

# PMC Function Library (Spindle control)

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# 1 Overview

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This document describes the specifications of PMC Function Library for spindle control, and how to integrate its functions. The spindle control function provides the function to control the spindle with PMC specifying the speed of spindle motor and the direction, and the function to control the CNC's spindle by PMC signals, such as the speed range switching control function and so on.

The spindle output control by PMC allows PMC ladder program to customize switching gear, clamping and overriding speed, and so on. Sample programs are provided to help your programming to control the spindle. This library provides function blocks that can be integrated to your ladder program by FANUC LADDER-III.

## 2 Applicable PMC models

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This library can be used for the PMC models listed below:

### Applicable PMC models

Series 30i/31i/32i -MODEL B PMC
Series 35i -MODEL B PMC
Series 30i/31i/32i -MODEL A PMC
Series 32i -MODEL A PMC/L
Series 0i -MODEL F PMC
Series 0i -MODEL D PMC
Series 0i -MODEL D PMC/L
Series 0i Mate-MODEL D PMC/L

# 3 PMC Function Library for Spindle Control

PMC Function Library for Spindle control is a function block library which provides sample programs for Spindle control by PMC.

Library name : PMC\_SPINDLE\_CONTROL.FLL

This library contains function blocks of Spindle control.

## Note

- 1 The option "Function Block function" is required to use function block function.
- 2 See the chapter of "SPINDLE OUTPUT CONTROL BY THE PMC" in "CONNECTION MANUAL (FUNCTION)" of your CNC model for more details of Spindle control by PMC.

## 3.1 List of Function blocks for Spindle control

The function blocks provided by PMC\_SPINDLE\_CONTROL.FLL are listed below:

Table 3.1 List of function blocks

No.	Function block name	Size of instance	Description
1	PFL2_CALC_SPNDL_MOTOR_SPEED	128 byte	Calculation of spindle motor speed data The spindle motor speed data with the selected gear is calculated, which can be specified for PMC spindle control signals.
2	PFL2_CNV_SCODE_TO_S12BCODE	17 byte	Conversion from S code to S12-bit code The command value data of S code (spindle speed) is converted into the S12-bit code data.
3	PFL2_CNV_S12BCODE_TO_SCODE	21 byte	Conversion from S12-bit code to S code The S12-bit code data is converted into the command value data of S code (spindle speed).
4	PFL2_SWITCHING_WINDING_SPEED	20 byte	Switching the winding by Speed range switching control According to the velocity command of S code, the output characteristic (winding) of a spindle motor will be switched properly between two types of windings; winding for low-speed output characteristic and winding for high-speed output characteristic.

## Note

- 1 Size of instance is the data size in byte that each instance of the function block occupies.

## 3.2 CNC parameters

The function blocks in this library control the spindle, which requires the following CNC parameter to be properly set before you use the function blocks.

For the CNC parameters related to each function block, please refer to the following detailed explanations of each function.

**Table 3.2 (a) Related CNC parameters**

CNC parameter	Value	Description
MHI (No.3001#7)	arbitrarily	Exchange of strobe and completion signals for the M,S,T and B 0: Normal 1: High speed
No.3031	arbitrarily	Allow able number of digits for the S code
ESF (No.3705#0)	0	When the spindle control function is used, and the constant surface speed control function is used or bit 4 (GTT) of parameter No. 3706 is set to 1: 0: S codes and spindle function strobe signal SF<Fn007.2> are output for all S commands. 1: For the T series: S codes and spindle function strobe signal SF are not output for an S command in the constant surface speed control mode and a command for maximum spindle speed clamping. For the M series: S codes and SF are not output for an S command in the constant surface speed control mode.
EVS (No.3705#4)	1	When the spindle control function is used, S codes and spindle function strobe signal SF<Fn007.2> are: 0: Not output for an S command. 1: Output for an S command.
NSF (No.3705#5)	0	For the M series, when a T type gear is selected (with bit 4 (GTT) of parameter No. 3706 set to 1 or with the option for constant surface speed control), and an S code is specified: 0: Spindle function strobe signal SF is output. 1: Spindle function strobe signal SF is not output.
SFA (No.3705#6)	1	The spindle function strobe signal SF is output: 0: When gears are switched. 1: Irrespective of whether gears are switched.

### Note

- 1 See "PARAMETER MANUAL" of your CNC for the details of the CNC parameters.

## 3.3 Signals for Spindle control function

### 3.3.1 Signals for Spindle control function handled by ladder program

The following table lists the main signals that shall be handled by ladder program. There are other signals related to Spindle control, which may be controlled by ladder program if necessary.

Table 3.3.1 (a) Main Spindle control signals controlled by ladder program

Signal name	Symbol	Address (group 1)	Description
Spindle-speed function code signals (binary output)	S00~S31	F22~F25	These signals send S codes specified for the CNC, in binary format, to the PMC.
Spindle-speed function strobe signal	SF	F7.2	This signal is completion of the Spindle-speed function code signals output.
End signal FIN	FIN	G4.3	This signal reports the completion of an auxiliary function, a spindle function, a tool function, a 2nd auxiliary function, or an external operation function.
Spindle function completion signal	SFIN	G5.2	This signal reports that the execution of a spindle speed function by the high-speed M/S/T/B interface is completed.
S12-bit code signals	R01O~R12O	F36.0~F37.3	These are code signals from 0 to 4095 which is calculated by CNC from the spindle speed command value.

#### Note

- 1 Only the signal of first path is described.
- 2 See "CONNECTION MANUAL (FUNCTION)" of your CNC for the details of each signal, or for related signals that are not listed in the table above.

## 3.4 How to use PMC Function Library

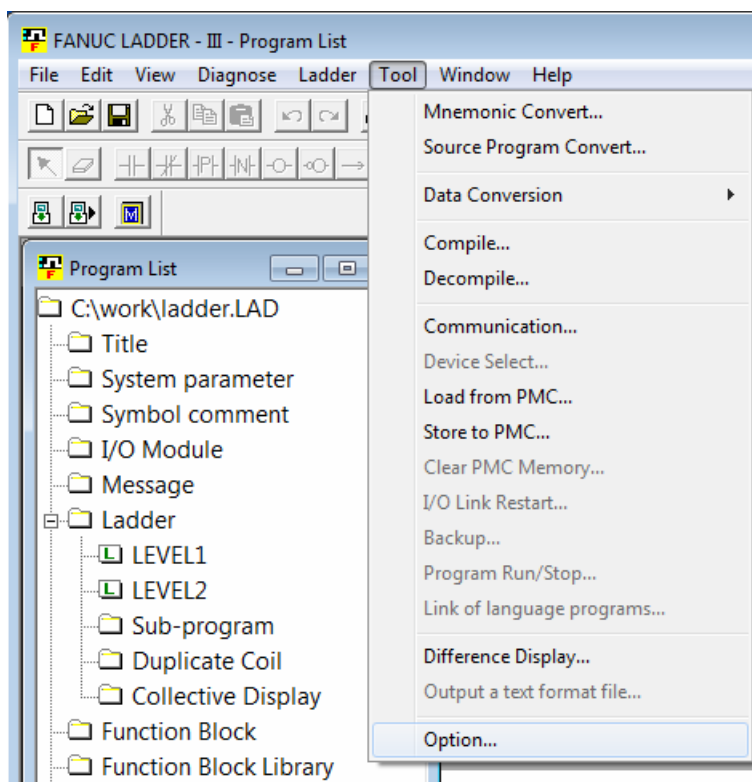
PMC Function Library for Spindle control is provided as a function block library.

This library is contained in the installation CD of FANUC LADDER-III, with the name

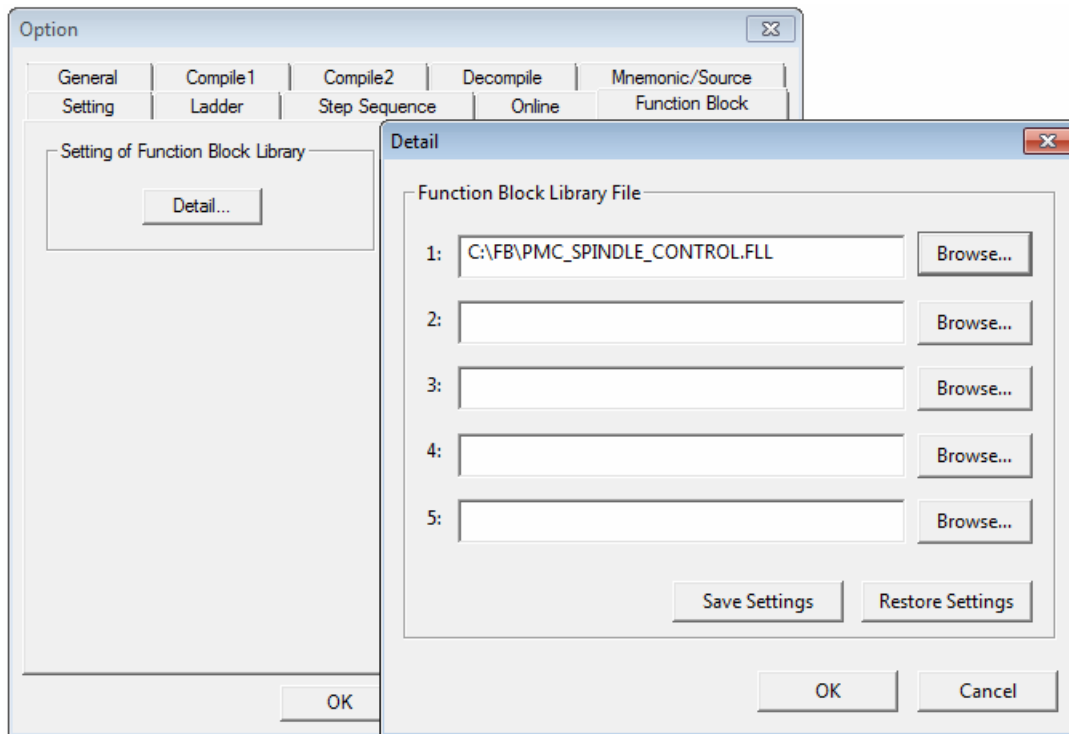
“PMC\_SPINDLE\_CONTROL.FLL”. You can copy the file to your hard disk drive or network drive to use it.

The function blocks in this library can be integrated to your ladder program by the following steps:

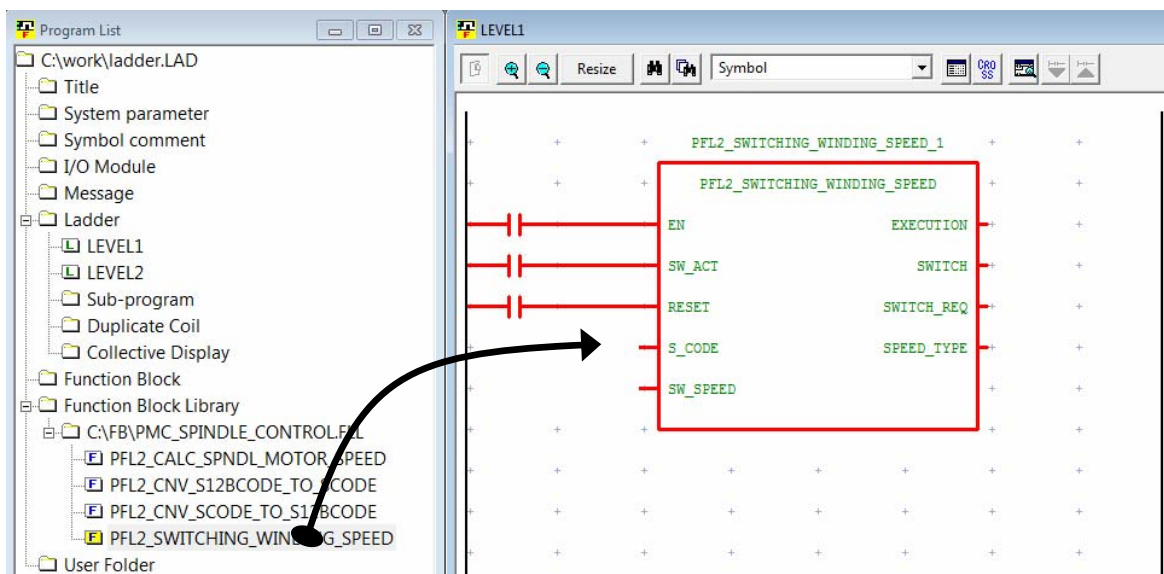
- 1) Open your ladder program, or create a new program, into which the function block will be integrated.
  - 2) Set “PMC\_SPINDLE\_CONTROL.FLL” as a function block library to be referred by the ladder program.
  - 3) After function blocks are displayed in the program list, drag & drop a function block you use.
  - 4) Connect proper signals and circuits to the input and output of the function block.
- 
- 1) Open or create a ladder program to use the function blocks
    - On FANUC LADDER-III, open a ladder program that support function block.
  - 2) Set “PMC\_SPINDLE\_CONTROL.FLL” as a function block library.
    - Select “Option” in the “Tool” menu.



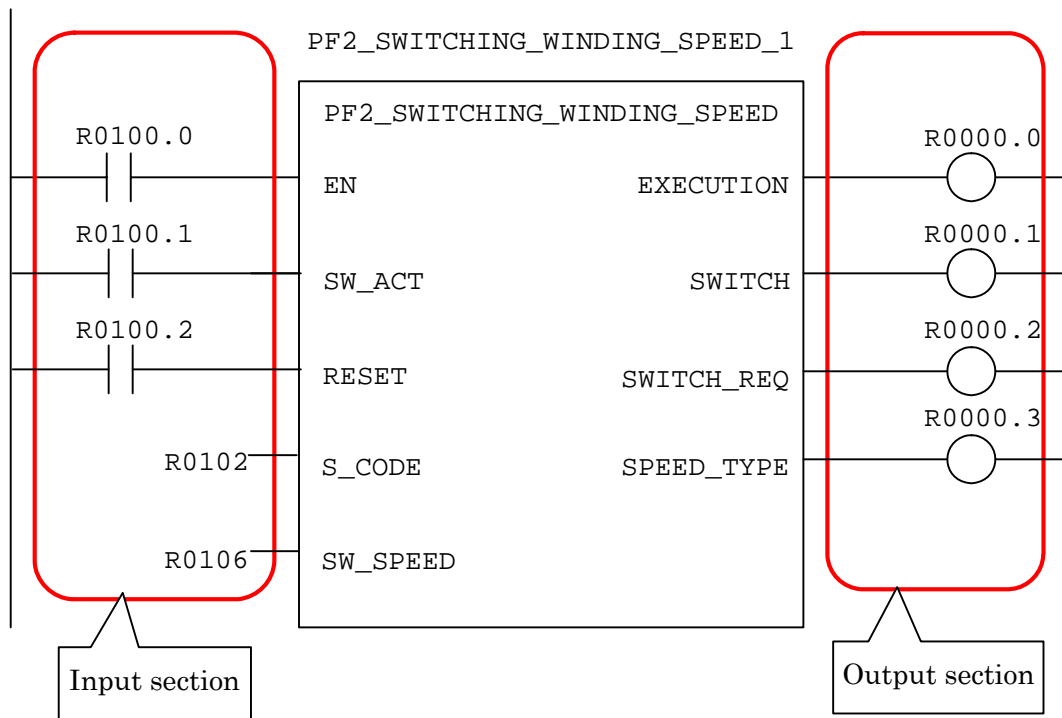
- Press “Detail” button in “Function Block” tab, and enter the path of the PMC Function Library file “PMC\_SPINDLE\_CONTROL.FLL”.



- 3) Drag & drop a function block in the program list onto the ladder edit window.
  - After the registered library is displayed under “Function Block Library” in the program list, drag & drop the function block you use at the proper place.



- 4) Connect proper signals and circuits to the input and output of the function block.
  - Connect proper signals to the input and output parameters to complete as a ladder circuit.



**Figure 3.4 (a) Sample FB**



# 4

## Function blocks of Spindle control

This chapter describes the usage of the function blocks provided by PMC Function Library for spindle control (PMC\_SPNDLE\_CONTROL.FLL).

### 4.1 Calculation of spindle motor speed data

#### 4.1.1 Function block name

PFL2\_CALC\_SPNDL\_MOTOR\_SPEED ···· Calculation of spindle motor speed data

#### 4.1.2 Function

The spindle output control by the PMC allows PMC ladder program to customize the way to control a spindle axis. This function block calculates the spindle motor speed data for the PMC spindle control signals from the spindle rotation speed command, and selects the most suitable gear number. This function block accepts four gears at the maximum; GR1-GR4.

This function block works as follows with the spindle rotation speed, the speed rotation data of each gear, the clamp data, and the override value specified by the each input parameter.

1. In the case of automatic gear, the most suitable gear number is automatically selected and the spindle motor speed data at the selected gear is calculated.
2. In the case of direct gear, the spindle motor speed data at the specified gear is calculated.
3. When the spindle override is enabled, the override value is applied to the output of the spindle motor speed data.
4. The output of the spindle motor speed data will be clamped by the upper /lower limit of the rotation speed of spindle motor.

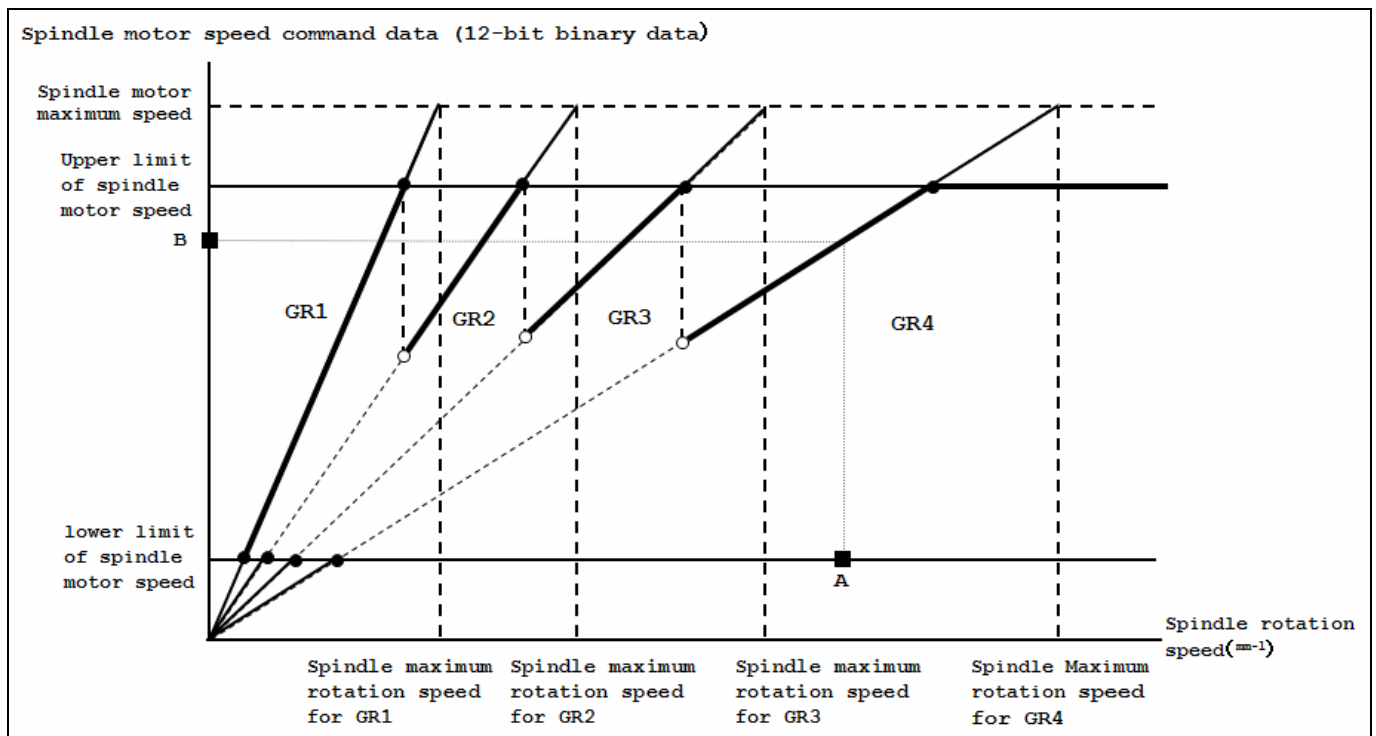


Figure 4.1.2 (a) Calculation of a spindle motor speed data by specification of the spindle rotation speed

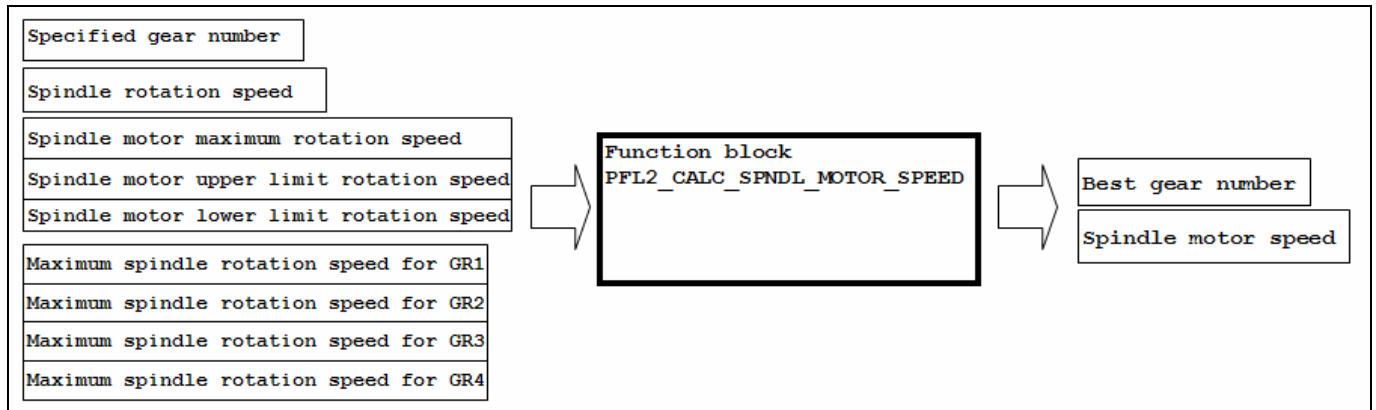
When the spindle rotation speed is “A” and the automatic gear is selected, the result of spindle motor speed data will be the value “B” and the GR4 is selected as the most suitable gear.

## Note

1. The maximum value 4095 of spindle motor speed data corresponds to 10V in analog voltage.
2. The spindle motor speed data including override will be clamped.
3. For details of the spindle output control by the PMC, please refer to the chapter of "SPINDLE OUTPUT CONTROL BY THE PMC" in "CONNECTION MANUAL (FUNCTION)" of your CNC.

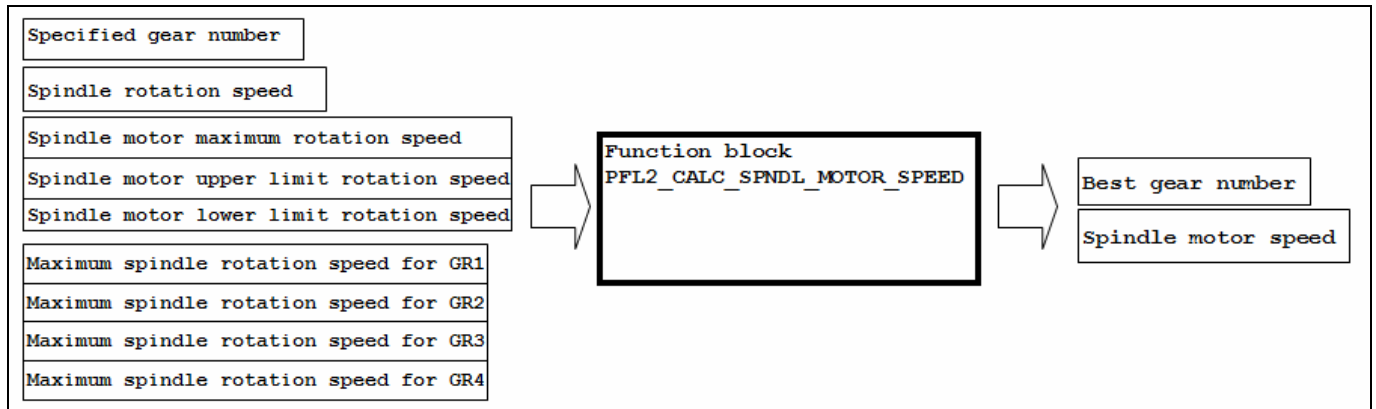
### (1) Automatic gear specification

The most suitable gear will be selected according to the spindle rotation speed and the maximum spindle rotation speed of each gear (GR1 - GR4), and the spindle motor speed data for the gear will be calculated.



### (2) Direct gear specification

The spindle motor speed data will be calculated according to the spindle rotation speed and the specified gear number. In this case, the spindle motor speed data has a linear relationship with the spindle rotation speed. The line for the selected gear is assumed to extend to its lower limit of spindle motor speed (indicated by broken lines “\_ \_ \_ \_”). See Figure 4.1.2(a).



## Note

1. In case of direct gear, the gear number output will be the specified gear number.

### (3) Clamping the spindle motor speed

The upper and lower limits of spindle motor speed are calculated by following formula of the clamp data; the maximum rotation speed, the lower and upper limit rotation speeds of the spindle motor.

Lower limit of spindle motor speed

$$= \text{Spindle motor lower limit rotation speed} \div \text{Spindle motor maximum rotation speed} \times 4095$$

Upper limit of spindle motor speed

$$= \text{Spindle motor upper limit rotation speed} \div \text{Spindle motor maximum rotation speed} \times 4095$$

The spindle motor maximum speed “4095” is the spindle motor speed at the specified voltage of 10V. The spindle motor speed is clamped at the lower and the upper limit of spindle motor speeds.

### 4.1.3 Format

Graphical format of PFL2\_CALC\_SPNDL\_MOTOR\_SPEED is shown below:

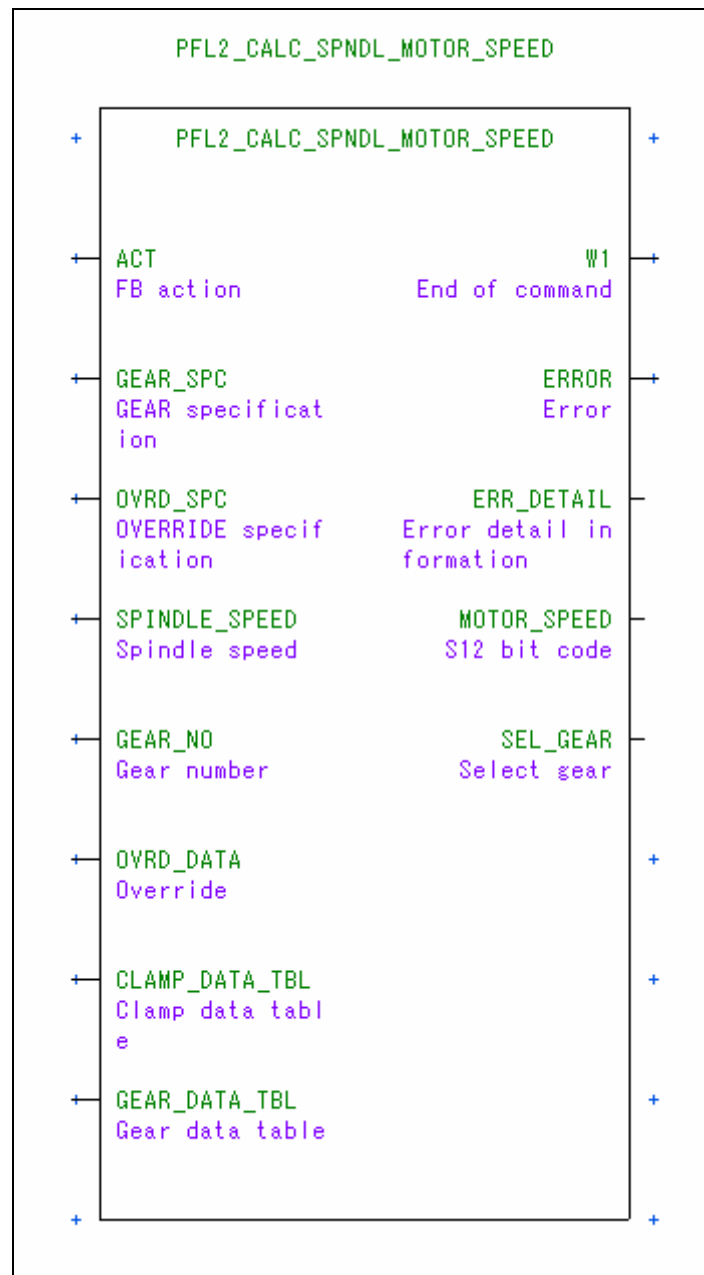


Figure 4.1.3 (a) PFL2\_CALC\_SPNDL\_MOTOR\_SPEED

## 4.1.4 Parameters

Details of the parameters of this function block are as shown below:

**Table 4.1.4 (a) List of parameters**

Symbol	Parameter type	Data type	Count	Description				
ACT	Input parameter	BOOL	-	Activation 0: Do not calculate the spindle motor speed. 1: Calculate the spindle motor speed. (Note 1)				
GEAR_SPC	Input parameter	BOOL	1	Gear specification 0: Automatic gear selection. The most suitable gear is automatically selected. 1: Direct gear selection. The specified gear is used.				
OVRD_SPC	Input parameter	BOOL	1	Override specification 0: Disable the override function. 1: Enable the override function.				
SPINDLE_SPEED	Input parameter	DINT	1	Spindle rotation speed Specify the spindle rotation speed. Valid range is 1 to 99999.				
GEAR_NO	Input parameter	USINT	1	Gear number specification Specify the gear number of the direct gear selection. Valid range is 1 to 4.				
OVRD_DATA	Input parameter	USINT	1	Spindle override data Specify the override value that will be applied to the spindle motor speed. Valid range is 0 to 255.				
CLAMP_DATA_TBL	Input parameter	DINT	3	Clamp data table Specify the address of the clamp data table. The size of this table is 12 bytes (4 bytes × 3). The data composition is as follows. <table border="1"><tr><td>Spindle motor maximum rotation speed</td></tr><tr><td>Spindle motor lower limit rotation speed</td></tr><tr><td>Spindle motor upper limit rotation speed</td></tr></table> Valid range of the spindle motor maximum rotation speed and the spindle motor upper limit rotation speed are 1 to 99999. Valid range of the spindle motor lower limit rotation speed is 0 to 99999. (Note 2) (Note 3)	Spindle motor maximum rotation speed	Spindle motor lower limit rotation speed	Spindle motor upper limit rotation speed	
Spindle motor maximum rotation speed								
Spindle motor lower limit rotation speed								
Spindle motor upper limit rotation speed								
GEAR_DATA_TBL	Input parameter	DINT	4	Gear rotation speed data table Specify the address of the data table of maximum spindle rotation speed for GR1-GR4. The size of this table is 16 bytes (4 bytes × 4). The data composition is as follows. <table border="1"><tr><td>Maximum spindle rotation speed for GR1</td></tr><tr><td>Maximum spindle rotation speed for GR2</td></tr><tr><td>Maximum spindle rotation speed for GR3</td></tr><tr><td>Maximum spindle rotation speed for GR4</td></tr></table> Valid range of GR1 is 1 to 99999. Valid range of GR2-GR4 is 0 to 99999. (Note 4), (Note 5)	Maximum spindle rotation speed for GR1	Maximum spindle rotation speed for GR2	Maximum spindle rotation speed for GR3	Maximum spindle rotation speed for GR4
Maximum spindle rotation speed for GR1								
Maximum spindle rotation speed for GR2								
Maximum spindle rotation speed for GR3								
Maximum spindle rotation speed for GR4								
W1	Output parameter	BOOL	-	Completion signal Indicates completion of the process. (Note 1) 0: Normally W1=0. 1: Turns on at completion of calculation. Also turns on at error (ERROR=1).				
ERROR	Output parameter	BOOL	-	Error signal Indicates an error occurs. (Note 1)				

				0: Finished successfully. 1: Finishes with an error.
ERR_DETAIL	Output parameter	INT	1	Error detail Detail information of the error at ERROR=1. See "4.1.6 Error information" for more details.
MOTOR_SPEED	Output parameter	INT	1	Spindle motor speed data Output the spindle motor speed data calculated according to the specified spindle rotation speed.
SEL_GEAR	Output parameter	USINT	1	Selected gear number In case of automatic gear selection, the most suitable gear number is output. In case of direct gear selection, the gear number specified as GERA_NO is output.

### Note

- 1 ACT shall be turned on (ACT=1) only when the function block needs to work. While ACT=1, the outputs of W1, ERROR, and ERR\_DETAIL are sustained. Turn off ACT (ACT=0) immediately when W1 turns on (W1=1).
- 2 The values in clamp data table must satisfy the following conditions. Otherwise, an error will occur.  
lower limit rotation speed < upper limit rotation speed ≤ maximum rotation speed
- 3 The spindle motor maximum rotation speed depends on the model of the motor. See "DESCRIPTIONS" manual of your spindle motor.
- 4 If there is no gear option for GR2-GR4, specify "0" to the maximum spindle rotation speed of the gear.
- 5 The gear rotation speed data table should satisfy the following conditions:  
Maximum spindle rotation speed for GR1 < Maximum spindle rotation speed for GR2  
< Maximum spindle rotation speed for GR3 < Maximum spindle rotation speed for GR4

## 4.1.5 Error information

Error detail information (ERR\_DETAIL) of this function block notifies the cause of error as follows:

**Table 4.1.5 (a) List of error codes**

Error code	Meaning
1	Gear number error (input parameter error) - Gear number for the direct gear selection is out of range.
2	Spindle rotation speed error (input parameter error) - A spindle rotation speed is a negative number.
3	Clamp data error (input parameter error) - Value in the clamping data table is wrong.
4	Gear rotation speed data error (input parameter error) - Value in the gear rotation speed data table is wrong.
21	Overflow error (operation error) - Overflow occurs while calculation.

## 4.1.6 Related signals

The signals related to this function block are listed below:

Table 4.1.6 (a) List of related signals

Symbol	Address	Signal name
SIND	G33.7	Spindle motor speed command selection signal
R01I~R12I	G32.0~G3.3	Spindle motor speed command signals by the PMC
SSIN	G33.6	Spindle motor command polarity selection signal
SGN	G33.5	Spindle motor command polarity command signal by the PMC

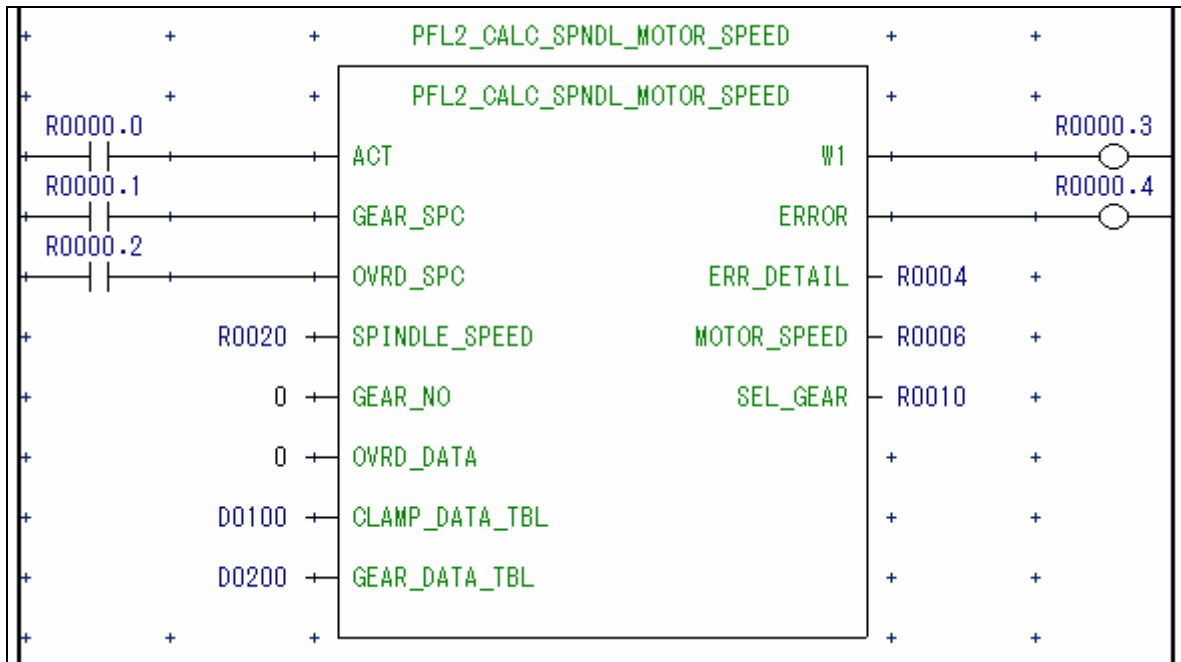
### Note

- 1 The above-mentioned addresses are for the 1<sup>st</sup> spindle.
- 2 For details of the signals, please refer to the chapter of "SPINDLE OUTPUT CONTROL BY THE PMC" in "CONNECTION MANUAL (FUNCTION)" of your CNC.

## 4.1.7 Example

The following example is to select the most suitable gear number and to calculate the spindle motor speed data according to the spindle rotation speed  $7200 \text{ min}^{-1}$ . The automatic gear selection is specified with four gears and the override is not used.

Function block to use:	PFL2_CALC_SPNDL_MOTOR_SPEDD
Parameters:	
- Activation (ACT):	R0000.0
- Gear specification (GEAR_SPC):	R0000.1    0: automatic gear
- Override specification (OVRD_SPC):	R0000.2    0: override is not used.
- Spindle rotation speed (SPINDLE_SPEED):	R0020    Spindle rotation speed; $7200 \text{ min}^{-1}$
- Gear number specification (GEAR_NO):	0    0: for automatic gear selection
- Spindle override data (OVRD_DATA):	0    0: override is not used.
- Clamp data table (CLAMP_DATA_TBL):	
Spindle motor maximum rotation speed	20000    Spindle motor maximum rotation speed; $20000 \text{ min}^{-1}$
Spindle motor lower limit rotation speed	500    Spindle motor lower limit rotation speed; $500 \text{ min}^{-1}$
Spindle motor upper limit rotation speed	15000    Spindle motor upper limit rotation speed; $15000 \text{ min}^{-1}$
- Gear rotation speed data table (GEAR_DATA_TBL):	
Maximum spindle rotation speed for GR1	5000    Maximum spindle rotation speed for GR1; $5000 \text{ min}^{-1}$
Maximum spindle rotation speed for GR2	8000    Maximum spindle rotation speed for GR2; $8000 \text{ min}^{-1}$
Maximum spindle rotation speed for GR3	10000    Maximum spindle rotation speed for GR3; $10000 \text{ min}^{-1}$
Maximum spindle rotation speed for GR4	13000    Maximum spindle rotation speed for GR4; $13000 \text{ min}^{-1}$
- Completion signal (W1):	R0000.3
- Error signal (ERROR):	R0000.4
- Error detail (ERR_DETAIL):	R0004
- Spindle motor speed data (MOTOR_SPEED):	R0006
- Best gear number (SEL_GEAR):	R0010

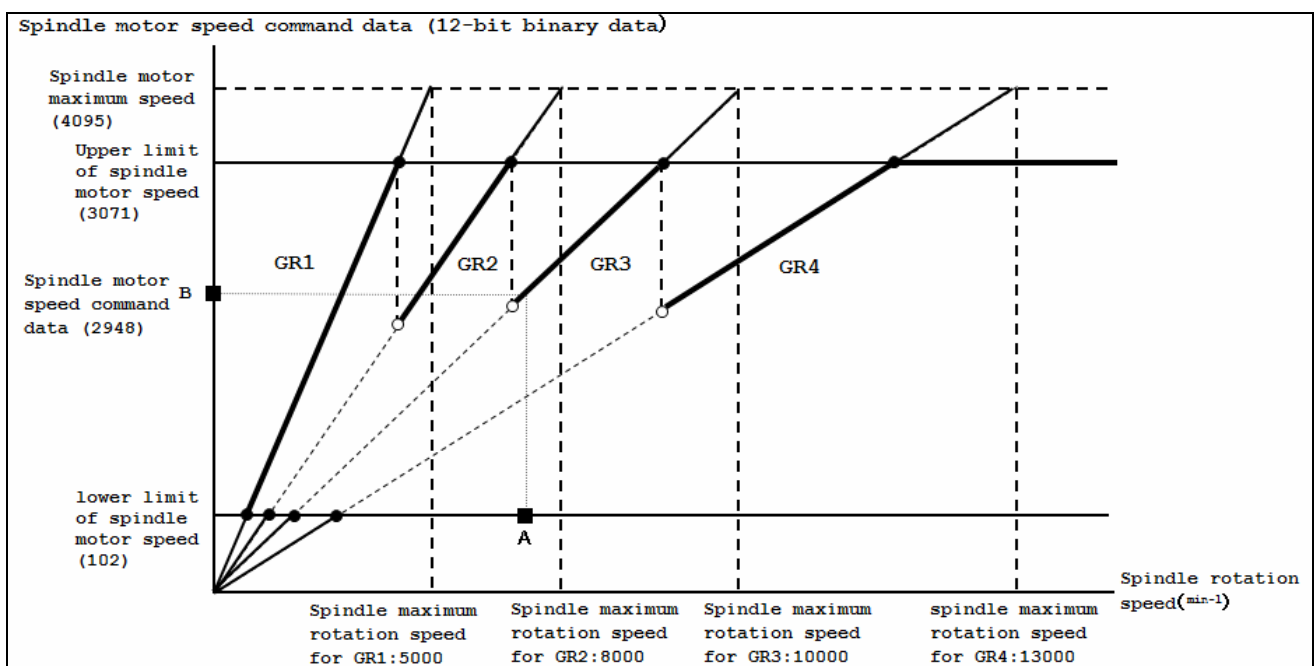


1. Prepare the clamp data table at D100-D111 in PMC parameter. (4 bytes × 3)
2. Prepare the gear rotation speed data table at D200-D215 in PMC parameter. (4 bytes × 4)
3. Write the spindle rotation speed 7200 to R0020.
4. Turn off GEAR\_SPC (R0000.1) to use the automatic gear selection.
5. Turn off OVER\_SPC (R0000.2) to cancel the override function.
6. Turn on ACT (R0000.0) and the spindle motor speed data “2948” is output to MOTOR\_SPEED (R0006) and the selected gear number “3” is output to SEL\_GEAR (R0010).
7. Turn off ACT (ACT=0) when W1 (R0000.3) turns on (W1=1).

### Note

- 1 The spindle motor maximum rotation speed depends on the model of the motor. See “DESCRIPTIONS” manual of your spindle motor.
- 2 Constant number or an address can be specified to the input parameters.

The spindle motor speed data (MOTOR\_SPEED) and the most suitable gear number (SEL\_GEAR) of this example are calculated as follows.



**Figure 4.1.7 (a) Calculation of a spindle motor speed data by specification of the spindle rotation speed**

- 1) The lower and the upper limit of spindle motor speeds are calculated as below:
  - Lower limit of spindle motor speed
    - = Spindle motor lower limit rotation speed  $\div$  Spindle motor maximum rotation speed  $\times$  4095
    - =  $500 \div 20000 \times 4095$
    - = 102 (rounded down to integer)
  - Upper limit of spindle motor speed
    - = Spindle motor upper limit rotation speed  $\div$  Spindle motor maximum rotation speed  $\times$  4095
    - =  $15000 \div 20000 \times 4095$
    - = 3071 (rounded down to integer)
- 2) Selection of most suitable gear number according to the clamp speed of each gear, the minimum spindle rotation speed and the maximum spindle rotation speed  
The minimum / maximum spindle rotation speed is calculated according to the lower / upper limit of spindle motor speed by 1) and the maximum spindle rotation speed for GR1-GR4. (Refer to figure 4.1.7(a))

**Table 4.1.7 (a) Relation between spindle rotation speed and gear**

	Minimum spindle rotation speed (min <sup>-1</sup> )	Maximum spindle rotation speed (min <sup>-1</sup> )
GR1	124	3749
GR2	3750	5999
GR3	6000	7499
GR4	7500	9749

The most suitable gear number (SEL\_GEAR) is “3” from Figure 4.1.8(a) when the spindle rotation speed (SPINDLE\_SPEED) is “7200”.

- 3) Output the spindle motor speed data  
The spindle motor speed data at the spindle rotation speed of 7200 min<sup>-1</sup> is calculated according to the maximum spindle rotation speed “10000” of the selected gear GR3.
  - Spindle motor speed data
    - = Spindle rotation speed  $\div$  Maximum spindle motor rotation speed for the selected gear  $\times$  4095
    - =  $7200 \div 10000$  (Maximum spindle motor rotation speed for GR3)  $\times$  4095
    - = 2948



## 4.2 Conversion from S code to S12-bit code

### 4.2.1 Function block name

PFL2\_CNV\_SCODE\_TO\_S12BCODE ..... Conversion from S code into S12-bit code

### 4.2.2 Function

This function block converts the command data of S code (spindle rotation speed) into the S12-bit code data to output.

The calculation of the conversion is as follows.

$$\text{S12-bit code} = \text{Spindle rotation speed (S code)} \div \text{Spindle maximum rotation speed} \times 4095$$

### 4.2.3 Format

Graphical format of PFL2\_CNV\_SCODE\_TO\_S12BCODE is shown below:

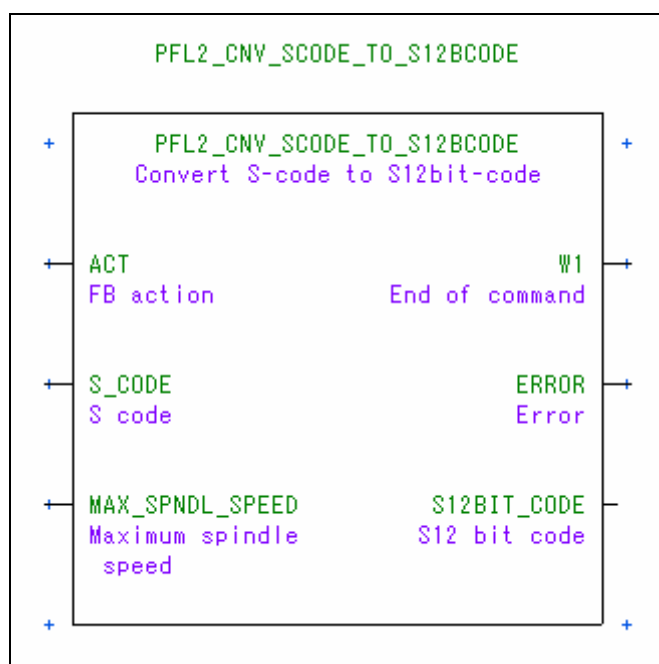


Figure 4.2.3 (a) PFL2\_CNV\_SCODEL\_TO\_S12BCODE

## 4.2.4 Parameters

Details of the parameters of this function block are as shown below:

Table 4.2.4 (a) List of parameters

Symbol	Parameter type	Data type	Count	Description
ACT	Input parameter	BOOL	-	Activation 0: Do not convert S code data into S12-bit code. 1: Convert S code data into S12-bit code. (Note 1)
S_CODE	Input parameter	DINT	1	S code data The command data of S code (spindle rotation speed). Valid range is 1 to 99999. (Note 2)
MAX_SPNDL_SPEED	Input parameter	DINT	1	Spindle maximum rotation speed The spindle maximum rotation speed. Valid range is 1 to 99999. (Note 2)
W1	Output parameter	BOOL	-	Completion signal Indicates completion of the process. (Note 1) 0: Normally W1=0. 1: Turns on at completion of conversion. Also turns on at error (ERROR=1).
ERROR	Output parameter	BOOL	-	Error signal Indicates error status. (Note 3) 0: No error. 1: An error occurs.
S12BIT_CODE	Output parameter	INT	1	S12-bit code Output the S12-bit code value as a result of the conversion.

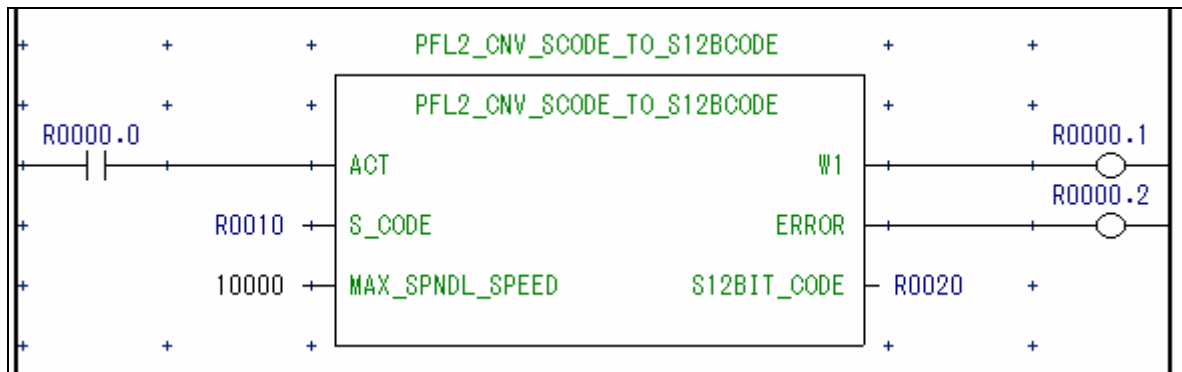
### Note

- 1 ACT shall be turned on (ACT=1) only when the function block needs to work. While ACT=1, the outputs of W1 and ERROR are sustained. Turn off ACT (ACT=0) immediately when W1 turns on (W1=1).
- 2 The S code data and the spindle maximum rotation speed must satisfy the following condition. Otherwise, an error will occur.  
$$\text{S code data} \leq \text{Spindle maximum rotation speed}$$
- 3 The causes of the error are as follows.
  - Value specified in input parameters (S code data, Spindle maximum rotation speed) is wrong.
  - Overflow occurs at conversion into the S12-bit code.

## 4.2.5 Example

The following example is to convert the command data of S code (spindle rotation speed) into the S12-bit code data.

Function block to use:	PFL2_CNV_SCODE_TO_S12BCODE	
Parameters:		
- Activation (ACT):	R0000.0	
- S code data (S_CODE):	R0010	Spindle rotation speed; 1000 min <sup>-1</sup>
- Spindle maximum rotation speed (MAX_SPNDL_SPEED):	10000	Spindle maximum rotation speed; 10000 min <sup>-1</sup>
- Completion signal (W1):	R0000.1	
- Error signal (ERROR):	R0000.2	
- S12-bit code data (S12BIT_CODE):	R0020	



1. Write "1000", which is the spindle rotation speed of the S code data, to R0010.
2. Turn on ACT (R0000.0) and the S12-bit code data "409" is output to S12BIT\_CODE (R0020).
  - $$\text{S12-bit code} = \text{Spindle rotation speed (S code)} \div \text{Spindle maximum rotation speed} \times 4095$$
$$= 1000 \div 10000 \times 4095$$
$$= 409 \text{ (rounded down to integer)}$$
3. Turn off ACT (ACT=0) when W1 (R0000.1) turns on (W1=1).

## 4.3 Conversion from S12-bit code to S code

### 4.3.1 Function block name

PFL2\_CNV\_S12BCODE\_TO\_SCODE ..... Conversion from S12-bit code into S code

### 4.3.2 Function

This function block converts the S12-bit code data into the command data of S code (spindle rotation speed) to output.

The calculation of the conversion is as follows.

$$\text{Spindle rotation speed (S code)} = \text{S12-bit code} \times \text{Spindle maximum rotation speed} \div 4095$$

### 4.3.3 Format

Graphical format of PFL2\_ S12BCODE \_TO\_CNV\_SCODE is shown below:

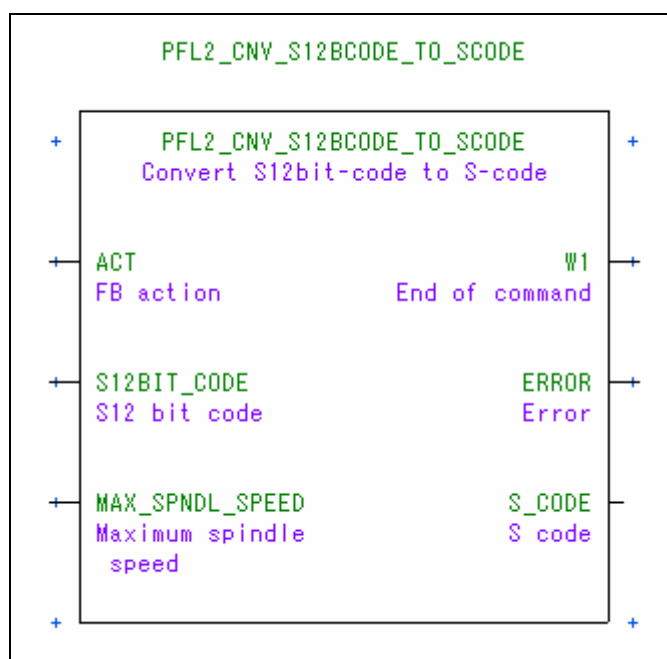


Figure 4.3.3 (a) PFL2\_CNV\_ S12BCODE \_TO\_SCODEL

## 4.3.4 Parameters

Details of the parameters of this function block are as shown below:

**Table 4.3.4 (a) List of parameters**

Symbol	Parameter type	Data type	Count	Description
ACT	Input parameter	BOOL	-	Activation 0: Do not convert S12-bit code into S code data. 1: Convert S12-bit code into S code data. (Note 1)
S12BIT_CODE	Input parameter	INT	1	S12-bit code The S12-bit code. Valid range is 0 to 4095.
MAX_SPNDL_SPEED	Input parameter	DINT	1	Spindle maximum rotation speed The spindle maximum rotation speed. Valid range is 1 to 99999. (Note 2)
W1	Output parameter	BOOL	-	Completion signal Indicates completion of the process. (Note 1) 0: Normally W1=0. 1: Turns on at completion of conversion. Also turns on at error (ERROR=1).
ERROR	Output parameter	BOOL	-	Error signal Indicates error status. (Note 2) 0: No error. 1: An error occurs.
S_CODE	Output parameter	DINT	1	S code data Output the command data of S code (spindle rotation speed) as a result of the conversion. It will be "0" in case of ERROR=1.

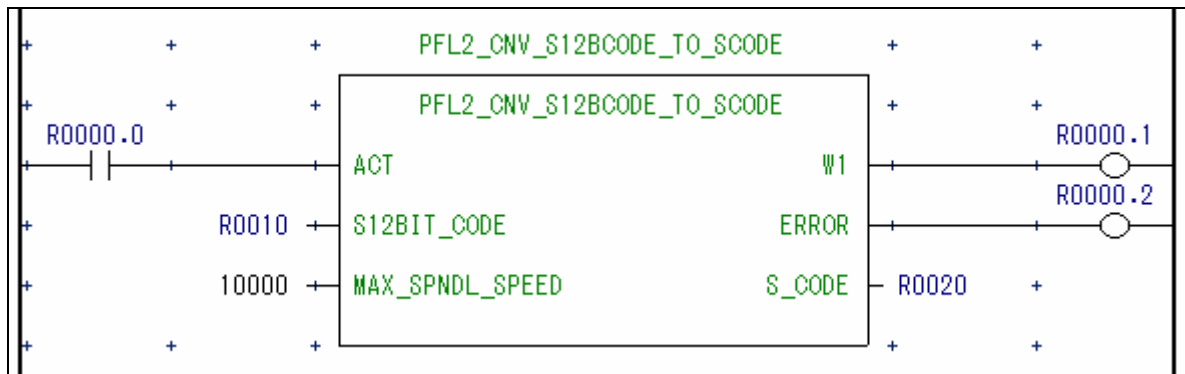
### Note

- 1 ACT shall be turned on (ACT=1) only when the function block needs to work. While ACT=1, the outputs of W1 and ERROR are sustained. Turn off ACT (ACT=0) immediately when W1 turns on (W1=1).
- 2 The cause of the error is as follows.
  - Value specified in input parameters (S12-bit code, Spindle maximum rotation speed) is wrong.
  - Overflow occurs at conversion into the S code data.

## 4.3.5 Example

The following example is to convert the S12-bit code data into the command data of S code (spindle rotation speed).

Function block to use:	PFL2_CNV_S12BCODE_TO_SCODE	
Parameters:		
- Activation (ACT):	R0000.0	
- S12-bit code data (S12B_CODE):	R0010	S12-bit code data; 3000
- Spindle maximum rotation speed (MAX_SPNDL_SPEED):	10000	Spindle maximum rotation speed; 10000 min <sup>-1</sup>
- Completion signal (W1):	R0000.1	
- Error signal (ERROR):	R0000.2	
- S code data (S_CODE):	R0020	



1. Write the S12-bit code data "3000" to R0010.
2. Turn on ACT (R0000.0) and the S code data "7326" is output to S\_CODE (R0020).
  - Spindle rotation speed (S code) = S12-bit code × Spindle maximum rotation speed ÷ 4095  

$$= 3000 \times 10000 \div 4095$$

$$= 7326 \text{ (rounded down to integer)}$$
3. Turn off ACT (ACT=0) when W1 (R0000.1) turns on (W1=1).

## 4.4 Switching of winding by Speed range switching control

### 4.4.1 Function block name

PFL2\_SWITCHING\_WINDING\_SPEED ···· Switching of winding

### 4.4.2 Function

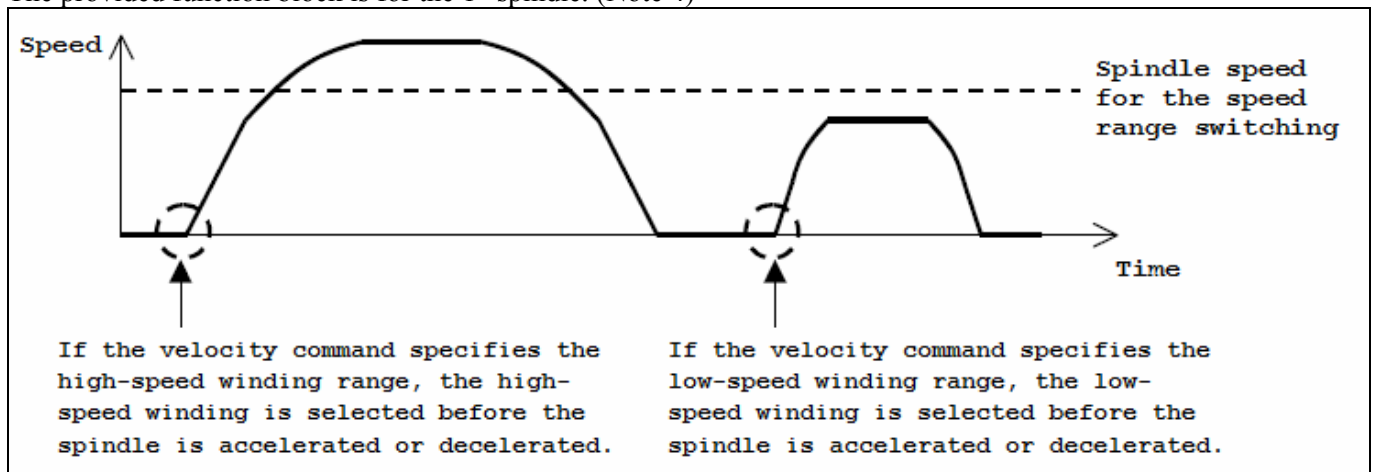
Speed range switching control of spindle motor can shorten the acceleration and deceleration time by switching the output characteristic (winding) of the spindle motor at appropriate timing according to the speed, which motor is designed for speed range switching control with two windings; winding for low-speed output characteristic and one for high-speed.

This function block determines and output the timing when switching winding types should be performed by the switching unit, which is driven by a magnetic contactor and a relay in it, according to the velocity command of S code provided through the input parameter sequentially. This output can be used by ladder program to manipulate the switching unit, which enables the output characteristic of the spindle motor to be switched at proper timing. See the following description “Switching specification of winding to the switching unit” for details of the switching process of winding.

This function block outputs the request to switch winding at the following timings.

- 1) In case of acceleration; the specified speed is faster than the current speed
  - a) When the next velocity command belongs to the high-speed winding range, it requests to switch to the high-speed winding immediately; switch before starting acceleration.
  - b) When the next velocity command belongs to the low-speed winding range, it requests to switch to the low-speed winding immediately; switch before starting acceleration.
- 2) In case of deceleration; the specified speed is slower than the current speed
  - a) When the next velocity command is not “0”, which means not to stop, it requests to switch to the low-speed winding when the speed detection signal SDTA (F45.2) turns on to be “1”. (Note 2)
  - b) When the next velocity command is “0”, which means to stop, switch request is not made and the motor stops with the current winding.

The provided function block is for the 1<sup>st</sup> spindle. (Note 4)



### Note

- 1 If the winding that should be switched to has already been selected, no switch request is made.
- 2 The speed detection signal SDTA (F45.2) is used in this function block. Therefore, the CNC parameter SDTCHG (No.4019#4) needs to be "1", and the speed detection level (No.4023) must be properly set. See "(a) Method that switches the winding based on the velocity command" of "5.1.4 Using Speed Range Switching Control" in "FANUC AC SPINDLE MOTOR  $\alpha$  /  $\beta$  series PARAMETER MANUAL (B-65280EN)" for details.
- 3 The speed range switching control function is an optional function. See "5.1 SPEED RANGE SWITCHING CONTROL (OPTIONAL FUNCTION)" in "FANUC AC SPINDLE MOTOR  $\alpha$  /  $\beta$  series PARAMETER MANUAL (B-65280EN)" for details.
- 4 You can create the same function blocks for the spindle other than the 1<sup>st</sup> spindle by changing the G/F addresses in this function block to the addresses of other spindle. For signals other than the 1<sup>st</sup> spindle, see the chapter of the spindle speed function in "CONNECTION MANUAL (FUNCTION)" of your CNC.

## Switching operation of the switching unit

The switching of winding is performed by requesting the switching to the switching unit, which is driven by a magnetic contactor and a relay in it, by ladder program. Please create a ladder program according to the configuration of the switching unit, which manipulate the switching unit to switch to the winding type requested by this function block.

The procedures to switch winding:

- 1) Pass the command value of S code (spindle rotation speed) and the spindle rotation speed for speed range switching to the input parameters of this function block. The command value of S code should be updated accordingly.
- 2) The function block outputs the switching request for the switching unit and the winding characteristic to use through the following output parameters at the proper timing.
  - Switching request (SWITCH\_REQ)
  - Switching winding characteristic (SPEED\_TYPE)
- 3) Ladder program detects that the switching request (SWITCH\_REQ) turns on to "1", and then manipulates the following signals to make the switching unit switch the windings:
  - Switching request signal to the switching unit (some Y signal) (Note 1)
  - Status confirmation signal for low-speed characteristic of the switching unit (MMC1 < some X signal)
  - Status confirmation signal for high-speed characteristic of the switching unit (MMC2 < some X signal>)
  - Low-speed characteristic magnetic contactor status signal (RCHA <G71.7>)
  - High-speed characteristic magnetic contactor status signal (RHHGA <G72.7>)

The switching request to the switching unit is processed by the following procedures.

- a) Order the switching unit to switch the winding to the characteristic specified by the switching winding characteristic (SPEED\_TYPE) of the output parameter.
  - b) Check the status confirmation signal for the switching unit (MCC1, MCC2), and set the magnetic contactor status signals (RCHA<G71.7>, RHHGA<G72.7>) accordingly.
- 4) When the switching of winding has completed, the execution signal (EXECUTION) of the output parameter of the function block turns off to "0".



### Note

- 1 There are two types of switch circuit configuration around the switching unit; one is the case of switching two magnetic contactors by one signal, and the other is the case to switching them by two signals that correspond to each of low-speed and high-speed characteristic. Please use appropriate ladder program to the circuit configuration.
- 2 The usage of the low-speed magnetic contactor status signal RCHA and the high-speed magnetic contactor status signal RCHHGA differ according to the parameter No.4014#3. See “5.1 SPEED RANGE SWITCHING CONTROL (OPTIONAL FUNCTION)” in “FANUC AC SPINDLE MOTOR  $\alpha$  /  $\beta$  series PARAMETER MANUAL (B-65280EN)” for details.
- 3 The output parameter EXECUTION of this function block turns on to “1” after raising request to switch until its completion.

### Switching operation of the switching unit at reset state

When the spindle stops by the reason other than the command in S code (spindle stop signal (\*SSTP <G29.6>) for example) while this function block is working, turn on the input parameter of reset (RESET). Output parameter of the switching winding characteristic (SPEED\_TYPE) is output while resetting it (RESET=1). Please create the ladder program to request the switch to the switching unit according to the state of the reset signal.

The procedures to switch winding at reset state:

- 1) Turn on the reset (RESET) of the input parameter of this function block.
- 2) Manipulate the following signals to make the switching unit switch the windings according to the output parameter of switching winding characteristic (SPEED\_TYPE).
  - Switching request signal to the switching unit (some Y signal)
  - Low-speed characteristic magnetic contactor status signal (RCHA <G71.7>)
  - High-speed characteristic magnetic contactor status signal (RCHHGA <G72.7>)
- 3) Turn off the input parameter of reset (RESET).

### Precautions

The speed range switching control should not be performed during cutting or position control. Since the motor current control is stopped during the switching operation, the motor does not generate torque. Be sure to select the winding before the motor enters any of the following control modes in order to prevent the switching operation from being performed while the motor is operating in one of these modes.

- Spindle orientation (lower than or equal to the orientation speed)
- Rigid tapping
- Cs contouring control
- Spindle synchronous control
- Spindle positioning

See “5.1 SPEED RANGE SWITCHING CONTROL (OPTIONAL FUNCTION)” in “FANUC AC SPINDLE MOTOR  $\alpha$  /  $\beta$  series PARAMETER MANUAL (B-65280EN)” for details.

### 4.4.3 Format

Graphical format of PFL2\_SWITCHING\_WINDING\_SPEED is shown below:

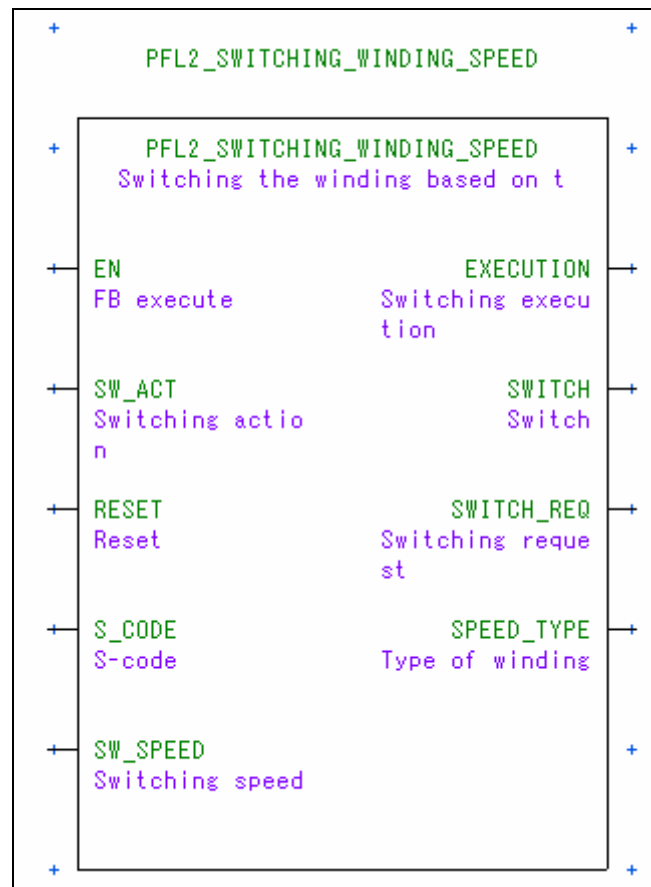


Figure 4.4.3 (a) PFL2\_SWITCHING\_WINDING\_SPEED

## 4.4.4 Parameters

Details of the parameters of this function block are as shown below:

**Table 4.4.4 (a) List of parameters**

Symbol	Parameter type	Data type	Count	Description
EN	input parameter	BOOL	-	Operation control of function block (Note 1) 0: Do not execute the function block. 1: Execute the function block.
SW_ACT	input parameter	BOOL	-	Activation of speed range switching control 0: Do not execute the switching control. 1: Execute the switching control. Maintain "1" while EXECUTION is "1".
RESET	input parameter	BOOL	1	Reset signal (Note 2) 0: Do not reset the operation. 1: Reset and initialize the operation.
S_CODE	Input parameter	DINT	1	S code data Specify the command data of S code (spindle rotation speed).
SW_SPEED	Input parameter	DINT	1	Spindle rotation speed for speed range switching ( $\text{min}^{-1}$ ) Specify the spindle rotation speed to switch high-speed winding and low-speed winding. Valid range is 0 to 99999.
EXECUTION	output parameter	BOOL	-	Execution signal Indicates that the switching control is working 0: Switching control has finished. 1: Switching control is pending or active.
SWITCH	output parameter	BOOL	-	Occurrence of switching Indicates that the switching took place actually. This output parameter is effective while SW_ACT=1 and EXECUTION=0. 0: Switching has not done 1: Switching has done.
SWITCH_REQ	output parameter	BOOL	-	Switching request Indicates that the switching is requested. 0: Do not request the switching. 1: Request the switching.
SPEED_TYPE	output parameter	BOOL	-	Selected winding characteristic Indicates which winding characteristic is selected at switching request. This output parameter is effective at SW_ACT=1 and SWITCH_REQ=1. 0: High-speed characteristic. 1: Low-speed characteristic.

### Note

- 1 This function block controls the clutch / gear signals (CTH1A <G70.3>, CTH2A <G70.2>). When other function uses these clutch / gear signals, EN of this function block should be turned off. When the EN is turned off, the output parameter EXECUTION must be "0".
- 2 Turn off the input parameter SW\_ACT in case of reset operation (RESET=1). The reset process is given priority in case of SW\_ACT=1 and RESET=1.
- 3 The FB instance monitor of this function block shows the executing state code as follows:

State code	Description
0	The switching winding has completed.
1	Waiting state of the speed detection signal SDTA<F45.2> at switching winding characteristic from high-speed to low-speed,.
2	Waiting state of the power line switching signal RCHPA<F46.2>.
3	Waiting state of the power line switching completion signal RCFNA<F46.3>.

## 4.4.5 Signals used inside function block

The modified signals and referred signals in the ladder in this function block are as follows.

**Table 4.4.5 (a) Signals to modify**

Symbol	Address	Signal name
CTH2A	G70.2	Clutch / gear signal
CTH1A	G70.3	Clutch / gear signal
RSLA	G71.6	Speed range switching request signal

### Note

- 1 The above-mentioned signals are for the 1<sup>st</sup> spindle.
- 2 See “5.1 SPEED RANGE SWITCHING CONTROL (OPTIONAL FUNCTION)” in “FANUC AC SPINDLE MOTOR  $\alpha$  /  $\beta$ i series PARAMETER MANUAL (B-65280EN)” for details of signals.

**Table 4.4.5 (b) Signals to refer**

Symbol	Address	Signal name
SDTA	F45.2	Speed detection signal
RCHPA	F46.2	Power line switching signal
RCFNA	F46.3	Power line switching completion signal

### Note

- 1 The above-mentioned signals are for the 1<sup>st</sup> spindle.
- 2 See “5.1 SPEED RANGE SWITCHING CONTROL (OPTIONAL FUNCTION)” in “FANUC AC SPINDLE MOTOR  $\alpha$  /  $\beta$ i series PARAMETER MANUAL (B-65280EN)” for details of signals.

## 4.4.6 Related CNC parameters

Details of the CNC parameters related to this function block are as shown below:

**Table 4.4.6 (a) List of related CNC parameters**

CNC parameter	Description
CHGSLT (No.4014#3)	Function of checking the both magnetic contactor contacts for high-/low-speed characteristics in speed range switching
SPDSW (No.4015#2)	Whether the speed range switching control function is available (To use this function, the CNC software option is required.)
SDTCHG (No.4019#4)	Function of checking the speed detection signal (SDTA <F45.2>) when switching is performed from high-speed characteristic to low-speed characteristic
No.4023	Speed detecting level
No.4160	Speed detection level hysteresis

### Note

- 1 See “5.1 SPEED RANGE SWITCHING CONTROL (OPTIONAL FUNCTION)” in “FANUC AC SPINDLE MOTOR  $\alpha$  /  $\beta$ i series PARAMETER MANUAL (B-65280EN)” for details of CNC parameters.

## 4.4.7 Related signals

The signals related to this function block are listed below:

Table 4.4.7 (a) List of related signals

Symbol	Address	Signal name
SFIN	G5.2	Spindle function completion signal
RCHA	G71.7	Low-speed characteristic magnetic contactor status signal (Note 1)
RCHHGA	G72.7	High-speed characteristic magnetic contactor status signal (Note 1)
S00 to S31	F22 to F25	Spindle function code signals
SF	F7.2	Spindle function strobe signal

### Note

- 1 The above-mentioned signals are for the 1<sup>st</sup> spindle.
- 2 See "5.1 SPEED RANGE SWITCHING CONTROL (OPTIONAL FUNCTION)" in "FANUC AC SPINDLE MOTOR  $\alpha$  /  $\beta$ i series PARAMETER MANUAL (B-65280EN)" for details of signals.

## 4.4.8 Example

The following example is to switch the winding of the spindle at the rotation speed 5000 min<sup>-1</sup> (high-speed characteristic), at 2000 of the velocity command of S code, and 4000 min<sup>-1</sup> of the spindle rotation speed to switch windings.

Function block to use:

PFL2\_SWICHING\_WINDING\_SPEED

Parameters:

- |  |         |  |
|--|---------|--|
| - Operation control of function block (EN):                    | R0000.0 |  |
| - Activation of speed range switching (SW_ACT):                | R0000.1 |  |
| - Reset signal (RESET):  | R0000.2 |  |
| - S code data (S_CODE):  | R0010   | Velocity command of S code; 2000 min <sup>-1</sup>                       |
| - Spindle rotation speed for speed range switching (SW_SPEED): | 4000    | Spindle rotation speed for speed range switching; 4000 min <sup>-1</sup> |
| - Signal under execution (EXECUTION):                          | R0000.3 |  |
| - Presence of switching of winding (SWITCH):                   | R0000.4 |  |
| - Switching request (SWITCH_REQ):                              | R0000.5 |  |
| - Switching winding characteristic (SPEED_TYPE):               | R0000.6 |  |

Ladder for switching request of winding to switching unit

- |  |         |
|--|---------|
| - Status confirmation signal for low-speed characteristic  | X0000.0 |
| - Status confirmation signal for high-speed characteristic | X0000.1 |
| - Switching request signal                                 | Y0000.0 |



**Note**

- 1 S code data and the spindle rotation speed for speed range switching can be specified by the constant or the address.
- 2 This example assumes the following configurations.
  - Circuit configuration to which the switching unit switches two magnetic contactors by one switching signal.
  - The function is used, which checks both magnetic contactor points of high-speed characteristic / low-speed characteristic of the switching unit. (CNC parameter CHGSLT (No.4014#3) =1)