(10)	i_bConst	Necessity for calculating a constant b	Bit	ON, OFF	ON: Calculate a constant b. OFF: The constant b is '0'.
(11)	i_bState	Necessity for calculating regression statistics	Bit	ON, OFF	Specify whether or not to calculate regression statistics of the following ❶ to ❽. ❶ Coefficient m standard error ❷ Constant b standard error ❸ Coefficient of determination ❹ Standard error of y ❺ F statistical value ❻ Degree of freedom ❼ Regression sum of squares ❽ Residual sum of squares ON: Calculate regression statistics. OFF: Not to calculate regression statistics.
(12)	i_udMCoef	Coefficient m storage destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory to store a coefficient m.
(13)	i_udMCoefSize	Coefficient m storage destination size	Double Word [unsigned]	A value greater than or equal to "i_uDataItem (number of data items)" × "number of bytes required for single-precision real number"	Specify a size of the coefficient m storage destination. Set a value greater than or equal to "Number of data items (i_uDataItem)" × "number of bytes required for single-precision real number" as a buffer memory size.
(14)	i_udMStdErr	Coefficient m standard error storage destination	Double Word [unsigned]	16384 to 2096126	Specify a start address of the buffer memory to store the standard error of a coefficient m. The operation result of a constant b is stored while the necessity for calculating regression statistics is ON. No result is returned when it is OFF.
(15)	i_udMStdErrSize	Coefficient m standard error storage destination size	Double Word [unsigned]	A value greater than or equal to "i_uDataItem (number of data items)" × "number of bytes required for single-precision real number"	Specify the size of a coefficient m standard error storage destination. Set a value greater than or equal to "Number of data items (i_uDataItem)" × "number of bytes required for single-precision real number" as a buffer memory size.

Output label

No.	Label	Label name	Data type	Default value	Description
(16)	o_bENO	Execution status	Bit	OFF	ON: The execution command is on. OFF: The execution command is OFF.
(17)	o_bOK	Normal completion	Bit	OFF	The ON state indicates that multiple regression analysis is completed.
(18)	o_bErr	Error completion	Bit	OFF	The ON state indicates that an error has occurred in the FB.
(19)	o_uErrId	Error code	Word [unsigned]	0	The error code of an error occurred in the FB is returned.
(20)	o_eBConst	Constant b	Single-precision real number	0.0	The operation result of a constant b is stored while the necessity for calculating regression statistics is ON. No result is returned when it is OFF.
(21)	o_eBStdErr	Constant b standard error	Single-precision real number	0.0	The operation result of a constant b standard error is stored while the necessity for calculating regression statistics is ON. No result is returned when it is OFF.
(22)	o_eDetermCoef	Coefficient of determination	Single-precision real number	0.0	The operation result of the coefficient of determination is stored while the necessity for calculating regression statistics is ON. No result is returned when it is OFF.
(23)	o_eYEstStdErr	Standard error of y estimation	Single-precision real number	0.0	The operation result of the standard error of y estimation is stored while the necessity for calculating regression statistics is ON. No result is returned when it is OFF.
(24)	o_eFStats	F statistical value	Single-precision real number	0.0	The operation result of an F statistical value is stored while the necessity for calculating regression statistics is ON. No result is returned when it is OFF.
(25)	o_eDF	Degree of freedom	Single-precision real number	0.0	The operation result of the degree of freedom is stored while the necessity for calculating regression statistics is ON. No result is returned when it is OFF.
(26)	o_eSSreg	Regression sum of squares	Single-precision real number	0.0	The operation result of regression sum of squares is stored while the necessity for calculating regression statistics is ON. No result is returned when it is OFF.
(27)	o_eSSresid	Residual sum of squares	Single-precision real number	0.0	The operation result of residual sum of squares is stored while the necessity for calculating regression statistics is ON. No result is returned when it is OFF.

FB details

Available device

■ C intelligent function module

Target module	Firmware version	Engineering tool
RD55UP06-V	07 or later	GX Works3 of version 1.050C or later
RD55UP12-V	01 or later	GX Works3 of version 1.065T or later

■ CPU module

MELSEC iQ-R series programmable controller CPU

> **Point**
>
> For the CPU modules classified as programmable controller CPUs, refer to the MELSEC iQ-R Module
> Configuration Manual.

Basic specifications

Item	Description
Language	— (The internal program of this FB is not open to the public.)
Number of steps	323 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.
FB dependence	No dependence
FB compilation method	Macro type
FB operation	Pulse execution (multiple scan execution type)

Processing

- As i_bEN (execution command) turns ON, a coefficient, constant, and regression statistics for multiple regression analysis are calculated for the specified X coordinate data and Y coordinate data.
- For X coordinate data, data for the number of units of data specified for i_udSize (number of data points) × i_uDataItem (number of data items) is read. For Y coordinate data, data for the number of points specified for i_udSize (number of data points) is read. Depending on the data type set for i_uDataType (input data type selection), the range of the buffer memory to be read varies.
  (☞ Page 66 Buffer memory points required for each input data type)
- In the multiple regression analysis, the following formula should be applicable for X coordinate data and Y coordinate data.
  $Y = b + m_0 \times X_0 + m_1 \times X_1 + ... + m_{n-1} \times X_{n-1}$
  (b: constant, m_i: coefficient (i=0, 1, ..., n-1))
- Input data for multiple regression analysis is read from the buffer memory address specified for i_udInputDataXAddr (start address of X coordinate data) and i_udInputDataYAddr (start address of Y coordinate data).

Ex.

i_udSize (number of data points): 100 points, i_uDataItem (number of data items): 10 items

	(1)	Y	X_0	X_1	~	X_9
	1	DataY[0]	DataX[0]	DataX[1]	~	DataX[9]
i_udSize	2	DataY[1]	DataX[10]	DataX[11]	~	DataX[19]
	~	~	~	~	~	~
	100	DataY[99]	DataX[990]	DataX[991]	~	DataX[999]

DataX[n]: nth data in the buffer memory address specified for i_udInputDataXAddr (start address of X coordinates storage destination) and its consecutive address.

DataY[n]: nth data in the buffer memory address specified for i_udInputDataYAddr (start address of Y coordinate data) and its consecutive address.

(1) Number of data points

- An operation result is stored to the buffer memory specified to the input/output. For details, refer to the following section.
  (☞ Page 67 Details of operation results)
- A calculation result is stored to the buffer memory as a single-precision real number. Additionally, an area for 'number of output points × 2' words is used in the buffer memory. For the start address and number of output points for each result, refer to the following section. (☞ Page 67 Start addresses and number of output points for each calculation result)
- If an overflow occurs during operation, review the input data. A value stored at the occurrence of an overflow varies depending on each engineering tool. Check the specification of the engineering tool used.
- Multiple scans are taken until the operation is completed; therefore, do not change the wave data before the completion of the process. When the process is completed, o_bOK (normal completion) turns ON.
- If an error occurs, o_bErr (error completion) turns ON and the processing of the FB is interrupted, and then an error code is stored to o_uErrId (error code). For error codes, refer to the error code list. (☞ Page 70 Error code)

■ Buffer memory points required for each input data type

Type of input data	i_uDataType (input data type selection)	Required buffer memory points (word)
X coordinate data	0: Word [signed]	i_udSize (number of data points)×i_uDataItem (number of data items)
	1: Double Word [signed]	i_udSize (number of data points)×i_uDataItem (number of data items)×2
	2: Single-precision real number	
Y coordinate data	0: Word [signed]	i_udSize (number of data points)
	1: Double Word [signed]	i_udSize (number of data points) × 2
	2: Single-precision real number	

■ Details of operation results

Label name	Description
Coefficient m storage destination	A regression coefficient m in a multiple regression formula is stored.
Coefficient m standard error storage destination	A standard error of the coefficient m is stored.
Constant b	A constant term b in a multiple regression formula is stored.
Constant b standard error	A standard error of the constant b is stored.
Coefficient of determination	Coefficient of determination = Regression sum of squares/(regression sum of squares + residual sum of squares) The range of the coefficient of determination is 0 to 1, and a higher coefficient is an indicator of a better goodness of fit for the observations. (A multiple regression formula obtained by multiple regression analysis will show the relationship between data items much more precisely.)
Standard error of y estimation	A standard error for the predicted y value.
F statistical value	Determine if a measured relationship between an X coordinate and a Y coordinate is obtained by coincidence.
Degree of freedom	The number of units of measured data, which was independently collected, is stored.[1] i_bConst (necessity for calculating a constant b) = 0: i_udSize (number of data points) - i_uDataItem (number of data items) i_bConst (necessity for calculating a constant b) = 1: i_udSize (number of data points) - i_uDataItem (number of data items) -1
Regression sum of squares	A sum of squares of residuals between a measured value and a mean value
Residual sum of squares	A sum of squares of residuals between a measured value and a predicted value

*1 In statistics, when there are n pieces of measured data that are independently collected, the data is referred to as 'degree of freedom n'. The word 'independently' means that a precise value cannot be obtained from any measured value using other measured values.
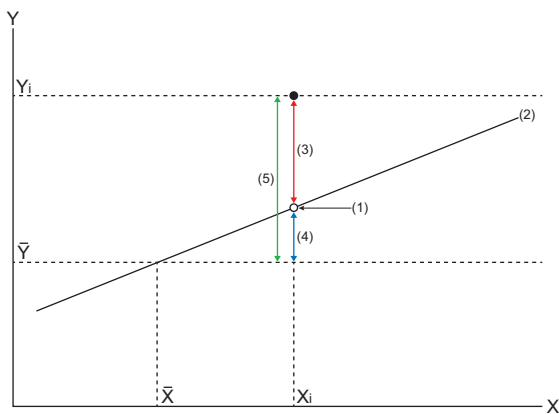
$\overline{X}$, $\overline{Y}$: Mean value
X_i, Y_i: Measured value
(1) Predicted value
(2) Regression line
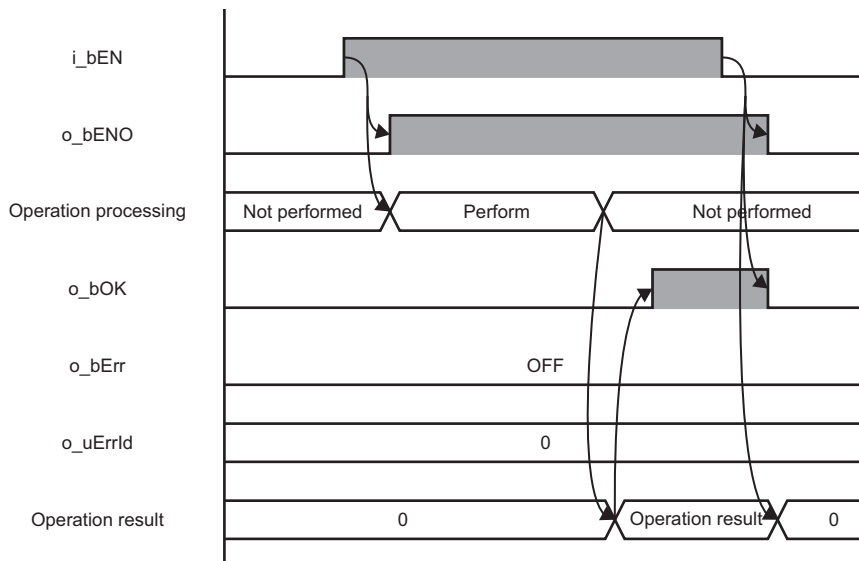(3) Remaining variation
(4) Regression variation
(5) Total variation

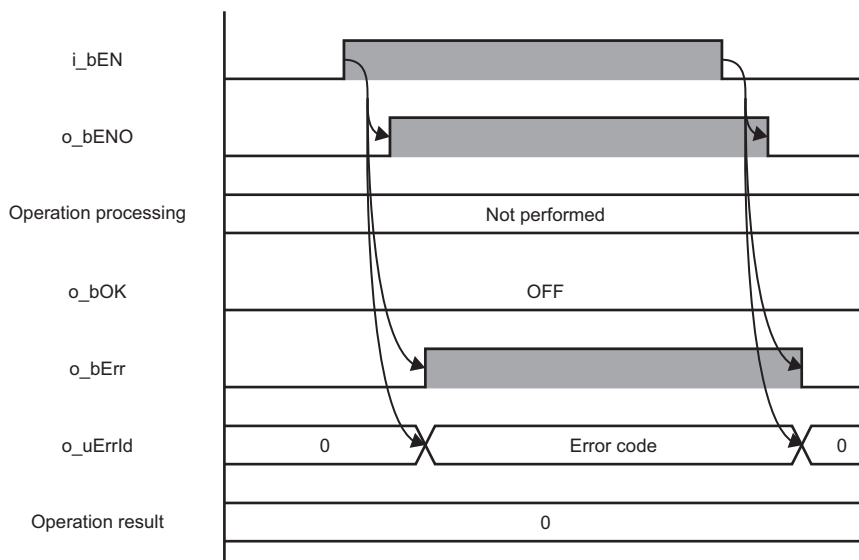## ■ Start addresses and number of output points for each calculation result

Type of calculation result	Start address for each result	Number of output points
Coefficient m	An address specified for i_udMCoef (coefficient m storage destination).	i_uDataItem (number of data items)
Coefficient m standard error	An address specified for i_udMStdErr (coefficient m standard error storage destination).	

Timing chart of I/O signals

■ Normal completion

i_bEN	
o_bENO	
Operation processing	Not performed / Perform / Not performed
o_bOK	
o_bErr	OFF
o_uErrId	0
Operation result	0 / Operation result / 0

■ Error completion

i_bEN	
o_bENO	
Operation processing	Not performed
o_bOK	OFF
o_bErr	
o_uErrId	0 / Error code / 0
Operation result	0

Restrictions or precautions

- This FB does not include the error recovery processing. Program the error recovery processing separately in accordance with the required system operation.
- A long index register (LZ0) is used for this FB. When creating an interrupt program, do not use the index register.
- This FB cannot be used in an interrupt program.
- If a program which is executed only once, such as a subroutine program or FOR-NEXT instruction, is used in this FB, the i_bEN (execution command) cannot be turned OFF, and as a result the program does not operate properly. This FB should be used in a program in which the i_bEN (execution command) can be turned OFF.
- Setting a circuit is required for all the input labels of this FB.
- i_bEN (execution command) should be turned OFF after o_bOK (normal completion) or o_bErr (error completion) is turned ON. Otherwise, o_bOK (normal completion) or o_bErr (error completion) turns OFF, and as a result o_uErrId (error code) will be cleared to '0'.
- During the execution of this FB, buffer memory addresses from 2096128 to 2097151 are not available.
- This FB operates on a C intelligent function module which is specified for i_stModule (module label). Even when i_bEN (execution command) turns OFF during an operation, it continues on the module until the processing ends. When the i_stModule (module label) turns OFF during the operation and the operation is completed successfully, the result is output to the buffer memory of the C intelligent function module; however, it is not output to the output label of this FB.
- The input and output data type of a data analysis library that is executed by this FB is single-precision real number; therefore, specifying double-word type for i_uDataType (input data type selection) may lead to a loss of trailing digits.
- During the execution of this FB, neither a dedicated instruction nor an FB can be executed for the same C intelligent function module. The operation under the situation as previously noted is not guaranteed; therefore, arrange a program that executes a dedicated instruction or an FB after o_bOK (normal completion) or o_bErr (error completion) is turned ON.

parameter settings

No parameter settings are required for using this FB.

Error code

Error code	Description	Corrective action
103H	The value set for the i_uDataType (input data type selection) is out of the range. Set 0 to 2 for i_uDataType (input data type selection).	After checking the setting, execute the FB again.
105H	The value set for the i_udSize (number of data points) is out of the range. Set 2 to 3000 for i_udSize (number of data points).	After checking the setting, execute the FB again.
125H	• The value set for the i_udInputDataXAddr (start address of X coordinate data) is out of the range. • The values set for the i_udInputDataXAddr (start address of X coordinate data) and i_udInputDataXAddrSize (X coordinate data start address size) are out of the range.	• Set 16384 to 2096127 for i_udInputDataXAddr (start address of X coordinate data). • Check the values set for the i_udInputDataXAddr (start address of X coordinate data) and i_udInputDataXAddrSize (X coordinate data start address size).
126H	• The value set for the i_udInputDataYAddr (start address of Y coordinate data) is out of the range. • The values set for the i_udInputDataYAddr (start address of Y coordinate data) and i_udInputDataYAddrSize (Y coordinate data start address size) are out of the range.	• Set 16384 to 2096127 for i_udInputDataYAddr (start address of Y coordinate data). • Check the values set for the i_udInputDataYAddr (start address of Y coordinate data) and i_udInputDataYAddrSize (Y coordinate data start address size).
12DH	The value set for the i_udInputDataXAddrSize (X coordinate data start address size) is out of the range.	For i_udInputDataXAddrSize (X coordinate data start address size), set a value greater than or equal to the one specified for i_udSize (number of data points) × i_uDataItem (number of data items) × number of bytes required for the data type specified for i_uDataType (input data type selection).
12EH	The value set for the i_udInputDataYAddrSize (Y coordinate data start address size) is out of the range.	For i_udInputDataYAddrSize (Y coordinate data start address size), set a value greater than or equal to the one specified for i_udSize (number of data points) × i_uDataType (input data type selection).
12FH	The value set for the i_udMCoefSize (coefficient m storage destination size) is out of the range.	For i_udMCoefSize (coefficient m storage destination size), set a value greater than or equal to the one set for the i_uDataItem (number of data items) × number of bytes required for single-precision real number.
130H	The value set for the i_udMStdErrSize (coefficient m standard error storage destination size) is out of the range.	For i_udMStdErrSize (coefficient m standard error storage destination size), set a value greater than or equal to the one set for the i_uDataItem (number of data items) × number of bytes required for single-precision real number.
131H	• The value set for the i_udMCoef (coefficient m storage destination) is out of the range. • The values set for the i_udMCoef (coefficient m storage destination) and i_udMCoefSize (coefficient m storage destination size) are out of the range.	• Set 16384 to 2096126 for i_udMCoef (coefficient m storage destination). • Check the values set for the i_udMCoef (coefficient m storage destination) and i_udMCoefSize (coefficient m storage destination size).
132H	• The value set for the i_udMStdErr (coefficient m standard error storage destination) is out of the range. • The values set for the i_udMStdErr (coefficient m standard error storage destination) and i_udMStdErrSize (coefficient m standard error storage destination size) are out of the range.	• Set 16384 to 2096126 for i_udMStdErr (coefficient m standard error storage destination). • Check the values set for the i_udMStdErr (coefficient m standard error storage destination) and i_udMStdErrSize (coefficient m standard error storage destination size).
142H	The value set for the i_uDataItem (number of data items) is out of the range. Set 1 to 64 for i_uDataItem (number of data items).	After checking the setting, execute the FB again.
20EH	A memory reservation error occurred in the C intelligent function module.	Reduce the number of processings that run simultaneously in the C intelligent function module.
212H	A zero division occurred during operation.	Check the input data because multicollinearity data may be used.

INSTRUCTION INDEX

M

I

MEMO

REVISIONS

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