



Safety Instructions and Precautions for AC Servos (Safety Sub-Function)

Table with 3 columns: Country/Region, Sales office, Tel. Lists sales offices for USA, Germany, China, Korea, and Japan.

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Specifications are subject to change without notice. Complied with the indicated safety standards and regulations is current as of the release date of this installation guide. The original instructions for Europe are in English.

IB(NA)-0300516-F(2309)MEE

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Contents of the package

Table with 3 columns: Packed articles, Quantity. Lists Servo amplifier or drive unit, MR-J5 Safety Instructions and Precautions for AC Servos, and MR-J5 Safety Instructions and Precautions for AC Servos (Safety Sub-Function) (this guide).

1. About the manuals

To use the MELSERVO-1S series safely, read MR-J5 User's Manuals carefully.

1.1 Purpose of this guide

This guide is subject to engineers of machine manufacturers and operators of machines, and explains functional safety of the MR-J5 servo amplifiers/MR-J5D drive units (hereafter "MR-J5"). For detailed information of the products, refer to MR-J5 User's Manual. This guide does not explain how to operate equipment that incorporates an MR-J5.

1.2 Terms related to safety

Table with 2 columns: Item, Detailed explanation. Defines terms like STO (Safe torque off), SS1 (Safe stop 1), SS2 (Safe stop 2), SOS (Safe operating stop), SLS (Safely-limited speed), SSM (Safe speed monitor), SBC (Safe brake control), SDI (Safe direction), SLS (Safely-limited increment), SLT (Safely-limited torque), and Status monitor (SM).

2. About safety

This chapter explains safety of users and machine operators. Please read the chapter carefully before mounting the equipment. In this guide, the specific warnings and caution levels are classified as follows.

- WARNIN: Indicates that incorrect handling may cause hazardous conditions, resulting in death or severe injury.
CAUTION: Indicates that incorrect handling may cause hazardous conditions, resulting in medium or slight injury.

2.1 Professional engineer

Only professional engineers should mount this to MR-J5. Only professional engineers should meet all the conditions below.
(1) Persons who took a proper training of related work of electrical equipment or persons who can avoid risk based on past experience.
(2) Persons who have read and familiarized himself/herself with this installation guide and operating manuals for the protective devices (e.g. light curtain) connected to the safety control system.

2.2 Conditions of use for the product

- (1) MR-J5 complies with a safety standard, but this fact does not guarantee that MR-J5 will be free from any malfunction or failure. The user of this product shall comply with any and all applicable safety standard, regulation or law and take appropriate safety measures for the system in which the product is installed or used and shall take the second or third safety measures other than the product. Our company is not liable for damages that could have been prevented by compliance with any applicable safety standard, regulation or law.
(2) Our company prohibits the use of Products with or in any application involving, and we shall not be liable for a default, a liability for defect warranty, a quality assurance, negligence or other tort and a product liability in these applications.
(a) Power plants
(b) Trains, railway systems, airplanes, airline operations, and other transportation systems
(c) Hospitals, medical care, dialysis and life support facilities or equipment
(d) Amusement equipment
(e) Incineration and fuel devices
(f) Handling of nuclear or hazardous materials or chemicals
(g) Mining and drilling
(h) Other applications where the level of risk to human life, health or property are elevated.

2.3 Correct use

CAUTION: You need to get close to the moving parts of the machine for inspection or other purposes, ensure safety by confirming the power off, etc. Otherwise, it may cause an accident.

Point

- The safety sub-function complies with the immunity-related basic specifications required for functional safety, and fulfills requirements for industrial uses. The safety sub-function is not for general use.

Only professional engineers can use control systems relating to the safety sub-function that are configured with an MR-J5. Additionally, only when a professional engineer installed, performed test operations, and adjusted a machine following the MR-J5 user's Manuals, an operator can use the machine.

2.4 Safety sub-function compatible unit

The safety sub-function is executed by writing parameters and programs to systems configured with the MR-J5 and the safety programmable controllers in the following table. Set the safety sub-function parameters of the MR-J5 correctly for proper operation of the safety sub-function. Prerequisite conditions such as the safety sub-function may not work due to an incorrect setting. Refer to the MR-J5 User's Manuals for the parameter setting details.

(1) List of safety sub-function compatible unit

Table with 3 columns: Product name, Model, Safety sub-function (IEC/EN 61800-5-2)*. Lists compatible units for Servo amplifier/drive unit, Programmable controller, and Servo motor type.

*1 For using the safety sub-function via CC-Link IE TSN

(2) List of safety sub-function compatible units

Table with 3 columns: Servo amplifier/drive unit, Servo motor type, Safety sub-function (IEC/EN 61800-5-2)*. Lists compatible units for MR-J5-G4, MR-J5-G4, MR-J5D, MR-J5D, MR-J5D, MR-J5D.

*1 Combine the MR-J5 with a programmable controller R_SFCPU with a firmware version 2.0 or later.
*2 The safety levels in the table apply if the safety sub-function control is performed by a programmable controller, a safety CPU or a safety controller that complies with Category 4 PL e, SIL 3.
*3 If the MR-J5s are directly connected with emergency stop switches, safety switches, enabling switches, or other similar devices, the safety level Category 3 PL d, SIL 2 applies.

- *3 Fully closed loop control systems do not support SS1-r, SS2, SOS, SLS, SSM, SDI, and SLT.
*4 The safety sub-function is supported by the MR-J5V-1-G manufactured in November 2019 or later. STO can be set separately for each axis.
*5 The safety sub-function via a network connection with CC-Link IE Field Network Basic cannot be used.
*6 For DiO connection (CN8), a diagnosis using test pulses is required to satisfy Category 4 PL e, SIL 3.
*7 For information on the firmware versions of the MR-J5 with which the safety sub-function can be used, refer to the User's Manual (Introduction).
*8 FS: Servo motor with functional safety, RO: Rotary servo motor, LI: Linear servo motor, DD: Direct drive motor
*9 The servo amplifiers support SS1-r when combined with MR-J5D05.
*10 STO can be set separately for each axis.

2.5 General cautions for safety protection and protective measures

- Point
Observe the cautions for safety protection and protective measures.
Observe the items in this section for proper use of the safety sub-function.

- (1) When mounting, installing, and using the safety sub-function, always observe the standards and directives applicable in the respective countries.
(2) The manufacturer and owner of machines for which the safety sub-function of MR-J5 is used should be familiarized with all the applicable laws and regulations and be responsible to observe them. For Declaration of Conformity (DoC), our company declares that the MR-J5 is in compliance with the necessary requirements and standards (2006/42/EC, 2014/30/EU, 2014/35/EU, 2011/65/EU, and (EU)2015/863). For the copy of Declaration of Conformity, contact your local sales office.
(3) The contents of the MR-J5 User's Manuals must be observed. When using an encoder manufactured by another company that complies with Mitsubishi Electric Serial EN communication or ABZ-pulse (TTI), also according to the manual for that encoder, estimate the PFH for the whole safety system according to the diagnostic coverage (DC) of the encoder given in specifications under the responsibility of the customer. All the encoder for PDS should comply IEC/EN 61800-5-1 and 5-2 including environmental and EMC.
When there is no PFH value of encoder, it should be calculated from based MTBF (acceptable range of failure rate of encoder Ad = 50 %, Adu = (1-DC) * Ad). And at least PFH = 9E-7 (for SIL2), PFH = 9E-8 (for SIL 3) or less.
(4) Tests should be performed by professional engineers, especially qualified and responsible personnel, and should be recorded/documentated for a third party to rebuild and confirm the tests.
(5) An external power supply of equipment should have resistance to instantaneous power failure for 20 ms according to the specifications of IEC/EN 60204-1.

2.6 Disposal
Disposal of unusable or irreparable devices should always occur in accordance with the applicable country-specific waste disposal regulations.

2.7 Risk assessment

To ensure safety, users should decide all the risk assessments and residual risks in the entire machine equipment. A company and/or individual who constructed the safety related system must take full responsibility for installation and commissioning of the system. Additionally, when complying with a European machine directive, the system must acquire safety standards certification as a whole. Perform all risk assessments and safe level certification to the machine or the system as a whole. It is recommended that a Certification Body final safety certification of the system be used. The following shows residual risks concerning the safety sub-function of this product.

2.7.1 Common residual risks in each function

- (1) At the shipment to end-users, check the settings of safety related components with programming tools and monitored/displayed contents on display and record and save the setting data concerning the safety sub-function and the programming tools you used. Perform them using a check sheet, etc.
(2) The safety will not be ensured such as in assembling machine until installing, wiring, and adjustment are completed properly. Install, wire, and adjust your system referring to installation guide for each unit.
(3) Only qualified personnel are authorized to install, repair or adjust the machines in which the components are installed. Only trained engineers should install and operate the equipment. (ISO 13849-1:2015 Table F.1 No. 5)
(4) Separate the wiring for the safety sub-function from other signal wirings. (ISO 13849-1:2015 Table F.1 No. 1)
(5) Protect the cable with appropriate ways (routing them in a cabinet, using a cable guard, etc.).
(6) We recommend using a switch, relay, sensor, etc. which comply with safety standards. When using a switch, relay, sensor, etc. which do not comply with safety standards, perform a safety confirmation.
(7) Keep the required clearance/creepage distance depending on voltage you use.
(8) The time to detect a safety observation error depends on the parameter setting.

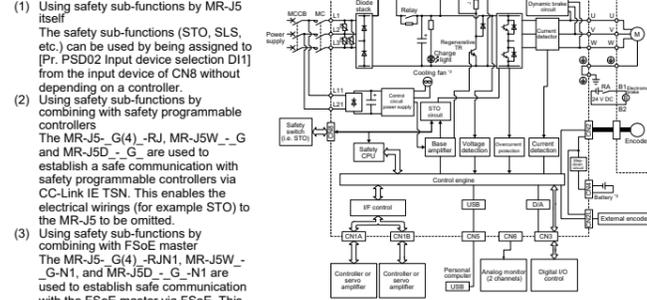
2.7.2 Residual risks specific to each function

- (1) Speed monitoring (SLS)
(a) Speed monitoring function guarantees the servo motor speed, but it does not guarantee the actual machine safety speed. Set parameters so that the safe speed of the machine is the same as the safety speed of the specified motor.
(b) Check if the speed of the monitored servo axis is the same as the actual speed by using a tachometer, etc. considering the speed includes an error caused by the command and encoder resolution.
(c) The defect of the mechanical section such as slid of shaft and wanting of a timing belt, etc. is not covered. Be sure to eliminate the risk of mechanical section before operation.
(d) Speed monitoring error detection time is set to 1 ms. Errors in shorter than this time are not detected.
(e) After speed is over the safety observation error (shut-off signal off) does not occur during the speed error detection time set by parameters. Make sure that safety can be ensured during this period.
(2) Safe speed monitor (SSM)
When SSM is used as a restart trigger, perform it according to IEC/EN 60204-1.
(3) Safe brake control (SBC)
This function guarantees only that power to mechanic break is properly supplied and abrasion of the brake cannot be detected. Check this function regularly that the mechanic brake can operate.
(4) Safe stop holding (SOS)
If the motor remains at the same stop position for a long time, move the motor slightly from time to time to prevent a cumulative malfunction.
(5) Safe travel distance limit (SLI)
If the motor shaft (or a coil, if a linear servo motor is used) remains at a stop for a long time after the motor has traveled as specified, switch the function to the SOS function.
(6) Safe rotation direction limit (SDI)
If the motor shaft (or a coil, if a linear servo motor is used) remains at a stop for a long time after the motor has traveled as specified, switch the function to the SOS function.

3. Using safety sub-functions and block diagram

3.1 Using safety sub-functions

This is an example of a combination with the MR-J5 -G, -RJ and MR-J5D -G, -N1. Refer to the MR-J5 User's Manual (Hardware) for precautions for wiring or other operations.



- (1) The built-in regenerative resistor is not used for MR-J5-10G or greater having a cooling fan.
(2) To configure an absolute position detection system by using a direct drive motor, the battery is required. To configure the absolute position detection system by using the HK series servo motor, the battery is not required.
(3) Support encoder type are OSBA/OBSA/CBWO/CSW, another company encoder that complies with Mitsubishi Electric Serial EN communication and ABZ-pulse.

4. Technical specifications

4.1 Servo amplifier/drive unit specifications

Table with 3 columns: Model, Mean time to dangerous failure (MTTF), Diagnostic coverage (DC). Lists specifications for MR-J5-G4, MR-J5D, MR-J5D.

4.2 Function specifications

Table with 3 columns: Model, Function, Specifications. Lists specifications for STO, SS1, SS2, SOS, SLS, SSM, SBC, SDI, SLI, SLT, SSM, SBC, SDI, SLI, SLT, SSM, SBC, SDI, SLI, SLT.

*1 For DiO connection (CN8), a diagnosis using test pulses is required to satisfy Category 4 PL e, SIL 3.
*2 The performance of special proof tests within the mission time of the product is regarded as not necessary. For example, on IEC 61800-5-2:2016, the diagnostic interval is suggested as at least one test per three months for Category 3 PL e, SIL 3.

Table with 3 columns: Model, Input device, Output device. Lists specifications for input and output devices for MR-J5-G4, MR-J5D, MR-J5D.

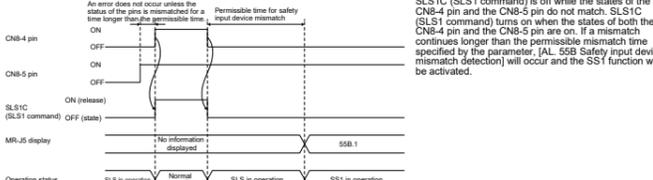
- *1 Available functions and safety levels differ depending on the combination of the MR-J5 and the servo motors. Refer to 2.4 (2).
*2 For DiO connection (CN8), a diagnosis using test pulses is required to satisfy Category 4 PL e, SIL 3.
*3 This value is applicable when the transmission interval monitor time is 32.0 ms or less.
*4 For the MR-J5-G4, -RJ and MR-J5D-G, connect to a network with a communication cycle of 125 us or longer. For the MR-J5-G4, -RJ and MR-J5D-G, -N1, connect to a network with a communication cycle of 250 us or longer. For the MR-J5V-1-G, -N1, MR-J5D-G, -N1 and MR-J5D-G, -N1, connect to a network with a communication cycle of 500 us or longer.
*5 The safety observation speed can be set separately.
*6 A test pulse is a signal which instantaneously turns off a signal to the MR-J5 at a constant period for external circuits to perform self-diagnosis.
*7 The specifications are for using the safety sub-functions via a network connection.
*8 This value is applicable when FSoE Watchdog Time is 30.0 ms or less.

4.3 When using the I/O of the CN8 connector of the MR-J5

This I/O function can be used when the safety sub-function control by network is not used.

4.3.1 I/O signal sequence

An operation sequence with the SLS function achieved by the input wiring CN8-4 and CN8-5 pins is shown as an example.



4.3.2 Selecting input devices

Input devices can be assigned to the CN8-4 and CN8-5 pins by using [Pr. PSD02 Input device selection DI1]. The safety sub-functions can be activated with axis-A itself by using an input signal, and also can be activated with axis-A, B, and C at the same time.

STOC (STO command), SS1C (SS1 command), SS2C (SS2 command), SLS1C (SLS1 command), SDIPC (SDIP command), SDINC (SDIN command), SLIC (SLI command), and SLT1C (SLT1 command)

4.3.3 Output signal sequence

An operation sequence with STOS (STO output) assigned to the input wiring CN8-6 and CN8-7 pins is shown as an example.



4.3.4 Selecting output devices

Output devices can be assigned to the CN8-6 and CN8-7 pins by using [Pr. PSD08 Output device selection DO1]. If a multi-axis servo amplifier/multi-axis drive unit are used, it is possible to select which axis will output a signal to the output signal. Outputting a signal only from axis-A is possible, and outputting signals from axis-A, B, and C by AND output is also possible.

STOS (STO output), SS1S (SS1 output), SS2S (SS2 output), SLS1S (SLS1 output) to SLS4S (SL4 output), SSM (SSM output), SSS (SOS output), SBCS (SBC output), SDIPS (SDIP output), SDINS (SDIN output), SLIS (SLI output), and SLT1S (SLT1 output) to SLT4S (SLT4 output)

5. Signals

5.1 Connector pin assignment of the safety sub-function I/O signals

The following shows connector pin assignments of the MR-J5-10G-RJ and MR-J5D-10G-RJ as a typical example. Refer to "MR-J5 User's Manual (Hardware)" for precautions for wiring or other operations.

Table with 5 columns: Devices, Symbol, Connector pin No., FUNCTION, Input pin states that during operations. Lists pin assignments for STO, SS1, SS2, SLS, SDIP, SDIN, SLI, and SLT1.

5.3 Output devices

The CN8-6 and CN8-7 pins output the status monitor (SM) of the safety sub-function. Output devices can be assigned to the CN8-6 and CN8-7 pins by using [Pr. PSD08 Output device selection DO1]. The status monitor can be output via network if the safety sub-function is controlled by network. In that case, the CN8-6 and CN8-7 pins can also be used at the same time.

Table with 5 columns: Devices, Symbol, Connector pin No., FUNCTION, Output pin states that during operations. Lists output devices for SSM, SBC, STOS, SOS, SS1, SS2, SDIP, SDIN, SLI, and SLT1.

6. Setting method

If using the safety sub-function, follow the procedure in this chapter.

Table with 2 columns: Step, Detailed explanation. Lists steps for checking wiring, setting safety parameters, and verifying functional safety.

6.1 Parameter setting

The safety sub-function parameters can be set with MR Configurator2. Settings related to the safety sub-function are configured with this group of parameters. The safety sub-function parameters have a password to prevent unintended changes of the parameters. The password is "000000" at the factory setting. The following parameters must be set.

Table with 3 columns: Parameter, Name, Detailed explanation. Lists parameters for safety sub-function activation, input mode selection, functional safety setting, SS1/SS2 deceleration monitor time, servo motor encoder resolution, servo motor rated speed, functional safety - rotation direction selection, functional safety - linear motor encoder resolution, and functional safety - linear motor encoder resolution - denominator.

6.2 Test operation

Test operation can be performed with the safety sub-function temporarily disabled. Set [Pr. PSA01.1 Input mode selection] to "2". Some of the diagnosis functions and the safety sub-functions are disabled in the test operation mode. The test operation can be used for JOG operation, positioning operation, machine analyzer, or other operations if safety devices have not been started up. To end the test operation, set [Pr. PSA01.1 Input mode selection] to "0" or "1" depending on the system configuration being used.

7. Troubleshooting

Details of main alarms related to the safety sub-function are shown in the following table.

Table with 3 columns: Alarm name, Alarm No., Cause, Action. Lists various alarms such as STO timing error, Encoder initial communication error, STO diagnosis error, Network communication error, STO function error, Voltage diagnosis error, Memory error, Synchronous error, Position feedback error, Parameter setting error, Parameter verification error, Input device mismatch error, Stop error, Safety speed monitor error, Deceleration monitor error, Torque monitor error, Safety communication error, FSoE Address mismatch error, FSoE communication error, FSoE communication error, FSoE communication error, FSoE communication error.

8. Maintenance, inspection, and environment

Refer to chapter 6 and 7 in "MR-J5 Safety Instructions and Precautions for AC Servos (IB(NA)0300527)" or "MR-J5D Safety Instructions and Precautions for AC Servos (IB(NA)0300527)".

9. Check list for user documentation

MR-J5 installation checklist for manufacturers/installers. The following items must be satisfied by the initial test operation at least. The manufacturer/installer must be responsible for checking the standards in the items. Maintain and keep this checklist with related documents of machines to use this for periodic inspection.

Checklist table with 5 columns: Item, Yes, No, Yes, No, Yes, No. Lists items for safety standards, safety sub-function, safety sub-function, safety sub-function, safety sub-function.