FANUC Series 0*i*-MODEL D

Dual Check Safety
CONNECTION MANUAL

B-64303EN-4/01

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In this manual we have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

This manual contains the program names or device names of other companies, some of which are registered trademarks of respective owners. However, these names are not followed by ® or ™ in the main body.

DEFINITION OF WARNING, CAUTION, AND NOTE

This manual includes safety precautions for protecting the user and preventing damage to the machine. Precautions are classified into Warning and Caution according to their bearing on safety. Also, supplementary information is described as a Note. Read the Warning, Caution, and Note thoroughly before attempting to use the machine.

⚠ WARNING
Applied when there is a danger of the user being injured or when there is a danger of both the user being injured and the equipment being damaged if the approved procedure is not observed.

⚠ CAUTION
Applied when there is a danger of the equipment being damaged, if the approved procedure is not observed.

NOTE
The Note is used to indicate supplementary information other than Warning and Caution.

- Read this manual carefully, and store it in a safe place.

PREFACE

Description of this manual

The manual consists of the following chapters:

Chapter 1, "OVERVIEW"
Chapter 2, "SYSTEM CONFIGURATION"
Chapter 3, "SAFETY FUNCTIONS"
Chapter 4, "INSTALLATION"
Chapter 5, "I/O SIGNALS"
Chapter 6, "PARAMETERS"
Chapter 7, "START-UP"
Chapter 8, "ALARM MESSAGE"
Chapter 9, "DIAGNOSIS"
Chapter 10, "SAMPLE SYSTEM CONFIGURATION"
Chapter 11, "APPLICATION OF OTHER FUNCTIONS"
Chapter 12, "COMPONENTS LIST"
Appendix A, "DIRECTIVES, STANDARDS AND TECHNICAL CONDITIONS FOR 3RD PARTY SERVO / SPINDLE MOTORS & ENCODERS WHEN APPLYING FANUC / GE FANUC DUAL-CHECK SAFETY"

Applicable models

This manual can be used with the following models. The abbreviated names may be used.

Model name	Abbreviation		
FANUC Series 0*i* -TD	0*i* -TD	Series 0*i* -D	0*i* -D
FANUC Series 0*i* -MD	0*i* -MD		

NOTE
1 The FANUC Series 0*i* Mate – MODEL D does not support this function.
2 For explanatory purposes, these models may be classified as shown below:
- T series: 0*i* -TD
- M series: 0*i* -MD
3 Some functions described in this manual may not be applied to some products.
For details, refer to the Descriptions (B-64302EN).
4 For the 0*i*-D, parameters need to be set to enable or disable some basic functions.
For these parameters, refer to Section 4.51, " PARAMETERS OF 0*i*-D / 0*i* Mate-D BASIC FUNCTIONS" in the PARAMETER MANUAL (B-64310EN).

Related manuals of Series 0*i* -D

The following table lists the manuals related to Series 0*i* -D. This manual is indicated by an asterisk (*).

Table 1 Related manuals

Manual name	Specification number	
DESCRIPTIONS	B-64302EN	
CONNECTION MANUAL (HARDWARE)	B-64303EN	
CONNECTION MANUAL (FUNCTION)	B-64303EN-1	
USER'S MANUAL (Common to Lathe System/Machining Center System)	B-64304EN	
USER'S MANUAL (For Lathe System)	B-64304EN-1	
USER'S MANUAL (For Machining Center System)	B-64304EN-2	
MAINTENANCE MANUAL	B-64305EN	
PARAMETER MANUAL	B-64310EN	
START-UP MANUAL	B-64304EN-3	
Programming		
Macro Executor PROGRAMMING MANUAL	B-64303EN-2	
Macro Compiler PROGRAMMING MANUAL	B-64303EN-5	
C Language Executor PROGRAMMING MANUAL	B-64303EN-3	
PMC		
PMC PROGRAMMING MANUAL	B-64393EN	
Network		
PROFIBUS-DP Board CONNECTION MANUAL	B-64403EN	
Fast Ethernet / Fast Data Server OPERATOR'S MANUAL	B-64414EN	
DeviceNet Board CONNECTION MANUAL	B-64443EN	
FL-net Board CONNECTION MANUAL	B-64453EN	
Dual Check Safety		
Dual Check Safety CONNECTION MANUAL	B-64303EN-4	*
Operation guidance function		
MANUAL GUIDE *i* (Common to Lathe System/Machining Center System) OPERATOR'S MANUAL	B-63874EN	
MANUAL GUIDE *i* (For Machining Center System) OPERATOR'S MANUAL	B-63874EN-2	
MANUAL GUIDE *i* (Set-up Guidance Functions) OPERATOR'S MANUAL	B-63874EN−1	
MANUAL GUIDE 0*i* OPERATOR'S MANUAL	B-64434EN	
TURN MATE *i* OPERATOR'S MANUAL	B-64254EN	

Related manuals of SERVO MOTOR

The following table lists the manuals related to SERVO MOTOR $\alpha i/\beta i$ series

Table 2 Related manuals

Manual name	Specification number
FANUC AC SERVO MOTOR αi series DESCRIPTIONS	B-65262EN
FANUC AC SPINDLE MOTOR αi series DESCRIPTIONS	B-65272EN
FANUC AC SERVO MOTOR βi series DESCRIPTIONS	B-65302EN
FANUC AC SPINDLE MOTOR βi series DESCRIPTIONS	B-65312EN
FANUC SERVO AMPLIFIER αi series DESCRIPTIONS	B-65282EN
FANUC SERVO AMPLIFIER βi series DESCRIPTIONS	B-65322EN
FANUC SERVO MOTOR αis series FANUC SERVO MOTOR αi series FANUC AC SPINDLE MOTOR αi series FANUC SERVO AMPLIFIER αi series MAINTENANCE MANUAL	B-65285EN
FANUC SERVO MOTOR βis series FANUC AC SPINDLE MOTOR βi series FANUC SERVO AMPLIFIER βi series MAINTENANCE MANUAL	B-65325EN
FANUC AC SERVO MOTOR αi series FANUC AC SERVO MOTOR βi series FANUC LINEAR MOTOR LiS series FANUC SYNCHRONOUS BUILT-IN SERVO MOTOR DiS series PARAMETER MANUAL	B-65270EN
FANUC AC SPINDLE MOTOR $\alpha i/\beta i$ series, BUILT-IN SPINDLE MOTOR Bi series PARAMETER MANUAL	B-65280EN

This manual mainly assumes that the FANUC SERVO MOTOR αi series of servo motor is used. For servo motor and spindle information, refer to the manuals for the servo motor and spindle that are actually connected.

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1 OVERVIEW

Setup for machining, which includes attaching and detaching a workpiece to be machined, and moving it to the machining start point while viewing it, is performed with the protection door opened. The Dual Check Safety function provides a means for ensuring a high level of safety with the protection door opened.

The simplest method of ensuring safety when the protection door is open is to shut off power to the motor drive circuit by configuring a safety circuit with a safety relay module. In this case, however, no movements can be made on a move axis (rotation axis). Moreover, since the power is shut off, some time is required before machining can be restarted. This drawback can be corrected by adding a motor speed detector to ensure safety. However, the addition of an external detector may pose a response problem, and the use of many safety relay modules results in a large and complicated power magnetic cabinet circuit.

With the Dual Check Safety function, two independent CPUs built into the CNC monitor the speed and position of motors in dual mode. An error in speed and position is detected at high speed, and power to the motor is shut off via two independent paths. Processing and data related to safety is cross-checked by two CPUs. To prevent failures from being built up, a safety-related hardware and software test must be conducted at certain intervals time.

The Dual Check Safety system need not have an external detector added. Instead, only a detector built into a servo motor or spindle motor is used. This configuration can be implemented only when those motors, detectors built into motors, and amplifiers that are specified by FANUC are used.

The Dual Check Safety function ensures safety with the power turned on, so that an operator can open the protection door to work without turning off the power. A major feature of the Dual Check Safety function is that the required time is very short from the detection of an abnormality until the power is shut off. A cost advantage of the Dual Check Safety function is that external detectors and safety relays can be eliminated or simplified.

If a position or speed mismatch is detected by a cross-check using two CPUs, the safety function of the Dual Check Safety works the power to be shut off (MCC off) to the motor drive circuit.

IMPORTANT
The Dual Check Safety function cannot monitor the stop state of the motors.

1.1 DIRECTIVES AND STANDARDS

1.1.1 Directives

Machine tools and their components must satisfy the EC directives listed below.
The FANUC CNC systems with the Dual Check Safety function are compatible with all of these directives.

Directives

Directive 98/37/EC	1998 Safety of machinery
Directive 2004/108/EC	2004 Electromagnetic compatibility
Directive 2006/95/EC	2006 Low Voltage Equipment

1.1.2 Related Safety Standards

To be compatible with the directives, especially the machine directive, the international standards and European standards need to be observed.

Important safety standards

ISO 12100-1:2003	Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology
ISO 12100-2:2003	Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles and specifications
EN954-1	1996 Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design
ISO 14121-1:2007	Safety of machinery - Principles for risk assessment
IEC 60204-1:2005	Safety of machinery - Electrical equipment of machines Part 1: General requirements
ISO 13849-1:2006	Safety of machinery -- Safety-related parts of control systems -- Part 1: General principles for design
ISO 13849-2:2006	Safety of machinery -- Safety-related parts of control systems -- Part 2: Validation
IEC 61508:2000	Functional safety of electrical/electronic/programmable electronic safety-related systems-- part 1-part 7
IEC 62061:2005	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems

1.1.3 Risk Analysis and Evaluation

According to the machine directive, the manufacturer of a machine or machine components and a responsible person who supplies a machine or machine components to the market must conduct risk evaluation to identify all risks that can arise in connection with the machine or machine components. Based on such risk analysis and evaluation, a machine and machine components must be designed and manufactured. Risk evaluation must reveal all remaining risks and must be documented.

1.1.4 Certification Test

Certification of the dual check safety function

The German certification organization TUV PS has certified that the dual check safety function satisfies the safety standards.

1.2 DEFINITION OF TERMS

1.2.1 General Definition of Terms

Reliability and safety

Reliability and safety are defined by EN292-1 as follows:

Term	Definition
Reliability	Capability of a machine, machine component, or equipment to perform its required function under a specified condition for a specified period
Safety	Capability of a machine to perform its function without injuring the health under a condition of use for an intended purpose specified in the operator's manual and allow its transportation, installation, adjustment, maintenance, disassembly, and disposal

1.2.2 Definition of Terms Related to the Safety Function

Safety-related I/O signal

Safety-related I/O signals are input/output signals monitored by two systems. These signals are valid for each feed axis and spindle with a built-in safety function, and are used with each monitoring system.
Example: Protection door state signal

Safety stop

When a safety stop occurs, power to the drive section is shut off. The drive section can generate neither a torque nor dangerous operation. The following are measures for incorporating the safety stop feature:
Contactor between the line and drive system (line contactor)
Contactor between the power section and drive motor (motor contactor)
If an external force is applied (such as a force applied onto a vertical axis), an additional measure (such as a mechanical brake) must be securely implemented to protect against such a force.

Safety limitation speed

When the drive system has reached a specified limitation speed, a transition is made to the safe stop state.
A measure must be implemented to prevent a set limitation speed from being changed by an unauthorized person.

Safety machine position

When the drive system has reached a specified positional limit, a transition is made to the safety stop state. When a positional limit is set, a maximum move distance traveled until a stop occurs must be considered. A measure must be implemented to prevent a set positional limit from being changed by an unauthorized person.

1.3 BASIC PRINCIPLE OF DUAL CHECK SAFETY

1.3.1 Features of Dual Check Safety

Dual Check Safety function has the following features.

- Two-channel configuration with two or more independent CPUs
- Cross-check function for detecting latent errors

Detection

A servo motor detector signal is sent via the servo amplifier and is applied to the CNC through the FSSB interface. Then, it is fed to two CPUs: a CNC CPU and a Servo CPU.
A spindle motor detector signal is sent via the spindle amplifier and is applied to the CNC connected through the serial interface. Then, it is fed to two CPUs: a CNC CPU and a CPU built into the spindle amplifier.
The safety related signal such as guard signal is sent via the independent I/O unit and is applied to the CNC through the I/O link interface. Then, it is fed to two CPUs: a CNC CPU and a PMC CPU.

Evaluation

The safety function is monitored independently by a CNC CPU and servo CPU or by a CNC CPU and spindle CPU. Each CPU cross-checks data and results at certain intervals.

Response

If the monitoring function detects an error, the CNC CPU and the servo/spindle CPU switch off the MCC via independent paths to shut off the power to the feed axis and spindle.

1.3.2 Compliance with the Safety Standard

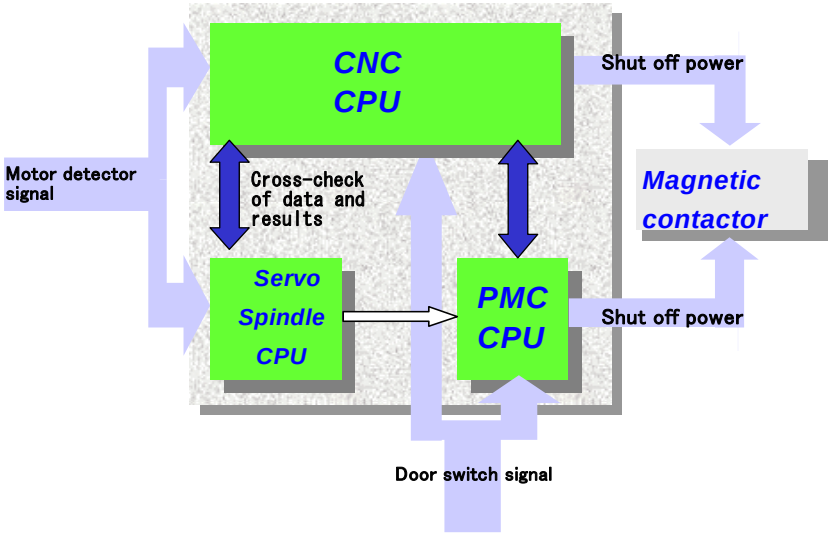
The Dual Check Safety function satisfies the requirements of the following safety standard.

- EN954-1 :1997 Category 3
- IEC62061 :2005 SIL2
- IEC61508 :2000 SIL2
- ISO13849-1 :2006 PL d

These safety standards require the following:

- The safety function of a safety-related portion must not degrade when a single failure occurs.
- Single errors must be detected at all times when natural execution is possible.

To satisfy these requirements, the Dual Check Safety function is implemented using the two-channel configuration shown below.



Monitoring of servo motor and spindle motor movement

Data output from the detector built into each motor is transferred to the CNC through the amplifier. The safety of this path is ensured by using motors and amplifiers specified by FANUC.

Cross-monitoring using 2 CPUs

Two CPUs built into the CNC are used to cross-monitor the safety function. Each CPU is periodically checked for errors. If one system fails, the servo and spindle can be stopped safely.

Power shutoff via two paths

If an error is detected, the power is shut off via two power shutoff paths. The paths need to be tested for built-up failures within a certain time.

Input signal safety

Safety-related input signals such as the protection door lock/unlock signal are monitored doubly. If a mismatch between the two occurrences of a signal is detected, the power to the motor drive circuit is shut off. This cross-check is constantly made.

Output signal safety

A signal is output (via two paths) to the relay used to shut off the power to the motor drive circuit. An error is detected by a MCC off Test. For detection of built-up failures, a MCC off Test needs to be conducted at certain intervals. This MCC off Test is not mandatory when machining is performed with the protection door closed. (The MCC off Test should be performed, before the protection door is open after the certain intervals.)

1.3.2.1 Latent error detection and cross-check

Detection of latent errors

This detection function can detect latent software and hardware errors in a system that has a two-channel configuration. So, the safety-related portions of the two channels need to be tested at least once within an allowable period of time for latent errors.
An error in one monitoring channel causes a mismatch of results, so that a cross-check detects the error.

> ⚠ **CAUTION**
> Forced detection of a latent error on the MCC shutoff path must be performed by the user through a MCC off Test (after power-on and at intervals of a specified time (within normally 24 hours)). When the system is operating in the automatic mode (when the protection door is closed), this detection processing is not requested as mandatory. But, before the protection door opens after the specified time, the detection processing is required mandatory. If this has not been performed, lock for the protection door should not be released.

Cross-check

A latent safety-related error associated with two-channel monitoring can be detected as a result of cross-checking.

> **NOTE**
> An error detected as the result of forced latent error detection or cross-checking leads to a safety stop state. (See Subsec. 3.3.3).

1.3.2.2 Safety monitoring cycle and cross-check cycle

The safety function is subject to periodical monitoring in a monitoring cycle.
The following functions are monitored at every 8ms.

- Safe speed monitoring (servo motor)
- Safe machine position monitoring (servo motor)
- Safe position error monitoring (servo motor)

The cross-check cycle represents a cycle at which all I/O data subject to cross-checking is compared.

Cross-check cycle: 8 ms

1.3.2.3 Error analysis

The table below indicates the results of system error analysis controlled by the Dual Check Safety function.

Error analysis when the protection door is open

Error	Cause	Action
Excessive speed for Spindle axis	Amplifier or control unit failure, operation error, etc.	Safety limitation speed monitoring function EN60204-1 Category 1/0 stop
Excessive speed for feed axis	Amplifier or control unit failure, operation error, etc.	Safety limitation speed monitoring function EN60204-1 Category 1/0 stop
Feed axis safety machine position error	Amplifier or control unit failure, operation error, etc.	Safety machine position monitoring function EN60204-1 Category 1/0 stop
Input/output signal error	Wiring error, control unit failure, etc.	Safe-related I/O signal monitoring function EN60204-1 Category 1/0 stop

Error analysis when the protection door is closed

Error	Cause	Action
Input/output signal error	Wiring error, control unit failure, etc.	Safe-related I/O signal monitoring function EN60204-1 Category 1/0 stop

1.3.2.4 Remaining risks

The machine tool builder is to make a failure analysis in connection with the control system and determine the remaining risks of the machine.

The Dual Check Safety system has the following remaining risks:

a) The safety function is not active until the control system and drive system have fully powered up. The safety function cannot be activated if any one of the components of the control or drive is not powered on.
b) Interchanged phases of motor connections, reversal in the signal of encoder and reversal mounting of encoder can cause an increase in the spindle speed or acceleration of axis motion. If abnormal speed detected, system controlled to brake to zero speed, but no effective for above error. MCC off is not activated until the delay time set by parameter has expired. Electrical faults (component failure etc.) may also result in the response described above.
c) Faults in the absolute encoder can cause incorrect operation of the safety machine position monitoring function.
d) With a 1-encoder system, encoder faults are detected in a single channel, but by various HW and SW monitoring functions. The parameter related to encoder must be set carefully. Depending on the error type, a category 0 or category 1 stop function according to EN60204-1 is activated.
e) The simultaneous failure of two power transistors in the inverter may cause the axis to briefly (motion depend on number of pole pairs of motor)

Example:

An 8-pole synchronous motor can cause the axis to move by a maximum of 45 degrees. With a lead-screw that is directly driven by, e.g.16mm per revolution, this corresponds to a maximum linear motion of approximately 2.0mm.

f) When a limit value is violated, the speed may exceed the set value briefly or the axis/spindle overshoot the set point position to a greater or lesser degree during the period between error detection and system reaction depending on the dynamic response of the drive and the parameter settings (see Section Safety-Functions)

g) The category 0 stop function according to EN60204-1 means that the spindles/axes are not braked to zero speed, but coast to a stop (this may take a very long time depending on the level of kinetic energy involved). This must be noted, for example, when the protective door locking mechanism is opened.

h) Amplifiers (drive power modules) and motors must always be replaced by the same equipment type or else the parameters will no longer match the actual configuration and cause Dual check Safety to respond incorrectly.

i) Dual check Safety is not capable of detecting errors in parameterization and programming made by the machine tool builder. The required level of safety can only be assured by thorough and careful acceptance.

j) There is a parameter that MCC off test is not to be made in the self test mode at power-on as in the case of machine adjustment. This parameter is protected, only changed by authorized person. IF MCC off test is not conducted, MCC may not be off at stop response is measured.

k) Safety machine position monitoring function does not apply to the spindle axis.

l) During machine adjustment, an exact motion may be executed incorrectly until the safety functions setup correctly and confirm test is completely.

m) Before the reference point return is performed and the MCC off test is performed, it may be dangerous because the correct operation does not be guaranteed. So, the careful operations are required when the machine is operated in the status that the protection door opens.

n) The delay timer is prepared for the cross-checking of the safety related input/output signals. When the inconsistency exists between the signal from the 2 paths, system will recognize this failure, after this time is passed. The system will start the sequence of MCC shut-off, when this time is passed after the inconsistency is detected.

o) Even if <Signal State via PMC> does not match <Signal State via DCSPMC> for the time specified by parameter No. 13810 after the CNC starts, no alarm occurs.

1.4 GENERAL INFORMATION

The following requirements must be fulfilled for the Dual-Check System:

- All conditions of the certification report have to be respected.
- The machine manufacturer is asked to check for insulation and protection connections before shipping the machine.
- The procedures for the changes in the System (either HW or SW) should be referred to maintenance manual (B-64305EN). When safety related components are exchanged, confirmation test regarding safety functions can be performed according to Chapter 7.
- Programming in ladder logic should be referred to PMC programming manual (B-64393EN).

Training

FANUC Training Center provides versatile training course for the person who is concerned with hardware installation, maintenance and operation. FANUC recommend studying and learning in the training center how efficiently operate FANUC products.
There are 3 CNC training course.

[CNC ELEMENTARY COURSE]
Provides basics of CNC functions, operation and programming. The course is recommended before taking more specialized training courses to gain best effects.

MAIN ITEMS OF TRAINING

- CNC functions
- Configuration of CNC
- Configuration and function of servo system
- Basic programming of CNC
- Part programming of milling machine
- Part programming of turning machine
- Introduction of Custom Macro function

More information and course registration
Yamanakako-mura, Yamanashi Prefecture : 401-0501, JAPAN
Phone : 81-555-84-6030
Fax : 81-555-84-5540
Internet:
www.fanuc.co.jp/eschool

2 SYSTEM CONFIGURATION

The Dual Check Safety function has the following components.

Applicable CNC

FANUC Series 0*i*-MODEL D

Amplifier, Motor and I/O

For details on applicable amplifiers, motors, and I/O units, see Chapter 12, "COMPONENTS LIST".

NOTE
The servo amplifiers and servo motors connected to the CNC via the I/O link interface do not support the Dual Check Safety function.

3 SAFETY FUNCTIONS

3.1 APPLICATION RANGE

The Dual Check Safety function assumes the following configuration:

A) At least, one protective door is provided.
B) If protective door is closed, safety is assured.

When the operator makes a request to open the protective door, the safety functions are enabled, and the protective door can be unlocked. While the protective door is open, the active safety functions assure safety. When the request to open the protective door is canceled, the protective door is locked, and the safety functions are disabled.

The Dual Check Safety function provides these safety functions while the protective door is open, as described above. Some of the safety functions continue working while the protective door is closed.

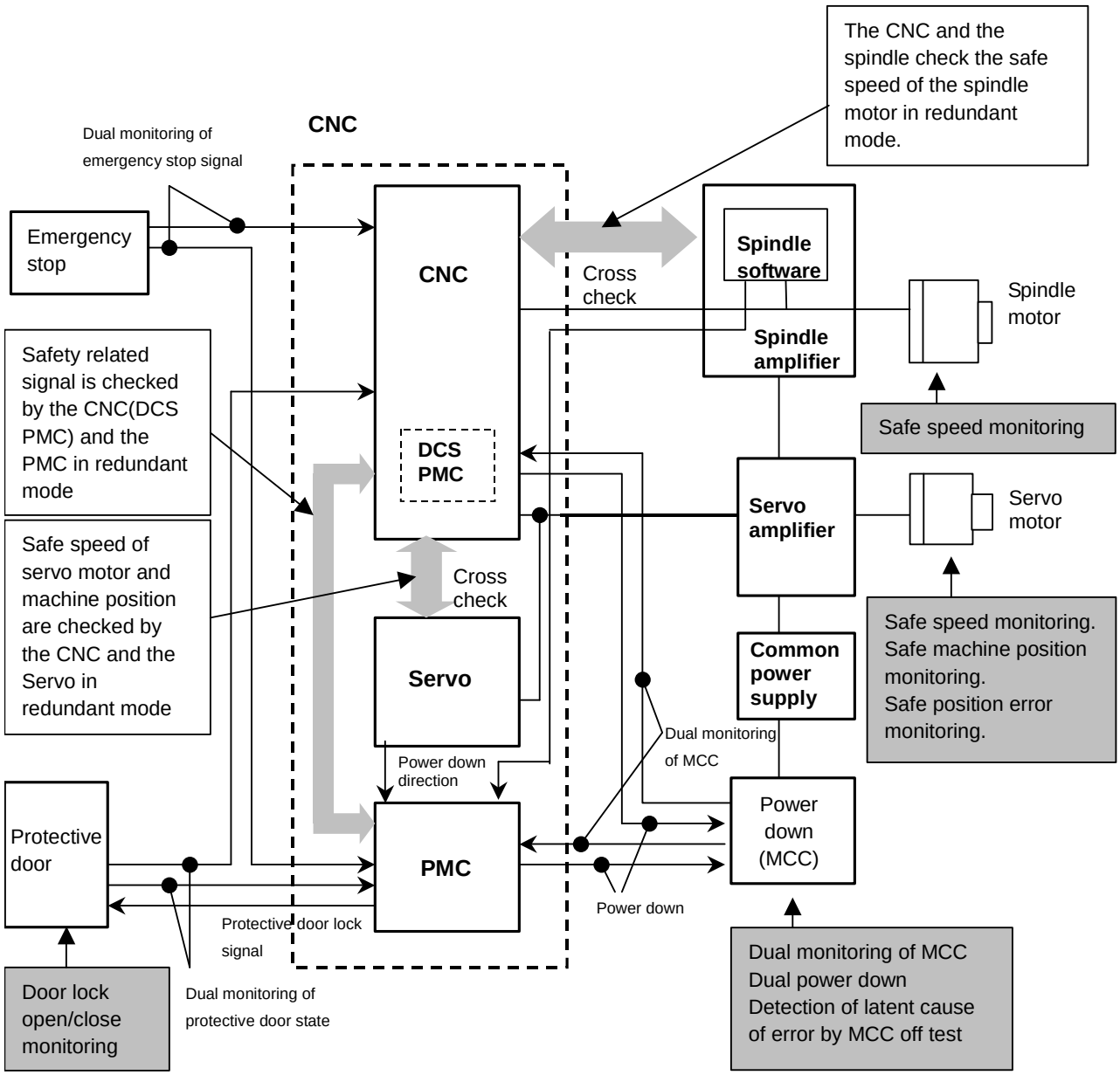
> ⚠ **WARNING**
> The machine tool builder is responsible for the followings.
> - To secure the safety by the sequence to make safety function effective according to the status of the protective door
> - To secure the safety while the protective door is closed
> - To secure the safety related to the other moving components and so on except FANUC servo motors and spindle motors controlled by the Dual Check Safety function, while the protective door is open

Safety function

The Dual Check Safety function has the following safety functions:

- Safe-related I/O signal dual monitoring
  Emergency stop input, protective door open/close state,
  relay state for turning off the MCC
  Output signal for shutting off the power (turning the MCC off)
  To detect the latent cause of an abnormal state of this output, a MCC off Test must be made.
- Spindle motor
  Safe speed monitoring
- Servo motor
  Safe speed monitoring
  Safe machine position monitoring
  Safe position error monitoring

> **⚠ CAUTION**
> This safety function is enabled while the protective door is open after a request to open the protective door is made. If the request to open the protective door is canceled and if the protective door is closed, this safety function is disabled. The dual input check of the safe-related I/O signal monitoring function and the emergency stop function are always active, regardless of whether the protective door is opened or closed.



3.2 BEFORE USING THE SAFETY FUNCTION

3.2.1 Important Items to Check Before Using the Safety Function

When using the safety function for the first time upon assembly of the machine, replacing a part, or changing a safety parameter (such as a safe speed limit or safe range as described in Chapter 6), the user must check that all safety parameters are correct and that all safety functions are working normally. A return reference position must be made on each axis. The user must also check the absolute position of the machine. For details, see Chapter 7, “START UP.”

3.2.2 MCC off Test of the Safe Stop Function

An MCC off Test of the safe stop function monitors the contact state of the electromagnetic contactor (MCC), compares the state with a command to the electromagnetic contactor, and checks that the safe stop function works normally. The user of the machine must carry out the test. This test must be carried out when the CNC is turned on or when 24 hours have elapsed after the previous test is completed. If the CNC is turned on or if 24 hours have elapsed after the previous test is completed, a guard open request (protective door open request) should not be accepted until the test is performed. A machine tool builder must make the ladder program to realize this sequence.

3.3 STOP

3.3.1 Stopping the Spindle Motor

Because the spindle motor is an induction type motor, power-down during rotation causes the motor to continue rotating for a certain amount of time. From a safety standpoint, the motor may have to be stopped immediately. If an error is detected and the spindle is judged to be controlled, it is possible to stop spindle motor by the ladder program. In case of emergency stop and abnormal condition of safety related I/O, it is necessary to design the ladder program to shut off the power after waiting the specified time elapses.

To speed down and stop the spindle, the PMC must input the spindle Emergency Stop signals (*ESPA<Gn071.1> and *ESPB<Gn075.1>). When this signal is input, the spindle slows down and stops. (A Ladder program for inputting this signal in case of alarm must be created.) The input of *EMG emergency stop input (connector CX4) of the common power supply or β*i*SVSP also has the same effect. If the Emergency Stop signal is connected to emergency stop input (connector CX4) of common power supply or β*i*SVSP, the spindle slows down and stops in the emergency stop state. If the spindle does not stop in spite of the stop command, the MCC is shut off.

If this processing is not performed, power-down causes the spindle motor to continue rotating at the speed prior to power-down (and eventually stopping in the end).

⚠ CAUTION

1 When the servo alarm or spindle alarm related to the communication error or position detector is caused, MCC off signal corresponding to the servo or spindle is output. Shut off the MCC after executing appropriate procedure such as spindle stop operation. According to the setting value of the parameter, MCC off signals of all axes, which belong to the same path of the spindle that causes an alarm, are output. Shut off the MCC after executing appropriate procedure such as spindle stop operation.
2 A controlled stop can be made based on parameter settings on occurrence of a safe speed over alarm.
3 Since the synchronous spindle motor is a synchronous motor, not an induction motor, power interruption causes a dynamic break stop depending on the system configuration.

3.3.2 Stopping the Servo Motor

Because the servo motor is a synchronous motor, power-down results in a dynamic brake stop. The dynamic brake stop is electric braking in which the excited rotor is isolated from the power source and the generated electric energy is used up in the winding. An internal resistor provides additional braking. Unlike an induction motor, the servo motor does not coast because of this function.
If the input of the Emergency Stop signal or an error of a safe-related signal or speed monitoring is detected, the CNC automatically specifies a command to zero the speed and reduces the speed to zero (controlled stop). After the motor slows down and stops, the power is turned off, and the motor is brought into the dynamic brake stop state.
To slow down and stop the motor, some parameters must be specified in the CNC. If those parameters are not specified, the motor is immediately brought into the dynamic brake stop state.
When abnormal state is detected in monitoring safety speed or so on, a dynamic brake stop is made.

3.3.3 Stop States

The following stop states are possible.

Safe stop state

The power to the motor is shut off (MCC off state) in this state. If the spindle motor can be controlled, the ladder program must shut off the power after the spindle motor is slowed down to a stop. If the spindle motor cannot be controlled, the power is immediately shut off.
If the servo motor can be controlled, the motor is slowed down to a stop and then brought into the dynamic brake stop state. If the motor cannot be controlled, the motor is immediately brought into the dynamic brake stop state.

If the power is shut off immediately, the spindle motor continues at the same speed prior to the abnormal event and eventually comes to a stop. If the spindle motor can be slowed down to a stop, the operation is performed as instructed by the PMC and then the power is shut off.
For the synchronous spindle motor, immediate power interruption causes a dynamic break stop depending on the system configuration.

Controlled stop state

The power to the motor is not shut off. The servo motor and the spindle motor are controlled to stop.

In the controlled stop state of either motor, the safety function is active if the condition for enabling the safety function is satisfied (the door is open). If a further abnormal event occurs, the motor is brought into the safe stop state by the ladder program.

> ⚠ **WARNING**
> 1 The machine tool builder must design the machine so that the machine is kept in the stop state if the power to the servo motor driving circuit is shut off. Example) Brake mechanism that would not drop the vertical axis after the power is shut off
> 2 If the power to the spindle motor driving circuit is shut off, the spindle motor continues rotating at the speed before the power-down and eventually comes to a stop. A measure must be taken so that this coasting does not affect safety.

3.4 SAFE-RELATED I/O SIGNAL MONITORING

A set of safe-related I/O signals are connected to the two channels of the I/O respectively. As for safe-related I/O signals, a pair of signals are prepared and connected to each I/O through different paths. The two independent CPUs individually check the input signals. If a mismatch between two corresponding signals is found, the system enters the safe stop state. The following safe-related I/O signals are monitored or output in redundant mode:

- Emergency stop input signal
- Protective door state input signal (Request to monitor for each axis)
- Input signal for selecting safety speed monitoring and safety position monitoring
- Input signal for monitoring the MCC contact state
- Output signal for turning off the MCC (power-down)
- Output signal for position switch
- Output signal for brake control
- User defined safe-related I/O signals

In order to setup double monitoring system, machine tool builder must connect safety signals to both I/O Link #1, #2 and I/O Link#3, PROFIBUS-DP.

IMPORTANT
If the safety input signals, except for Emergency Stop input signals, are connected to the I/O module, a Ladder program must be created to establish a one-to-one relationship between the actual input (X) and the input to the CNC (G).

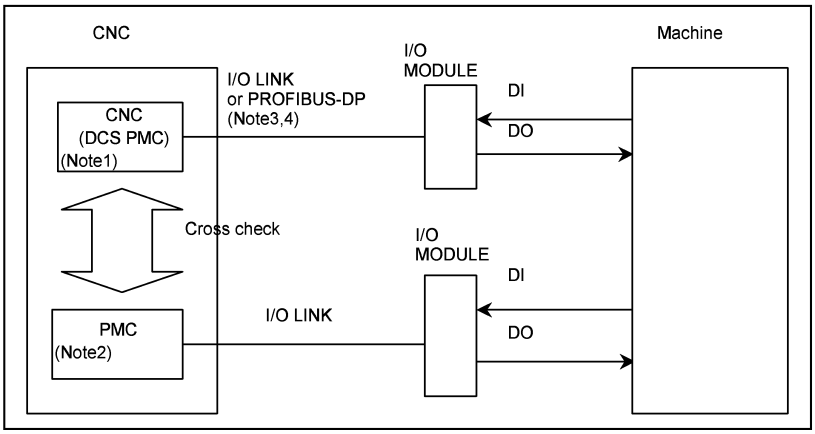
The duplicated signals are always checked for a mismatch, regardless of whether the safety function is active or not. When a signal state changes, the pair of signals may not match for some period because of a difference in response. The Dual Check Safety function checks whether a mismatch between the two signals continues for a certain period of time, so that an error resulting from the difference in response can be avoided. The check period must be specified as a safety parameter.

Parameter number	Name
1945	Safe-related input/output signal check timer

The following signals are not defined as safe-related I/O signals and are not duplicated. The signals, however, are necessary for the system.

- Input signal for making a protective door open request
- Input signal for starting the test mode
- Output signal for requesting a MCC off Test

This section briefly describes the signals. For details, see Chapter 5, "I/O SIGNALS." For specific connections, see the sample system configuration in Chapter 10, "SAMPLE SYSTEM CONFIGURATION".



NOTE

1 Dual Check Safety PMC (DCS PMC)
2 For the PMC, refer to "PMC PROGRAMMING MANUAL (B-64393EN)".
3 When I/O Link and PROFIBUS-DP are connected to DCS PMC at the same time, the X/Y signals cannot be allocated to PROFIBUS-DP.
4 Please activate "Broken wire detection" of the slave, which connect with PROFIBUS network as Safety-related I/O. As for detail, please refer to Section 6.6, "PROFIBUS-DP parameter settings".

⚠ CAUTION

Ladder functional instruction MOVB, MOVD and MOVW cannot be used with ladder for Dual Check Safety PMC. Use MOVN instead of them.

IMPORTANT

Some I/O signals related to the Dual Check Safety function are set for each machine group. With the FS0*i*-D, the number of machine groups is 1 at all times. In this case, those signals that are set for each machine group are always assigned to the first path. So, use the signal area for the first path to input/output those signals.

I/O related with Dual Check Safety Function
n = (NC path number - 1) (for PMC)
m = (NC path number - 1) × 20 (for DCS PMC)

	Symbol	Signal name	I/O address	
1	*ESP	Emergency Stop signal	<X0008.4> (PMC) <X0008.4> (DCS PMC)	Dual input monitoring
2	*SGOPN	Guard State signal	Machine side signal	Dual input
3	*VLDVx	Safety Check Request signal (Servo)	<Gn750.0 to 4> (PMC) <G(002+m).0 to 4> (DCS PMC)	Dual input monitoring
	*VLDPs	Safety Check Request signal (Spindle)	<Gn751.0 to 1> (PMC) <G(003+m).0 to 1> (DCS PMC)	Dual input monitoring
4	SVAn/ SVBn	Safety Speed / Safety Position Selection signal (Servo)	<Gn752.0 to 4/Gn753.0 to 4> (PMC) <G(004+m).0 to 4 / G(005+m).0 to 4> (DCS PMC)	Dual input monitoring
	SPAn/ SPBn	Safety Speed Selection signal (Spindle)	<Gn754.0 to 1/.4 to 5> (PMC) <G(006+m).0 to 1/.4 to 5> (DCS PMC)	Dual input monitoring
5	*SMC	MCC Contact State signal	<Gn748.6> (PMC) <G(000+m).6> (DCS PMC)	Dual input monitoring
6	*DCALM	MCC Off signal (for all system)	<F0748.7> (PMC) <F000.7> (DCS PMC)	Dual output
	*MCF	MCC Off signal (for each machine group)	<Fn748.1> (PMC) <F(000+m).1> (DCS PMC)	Dual output
	*MCFVx	MCC Off signal (for each servo axis)	<Fn752.0 to 4> (PMC) <F(004+m).0 to 4> (DCS PMC)	Dual output
	*MCFPs	MCC Off signal (for each spindle)	<Fn753.0 to 1> (PMC) <F(005+m).0 to 1> (DCS PMC)	Dual output
7	BRKx	Safety Brake signal (Servo)	<Fn754.0 to 4> (PMC) <F(006+m).0 to 4> (DCS PMC)	Dual output
8	SPS	Safety Position Switch signal	<Fn755 to 758> (PMC) <F(007+m) to (010+m)> (DCS PMC)	Dual output
9		Programmable Safety I/O signals		Dual input monitoring Dual output
10	ORQ	Guard Open Request signal	<Gn191.3> (PMC)	Input
11	OPT	Test Mode signal	<Gn191.2> (PMC)	Input
12	*OPIHB	Guard Open Inhibit signal	<Fn191.0> (PMC) <F(019+m).0> (DCS PMC)	Dual output
13	RSVx	Monitoring result signal (Servo)	<Fn750.0 to 4> (PMC) <F(002+m).0 to 4> (DCS PMC)	Dual output
	RSPs	Monitoring result signal (Spindle)	<Fn751.0 to 1> (PMC) <F(003+m).0 to 1> (DCS PMC)	Dual output
14	RQT	MCC Off Test Execution Request signal	<Fn191.2> (PMC)	Output
15	POSEx	Position Information Effect signal (Servo)	<Fn766.0 to 4> (PMC) <F(018+m).0 to 4> (DCS PMC)	Dual output
16	STBT	Brake Test Start signal	<Gn193.2> (PMC)	Input
17	RQBT	Brake Test Execution Request signal	<Fn191.3> (PMC)	Output

Safe-related I/O

1. *ESP Emergency Stop signal (input)

This signal is Emergency Stop signal and is monitored in redundant mode.
The signal is connected to the *ESP input of the servo amplifier as well.

2. *SGOPN Guard State signal (Machine side input signal)

The signal is provided for double monitoring of the protective door state. The signal is connected so that it is normally set to 1 while the protective door is closed and locked (door closed) and set to 0 otherwise (door opened). These states are implemented by the combination of the safety door and safety relays. The PMC ladder for safety check must check the state of axes by asserting the Safety Request signal, when a protective door is open.

3. *VLDVx, *VLDPs Safety Check Request signal (input)

These signals are monitored in redundant mode. These signals request safety check when a protective door is open. These signals are prepared for each axis and each spindle.
CNC monitors these signals. If safe speed range of a servo motor is exceeded in the door open state, the system enters the controlled stop state. If an axis is still not stopped, the system enters the safe stop state.
If safe speed range of a spindle motor is exceeded in the door open state, the spindle motor enters free run state.
(The spindle motor can also enter the controlled stop state when the safe speed range is exceeded, depending on the parameter setting.)
If the spindle motor is not decelerated, the system enters the safe stop state.

4. SVAx/SVBx,SPAs/SPBs Safety Speed / Safety Position Selection signal (input)

These signals are monitored in redundant mode. SVA/SVB are the signals to select safety speed / safety position for each servo axis.
SPA/SPB are the signals to select safety speed for each spindle.
(The values of safety speed / safety position are given by the parameters.)

5. *SMC MCC Contact State signal (input)

The MCC contact state is monitored in redundant mode. In normal operation, the MCC is closed, therefore whether the contact of a relay is in an abnormally closed state cannot be detected. In the test mode, it can be detected whether the contact of relay is abnormally closed.

6. *DCALM, *MCF, *MCFVx, *MCFPs MCC Off signal (output)

With these signals, the MCC is shut off by 2 channels I/O when either one of these signals state is “0”.
*DCALM is to allow turning off MCC of all system when I/O cross check alarm or some problems of safety check function are found.
*MCF is to allow turning on MCC of each machine group according to emergency stop or MCC off Test. (With the FS0*i*-D, the number of machine groups is 1 at all times. So, the signals set for each machine group are always assigned to the first path.)
*MCFVx is to allow turning on MCC of each axis according to monitor safety speed of servo axis or so on. *MCFPs is to allow turning on MCC of each spindle according to the result of monitoring safety speed of spindle.
These signals are assigned on both PMC and DCS PMC. Machine tool builder must output the signal to shut off MCC when either one of these signal is “0”.

7. BRKx Safety Brake signal (output)

These signals are output to control the brake of each servo axis.

8. SPS1 to SPS32 (SPS1 to SPS64 in case of T series with 2-path system) Safety Position Switch (output)

These signals show whether the machine position of each axis is stayed within the range specified by the parameters or not. When a one-path system is used, up to 32 points can be set. When a two-path system is used with the T series, up to 64 points can be set.

9. Programmable Safety I/O signals (input/output)

The 8 bytes (64 bit) programmable safe I/Os can be freely defined as the different address from the above basic safe signals. Each byte of 8 byte programmable safe I/Os can be assigned on either address of X/Y or R or D by parameter. Each byte of the programmable safe I/O between the PMC and DCS PMC is cross-checked by the CNC and PMC. The combinations of cross-checking these signals are defined by using Safety parameters as follows.

Signal type	Combination No.	DCS PMC	PMC
Input	1	No.11950	No.11970
	2	No.11951	No.11971
	3	No.11952	No.11972
	4	No.11953	No.11973
	5	No.11954	No.11974
	6	No.11955	No.11975
	7	No.11956	No.11976
	8	No.11957	No.11977

Signal type	Combination No.	DCS PMC	PMC
Output	1	No.11960	No.11980
	2	No.11961	No.11981
	3	No.11962	No.11982
	4	No.11963	No.11983
	5	No.11964	No.11984
	6	No.11965	No.11985
	7	No.11966	No.11986
	8	No.11967	No.11987

Signals other than safe-related I/O

The following signals are not safe-related signals (are not checked in redundant mode) but are important signals in the Dual Check Safety system. The machine tool builder must create an appropriate Ladder program with these signals.

IMPORTANT
The error of ladder program cannot be checked by safety function itself. Please make sure to check safety function (see Chapter 7).

10. ORQ Guard Open Request signal (input)

When this signal is input, the CNC set the Guard Open Inhibit signal (*OPIHB) to “1” (Guard open accept). The PMC ladder program of a machine tool builder confirms the safety machine position and the safety speed. If both machine position and speed are judged within safe range according to the result of confirmation, the guard unlock signal is set to 1 (guard unlock enabled). The machine tool builder must provide an output signal that opens the actual protective door through the PMC.

11. OPT Test Mode signal (input)

When the signal is input, a MCC off Test is executed. The MCC off Test checks whether the contact of the MCC is abnormally closed. When carrying out the MCC off Test manually, input this signal after the preparation of a MCC off Test is completed by the PMC.

12. *OPIHB Guard Open Inhibit signal (output)

When the Guard Open Request signal (ORQ) is input, the CNC sets this signal to "1". The machine tool builder must design the PMC ladder logic by this signal.
If this signal is set to "1", the PMC confirms safety machine position and safety speed. If the result of confirmation is judged safe, PMC turns on the signal to release guard lock and outputs the signal to open the actual protective door.
If the protective door is unlocked (*SGOPN becomes "0") while the signal is set to 0, PMC will notify alarm occurrence to an operator by lighting a lamp or so on and bring the motor into the safe stop state.

NOTE
This signal is not output while MCC off Test is carried out.

13. RSVx, RSPs Monitoring Result signal (output)

These signals show the result of monitoring safety machine position and safety speed of each axis and the result of monitoring safety speed of each spindle. When Guard Open Inhibit signal (*OPIHB) is set to "1", a machine tool builder can judge whether the machine is in the safety state or not according to these signals. If safety is confirmed as a result, turn on the signal to unlock the guard lock and output the signal to open the actual protective door.

14. RQT MCC Off Test Execution Request signal (output)

If the execution of a MCC off Test is required, this signal is output. At power-on, this signal is always output. If this signal is output, a MCC off Test must be executed.

15. POSEx Position Information Effect signal (output)

This signal is output when Dual Check Safety Function is effective and the reference point is established. When the reference point is not established, the machine system is in danger state because Safety Machine Position Monitoring and Safety Position Error Monitoring are not active. If this signal is "0", Machine Tool Builder has to control not to open the protective door.

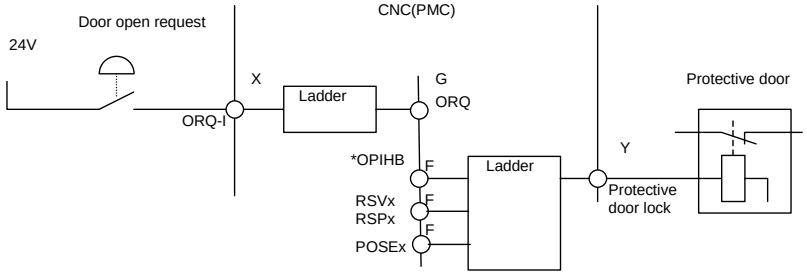
16. STBT Brake Test Start signal (input)

When this signal is input, a brake test is executed. When a brake test is executed, the brake mechanism is checked by a combination of the Safety Brake signals *BRKx (PMC, DSC PMC) doubly monitored.

17. RQBT Brake Test Execution Request signal (output)

This signal is output when a brake test needs to be executed. When the power is turned on, this signal is always output. When this signal is output, execute a brake test.

Guard Open Request signal and Guard Unlock signal



The figure shows a sample connection of the protective door open request switch and the guard unlock signal. In the normal state, the door lock state is changed as follows before the safety monitoring state is established.

Door lock state transition

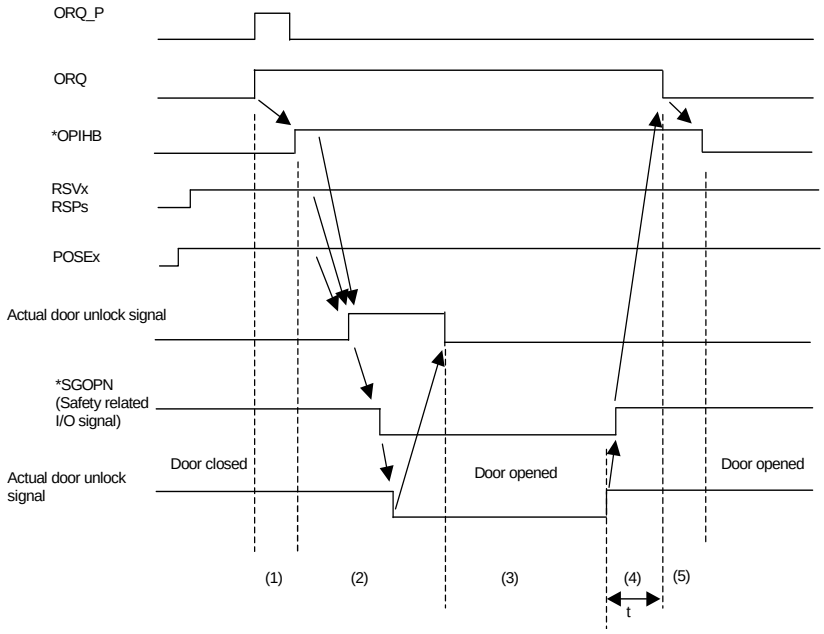
	ORQ-I	ORQ	*OPIHB	RSVx RSPs	POSEx	Protective door lock (*SGOPN)		
A	0	0	0			Locked	A protective door open request is not made, and the door is locked.	Normal operating state
B	1	0	0			Locked	A guard open request is made.	
C1	1	1	0			Locked	The request is transferred to the CNC.	
C2	1	1	1			Locked	The CNC receives the request.	
D	1	1	1	1	1	Locked	Reference point is established and a safe speed check, a machine position check and a position error check prove that there is no failure and that the CNC can enter the safe state.	
E	1	1	1	1	1	Unlocked (*SGOPN=0)	The actual safety door is unlocked. Operations can be performed with the door open.	Safety function is enabled.
D	1	1	1	1	1	Locked	The door is closed and locked again.	
F	0	1	1	1	1	Locked	The guard open request is canceled.	
G	0	0	1	1	1	Locked	The CNC is notified of the release of the above request.	
A	0	0	0			Locked	The CNC receives the release of the above request.	

NOTE

The PMC ladder must be designed to monitor whether the protective door is open (*SGOPN is set to 0) while ORQ is set to 0. If the door open is detected, the PMC ladder judges that an abnormal event has occurred and enters the safe stop state. This can occur, for instance, when the door happens to open (or to be unlocked) while machining is in progress with the protective door closed.

Timing diagram from door close state to door open state

The following diagram shows the timings at which the door is opened and closed again.



(1) When the Guard Open Request signal (ORQ) is input, the CNC returns the answer signal (*OPIHB) to PMC.

(2) The PMC ladder program checks that the machine position, speed and position error are within safe ranges by the Monitoring Result signal (RSVx/RSPs) and the reference point is established by the Position Information Effect signal (POSEx). Then, it turns on the guard unlock signal. (Caution)
This example assumes that the protective door has an electromagnetic lock mechanism. While the door is open, the unlock signal is turned off.

(3) The door is open.

(4) The protective door is closed and locked. After this, the Guard Open Request signal (ORQ) must be turned off. (Caution)

(5) When the Guard Open Request signal (ORQ) is turned off, the CNC turned off the answer signal (*OPIHB).

⚠ CAUTION

1 The RSVx and RSPs are redundant and output to both PMCs (PMC and DCSPMC). Since the RSVx and RSPs signals, the monitoring results of two independent circuits, are output to two PMCs, the output states of the results may not match temporarily (when, for example, the spindle speed is close to the safe speed). Therefore, keep the following in mind when only RSVx and RSPs are used as conditions for releasing a guard lock.
Confirm that RSVx and RSPs of the PMCs (PMC and DCSPMC) are both placed in the safe state before releasing a guard lock. When RSVx and RSPs of one PMC are used as conditions for releasing a guard lock, keep in mind that, before releasing a guard lock, wait until the speed becomes low enough after RSVx and RSPs enter the safe state.
When the protective door is assumed to be open if RSVx and RSPs of only one PMC enter the safe state, a safe speed limit monitoring alarm may occur depending on the result of the other monitoring state.

2 Ensure a time of 100 ms or longer (“t” in the figure) from when the door is closed (locked) until the Guard Open Request signal (ORQ) goes off. If this time requirement is not satisfied, an alarm may be raised when the door is closed (locked).
Design an operator panel to inform an operator that Guard Open Request signal (ORQ) is turned on by lighting a lamp.

3.5 EMERGENCY STOP

The Emergency Stop signal is monitored in redundant mode. When the emergency stop is input, the servo motor slows down to a stop (Caution) and enters the dynamic brake stop. The spindle slows down to a stop (Caution) as instructed by the PMC (Ladder program), and then the power is shut off.

⚠ CAUTION

To enable the function to slow down and stop the servo motor, the corresponding parameter must be specified. If the parameter is not specified, the motor immediately enters the dynamic brake stop state. The spindle motor slows down and stops as instructed by the PMC (Ladder program). If the PMC does not instruct this, the motor maintains the high speed prior to the power-down and coasts. If an illegal speed is specified because of a failure on the PMC side while the safety function is active (the protective door is open), the CNC enters the safe stop state.

⚠ WARNING

In the emergency stop state, the processing to open or close the protective door depends on the Ladder program created by the machine tool builder. For example, when the protective door is prohibited from being opened in the emergency stop state (when, for example, the spindle rotates at a speed not allowed in situations where the protective door is open, that is a speed exceeding the safe speed limit), the processing needs to be implemented by the ladder program.

IMPORTANT

Emergency Stop Button must fulfill the Standard IEC60947-5-1. This is mandatory.

3.6 SAFE SPEED MONITORING

If the safe speed range is exceeded while the protective door is open, the Dual Check Safety function immediately enters the stop state. If each axis or spindle is not stopped, the Dual Check Safety function enters the safety stop state. For each feed axis and spindle, up to four safe speed ranges can be specified in safety parameters.

Both the CNC and the SV/SP monitor whether a safe speed is kept on each feed axis and spindle. Limit speed can be changed by the Safety Speed / Safety Position Selection signals (SVAn/SVBn for feed axis, SPAn/SPBn for spindle).

Name	Safety Speed/Safety Position Selection signal		Safety speed parameter	
	SVAn/ SPAn	SVBn/ SPBn	Feed axis	Spindle
Safety speed 1	0	0	No.13821	No.4372
Safety speed 2	1	0	No.13822	No.4438
Safety speed 3	0	1	No.13823	No.4440
Safety speed4	1	1	No.13824	No.4442

When excess limit error is detected, Monitoring Result signal (RSVx/RSPs) is set to “0”. In this situation, if Safety Check Request signal (*VLDVx/ *VLDPs) is “0” and safety monitor is executed, an alarm is generated.

Error detected CPU	Alarm
CNC	SV0494/SP0757
SV	SV0476
SP	SP9069(SPINDLE ALARM 69)

⚠ CAUTION

1 When an illegal speed is detected for the servo axis, if the axis is not stopped after the time specified in the parameter, the MCC Off signal (*MCFVx) is turned to “0”.
2 When an illegal speed is detected for the spindle axis, CNC checks whether the spindle speed decelerates continuously or not. If acceleration is detected, the MCC Off signal (*MCFPs) is turned to “0”.
3 For the spindle, bit 1 (CTLSTP) of parameter No. 4399 can be used to select a stop method (free run stop or controlled stop) on occurrence of a safe speed excess alarm.

IMPORTANT

1 A gear ratio, ball screw, and the like must be carefully selected so that a safe speed can be kept on the feed axis.
2 Before inputting the Guard Open Request signal (ORQ), reduce each axial speed and spindle speed to a safe speed range or below. If a speed exceeds the limit, do not unlock the protective door. The PMC ladder must be designed that the power to the driving circuit is shut off (safe stop state) if the door is forced open.

⚠ **WARNING**

The safe speed monitoring function monitors whether the traveling speed exceeds a specified limit. The function cannot monitor the stop state (zero speed). If an error causes a movement on the feed axis at a speed lower than the safe speed range while the protective door is open, for instance, the function cannot detect this state. The machine must be designed so that this state does not affect the safety of the machine system.

3.7 SAFE MACHINE POSITION MONITORING

While the door is open, the Dual Check Safety function checks whether the position on each feed axis is within the safe machine position range defined by safety parameters. If it detects a machine position beyond the safety range, the Dual Check Safety function immediately enters the stop state. If each axis is not stopped, the Dual Check Safety function enters the safety stop state.
For each feed axis, up to four safe positions can be specified in safety parameters.

Both the CNC and the Servo monitor whether each axis is within the safety position. The range of the safety machine position can be changed by the Safety Speed / Safety Position Selection signals (SVAn/SVBn for feed axis).

Name	Safety Speed/Safety Position Selection signal		Safety machine position parameter	
	SVAn	SVBn	+ direction	- direction
Safety machine position 1	0	0	No.13831	No.13832
Safety machine position 2	1	0	No.13833	No.13834
Safety machine position 3	0	1	No.13835	No.13836
Safety machine position 4	1	1	No.13837	No.13838

When “out of position error” is detected, Monitoring Result signal (RSVx) is set to “0”. In this situation, if Safety Check Request signal (*VLDVx) is “0” and safety monitor is executed, an alarm is generated.

Error detected CPU	Alarm
CNC	SV0495
SV	SV0477

⚠ CAUTION

1 The safe machine position monitoring function does not keep monitoring the specified range. Only after the function detects that a position on a feed axis exceeds the range, the system enters the stop state. Accordingly, in the stop state, an over travel has occurred on the feed axis. The travel distance depends on the traveling speed and other conditions.
2 When an “out of position error” is detected, if the axis is not stopped after the time specified in the parameter, the MCC Off signal (*MCFVx) is turned to “0”.

The user of the machine must first carry out a reference position return in order to obtain the initial position. If the reference position return is not carried out, the check function is disabled. This check function is enabled after the reference position is established. (The function cannot be disabled by any means after the reference position is established.) A safe machine position limit on each feed axis is specified in a safety parameter.

> ⚠ **CAUTION**
> A machine operator must confirm whether the machine reference position is established correctly by checking the actual machine position and position display of the CNC.

At power-on, the safety function does not work. After power-on, the CNC checks whether a reference position return is completed. If the reference position return is completed and if the protective door is open, safe machine position monitoring, safe speed monitoring and safety position error monitoring are performed. Then, the safety functions start working. If the reference position return is not completed, safe machine position monitoring cannot be performed because the coordinates are not established. In this state, the machine position monitoring function is disabled. After a reference position return is made, this function is enabled. Depending on the safety parameter setting, however, an alarm may be raised. To avoid this alarm, specify the safe machine position parameters before making a reference position return.

> ⚠ **CAUTION**
> 1 The machine coordinate of the safety function is based on position feed back. So it does not always indicate the same value as the machine coordinate based on the summation of the command value.
> 2 This function is activated only in position control mode.

3.8 MCC OFF TEST

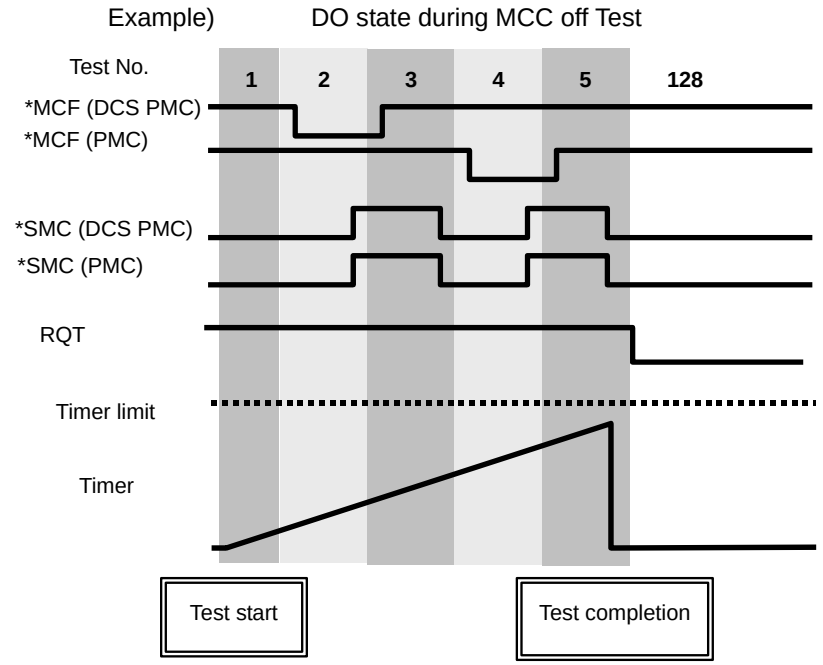
A MCC off Test must be carried out in intervals of 24 hours, so that the safety functions would not be damaged by a possible cause of failure. A message telling that the MCC off Test must be carried out is displayed at power-on or when 24 hours have elapsed after the previous MCC off Test. The machine tool builder must set up the machine not to open the protective door before a MCC off Test is not completed.
The protective door can be opened only after the MCC off Test is carried out accordingly.

A MCC off Test performs the test to turn on and off MCC by controlling *SMC signal in order to confirm whether the circuit to shut off MCC is normal. The MCC off Test is performed both on PMC and DCS PMC. If the MCC off Test is not completed within the time specified by the parameter No.1946 (MCC off Test timer), servo alarm SV0488 is generated. It is necessary to carry out the MCC off Test before the protective door is open, when power is on or 24 hours have elapsed after previous MCC off Test.

The PMC ladder program must be designed to carry out the following control.

<1> When MCC off Test request signal (RQT) is set to "1" at power-on or in case 24 hours are elapsed after the previous MCC off Test, the protective door is locked till the MCC off Test is performed. But the operator can operate the machine while the protective door is closed.

<2> When the MCC off Test request signal (RQT) is turned to "0", the protective door can be unlocked.



Test number	Description
1	When the *MCF signals on both the PMC and DCSPMC sides are 1, confirm that the MCC is on. (*SMC = 0)
2	Confirm that the MCC turns off when the *MCF signal on the DCSPMC side is set to 0. (*SMC = 1)
3	Confirm that the MCC turns on when the *MCF signal on the DCSPMC side is returned to 1. (*SMC = 0)
4	Confirm that the MCC turns off when the *MCF signal on the PMC side is set to 0. (*SMC = 1)
5	Confirm that the MCC turns on when the *MCF signal on the PMC side is returned to 1. (*SMC = 0)
128	This state is entered when tests 1 to 5 end successfully.

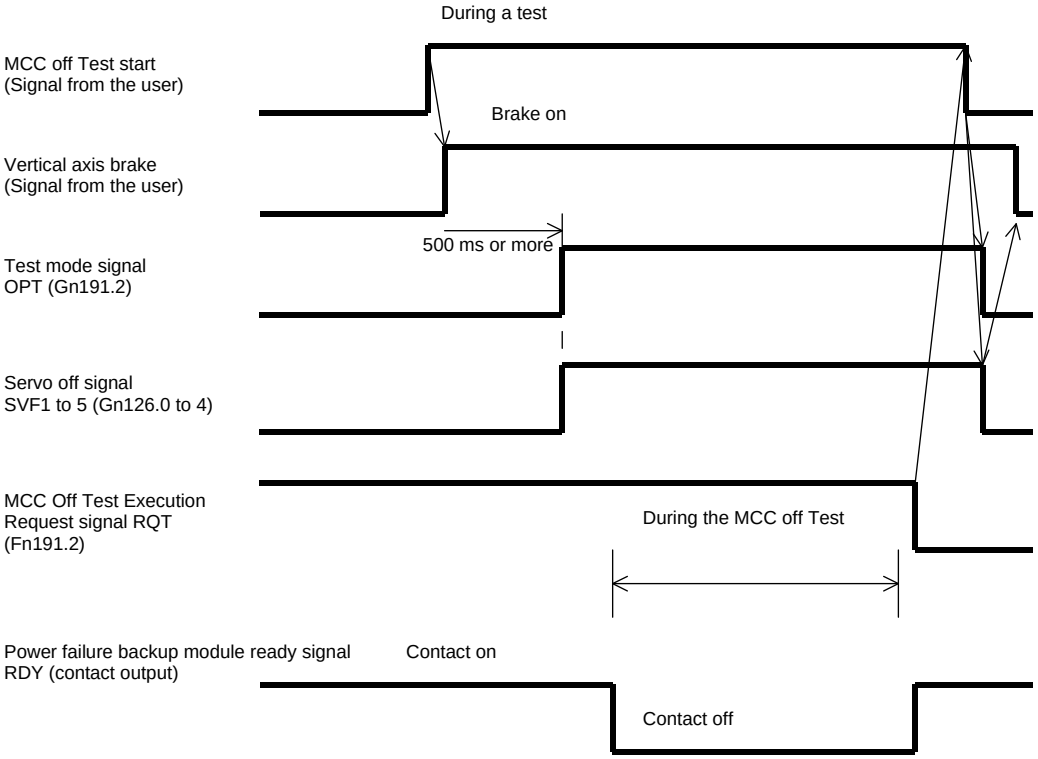
IMPORTANT

Carry out the MCC off Test with the protective door closed. As the test shuts off the MCC, prepare the system for mechanical MCC shut-off before starting the MCC off Test.

The following describes notes and a timing chart during the MCC off Test.

<1> Before performing the MCC off Test, stop the feed axis and spindle.
<2> When the MCC off Test ends, the MCC Off Test Execution Request signal goes off. After the MCC Off Test Execution Request signal goes off, set the test mode signal to off.
<3> When the vertical axis is present, take measures such as preparing a brake circuit for drop prevention. Take 500 ms or more from when the brake is driven until test start signal OPT is activated, in the ladder.
<4> Do not connect a peripheral device or noise filter between the MCC and the common power supply. Otherwise, the test may not terminate normally.
<5> Enable the servo off signals (SVF1-5) after applying a brake to the servo axis connected to the common power supply to be tested. If the servo off signals are not input, an alarm may occur during the test.
<6> When the power failure backup module is connected, the ready signal (contact output signal RDY) of the power failure backup module goes off during the MCC off Test. Therefore, make considerations to eliminate a problem in the ladder. A possible measure is to mask the ready signal by the test mode signal.

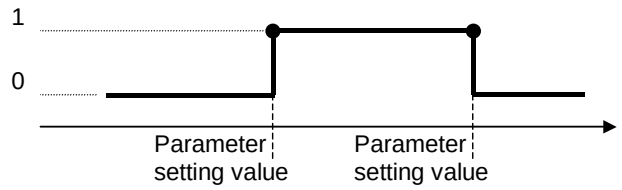
[Timing chart of the MCC off Test]



3.9 SAFETY POSITION SWITCH FUNCTION

It is checked whether the machine position is within the range of safety position switch. The checked result is outputted to the Safety Position Switch signal. The correspondence between axes and each signal is specified by the parameters. In case of 1 path system, up to 32 points can be specified. In the case of a 2-path system based on the T series, up to 64 points can be set.

When a machine position of controlled axis is within a range, which is specified by the safety parameters, this signal is output.



The signals are output after establishment of the reference position. The signal is not output before the completion of return to reference position.
The "machine position" is the actual machine position (which is calculated using feedback of position detector), not the commanded position.
The comparison of position for safe position switch is executed in detection unit.
If the machine position equals parameter setting value, the safe position switch signal is output.
The safe position switch signal is not output for axis which the Dual Check Safety (bit 6 (DCN) of parameter No.1904=1)) is not applied to.

Safety Position switch can be assigned up to 16 points per 1 group to the output signal (F area) and totally up to 4 groups can be used in the CNC system.
Two areas per a path are provided to assign. It is possible to assign the signal to an appropriate area.
Safe position switch signals can be assigned to arbitrary controlled axes. (All points can be also assigned to one axis.) The assignment of controlled axes is set by the safety parameters (No.13880 to No.13911, No.10501 to No.10532).
And the signals can be also assigned to the rotary axes.

When inconsistency between the position switch on PMC and that on DCS PMC is lasted for the time that is specified by the parameter No.1945, the safety function sets MCC Off signal (*DCALM) to "0" and generates the alarm "safe I/O cross check error" (PW0010/PW0011).

NOTE
The machine coordinate of the safety function is based on position feed back. So it does not always indicate the same value as the machine coordinate based on the summation of the command value. Two machine coordinates that are calculated by two CPU independently are not always the same because the position feedback is continuously changed a little. As there is a possibility that the condition of two signals is different from each other near the boundary, do not stop an axis near the boundary.

⚠ CAUTION
This function is activated only in position control mode.

- **Hysteresis**
  Position switch sometimes turns on and off repeatedly near the boundary of position switch area by very small vibration of a servo motor. According to this problem, position switch is inconvenient to use. So "hysteresis" described below is applied.

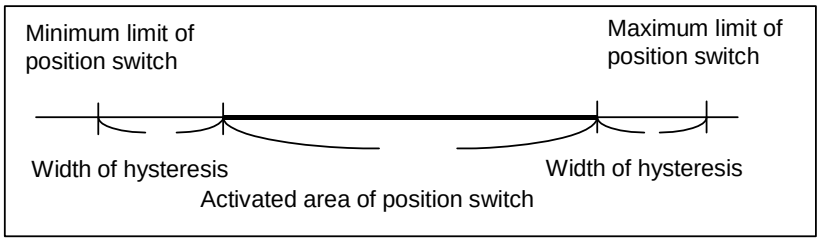


Fig.3.9(a) Measuring area of position switch in case state of switch is "0"

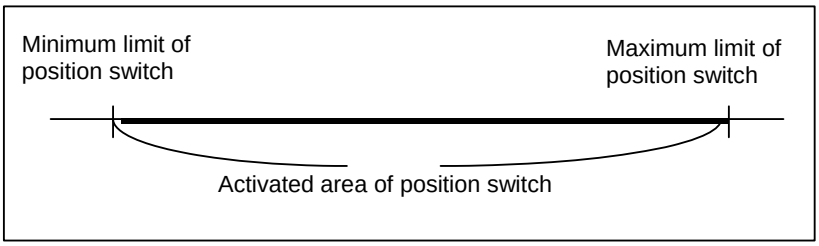


Fig.3.9(b) Measuring area of position switch in case state of switch is "1"

The position switch is checked at every sampling period. When the minimum and maximum limit of position switch are given like above figure, activated area is checked by the area shown in the figure 3.9(a) considering hysteresis if the state of position switch measured at last time is "0". And activated area is checked by the area shown in the figure 3.9(b) not considering hysteresis if the state of position switch measured at last time is "1". According to this, it is possible to suppress frequent changing of position switch.

3.10 SAFETY RELATED PARAMETERS CHECK FUNCTION

At every power-on, the CNC checks whether the safety related parameters are destroyed and are transferred to the SV, the SP and the PMC normally or not. The SV, the SP and the PMC also check whether the safety related parameters are transferred from the CNC normally or not.
If some problem is found in this check, an alarm is generated and the MCC is shut off. (*DCALM=0)

3.11 PARAMETER LOCK FUNCTION

Parameters related to the Dual Check Safety function (safety parameters) can be locked to protect against modification.
The parameter No.3225 and No.3226 unlock these parameters. The following parameters are locked.

No.0980, No.0981, No.0982, No.1023, No.1240, No.1838, No.1839, No.1840, No.1841, No.1842, No.1902#6, No1904, No.1945, No.1946, No.1948, No.1950, No.3225, No.3717, No.3797, No.4372, No.4438, No.4440, No.4442, No.4448, No.4460, No.10500 to No.10596, No.11950 to No.11957, No.11960 to No.11967, No.11970 to No.11977, No.11980 to No.11987, No.13805, No.13810, No.13811, No.13821 to No.13829, No.13831 to No.13838, No.13840 to No.13843, No.13880 to No.13911, No.13912 to No.13919, No.13920 to No.13951, No.13960 to No.13991

3.12 SEFETY POSITION ERROR MONITORING FUNCTION

Both the CNC and the SV check whether the servo following error of each axis exceeds the limit of deviation specified by the parameters.
If the servo following error exceeds, an alarm is generated and MCC OFF signal (*MCFVx) is output immediately.
The relation between the safety monitoring state and the parameter of limit of deviation is shown in the following table.

	Safety monitoring is activated (In case *VLDVx =0)	**Safety monitoring is not activated (In case *VLDVx =1)**
Moving	No.1838	No.1841
Stopping	No.1839	No.1842
Servo-off	No.1840	No.1840

Error detected CPU	**Alarm**
CNC	SV1069/SV1071/SV1072
SV	SV0474/SV0475/SV1070

When position deviation exceeds the limit given by the parameter (No.1839 in stop state, No.1838 in moving state and No.1840 in servo off state) during safety monitoring, Monitoring result signal RSVx is set to “0” regardless of the state of Safety check request signal *VLDVx.

This function is valid after the reference position return is finished or the follow-up of absolute position is finished in case an absolute position coder.

> ⚠ **CAUTION**
> This function is activated only in position control mode.

3.13 AMPLIFIER CIRCUIT MONITORING FUNCTION

The SV and the SP transmit the data of plural axes to amplifiers through one electronic circuit (LSI). The CNC, the SV and the SP check whether this transmission is performed normally without placing data on wrong address.
In case of servo amplifier, the CNC axis numbers kept by the CNC are compared with the CNC axis numbers kept by the SV. In case of spindle amplifier, the spindle numbers kept by the CNC are compared with the spindle number kept by the SP. The checking sequence is as follows.

Checking sequence for servo amplifier

<1> When a servo amplifier is set up at the first time, an alarm SV0498 is generated. At that time, the CNC transfers the CNC axis numbers to the SV and the SV keeps the data. Then the power of all CNC system (amplifiers are included) must be turned off and on.
When an alarm is generated after the configuration of servo amplifiers is changed, it is necessary to carry out the operation to send the CNC axis numbers to servo amplifiers. Set the parameter No.2212#4 to "1" then return to "0". Then turned off the power of all CNC system (amplifiers are included.)

<2> After the power-on, the CNC and the SV start monitoring the CNC axis numbers. The CNC monitors by comparing the CNC axis number kept by the CNC itself with that kept by the SV. The SV monitors by comparing the CNC axis numbers kept by the SV with that sent by the CNC.
When some error is found, an alarm SV0478 or SV0496 is output, and MCC Off signal (*DCALM) is turned to "0".

Checking sequence for spindle amplifier

<1> When spindle is set up, the spindle numbers are transferred from the SP to the CNC.

<2> The CNC compares the spindle numbers kept by the CNC itself with that sent from spindle amplifier. If inconsistency is found, an alarm SP0756 is output and MCC Off signal (*DCALM) is turned to "0".

<3> The SP compares the spindle numbers with that kept by the SP. If inconsistency is found, alarm SP9070 (Spindle alarm 70) is output, and MCC Off signal (*DCALM) is turned to "0".

3.14 SAFETY BRAKE SIGNAL OUTPUT FUNCTION

The CNC and the SV output the Safety Brake signal (*BRKx) to control the mechanical brake. When this signal is “0”, mechanical brake must be activated. When this signal is “1”, mechanical brake is allowed to be released.

When the inconsistency between the break signal on PMC and that on DCS PMC is lasted for the time that is specified by the parameter No.1945, the safety function sets MCC Off signal (*DCALM) to “0” and generates the alarm “safe I/O cross check error” (PW0010/PW0011).

3.15 CPU SELF TEST FUNCTION

The CNC, the PMC, the SV and the SP carry out the following self-diagnosis. If the error is detected, the alarm is generated and sets MCC Off signal (*DCALM) to “0”.

<1> CPU check
It is checked whether each CPU runs normally or not.
It is checked whether the instructions related to safety function is executed normally or not.

Error detected CPU	ALARM
CNC	PW0014
PMC	PW0009
SV	SV0484
SP	SP9074 (Spindle alarm 74)

<2> Program monitoring
It is confirmed whether all safety related function run normally.

Error detected CPU	ALARM
CNC	PW0017/SV0490
PMC	PW0008 (DCS PMC)/PW0009 (PMC)
SV	SV0484
SP	SP9076 (Spindle alarm 76)/SP0755

<3> Cross check
It is checked whether the result of the judgment about the safety related function of a CPU is consistent with that of another CPU.

If some error is found, an alarm is output.

	ALARM
SV relation	SV0490/SV0484
SP relation	SP9072 (Spindle alarm 72)/ SP9077 (Spindle alarm 77)/ SP9078 (Spindle alarm 78)/ SP0755
PMC relation	PW0008 (DCS PMC)/PW0009 (PMC)

3.16 RAM CHECK FUNCTION

ECC (Error Check and Correct) function is applied to the battery back-upped file memory. Then a single-bit error is corrected. And, when an error that cannot be corrected occurs, memory parity error is generated.

Other memory for Dual Check Safety is checked as follows:(If the error is detected, the alarm is generated and sets MCC Off signal (*DCALM) to “0”)

(1) Test at power-on
The several test patterns are written to the RAM area. It is checked whether the written test data are read correctly. If read error occurs, an alarm is generated.
(2) Test during normal operation
RAM area is checked in turn at constant interval during normal operation. The several test patterns are written to the RAM. It is checked whether the written test data are read correctly. If read error occurs, an alarm is generated.

Alarm detected CPU	Alarm
CNC	PW0016
SV	SV0484
PMC	PW0008 (DCS PMC)/PW0009 (PMC)
SP	SP9016 (Spindle alarm 16)

3.17 CRC CHECK FUNCTION

At power-on and after power on, the data that are related to Dual Check Safety and stored in the ROM area are checked. The CNC software, the servo software, the PMC software and the spindle software are checked. If some error is found, an alarm is generated.

After power on

Error detected Software	Alarm
CNC software	CRC CHECK ERROR: NC BASIC.
Servo software	SERVO ROM TEST: CRC CHECK ERROR
PMC management software	LED “6”
Spindle software	Spindle alarm 75

After power on

Error detected Software	Alarm
CNC software	PW0018 CRC CHECK ERROR
PMC management software	SYS-ALM199 NON MASK INTERRUPT OTHER-CPU

3.18 SAFE STOP MONITORING

When a safety door is open, safe stop monitoring for servo axis and spindle can be realized by the combination of several functions.

Safe stop monitoring for servo axis

According to the safe speed monitoring for servo axis and the safe positing error monitoring, CNC and Servo monitor actual feedrate and deviation of each axis. When a safety door is open, monitoring of stop condition of each axis can be performed by the combination of the following three functions.

a) By the safety speed monitoring function, check whether the actual feed rate is lower than the safety level. If the feedrate exceeds the safety limit, an alarm is generated.
   Actual speed is calculated with the feedback of a position detector. So, even if command feedrate is 0, actual feedrate may be detected as not 0 when an axis is moved by external power. Set the value of safety limit that does not cause an alarm when feedrate command is 0.
b) By the safe positioning error monitoring function, check whether position deviation is within a safety limit. If an axis is moved unexpectedly, an alarm is generated.
c) According to "Axis moving signal MVx (Fn102)", check whether axis motion command is not given. (Axis moving signal is prepared for PMC and is not double check signal.)

Safe stop monitoring for spindle

In monitoring of the safe speed limit of the spindle, the actual speed of the spindle motor is monitored at the CNC and spindle. When a safety door is open, monitoring of stop condition of each spindle can be performed by the combination of the following two functions.

a) By the safety speed monitoring function, check whether the actual speed is lower than the safety level. If the feedrate exceeds the safety limit, an alarm is generated.
   Actual speed is calculated with the feedback of a position detector. So, even if command speed is 0, actual speed may be detected as not 0 when a spindle is moved by external power. Set the value of safety limit that does not cause an alarm when speed command is 0.
b) There is a possibility that spindle rotate at speed lower than safety speed limit. Then it is necessary to select the function to make position control loop, such as spindle positioning (T series), Cs contouring control or spindle orientation.

3.19 SAFE SERVO STOP FUNCTION

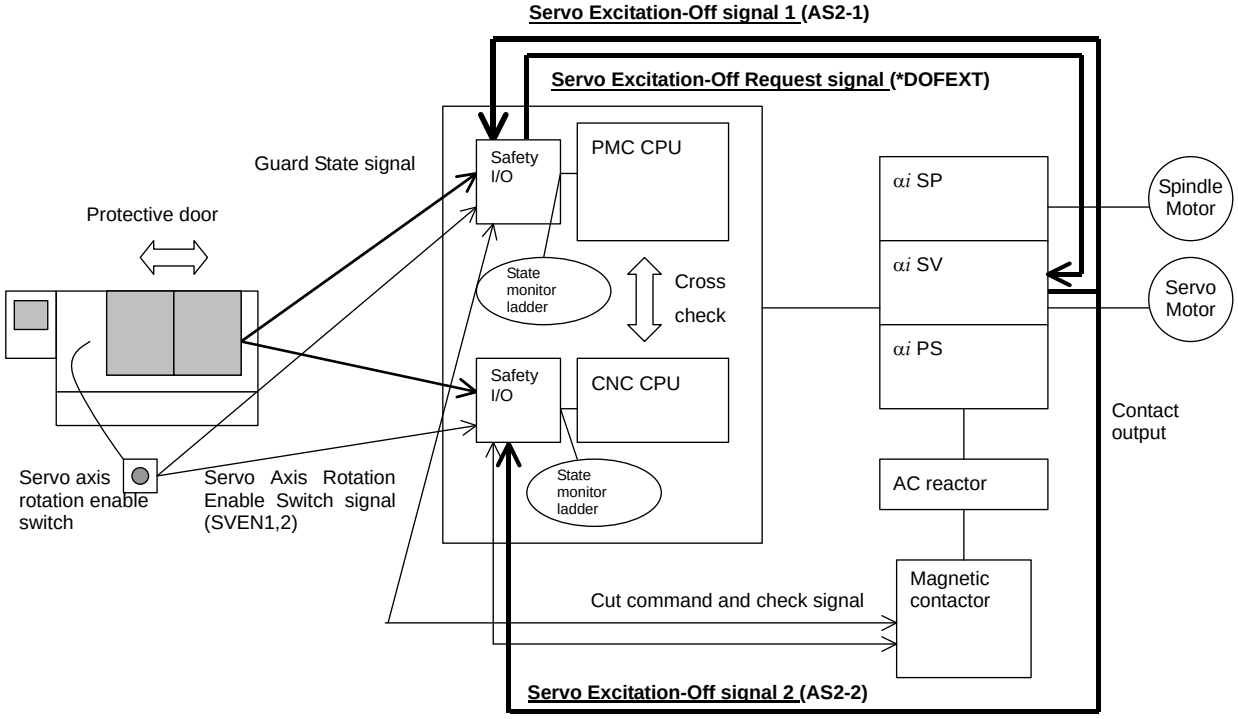
During machine tool setup, the operator may attach or detach a workpiece in the machining area with the protective door opened. Conventionally, the following measures have been used to ensure safety in such work:

- The emergency stop state is set to turn off the power to the spindle and feed axes.
- A device such as a magnetic contactor is installed between the servo amplifier and servo motor and between the spindle amplifier and spindle motor.

This function turns off the power to the servo axis in a safe manner based on the dual monitoring function. For this purpose, this function outputs the state signal (excitation-off signal) of the power output circuit built into the servo amplifier as two independent signals from the servo amplifier and assigns them as Programmable Safety I/O signals (Section 5.4).

By using this function, safety can be secured in turning off the power to the servo axis only, without using an emergency stop or magnetic contactor. So, machine usability can be enhanced.

A function for rotating the servo axis by power with the door open can be additionally used by setting a servo axis rotation enable switch.



Safety function

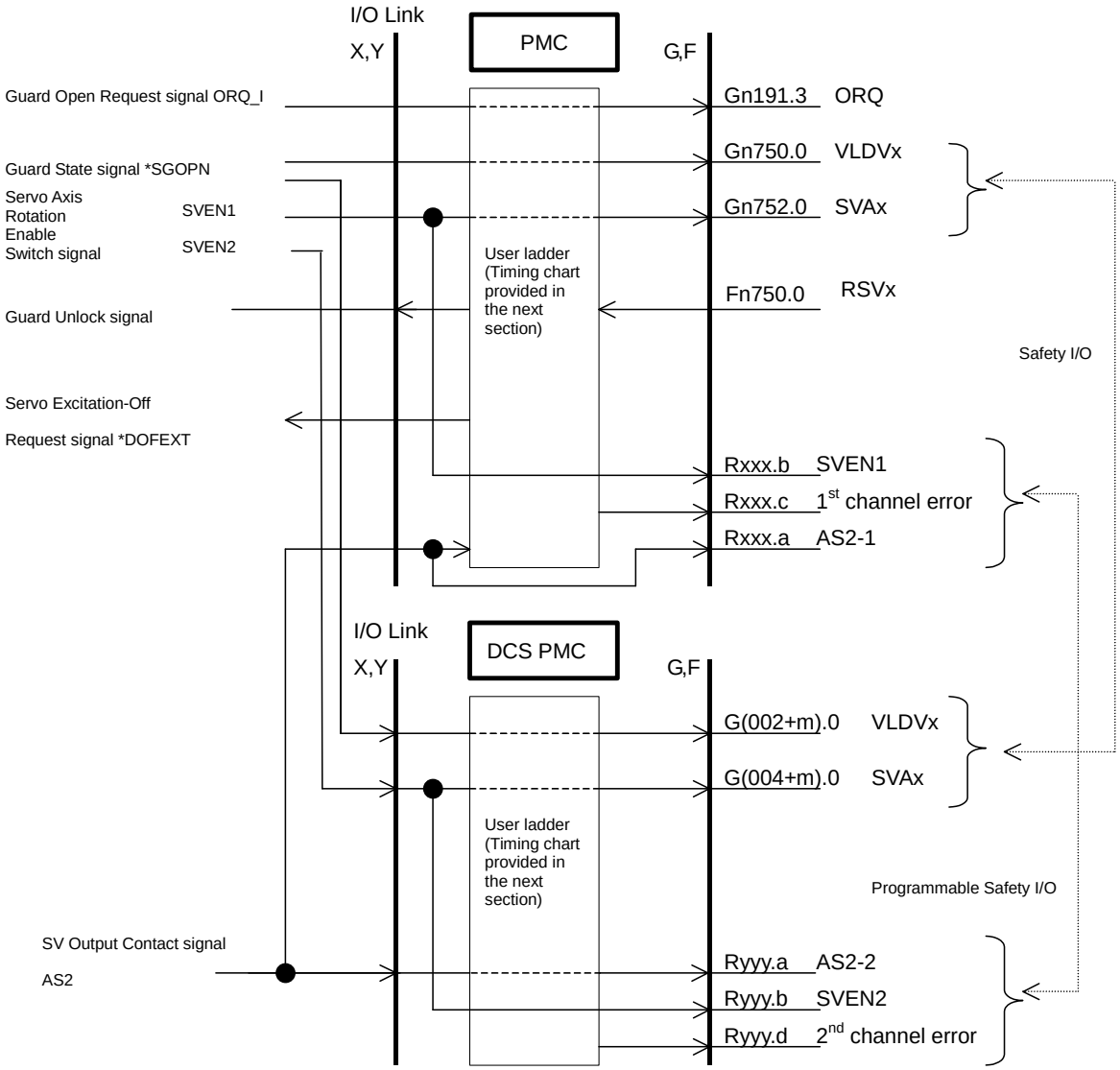
When the protective door is open, the safety function monitors whether the power to the servo motor is turned off, without turning off the magnetic contactor connected to the power supply, or the input power supply, of the main circuit of the servo amplifier. If an error is detected during monitoring, the magnetic contactor of the power supply is turned off to turn off the power to the main circuit.

3.19.1 Monitoring of the Excitation-Off Signal

Assign the two Excitation-Off signals (AS2-1 and AS2-2) output from the αi SV as Programmable Safety I/O signals to check signal matching. Moreover, monitor whether the excitation-on and excitation-off states are normal, by using two types of ladders, namely, PMC ladder and DCS PMC ladder. If an error is detected, secure safety by turning off the magnetic contactor of the αi PS to turn off the power to the main circuit.

When additionally using a function for rotating the servo axis by power with the door open, assign the two switch signals (SVEN1 and SVEN2) output from the servo axis rotation enable switch as Programmable Safety I/O signals to check signal matching.

Signal connection diagram (example)

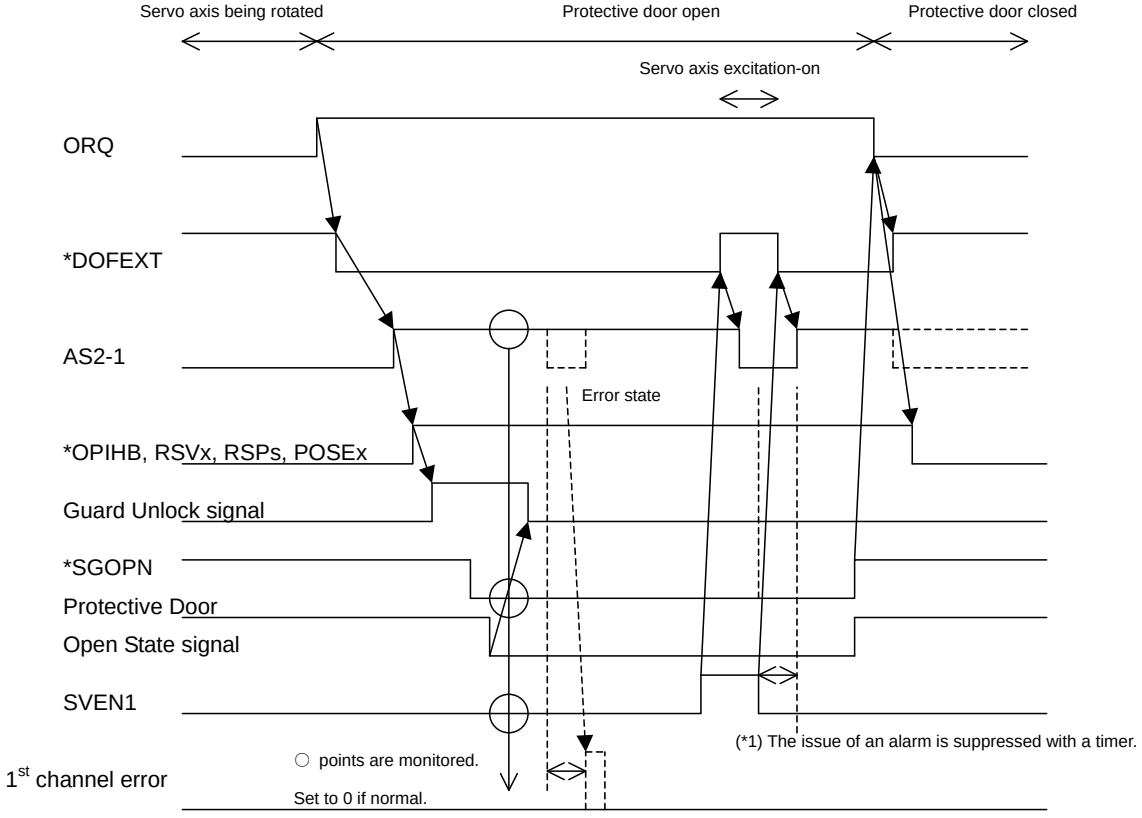


3.19.2 User Ladder Processing

Processing on the PMC side

- With the Guard Open Request signal (ORQ), motor excitation is turned off (*DOFEXT=0) then the excitation-off state (AS2=1) is confirmed. Next, the locking of the protective door (guard lock signal) is released.
- If AS2-1=0 or AS2-2=0 (contact open) (servo excitation-on) for a certain time(*1) when *SGOPN is 0 (door open) and SVEN is 0 (Servo Axis Rotation Enable Switch signal turned off), an error is assumed to issue a 1st channel (or 2nd channel) alarm.

- Timing chart 1
Error judgment processing by the PMC side ladder

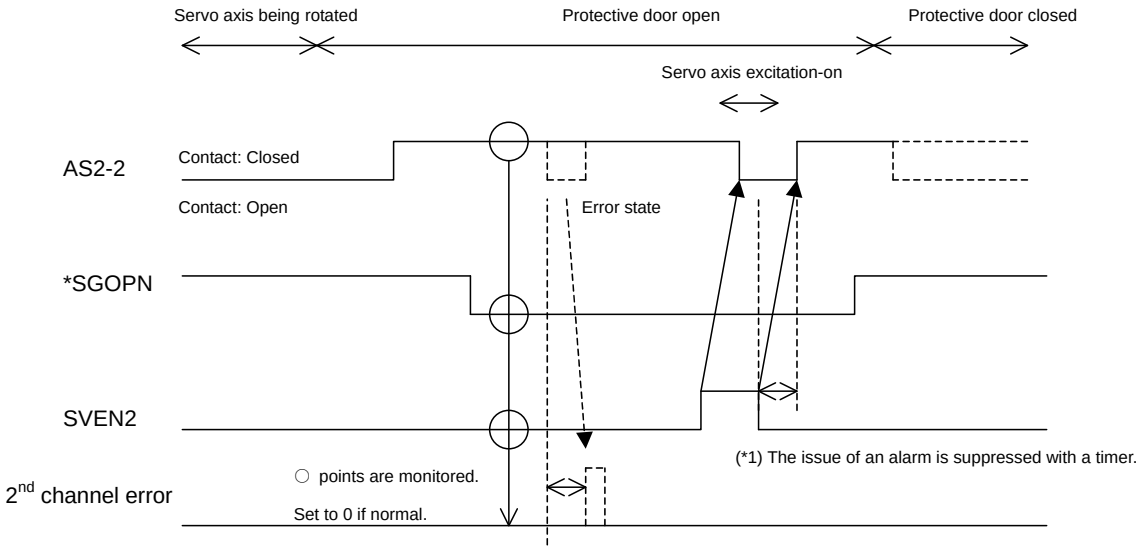


(*1) An alarm condition is detected for the period until servo excitation is turned off (AS2-1=1) after the Servo Axis Rotation Enable Switch signal (SVEN1) is switched from on to off. However, by setting a timer on the ladder side, ensure that no alarm is detected during this period.

Processing on the DCS PMC side

- If AS2-1=0 or AS2-2=0 (contact open) (servo excitation-on) for a certain time(*1) when *SGOPN is 0 (door open) and SVEN is 0 (Servo Axis Rotation Enable Switch signal turned off), an error is assumed to issue a 1st channel (or 2nd channel) alarm.

- Timing chart 2
Error judgment processing by the DCS PMC side ladder



(*1) An alarm condition is detected for the period until servo excitation is turned off (AS2-2=1) after the Servo Axis Rotation Enable Switch signal (SVEN2) is switched from on to off. However, by setting a timer on the ladder side, ensure that no alarm is detected during this period.

3.19.3 Assignment of Programmable Safety I/O Signals

Assign Rxxx of the PMC and Ryyy of the DCS PMC as Programmable Safety I/O signals (input) for double monitoring. Thus, the CNC and PMC doubly check whether the Rxxx and Ryyy bits match each other at all times.

Rxxx

	a	b	c	d			
	AS2-1	SVEN1	1st channel error	“0”			

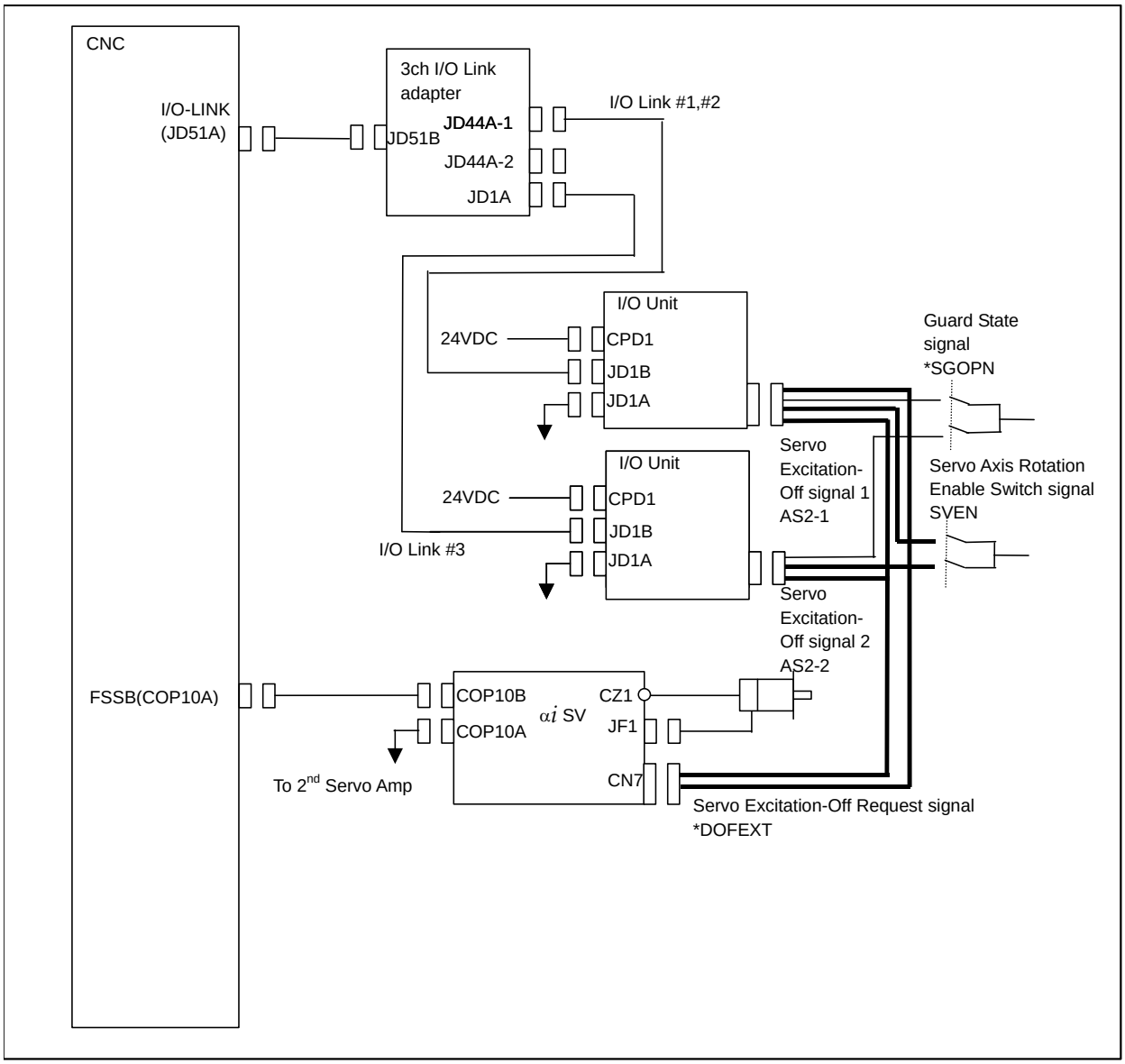
Ryyy

	a	b	c	d			
	AS2-2	SVEN2	“0”	2nd channel error			

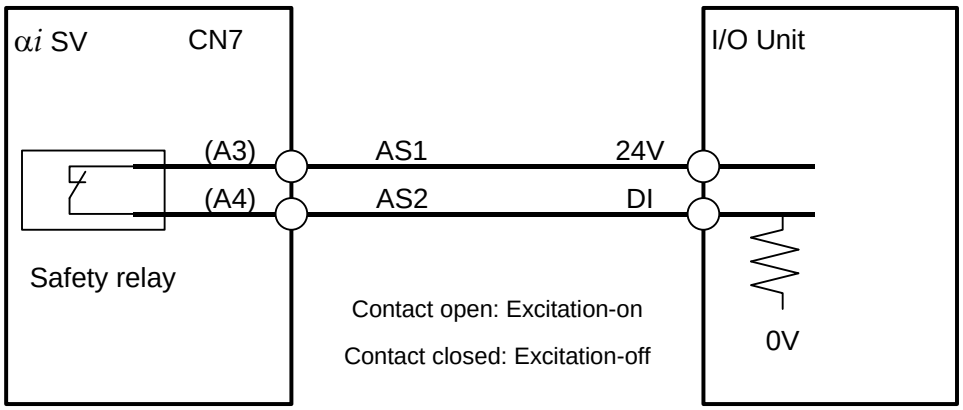
The 1st channel error signal or 2nd channel error signal set to 1 indicates an error state. So, by monitoring for matching with the state of 0, an error state is detected. If a mismatch occurs due to an error state, safety is secured by turning off the magnetic contactor of the αi PS to turn off the power to the main circuit.

3.19.4 Connections

In addition to Dual Check Safety connections, a connection from connector CN7 on the αi SV to the I/O Unit (I/O Link#3) is required. On a system that uses a servo axis rotation enable switch, a connection from the switch is additionally required. (Indicated in heavy lines).

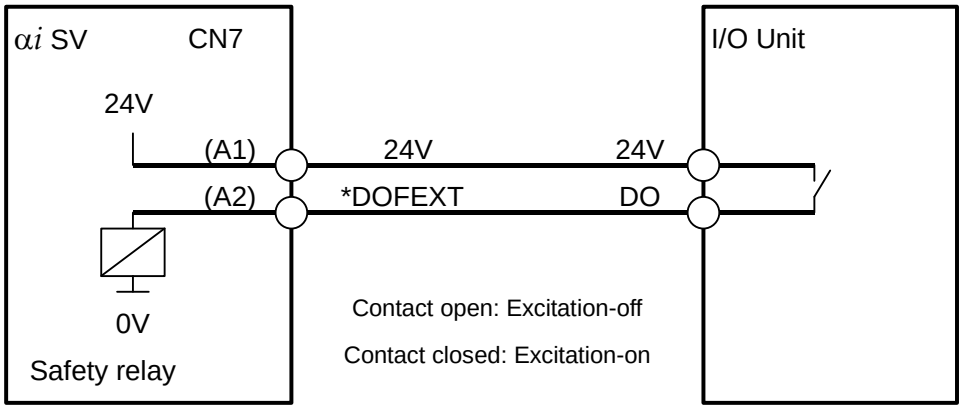


Connection from αi SV connector CN7 to I/O Link#3



D2100 series connector

Tyco Electronics



D2100 series connector

Tyco Electronics

- Coil and contact specification of the safety relay of connector CN7

Allowable voltage range for input to the coil: 20.4 VDC to 26.4 VDC
Rated contact load: 30 VDC/6 A (resistive load)

⚠ CAUTION

1 If the connector is connected incorrectly, the 24 V power externally supplied can damage the internal circuitry of the αi SV. Use special care when connecting the connector.
2 At the time of shipment from factory, a dummy connector for connecting CN7-A1 with CN7-A2 is set. When this function is not used, use the servo amplifier without removing the dummy connector.
3 Be careful not to short-circuit 24V (CN7-A1).

3.19.5 Restrictions

- System configuration

To use this function, the following αi series servo amplifier supporting the function for doubly outputting the Servo Excitation-Off signal needs to be used:

- Servo amplifier based on the drawing number A06B-6127-H1uv (uv = 02, 03, 04, 05)

Moreover, the following Dual Check Safety function needs to be used:

- Programmable Safety I/O signal (Section 5.4)

3.20 SAFE SPINDLE STOP FUNCTION

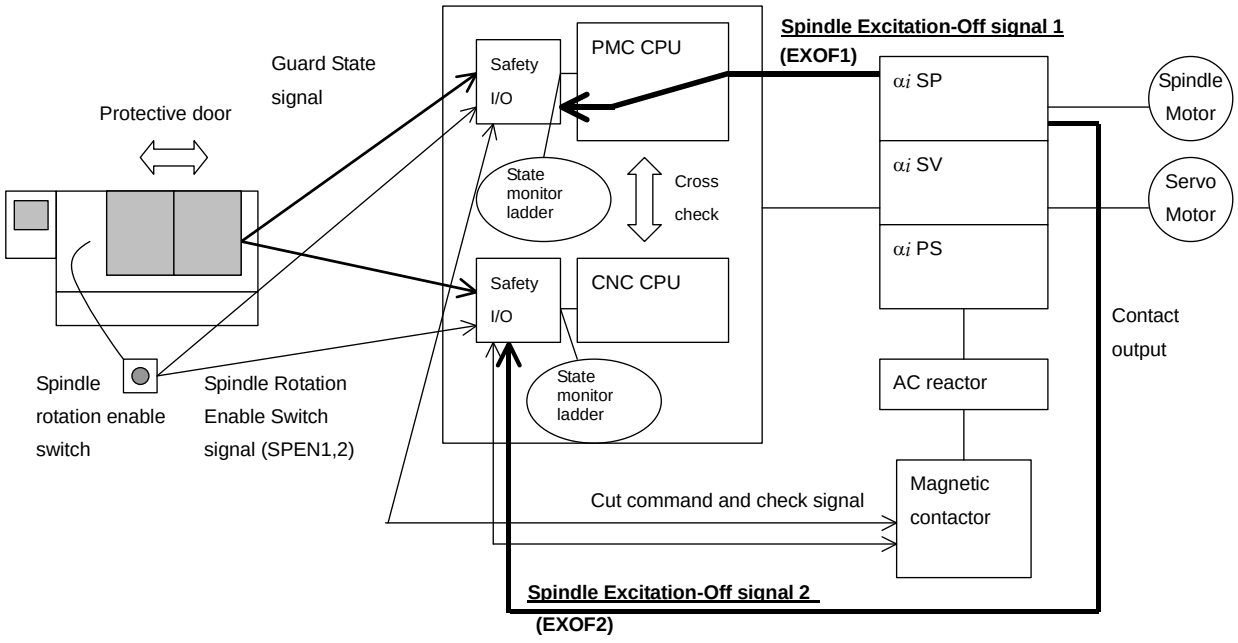
During machine tool setup, the operator may attach or detach a workpiece in the machining area with the protective door opened. Conventionally, the following measures have been used to ensure safety in such work:

- The emergency stop state is set to turn off the power to the spindle and feed axes.
- A device such as a magnetic contactor is installed between the servo amplifier and servo motor and between the spindle amplifier and spindle motor.

This function turns off the power to the spindle in a safe manner based on the dual monitoring function. For this purpose, this function outputs the state signal (excitation-off signal) of the power output circuit built into the spindle amplifier as two independent signals from the spindle amplifier and assigns them as Programmable Safety I/O signals (Section 5.4).

By using this function, safety can be secured in turning off the power to the spindle only, without using an emergency stop or magnetic contactor. So, machine usability can be enhanced.

A function for rotating the spindle by power with the door open can be additionally used by setting a spindle rotation enable switch.



Safety function

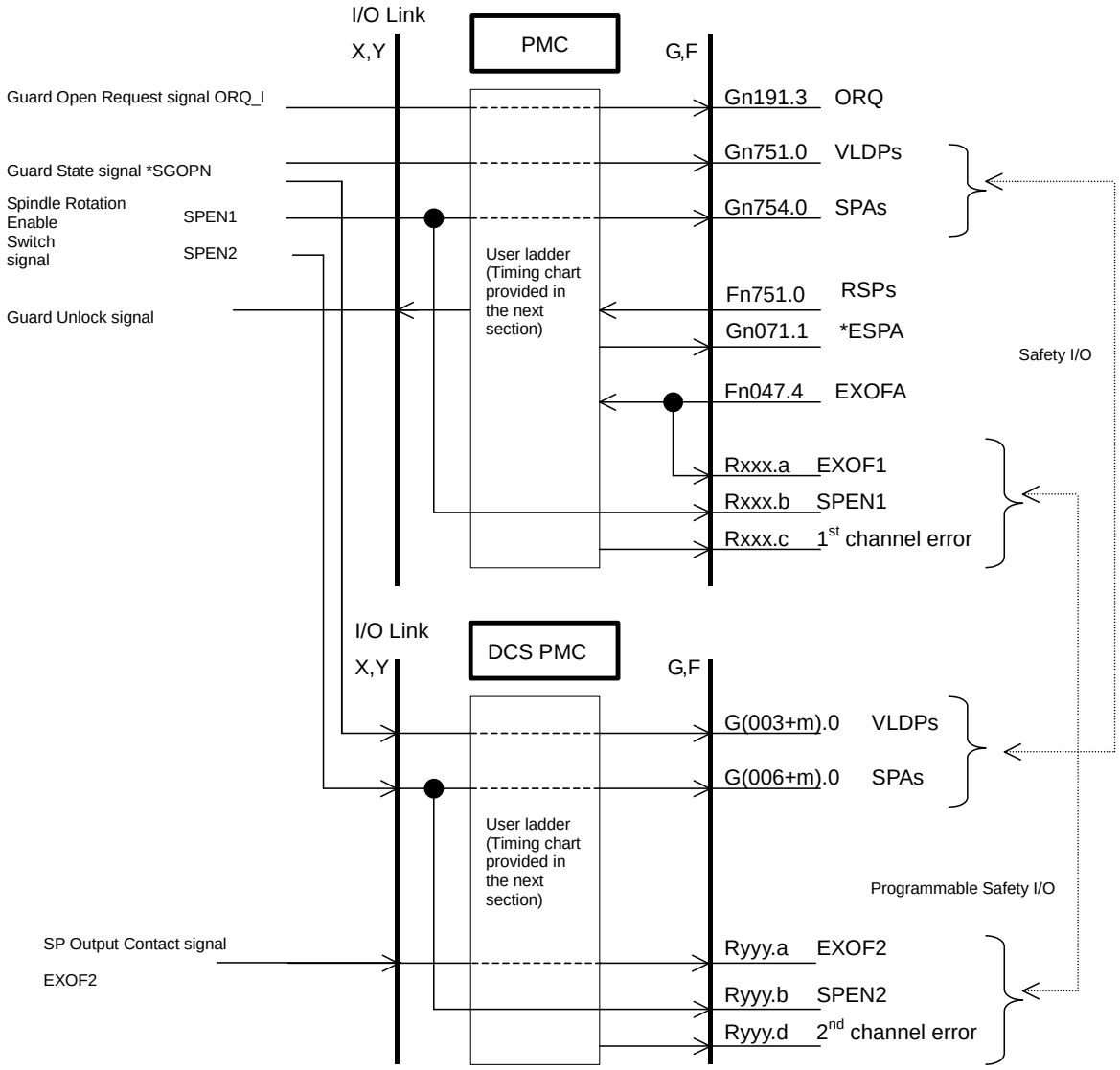
When the protective door is open, the safety function monitors whether the power to the spindle motor is turned off, without turning off the magnetic contactor connected to the power supply, or the input power supply, of the main circuit of the spindle amplifier. If an error is detected during monitoring, the magnetic contactor of the power supply is turned off to turn off the power to the main circuit.

3.20.1 Monitoring of the Excitation-Off Signal

Assign the two Excitation-Off signals (EXOF1 and EXOF2) output from the α*i*SP or β*i*SVSP as Programmable Safety I/O signals to check signal matching. Moreover, monitor whether the excitation-on and excitation-off states are normal, by using two types of ladders, namely, PMC ladder and DCS PMC ladder. If an error is detected, secure safety by turning off the magnetic contactor of α*i*PS or β*i*SVSP to turn off the power to the main circuit.
(The Excitation-Off signal (EXOF1) is the Excitation-Off signal (EXOFA) that is actually output from the α*i*SP or β*i*SVSP, it is forcibly masked to 1 at power-on time. For the difference between EXOF1 and EXOFA, see timing chart 2 shown in the next subsection.)

When additionally using a function for rotating the spindle by power with the door open, assign the two switch signals (SPEN1 and SPEN2) output from the spindle rotation enable switch as Programmable Safety I/O signals to check signal matching.

Signal connection diagram (example)

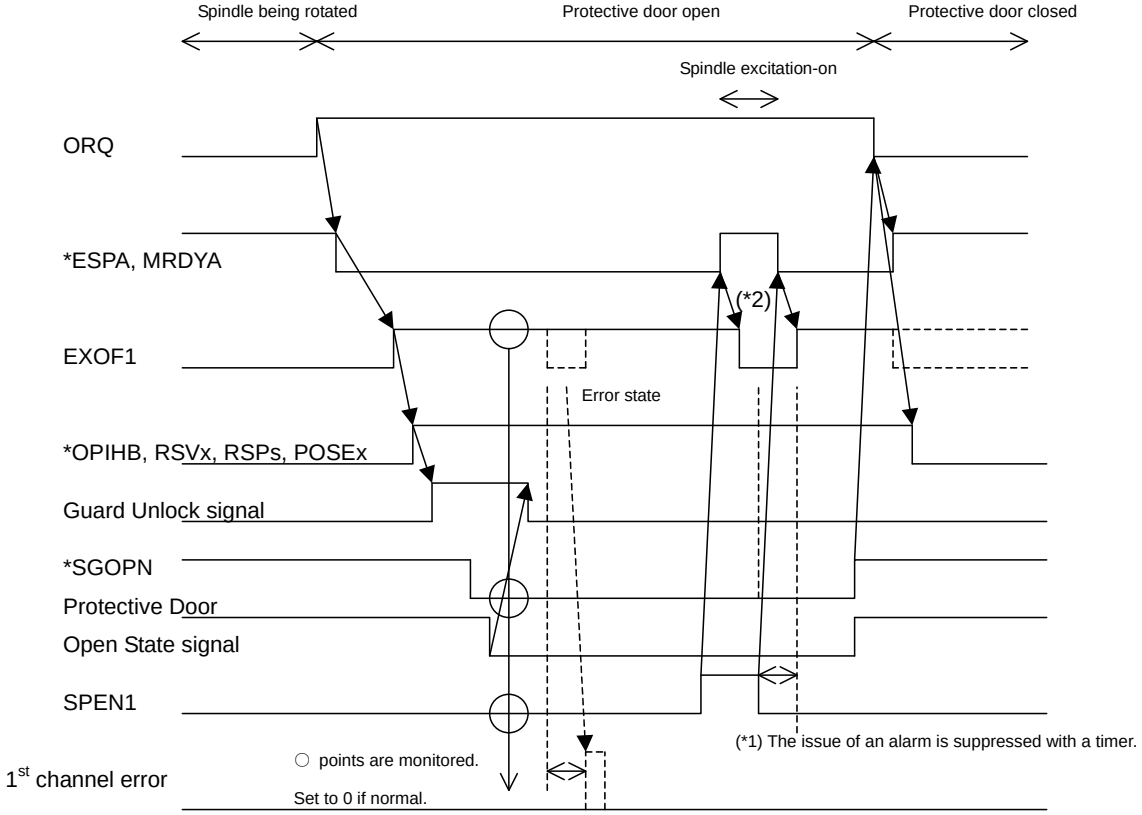


3.20.2 User Ladder Processing

Processing on the PMC side

- With the Guard Open Request signal (ORQ), the spindle is stopped then the excitation-off state (EXOF=1) is confirmed. Next, the locking of the protective door (guard lock signal) is released.
- If EXOF1=0 or EXOF2=0 (contact open) (servo excitation-on) for a certain time(*1) when *SGOPN is 0 (door open) and SPEN is 0 (Spindle Rotation Enable Switch signal turned off), an error is assumed to issue a 1st channel (or 2nd channel) alarm.

- Timing chart 1
Error judgment processing by the PMC side ladder

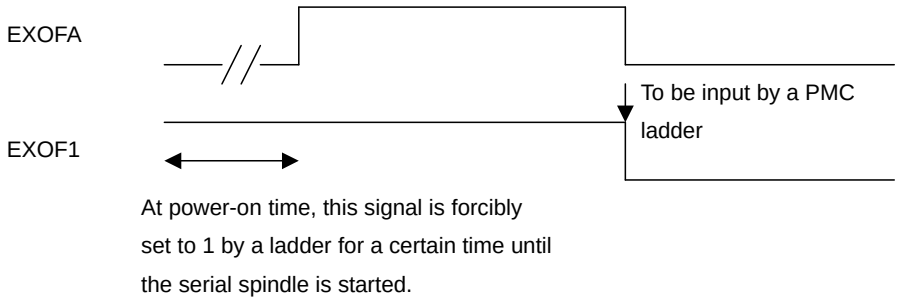


(*1) An alarm condition is detected for the period until spindle excitation is turned off (EXOF1=1) after the Spindle Rotation Enable Switch signal (SPEN1) is switched from on to off. However, by setting a timer on the ladder side, ensure that no alarm is detected during this period.

(*2) The excitation-on state (EXOF1=0 or EXOF2=0: Contact open) is set when the Spindle Excitation signal SFRA (G70.5) or SRVA (G70.4), or the orientation command ORCMA (G70.6) is set to 1. (The G signal is applicable to the first spindle.)

- At power-on time, EXOFA is not output normally until the serial spindle is started. So, EXOF1 input to the dual monitoring function is forcibly masked to 1 by setting a timer.

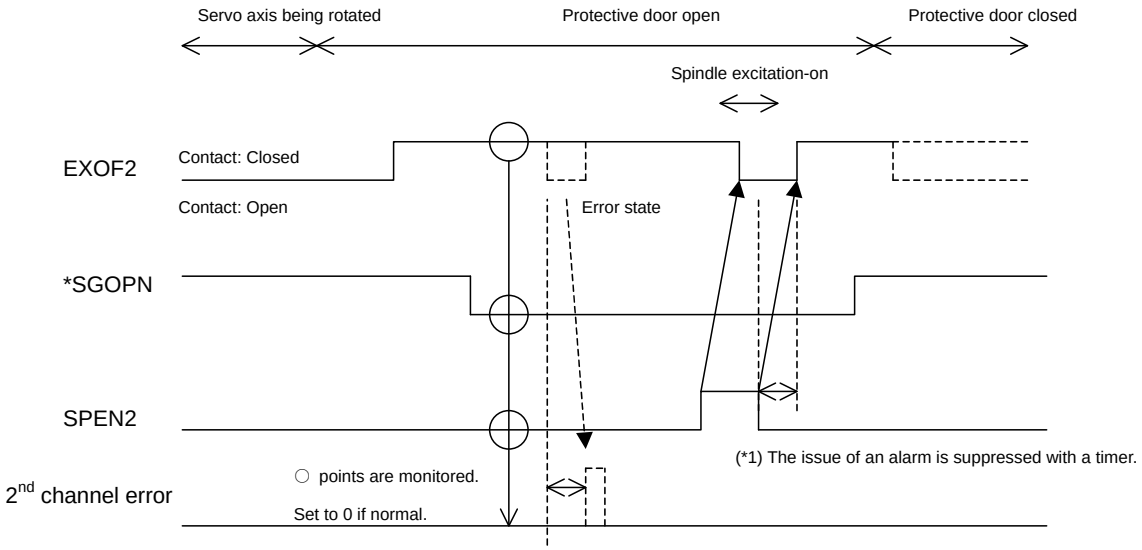
- Timing chart 2
Processing at power-on time



Processing on the DCS PMC side

- If EXOF1=0 or EXOF2=0 (contact open) (spindle excitation-on) for a certain time(*) when *SGOPN is 0 (door open) and SPEN is 0 (Spindle Rotation Enable Switch signal turned off), an error is assumed to issue a 1st channel (or 2nd channel) alarm.

- Timing chart 3
Error judgment processing by the DCS PMC side ladder



(*1) An alarm condition is detected for the period until spindle excitation is turned off (EXOF2=1) after the Spindle Rotation Enable Switch signal (SPEN2) is switched from on to off. However, by setting a timer on the ladder side, ensure that no alarm is detected during this period.

3.20.3 Assignment of Programmable Safety I/O Signals

Assign Rxxx of the PMC and Ryyy of the DCS PMC as Programmable Safety I/O signals (input) for double monitoring. Thus, the CNC and PMC doubly check whether the Rxxx and Ryyy bits match each other at all times.

Rxxx

	a	b	c	d			
	EXOF1	SPEN1	1st channel error	"0"			

Ryyy

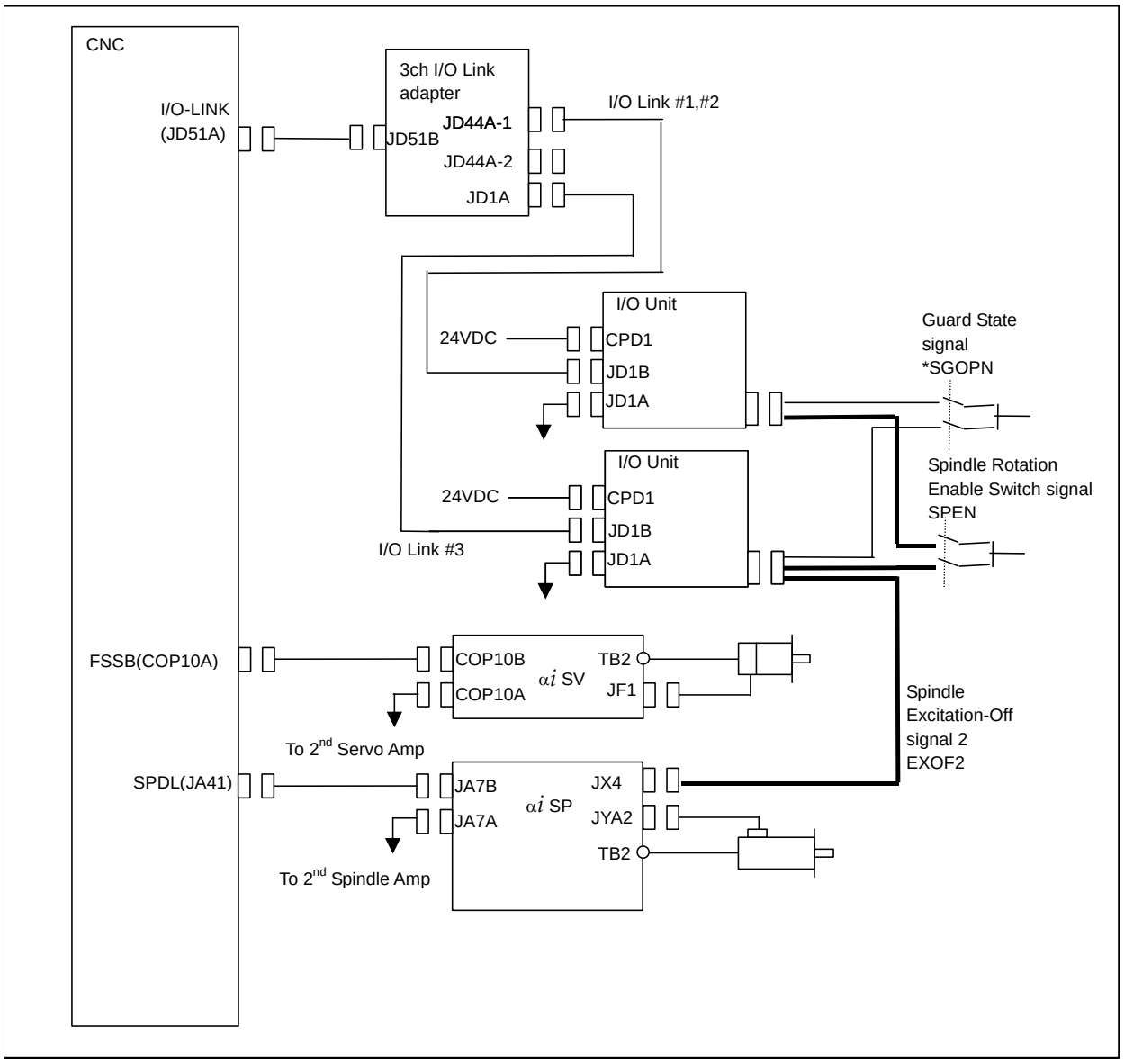
	a	b	c	d			
	EXOF2	SPEN2	"0"	2nd channel error			

The 1st channel error signal or 2nd channel error signal set to 1 indicates an error state. So, by monitoring for matching with the state of 0, an error state is detected. If a mismatch occurs due to an error state, safety is secured by turning off the magnetic contactor of the αi PS to turn off the power to the main circuit.

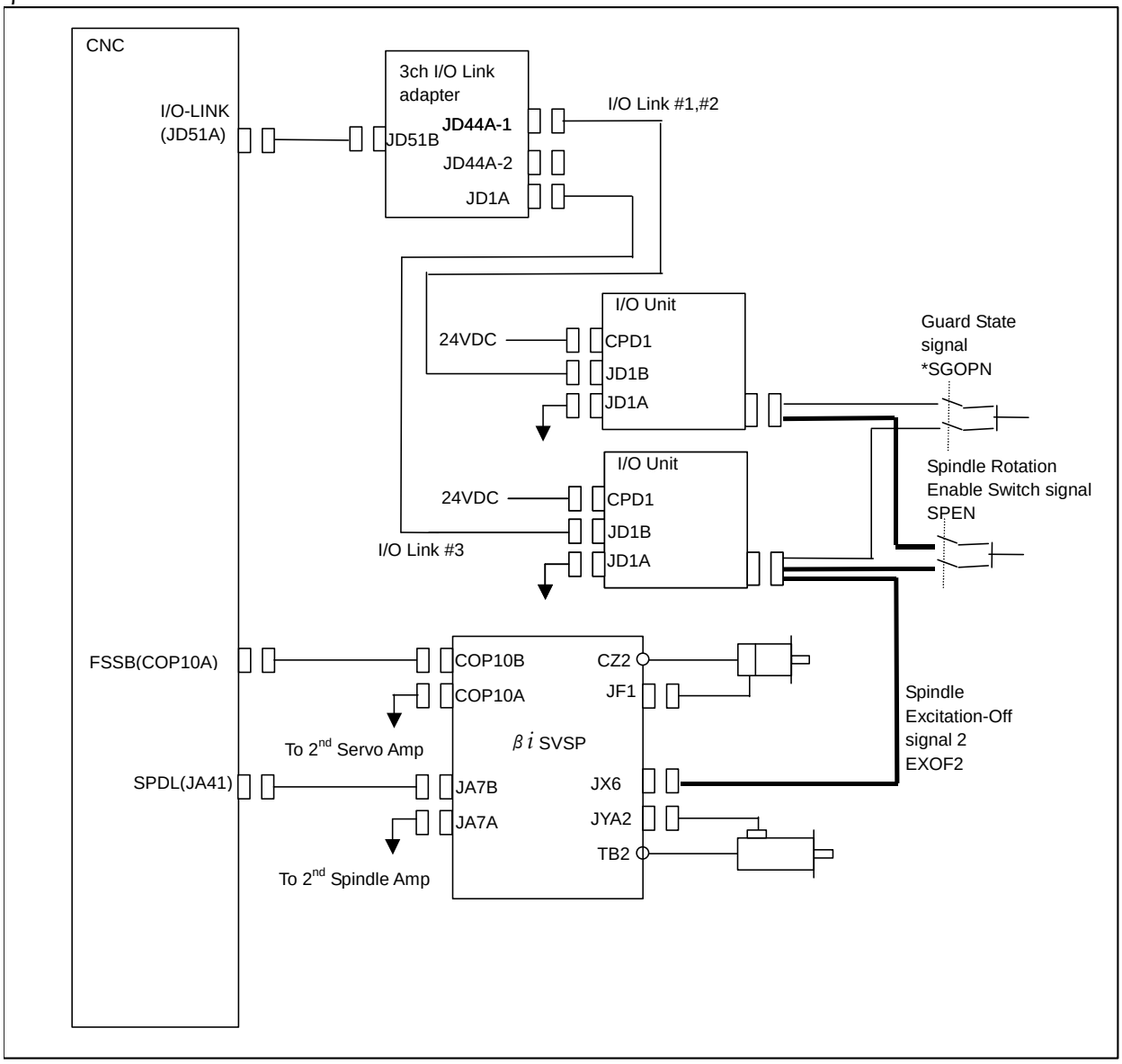
3.20.4 Connections

In addition to Dual Check Safety connections, a connection from connector JX4 on the α*i*SP or connector JX6 on the β*i*SVSP to the I/O Unit (I/O Link#3) is required. On a system that uses a spindle rotation enable switch, a connection from the switch is additionally required. (Indicated in heavy lines).

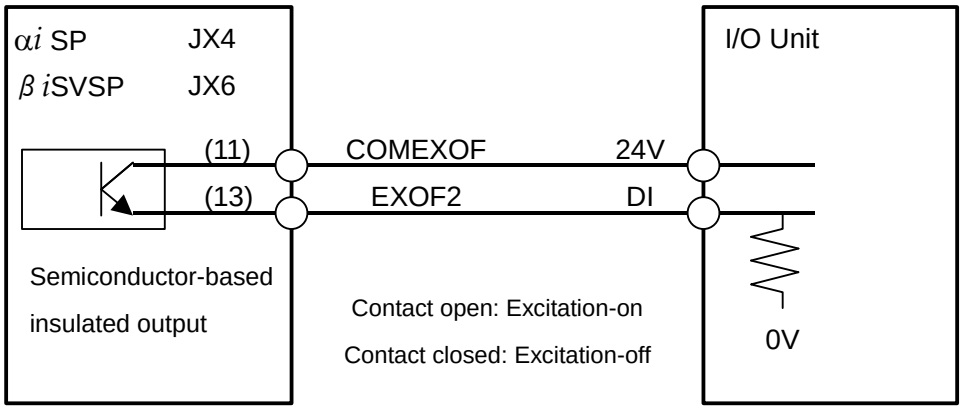
α*i* Series



βiSVSP Series



Connection JX4 of αiSP and I/O Link#3 or Connection JX6 of βiSVSP) and I/O Link#3



Half-pitch connector

Hirose Electric

Connector case

FI40B-20S-CVS5

- Specification of contact output of the αiSP or βiSVSP

Circuit type: Polarized photocoupler
Rated voltage: 30 VDC or less
Output current: DC 40 mA or less
Saturation voltage: 1.5 V or less (at an output current of 40 mA)

> ⚠ **CAUTION**
> If the connector is connected incorrectly, the 24 V power externally supplied can damage the internal circuitry of the αiSP and βiSVSP. Use special care when connecting the connector.

3.20.5 Restrictions

- System configuration

To use this function, the following αi series spindle amplifiers or βiSVSP series supporting the function for doubly outputting the Spindle Excitation-Off signal needs to be used:

- For 200V system
  A06B-6141-H002 to H055#H580
  A06B-6142-H002 to H055#H580
  A06B-6164-H201 to H343#H580
- For 400V system
  A06B-6151-H006 to H100#H580
  A06B-6152-H006 to H100#H580

Moreover, the following Dual Check Safety function needs to be used:

- Programmable Safety I/O signal (Section 5.4)

3.21 DUAL BRAKE MONITOR FUNCTION

With the Dual Check Safety function, mechanical control is exercised on the servo axis brake to secure the safety of the brake, by using the doubly output Safety Brake signal (*BRKx).

This function conducts a test periodically on the servo axis brake to secure the safety of brake control mentioned above.

Residual risk

When this function is used, the following risk is known to be present:

If a brake failure occurs between a brake test and the next brake test on the vertical axis for which the brake mechanism is not redundant, a drop on the axis can occur when servo motor excitation is turned off by an emergency stop or servo alarm.

3.21.1 Brake Test

A brake test can be conducted for a servo axis that has a brake. A brake test may be conducted only for those axes including the vertical axis that require brake control. For each axis, whether to conduct a brake test can be selected using parameter No. 13912. As with MCC off Test, a brake test is to be performed when the power is turned on and when time t has elapsed after the previous test. (Set the value of t in parameter No. 13913.)

3.21.2 Brake Test Procedure

Starting a brake test

<1> The Brake Test Execution Request signal RQBT is set to 1 when the power is turned on and when time t has elapsed after the previous brake test (the value of t is set in parameter No. 13913). When the Brake Test Execution Request signal RQBT is set to 1, conduct a brake test. Even if RQBT is set to 1, operation can be continued until the current machining is completed. To secure safety, however, a brake test should be conducted as soon as possible.

<2> Clear all NC alarms and set the JOG mode then retract the brake test target axis to a safe position.

<3> The execution of a brake test is started by setting the Brake Test Start signal STBT to 1.

NOTE
In a brake test, a move command is issued to the servo motor. So, ensure that the position control mode and servo-on state are set. No brake test is conducted when the test target axis is in a mode (speed control or torque control mode) other than the position control mode, in the servo-off state, or in torque limit control. When the test start condition is not satisfied, alarm DS0039 or DS0040 is issued. The cause of alarm DS0039 or DS0040 is indicated in diagnosis No. 3701.

Brake test execution

<4> When the NC accepts brake test execution, a test is conducted on the brake test target axes simultaneously. By combining the states of two Safety Brake signals *BRKx (PMC, DCS PMC), three patterns of test are conducted on each axis in the order from test 1 to test 3 as indicated below.

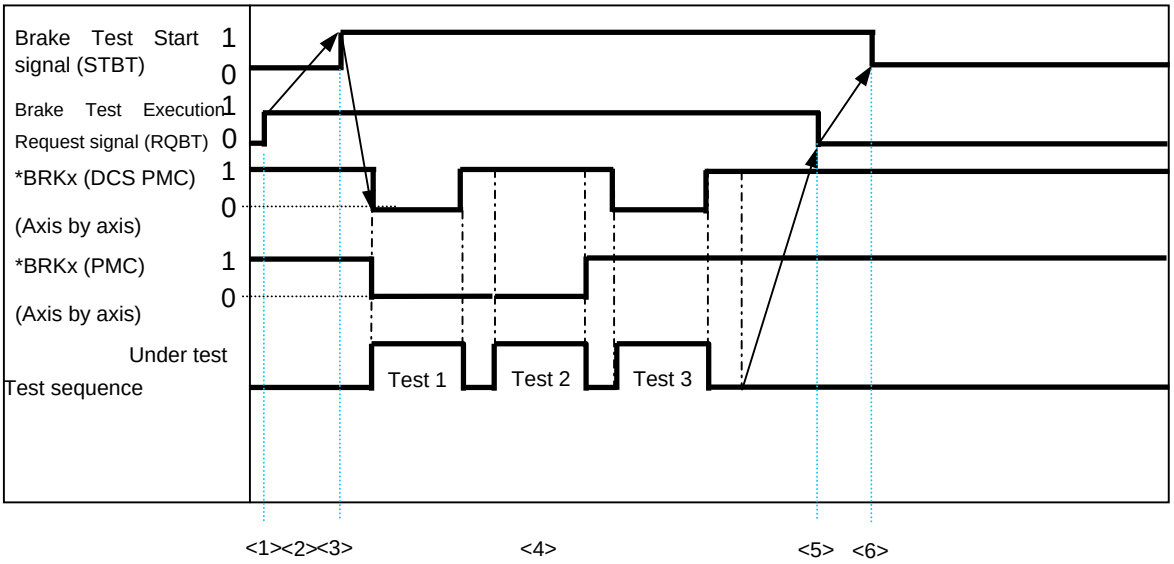
	Test 1	Test 2	Test 3
*BRKx (PMC)	0	0	1
*BRKx (DCS PMC)	0	1	0
State of brake	Applied	Applied	Applied

Ending a brake test

<5> Upon normal completion of test on all test target axes, the Brake Test Execution Request signal RQBT is set to 0. If an error occurs during test, alarm DS0039 or DS0040 is issued. Even if alarm DS0039 or DS0040 is issued, servo motor excitation is kept. In this state, however, automatic operation cannot be continued. Retract the axes to a safe position by manual operation then turn off the power. Next, take action for the brake in trouble.
To conduct another brake test, perform a reset operation once to clear the alarm state beforehand.

<6> Upon normal completion of test, set the Brake Test Start signal STBT to 0.

Brake test timing chart



NOTE

1 Set a travel distance, speed command, and tolerance for position deviation to be used for a brake test in parameter No. 13916, parameter No. 13917, and parameter No. 13918, respectively, beforehand.
2 Be sure to close the protective door when conducting a brake test. To secure safety, specify a ladder so that if the Brake Test Execution Request signal RQBT is set to 1, the protective door is not opened until completion of a brake test even when a protective door open request is issued.
3 Do not conduct a brake test when the protective door is open. Specify a ladder so that when the protective door is open, the Brake Test Start signal STBT is not set to 1.
4 When a brake test target axis is under synchronization control, composite control, or superposition control (T series), no brake test can be conducted. Cancel synchronization control, composite control, or superposition control beforehand.
5 If alarm DS0039 or DS0040 is issued in a brake test, axis movements can be made by manual operation. However, automatic operation is enabled only after clearing the alarm by a reset. When performing an automatic operation, ensure that safety is secured.
If a brake test is suspended for a cause such as an alarm, the target axis may not return to the original position.
6 A fixed override value of 100% is applied to a speed command. Dry run is also disabled.
7 During a brake test, interlock/machine lock is enabled.

⚠ CAUTION

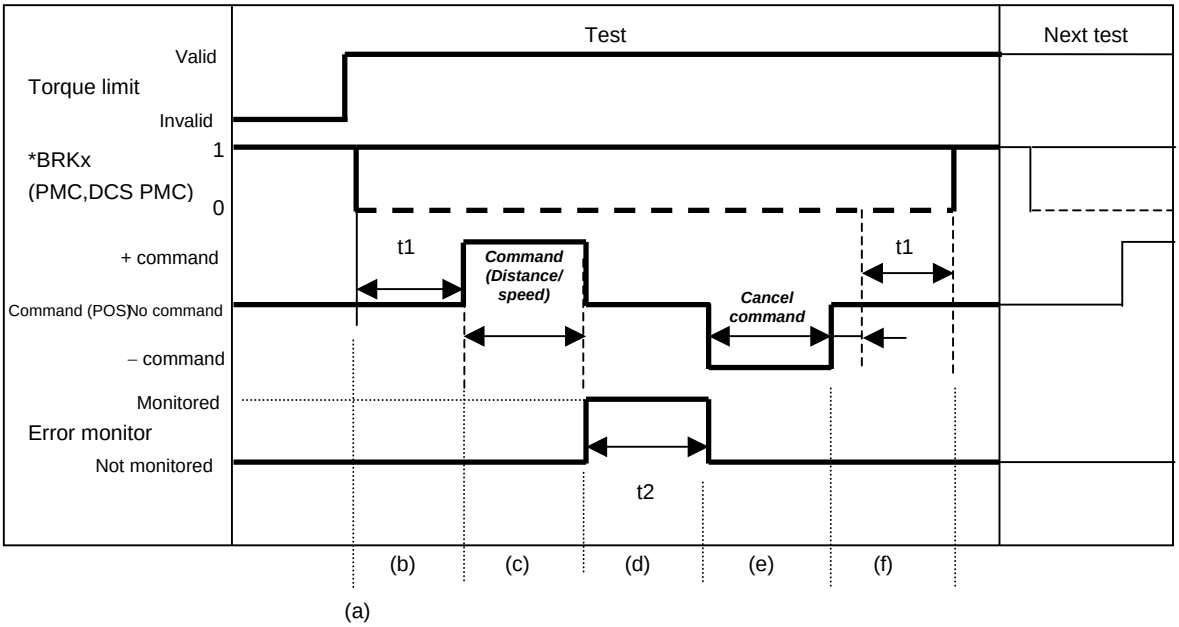
During a brake test, an axis movement can occur. So, make an axis movement beforehand to a safe position that causes no interference.

3.21.3 Details of Brake Test

The following operations are performed in brake tests 1 to 3:

(a) The Safety Brake signal *BRKx is output according to a test pattern. The torque limit value of a brake test target axis is used as a torque limit value for brake test. A torque limit value can be set in parameter No. 13915.
(b) Time t1 is awaited until the brake has been applied to enable a command to be issued. (Time t1 is set in parameter No. 13914.)
(c) A position command from the NC is output according to the travel distance set in parameter No. 13916 and the speed command set in parameter No. 13917.
(d) A position deviation is checked to see if the brake has been applied normally when the issue of commands is completed. If the brake has been applied normally, no axis movement is made. So, the position deviation corresponding to a specified travel distance is accumulated. The range of position deviation to be checked is the corresponding position deviation plus/minus the tolerance value (parameter No. 13918). Parameter No. 13919 is used to set time t2 for checking whether the brake has been applied normally. If the position deviation is outside the range, alarm DS0039 or DS0040 is issued, assuming that the brake has not been applied normally.
(e) Upon completion of checking, a command is issued to return the accumulated position deviation to the original value.
(f) Time t1 (parameter No. 13914) is awaited before starting the next test.

Brake test timing chart



3.21.4 Suspension and Restart of Brake Test

Suspension based on STBT=0

A brake test is suspended by setting the Brake Test Start signal STBT to 0 during the test. When the signal is set to 0, the test sequence being executed is suspended, and the Safety Brake signal *BRKx and torque limit are returned to the original states.

Suspension based on an emergency stop or servo alarm

If a brake test is suspended for an emergency stop or servo alarm, the brake test is forcibly terminated even during a test sequence, and operation for returning the Safety Brake signal *BRKx and torque limit to the original states is performed after reset-based excitation. During a brake test, ensure that brake control is exercised by monitoring the Servo Ready signal SA (Fn000.6) as well as the Safety Brake signal *BRKx.

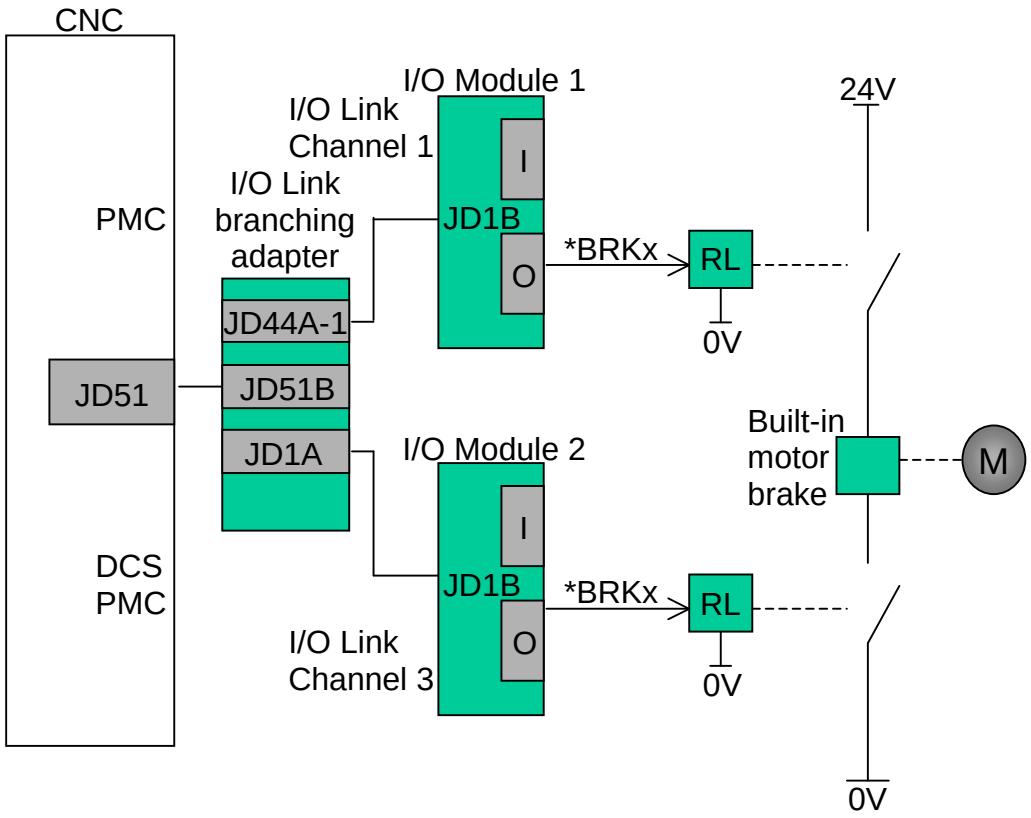
Suspension based on a reset or mode switching

If a brake test is suspended for a reset or mode switching, the test sequence under execution is suspended. However, operation for returning the Safety Brake signal *BRKx and torque limit to the original states is not performed. The test is restarted by setting the Brake Test Start signal STBT to 1 again.

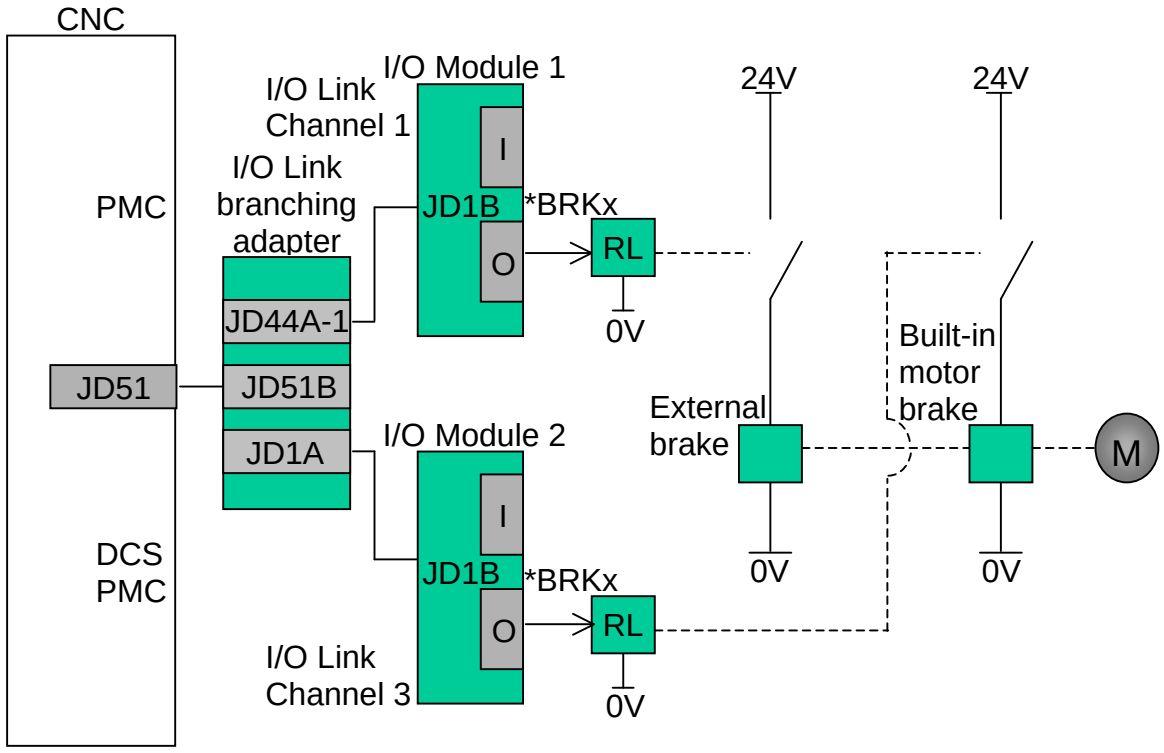
3.21.5 Brake Configuration

This function assumes the following two brake configurations:

Brake configuration 1



Brake configuration 2



4 INSTALLATION

The hardware installation such as field wiring, power supply, etc. should be referred to connection manual for CNC units and for servo amplifier. EMC problem should be referred to EMC guideline manual.

Degree of IP protection:
Servo Motors: IP55
Spindle Motors: IP54 with oil-seal, IP40 without oil-seal
Servo and Spindle amplifiers: IP1x
CNC and other accessories: IPxx

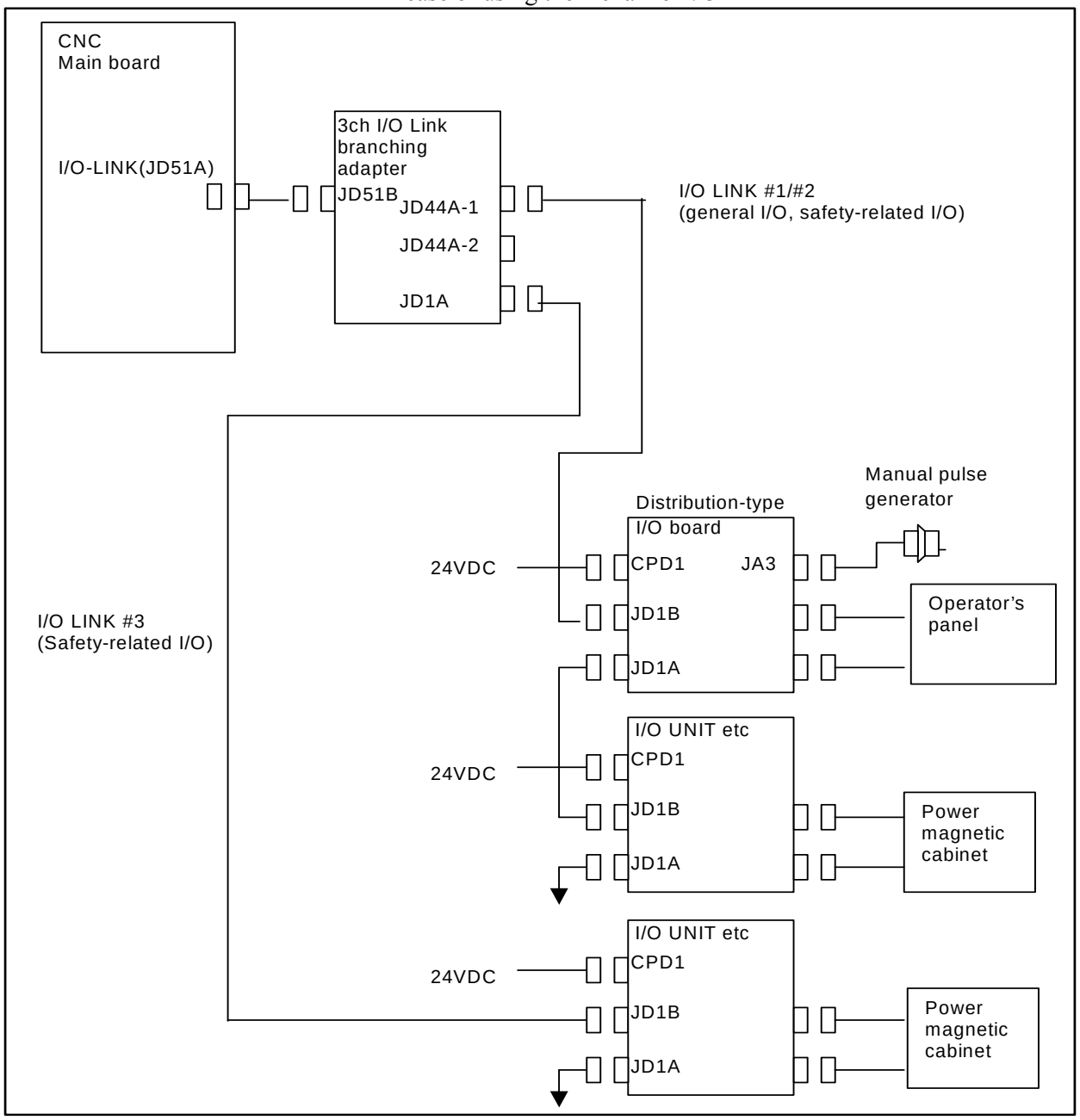
NOTE
Servo/Spindle amplifiers, CNC are to be installed in IP54 protected cabinets.

The peripheral units and the control unit have been designed on the assumption that they are housed in closed cabinets.

As for the environmental conditions for each unit, such as CNC controller, servo amplifier and etc, please refer to each connection manual.

4.1 OVERALL CONNECTION DIAGRAM

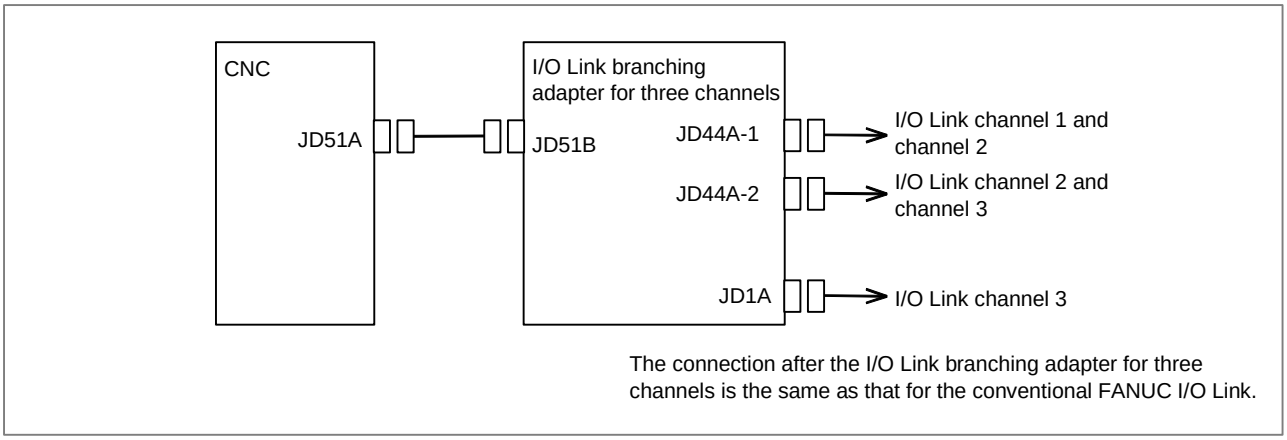
In case of using the 2 channel I/O link



Above shows only the 2 channel I/O link for the safety-related I/Os of the Dual Check Safety Function. As for the other connections, please refer to the Connection manual.

Using the third channel

The Dual Check Safety system use I/O Link channel 3.
When using channel 3, use the I/O Link branching adapter for three channels to branch the FANUC I/O Link.



I/O Link branching adapter for three channels: A20B-1008-0360

Connection between the CNC and I/O Link branching adapter for three channels

CNC
JD51A
(such as PCR–E20MDK–SL–A)

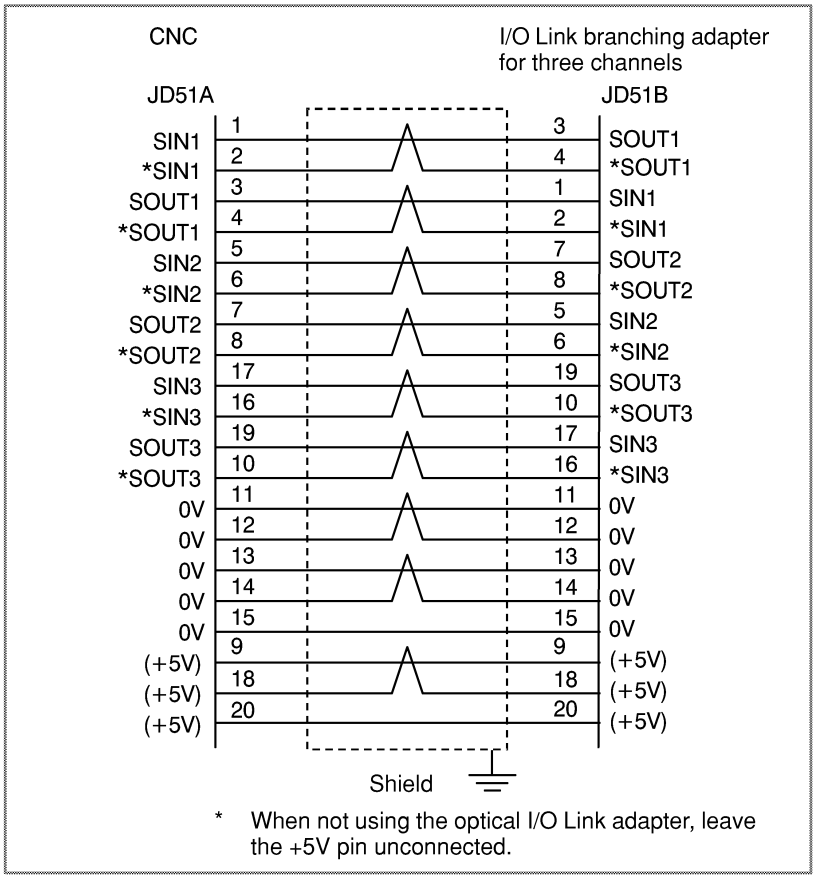
1	SIN1	11	0V
2	*SIN1	12	0V
3	SOUT1	13	0V
4	*SOUT1	14	0V
5	SIN2	15	0V
6	*SIN2	16	*SIN3
7	SOUT2	17	SIN3
8	*SOUT2	18	(+5V)
9	(+5V)	19	SOUT3
10	*SOUT3	20	(+5V)

I/O Link branching adapter for three channels
JD51B
(PCR–E20MDT)

1	SIN1	11	0V
2	*SIN1	12	0V
3	SOUT1	13	0V
4	*SOUT1	14	0V
5	SIN2	15	0V
6	*SIN2	16	*SIN3
7	SOUT2	17	SIN3
8	*SOUT2	18	(+5V)
9	(+5V)	19	SOUT3
10	*SOUT3	20	(+5V)

The +5V pin is provided to use the optical I/O Link adapter for optical fiber transmission. When not using the optical I/O Link adapter, leave the +5V pin unconnected.

Cable connection



Recommended cable connectors:
PCR-E20FA (Honda Tsushin Kogyo Co., Ltd.)

FI30-20S (Hirose Electric Co., Ltd.)
FCN-247J020-G/E (Fujitsu)
52622-2011 (Molex Japan Co., Ltd.)

Connector FI30-20S (Hirose Electric Co., Ltd.) cannot be used as connector JD51A for the stand-alone type 30*i* series main CPU board.

Recommended cable: A66L-0001-0284#10P

Signal configuration of the I/O Link branching adapter for three channels

I/O Link branching adapter for three channels

JD44A−1 (PCR−E20MDT)

1	SIN1	11	0V
2	*SIN1	12	0V
3	SOUT1	13	0V
4	*SOUT1	14	0V
5	SIN2	15	0V
6	*SIN2	16	0V
7	SOUT2	17	
8	*SOUT2	18	(+5V)
9	(+5V)	19	
10		20	(+5V)

JD44A−2 (PCR−E20MDT)

1	SIN2	11	0V
2	*SIN2	12	0V
3	SOUT2	13	0V
4	*SOUT2	14	0V
5	SIN3	15	0V
6	*SIN3	16	0V
7	SOUT3	17	
8	*SOUT3	18	(+5V)
9	(+5V)	19	
10		20	(+5V)

JD1A (PCR−E20MDT)

1	SIN3	11	0V
2	*SIN3	12	0V
3	SOUT3	13	0V
4	*SOUT3	14	0V
5		15	0V
6		16	0V
7		17	
8		18	(+5V)
9	(+5V)	19	
10		20	(+5V)

Connection between the I/O Link branching adapter for three channels and each channel

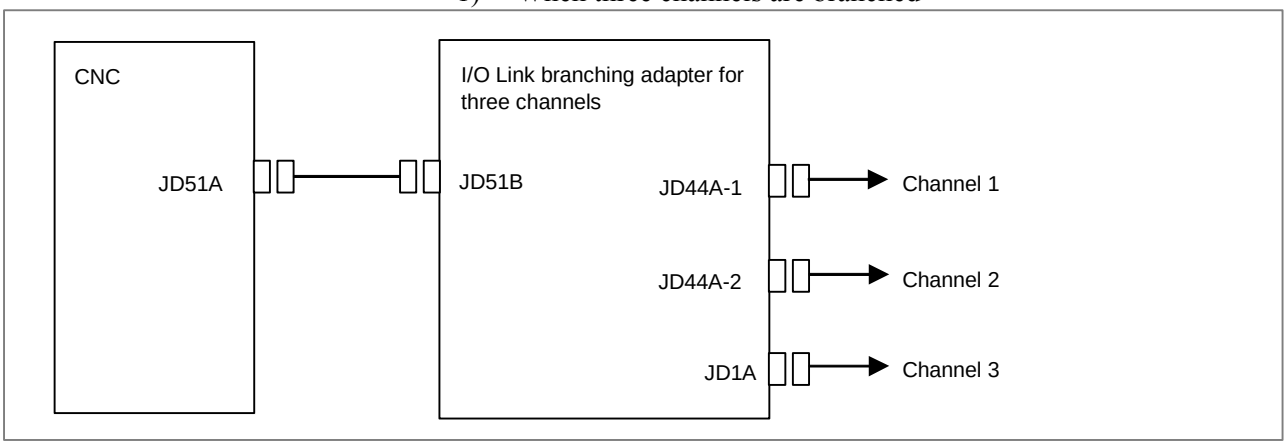
The connection between the I/O Link branching adapter for three channels and each channel is the same as that for the conventional FANUC I/O Link. However, keep the following in mind.

Connector JD44A-1 outputs I/O Link channel 1 and channel 2 signals and connector JD44A-2 outputs I/O Link channel 2 and channel 3 signals.

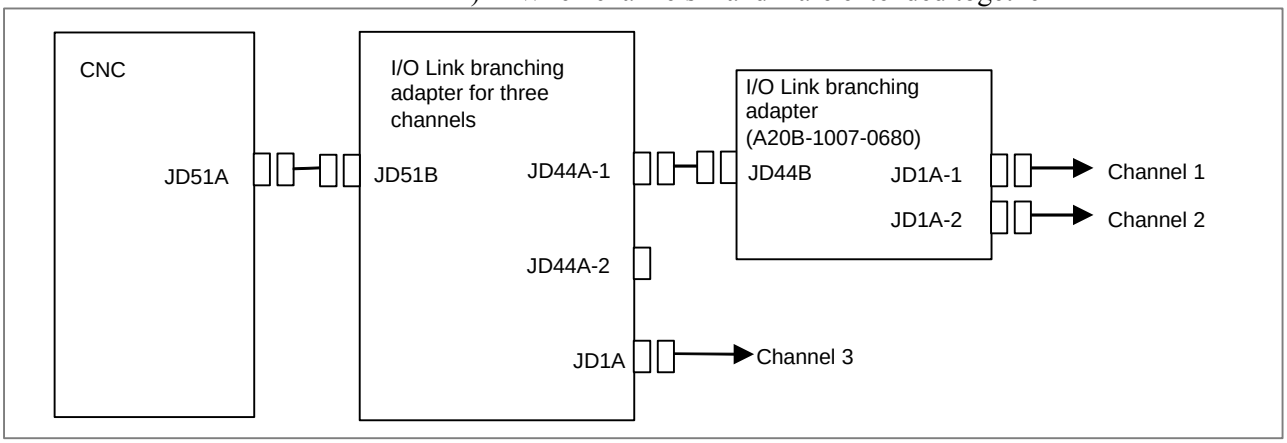
Connector JD1A is dedicated to I/O Link channel 3.

1) When the FANUC I/O Link is branched to three channels, normal I/O cables are used for JD44A-1, JD44A-2, and JD1A. Channel 1 corresponds to JD44A-1, channel 2 corresponds to JD44A-2, and channel 3 corresponds to JD1A.
2) When channels 1 and 2 are extended together, the I/O Link branching adapter (A20B-1007-0680) must be connected to JD44A-1 to branch channel 1 and channel 2 at the end of the adapter.
   JD1A is used as channel 3.
   JD44A-2 is not used.
3) When channels 2 and 3 are extended together, the I/O Link branching adapter (A20B-1007-0680) must be connected to JD44A-2 to branch to channel 2 and channel 3 at the end of the adapter.
   JD44A-1 is used as channel 1.
   JD1A is not used.

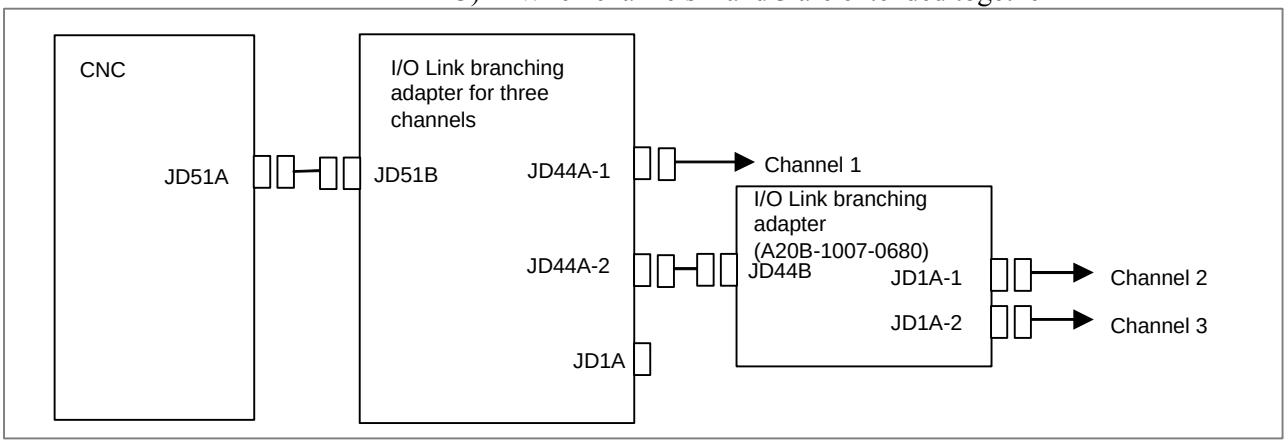
1) When three channels are branched



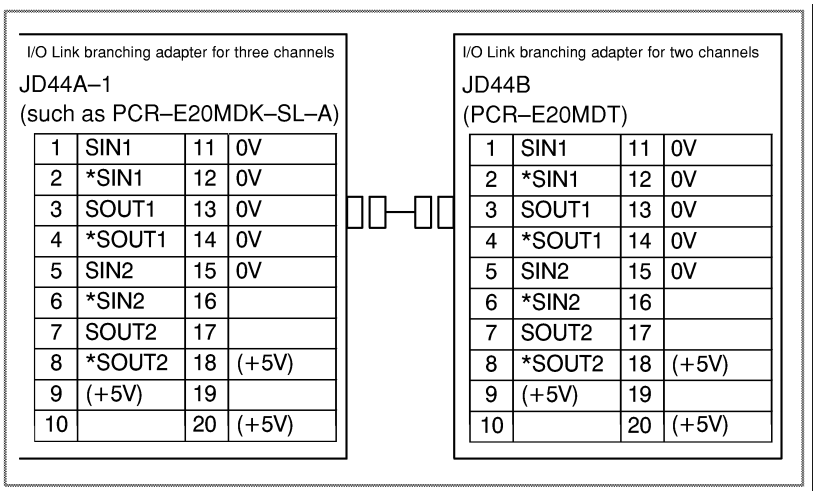
2) When channels 1 and 2 are extended together



3) When channels 2 and 3 are extended together



Connection between the I/O Link branching adapter for three channels and I/O Link branching adapter for two channels



I/O Link branching adapter for three channels
JD44A–1
(such as PCR–E20MDK–SL–A)

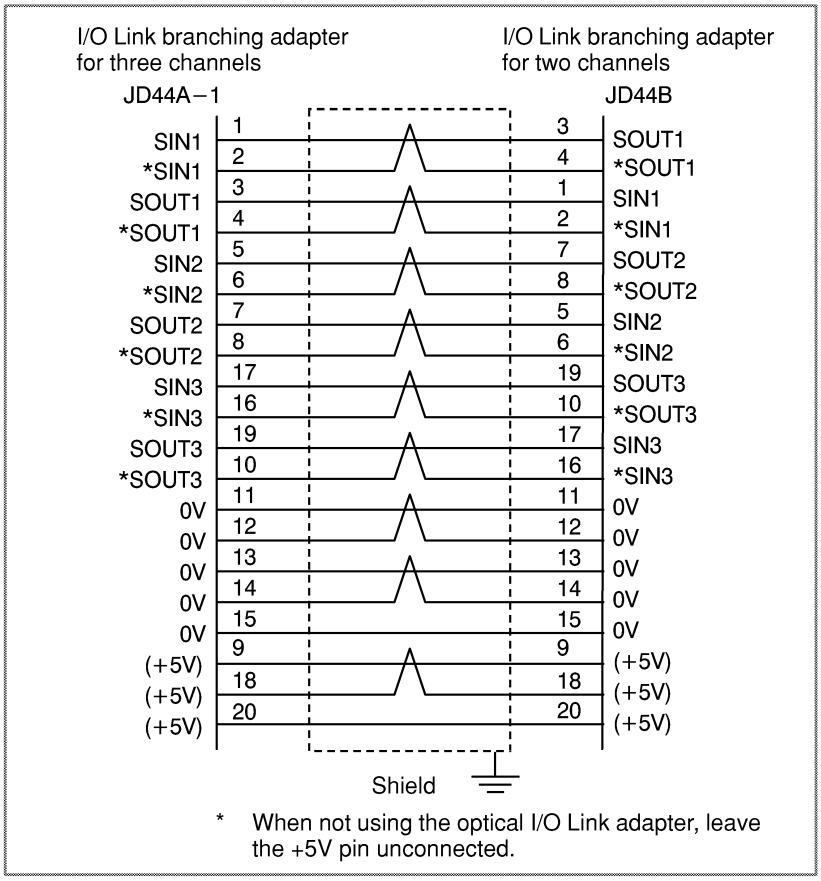
1	SIN1	11	0V
2	*SIN1	12	0V
3	SOUT1	13	0V
4	*SOUT1	14	0V
5	SIN2	15	0V
6	*SIN2	16	
7	SOUT2	17	
8	*SOUT2	18	(+5V)
9	(+5V)	19	
10		20	(+5V)

I/O Link branching adapter for two channels
JD44B
(PCR–E20MDT)

1	SIN1	11	0V
2	*SIN1	12	0V
3	SOUT1	13	0V
4	*SOUT1	14	0V
5	SIN2	15	0V
6	*SIN2	16	
7	SOUT2	17	
8	*SOUT2	18	(+5V)
9	(+5V)	19	
10		20	(+5V)

The +5V pin is provided to use the optical I/O Link adapter for optical fiber transmission. When not using the optical I/O Link adapter, leave the +5V pin unconnected.

Cable connection



Recommended cable connectors:

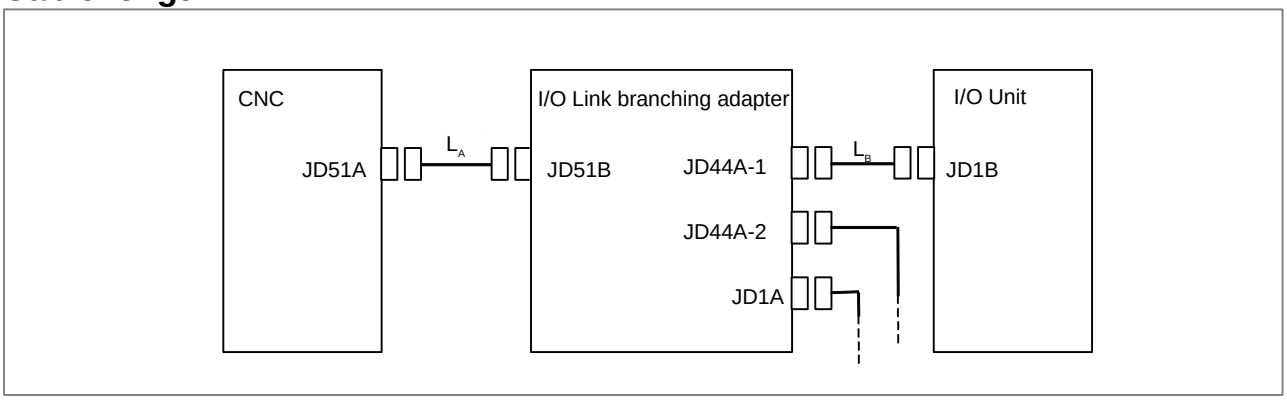
PCR-E20FA (Honda Tsushin Kogyo Co., Ltd.)
FI30-20S (Hirose Electric Co., Ltd.)

FCN-247J020-G/E (Fujitsu)
52622-2011 (Molex Japan Co., Ltd.)

Connector FI30-20S (Hirose Electric Co., Ltd.) cannot be used as connector JD51A for the stand-alone type 30*i* series main CPU board.

Recommended cable: A66L-0001-0284#10P

Cable length

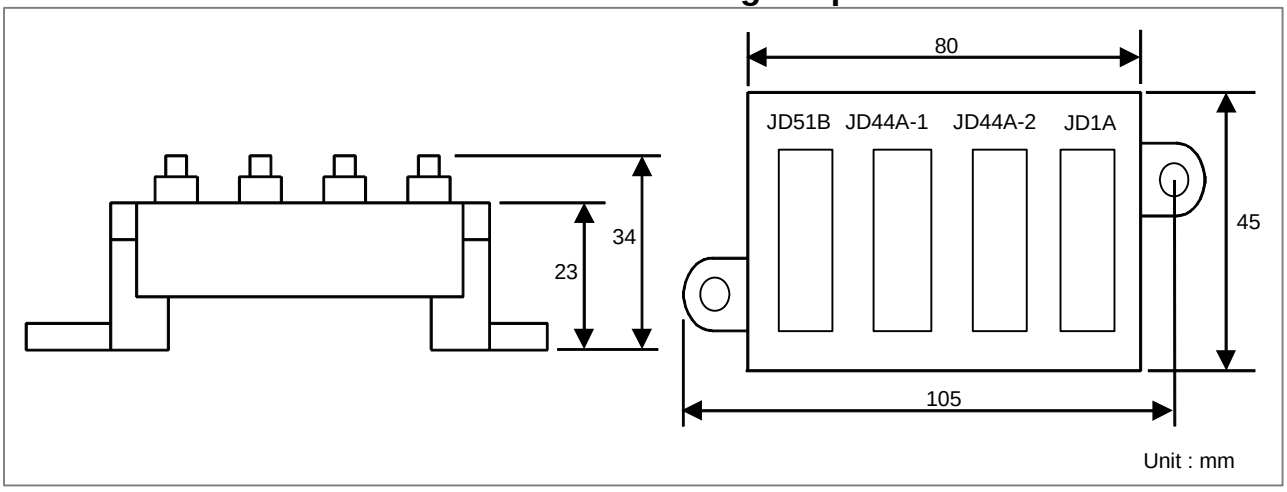


The total of L_A and L_B must not exceed 10 m; where L_A is the length of the cable between connector JD51A on the CNC and connector JD51B on the I/O Link branching adapter, and L_B is the length of the cable between connector JD44A-1, JD44A-2, or JD1A on the I/O Link branching adapter and connector JD1B on the I/O unit. When all cables are accommodated in the same cabinet, however, a total cable length of up to 15 m is allowed.

Installation of the I/O Link branching adapter for three channels

Install the I/O Link branching adapter for three channels in a hermetically sealed cabinet like the CNC.

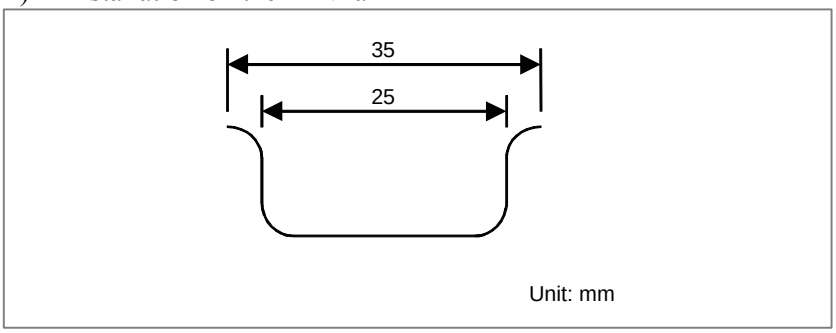
External dimensions of the I/O Link branching adapter for three channels



Allow a clearance of about 10 cm above the adapter for connection and routing of cables.

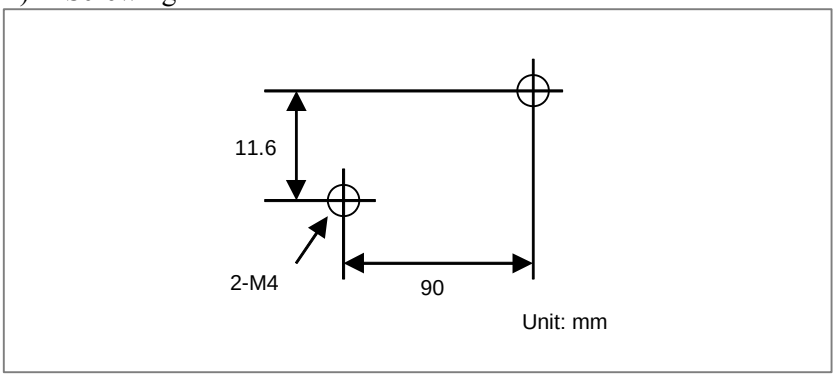
Installation of the I/O Link branching adapter for three channels

1) Installation on the DIN rail



Recommended DIN rail

2) Screwing



Drilling on the plate

5 I/O SIGNALS

5.1 OVERVIEW

The Dual Check Safety Function provides two input paths and two output paths for safe-related signals (safety signals).
For input signals (safety input signals), two paths are used: one path for input to the CNC via I/O Link#3 or PROFIBUS-DP (Note1), and another for input to the PMC via I/O Link#1,#2. The CNC (DCS PMC) and the PMC exchange the safety input signals with each other at all times to check each other. If a mismatch is found between a safety input signal via one path and the same signal via another path and such a state lasts for the period set in a parameter or more, the CNC (DCS PMC) and the PMC independently detect an alarm. (Dual-check for safety input signals)
For output signals (safety output signals), two paths are also used: one path for output from the CNC via the I/O Link#3 or PROFIBUS-DP, and another for output from the PMC via the I/O Link#1,#2. The MCC Off signal (*MCF) is output via these two paths. When both a signal via one path and the same signal via another path are 1, the signal is assumed to be 1. If either is 0, the signal is assumed to be 0. That is, if the signal (*MCF of DCS PMC)(Note2) via the I/O Link#3 or PROFIBUS-DP and the signal (*MCF of PMC)(Note2) via the I/O Link#1,#2 are both 1, the MCC may be turned on. If either is 0, the MCC must be turned off.

In Subsection 5.3, a signal name is followed by its symbol and addresses <via I/O Link#1,#2> and <via I/O Link#3 or PROFIBUS-DP>. Then, for an input signal, its classification, function, and operation are described, in this order. For an output signal, its classification, function, and output condition are described in this order.
For information about the emergency stop mode and MCC off Test mode described in Subsection 5.3, see Subsection 5.3.

NOTE
1 I/O Link and PROFIBUS-DP can not be used for the safety X/Y signals at the same time.
2 DCS PMC : Dual Check Safety PMC
PMC : For the PMC, refer to "PMC PROGRAMMING MANUAL (B-64393EN)".

5.2 SIGNAL ADDRESS

Via I/O Link#1/#2

PMC (n=0 or 1 (NC path number - 1))

	#7	#6	#5	#4	#3	#2	#1	#0
X0008				*ESP				

	#7	#6	#5	#4	#3	#2	#1	#0
Gn008				*ESP				

	#7	#6	#5	#4	#3	#2	#1	#0
Gn191					ORQ	OPT		

	#7	#6	#5	#4	#3	#2	#1	#0
Gn193						STBT		

	#7	#6	#5	#4	#3	#2	#1	#0
Gn748		*SMC						

	#7	#6	#5	#4	#3	#2	#1	#0
Gn749								

	#7	#6	#5	#4	#3	#2	#1	#0
Gn750				*VLDV5	*VLDV4	*VLDV3	*VLDV2	*VLDV1

	#7	#6	#5	#4	#3	#2	#1	#0
Gn751							*VLDP2	*VLDP1

	#7	#6	#5	#4	#3	#2	#1	#0
Gn752				SVA5	SVA4	SVA3	SVA2	SVA1

	#7	#6	#5	#4	#3	#2	#1	#0
Gn753				SVB5	SVB4	SVB3	SVB2	SVB1

	#7	#6	#5	#4	#3	#2	#1	#0
Gn754			SPB2	SPB1			SPA2	SPA1

	#7	#6	#5	#4	#3	#2	#1	#0
Fn191					RQBT	RQT		*OPIHB

	#7	#6	#5	#4	#3	#2	#1	#0
Fn748	*DCALM						*MCF	

	#7	#6	#5	#4	#3	#2	#1	#0
Fn749								

	#7	#6	#5	#4	#3	#2	#1	#0
Fn750				RSV5	RSV4	RSV3	RSV2	RSV1

	#7	#6	#5	#4	#3	#2	#1	#0
Fn751							RSP2	RSP1

	#7	#6	#5	#4	#3	#2	#1	#0
Fn752				*MCFV5	*MCFV4	*MCFV3	*MCFV2	*MCFV1

	#7	#6	#5	#4	#3	#2	#1	#0
Fn753							*MCFP2	*MCFP1

	#7	#6	#5	#4	#3	#2	#1	#0
Fn754				*BRK5	*BRK4	*BRK3	*BRK2	*BRK1

	#7	#6	#5	#4	#3	#2	#1	#0
Fn755	SPS08	SPS07	SPS06	SPS05	SPS04	SPS03	SPS02	SPS01

	#7	#6	#5	#4	#3	#2	#1	#0
Fn756	SPS16	SPS15	SPS14	SPS13	SPS12	SPS11	SPS10	SPS09

	#7	#6	#5	#4	#3	#2	#1	#0
Fn757	SPS24	SPS23	SPS22	SPS21	SPS20	SPS19	SPS18	SPS17

	#7	#6	#5	#4	#3	#2	#1	#0
Fn758	SPS32	SPS31	SPS30	SPS29	SPS28	SPS27	SPS26	SPS25

	#7	#6	#5	#4	#3	#2	#1	#0
Fn766				POSE5	POSE4	POSE3	POSE2	POSE1

Via I/O Link#3 or PROFIBUS-DP

DCS PMC (m=0, 20 ((NC path number - 1) × 20))

	#7	#6	#5	#4	#3	#2	#1	#0
X0008				*ESP				

	#7	#6	#5	#4	#3	#2	#1	#0
G000+m		*SMC						

	#7	#6	#5	#4	#3	#2	#1	#0
G001+m								

	#7	#6	#5	#4	#3	#2	#1	#0
G002+m				*VLDV5	*VLDV4	*VLDV3	*VLDV2	*VLDV1

	#7	#6	#5	#4	#3	#2	#1	#0
G003+m							*VLDP2	*VLDP1

	#7	#6	#5	#4	#3	#2	#1	#0
G004+m				SVA5	SVA4	SVA3	SVA2	SVA1

	#7	#6	#5	#4	#3	#2	#1	#0
G005+m				SVB5	SVB4	SVB3	SVB2	SVB1

	#7	#6	#5	#4	#3	#2	#1	#0
G006+m			SPB2	SPB1			SPA2	SPA1

	#7	#6	#5	#4	#3	#2	#1	#0
G007+m								

	#7	#6	#5	#4	#3	#2	#1	#0
G008+m								

	#7	#6	#5	#4	#3	#2	#1	#0
G019+m				*ESP				

	#7	#6	#5	#4	#3	#2	#1	#0
F000+m	*DCALM						*MCF	

	#7	#6	#5	#4	#3	#2	#1	#0
F001+m								

	#7	#6	#5	#4	#3	#2	#1	#0
F002+m				RSV5	RSV4	RSV3	RSV2	RSV1

	#7	#6	#5	#4	#3	#2	#1	#0
F003+m							RSP2	RSP1

	#7	#6	#5	#4	#3	#2	#1	#0
F004+m				*MCFV5	*MCFV4	*MCFV3	*MCFV2	*MCFV1

	#7	#6	#5	#4	#3	#2	#1	#0
F005+m							*MCFP2	*MCFP1

	#7	#6	#5	#4	#3	#2	#1	#0
F006+m				*BRK5	*BRK4	*BRK3	*BRK2	*BRK1

	#7	#6	#5	#4	#3	#2	#1	#0
F007+m	SPS08	SPS07	SPS06	SPS05	SPS04	SPS03	SPS02	SPS01

	#7	#6	#5	#4	#3	#2	#1	#0
F008+m	SPS16	SPS15	SPS14	SPS13	SPS12	SPS11	SPS10	SPS09

	#7	#6	#5	#4	#3	#2	#1	#0
F009+m	SPS24	SPS23	SPS22	SPS21	SPS20	SPS19	SPS18	SPS17

	#7	#6	#5	#4	#3	#2	#1	#0
F010+m	SPS32	SPS31	SPS30	SPS29	SPS28	SPS27	SPS26	SPS25

	#7	#6	#5	#4	#3	#2	#1	#0
F018+m				POSE5	POSE4	POSE3	POSE2	POSE1

	#7	#6	#5	#4	#3	#2	#1	#0
F019+m								*OPIHB

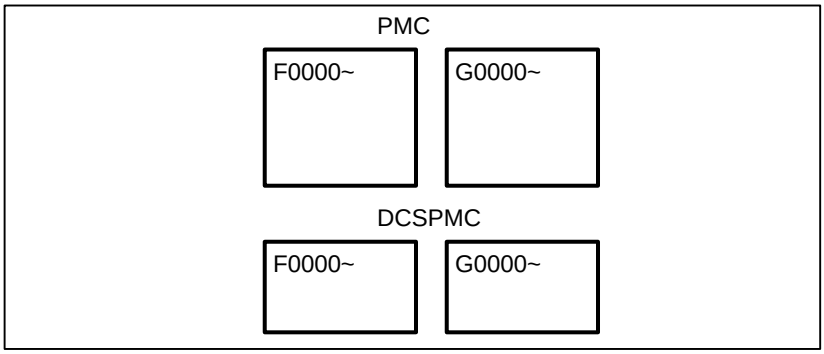
NOTE

1 The signals with a background color are cross-check target signals.
2 The Emergency Stop signals in X address are double checking signals.
3 Position switch signals as many as indicated below are provided, depending on the number of paths:
  (1) When one path is used: 32 points maximum
  (2) When two paths are used with the T series: 64 points maximum
4 The following signals are provided for each machine group. Emergency Stop (*ESP: X0008), Test Mode signal(OPT), Guard Open Request signal(ORQ), Guard Open Inhibit signal(*OPIHB), MCC Off signal (*MCF), MCC Contact State signal (*SMC), MCC Off Test Execution Request signal (RQT)
  (With the FS0*i*-D, the number of machine groups is 1 at all times.)
5 With the FS0*i*-D, the signals (Fxxxx/Gxxxx) prepared for each machine group are located in the signal area for the first path at all times.

Interface Signals between the CNC and the PMC

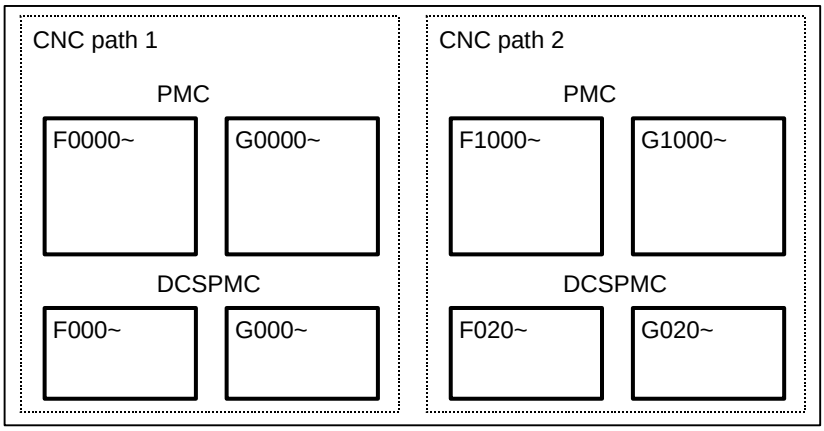
The addresses for the interface signals (F and G signal addresses viewed from the CNC) between the CNC and the PMC are shown below.

- [For 1-path CNC]



T

- [When two paths are used with a CNC of the T series]



The signal for the x-th axis of the k-th path is placed in the (x - 1)-th bit in the address (G or F) for the k-th path in the above figure.

PMC (n = k-1)

	#7	#6	#5	#4	#3	#2	#1	#0
Gn???				5th axis	4th axis	3rd axis	2nd axis	1st axis

	#7	#6	#5	#4	#3	#2	#1	#0
Fn???				5th axis	4th axis	3rd axis	2nd axis	1st axis

DCS PMC (m = (k-1) × 20)

	#7	#6	#5	#4	#3	#2	#1	#0
G0??+m				5th axis	4th axis	3rd axis	2nd axis	1st axis

	#7	#6	#5	#4	#3	#2	#1	#0
F0??+m				5th axis	4th axis	3rd axis	2nd axis	1st axis

5.3 SIGNALS

Emergency Stop signal (input)

***ESP <PMC: X0008.4><DCS PMC: X0008.4> (for each machine group)**

***ESP <PMC: Gn008.4> <DCS PMC: G019+m.4> (for each path)**

This is Emergency Stop signal. The Emergency Stop signal must be connected to the Emergency Stop input of the amplifier.

[Classification] Input signal (Dual signal)

[Function] Stops machine movement immediately in an emergency.

0: Emergency stop state

1: Normal state

[Operation] When Emergency Stop signal (*ESP) is set to 0, the CNC is reset, and the system enters emergency stop state. A machine tool builder must output a signal to shut off directly the MCC when “MCC Off signal” (*MCF) is set to “0”.

In emergency stop state, a machine tool builder must check “MCC Contact State signal” (*SMC). If *SMC signal is “0” (MCC is on), a machine tool builder must not release the guard lock signal of protective door.

In general, Emergency Stop signal (*ESP) is specified by the pushbutton switch B contact. When an emergency stop occurs, the servo ready signal SA is set to 0.

If the input of the Emergency Stop signal is detected, the CNC automatically specifies a command to zero the speed of a servo motor and reduces the speed to zero (controlled stop). (See below caution) After the servo motor slows down and stops, the power is turned off, and the servo motor is brought into the dynamic brake stop state.
The spindle motor is slowed down by the PMC command (see below caution) and the power is shut off.

⚠ CAUTION

1 The Emergency Stop signal for DCS PMC is assigned to each machine group, like the signal for PMC.
<X0008.4>
2 The related parameter must be set in order to perform the controlled stop of a servo motor. If the parameter is not set, a servo motor is stopped by dynamic brake control just after an emergency stop is detected.
3 A spindle motor is slowed down by the command (PMC ladder program). If the PMC does not command to slow down, the spindle motor continues rotating at the speed prior to power-down and runs by inertia (and eventually stopping in the end). When safety function is active (protective door is open) and abnormal speed is given due to the trouble of PMC, the spindle is brought into safe stop state.

⚠ WARNING

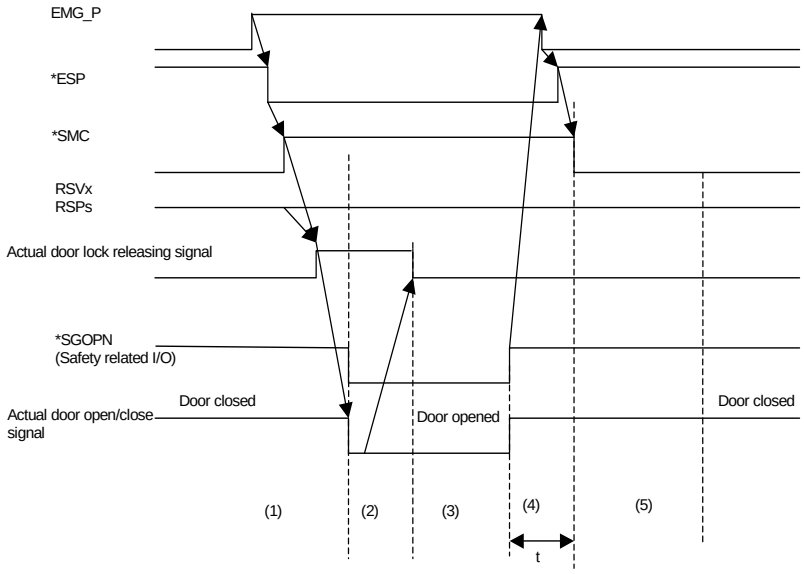
A machine tool builder must make the ladder to control to open and shut protective door in emergency stop state. For instance, a machine tool builder must make the ladder program for procedure to inhibit to open the protective door in emergency stop state.

IMPORTANT

1 Emergency stop button must fulfill the Standard IEC60947-5-1.This is mandatory.
2 A G signal for emergency stop is available for each path. However, ensure that the G signals are controlled from the viewpoint of all paths.

Example of protective door open/shut sequence

The following figure shows the sequence in case of emergency stop.



A machine tool builder must design the ladder program as follows:

(1) In case Emergency Stop signal (*ESP) is input, the guard lock signal is turned off after confirming safety machine position, safety speed and safety position error by the Monitoring Result signals RSVx/RSPs.
(2) In this example, it is assumed that a protective door with an electronic door lock is applied. When a door is opened, door lock releasing signal must be turned off. At the same time, Guard State signal (*SGOPN: machine side signal) is changed to show guard-releasing state.
(3) This is door open state
(4) Protective door is shut and locked. Then Emergency Stop signal (*ESP) is released (“1”). Pay attention the time “t”.
(5) After Emergency Stop signal is released, CNC turns MCC Off signal (*MCF) to “1”.

Test Mode signal (input)

OPT <PMC:Gn191.2> (for each machine group)

When this signal is input, MCC off Test is carried out. MCC off Test checks whether the contact of the MCC is abnormally closed or not. MCC Off Test Execution Request signal (RQT) notifies that MCC off Test should be executed. Input this signal while servo ready signal (SA) is set to “1”.

When MCC off Test is carried out by manual operation, input this signal after preparing to carry out MCC off Test by PMC.

[Classification] Input signal (Single signal)

[Function] This signal notifies CNC to enter MCC off Test mode.

0: Not enter MCC off Test mode

1: Enter MCC off Test mode

Test Mode signal (OPT) through I/O Link#3, PROFIBUS-DP is not provided.

[Operation] When this signal (OPT) is set to "1", CNC turns on/off MCC in various combinations with MCC Off signals *MCF(PMC)/*MCF(DCS PMC). And CNC checks whether MCC Contact State signals *SMC(PMC)/ *SMC(DCS PMC) are input in proper combination corresponding to the combination with MCC Off signals.

However MCC off Test should not be carried out in case of emergency stop state, servo alarm state or spindle alarm state.

If MCC off Test is not completed within the time specified by the parameter No.1946, a servo alarm SV0488 occurs.

⚠ CAUTION

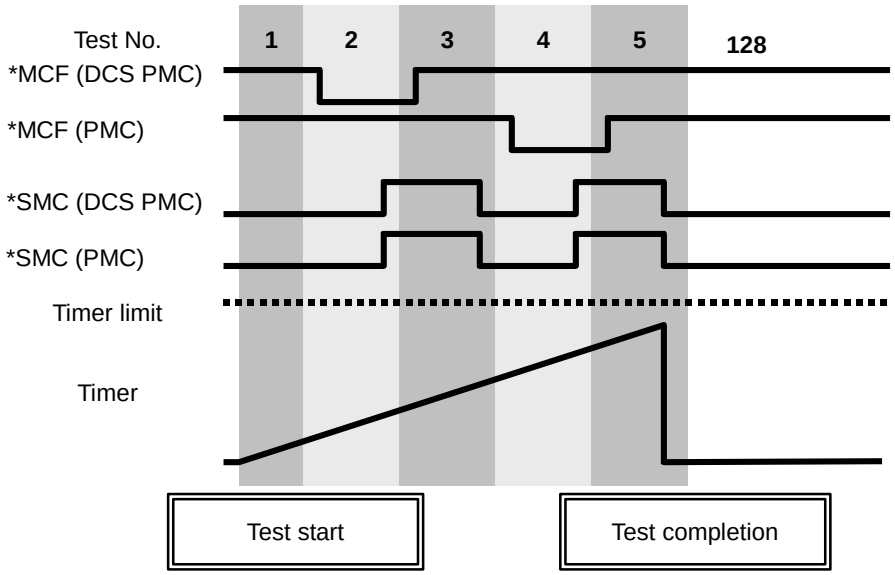
1 While MCC off Test is being carried out, do not turn Test Mode signal (OPT) to "0".
2 The MCC shall have forced guided contacts , and must fulfill the standard IEC60204 and IEC 60255. This is mandatory.
3 Before performing the MCC off Test, stop the spindle and feed axis. For axes (such as the vertical axis) that move when the MCC is turned off, apply a brake in advance regardless of the state of the brake signal (*BRKx) to place the axes in the servo off state.

⚠ WARNING

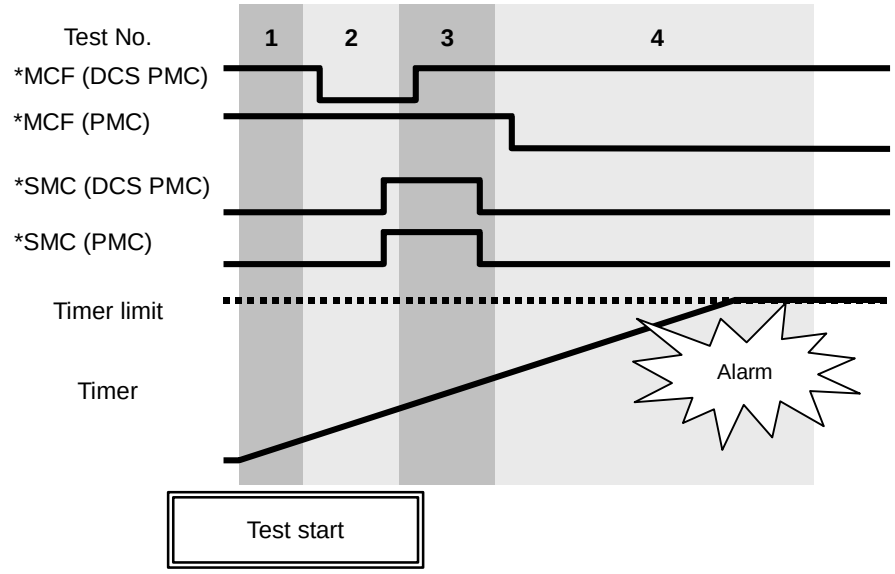
While the MCC off Test processing is in progress, the MCC Off signal (*MCF) goes high and low to turn on and off the MCC. Carry out the MCC off Test in such a state that the turning on or off of the MCC will not cause a problem.

NOTE

If MCC off Test is executed when MCC is forced to shut off in emergency stop state, servo alarm state or spindle alarm state, the test cannot be executed normally. MCC off Test should be executed only when the test can be executed normally.



Example 1) Timing chart 1 of MCC off test (normal state)



Example 2) Timing chart 2 of MCC off test (abnormal state)

Guard Open Request signal (input)

ORQ <PMC: Gn191.3>（for each machine group）

This signal is input when an operator intends to release the guard lock and open the protective door.

[Classification] Input signal (Single signal)

[Function] In order to open the protective door, this signal requests CNC to unlock the guard lock with the Dual Check Safety Function. Guard Open Request signal (ORQ) is not input via the DCS PMC.

0: Not request to open guard lock.

1: Request to open guard lock

[Operation] When CNC detects that the Guard Open Request signal (ORQ) is 1, CNC returns Guard Open Inhibit signal (*OPIHB). A machine tool builder must design the PMC ladder program so that the guard lock is released after judging the result of safety machine position check, safety speed check, safety position error check to be safe or other safety condition such as Dual Check alarm status signal to be safe.

This signal is not a safety signal that is checked doubly. But this is an important signal to make up the safety system. Then a machine tool builder must design the proper ladder program to deal with this signal.

IMPORTANT

The mistake of the ladder program cannot be checked. So be sure to perform the confirmation of the safety function. (refer to the chapter 7)

Guard State signal (Machine side input signal)

***SGOPN <PMC:X machine side signal><DCS PMC:X machine side signal> (for each safety door)**

Input the guard state of the protective door to this signal. When the protective door is open (Guard State signal (*SGOPN) =0), set Safety Check Request signal (*VLDVx, *VLDPs) to “0” in order to activate the alarm monitoring of safety functions.

[Classification] Input signal (Dual signal)

[Function] Guard State signal informs CNC of the guard open/closed state for the Dual Check Safety Function.

0: Guard open state

1: Guard closed state

[Operation] When Guard State signal (*SGOPN) is “0”, the ladder program turn Safety Check Request signal (*VLDVx, *VLDPs) to “0” in order to activate the alarm monitoring of safety speed, safety machine position and safety position error. If the ladder program detects abnormal condition in each CPU, it generates a safety related alarm and stops motors.

IMPORTANT

As for the contacts for Guard State signal, it is recommended to fulfill the Standard IEC60947-5-1.

MCC Contact State (input)

***SMC <PMC: Gn748.6><DCS PMC: G(000+m).6> (for each machine group)**

The state of MCC contact is checked doubly. It is not possible to check whether the contact of MCC is melted and adhered abnormally because MCC contact is closed during normal operation. The state of MCC contact can be checked by performing MCC off Test.

[Classification] Input signal (Dual signal)

[Function] MCC Contact State signals (*SMC) inform CNC of the MCC state for the Dual Check Safety Function.

0: MCC-on state

1: MCC-off state

[Operation] MCC Contact State signals (*SMC) is used to check if the MCC Off signals (*MCF) operates normally in MCC off Test mode.

When the MCC Contact State signals (both *SMC(PMC) and *SMC(DCS PMC)) are 1 in the emergency stop state (*ESP=0), it is possible to design the ladder program to release the guard lock.

> ⚠ **CAUTION**
> Input this signal according to the MCC state.

Safety Check Request signal (input)

***VLDVx <PMC:Gn750.0 to 4><DCS PMC:G(002+m).0 to 4> (for each axis)**

***VLDPs <PMC:Gn751.0 to 1><DCS PMC:G(003+m).0 to 1> (for each spindle)**

If these signals are set to “0” when Guard State signal (*SGOPN: machine side signal) is “0”, the alarm monitoring of safety speed limit, safety machine position and safety position error is activated.

[Classification] Input signal (Dual signal)

[Function] Safety Check Request signals request each CPU to carry out the safety check for the Dual Check Safety Function.

These signals select a servo axis and a spindle that must be checked when a protective door is open.

0: Alarm by safety check is monitored, as a protective door is open.

1: Alarm by safety check is not monitored, as a protective door is closed

[Operation] Each CPU carries out the safety check of the servo axis and the spindle that are selected by these signals. (Safety speed limit for a spindle, safety speed, safety machine position and safety position error for a servo axis.) If each CPU finds out any problem, it generates a safety related alarm and stops motors.

Guard Open Inhibit signal (output)

***OPIHB <PMC: Fn191.0><DCS PMC: F(019+m).0> (for each machine group)**

CNC returns these signals as answer when CNC detects that Guard Open Request signal (ORQ) is set to "1".

[Classification] Output signal (Not checked doubly)

[Function] When CNC receives Guard Open Request signal (ORQ) =1, CNC returns these signal as answer. CNC outputs Guard Open Inhibit signal (*OPIHB) through both PMC and DCS PMC.

0: Inhibit guard open

1: Permit guard open

[Operation] A machine tool builder can release a guard lock by his ladder program when Guard Open Inhibit signal (*OPIHB) =1, Monitoring Result signal (RSVx/RSPs) =1 and the condition of machine side is confirmed to be safe.

NOTE
During the MCC off Test, this signal is set to "0" regardless of the state of the guard open request signal (ORQ).

IMPORTANT
The mistake of the ladder program cannot be checked. So be sure to perform the confirmation of the safety function. (refer to the chapter 7)

Monitoring Result signal (output)

RSVx <PMC:Fn750.0 to 4><DCS PMC:F(002+m).0 to 4> (for each axis)

RSPs <PMC:Fn751.0 to 1><DCS PMC:F(003+m).0 to 1> (for each spindle)

These signals show the result of monitoring safety speed, safety machine position and safety position error.
By checking these signals, a machine tool builder can judge whether a machine is in safe state or not. When a machine is judged to be in safe state, it is necessary to turn on the signal for releasing a guard lock and outputs a signal actually to open a protective door.

[Classification] Output signal (Output to both PMC but not checked doubly)

[Function] These signals show the result of monitoring of the Dual Check Safety Function.
These signals notify that an abnormal condition is detected in safety monitoring function of the Dual Check Safety Function, such as safety speed check, safety machine position check and safety position error check.
In the following case, these signals are turned to "0".

0: In dangerous condition (Abnormal condition is detected by safety function.)

In the following case, these signals are turned to "1".

1: In safe condition (Abnormal condition is not detected.)

[Operation] Each CPU notifies PMC of the result of safety monitoring through these signal.
A machine tool builder can release a guard lock by his ladder program when Guard Open Inhibit signal (*OPIHB) =1, these Monitoring Result signal (RSVx/RSPs) =1 and the condition of machine side is confirmed to be safe.

MCC Off signal (output)

***DCALM <PMC: F0748.7><DCS PMC: F000.7> (for all system)**

In case this signal is “0”, MCC is shut off through 2 channels of I/O line respectively.
This signal is set to “0”, when a crosscheck alarm of safety related signals or a CPU self-diagnosis alarm occurs.
A machine tool builder makes a ladder program to output a signal to shut off MCC when this signal is turned to “0”. If necessary, control DO signal for peripheral devices.

[Classification] Output signal (This signal output to both PMC but is not monitored doubly)

[Function] This is a signal to turn on MCC when both a crosscheck alarm and a CPU self-diagnosis alarm are not caused.
0: MCC off
1: MCC on

[Operation] When each CPU finds out any abnormal condition, it generates an alarm and turns off this signal at the same time.

NOTE
When the spindle motor (induction motor) is powered off while rotating, the motor performs free-running at the speed before power-off, eventually stopping after a period of time. In some cases, however, it is better to stop the motor as early as possible for safety.
When the spindle is decided to be controlled even if the MCC Off signal is set to "0", the rotation of the spindle can be stopped under control of the ladder program (controlled stop). To do this, make a ladder program that interrupts power upon lapse of the timer set time after the MCC Off signal is set to "0".

MCC Off signal (output)

***MCF <PMC: Fn748.1, DCS PMC: F(000+m).1> (for each machine group)**

In case this signal is “0”, MCC is shut off through 2 channels of I/O Link line respectively.
This signal is set to “0”, when Emergency Stop signal (*ESP) is “0” or MCC off Test is carried out.
A machine tool builder makes a ladder program to output a signal to shut off MCC when this signal is turned to “0”.

[Classification] Output signal (This signal output to both PMC but is not monitored doubly)

[Function] When the Dual Check Safety Function is applied, this signal allows turning on MCC.
When either MCC Off signal through PMC or that through DCS PMC is “0”, MCC is turned off. When both MCC Off signal through PMC and that through DCS PMC is “1”, MCC is turned on.
0: MCC off
1: MCC on

[Operation] When Emergency Stop signal is input, CNC turns off this signal.
When MCC off Test is carried out, CNC turns off this signal, too.

[Output condition] In the following case, this signal turns to “0” (not permit MCC on)

- MCC off Test is carried out.
- In emergency stop state

In other than the above case, this signal turns to “1” (permit MCC on).

NOTE
When the spindle motor (induction motor) is powered off while rotating, the motor performs free-running at the speed before power-off, eventually stopping after a period of time. In some cases, however, it is better to stop the motor as early as possible for safety.
When the spindle is decided to be controlled even if the MCC Off signal is set to "0", the rotation of the spindle can be stopped under control of the ladder program (controlled stop). To do this, make a ladder program that interrupts power upon lapse of the timer set time after the MCC Off signal is set to "0".

MCC Off signal (output)

***MCFVx <PMC: Fn752.0 to 4><DCS PMC: F(004+m).0 to 4> (for each axis)**

In case this signal is “0”, MCC is shut off through 2 channels of I/O line respectively.
This signal is set to “0”, when an alarm occurs in safety speed limit check, safety machine position check or safety position error check for each servo axis.
A machine tool builder makes a ladder program to output a signal to shut off the MCC of the path that the axis belongs, when this signal is turned to “0”.

[Classification] Output signal (This signal output to both PMC but is not monitored doubly)

[Function] When the Dual Check Safety Function is applied, this signal allows turning on MCC.
0: MCC off
1: MCC on

[Operation] If each CPU finds out the abnormal state of the axis when Safety Check Request signal for the axis (*VLDVx)=0, each CPU brings the axis into controlled stop state at first. In case of an alarm of Safety Speed Monitoring or Safety Machine Position Monitoring, each CPU watches whether the axis is decelerated and stopped or not. If the axis does not stop, each CPU turns this signal corresponding to the alarm axis to “0”. In case of an alarm of Safety Position Error Monitoring, each CPU turns this signal corresponding to the alarm axis to “0” immediately.
In case of an alarm other than described above and related to data communication or position detector, each CPU turns this signal corresponding to the alarm axis to “0” immediately. But according to the parameter setting, it is possible to turn to “0” this signals of all the axes belonged to the path that involves the alarm axis in case of any servo alarms.

NOTE
When the spindle motor (induction motor) is powered off while rotating, the motor performs free-running at the speed before power-off, eventually stopping after a period of time. In some cases, however, it is better to stop the motor as early as possible for safety.
When the spindle is decided to be controlled even if the MCC Off signal is set to "0", the rotation of the spindle can be stopped under control of the ladder program (controlled stop). To do this, make a ladder program that interrupts power upon lapse of the timer set time after the MCC Off signal is set to "0".

MCC Off signal (output)

***MCFPs <PMC: Fn753.0 to 1><DCS PMC: F(005+m).0 to 1> (for each spindle)**

In case this signal is “0”, MCC is shut off through 2 channels of I/O Link line respectively.
This signal is set to “0”, when an alarm occurs in safety speed check for each spindle.
A machine tool builder makes a ladder program to output a signal to shut off the MCC of the path that the spindle belongs, when this signal is turned to “0”.

[Classification] Output signal (This signal output to both PMC but is not monitored doubly)

[Function] When the Dual Check Safety Function is applied, this signal allows turning on MCC.
0: MCC off
1: MCC on

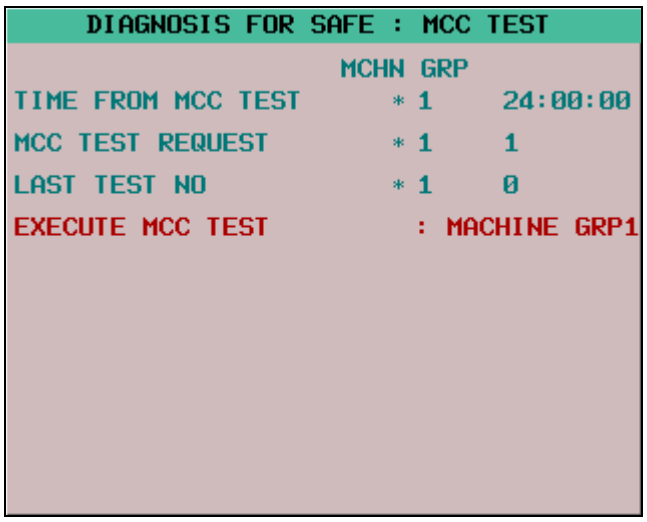
[Operation] When the safe speed limit monitoring alarm is detected because the Safety Check Request signal (*VLDPs) of each spindle is 0, each CPU first sets the spindle to the free-running state or the controlled stop state. After that, if the spindle is not decelerated, each CPU turns this signal to “0”.
In case of an alarm other than described above and related to data communication or position detector, each CPU turns this signal corresponding to the alarm spindle to “0” immediately. But according to the parameter setting (No.10500#1 = 1), it is possible to turn to “0” this signals of all the spindles belonged to the path that involves the alarm spindle in case of any spindle alarms.

MCC Off Test Execution Request signal (output)

RQT <PMC:Fn191.2> (for each machine group)

[Classification] Output signal (Single signal)

[Function] This signal notifies that MCC off Test mode is required and a check should be made to determine whether the safety output signals (MCC Off signal (*MCF)) operate normally. When MCC Off Test Execution Request signal (RQT) is set to 1, set MCC off Test mode and carry out a safety output signal MCC off Test as soon as possible.
When MCC Off Test Execution Request signal (RQT) is 1, a machine tool builder must make ladder not to release a guard lock.
Once a guard is closed when MCC Off Test Execution Request signal (RQT) is set to “1” while a guard is open by Guard Open Request signal (ORQ), it is necessary not to release a guard lock until MCC off Test request signal (RQT) turns to “0”.
When MCC Off Test Execution Request signal (RQT) is 1, the following screen is displayed and the warning “EXECUTE MCC TEST” is displayed.



MCC Off Test Execution Request signal (RQT) is not output via the DCS PMC.
Make a ladder program to lock a protective door when MCC Off Test Execution Request signal (RQT) =1.

[Output condition] In the following case, this signal is set to “1”.

- MCC off Test is not completed after power-on (when bit 3 (STP) of parameter No.10500 is 0).
- Twenty-four hours have elapsed since the completion of the last MCC off Test.

In the following case, this signal sets to “0”.

- MCC off Test is completed.

> ⚠ **CAUTION**
> Do not turn Test Mode signal (OPT) to “0” during MCC off Test.

> ⚠ **WARNING**
> While the MCC off Test processing is in progress, the MCC Off signal (*MCF) goes high and low to turn on and off the MCC. Carry out the MCC off Test in such a state that the turning on or off of the MCC will not cause a problem.

Safety Brake signal (output)

***BRKx <PMC:Fn754.0 to 4><DCS PMC:F(006+m).0 to 4> (for each axis)**

This signal is used to control mechanical brake of each axis.
CNC and SV output Safety Brake signal (*BRKx) to control mechanical brake. When *BRKx is "0", mechanical brake is active. When *BRKx is "1", mechanical brake is not active.

[Classification] Output signal (Dual signal)

[Function] When the Dual Check Safety Function is applied, this signal notifies to activate a mechanical brake. When MCC is off, a brake should be activated.

[Operation] In emergency stop state or alarm state, a mechanical brake is activated by this signal.
A machine tool builder must connect this signal to a mechanical brake.

[Output condition] In the following case, this signal is "1".

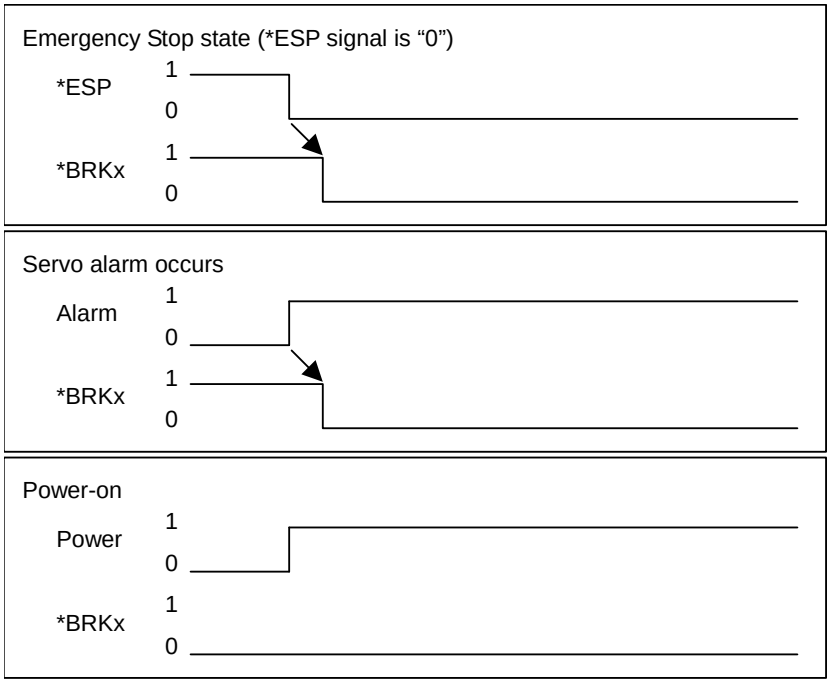
- Releasing brake state

In the following case, this signal is "0".

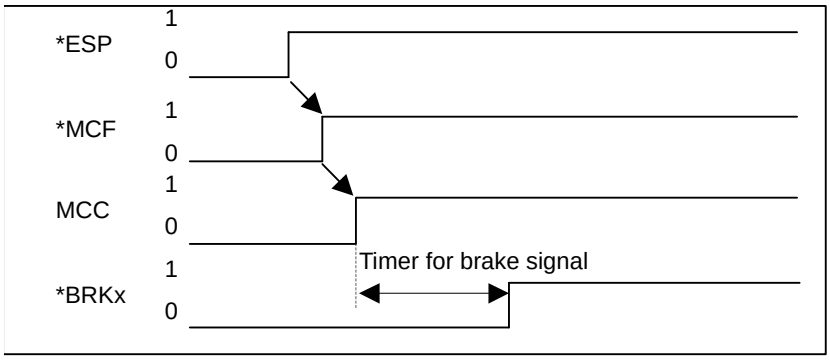
- Activating brake state

> ⚠ **CAUTION**
> During the MCC off Test, the MCC is turned off and on several times. The brake state of the signal may change depending on the state of the MCC.
> For the control of the brake during the MCC off Test, see "MCC off Test".

(a) In case *BRKx signal is "0"



(b) In case *BRKx signal is “1”
When emergency stop is released (*ESP signal is “1”), MCC can be enabled l (*MCF signal is “1”). After that, when MCC is turned on, Safety Brake signal *BRKx is turned to “1” after the time specified by the parameter No.1950 is elapsed.



NOTE
Regular maintenance of a brake must be done.

Safety Position Switch signal (output)
SPS1 to SPS32<PMC:Fn755 to Fn758><DCS PMC:F(007+m) to F(010+m)>

This signal shows whether the machine position of a servo axis is within the range specified by the parameter or not.

[Classification] Output signal (Dual signal)

[Function] This signal notifies that the machine position of the axis specified by the safety parameter (No.13880 to No.13911) is within the range specified by the safety parameter (No.13920 to No.13951, No.13960 to No.13991). In case of single path system, up to 32 points can be used.
When a two-path system is used with the T series, 32 points in the area for the second path can be additionally used. Then up to 64 points can be used at maximum. This signal notifies that the machine position of the axis specified by the safety parameter (No.10501 to No.10532) is within the range specified by the safety parameter (No.10533 to No.10564, No.10565 to No.10596).

NOTE
In a two-path system, 64 points of safety position switch output destinations can be assigned to each path in units of 16 points. For details, see the descriptions of parameter No. 13840 to No. 13843 in Chapter 6, "PARAMETERS".

[Output condition] In the following case, this signal is set to “1”.

- The machine position of the axis is within the specified range.

In the following case, this signal is set to “0”.

- The machine position of the axis is out of the specified range.

[Note] When the axis is just on the boundary of the range (machine position is equal to parameter setting value), it is regarded that the machine position is within the range.
If the state of two Safety Position Switch of the signal of DCS PMC side and the signal of PMC side is different more than the specified period, each CPU shuts off MCC by DCS alarm. (A safety-related I/O cross-check error (PW0010 or PW0011) is output.)

NOTE
Position switch signal is activated when the reference point correspond to the axis is established after power-on. The state of position switch is kept to “0” till then.
Once activating, position is always checked and state of signal is changed according to the result of checking. Even if the reference point is lost, the state of signal is changed according to the coordinate kept in both CNC and servo CPU. So if the special procedure is required when the reference point is lost, design the ladder program by combining with Position Information Effect signal (POSEx).

Safety Speed/Safety Position Selection signal A (input)
SVAx <PMC:Gn752.0 to 4> <DCS PMC:G(004+m).0 to 4> (for each axis)
SPAs <PMC:Gn754.0 to 1> <DCS PMC:G(006+m).0 to 1> (for each spindle)
Safety speed/safety position selection signal B (input)
SVBx <PMC:Gn753.0 to 4> <DCS PMC:G(005+m).0 to 4> (for each axis)
SPBs <PMC:Gn754.4 to 5> <DCS PMC:G(006+m).4 to 5> (for each spindle)

[Classification] Input signal (Dual signal)

[Function] When the Dual Check Safety Function is activated, it is possible to select safety limit speed and safety machine position of each axis.
This signal is prepared for each axis and each spindle. The final number in the signal name shows the number of the controlled axis and spindle.

SVAx, SVBx
x 1: Select safety speed/safety machine position of the 1st axis
2: Select safety speed/safety machine position of the 2nd axis
3: Select safety speed/safety machine position of the 3rd axis
4: Select safety speed/safety machine position of the 4th axis
5: Select safety speed/safety machine position of the 5th axis

SPAs, SPBs
s 1: Select safety speed of the 1st spindle
2: Select safety speed of the 2nd spindle

[Operation] According to the combination of Safety Speed/Safety Machine Position Selection signal, safety speed and safety machine position are selected as the following table.

Safety Speed/ Safety Machine Position Selection signal		Safety limit speed		Safety machine position	
SVAn	SVBn	Parameter for servo axis	Parameter for spindle	+ direction parameter	- direction parameter
SPAn	SPBn				
0	0	Safety limit speed 1		Safety machine position 1	
		No.13821	No.4372	No.13831	No.13832
1	0	Safety limit speed 2		Safety machine position 2	
		No.13822	No.4438	No.13833	No.13834
0	1	Safety limit speed 3		Safety machine position 3	
		No.13823	No.4440	No.13835	No.13836
1	1	Safety limit speed 4		Safety machine position 4	
		No.13824	No.4442	No.13837	No.13838

> ⚠ **CAUTION**
> Safety Speed/Safety Machine Position Selection signal is a safety signal. This signal is input through both PMC and DCS PMC. Both CNC and PMC check doubly inconsistency of this signal.

Position Information Effect signal (output)

POSEx <PMC: Fn766.0 to 4><DCS PMC: F(018+m).0 to 4> (for each axis)

This signal is output when Dual Check Safety function is activated and the reference point is established. When the reference point is not established, the machine system is in danger state because Safety Machine Position Monitoring and Safety Position Error Monitoring are not active. If this signal is "0", Machine Tool Builder has to control not to open the protective door.

[Classification] Output signal (This signal output to both PMC but is not monitored doubly)

[Function] This signal informs whether the reference point is established or not.

0: The reference point is not established.

1: The reference point is established.

[Operation] Each CPU informs whether the reference point is established or not.

In the following case, this signal is turned to "1".

- After the reference point is established.
- When the follow up operation of absolute pulse coder is finished after power-on

In the following case, this signal is turned to "0".

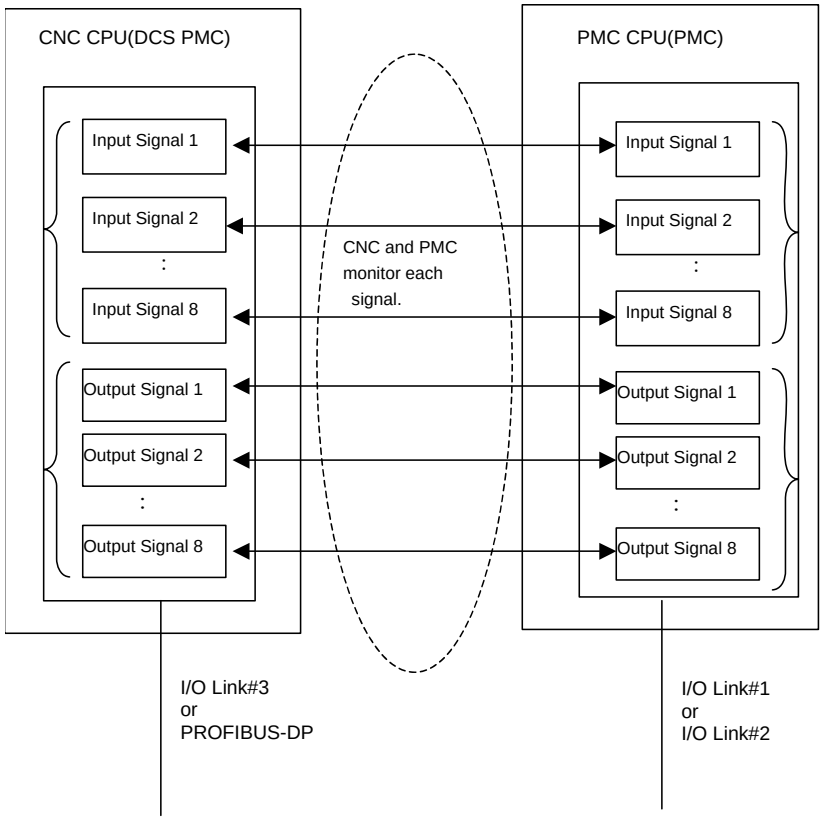
- When the reference point is lost

NOTE
In case that the reference point is re-established, this signal is turned to "0" till the reference point is re-established from the dog-signal is turned off.

Programmable Safety I/O signals (input/output)

[Classification] Input/Output signal (Dual signal)

[Function] The 8 bytes (64 bit) programmable safe I/Os can be freely defined as the different address from the above basic safe signals. Each byte of 8 byte programmable safe I/Os can be assigned on either address of X/Y or R or D by parameter. Each byte of the programmable safe I/O between the PMC and DCS PMC is cross-checked by the CNC and PMC.



[Operation] The combinations of cross-checking these signals are defined by using Safety parameters as follows.

Signal type	Combination No.	CNC (DCS PMC)	PMC (PMC)
Input	1	No.11950	No.11970
	2	No.11951	No.11971
	3	No.11952	No.11972
	4	No.11953	No.11973
	5	No.11954	No.11974
	6	No.11955	No.11975
	7	No.11956	No.11976
	8	No.11957	No.11977
Output	1	No.11960	No.11980
	2	No.11961	No.11981
	3	No.11962	No.11982
	4	No.11963	No.11983
	5	No.11964	No.11984
	6	No.11965	No.11985
	7	No.11966	No.11986
	8	No.11967	No.11987

Brake Test Start signal (input)
STBT <PMC: Gn193.2> (for each machine group)

[Classification] Input signal (Single signal)

[Function] Input signal for starting and suspending a brake test

When this signal is switched from 0 to 1, a brake test is started. Upon normal completion of brake test, the Brake Test Execution Request signal RQBT is set to 0. So, upon confirmation of RQBT set to 0, this signal is also switched from 1 to 0.

If this signal is switched from 1 to 0 during a brake test, the brake test is suspended upon completion of the test sequence currently under execution.

A brake test can be restarted from the beginning by setting this signal to 1 again.

Brake Test Execution Request signal (output)
RQBT <PMC: Fn191.3> (for each machine group)

[Classification] Output signal (Single signal)

[Function] Output signal for requesting a brake test

When this signal is set to 1, execute a brake test. Even if this signal is set to 1, operation can be continued until the current machining is completed. To secure safety, however, a brake test should be conducted as soon as possible by setting the Brake Test Start signal STBT to 1.

Upon normal completion of brake test, this signal is set to 0.

5.4 PROGRAMMABLE SAFETY I/O SIGNAL

The programmable safety I/O signal is a safety signal that can be defined by the machine tool builder. The Dual Check Safety function monitors both the safety signal determined by the system and the programmable safety I/O signal defined by the machine tool builder redundantly. The programmable safety I/O signal is defined by parameters. (See also the description of the programmable safety I/O signal in Section 5.3.)

How to turn off programmable safety I/O signal

When it is confirmed that *DCALM, *MCF, *MCFVx and *MCFPs is “0”, turn programmable safety I/O signal off if necessary.

(a) In case MCC off Test is carried out,
When RQT=1 and OPT=1, ignore *MCF=0.

(b) In case of emergency stop (*ESP=0)
When *ESP=0, ignore *MCF=0.

5.5 NOTE ON 2-PATH CONTROL (T SERIES)

T

This section describes cautions about safe-related I/O signals that should be taken in 2-path control.

5.5.1 2-path Control (T Series)

Two-path control is used, for example, when one workpiece is machined using two tools simultaneously with independent programs. An alarm is checked on a path-by-path basis. If a servo alarm is issued on a path, the MCC of all axes of the path are shut off. If an alarm related to the safety check function is issued, the MCC is also shut off on a path-by-path basis. So, basically, a safety area needs to be set on a path-by-path basis.
If multiple safety areas are set within one path, the MCC may be shut off for an alarm in another area. If a safety area is configured using an axis that belongs to one of the paths selected by switching, the MCC of another axis of the path may not be shut off when an alarm is issued. If an axis that belongs to one of the paths selected by switching is used, make connections so that the MCCs of both paths are shut off at the same time.
Two sets of cross-check target safety input signals, one set for the PMC and the other for the DCS PMC, are used for each path. Ensure that the two sets are exactly the same.

> ⚠ **CAUTION**
> When “Composite control” or “Path speed control of Multi path control” is specified, it is possible to give a command to control a servo axis or a spindle in another path. But in this case, the correspondence between a path and a belonging servo axis or spindle is not changed. An alarm related to a servo axis or a spindle occurs in the path that the axis and the spindle originally belong to, and MCC shut off signal correspond to the axis or spindle is output also in original path.
> Then, as the path that gives a command and the path that an axis and a spindle belongs to should be regarded as the same group, it is necessary to wire MCC off signal (*MCFVx, *MCFPs) to shut off the MCC of both path at the same time when “Composite control” or “Path speed control of Multi path control” is specified.

6 PARAMETERS

6.1 OVERVIEW

The parameters related to the Dual Check Safety function (safety parameters) are protected by a code (No. 3225) for the safety parameters. The value of a safety parameter cannot be modified unless the same value as the code for the safety parameters is set as the key (No. 3226) for the safety parameters.
The safety parameters are stored in two locations on the CNC. The CNC, PMC, servo and spindle software check the matching of the parameters stored at the two locations. If a mismatch is found, an alarm is issued.

If the setting of a safety parameter is modified, the power must be turned off then back on. The new setting of the parameter becomes effective after the power is turned back on.

6.2 DATA TYPE

Parameters are classified by data type as follows:

Data type	Valid data range	Remarks
Bit	0 or 1	
Bit machine group		
Bit path		
Bit axis		
Bit spindle		
Byte	-128 to 127 0 to 225	Some parameters handle these types of data as unsigned data.
Byte machine group		
Byte path		
Byte axis		
Byte spindle		
Word	-32768 to 32767 0 to 65535	Some parameters handle these types of data as unsigned data.
Word machine group		
Word path		
Word axis		
Word spindle		
2-word	0 to ±999999999	Some parameters handle these types of data as unsigned data.
2-word machine group		
2-word path		
2-word axis		
2-word spindle		
Real	See the Standard Parameter Setting Tables.	
Real machine group		
Real path		
Real axis		
Real spindle		

NOTE

1 Each of the parameters of the bit, bit machine group, bit path, bit axis, and bit spindle types consists of 8 bits for one data number (parameters with eight different meanings).
2 Machine group type indicates that parameters are available for the maximum number of machine groups and independent data can be set for each machine group. With the 0*i* -D, the maximum number of machine groups is 1 at all times.
3 Path type indicates that parameters are available for the maximum number of paths and independent data can be set for each path.
4 Axis type indicates that parameters are available for the maximum number of controlled axes and independent data can be set for each controlled axis.
5 Spindle type indicates that parameters are available for the maximum number of spindles and independent data can be set for each spindle.
6 The valid data range for each data type indicates a general range. The range varies according to the parameters. For the valid data range of a specific parameter, see the explanation of the parameter.

6.3 REPRESENTATION OF PARAMETERS

Parameters of the bit type, bit machine group type, bit path type, bit axis type, and bit spindle type

	#7	#6	#5	#4	#3	#2	#1	#0
0000				EIA	NCR	ISP	CTV	TVC

Data No. Data (Data #0 to #7 are bit positions.)

Parameters other than the bit-type parameters above

1023	Number of the servo axis for each axis

Data No. Data

NOTE

1 The parameters, which are described here, are related directly to Dual Check Safety function. As for the other parameters, please refer to the parameter manual (B-64310EN).

2 A parameter usable for only one of the lathe system (T series) and machining center system (M series) is indicated using two rows as shown below. When a row is blank, the parameter is not usable with the corresponding series. Basically, set those parameters to 0.

[Example 1]

Parameter HTG is a parameter common to the M and T series, but Parameters RTV and ROC are parameters valid only for the T series.

	#7	#6	#5	#4	#3	#2	#1	#0	
1403	RTV		HTG	ROC					T series
			HTG						M series

[Example 2]

The following parameter is provided only for the M series.

1411		T series
	Cutting feedrate	M series

3 When "to" is inserted between two parameter numbers, there are parameters with successive numbers between the two starting and ending parameter numbers, but those intermediate parameter numbers are omitted for convenience.

4 The lower-case letter "x" or "s" following the name of a bit-type parameter indicates the following:

- "□□□x" : Bit axis type parameters
- "○○○s" : Bit spindle type parameters

6.4 STANDARD PARAMETER STTING TABLES

Overview

This section defines the standard minimum data units and valid data ranges of the CNC parameters of the real type, real machine group type, real path type, real axis type, and real spindle type. The data type and unit of data of each parameter conform to the specifications of each function.

Explanation

(A) Length and angle parameters (type 1)

Unit of data	Increment system	Minimum data unit	Valid data range
mm degree	IS-A	0.01	-999999.99 to +999999.99
	IS-B	0.001	-999999.999 to +999999.999
	IS-C	0.0001	-99999.9999 to +99999.9999
inch	IS-A	0.001	-99999.999 to +99999.999
	IS-B	0.0001	-99999.9999 to +99999.9999
	IS-C	0.00001	-9999.99999 to +9999.99999

(B) Length and angle parameters (type 2)

Unit of data	Increment system	Minimum data unit	Valid data range
mm degree	IS-A	0.01	0.00 to +999999.99
	IS-B	0.001	0.000 to +999999.999
	IS-C	0.0001	0.0000 to +99999.9999
inch	IS-A	0.001	0.000 to +99999.999
	IS-B	0.0001	0.0000 to +99999.9999
	IS-C	0.00001	0.00000 to +9999.99999

(C) Velocity and angular velocity parameters

Unit of data	Increment system	Minimum data unit	Valid data range
mm/min degree/min	IS-A	0.01	0.00 to +999000.00
	IS-B	0.001	0.000 to +999000.000
	IS-C	0.0001	0.0000 to +99999.9999
inch/min	IS-A	0.001	0.00 to +96000.000
	IS-B	0.0001	0.000 to +9600.0000
	IS-C	0.00001	0.0000 to +4000.00000

If bit 7 (IESP) of parameter No. 1013 is set to 1, the valid data ranges for IS-C are extended as follows:

Unit of data	Increment system	Minimum data unit	Valid data range
mm/min degree/min	IS-C	0.001	0.000 to +999000.000
inch/min	IS-C	0.0001	0.0000 to +9600.0000

(D) Acceleration and angular acceleration parameters

Unit of data	Increment system	Minimum data unit	Valid data range
mm/sec^2 $degree/sec^2$	IS-A	0.01	0.00 to +999999.99
	IS-B	0.001	0.000 to +999999.999
	IS-C	0.0001	0.0000 to +99999.9999
$inch/sec^2$	IS-A	0.001	0.000 to +99999.999
	IS-B	0.0001	0.0000 to +99999.9999
	IS-C	0.00001	0.00000 to +9999.99999

If bit 7 (IESP) of parameter No. 1013 is set to 1, the valid data ranges for IS-C are extended as follows:

Unit of data	Increment system	Minimum data unit	Valid data range
mm/sec^2 $degree/sec^2$	IS-C	0.001	0.000 to +999999.999
$inch/sec^2$	IS-C	0.0001	0.0000 to +99999.9999

Notes

(1) Values are rounded up or down to the nearest multiples of the minimum data unit.
(2) A valid data range means data input limits, and may differ from values representing actual performance.
(3) For information on the ranges of commands to the CNC, refer to Appendix D, "List of Command Ranges," in the "USER'S MANUAL" (B-64304EN).

6.5 PARAMETERS

0980 **Machine group number of each path**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Byte path
[Valid data range] 1
Set the machine group number which each path belongs.
When using the 0*i* -D, set 1 in this parameter at all times.

NOTE
When 0 is set, the setting of 1 is assumed.

0981 **Absolute path number of each axis**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Byte axis
[Valid data range] 1, 2
Set the path to which each axis belongs.

NOTE
1 If 0 is set for all axes, the parameter is automatically set according to the setting of the number of controlled axes of each path.
2 If a value not within the valid data range is set, each axis is assumed to belong to the first path.

0982	Absolute path number of each spindle

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Byte spindle
[Valid data range] 1, 2

Set the path to which each spindle belongs.

NOTE
1 If 0 is set for all axes, the parameter is automatically set according to the setting of the number of controlled axes of each path.
2 If a value not within the valid data range is set, each axis is assumed to belong to the first path.
3 If the rotation tool control function based on a servo motor is enabled, the servo motor used as a tool rotation axis is treated as a spindle. So, the path to which the tool rotation axis belongs needs to be set.

1023	Servo axis number of each axis

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Byte axis
[Valid data range] 0 to Number of controlled axis

Set the servo axis for each control axis. Usually set to same number as the control axis number.

The control axis number is the order number that is used for setting the axis-type parameters or axis-type machine signals

* With an axis for which Cs contour control/spindle positioning is to be performed, set -(spindle number) as the servo axis number.
  Example) When exercising Cs contour control on the fourth controlled axis by using the first spindle, set -1.
* For tandem controlled axes or electronic gear box (EGB) controlled axes, two axes need to be specified as one pair. So, make a setting as described below.
  Tandem axis: For a master axis, set an odd (1, 3, 5, 7, ...) servo axis number. For a slave axis to be paired, set a value obtained by adding 1 to the value set for the master axis.
  EGB axis: For a slave axis, set an odd (1, 3, 5, 7, ...) servo axis number. For a dummy axis to be paired, set a value obtained by adding 1 to the value set for the slave axis.

1240 **Coordinates value of the reference position in the machine coordinate system**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Real axis
[Unit of data] mm, inch, degree (machine unit)
[Minimum unit of data] Depend on the increment system of the applied axis
[Valid data range] 9 digit of minimum unit of data (Refer to standard parameter setting table(A).)
(When the increment system is IS-B, -999999.999 to +999999.999)
Set the coordinate values of the reference position in the machine coordinate system.

1838 **Position deviation limit for each axis in moving state during safety check**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word axis
[Unit of data] Detection unit
[Valid data range] 0 to 99999999
Position deviation limit for each axis in moving state for safety check of Dual Check Safety function is specified.
If position deviation of a moving axis exceeds position deviation limit while Safety Check is carried out (Safety Monitoring Request "*VLDVx" =0), a servo alarm (SV0475, SV1071) is generated and axes are stopped immediately like emergency stop state.
In Dual Check Safety function, position deviation is always checked by CNC and Servo. In case that Safety Check is carried out (Safety Monitoring Request "*VLDVx" =0), the servo alarm (SV0475,SV1071) is generated when each CPU finds out that the deviation exceeds position deviation limit in moving state.

1839 **Position deviation limit for each axis in stopped state during safety check**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word axis
[Unit of data] Detection unit
[Valid data range] 0 to 99999999

Set the positioning deviation limit in stopped state for each axis for Dual Check Safety function.
If the position deviation at halt time exceeds the position deviation limit at halt time set in this parameter during safety monitoring (when the Safety Check Request signal *VLDVx is set to 0), servo alarm SV0474 or SV1072 is issued.
In Dual Check Safety function, position deviation is always checked by CNC and Servo. In case that Safety Check is carried out (Safety Monitoring Request "*VLDVx" =0), servo alarm (SV0474,SV1072) is generated when each CPU finds out that the deviation exceeds position deviation limit in stopped state.

1840 **Position deviation limit for each axis in servo-off state during safety check**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word axis
[Unit of data] Detection unit
[Valid data range] 0 to 99999999

Set the positioning deviation limit in servo-off state for each axis for Dual Check Safety function.
If the positioning deviation in servo off state exceeds the positioning deviation limit in servo off state, which is set in this parameter, a servo alarm (SV1069 or SV1070) occurs.
In Dual Check Safety function, position deviation is always checked by CNC and Servo. If it is detected that the position deviation in servo off state is exceeded, a servo alarm (SV1069 or SV1070) occurs.

1841	Position deviation limit of each axis in moving state during other than Dual Check Safety monitoring (for Dual Check Safety Function)

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word axis
[Unit of data] Detection unit
[Valid data range] 0 to 99999999

Set the positioning deviation limit in moving state for each axis for Dual Check Safety function, in case that Safety Check is not carried out (Safety Monitoring Request "*VLDVx"=1).
In case that Safety Check is not carried out (Safety Monitoring Request "*VLDVx" =1), servo alarm (SV0475,SV1071) is generated and operation is stopped immediately (as in emergency stop), when each CPU finds out that the deviation exceeds position deviation limit in moving state.
If the value of this parameter is "0", the parameter No.1828 is used for the value of deviation limit in moving state.

In case that Safety Check is carried out (Safety Monitoring Request "*VLDVx" =0), the parameter No.1838 is used for the value of deviation limit in moving state.

1842	Position deviation limit of each axis in stopped state during other than Dual Check Safety monitoring (for Dual Check Safety Function)

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word axis
[Unit of data] Detection unit
[Valid data range] 0 to 99999999

Set the positioning deviation limit in stopped state for each axis for Dual Check Safety function, in case that Safety Check is not carried out (Safety Monitoring Request "*VLDVx"=1).
In case that Safety Check is not carried out (Safety Monitoring Request "*VLDVx" =1), servo alarm (SV0474,SV1072) is generated and operation is stopped immediately (as in emergency stop), when each CPU finds out that the deviation exceeds position deviation limit in stopped state.
If the value of this parameter is "0", the parameter No.1829 is used for the value of deviation limit in stopped state.

In case that Safety Check is carried out (Safety Monitoring Request "*VLDVx" =0), the parameter No.1839 is used for the value of deviation limit in stopped state.

	#7	#6	#5	#4	#3	#2	#1	#0
1902		DCE						

NOTE
When at least one of these parameters is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Bit

 # 6 DCE Dual Check Safety function is
0: inactive.
1: active.

This parameter invalidates Dual Check Safety function temporarily.
In the system with Dual Check Safety function, this parameter is used when the system set up without wiring and ladder related with Dual Check Safety in order to set up other function.

NOTE

1 When Dual Check Safety function is used, this parameter must be set to “1”. If Dual Check Safety function is ordered and this parameter is “0”, an alarm (DS0022) is displayed at power-on. This alarm can be reset by pushing “CAN” and “RESET” key on MDI at the same time.

2 When the Dual Check Safety function is disabled, almost safety-related functions become disabled. Only the following functions become enabled when the Dual Check Safety function is disabled.

- MCC Off signal *MCF (for each machine group)
  The state of MCC Off signal *MCF on the PMC and DCS PMC sides changes depending on the state of the emergency stop signal on the PMC side (the state of the emergency stop signal on the DCS PMC side has no effect). The MCC off Test is disabled.
- Brake signal *BRKx (for each axis)
  Brake signal *BRKx operates only on the PMC side. Note that the signal on the DCS PMC side always indicates the brake release state.

The output signals other than the above are described below.

(1) The following signals always indicate "1" on both the PMC and DCS PMC sides.
- MCC Off signal *DCALM (one for each system)
- MCC Off signals *MCFVx (for each axis) and *MCFPs (for each spindle)
- Safety monitoring result signals RSVx (for each axis) and RSPs (for each spindle)

(2) The following signals always indicate "0" on both the PMC and DCS PMC sides.
- Safe Position Switch signals SPS1 to SPS32
- Guard Open Inhibit signal *OPIHB
- MCC Off Test Execution Request signal RQT
- Position Information Effect signal POSEx

	#7	#6	#5	#4	#3	#2	#1	#0
1904		DCNx						

NOTE
When at least one of these parameters is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Bit axis

 # 6 DCNx The checks of the target axis by Dual Check Safety function are:
0: carried out.
1: not carried out.

NOTE
1 It is not possible to inhibit each check of Dual Check Safety Function of all axes by the parameter DCN.
2 Set the DCNx bit to 1 for the slave axis under tandem control or for the tool axis of an electronic gear box (M series).
3 The checks by the Dual Check Safety function are not carried out on an axis for which the DCNx bit is set to 1. Set the DCNx bit to 0 for normal axes.

1945	Safety input signal check timer

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Word machine group
[Unit of data] msec
[Valid data range] 0 to 1000

Input/output signals related to Dual Check Safety function (safety double input/output signals) are transmitted through two paths, "I/O Link #1 or #2" and "I/O Link#3 or PROFIBUS-DP". CNC CPU and PMC CPU exchange the input/output signals with each other at all time to check each other. If a mismatch between double input/output signals through two paths lasts greater than the time set in this parameter, alarm PW0010, PW0011, PW0012, or PW0013 is generated.
If a value of less than 16 is specified, it is assumed that 16 ms is specified.
If a value of more than 1000 is specified, it is assumed that 1000 ms is specified.

NOTE
All paths are checked using the setting of this parameter.

1946	MCC off Test timer

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Word machine group
[Unit of data] msec
[Valid data range] 0 to 32767

When MCC off Test mode is selected with Dual Check Safety function, CNC CPU carries out MCC off Test by the safety output signal (*MCF). If MCC off Test is not completed within the time set in this parameter, a servo alarm SV0488 is generated.
If a value of less than 0 is specified, it is assumed that 10000 ms is specified.

NOTE
All paths are checked using the setting of this parameter.

1948	MCC off timer

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Word machine group
[Unit of data] msec
[Valid data range] 0 to 32767

- CNC CPU and PMC CPU set MCC Off signal (*MCFVx) to 0, when an axis is not stopped within the time set by this parameter after Safe Speed Monitoring or Safe Machine Position Monitoring function of Dual Check Safety function detects abnormal condition.
- When there is no spindle (spindle for which *VLDPs = 1 is set) not being monitored for its safety, MCC Off signal *MCF (for each machine group) is set to "0" upon elapse of the time set in this parameter after an emergency stop is made.
- When a crosscheck alarm or CPU self diagnosis alarm occurs, MCC Off signal *DCALM (one for each system) is set to "0" upon elapse of the time set in this parameter. If a crosscheck alarm or CPU self diagnosis alarm related to the spindle occurs, however, the time set in this parameter takes no effect.

NOTE
All paths are checked using the setting of this parameter.

1950	Brake signal timer

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Word machine group
[Unit of data] msec
[Valid data range] 0 to 32767

Set a time period from when CNC CPU and Servo CPU in Dual Check Safety function detects that the servo amplifier is ready (MCC on state) until Safety Brake signal (*BRKx) goes 1 (brake release enabled).

NOTE
All paths are checked using the setting of this parameter.

3225	Code for safety parameters

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word
[Valid data range] 0 to 99999999

Set a code (password) for protecting against modifications to parameters related to Dual Check Safety function (safety parameters). When a code for safety parameters is set other than the value "0", the parameters are locked. In this state, the setting (code) is not displayed but is blank, and safety parameter input is disabled.
If an attempt is made to input data in a locked safety parameter, the result indicated in the table below is produced, depending on the method of input. No attempt is successful.

Input method	Result
MDI input	Warning "WRITE PROTECT"
Input via reader/puncher interface	No alarm is generated. But parameter input is disabled.
Input through window function	Completion code 7 (WRITE PROTECT)

If the value other than "0" is set to this parameter, the safety parameter cannot be modified. The safety parameters can be set when the safety parameters are not locked, that is, when the code for safety parameters is 0, or when the code for safety parameters is the same as the key for safety parameters (No. 3226).
The following safety parameters are protected by a code for safety parameters:

No.0980, No.0981, No.0982, No.1023, No.1240, No.1838, No.1839, No.1840, No.1841, No.1842, No.1902#6, No1904, No.1945, No.1946, No.1948, No.1950, No.3225, No.3717, No.3797, No.4372, No.4438, No.4440, No.4442, No.4448, No.4460, No.10500 to No.10596, No.11950 to No.11957, No.11960 to No.11967, No.11970 to No.11977, No.11980 to No.11987, No.13805, No.13810, No.13811, No.13821 to No.13829, No.13831 to No.13838, No.13840 to No.13843, No.13880 to No.13911, No.13912 to No.13919, No.13920 to No.13951, No.13960 to No.13991

NOTE
Once parameters are locked, the lock must be released or memory must be cleared before the safety parameters can be modified. Moreover, the code for the safety parameters cannot be modified in locked condition. Be careful when setting a code for safety parameters.

3226	Key for safety parameters

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word
[Valid data range] 0 to 99999999

When the same value as the code for safety parameters No.3225 is set in this parameter, the key is opened to enable modifications to the safety parameters. The value set in this parameter is not displayed.
When the value other than 0 is set to the code for safety parameters No.3225 and the value is different from this parameter, the key is locked and the safety parameters can not be modified.
When the power is turned off, the value set in this parameter is cleared to 0. Then the power-off results in the locked state.

3717	Motor number to each spindle

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Byte spindle
[Valid data range] 0 to Maximum number of controlled axes

Set a spindle amplifier number to be assigned to each spindle.
0: No spindle amplifier is connected.
1: Spindle motor connected to amplifier number 1 is used.
2: Spindle motor connected to amplifier number 2 is used.
3: Spindle motor connected to amplifier number 3 is used.

NOTE
When using an analog spindle, set the analog spindle at the end of the spindle configuration.
(Example)
When a system uses three spindles (two serial spindles and one analog spindle) in total, set 3 as the spindle amplifier number (this parameter) of the analog spindle.

	#7	#6	#5	#4	#3	#2	#1	#0
3797								DCNs

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Bit spindle

 # 0 DCNs Each safety check of Dual Check Safety function for the specified spindle is
0: carried out.
1: not carried out.
Set "1" to this bit for the spindle that is not required to apply Dual Check Safety.

4372	Safe speed 1 for each spindle
4438	Safe speed 2 for each spindle
4440	Safe speed 3 for each spindle
4442	Safe speed 4 for each spindle

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] min^{-1}
[Valid data range] 0 to 32767
Set a safe speed for each spindle in terms of motor speed. In case Dual Check Safety function is activated, CNC and Spindle always check the speed of each spindle motor. When it is detected that revolution speed of spindle exceeds safety speed limit, Monitoring Result signal (RSPs) is set to "0". Moreover if the safety check is carried out (Safety Check Request signal *VLDPs ="0"), an alarm SP0757(CNC side) or SP9069(Spindle side) occurs.
Safety Speed can be set up to 4 data. Which speed should be selected is decided by Safety Speed Selection signal (SPAs/SPBs). Please refer more detail to the description about Safety Speed/Safety Position Selection signal.

	#7	#6	#5	#4	#3	#2	#1	#0
4399							CTLSTP	

[Input type] Parameter input
[Data type] Bit spindle

 # 1 CTLSTP When the safe speed over alarm is detected:
0: Performs a free running stop.
1: Performs a controlled stop. (When the motor speed is reduced to the zero-speed detection signal (SST) level or less, excitation is turned off.)

4448	Stop check level

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] min^{-1}
[Valid data range] 0 to 32767
When the speed of the spindle motor is reduced to the speed specified by this parameter or less during free running or controlled stop operation due to the safe speed over alarm, the motor is assumed to have stopped. The setting value must be lower than the parameter "Safe Speed for each spindle".

	#7	#6	#5	#4	#3	#2	#1	#0
10500					STP		APM	AVM

NOTE
When at least one of these parameters is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Bit path

 # 0 AVM In case that a servo alarm occurs,
0: MCC off signal (*MCFVx) is turned to "0" when some alarm occurs.
1: MCC off signal (*MCFVx) is turned to "0" when any alarm occurs.
In case that this parameter is set to "1", MCC off signal (*MCFVx) of all axes, which belong to the same path as the alarm axis, are turned to "0" when a servo alarm occurs.

 # 1 APM In case that a spindle alarm (SPxxxx) occurs

0: MCC off signal (*MCFPs) is turned to “0” when some alarm occurs.

1: MCC off signal (*MCFPs) is turned to “0” when any alarm occurs.

In case that this parameter is set to “1”, MCC off signal (*MCFPs) of all spindles, which belong to the same path as the alarm spindle, are turned to “0” when a spindle alarm occurs.

 # 3 STP When the power is turned on, a MCC off test is:

0: Carried out. (The screen is changed to Dual Check Safety Diagnosis screen automatically and the warning "EXECUTE MCC TEST" is displayed at power-on, and MCC off Test execution request signal (RQT) is output.)

1: Not carried out.

NOTE
1 The STP parameter is used temporarily, for example, when a MCC off Test is not to be made at power-on as in the case of machine adjustment.
2 After adjustment, set STP = 0.
3 Even when STP = 1, a MCC off Test is required if the power is turned 24 hours or more after the completion of the previous MCC off Test.
4 Set the same value for all paths.
5 The screen is changed to “ALARM SCREEN” when an alarm occurs at power-on. In this case, Dual Check Safety Diagnosis screen is not displayed at power-on automatically.

13810 **Timer to start safety I/O signal after power-on**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Word
[Unit of data] msec
[Valid data range] 0 to 32767

In Dual Check Safety function, the time from “CNC start-up” to “I/O cross check error start” is specified just after power-on.

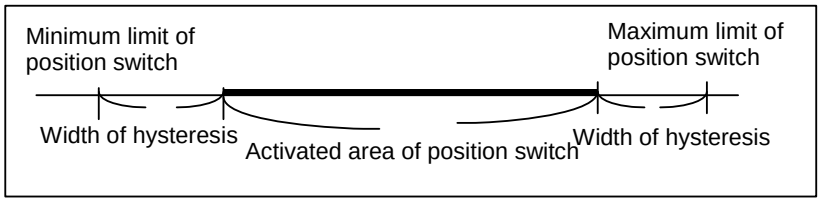
13811	Hysteresis width of position switch (Dual Check Safety)

NOTE
When this parameter is set, the power must be turned off before operation is continued.

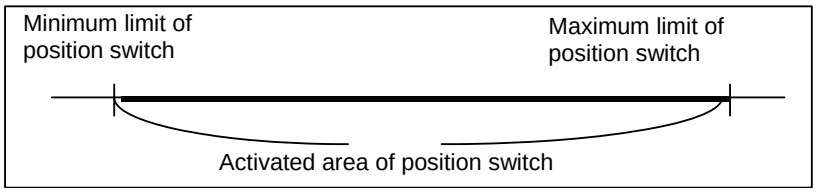
[Input type] Parameter input
[Data type] Real axis
[Unit of data] mm, inch, deg (Machine unit)
[Least unit of data] According to the input increment of corresponding axis
[Valid data range] 0 or positive 9 digit of least input increment of data (Refer to standard parameter setting table(B). But in case that CMR≥1, data range becomes 1/CMR of 9 digits of least input increment of data.)
(When the increment system is IS-B and CMR=1, 0 to +999999.999)
(When the increment system is IS-B and CMR=2, 0 to +499999.999)

NOTE
Whether to specify this parameter by using a diameter value or radius value depends on whether the corresponding axis is based on diameter specification or radius specification.

Position switch sometimes turns on and off repeatedly near the boundary of position switch area by very small vibration of a servo motor. According to this problem, position switch is inconvenient to use. So “hysteresis” described below is applied.



Measuring area of position switch in case state of switch is “0”



Measuring area of position switch in case state of switch is “1”

The position switch is checked at every sampling period. When the minimum and maximum limit of position switch are given like above figure, activated area is checked by the area shown in the upper figure above considering hysteresis if the state of position switch measured at last time is “0”. And activated area is checked by the area shown in the lower figure above not considering hysteresis if the state of position switch measured at last time is “1”. According to this, it is possible to suppress frequent changing of position switch.

13821	Safety limit speed 1 in position control for each axis
13822	Safety limit speed 2 in position control for each axis
13823	Safety limit speed 3 in position control for each axis
13824	Safety limit speed 4 in position control for each axis

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Real axis
[Unit of data] mm/min, inch/min, degree/min (machine unit)
[Minimum unit of data] Depend on the increment system of the applied axis
[Valid data range] Refer to the standard parameter setting table (C)
(When the increment system is IS-B, 0.0 to +240000.0)

Set a safety speed for each axis in position control.
CNC and Servo always check the velocity command of each axis in Dual Check Safety function. If an axis for which a speed higher than the safety speed is specified is detected, the Monitoring Result signal RSVx is set to 0. Moreover if Safety Check request signal (*VLDVx) is set to "0", an alarm SV0476 or SV0494 is generated for the corresponding axis.
A safety speed parameter for each axis in feed control is from No.13826 to No.13829.
Up to 4 safety speed can be specified. Safety speed is selected by Safety Speed / Safety Position Selection signal (SVAx/SVBx). As for the detail of Safety Speed / Safety Position Selection signal, refer to the description about Safety Speed / Safety Position Selection signal.

NOTE
1 The safety speed checks are made on the basis of the speed converted to the detection unit. Accordingly, a calculation error may occur.
2 After safety speed parameters No.13821 to No.13824 have been set, the power must be turned off then back on for the setting to become effective
3 For diameter specification, set the speed by the diameter (use changes in diameter/rev or in diameter/min).

13825	Speed regarded as axis stop for Dual Check Safety

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Real axis
[Unit of data] mm/min, inch/min, degree/min (machine unit)
[Minimum unit of data] Depend on the increment system of the applied axis
[Valid data range] 0 to 10000

This parameter sets the speed regarded as axis stop in case that an abnormal condition is found in safety speed check or safety machine position check of Dual Check Safety function.
When an abnormal condition is found in safety speed check or safety machine position check, a servo alarm occurs. And whether MCC off signal (*MCFVx) is turned off or not is decided by judging if an axis is stopped after the decided time elapse. At that time, this parameter gives the speed to judge axis stop.
In case an abnormal condition is detected and an axis is stopped within the given time, an MCC is not turned off. Then the system can be recovered by reset operation without power-off.

NOTE
1 For diameter specification, set the speed by the diameter (use changes in diameter/rev or in diameter/min).
2 In case of velocity control, set the value calculated by the following formula to this parameter when R(min^{-1}) is the velocity, at which the axis is regarded as stopped.

Setting value = R × PLS × Minimum data unit (Machine unit) × N / CMR

PLS: Pulse per one revolution of motor (Detection unit)
CMR: Command multiplier
N: In case of diameter specification, N=2.
In case of radius specification, N=1.
Minimum data unit: Refer to “STANDARD PARAMETER SETTING TABLE”.

13826	Safety limit speed 1 in velocity control for each axis
13827	Safety limit speed 2 in velocity control for each axis
13828	Safety limit speed 3 in velocity control for each axis
13829	Safety limit speed 4 in velocity control for each axis

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word axis
[Unit of data] min^{-1}
[Valid data range] 0 to maximum motor speed
This parameter sets the safety speed 1 to 4 for each axis in velocity control mode in Dual Check Safety function.

13831	Safety machine position 1 for each axis (+ direction)
13832	Safety machine position 1 for each axis (- direction)
13833	Safety machine position 2 for each axis (+ direction)
13834	Safety machine position 2 for each axis (- direction)
13835	Safety machine position 3 for each axis (+ direction)
13836	Safety machine position 3 for each axis (- direction)
13837	Safety machine position 4 for each axis (+ direction)
13838	Safety machine position 4 for each axis (- direction)

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Real axis
[Unit of data] mm, inch, degree (machine unit)
[Minimum unit of data] Depend on the increment system of the applied axis
[Valid data range] 9 digits of minimum unit of data (Refer to standard parameter setting table(A). But in case that CMR≥1, data range becomes 1/CMR of 9 digits of minimum unit of data.)
(When the increment system is IS-B and CMR=1, -999999.999 to +999999.999)
(When the increment system is IS-B and CMR=2, -499999.999 to +499999.999)

NOTE
Whether to specify this parameter by using a diameter value or radius value depends on whether the corresponding axis is based on diameter specification or radius specification.

Set a safe machine position for each axis.
CNC and Servo always check the machine position on each axis in Dual Check Safety function.
If the machine position is out of the safety machine range even on one axis, Monitoring Result signal (RSVx) corresponding to that axis is set to "0". Moreover if Safety Check request signal (*VLDVx) is set to "0", an alarm SV0477 or SV0495 is generated for the corresponding axis.
Up to 4 safety machine position can be specified. Safety machine position is selected by Safety Speed / Safety Position Selection signal (SVAx/SVBx). As for the detail of Safety Speed / Safety Position Selection signal, refer to the description about Safety Speed / Safety Position Selection signal.

⚠ CAUTION
The safety machine position checks are made on the basis of the machine position to the detection unit. Accordingly, a calculation error may occur.

⚠ WARNING
1 CNC and Servo check the machine position of only each axis whose reference position is established, and not check it of each axis whose reference position is not established.
2 After safety machine position parameters No.13831 to No.13838 have been set, the power must be turned off then back on for the setting to become effective.

13840	Address to which safety position switch 1 to 16 are assigned
13841	Address to which safety position switch 17 to 32 are assigned
13842	Address to which safety position switch 33 to 48 are assigned
13843	Address to which safety position switch 49 to 64 are assigned

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Byte
[Valid data range] 0, 1, 10, 11

According to this parameter, the address to output 64 points of position switch signals can be assigned for each 16 points.
When one path is used, up to 32 safety position switches can be set. When two paths are used with the T series, up to 64 safety position switches can be set.
The assigning addresses are Fn755 to Fn756 (PMC) / F(007+m) to F(008+m) (DCS PMC) and Fn757 to Fn758 (PMC) / F(009+m) to F(010+m) (DCS PMC) in each path. (n: 0 to 1, m: (0 to 1) × 20)

The units of this parameter value specifies which address the signal of each path should be output to, “Fn755 to Fn756” (PMC) / “F(007+m) to F(008+m)” (DCS PMC) or “Fn757 to Fn758” (PMC) / “F(009+m) to F(010+m)” (DCS PMC).

Setting value	Assigned address
0	Fn755 to Fn756(PMC), F(007+m) to F(008+m) (DCS PMC)
1	Fn757 to Fn758(PMC), F(009+m) to F(010+m) (DCS PMC)

The tens of this parameter value specify which path the signal should be output to.

Setting value	Output path
0	Path 1
1	Path 2

The relationship between parameter settings and assigned addresses is shown below.

Setting value	Assigned address (PMC)	Assigned address (DCS PMC)
00	F0755 - F0756	F007 - F008
01	F0757 - F0758	F009 - F010
10	F1755 - F1756	F027 - F028
11	F1757 - F1758	F029 - F030

[Example]

Parameter No.	Setting value	Output address of position switch signal
13840	00	F755-F756 (1st to 16th position switch)(PMC) F007-F008 (1st to 16th position switch)(DCS PMC)
13841	10	F1755-F1756 (17th to 32nd position switch) (PMC) F027-F028 (17th to 32nd position switch)(DCS PMC)
13842	01	F757-F758 (33rd to 48th position switch) (PMC) F009-F010 (33rd to 48th position switch)(DCS PMC)
13843	11	F1757-F1758 (49th to 64th position switch) (PMC) F029-F030 (49tht to 64th position switch)(DCS PMC)

NOTE

1 If all setting values are “0”, the output address is regarded as follows.
Position switch 1 to 16: F755-F756(PMC) / F007-F008(DCS PMC)
Position switch 17 to 32: F757-F758(PMC) / F009-F010(DCS PMC)
Position switch 33 to 48: F1755-F1756(PMC) / F027-F028(DCS PMC)
Position switch 49 to 64: F1757-F1758(PMC) / F029-F030(DCS PMC)

2 Do not assign two or more position switch to the same address.

13880	Axis corresponding to the 1st safe position switch
:	:
13911	Axis corresponding to the 32nd safe position switch
10501	Axis corresponding to the 33rd safe position switch
:	:
10532	Axis corresponding to the 64th safe position switch

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Byte
[Valid data range] 0 to Number of controlled axes

These parameters specify the control-axes numbers corresponding to the 1st thorough 64th safe position switch functions. When one path is used, up to 32 safety position switches can be set. When two paths are used with the T series, up to 64 safety position switches can be set. A corresponding position switch signal is output to "I/O Link#1 or #2" and "I/O Link#3, #4 or PROFIBUS-DP" when the machine coordinate value of a corresponding axis is within the range that is set using a parameter.

NOTE
1 Set 0 for those position switch numbers that are not to be used. (The safe position switch signal of that number is not output.)
The safe position switch signal for the axis whose parameter No.1904#6 is 1 (Dual Check Safety function is disabled) is not output.
2 After safety position switch parameters No.13880 to No.13911, No.10501 to No.10532 have been set, the power must be turned off then back on for the setting to become effective

13912	Enable/disable brake test

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Integer axis
[Valid data range] 0,1

This parameter enables or disables brake test. To disable brake test, set this parameter to 0. To enable brake test, set this parameter to 1.

13913 **Brake test interval**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Word
[Unit of data] Time
[Valid data range] 0 to 168
This parameter sets a time interval between two successive brake tests. When the time set in this parameter has elapsed after a brake test, the Brake Test Execution Request signal RQBT is set to 1. When 0 is set in this parameter, the setting of 8 hours is assumed.

13914 **Time t1 after output of the brake signal until the brake operates**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Integer axis
[Unit of data] msec
[Valid data range] 0 to 999999999
To ensure correct timing relative to the *BRKx signal until a move command is issued in a brake test on each axis, this parameter sets a time after controlling of the *BRKx signal until the brake is applied and a time after controlling of the *BRKx signal until the brake is released. If a time for applying the brake differs from a time for releasing the brake, set a longer time. When 0 is set in this parameter, the setting of 400 ms is assumed.

13915 **Brake test current limit override value**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Integer axis
[Unit of data] (100/255)%
[Valid data range] 0 to 255
This parameter sets a current limit override value applicable to a brake test. The relationship between a set value and torque limit override value is as follows:

$$\text{Torque limit override value} = (\text{Setting}/255) \times 100(\%)$$

When 0 is set in this parameter, the setting of 12% is assumed.

13916	Travel distance to be specified for brake test

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Real axis
[Unit of data] mm, inch, degree (machine unit)
[Minimum unit of data] Depend on the increment system of the applied axis
[Valid data range] 9 digit of minimum unit of data (refer to standard parameter setting table (A))
(When the increment system is IS-B, -999999.999 to +999999.999)
This parameter sets a travel distance on each axis to be specified for brake test. When 0 is set in this parameter, the setting of 1.000 mm (or value equivalent to 1.000 mm on an inch machine) or 1.000 degree is assumed.

⚠ CAUTION
If a value smaller than the tolerance value (parameter No. 13918) for position deviation to be monitored in a brake test is set in this parameter, the brake test may not be conducted normally.

NOTE
For an axis based on diameter specification, set a diameter value.

13917	Speed command to be specified for brake test

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Real axis
[Unit of data] mm/min, inch/min, degree/min (machine unit)
[Minimum unit of data] Depend on the increment system of the applied axis
[Valid data range] Refer to the standard parameter setting table (C)
(When the increment system is IS-B, 0.0 to +240000.0)
This parameter sets a speed to be specified for each axis in a brake test. When 0 is set in this parameter, the setting of 10 mm/min (value equivalent to 10 mm/min on an inch machine) or 10 degrees/min is assumed.

13918 **Tolerance value for position deviation to be monitored in brake test**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Integer axis
[Unit of data] Detection unit
[Valid data range] 0 to 999999999

This parameter sets a tolerance value for position deviation to be monitored in a brake test on each axis. In a comparison made between a travel distance and position deviation when brake control is exercised, the normal range spans from the reference position deviation plus the setting of this parameter to the reference position deviation minus the setting of this parameter. If a value not within the normal range is detected, alarm DS0039 or DS0040 is issued. When 0 is set in this parameter, the setting of 100 is assumed.

Normal position deviation range

Reference position deviation (position deviation relative to a specified value)

13919 **Position deviation monitor time t2 in brake test**

NOTE
When this parameter is set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Integer axis
[Unit of data] msec
[Valid data range] 0 to 32767

This parameter sets time t2 for position deviation monitoring in a brake test on each axis. During this time, torque is applied to the brake. When 0 is set in this parameter, the setting of 1000 ms is assumed.

13920	Maximum operation range of the 1st safe position switch
:	:
13951	Maximum operation range of the 32nd safe position switch
10533	Maximum operation range of the 33rd safe position switch
:	:
10564	Maximum operation range of the 64th safe position switch

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Real
[Unit of data] mm, inch, degree (machine unit)
[Minimum unit of data] Depend on the increment system of the reference axis
[Valid data range] 9 digits of minimum unit of data (Refer to standard parameter setting table(A). But in case that CMR≥1, data range becomes 1/CMR of 9 digits of minimum unit of data.)
(When the increment system is IS-B and CMR=1, -999999.999 to +999999.999)
(When the increment system is IS-B and CMR=2, -499999.999 to +499999.999)

NOTE
Whether to specify this parameter by using a diameter value or radius value depends on whether the corresponding axis is based on diameter specification or radius specification.

These parameters set the maximum operation range of the 1st through 64th safe position switches. When one path is used, up to 32 safety position switches can be set. When two paths are used with the T series, up to 64 safety position switches can be set.

⚠ CAUTION
1 When the machine position is on the boundary of the specified ranges (machine position = parameter setting value), it is considered within the specified ranges.
2 When the setting of operation range is “maximum operation range < minimum operation range”, the safe position switch is not output.
3 If parameter No.13920 to No.13951, No.13533 to No.13564 are changed, please turn the power of the machine off once.

13960	Minimum operation range of the 1st safe position switch
:	:
13991	Minimum operation range of the 32nd safe position switch
10565	Minimum operation range of the 33rd safe position switch
:	:
10596	Minimum operation range of the 64th safe position switch

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] Real
[Unit of data] mm, inch, degree (machine unit)
[Minimum unit of data] Depend on the increment system of the reference axis
[Valid data range] 9 digits of minimum unit of data (Refer to standard parameter setting table(A). But in case that CMR≥1, data range becomes 1/CMR of 9 digits of minimum unit of data.)
(When the increment system is IS-B and CMR=1, -999999.999 to +999999.999)
(When the increment system is IS-B and CMR=2, -499999.999 to +499999.999)

NOTE
Whether to specify this parameter by using a diameter value or radius value depends on whether the corresponding axis is based on diameter specification or radius specification.

These parameters set the minimum operation range of the 1st through 64th safe position switches. When one path is used, up to 32 safety position switches can be set. When two paths are used with the T series, up to 64 safety position switches can be set.

⚠ CAUTION
1 When "machine position = parameter setting", the safety position switch operation range is assumed to be satisfied.
2 When the setting of operation range is “maximum operation range < minimum operation range”, the safe position switch is not output.
3 If parameter No.13960 to No.13991, No.10565 to No.10596 are changed, please turn the power of the machine off once.

11950	1st byte address of Safety input signal for CNC CPU
:	:
11957	8th byte address of Safety input signal for CNC CPU

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word
[Valid data range] 0 to 3999999

Besides the standard safety I/O signals, 8-byte (64-bit) Programmable Safety I/O signals can be freely defined. These parameters set the address of the 1st through 8th double checked input signals of CNC CPU (DCS PMC).

Setting value = TYPE + ADRS
ADRS = Byte address

TYPE	Meaning
0	This signal is not checked.
1000000	X address
2000000	R address
3000000	D address

Setting example) X8 : setting value = 1000008
R8 : setting value = 2000008

11960	1st byte address of Safety output signal for CNC CPU
:	:
11967	8th byte address of Safety output signal for CNC CPU

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word
[Valid data range] 0 to 3999999

Besides the standard safety I/O signals, 8-byte (64-bit) Programmable Safety I/O signals can be freely defined. These parameters set the address of the 1st through 8th double checked output signals of CNC CPU(DCS PMC).

Setting value = TYPE + ADRS
ADRS = Byte address

TYPE	Meaning
0	This signal is not checked.
1000000	Y address
2000000	R address
3000000	D address

Setting example) Y8 : setting value = 1000008
R8 : setting value = 2000008

11970	1st byte address of Safety input signal for PMC CPU
:	:
11977	8th byte address of Safety input signal for PMC CPU

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word
[Valid data range] 0 to 104999999

Besides the standard safety I/O signals, 8-byte (64-bit) Programmable Safety I/O signals can be freely defined. These parameters set the address of the 1st through 8th double checked input signals of PMC CPU.

Setting value = TYPE + ADRS
ADRS = Byte address

TYPE	Meaning
0	This signal is not checked
101000000	X address
102000000	R address
103000000	D address
104000000	E address

Setting example) X8 : setting value = 101000008
E8 : setting value = 104000008

11980	1st byte address of Safety output signal for PMC CPU
:	:
11987	8th byte address of Safety output signal for PMC CPU

NOTE
When these parameters are set, the power must be turned off before operation is continued.

[Input type] Parameter input
[Data type] 2-word
[Valid data range] 0 to 104999999

Besides the standard safety I/O signals, 8-byte (64-bit) Programmable Safety I/O signals can be freely defined. These parameters set the address of the 1st through 8th double checked output signals of PMC CPU.

Setting value = TYPE + ADRS
ADRS = Byte address

TYPE	Meaning
0	This signal is not checked
101000000	Y address
102000000	R address
103000000	D address
104000000	E address

Setting example) X8 : setting value = 101000008
E8 : setting value = 104000008

6.6 PROFIBUS-DP PARAMETER SETTINGS

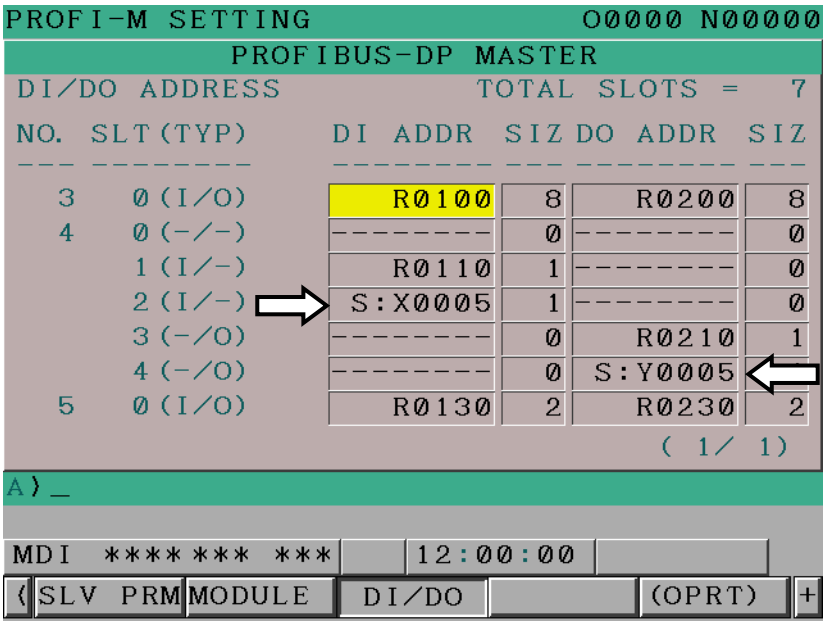
PROFIBUS DI/DO signals can be assigned to Dual Check Safety PMC per each slot unit.
To configure PROFIBUS parameters, please refer to Part II, "SETTING" of "FANUC PROFIBUS-DP board (for Series 0*i*-MODEL-D) Operator's manual / B-64404EN". The following is the additional information relating to Dual Check Safety function.

Assigning PROFIBUS DI/DO signals to Dual Check Safety PMC

Assigning PROFIBUS DI/DO signals to Dual Check Safety PMC can be set up as follows.

1. Press soft key [DI/DO] ([DI/DO ADDR]) to display the DI/DO ADDRESS screen.
2. Set the DI/DO addresses (DI ADDR and DO ADDR) according to the following format.
   S : <PMC-address>

For R0500 of Dual Check Safety PMC, for example, "S:R0500" must be entered.
X and R address is available to DI ADDRess.
Y and R address is available to DO ADDRess.
If there is no ":" key in your CNC unit, it is substituted with the "/" or "EOB" key.



Broken wire detection

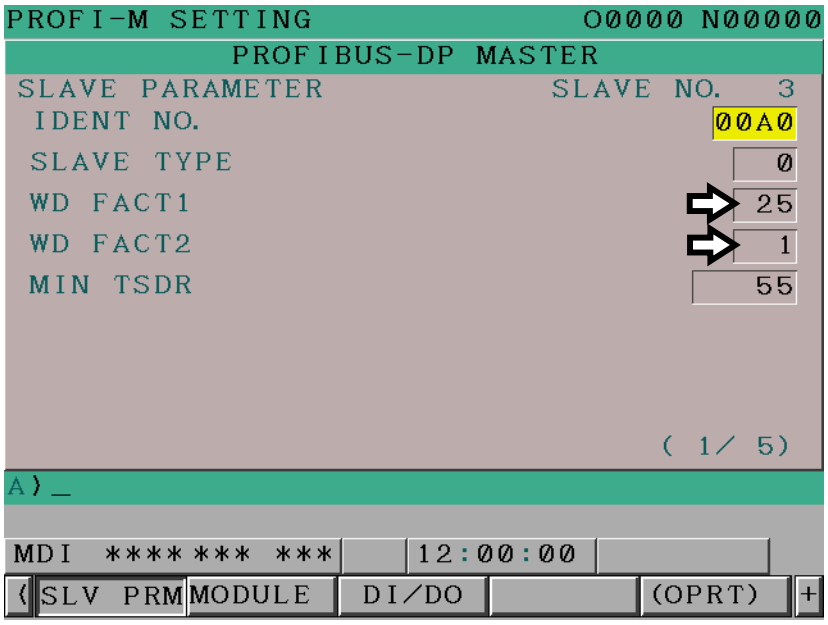
"Broken wire detection" enables slaves to monitor the communication interval, detect the communication error when a slave cannot receive data from the Master, and clear the DO data which is received from Master.
"Broken wire detection" and "Watchdog time" are configured with Slave parameters which are transferred from Master to Slaves during initialization.

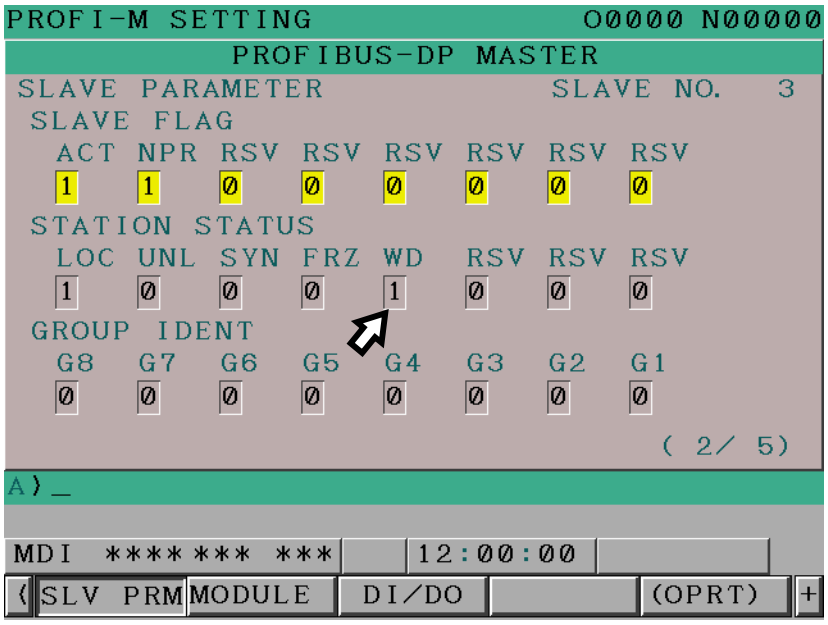
When PROFIBUS-DP signal is used for Dual Check Safety function, please activate “Broken wire detection”.
“Watchdog time” should be set to several times longer than the refresh time in consideration of re-transmission. The refresh time can be observed in STATUS INFORMATION screen of PROFIBUS setting screen.

“Broken wire detection” and “Watchdog time” can be configured in PROFIBUS setting screen.
When “1” is set into “WD”, “Broken wire detection” becomes active.
“Watchdog time” is calculated with the following expression.

$$10 \times \text{WD\_FACT1} \times \text{WD\_FACT2 (ms)}$$

For example, in the following setting, “Broken wire detection” will activate when a watchdog time of 250ms expires.





7 START-UP

7.1 START-UP OPERATION

The machine tool builder has to do tests for insulation and protective bonding. Testing must be performed according to Chapter 19.2 and 19.3 of the standard IEC 60204-1 by an appropriately authorized person and recorded.

Continuity of the protective bonding circuit

When the machine is installed and the electrical connections are complete, including those to the power supply, the continuity of the protective bonding circuit can be verified by a loop impedance test in accordance with 612.6.3 of IEC 60364-6-61. For further details, please refer to Chapter 19.2 of IEC 60204-1.

Insulation resistance tests

The insulation resistance measured at 500 V d.c. between the power circuit conductors and the protective bonding circuit is to be not less than 1 M Ω. For further details, please refer to Chapter 19.3 of IEC 60204-1.

7.1.1 Acceptance Test and Report for Safety Functions

Acceptance test for Safety function

The machine tool builder is to conduct a Dual Check Safety function check test during machine start-up operation.
In this test, limits need to be exceeded to check that the Dual Check Safety function operates normally.

Acceptance report

A qualified person is to check each Dual Check Safety function and record the test results in a check report.

NOTE
When modifying Dual Check Safety function data, conduct an additional check test on the modified Dual Check Safety function and record the test results in a check report.

Safety-related I/O monitoring test

Data cross-check operation is tested with the I/O device connector detached.

MCC off Test check

The test mode signal is used to check that a MCC off Test is conducted.
Negative test:

Conduct a MCC off Test by disconnecting the MCC contact signal (input). Check that an alarm is issued and the MCC remains to be shut off.

Safety limitation speed monitoring test

This test checks that when the actual speed exceeds a speed limit, safety stop state is set by a stop response.

Safety machine position monitoring test

A positional limit test is conducted by making many different movements.
A positional limit is placed at the center of an axis, and the position is moved at many different speeds in a rapid traverse mode. Thus, the distance traveled on the axis until stop state is set by a stop response is measured. The machine tool builder is to determine a safety limit stop position including a safety margin.

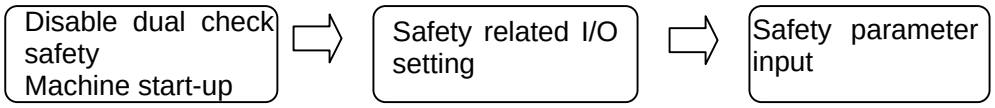
Data modification

The user needs to enter the correct password before setting safety parameters with the system. After a safety parameter is modified, a check test needs to be conducted on the related safety function, and the test results need to be recorded in a report.

7.2 START-UP OF THE SAFETY FUNCTION

7.2.1 Initial Start-up

Main flow



Step 1

Initial state

First, check that the machine starts up normally when the Dual Check Safety function is disabled.

Preparation 1	Disable the Dual Check Safety function	Bit 6 (DCE) of parameter No. 1902 = 0
Preparation 2	Wire to control the MCC	Connect the relay to control MCC with I/O output

NOTE

When the Dual Check Safety function is disabled, the MCC Off signal (*DCALM, *MCFVx, *MCFPs) is set to “1”. (The MCC Off signal (*MCF) changes according to the state of the emergency stop signal on the PMC side.) So, make a ladder program to output DO signal to control the relay for the MCC control according to the MCC Off signal.

Step 2

DCS PMC side I/O setting

Make the settings as for the I/O Link#3 or PROFIBUS. Make a ladder program for the safe related I/O. (PMC/DCS PMC)

In case PROFIBUS is used, please refer to the Section 6.6, “Assignment of PROFIBUS DI/DOs to Dual Check Safety PMC”

Step 3

Safety parameter input

Enable the Dual Check Safety function, and enter the safety parameters.

Preparation 1	Enable the Dual Check Safety function	Bit 6 (DCE) of parameter No. 1902 = 1

Set the safety parameters indicated in the table below.

Parameter setting	Meaning
980	Machine group number of each path
981	Absolute path number of each axis
982	Absolute path number of each spindle
1023	Servo axis number of each axis
1240	Coordinates value of the reference position in the machine coordinate system
1838	Position deviation limit for each axis in moving state
1839	Position deviation limit for each axis in stopped state
1840	Position deviation limit for each axis in servo-off state
1841	Position deviation limit of each axis in moving state during other than Dual Check Safety monitoring (for Dual Check Safety Function)
1842	Position deviation limit of each axis in stopped state during other than Dual Check Safety monitoring (for Dual Check Safety Function)
1904#6	Enable safety function for each axis
1945	Timer for safety input signal check
1946	Timer for MCC off Test
1948	Timer for MCC off
1950	Break signal timer
3717	Motor number to each spindle
3797#0	Enable safety function for each spindle
4372	Safety speed 1 on each spindle
4438	Safety speed 2 on each spindle
4440	Safety speed 3 on each spindle
4442	Safety speed 4 on each spindle
4448	Speed regarded as spindle stop for Dual Check Safety
13821	Safety speed 1 on each axis
13822	Safety speed 2 on each axis
13823	Safety speed 3 on each axis
13824	Safety speed 4 on each axis
13825	Speed regarded as axis stop for Dual Check Safety
13831	Safety position 1 (+ direction) on each axis
13832	Safety position 1 (- direction) on each axis
13833	Safety position 2 (+ direction) on each axis
13834	Safety position 2 (- direction) on each axis
13835	Safety position 3 (+ direction) on each axis
13836	Safety position 3 (- direction) on each axis
13837	Safety position 4 (+ direction) on each axis
13838	Safety position 4 (- direction) on each axis

Step 4

If alarm SV0478 or SV0496 occurs, set the parameter No.2212#4 is set to “1” and then set to “0”.
Then turn off the CNC and the amplifier. And turn on the CNC and the amplifier.

Step 5

Execution of general machine tests
Axis and spindle optimization
Dual Check Safety function adjustment (safety limitation speed, safety machine position, Safe position error monitoring)

Step 6

Test for checking the safety function
Check test execution and report creation

Step 7

Parameter preservation

Save all parameters including the safety parameters. The parameters are used to start up the series.

Step 8

Set a password.

A password is used to disable unauthorized persons from modifying safety parameters. Before safety parameters of the equipment for which a password (parameter No. 3225) is set can be modified, the password value must be set as the keyword (parameter No. 3226). Only those persons authorized to conduct a check test should know the password value.

7.2.2 Series (2nd and Subsequent Machines) Startup

The parameters for the safety monitoring function are transferred together with other parameters to the CNC as in the case of normal series start-up. Perform a safety function check test in addition to the normal start-up procedure.

7.2.3 Troubleshooting

Alarms related to the safety function are output on the ALARM screen.
Correct the cause of trouble according to the chapter describing alarms and messages in this manual. When a component related to the safety function is to be replaced, an authorized person must conduct a safety function check test.

8 ALARM MESSAGE

Alarm

When Dual Check Safety function finds out some abnormal condition in safety check and generates an alarm, the alarm can be reset by reset operation if the abnormal condition is cleared.
However, if the problem related with the system is found and an alarm is generated when unfit condition is found by double check function of signals or so on, alarm cannot be cancelled by a reset. In this case, to cancel the alarms, turn off the power.

Servo Alarms (SV alarm)

No.	Message	Description
SV0474	EXCESS ERROR (STOP:SV)	The Servo detected that the positional deviation during stopping exceeded the parameter (No. 1839, No.1842) setting value.
SV0475	EXCESS ERROR (MOVE:SV)	The Servo detected that the positional deviation during traveling exceeded the parameter (No. 1838, No.1841) setting value. (Dual Check Safety)
SV0476	ILLEGAL SPEED CMD. (SV)	The Servo detected that the specified speed on the axis exceeded the safety speed (parameter No. 13821 to 13824, No. 13826 to 13829) during safety monitoring (the safety check request signal (*VLDVx) is 0). When the guard is open, confirm a proper value is set to parameter (No. 13821 to 13824, No. 13826 to 13829), and the operation is done within the safety speed.
SV0477	ILLEGAL MACHINE POS.(SV)	The Servo detected that the machine position on the axis is not in the safety area (parameter No.13831 to 13838) during safety monitoring (the safety check request signal (*VLDVx) is 0). When the guard is open, confirm a proper value is set to parameter No.13831 to 13838 and do an operation in the safety area. The safe machine position monitoring is done after the machine reference position is established.
SV0478	ILLEGAL AXIS DATA (SV)	The Servo detected that an error occurred on the axis during axis data transfer. If the alarm occurs after performing axis number setting for the servo amplifier, set parameter No.2212#4 to 1, and reset the bit to 0, and then turn off the power to the entire system. When a multiaxis amplifier is used, the alarm may not be cleared even if the above operation is performed once. In this case, repeat the operation on the axis for which the alarm persists until it is cleared. In the other case, replace the servo amplifier if the alarm occurred.
SV0481	SAFETY PARAM ERROR(SV)	Error detected for safety parameter check function by Servo.
SV0484	SAFETY FUNCTION ERROR (SV)	An error occurred in safety functions of Servo: 1) The Servo or CNC detected the inexecution of servo software safety functions. 2) A mismatch between the servo software results of the safety functions and the CNC results of them occurred. 3) An error occurred in a servo CPU test. 4) An error occurred in a servo RAM test.

No.	Message	Description
SV0488	SELF TEST OVER TIME	MCC off Test was not completed within the specified time (parameter No. 1946). Check the MCC contact.
SV0489	SAFETY PARAM ERROR(CNC)	Error for safety parameter check function is detected on n-th axis by CNC.
SV0490	SAFETY FUNCTION ERROR (CNC)	An error occurred in safety functions of CNC: 1) The Servo detected the inexecution of CNC safety functions. 2) A mismatch between the CNC results of the safety functions and the Servo results of them occurred.
SV0494	ILLEGAL SPEED CMD. (CNC)	The CNC detected that the specified speed exceeded the setting (parameter No. 13821 to 13824 in case of position control, No. 13826 to 13829 in case of velocity control) during safety monitoring (the safety check request signal(*VLDVx) is 0). When the guard is open, confirm a proper value is set to parameter (No. 13821 to 13824, No. 13826 to 13829), and the operation is done within the safety speed.
SV0495	ILLEGAL MACHINE POS.(CNC)	The CNC detected that the machine position is not in the safety area (parameter No.13831 to 13838) during safety monitoring (the safety check request signal(*VLDVx) is 0). When the guard is open, confirm proper values is set to parameter No. No.13831 to 13838, and operation is done in the safety area. The safe machine position monitoring is done for the axis whose machine reference position is established.
SV0496	ILLEGAL AXIS DATA (CNC)	The CNC detected that an error occurred during axis data transfer. If the alarm occurs after performing axis number setting for the servo amplifier, set parameter No.2212#4 to 1, and reset the bit to 0, and then turn off the power to the entire system. When a multiaxis amplifier is used, the alarm may not be cleared even if the above operation is performed once. In this case, repeat the operation on the axis for which the alarm persists until it is cleared. In the other case, replace the servo amplifier where the alarm occurred.
SV0498	AXIS NUMBER NOT SET (CNC)	The CNC detected that the axis number is not set with the servo amplifier. Turn off the power to the entire system. Then an axis number is automatically set.
SV1068	DUAL CHECK SAFETY ALARM	The alarm which shut off the MCC(system common) occurred in the Dual Check Safety function.
SV1069	EXCESS ERROR (SERVO OFF: CNC)	The CNC detected that the positional deviation at servo off time exceeded the parameter (No. 1840) setting value.
SV1070	EXCESS ERROR (SERVO OFF:SV DSP)	The Servo detected that the positional deviation at servo off time exceeded the parameter (No. 1840) setting value.
SV1071	EXCESS ERROR (MOVE: CNC)	The CNC detected that the positional deviation during moving exceeded the parameter (No.1838, No.1841) setting value. (Dual Check Safety)
SV1072	EXCESS ERROR (STOP:CNC)	The CNC detected that the positional deviation during stopping exceeded the parameter (No.1839, No.1842) setting value.

Spindle Alarms (SP alarm)

No.	Message	Description
SP0755	SAFETY FUNCTION ERROR	The CNC CPU detected that the safety function of the n-th spindle was not executed. Alternatively, the result of CNC safety function checking did not match the result of spindle safety function checking.
SP0756	ILLEGAL AXIS DATA	The CNC CPU detected that the connection state and the hardware setting of the spindle amplifier were incompatible on the n-th spindle. If an alarm occurs because of the configuration change of the spindle amplifier, set the spindle amplifier correctly.

No.	Message	Description
SP0757	SAFETY SPEED OVER	The CNC CPU detected that during safety monitoring (the safety check request signal(*VLDPs) is 0), the spindle motor speed was greater than the safety speed (parameter No. 4372, 4438, 4440, or 4442) on the n-th spindle. Operate within the safety speed.
SP1700	SAFETY PARAM ERROR	The CNC CPU detected error in safety parameter check function.

Alarms requiring power to be turned off (PW alarm)

No.	Message	Description
PW0008	CPU SELF TEST ERROR(DCS PMC)	The DCS PMC detected the error in the CPU self test function and RAM check function.
PW0009	CPU SELF TEST ERROR(PMC)	The PMC detected the error in the CPU self test function and RAM check function.
PW0010	SAFE I/O CROSS CHECK ERROR(DCS PMC)	The DCS PMC detected the error of system define safe I/O in the I/O cross check function.
PW0011	SAFE I/O CROSS CHECK ERROR(PMC)	The PMC detected the error of system define safe I/O in the I/O cross check function.
PW0012	USER I/O CROSS CHECK ERROR(DCS PMC)	The DCS PMC detected the error of user define safe I/O in the I/O cross check function.
PW0013	USER I/O CROSS CHECK ERROR(PMC)	The PMC detected the error of user define safe I/O in the I/O cross check function.
PW0014	CPU TEST ALARM (CNC)	An error occurred in a CNC CPU test.
PW0015	SAFETY PARAM ERROR	The CNC detected error for safety parameter check function.
PW0016	RAM CHECK ERROR	The CNC detected error in RAM check function.
PW0017	INEXECUTION OF SAFETY FUNCTIONS	The CNC detected abnormal condition in the execution of CNC safety functions.
PW0018	CRC CHECK ERROR	The CNC detected the CRC check error in the CNC ROM.

Other alarms (DS alarm)

No.	Message	Description
DS0022	DUAL CHECK SAFETY IS NOT WORKED	Dual Check Safety function is unavailable by setting a parameter No.1902#6 to 0.

Serial Spindle Alarms

No.	Message	SP indication	Faulty location and remedy	Description
SP9016	SSPA:16 RAM ERROR	16	Replace the Spindle amplifier control printed-circuit board.	An error in a spindle amplifier control circuit component was detected. (Error in RAM for external data)
SP9069	SAFETY SPEED OVER	69	1) Check the speed command. 2) Check the parameter setting. 3) Check the sequence.	Safety speed exceeded A motor speed exceeding the safety speed was detected when the safety speed monitoring is enabled. Alternatively, an error was detected at free-run stop time.
SP9070	ILLEGAL AXIS DATA	70	Match the setting on the spindle amplifier side to the connection state.	Axis data error The connection state of the spindle amplifier does not match the amplifier setting.

No.	Message	SP indication	Faulty location and remedy	Description
SP9071	SAFETY PARAMETER ERROR	71	1) Reenter the safety parameters. 2) Replace the Spindle amplifier control printed-circuit board.	Safety parameter error An error wad detected in safety parameter checking.
SP9072	MISMATCH RESULT OF MOTOR SPEED CHECK	72	1) Replace the Spindle amplifier control printed-circuit board. 2) Replace the main board or sub-CPU board on the CNC.	Motor speed judgment mismatch A motor speed judgment mismatch occurred between the CNC and spindle amplifier.
SP9074	CPU TEST ERROR	74	Replace the Spindle amplifier control printed-circuit board.	An error was detected in CPU test.
SP9075	CRC ERROR	75	Replace the Spindle amplifier control printed-circuit board.	An error was detected in ROM CRC test.
SP9076	INEXECUTION OF SAFETY FUNCTIONS	76	Replace the Spindle amplifier control printed-circuit board.	Safety function not executed Any safety function was not executed.
SP9077	MISMATCH RESULT OF AXIS NUMBER CHECK	77	1) Replace the Spindle amplifier control printed-circuit board. 2) Replace the main board or sub-CPU board on the CNC.	Axis number judgment mismatch An axis number check result mismatch occurred between the CNC and spindle amplifier.
SP9078	MISMATCH RESULT OF SAFETY PARAMETER CHECK	78	1) Replace the Spindle amplifier control printed-circuit board. 2) Replace the main board or sub-CPU board on the CNC.	Safety parameter judgment mismatch A safety parameter check result mismatch occurred between the CNC and spindle amplifier.
SP9079	INITIAL TEST ERROR	79	Replace the Spindle amplifier control printed-circuit board.	The safety functions at power-up for spindle were not executed.

Boot System Alarms

Message	Description
CRC CHECK ERROR:NC BASIC.	CRC error occurs in CNC BASIC ROM. Please install CNC BASIC ROM in flash memory again.

Servo Alarms to turn MCC off Signal (*MCFVx) to “0”

In case that the parameter No.10500#0 (AVM) is set to “0”, the MCC off Signal (*MCFVx) of an alarm axis is turned to “0” immediately when the alarm related to data communication or detector occurs. The following table shows this kind of servo alarm.

Number	Message	Description
SV0301	APC ALARM: COMMUNICATION ERROR	Since the absolute-position detector caused a communication error, the correct machine position could not be obtained. (data transfer error) The absolute-position detector, cable, or servo interface module is thought to be defective.
SV0302	APC ALARM: OVER TIME ERROR	Since the absolute-position detector caused an overtime error, the correct machine position could not be obtained. (data transfer error) The absolute-position detector, cable, or servo interface module is thought to be defective.
SV0303	APC ALARM: FRAMING ERROR	Since the absolute-position detector caused a framing error, the correct machine position could not be obtained. (data transfer error) The absolute-position detector, cable, or servo interface module is thought to be defective.

Number	Message	Description
SV0304	APC ALARM: PARITY ERROR	Since the absolute-position detector caused a parity error, the correct machine position could not be obtained. (data transfer error) The absolute-position detector, cable, or servo interface module is thought to be defective.
SV0305	APC ALARM: PULSE ERROR	Since the absolute-position detector caused a pulse error, the correct machine position could not be obtained. The absolute-position detector or cable is thought to be defective.
SV0306	APC ALARM: OVER FLOW ERROR	Since the amount of positional deviation overflowed, the correct machine position could not be obtained. Check parameter No. 2084 and No. 2085.
SV0307	APC ALARM: MOVEMENT EXCESS ERROR	Since the machine moved excessively, the correct machine position could not be obtained.
SV0360	ABNORMAL CHECKSUM(INT)	The checksum alarm occurred on the built–in Pulsecoder.
SV0361	ABNORMAL PHASE DATA(INT)	The phase data abnormal alarm occurred on the built–in Pulsecoder.
SV0362	ABNORMAL REV. DATA(INT)	The speed count abnormal alarm occurred on the built-in Pulsecoder.
SV0363	ABNORMAL CLOCK(INT)	The clock alarm occurred on the built–in Pulsecoder.
SV0364	SOFT PHASE ALARM(INT)	A digital servo soft detected an abnormality on the built in Pulsecoder.
SV0365	BROKEN LED(INT)	The digital servo software detected abnormal data on the built–in Pulsecoder.
SV0366	PULSE MISS(INT)	A pulse error occurred on the built–in Pulsecoder.
SV0367	COUNT MISS(INT)	A count error occurred on the built–in Pulsecoder.
SV0368	SERIAL DATA ERROR(INT)	The communications data could not be received from the built–in Pulsecoder.
SV0369	DATA TRANS. ERROR(INT)	A CRC error or stop bit error occurred in the communications data from the built–in Pulsecoder.
SV0380	BROKEN LED(EXT)	Separate detector error
SV0381	ABNORMAL PHASE (EXT)	An abnormal alarm in the position data occurred on the separate linear scale.
SV0382	COUNT MISS(EXT)	A count error occurred on the separate detector.
SV0383	PULSE MISS(EXT)	A pulse error occurred on the separate detector.
SV0384	SOFT PHASE ALARM(EXT)	The digital servo software detected abnormal data on the separate detector.
SV0385	SERIAL DATA ERROR(EXT)	The communications data could not be received from the separate detector.
SV0386	DATA TRANS. ERROR(EXT)	A CRC error or stop bit error occurred in the communications data from the standalone detector.
SV0387	ABNORMAL ENCODER(EXT)	An abnormality occurred on a separate detector. For more information, contact the scale manufacturer.
SV0445	SOFT DISCONNECT ALARM	The digital servo software detected a disconnected Pulsecoder.
SV0448	UNMATCHED FEEDBACK ALARM	The sign of the feedback signal from the standalone detector is opposite to that from the feedback signal from the built–on Pulsecoder.
SV0453	SPC SOFT DISCONNECT ALARM	Software disconnection alarm of the α pulse coder. Turn off the power to the CNC, then remove and insert the pulse coder cable. If this alarm is issued again, replace the pulse coder.
SV0460	FSSB DISCONNECT	The FSSB connection was discontinued. Or, the FSSB connection cable was disconnected or broken. The amplifier was turned off. In the amplifier, the low-voltage alarm occurred.

Number	Message	Description
SV0462	SEND CNC DATA FAILED	The correct data could not be received on a slave side because of the FSSB communication error.
SV0463	SEND SLAVE DATA FAILED	The correct data could not be received in the servo software because of the FSSB communication error.
SV0474	EXCESS ERROR(STOP:SV)	The Servo detected that the positional deviation during stopping exceeded the parameter (No. 1839, No.1842) setting value.
SV0475	EXCESS ERROR(MOVE:SV)	The Servo detected that the positional deviation during traveling exceeded the parameter (No. 1838, No.1841) setting value.
SV1067	FSSB:CONFIGURATION ERROR(SOFT)	The FSSB configuration error occurred. (Detected in software). Or, there is a difference in the type of connected amplifier and FSSB setting.
SV5134	FSSB:OPEN READY TIME OUT	In the initialization, the FSSB could not be in an open ready sate. The axis card is thought to be defective.
SV5136	FSSB:NUMBER OF AMP. IS INSUFFICIENT	The number of amplifier identified by the FSSB is insufficient than the number of control axes. Or, the setting of the number of axes or the amplifier connection is in error.
SV5137	FSSB:CONFIGURATION ERROR	An FSSB configuration error occurred. The connecting amplifier type is incompatible with the FSSB setting value.
SV5139	FSSB : ERROR	Servo initialization did not terminate normally. The optical cable may be defective, or there may be an error in connection to the amplifier or another module. Check the optical cable and the connection status.
SV5197	FSSB:OPEN TIME OUT	The CNC permitted the opening of the FSSB, but the FSSB is not opened. Check the connection between the CNC and amplifier.

Spindle Alarms to turn MCC off Signal (*MCFPs) to “0”

In case that the parameter No.10500#1 (APM) is set to “0”, the MCC off Signal (*MCFPs) of an alarm spindle is turned to “0” immediately when the alarm related to data communication or detector occurs. The following table shows this kind of spindle alarm.

Number	Message	Description
SP1220	NO SPINDLE AMP.	Either the cable connected to a serial spindle amplifier is broken, or the serial spindle amplifier is not connected.
SP1225	CRC ERROR (SERIAL SPINDLE)	A CRC error (communications error) occurred in communications between the CNC and the serial spindle amplifier.
SP1226	FRAMING ERROR (SERIAL SPINDLE)	A framing error occurred in communications between the CNC and the serial spindle amplifier.
SP1227	RECEIVING ERROR (SERIAL SPINDLE)	A receive error occurred in communications between the CNC and the serial spindle amplifier.
SP1228	COMMUNICATION ERROR (SERIAL SPINDLE)	A communications error occurred between the CNC and the serial spindle amplifier.
SP1229	COMMUNICATION ERROR SERIAL SPINDLE AMP.	A communications error occurred between serial spindle amplifiers (motor Nos. 1 and 2, or motor Nos. 3–4).
SP1245	COMMUNICATION DATA ERROR	A communication data error was detected on the CNC.
SP1246	COMMUNICATION DATA ERROR	A communication data error was detected on the CNC.
SP1247	COMMUNICATION DATA ERROR	A communication data error was detected on the CNC.
SP1976	SERIAL SPINDLE COMMUNICATION ERROR	The amplifier No. could not be set to the serial spindle amplifier.
SP1977	SERIAL SPINDLE COMMUNICATION ERROR	An error occurred in the spindle control software.

Number	Message	Description
SP1978	SERIAL SPINDLE COMMUNICATION ERROR	A time–out was detected during communications with the serial spindle amplifier.
SP1979	SERIAL SPINDLE COMMUNICATION ERROR	The communications sequence was no longer correct during communications with the serial spindle amplifier.
SP1980	SERIAL SPINDLE AMP. ERROR	Defective SIC–LSI on serial spindle amplifier
SP1981	SERIAL SPINDLE AMP. ERROR	An error occurred during reading of the data from SIC–LSI on the analog spindle amplifier side.
SP1982	SERIAL SPINDLE AMP. ERROR	An error occurred during reading of the data from SIC–LSI on the serial spindle amplifier side.
SP1983	SERIAL SPINDLE AMP. ERROR	Could not clear on the spindle amplifier side.
SP1987	SERIAL SPINDLE CONTROL ERROR	Defective SIC–LSI on the CNC

Number	Message	Amplifier indication *1	Faulty location and remedy	Description
SP9073	MOTOR SENSOR DISCONNECTED	73	1) Replace the feedback cable. 2) Check the shield processing. 3) Check and correct the connection. 4) Adjust the sensor.	The motor sensor feedback signal is not present. (connector JYA2)
SP9081	1-ROT MOTOR SENSOR ERROR	81	1) Check and correct the parameter. 2) Replace the feedback cable. 3) Adjust the sensor.	The one-rotation signal of the motor sensor cannot be correctly detected. (connector JYA2)
SP9082	NO 1-ROT MOTOR SENSOR	82	1) Replace test feedback cable. 2) Adjust the sensor.	The one-rotation signal of the motor sensor is not generated. (connector JYA2)
SP9083	MOTOR SENSOR SIGNAL ERROR	83	1) Replace the feedback. 2) Adjust the sensor.	An irregularity was detected in a motor sensor feedback signal. (connector JYA2)

Reference of Dual Check Alarm message

Dual Check Alarm by Servo CPU and CNC CPU

No.	Message (Servo)	No.	Message (CNC)
SV0474	EXCESS ERROR(STOP:SV)	SV1072	EXCESS ERROR(STOP:CNC)
SV0475	EXCESS ERROR(MOVE:SV)	SV1071	EXCESS ERROR(MOVE:CNC)
SV0476	ILLEGAL SPEED CMD.(SV)	SV0494	ILLEGAL SPEED CMD.(CNC)
SV0477	ILLEGAL MACHINE POS.(SV)	SV0495	ILLEGAL MACHINE POS.(CNC)
SV0478	ILLEGAL AXIS DATA(SV)	SV0496	ILLEGAL AXIS DATA(CNC)
SV0481	SAFETY PARAM ERROR(SV)	SV0489	SAFETY PARAM ERROR(CNC)
SV0484	SAFETY FUNCTION ERROR(SV)	SV0490	SAFETY FUNCTION ERROR(CNC)
SV1070	EXCESS ERROR(SERVO OFF:SV)	SV1069	EXCESS ERROR(SERVO OFF:CNC)

Dual Check Alarm by Spindle CPU and CNC CPU

No.	Message (Spindle)	No.	Message (CNC)
SP9069 (69)	SAFETY SPEED OVER	SP0757	SAFETY SPEED OVER
SP9070 (70)	ILLEGAL AXIS DATA	SP0756	ILLEGAL AXIS DATA

No.	Message (Spindle)	No.	Message (CNC)
SP9071 (71)	SAFETY PARAMETER ERROR	SP1700	SAFETY PARAM ERROR
SP9072 (72)	MISMATCH RESULT OF MOTOR SPEED CHECK	SP0755	SAFETY FUNCTION ERROR
SP9076 (76)	INEXECUTION OF SAFETY FUNCTIONS		
SP9077 (77)	MISMATCH RESULT OF AXIS NUMBER CHECK		
SP9078 (78)	MISMATCH RESULT OF SAFETY PARAMETER CHECK		

Dual Check Alarm by PMC CPU and CNC CPU (Power must be off)

No.	Message (PMC)	No.	Message (CNC)
PW0009	CPU SELF TEST ERROR(PMC)	PW0008	CPU SELF TEST ERROR(DCS PMC)
PW0011	SAFE I/O CROSS CHECK ERROR(PMC)	PW0010	SAFE I/O CROSS CHECK ERROR(DCS PMC)
PW0013	USER I/O CROSS CHECK ERROR(PMC)	PW0012	USER I/O CROSS CHECK ERROR(DCS PMC)

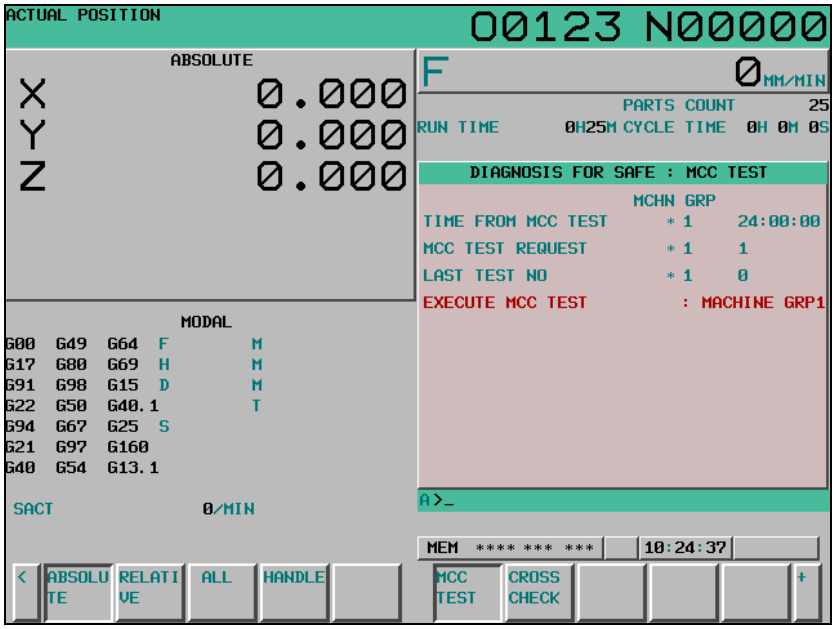
9 DIAGNOSIS

The diagnosis screen for the maintenance operation of the Dual Check Safety function is displayed in the group of [SYSTEM] screens.
To display the Dual Check Safety diagnosis screen, press the function key SYSTEM then press the [DUAL CHECK] soft key displayed by pressing the continuous menu key [+] several times.
The state of MCC OFF TEST, the state of signals in case that the alarm related to safety occurs and the cause of alarm is displayed on the Dual Check Safety diagnosis screen.

If an alarm is issued during execution of the dual brake monitor function, information about brake test is displayed on the diagnosis screen.

9.1 MCC OFF TEST STATUS SCREEN

By pressing [MCC TEST] soft key, the following MCC OFF TEST STATUS screen is displayed.



The following items are displayed.

Passing time from the last MCC OFF TEST

Passing time (hour : minute : second) from the last MCC OFF TEST is displayed.
Count of time is stopped when reaching 24:00:00 (24 hours).
24:00:00 is displayed at power-on.

MCC OFF TEST execution request

The CNC system notifies that it is necessary to select MCC OFF TEST mode and check whether MCC off signal (*MCF) works normally or not. When the MCC OFF TEST execution request signal is turned to “1”, select MCC OFF TEST mode and execute MCC OFF TEST as soon as possible.

Last number of test sequence

The current sequence number of MCC OFF TEST is displayed. If MCC OFF TEST is finished normally, “128” is displayed. Refer to the section of “MCC OFF TEST” for further detail.
When the MCC off Test has never been performed after power-on, "0" is displayed.

Message

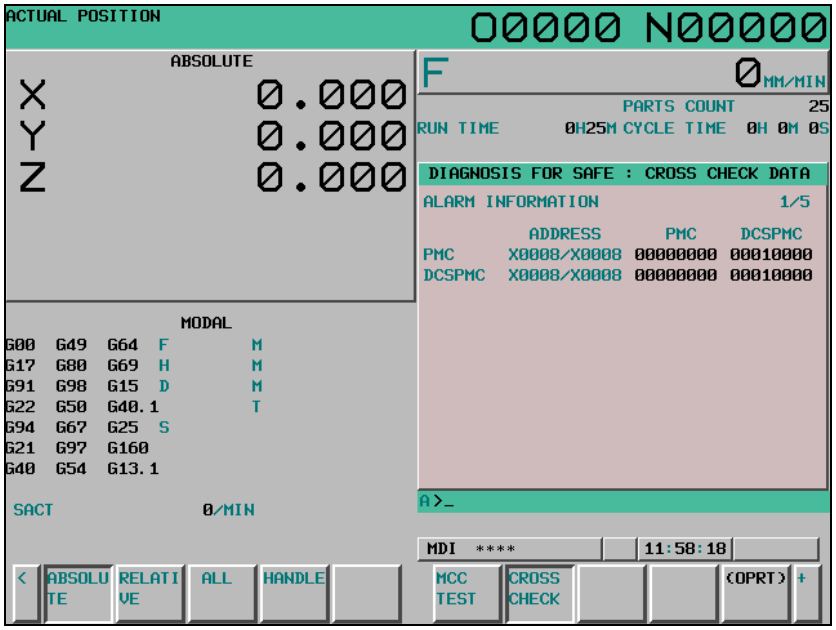
When the power is turned on or 24 hours passes from the last MCC OFF TEST, this screen is selected and the message “EXECUTE MCC TEST” is displayed.

9.2 CROSS CHECK DATA SCREEN

The CROSS CHECK DATA screen displays.

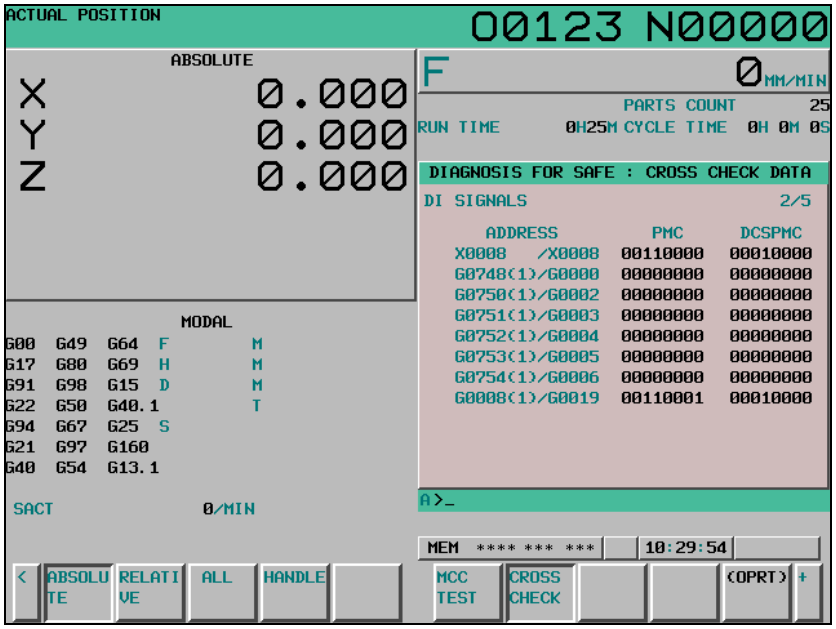
[ALARM INFORMATION] SCREEN

Press the [CROSS CHECK] soft key then the screen shown below appears.
This screen shows the DI/DO status when the cross check alarm occurs.



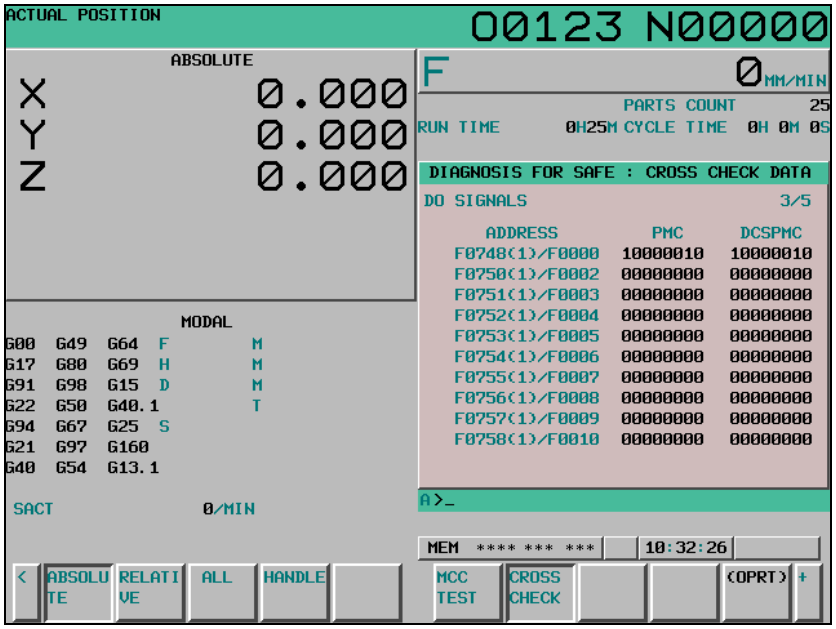
[DI SIGNAL STAUS] SCREEN

Press the page key PAGE and select the second page. The screen shown below appears. This screen shows the current DI status. If there is difference of DI state between PMC and DCS PMC, "#" is displayed on the left side of the address.



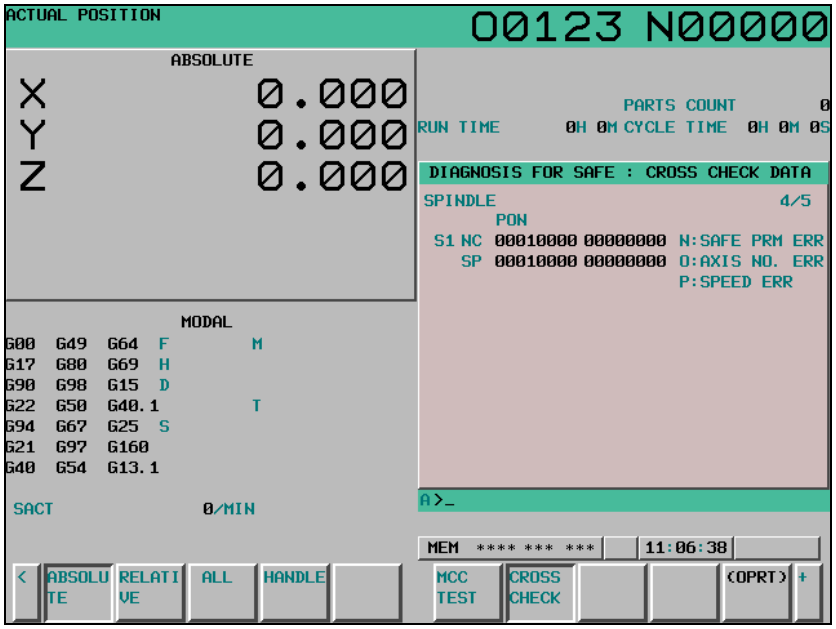
[DO SIGNAL STATUS] SCREEN

Press the page key PAGE and select the third page. The screen shown below appears. This screen shows the current DO status. If there is difference of DO state between PMC and DCS PMC, "#" is displayed on the left side of the address.



[SPINDLE STATUS] SCREEN

Press the page key PAGE and select the fourth screen. The screen shown below appears. When the judging result of safety function of CNC is not the same as other CPU, the cross check alarm occurs. This screen shows the cause of cross check alarm related to a spindle.

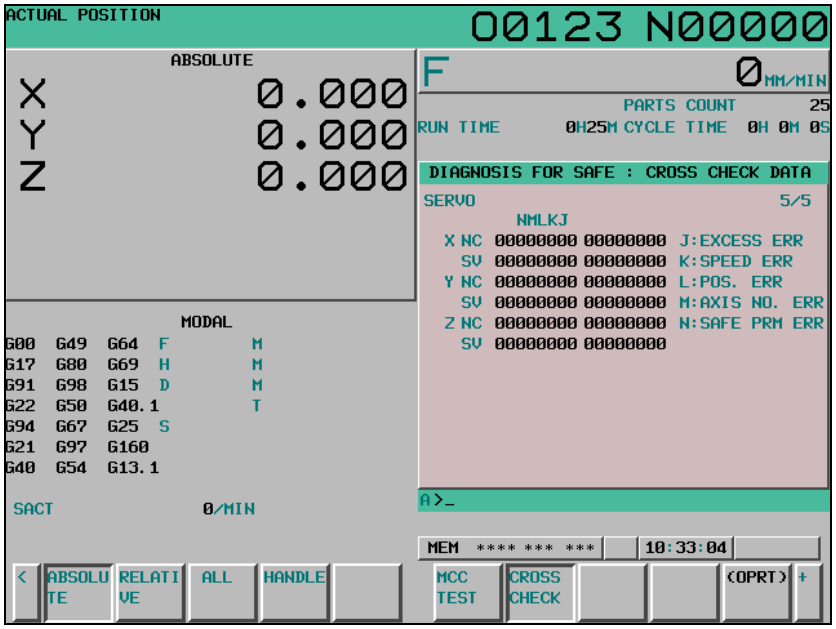


Cross check data about the following items for the spindle CPU and CNC CPU is displayed.
When no alarm is detected in a cross check, the results of the current check are indicated. When an alarm is detected in a cross check, the held data is indicated upon detection.

Bit (symbol)	Description
N	Set to "1" when a safety parameter failure is detected.
O	Set to "1" when an axis data failure is detected.
P	Set to "1" when the speed exceeds "Safety Limit Speed for each Spindle" set by the parameter.

[SERVO STATUS] SCREEN

Press the page key PAGE and select the fifth page. The screen shown below appears. When the judging result of safety function of CNC is not the same as other CPU, the cross check alarm occurs. This screen shows the cause of cross check alarm related to a servo motor.

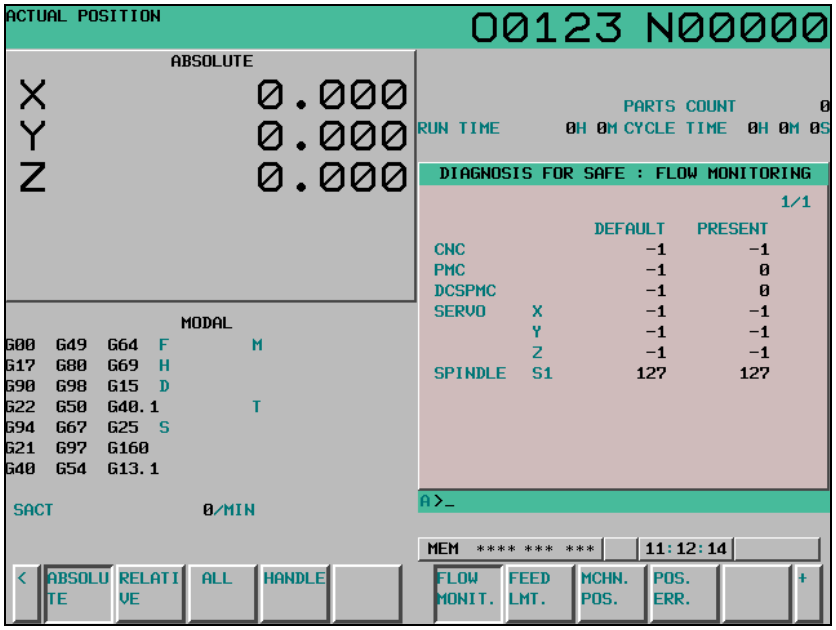


Cross check data about the following items for the servo CPU and CNC CPU is displayed.
When no alarm is detected in a cross check, the results of the current check are indicated. When an alarm is detected in a cross check, the held data is indicated upon detection.

Bit (symbol)	Description
J	Set to "1" when the amount of positional deviation exceeds "Positional Deviation Limit during Safety Monitoring" set by the parameter.
K	Set to "1" when the speed exceeds "Safety Limit Speed for each Axis" set by the parameter.
L	Set to "1" when the machine position falls outside the range of "Safety Machine Position for each Axis" set by the parameter.
M	Set to "1" when an axis data failure is detected.
N	Set to "1" when a safety parameter failure is detected.

9.3 FLOW MONITORING SCREEN

The FLOW MONITORING screen displays.
Press the [+] continuous menu soft key.
And press the [FLOW MONIT.] soft key. The screen shown below appears.
This screen shows the counter for program flow monitoring.

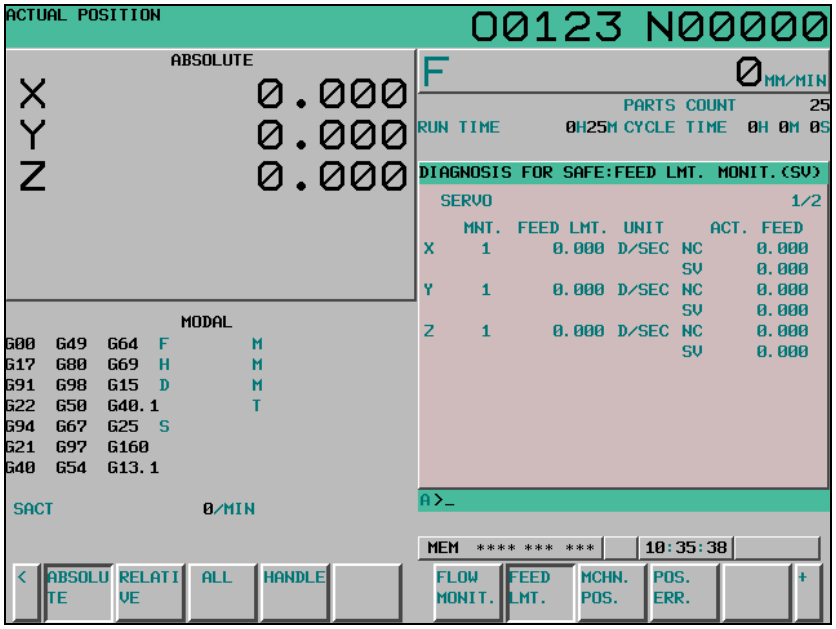


If each safety function works normally, the present value shows the same value as the default.

9.4 FEED LIMIT MONITORING SCREEN

SERVO

The data that are related to the safety limitation feed of the servo and the Dual Check Safety function are displayed.
Press the [FEED LMT.] soft key. The screen shown below appears.



The following items (a) to (d) are displayed for every servo axis.

(a) MNT. 0:Not Monitoring / 1:Monitoring

(b) FEED LMT. In the safety limitation feed 1 to 4 (Set by the parameter No.13821 to No.13829), the safety limit feed that is selected by the Safety speed/Safety Position Selection signal A,B(SVAx,SVBx) is displayed

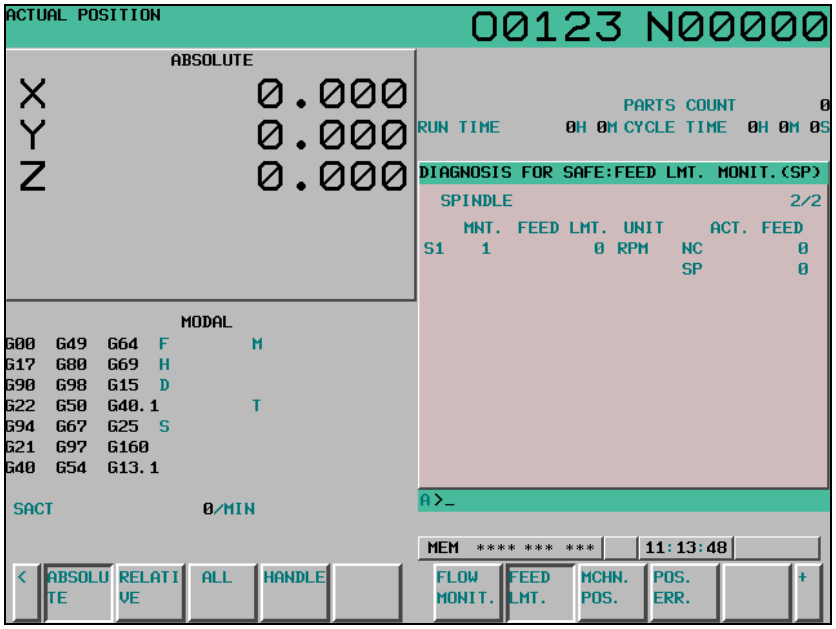
(c) UNIT Unit of feed (Position control: D/sec, Velocity control: min^{-1})

(d) ACT. FEED Current actual feed rate (NC side and Servo side)

SPINDLE

The data that are related to the safety limitation feed of the spindle and the Dual Check Safety function are displayed.

Press the page key [PAGE ⇩], the screen of the Safety limitation feed of the spindle shown below appears.



The following items (a) to (d) are displayed for every spindle axis.

(a) MNT. 0:Not Monitoring / 1:Monitoring

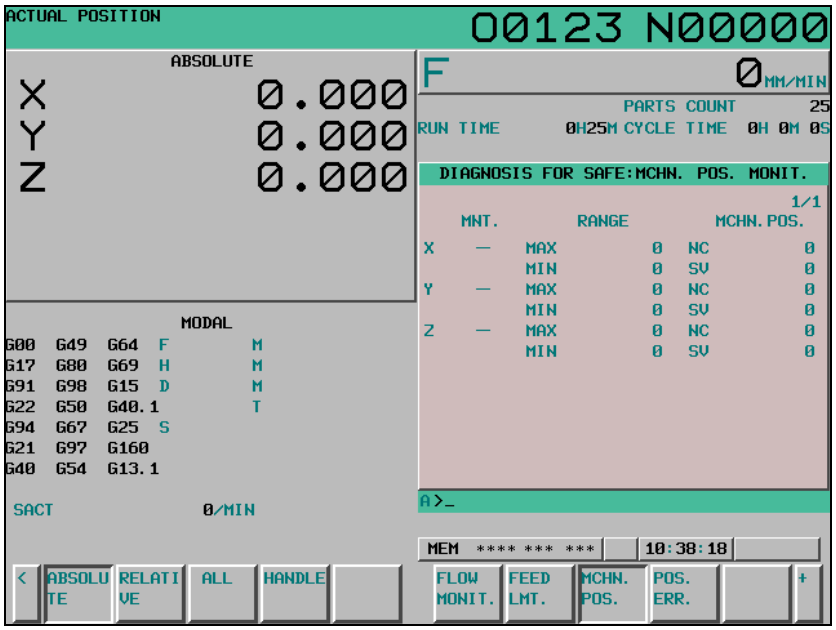
(b) FEED LMT. In the Safety feed limit 1 to 4 (Set by the parameter No.4372, 4438, 4442 to 4444), the safety limit feed that is selected by the Safety speed/Safety Position Selection signal A,B (SPAx, SPBx) is displayed

(c) UNIT Unit of the feed (min^{-1})

(d) ACT. FEED Current actual feed rate （NC side and Spindle side)

9.5 SAFE MACHINE POSITIONING MONITORING SCREEN

The data that are related to the safe machine positioning monitoring of the Dual Check Safety function are displayed.
Press the [MCHN. POS] soft key, The screen shown below appears.



The following items (a) to (c) are displayed for every servo axis.

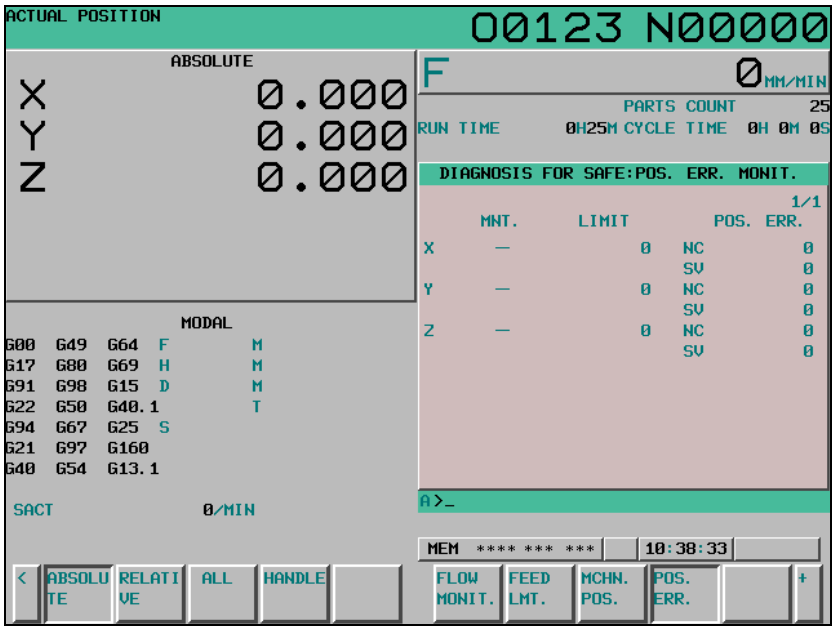
(a) MNT. 0:Not Monitoring / 1:Monitoring/-: The reference position is not established

(b) RANGE In the safety machine position 1 to 4 (Set by the parameter No.13830 to 13838), the upper limit value and lower limit value of the safety machine position that are selected by the Safety speed/Safety Position Selection signal A,B (SPAx, SPBx) are displayed

(c) MCHN. POS. Current machine position (NC side and Spindle side)

9.6 SAFETY POSITION ERROR MONITORING SCREEN

The data that are related to the safety position error monitoring of the Dual Check Safety function are displayed.
Press the [POS. ERR.] soft key, the screen shown below appears.



The following items (a) to (c) are displayed for every servo axis.

(a) MNT. 0:Not Monitoring / 1:Monitoring/-: The reference position is not established

(b) LIMIT From the safety position error limits at stop time/move time/servo-off time, the pertinent safety position error limit is displayed by judging the current state.

(c) POS. ERR. Current positioning error (NC side and Servo side)

9.7 DIAGNOSIS SCREEN

If an alarm is issued during execution of the dual brake monitor function, information about brake test is displayed on the diagnosis screen.

To display the diagnosis screen, press the function key SYSTEM then press the [DIAGNOSIS] soft key.

Display data

Diagnosis	3700	Brake test sequence number

[Data type] Word axis

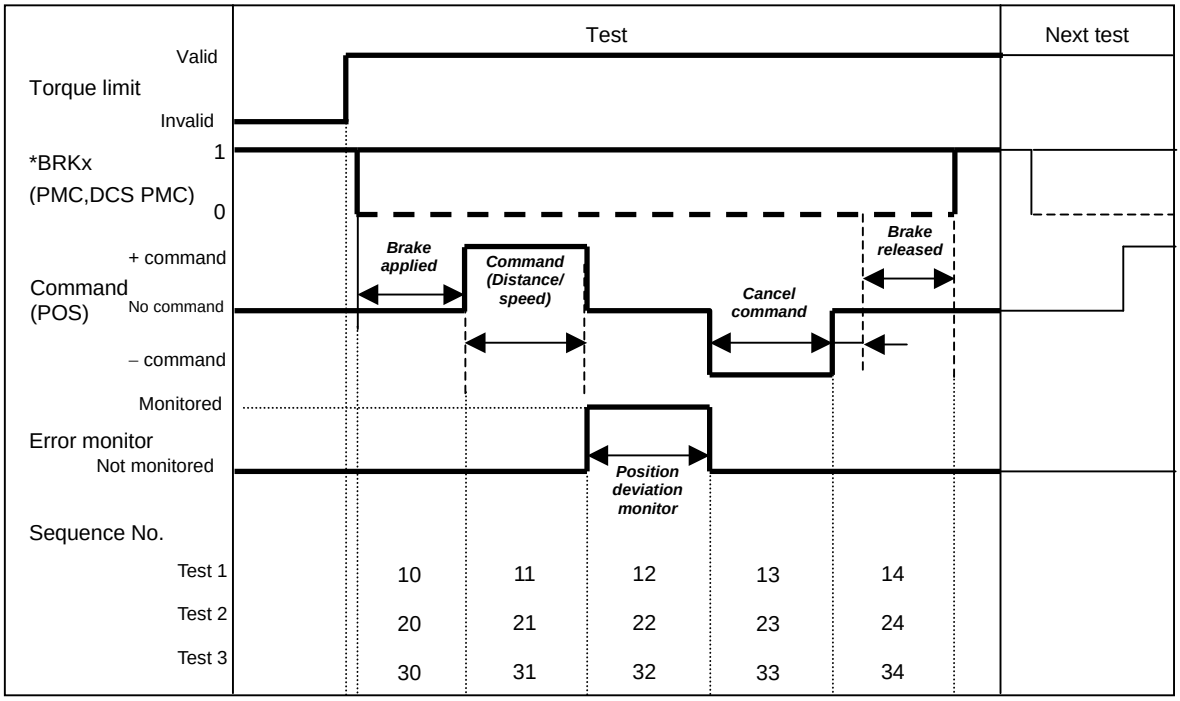
[Valid data range] 0 to 128

This item displays the current test sequence number for each axis when a Dual Check Safety brake test is being executed.
When a test is suspended, the suspended sequence number is displayed.

0	:	Test not started (normal state)
1	:	Torque limit change
10	:	Test 1 Brake applied, wait for a timer
11	:	Test 1 Move
12	:	Test 1 Position deviation check
13	:	Test 1 Move in reverse direction
14	:	Test 1 Brake released, wait for a timer
20	:	Test 2 Brake applied, wait for a timer
21	:	Test 2 Move
22	:	Test 2 Position deviation check
23	:	Test 2 Move in reverse direction
24	:	Test 2 Brake released, wait for a timer
30	:	Test 3 Brake applied, wait for a timer
31	:	Test 3 Move
32	:	Test 3 Position deviation check
33	:	Test 3 Move in reverse direction
34	:	Test 3 Brake released, wait for a timer
2	:	Torque limit released
128	:	Normal termination

The test sequence numbers correspond to the states indicated in the brake test timing chart below.

Brake test timing chart



Diagnosis	3701	Cause for brake test suspension

[Data type] Word axis

[Valid data range] 0 to 128

When a brake test being conducted is suspended for a cause such as an alarm, this item indicates the cause with one of the following numbers:

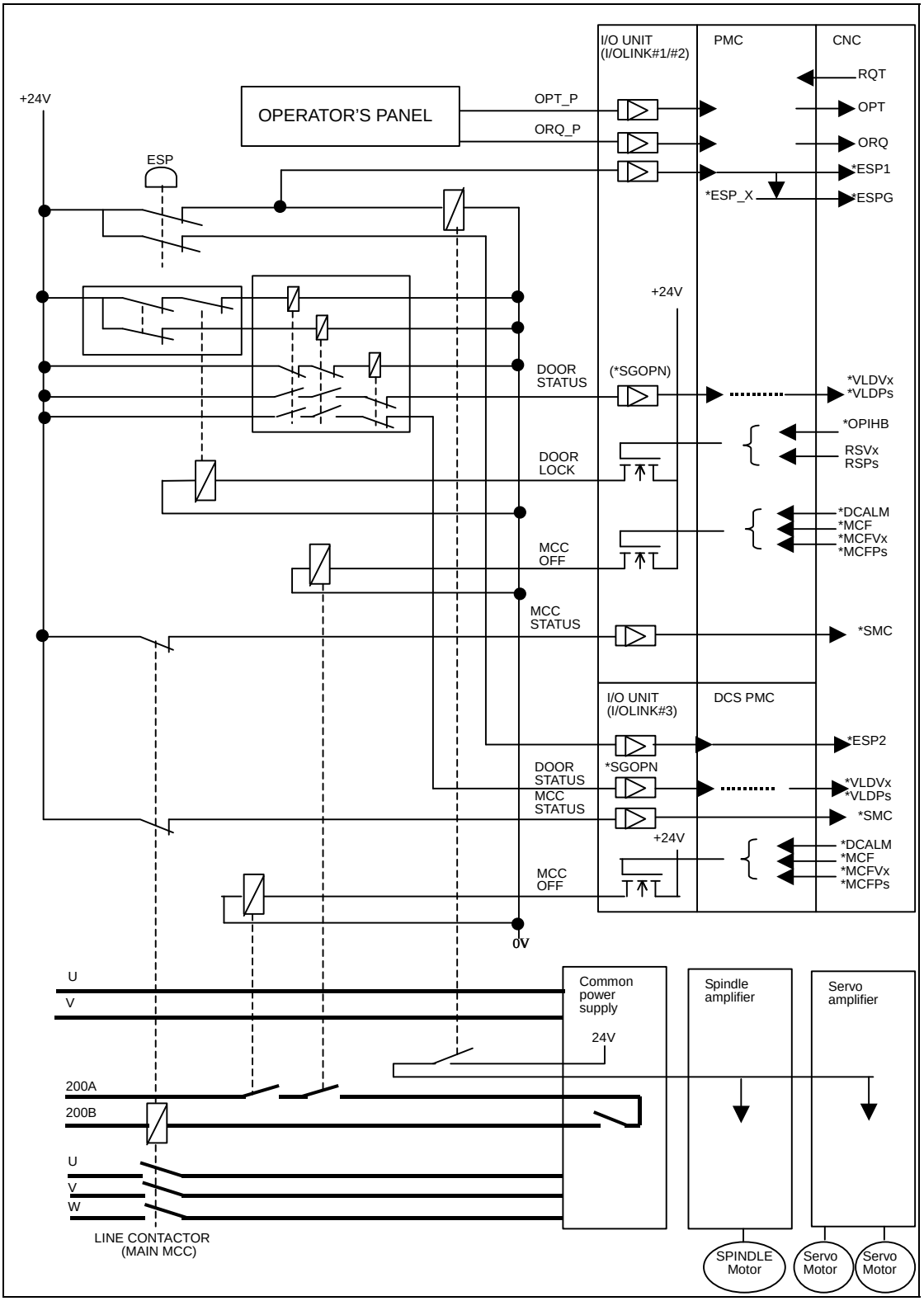
- 0 : Normal state (no suspension performed)
- 1 : An alarm was issued at the start of a brake test.
- 2 : PMC axis control was exercised at the start of a brake test.
- 3 : A mode other than the JOG mode was set at the start of a brake test.
- 4 : An axis movement was being made at the start of a brake test.
- 6 : The servo-off or emergency stop state was set at the start of a brake test.
- 7 : A reset was being made at the start of a brake test.
- 8 : A torque limit was applied at the start of a brake test.
- 9 : Torque control or speed control was exercised at the start of a brake test.
- 10 : Automatic operation was being performed at the start of a brake test.
- 20 : A brake test was suspended for an alarm detected by position deviation checking during brake test. (A brake error was detected.)
- 21 : During brake test, the D-READY signal or V-READY signal of the amplifier was turned off.
- 22 : A brake test being conducted was suspended by a reset or mode switching. (Restart operation is needed.)

23 : A brake test being conducted was suspended for another cause.
24 : The mode of control was switched to torque control or speed control during brake test.
25 : A brake test being conducted was suspended by an emergency stop.

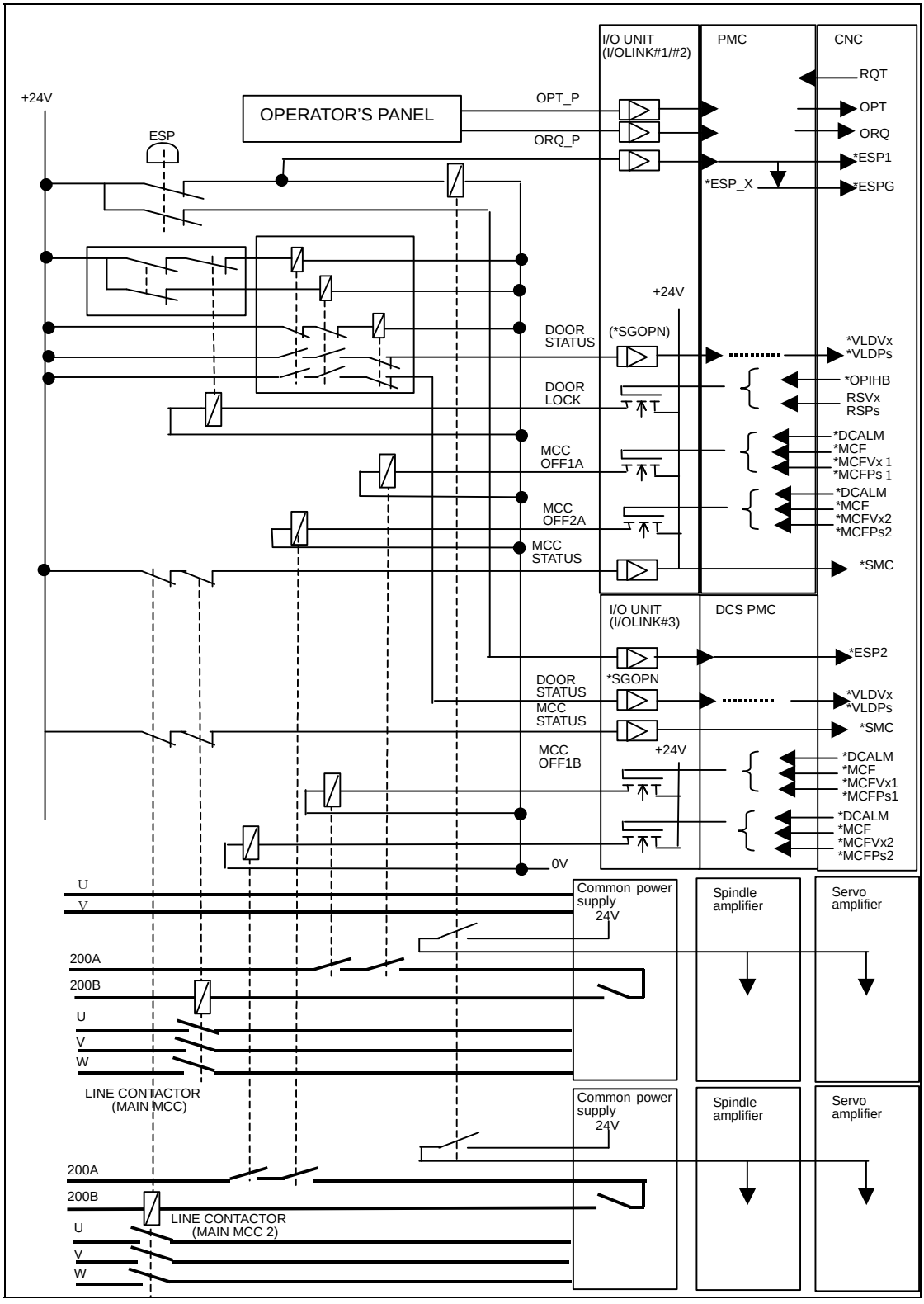
10 SAMPLE SYSTEM CONFIGURATION

10.1 SAMPLE CONFIGURATION

10.1.1 Example of Configuration Using a Single MCC

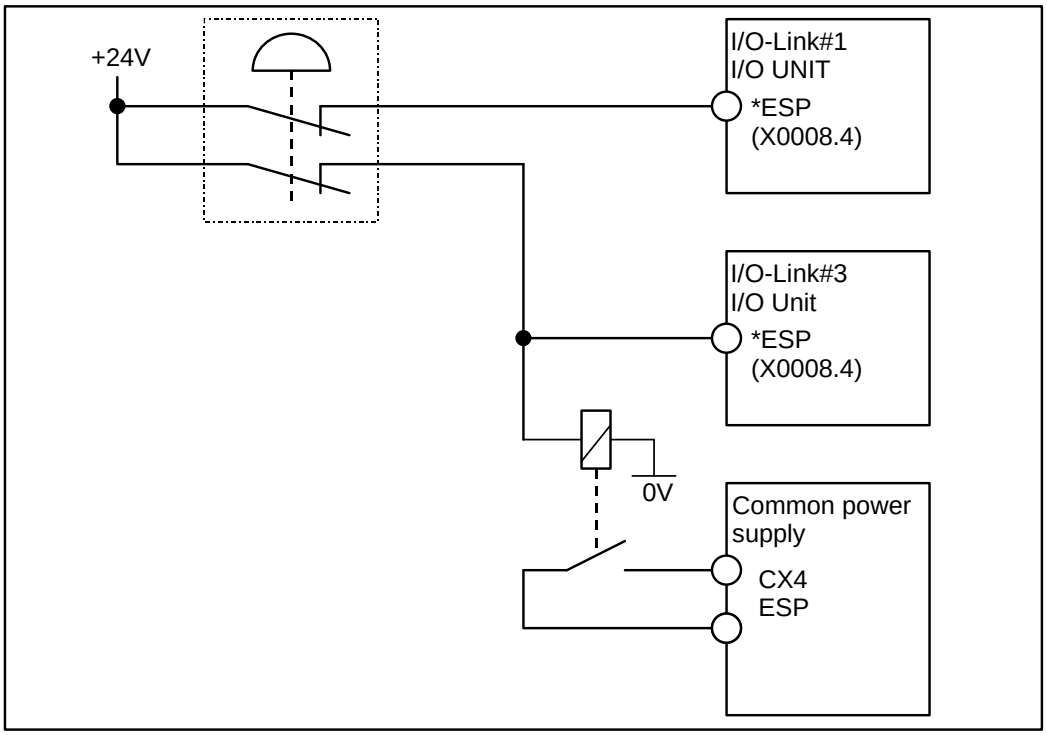


10.1.2 Example of Configuration Using Multiple MCCs



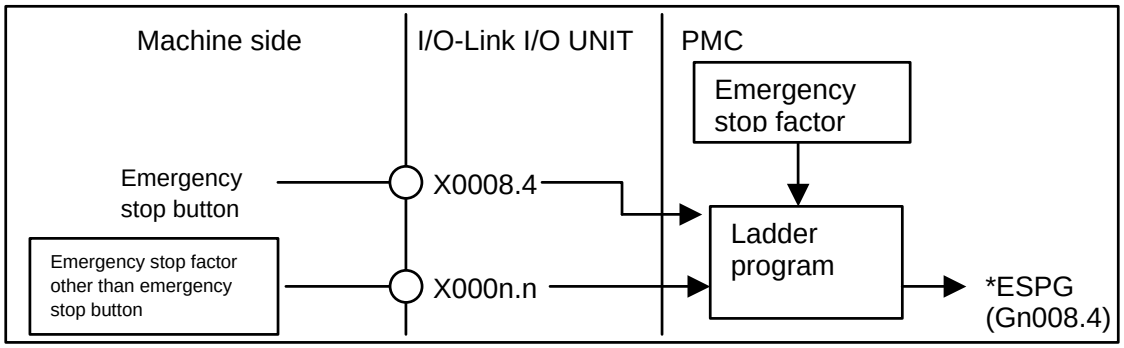
10.2 SAMPLE CONNECTIONS

10.2.1 Emergency Stop Signal (*ESP)



NOTE

Use a two-contact emergency stop button with a forced guided contact mechanism. Connect the emergency stop button to the PSM(common power supply), as illustrated in the figure. When the signal is input, the spindle slows down and stops. Input a power-down factor to [Gn008.4] other than the signal from the emergency stop button. Create a Ladder program so that [X0008.4] becomes a factor of [Gn008.4].



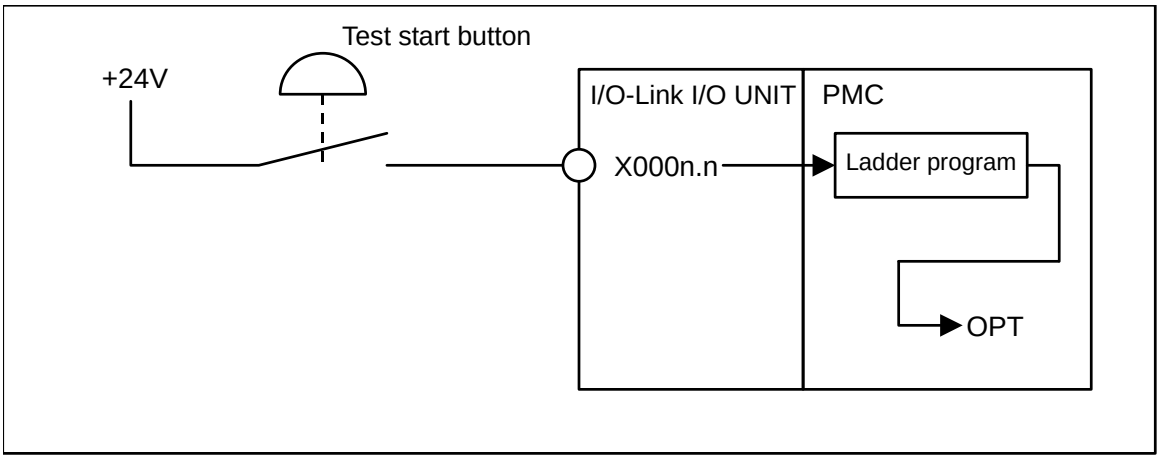
IMPORTANT
Emergency stop button must fulfill the Standard IEC60947-5-1.This is mandatory.

10.2.2 Guard Open Request Signal (ORQ)

NOTE

Create a Ladder program of conditions for making a guard open request and then input the program to the PMC side.
When the guard open request signal (ORQ) is input, CNC will output the *OPNIHB signal. After the ladder program confirms the safety status, the signal for the guard unlock enable signal should be outputted by the ladder program. Also, the ladder program should inform the status of guard open by the *VLDVx and *VLDPs signals.
If the input of ORQ is canceled while the guard is open, the ladder program should enter a safely stopped status (state in which the guard is open although the guard open request signal is not input). Close the guard (*VLDVx and *VLDPs are set to 1), then cancel this signal.

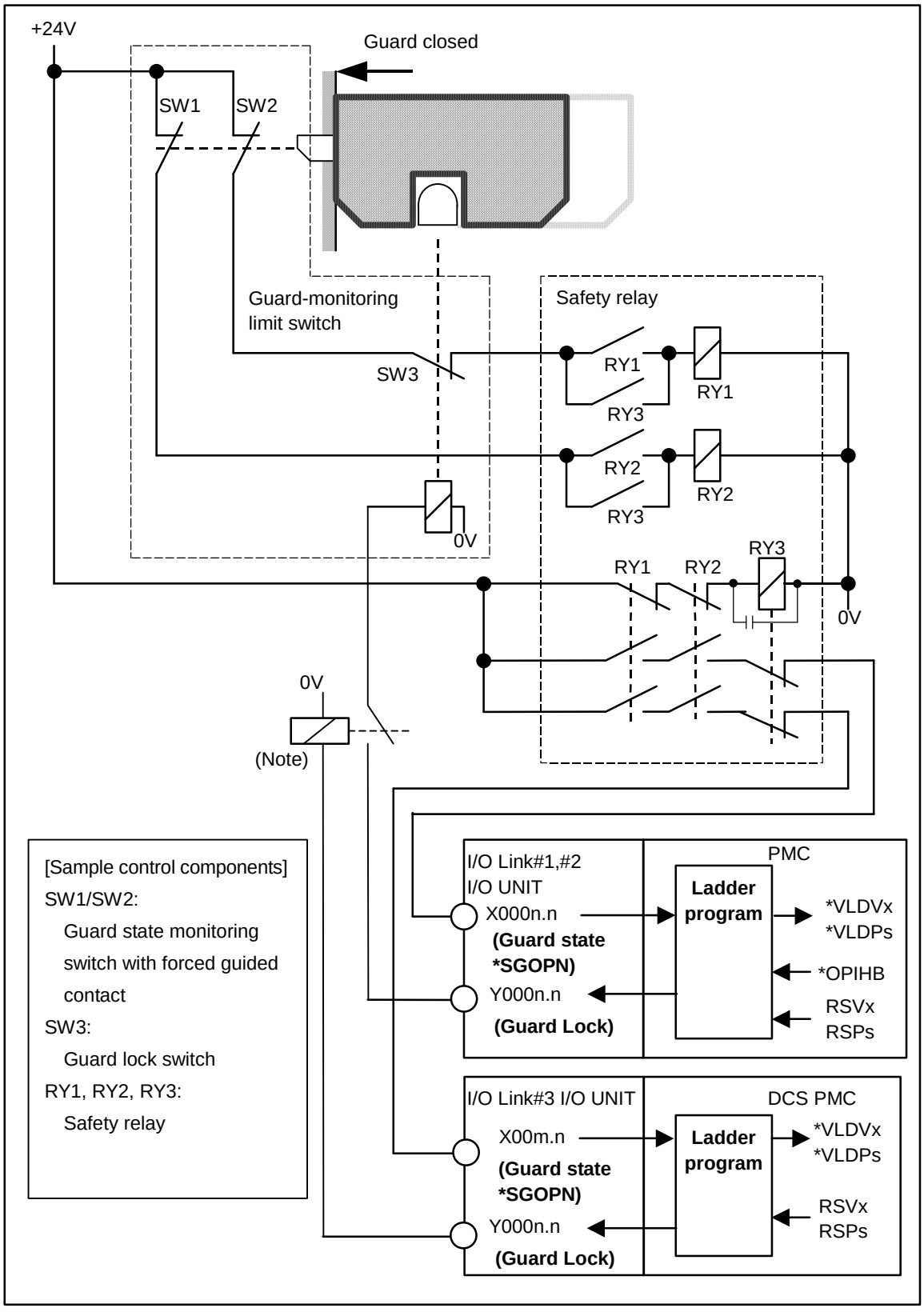
10.2.3 Test Mode Signal (OPT)



NOTE

When all the conditions for the MCC off test become ready, this signal (OPT) should be set to “1”.

10.2.4 Guard Open Inhibit Signal (*OPIHB), Monitoring Result Signal (RSVx,RSPs), Safety check Request Signal (*VLDVx,*VLDPs)



OPERATING PRINCIPLE

This section describes the operation of various guard monitoring limit switches with lock mechanism and safety relays.

State transition of components

		SW1	SW2	SW3	RY1	RY2	RY3	*SGOPN (*VLDVx, *VLDPs)
1	Guard closed Protection door locked	CLOSE	CLOSE	CLOSE	ON	ON	OFF	1
2	Guard closed Protection door unlocked	CLOSE	CLOSE	OPEN	OFF	ON	OFF	0
3	Guard opened Protection door unlocked	OPEN	OPEN	OPEN	OFF	OFF	ON	0
4	Guard opened Protection door locked	OPEN	OPEN	CLOSE	OFF	OFF	ON	0
1	Guard closed Protection door locked	CLOSE	CLOSE	CLOSE	ON	ON	OFF	1

In a normal operation, the transition of 1, 2, 3, 4, 1, and so on is repeated.
RY3 detects whether RY1 and RY2 contacts are made. If an unusual event is detected, *SGOPN input is turned off.

NOTE

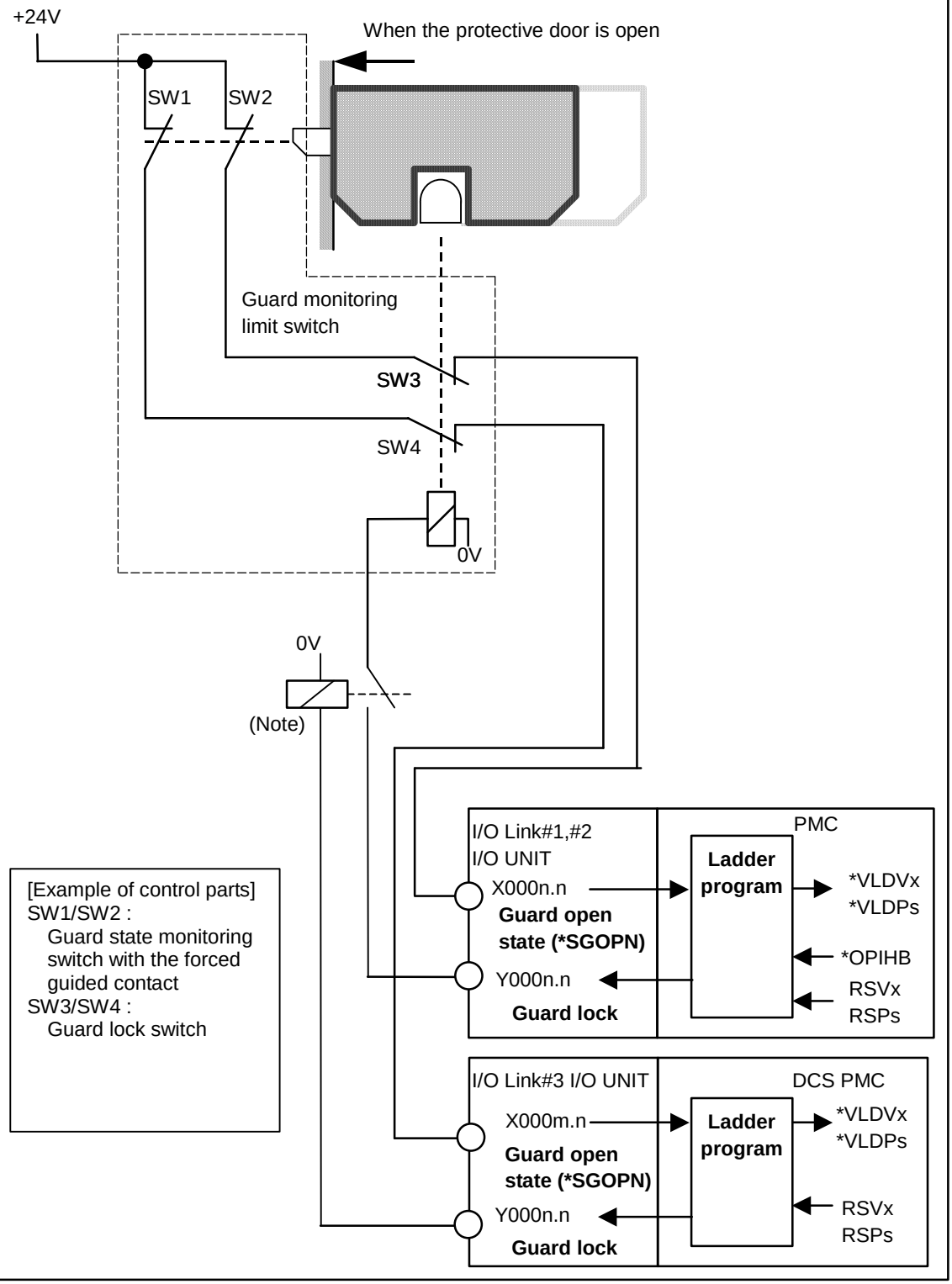
The VLDVx and VLDPs signals monitor the state of the protective door and their states affect the Dual Check Safety function.
The illustrated sample system determines that the protection door is open (sets *VLDVx and *VLDPs to 0) when the guard is unlocked.
When the guard open request signal (ORQ) is accepted, CNC will negate the guard open inhibit signal (*OPIHB).
Machine tool builder can create the signal to release the guard-lock by his ladder program, when the following conditions are met.
*OPIHB=1, RSVx and RSPs to be refered=1 and the safety conditions of the machine

The safety monitor signals (RSVx and RSPs) are redundant output signals. Each set of RSVx and RSPs monitors the speed or other data items with a separate circuit. Therefore, a temporary mismatch may occur between both sets when, for example, one set of RSVx and RSPs has been shifted to the safe state, while the other set is not yet shifted to the safe state (for example, situations where the spindle is in a deceleration state).
In such a case, if a circuit that releases a guard lock based on the state of one set of RSVx and RSPs is created, an alarm such as speed limit monitoring may occur depending on the state of the other set of RSVx and RSPs.

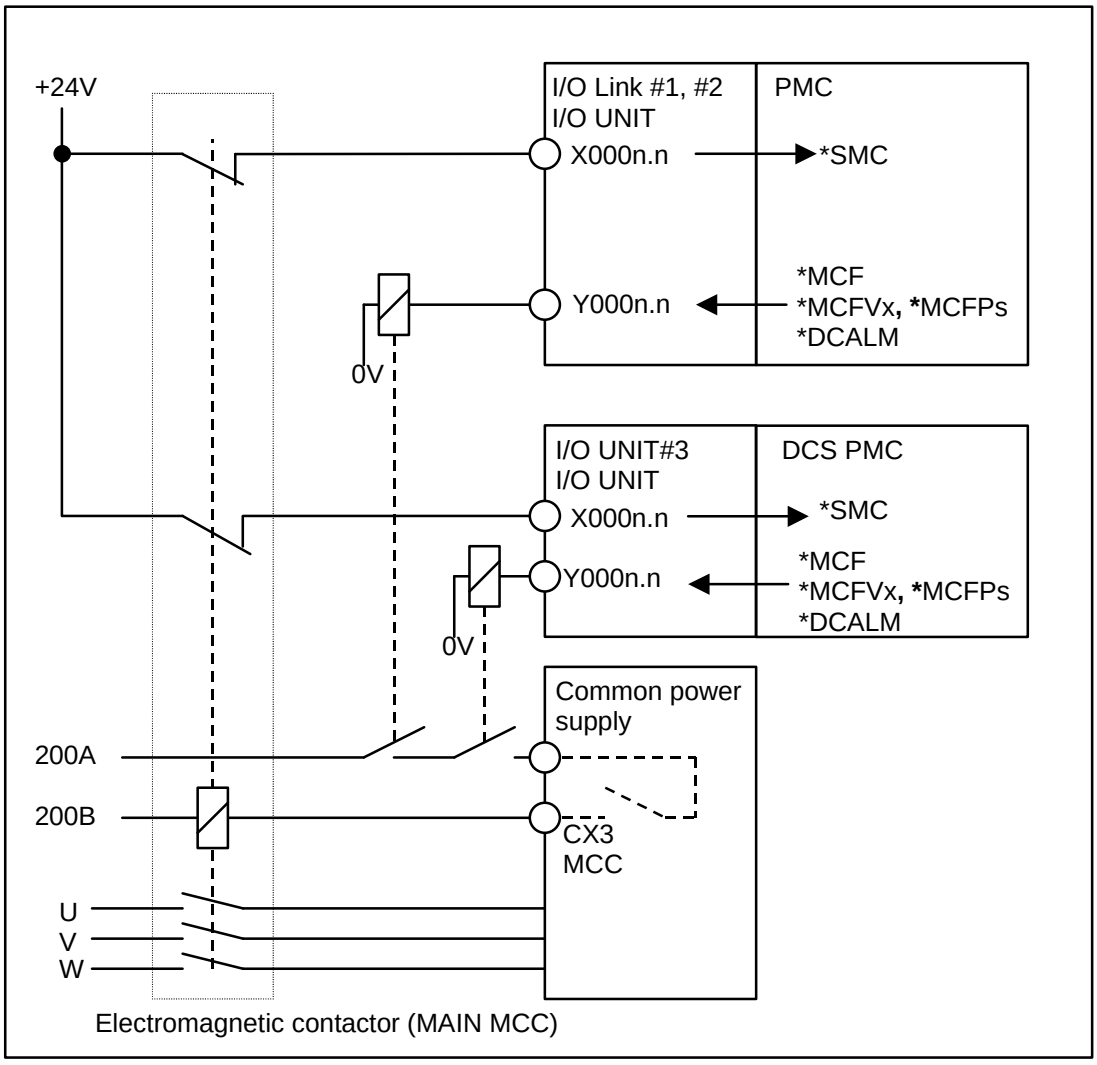
- To prevent this, create a circuit that releases a guard lock when both sets of RSVx and RSPs have shifted to the safe state as shown by (NOTE) in the figure
- Or a circuit that releases a guard lock after a while from when RSVx and RSPs shift to the safe state.

When using a guard lock switch of two-contact type, the safety relay can be omitted as shown in the following figure.

Example of connection when both the guard state monitoring switch and the guard lock switch are of two-contact type.



10.2.5 MCC Off Signal (*MCF,*MCFVx,*MCFPs,*DCALM), MCC Contact State Signal (*SMC)



NOTE

Only in case that all the signals (*MCF, *MCFVx, *MCFPs, *DCALM) of the PMC side are "1", the signal which turns on the MCC should be asserted by the ladder program. Also in the DCS PMC side, similar logic should be made.
Also connect the MCC control signal to common power supply, as illustrated in the figure. If an error occurs in the common power supply, the common power supply turns off the MCC.
Any equipment should not be connected on the 3- phase AC line between the MAIN MCC and common power supply.

NOTE
The MCC shall have forced guided contacts , and must fulfill the standard IEC60204 and IEC 60255. This is mandatory.

10.3 EXAMPLE OF APPLICATION

10.3.1 Rotating the Spindle Manually in the Emergency Stop State

The Dual Check Safety function allows the spindle to rotate at a safe speed by using the safe speed limit monitoring function even when the protective door is open.
In some cases, the operator rotates the spindle manually by entering the emergency stop state to interrupt excitation of the spindle with the protective door open. Generally, the safe speed limit with the protective door open is set to a much lower value. Therefore, if the spindle is rotated manually, the rotation speed may exceed the safe speed limit. To prevent a safe speed limit monitoring alarm from occurring even in the case above, it is necessary to create a ladder program that implements the following circuitry.

(1) Method by the Safety Check Request signal (*VLDPs)
When the MCC is placed in the off state (*SMC = 1) in the emergency stop state, a safety monitoring alarm can be disabled by setting *VLDPs to "1" even if the protective door is open.

(2) Method by the safe speed limit/safe machine position selection signals (SPAs and SPBs)
Switching between SPAs and SPBs is made depending on whether the MCC is placed in the off state (*SMC = 1) in the emergency stop state.
As the safe speed setting (parameter) selected when the MCC is placed in the off state in the emergency stop state (*SMC = 1), select a value that does not cause a safety monitoring alarm to occur even when the operator rotates the spindle manually.

11 APPLICATION OF OTHER FUNCTIONS

11.1 OVERVIEW

The Dual Check Safety function becomes easier to use when combined with various other functions. This section describes the functions.

Part of the section assumes the use of the Dual Check Safety function. Therefore, if the function is not used, the specifications described in the chapter may differ.

Since only a summary is provided for each function, refer to the Connection Manual (Function) (B-64303EN-1) or other documents for detailed specifications.

Section 11.2 describes combination with external deceleration, Section 11.3 describes combination with spindle output control by the PMC, Section 11.4 describes combination with spindle positioning, Section 11.5 describes combination with Cs contour control, and Section 11.6 describes combination with spindle orientation.

11.2 EXTERNAL DECELERATION

11.2.1 Overview

The Dual Check Safety function uses the CNC CPU and monitor DSP to separately monitor the speed of the feed axis (safe speed monitoring function). When the safe speed is exceeded by some axes with the protective door closed after a guard open request is input (RSVx = 0), the protective door needs to be locked by the ladder program to prevent it from opening. When the safe speed is exceeded in some axes with the protective door open (*VLDVx = 0), alarm SV0476 or SV0494 occurs to stop the servo motor.

The external deceleration function decelerates the speed of the feed axis to the external deceleration speed specified in the parameter by inputting the external deceleration signal. A maximum of three external deceleration speeds can be set.

The Dual Check Safety function and external deceleration function can be used to construct a machine that operates as shown below.

- Automatically reduces the speed of the feed axis to the safe speed or lower after a guard open request is input to allow the guard to open.
- Prevents an alarm by the safe speed limit monitoring function from occurring by limiting the speed of the feed axis to the safe speed limit or less with the protective door open.

To use the external deceleration function, set bit 2 (EDC) of parameter No. 8131 to 1.

For speed control of the spindle, see Section 11.3, "SPINDLE OUTPUT CONTROL BY THE PMC."

11.2.2 Specifications

External deceleration speed

The external deceleration speed is set for each of rapid traverse and cutting feed. Three sets of external deceleration speeds and external deceleration signals are provided as external deceleration settings 1, 2, and 3, which can be selected depending on the operator's skill or machine condition. When multiple cutting conditions are provided, the lowest deceleration speed is selected. External deceleration settings 2 and 3 can be disabled by the parameters EX2 and EX3.
Since the Dual Check Safety function monitors the safe speed for both rapid traverse and cutting feed, the external deceleration speed of the cutting feed must be set according to the axis having the lowest safe speed.

External deceleration signal

For safety, external deceleration is enabled when the external deceleration speed signal is 0, and disabled when the signal is 1. Two signals in the positive and negative directions are provided for each axis to select a deceleration direction. For manual handle feed, however, when either the signal in the positive direction or the signal in the negative direction is 0, external decelerations in both directions are enabled (it is impossible to select one direction).

JOG feed

For JOB feed, the external deceleration speed of rapid traverse is enabled.

Manual handle feed

The maximum speed of manual handle freed is normally the manual rapid traverse rate, but can be the maximum speed set in the parameter with the maximum speed switching signal. However, another speed can be selected by the external deceleration function depending on the external deceleration signal.

Relationships between signals and parameters

For cutting feed, rapid traverse, and JOG feed, the relationships between external deceleration settings, external signals, and parameters are shown in the table below.

External deceleration settings	Signal	Parameter			
	External deceleration signal	External deceleration valid/Invalid		External deceleration speed	
		Positive direction	Negative direction	Cutting feed	Rapid traverse JOG feed
1	Gn118, Gn120	No.1005#4(*1)	No.1005#5(*1)	No.1426	No.1427
2	Gn101, Gn103	No.1406#0		No.1440	No.1441
3	Gn107, Gn109	No.1406#1		No.1443	No.1444

(*1) To enable the external deceleration function in cutting feed, both of bits 4 and 5 of parameter No. 1005 need to be set to 1. (In rapid traverse and JOG feed, external deceleration is enabled regardless of this setting.)

In manual handle feed, the relationships between external deceleration settings, external signals, and parameters are shown in the table below.

External deceleration settings	Signal		Parameter	
	External deceleration signal	Manual handle feed maximum speed switching signal	External deceleration valid/Invalid	External deceleration speed
1	- (*2)	Gn023.3	-	No.1434(*4)
2	Gn101, Gn103	Gn023.3(*3)	No.1406#0	No.1442(*4)
3	Gn107, Gn109	Gn023.3(*3)	No.1406#1	No.1445(*4)

(*2) The external deceleration signal (Gn118, Gn120) of external deceleration setting 1 has no effect on the maximum speed of manual handle feed.

(*3) In manual handle feed, Gn023.3 and both of Gn101 and Gn103 need to be operated to enable external deceleration setting 2, and Gn023.3 and both of Gn107 and Gn109 need to be operated to enable external deceleration setting 3.

(*4) The maximum speed for manual handle feed is usually the manual handle feedrate. When the manual handle feed maximum feedrate change signal HNDLF (Gn023.3) is set to 1, the speed set in these parameters is applied.

11.2.3 Signals

11.2.3.1 Details on signals

Manual handle feed maximum feedrate change signal
HNDLF <Gn023.3>

[Classification] Input signal
[Function] This signal switches to or from the maximum manual handle feedrate.
[Operation] When this signal is 1, the speed set in parameter No. 1434 is assumed as the manual handle feed maximum speed. When external deceleration setting 2 or 3 is used, the speed set in parameter No. 1442 or 1445 can also be enabled.

External deceleration signals
***+ED1 to *+ED5 <Gn118.0 to 4>**
***-ED1 to *-ED5 <Gn120.0 to 4>**
***+ED21 to *+ED25 <Gn101.0 to 4>**
***-ED21 to *-ED25 <Gn103.0 to 4>**
***+ED31 to *+ED35 <Gn107.0 to 4>**
***-ED31 to *-ED35 <Gn109.0 to 4>**

[Classification] Input signal
[Function] This signal selects which external deceleration to apply for each direction of the control axes with the external deceleration function. In a signal name, "+" and "-" indicate a direction, the second number from the end indicates the target setting, and the last number indicates the control axis number.

*±EDnx

±	+:	Feed in the positive direction
	-:	Feed in the negative direction
n	:	External deceleration setting 1
	2:	External deceleration setting 2
	3:	External deceleration setting 3
x	1:	External deceleration for 1st axis
	2:	External deceleration for 2nd axis
	3:	External deceleration for 3rd axis
	4:	External deceleration for 4th axis
	5:	External deceleration for 5th axis

[Operation] When this signal is 0, the feedrate of the corresponding axis in the corresponding direction is decreased to the corresponding speed.
In manual handle feed, however, when the external deceleration signal in either the positive direction or the negative direction is 0, external decelerations in both directions are enabled (it is impossible to select one direction). The external deceleration signal (Gn118, Gn120) of external deceleration setting 1 has no effect on the maximum speed of manual handle feed.

11.2.3.2 Signal address

	#7	#6	#5	#4	#3	#2	#1	#0
Gn023					HNDLF			
Gn101				*+ED25	*+ED24	*+ED23	*+ED22	*+ED21
Gn103				*-ED25	*-ED24	*-ED23	*-ED22	*-ED21
Gn107				*+ED35	*+ED34	*+ED33	*+ED32	*+ED31
Gn109				*-ED35	*-ED34	*-ED33	*-ED32	*-ED31
Gn118				*+ED5	*+ED4	*+ED3	*+ED2	*+ED1
Gn120				*-ED5	*-ED4	*-ED3	*-ED2	*-ED1

11.2.4 Parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1005			EDMx	EDPx				

[Input type] Parameter input
[Data type] Bit axis

 # 4 EDPx In cutting feed, an external deceleration signal in the + direction for each axis is:
0: Invalid
1: Valid

 # 5 EDMx In cutting feed, an external deceleration signal in the - direction for each axis is:
0: Invalid
1: Valid

> ⚠ **CAUTION**
> In rapid traverse, JOG feed, and manual handle feed, external deceleration is enabled regardless of the settings of bits 4 (EDPx) and 5 (EDMx) of parameter No. 1005.

	#7	#6	#5	#4	#3	#2	#1	#0
1406							EX3	EX2

[Input type] Parameter input
[Data type] Bit path

 # 0 EX2 External deceleration function setting 2 is:
0: Invalid
1: Valid

 # 1 EX3 External deceleration function setting 3 is:
0: Invalid
1: Valid

1426	External deceleration rate setting 1 in cutting feed
1440	External deceleration rate setting 2 in cutting feed
1443	External deceleration rate setting 3 in cutting feed

[Input type] Parameter input
[Data type] Real path
[Unit of data] mm/min, inch/min, degree/min (machine unit)
[Minimum unit of data] Depend on the increment system of the reference axis
[Valid data range] Refer to the standard parameter setting table (C)
(When the increment system is IS-B, 0.0 to +999000.0)
Set an external deceleration rate for cutting feed or positioning of linear interpolation type (G00).

1427	External deceleration rate setting 1 for each axis in rapid traverse
1441	External deceleration rate setting 2 for each axis in rapid traverse
1444	External deceleration rate setting 3 for each axis in rapid traverse

[Input type] Parameter input
[Data type] Real axis
[Unit of data] mm/min, inch/min, degree/min (machine unit)
[Minimum unit of data] Depend on the increment system of the applied axis
[Valid data range] Refer to the standard parameter setting table (C)
(When the increment system is IS-B, 0.0 to +999000.0)
Set the external deceleration rate of rapid traverse for each axis.

1434	Maximum manual handle feedrate setting 1 for each axis
1442	Maximum manual handle feedrate setting 2 for each axis
1445	Maximum manual handle feedrate setting 3 for each axis

[Input type] Parameter input
[Data type] Real axis
[Unit of data] mm/min, inch/min, degree/min (machine unit)
[Minimum unit of data] Depend on the increment system of the applied axis
[Valid data range] Refer to the standard parameter setting table (C)
(When the increment system is IS-B, 0.0 to +999000.0)
Set a maximum manual handle feedrate for each axis.

11.3 SPINDLE OUTPUT CONTROL BY THE PMC

11.3.1 Overview

The Dual Check Safety function uses the CNC CPU and spindle DSP to separately monitor the spindle speed (safe speed monitoring function). When the safe speed is exceeded by some axes with the guard closed after a guard open request is input (RSPs = 0), the protective door needs to be locked by the ladder program to prevent it from opening. When the safe speed is exceeded by some axes with the guard open (*VLDPs = 0), alarm SP0757 or SP9069 occurs to stop the spindle (in the free running or controlled stop state).

Spindle output control by PMC is a function of controlling the speed and polarity of spindle motor rotation of each spindle by using the PMC.

The Dual Check Safety function and spindle output control by PMC can be used to construct a machine that operates as shown below.

- Automatically reduces the speed of the spindle motor to the safe speed or lower after a guard open request is input to allow the guard to open.
- Prevents an alarm by the safe speed limit monitoring function from occurring by limiting the speed of the spindle motor to the safe speed limit or less with the guard open.

For speed control of the feed axis, see Section 11.2, "EXTERNAL DECELERATION."

11.3.2 Specifications

Switching control

Spindle output control function by the PMC can be used to specify the following:

- Spindle motor speed (number of rotations)
- Output polarity for each spindle motor (direction of rotation)

Usually, the CNC is used to control the speed and polarity of the first spindle motor. If a multi-spindle control function (T series) is added (bit 3 (MSP) of parameter No. 8133 = 1), the CNC can also control the second spindle motor.
Spindle output control by the PMC can be used to specify that either the CNC or the PMC is used to set each of the spindle motor speed and output polarity.
If TYPE-A is specified (bit 2 (MSI) of parameter No. 3709 is 0) when multi-spindle control is used, signals for the second spindle cannot be used.

Specifying the spindle motor speed

The PMC can be used to specify the spindle motor speed upon executing the following:

- Switching the controller from the CNC to the PMC, by issuing SINDx signal
- Setting the spindle motor speed data, calculated by the PMC, in spindle control signals R01Ix to R12Ix

When controlled by the PMC, the spindle motor speed is not affected by any signal (for example, the spindle speed override signal) or parameter settings (for example, the maximum speed clamp parameter) related to the spindle speed command of the CNC spindle control function. However, the individual spindle stop signals (*SSTPx <Gn027.3 and 4>) during use of multi-spindle control are enabled (bit 3 (MSP) of parameter No. 8133 = 1).
The spindle motor speed data is obtained from the following expression. Its value can range from 0 to 4095:
Spindle motor speed data =
(Spindle motor speed/Maximum spindle motor speed)×4095

Normally, the speed of the spindle is actually controlled. If a gear train is used to connect the spindle to the spindle motor, first obtain the maximum spindle speed at the maximum spindle motor speed.
Spindle motor speed data =
(Spindle speed/Maximum spindle speed)×4095
By using this expression, the spindle motor speed data can easily be obtained.

Specifying the output polarity for the spindle motor

The PMC can specify the spindle motor output polarity when the following are executed:

- Switching the controller from the CNC to the PMC, by issuing an SSINx signal
- Specifying the output polarity to the SGNx signal

11.3.3 Signals

11.3.3.1 Details on signals

Spindle motor speed command selection signal
SIND <Gn033.7> (for 1st spindle)
SIND2 <Gn035.7> (for 2nd spindle)

[Classification] Input signal
[Function] This signal specifies that either the CNC or PMC is used to control the spindle motor speed command.
[Operation] When this signal is 0, the spindle motor speed command is controlled by the CNC.
When this signal is 1, the spindle motor speed command is controlled by the PMC.

Spindle motor speed command signals
R01I to R12I <Gn032.0 to Gn033.3> (for 1st spindle)
R01I2 to R12I2 <Gn034.0 to Gn035.3> (for 2nd spindle)

[Classification] Input signal
[Function] When the spindle motor speed command is controlled by the PMC, set the value obtained from the following expression for this signal in binary.
Spindle motor speed data =
(Spindle motor speed/Maximum spindle motor speed)×4095

Spindle motor command polarity selection signals
SSIN <Gn033.6> (for 1st spindle)
SSIN2 <Gn035.6> (for 2nd spindle)

[Classification] Input signal
[Function] This signal specifies that either the CNC or PMC is used to control the output polarity of the spindle motor speed command.
[Operation] When this signal is 0, the output polarity of the spindle motor speed command is controlled by the CNC.
When this signal is 1, the output polarity of the spindle motor speed command is controlled by the PMC.

Spindle motor command polarity command signals
SGN <Gn033.5> (for 1st spindle)
SGN2 <Gn035.5> (for 2nd spindle)

[Classification] Input signal
[Function] When the output polarity of the speed command for the spindle motor is controlled by the PMC, set this signal.
[Operation] When this signal is 0, the output polarity of spindle is the positive direction. When this signal is 1, the output polarity of spindle is the negative direction.

11.3.3.2 Signal address

	#7	#6	#5	#4	#3	#2	#1	#0
Gn032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
Gn033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I

	#7	#6	#5	#4	#3	#2	#1	#0
Gn034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
Gn035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

11.3.4 Parameters

	#7	#6	#5	#4	#3	#2	#1	#0
3709						MSI		

[Input type] Parameter input
[Data type] Bit path

 # 2 MSI In multi-spindle control, the SIND signal is valid

0: Only when the first spindle is valid (SIND signal for the 2nd, 3rd spindle becomes ineffective) (TYPE-A)

1: For each spindle irrespective of whether the spindle is selected (Each spindle has its own SIND signal). (TYPE-B)

11.4 SPINDLE POSITIONING (T SERIES)

T

11.4.1 Overview

The Dual Check Safety function uses the CNC CPU and spindle DSP to separately monitor the spindle speed (safe speed monitoring function). When monitoring the stop state of the spindle with the safe speed monitoring function, set the safe speed parameter to a non-zero value by considering a margin according to the machine. This is because the actual speed cannot be assumed to be 0. In this case, the spindle may rotate at a speed less than the set safe speed, so it is necessary to position the spindle by forming a position control loop at the same time.

The spindle positioning function positions the spindle with the spindle motor and position coder or the like.

To use the spindle positioning function, set bit 1 (AXC) of parameter No. 8133 to 1. The Cs contour control function and the spindle positioning function cannot be used at the same time.

11.4.2 Specifications

Spindle positioning

Spindle positioning is performed as follows.

- Cancel the spindle rotation mode, which is used for turning with the spindle rotating, and enter the spindle positioning mode.
- Position the spindle in the spindle positioning mode.
- Cancel the spindle positioning mode and enter the spindle rotation mode.

Selecting a spindle positioning axis

Any axis address can be set (with parameter No. 1020) as the axis name of an axis to be subject to spindle positioning. To set the servo axis number of the spindle positioning axis (with parameter No. 1023), use a negative value (-(the number of a spindle to be subject to spindle positioning)).

Switching to spindle positioning mode

Orientation is required when spindle positioning is performed for the first time after the spindle motor is used as a normal spindle or when spindle positioning is resumed after the spindle positioning is suspended.
Orientation is the function for stopping the spindle at a fixed position. The grid shift function can be used to shift the orientation position from 0 to 360 degrees (parameter No. 4073).
Orientation can be specified by the M code set in parameter No. 4960.
The direction of orientation is set in RETSV (bit 4 of parameter No. 4000).
The position where orientation is completed is assumed as the program zero point. However, the coordinate system setting (G92 (for G-code system B, C) or G50 (for G-code system A)) or automatic coordinate system setting (bit 0 (ZPR) of parameter No.1201) can be used to change the program zero point.

Positioning command

There are two types of spindle positioning: semi-fixed angle positioning and optional angle positioning.

Semi-fixed angle positioning

Semi-fixed angle positioning is specified with an M code (parameter No.4960). Six values (Mx to M(x + 5)) can be specified and x needs to be set in parameter No. 4962 in advance. By specifying the number (n) of used M codes in parameter No. 4964, any of the values from Mx to M(x+(n-1)) not exceeding M(x+(255-1)) (255 ways) can be specified. The positioning angles corresponding to the values are shown in the table below. The value of base rotation angle y is set in parameter No. 4963. The rotation direction is set in bit 1 (IDM) of parameter No. 4950. Incremental specification is always assumed.

M code	Indexing angle	(Example) y=30deg
Mx	y	30 deg
M(x+1)	2y	60 deg
M(x+2)	3y	90 deg
M(x+3)	4y	120 deg
M(x+4)	5y	150 deg
M(x+5)	6y	180 deg
:	:	:
M(x+n-1)	ny	30 × n deg

Optional angle positioning

Optional angle positioning is specified by an axis angle followed by a signed value. Use the G00 mode to specify this positioning.
Example) C-1000

The minimum setting unit is 0.001 degrees and the allowable specification range is between -999999.999 degrees and 999999.999 degrees.
A command with a decimal point is also allowed. The position of the decimal point denotes the degree position.
Example) C35.0 = C35 deg

Feedrate and acceleration/deceleration type

The feedrate used in positioning is the rapid traverse rate set in parameter No. 1420. An override of 100%, 50%, 25%, or F0 (parameter No. 1421) can be applied to the rapid traverse rate. Liner acceleration/deceleration is used as the acceleration/deceleration type.

Spindle positioning reset

Switching from the spindle positioning mode to the spindle rotation mode is specified by the M code set in parameter No. 4961.

11.4.3 Signals

11.4.3.1 Details on signals

Spindle stop complete signal
SPSTPA <Gn028.6> (for 1st spindle)
SPSTPB <Gn402.1> (for 2nd spindle)

[Classification] Input signal
[Function] The CNC checks that this signal turns 1 and then performs orientation before spindle positioning, spindle positioning, or spindle positioning cancellation.

Spindle unclamp signal
SUCLPA <Fn038.1> (for 1st spindle)
SUCLPB <Fn400.1> (for 2nd spindle)

[Classification] Output signal
[Function] This signal specifies that spindle mechanical clamping be released in a spindle positioning sequence.
When the signal turns 1, release spindle clamping on the machine side (release the brake or draw the pin).
[Output condition] For details, refer to the sequence (time chart) in the Connection Manual (Function) (B-64303EN-1).

Spindle unclamp completion signal
***SUCPFA <Gn028.4> (for 1st spindle)**
***SUCPFB <Gn400.1> (for 2nd spindle)**

[Classification] Input signal
[Function] This signal indicates that unclamping the spindle is complete in response to the spindle unclamp signal SUCLPs.

Spindle clamp signal
SCLPA <Fn038.0> (for 1st spindle)
SCLPB <Fn401.1> (for 2nd spindle)

[Classification] Output signal
[Function] This signal specifies that the spindle be clamped mechanically in a spindle positioning sequence.
When the signal turns 1, perform spindle clamping on the machine side (insert the brake or pin).
[Output condition] For details, refer to the sequence (time chart) in the Connection Manual (Function) (B-64303EN-1).

Spindle clamp completion signal
***SCPFA <Gn028.5> (for 1st spindle)**
***SCPFB <Gn401.1> (for 2nd spindle)**

[Classification] Input signal
[Function] This signal indicates that clamping the spindle is complete in response to the spindle clamp signal SCLPs.

Spindle orientation completion signal
ZP1 to ZP5 <Fn094.0 to 4>

[Classification] Output signal
[Function] This signal indicates that spindle orientation of the spindle positioning axis is completed.
[Output condition] When the orientation of spindle positioning is completed, this signal is 1. When spindle positioning is performed or released, this signal is 0.

11.4.3.2 Signal address

	#7	#6	#5	#4	#3	#2	#1	#0
Gn028		SPSTPA	*SCPFA	*SUCPFA				
Gn400							*SUCPFB	
Gn401							*SCPFB	
Gn402							SPSTPB	

	#7	#6	#5	#4	#3	#2	#1	#0
Fn038							SUCLPA	SCLPA
Fn094				ZP5	ZP4	ZP3	ZP2	ZP1
Fn400							SUCLPB	
Fn401							SCLPB	

11.4.4 Parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1013							ISCx	ISAx

[Input type] Parameter input
[Data type] Bit axis
For an axis to be subject to spindle positioning, set ISAx to ISCx to 0.

1020	Program axis name for each axis

[Input type] Parameter input
[Data type] Byte axis
Set the axis name of an axis to be subject to spindle positioning.

1023	Number of the servo axis for each axis

[Input type] Parameter input
[Data type] Byte axis
This parameter sets the relationships between the individual axes and the servo axis numbers.
For an axis to be subject to spindle positioning, set the number of the spindle to be subject to spindle positioning preceded by a minus sign.

1260	The shift amount per one rotation of a rotation axis

[Input type] Parameter input
[Data type] Real axis
For the rotation axis, set the amount of movement for one turn.
For the spindle positioning axis, set 360.0.

1820	Command multiplier for each axis (CMR)

[Input type] Parameter input
[Data type] Byte axis
Set a value of 2 targeted for spindle positioning.

1821	Reference counter size for each axis

[Input type] Parameter input
[Data type] 2-word axis
Set a value of 10000 targeted for spindle positioning.

3720	Number of position coder pulses

[Input type] Parameter input
[Data type] 2-word spindle
Set the number of position coder pulses.
For spindle positioning, set 4096.

3721	Number of gear teeth on the position coder side

[Input type] Parameter input
[Data type] Word spindle
Set the number of gear teeth on the position coder side in speed control (such as feed per revolution and threading).
For spindle positioning, set 2^n (where n is an integer greater than or equal to 0).

3722	Number of gear teeth on the spindle side

[Input type] Parameter input
[Data type] Word spindle
Set the number of gear teeth on the spindle side in speed control (such as feed per revolution and threading).
For spindle positioning, set 1.

	#7	#6	#5	#4	#3	#2	#1	#0
4000				RETSV				

[Input type] Parameter input
[Data type] Bit spindle

 # 4 RETSV The reference position return direction of the spindle in spindle positioning is:
0: CCW (counterclockwise)
1: CW (clockwise)

4044	Proportional gain of the velocity loop in servo mode (HIGH gear)
4045	Proportional gain of the velocity loop in servo mode (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
Set a proportional gain for the velocity loop on spindle positioning.

4052	Integral gain of the velocity loop in the servo mode (HIGH gear)
4053	Integral gain of the velocity loop in the servo mode (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data]
[Valid data range] 0 to 32767
Set an integral gain of the velocity loop on spindle positioning.

4056	Gear ratio (HIGH gear)
4057	Gear ratio (MEDIUM HIGH gear)
4058	Gear ratio (MEDIUM LOW gear)
4059	Gear ratio (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] Motor speed per spindle rotation × 100
[Valid data range] 0 to 32767
These parameters set the gear ration between the spindle and spindle motor.

4065	Position gain in servo mode (HIGH gear)
4066	Position gain in servo mode (MEDIUM HIGH gear)
4067	Position gain in servo mode (MEDIUM LOW gear)
4068	Position gain in servo mode (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 0.01 sec^{-1}
[Valid data range] 0 to 32767
These parameters set a servo loop gain on spindle positioning.

4073	Grid shift amount on servo mode

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 1 pulse (=360deg/4096)
[Valid data range] 0 to 4095
The reference position is shifted counterclockwise by the set number of pulses.

4085	Motor voltage in the servo mode

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 1%
[Valid data range] 0 to 100
Set the motor voltage in the servo mode.

	#7	#6	#5	#4	#3	#2	#1	#0
4950	IMBs	ESIs	TRVs			ISZs	IDMs	IORs

[Input type] Parameter input
[Data type] Bit spindle

 # 0 IORs Resetting the system in the spindle positioning mode
0: Does not release the mode.
1: Releases the mode

 # 1 IDMs The direction of spindle positioning (half-fixed angle positioning based on M codes) is:
0: Plus direction.
1: Minus direction.

 # 2 ISZs When an M code for spindle orientation is specified in spindle positioning:
0: The spindle is switched to the spindle positioning mode, and spindle orientation operation is performed.
1: Only the switching of the spindle to the spindle positioning mode is performed. (Spindle orientation operation is not performed.)

 # 5 TRVs The rotation direction for spindle positioning is:
0: Same as the specified sign.
1: Opposite to the specified sign.

> **NOTE**
> When a serial spindle is used, this parameter is invalid for the specification of a rotation direction for the orientation command.

 # 6 ESIs The unit of rapid traverse rate on the spindle positioning axis is:
0: Not increased by a factor of 10.
1: Increased by a factor of 10.

 # 7 IMBs When the spindle positioning function is used, half-fixed angle positioning based on M codes uses:
0: Specification A
1: Specification B

In the case of half-fixed angle positioning based on M codes, three types of spindle positioning operations can occur:
(1) The spindle rotation mode is cleared, then the mode is switched to the spindle positioning mode. (After switching to the spindle positioning mode, spindle orientation operation is also performed.)
(2) Spindle positioning is performed in the spindle positioning mode.
(3) The spindle positioning mode is cleared, then the mode is switched to the spindle rotation mode.

- In the case of specification A:
  Operations (1) to (3) are specified using separate M codes.
  (1) Specified using an M code for switching to the spindle positioning mode.
  (See parameter No.4960)
  (2) Specified using M codes for specifying a spindle positioning angle.
  (See parameter No.4962)
  (3) Specified using M codes for clearing spindle positioning operation.
  (See parameter No.4961.)
- In the case of specification B:
  When M codes for specifying a spindle positioning angle are specified, operations (1) to (3) are performed successively. (See parameter No.4962.) (However, spindle orientation operation of (1) is not performed.)

4960	M code specifying the spindle orientation

[Input type] Parameter input
[Data type] 2-word spindle
[Valid data range] 6 to 97
Set an M code for switching to the spindle positioning mode.

NOTE
1 Do not set an M code that duplicates other M codes used for spindle positioning.
2 Do not set an M code used with other functions (such as M00-05, 30, 98, and 99, and M codes for calling subprograms).

4961	M code releasing the spindle positioning mode

[Input type] Parameter input
[Data type] 2-word spindle
[Valid data range] 6 to 97
Set an M code for canceling the spindle positioning mode on the spindle positioning axis.

NOTE
1 Do not set an M code that duplicates other M codes used for spindle positioning.
2 Do not set an M code used with other functions (such as M00-05, 30, 98, and 99, and M codes for calling subprograms).

4962	M code for specifying a spindle positioning angle

[Input type] Parameter input
[Data type] 2-word spindle
[Valid data range] 6 to 9999999

Two methods are available for specifying spindle positioning. One method uses axis address for arbitrary-angle positioning. The other use an M code for half-fixed angle positioning. This parameter sets an M code for the latter method.

In this parameter, set an M code to be used for half-fixed angle positioning based on M codes.

Six M code from Mα to M(α+5) are used for half-fixed angle positioning, when α is the value of this parameter.

- When the number of M codes is set in parameter No. 4964, let α be the value set in parameter No. 4962, and let β be the value set in parameter No. 4964. Then, β M codes from Mα to M(α+β-1) are used as M codes for half-fixed angle positioning based on M codes.

The table below indicates the relationship between the M codes and positioning angles.

M code	Positioning angle	Example: Positioning angle when θ = 30°
Mα	θ	30°
M(α+1)	2θ	60°
M(α+2)	3θ	90°
M(α+3)	4θ	120°
M(α+4)	5θ	150°
M(α+5)	6θ	180°
:	:	:
M(α+β-1)	β×θ	β×30°

β represents the number of M codes set in parameter No. 4964.
(When parameter No. 4964 is set to 0, β = 6.)
θ represents the basic angular displacement set in parameter No.4963.

NOTE
1 Do not set an M code that duplicates other M codes used for spindle positioning.
2 Do not set an M code used with other functions (such as M00-05, 30, 98, and 99, and M codes for calling subprograms).

4963	Basic angle for half-fixed angle positioning

[Input type] Parameter input
[Data type] Real spindle
[Unit of data] Degree
[Minimum unit of data] Depend on the increment system of the applied axis
[Valid data range] 0 to 60
This parameter sets a basic angular displacement used for half-fixed angle positioning using M codes.

4964	Number of M codes for specifying a spindle positioning angle

[Input type] Parameter input
[Data type] 2-word spindle
[Valid data range] 0 to 255
This parameter sets the number of M codes used for Half-fixed angle positioning using M codes.
As many M codes as the number specified in this parameter, starting with the M code specified in parameter No.4962, are used to specify half-fixed angle positioning.
Let α be the value of parameter No.4962, and let β be the value of parameter No.4964. That is, M codes from Mα to M(α+β-1) are used for half-fixed angle positioning.
Setting this parameter to 0 has the same effect as setting 6. That is, M code from Mα to M(α+5) are used for half-fixed angle positioning.

NOTE
1 Make sure that M codes from Mα to M (α+β-1) do not duplicate other M codes.
2 Do not set an M code that duplicates other M codes used for spindle positioning.
3 Do not set an M code used with other functions (such as M00-05, 30, 98, and 99, and M codes for calling subprograms).

11.5 Cs CONTOUR CONTROL

11.5.1 Overview

The Dual Check Safety function uses the CNC CPU and spindle DSP to separately monitor the spindle motor speed (safe speed monitoring function). When the stop status of the spindle is monitored by the safe speed monitoring function, set the safe speed parameter to a value including a margin appropriate for the machine instead of 0 because the actual speed cannot be assumed to be 0. Since the spindle may rotate at a speed less than the set safe speed in this case, it is necessary to position the spindle with a position control loop formed at the same time.

The Cs contour control function makes spindle positioning control (spindle contour control).

When Cs contour control is performed, the configuration of the spindle detector is restricted. For details, refer to the FANUC AC SPINDLE MOTOR αi series Parameter Manual (B-65280EN) or other documents.

To use Cs contour control, set bit 2 (SCS) of parameter No. 8133 to 1. The Cs contour control function and the spindle positioning function cannot be used at the same time.

11.5.2 Specifications

Cs contour control mode

The Cs contour control change signal is used to switch between spindle rotation control (method of controlling the rotation of the spindle with the velocity command) and spindle contour control (method of controlling the rotation of the spindle with the move command). The mode for spindle contour control is called the Cs contour control mode. The manual and automatic operation of the spindle in the Cs contour control mode can be performed as with normal servo axes.

Although interpolation is enabled for the spindle and servo axis in the Cs contour control mode, this subsection describes only spindle positioning, not interpolation of the spindle and servo axis.

Setting the Cs contour control axis

The axis targeted for Cs contour control is placed as one axis of CNC control axes. Any of the control axes can be selected as the Cs contour control axis, but one of -1 to -2 (The 1st to 2nd logical spindle is used as the Cs axis.) must be set for specifying the servo axis number (parameter No. 1023).

The Cs contour control axis must be set as a rotation axis (bit 0 (ROTx) of parameter No. 1006 is 1 and parameter No. 1022 is 0).

The axis name (parameter No. 1020) of the Cs contour control axis can be arbitrarily selected.

To use the second spindle within the path as a Cs axis, set bit 7 (CSS) of parameter No. 3704 to 1.

Shifting to Cs contour control

To shift from the spindle rotation control mode to the Cs contour control mode, set the Cs contour control change signal CON (or CONS1 to CONS2) to 1. This immediately stops the spindle and then executes mode switching.

Shifting to spindle rotation control

To shift from the Cs contour control mode to the spindle rotation control mode, set the Cs contour control change signal CON (or CONS1 to CONS2) to 0.

Before switching, make sure that the move command for the spindle during automatic or manual operation is fully completed. If the switching is made while the spindle is rotating, the interlock state is entered or an alarm indicating a too large positional deviation occurs.

11.5.3 Signals

11.5.3.1 Details on signals

Cs contour control change signal
CON <Gn027.7>

[Classification] Input signal

[Function] When the Cs contour control function is used, this signal specifies switching between the spindle rotation control mode and Cs contour control mode for the first spindle within the path.
When this signal is set to 1, the spindle is switched from the spindle rotation mode to the Cs contour control mode. When this signal is set to 1 while the spindle is rotating, the spindle stops immediately and then enters the Cs contour control mode.
When this signal is set to 0, the spindle is switched from the Cs contour control mode to the spindle rotation mode.

> ⚠ **CAUTION**
> This signal is enabled only when bit 7 (CSS) of parameter No. 3704 is 0.
> When bit 7 (CSS) of parameter No. 3704 is 1 (when Cs-axis contour control by the individual spindles is used), use the Cs contour change signals (CONS1(Gn274.0) to CONS2(Gn274.1)) of the individual spindles.

Cs contour control change completion signal
FSCSL <Fn044.1>

[Classification] Output signal

[Function] This signal indicates that the Cs contour control mode is entered.

[Output condition] In the spindle rotation control mode, this signal is 0.
In the Cs contour control mode, this signal is 1.

> ⚠ **CAUTION**
> This signal is enabled only when bit 7 (CSS) of parameter No. 3704 is 0.
> When bit 7 (CSS) of parameter No. 3704 is 1 (when Cs contour control by the individual spindles is used), use the Cs contour change completion signals (FCCS1(Fn274.0) to FCCS2(Fn274.1)) of the individual spindles.

Cs contour control change signals in each axis CONS1 to CONS2 <Gn274.0 to Gn274.1>

[Classification] Input signal

[Function] When the Cs contour control function is used, this signal specifies switching between the spindle rotation control mode and Cs axis control mode for the first and second spindles within the path.
When this signal is set to 1, the spindles are switched from the spindle rotation mode to the Cs contour control mode. When this signal is set to 1 while the spindles are rotating, the spindles stop immediately and then enter the Cs contour control mode.
When these signals are set to 0, the spindles are switched from the Cs contour control mode to the spindle rotation mode.

> ⚠ **CAUTION**
> These signals are enabled only when bit 7 (CSS) of parameter No. 3704 is 1 (when Cs contour control by the individual spindles is used).
> When bit 7 (CSS) of parameter No. 3704 is 0, use the Cs contour change signal (CON(Gn027.7)).

Cs contour control change completion signals in each axis FCCS1 to FCCS2 <Fn274.0 to Fn274.1>

[Classification] Output signal

[Function] This signal indicates that the first and second spindles within the path are switched to the Cs contour control mode.

[Output condition] In the spindle rotation control mode, these signals are 0.
In the Cs contour control mode, these signals are 1.

> ⚠ **CAUTION**
> These signals are enabled only when bit 7 (CSS) of parameter No. 3704 is 1 (when Cs contour control by the individual spindles is used).
> When bit 7 (CSS) of parameter No. 3704 is 0, use the Cs contour change completion signal (FSCSL(Fn044.1)).

11.5.3.2 Signal address

	#7	#6	#5	#4	#3	#2	#1	#0
Gn027	CON							
Gn274							CONS2	CONS1

	#7	#6	#5	#4	#3	#2	#1	#0
Fn044							FSCSL	
Fn274							FCCS2	FCCS1

11.5.4 Parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1006					DIAx			ROTx

[Input type] Parameter input
[Data type] Bit axis

 # 0 ROTx Setting linear or rotation axis.
0: Linear axis.
1: Rotation axis.
Set 1 for the Cs contour control axis.

 # 3 DIAx The move command for each axis is based on:
0: Radius specification
1: Diameter specification
Set 0 for the Cs contour control axis.

1022	Setting of each axis in the basic coordinate system

[Input type] Parameter input
[Data type] Byte axis
Specify whether each axis is one of the three basic axes (X, Y, Z) or one of their parallel axes.
Set 0 for the Cs contour control axis.

1023	Number of the servo axis for each axis

[Input type] Parameter input
[Data type] Byte axis
Set relationships between the individual axes and the servo axis numbers.
Set one of -1 to -2 (1 to 2: logical spindle number) for the Cs contour control axis.
(Setting value)
-1 : Cs contour control axis by the first logical spindle
-2 : Cs contour control axis by the second logical spindle

> ⚠ **CAUTION**
> 1 When Cs contour control is to be exercised on the second spindle within the path, bit 7 (CCS) of parameter No. 3704 needs to be set to 1.
> 2 One spindle cannot be set as multiple Cs contour control axes.

1260	The shift amount per one rotation of a rotation axis

[Input type] Parameter input
[Data type] Real axis
Set the amount of a shift per one rotation of a rotation axis.
Set 360.0 for the Cs contour control axis.

1820	Command multiplier for each axis (CMR)

[Input type] Parameter input
[Data type] Byte axis
Set 2 for the Cs contour control axis.

	#7	#6	#5	#4	#3	#2	#1	#0
3704	CSS							

[Input type] Parameter input
[Data type] Bit path

 # 7 CSS On the second spindle in the path, Cs contour control is:
0: Not performed.
1: Performed.
To exercise Cs contour control on the second spindle in the path, set this bit to 1.

	#7	#6	#5	#4	#3	#2	#1	#0
4000					RETRN			

[Input type] Parameter input
[Data type] Bit spindle

 # 3 RETRN The reference position return direction of the spindle in Cs contour control is:
0: CCW (counterclockwise)
1: CW (clockwise)

4046	Speed loop proportional gain in Cs contour control (HIGH gear)
4047	Speed loop proportional gain in Cs contour control (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data]
[Valid data range] 0 to 32767
Set the speed loop proportional gain in Cs contour control.

4054	Speed loop integral gain in Cs contour control (HIGH gear)
4055	Speed loop integral gain in Cs contour control (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data]
[Valid data range] 0 to 32767
Set the speed loop integral gain in Cs contour control.

4056	Gear ratio (HIGH gear)
4057	Gear ratio (MEDIUM HIGH gear)
4058	Gear ratio (MEDIUM LOW gear)
4059	Gear ratio (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] Motor speed per spindle rotation × 100
[Valid data range] 0 to 32767
These parameters set the gear ration between the spindle and spindle motor.

4069	Position gain in Cs contour control (HIGH gear)
4070	Position gain in Cs contour control (MEDIUM HIGH gear)
4071	Position gain in Cs contour control (MEDIUM LOW gear)
4072	Position gain in Cs contour control (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 0.01 sec^{-1}
[Valid data range] 0 to 32767
Set the servo loop gain in Cs contour control.

4086	Motor voltage in Cs contour control

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 1%
[Valid data range] 0 to 100
Set the motor voltage in Cs contour control.

4135	Amount of grid shift in Cs contour control

[Input type] Parameter input
[Data type] 2-word spindle
[Unit of data] 1 pulse (=0.001deg)
[Valid data range] -360000 to +360000
The reference position of the spindle shifts counterclockwise by the specified number of pluses.

11.6 SPINDLE ORIENTATION

11.6.1 Overview

The Dual Check Safety function uses the CNC CPU and spindle DSP to separately monitor the spindle motor speed (safe speed monitoring function). When the stop status of the spindle is monitored by the safe speed monitoring function, set the safe speed parameter to a value including a margin appropriate for the machine instead of 0 because the actual speed cannot be assumed to be 0. Since the spindle may rotate at a speed less than the set safe speed in this case, it is necessary to position the spindle with a position control loop formed at the same time.

The spindle orientation function stops the spindle at a fixed position using the position coder mounted on the spindle. For details, refer to the FANUC AC SPINDLE MOTOR αi series Parameter Manual (B-65280EN) or other documents.

To use the spindle orientation function, set bit 4 (NOR) of parameter No. 8135 to 0.

11.6.2 Specifications

Orientation

The orientation command (ORCMx) can be used to stop the spindle at a fixed position.
When the orientation command is entered while the spindle is rotating, the spindle decelerates immediately and stops at the fixed position.

Switching to the orientation mode

When the orientation command signal ORCMx is set to 1, spindle rotation control mode (method of controlling the rotation of the spindle with the velocity command) is switched to the orientation mode.

Switching to spindle rotation control

When the orientation command signal ORCMx is set to 0, the orientation mode is switched to the spindle rotation control mode.
As soon as the orientation command signal is set to 0, the velocity command for spindle rotation control becomes valid and the spindle rotates. For safety, set the forward/reverse spindle rotation commands (SFRx/SRVx) and the velocity command to 0.

11.6.3 Signals

11.6.3.1 Details on signals

Orientation command signal
ORCMA <Gn070.6> (for 1st spindle)
ORCMB <Gn074.6> (for 2nd spindle)

[Classification] Input signal

[Function] This signal specifies spindle orientation.
When this signal is set to 1, the spindle immediately decelerates during rotation and stops at a fixed position.
Be sure to set the signal to 0 before power-on.

Emergency stop signal
***ESPA <Gn071.1> (for 1st spindle)**
***ESPB <Gn075.1> (for 2nd spindle)**

[Classification] Input signal

[Function] This signal specifies an emergency stop.
When the signal is set to 1, the spindle motor and spindle amplifier become ready to operate.
When the signal is set to 0, the spindle motor immediately decelerates and then stops.
By monitoring the orientation completion signal (ORARx), set the signal to 0 if there is a deviation from the stop position.
Since the spindle motor becomes ready to rotate when the signal is set to 1, the spindle motor immediately rotates upon receiving the rotation command. Therefore, immediately after setting this signal to 0, reset the command signals (velocity command, forward command, and reverse command) for the spindle amplifier.

Power interruption signal
MPOFA <Gn073.2> (for 1st spindle)
MPOFB <Gn077.2> (for 2nd spindle)

[Classification] Input signal

[Function] This signal turns off the excitation of the motor.
By setting the signal to 1, the excitation of the spindle motor can be turned off to enable free running.
By monitoring the orientation completion signal (ORARx), set the signal to 1 if there is a deviation from the stop position.
The excitation of the motor can be turned on again after the motor stops (zero speed signal SSTx = 1). Even if this signal is set to 0, excitation cannot be turned on while the motor is rotating (SSTx = 0).
After turning off the excitation of the motor, reset the command signals (velocity command, forward command, and reverse command) for the spindle amplifier.

Orientation completion signal
ORARA <Fn045.7> (for 1st spindle)
ORARB <Fn049.7> (for 2nd spindle)

[Classification] Output signal

[Function] This signal is set to 1 when the orientation command is entered and the spindle stops near the specified fixed position.

[Output condition] This signal is set to 1 when all conditions below are satisfied.

- ORCMx (orientation command) = 1
- SSTx (zero speed detection signal) = 1
- The spindle is present near the fixed position.

The conditions of proximity to the fixed position are set by the parameter (orientation completion signal detection level: No. 4075).

This signal is set to 0 when the spindle deviates from the fixed position due to application of an external force or other causes. To monitor the stop status of the spindle by setting a spindle positioning loop with the spindle orientation function, set a sequence that interrupts the power of the spindle motor if there is deviation from the stop position by monitoring the signal.

Zero speed detection signal
SSTA <Fn045.1> (for 1st spindle)
SSTB <Fn049.1> (for 2nd spindle)

[Classification] Output signal

[Function] This signal is set to 1 when the rotation speed of the actual spindle motor becomes equal to or less than the zero speed detection level.

11.6.3.2 Signal address

	#7	#6	#5	#4	#3	#2	#1	#0
Gn070	MRDYA	ORCMA	SFRA	SRVA				
Gn071							*ESPA	
Gn073						MPOFA		
Gn074	MRDYB	ORCMB	SFRB	SRVB				
Gn075							*ESPB	
Gn077						MPOFB		

	#7	#6	#5	#4	#3	#2	#1	#0
Fn045	ORARA						SSTA	
Fn049	ORARB						SSTB	

11.6.4 Parameters

	#7	#6	#5	#4	#3	#2	#1	#0
4003					DIRCT2	DIRCT1		

[Input type] Parameter input
[Data type] Bit spindle

 # 2 DIRCT1 Setting of rotation direction at spindle orientation
 # 3 DIRCT 2

DIRCT2	DIRCT1	Rotation direction at spindle orientation
0	0	By rotation direction immediately before (It is CCW at the power on.)
0	1	By rotation direction immediately before (It is CW at the power on.)
1	0	CCW (counterclockwise) direction looking from shaft of motor
1	1	CW (clockwise) direction looking from shaft of motor

4031	Position coder method orientation stop position

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 1 pulse unit (360°/4096)
[Valid data range] 0 to 4096
Set the position coder method orientation stop position.

4038	Spindle orientation speed

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] $1min^{-1}$
[Valid data range] 0 to 32767
This parameter sets the orientation speed at the end of the spindle.

4042	Velocity loop proportional gain on orientation (HIGH gear)
4043	Velocity loop proportional gain on orientation (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data]
[Valid data range] 0 to 32767
This parameter sets the velocity loop proportional gain for spindle orientation.

4050	Velocity loop integral gain on orientation (HIGH gear)
4051	Velocity loop integral gain on orientation (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data]
[Valid data range] 0 to 32767
This parameter sets the velocity loop integral gain for spindle orientation.

4056	Gear ratio (HIGH gear)
4057	Gear ratio (MEDIUM HIGH gear)
4058	Gear ratio (MEDIUM LOW gear)
4059	Gear ratio (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] Motor speed per spindle rotation × 100
[Valid data range] 0 to 32767
These parameters set the gear ration between the spindle and spindle motor.

4060	Position gain on orientation (HIGH gear)
4061	Position gain on orientation (MEDIUM HIGH gear)
4062	Position gain on orientation (MEDIUM LOW gear)
4063	Position gain on orientation (LOW gear)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 0.01 sec^{-1}
[Valid data range] 0 to 32767
These parameters set the position gain for orientation.

4064	Modification rate of position gain on orientation completion

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 1%
[Valid data range] 0 to 1000
This data is used to set the modification rate of position gain on spindle orientation completion.

4075	Orientation completion signal detection level (limits of in-position)

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 1 pulse unit (360°/4096)
[Valid data range] 0 to 100
This data is used to set the detecting level of orientation completion signal (ORARx).
When the spindle position is located within the setting data on orientation completion, the bit of orientation completion signal (ORARx) in the spindle control signals is set to "1".

4076	Motor speed limit ratio on orientation

[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 1%
[Valid data range] 0 to 100
This data is used to set motor speed limit ratio on orientation.

4077	Orientation stop position shift value

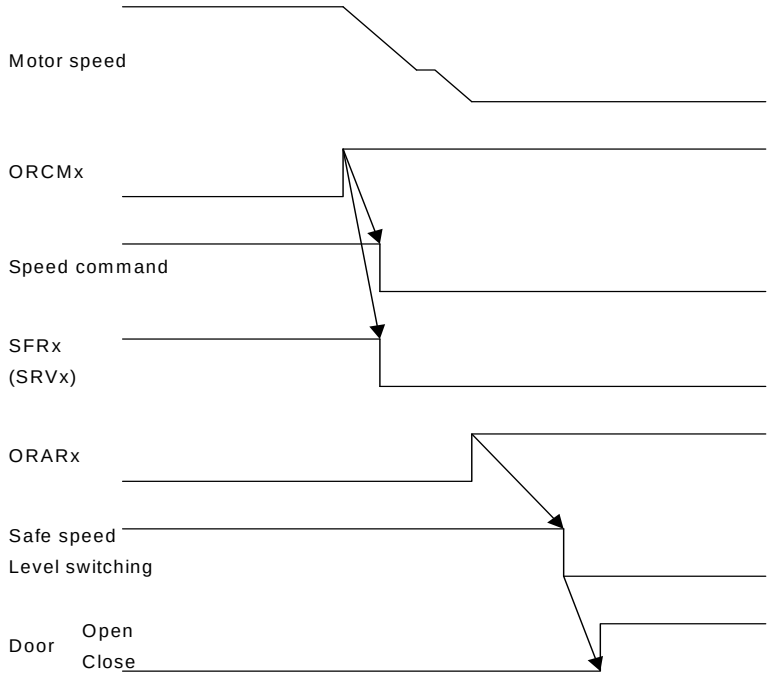
[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 1 pulse unit (360°/4096)
[Valid data range] -4095 to 4095
In the position coder method orientation, set this data to shift stop position.

4084	Motor voltage setting on orientation

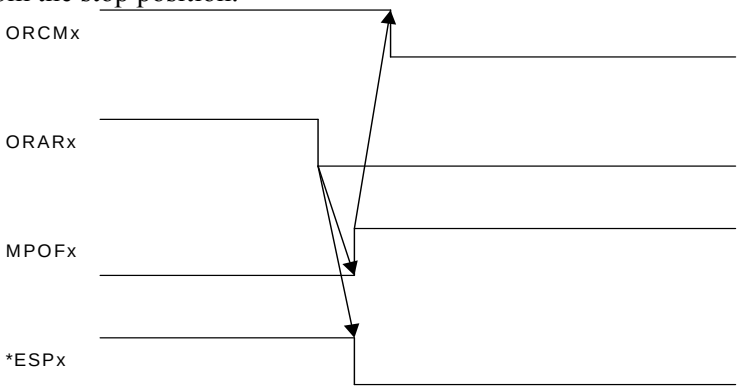
[Input type] Parameter input
[Data type] Word spindle
[Unit of data] 1%
[Valid data range] 0 to 100
This parameter sets the motor voltage for orientation.

11.6.5 Sequence

The following is a sample sequence in which orientation is specified during rotation of the spindle and work is conducted with the spindle stopped.



To monitor the stop status of the spindle, use a sequence as shown below.
By monitoring the orientation completion signal (ORARx), interrupt the power of the spindle motor with the power interruption signal (MPOFx) and emergency stop signal (*ESPx) if there is a deviation from the stop position.



⚠ CAUTION
This sequence uses the spindle orientation function to monitor the stop status of the spindle. If there is a deviation from the stop position since an excessive load is applied to the spindle, a large reaction force is generated. When the deviation is greater than or equal to the orientation completion level, excitation is turned off and the output torque is immediately reduced to zero.

12 COMPONENTS LIST

12.1 HARDWARE COMPONENTS

12.1.1 Series 0*i*-MODEL D

CNC Control unit

No.	Description	Specification Number	Remarks
1	Main board A1	A20B-8200-0541	
2	Main board A3	A20B-8200-0543	
3	Axes control card A1	A20B-3300-0635	
4	Axes control card A2	A20B-3300-0638	
5	Axes control card A3	A20B-3300-0637	
6	Axes control card B2	A20B-3300-0632	
7	Axes control card B3	A20B-3300-0631	
8	FROM/SRAM module A1 (FROM 64MB, SRAM 1MB)	A20B-3900-0242	
9	FROM/SRAM module B1 (FROM 128MB, SRAM 1MB)	A20B-3900-0240	
10	FROM/SRAM module B2 (FROM 128MB, SRAM 2MB)	A20B-3900-0241	
11	Power supply 0 slot	A20B-8200-0560	
12	Power supply 2 slot	A20B-8200-0570	
13	Inverter (for 8.4-inch color LCD)	A20B-8002-0703	
14	Inverter (for 10.4-inch color LCD)	A20B-8002-0702	
15	PROFIBUS-DP master board	A20B-8101-0050	
16	PROFIBUS-DP slave board	A20B-8101-0100	

NOTE
Only the hardware for the Dual Check Safety function is indicated above.

12.1.2 Hardware Components for Other Units

Other unit for CNC

No.	Description	Specification Number	Remarks
1	Separate detector I/F unit (Basic 4 axes)	A02B-0303-C205	
2	Separate detector I/F unit (Additional 4 axes)	A02B-0236-C204	
3	Analog input separate detector interface unit (Basic 4 axes)	A06B-6061-C201	
4	Optical I/O Link adapter	A13B-0154-B001	
5	Optical adapter	A13B-0154-B003	
6	Spindle connector adapter	A13B-0180-B001	
7	I/O Unit for 0i	A02B-0309-C001	DI/DO: 96/64 With manual pulse generator I/F
8	I/O module for operator's panel A1	A03B-0815-K200	DI/DO: 72/56 (DI : General=16, Matrix=56), With manual pulse generator I/F
9	I/O module for operator's panel B1	A03B-0815-K202	DI/DO: 48/32 With manual pulse generator I/F
10	I/O module for operator's panel B2	A03B-0815-K203	DI/DO: 48/32
11	I/O module for connector panel Basic	A03B-0815-C001	DI/DO: 24/16
12	I/O module for connector panel Extension A	A03B-0815-C002	DI/DO: 24/16 With manual pulse generator I/F
13	I/O module for connector panel Extension B	A03B-0815-C003	DI/DO: 24/16
14	I/O module for connector panel Extension C	A03B-0815-C004	DO: 16 (2A output)
15	I/O module for connector panel Extension D	A03B-0815-C005	Analog input
16	I/O module type-2 for connector panel B1	A03B-0815-C040	DI/DO:48/32 With manual pulse generator I/F
17	I/O module type-2 for connector panel B2	A03B-0815-C041	DI/DO:48/32 Without manual pulse generator I/F
18	I/O module type-2 for connector panel E1	A03B-0815-C042	DI/DO:48/32
19	Terminal Type I/O module Basic Module	A03B-0823-C001	DI/DO:24/16 With I/O Link I/F
20	Terminal Type I/O module Extension module A	A03B-0823-C002	DI/DO:24/16 With manual pulse generator I/F
21	Terminal Type I/O module Extension module B	A03B-0823-C003	DI/DO:24/16 Without manual pulse generator I/F
22	Terminal Type I/O module Extension module C	A03B-0823-C004	DO: 16 (2A output)
23	Terminal Type I/O module Extension module D	A03B-0823-C005	Analog input
24	Machine operator's panel Main panel A	A02B-0319-C242	Key with both symbol and English indicated With alphabetic MDI Three-point pressing supported
25	Machine operator's panel Main panel B	A02B-0319-C243	Key with both symbol and English indicated Three-point pressing supported
26	Machine operator's panel Sub panel A	A02B-0236-C232	
27	Machine operator's panel Sub panel B	A02B-0236-C233	
28	Machine operator's panel Sub panel B1	A02B-0236-C235	
29	Machine operator's panel Sub panel C	A02B-0236-C234	
30	Machine operator's panel Sub panel C1	A02B-0236-C236	
31	Small Machine operator's panel	A02B-0299-C152#M,T	

No.	Description	Specification Number	Remarks
32	Small Machine operator's panel B	A02B-0309-C151#M,T	
33	Operator's panel connection unit (source DO: A)	A16B-2202-0731	DI/DO: 64/32
34	Operator's panel connection unit (source DO: B)	A16B-2202-0730	DI/DO: 96/64
35	Handy machine operator's panel	A02B-0259-C221#A	
36	Interface unit for Handy machine operator's panel	A02B-0259-C220	
37	FANUC I/O LINK connection unit A	A20B-2000-0410	Electrical-Optical I/F
38	FANUC I/O LINK connection unit B	A20B-2000-0411	Electrical-Electrical I/F
39	FANUC I/O LINK connection unit C	A20B-2000-0412	Optical-Optical I/F
40	FANUC I/O Link-AS-i converter (for AS-I Ver.2.0)	A03B-0817-C001	
41	FANUC I/O Link-AS-i converter (for AS-I Ver.2.1)	A03B-0817-C002	
42	I/O Link signal divider (2ch)	A20B-1007-0680	
43	I/O Link signal divider (3ch)	A20B-1008-0360	
44	I/O unit base module ABU10A	A03B-0819-C001	
45	I/O unit base module ABU05A	A03B-0819-C002	
46	I/O unit base module ABU10B	A03B-0819-C003	
47	I/O unit base module ABU05B	A03B-0819-C004	
48	I/O unit interface module AIF01A	A03B-0819-C011	
49	I/O unit interface module AIF01B	A03B-0819-C012	
50	DC digital input module AID32A1	A20B-9000-0970 A03B-0819-C101	
51	DC digital input module AID32B1	A20B-9000-0971 A03B-0819-C102	
52	DC digital input module AID16D	A03B-0819-C104	
53	DC digital input module AID16L	A03B-0819-C114	
54	DC digital input module AID32E1	A03B-0819-C105	
55	DC digital input module AID32F1	A03B-0819-C106	
56	DC digital input module AIA16G	A03B-0819-C107	
57	DC digital input module AID32F2	A03B-0819-C109	
58	DC digital input module AID32E2	A03B-0819-C110	
59	DC digital input module AID32H1	A03B-0819-C111	
60	DC digital input module AID16G	A03B-0819-C115	
61	DC digital output module AOD08D	A03B-0819-C152	
62	DC digital output module AOD16D	A03B-0819-C154	
63	DC digital output module AOD32D1	A03B-0819-C156	
64	AC digital output module AOA05E	A03B-0819-C157	
65	AC digital output module AOA08E	A03B-0819-C158	
66	AC digital output module AOA12F	A03B-0819-C159	
67	Relay output module AOR08G	A03B-0819-C160	
68	Relay output module AOR16G	A03B-0819-C161	
69	Relay output module AOR16H2	A03B-0819-C165	
70	DC digital output module AOD32D2	A03B-0819-C167	
71	DC digital output module AOD16D2	A03B-0807-C171	
72	AC digital output module AOA05E	A03B-0819-C176	
73	AC digital output module AOA08E	A03B-0819-C177	
74	AC digital output module AOA12F	A03B-0819-C178	
75	Relay output module AOR08G	A03B-0819-C179	
76	Relay output module AOR16G	A03B-0819-C180	
77	DC digital output module AOD16DP	A03B-0819-C182	
78	DC digital output module AOD08DP	A03B-0819-C183	
79	DC digital input/output module AIO40A	A03B-0807-C200	

No.	Description	Specification Number	Remarks
80	Relay output module AOR16G2	A03B-0819-C184	

12.2 SOFTWARE

CNC CPU software

Name	Series/Edition	Remarks
FS0i-TD	D6F1/06~	
FS0i-MD	D4F1/06~	

PMC CPU software

Name	Series / Edition	Remarks
PMC BASIC	40B0/01~	

Servo control software

Name	Series / Edition	Remarks
Servo DSP	90C5/02~	
Servo DSP	90E5/02~	

Spindle software

Name	Series / Edition	Remarks
Spindle Software (αiSP series)	9D80/01~	
Spindle Software (βiSVSP series)	9D80/11~	

12.3 SERVO AMPLIFIER

SERVO AMPLIFIER αi series (200V)

- Common power supply

Series Name	Model Name	Specification Number	Remarks
αi PS series	αi PS 5.5	A06B-6140-H006	
	αi PS 11	A06B-6140-H011	
	αi PS 15	A06B-6140-H015	
	αi PS 26	A06B-6140-H026	
	αi PS 30	A06B-6140-H030	
	αi PS 37	A06B-6140-H037	
	αi PS 55	A06B-6140-H055	
αi PS_R series (Resistance regeneration type)	αi PS_R 3	A06B-6115-H003	
	αi PS_R 5.5	A06B-6115-H006	

- Spindle Amplifier

Series Name	Model Name	Specification Number	Remarks
αi SP series	αi SP 2.2 TYPE A	A06B-6141-H002#Hxxx	
	αi SP 5.5 TYPE A	A06B-6141-H006#Hxxx	
	αi SP 11 TYPE A	A06B-6141-H011#Hxxx	
	αi SP 15 TYPE A	A06B-6141-H015#Hxxx	
	αi SP 22 TYPE A	A06B-6141-H022#Hxxx	
	αi SP 26 TYPE A	A06B-6141-H026#Hxxx	
	αi SP 30 TYPE A	A06B-6141-H030#Hxxx	
	αi SP 37 TYPE A	A06B-6141-H037#Hxxx	
	αi SP 45 TYPE A	A06B-6141-H045#Hxxx	
	αi SP 55 TYPE A	A06B-6141-H055#Hxxx	
	αi SP 2.2 TYPE B	A06B-6142-H002#Hxxx	
	αi SP 5.5 TYPE B	A06B-6142-H006#Hxxx	
	αi SP 11 TYPE B	A06B-6142-H011#Hxxx	
	αi SP 15 TYPE B	A06B-6142-H015#Hxxx	
	αi SP 22 TYPE B	A06B-6142-H022#Hxxx	
	αi SP 26 TYPE B	A06B-6142-H026#Hxxx	
	αi SP 30 TYPE B	A06B-6142-H030#Hxxx	
	αi SP 37 TYPE B	A06B-6142-H037#Hxxx	
	αi SP 45 TYPE B	A06B-6142-H045#Hxxx	
	αi SP 55 TYPE B	A06B-6142-H055#Hxxx	

Note) xxx = 580

- Servo Amplifier

Series Name	Model Name	Specification Number	Remarks
αi SV series	αi SV 4	A06B-6117-H101	
	αi SV 20	A06B-6117-H103	
	αi SV 20L	A06B-6117-H153	
	αi SV 40	A06B-6117-H104	
	αi SV 40L	A06B-6117-H154	
	αi SV 80	A06B-6117-H105	
	αi SV 80L	A06B-6117-H155	
	αi SV 160	A06B-6117-H106	
	αi SV 160L	A06B-6117-H156	
	αi SV 360	A06B-6117-H109	
	αi SV 4/4	A06B-6117-H201	
	αi SV 4/20	A06B-6117-H203	
	αi SV 20/20	A06B-6117-H205	
	αi SV 20/20L	A06B-6117-H255	
	αi SV 20/40	A06B-6117-H206	
	αi SV 20/40L	A06B-6117-H256	
	αi SV 40/40	A06B-6117-H207	
	αi SV 40/40L	A06B-6117-H257	
	αi SV 40/80	A06B-6117-H208	
	αi SV 40/80L	A06B-6117-H258	
	αi SV 80/80	A06B-6117-H209	
	αi SV 80/80L	A06B-6117-H259	
	αi SV 80/160	A06B-6117-H210	
	αi SV 160/160	A06B-6117-H211	
	αi SV 4/4/4	A06B-6117-H301	
	αi SV 20/20/20	A06B-6117-H303	
	αi SV 20/20/40	A06B-6117-H304	

- Detector (αi series)

Name	Module Name	Specification Number	Remarks
Pulsecoder	αiA1000	A860-2000-T3x1	
	αiA16000	A860-2001-T3x1	
	αiI1000	A860-2005-T3x1	
	βA64B	A860-0374-T3x3	
	βi64B	A860-0379-T3x3	
Spindle sensor	αiMZ	A860-2110-V001	
	αiM	A860-2100-V001	
	αiBZ	A86L-0050-0024#x	Sensor head only (The specification number of the sensor unit is A860-2120-Txxx.)
	αi CZ	A860-2140-Tx11 A860-216x-Tx11	

- High Resolution Serial Output Circuit

Name	Module Name	Specification Number	Remarks
High resolution serial output circuit	2048/1ch	A860-0333-T201	
	2048/1ch	A860-0333-T301	
	2048/1ch	A860-0333-T701	
	2048/1ch	A860-0333-T801	

SERVO AMPLIFIER αi series (400V)

- Common power supply

Series Name	Model Name	Specification Number	Remarks
αi PS series	αi PS 11HV	A06B-6150-H011	
	αi PS 18HV	A06B-6150-H018	
	αi PS 30HV	A06B-6150-H030	
	αi PS 45HV	A06B-6150-H045	
	αi PS 75HV	A06B-6150-H075	
	αi PS 100HV	A06B-6150-H100	

- Spindle Amplifier

Series Name	Model Name	Specification Number	Remarks
αi SP series	αi SP 5.5HV TYPE A	A06B-6151-H006#Hxxx	
	αi SP 11HV TYPE A	A06B-6151-H011#Hxxx	
	αi SP 15HV TYPE A	A06B-6151-H015#Hxxx	
	αi SP 30HV TYPE A	A06B-6151-H030#Hxxx	
	αi SP 45HV TYPE A	A06B-6151-H045#Hxxx	
	αi SP 75HV TYPE A	A06B-6151-H075#Hxxx	
	αi SP 100HV TYPE A	A06B-6151-H100#Hxxx	
	αi SP 5.5HV TYPE B	A06B-6152-H006#Hxxx	
	αi SP 11HV TYPE B	A06B-6152-H011#Hxxx	
	αi SP 15HV TYPE B	A06B-6152-H015#Hxxx	
	αi SP 30HV TYPE B	A06B-6152-H030#Hxxx	
	αi SP 45HV TYPE B	A06B-6152-H045#Hxxx	
	αi SP 75HV TYPE B	A06B-6152-H075#Hxxx	
	αi SP 100HV TYPE B	A06B-6152-H100#Hxxx	

Note) xxx = 580

- Servo Amplifier

Series Name	Model Name	Specification Number	Remarks
αi SV series	αi SV 10HV	A06B-6127-H102	
	αi SV 10HVL	A06B-6127-H152	
	αi SV 20HV	A06B-6127-H103	
	αi SV 20HVL	A06B-6127-H153	
	αi SV 40HV	A06B-6127-H104	
	αi SV 40HVL	A06B-6127-H154	
	αi SV 80HV	A06B-6127-H105	
	αi SV 80HVL	A06B-6127-H155	
	αi SV 180HV	A06B-6127-H106	
	αi SV 360HV	A06B-6127-H109	
	αi SV 10/10HV	A06B-6127-H202	
	αi SV 10/10HVL	A06B-6127-H252	
	αi SV 20/20HV	A06B-6127-H205	
	αi SV 20/20HVL	A06B-6127-H255	
	αi SV 20/40HV	A06B-6127-H206	
	αi SV 20/40HVL	A06B-6127-H256	
	αi SV 40/40HV	A06B-6127-H207	
	αi SV 40/40HVL	A06B-6127-H257	
	αi SV 40/80HV	A06B-6127-H208	
	αi SV 80/80HV	A06B-6127-H209	

SERVO AMPLIFIER βi series

- Servo Amplifier

Series Name	Model Name	Specification Number	Remarks
βi SV series	βi SV 4	A06B-6130-H001	
	βi SV 20	A06B-6130-H002	
	βi SV 40	A06B-6130-H003	
	βi SV 80	A06B-6130-H004	

SERVO AMPLIFIER βi series (400V)

- Servo Amplifier

Series Name	Model Name	Specification Number	Remarks
βi SV series	βi SV 10HV	A06B-6131-H001	
	βi SV 20HV	A06B-6131-H002	
	βi SV 40HV	A06B-6131-H003	

- Servo Amplifier

Series Name	Model Name	Specification Number	Remarks
βi SVSP series	βi SVSP 20/20-7.5	A06B-6164-H201#H580	
	βi SVSP 20/20-11	A06B-6164-H202#H580	
	βi SVSP 40/40-15	A06B-6164-H223#H580	
	βi SVSP 20/20/40-7.5	A06B-6164-H311#H580	
	βi SVSP 20/20/40-11	A06B-6164-H312#H580	
	βi SVSP 40/40/40-15	A06B-6164-H333#H580	
	βi SVSP 40/40/80-15	A06B-6164-H343#H580	

APPENDIX

A Directives, Standards and Technical Conditions for 3rd Party Servo / Spindle Motors & Encoders when Applying FANUC / GE Fanuc Dual-check Safety

A.1 GENERAL

Applying 3rd party servo/spindle motors and 3rd party feedback devices with FANUC / GE Fanuc Dual-check Safety Function these 3rd party devices must comply with specific mandatory standards and directives, i. e. regulations regarding

- EMC and LVD
- IP classification
- Electrical safety and environmental testing

Further details regarding standards and directives to comply with are described under chapter 2 “Mandatory Standards and Directives”. Please refer to it.

The components also need to meet the technical requirements as specified in this document.

A.2 MANDATORY STANDARDS AND DIRECTIVES

(1) The standards and directives to be followed in general are listed below.

73/23/EEC	Low voltage directive (LVD)
93/68/EEC	Council directive from 19th February 1973 on the approximation of the laws of the member states relating electrical equipment designed for use in certain voltage limits (relating to electromagnetic compatibility)
89/336/EEC	Electromagnetic compatibility (EMC)
92/31/EEC	Council directive from 3rd May 1989 on the approximation of the laws of the member states
98/37/EEC	Machinery directive
DIN EN 60068	Environmental testing
EN 60204-1:1998	Safety of machinery - electrical equipment of machines
EN 60529:1991	Degrees of protection provided by enclosures (IP code), applicable for encoders (feedback devices)
IEC 60034-1:1999	General requirements for motors, to be considered for spindle/servo motors

(2) The standards and directives the 3rd party spindle/servo motors must comply with are listed below.

IEC 60034-1:1999	Rotating electrical machines - part 1: rating and performance
IEC 60034-5:2000	Rotating electrical machines - part 5: degrees of protection provided by the integral design of rotating electrical machines (IP code) – classification, applicable for motors
IEC 60034-11:1978	Rotating electrical machines - part 11: built-in thermal protection - chapter 1: rules for protection of rotating electrical machines
EN 61000-6-2:1999	Electromagnetic compatibility (EMC) - generic immunity standard Part 2: industrial environment
EN 55011-2:1998	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment

(3) The standards and directives the linear motors and 3rd party feedback devices must comply with are listed below.

EN 60335-1:1995	Safety of household and similar electrical appliances - part 1: General requirements
EN 61000-6-2:1999	Electromagnetic compatibility (EMC) - generic immunity standard Part 2: industrial environment
EN 55011-2:1998	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment

(4) The standards and directives the 3rd party feedback devices must comply with are listed below.

EN 50178:1997	Electronic equipment for use in power installations
EN 61000-6-2:1999	Electromagnetic compatibility (EMC) - generic immunity standard Part 2: industrial environment
EN 55011-2:1998	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment

NOTE
1 All products should be considered that the electrical safety of the final products can be guaranteed.
2 Degrees of protection provided by enclosures should be guaranteed according mandatory regulations for the machine applications.

A.3 SPINDLES

A.3.1 Spindle Motors – Driven by FANUC / GE Fanuc Spindle Amplifier

- 3-phase AC asynchronous motor, compact type or built-in type
- Input voltage: 200 V AC or 400 V AC
- Winding switching available, e.g. start/delta or 2 different windings like star/star
- Number of pole-pairs: 1, 2, 3 or 4
- Rated current must be equal or less than rated current of Spindle Amplifier.
- Maximum current must be equal or less than maximum current of Spindle Amplifier.
- Applicable maximum speed of spindle motors
  ⇨ maximum speed = 60 / pole-pairs * max output freq.

A.3.2 Spindle Encoder – Speed / Position Feedback Sensor Embedded in Motor

- Signal type: A/B-phase sine-wave for speed feedback
  Z-phase (one-per-rotation) signal for position feedback
- Signal specifications: see Attachment 1

A.4 SERVO

A.4.1 Servo Motors – Driven by FANUC / GE Fanuc Servo Amplifier

- 3-phase AC synchronous motor, compact type
- Input voltage: 200 V AC or 400 V AC
- Number of pole-pairs actually limited to 72
- Applicable maximum speed of servomotors = 60/pole-pairs * f_{max} (f_{max} = 266 Hz)
- Rated current must be equal or less than rated current of servo amplifier
- Maximum current must be equal or less than maximum current of servo amplifier
- Maximum peak current of servo amplifier must be less than demagnetization current of motor.
- Current at dynamic braking must not exceed the maximum DB current.
  Maximum DB current depends on servo amplifier model (DB resistor, relay contacts).
- Regenerated energy at dynamic braking must not exceed the DB resistor capacity.
  DB resistor capacity depends on servo amplifier model.

A.4.2 Servo Encoder – Speed / Position Feedback Sensor Embedded in Motor

A.4.2.1 Encoder with FANUC / GE Fanuc Serial Interface

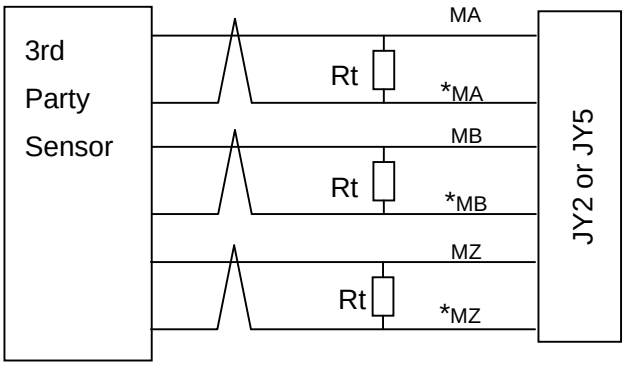
- Signal type: Special FANUC serial interface (e.g.: αA1000S, RCN723F, LC191F)
- Number of pulses per revolution: up to 2^{24} ppr

A.4.2.2 A/B-Phase Sine-wave Interface Connected to FANUC / GE Fanuc Interpolation Circuit

- Signal type:
  sine-wave 1V (peak-to-peak), e.g. Heidenhain ERM 180
- Number of pulses per revolution:
  up to 32768 ppr (32768 * 512 = 2^{24} ppr)
- Signal specification: see Attachment 2
- Maximum input frequency: 200 kHz

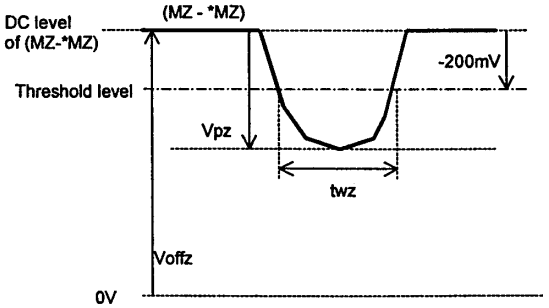
Attachment 1: Specification of 3rd Party Spindle Encoders

The GE Fanuc SPM does not include the *terminating resistor* (like e.g. Siemens).
Depending on the sensor supply voltage and the sensor output impedance, the signal amplitude varies.
In order to match the sensor output signals with the amplifier input requirement, the *terminating resistor* might be necessary. See table on following page for required signal specs.
If the *terminating resistor* is required, place it outside the SPM.

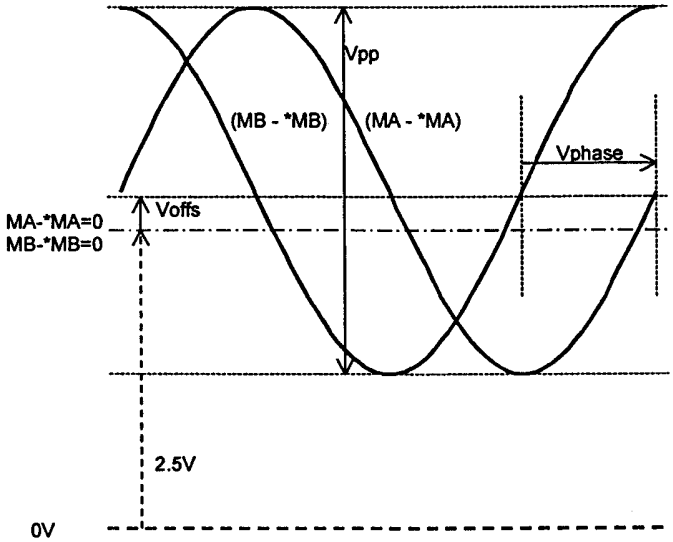


Rt is defined by the specification of the 3rd party sensor

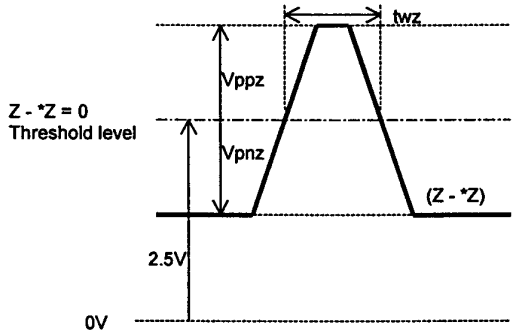
Z-Phase Signal (Type B)



A/B-Phase Signal



(Type A)



A/B-Phase Signals

		Symbol	Check Terminal	Value
1	Maximum Frequency	Fmax	PA1 and PB1 (from JY2) PA2 and PB2 (from JY5)	205 kHz in Spec A 256 kHz in Spec B
2	Signal Amplitude (MA - *MA) (MB - *MB)	Vpp Spec A		0.50 Vpp min 1.2 Vpp max (incl. tolerances)
		Vpp Spec B		0.60 Vpp min 1.2 Vpp max (incl. tolerances)
3	Signal Offset	Voffs		± 100 mV max
4	Signal Amplitude Difference (MA - *MA) / (MB - *MB)	Vppdef		1.00 ± 0.10 V max
5	Phase Offset (MA - *MA) (MB - *MB)	Vphase		90 ± 3 deg

Z-Phase Signal

	Type A	Symbol	Check Terminal	Value	
1	Pulse Width (MZ - *MZ)	twz	PS1 (from JY2) PS2 (from JY5)	4 µsec min	SPM type 1 (JY2): N4005#4 = 1
2	Signal Amplitude of Reference Signal (MZ - *MZ) x 2.4	Vppz		0.25 V min	SPM type 4 (JY5): N4004#4 = 1
		Vpnz		0.25 V min	

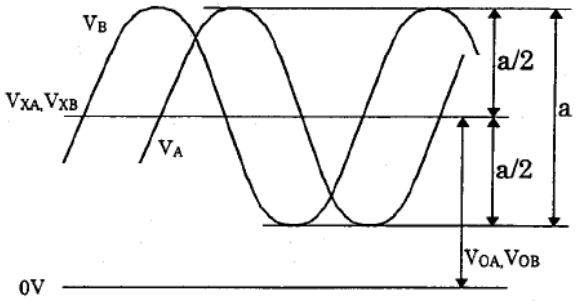
	Type B	Symbol	Check Terminal	Value	
1	Pulse Width (MZ - *MZ)	twz	PS1 (from JY2) PS2 (from JY5)	4 µsec min	SPM type 1 (JY2): N4005#4 = 0 SPM type 4 (JY5): N4004#4 = 0
2	Signal Amplitude of Reference Signal (MZ - *MZ) x 2.4	Vpz		0.25 V min	
3	Signal Offset (Z - *Z)	Voffz		3.5 V max 2 V min	

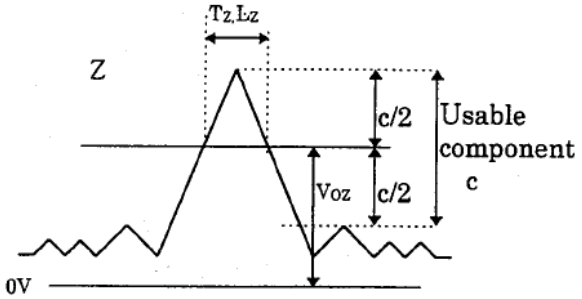
Attachment 2: Specification of 3rd Party Servo Encoders

(4) Input specifications and examples of available linear encoders

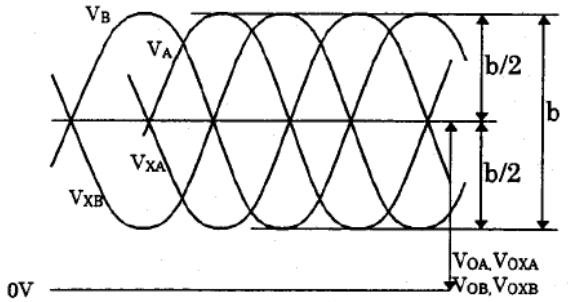
(4)-1 Input specifications

A/B(type Ⅰ)





A/B (type Ⅱ)



Item	Symbol	Specification Min.	Specification Typ.	Specification Max.	Unit
Amplitude (A/B phase)	type Ⅰ a of A,B phase type Ⅱ b of A phase+b of XA phase, b of B phase+b of XB phase	0.6	1.0	1.5	V_{P-P}
Amplitude (Z phase)	c pf Z pahse + c of XZ phaseZ	0.2	0.4	–	V
Center Level (DC Level)	type Ⅰ V_{OA},V_{XA} ,V_{OB},V_{XB} type Ⅱ V_{OA},V_{OXA} ,V_{OB},V_{OXB} V_{OZ},V_{OXZ}	2.0	2.5	3.0	V
Offset Voltage (A/B phase)	type Ⅰ $V_{OA}-V_{XA}$, $V_{OB}-V_{XB}$ type Ⅱ $V_{OA}-V_{OXA}$, $V_{OB}-V_{OXB}$	-0.1	0	+0.1	V
Offset Voltage (Z phase)	$V_{OZ}-V_{OXZ}$	-0.05	0	+0.05	V
Pulse width of Z	Tz	600	–	–	nSec
Length of Z	Lz	1/4	–	–	pitch of A(or B)
Input Impedance		100	120	140	Ω
Input Frequency		–	–	200 ①	kHz

* The position accuracy depends on the quality of the signal from the encoder.

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Revision Record

FANUC Series 0*i*-MODEL D Dual Check Safety CONNECTION MANUAL (B-64303EN-4)

01	Dec., 2008	_____			
Edition	Date	Contents	Edition	Date	Contents

B-64303EN-4/01