



Read through this “Safety function Guide”, and keep it handy for future reference

Safety function Guide

HITACHI INVERTER

SJ series **P1**



Introduction

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(Memo)

S.1 Introduction

Thank you for purchasing Hitachi SJ Series P1 Inverter (here after SJ-P1).

This Safety function Guide describes the information about planning the installation, installing, commissioning, using and servicing the Safety function of the SJ-P1 inverter.

The information not described in the Safety function Guide must be referred to the User's Guide of the SJ-P1 inverter.

If there are any contents inconsistent between the User's Guide of the SJ-P1 inverter and this Safety function Guide, the instructions provided in this Safety function Guide always have priority when the Safety function is used.

This Safety function Guide is provided in only electric data (pdf) aiming to reduce the amount of paper resource consumption and also to provide the latest information. Only the Safety function Guide Supplement describing minimum necessary information is enclosed with the inverter.

■ Safety function Guide (this document)

The Safety function Guide provides the information necessary for handling the Safe Torque Off (STO) function of the SJ-P1 inverter. Please make sure to read through this documentation as well as the User's Guide of the SJ-P1 inverter when using the STO function of the SJ-P1 inverter.

If future updates make any difference from the Basic Guide and the User's Guide, the description in the Safety function Guide will have higher priority. Please make sure that the inverter is always used within the specification provided in the Safety function Guide and the User's Guide of the SJ-P1 inverter. Additionally, please ensure to perform proper inspection and maintenance in order to prevent failures and risk before it happens.

Please refer to the following link for downloading the latest documentation.

Hitachi Industrial Equipment Systems' Website

<http://www.hitachi-ies.co.jp/english/index.htm>

Please follow as below on the Website.

[Products information] → [Inverter] → [Download of technical data]

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Hitachi industrial equipment systems Co.,Ltd. or distributor of Hitachi

S.2 Precaution

■ For the proper use of the inverter

Please read through the User's Guide of the SJ-P1 inverter as well as the Safety function Guide (this document) to perfectly understand proper handling and safety precaution for the product to ensure safety and proper usage before operating the inverter and using the STO function.

Before attempting installation, operation, maintenance, and inspection work of the safety related system, you should understand the essential knowledge of the functional safety as well as the knowledge of equipment, information of safety, caution and how to use the inverter.

■ Cautions

No part of this documentation may be reproduced or revised in any form without the publisher's permission.

The contents in this documentation are subject to change without prior notice.

You "CANNOT DO" what is not described in this Safety function Guide. In addition, do not operate the product in a manner not specified in the Safety function Guide. An unexpected failure or accident may occur.

HITACHI (include distributor) does not accept any liability for direct or indirect injury or damage caused by the handling, operation and maintenance in manners which are not specified in this Safety function Guide.

If you find any unclear or incorrect description, missing description, misplaced or missing pages, or have a question concerning the contents of the Safety function Guide, please contact Hitachi industrial equipment systems Co.,Ltd. or distributor of Hitachi.

Please note that the Basic Guide, User's Guide, the Safety function Guide and the guides for each optional product to be used should be delivered to the end user of the inverter.

S.3 Relevant document

Document name	Document code *1)
SJ-P1 User's Guide	NT251X
SJ-P1 Basic Guide	NT2511X
SJ-P1 Safety function Guide (this documentation)	NT2512X
SJ-P1 Safety function Guide Supplement	NTZ2512X

*1) Version information is written at the end of the document code.

S.4 List of abbreviation and technical terms

A

Term / Abbreviation	Description
AWG	American wire gauge Standardized wire gauge used in North America

B

Term / Abbreviation	Description
Basic Guide	The documentation that provides basic information to handle the inverter

C

Term / Abbreviation	Description
CAT.	Category Structural Classification of the safety-related parts defined in EN ISO13849-1 (B,1,2,3,4)
CCF	Common Cause Failure (EN ISO 13849-1) Failure, which is the result of one or more events, causing concurrent failure of two or more separate channels in a multiple channel system, leading to failure of the safety function
CE marking	A mandatory conformity marking for products sold within the European Economic Area.
Charge lamp	The lamp indicates power supply status of the main circuit of the inverter. Even after powered down, the internal voltage remains while the lamp lights.
Control supply power	Internal power supply necessary for powering up the logic board and configuring the inverter using operator keypad. Supplying power to ROTO terminal or P+, P-terminal can power up the internal power supply.

*) Trademark

Some proper nouns such as product name or function names may be registered as trademark or registered trademark. Particularly this documentation does not describes ® mark or ™ mark.

D

Term / Abbreviation	Description
Dangerous failure	Failure of a component and/or subsystem and/or system that plays a part in implementing the safety function
DC	Diagnostic coverage (%) (EN ISO 13849-1)

E

Term / Abbreviation	Description
EMC	Electromagnetic compatibility
EUC	Equipment Under Control

F

Term / Abbreviation	Description
Functional Safety	Part of the overall safety relating to the EUC and the EUC control system that depends on the correct functioning of the E/E/PE safety-related systems and other risk reduction measures.(IEC61508)

H

Term / Abbreviation	Description
HFT	Hardware fault tolerance (IEC61508)

I

Term / Abbreviation	Description
I/O	Input / Output
IGBT	Insulated gate bipolar transistor
Inverter model code	The model code written on the specification label of the inverter.

M

Term / Abbreviation	Description
Main power supply	Power supply necessary for operation of inverter
MFG No.	Manufacturing No.
MTTFd	Mean time to dangerous failure Expectation of the mean time to dangerous failure

O

Term / Abbreviation	Description
Operator keypad	The keypad mounted on the inverter used for configuration of parameters and monitoring of inverter's state

P

Term / Abbreviation	Description
PELV	Protected extra-voltage (EN/IEC60204)
PFD	Probability of dangerous failure on demand (IEC61508)
PFH	Average frequency of a dangerous failure (EN/IEC61800-5-2)
PL	Performance level (a-e) (EN ISO 13849-1)
PLC	Programmable logic controller
PWM	Pulse width modulation

R

Term / Abbreviation	Description
Residual risk	Risk remaining after protective measures have been taken
Response time	Delay time inside of the inverter from a request of activation of a function until actual execution of the function
Risk	Probability and severity of hazard

S

Term / Abbreviation	Description
Safety Function	Safety functions to achieve safe state of system such as STO function defined in IEC61800-5-2.
Safety-Related System	Whole system including inverter, sensor, switch and safety relay etc. that achieves safety function(s)
SELV	Safety extra-low voltage (EN/IEC60950)
SFF	Safe failure fraction (%) (IEC61508)

S

Term / Abbreviation	Description
SIL	Safety integrity level (1-3) (IEC61508)
SILCL	SIL claim limit (EN/IEC62061)
Sink logic	Signal is recognized as ON when current flows out from signal terminal. That may differ depending on systems.
Source logic	A type of logic that signal is recognized as ON when current flows into the terminal. This logic may differ depending on region or system.
Specification label	The label affixed on the product, on which specification of the inverter is written
STO	Safe torque off (EN/IEC61800-5-2)
Stop category 0	A type of stop category defined in EN/IEC60204-1. Stopping by immediate removal of power to the machine actuator.

U

Term / Abbreviation	Description
User's Guide	The documentation that provides the detailed information to handle the inverter

V

Term / Abbreviation	Description
Validation	Confirmation by examination and provision of objective that the safety system meets the requirements set by the specification
Verification	Confirmation by examination and provision of objective evidence that the requirements have been fulfilled

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Chapter 1 Safety Precaution/Risk

1.1 Contents in this chapter

This chapter describes precautions for using the STO function of the SJ-P1 inverter.

Before installation, wiring, operation, maintenance, inspection and running, please make sure to read through **the Safety function Guide, the User's Guide** of the SJ-P1 inverter and all the other documentation enclosed with the product.

1.2 Safety Precaution

	General warning indicates a potentially hazardous situation that, if not avoided, can result in serious injury or death, or damage to the equipment.
	This symbol indicates High voltage. It calls to your attention to items or operations that could be dangerous to you and other persons operating this equipment.

1.2.1 Planning

The persons who design, install and perform maintenance of safety-related system must have sufficient knowledge of the functional safety.

It is a responsibility of the manufacturer of safety-related system to perform risk analysis of the overall system and to apply appropriate measures accordingly.

1.2.2 Consideration

in Designing safety-related system



The SJ-P1 does not support a holding function of STO state after release of STO inputs. Therefore after STO inputs to the SJ-P1 inverter are released, the SJ-P1 inverter becomes available to restart the motor operation. (A function of SJ-P1 to hold Shut off state without STO inputs is not safety-related function.)

Please ensure to design a system so that the above-mentioned behavior does not lead to any unsafe situation.

Please note that SJ-P1 inverters are delivered with the STO function being disabled by a jumper wire to allow initial drive commissioning without the need of configuring the STO function first.

1.2.3 Installation

Installation must be performed by the competent electricians who have sufficient knowledge of the functional safety.

Ensure to use the SJ-P1 inverter within the specified environmental condition including EMS environment.

1.2.4 Commissioning



The safety system must always be properly carried out the commissioning and verified/validated before it is considered safe.

1.2.5 Maintenance



The STO function does not cut the power supply to the inverter and the peripheral circuits, and does not provide any electrical isolation. Before maintenance, please ensure to separate the system/machine from main power supply lines and from the other devices which may supply any voltage (e.g. permanent magnetic motor, device including capacitors). Additionally, wait more than 10 minutes (*1) / more than 15 minutes (*2) and check the charge lamp of the inverter is disappeared, and then confirm that the voltage between P and N terminal is lower than 45V before performing maintenance.

A function test must be conducted at least once in a year.

*1) Type of P1-00044-L~P1-01240-L (P1-004L~P1-220L) and P1-00041-H~00620-H (P1-007H~P1-220H)

*2) Type of P1-01530-L~P1-02950-L (P1-300L~P1-550L) and P1-00770-H~P1-03160-H (P1-300H~P1-1320H)

1.2.6 Others



Never modify the inverter. Any modification immediately invalidates the conformities to the all applicable norms, and the product guarantee.

The precaution items provided in User's Guide of the SJ-P1 inverter are not always described in this chapter. Please ensure to read through and understand the precaution in the User's Guide before using the SJ-P1.

2

Chapter 2 Introduction to the Safety function Guide

2.1 Contents in this chapter

This chapter describes the applicable product, required knowledge, target audience, purpose and general information of this documentation.

2.2 Applicable product

This documentation is only applicable to the SJ-P1 inverter having the model code listed in 『Appendix EC declaration of conformity』 .

2.3 Target audience

The Safety function Guide is intended for qualified persons who design the safety application, plan the installation, install, commission and maintenance. Read through this documentation as well as the User's Guide of the SJ-P1 inverter before starting operation on a safety-related application. The persons must have sufficient knowledge of functional safety.

2.4 Purpose of the Safety function Guide

The purpose of this document is to provide necessary information to use the STO function of the SJ-P1 inverter.

2.5 Recommended readings

The Safety function Guide is based on the following standards. It is recommended you to read and familiarize with these standards before implementing safety-related systems.

- EN/IEC 61508 part 1-2: 2010 *Functional safety of electrical/electronic/programmable electronic safety-related system – Part 1-7*
- IEC 61800-5-2: 2016, *Adjustable speed electrical power drive system – Part 5-2: Safety requirements – Functional.*
- EN ISO 13849-1: 2015, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design.*
- EN/IEC 62061:2005+A2:2015, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems.*
- EN 60204-1:2016, *Safety of machinery – Electrical equipment of machines – Part 1: General requirement.*

Additionally, before implementing safety-related systems, it is highly recommended to read and understand the documentation listed in section S.3.

For the standards with which the SJ-P1 complies, please refer to Chapter 4

Chapter 3 Safety-related information and consideration

3.1 Contents in this chapter

This chapter describes safety-related information and considerations.

3.2 Requirement of Machinery Directive

In order to fulfill the requirements of the Machinery Directive, all requirements in the applicable standards must be satisfied and SJ-P1 inverters must be used in accordance with the instructions provided in this Safety function Guide and the User's Guide of the SJ-P1.

Before using the inverter, the risk assessment of whole system must be conducted and appropriate measures must be taken.

3.3 Intentional misuse

The SJ-P1 is not designed to protect against intentional misuse/interference for STO function.

3.4 Safety consideration

3.4.1 Safety function

The SJ-P1 inverter supports the STO function which is equivalent to STO (Safe Torque Off) function defined in EN/IEC61800-5-2 as well as Category 0 Stop defined in EN/IEC60204-1.

The SJ-P1 inverter shuts off power to a motor when STO inputs are given.

3.4.2 Response time

The response time is defined as a time from input of Safety request to actual activation of safety function.

In case of STO function, it is a time from input of STO signals until power to a motor is shut off.

The response time of the STO function of the SJ-P1 is less than 10ms.

A safety-related system must be designed in consideration of the above mentioned response time so that this delay time may not lead to any hazardous situation.

3.4.3 Self-Diagnosis of internal path

The SJ-P1 is equipped with the self-diagnosis function which detects a fault in the internal safety paths.

When an internal fault has been detected, the safety paths are maintained shut-off regardless of the states of the STO inputs to the SJ-P1.

3.4.4 STO Input

The STO inputs of the SJ-P1 are redundant and the both input signals must be input. The two STO inputs must be appropriately separated from each other. If only one of the inputs is used, the conformities to the applicable norms become invalid.



The SJ-P1 inverter is not equipped with a diagnosis function of input signal and line from an external device. A system must be designed so that both of the STO inputs are always given properly and simultaneously. As needed, please use the EDM signal for failure detection of STO input lines to configure a system which is able to detect a fault in STO input lines.

3.4.5 Holding function of STO state

(Not supported as Safety related function)



SJ-P1 does not support a function to hold STO state even after releasing of STO inputs. Please consider it when designing a system and, if needed, prepare an external mechanism to avoid an unintentional restart of the system. For more detailed information, please refer to Chapter 4.

3.4.6 STO state monitor output (EDM)

Please use EDM signal output when it is required to monitor state of the STO inputs to SJ-P1 and state of internal safety paths (failure detection state) by external devices.

Please refer to Chapter 4 for the behavior and function (signal matrix) of EDM signal.



EDM signal output is NOT a safety-related signal, but a reference signal. This signal is not capable of being used to activate another safety function.

3.4.7 Periodical functional test

A periodical functional test to check proper functioning of the STO function must be performed at least once a year in order to maintain the intended SIL / PL.

Please refer to Chapter 10 for the details of the functional test.

3.4.8 Caution for using the STO function

The STO function does not cut the power supply to the inverter and the peripheral circuits, and does not provide any electrical isolation. Before maintenance, please ensure to separate the system/machine from main power supply lines and from the other devices which may supply any voltage (e.g. permanent magnetic motor, device including capacitors). Additionally, wait more than 10 minutes(*1) / more than 15 minutes (*2) and check the charge lamp of the inverter is disappeared, and then confirm that the voltage between P and N terminal is lower than 45V before performing maintenance.

*1) Type of P1-00044-L~P1-01240-L (P1-004L~P1-220L) and P1-00041-H~00620-H (P1-007H~P1-220H)

*2) Type of P1-01530-L~P1-02950-L (P1-300L~P1-550L) and P1-00770-H~P1-03160-H (P1-300H~P1-1320H)



The STO functionality is achieved only through the ST1 and ST2 connector of the inverter.



When permanent magnet motor or synchronous reluctance motor is driven, in case of a multiple IGBT power semiconductor failure, the inverter system can produce an alignment torque which maximally rotates the motor shaft below regardless of the activation of the STO function.

- $180/(p/2)$ degrees (with permanent magnet motors)

- $180/p$ degrees (with synchronous reluctance motors)

p denotes the number of pole.

4

Chapter 4 Safety function

4.1 Contents in this chapter

This chapter describes the information about the safety function of the SJ-P1.

4.2 Safety function (STO)

The STO function of the SJ-P1 is a function equivalent to STO (Safe Torque Off) defined in IEC61800-5-2 as well as Category 0 Stop in EN60204-1.

4.3 Applicable standard

The applicable standards are listed in the table below.

Applicable standard

Standard	Remark
EN 13849-1:2015	CAT.4 PL e
IEC 61800-5-2:2016	STO, SIL 3
EN62061:2005/AMD2:2015	SILCL 3 Capability
EN60204-1	Stop category 0
UL1998	Diagnostic software class 1
NFPA79	

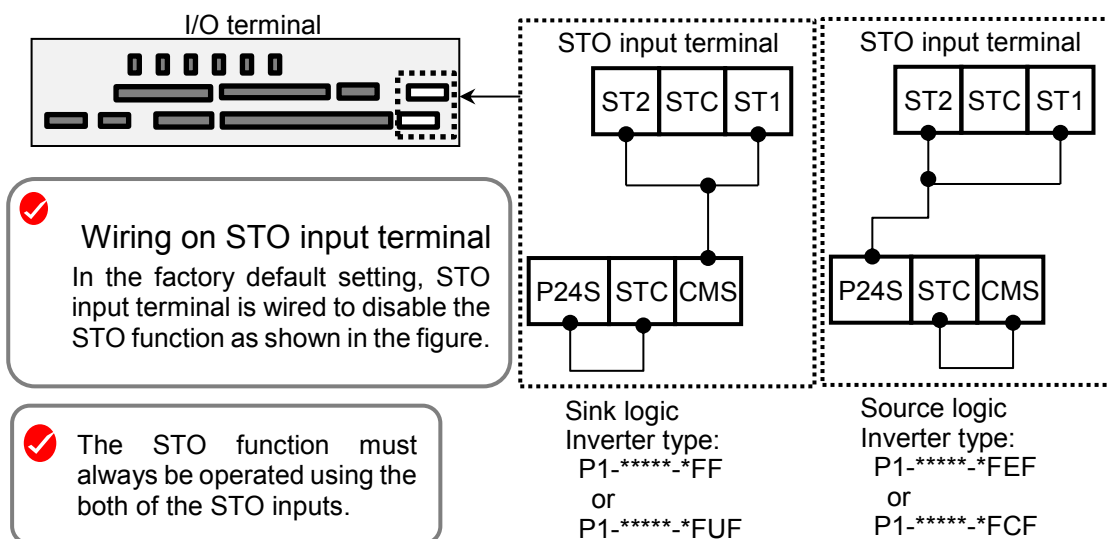
4.4 How STO function works

4.4.1 STO input terminal

Signal inputs for the STO function are redundant inputs of ST1 and ST2

When voltage is applied to each input, currents flow on each safety path enabling the motor operation of the inverter (output to the motor is permitted). The product is delivered with the STO function being disabled with a jumper-wire (See the figure below) so to allow initial commissioning of the inverter without configuring the STO function. Please remove the jumper-wire and perform wiring appropriately to use the STO function.

When voltage is removed from at least one of the STO inputs, the output of the inverter is disabled (shut off) by the corresponding shut-off path (safety path).



*: Depending on the inverter type. Refer to the User's Guide of the SJ-P1.

4.4.2 How to input STO signal

The voltage source for STO signal input is selectable from the internal DC24V power supply (P24S terminal) or an externally prepared DC24V power supply.

When using an external DC24V power supply, please remove the jumper-wire (between P24S-STC or CMS-STC) on the STO input terminal.

The external DC24V power supply must be SELV (EN/IE60950) or PELV (EN/IEC60204).

In case of using the internal 24V power supply, the input logic “Sink” or “Source” of the STO inputs can be configured by changing the connecting position of the jumper-wire. (See the wiring examples below)

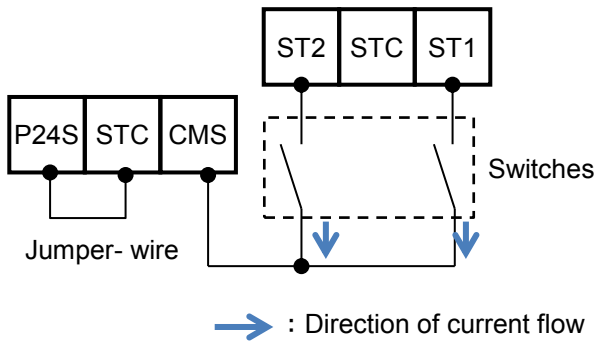
By turning off the external switches (contacts) connected to the STO inputs (see the figures of the wiring examples below), the STO function is activated and the output to the motor is shut off.



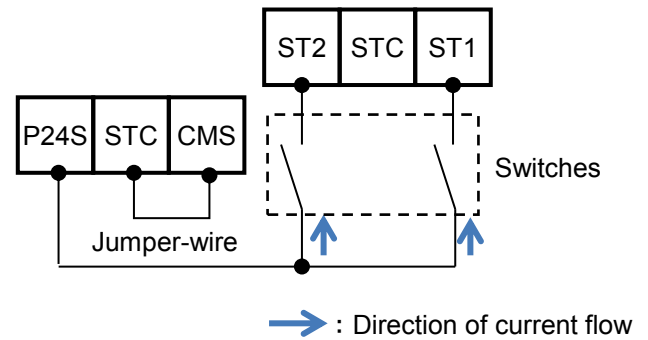
Refer to the User’s Guide of SJ-P1 for the detailed information for wiring on I/O terminal.

Wiring Example

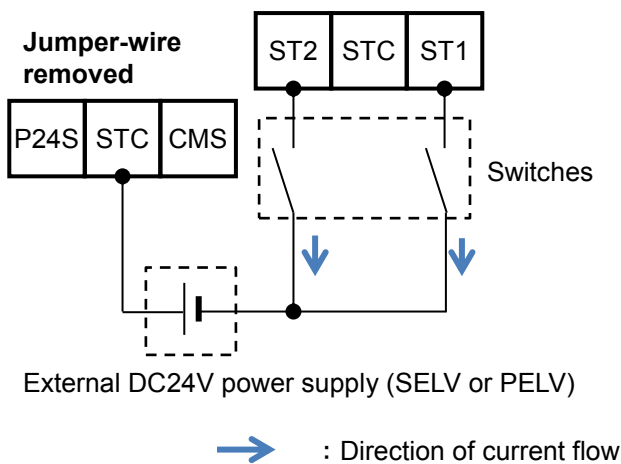
Internal power supply with “Sink” logic



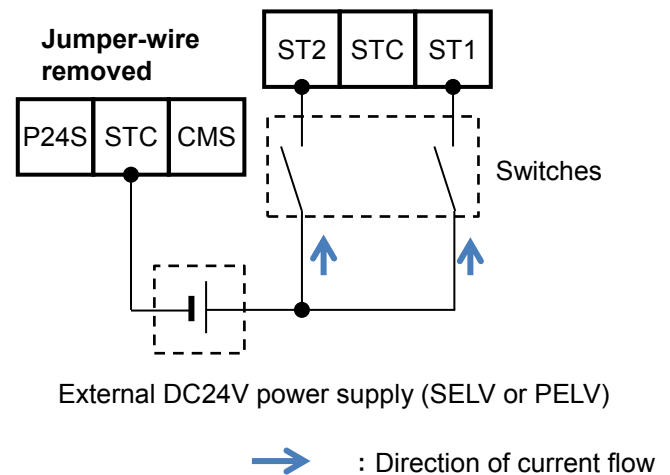
Internal power supply with “Source” logic



External power supply with “Sink” logic



External power supply with “Source” logic



See Chapter 11 for the specification of the STO terminal

4.4.3 Holding function of STO state

(Not supported as Safety related function)

The SJ-P1 does not support a safety related function to hold STO state even after the STO inputs to SJ-P1 have been released.

Therefore when RUN command is input after releasing STO inputs or when the STO inputs is released with holding input status, SJ-P1 immediately becomes available to restart the motor operation.

Considering the above-mentioned behavior, please apply at least one of the measures below in order to fulfill the requirement of EN60204-1:

- (1) The RUN command is released simultaneously when the STO inputs are activated and then given when restart of the inverter is requested intentionally by an operator of the system.
- (2) The system is designed so that the STO inputs to SJ-P1 are released only when restart of the system is requested intentionally by an operator of the system.



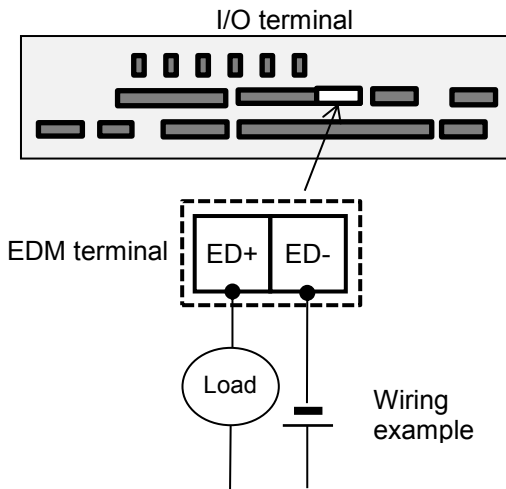
Not supported as Safety related function below.
Using some parameters of SJ-P1, it is possible to select following operation. (See section 4.7)

- (1) It is possible to configure SJ-P1 to trip once the STO inputs are activated. With this setting, the inverter remains in an error state and refrains from outputting to a motor until a reset input (non-safety) is given or the power to SJ-P1 is cycled.
- (2) When only a STO input is activated, SJ-P1 keeps shut off state until two STO inputs are activated.

4.5 STO state monitor output (EDM)

The STO state monitor output (EDM signal) can be used to monitor the STO input state and failure state detection in the safety paths of SJ-P1 using an external device.

EDM terminal (ED+ / ED-) and wiring example



Please refer to the signal matrix for the behavior of the STO state monitor (EDM signal) corresponding to STO state and internal failure detection state. The EDM signal turns ON only when both of the STO inputs are given and no internal failure in the safety paths has been detected.

Signal matrix

Signal / Item	#1	#2	#3	#4	#5
ST1*1)	OFF	ON	OFF	ON	*2)
ST2*1)	OFF	OFF	ON	ON	*2)
Internal Failure detection	No	No	No	No	Yes
EDM	ON	OFF	OFF	OFF	OFF
Output to motor	Shut off	Shut off	Shut off	Permitted	Shut off

*1) State of contact connected to ST1/ST2 and corresponding state are as below.

*2) ON or OFF

State of contact	Corresponding State
OFF	STO
ON	Allow operation



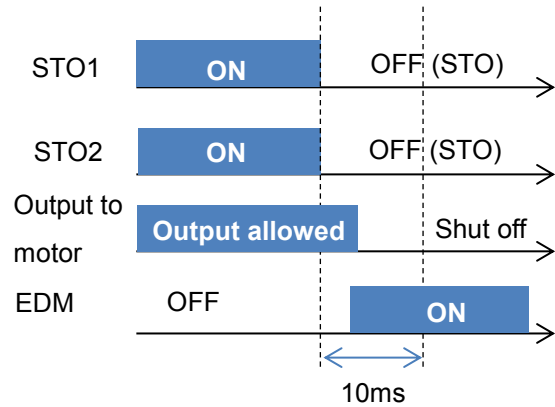
Refer to the User's Guide of the SJ-P1 for the detailed information for wiring on I/O terminal.

See Chapter 11 for the specification of STO terminal

4.6 Timing chart

The timing chart below shows the state of motor output in response to STO inputs (ST1/ST2).

Timing chart



4.7 State Display Function

STO inputs status can be displayed on the operator keypad by configuring the parameters listed in the table below.

It can be also confirmed on the monitor parameter [dA-45].



Contents of display, monitor and the interruption of output by a trip are non-safety function (not certified as safety-related function).

List of parameter related to STO display function

Item	Parameter	Data	Description
STO input display selection	[bd-01]	00	"STO" is displayed on the operator keypad when both ST1 and ST2 signals are STO (ST1=ST2=OFF).
		01	"STO" is NOT displayed on operation panel screen even both ST1 and ST2 are STO (ST1=ST2=OFF).
		02	E90 is generated when both ST1 and ST2 are STO (ST1=ST2=OFF).
STO input switch allowable time	[bd-02]	0.00~60.00(s)	Allowable time for inconsistent Input states of ST1 and ST2 (i.e. ST1=on and ST2=off). When 0.0 is set, tolerance in timing is deactivated.
STO display selection within allowable input time	[bd-03]	00	Warning message is displayed while ST1 and ST2 are discrepant for the period defined by [bd-02].
		01	Warning message is NOT displayed even while ST1 and ST2 are discrepant for the period defined by [bd-02].
STO behavior selection after expiration of input allowable time	[bd-04]	00	Warning message is displayed when inconsistency of STO inputs continues more than the time defined by [bd-02]
		01	Warning message is NOT displayed even when inconsistency of STO inputs continues more than the time defined by [bd-02]
		02	Trips with an error [E092] or [E093] when inconsistency of STO inputs continues more than the time defined by [bd-02]

■ STO monitor [dA-45] and operator keypad status display

STO monitor [dA-45] Display	Operator keypad status display	Condition*1)	Description
00:Non	(no display)	<1>	Both ST1 and ST2 are ON (Allow operation) and the drive is enabled to operate.
01:P-1A	P-1A	<2>	ST2 only becomes OFF (STO) while ST1 remains ON (Allow operation) from the status where both ST1 and ST2 are ON (Allow operation).
02:P-2A	P-2A	<3>	ST1 only becomes OFF (STO) while ST2 remains ON (Allow operation) from the status where both ST1 and ST2 are ON (Allow operation).
03:P-1b	P-1b	<5>	(1) Status P-1A or P-1C continues for the time defined by the parameter [bd-02]. (2) Only ST2 becomes OFF (STO) and then ON (Allow operation) while ST1 remains ON (Allow operation) from the status where both ST1 and ST2 are ON (Allow operation)
04:P-2b	P-2b	<6>	(1) Status P-2A or P-2C continues for the time defined by the parameter [bd-02]. (2) Only ST1 becomes OFF (STO) and then ON (Allow operation) while ST2 remains ON (Allow operation) from the status where both ST1 and ST2 are ON (Allow operation)
05:P-1C	P-1C	<7>	Only ST2 becomes ON (Allow operation) while ST1 remains OFF (STO) from the status where both ST1 and ST2 are OFF (STO).
06:P-2C	P-2C	<8>	Only ST1 becomes ON (Allow operation) while ST2 remains OFF (STO) from the status where both ST1 and ST2 are OFF (STO).
07:STO	STO	<4>	Both ST1 and ST2 are OFF (STO)

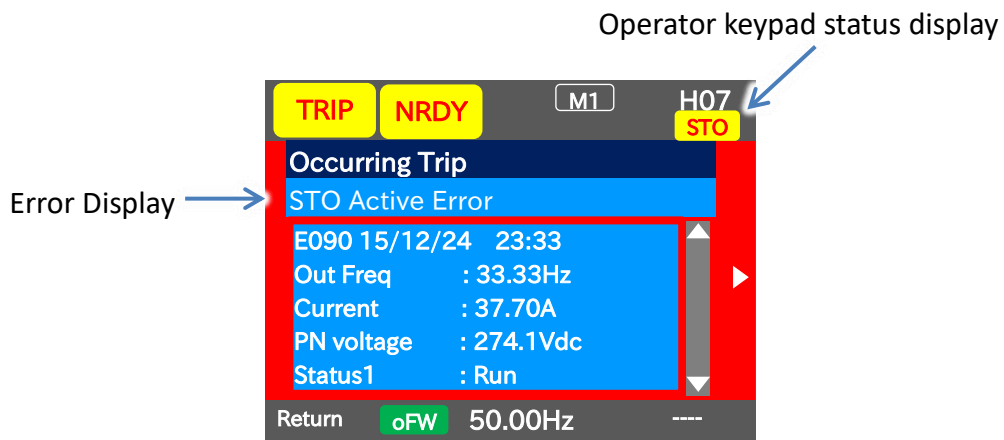
*1) Refer to the state transition diagram for the conditions.

■ Error Display

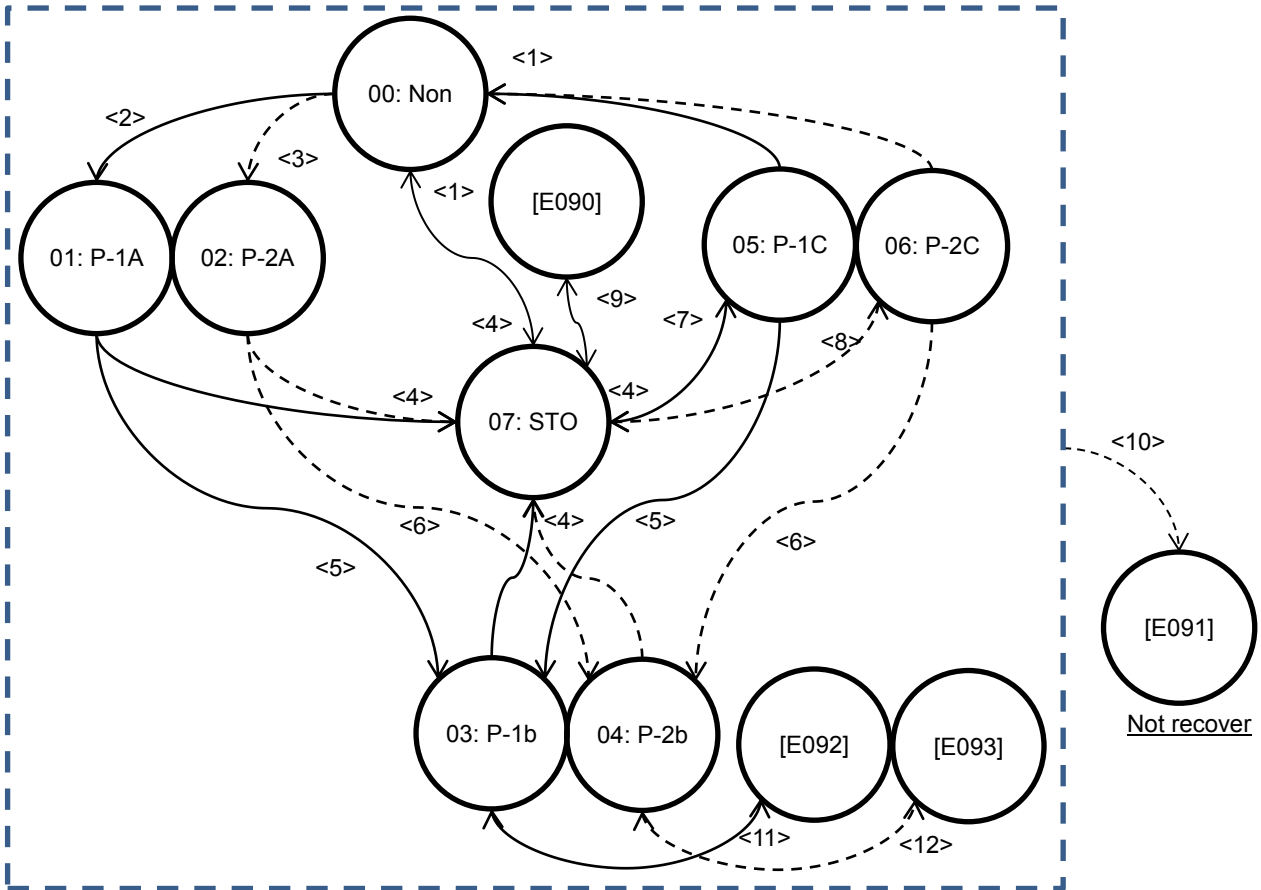
Item	Code	Condition*1)	Description
STO shut off error	[E090]	<9>	In case of [bd-01] = 02, both ST1 and ST2 are OFF (STO).
STO internal error	[E091]	<10>	Internal failure is detected
STO path 1 error	[E092]	<11>	In case of [bd-04] = 02, and in the status of [P-1b]
STO path 2 error	[E093]	<12>	In case of [bd-04] = 02, and in the status of [P-2b]

*1) Refer to the state transition diagram for the conditions.

■ Displaying on the operator keypad



State transition diagram



4.8 Activation method of STO function

After completing wiring on STO terminals (See section 4.4), the STO function is automatically activated when SJ-P1 is energized and established. Any special key operation is not required.



The instructions in the User's Guide are to be followed and "verification & validation" of a system is to be completed. Otherwise the system cannot be regarded as safe.

(Memo)

5

Chapter 5 Planning installation

5.1 Contents in this chapter

This chapter describes the items which must be taken into consideration for planning installation SJ-P1.

5.2 Requirement for designer and installer (installation supervisor)

Designers and installers (installation supervisor) who design and install safety-related system must have been trained to have the specialist knowledge of the essential principles for designing and installing safety-related systems.

Designers and those who maintenance safety-related system must have been trained to understand the cause and consequences of the common cause failure (CCF)

5.3 Installation environment

The product must be installed in a place where environmental condition such as temperature, humidity, corrosive gas, dust, vibration, is within the specification of the product without external environmental controls. Please refer to the User's Guide of SJ-P1 for the requirements and specification for installation as well as the environmental specification provided in chapter 11 in this documentation.

The SJ-P1 must be installed in an enclosure (cabinet) having a protection rating of IP54 or higher for protection against conductive dust and contamination.

5.4 Electrical installation

5.4.1 General Requirement

Please follow the instruction provided in the User's Guide of SJ-P1 for electrical installation. If there is any conflict or different description in the User's Guide of SJ-P1 and this documentation, the description in this documentation shall be considered to have priority.

All of the cables and signal lines must be protected, routed and fixed appropriately.

5.4.2 STO input

The two STO inputs (ST1 and ST2) must be appropriately separated and protected from each other to avoid mutual interference. (E.g. separated cables, protection, double-shield cable)

The length of the cablings connected to STO terminals (ST1, ST2, P24S, CMS and STC) must be twenty (20) meters or shorter.

Please refer to the wiring examples in Chapter 4 for wirings on STO terminals.

At least one of the measures 1 to 3 below must be adapted to STO input wirings for the protection against grounding fault:

1. Grounding STO signal power line (STC)
 - ♦ In case of use of the internal power supply
Ground STC terminal
 - ♦ In case of use of an external power supply
Use a power supply (PELV) which is grounded on STC terminal side.

2. A fail-safe cable routing (The requirement of ISO13849-2 table D.4 to be met. One of the following measures needs to be adopted)

- ♦ Permanently connected (fixed) and protected against external damage, e.g. by cable ducting or
- ♦ Use of separate multicore cable
- ♦ Within an electrical enclosure, with both conductor and enclosure meeting the requirement of IEC 60204-1
- ♦ Individually shielded with earth connection

3. Using an external device for grounding fault detection

In case of connecting a device applies diagnostic test pulses on STO input lines, the width of the test pulse (width of OFF pulse) must be 300us or shorter.

5.4.3 STO status monitor (EDM)

The EDM signal which indicates state of STO inputs and internal fault detection is a reference signal, non-safety signal. This signal may not be used to activate another safety function.

The length of the cabling connected to ED+ and ED- terminals must be twenty (20) meters or shorter.

5.4.4 EMC

The system must only be used in the EMC environment that it is designed for, or necessary mitigations must be applied.

SJ-P1 must only be used within the EMC environment specified in IEC61800-5-2:2016, 2nd environment.

5.4.5 Routing the cables

Cabling of input and output of the safety function must be physically and appropriately separated from the other signal cablings.

6

Chapter 6 Installation

6.1 Contents in this chapter

This chapter describes the items to be taken into consideration for installation.

6.2 Installation

The product must be installed as following the instructions provided in the User's Guide of SJ-P1 and this documentation.

In case of using any optional devices such as a fieldbus module, please read through the guides of each optional device before working on the product.

Operation sequence of wiring example

1. When the safety switch is pressed, S14 and S24 become OFF, the current flowing in ST1 and ST2 terminals are shut off, STO signals are delivered to SJ-P1 and the STO function is activated. (The output of the inverter is shut off).
2. Even after the safety switch has been released, the STO inputs to ST1/ST2 on SJ-P1 are held by the safety relay.
3. After the operator of the system has confirmed the safety of human and the system, and then presses the reset switch, STO inputs to ST1/ST2 on SJ-P1 are released and the inverter becomes available to restart motor operation.

6.3 Wiring example

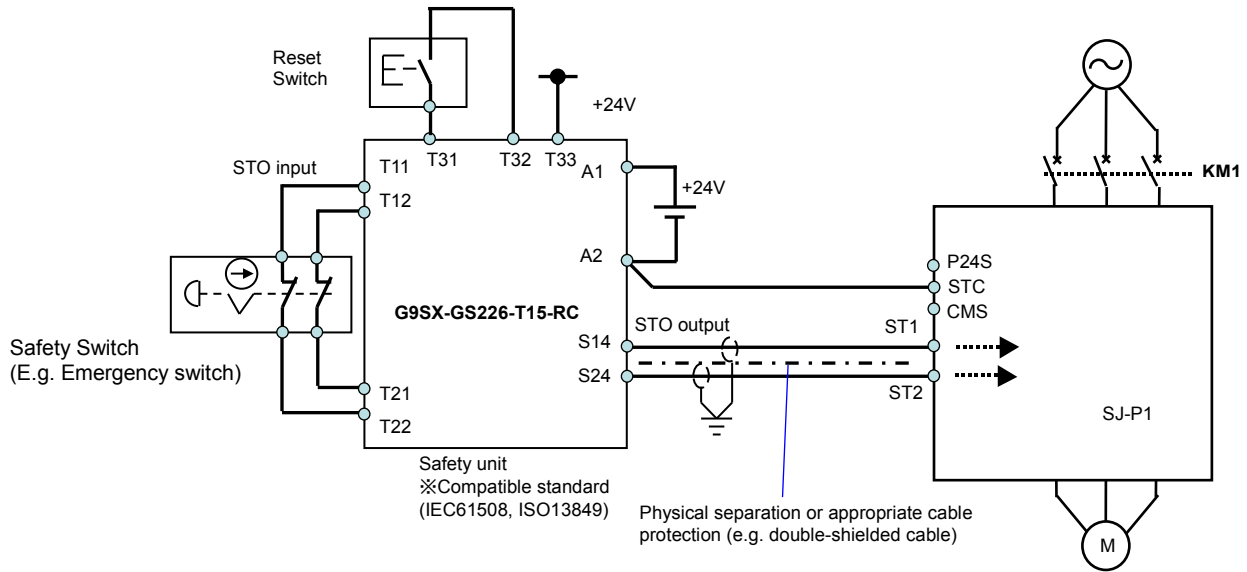
The figure below is a wiring example under the following conditions.

- ♦ Use of an external power supply for STO inputs
- ♦ STO input logic : "Sink" logic

Note: In case of using the internal power supply or wiring with source logic, please perform wiring appropriately as referring to Chapter 4.

- ♦ No use of EDM signal output
- ♦ Reset/Release of STO input to SJ-P1 is controlled using the reset function of a safety unit

Wiring Example



6.4 External device

All power supply connected to I/O terminal block must comply with SELV or PELV.

The signal lines to ST1 and ST2 terminals must be physically separated or appropriately protected.

All devices used to deliver STO signals must comply with the function safety norms such as EN ISO 13849-1, IEC61508.

The followings are the examples of the safety devices to be combined with SJ-P1.

Example of Safety relay

Series	Model	Compatible norm
PNOZsigma	PNOZ s3 24VDC 2n/o	ISO13849-1 cat4, PL e / IEC 61511 SIL 3 EN IEC62061 SIL CL 3
3TK28	3TK2823-2CB30	ISO13849-1 cat4, PL e IEC 61508 SIL 3
PSR-SCP	PSR-SCP-24DC/ESD/4X1/30 -2981800	ISO13849-1 cat3/4, PL d/e IEC61508 SIL 3 / IEC62061 SIL CL 3
GS9A	301	ISO13849-1 cat4, SIL3
G9SX	GS226-T15-RC	IEC61508 SIL1-3
NE1A	SCPU01-V1	IEC61508 SIL3

The configuration of all components used in any circuit other than an appropriately pre-approved safety module that interfaces with the SJ-P1 STO terminals MUST be at least equivalent to Cat.3 PLe under EN ISO 13849-1 in order to be able to claim Cat.3/PLe for the combination of SJ-P1 and external circuits.

The width of test pulse (OFF pulse) applied to ST1/ST2 terminals must be 300us or shorter

7

Chapter 7 Commissioning

7.1 Contents in this chapter

This chapter describes the items to be considered for commissioning.

7.2 Considerations

After completion of installation, commission of whole system must be conducted.

Commissioning of the system must be conducted by only competent electricians who have sufficient knowledge on functional, machine and process safety.

7.3 Enabling STO function

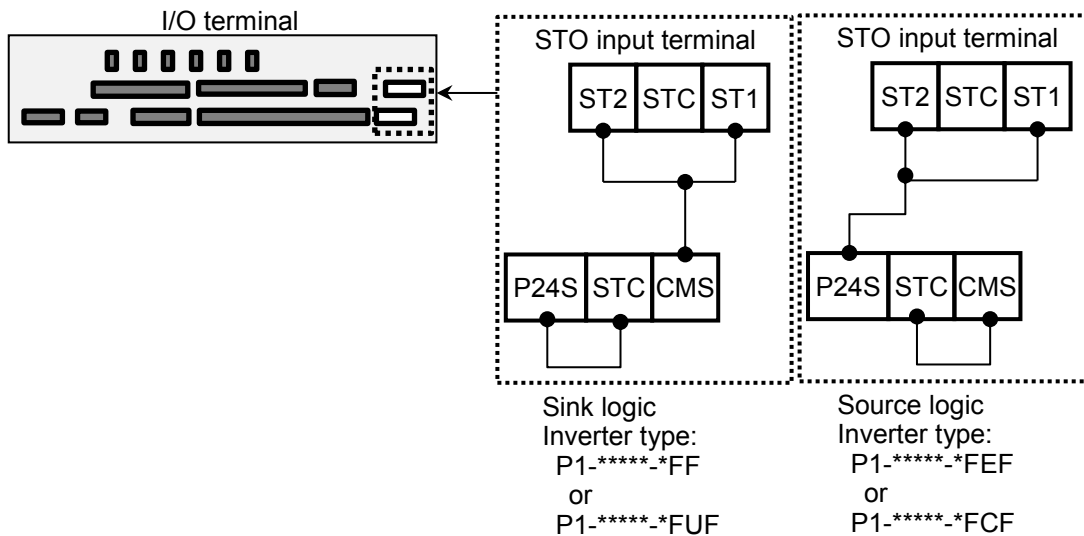
The STO function is automatically activated when SJ-P1 is energized and established according to this Safety function Guide and the User's Guide of the SJ-P1 inverter.

7.4 Disabling STO function

To disable the STO function, please connect the short-wiring as shown in the figure below. (The same wiring condition as the factory default)



The system must not be considered safe until all the safety functionality is verified and validated.



*: Depending on the inverter type. Refer to the User's Guide of the SJ-P1.

(Memo)

8

Chapter 8 Verification and Validation

8.1 Contents in this chapter

This chapter describes information related to verification and validation of system.

8.2 Verification

It is to be verified that the system has achieved the required safety level and function.

8.3 Validation

It is the responsibility of machine manufacturer who uses safety devices and configure safety-related system to ensure that the required safety functions have been achieved in the system.

A test plan for validation test must be prepared and validation test must be conducted in accordance with the test plan. The result of the validation test is to be documented in a report.

Validation test must be conducted in the following timing.

- (1) Start-up of the safety-related system (commissioning)
- (2) When a change which may affect the safety function has been applied
- (3) After maintenance
- (4) In case that a periodical test is required by the applicable EU directive/standard or local standard.

In the validation test, it is to be confirmed that the STO function of SJ-P1 works as intended with the same procedure as the functional test.

Note: In order to maintain the intended functionality of the STO function, it is necessary to conduct a functional test at least once in a year. For the details of the functional test, please refer to Chapter 10.

8.4 Requirement for Validator

Validation of the system must be conducted by only competent electricians who have essential knowledge of the functional safety as well as the safety function realized in the system.

The report of the validation must be completed by the above-mentioned competent electricians.

8.5 Residual Risk

The safety functions are applied to reduce the recognized risk and hazardous conditions in the system.

It may not be always possible to eliminate the all potential risks and hazards.

Therefore, warning for the residual risks must be given to the operators.

(Memo)

9

Chapter 9 Error and Troubleshooting

9.1 Contents in this chapter

This chapter describes the error related to the STO function and the troubleshooting

9.2 Error

An error is generated when the internal diagnosis function detects a failure in the internal safety paths or when configured by related parameters. Please refer to the sections below for the error contents and their troubleshooting.

9.2.1 [E090] STO shut off error

In case of the parameter [bd-01] is set to "02", the error [E090] is generated when both of the STO inputs becomes OFF (STO).

What to do

- If this error is not released even after releasing STO inputs to SJ-P1 and then cycling power, please check wirings and signals of the STO inputs.
- If this error is generated in an unintentional condition, please perform the functional test of the STO function of SJ-P1 to check proper functionality of the STO function.
- If the generation of this error is not desired in the system, it can be disabled by setting [bd-01] to other than "02".

9.2.2 [E091] STO internal error

The error [E091] is generated when a fault in the internal safety paths has been detected.

After generation of this error, the internal safety paths are held on STO state until powered down.

What to do

- When this error is generated, it is likely that a fault exists in the internal safety paths of the SJ-P1.
- Please ensure to stop the operation of the system and shut off the power supply, and then conduct the functional test.

9.2.3 [E092]/[E093] STO path 1/2 error

The error [E092] and [E093] may be generated when [bd-04] is set to other than "0.00" and [bd-04] to "02".

This error is generated when inconsistent input state of ST1 and ST2 continues for the time specified by the parameter [bd-02].

Refer to Chapter 4 for the details of the conditions generating [E092] and [E093].

What to do

- Check the wiring and signal on STO input.
- Set the parameter [bd-02] suitable for the system. When adjusting the time, please ensure the specified time is appropriate for the system.
- If this error is not desired, it can be disabled by setting the parameter [bd-04] to other than "02".

9.3 Warning display

In case that a warning (one of [P-1A] / [P-2A] / [P-1b] / [P-2b] / [P-1C] / [P-2C]) is displayed on the operator keypad, there is a possibility that input state of ST1 and ST2 is inconsistent. Please check that the two STO inputs are given properly.

In case the inconsistent state of ST1/ST2 during state transition is inevitable because of system configuration, please adjust the parameter [bd-02] suitable for the system.

9.4 When internal fault found

Please contact the nearest Hitachi distributor when it has been found a malfunction of the STO function.

- [E091] is occurred
- STO or any warning is displayed on the operator keypad even if the power is turned on with the wiring set to the factory default.

10

Chapter 10 Maintenance

10.1 Contents in this chapter

This chapter describes the items related to maintenance.

10.2 Planning of maintenance

The maintenance on a safety system is critical importance for safety reasons.

You must plan and perform maintenance accordingly.

The SJ-P1 requires conducting the functional test at least once in a year. When planning maintenance of the system, this functional test must be considered.

10.3 Daily and periodical inspection

The SJ-P1 requires daily and periodical inspection in addition to the functional test of the STO function. Please perform inspections as instructed in the User's Guide of SJ-P1.

10.4 Periodical functional test

A periodical STO functional test must be performed at least once in a year in order to maintain the intended safety performance level of the STO function.

This periodical STO function test is one of the conditions for the STO function of SJ-P1 to meet PLe of EN ISO13849-1 and SIL 3 of IEC61800-5-2.

In the functional test, it is to be verified that output to the motor is appropriately shut off and EDM signal is output as intended (see the signal matrix in the following page)

The procedure of the functional test is as below:

- (1) Check if the EDM terminal (ED+ and ED-) is OFF (open) when power to SJ-P1 is not supplied. **(State 1)**
- (2) Power up SJ-P1 and set both ST1/ST2 to ON (Allow operation: short), and then start motor operation. **(State 5)**
- (3) Set both ST1 and ST2 to OFF (STO: open), and check if the output to the motor is shut off and EDM terminal (ED+ and ED-) is ON (Conducted). **(State 2)**
- (4) Set both ST1 and ST2 to ON (Allow operation) and then restart the motor operation. **(State 5)**
- (5) Set only ST1 to OFF (STO: open) and check if the output to the motor is shut off and EDM terminal (ED+ and ED-) is OFF. **(State 3)**
- (6) Set both ST1 and ST2 to ON (Allow operation) and then restart motor operation. **(State 5)**
- (7) Set only ST2 to OFF (STO: open) and check if the output to the motor is shut off and EDM terminal (ED+ and ED-) is OFF. **(State 4)**

When finding any state not following the signal matrix below, there may be a fault in the safety path of the SJ-P1. In that case, stop using the inverter immediately and contact Hitachi distributor.

Signal Matrix for functional test

	State				
	State 1	State 2	State 3	State 4	State 5
Main power supply	OFF	ON	ON	ON	ON
ST1	-	OFF(STO)	OFF(STO)	ON(Allow operation)	ON(Allow operation)
ST2	-	OFF(STO)	ON(Allow operation)	OFF(STO)	ON(Allow operation)
Outout to motor	Shut-off (Disabled)	Shut-off (Disabled)	Shut-off (Disabled)	Shut-off (Disabled)	Permitted
EDM	OFF(Open)	ON(Conducted)	OFF(Open)	OFF(Open)	OFF(Open)

Chapter 11 Specification and Technical data

11

11.1 Contents in this chapter

This chapter describes the specification related to the STO function and its technical data.

11.2 Electrical specification

Refer to the table below for the specifications of the terminals related to the STO function.

■ STO Terminal Specification

Terminal Symbol	Terminal Name	Description	Electrical Characteristics
ST1, ST2	STO input 1, STO input 2	STO signal input terminals	ST1-STC/ST1-STC voltage <ul style="list-style-type: none"> · ON voltage Min.DC15V · OFF voltage Max.DC5V · Max. voltage DC27V · Current 5.8mA (at DC27V) (Note 1)
P24S	24V power supply terminal (Dedicate for STO terminals)	24V power supply dedicated for ST1/ST2 input Not used when the STO input voltage is supplied from an external power supply.	24VDC, Max. 100mA
CMS	24V power supply common terminal (Dedicate for STO terminals)	Common for P24S	-
STC	Logic switching terminal	Sink / Source logic of input terminal can be configured <Sink logic> Short-wire: Between P24S-STC <Source logic> Short-wire : Between CMS-STC * When the STO input voltage is supplied from an external power supply, remove the short-wire and STC terminal can be used as common terminal for ST1/ST2.	-
ED+	EDM signal output terminal (+)	Positive terminal of EDM signal output (STO status monitor)	Open collector output <ul style="list-style-type: none"> · ED+/ED- · Voltage drop: less than 4V · Max. voltage: 27V · Max. current: 50mA
ED-	EDM signal output terminal (-)	Negative terminal of EDM signal output (STO status monitor)	

Note 1: Corresponding to “Digital input type 1” defined in IEC61131-2

Please refer to the User’s Guide of SJ-P1 for the specifications of the other terminals of I/O terminal block and main terminals.

Length of cabling connected to the terminals above must be twenty (20) meters or shorter.

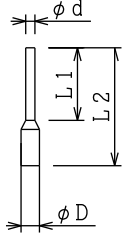
11.3 Recommended ferrule

I/O terminal block is a spring-clamp type.

For safe wiring and reliability, it is recommended for the signal line to use the ferrules of following specification.

Refer to the User's Guide of SJ-P1 for the detail information of wiring on the I/O terminal block.

* Ferrules with sleeve

Wire size mm ² (AWG)	Model name of ferrule *1	L1 [mm]	L2 [mm]	φd [mm]	φD [mm]	
0.25 (24)	AI 0,25-8YE	8	12.5	0.8	2.0	
0.34 (22)	AI 0,34-8TQ	8	12.5	0.8	2.0	
0.5 (20)	AI 0,5-8WH	8	14	1.1	2.5	
0.75 (18)	AI 0,75-8GY	8	14	1.3	2.8	

Note 1: Supplier: Phoenix contact
Crimping pliers: CRIMPFOX UD 6-4 or
CRIMPFOX ZA 3

11.4 Safety function

The STO function of SJ-P1 is equivalent to the function listed below.

Function	Standard
STO (Safe Torque Off)	EN/IEC61800-5-2
Stop category 0	EN 60204-1

11.5 Response time

Item	Time
Response time of STO	10ms max.
Response time of EDM signal (reference)	20ms max.

11.6 Safety-related parameters

Parameter	Value	Standard
PL	e	EN ISO 13849-1:2015
CAT.	4	
MTTFd	100 years	
DCavg	99.8%	
SIL	3	IEC61508: 2010
HFT	1	IEC61800-5-2:2016
SFF	99.9%	EN62061:2012
PFH	1.17×10^{-9}	
PFd	1.03×10^{-4}	

11.7 Environmental specification

Ambient temperature	-10~50°C	
Storage temperature	-20~65°C	
Humidity	20~90%RH (No condensation)	
Vibration	*1)	5.9m/s ² (0.6G), 10~55Hz
	*2)	2.94m/s ² (0.3G), 10~55Hz
Location	Altitude 1,000m or less Indoors (No corrosive gasses or dust)	

*1) P1-00044-L(P1-004L)~P1-03160-L(P1-550L)/
P1-00041-H(P1-007H)~P1-01800(P1-550H)

*2) P1-03520-L(P1-750L)~P1-04300-L(P1-900L)/
P1-01760-H(P1-750H)~P1-03160-H(P1-1320H)

Appendix

EC Declaration of Conformity (Copy)



<Remark>

- Purpose of this chapter is to provide necessary information related to EC declaration of conformity
- The original version is available separately. Please contact Hitachi distributor for the original.

EC-DECLARATION OF CONFORMITY

We, Hitachi Industrial Equipment Systems Co., Ltd.

1-1 Higashinarashino 7-chome, Narashino-shi, Chiba 275-8611, Japan, declare in our sole responsibility that the following products conform to all the relevant provisions.

Product name: **AC Inverter, SJ series Type P1**
 Three-phase, 200-240VAC, 50/60Hz
 Three-phase, 380-500VAC, 50/60Hz

Models Covered:

Model P1, maybe followed by -, followed by 00044, 00080, 00104, 00156, 00228, 00330, 00460, 00600, 00800, 00930, 01240, 01530, 01850, 02290 or 02950, maybe followed by -, followed by L, followed by B or F, maybe followed by C, E or U, maybe followed by F, maybe followed by any letters or numbers.
 Model P1, maybe followed by -, followed by 00041, 00054, 00083, 00126, 00175, 00250, 00310, 00400, 00470, 00620, 00770, 00930, 01160, 01470, 01760, 02130, 02520 or 03160 maybe followed by -, followed by H, followed by B or F, maybe followed by C, E or U, maybe followed by F, maybe followed by any letters or numbers.

Authorized Representative: Hitachi Europe GmbH
 Niederkasseler Lohweg 191, 40547 Dusseldorf, Germany

Council Directives: MD: 2006/42/EC (MD: Machinery Directive)
 EMC: 2014/30/EU

Harmonized Standards: MD: EN 61800-5-2:2017 / IEC 61800-5-2:2016
 EN ISO 13849-1:2015 / ISO13849-1:2015
 EN 62061: 2005+A1:2013+A2:2015 / IEC 62061:2015
 EMC: EN61800-3:2004 / A1:2012

Relevant Standard: IEC61508 Parts 1-7:2010
 EN/IEC 61800-5-1:2007
 EN/IEC 60204-1 (Stop Category 0)
 (To apply the EMC EN61800-3, use a filter designed for above models.)

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