The Performance index of programmable controllers（PLC-MIX）

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社団法人日本電機工業会

The Japan Electrical Manufacturers' Association

P L C 技 術 専 門 委 員 会

The Programmable Controller Technical Committee

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Introduction

Japan Electrical Manufacture's Association introduces "PLC-MIX" as general Performance index that helps users to choose suitable PLC in each industrial application.

Total performance of PLC includes not only the operation processing performance that PLC-MIX focuses its attention on but also communication with peripheral devices, network processing, diagnostics and input and output processing. User should refer to information of a manufacturer about these performances individually.

1. The reference system in calculation of “PLC-MIX”

Since the comprehensive processing performance of PLC is influenced by the system configuration. The reference system configuration is defined in PLC-MIX in order to eliminate the influence of system configuration. Table 2 shows reference system configuration.

Table 1 Reference system configuration

Item	Contents	Note
Language	Ladder Logic language	IEC61131-3 conformity
System scale	128 inputs / 128 outputs	Direct I/O
Internal data	64 words	WORD width depends on the system.
Application	8,000 steps (Equivalent)	
Instruction	Basic instruction Application instruction	Floating-point instructions are not included.

2. The reference distribution ratio of the operation processing instruction classification in calculation of "PLC-MIX"

Since application influences the processing performance of PLC, PLC-MIX adopts the average of the instruction distribution ratio from the application programs used in real industrial fields as shown in Table 2.

Table 2 Applications

Industry	Application	The number of systems	Basic instruction rate	Standard deviation
Equipment surveillance and control	Equipment Monitoring	4	69.3%	21.9%
	Electric energy Monitoring	1		
	Operation Panel	1		
Line control	Line control	8	78.5%	10.4%
	Steel mill control	1		
Materials handling machine	Materials handling machine	4	76.85%	10.4%
	Conveyor control	1		
Paper manufacture / printing machine	Printing machine	5	74.15%	2.5%
Converting machinery	Metalworking	3	60.8%	12.4%
	Extrusion machine	3		
	Lathe	1		
Food and packaging machinery	Food processing	1	79.2%	5.18%
	Cultivation monitoring	1		
A semiconductor and liquid crystal manufacture equipment	Semiconductor	4	86.4%	5.72%
Total		38	67.4%	9.09%

3. Definition

a) PLC-MIX

It is the number of the instructions that PLC can carry out in the unit time and it is weighted according to the instruction distribution ratio. It provides one performance index of PLC instruction processing.

b) Basic PLC-MIX

It is the number of instructions by which gives the index of the operation processing performance of PLC. It is the number of the Basic instructions that PLC can carry out in the unit time and it is weighted according to the instruction distribution ratio of the basic instructions such as input and output for one bit, timers and counters.

c) Application PLC-MIX

It is the number of instructions by which gives the index of the operation processing performance of PLC. It is the number of the Application instructions that PLC can carry out in the unit time and it is weighted according to the instruction distribution ratio of the basic instructions of the various operations to WORD (16 bits and 32 bits), transmission, etc.

d) Total PLC-MIX

It is the number of instructions by which gives the index of the operation processing performance of PLC. It is the number of the instructions that PLC can carry out in the unit time and it is weighted according to the instruction distribution ratio of all instructions.

e) Instruction

The instruction of PLC-MIX is based on the ladder Logic language provided in Chapter 4 of IEC61131-3 (programmable controller program language).

f) Equivalent application instruction.

PLC-MIX is based on the ladder Logic language that is very popular in the industry. However, an equivalent application instruction is defined to calculate PLC-MIX in PLC that uses the application program by the structure text (ST) language or a functional block diagram (FBD) language.

g) Changed state – Unchanged state

PLC is a Change state when an output state is reversed. and It is an unchanged state when an output state is the same before and after execution of an instruction

h) Executed state – Unexecuted state.

Execution state is a state where an instruction is executed according to the logical true input of the instruction.

Unexecuted state is a state where an instruction is not executed according to the logical false input of the instruction.

i) Instruction distribution ratio

The table 3 shows the distribution ratio of the instruction used for calculation of PLC-MIX from the average of 38 application programs used in real industrial field.

Table 3 Instruction allocation sheet

Instruction classification	Instruction			Instruction ratio	
Basic instruction	Input	1-bit external input	-	18.399%	84.399%
	Output	1-bit external output	Changed	0.774%	
			Unchanged	6.969%	
	Operation	Inside input of 1 bit	-	30.353%	
		Inside output of 1 bit	Changed	6.618%	
			Unchanged	19.855%	
	A timer/counter	16-bit timer	Unexecuted.	0.438%	
			Inside of a time	0.438%	
			After rise	0.438%	
		16-bit counter	Under a count	0.012%	
			Unexecuted.	0.104%	
Application instruction	16-bit transmission	16-bit transmission	Executed	0.724%	15.601%
			Unexecuted.	2.895%	
	16 bits Four operations	16-bit addition	Executed	0.158%	
			Unexecuted.	0.631%	
		16-bit subtraction	Executed	0.074%	
			Unexecuted.	0.297%	
		16-bit multiplication	Executed	0.037%	
			Unexecuted.	0.149%	
		16-bit division	Executed	0.010%	
			Unexecuted.	0.041%	
	16-bit conversion	16-bit BCD conversion	Executed	0.007%	
			Unexecuted.	0.030%	
		16-bit BIN conversion	Executed	0.010%	
			Unexecuted.	0.041%	
	16 bits Logical operation	16 bit comparisons	Executed	0.678%	
			Unexecuted.	2.713%	
		16-bit logic	Executed	1.092%	
			Unexecuted.	4.368%	
	32-bit transmission	32-bit transmission	Executed	0.067%	
			Unexecuted.	0.267%	
	32 bits Four operations	32-bit addition	Executed	0.041%	
			Unexecuted.	0.163%	
		32-bit subtraction	Executed	0.024%	
			Unexecuted.	0.097%	
		32-bit multiplication	Executed	0.040%	
			Unexecuted.	0.160%	
		32-bit division	Executed	0.087%	
			Unexecuted.	0.349%	
	32-bit conversion	32-bit BCD conversion	Executed	0.002%	
			Unexecuted.	0.010%	
		32-bit BIN conversion	Executed	0.002%	
			Unexecuted.	0.008%	
	32 bits Logical operation	32 bit comparisons	Executed	0.065%	
			Unexecuted.	0.258%	
		32-bit logic	Executed	0.001%	
			Unexecuted.	0.005%	

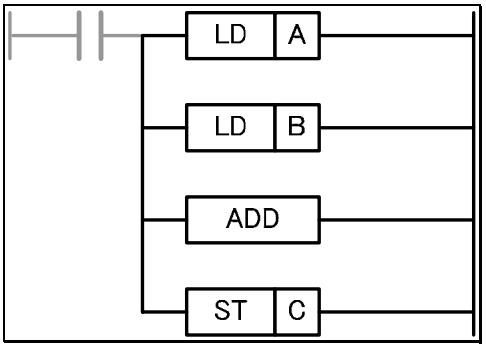
4. Calculation of PLC-MIX

a) Application instruction

An application instruction of the various operations to WORD (16 bits and 32 bits) is depend on the PLC architecture. PLC-MIX is calculated as one application instruction with a series of operation to access to the data for operation, to execute the operation, and to storing the operation result. When an equivalent operation is realized by two or more instructions, those instruction executed time are summed and it is considered as an equivalent instruction executed time.

Example 1 When on instruction performs to access to the data for operation, to execute the operation, and to store the result, the processing time is the executed time of the instruction.

Example 2 When accessing each data, executing the operation, and storing the result are carried out by individual instructions, the execution time is summation of each instruction processing time.



b) Notes: Calculating processing times

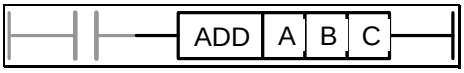
1) When the operand influences the processing time, the shortest processing time is adopted.
2) When a 16-bit instruction does not exist, the executed time of a similar instruction is adopted (for example, =, ≧ and a logical product instruction, Not-exclusion logical sum, etc.).
3) When a 32-bit instruction does not exist, a time that is 1.8 times as long as the 16-bit instruction is adopted.
4) When the value of the unexecuted state is unknown, (NOP processing time)×(the number of instruction steps) is adopted as an equivalent value.
5) When an unchanged state processing time of an external output is unknown, the value of changed state is adopted.
6) When the processing time after set of a timer is unknown, the value under count is adopted.

Equivalent operation processing time is sometime not equal to actual value, it is recommended to contact with manufacturer representatives.

5. Evaluation of PLC-MIX in program language other than a ladder logic language

In program language other than the ladder logic language provided in IEC61131-3, PLC-MIX is computed by equivalent Executed total time of the instruction group, that is realizing a series of operation to access to the data for operation, Executed of operation, and storing of an operation result for an application instruction as an equivalent application instruction. Moreover, about Executed and unexecuted states, the influence of the discriminate operation for the equivalent instruction (group) shall be considered,

The following examples show how to calculate an equivalent execution time for an addition instruction.



a) Structure text (ST) language

Example:

The figure shows instructions by ST language equivalent to the above 16-bit WORD addition instruction of ladder Logic Language.

```
VAR_INPUT
                    ENABLE: BOOL;
END_VAR
VAR
                    A,B,C: INT;
END_VAR
IF ENABLE=1 THEN
                    C: =A+B;
END_IF
```

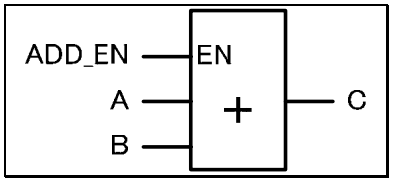
In the above example, an equivalent execution time is considered as executed state when a value of ENABLE is 1, and it is considered as unexecuted state when a value of ENABLE is 0.

The value of ENABLE	Executed time
1	Executed state.
0	Unexecuted state

b) Functional block diagram (FBD) language

Example

The figure shows instructions by FBD language equivalent to the above 16-bit WORD addition instruction of ladder Logic Language



A function block element with the ENABLE (EN) terminal for executed / unexecuted state is an equivalent application instruction.

In the above example, an equivalent execution time is considered as executed state when a value of ADD_EN is 1, and it is considered as unexecuted state when a value of ADD_EN is 0.

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The value of ADD_EN	Executed time
1	Executed state.
0	Unexecuted state

c) Simple equivalent application instruction

Simple equivalent application instruction Simple equivalent application instruction is defined as an equivalent application instruction without discriminate operation of executed/ unexecuted state. It provides simple evaluation, while it is not easy to calculate the execution time of an equivalent application instruction in the ST language or FBD language that has a mechanism to discriminate an executed state.

An execution time of a simple equivalent application instruction is not identical to one of the equivalent application instruction, because it does not take count of executed/-unexecuted state.

Example 1 The simple equivalent application instruction of a 16-bit WORD addition instruction in Structure text (ST) language

```
VAR
        A, B, C; REAL
END_VAR
        C: =A+B;
END
```

Example 2 The simple equivalent application instruction of a 16-bit WORD addition instruction in Functional block (FBD) language