Programmable Controller

MELSEC iQ-R MELSEC iQ-F

MELSEC iQ-R/MELSEC iQ-F Structured Text (ST) Programming Guide Book
SAFETY PRECAUTIONS

(Read these precautions before using this product.)
Before using this product, please read this manual and the relevant manuals carefully and pay full attention to safety to handle the product correctly.
The precautions given in this manual are concerned with this product only. For the safety precautions of the programmable controller system, refer to the user's manual for the CPU module used.
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.

[Design Precautions]

⚠️ WARNING
- When data change, program change, or status control are performed from a personal computer to a running programmable controller, create an interlock circuit outside the programmable controller to ensure that the whole system always operates safely.

[Security Precautions]

⚠️ WARNING
- To maintain the security (confidentiality, integrity, and availability) of the programmable controller and the system against unauthorized access, denial-of-service (DoS) attacks, computer viruses, and other cyberattacks from external devices via the network, take appropriate measures such as firewalls, virtual private networks (VPNs), and antivirus solutions.
CONDITIONS OF USE FOR THE PRODUCT

(1) MELSEC 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 ELECTRIC 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 ELECTRIC USER'S, 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 Electric 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 Electric 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 Electric representative in your region.

(3) Mitsubishi Electric 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 and MELSEC iQ-F series programmable controllers. This manual describes the programming using Structured Text (ST) in GX Works3.

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

When applying the program and circuit examples provided in this manual to an actual system, ensure the applicability and confirm that it will not cause system control problems.

Description in this manual is based on the use of MELSEC iQ-R series.

For the considerations when using MELSEC iQ-F series, refer to the following:

Page 104 Considerations for Using the MELSEC iQ-F Series
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Detailed specifications of Structured Text language are not described in this manual. For details, refer to the following:

- MELSEC iQ-R Programming Manual (Program Design)
- MELSEC iQ-F FX5 Programming Manual (Program Design)

**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.
## TERMS

Unless otherwise specified, this manual uses the following terms.

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>A variable of which name, type, and usage are defined by system.</td>
</tr>
<tr>
<td>Engineering tool</td>
<td>A tool for setting, programming, debugging, and maintaining programmable controllers.</td>
</tr>
<tr>
<td>Execution program</td>
<td>A program which has been converted. This program can be executed in a CPU module.</td>
</tr>
<tr>
<td>Function</td>
<td>A function that can be used as a POU. This function always outputs same result for the same input.</td>
</tr>
<tr>
<td>Function block</td>
<td>A function that can be used as a POU. This function retains values in the internal variables. It can be used by creating an instance.</td>
</tr>
<tr>
<td>Instance</td>
<td>An entity of a function block of which devices are assigned to the defined internal variables to be processed and executed. One or more instances can be created for one function block.</td>
</tr>
<tr>
<td>Label</td>
<td>A variable that is defined by user.</td>
</tr>
<tr>
<td>POU</td>
<td>A unit that configures a program. Units are categorized and provided in accordance with functions. Use of POUs enables dividing the lower-layer processing in a hierarchical program into some units in accordance with processing or functions, and creating programs for each unit.</td>
</tr>
</tbody>
</table>

## GENERIC TERMS AND ABBREVIATIONS

Unless otherwise specified, this manual uses the following generic terms and abbreviations.

<table>
<thead>
<tr>
<th>Generic term/abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FB</td>
<td>An abbreviation for function block.</td>
</tr>
<tr>
<td>FUN</td>
<td>An abbreviation for function.</td>
</tr>
<tr>
<td>GX Developer</td>
<td>The product name of the software package for the MELSEC programmable controllers. A generic product name for SW8D5C-GPPW.</td>
</tr>
<tr>
<td>GX Works2</td>
<td>The product name of the software package for the MELSEC programmable controllers. A generic product name for SWnDND-GXW2 and SWnDNC-GXW2. (‘n’ indicates version.)</td>
</tr>
<tr>
<td>GX Works3</td>
<td>The product name of the software package for the MELSEC programmable controllers. A generic product name for SWnDND-GXW3. (‘n’ indicates version.)</td>
</tr>
<tr>
<td>LD</td>
<td>An abbreviation for Ladder Diagram.</td>
</tr>
<tr>
<td>ST</td>
<td>An abbreviation for Structured Text.</td>
</tr>
</tbody>
</table>
This part explains the ST programming with the MELSEC-iQ-R series and MELSEC iQ-F series.

<table>
<thead>
<tr>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 WHAT IS STRUCTURED TEXT?</td>
</tr>
<tr>
<td>2 BASIC RULES FOR DESCRIPTION</td>
</tr>
<tr>
<td>3 DESCRIBING PERSPICUOUS PROGRAMS IN STRUCTURED TEXT</td>
</tr>
<tr>
<td>4 HANDLING VARIOUS DATA TYPES</td>
</tr>
<tr>
<td>5 DESCRIBING LADDER PROGRAM IN STRUCTURED TEXT</td>
</tr>
<tr>
<td>6 PROGRAM CREATION PROCEDURE</td>
</tr>
</tbody>
</table>
1  WHAT IS STRUCTURED TEXT?

1.1  International Standard IEC 61131-3

IEC 61131-3 is the international standard for the PLC (Programmable Logic Controller) system, which is established by one of the international standard association, IEC (International Electrotechnical Commission).

In IEC 61131-3, five programming languages (IL/LD/ST/FBD/SFC) are regulated, and the guidelines for creating programs are described.

1.2  Features of Structured Text Language

Structured Text language is a description method for programming in text format. This language can be described in the same manner as a programming language for a personal computer such as C language. By using this language, the visibility of a program can be improved because the operation and data processing can be described simply.

**Operation using mathematical expression**

Arithmetic operations and comparison operations can be described in the same manner as the generic expression.

■ Multiple operations can be described in one line

Since the operators (such as + and -) can be used, a program can be read much more easily than a ladder program.

**Program example**

Assign the average from the wValue0 to the wValue2 in the wAverage3.

\[
\text{wAverage3} = \frac{\text{wValue0} + \text{wValue1} + \text{wValue2}}{3}
\]

For details of the description method using Structured Text language, refer to the following:

Page 18 Operational Expressions
**Description of expression regardless of data type**
The description method for the expression of which value of decimal place is required to be considered is the same as the ordinary expression. The complex operations for real number type can be described simply.

**Program example**
Scaling analog data.
Scaling value = \((\text{After conversion.Upper limit} - \text{After conversion.Lower limit}) \div (\text{Before conversion.Upper limit} - \text{Before conversion.Lower limit}) \times (\text{Measured value} - \text{Before conversion.Lower limit}) + \text{After conversion.Lower limit}\)

**Point**
For details of the description method using Structured Text language, refer to the following:
Page 29 Integer and Real Number

**Complex information processing**
By using a selection statement or an iteration statement, a complex processing of which execution contents branches depending on the condition, and the processing to be repeated can be described more easily than a ladder program.

**Program example**
Set 0 to 3 to the wValue1 depending on the value of the wValue0.
- 100 or 200: 0
- 1 to 99: 1
- 150: 2
- Other than above: 3

**Point**
For details of the description method using Structured Text language, refer to the following:
Page 22 Selection, Page 25 Iteration
1.3 Proper Use for Programming Languages

The features of the five programming languages described in IEC 61131-3 are as follows:

<table>
<thead>
<tr>
<th>Programming language</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>IL</td>
<td>Instruction list</td>
</tr>
<tr>
<td>LD</td>
<td>Ladder diagram</td>
</tr>
<tr>
<td>ST</td>
<td>Structured text</td>
</tr>
<tr>
<td>FBD</td>
<td>Function block diagram</td>
</tr>
<tr>
<td>SFC</td>
<td>Sequential function chart</td>
</tr>
</tbody>
</table>

To take full advantage of the features of each language, create a program by combining each language in accordance with the process.

In GX Works3, the combination of the Structured Text and other languages can be used in the following functions.

<table>
<thead>
<tr>
<th>Function</th>
<th>Language</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inline Structured Text</td>
<td>LD</td>
<td>Describe the part of a relay sequence processing using Structured Text.</td>
</tr>
<tr>
<td>FUN/FB</td>
<td>LD, FBD</td>
<td>Define a sub program (subroutine) described in Structured Text as a POU, and call it from other programs such as LD.</td>
</tr>
</tbody>
</table>

By describing a simple relay sequence process and perspicuous process using the Ladder Diagram, and describing a part of complex process using the Structured Text of which process can be segmented, an easy-to-see program can be created.

**LD with inline structured text**

```plaintext
wAverage3 := (wValue0 + wValue1 + wValue2) / 3;
```

**LD with FUN/FB**

```plaintext
CASE i_wValue0 OF
1 100, 200: o_wValue1 := 0;
2 100, 200: o_wValue1 := 1;
3 150: o_wValue1 := 2;
4 ELSE          o_wValue1 := 3;
5 END_CASE;
```
2  BASIC RULES FOR DESCRIPTION

This chapter explains the basic rules for describing programs in the Structured Text language.

2.1  Characters

The Structured Text is a programming language that can be described in text format. This section explains the characters and symbols that can be used in the Structured Text language.

Character code

GX Works3 supports the characters in the Unicode Basic Multilingual Plane (UTF-16).

Basic characters and symbols in multiple languages such as Japanese, English, and Chinese can be used for not only comments but also label names and data names.

For the characters (reserved words) that cannot be used for a label name and data name, refer to the following:

GX Works3 Operating Manual

Basic component (Token)

A term or symbol that configures the program is referred to as a token.

In the Structured Text language describe the program using the following tokens.

<table>
<thead>
<tr>
<th>Type</th>
<th>Example</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator</td>
<td>+, -, *, &lt;, &gt;, =, &amp;, NOT</td>
<td>Page 93 Operator</td>
</tr>
<tr>
<td>Keyword of control statement (defined standard identifier)</td>
<td>IF, CASE, WHILE, RETURN</td>
<td>Page 92 Statement</td>
</tr>
<tr>
<td>Identifier</td>
<td>X0, Y10, M100, D10, ZR0, bSwitch_A (arbitrary name)</td>
<td>Page 94 Device Page 96 Label</td>
</tr>
<tr>
<td>POU</td>
<td>BMov, FunPou (arbitrary name), COUNTER_FB_M_1, FbPou_1 (arbitrary name)</td>
<td>Page 99 Function and function block</td>
</tr>
<tr>
<td>Constant</td>
<td>123, 'Character string', TRUE, FALSE</td>
<td>Page 97 Constant</td>
</tr>
<tr>
<td>Break character</td>
<td>;, (, )</td>
<td>—</td>
</tr>
</tbody>
</table>

A blank, line feed, and comment can be inserted among tokens.

<table>
<thead>
<tr>
<th>Type</th>
<th>Example</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>Space, TAB</td>
<td>—</td>
</tr>
<tr>
<td>Line feed</td>
<td>Line feed</td>
<td>—</td>
</tr>
<tr>
<td>Comment</td>
<td>(<strong>), &quot;</strong>, //</td>
<td>Page 93 Comment</td>
</tr>
</tbody>
</table>

```
wValue0 := D10 - 123;

IF wValue0 < 0 THEN
  bFlag0 := TRUE; (* ON *)
ELSE
  bFlag0 := FALSE; (* OFF *)
END_IF;

bResult := FunPou(wValue0);
FbPou_1(i._wValue := wValue0,
  _wValue => wValue1);
```
## 2.2 Instructions and Functions

The instructions which can be used in a ladder program is treated as functions in the Structured Text language. The instructions and functions can be used in a similar format as function call of C language.

![Image]

\[
\text{bResult := BMOV( TRUE, wValue0, 1, wValue1);}
\]

In GX Works3, the following functions and function blocks can be used.

<table>
<thead>
<tr>
<th>Type</th>
<th>Instruction and function that corresponds to MELSEC-Q/L series</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GX Works2</td>
</tr>
<tr>
<td>CPU module instruction</td>
<td>Common instruction</td>
</tr>
<tr>
<td>Module dedicated instruction</td>
<td>Application function</td>
</tr>
<tr>
<td>Standard function</td>
<td>MELSOFT Library</td>
</tr>
<tr>
<td>Standard function block</td>
<td>—</td>
</tr>
<tr>
<td>Module FB</td>
<td>—</td>
</tr>
<tr>
<td>MELSOFT Library (sample libraries)</td>
<td>—</td>
</tr>
<tr>
<td>Function and function block that are created by user</td>
<td>—</td>
</tr>
</tbody>
</table>

The instructions which are not necessary for Structure Text language (such as contact) are not supported.

Page 101 Instructions That Cannot be Used in ST Programs

For details of the instructions, refer to the following:

- MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks)
- MELSEC iQ-R Programming Manual (Module Dedicated Instructions)
- MELSEC iQ-F FX5 Programming Manual (Instructions, Standard Functions/Function Blocks)
- FB reference of each module
Function and function block

Function and function block are the POUs in which a subroutine to be called in a program is defined.

- **Function**
  Function is a POU that outputs same result for the same input. Function is suitable for segmenting a simple and independent processing.
  
  Describe the function name and arguments in an ST program as follows:

  ```
  bResult := FunPou( ?BOOL_EN?, ?BOOL_ENO?, ?INT_i_wValue0?, ?INT_o_wValue1? );
  ```

- **Function block**
  Function block is a POU of which internal values can be used for operations. The different result is output for the same input depending on the value retained in each instance (entity). Function block is suitable for segmenting much more complex processing than a function, or for processing which is required to be executed repeatedly using the retained value.
  
  To use a function block in an ST program, describe an instance and arguments as follows:

  ```
  FbPou_1(EN:= ?BOOL?, ENO=> ?BOOL?, i_wValue0:= ?INT?, o_wValue1=> ?INT? );
  ```

For details of the description method using Structured Text language, refer to the following:

- Page 99 Function and function block

For details of the functions and function blocks, refer to the following:

- MELSEC iQ-R Programming Manual (Program Design)
- MELSEC iQ-F FX5 Programming Manual (Program Design)
2.3 Statement and Expression

This section explains "statement" and "expression" which indicate units that configure an ST program.

Statement

A group of one execution process is referred to as "statement". A program is described in "statement" units.
Each statement must end with a semicolon ‘;’.

The following shows the types of the statements.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment statement</td>
<td>Assigns the evaluation result in the right side to the variable in the left side.</td>
<td>Page 18 Assignment (=)</td>
</tr>
<tr>
<td>Control statement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection statement (IF, CASE)</td>
<td>Selects an execution statement depending on the condition.</td>
<td>Page 22 Selection</td>
</tr>
<tr>
<td>Iteration statement (FOR, WHILE, REPEAT)</td>
<td>Continues executing the execution statement for multiple times depending on the end condition.</td>
<td>Page 25 Iteration</td>
</tr>
<tr>
<td>Exit of an iteration statement (EXIT)</td>
<td>Exits an iteration statement.</td>
<td>EXIT;</td>
</tr>
<tr>
<td>Subprogram control statement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call statement</td>
<td>Calls a function or function block.</td>
<td>Page 99 Function and function block</td>
</tr>
<tr>
<td>RETURN statement</td>
<td>Ends a process in the middle of a program.</td>
<td>RETURN;</td>
</tr>
<tr>
<td>Empty statement</td>
<td>Nothing is processed.</td>
<td></td>
</tr>
</tbody>
</table>

Hierarchization of a control statement can be performed. (Other statements such as a select statement or an iteration statement can be described among the statements.)
Expression

A description of values which are required for processing for a statement is referred to as "expression".

An expression is configured with variables and operators. The value of an expression is evaluated during the execution of a program.

The expressions are used in the following position in the statement.

- Right side of an assignment statement
- Execution result (EN) or input argument of a function and a function block
- Condition that is specified with a selection statement or iteration statement

<table>
<thead>
<tr>
<th>Type</th>
<th>Data type of expression (operation result)</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational expression</td>
<td>Arithmetic expression: Integer, real number (depending on the operation target)</td>
<td>wValue0 + wValue1</td>
</tr>
<tr>
<td></td>
<td>Logical expression: Boolean value (TRUE/FALSE)</td>
<td>bFlag0 OR bFlag1</td>
</tr>
<tr>
<td></td>
<td>Comparison expression: Boolean value (TRUE/FALSE)</td>
<td>wValue0 &gt; 0</td>
</tr>
<tr>
<td>Primary expression</td>
<td>Variable, constant: Defined data type</td>
<td>X0, wValue0, 123, TRUE</td>
</tr>
<tr>
<td></td>
<td>Function call expression: Data type of return value</td>
<td>FunPou(wValue0, wValue1)</td>
</tr>
</tbody>
</table>

A function which does not have a return value cannot be used as an expression.
3 DESCRIBING PERSPICIUS PROGRAMS IN STRUCTURED TEXT

This chapter explains the process which makes it easy to read by describing using Structured Text language.

3.1 Operational Expressions

Complex operations which include decimal point or exponent can be described in the same manner as a general arithmetic expression using Structured Text language.

Assignment (:=)

The result of an evaluation can be stored to a variable using an assignment statement. Describe an assignment statement using ‘:=’. This operational expression stores the calculation result of the right side to the variable in the left side.

Assign the result

Use ‘:=’ in the Structured Text language instead of ‘=’ which is used in a general expression.

Basic arithmetic operations (+, -, *, /)

Describe a basic arithmetic operation in the same manner as a general arithmetic expression using the operator (+, -, *, /). The operation which cannot be described once in a ladder program can be described in one expression in the Structured Text language.

Program example

The sum from the wValue0 to the wValue2 is assigned to wTotal.

\[ wTotal = wValue0 + wValue1 + wValue2 \]

When multiple operational expressions are described in one statement, the operation is processed in order from high priority operation.

- Priority of basic arithmetic operations (high to low): Multiplication and division (\(^*, /\)), addition and subtraction (+, -)

When some operators of which priority is the same are used in one statement, the operators are calculated in order from the left.
An operational expression in parentheses ( ) is calculated first. Using the parentheses ( ) in complex basic arithmetic operations makes it easy to read the order of the expression.

**Program example**

The average from the wValue0 to the wValue2 is assigned to the wAverage3.

\[
wAverage3 = (wValue0 + wValue1 + wValue2) \div 3
\]

**ST**

\[
wAverage3 := ( wValue0 + wValue1 + wValue2) / 3;
\]

**LD**

AlwaysON

\[
\begin{align*}
&\text{MOV} & 0 & \text{wTotal} \\
&\text{+} & \text{wValue0} & \text{wTotal} \\
&\text{+} & \text{wValue1} & \text{wTotal} \\
&\text{+} & \text{wValue2} & \text{wTotal} \\
&\text{/} & \text{wTotal} & 3 & \text{wArray0} \\
&\text{MOV} & \text{wArray0[0]} & \text{wAverage3}
\end{align*}
\]
Advanced operations (exponent function, trigonometric function)

Describe exponent functions and trigonometric functions using standard functions.

<table>
<thead>
<tr>
<th>Type</th>
<th>Function name</th>
<th>General mathematical expression</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute value</td>
<td>ABS</td>
<td>B =</td>
<td>A</td>
</tr>
<tr>
<td>Square root</td>
<td>SQRT</td>
<td>$B = \sqrt{A}$</td>
<td>eValueB := SQRT(eValueA);</td>
</tr>
<tr>
<td>Natural logarithm</td>
<td>LN</td>
<td>$B = \log e^A$</td>
<td>eValueB := LN(eValueA);</td>
</tr>
<tr>
<td>Common logarithm</td>
<td>LOG</td>
<td>$B = \log 10^A$</td>
<td>eValueB := LOG(eValueA);</td>
</tr>
<tr>
<td>Exponent</td>
<td>EXP</td>
<td>$B = e^A$</td>
<td>eValueB := EXP(eValueA);</td>
</tr>
<tr>
<td>Trigonometric</td>
<td>SIN, ASIN</td>
<td>$B = \sin A$</td>
<td>eValueB := SIN(eValueA)</td>
</tr>
<tr>
<td></td>
<td>COS, ACOS</td>
<td>$B = \cos A$</td>
<td>eValueB := COS(eValueA);</td>
</tr>
<tr>
<td></td>
<td>TAN, ATAN</td>
<td>$B = \tan A$</td>
<td>eValueB := TAN(eValueA);</td>
</tr>
</tbody>
</table>

Describe an exponentiation using **.

<table>
<thead>
<tr>
<th>Type</th>
<th>Operator</th>
<th>General mathematical expression</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exponentation</td>
<td>**</td>
<td>$B = C^A$</td>
<td>eValueB := eValueC ** eValueA;</td>
</tr>
</tbody>
</table>

Program example

The length of a hypotenuse is obtained.

\[ C = \sqrt{(A^2 + B^2)} \]

ST

\[
eValueC := \text{SQRT}((eValueA ^ 2.0) + (eValueB ^ 2.0));
\]

LD

```plaintext
AlwaysON
POW eValueA 2.0 eTmp1
POW eValueB 2.0 eTmp2
ESQRT eTmp2 eValueC
```
Logical operation (AND, OR, XOR, NOT)

Describe a logical operation not with symbols (such as ∧, ∨, and ∀) but with an operator, which can easily be input and understood.

Program example

The logical product (AND) of the bFlag0 and the bFlag1 is assigned to the bResult.

Program example

ST
bResult := bFlag0 AND bFlag1;

LD

Point

AND operation can also be described using '&'.
When multiple operational expressions are described in one statement, the operation is processed in order from high priority operation.
• Priority of logical operator (high to low): NOT operation, AND operation (AND, &), XOR operation, OR operation

Comparison (<, >, <=, >=), equality/inequality (=,<>)

Describe a comparison operation using an equal sign or an inequality sign, which is the same symbol as a general arithmetic symbol.

Program example

The comparison result of the wValue0 and the wValue1 (equality: TRUE, inequality: FALSE) is assigned to the bResult.

Program example

ST
bResult := wValue0 = wValue1;

LD

Point

In the Structured Text language, '=' is regarded as an operator which compares if the left side and right side of the statements are equal.
Describe an assignment statement using ':='.
3.2 Selection

In the Structured Text language, the process which branches off depending on the condition can be used in the same manner as a high-level programming language, such as C language.

By using the selection statement (IF, CASE), the case to be executed and the statement to be executed can be described.

Selection by boolean value (IF)

Describe the process which branches off depending on the condition (TRUE or FALSE) using an IF statement.

The following process is performed in an IF statement.

1. Judgment of IF
   When Condition expression 1 is TRUE, the Statement 1 is executed.

2. Judgment of ELSIF
   When the conditional expression above is FALSE, the condition is judged.
   When the Condition expression 2 is TRUE, the Statement 2 is executed.

3. Judgment of ELSE
   When all the conditions of 'IF' and 'ELSIF' are FALSE, the Statement 3 after 'ELSE' is executed.

The following items can be specified in the conditional expression of IF statement.

- Operational expression of which result is to be a boolean value
- Variable of boolean type
- Function call expression of which return value is boolean type

Multiple selections using ELSIF (ELSIF<Condition>THEN<Statement>; ) can be set.

Describe the selection using ELSIF or ELSE as necessary. (Omittable)

Program example

The different value is set to the wValue0 depending on the condition of the bFlag0.

- When ON (bFlag0 is TRUE): wValue0 = 100
- When OFF (bFlag0 is FALSE): wValue0 = 0

ST

IF bFlag0 THEN
    wValue0 := 100;
ELSE
    wValue0 := 0;
END_IF;

LD

bFlag0

MOV 100 wValue0
MOV 0 wValue0
By using the expression in which a logical operation (AND, OR, etc.) or a comparison (<, >, =, etc.) are combined for a conditional expression of the selection statement, a program which can be branched with complex conditions can be described.

### Program example

0, 1, 2, or 3 is set to the wValue1 depending on the value of the bFlag0 and the wValue0.

- When bFlag0 is FALSE: 0
- When the bFlag0 is TRUE and the wValue0 is 100 or 200: 1
- When the bFlag0 is TRUE and the wValue0 is 1 to 99: 2
- Other than above: 3

```st
IF NOT bFlag0 THEN
    wValue1 := 0;
ELSIF (wValue0 = 100) OR (wValue0 = 200) THEN
    wValue1 := 1;
ELSIF (1 <= wValue0) AND (wValue0<= 99) THEN
    wValue1 := 2;
ELSE
    wValue1 := 3;
END_IF;
```

```ld
bFlag0MOV 0 wValue1 = wValue0 100MOV 1 wValue1 = wValue0 200

< wValue0MOV 2 wValue1 <= wValue0 99

< wValue0MOV 3 wValue1
```
Selection (CASE) by integer

Describe the process of which process branches using integer values with CASE statement. The following process is performed in a CASE statement.

Selects an execution statement depending on the condition of the integer value.

1. Judgment of the Value 1
   Execute the Statement 1 if the result of the conditional expression is equals to the Value 1.

2. Judgment of the integer value in the specified range
   When specifying the range of the integer value to be judged, use ‘..’.
   When the result of the conditional expression is within the range of the Value 2 to Value 3, the Statement 2 is executed.

3. Judgment of ELSE
   When all the integer values or ranges are equal, the Statement 3 after ‘ELSE’ is executed.

The following items can be specified in the conditional expression of CASE statement.

- Operational expression of which result is to be an integer (INT or DINT) value
- Variable of integer (INT or DINT) type
- Function call expression of which return value is integer (INT or DINT) type

Multiple selections (\(<\text{Value}>:\text{<Statement}>;\) determined by an integer value can be set.

Describe the selection using ELSE (ELSE<Statement>) as necessary. (Omittable)

For an integer value to be judged, a label that satisfies the following conditions can be set: the data type is Word [Signed] or Double Word [Signed], and the class is VAR_CONSTANT.

Program example

0, 1, 2, or 3 is set to the wValue1 depending on the value of the wValue0.

- When 100 or 200: 0
- When 1 to 99: 1
- When 150: 2
- Other than above: 3

ST

```
CASE wValue0 OF
  100, 200: wValue1 := 0;
  1..99: wValue1 := 1;
  150: wValue1 := 2;
  ELSE wValue1 := 3;
END_CASE;
```

LD

```
AlwaysON = wValue0 100
= wValue0 200
= wValue0 150
<= 1 wValue0
<= wValue0 99
<= wValue0 100
MOV 0 wValue1
MOV 1 wValue1
MOV 2 wValue1
MOV 3 wValue1
```
3.3 Iteration

By using the iteration statement (WHILE, REPEAT, FOR), the process can be executed for multiple times with the end condition specified.

Iteration by boolean condition (WHILE, REPEAT)

Describe the process to be repeated depending on the result of its condition (TRUE or FALSE) using WHILE statement or REPEAT statement.

The following process is performed in a WHILE statement.

1. Execution of the process
   Execute the execution statement.
2. Judgment of the condition
   If a conditional expression is TRUE, the process is end.
   If a conditional expression is FALSE, the process is repeated.

```tcl
WHILE <Condition> DO
    <Statement>
END_WHILE;
```

Repeat processing until the result of the conditional expression is FALSE.

The following process is performed in a REPEAT statement.

1. Execution of the process
   Execute the execution statement.
2. Judgment of the condition
   If a conditional expression is TRUE, the process is end.
   If a conditional expression is FALSE, the process is repeated.

```tcl
REPEAT <Statement> UNTIL <Condition>
END_REPEAT;
```

Execute the execution statement for multiple times depending on the end condition of the boolean value.

The following items can be specified in the conditional expression of WHILE and REPEAT statement.

- Operational expression of which result is to be a boolean value
- Variable of boolean type
- Function call expression of which return value is boolean type

Program example

When the bFlag0 is TRUE, the wValue0 is incremented.

```tcl
ST
WHILE bFlag0 DO
    wValue0 := wValue0 + 1;
END_WHILE;
```

LD

![Program flowchart diagram]
By using the expression in which a logical operation (AND, OR, etc.) and a comparison (<, >, =, etc.) are combined for a conditional expression of the iteration statement, a program of which end condition is complex can be described.

**Program example**

The wValue0 is incremented until the bFlag0 is TRUE or the wValue0 is 10 or more.

```st
REPEAT
  wValue0 := wValue0 + 1;
  UNTIL bFlag0 OR (wValue0 >= 10)
END_REPEAT;
```

LD

```
P21
  AlwaysON
  bFlag0
  >= wValue0 K10

+ 1 wValue0

CJ P21
```
Iteration by integer value (FOR)

Describe the process which repeats processing until the variable of an integer type meets the condition using FOR statement.

The following process is performed in a FOR statement.

1. Initialization of variable
   Set the initial value to the variable to be a condition.
2. Judgment of the condition
   If the variable is reached at the last value, the process is end.
3. Execution of the process
   Execute the execution statement.
4. Addition of increment value
   Add the increment value to the variable, and repeat processing.

```
FOR wIndex0 := 0 TO 10 BY 1 DO
  wArray0[wIndex0] := wArray1[wIndex0 + 10];
END_FOR;
```

The following items can be specified for the initial value, last value, and increment value of FOR statement.

- Operational expression of which result is to be an integer (INT or DINT) value
- Variable of integer (INT or DINT) type
- Function call expression of which return value is integer (INT or DINT) type

Convert the type in order that the value is to be an integer type.

If the increment value is 1, the addition process of the increment value (BY<Increment (expression)>;) can be omitted.

After the execution of the FOR statement, the variable set as a condition retains the value at the end of the FOR statement.

Program example

The element from 10 to 20 of the wArray1 are set to the element from 0 to 10 of the wArray0.

```
FOR wIndex0 := 0 TO 10 BY 1 DO
  wArray0[wIndex0] := wArray1[wIndex0 + 10];
END_FOR;
```
By combining the array type data with iteration statement, the identical data processing can be performed for multiple array elements.
This chapter explains the considerations when handling the variables of each data type, how to specify the data types, and how to convert using the Structured Text language.

Define the data type of labels at registration of labels. The data type of devices differ depending on the device type.

When using the value with the different data type as the defined one, use a type conversion function of a standard function.

### 4.1 Boolean Value

Boolean is a 1 bit data type that holds 0 or 1.

Use this data type when indicating the ON/OFF for a bit device or TRUE/FALSE for an execution result.

A label to which a bit device or "Bit" data type is set is treated as a variable of boolean value.

### 4.2 Integer and Real Number

An integer type label, a real number type label, and a word device are treated as a variable of integer or real number.

The basic data type of a value used for each processing is integer type. When handling the value of decimal place, use a value of real number type.

#### Value of range

Depending on the type of variable, the effective digits differ. Specify the variable of the appropriate data type depending on the operation to be executed.

The following shows the ranges that can be handled in operation depending on the data type of the variable.

<table>
<thead>
<tr>
<th>Data type</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integer</td>
<td></td>
</tr>
<tr>
<td>Word [Unsigned]</td>
<td>0 to 65535</td>
</tr>
<tr>
<td>Double Word [Unsigned]</td>
<td>0 to 4294967295</td>
</tr>
<tr>
<td>Word [Signed]</td>
<td>-32768 to 32767</td>
</tr>
<tr>
<td>Double Word [Signed]</td>
<td>-2147483648 to 2147483647</td>
</tr>
<tr>
<td>Real number</td>
<td></td>
</tr>
<tr>
<td>FLOAT [Single Precision]</td>
<td>-2^{128} to -2^{-128}, 0, 2^{-128} to 2^{128}</td>
</tr>
<tr>
<td>FLOAT [Double Precision]</td>
<td>-2^{1024} to -2^{-1022}, 0, 2^{-1022} to 2^{1024}</td>
</tr>
</tbody>
</table>
Type conversion which is performed automatically

When using the Structured Text language in GX Works3, data types of an integer and a real number are converted automatically with the following processing even when a different variable of data type or constant is described.

- Assignment statement
- Pass of the input argument to a function or function block
- Arithmetic operational expression

The data type conversion is performed automatically to the data type of which range is larger.

**Example**

Assignment between Word [Signed] (INT) and Double Word [Signed] (DINT)

<table>
<thead>
<tr>
<th>ST</th>
<th>Operation result</th>
</tr>
</thead>
<tbody>
<tr>
<td>dValue0 := wValue1;</td>
<td>○ The type conversion from INT to DINT is performed automatically.</td>
</tr>
<tr>
<td>wValue1 := dValue0;</td>
<td>× A conversion error occurs since the data may be lost at conversion from DINT to INT.</td>
</tr>
<tr>
<td>wValue1 := DINT_TO_INT(dValue0);</td>
<td>○ Perform a type conversion from DTIN to INT using a type conversion function. If the range of the value before conversion exceeds the range of INT type, an operation error occurs.</td>
</tr>
</tbody>
</table>

The type conversion is not performed automatically under the following situation. In this case, use a type conversion function.

- Type conversion for the integer which has same data size and different sign
- Type conversion for the type of which data may be lost
- Type conversion other than integer type and real number type

**Data type that can be converted automatically**

The following shows the combinations of data types which are converted automatically.

<table>
<thead>
<tr>
<th>Data type before conversion</th>
<th>Data type after conversion</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word [Signed]</td>
<td>Double Word [Signed]</td>
<td>The value is converted to the sign-extended value automatically.</td>
</tr>
<tr>
<td></td>
<td>FLOAT [Single Precision]</td>
<td>The value is converted to the same value before the conversion automatically.</td>
</tr>
<tr>
<td></td>
<td>FLOAT [Double Precision]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Double Word [Unsigned]/Bit String [32-bit]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FLOAT [Single Precision]</td>
<td>The value is converted to the same value before the conversion automatically.</td>
</tr>
<tr>
<td></td>
<td>FLOAT [Double Precision]</td>
<td></td>
</tr>
<tr>
<td>Double Word [Signed]</td>
<td>FLOAT [Double Precision]</td>
<td></td>
</tr>
<tr>
<td>Double Word [Unsigned]/Bit String [32-bit]</td>
<td>FLOAT [Single Precision]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FLOAT [Double Precision]</td>
<td></td>
</tr>
<tr>
<td>FLOAT [Single Precision]</td>
<td>ANY_REAL_64</td>
<td></td>
</tr>
</tbody>
</table>

The data conversion is also performed automatically when passing the input argument to a standard function, standard function block, and instruction.

The following shows the combinations of data types which are converted automatically when the input argument is defined as the generic data type.

<table>
<thead>
<tr>
<th>Data type of variable (before conversion) to be specified to argument</th>
<th>Data type definition of input argument</th>
<th>Data type after conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word [Signed]</td>
<td>ANY32, ANY32_S</td>
<td>Double Word [Signed]</td>
</tr>
<tr>
<td></td>
<td>ANY_REAL, ANY_REAL_32</td>
<td>FLOAT [Single Precision]</td>
</tr>
<tr>
<td></td>
<td>ANY_REAL_64</td>
<td>FLOAT [Double Precision]</td>
</tr>
<tr>
<td></td>
<td>ANY_REAL, ANY_REAL_32</td>
<td>FLOAT [Single Precision]</td>
</tr>
<tr>
<td></td>
<td>ANY_REAL_64</td>
<td>FLOAT [Double Precision]</td>
</tr>
<tr>
<td>Double Word [Signed]</td>
<td>ANY_REAL, ANY_REAL_64</td>
<td>FLOAT [Double Precision]</td>
</tr>
<tr>
<td>Double Word [Unsigned]/Bit String [32-bit]</td>
<td>ANY_REAL, ANY_REAL_64</td>
<td>FLOAT [Double Precision]</td>
</tr>
<tr>
<td>FLOAT [Single Precision]</td>
<td>ANY_REAL_64</td>
<td></td>
</tr>
</tbody>
</table>
Data type of the operation result of arithmetic expression

The operation result of an arithmetic operational expression (basic arithmetic operation) for the Structured Text language is the same data type as the variable and constant of the operation target. (For an exponentiation (**), the operation result will be a real number type.)

If the data type of the operator on the right side and left side differ, the data type of the operation result will be a bigger data type.

- Priority of the data type of an operation result (high to low): FLOAT [Double Precision], FLOAT [Single Precision], Double Word, Word [Signed] and [Unsigned] cannot be mixed in binary operation of the integer.

Considerations

If the value is outside the range of the data type which can be handled in the operation result, the accurate result (value) cannot be reflected to the process after the operation.

Convert the data type of the variable for the operation target to the data type within the range of the operation result in advance.

Ex.
Arithmetic operation of Word [Signed] (INT)

<table>
<thead>
<tr>
<th>ST</th>
<th>Operation result</th>
</tr>
</thead>
<tbody>
<tr>
<td>dValue0 := wValue1 * 10;</td>
<td>✗</td>
</tr>
<tr>
<td>dValue1 := INT_TO_DINT(wValue1); dValue0 := dValue1 * 10;</td>
<td>✓</td>
</tr>
</tbody>
</table>

Division of integer and real number

For a division, the operation result may differ depending on the type of variable.

For a division of an integer type variable, the value of decimal place is cut off.

For a division of a real number type variable, the value of decimal place is calculated.

- FLOAT [Single Precision]: 7 effective digits (6 digits of decimal places)
- FLOAT [Double Precision]: 15 effective digits (14 digits of decimal places)

Ex.
Assign the operation result of the expression '(2 ÷ 10) × 10' to D0

<table>
<thead>
<tr>
<th>Data type</th>
<th>ST</th>
<th>Operation result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integer</td>
<td>Word [Signed]</td>
<td>D0 := (2 / 10) * 10;</td>
</tr>
<tr>
<td>Real number</td>
<td>FLOAT [Single Precision]</td>
<td>D0:E := (2.0 / 10.0) * 10.0;</td>
</tr>
</tbody>
</table>

For word devices, a data type can be specified by adding ':E' in the Structured Text language. (Page 94 Type specification of word device)

Remainder of division (MOD)

Calculate the remainder of division by modulus operation (MOD).

Ex.
Calculate the lower two-digits of a five-digits integer

<table>
<thead>
<tr>
<th>Data type</th>
<th>ST</th>
<th>Operation result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integer</td>
<td>Word [Signed]</td>
<td>D0 := (-32368 MOD 100);</td>
</tr>
</tbody>
</table>
4.3 Character String

Use a character string processing instruction and standard function (character string function) for the processing of the variable of a character string type.

Program example

The length of a character string is calculated.

```
ST
wLen0 := LEN(sString0);
```

Assignment of character string

Describe a character string type variable using an assignment statement.

Program example

The character string 'ABC' is assigned to the sString0 (character string variable) and the wsString1 (character string [Unicode] type variable).

```
ST
sString0 := 'ABC';
wsString1 := "ABC";
```

Point

Enclose ASCII character string constant in single quotes (').
Enclose Unicode character string constant in double quotes (").

Comparison of character strings

Describe a comparison operation (comparison, equality, inequality) of a character string type variable using an operator.

Program example

After the comparison of the character strings, the sString1 is assigned to the sString0 if the characters are not equal.

```
ST
IF sString0 <> sString1 THEN
  sString0 := sString1;
END_IF;
```

Point

For the character string type variable, a comparison operator (<, >, <=, >=) compares the values using the value of ASCII code or Unicode.
Depending on the first character code number of which inequality is detected, the comparison result of the character string is determined.
The details of the comparison conditions are the same as the one as the character string comparison instruction (LD$<, etc.)
4.4 Time

Time data is used for the time type variable or clock data (array data used for CPU module instructions).

Time type variable

By using the time type variable, an easy-to-see program in which time data in milliseconds is included can be created. Describe the time type of constants as follows:

• T#23d23h59m59s999ms

<table>
<thead>
<tr>
<th>Time unit</th>
<th>d (day)</th>
<th>h (hour)</th>
<th>m (minute)</th>
<th>s (second)</th>
<th>ms (millisecond)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>0 to 24</td>
<td>0 to 23</td>
<td>0 to 59</td>
<td>0 to 59</td>
<td>0 to 999</td>
</tr>
</tbody>
</table>

The time type variable can be set in the range from T#-24d20h31m23s648ms to T#24d20h31m23s647ms. For details on the description method of the time length, refer to the following:

Page 98 Description method of the time length

Assignment of time

Describe a time type variable using as assignment statement.

Program example

The value that indicates 1 hour 30 minutes is assigned to the tmData0 (time type variable).

```
ST
  tmData0 := T#1h30m;
```

Comparison of time

Describe a comparison operation (comparison, equality, inequality) of a time type variable using an operator.

Program example

If the time data is one day or more, the processing is ended.

```
ST
  IF tmData0 >= T#1d THEN
    RETURN;
  END_IF;
```

Basic arithmetic expression for time

Describe a multiplication and division of the time type variable using a standard function (time data type function). An addition or subtraction can be described using an operator.

Program example

The value in which 10 ms is added and doubled is assigned to the tmData0 (time type variable).

```
ST
  tmData0 := MUL_TIME(tmData0 + T#10ms, 2);
```
Clock data (date and time)

Clock data is an array data that is used for CPU module instructions.

- Clock data: An array that stores year, month, day, hour, minute, second, and day of week
- Extended clock data: An array of which millisecond unit is added to a clock data
- Date data: An array only for year, month, and day of clock data
- Time data: An array only for hour, minute, and second of clock data

Clock instruction and clock data

Use the clock instruction of the application instruction to process a clock data (array of Word [Signed] data).

Program example

"year, month, day, hour, minute, second, and day of week" are read from the clock element of the CPU module.

```
| wArray[0] | Year       | (1980 to 2079) |
|          | Month      | (1 to 12)      |
|          | Day        | (1 to 31)      |
| [3]      | Hour (24 hours) | (0 to 23)    |
| [4]      | Minute     | (0 to 59)      |
| [5]      | Second     | (0 to 59)      |
| [6]      | Day of week| (0 to 6)       |
```

```
ST
DATERD(TRUE, wArray);
```

Comparison of date data and time data

The comparison instruction for date data and time data cannot be used in ST programs. (Page 101 Instructions That Cannot be Used in ST Programs)

To compare a date data and time data, compare each element of the array or convert the data to the time type variable.
4.5 Array and Structure

An array and structure are the data format that can handle multiple data at once.
- Array: A consecutive aggregation of same data type variables
- Structure: A aggregation of different data type variables

Array

Describe only the label name when indicating whole array type variables.
When indicating each element of the array, describe the element number to be specified enclosing with ‘[ ]’ as an index after the label name.

Assignment of array

Describe an array type variable using the assignment statement to assign the value to the element specified by the index. By describing the element without index, the value is assigned (copied) to the whole array elements.

Program example

The following data is assigned to the wArray1 (array type variable) of Word [Signed] data.
- Array 0: 10
- Array 1: Array [0,1] of two-dimensional array, wArray2

```
ST
wArray1[0] := 10;
wArray1[1] := wArray2[0, 1];
```

Program example

All the elements of wArray0 are assigned to all the elements of the wArray1 (array type variable of Word [Signed] data). (This program example can be described when the data type and number of array data on the right side and left side are the same.)

```
ST
wArray1 := wArray0;
```
**Expression of array**

Describe the elements of each array using an operational expression as a variable of the defined data type. (Comparison and basic arithmetic expression can be described.) However, the array type variable with no index cannot be used in the operational expression. Array element can be described in an expression in the Structured Text language.

**Program example**

The following data is assigned to the wArray1 (array type variable) of the Word [Signed] data.
- Element wIndex0+1: Sum of the element 0 and element 1 in the wArray0

```
ST
wArray1[wIndex0 +1] := wArray0[0] + wArray0[1];
```

**Structure**

Define the structure combining the multiple different data types as one data type. Structure can be used for data management because the arbitrary name of structure type definition and name of each member can be set.

When indicating whole structure type variables, describe only the label name.

When indicating each member of the structure, list the member names by adding a dot "." after the label name.

**Assignment of structure**

Describe a structure type variable using the assignment statement to assign the value to the specified member.

By describing the structure without specifying the member, the value is assigned (copied) to the whole structures.

**Program example**

The following data is assigned to the member of the stData0 (structure type variable).
- Member1 (FLOAT [Single Precision]): 10.5
- Member2 (Bit): TRUE

```
ST
stData0.Member1 := 10.5;
stData0.Member2 := TRUE;
```

**Program example**

All the elements of stData0 are assigned to all the elements of the stData1 (structure type variable).
(This program example can be described when the data type of the structure (structure type definition) on the right side and left side are the same.)

```
ST
stData1 := stData0;
```
Data type combined with structure and array

A structure which includes array in the member and a structure type array can be used in ST programs.

---

**Program example**

The wArray1 (array type variable) is assigned to the wArray (array member) of the stData0 (structured type variable). (Both of them are Word [signed] type and same size.)

```st
stData0.wArray := wArray1;
```

---

**Program example**

The member of the element number 1 and the member of element number 0 in the stArray0 (structured array type variable) are compared.

```st
bResult := stArray0[1].Member1 > stArray0[0].Member1;
```

---

**Point**

Structure arrays can be used in the assignment statement in GX Works3.
This chapter explains how to describe ladder symbols and sequence instructions in the Structure Text language.

5.1 Describing Contacts and Coils

The program using contacts and coils of a ladder program can be described with the logical operations such as AND operation, OR operation, and NOT operation and assignment statements in the Structured Text language.

Open contact and coil

Describe a program configured with an open contact and coil using an assignment statement.

Program example

The bResult0 turns ON/OFF according to the ON/OFF statue of the bFlag0.

| ST  | bResult0 := bFlag0; |
| LD  | bFlag0 bResult0 |

Point

Describe an assignment statement using ‘:=’. The calculation result of a right side is stored to a variable on the left side.

Closed contact (NOT)

Describe a closed contact with the operator of a NOT operation.

Program example

The bResult0 turns OFF when the bFlag0 is ON, and the bResult0 turns ON when the bFlag0 is OFF.

| ST  | bResult0 := NOT bFlag0; |
| LD  | bFlag0 bResult0 |
Series connection, parallel connection (AND, OR)

Describe the condition described in a series connection and parallel connection using AND operation (AND, &), OR operation.

Program example

The bResult0 turns ON when any of the following conditions is met.
- Condition 1: The bFlag0 is ON and the bFlag1 is ON
- Condition 2: The bFlag2 is ON

Program example:

ST
bResult0 := bFlag0 AND bFlag1 OR bFlag2;

LD

Point

When multiple operational expressions are described in one statement, the operation is processed in order from high priority operation.
- Priority of logical operator (high to low): AND operation (AND, &), XOR operation, OR operation

When some operators of which priority is the same are used in one statement, the operators are operated in order from the left.
Contact and coil of which execution order are complicated

The complex combination of contacts and coils can be described in the Structured Text language. By using the parentheses ( ), the statements of a complex execution order can be described clearly.

Program example

The bResult0 turns ON when the following condition 1 and condition 2 are met. The bResult1 turns ON when the following condition 1, condition 2, and condition 3 are met.

- Condition 1: Either the bFlag0 or the bFlag1 is ON
- Condition 2: The bFlag2 is ON
- Condition 3: The bFlag3 is ON

Program example

ST

bResult0 := (bFlag0 OR bFlag1) AND bFlag2;
bResult1 := bResult0 AND bFlag3;

LD

When the above program is executed, the ON/OFF timing of each device are as follows;
5.2 Describing Instructions

In the Structured Text language, an instruction which can commonly be used with Ladder Diagram is handled as a function. Some instructions which are not supported by the Structure Text language (Page 101 Instructions That Cannot be Used in ST Programs) can be described using the format for the Structured Text language such as operators.

Instructions that can be used in ladder program and ST program

Basically, every instructions can be used in a ladder program and ST program. (Page 14 Instructions and Functions)

In accordance with the definitions of each instruction, describe the instruction as a function.

Program example

The bResult0 turns ON for one scan when the bFlag0 is turned ON from OFF.

```
ST
PLS(bFlag0, bResult0);
LD
```

Considerations when entering instructions

Despite the same function, some instruction names differ between Ladder Diagram and Structured Text. (Low-speed timer instruction (OUT_T) of output instruction, etc.)

When entering an instruction name in the ST editor, the list of the instructions start with the character of the input instruction name is displayed.

Check if the instruction name can be used in the ST program.

Considerations when entering arguments

The order of arguments for the same instruction may differ between Ladder Diagram and Structured Text.

The format of an instruction is displayed in tooltip when entering an argument in an ST editor.

Input the arguments in accordance with the tooltip.

For details on the instructions, refer to the programming manual. Press the [F1] key with the cursor on the instruction to display the page of the instruction.
Instructions that can be described using assignment statements

Describe a data conversion instruction using the type conversion function of a standard function and assignment statement. Describe a character string transfer instruction (MOV) using the assignment statement of a string type label.

**Program example**

The eValue0 (FLOAT [Single Precision]) is converted to the wValue1 (16-bit binary data with sign).

```
ST
wValue1 := REAL_TO_INT(eValue0);
```

```
LD
AlwaysON

AlwaysON

FLT2INT eValue0 wValue1
```

```
Program example

The sString0 (character string type variable) is transferred (assigned) to the sString1.

```
ST
sString1 := sString0;
```

```
LD
AlwaysON

AlwaysON

$MOV sString0 sString1
```

Instructions that can be described using operator

Describe basic instructions such as comparison operation instructions and arithmetic operation instructions using operators.

**Program example**

Depending on the comparison result of the Word [Signed] (INT) valuable, the two values of Double Word [Signed] (DINT) are added.

```
ST
IF (wValue0 < wValue1) AND (wValue2 > wValue3) OR (wValue4 <> wValue5) THEN
  dValue1 := dValue0 + dValue1;
END_IF;
```

```
LD
< wValue0 wValue1 > wValue2 wValue3 D+ dValue0 dValue1

< wValue4 wValue5
```
Describe FOR to NEXT instructions of the structured instructions using an iteration statement (Page 25 Iteration).

A program in which a pointer is specified using a subroutine program instruction (such as CALL) or a pointer branch instruction (such as CJ, SCJ, and JMP) cannot be used in ST program. Structure the program using a selection statement, function , or function block.

END instruction is not required for the Structured Text language. (Page 103 Unnecessary instructions for ST program)

5.3 Describing Statements of Ladder and Notes

Describe a statement and note of a ladder program as a comment.
The comment of the Structured Text language is more useful than statement and note since it can be described in arbitrary position.

(* The processing is performed depending on the ten-key input. *)
IF G_wTenKey <> c_wNONE THEN
CASE G_wTenKey OF
  0..9 : (* For number-key input (0 to 9) *)
    (* Add the input numeric value to the end of the display value. *)
    IF G_eDecimal = 0.0 THEN
      (* For integer part *)
      G_eDisplayValue := (G_eDisplayValue * 10) + G_wTenKey;
    ELSE
      (* For after decimal point *)
      G_eDisplayValue := G_eDisplayValue + (G_eDecimal * G_wTenKey);
      G_eDecimal := G_eDecimal * 0.1;
    END_IF;
  10 : (* For input of decimal point key *)
    G_eDecimal := 0.1;
  11..14 : (* For input of addition, subtraction, multiplication, or division key (11 to 14) *)
    (* Retain the operation type *)
    G_wOperation := G_wTenKey - 10;
    (* Move the display value to the previous operation value and then reset the displayed value *)
    G_eLastValue := G_eDisplayValue;
    G_eDisplayValue := 0.0;
    G_eDecimal := 0.0;
  15 : (* For equal-key input *)
    (* Add, subtract, multiply, or divide the displayed value to/from the current value. *)
    G_eLastValue := Calculation(G_eLastValue, G_wOperation, G_eDisplayValue);
    (* Assign the rounding result to the display value. *)
    G_eDisplayValue := FractionProcessing(G_eLastValue, G_wSwitch1, G_wSwitch2);
    G_wOperation := 0; (* Clear the operation type *)
    G_eDecimal := 0.0;
END_CASE;
(* Clear the key input*)
G_wTenKey := c_wNONE;
END_IF;
6 PROGRAM CREATION PROCEDURE

6.1 Overview of Procedure

This section explains the creation procedure of a program.

1. Open an ST editor.
2. Edit the ST program.
3. Convert and debug the program.
4. Check the program in the CPU module.

For details on the operations of GX Works3, refer to the following:

- GX Works3 Operating Manual

6.2 Opening ST Editor

Create an ST program using the programming function of the engineering tool (GX Works3).
Select "ST" in "Program Language" and create a new project and program.

6.3 Editing ST Programs

This section explains a series of steps from creating a simple program to execute it.
Create the following program as an example.

Program example

```plaintext
wValue0 := D10 - 123;

IF wValue0 < 0 THEN
  bFlag0 := TRUE; (* ON *)
ELSE
  bFlag0 := FALSE; (* OFF *)
END_IF;

bResult := FunPou(wValue0);
FbPou_I(l_wValue := wValue0,
       o_wValue => wValue1);
```
## Entering texts

Enter texts in the same manner as a generic text editor in an ST editor.

### Operating procedure

1. Enter 'wValue0 := D10 - 123;'

### Point

By pressing the `Ctrl` + `ALT` + `INS` keys, the assignment symbol (:=) can be entered.

Other than the operation from the [Edit] menu, the following generic key operations can be used.
- `Ctrl` + `Delete` / `Shift` + `Insert`: Cut/paste
- `ALT` + `Back space` / `ALT` + `Back space`: Undo/redo

### Copying/pasting data among editors

Text data can be copied/pasted among the generic text editors.
- Utilizing the created programs by copying texts from other text editor or PDF and pasting them to an ST editor.
- Creating documents by copying the programs created in an ST editor and pasting them to other text editor.

### Entering control statement

Enter the control statement (IF statement).

### Operating procedure

1. Enter 'IF'.
2. The syntax templates are displayed by pressing the `Ctrl` + `F1` keys.
3. Move the cursor position on "?Condition?".
   (The cursor can be moved by pressing the `Ctrl` + `ALT` + `Left` / `Right` keys.)
4. Enter "wValue0 < 0" as a conditional expression.
5. Move the cursor position on "?Statement?".
   (The cursor can be moved by pressing the `Ctrl` + `ALT` + `Left` / `Right` keys.)
6. Enter "bFlag0 := TRUE;" as an execution statement.
   - If "TRUE" is entered in lower case, it will be changed to upper case automatically.
   Enter "bFlag0 := FALSE;" as well.

### Point

The following functions are used in the operation procedure above.
- [Edit] ⇒ [Display Template] (`Ctrl` + `F1`)
- [Edit] ⇒ [Mark Template (Left)] / [Mark Template (Right)] (`Ctrl` + `ALT` + `Left` / `Right`)
**Collapsing statements**

Collapse the control statement (`IF...END_IF`) by clicking the icon ( ) displayed on the left side of the control statement.

**Entering comment**

Enter a comment in the ST program.

**Operating procedure**

1. Enter a comment in the arbitrary position in the program. (In the figure on the left, enter a comment after `bFlag0 := TRUE;`)
   - A space or TAB can be inserted anywhere.

2. Enter the delimiter (`/*` and `*/`) before and after the comment.
   - The range enclosed with the symbols is regarded as a comment.
   - Enter `/* OFF */` after "FALSE" as well.

**Point**

In GX Works3, `/**` and `//`, which are the same symbols as C language, can be used for comment.

By adding `//` in front of the statement, the statement is regarded as a comment.

By using the following functions, the comment out/disable comment out function can be performed in the selected range.

- [Edit] ⇒ [Comment Out of Selected Range] (Ctrl + Shift + S)
- [Edit] ⇒ [Disable Comment Out of Selected Range] (Ctrl + Shift + D)

**Collapsing comments**

Collapse the comment (`//`) by clicking the icon ( ) displayed on the left side of the comment.
Using labels

Register a label and use it in an ST program.

Registering labels

Register a label from an ST editor.

Operating procedure

Unregistered label name is displayed as an error.

1. By pressing the \( \text{F2} \) key on the label name, the "Undefined Label Registration" screen is displayed.

2. Set the following items to register the label, \( \text{wValue0} \).
   - Registered Destination: Local label
   - Class: VAR
   - Data Type: Word [Signed]

3. The registered label is displayed with the color for labels.

The registered label is set on the label setting screen.

The following function is used in the operation procedure above.

- \[[\text{Edit}]] \Rightarrow [\text{Register Label}] (F2)

The colors for each configuration element on the ST editor can be set using the following function.

- \[[\text{View}]] \Rightarrow [\text{Color and Font}]

Using labels

Register a label and use it in an ST program.

Registering labels

Register a label from an ST editor.

Operating procedure

Unregistered label name is displayed as an error.

1. By pressing the \( \text{F2} \) key on the label name, the "Undefined Label Registration" screen is displayed.

2. Set the following items to register the label, \( \text{wValue0} \).
   - Registered Destination: Local label
   - Class: VAR
   - Data Type: Word [Signed]

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Operating procedure

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1. By pressing the \( \text{F2} \) key on the label name, the "Undefined Label Registration" screen is displayed.

2. Set the following items to register the label, \( \text{wValue0} \).
   - Registered Destination: Local label
   - Class: VAR
   - Data Type: Word [Signed]

3. The registered label is displayed with the color for labels.

The registered label is set on the label setting screen.

The following function is used in the operation procedure above.

- \[[\text{Edit}]] \Rightarrow [\text{Register Label}] (F2)

The colors for each configuration element on the ST editor can be set using the following function.

- \[[\text{View}]] \Rightarrow [\text{Color and Font}]
Registering labels on the label editor

Register labels on the label editor.

Operating procedure

1. Display the "Local Label Setting" screen.
2. Set the following items to register labels.
   • Label Name: bFlag0
   • Data Type: Bit
   • Class: VAR (automatically set)
3. The registered label is displayed with the color for labels on the ST editor.

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>wValue0</td>
<td>Word [Signed]</td>
<td>VAR</td>
</tr>
<tr>
<td>wValue1</td>
<td>Word [Signed]</td>
<td>VAR</td>
</tr>
<tr>
<td>bFlag0</td>
<td>Bit</td>
<td>VAR</td>
</tr>
<tr>
<td>bResult</td>
<td>Bit</td>
<td>VAR</td>
</tr>
</tbody>
</table>

Using registered labels on the ST editor

Enter a label on the ST editor by selecting a label registered on the label editor.

Operating procedure

1. Register the bit type label, bResult.
2. Enter the first two letters "bR". The corresponding data such as registered label names are displayed in a list.
3. Select a label name by pressing the key and press the key to enter the selected label name.
Creating functions and function blocks

Create a new POU (function and function block) to be used in a program.

**Creating function**

Create the new data of a function in the project, and define the function program and its local label.

**Creating new data**

Create the new data of a function in the project.

**Operating procedure**

1. Select [Project] ⇒ [Data Operation] ⇒ [New Data].
2. Set the following items on the "New Data" screen.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Item</th>
<th>Description</th>
<th>Setting value in the program example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Data Name</td>
<td>An identifier for calling a function.</td>
<td>FunPou</td>
</tr>
<tr>
<td>Program Language</td>
<td>A language to describe a function program.</td>
<td>ST</td>
<td></td>
</tr>
<tr>
<td>Result Type</td>
<td>Set the data type to be returned after the completion of an execution.</td>
<td>Bit</td>
<td></td>
</tr>
<tr>
<td>Use EN/ENO</td>
<td>When &quot;Yes&quot; is selected, EN and ENO are added to the arguments.</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

- EN: A boolean type input argument to which an execution condition is to be set.
- ENO: A boolean type output argument to which an execution result is to be returned.

- **Point**

The setting items of the created function can be checked on the "Properties" screen.

The "Properties" screen can be displayed with the following operation.

- Select and right-click the data on the Navigation window and select [Property] from the shortcut menu.

**Setting argument and internal variable**

Define the arguments and internal variables used in the function.

Set the arguments and internal variables in the local label of the function. Set the following items on the label setting screen.

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_wValue</td>
<td>Word [Signed]</td>
<td>VAR_INPUT</td>
</tr>
<tr>
<td>bFlag</td>
<td>Bit</td>
<td>VAR</td>
</tr>
</tbody>
</table>

- **Point**

A local label of which class is set to "VAR_INPUT" is an input argument.

A local label of which class is set to "VAR_OUTPUT" is an output argument.

The order of arguments when executing a function call will be the order defined in the local label setting.
Creating function block

Create the new data of a function block in the project, and define the function block program and its local label.

- Creating new data
Create new data of function block in the project.

Operating procedure

1. Select [Project] ⇒ [Data Operation] ⇒ [New Data].
2. Set the following items on the "New Data" screen.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Item</th>
<th>Description</th>
<th>Setting value in the program example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function Block</td>
<td>Data Name</td>
<td>A data type name of a function block to be defined.</td>
<td>FbPou</td>
</tr>
<tr>
<td></td>
<td>Program Language</td>
<td>A language to describe a function block program.</td>
<td>ST</td>
</tr>
</tbody>
</table>
| Use EN/ENO  | When "Yes" is selected, EN and ENO are added to the arguments.              | • EN: A boolean type input argument to which an execution condition is to be set.  
  • ENO: A boolean type output argument to which an execution result is to be returned. | No                                    |
| FB Type     | Set the conversion type of a function block. Macro type or subroutine type can be selected. | Subroutine Type                                                                |                                       |
| FB File of Add Destination | Set the name of a file to which a function block is to be created is stored. | FBFILE                             |                                       |

Point

The setting items of the created function block can be checked on the "Properties" screen. The "Properties" screen can be displayed with the following operation.

- Select and right-click the data on the Navigation window and select [Property] from the shortcut menu.

Setting argument and internal variable

Define the arguments and internal variables to be used in the function block.

Set the arguments and internal variables in the local label of the function block. Set the following items on the label setting screen.

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_wValue</td>
<td>Word [Signed]</td>
<td>VAR_INPUT</td>
</tr>
<tr>
<td>o_wValue</td>
<td>Word [Signed]</td>
<td>VAR_OUTPUT</td>
</tr>
</tbody>
</table>

Point

A local label of which class is set to "VAR_INPUT" is an input argument.
A local label of which class is set to "VAR_OUTPUT" is an output argument.
Entering function

Enter a function.

A function with a return value can be used as an expression. (Function call expression)
A function with no return value must be described as a call statement. (Function call statement)

\[ \text{FunPou}(\text{value0}); \quad \text{Function call statement} \]

Entering function call expression to assignment statement

- **Assigning return value to variable**
  To assign the return value to the variable, describe a function call statement to the right side of the assignment statement.

  1. Enter a variable to which a returned value is to be assigned.
  2. Enter the assignment symbol, ":=".

- **Entering function name**
  Select and enter a function name from the undefined functions.

  **Operating procedure**

  1. Enter the first three letters, "Fun". The corresponding functions are displayed in a list.
  2. Select a label name by pressing the \[ \text{key} \] key and press the \[ \text{Enter} \] key to enter the selected function name.

  Instructions can also be entered from the list. (\(\rightarrow\) Page 41 Describing Instructions)
  By pressing the \[ \text{key} \] on the instruction, the details of the instruction can be checked on the e-Manual Viewer.
  (To check the instructions, the files of the corresponding programming manuals are required to be registered to e-Manual Viewer.)
## Entering arguments

Enter the argument in accordance with the tooltip.

### Operating procedure

1. By entering “(”, the format of the instruction is displayed in the tooltip.
2. Enter the argument in accordance with the tooltip.
3. Enter “)” at the end of the argument.
4. Enter “;” which indicates the end of the call statement.

### Point

For the defined function, the arguments can also be inserted using the template.

```
By pressing the [ ] + [ ] keys, the template of the selected function name is displayed.

bResult := FunPou(2INT_wValue);
```

The argument can be selected by the following functions.
- [Edit] [Display Template] ( [ ] + [ ] )
- [Edit] [Mark Template (Left)]/[Mark Template (Right)] ( [ ] + [ ] + [ ] )

### Selecting functions from the Navigation window or the Element Selection window

Insert a function by selecting it from the Navigation window or the Element Selection window.

### Point

Insert a function from the Navigation window or the Element Selection window by dragging or dropping it to the ST editor.
Entering function block

Enter a function block.

Entering function block call statement

■ Entering instance of function block

Enter the defined function block.

Operating procedure

1. Enter the instance name, "FbPou_1" (example).
2. By pressing the \[Esc\] key on the instance name, the "Undefined Label Registration" screen is displayed.
3. Set the following items and register the instance.
   • Registered Destination: Local label
   • Class: VAR
   • Data Type: FbPou

By selecting "Function Block" in "Type Category" at data type selection, the defined function block can be selected.

The registered instance name is displayed with the color for labels.

Enter arguments

Enter the argument in accordance with the tooltip.

Operating procedure

1. By entering ",", the format of function block is displayed in the tooltip.
2. Enter the argument in accordance with the tooltip. Delimit the multiple argument using commas ",".
3. Enter ")" at the end of the argument.
4. Enter ";" which indicates the end of the call statement.

For the defined function block, the arguments can also be inserted using the template.

By pressing the \[Ins\]+\[Esc\] keys, the template of the selected instance name is displayed.

FbPou_1(i_wValue := vValue0, o_wValue := vValue1);

The argument can be selected by the following functions.

• [Edit] ⇒ [Display Template](\[Ins\] + \[Esc\])
• [Edit] ⇒ [Mark Template (Left)]/[Mark Template (Right)](\[Ins\] + \[Alt\] + \[Left\]/\[Right\])
Selecting function blocks from the Navigation window or the Element Selection window

Insert a function block by selecting it from the Navigation window or the Element Selection window.

- Insert a function block from the Navigation window or the Element Selection window by dragging or dropping it to the ST editor.
6.4 Converting and Debugging Programs

The created program is required to be converted to the code which can be executed in the CPU module of a programmable controller (execution program).

An illegal program is checked at the conversion. Modify the program according to the displayed message.

Converting programs

Convert the created program to the executable code.

Operating procedure

1. Execute [Convert] ⇒ [Convert] ( ).

Point

By performing the conversion ( ), only the added or changed program is converted.

When converting all programs including the converted programs, perform the following function.

• [Convert] ⇒ [Rebuild All] ([ ] + [ ] + [ ])

Checking error/warning

An illegal program is checked at the conversion, and an error/warning message is displayed.

Convert the following program as an example.

Program example

1. (*wValue0 := D10 - 123;)
2. wValue0 = D10 - 123;  The assignment symbol is different.
3. IF wValue0 < 0 THEN
4. bFlag0 := TRUE; (* ON *)
5. ELSE
6. bFlag0 := FALSE; (* OFF *)
7. (*END_IF;*)
8. END_IF  ; does not exist at the end of statement.
9. (*bResult := FunPou( wValue0 );*)
10. FunPou( wValue0 );  A return value is not used.
11. FbPou_1(i_iValue := wValue0,)
12. (* o_iValue := wValue1;*)
13. o_iValue := wValue1;  The output variable is "i".

Operating procedure

1. Double-click the error/warning message displayed on the Output window.

2. The cursor is moved to the corresponding error location.

Modify the program according to the message.

```plaintext
1. (*wValue0 := D10 - 123;*)
2. wValue0 = D10 - 123;
```
If the program cannot be analyzed, check the statement above and below. An error location is underlined.

```java
8: (*END_IF;*)
9: END_IF;
10: (*END_IF;*)
11: (*bResult := FunPou( nValue0 );*)
12: FunPou( nValue0 );
```

If only a warning occurs, the conversion is completed.

### 6.5 Checking Execution on CPU Module

Execute the converted execution program by writing it to the CPU module of a programmable controller. Check if the program is running properly by monitoring the running program.

**Operating procedure**

1. Connect a personal computer to the CPU module, and set the connection target in the engineering tool (GX Works3).
2. Change the operation status of the CPU module to 'STOP'.
3. Select [Online] ⇒ [Write to PLC] to write "Program".
   - Write "Parameter" according to change of the system or device settings.
   - When using global labels, write "Global Label Setting".
   - When using devices/labels of which initial values are set, write "Local Label Initial Value", "Global Label Initial Value", or "Device Initial Value".
4. Reset the CPU module.
5. Change the operation status of the CPU module to 'RUN'.

---

**Conversion is completed despite of occurrence of 'Warning'.**

---

**Executing programs in the programmable controller**

The following shows the procedure to execute an execution program in a CPU module.
Checking the running program

The following shows how to check the running program on the program editor.

Operating procedure

Select [Online] ⇒ [Monitor] ⇒ [Start Monitoring](+) / [Stop Monitoring](-) / [Restart Monitoring]().

Display of current values

The following shows the display of the monitoring value on the ST editor.

■ Bit type

The monitoring values of bit types are displayed on the program as follows;
- TRUE: T
- FALSE: F

■ Other than bit type

The monitoring values other than bit types are displayed on the right side of the split window.

Point

Place the cursor on the device/label name to display a monitoring value on the tooltip.

Changing current values

The current value of the devices and labels can be changed with the following method.

Operating procedure

1. Select the device/label of which current value is to be changed on the ST editor.
2. Click the (Shift)+ (Enter) keys. (Or double-click while pressing the (Shift) key)

The devices/labels other than bit type are registered to the Watch window. Change the current value on the Watch window.

■ Changing current values on the Watch window

The current values of devices/labels registered to the Watch window can be changed by the following method.

Operating procedure

1. Select [Online] ⇒ [Watch] ⇒ [Start Watching](+/-) / [Stop Watching](-+)
2. Enter a value to which “Current Value” is to be changed directly while monitoring.

Point

Devices/labels can be registered to the Watch window by any of the following operations.
- Drag and drop the devices/labels from the ST editor to the Watch window.
- [Tool] ⇒ [Options] ⇒ “Monitor” ⇒ “ST Editor” ⇒ “Setting for Automatic Registration to Watch Window”
6.6 Inserting ST Program in Ladder Program (Inline structured text)

When describing a part of a ladder program using an ST program, use the Inline structured text function. An ST program can be described instead of the ladder instructions by using an inline structured text.

Operating procedure

1. Select [Edit] \(\Rightarrow\) [Inline Structured Text] \(\Rightarrow\) [Insert Inline Structured Text Box](+). 
2. Edit the ST program in the inline structured text box. 
   For details on how to edit the program in an inline structured text box is the same as that of the ST editor. 
3. Convert the ladder program. 
   Inline structured text is compiled (converted) as a part of the ladder program.

Point

Enter ‘STB’ on the ladder entry dialog to insert an inline structured text box.
This part shows the examples of ST programming with simple functions.

7 OVERVIEW OF PROGRAM EXAMPLE

8 CALCULATOR PROCESSING (BASIC ARITHMETIC OPERATION AND SELECTION)

9 POSITIONING PROCESSING (EXPONENT FUNCTION, TRIGONOMETRIC FUNCTION AND STRUCTURE)

10 SORTING OF DEFECTIVE PRODUCTS (ARRAY AND ITERATION PROCESSING)

11 MEASUREMENT OF OPERATING TIME (TIME AND CHARACTER STRING)
This chapter explains the list of program examples and their usage.

### 7.1 List of Program Example

In the part 2, the following program examples are described using the simple applications.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calculator</strong></td>
<td><strong>processing</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basic arithmetic expression Selection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Selection statement (IF)</td>
<td>Page 64 Initialization Program: Initialization</td>
</tr>
<tr>
<td></td>
<td>Assignment of integer, real number, and boolean value</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Selection statement (CASE)</td>
<td>Page 65 Basic Arithmetic Operation (FUN): Calculation</td>
</tr>
<tr>
<td></td>
<td>Basic arithmetic expression</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Round down/round up/rounds off of integer</td>
<td>Page 66 Rounding Processing (FUN): Rounding</td>
</tr>
<tr>
<td></td>
<td>Operation of integer and real number</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type conversion of integer and real number</td>
<td>Page 67 Fraction Processing (FUN): FractionProcessing</td>
</tr>
<tr>
<td></td>
<td>Hierarchization of selection statement</td>
<td>Page 69 Calculator Program: Calculator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Page 71 Post-Tax Price Calculation: IncludingTax</td>
</tr>
<tr>
<td><strong>Positioning</strong></td>
<td><strong>processing</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exponent function</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trigonometric function (TAN(^{-1}))</td>
<td>Page 73 Rotation Angle Calculation (FUN): GetAngle</td>
</tr>
<tr>
<td></td>
<td>Structure type argument</td>
<td>Page 74 Distance Calculation (FUN): GetDistance</td>
</tr>
<tr>
<td></td>
<td>Operation of structure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exponent function (exponentiation, square root)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trigonometric function (COS, SIN)</td>
<td>Page 75 X, Y-Coordinate Calculation (FUN): GetXY</td>
</tr>
<tr>
<td></td>
<td>Structure type return value</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operation of integer and real number</td>
<td>Page 76 Command Pulse Calculation (FB): PulseNumberCalculation</td>
</tr>
<tr>
<td></td>
<td>Assignment of structure</td>
<td>Page 77 Positioning Control: PositionControl</td>
</tr>
<tr>
<td><strong>Sort of defective</strong></td>
<td>products</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Array</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iteration processing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two dimensional array</td>
<td>Page 80 Product Check (FB): ProductCheck</td>
</tr>
<tr>
<td></td>
<td>Operation of array</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Array type argument</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hierarchization of iteration statement and selection statement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Structure which includes array type member</td>
<td>Page 82 Sorting Product Data (FB): Assortment</td>
</tr>
<tr>
<td></td>
<td>Structure array</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Initialization of array element</td>
<td>Page 83 Product Data Management: DataManagement</td>
</tr>
<tr>
<td></td>
<td>Argument specification of array</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iteration statement (FOR, WHILE, REPEAT)</td>
<td></td>
</tr>
<tr>
<td><strong>Measurement of</strong></td>
<td><strong>running time</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Character string</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time type data</td>
<td>Page 86 Operating Time Management: OperatingTime</td>
</tr>
<tr>
<td></td>
<td>Contact, coil, and current value of timer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Timer</td>
<td>Page 87 Flicker Timer (FB): FlickerTimer</td>
</tr>
<tr>
<td></td>
<td>Operation of boolean value</td>
<td>Page 88 Lamp ON/OFF: LampOnOff</td>
</tr>
<tr>
<td></td>
<td>Clock data (INT type array data)</td>
<td>Page 89 Conversion from Sec. to Hour/Min/Sec: SecondsToTimeArray</td>
</tr>
<tr>
<td></td>
<td>Time type data</td>
<td>Page 90 Conversion from Time to String: TimeToString</td>
</tr>
<tr>
<td></td>
<td>String data</td>
<td></td>
</tr>
</tbody>
</table>
7.2 Applying Program Example in GX Works3

This manual shows the program examples to be created in the Structured Text language using GX Works3.

Considerations

The program examples described in this manual do not guarantee the actual operation. When applying program examples to the actual system, make sure to match the program example with the system and its required operation. Assign the devices for the labels used in the program example according to the equipment to be used as necessary. Set the parameters in accordance with the equipment or devices to be used as necessary.

Application procedure of sample program

Apply the sample program by the following procedure.

1. Set the global labels on the label editor. (Page 48 Registering labels on the label editor)
   • When using a structure, create a new structure definition and set the structure.

2. Create a POU.
   • Set the local labels. (Page 48 Registering labels on the label editor)
   • Apply a program example to the program. (Page 45 Copying/pasting data among editors)

When a POU defined in this manual is used in the sample program, create the function or the function block in the same project. (Page 49 Creating new data)

3. Convert the program. (Page 55 Converting and Debugging Programs)

Point

When reading this manual in PDF or e-Manual format, a sample program can easily be applied by copying and pasting it.
8 CALCULATOR PROCESSING (BASIC ARITHMETIC OPERATION AND SELECTION)

This chapter shows the program examples for the processing such as basic arithmetic operations and selections in the program that enables calculator processing.

Create the following POUs in the program example.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initialization</td>
<td>Program block</td>
<td>Initializes variables when a clear instruction is issued.</td>
<td>Page 64 Initialization Program: Initialization</td>
</tr>
<tr>
<td>Calculation</td>
<td>Function</td>
<td>Adds, subtracts, multiplies, or divides two values.</td>
<td>Page 65 Basic Arithmetic Operation (FUN): Calculation</td>
</tr>
<tr>
<td>Rounding</td>
<td>Function</td>
<td>Rounds down/rounds up/rounds off a variable.</td>
<td>Page 66 Rounding Processing (FUN): Rounding</td>
</tr>
<tr>
<td>FractionProcessing</td>
<td>Function</td>
<td>Rounds a value right after the specified decimal place.</td>
<td>Page 67 Fraction Processing (FUN): FractionProcessing</td>
</tr>
<tr>
<td>Calculator</td>
<td>Program block</td>
<td>Operates values in accordance with the input.</td>
<td>Page 69 Calculator Program: Calculator</td>
</tr>
<tr>
<td>IncludingTax</td>
<td>Program block</td>
<td>Calculates post-tax price and amount of tax, and displays the post-tax price when a post-tax calculation instruction is issued.</td>
<td>Page 71 Post-Tax Price Calculation: IncludingTax</td>
</tr>
</tbody>
</table>

Overview of function

The following processing are performed.

- When the clear key is input, the current value (previous calculation result) and displayed value are initialized.
- The displayed value is updated according to the input of the ten key. The value after decimal point is rounded depending on the setting of the slide switches.
- When the post-tax calculation key is input, a post-tax price is displayed.

<table>
<thead>
<tr>
<th>Device</th>
<th>Number</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1) Decimal part specification switch</td>
<td>0 to 5 Specifies the number of digits after a decimal point to be displayed. The values after the specified digits are processed with the setting of the Rounding processing switch.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Rounding processing switch</td>
<td>Round up (↑) Adds 1 to the specified digit if the digit right after the specified digit is other than 0.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Round off (5/4) Rounds off the value right after the specified digit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Round down (↓) ROUNDS down the value under the specified digits.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3) Post-tax calculation key</td>
<td>Calculates post-tax price.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4) Clear key</td>
<td>Initializes current value (previous calculation result) and displayed value.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5) Ten key</td>
<td>0 to 5 decimal point (.) Enters a numerical value.</td>
</tr>
</tbody>
</table>

Global labels to be used

The following shows the global labels and structure definitions used in the program example.

Set the following items in GX Works3.

- **Global label**

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/ Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_eDisplayValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Display value</td>
</tr>
<tr>
<td>G_eLastValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Current value (Previous calculation result)</td>
</tr>
<tr>
<td>G_wSwitch1</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Setting value of switch (0 to 5: Number of decimal part, 6: Floating point)</td>
</tr>
<tr>
<td>Label Name</td>
<td>Data Type</td>
<td>Class</td>
<td>Assign/Initial Value/ Constant</td>
<td>Comment</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------</td>
<td>---------------</td>
<td>-------------------------------</td>
<td>--------------------------------------------------------------</td>
</tr>
<tr>
<td>G_wSwitch2</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>---</td>
<td>Setting value of switch (0: Round down, 1: Round up, 2: Round off)</td>
</tr>
<tr>
<td>G_bTax</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>---</td>
<td>Post-tax calculation key input</td>
</tr>
<tr>
<td>G_bClear</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>---</td>
<td>Clear-key input</td>
</tr>
<tr>
<td>G_wTenKey</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>---</td>
<td>Ten-key input (0 to 9: Numerical value, 10: Decimal point, 11 to 14: Basic arithmetic operation, 15: =)</td>
</tr>
<tr>
<td>G_wOperation</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>---</td>
<td>Operation type</td>
</tr>
<tr>
<td>G_eDecimal</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>Initial Value: 0</td>
<td>Operation for decimal part</td>
</tr>
</tbody>
</table>

**Structure**

Do not use.
8.1 Initialization Program: Initialization

This program initializes variables when a clear instruction is issued.
Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Block</td>
<td>Initialization</td>
<td>ST</td>
<td>Initialization</td>
</tr>
</tbody>
</table>

**Program example**

(`* Initialize the variables when a clear instruction is issued. *`)

IF G_bClear THEN
  G_eDisplayValue := 0.0;
  G_eLastValue := 0.0;
  G_wOperation := 0;
  G_eDecimal := 0.0;
  G_bClear := FALSE;
END_IF;

**Point**

The values of each variable at first execution depend on the label settings or the setting of the assigned devices.
Global labels can be used in all programs in the project.
Statements in an IF statement are executed when its conditional expression is TRUE. It is not executed when the conditional expression is FALSE.

**Variable**

Define the labels by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/ Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_bClear</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Clear-key input</td>
</tr>
<tr>
<td>G_eDisplayValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Display value</td>
</tr>
<tr>
<td>G_eLastValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Current value (Previous calculation result)</td>
</tr>
<tr>
<td>G_wOperation</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operation type</td>
</tr>
<tr>
<td>G_eDecimal</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>Initial Value: 0</td>
<td>Operation for decimal part</td>
</tr>
</tbody>
</table>

**Global label**

Do not use.

**Local label**

Do not use.

**POU**

Do not use.
8.2 Basic Arithmetic Operation (FUN): Calculation

This function performs basic arithmetic operation for two values according to the specified operation type.

Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Result Type</th>
<th>EN/ENO</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Calculation</td>
<td>ST</td>
<td>FLOAT [Single Precision]</td>
<td>No</td>
<td>Basic arithmetic operation</td>
</tr>
</tbody>
</table>

Program example

(* Add, subtract, multiply, or divide value 2 to/from value 1.*)

CASE i_wOperation OF

1: (* Operation type is addition: Operation result = Value 1 + Value 2 *)
   Calculation := i_eValue1 + i_eValue2;

2: (* For subtraction *)
   Calculation := i_eValue1 - i_eValue2;

3: (* For multiplication *)
   Calculation := i_eValue1 * i_eValue2;

4: (* For division *)
   IF i_eValue2 = 0.0 THEN (* If the value 2 is 0, do not operate. *)
   Calculation := i_eValue1;
   ELSE
   Calculation := i_eValue1 / i_eValue2;
   END_IF;
END_CASE;

CASE statement selects an execution statement depending on the condition of the integer value. The statement which does not match the condition is not executed. Selection statement (IF statement, CASE statement) can be hierarchized.

Variable

Define the labels by setting the following items in GX Works3. Result type can be set in the property of the function.

Local label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_eValue1</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Value 1</td>
</tr>
<tr>
<td>i_wOperation</td>
<td>Word [Signed]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Operation type</td>
</tr>
<tr>
<td>i_eValue2</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Value 2</td>
</tr>
</tbody>
</table>

Result type

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculation</td>
<td>FLOAT [Single Precision]</td>
<td>Operation result</td>
</tr>
</tbody>
</table>

POU

Do not use.
8.3 Rounding Processing (FUN): Rounding

This function rounds down/rounds up/rounds off the first digit of an integer variable. Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Result Type</th>
<th>EN/ENO</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Rounding</td>
<td>ST</td>
<td>Double Word [Signed]</td>
<td>No</td>
<td>Rounding processing</td>
</tr>
</tbody>
</table>

**Program example**

(* Round the first digit with the specified rounding method. *)

```
CASE i_wType OF
  0: (* Round down *)
    Rounding := i_dValue / 10 * 10; (* Round down the first decimal place *)
  1: (* Round up *)
    Rounding := (i_dValue + 9) / 10 * 10; (* Round up the first decimal place *)
  2: (* Round off *)
    Rounding := (i_dValue + 5) / 10 * 10; (* Round off the first decimal place *)
ELSE (* Input value is returned when the value is other than specified value. *)
    Rounding := i_dValue;
END_CASE;
```

For the division for an integer, the values after decimal point are rounded down.

**Variable**

Define the labels by setting the following items in GX Works3. Result type can be set in the property of the function.

- **Local label**

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_wType</td>
<td>Word [Signed]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Rounding method (0: Round down, 1: Round up, 2: Round off)</td>
</tr>
<tr>
<td>i_dValue</td>
<td>Double Word [Signed]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Input value</td>
</tr>
</tbody>
</table>

- **Result type**

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rounding</td>
<td>Double Word [Signed]</td>
<td>Operation result</td>
</tr>
</tbody>
</table>

**POU**

Do not use.
8.4 Fraction Processing (FUN): FractionProcessing

This function rounds a value right after the specified decimal place.
Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Result Type</th>
<th>EN/ENO</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>FractionProcessing</td>
<td>ST</td>
<td>FLOAT [Single Precision]</td>
<td>No</td>
<td>Fraction processing</td>
</tr>
</tbody>
</table>

**Program example**

(* Round a value right after the specified decimal place. *)
(* If the specified digit is out of the range, return the input value. *)

IF (i_wDigits <= 0) OR (i_wDigits > c_wMAX) THEN
    FractionProcessing := i_eValue;
    RETURN; (* End processing *)
END_IF;

(* Move the decimal point in order that the specified value becomes the first place. *)

wDigits := i_wDigits + 1;
eValue := i_eValue * (10.0 ** wDigits) - 0.5;

(* Perform the specified rounding processing for the first digit of an integer value. *)

dValue := Rounding(i_wType, REAL_TO_DINT(eValue));

(* Change the value to the real number, and move the decimal point back to its original position. *)

FractionProcessing := DINT_TO_REAL(dValue) / (10.0 ** wDigits);

**Variable**

Define the labels by setting the following items in GX Works3. Result type can be set in the property of the function.

**Local label**

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_eValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Input value</td>
</tr>
<tr>
<td>i_wDigits</td>
<td>Word [Signed]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Number of decimal part to be displayed (Decimal part: 0 to 5 digits)</td>
</tr>
<tr>
<td>i_wType</td>
<td>Word [Signed]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Rounding method (0: Round down, 1: Round up, 2: Round off)</td>
</tr>
<tr>
<td>c_wMAX</td>
<td>Word [Signed]</td>
<td>VAR_CONSTANT</td>
<td>Constant: 5</td>
<td>Maximum value of decimal place specification</td>
</tr>
<tr>
<td>wDigits</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Digits of decimal part for processing (Decimal part: 1 to 6 digits)</td>
</tr>
<tr>
<td>eValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Real number value (for internal calculation)</td>
</tr>
<tr>
<td>dValue</td>
<td>Double Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Integer value (for internal calculation)</td>
</tr>
</tbody>
</table>

**Result type**

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FractionProcessing</td>
<td>FLOAT [Single Precision]</td>
<td>Operation result</td>
</tr>
</tbody>
</table>

**POU**

For details on the POUs used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rounding</td>
<td>Function</td>
<td>Rounds down/rounds up/rounds off a variable.</td>
<td>Page 66 Rounding Processing (FUN): Rounding</td>
</tr>
<tr>
<td>Data name</td>
<td>Data type</td>
<td>Description</td>
<td>Reference</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------</td>
<td>-------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| REAL_TO_DINT| Standard function | Conversion of REAL type $\rightarrow$ DINT type  
               |                                                    | Converts a value from REAL type data to DINT type data.                  | MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks) |
| DINT_TO_REAL| Standard function | Conversion of DINT type $\rightarrow$ REAL type  
               |                                                    | Converts a value from DINT type data to REAL type data.                  | MELSEC iQ-F FX5 Programming Manual (Instructions, Standard Functions/Function Blocks)   |
8.5 Calculator Program: Calculator

This program updates the displayed value according to the input of the ten key. The values after decimal point are rounded depending on the setting of the Decimal place digit specification switch.

Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Block</td>
<td>Calculator</td>
<td>ST</td>
<td>Calculator</td>
</tr>
</tbody>
</table>

**Program example**

(* The processing is performed depending on the ten-key input. *)

IF G_wTenKey <> c_wNONE THEN

CASE G_wTenKey OF

0..9: (* For number-key input (0 to 9) *)

(* Add the input numeric value to the end of the display value. *)

IF G_eDecimal = 0.0 THEN

(* For integer part *)

G_eDisplayValue := (G_eDisplayValue * 10) + G_wTenKey;

ELSE (* For after decimal point *)

G_eDisplayValue := G_eDisplayValue + (G_eDecimal * G_wTenKey);

G_eDecimal := G_eDecimal * 0.1;

END_IF;

10: (* For input of decimal point key *)

G_eDecimal := 0.1;

11..14: (* For input of addition, subtraction, multiplication, or division key (11 to 14) *)

(* Retain the operation type *)

G_wOperation := G_wTenKey - 10;

(* Move the display value to the previous operation value and then reset the displayed value *)

G_eLastValue := G_eDisplayValue;

G_eDisplayValue := 0.0;

G_eDecimal := 0.0;

15: (* For equal-key input *)

(* Add, subtract, multiply, or divide the displayed value to/from the current value. *)

G_eLastValue := Calculation(G_eLastValue, G_wOperation, G_eDisplayValue);

(* Assign the rounding result to the display value. *)

G_eDisplayValue := FractionProcessing(G_eLastValue, G_wSwitch1, G_wSwitch2);

G_wOperation := 0; (* Clear the operation type *)

G_eDecimal := 0.0;

END_CASE;

(* Clear the key input *)

G_wTenKey := c_wNONE;

END_IF;

If the data type of the operators on the right side and left side differ, the data type of the operation result will be a bigger data type. (The operation result between INT type (Word [Signed]) and REAL type (FLOAT [Single Precision]) will be the REAL type (FLOAT [Single Precision]).)
Define the labels by setting the following items in GX Works3.

### Global label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_wTenKey</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Ten-key input (0 to 9: Numerical value, 10: Decimal point, 11 to 14: Basic arithmetic operation, 15: =)</td>
</tr>
<tr>
<td>G_eDecimal</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>Initial Value: 0</td>
<td>Operation for decimal part</td>
</tr>
<tr>
<td>G_wOperation</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operation type</td>
</tr>
<tr>
<td>G_eDisplay</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Display value</td>
</tr>
<tr>
<td>G_eLastValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Current value (Previous calculation result)</td>
</tr>
<tr>
<td>G_wSwitch1</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Setting value of switch (0 to 5: Number of decimal part, 6: Floating point)</td>
</tr>
<tr>
<td>G_wSwitch2</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Setting value of switch (0: Round down, 1: Round up, 2: Round off)</td>
</tr>
</tbody>
</table>

### Local label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>c_wNONE</td>
<td>Word [Signed]</td>
<td>VAR_CONSTANT</td>
<td>Constant: -1</td>
<td>No ten-key input</td>
</tr>
</tbody>
</table>

### POU

For details on the POUs used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculation</td>
<td>Function</td>
<td>Adds, subtracts, multiplies, or divides a current value to an input value.</td>
<td>Page 65 Basic Arithmetic Operation (FUN): Calculation</td>
</tr>
<tr>
<td>FractionProcessing</td>
<td>Function</td>
<td>Calculates a value by selecting round down/round up/round off at the specified decimal place.</td>
<td>Page 67 Fraction Processing (FUN): FractionProcessing</td>
</tr>
</tbody>
</table>
8.6 Post-Tax Price Calculation: IncludingTax

This program calculates post-tax price and amount of tax, and displays the post-tax price when a post-tax calculation instruction is issued.

Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Block</td>
<td>IncludingTax</td>
<td>ST</td>
<td>Post-tax price calculation</td>
</tr>
</tbody>
</table>

**Program example**

(* When a post-tax calculation instruction is issued, display the post-tax price. *)

IF G_bTax THEN

(* Calculate the amount of tax. (Calculate the values after decimal point as well.) *)

eTaxAmount := G_eDisplayValue * c_eTaxRate / 100.0;

(* Calculate the post-tax price. (Calculate the values after decimal point as well.) *)

G_eLastValue := G_eDisplayValue + eTaxAmount;

(* Set the post-tax price as a display value. (Values after decimal point are rounded off) *)

dPrice := REAL_TO_DINT(G_eLastValue);

G_eDisplayValue := DINT_TO_REAL(dPrice);

(* Clear the key input *)

G_bTax := FALSE;
END_IF;

When converting a real number type to an integer type, use the type conversion function such as REAL_TO_DINT.

The data after type conversion using REAL_TO_DINT will be the value of which first decimal place is rounded off of REAL type data.

**Variable**

Define the labels by setting the following items in GX Works3.

**Global label**

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/ Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_eDisplayValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Display value</td>
</tr>
<tr>
<td>G_eLastValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Current value (Previous calculation result)</td>
</tr>
<tr>
<td>G_bTax</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Post-tax calculation key input</td>
</tr>
</tbody>
</table>

**Local label**

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>c_eTaxRate</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_CONSTANT</td>
<td>Constant: 8.0</td>
<td>Rate of tax (%)</td>
</tr>
<tr>
<td>eTaxAmount</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Amount of tax</td>
</tr>
<tr>
<td>dPrice</td>
<td>Double Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Post-tax price</td>
</tr>
</tbody>
</table>

**POU**

For details on the POUs used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data Type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>REAL_TO_DINT</td>
<td>Standard function</td>
<td>Converting REAL to DINT Converts a value from REAL type data to DINT type data.</td>
<td>MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks) MELSEC iQ-F FX5 Programming Manual (Instructions, Standard Functions/Function Blocks)</td>
</tr>
<tr>
<td>DINT_TO_REAL</td>
<td>Standard function</td>
<td>Converting DINT to REAL Converts a value from DINT type data to REAL type data.</td>
<td></td>
</tr>
</tbody>
</table>
This chapter shows the examples of programs for calculating position on an X, Y-coordinate and amount of rotation of a device, and data processing using an exponent function, arithmetic operation of trigonometric function, or structure. Create the following POUs in the program example.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetAngle</td>
<td>Function</td>
<td>Calculates a rotation angle for the target X, Y-coordinate.</td>
<td>Page 73 Rotation Angle Calculation (FUN): GetAngle</td>
</tr>
<tr>
<td>GetDistance</td>
<td>Function</td>
<td>Calculates the distance between two points from X, Y-coordinate.</td>
<td>Page 74 Distance Calculation (FUN): GetDistance</td>
</tr>
<tr>
<td>GetXY</td>
<td>Function</td>
<td>Calculates X, Y-coordinate from radius and angle.</td>
<td>Page 75 X, Y-Coordinate Calculation (FUN): GetXY</td>
</tr>
<tr>
<td>PulseNumberCalculation</td>
<td>Function block</td>
<td>Calculates number of command pulses to a motor from the movement amount.</td>
<td>Page 76 Command Pulse Calculation (FB): PulseNumberCalculation</td>
</tr>
<tr>
<td>PositionControl</td>
<td>Program block</td>
<td>Calculates the angle and length of the arm to be moved from the target X, Y-coordinate.</td>
<td>Page 77 Positioning Control: PositionControl</td>
</tr>
</tbody>
</table>

Overview of function

This function calculates the rotation angle of the arm and number of command pulses of the motor for adjusting the length of the arm in order to move the head of the arm to the target X, Y-coordinate with the following procedure.

1. Rotate the arm towards the target specified in X, Y-coordinate.
2. Extend the head of the arm towards the target using a stepping motor.

Global labels to be used

The following shows the global labels and structure definitions used in the program example.

Set the following items in GX Works3.

Global label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_stTarget</td>
<td>sPosition</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Target (X, Y-coordinate)</td>
</tr>
<tr>
<td>G_stArm</td>
<td>sPosition</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Head of the arm (X, Y-coordinate)</td>
</tr>
<tr>
<td>G_eAngle</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Rotation angle (Degree)</td>
</tr>
<tr>
<td>G_ePulses</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Number of command pulses of the motor</td>
</tr>
<tr>
<td>G_bOneScanOnly</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>Assign (Device/Label): SM402</td>
<td>Turn ON for only 1 scan after RUN</td>
</tr>
</tbody>
</table>

Structure

<table>
<thead>
<tr>
<th>Structure name</th>
<th>Label Name</th>
<th>Data Type</th>
<th>Initial Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>sPosition</td>
<td>eXcoordinate</td>
<td>FLOAT [Single Precision]</td>
<td>0.0</td>
<td>X-coordinate</td>
</tr>
<tr>
<td></td>
<td>eYcoordinate</td>
<td>FLOAT [Single Precision]</td>
<td>0.0</td>
<td>Y-coordinate</td>
</tr>
</tbody>
</table>
9.1 Rotation Angle Calculation (FUN): GetAngle

This function calculates the rotation angle (0 to 180) for the target X, Y-coordinate.

![Diagram of rotation angle calculation]

**Program example**

(* Calculate radian from X, Y-coordinate, and convert the radian to degree. *)

(* If X-coordinate is 0, 90 degree (End processing without calculation.) *)

IF i_eXcoordinate = 0.0 THEN
  GetAngle := 90.0;
  ENO := TRUE;
  RETURN; (* End processing. *)
END_IF;

(* Calculate radian from X-coordinate and Y-coordinate. *)

eAngleRad := ATAN(i_eYcoordinate / i_eXcoordinate); (* Angle (radian) rad = ATAN (Y-coordinate/X-coordinate) *)

(* Error end if the data which cannot be handled with ATAN instruction is included *)

IF SD0 = H3402 THEN (* Error code : 3402H (Operation error) *)
  ENO := FALSE;
  RETURN; (* End processing *)
ELSE
  ENO := TRUE;
END_IF;

(* Convert radian to degree. *)

GetAngle := eAngleRad * 180.0 / c_ePi; (* Angle (degree) = Angle (radian) rad * 180/pi *)

(* If X-coordinate is negative, add 180 degree. *)

IF i_eXcoordinate < 0.0 THEN
  GetAngle := GetAngle + 180.0;
END_IF;

**Point**

DEG instruction can be used for the conversion from single-precision real number radian to angle. SD0 is a device for error check. The latest error code will be stored to it.

**Variable**

Define the labels by setting the following items in GX Works3. Result type can be set in the property of the function.

### Local label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_eXcoordinate</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>X-coordinate</td>
</tr>
<tr>
<td>i_eYcoordinate</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Y-coordinate</td>
</tr>
<tr>
<td>eAngleRad</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Angle (radian)</td>
</tr>
<tr>
<td>c_ePi</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_CONSTANT</td>
<td>Constant: 3.14159</td>
<td>Circular constant</td>
</tr>
</tbody>
</table>
### Distance Calculation (FUN): GetDistance

This function calculates the distance between two points from X, Y-coordinate. Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Result Type</th>
<th>EN/ENO</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>GetDistance</td>
<td>ST</td>
<td>FLOAT [Single Precision]</td>
<td>No</td>
<td>Distance calculation</td>
</tr>
</tbody>
</table>

(* Calculate distance between two points from X, Y-coordinate.*)

GetDistance := SQRT((i_stPosition0.eXcoordinate - i_stPosition1.eXcoordinate) ** 2.0 + (i_stPosition0.eYcoordinate - i_stPosition1.eYcoordinate) ** 2.0);

**Point**

The argument of a structure can be specified for a function/function block. Structure member can be specified to the operand (operation target value) of the operational expression, and left side and right side of the iteration statement.

**'** is the operator of an exponentiation.

### Variable

Define the labels by setting the following items in GX Works3. Result type can be set in the property of the function.

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_stPosition0</td>
<td>stPosition</td>
<td>VAR_INPUT</td>
<td>---</td>
<td>Position 0 (X, Y-coordinate)</td>
</tr>
<tr>
<td>i_stPosition1</td>
<td>stPosition</td>
<td>VAR_INPUT</td>
<td>---</td>
<td>Position 1 (X, Y-coordinate)</td>
</tr>
</tbody>
</table>

### Result type

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetDistance</td>
<td>FLOAT [Single Precision]</td>
<td>Distance between two points</td>
</tr>
</tbody>
</table>

### Structure

<table>
<thead>
<tr>
<th>Structure name</th>
<th>Label Name</th>
<th>Data Type</th>
<th>Initial Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>stPosition</td>
<td>eXcoordinate</td>
<td>FLOAT [Single Precision]</td>
<td>0.0</td>
<td>X-coordinate</td>
</tr>
<tr>
<td></td>
<td>eYcoordinate</td>
<td>FLOAT [Single Precision]</td>
<td>0.0</td>
<td>Y-coordinate</td>
</tr>
</tbody>
</table>

### POU

For details on the POUs used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQRT</td>
<td>Standard function</td>
<td>Square root Outputs the square root of an input value.</td>
<td>MELSEC IQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks) MELSEC IQ-F FX5 Programming Manual (Instructions, Standard Functions/Function Blocks)</td>
</tr>
</tbody>
</table>
9.3 X, Y-Coordinate Calculation (FUN): GetXY

This function calculates X, Y-coordinate from the specified radius and angle.

\[ \begin{align*}
\theta &= \text{Angle (degree)} \times \frac{\pi}{180} \\
X &= \text{radius} \times \cos(\theta) \\
Y &= \text{radius} \times \sin(\theta)
\end{align*} \]

Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Result Type</th>
<th>EN/ENO</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>GetXY</td>
<td>ST</td>
<td>stPosition</td>
<td>No</td>
<td>X, Y-coordinate calculation</td>
</tr>
</tbody>
</table>

**Program example**

(* Convert the unit from degree to radian. *)

\[
e\text{AngleRad} := i\_e\text{Angle} \times c\_e\Pi / 180.0; (* \text{Angle (radian)} = \text{Angle (degree)} \times \pi/180 *)
\]

(* Calculate X, Y-coordinate. *)

\[
\text{GetXY.eXcoordinate} := i\_e\text{Radius} \times \cos(e\text{AngleRad}); (* \text{X-coordinate} = \text{Radius} \times \cos(\text{rad}) *)
\]

\[
\text{GetXY.eYcoordinate} := i\_e\text{Radius} \times \sin(e\text{AngleRad}); (* \text{Y-coordinate} = \text{Radius} \times \sin(\text{rad}) *)
\]

**Point**

A structure type can be specified to the Result Type of a function. RAD instruction can be used for the conversion from single-precision real number angle to radian.

**Variable**

Define the labels by setting the following items in GX Works3. Result type can be set in the property of the function.

■Local label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_eRadius</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Radius (mm)</td>
</tr>
<tr>
<td>i_eAngle</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Angle (degree): 0 to 180</td>
</tr>
<tr>
<td>e\text{AngleRad}</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Angle (radian)</td>
</tr>
<tr>
<td>c_e\Pi</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_CONSTANT</td>
<td>Constant: 3.14159</td>
<td>Circular constant</td>
</tr>
</tbody>
</table>

■Result type

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetXY</td>
<td>stPosition</td>
<td>X, Y-coordinate</td>
</tr>
</tbody>
</table>

■Structure

<table>
<thead>
<tr>
<th>Structure name</th>
<th>Label Name</th>
<th>Data Type</th>
<th>Initial Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>stPosition</td>
<td>e\text{Xcoordinate}</td>
<td>FLOAT [Single Precision]</td>
<td>0.0</td>
<td>X-coordinate</td>
</tr>
<tr>
<td></td>
<td>e\text{Ycoordinate}</td>
<td>FLOAT [Single Precision]</td>
<td>0.0</td>
<td>Y-coordinate</td>
</tr>
</tbody>
</table>

**POU**

For details on the POUs used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>COS</td>
<td>Standard function</td>
<td>COS operation Outputs COS (cosine) of an input value.</td>
<td>MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks)</td>
</tr>
<tr>
<td>SIN</td>
<td>Standard function</td>
<td>SIN operation Outputs SIN (sine) of an input value.</td>
<td>MELSEC iQ-F FX5 Programming Manual (Instructions, Standard Functions/Function Blocks)</td>
</tr>
</tbody>
</table>
9.4 Command Pulse Calculation (FB): PulseNumberCalculation

This function block calculates number of command pulses to a motor from the movement amount.
Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>EN/ENO</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function Block</td>
<td>PulseNumberCalculation</td>
<td>ST</td>
<td>No</td>
<td>Command pulse calculation</td>
</tr>
</tbody>
</table>

Program example

(* Calculate the number of command pulses. *)

IF e1round <> 0.0 THEN
  (* Number of command pulses = Motor resolution*(Target movement amount/Movement amount for one motor rotation) *)
  o_ePulses := eResolution * (i_eDistance / e1round);
END_IF;

Variable

Define the labels by setting the following items in GX Works3.

Local label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_eDistance</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Target movement amount (mm)</td>
</tr>
<tr>
<td>o_ePulses</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_OUTPUT</td>
<td>—</td>
<td>Number of command pulses of motor (pulse)</td>
</tr>
<tr>
<td>e1round</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Movement amount for one motor rotation (mm/rev)</td>
</tr>
<tr>
<td>eResolution</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Motor resolution (Pulse/rev)</td>
</tr>
</tbody>
</table>

POU

Do not use.
9.5 Positioning Control: PositionControl

This program calculates the angle and length of the arm to be moved from the target X, Y-coordinate. Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Block</td>
<td>PositionControl</td>
<td>ST</td>
<td>Positioning control</td>
</tr>
</tbody>
</table>

### Program example

(* Calculate the rotation angle and number of command pulses of the motor for adjusting the length of the arm in order to move the head of the arm to the target X, Y-coordinate. *)

(* Set the initial value to the coordinate of the arm only at the first time after RUN. *)

IF G_bOneScanOnly THEN
  G_stArm.eXcoordinate := 500.0;
  G_stArm.eYcoordinate := 0.0;
END_IF;

(* The position of the target will be set to the global variable, G_stTarget in other program. [The program is omitted in this program example.] *)

(* Calculate the moving angle of the arm for the target X, Y-coordinate. *)

eTargetAngle := GetAngle( TRUE, bResult1, G_stTarget.eXcoordinate, G_stTarget.eYcoordinate );
eArmAngle := GetAngle( bResult1, bResult2, G_stArm.eXcoordinate, G_stArm.eYcoordinate );

IF bResult2 THEN
  G_eAngle := eTargetAngle - eArmAngle;
ELSE
  RETURN; (* Error end *)
END_IF;

(* Calculate the current length of the arm (distance from origin) from the X, Y-coordinate of the head of the arm. *)
eDistance := GetDistance( G_stArm, stOrigin ); (* Input variable is a function call of structure *)

(* Calculate the X, Y-coordinate of the head of the arm after the rotation. *)
G_stArm := GetXY( eDistance, G_eAngle); (* Return value is a function call of structure *)

(* Calculate the distance between two points from the X, Y-coordinate of the target and head of the arm. *)
eDistance := GetDistance( G_stTarget, G_stArm );

(* Calculate the number of command pulses to the motor for adjusting the length of the arm from the movement amount. *)
PulseNumberCalculation_1(i_eDistance := eDistance, o_ePulses => G_ePulses ); (* Function block call *)

(* Rotate the arm by specifying the angle. [The program is omitted in this program example.] *)

(* Stretch the head of the arm by specifying the number of command pulses of the motor. [The program is omitted in this program example.] *)

(* Update the coordinate of the arm. *)
G_stArm := G_stTarget;

---

**Point**

When creating a function and function block, whether or not to use an EN and ENO can be selected. If FALSE is specified to EN, the processing is not executed. ENO becomes FALSE. Specify the output valuable using "=>" for a function block instance.
Variable
Define the labels by setting the following items in GX Works3.

### Global label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_bOneScanOnly</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>Assign (Device/Label): SM402</td>
<td>Turn ON for only 1 scan after RUN</td>
</tr>
<tr>
<td>G_stTarget</td>
<td>stPosition</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Target (X, Y-coordinate)</td>
</tr>
<tr>
<td>G_stArm</td>
<td>stPosition</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Head of arm (X, Y-coordinate)</td>
</tr>
<tr>
<td>G_eAngle</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Rotation angle (degree)</td>
</tr>
<tr>
<td>G_ePulses</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Number of command pulses of motor (pulse)</td>
</tr>
</tbody>
</table>

### Local label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>eTargetAngle</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Angle to the target (degree): 0 to 180</td>
</tr>
<tr>
<td>eArmAngle</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Angle of arm (degree): 0 to 180</td>
</tr>
<tr>
<td>bResult1</td>
<td>Bit</td>
<td>VAR</td>
<td>—</td>
<td>Operation result 1</td>
</tr>
<tr>
<td>bResult2</td>
<td>Bit</td>
<td>VAR</td>
<td>—</td>
<td>Operation result 2</td>
</tr>
<tr>
<td>stOrigin</td>
<td>stPosition</td>
<td>VAR</td>
<td>—</td>
<td>Origin (X, Y-coordinate = 0. 0)</td>
</tr>
<tr>
<td>eDistance</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Distance</td>
</tr>
<tr>
<td>PulseNumberCalculation_1</td>
<td>PulseNumberCalculation</td>
<td>VAR</td>
<td>Initial Value</td>
<td>Calculation of number of command pulses</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• e1round: 0.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• eResolution: 3000.0</td>
<td></td>
</tr>
</tbody>
</table>

### Structure

<table>
<thead>
<tr>
<th>Structure name</th>
<th>Label Name</th>
<th>Data Type</th>
<th>Initial Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>stPosition</td>
<td>eXcoordinate</td>
<td>FLOAT [Single Precision]</td>
<td>0.0</td>
<td>X-coordinate</td>
</tr>
<tr>
<td></td>
<td>eYcoordinate</td>
<td>FLOAT [Single Precision]</td>
<td>0.0</td>
<td>Y-coordinate</td>
</tr>
</tbody>
</table>

**Point**

The setting for initial values of labels does not exist for the MELSEC iQ-F series; therefore, set the initial values by using a program or a watch window of an engineering tool.

### POU

For details on the POU used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetAngle</td>
<td>Function</td>
<td>Calculates angle for the target X, Y-coordinate.</td>
<td>Page 73 Rotation Angle Calculation (FUN): GetAngle</td>
</tr>
<tr>
<td>GetXY</td>
<td>Function</td>
<td>Calculates X, Y-coordinate from radius and angle.</td>
<td>Page 75 X, Y-Coordinate Calculation (FUN): GetXY</td>
</tr>
<tr>
<td>GetDistance</td>
<td>Function</td>
<td>Calculates distance between two points from X, Y-</td>
<td>Page 74 Distance Calculation (FUN): GetDistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>coordinate.</td>
<td></td>
</tr>
<tr>
<td>PulseNumberCalculation</td>
<td>Function block</td>
<td>Calculates number of command pulses to a motor</td>
<td>Page 76 Command Pulse Calculation (FB):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>from the movement amount.</td>
<td>PulseNumberCalculation</td>
</tr>
</tbody>
</table>
10 SORTING OF DEFECTIVE PRODUCTS (ARRAY AND ITERATION PROCESSING)

This chapter shows the examples for an iteration statement using an array in the program which organizes multiple product data.

Create the following POUs in the program example.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProductCheck</td>
<td>Function block</td>
<td>Judges the products as non-defective or defective from the product data.</td>
<td>Page 80 Product Check (FB): ProductCheck</td>
</tr>
<tr>
<td>Assortment</td>
<td>Function block</td>
<td>Sorts product data into non-defectives and defectives.</td>
<td>Page 82 Sorting Product Data (FB): Assortment</td>
</tr>
<tr>
<td>DataManagement</td>
<td>Program block</td>
<td>Organizes product data.</td>
<td>Page 83 Product Data Management: DataManagement</td>
</tr>
</tbody>
</table>

Overview of function

This function sorts product data into non-defectives and defectives by checking the data of the multiple products of which sizes and weights are measured.

Global labels to be used

The following shows the global labels and structure definitions used in the program example.

Set the following items in GX Works3.

Global label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_eValueArray</td>
<td>FLOAT <a href="0..7,0..1">Single Precision</a></td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Measured values for all products (Values are stored in order of product number.)</td>
</tr>
</tbody>
</table>
10.1  Product Check (FB): ProductCheck

This function block checks if the value is within the allowable range.
Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>EN/ENO</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function Block</td>
<td>ProductCheck</td>
<td>ST</td>
<td>No</td>
<td>Product check</td>
</tr>
</tbody>
</table>

Program example

(* Check if the values of each element in the array are within the allowable range. *)

FOR wIndex := 0 TO (i_wValueNumber - 1) BY 1 DO
    (* Calculate the upper and lower limit from the standard value and tolerance. *)
    eMaxValue := i_eAcceptableArray[wIndex, c_wBasicSize] + i_eAcceptableArray[wIndex, c_wTolerance];
    eMinValue := i_eAcceptableArray[wIndex, c_wBasicSize] - i_eAcceptableArray[wIndex, c_wTolerance];
    (* Check the upper and lower limit. *)
    IF (eMaxValue >= i_eValueArray[wIndex]) AND (eMinValue <= i_eValueArray[wIndex]) THEN
        o_bResult := TRUE;
    ELSE
        o_bResult := FALSE;
    EXIT; (* End processing when the value out of the range exists. *)
END_IF;
END_FOR;

The same data processing can be performed for the multiple elements of array by combining array type data and iteration statement.
Specify the elements of each array using an operational expression as a variable of the defined data type. Selection statement (IF statement, CASE statement) and iteration statement (FOR statement, WHILE statement, REPEAT statement) can be hierarchized.

Variable

Define the labels by setting the following items in GX Works3.
Global data can be used in a function block.
Array type data can be specified to an input variable.

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>c_wBasicSize</td>
<td>Word [Signed]</td>
<td>VAR_CONSTANT</td>
<td>Constant: 0</td>
<td>Element number to which the standard value is to be stored.</td>
</tr>
<tr>
<td>c_wTolerance</td>
<td>Word [Signed]</td>
<td>VAR_CONSTANT</td>
<td>Constant: 1</td>
<td>Element number to which the tolerance is to be stored.</td>
</tr>
<tr>
<td>eMaxValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Upper limit of judgment</td>
</tr>
<tr>
<td>eMinValue</td>
<td>FLOAT [Single Precision]</td>
<td>VAR</td>
<td>—</td>
<td>Lower limit of judgment</td>
</tr>
<tr>
<td>wIndex</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Element number</td>
</tr>
</tbody>
</table>

**POU**

Do not use.
10.2  Sorting Product Data (FB): Assortment

This function block stores product data after sorting them into non-defective products and defective products.

Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>EN/ENO</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function Block</td>
<td>Assortment</td>
<td>ST</td>
<td>No</td>
<td>Sorting product data</td>
</tr>
</tbody>
</table>

**Program example**

(* Sort the product data into non-defectives and defectives depending on the check result. *)

IF i_bCheck THEN
   (* Non-defective product *)
   (* Store the measured value to the Product data (non-defective product). *)
   o_stProductArray[wTotal] := i_stProduct;
   (* Increment the number of non-defective products *)
   wTotal := wTotal + 1;
ELSE
   (* Defective product *)
   (* Store the measured value to the Product data (defective product). *)
   o_stDefectiveArray[wDefectiveTotal] := i_stProduct;
   (* Increment the number of defective products *)
   wDefectiveTotal := wDefectiveTotal + 1;
END_IF;

(* Update yield rate *)

o_eYieldRatio := INT_TO_REAL(wTotal) / INT_TO_REAL(wTotal + wDefectiveTotal);

**Variable**

Define the labels by setting the following items in GX Works3.

**Local label**

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_bCheck</td>
<td>Bit</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Check result</td>
</tr>
<tr>
<td>i_stProduct</td>
<td>stProduct</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Checked product data</td>
</tr>
<tr>
<td>o_stProductArray</td>
<td>stProduct(0..7)</td>
<td>VAR_OUTPUT</td>
<td>—</td>
<td>Product data (non-defective product)</td>
</tr>
<tr>
<td>o_stDefectiveArray</td>
<td>stProduct(0..7)</td>
<td>VAR_OUTPUT</td>
<td>—</td>
<td>Product data (defective product)</td>
</tr>
<tr>
<td>o_eYieldRatio</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_OUTPUT</td>
<td>—</td>
<td>Yield rate</td>
</tr>
<tr>
<td>wTotal</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Number of non-defective products</td>
</tr>
<tr>
<td>wDefectiveTotal</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Number of defective products</td>
</tr>
</tbody>
</table>

**Structure**

<table>
<thead>
<tr>
<th>Structure name</th>
<th>Label Name</th>
<th>Data Type</th>
<th>Initial Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>stProduct</td>
<td>wProductNumber</td>
<td>Word [Signed]</td>
<td>—</td>
<td>Product number</td>
</tr>
<tr>
<td></td>
<td>eValueArray</td>
<td>FLOAT <a href="0..1">Single Precision</a></td>
<td>—</td>
<td>Measured value</td>
</tr>
</tbody>
</table>

**POU**

For details on the POU used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_TO_REAL</td>
<td>Standard function</td>
<td>Convert of INT type → REAL Converts a value from INT type data to REAL type data.</td>
<td>MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MELSEC iQ-F FX5 Programming Manual (Instructions, Standard Functions/Function Blocks)</td>
</tr>
</tbody>
</table>
This program stores the measured values for each product with sorting non-defective products and defective products. Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Block</td>
<td>DataManagement</td>
<td>ST</td>
<td>Product data management</td>
</tr>
</tbody>
</table>

**Program example**

(* Check the product data and sort them into non-defectives and defectives. *)
(* Set the allowable range to be checked. *)
Check_1.i_eAcceptableArray[0,0] := 1.0; (* Standard value of Measured value 0 *)
Check_1.i_eAcceptableArray[0,1] := 0.5; (* Tolerance of Measured value 0 *)
Check_1.i_eAcceptableArray[1,0] := 100.0; (* Standard value of Measured value 1 *)
Check_1.i_eAcceptableArray[1,1] := 1.0; (* Tolerance of Measured value 1 *)
Check_1.i_wValueNumber := GC_wValueNumber; (* Number of measured values for one product *)
(* Check the measured values for all products by iteration processing. *)
REPEAT
  (* Processing each three product *)
  wDataEnd := wProductNumber + 3;
  (* If the remaining number of products are three or less, the processing is continued to the end. *)
  IF wDataEnd > GC_wTotalProduct THEN
    wDataEnd := GC_wTotalProduct;
  END_IF;
  (* Repeat judging and sorting for three products. *)
  WHILE wProductNumber < wDataEnd DO
    (* Acquire the measured values of the processing target. *)
    FOR wIndex := 0 TO (GC_wValueNumber - 1) BY 1 DO
      eValueArray[wIndex] := G_eValueArray[wProductNumber, wIndex];
    END_FOR;
    (* Judge the product as non-defective or defective from the product data. *)
    Check_1(i_eValueArray := eValueArray, o_bResult => bResult);
    (* Sort the product data into non-defectives and defectives depending on the result of the bResult (check result). *)
    stProductData.wProductNumber := wProductNumber;
    stProductData.eValueArray := eValueArray;
    Assortment_1(i_bCheck := bResult, i_stProduct := stProductData);
    (* Go to the next product number. *)
    wProductNumber := wProductNumber + 1;
  END_WHILE;
  (* End processing under the following conditions. *)
  UNTIL ((Assortment_1.o_eYieldRatio < c_eLimit) (* The yield rate is lower than the standard. *)
    OR(wProductNumber >= GC_wTotalProduct) (* Or, number of total products exceed the product number *)
END_REPEAT;
(* Acquire the product data sorted into non-defective products and defective products. *)
G_stProductArray := Assortment_1.o_stProductArray;
G_stDefectiveArray := Assortment_1.o_stDefectiveArray;

**Point**

Different initial values cannot be set for each element of an array. Set the different values by a program.
For a function block, arguments can be specified before and after the call statement.
Selection statement (IF statement, CASE statement) and iteration statement (FOR statement, WHILE statement, REPEAT statement) can be hierarchized.
**Variable**

Define the labels by setting the following items in GX Works3.

### Global label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_eValueArray</td>
<td>FLOAT <a href="0..7,0..1">Single Precision</a></td>
<td>VAR_GLOBAL</td>
<td></td>
<td>Measured values for all products (Values are stored in order of product number.)</td>
</tr>
<tr>
<td>GC_wValueNumber</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL_CONSTANT</td>
<td>Constant: 2</td>
<td>Number of measured values for one product</td>
</tr>
<tr>
<td>GC_wTotalProduct</td>
<td>Word [Signed]</td>
<td>VAR_GLOBAL_CONSTANT</td>
<td>Constant: 8</td>
<td>Total number of products</td>
</tr>
<tr>
<td>G_stProductArray</td>
<td>stProduct(0..7)</td>
<td>VAR_GLOBAL</td>
<td></td>
<td>Product data (non-defective product)</td>
</tr>
<tr>
<td>G_stDefectiveArray</td>
<td>stProduct(0..7)</td>
<td>VAR_GLOBAL</td>
<td></td>
<td>Product data (defective product)</td>
</tr>
</tbody>
</table>

### Local label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>wProductNumber</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td></td>
<td>Product number (for internal iterative processing)</td>
</tr>
<tr>
<td>wDataEnd</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td></td>
<td>Data termination (for internal iterative processing)</td>
</tr>
<tr>
<td>wIndex</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td></td>
<td>Element number (for internal iterative processing)</td>
</tr>
<tr>
<td>eValueArray</td>
<td>FLOAT <a href="0..1">Single Precision</a></td>
<td>VAR</td>
<td></td>
<td>Measured value</td>
</tr>
<tr>
<td>bResult</td>
<td>Bit</td>
<td>VAR</td>
<td></td>
<td>Checking result (for internal iterative processing)</td>
</tr>
<tr>
<td>stProductData</td>
<td>stProduct</td>
<td>VAR</td>
<td></td>
<td>Checked product data</td>
</tr>
<tr>
<td>c_eLimit</td>
<td>FLOAT [Single Precision]</td>
<td>VAR_CONSTANT</td>
<td>Constant: 0.8</td>
<td>Allowable yield rate</td>
</tr>
<tr>
<td>Check_1</td>
<td>ProductCheck</td>
<td>VAR</td>
<td></td>
<td>Product check processing</td>
</tr>
<tr>
<td>Assortment_1</td>
<td>Assortment</td>
<td>VAR</td>
<td></td>
<td>Sorting processing for product data</td>
</tr>
</tbody>
</table>

### Structure

<table>
<thead>
<tr>
<th>Structure name</th>
<th>Label Name</th>
<th>Data Type</th>
<th>Initial Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>stProduct</td>
<td>wProductNumber</td>
<td>Word [Signed]</td>
<td></td>
<td>Product number</td>
</tr>
<tr>
<td></td>
<td>eValueArray</td>
<td>FLOAT <a href="0..1">Single Precision</a></td>
<td></td>
<td>Measured value</td>
</tr>
</tbody>
</table>

### POU

For details on the POUs used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProductCheck</td>
<td>Function block</td>
<td>Judges the products as non-defective or defective from the product data.</td>
<td>Page 80 Product Check (FB): ProductCheck</td>
</tr>
<tr>
<td>Assortment</td>
<td>Function block</td>
<td>Sorts product data into non-defectives and defectives.</td>
<td>Page 82 Sorting Product Data (FB): Assortment</td>
</tr>
</tbody>
</table>
11 MEASUREMENT OF OPERATING TIME (TIME AND CHARACTER STRING)

This chapter shows the examples for processing timer or time data using the program for the device which turns ON a lamp depending on the operating time and displays its operating time.

Create the following POU in the program example.

### Overview of function

The following processing are performed.

1. Operating time of the device is counted in second unit.
2. The lamp is turned ON/OFF by judging the status of device from the operation status and operating time.
3. Operating time is converted to hour, minute, and second unit.
4. Operating time is converted to the character string for screen display.

### Global labels to be used

The following shows the global labels and structure definitions used in the program example.
Set the following items in GX Works3.

#### Global label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/ Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_bOperatingStatus</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operation status (TRUE: Operating, FALSE: Stopped)</td>
</tr>
<tr>
<td>G_tmTime</td>
<td>Time</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Total operating time (Up to T#24d20h31m23s647ms)</td>
</tr>
<tr>
<td>G_bOperationLamp</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operation lamp (TRUE: ON, FALSE: OFF)</td>
</tr>
<tr>
<td>G_bWarningLamp</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Warning lamp (TRUE: ON, FALSE: OFF)</td>
</tr>
<tr>
<td>G_dSeconds</td>
<td>Double Word[Signed]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operating time (0 to 86399 seconds)</td>
</tr>
<tr>
<td>G_wTimeArray</td>
<td>Word[Signed][0..2]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operating time ([0]: Hour, [1]: Minute, [2]: Second)</td>
</tr>
<tr>
<td>G_sDisplayedCharacters</td>
<td>String[32]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Characters to be displayed on the operating time display screen</td>
</tr>
<tr>
<td>G_bOneScanOnly</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>Assign (Device/Label): SM402</td>
<td>Turn ON for only 1 scan after RUN</td>
</tr>
</tbody>
</table>

#### Structure

Do not use.
11.1 Operating Time Management: OperatingTime

This program counts operating time of a device in second unit. Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Program Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Block</td>
<td>OperatingTime</td>
<td>ST</td>
<td>Operating time management</td>
</tr>
</tbody>
</table>

**Program example**

(* Count the operating time for each one second. *)

```
bResult := OUT_T(G_bOperatingStatus, td1sTimer, 10); (* Timer setting value: 1000 ms *)
IF td1sTimer.S THEN (* After one second *)
  (* Operating time (Timer type) count up *)
  G_tmTime := G_tmTime + T#1000ms;
  IF G_tmTime < T#0ms THEN (* If an overflow occurred *)
    G_tmTime := T#0ms; (* Clear to 0 *)
  END_IF;
  (* Operating time (second unit) count up *)
  G_dSeconds := G_dSeconds +1;
  IF G_dSeconds >= 86400 THEN
    G_dSeconds := 0; (* Clear to 0 if the time is reached at 24 hours *)
  END_IF;
  (* Reset the timer (Current value: 0, Contact: OFF) *)
  RST(TRUE, td1sTimer.N);
  RST(TRUE, td1sTimer.S);
END_IF;
```

**Variable**

Define the labels by setting the following items in GX Works3.

- **Global label**

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_bOperatingStatus</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operation status (TRUE: Operating, FALSE: Stopped)</td>
</tr>
<tr>
<td>G_tmTime</td>
<td>Time</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Total operating time (Up to T#24d20h31m23s647ms)</td>
</tr>
<tr>
<td>G_dSeconds</td>
<td>Double Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operating time (0 to 86399 seconds)</td>
</tr>
</tbody>
</table>

- **Local label**

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bResult</td>
<td>Bit</td>
<td>VAR</td>
<td>—</td>
<td>ENO for executing timer</td>
</tr>
<tr>
<td>td1sTimer</td>
<td>Timer</td>
<td>VAR</td>
<td>—</td>
<td>Timer for measuring one second</td>
</tr>
</tbody>
</table>

**POU**

For details on the POU used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT_T</td>
<td>Instruction</td>
<td>Low-speed timer instruction</td>
<td>MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Starts time measurement when the operation result up to the OUT instruction is ON and the coil is turned ON.</td>
<td>MELSEC iQ-F FX5 Programming Manual (Instructions, Standard Functions/Function Blocks)</td>
</tr>
</tbody>
</table>
## 11.2  Flicker Timer (FB): FlickerTimer

This function block flashes Output signal 0 and 1 alternately when the input signal is ON. Create a POU by setting the following items in GX Works3.

### Program example

(* Flash the Output signal 0 and 1 alternately. (Flip-flop circuit) *)

(* Calculate the setting value for the low-speed timer. *)

\[
\text{wInterval} := \text{TIME_TO_INT(i_tmInterval)} / 100;
\]

(* If the Timer 1 is OFF, turn the Timer 0 ON after the set time (ms). *)

\[
\text{bResult} := \text{OUT_T}(\text{NOT tdTimer1.S}, \text{tdTimer0}, \text{wInterval});
\]

(* If the Timer 0 is turned ON from OFF, turn the Timer 1 ON after the set time (ms). *)

\[
\text{bResult} := \text{OUT_T}(\text{tdTimer0.S}, \text{tdTimer1}, \text{wInterval});
\]

(* If the Timer 0 is ON, turn ON the Output signal 0. *)

\[
\text{o_bOutputSignal0} := \text{tdTimer0.S};
\]

(* If the Timer 0 is OFF, turn ON the Output signal 1. *)

\[
\text{o_bOutputSignal1} := \text{NOT tdTimer0.S};
\]

The setting value for a timer needs to be equal to or more than the total value of scan time and timer limit setting. The timer limit is set as follows:

- **MELSEC iQ-R**: Set it in the parameter of an engineering tool. (Default: 100 ms)
- **MELSEC iQ-F**: The OUT_T instruction operates as a timer of 100 ms, the OUTH instruction as a timer of 10 ms, and the OUTHS instruction as a timer of 1 ms.

### Variable

Define the labels by setting the following items in GX Works3.

#### Local label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>i_tmInterval</td>
<td>Time</td>
<td>VAR_INPUT</td>
<td>—</td>
<td>Switching interval</td>
</tr>
<tr>
<td>o_bOutputSignal0</td>
<td>Bit</td>
<td>VAR_OUTPUT</td>
<td>Initial Value: TRUE</td>
<td>Output signal 0</td>
</tr>
<tr>
<td>o_bOutputSignal1</td>
<td>Bit</td>
<td>VAR_OUTPUT</td>
<td>Initial Value: TRUE</td>
<td>Output signal 1</td>
</tr>
<tr>
<td>bResult</td>
<td>Bit</td>
<td>VAR</td>
<td>—</td>
<td>ENO for executing timer</td>
</tr>
<tr>
<td>winterval</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Low-speed timer setting value</td>
</tr>
<tr>
<td>tdTimer0</td>
<td>Timer</td>
<td>VAR</td>
<td>—</td>
<td>Timer 0</td>
</tr>
<tr>
<td>tdTimer1</td>
<td>Timer</td>
<td>VAR</td>
<td>—</td>
<td>Timer 1</td>
</tr>
</tbody>
</table>

### POU

For details on the POUs used, refer to the following table.

<table>
<thead>
<tr>
<th>Data Name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT_T</td>
<td>Instruction</td>
<td>Low-speed timer instruction</td>
<td>MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Starts time measurement when the operation result up to the OUT instruction is ON and the coil is turned ON.</td>
<td>MELSEC iQ-F FXS Programming Manual (Instructions, Standard Functions/Function Blocks)</td>
</tr>
<tr>
<td>TIME_TO_INT</td>
<td>Standard function</td>
<td>Conversion of TIME type to INT type</td>
<td></td>
</tr>
</tbody>
</table>
11.3 Lamp ON/OFF: LampOnOff

This program turns the lamp ON/OFF depending on the device status.

![Diagram of lamps](image)

<table>
<thead>
<tr>
<th>Number</th>
<th>Operation lamp</th>
<th>Warning lamp</th>
<th>Device status</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>OFF</td>
<td>OFF</td>
<td>Normal</td>
<td>Stopped Before operation</td>
</tr>
<tr>
<td>(2)</td>
<td>ON</td>
<td>OFF</td>
<td>Operating</td>
<td>Operating time: 0 to 7 days</td>
</tr>
<tr>
<td>(3)</td>
<td>ON</td>
<td>ON</td>
<td>Warning</td>
<td>Operating time: One week or more</td>
</tr>
<tr>
<td>(4)</td>
<td>Flashing alternately</td>
<td>ON</td>
<td>Error</td>
<td>Operating time: Three weeks or more</td>
</tr>
</tbody>
</table>

Create a POU by setting the following items in GX Works3.

**Data Type** | **Data Name** | **Program Language** | **Title** |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Block</td>
<td>LampOnOff</td>
<td>ST</td>
<td>Lamp ON/OFF</td>
</tr>
</tbody>
</table>

**Program example**

(* Turn the operation lamp ON/OFF according to the operation state. *)

G_bOperationLamp := G_bOperatingStatus;

(* Turn the warning lamp ON if the total operating time is one week (seven days) or more. *)

G_bWarningLamp := G_tmTime >= T#7d;

(* If the operating time is three weeks (21 days) or more *)

(* Turn the operation lamp and warning lamp alternately. *)

FlickerTimer_1(EN := G_tmTime >= T#21d, i_tmInterval := T#1000ms);

IF FlickerTimer_1.ENO THEN

    G_bOperationLamp := FlickerTimer_1.o_bOutputSignal0;
    G_bWarningLamp := FlickerTimer_1.o_bOutputSignal1;

END_IF;

**Variable**

Define the labels by setting the following items in GX Works3.

### Global label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_bOperatingStatus</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operation status (TRUE: Operating, FALSE: Stopped)</td>
</tr>
<tr>
<td>G_bOperationLamp</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operation lamp (TRUE: ON, FALSE: OFF)</td>
</tr>
<tr>
<td>G_bWarningLamp</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Warning lamp (TRUE: ON, FALSE: OFF)</td>
</tr>
<tr>
<td>G_tmTime</td>
<td>Time</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Total operating time (up to T#24d220h31m23s647ms)</td>
</tr>
</tbody>
</table>

### Local label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FlickerTimer_1</td>
<td>FlickerTimer</td>
<td>VAR</td>
<td>—</td>
<td>Flicker timer</td>
</tr>
</tbody>
</table>

**POU**

For details on the POU used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>FlickerTimer</td>
<td>Function block</td>
<td>Flashes the output signals alternately.</td>
<td>Page 87 Flicker Timer (FB): FlickerTimer</td>
</tr>
</tbody>
</table>

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11 MEASUREMENT OF OPERATING TIME (TIME AND CHARACTER STRING)
11.3 Lamp ON/OFF: LampOnOff
11.4 Conversion from Sec. to Hour/Min/Sec: SecondsToTimeArray

This program calculates hour, minute, second from the time in second unit. The values of hour, minute, and second are stored to the array type data (same format data as the argument of SEC2TIME (clock instruction)).

Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Block</td>
<td>SecondsToTimeArray</td>
<td>ST</td>
<td>Conversion from sec. to h/m/s</td>
</tr>
</tbody>
</table>

**Program example**

(* Calculate hour, minute, second from the time in second unit. *)

G_wTimeArray[0] := GET_INT_ADDR( G_dSeconds / 3600); (* Hour *)
G_wTimeArray[1] := GET_INT_ADDR((G_dSeconds MOD 3600) / 60); (* Minute *)
G_wTimeArray[2] := GET_INT_ADDR((G_dSeconds MOD 3600) MOD 60); (* Second *)

**Variable**

Define the labels by setting the following items in GX Works3.

■Global label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_dSeconds</td>
<td>Double Word [Signed]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operating time (0 to 86399 seconds)</td>
</tr>
<tr>
<td>G_wTimeArray</td>
<td>Word [Signed][0..2]</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Operating time ([0]: Hour, [1]: Minute, [2]: Second)</td>
</tr>
</tbody>
</table>

■Local label

Do not use.

**POU**

For details on the POU used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET_INT_ADDR</td>
<td>Standard function</td>
<td>Eliminate the need for type conversion</td>
<td>MELSEC IQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outputs the input variable as INT type.</td>
<td>MELSEC IQ-F FX5 Programming Manual (Instructions, Standard Functions/Function Blocks)</td>
</tr>
</tbody>
</table>
11.5 Conversion from Time to String: TimeToString

This program converts operating time (time type) to character string for display.

![Diagram showing conversion from time to string]

Create a POU by setting the following items in GX Works3.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Name</th>
<th>Program Language</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Block</td>
<td>TimeToString</td>
<td>ST</td>
<td>Conversion from Time to String</td>
</tr>
</tbody>
</table>

**Program example**

(* Convert the operating time to character string for display. *)

(* Initialize the internal variable. *)

IF G_bOneScanOnly THEN (* Execute only once after RUN *)

(* Initialize time unit (day, hour, minute, second in milliseconds). *)

dUnitArray[0] := TIME_TO_DINT(T#1d); (* Day *)
dUnitArray[1] := TIME_TO_DINT(T#1h); (* Hour *)
dUnitArray[2] := TIME_TO_DINT(T#1m); (* Minute *)
dUnitArray[3] := TIME_TO_DINT(T#1s); (* Second *)

(* Specify the digit of numeric value to be converted to a character string. *)
wDigitArray[0] := 2; (* Convert to character string for 2 digits *)
wDigitArray[1] := 0; (* No decimal point *)

END_IF;

sTimeString := ''; (* Initialize character string. *)

(* Convert the time type data to milliseconds. *)
dTime := TIME_TO_DINT(G_tmTime);

(* Processing the day, hour, minute, second in this order. *)

FOR wIndex := 0 TO 3 BY 1 DO

(* Convert the time (in milliseconds) to day/hour/minute/second. *)
wTime := DINT_TO_INT(dTime /dUnitArray[wIndex]);
dTime := dTime MOD dUnitArray[wIndex];

(* Convert the value of day/hour/minute/second to 2-digit character string. *)

STR(TRUE, wDigitArray, wTime, sItemString);

(* Set the character string to be added. *)

CASE wIndex OF
  0 : sAdd := 'Day ';
  1 : sAdd := '$nTime ';
  2,3:sAdd := ':';
END_CASE;

(* Add a character string. *)

sTimeString := CONCAT(sTimeString, sAdd, sItemString);

END_FOR;

(* Set the created character string to the display character string. *)

G_sDisplayedCharacters := sTimeString;

Use TIME_TO_STRING of the standard function to convert the values (in milliseconds) to character string.
The program above converts the values to the character string after calculating the value for each day, time, minute, and second.

'\$n' is a linefeed code.
### Variable
Define the labels by setting the following items in GX Works3.

#### Global label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Assign/Initial Value/Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_tmTime</td>
<td>Time</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Total operating time (Up to T#24d20h31m23s647ms)</td>
</tr>
<tr>
<td>G_bOneScanOnly</td>
<td>Bit</td>
<td>VAR_GLOBAL</td>
<td>Assign (Device/Label): SM402</td>
<td>Turn ON for only 1 scan after RUN</td>
</tr>
<tr>
<td>G_sDisplayedCharacters</td>
<td>String(32)</td>
<td>VAR_GLOBAL</td>
<td>—</td>
<td>Characters to be displayed on the operating time display screen</td>
</tr>
</tbody>
</table>

#### Local label

<table>
<thead>
<tr>
<th>Label Name</th>
<th>Data Type</th>
<th>Class</th>
<th>Initial Value/Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dUnitArray</td>
<td>Double Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Unit (day, hour, minute, second in milliseconds)</td>
</tr>
<tr>
<td>wDigitArray</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Digit specification ([0]: Number of all digits, [1]: Number of decimal place)</td>
</tr>
<tr>
<td>sTimeString</td>
<td>String(32)</td>
<td>VAR</td>
<td>—</td>
<td>Character string to be created (Day, hour, minute, second)</td>
</tr>
<tr>
<td>dTime</td>
<td>Double Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Time (in milliseconds)</td>
</tr>
<tr>
<td>wIndex</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Element number</td>
</tr>
<tr>
<td>wTime</td>
<td>Word [Signed]</td>
<td>VAR</td>
<td>—</td>
<td>Time (Day/hour/minute/second)</td>
</tr>
<tr>
<td>sItemString</td>
<td>String(32)</td>
<td>VAR</td>
<td>—</td>
<td>Character string of two-digit numeric value for day/time/minute/second</td>
</tr>
<tr>
<td>sAdd</td>
<td>String(32)</td>
<td>VAR</td>
<td>—</td>
<td>Character string to be added</td>
</tr>
</tbody>
</table>

#### POU
For details on the POUs used, refer to the following table.

<table>
<thead>
<tr>
<th>Data name</th>
<th>Data type</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIME_TO_DINT</td>
<td>Standard function</td>
<td>Conversion of TIME type → DINT type</td>
<td>MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/ Function Blocks)</td>
</tr>
<tr>
<td>DINT_TO_INT</td>
<td>Standard function</td>
<td>Conversion of DINT type → INT type</td>
<td>MELSEC iQ-F FX5 Programming Manual (Instructions, Standard Functions/Function Blocks)</td>
</tr>
<tr>
<td>STR</td>
<td>Instruction</td>
<td>Converts 16-bit binary data to character string by adding a decimal point to the specified place of the data.</td>
<td></td>
</tr>
<tr>
<td>CONCAT</td>
<td>Standard function</td>
<td>Concatenation of string data</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 1 Specifications of Structured Text language

This section explains the types of basic components and their descriptions used in the Structured Text language.

### Statement

The following shows the types of statement and their description method.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment statement</td>
<td><code>&lt;Variable&gt; := &lt;Expression&gt;;</code></td>
<td>Assign the result. An evaluation result of the right side is assigned to the variable of the left side.</td>
</tr>
<tr>
<td>Subprogram control statement</td>
<td>Call statement <code>&lt;Identifier&gt;(argument 1, argument 2, ...)</code></td>
<td>A function or function block is called.</td>
</tr>
<tr>
<td>RETURN statement</td>
<td>RETURN;</td>
<td>A program is ended.</td>
</tr>
<tr>
<td>Control statement</td>
<td>Selection statement IF <code>&lt;Condition 1&gt;</code> THEN <code>&lt;Statement 1&gt;</code>; ELSIF <code>&lt;Condition 2&gt;</code> THEN <code>&lt;Statement 2&gt;</code>; ELSE <code>&lt;Statement 3&gt;</code>; END_IF;</td>
<td>An execution statement is selected depending on the condition of the boolean value. If the Condition 1 is TRUE, the Statement 1 is executed. If the Condition 1 is FALSE, the condition of ELSIF is judged. If the Condition 2 is TRUE, the Statement 2 is executed. If the conditions both IF and ELSIF are FALSE, the Statement 3 after ELSE is executed.</td>
</tr>
<tr>
<td>CASE</td>
<td>CASE <code>&lt;Condition&gt; OF </code>&lt;Value 1&gt;<code>:</code>&lt;Statement 1&gt;<code>; </code>&lt;Value 2&gt;<code>..&lt;Value 3&gt; : </code>&lt;Statement 2&gt;<code>; ELSE </code>&lt;Statement 3&gt;`; END_CASE;</td>
<td>An execution statement is selected depending on the condition of the integer value. If the result of the conditional expression is equals to the Value 1, the Statement 1 is executed. When specifying the range of an integer value to be judged, use ‘..’ to describe the statement. If the value of the result of the conditional expression is within the range from the Value 2 to the Value 3, the Statement 2 is executed. If the result of the conditional expression is not equal to all the integer values or their ranges, the Statement 3 after ELSE is executed.</td>
</tr>
<tr>
<td>Iteration statement</td>
<td>FOR <code>&lt;Variable&gt; := &lt;Initial (expression)&gt;</code> TO <code>&lt;End (expression)&gt;</code> BY <code>&lt;Increment (expression)&gt;</code> DO <code>&lt;Statement&gt;;</code> END_FOR;</td>
<td>The execution statement is executed for multiple times depending on the end condition of the integer value. Set the initial value to the Variable of an integer type first. After that, the Statement is executed until the Variable reaches the value of the End. The Increment value is added to the variable each time when the Statement is executed.</td>
</tr>
<tr>
<td>WHILE</td>
<td>WHILE <code>&lt;Condition&gt;</code> DO <code>&lt;Statement&gt;;</code> END_WHILE;</td>
<td>The execution statement is executed for multiple times depending on the end condition of boolean value. If the conditional expression is TRUE, the execution statement is executed. The processing is repeated until the result of the conditional expression becomes FALSE.</td>
</tr>
<tr>
<td>REPEAT</td>
<td>REPEAT <code>&lt;Statement&gt;;</code> UNTIL <code>&lt;Condition&gt;</code> END_REPEAT;</td>
<td>The execution statement is executed for multiple times depending on the end condition of boolean value. The condition is judged after the execution of the execution statement. The processing is repeated until the result of the conditional expression becomes TRUE.</td>
</tr>
<tr>
<td>Exit of iteration statement</td>
<td>EXIT;</td>
<td>Exits the iteration statement.</td>
</tr>
<tr>
<td>Empty statement</td>
<td>;</td>
<td>Nothing is processed.</td>
</tr>
</tbody>
</table>
Hierarchization of functions and function blocks can be performed up to 32 times in total.
Hierarchization of IF statement, CASE statement, WHILE statement, and REPEAT statement can be performed up to 128 times in total.

Operator

The following shows the types of operators and their description method.

<table>
<thead>
<tr>
<th>Type</th>
<th>Operator</th>
<th>Priority (High to low)</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inversion of sign</td>
<td>-</td>
<td>1</td>
<td>B = - A</td>
</tr>
<tr>
<td>Logical operation</td>
<td>NOT</td>
<td>NOT</td>
<td>bFlagB := NOT bFlagA;</td>
</tr>
<tr>
<td>Exponentiation</td>
<td>**</td>
<td>2</td>
<td>B = C^A</td>
</tr>
<tr>
<td>Basic arithmetic</td>
<td>Multiplication</td>
<td>*</td>
<td>3</td>
</tr>
<tr>
<td>expression</td>
<td>Division</td>
<td>/</td>
<td>A ÷ B = C</td>
</tr>
<tr>
<td>Modulus operation</td>
<td>MOD</td>
<td></td>
<td>A MOD B</td>
</tr>
<tr>
<td>Addition</td>
<td>+</td>
<td>4</td>
<td>A + B = C</td>
</tr>
<tr>
<td>Subtraction</td>
<td>-</td>
<td></td>
<td>A - B = C</td>
</tr>
<tr>
<td>Comparison operation</td>
<td>Greater that, less than</td>
<td>&gt;, &lt;</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Greater than or equal to, less than or equal to</td>
<td>&gt;=, &lt;=</td>
<td>A ≥ B</td>
</tr>
<tr>
<td>Logical operation</td>
<td>AND</td>
<td>AND, &amp;</td>
<td>A ∧ B</td>
</tr>
<tr>
<td></td>
<td>XOR</td>
<td>XOR</td>
<td>A ⊻ B</td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td>OR</td>
<td>A ∨ B</td>
</tr>
</tbody>
</table>

Operator Symbol

- Inversion of sign
- Logical operation
- Exponentiation
- Basic arithmetic expression
- Modulus operation
- Addition
- Subtraction
- Comparison operation
- Logical operation

Priority

When multiple operational expressions are described in one statement, the operations are processed in order from a high priority operator.
When some operators of which priority is the same are used in one statement, the operators are operated in order from the left.
The operational expression in the brackets ‘(’) is operated first.

Comment

The following shows the types of comments and their description method.

<table>
<thead>
<tr>
<th>Type</th>
<th>Symbol</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple line comment</td>
<td>/*</td>
<td>The range from start symbol to end symbol is regarded as a comment.</td>
<td>/* Comment */</td>
</tr>
<tr>
<td></td>
<td>*/</td>
<td></td>
<td>*/ Comment */</td>
</tr>
<tr>
<td>Single line comment</td>
<td>//</td>
<td>The range from start symbol to end of the line is regarded as a comment.</td>
<td>// Comment</td>
</tr>
</tbody>
</table>

Comment Symbol

- A comment symbol for the Structured Text language defined in IEC 61131-3 is (***) only, however, in GX Works3, the same symbols as C language (**/, //) can be described.
- In GX Works2, the comment used (**) can only be used.
Device

Devices can be specified in the same manner as a ladder program. Add # when specifying local devices. Device specification (digit specification, bit specification, and indirect specification) and index modification can be used.

Restriction

A pointer cannot be used in ST program.

Contact/coil/current value of timer and counter

The devices such as timer and counter can be used by specifying their purpose to be used as a contact/coil/current value in the Structured Text language.

When do not specify them, the devices are distinguished to be used as a contact/coil/current value automatically depending on the instruction to be used.

Contact and coil are treated as a bit type. Current value is treated as the following data type.

<table>
<thead>
<tr>
<th>Device</th>
<th>Notation</th>
<th>Data type of current value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timer</td>
<td>T</td>
<td>Word [Unsigned]/Bit String [16-bit]</td>
</tr>
<tr>
<td>Retentive timer</td>
<td>ST</td>
<td>Double Word [Unsigned]/Bit String [32-bit]</td>
</tr>
<tr>
<td>Counter</td>
<td>C</td>
<td>Word [Signed]</td>
</tr>
<tr>
<td>Long timer</td>
<td>LT</td>
<td>Double Word [Signed]</td>
</tr>
<tr>
<td>Long retentive timer</td>
<td>LST</td>
<td>FLOAT [Single Precision]</td>
</tr>
<tr>
<td>Long counter</td>
<td>LC</td>
<td>FLOAT [Double Precision]</td>
</tr>
</tbody>
</table>

Type specification of word device

Word device can be used by specifying its data type.

<table>
<thead>
<tr>
<th>Data type</th>
<th>Device type specifier</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word [Unsigned]/Bit String [16-bit]</td>
<td>:U</td>
<td>D0:U</td>
<td>The value of D0 is treated as the value of 16-bit WORD type.</td>
</tr>
<tr>
<td>Double Word [Unsigned]/Bit String [32-bit]</td>
<td>:UD</td>
<td>D0:UD</td>
<td>The values of D10 and D1 are treated as the value of 32-bit DWORD type.</td>
</tr>
<tr>
<td>Word [Signed]</td>
<td>(None)</td>
<td>D0</td>
<td>The value of D0 is treated as the value of 16-bit INT type.</td>
</tr>
<tr>
<td>Double Word [Signed]</td>
<td>:D</td>
<td>D0:D</td>
<td>The values of D0 and D1 are treated as the value of 32-bit DINT type.</td>
</tr>
<tr>
<td>FLOAT [Single Precision]</td>
<td>:E</td>
<td>D0:E</td>
<td>The values of D0 and D1 are treated as the value of 32-bit REAL type.</td>
</tr>
<tr>
<td>FLOAT [Double Precision]</td>
<td>:ED</td>
<td>D0:ED</td>
<td>The values from D0 to D3 are treated as the value of 64-bit LREAL type.</td>
</tr>
</tbody>
</table>

A device type specifier cannot be added to digit-specified devices or indirectly specified devices.

Type conversion of word device

When the word device with no type specification is used for an argument of function or function block, the word device is treated according to the data type of the argument definition. (Same as standard function, standard function block, and instruction.)

The result may differ depending on the specification method for the argument since the type conversion is performed automatically at the specification of the input argument.

Ex

32-bit binary data transfer instruction (DMOV) (Instruction of which input argument and output argument are both ANY32 type)

• D0 = 16#ABCD
• D1 = 16#1234
• Word [Signed] type label, G_wLabel to which D0 is assigned

<table>
<thead>
<tr>
<th>ST</th>
<th>Description</th>
<th>Value to be transferred</th>
</tr>
</thead>
<tbody>
<tr>
<td>bResult := DMOV(TRUE, D0, D10);</td>
<td>The 32-bit data stored to D0 and D1 are transferred to D10 and D11.</td>
<td>16#1234ABCD</td>
</tr>
<tr>
<td>bResult := DMOV(TRUE, D0:UD, D10:UD);</td>
<td>The integer value of Word [Unsigned]/Bit String [16-bit] type stored to D0 is converted to Double Word [Signed] type automatically, and the zero-extended value is transferred to D10 and D11.</td>
<td>16#0000ABCD</td>
</tr>
<tr>
<td>bResult := DMOV(TRUE, G_wLebel, D10);</td>
<td>The integer value of Word [Signed] type stored to D0 is converted to Double Word [Signed] type automatically, and the sign-extended value is transferred to D10 and D11.</td>
<td>16#FFFFABCD</td>
</tr>
<tr>
<td>bResult := DMOV(TRUE, D0:U, D10:U);</td>
<td>A conversion error occurs in D10:U since the output variable cannot be converted automatically.</td>
<td>—</td>
</tr>
</tbody>
</table>

When using a word device with no type specification in an operational expression, the data type is converted from Word [Signed] automatically.

_page_30 Data type that can be converted automatically_
Label

Specify labels in the same manner as a ladder program.
Bit specification (example: Lbl.3) and digit specification (example: K4Lbl) of labels can be used.

Restriction

Pointer type labels cannot be used in an ST program.
## Constant

The following shows the description method of constant.

<table>
<thead>
<tr>
<th>Type</th>
<th>Notation</th>
<th>Example</th>
<th>Example with * '_' added *2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boolean value</td>
<td>Describe a boolean value with TRUE or FALSE.</td>
<td>TRUE, FALSE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specify the value with 1 or 0. Each notation for integer can be applied.</td>
<td>290, B#1, 0, H1</td>
<td></td>
</tr>
<tr>
<td>Integer</td>
<td>Binary: Add &quot;2#&quot; in front of a binary number.</td>
<td>2#0010, 2#01101010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Octal: Add &quot;8#&quot; in front of an octal number.</td>
<td>8#2, 8#152, 8#377</td>
<td>8#7_777</td>
</tr>
<tr>
<td></td>
<td>Decimal: Enter a decimal number directly.</td>
<td>2, 106, -1</td>
<td>32_767</td>
</tr>
<tr>
<td></td>
<td>Add &quot;K&quot; in front of a decimal number.</td>
<td>K2, K106, K-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hexadecimal: Add &quot;16#&quot; in front of a hexadecimal number.</td>
<td>16#2, 16#6A, 16#FF</td>
<td>16#7F_FF</td>
</tr>
<tr>
<td></td>
<td>Add &quot;H&quot; in front of a hexadecimal number.</td>
<td>H2, H6A, HFF</td>
<td></td>
</tr>
<tr>
<td>Real number</td>
<td>Decimal notation: Enter a real number directly.</td>
<td>1200.0, 0.012, -0.1</td>
<td>3.14_159</td>
</tr>
<tr>
<td></td>
<td>Exponential notation: Add &quot;E&quot; between the mantissa part and the exponent.</td>
<td>1E23, 1.2E-2, -1.0E-1</td>
<td>2.99_792_458E8</td>
</tr>
<tr>
<td></td>
<td>Add &quot;E&quot; in front of the mantissa part, and add '+' or '-' between the mantissa part and the exponent.</td>
<td>E1.2+3, E1.2-2, E-1.0-1</td>
<td></td>
</tr>
<tr>
<td>Character string</td>
<td>ASCII: Enclose a character string in single quotes (').</td>
<td>'ABC'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shift-JIS: Enclose a character string in double quotes (&quot;').</td>
<td>&quot;ABC&quot;</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Add &quot;T#&quot; or &quot;TIME#&quot; in front of a value.</td>
<td>T#1h, T#1d2h3m4s5ms, TIME#1h</td>
<td></td>
</tr>
</tbody>
</table>

*1 In the notation of integer and real numbers, the numbers can be delimited using an underscore '_'. Add it to make programs easy to see. And, the delimiters of values (underscore '_') are ignored in the program processing.

*2 For the notation with K, H, or E added in front, underscores (_) cannot be used.

*3 By adding '+' or '-' right after the value for the real number with 'E' added, it is regarded as an index.

When describing it as an arithmetic operation, insert a space or tabulator between the value and operator.

(Example: 'E1.2+3' indicates 1200.0, and 'E1.2 +3' indicates 4.2.)

### Specifying a data type

The data types of the following values can explicitly be specified. When not specified, the data types are determined automatically.

Data type names are not case-sensitive and cannot be used together with the constant notation using K, H, or E.

<table>
<thead>
<tr>
<th>Constant</th>
<th>Available data type</th>
<th>Example</th>
<th>Example with * '_' added *2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boolean value</td>
<td>Bit</td>
<td>BOOL</td>
<td>BOOL TRUE, BOOL FALSE, BOOL#0, BOOL#1</td>
</tr>
<tr>
<td>Integer</td>
<td>Word [Unsigned]/Bit String [16-bit]</td>
<td>UINT</td>
<td>UINT##2#01101010, UINT##2#011010, UINT##2#152, UINT##8#106, UINT##16#6A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WORD#1</td>
<td>WORD##2#01101010, WORD##2#152, WORD##8#106, WORD##16#6A</td>
</tr>
<tr>
<td></td>
<td>Double Word [Unsigned]/Bit String [32-bit]</td>
<td>UDINT</td>
<td>UDINT##2#0111111111111111, UDINT##8#777777, UDINT##32#767, UDINT##16#7FFFF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DWORD#1</td>
<td>DWORD##2#0111111111111111, DWORD##8#777777, DWORD##32#767, DWORD##16#7FFFF</td>
</tr>
<tr>
<td></td>
<td>Word [Signed]</td>
<td>INT</td>
<td>INT##2#01101010, INT##2#0110, INT#16#6A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DINT</td>
<td>DINT##2#0111111111111111, DINT##8#777777, DINT##32#767, DINT##16#7FFFF</td>
</tr>
<tr>
<td>Real number</td>
<td>FLOAT [Single Precision]</td>
<td>REAL</td>
<td>REAL##2.34, REAL##1.0E6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LREAL</td>
<td>LREAL##2-3.4, LREAL##1.00E1E16</td>
</tr>
</tbody>
</table>

*1 *WORD#* and *DWORD#* cannot be used for the operands of basic arithmetic operations (target values of operations), the call statements of functions and function blocks, and the ANY_NUM type arguments in function call expressions. Use *UINT#* or *UDINT#* instead.
Using '§' in a character string type constant

When specifying linefeed using a character string type constant, add '$'.

<table>
<thead>
<tr>
<th>Type</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dollar sign ($)</td>
<td>$$, $24</td>
</tr>
<tr>
<td>Single quote (')</td>
<td>$', $27</td>
</tr>
<tr>
<td>Double quote ('')</td>
<td>$&quot;, $22</td>
</tr>
<tr>
<td>Line feed</td>
<td>$L, $l, $0A</td>
</tr>
<tr>
<td>Newline</td>
<td>$N, $n, $0D $0A</td>
</tr>
<tr>
<td>Form feed (page)</td>
<td>$P, $p, $0C</td>
</tr>
<tr>
<td>Carriage Return</td>
<td>$R, $r, $0D</td>
</tr>
<tr>
<td>Tabulator</td>
<td>$T, $t, $09</td>
</tr>
<tr>
<td>Character corresponding to ASCII code</td>
<td>${\text{ASCII code (2-digits of hexadecimal value)}}</td>
</tr>
</tbody>
</table>

Description method of the time length

Describe the time type of constants as follows:

- T#23d23h59m59s999ms or TIME#23d23h59m59s999ms

<table>
<thead>
<tr>
<th>Time unit</th>
<th>d (day)</th>
<th>h (hour)</th>
<th>m (minute)</th>
<th>s (second)</th>
<th>ms (millisecond)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>0 to 24</td>
<td>0 to 23</td>
<td>0 to 59</td>
<td>0 to 59</td>
<td>0 to 999</td>
</tr>
</tbody>
</table>

Time units should be consecutive in order of d, h, m, s, and ms.
By adding a sign (-) after '#', values can be described as signed ones.
(Example: T#-24d20h31m23s648ms)

Omitting a time unit

Time units that are placed before and after ones to be described can be omitted.
(Example: T#1m2s)

Time units that are placed between ones to be described cannot be omitted.
(Example: 'T#1m2ms' is not allowed. Describe 'T#1m0s2ms'.)
The last time unit can be described in a notation using a decimal point (decimal representation of unsigned real numbers).
(Example: 'T#1.234s' is described as 'T#1s234ms'.)
The ms (millisecond) unit cannot be described in a decimal point notation. Values after a decimal point are rounded down.
(Example: 'T#1.234ms' is described as 'T#1ms'.)

Setting range

When using a sign (-) or omitting time units that are placed before ones to be described, the range of values that can be described is as follows:

<table>
<thead>
<tr>
<th>Time unit</th>
<th>d (day)</th>
<th>h (hour)</th>
<th>m (minute)</th>
<th>s (second)</th>
<th>ms (millisecond)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No omission</td>
<td>-24 to 24</td>
<td>0 to 23</td>
<td>0 to 59</td>
<td>0 to 59</td>
<td>0 to 999</td>
</tr>
<tr>
<td>'d' omitted</td>
<td>—</td>
<td>-596 to 596</td>
<td>0 to 59</td>
<td>0 to 59</td>
<td>0 to 999</td>
</tr>
<tr>
<td>'d' and 'h' omitted</td>
<td>—</td>
<td>—</td>
<td>-36791 to 35791</td>
<td>0 to 59</td>
<td>0 to 999</td>
</tr>
<tr>
<td>'d', 'h', and 'm' omitted</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>-2147483 to 2147483</td>
<td>0 to 999</td>
</tr>
<tr>
<td>'d', 'h', 'm', and 's' omitted</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>-2147483648 to 2147483647</td>
</tr>
</tbody>
</table>

The time length can be set to the time type variable (Page 33 Time type variable) in the following range.

- T#24d20h31m23s648ms to T#24d20h31m23s647ms
- T#-596h31m23s648ms to T#596h31m23s647ms
- T#-35791m23s648ms to T#35791m23s647ms
- T#-2147483648ms to T#2147483647ms
- T#-2147483648ms to T#2147483647ms
**Function and function block**

Function and function block are the POUs in which a subroutine to be called from a program is defined. The defined function can be used in a program block, function block, and other functions. The defined function block can be used in the program block and other function blocks by creating an instance.

**Argument**

The following shows the description method of arguments in a call statement.

**Argument specification with actual argument**

List the arguments by delimiting them with commas (,) in the brackets.

The template of a function is displayed in the following format. (Page 52 Entering arguments)

```
FunPou( ?BOOL? , ?BOOL? , INT iValue0? , INT oValue1? );
```

The order of the arguments will be the order defined in the local label setting of function definition or function block definition. When function or function block is created with the setting to use EN/ENO, specify EN for the first argument and ENO for the second one.

**Argument specification for assigning actual argument to formal argument**

List the formal arguments and actual arguments by delimiting with commas (,) in the brackets.

The template of a function block is displayed in the following format. (Page 53 Entering arguments)

```
FbPou_1(EN:= ?BOOL?, ENO=> ?BOOL?, i_wValue0:= ?INT?, o_wValue1=> ?INT? );
```

The names of formal arguments will be the variable names specified in the local label setting of function definition or function block definition.

Specify ‘EN’ and ‘ENO’ as formal arguments for EN and ENO.

**Point**

When assigning the actual argument to the formal argument, use the following format.

- Input argument, input/output argument and EN: `<Formal argument name>:=<Expression>'
- Output argument and ENO: `<Formal argument name>=><Variable>'

When assigning the actual argument to the formal argument, the order of the arguments can be changed arbitrary.

```
FbPou_1(EN:= ?BOOL?, ENO=> ?BOOL?, i_wValue0:= ?INT?, o_wValue1=> ?INT? );
```

**Point**

When specifying the argument by assigning the actual argument to the formal argument, the description of the argument can be omitted.

**Argument specification before and after the call statement**

For a function block, arguments can be specified before and after the call statement. Describe the assignment statement for an input variable before the call statement, and describe an assignment statement for the output variable after the call statement.

```
Substitution statement for input argument — FbPou_1.i_wValue0 := wValue0;
Function block call statement — FbPou_1();
Substitution statement for output variable — wValue1 := FbPou_1.o_wValue1;
```
Return value
A function which has a return value returns the value to the call source after the completion of the execution.

■ Data type of return value
Set the data type of a return value on the "New Data" screen or the "Properties" screen.
A function with no data type set is treated as a function with no return value.
A function with no return value must be described as a call statement. (Function call statement)

■ Setting value to return value
Set the value to be returned as a return value to the variable of which function name is its identifier in the function.

Program example
The sum from i_wValue0 to i_wValue2 (input argument) are returned as a return value of FunAdd (function).

ST (Program of function, FunAdd)
FunAdd := wValue0 + wValue1 + wValue2;

■ Using return value in call source program
A function with return value can be handled as an expression. (Function call expression)
In the call source program of a function, operational expressions and conditional statements can be described using a function call expression as a variable of return value data type.

Program example
The average from wValue0 to wValue2 are assigned to Average3.
FunAdd (function) returns the sum of wValue0 to wValue2 (input argument) as a return value.

ST (Call source program)
Average3 := FunAdd( wValue0, wValue1, wValue2) / 3;

EN and ENO
When creating a function and function block, whether or not to use an EN and ENO can be selected.
By using an EN (enable input) and ENO (enable output), the execution processing can be controlled.
• EN: Set the execution condition.
• ENO: Execution result is output.
EN/ENO is boolean type.
A function or function block with an EN is executed only when the execution condition of the EN is TRUE.
The following shows the values of output variable and return value depending on the state of EN and ENO.

<table>
<thead>
<tr>
<th>EN</th>
<th>ENO</th>
<th>Output variable, returned value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRUE</td>
<td>TRUE</td>
<td>Operation output value</td>
<td>Normal completion</td>
</tr>
<tr>
<td>FALSE</td>
<td></td>
<td>Undefined value</td>
<td></td>
</tr>
<tr>
<td>FALSE</td>
<td>FALSE</td>
<td>Function: Value at call</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Function block: Previous result</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FALSE</td>
<td>The processing is ended without execution.</td>
<td>The output value depends on the actual system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assignment of value to the input variable and output variable are not executed.</td>
<td></td>
</tr>
</tbody>
</table>

■ Setting value to ENO
To set the value of ENO, assign a boolean value to the variable, 'ENO' in a function or function block.

Program example
If an operation error occurs in the BCD instruction, the processing of function/function block is terminated and resulted in error end.

ST (Program of function/function block)
ENO := BCD(EN, wValue0, D0);
IF ENO = FALSE THEN
  RETURN;
END_IF;
Appendix 2 Instructions That Cannot be Used in ST Programs

The following instructions, which are used in ladder programs, are described by using an operator or a control statement in ST programs.

Instructions that can be described in assignment statement

<table>
<thead>
<tr>
<th>Type</th>
<th>Instruction symbol</th>
<th>Corresponding type conversion function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Converting single-precision real number to 16-bit signed binary data</td>
<td>FLT2INT(P)</td>
<td>REAL_TO_INT(E)</td>
</tr>
<tr>
<td>Converting single-precision real number to 16-bit unsigned binary data</td>
<td>FLT2UINT(P)</td>
<td>REAL_TO_DINT(E)</td>
</tr>
<tr>
<td>Converting single-precision real number to 32-bit signed binary data</td>
<td>FLT2DINT(P)</td>
<td>REAL_TO_DINT(E)</td>
</tr>
<tr>
<td>Converting single-precision real number to 32-bit unsigned binary data</td>
<td>FLT2UDINT(P)</td>
<td>REAL_TO_DINT(E)</td>
</tr>
<tr>
<td>Converting double-precision real number to 16-bit signed binary data</td>
<td>DBL2INT(P)</td>
<td>LREAL_TO_INT(E)</td>
</tr>
<tr>
<td>Converting double-precision real number to 16-bit unsigned binary data</td>
<td>DBL2UINT(P)</td>
<td>LREAL_TO_DINT(E)</td>
</tr>
<tr>
<td>Converting 16-bit signed binary data to 16-bit unsigned binary data</td>
<td>INT2UINT(P)</td>
<td>INT_TO_WORD(E)</td>
</tr>
<tr>
<td>Converting 16-bit signed binary data to 32-bit signed binary data</td>
<td>INT2DINT(P)</td>
<td>INT_TO_DINT(E)</td>
</tr>
<tr>
<td>Converting 16-bit signed binary data to 32-bit unsigned binary data</td>
<td>INT2UDINT(P)</td>
<td>INT_TO_DWORD(E)</td>
</tr>
<tr>
<td>Converting 16-bit unsigned binary data to 16-bit signed binary data</td>
<td>UINT2INT(P)</td>
<td>WORD_TO_INT(E)</td>
</tr>
<tr>
<td>Converting 16-bit unsigned binary data to 16-bit unsigned binary data</td>
<td>UINT2UINT(P)</td>
<td>WORD_TO_DINT(E)</td>
</tr>
<tr>
<td>Converting 32-bit signed binary data to 16-bit signed binary data</td>
<td>DINT2INT(P)</td>
<td>DINT_TO_INT(E)</td>
</tr>
<tr>
<td>Converting 32-bit signed binary data to 16-bit unsigned binary data</td>
<td>DINT2UINT(P)</td>
<td>DINT_TO_DWORD(E)</td>
</tr>
<tr>
<td>Converting 32-bit signed binary data to 32-bit signed binary data</td>
<td>DINT2DINT(P)</td>
<td>DINT_TO_DINT(E)</td>
</tr>
<tr>
<td>Converting 32-bit unsigned binary data to 16-bit signed binary data</td>
<td>UDINT2INT(P)</td>
<td>DWORD_TO_INT(E)</td>
</tr>
<tr>
<td>Converting 32-bit unsigned binary data to 16-bit unsigned binary data</td>
<td>UDINT2UINT(P)</td>
<td>DWORD_TO_DINT(E)</td>
</tr>
<tr>
<td>Converting 32-bit unsigned binary data to 32-bit signed binary data</td>
<td>UDINT2DINT(P)</td>
<td>DWORD_TO_DINT(E)</td>
</tr>
<tr>
<td>Transferring string data</td>
<td>MOV(P)</td>
<td>&quot;1&quot;</td>
</tr>
<tr>
<td>Transferring Unicode string data</td>
<td>MOV(P)_WS</td>
<td>&quot;1&quot;</td>
</tr>
<tr>
<td>Converting 16-bit signed binary data to single-precision real number</td>
<td>INT2FLT(P)</td>
<td>INT_TO_REAL(E)</td>
</tr>
<tr>
<td>Converting 16-bit unsigned binary data to single-precision real number</td>
<td>UINT2FLT(P)</td>
<td>DWORD_TO_DINT(E)</td>
</tr>
<tr>
<td>Converting 32-bit signed binary data to single-precision real number</td>
<td>DINT2FLT(P)</td>
<td>DINT_TO_REAL(E)</td>
</tr>
<tr>
<td>Converting 32-bit unsigned binary data to single-precision real number</td>
<td>UDINT2FLT(P)</td>
<td>DINT_TO_REAL(E)</td>
</tr>
<tr>
<td>Converting double-precision real number to single-precision real number</td>
<td>DBL2FLT(P)</td>
<td>LREAL_TO_REAL(E)</td>
</tr>
<tr>
<td>Converting 16-bit signed binary data to double-precision real number</td>
<td>INT2DBL(P)</td>
<td>INT_TO_LREAL(E)</td>
</tr>
<tr>
<td>Converting 16-bit unsigned binary data to double-precision real number</td>
<td>UINT2DBL(P)</td>
<td>DWORD_TO_DINT(E)</td>
</tr>
<tr>
<td>Converting 32-bit signed binary data to double-precision real number</td>
<td>DINT2DBL(P)</td>
<td>DINT_TO_LREAL(E)</td>
</tr>
<tr>
<td>Converting 32-bit unsigned binary data to double-precision real number</td>
<td>UDINT2DBL(P)</td>
<td>DINT_TO_LREAL(E)</td>
</tr>
</tbody>
</table>

*1 Only assignment statement can be used for transferring character string data, or for a data type that can be converted automatically (Page 30 Type conversion which is performed automatically).

Instructions that can be described with arithmetic operator

<table>
<thead>
<tr>
<th>Type</th>
<th>Instruction symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adding 16-bit binary data</td>
<td>+(P)_U [Using two operands]</td>
</tr>
<tr>
<td>Subtracting 16-bit binary data</td>
<td>-(P)_U [Using two operands]</td>
</tr>
<tr>
<td>Adding 32-bit binary data</td>
<td>D+(P)_U [Using two operands]</td>
</tr>
<tr>
<td>Subtracting 32-bit binary data</td>
<td>D-(P)_U [Using two operands]</td>
</tr>
<tr>
<td>Multiplying 16-bit binary data</td>
<td>*(P)_U</td>
</tr>
<tr>
<td>Multiplying 32-bit binary data</td>
<td>**(P)_U</td>
</tr>
</tbody>
</table>

APPX
101
### Instructions That Cannot be Used in ST Programs

<table>
<thead>
<tr>
<th>Type</th>
<th>Instruction symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dividing 16-bit binary data</td>
<td>/P(_U)</td>
</tr>
<tr>
<td>Multiplying 32-bit binary data</td>
<td>D*(P)_U</td>
</tr>
<tr>
<td>Dividing 32-bit binary data</td>
<td>D/P(_U)</td>
</tr>
<tr>
<td>Adding BCD 4-digit data</td>
<td>B+P</td>
</tr>
<tr>
<td>Subtracting BCD 4-digit data</td>
<td>B-(P)</td>
</tr>
<tr>
<td>Adding BCD 8-digit data</td>
<td>DB+P</td>
</tr>
<tr>
<td>Subtracting BCD 8-digit data</td>
<td>DB-(P)</td>
</tr>
<tr>
<td>Multiplying BCD 4-digit data</td>
<td>B*(P)</td>
</tr>
<tr>
<td>Dividing BCD 4-digit data</td>
<td>B/(P)</td>
</tr>
<tr>
<td>Multiplying BCD 8-digit data</td>
<td>DB*(P)</td>
</tr>
<tr>
<td>Dividing BCD 8-digit data</td>
<td>DB/(P)</td>
</tr>
<tr>
<td>Adding 16-bit binary block data</td>
<td>BK+(P)_U</td>
</tr>
<tr>
<td>Subtracting 16-bit binary block data</td>
<td>BK-(P)_U</td>
</tr>
<tr>
<td>Adding 32-bit binary block data</td>
<td>DBK+(P)_U</td>
</tr>
<tr>
<td>Subtracting 32-bit binary block data</td>
<td>DBK-(P)_U</td>
</tr>
<tr>
<td>Concatenating string data</td>
<td>$+(P)</td>
</tr>
<tr>
<td>Adding single-precision real numbers</td>
<td>E+(P)</td>
</tr>
<tr>
<td>Subtracting single-precision real numbers</td>
<td>E-(P)</td>
</tr>
<tr>
<td>Adding double-precision real numbers</td>
<td>ED+(P)</td>
</tr>
<tr>
<td>Subtracting double-precision real numbers</td>
<td>ED-(P)</td>
</tr>
<tr>
<td>Multiplying single-precision real numbers</td>
<td>E*(P)</td>
</tr>
<tr>
<td>Dividing single-precision real numbers</td>
<td>E/(P)</td>
</tr>
<tr>
<td>Multiplying double-precision real numbers</td>
<td>ED*(P)</td>
</tr>
<tr>
<td>Dividing double-precision real numbers</td>
<td>ED/(P)</td>
</tr>
<tr>
<td>Adding clock data</td>
<td>DATE+(P)</td>
</tr>
<tr>
<td>Subtracting clock data</td>
<td>DATE-(P)</td>
</tr>
<tr>
<td>Adding expansion clock data</td>
<td>S(P).DATE+</td>
</tr>
<tr>
<td>Subtracting expansion clock data</td>
<td>S(P).DATE-</td>
</tr>
</tbody>
</table>

### Instructions that can be described with logical operator and comparison operator

<table>
<thead>
<tr>
<th>Type</th>
<th>Instruction symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation start, series connection, parallel connection</td>
<td>LD, LDI, AND, ANI, OR, ORI</td>
</tr>
<tr>
<td>Ladder block series/parallel connection</td>
<td>ANB, ORB</td>
</tr>
<tr>
<td>Comparing 16-bit binary data</td>
<td>LDCI(U), ANDCI(U), ORDI(U)</td>
</tr>
<tr>
<td>Comparing 32-bit binary data</td>
<td>LDDCI(U), ANDDDCI(U), ORDDCI(U)</td>
</tr>
<tr>
<td>Comparing 16-bit binary block data</td>
<td>BKCMPI(P)_U</td>
</tr>
<tr>
<td>Comparing 32-bit binary block data</td>
<td>DBKCMPI(P)_U</td>
</tr>
<tr>
<td>Performing an AND operation on 16-bit data</td>
<td>WAND(P)</td>
</tr>
<tr>
<td>Performing an AND operation on 32-bit data</td>
<td>DAN(D(P))</td>
</tr>
<tr>
<td>Performing an OR operation on 16-bit data</td>
<td>WOR(P)</td>
</tr>
<tr>
<td>Performing an OR operation on 32-bit data</td>
<td>DOR(P)</td>
</tr>
<tr>
<td>Performing an XOR operation on 16-bit data</td>
<td>WXOR(P)</td>
</tr>
<tr>
<td>Performing an XOR operation on 32-bit data</td>
<td>DXOR(P)</td>
</tr>
<tr>
<td>Performing an XNOR operation on 16-bit data</td>
<td>WNXR(P)</td>
</tr>
<tr>
<td>Performing an XNOR operation on 32-bit data</td>
<td>DXNR(P)</td>
</tr>
<tr>
<td>Comparing string data</td>
<td>LD$O, AND$O, OR$O</td>
</tr>
<tr>
<td>Comparing single-precision real numbers</td>
<td>LDEO, ANDEO, OREO</td>
</tr>
<tr>
<td>Comparing double-precision real numbers</td>
<td>LDEO, ANDEO, OREO</td>
</tr>
<tr>
<td>Comparing date data</td>
<td>LDDTO, ANDDTO, ORDTO</td>
</tr>
<tr>
<td>Comparing time data</td>
<td>LDTMO, ANDTMO, ORTMO</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Type</th>
<th>Instruction symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performing the FOR to NEXT instruction loop</td>
<td>FOR, NEXT</td>
</tr>
<tr>
<td>Pointer branch</td>
<td>CJ, SCJ, JMP</td>
</tr>
<tr>
<td>Jumping to END</td>
<td>GOEND</td>
</tr>
<tr>
<td>Returning from the interrupt program</td>
<td>IRET</td>
</tr>
<tr>
<td>Forcibly terminating the FOR to NEXT instruction loop</td>
<td>BREAK(P)</td>
</tr>
<tr>
<td>Calling a subroutine program</td>
<td>CALL(P)</td>
</tr>
<tr>
<td>Returning from the subroutine program called</td>
<td>RET</td>
</tr>
<tr>
<td>Calling a subroutine program and turning the output OFF</td>
<td>FCALL(P)</td>
</tr>
<tr>
<td>Calling a subroutine program in the specified program file</td>
<td>ECALL(P)</td>
</tr>
<tr>
<td>Calling a subroutine program in the specified program file and turning the output OFF</td>
<td>EFCALL(P)</td>
</tr>
<tr>
<td>Calling a subroutine program</td>
<td>XCALL</td>
</tr>
</tbody>
</table>

## Unnecessary instructions for ST program

<table>
<thead>
<tr>
<th>Type</th>
<th>Instruction symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ending the sequence program</td>
<td>END</td>
</tr>
<tr>
<td>No operation (NOP)</td>
<td>NOP, NOPLF</td>
</tr>
</tbody>
</table>
Appendix 3  Considerations for Using the MELSEC iQ-F Series

Description in this manual is based on the use of MELSEC iQ-R series.
This section shows the considerations for creating an ST program for the MELSEC iQ-F series by referring to this manual.

Differences between the MELSEC iQ-F series and MELSEC iQ-R series

The MELSEC iQ-F series has specifications different from the MELSEC iQ-R series for the items in the table below.
Note that some devices and data types that are described in this manual are not available for creating an ST program for the MELSEC iQ-F series.

<table>
<thead>
<tr>
<th>Item</th>
<th>Difference</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Available device types are different.</td>
<td>MELSEC iQ-F FX5 User's Manual (Application)</td>
</tr>
<tr>
<td></td>
<td>Check the specifications of a CPU module to be used.</td>
<td></td>
</tr>
<tr>
<td>Data type</td>
<td>FLOAT [Double Precision] (LREAL)</td>
<td>MELSEC iQ-F FX5 Programming Manual (Program Design)</td>
</tr>
<tr>
<td></td>
<td>The MELSEC iQ-F series does not support it.</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>String [Unicode] type</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The MELSEC iQ-F series does not support it.</td>
<td></td>
</tr>
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</table>

Restrictions on Structured Text language are the same between the MELSEC iQ-R series and MELSEC iQ-F series. However, besides above, there may be differences in some other specifications such as for instructions, etc. between the series.
Check the specifications of modules to be used when creating an ST program.
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# REVISIONS

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

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<th>Description</th>
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<tr>
<td>February 2015</td>
<td>SH(NA)-081483ENG-A</td>
<td>First edition</td>
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<td>April 2015</td>
<td>SH(NA)-081483ENG-B</td>
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<td>SH(NA)-081483ENG-D</td>
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<td>November 2020</td>
<td>SH(NA)-081483ENG-E</td>
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Japanese manual number: SH-081445-F

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