

HF-620 Series Inverter

Single-phase 200V class 0.2 to 2.2kW

Three-phase 200V class 0.2 to 7.5kW

Three-phase 400V class 0.4 to 7.5kW

Safety Function Guide



<Note>

- This product should be handled by only those who have been trained for the work.
Please read this manual carefully before use.
- Deliver this manual to the customer who will actually use the product.
- This instruction manual should be carefully stored.

Introduction

Thank you for purchasing HF-620 Series Inverter. (Afterward "HF-620 Series Inverter" referred to as HF-620.)

The information not in the Safety function Guide must be referred to the User's Guide of the HF-620.

If there are any inconsistent contents between the User's Guide of the HF-620 and this Safety function Guide, the instructions provided in this Safety function Guide always have priority when the Safety function is used.

For the purpose of reduction of paper consumption and provision of the latest information, we enclose the Safety function Guide Caution only, while providing the Safety function Guide (this Guide) for more detailed description through electronic means instead of CD or a printed document.

■ Safety function Guide (this document)

This document is 'Original instructions'.

The Safety function Guide provides the information necessary for handling the Safe Torque Off (STO) function of the HF-620. Be sure to read through this documentation as well as the User's Guide of the HF-620 when using the STO function of the HF-620.

If future updated descriptions differ from the HF-620 manual and User's Guide, the description in the Safety function Guide will have higher priority. Always use the HF-620 strictly within the range described in the Safety function Guide and perform proper inspection and maintenance to prevent failures or accidents.

Please note that the HF-620 User's Guide is basically provided as electronic data (such as PDF). The latest version of the HF-620 User's Guide, please contact the supplier where this device was purchased.

Precaution

■ For a Proper Use

Before using the inverter, carefully read Safety function Guide/Caution, HF-620 manual, User's Guide, and the instruction manuals for optional products.

In addition, any personnel handling or performing maintenance of the product must read carefully HF-620 manual, User's Guide, Safety function Guide, and each optional products instruction manuals.

Before any attempt to install, operate, maintain or inspect this equipment, a complete understanding of the equipment specifications, safety instructions, precautions, handling and operation instructions is required. Follow all the specifications and instructions for a proper use.

Additionally, review HF-620 manual, User's Guide, Safety function Guide, and each optional product instruction manuals periodically.

■ Precautions

It is prohibited to reproduce or reform this document partially or totally in any form without the publisher's permission. The contents of the document are subject to change without prior notice.

Any handling, maintenance or operation method NOT described in HF-620 manual, User's Guide, safety function Guide, and each optional product instruction manuals is not covered by the product warranty. DO NOT perform any procedure NOT described in the HF-620 and optional product guides since it can be the cause of unexpected failures or accidents.

We are not responsible for any injury or damage due to handling, maintenance or operation of the product in a manner not specified in HF-620 manual, User's Guide, Safety function Guide, and each optional product instruction manuals. We appreciate your understanding.

If you find any unclear or incorrect description, missing description, or misplaced or missing pages, please inform the distributor.

Note that, in case HF-620 manual, User's Guide, Safety function Guide, and each optional product instruction manuals are enclosed with the product, they should be delivered to the end user of the inverter. For detailed information, please contact the supplier where this device was purchased.

■ Trademark

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

■ Relevant document

Document name	Document Code ^{Note}
HF-620 Manual	DM2501E
HF-620 User's Guide	DM2502E
HF-620 Safety function Guide (this documentation)	DM2503E
HF-620 Safety function Guide Caution	DM2504E

Note: The document version is added to the end of the document code.

■ List of Abbreviation and Technical Terms

Term / Abbreviation	Description
AWG	American wire gauge Standardized wire gauge used in North America
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 power supply	Internal power supply necessary for powering up the logic board and configuring the inverter using keypad. Supplying power to R/L1, S/L2, T/L3 terminals (In case of single-phase model, please use R/L1 and S/L2 terminals.) or P24, COM terminals can power up the internal power supply.
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)
DCavg	Diagnostic coverage average
EMC	Electromagnetic compatibility
EUC	Equipment Under Control
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. (EN 61508)
HFT	Hardware fault tolerance (EN 61508)
I/O	Input/Output
IGBT	Insulated gate bipolar transistor
Inverter model code	The model code written on the specification label of the inverter.
Keypad	The keypad mounted on the inverter used for configuration of parameters and monitoring of inverter's state.
Machinery Safety Directive	One of the EC Directive which is related to inverters or machines with inverters.
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
PELV	Protected Extra-Low voltage (IEC 61800-5-2)
PFD	Probability of failure on demand (EN 61508)
PFH	Average frequency of a dangerous failure [1/h] (EN 61508)
PL	Performance level (a-e) (EN ISO 13849-1)
PLC	Programmable logic controller
PWM	Pulse width modulation
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
Safety Function	Safety functions to achieve safe state of system such as STO function defined in EN 61800-5-2.
Safety path	Path of signal to perform the safety function.
Safety-Related System	Whole system including inverter, sensor, switch, and safety relay etc. that achieves safety function(s).
SELV	Safety extra-low voltage (IEC 61800-5-2)
SFF	Safe failure fraction (%) (EN 61508)
SIL	Safety integrity level (1-3) (EN 61508)
Specification label	The label affixed on the product, on which specification of the inverter is written.
STO	Safe torque off (EN 61800-5-2)
Stop category 0	A type of stop category defined in IEC 60204-1. Stopping by immediate removal of power to the machine actuator.
T _M	Mission time
User's Guide	The documentation that provides the detailed information to handle the inverter.
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 What this chapter explains

This chapter describes precautions for using the STO function of the HF-620.

Before installation, wiring, operation, maintenance, inspection and running, please make sure to read through the Safety Function Guide, the User's Guide of the HF-620 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 HF-620 does not support a retention function of STO state after release of STO inputs. Therefore, after STO inputs to the HF-620 are released, the HF-620 becomes available to restart the motor operation. (A function of HF-620 to hold Shut off state without STO inputs is not safety function.)

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

Please note that HF-620 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 HF-620 within the specified environmental condition including EMS environment.

1.2.4 Commissioning

The safety-related system must always need to properly carry out the commissioning and be 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 and check the charge lamp of the inverter disappears, and then confirm that the voltage between P(+) and N(-) terminals is lower than DC45V before performing maintenance.

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

1.2.6 Others

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

The precaution items provided in User's Guide of the HF-620 are not always described in this chapter. Please ensure to read through and understand the precaution in the User's Guide before using the HF-620.

Chapter 2 Introduction to the Safety Function Guide

2.1 What this chapter explains

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 HF-620 having the model code listed in EC declaration of conformity (see the appendix of this documentation).

2.3 Target audience

The Safety function Guide is intended for qualified persons who design the safety application, plan the installation, install, carry out the test run and maintenance. Read through this documentation as well as the User's Guide of the HF-620 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 HF-620.

2.5 Recommended readings

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

- 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.
- IEC60204-1:2016, 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 manual and the User's Guide of the HF-620.

For the standards with which the HF-620 complies, please refer to Chapter 4.

Chapter 3 Safety-related Information and Consideration

3.1 What this chapter explains

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 HF-620 must be used in accordance with the instructions provided in this Safety function Guide and the User's Guide of the HF-620.

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

Potential risks and predictable misuse should be mentioned in a manual of machine.

3.3 Intentional misuse

The HF-620 is not designed to protect against intentional misuse/interference for STO function.

3.4 Safety consideration

3.4.1 Safety function

The HF-620 supports the STO function which is equivalent to STO (Safe Torque Off) function defined in EN 61800-5-2 as well as Stop Category 0 defined in IEC 60204-1.

The HF-620 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 HF-620 is 20ms or less.

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 HF-620 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 maintain shut-off regardless of the states of the STO inputs to the HF-620.

3.4.4 STO input

The STO inputs of the HF-620 are redundant and 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 HF-620 is not equipped with a diagnosis function of STO input signal from an external device.

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 STO Status retention function (Not supported as Safety related function)

The retention function that retains the STO status of internal safety path even if STO input is canceled is not implemented as a safety circuit.

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 signal)

Please use EDM signal when it is required to monitor state of the STO inputs to HF-620 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 Functional test (Proof test)

A periodical functional test (proof 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 (proof 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 and check the charge lamp of the inverter disappears, and then confirm that the voltage between P and N terminals is lower than DC45V before performing maintenance.



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 multiple IGBT power semiconductors fail, the inverter system can produce an alignment torque which maximally rotates the motor shaft as 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 poles.

Chapter 4 Safety Function

4.1 What this chapter explains

This chapter describes the information about the safety function of the HF-620.

4.2 Safety function (STO)

The HF-620 is equipped with the STO (Safe Torque Off) function defined in EN 61800-5-2. This function is equivalent to stop category 0 defined in IEC 60204-1.

4.3 Conformity standards

The conformity standards are listed in the table below.

■ Conformity standards

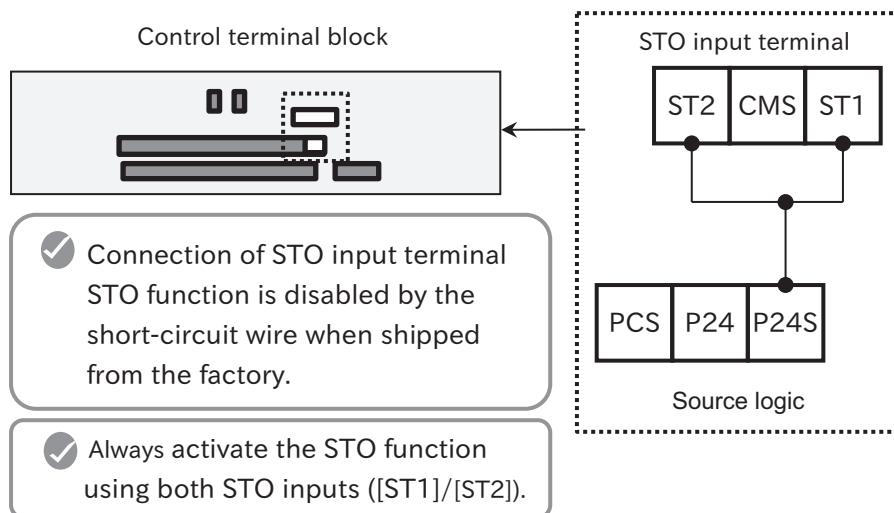
Standard ^{Note}	Remark
EN ISO 13849-1:2015	CAT.3 PL e
EN 61800-5-2:2017	SIL 3
UL1998	Diagnostic software class 1
IEC 60204-1:2016	Stop Cat.0

Note: The standards information on this document is as of June 2023.

4.4 Operation procedure of safety function

4.4.1 STO input terminal

- Input of STO signal is performed by redundant input of STO input terminals [ST1] and [ST2].
- When voltage is applied to each input terminal and current flows, operation of safety path is enabled. (When shipped from the factory, operation is always enabled. See the figure below.)
- STO function is enabled and the output to the motor is shut off by turning OFF either of the external switches for STO signal input as shown in the wiring diagram on the next page.



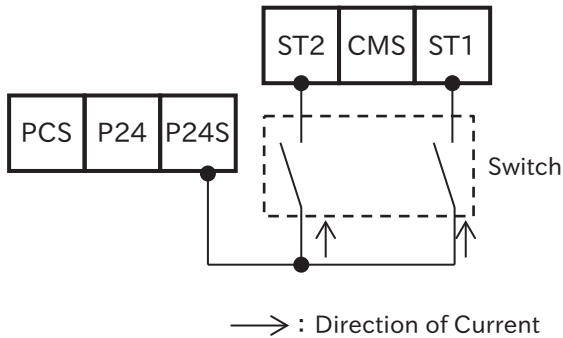
4.4.2 Input method of STO signal

Input voltage for the STO signal can be chosen from the internal power supply of inverter (P24S terminal) or an external DC24V power supply.

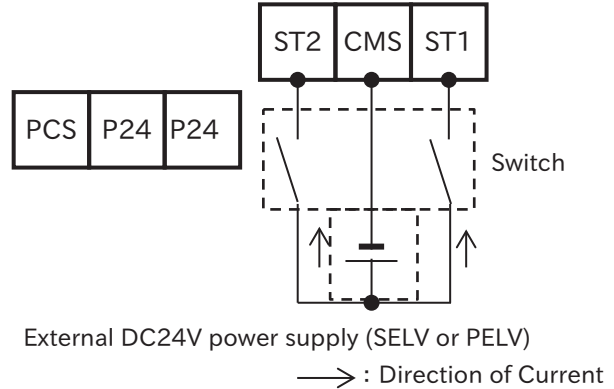
The external DC24V power supply must be SELV or PELV.

■ Wiring example

(1) Internal power supply



(2) External power supply



See Chapter 11 for the specification of the STO input terminal.

By turning off the external switch (contact point) for STO input shown in the wiring example above, STO function is enabled, and output to the motor is shut off.

Refer to the User's Guide of HF-620 for the detailed information for wiring on the control terminal.

4.4.3 STO status retention function (not supported as the safety function)

The retention function that retains the STO status of internal safety path even if STO input is canceled is not implemented as a safety circuit. Therefore, if a RUN command is given after cancellation of STO input or STO input is canceled while the command is given, the inverter starts output to the motor.

Hence, to satisfy the requirements about cancellation of emergency stop specified in IEC60204-1, either of the following measures has to be taken.

- (1) At the same time as STO input, set the RUN command to the inverter to stopped status.
- (2) Configure the system so that STO input to HF-620 is canceled when system reboot is required by the user.



By parameter settings, you can select the following operations. (see section 4.7)

- (1) Trip the inverter by STO input. In this case, the inverter is tripped and output is stopped until power is shut off or the error reset signal for the inverter is input.
- (2) If two STO input systems to the inverter are not input at the same time, the inverter is shut off and enters standby mode until STO input for the two systems is input.

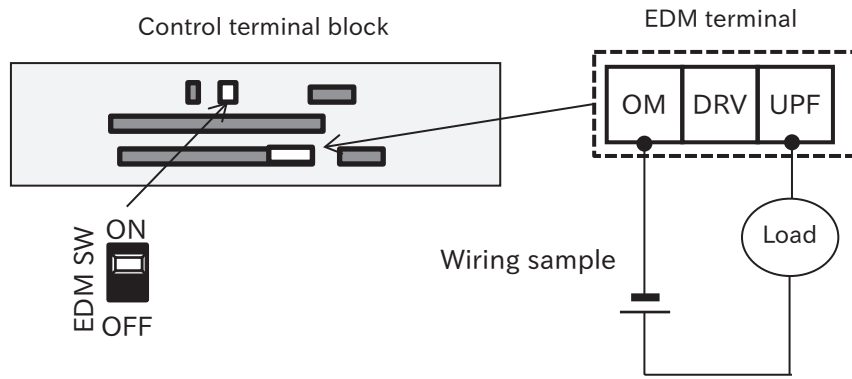
4.5 STO state monitor output (EDM signal)

The STO state monitor output (EDM signal) is the output signal for monitoring the input status of STO signal and failure detection status on the internal safety path. When using STO state monitor output (EDM signal), turn ON EDM function selector switch on the control circuit terminal. "Output terminal [UPF] function (CC-01)" is automatically changed to "STO state monitor output (96[EDM])". At the same time, "Output terminal [UPF] active state (CC-11)" becomes "NO: Normally Open (00)" automatically.

"Output terminal [UPF] function (CC-01)" and "Output terminal [UPF] active state (CC-11)" cannot be changed when EDM function selector switch is turned on.

When EDM function selector switch is turned OFF from ON, "Output terminal [UPF] function (CC-01)" is automatically changed to "No assignment (no)".

■ EDM terminal (UPF/OM) and wiring example



For operation of ST1/ST2 and output of EDM signal against failure detection status, see the matrix below. EDM signal turns ON only when both STO inputs are correctly input, and internal failure is not detected.

■ Signal matrix

Signal	Status 1	Status 2	Status 3	Status 4	Status 5
ST1 Note:1	STO	Operation permitted	STO	Operation permitted	Note:2
ST2 Note:1	STO	STO	Operation permitted	Operation permitted	Note:2
Failure detection	None	None	None	None	Detected
EDM	ON	OFF	OFF	OFF	OFF
Output to the motor	OFF	OFF	OFF	Output permitted	OFF

Input Status	Contact point
STO	OFF
Operation permitted	ON

Note: 1. Correspondence between the input status of [ST1]/[ST2] and the contact status.
 2. STO or Operation permitted

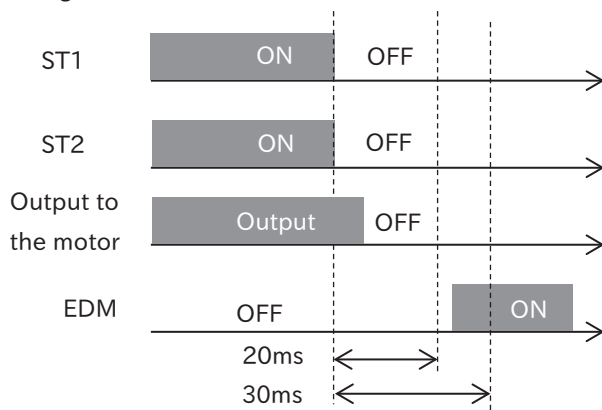


Refer to the User's Guide of the HF-620 for the detailed information for wiring on the control circuit terminal. See Chapter 11 for the specification of STO input terminal.

4.6 STO timing chart

The timing chart of the output to the motor and EDM signal for STO input [ST1]/[ST2] is shown below. The output to the motor is shut off within 20ms after [ST1] and [ST2] are turned off.

■ Timing chart



4.7 States Indication Function

By setting parameters described in the table below, the status of STO input is displayed on the keypad.

■ List of parameter related to STO display function

Code	Item	Description	Data	Initial setting
bd-01	STO input display selection	If input of both ST1 and ST2 is STO (input contact point is OFF), "STO" is shown on the keypad.	00	01
		Also if input of both ST1 and ST2 is STO (input contact point is OFF), "STO" is not shown on the keypad.	01	
		If input of both ST1 and ST2 is STO (input contact point is OFF), [E090] error occurs. * Even if either ST1 or ST2 is set to STO, [E090] error does not occur.	02	
bd-02	STO input change time (release)	Set the allowable time for which input status of ST1 and ST2 is different (e.g., input contact point: ST1=ON, ST2=OFF) when either ST1 or ST2 is released from STO. If there is a difference between the switching time of ST1 and ST2, set the time that the system can allow the difference. If it is set to 0.00, the determination of allowable time becomes invalid.	0.00 to 60.00 s	0.01
bd-03	Display selection During STO input change time	Displays a warning during the STO input change time [bd-02]/[bd-05] after the difference between the states of ST1 and ST2 occurs.	00	01
		Does not display a warning during the STO input change time [bd-02]/[bd-05] after the difference between the states of ST1 and ST2 occurs.	01	
bd-04	Action selection after STO input change time	Displays a warning after the STO input change time [bd-02]/[bd-05].	00	01
		Does not display a warning after the STO input change time [bd-02]/[bd-05].	01	
		[E092] or [E093] error occurs after the STO input change time [bd-02]/[bd-05].	02	
bd-05	STO input change time (shutoff)	Set the allowable time for which input status of ST1 and ST2 is different (e.g., input contact point: ST1=ON, ST2=OFF) when either ST1 or ST2 is shut off from the state that both ST1 and ST2 are operation enabled state (contact point is ON). If there is a difference between the switching time of ST1 and ST2, set the time that the system can allow the difference. If it is set to 0.00, the determination of allowable time becomes invalid.	0.00 to 60.00 s	0.01
bd-06	Warning release mode selection	Cancellation of warning display is invalid.	00	00
		Cancellation of warning display is valid.	01	
bd-07	Warning re-display time	Time to return to warning display.	1 to 30 s	30



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

■ Safety STO monitor [dA-45] and status indication the keypad

Safety STO monitor [dA-45] Display <small>Notr:1</small>	Keypad status display <small>Note:1</small>	Condition <small>Note:2</small>	Description
00	(No indication)	<1>	Both ST1 and ST2 are operation enabled state (contact point is ON) and inverter output is available.
01	P-1A	<2>	When both ST1 and ST2 are operation enabled status (contact point is ON), only ST2 changes to STO (contact point is OFF). Then, ST1 remains operation enabled status during STO input change time (shutoff) [bd-05].
02	P-2A	<3>	When both ST1 and ST2 are operation enabled status (contact point is ON), only ST1 changes to STO (contact point is OFF). Then, ST2 remains operation enabled status during STO input change time (shutoff)[bd-05].
03	P-1b	<5>	(1) This status is displayed in the P-1C or P-1A status after the STO input change time [bd-02]/[bd-05]. (2) When both ST1 and ST2 are operation enabled status (contact point is ON), only ST2 changes to STO (contact point is OFF), and then ST2 is operation enabled status (contact point is ON) again.
04	P-2b	<6>	(1) This status is displayed in the P-2C or P-2A status after the STO input change time [bd-02]/[bd-05]. (2) When both ST1 and ST2 are operation enabled status (contact point is ON), only ST1 changes to STO (contact point is OFF), and then ST1 operation enabled status (contact point is ON) again.
05	P-1C	<7>	From the status that both ST1 and ST2 is STO (contact point is OFF), ST2 is operation enabled status (contact point is ON). Then, ST1 remains STO (contact point is OFF) during the STO input change time (release) [bd-02].
06	P-2C	<8>	From the status that both ST1 and ST2 is STO (contact point is OFF), ST1 is operation enabled status (contact point is ON). Then, ST1 remains STO (contact point is OFF) during the STO input change a time (release) [bd-02].
07	StO	<4>	Both ST1 and ST2 are STO (contact point is OFF).

Note: 1. Safety STO monitor [dA-45] and status indication of keypad can be displayed or hidden by the settings of [bd-01], [bd-03], and [bd-04].

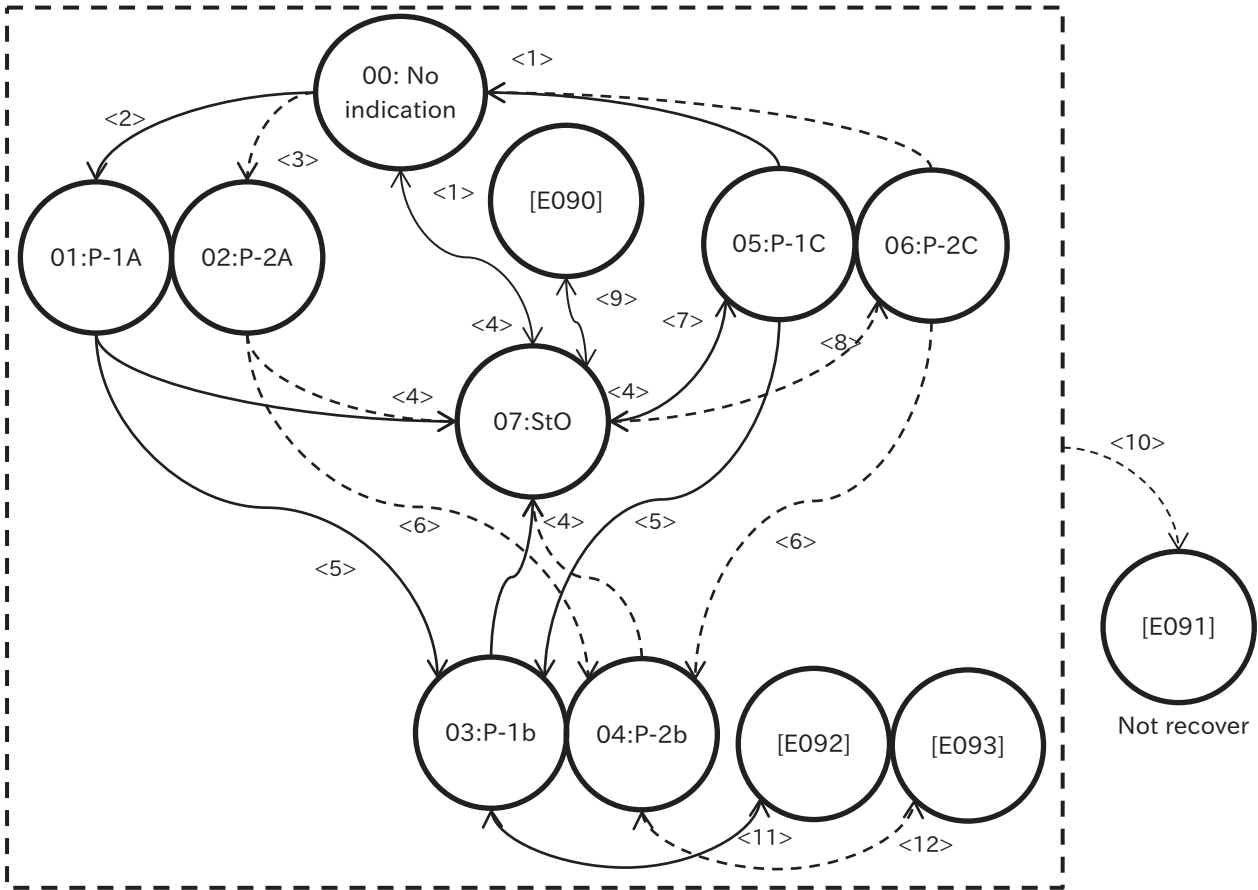
2. Refer to the state transition diagram for the conditions.

■ Error indication

Error Code	Item	Condition <small>Note</small>	Description
E090	STO shut off error	<9>	If [bd-01] is set to 02, the error occurs when both ST1 and ST2 are input.
E091	STO internal error	<10>	The error occurs when Internal failure is found. It cannot be canceled by reset operation.
E092	STO path 1 error	<11>	If [bd-04] is set to 02, the error occurs at P-1b.
E093	STO path 2 error	<12>	If [bd-04] is set to 02, the error occurs at P-2b.

Note: Refer to the state transition diagram for the conditions.

■ State transition diagram



4.8 Activation method of STO function

After completing wiring on STO input terminals (See section 4.4), the STO function is automatically activated when HF-620 is energized and established. Any special key operation is not required.



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

4.9 SFM1/SFM2 (ST1/ST2 feedback monitor) output signal

The [SFM1]/ [SFM2] signal outputs the input status of [ST1]/[ST2]. [SFM1] is ON when [ST1] is turned on and [SFM1] is OFF when [ST1] is turned off. [SFM2] is ON when [ST2] is turned on and [SFM2] is OFF when [ST2] is turned off.

Code	Item	Description	Data	Initial setting
CC-01	Selection of output terminal [UPF] (EDM is assigned automatically when EDM SW is ON)	094: ST1 feedback monitor [SFM1] 095: ST2 feedback monitor [SFM2]	000 to 098	002
CC-02	Selection of output terminal [DRV]			001
CC-07	Selection of output terminal [ML]			017

4.10 FSC (STO input discrepancy) output signal

The [FSC] signal can be output when the states of ST1 and ST2 matches.

ON/OFF of the [FSC] signal within STO input change time and after STO input change time can be changed by setting [bd-03] and [bd-04].

The judgement cycle of the [FSC] signal is 10ms.

Code	Item	Description	Data	Initial value
CC-01	Selection of output terminal [UPF] (EDM is assigned automatically when EDM SW is ON)	088: STO input discrepancy [FSC]	000 to 098	002
CC-02	Selection of output terminal [DRV]			001
CC-07	Selection of output terminal [ML]			017

■ Output of [FSC] signal when [bd-01]=00, 01.

bd-03	bd-04	State of the inverter in the state transition diagram							
		00 Operation permitted	01 P-1A	02 P-2A	03 P-1b	04 P-2b	05 P-1C	06 P-2C	07 StO
00	00	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON
	01	ON	OFF	OFF	ON	ON	OFF	OFF	
	02	ON	OFF	OFF	OFF (Trip)	OFF (Trip)	OFF	OFF	
01	00	ON	ON	ON	OFF	OFF	ON	ON	ON
	01	ON	ON	ON	ON	ON	ON	ON	
	02	ON	ON	ON	OFF (Trip)	OFF (Trip)	ON	ON	

■ Output of [FSC] signal when [bd-01]=02.

bd-03	bd-04	State of the inverter in the state transition diagram							
		00 Operation permitted	01 P-1A	02 P-2A	03 P-1b	04 P-2b	05 P-1C	06 P-2C	07 StO
00	00	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF (Trip)
	01	ON	OFF	OFF	ON	ON	OFF	OFF	
	02	ON	OFF	OFF	OFF (Trip)	OFF (Trip)	OFF	OFF	
01	00	ON	ON	ON	OFF	OFF	ON	ON	OFF (Trip)
	01	ON	ON	ON	ON	ON	ON	ON	
	02	ON	ON	ON	OFF (Trip)	OFF (Trip)	ON	ON	

Chapter 5 Installation Planning

5.1 What this chapter explains

This chapter describes the items which must be taken into consideration for planning installation of HF-620 and safety-related system.

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 maintain 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 HF-620 for the requirements and specification for installation as well as the environmental specification provided in chapter 11 in this documentation.

The HF-620 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 requirements

Please follow the instruction provided in the User's Guide of HF-620 for electrical installation. If there is any conflict or different description in the User's Guide of HF-620 and this documentation, the description in this documentation shall be considered to have priority.

All 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 ST1, ST2, and EDM terminal must be twenty (20) meters or shorter.

Please refer to the wiring examples in Chapter 4 for wiring.

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 (CMS)
 - In case of use of the internal power supply Ground CMS terminal
 - In case of use of an external power supply
Use a power supply (PELV) which is grounded on CMS terminal side.
- (2) A fail-safe cable routing (The requirements of EN ISO 13849-2: 2012 table D.4 to be met. One of the following measures needs to be adopted.)
 - STO input wirings are permanently connected (fixed) and protected against external damage, e.g. by cable ducting.
 - Use separate multicore cable for STO input wirings.
 - STO input wirings are within an electrical enclosure, with both conductor and enclosure meeting the requirement of IEC 60204-1.
 - STO input wirings are individually shielded with earth connection.
- (3) Using an external device for grounding fault detection.
 - In case of connecting a device that generates diagnostic test pulses on STO input lines, the width of the test pulse (width of OFF pulse) must be 500µs or shorter.

5.4.3 STO status monitor (EDM signal)

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 UPF and OM 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.

HF-620 must only be used within the EMC environment specified in EN 61800-5-2 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.

Chapter 6 Installation

6.1 What this chapter explains

This chapter describes the items to be taken into consideration for installation of HF-620 and safety-related system.

6.2 Installation

The product must be installed according to the instructions provided in the User's Guide of HF-620 and this documentation.

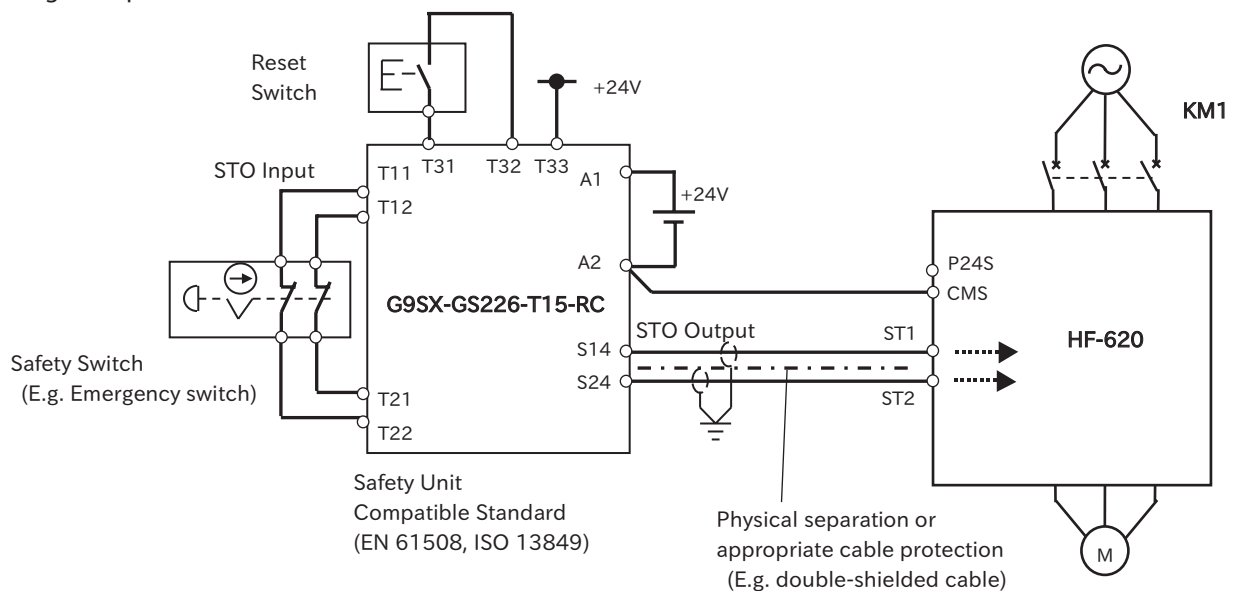
In case of using any optional devices such as a fieldbus module, please read through the guides of each optional device before working on the product.

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 : "Source" logic
Note: In case of using the internal power supply, please refer to Chapter 4 to perform wiring appropriately.
- No use of EDM signal output
- Reset/Release of STO input to HF-620 is controlled using the reset function of a safety unit.

■ Wiring Example



■ 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, 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 HF-620 maintain shut off by the safety unit.
- (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 HF-620 are released and the inverter becomes available to restart motor operation. In case of [bd-01]=02, a release of trip on HF-620 is needed to become available to restart motor operation.

6.4 External device

All power supply connected to control circuit 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 functional safety such as EN ISO13849-1, EN 61508.

HF-620 does not diagnose external devices.

The followings are the examples of the safety devices to be combined with HF-620.

■ Example of Safety devices

Series	Model	Manufacturer	Conformity standards
G9SA	301	OMRON	EN ISO13849-1 cat4, PLe
G9SX	GS226-T15-RC		EN ISO13849-1 cat4, PLe EN 61508 SIL3

To achieve CAT.3, PL e / SIL3 as a system which use HF-620, at least it must be combined with Cat.3 PL e /SIL3 equipment.

The width of test pulse (OFF pulse) applied to ST1/ST2 terminals must be 500µs or shorter.

Stop category 0 (IEC60204-1) is realized when used in combination with external devices complying with the standards and installed following the instructions of the manual, in particular the safety related instructions.

Chapter 7 Test Run

7.1 What this chapter explains

This chapter describes the items to be considered for a test run.

7.2 Considerations

After completion of installation, the test run of whole system must be conducted.

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



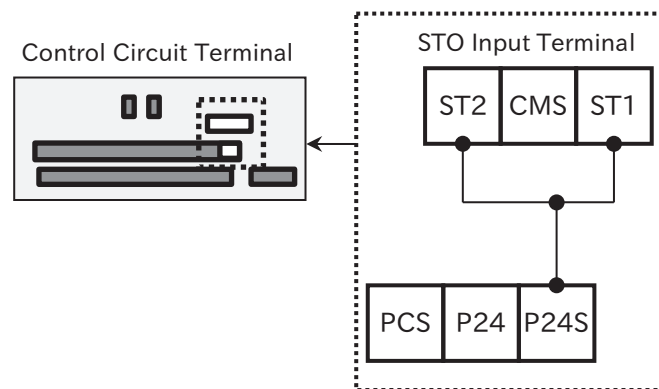
The system must not be considered safe until all the safety functionality is verified and validated.

7.3 Enabling STO function

The STO function is automatically activated when HF-620 is energized and established according to this Safety function Guide and the User's Guide of the HF-620.

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)



7.5 Validation test

- (1) Start operation of the motor by giving RUN and frequency command.
- (2) Open ST1 and ST2 and check if the inverter displays the status and the power to the motor is shut off (free-run).
- (3) HF-620 without failure is confirmed by com.

Chapter 8 Verification and Validation

8.1 What this chapter explains

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 (test run)
- (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 HF-620 works as intended with the same procedure as the functional test (proof test).

Note: In order to maintain the intended functionality of the STO function, it is necessary to conduct a functional test (proof 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 all potential risks and hazards.

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

Chapter 9 Error and Troubleshooting

9.1 What this chapter explains

This chapter describes the errors related to the STO function and their troubleshooting.

9.2 Error events

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

When "STO input display selection [bd-01]" is set to "02" and both of the [ST1]/[ST2] input terminals are off, the inverter trips.

What to do

- If this error is not released even after releasing STO inputs to HF-620 and then cycling power, please check wiring 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 HF-620 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

When a failure is detected in the safety path inside HF-620.

After this error occurs, the internal safety paths hold 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 HF-620.
- 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] STO path 1 error / [E093] STO path 2 error

When "Action selection after STO input change time [bd-04]" is 02 and the state of the inverter in the state transition diagram is P-1b or P-2b, the inverter trips.

What to do

- Check the wiring and signal on STO input.
- Please set [bd-02] and [bd-05] appropriately. When you adjust STO input change time, please verify that the setting value is appropriate as a 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 keypad, there is a possibility that input status 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] / [bd-05] suitable for the system.

9.4 When fault found in safety path

Please contact the nearest distributor when there is a fault in the safety path of HF-620.

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

Chapter 10 Maintenance

10.1 What This Chapter Explains

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 HF-620 requires conducting the functional test (proof 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 HF-620 requires daily and periodical inspection in addition to the functional test (proof test) of the STO function. Please perform inspections as instructed in the User's Guide of HF-620.

10.4 Functional test (proof test)

A periodical STO functional test (proof 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 (proof test) is one of the conditions for the STO function of HF-620 to meet PLe of EN ISO13849-1 and SIL 3 of EN 61800-5-2.

In the functional test (proof 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 (proof test) is as below:

- (1) Check if the EDM terminal (UPF and OM) is OFF (open) when power to HF-620 is not supplied and EDM function selector switch is turned on. (State 1)
- (2) Power up HF-620 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 signal (UPF and OM) 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 signal (UPF and OM) 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 signal (UPF and OM) 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 HF-620. In that case, stop using the inverter immediately and contact our distributor.

■ Signal Matrix for functional test (proof test)

Item \ Status	Status 1	Status 2	Status 3	Status 4	Status 5
Power	OFF	ON	ON	ON	ON
ST1	-	OFF (Open circuit)	OFF (Open circuit)	ON (Short circuit)	ON (Short circuit)
ST2	-	OFF (Open circuit)	ON (Short circuit)	OFF (Open circuit)	ON (Short circuit)
Output to the motor	Shut-off	Shut-off	Shut-off	Shut-off	Output permitted
EDM	OFF (Open)	ON (Closed)	OFF (Open)	OFF (Open)	OFF (Open)

Chapter 11 Specifications and Technical data

11.1 What this chapter explains

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

11.2 Electrical specifications

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

■ Electrical Specifications

Terminal Symbol	Terminal Name	Description	Electrical Characteristics
ST1/ST2	STO input terminal	Input terminals for STO signal	ST1- CMS/ST2–CMS voltage • ON voltage Min.DC15V • OFF voltage Max.DC5V • Max. allowable voltage DC27V • Load current 5.8 mA (at DC27V) ^{Note}
P24S	DC24V output power terminal (STO dedicated terminal)	DC24V power supply dedicated for ST1/ST2 input Not used when the STO input voltage is supplied from an external power supply.	DC24V 100mA output at maximum
CMS	Common for DC24V output power terminal (STO dedicated terminal)	Common terminal for P24S	
UPF	Output terminal [UPF]	Terminal UPF outputs EDM signal when EDM SW is turned ON.	Open collector output UPF-OM • Voltage drop when turned on: DC4V or less • Max. allowable voltage: DC27V • Max. allowable current: 50mA
OM	Common for output terminal	Common terminal for output terminal [UPF]	

Note: Corresponding to "Digital input type 1" defined in IEC61131-2: 2017

Please refer to the User's Guide of HF-620 for the specifications of the other terminals, main terminals, and wiring of the control terminal block.

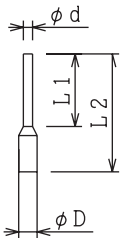
Length of cabling connected to the terminals above must be twenty (20) meters or shorter.

11.3 Recommended terminals for wiring

For the control circuit terminal block, a spring clamp type terminal block is employed.

For the convenience of wiring and improvement of connection reliability, it is recommended to use ferrules terminals with the following specifications.

■ Ferrule with sleeve

Wire size mm ² (AWG)	Rod terminal model ^{Note}	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: Manufacturer: Phoenix Contact GmbH & Co. KG, Crimping tool: CRIPMFOX 6

11.4 Safety function

Function	Standard
STO (Safe Torque Off)	EN 61800-5-2:2017
Stop category 0	IEC 60204-1:2016

11.5 Response time

Item	Time	Remarks
Response time of STO	20ms max.	Response time until power for the motor is turn off, after ST1/ST2 signal become STO.
Response time of EDM signal (reference)	30ms max.	Response time until EDM signal is ON, after ST1/ST2 signal become STO.

11.6 Safety-related parameters

Parameter	Value	Standard
PL	e	EN ISO 13849-1:2015
CAT.	3	
MTTFd	100 years	
DCavg	> 99%	
SIL	3	EN 61508:2010 EN 61800-5-2:2017
HFT	1	
SFF	> 90%	
PFH	< 2×10 ⁻⁸	
PFD	< 2×10 ⁻⁴	
T _M	20 years	

11.7 Operating environment

Item	Description
Ambient temperature	ND (normal duty): -10 to 50°C LD (Low duty): -10 to 40°C
Storage temperature	-20 to 65°C
Level of humidity	20 to 90%RH (No condensation allowed)
Vibration tolerance	5.9m/s ² (0.6G), 10 to 55Hz
Installation place	1,000m altitude or lower (location free from corrosive gas, oil mist, and dust)

EC Declaration of Conformity (Copy)

<Remarks>

- Purpose of this chapter is to provide necessary information related to EC declaration of conformity.

EC-DECLARATION OF CONFORMITY (Sample)

We, Sumitomo Heavy Industries, Ltd.

6-1 Asahi-Cho, Ohbu City, Aichi 474-8501, Japan, declare in our sole responsibility that the following products conform to all the relevant provisions.

Product name: AC Inverter, HF-620 series

Single-phase, 200-240 VAC, 50/60 Hz

Three-phase, 200-240 VAC, 50/60 Hz

Three-phase, 380-480 VAC, 50/60 Hz

Models Covered:

Model HF620, may be followed by S, followed by -A20, -A40, -A75, -1A5, -2A2.

Model HF620, may be followed by 2, followed by -A20, -A40, -A75, -1A5, -2A2, -3A7, -5A5, -7A5.

Model HF620, may be followed by 4, followed by --A40, -A75, -1A5, -2A2, -3A7, -5A5, -7A5.

[followed by none, may be followed by one letter and any letter or number.]

Authorized Representative: Sumitomo Cyclo Drive Germany, GmbH

Cyclostra ß e 92 D-85229 Markt Indersdorf, Germany

An EC Type Examination Certificate (No. 2821-ME-0011) has been issued by Notified Body (2821) under the EU Machinery Directive by UL International (Netherlands) B.V.

Council Directives: MD: 2006/42/EC (MD: Machinery Directive)
EMC: 2014/30/EU (EMC: Electromagnetic Compatibility Directive)
ErP: 2009/125/EU (ErP: Energy-related Products Directive)
(Commission Regulation (EU)No.1781/2019)

Harmonized Standards forming the basis of conformity for the EU Machinery Directive

EN 61800-5-2 :2017

EN 61800-5-1 :2007, EN 61800-5-1 :2007/A1 :2017, EN 61800-5-1 :2007/A11 :2021

EN ISO 13849-1 :2015

EN 61508 Parts 1-7 :2010

IEC 60204-1 :2016, IEC60204-1 :2016/AMD1 : 2021

Harmonized Standards forming the basis of conformity for the EU EMC Directive

EN IEC 61800-3:2018

Harmonized Standards forming the basis of conformity for the EU ErP Directive

EN 61800-9-2:2017

Warranty

Warranty period	The warranty shall be 18 months from date of shipment or 12 months after initial operation, whichever is shorter.
Warranty condition	<p>In the event that any problem or damage to the Product arises during the “Warranty Period” from defects in the Product whenever the Product is properly installed and combined with the Buyer’s equipment or machines maintained as specified in the maintenance manual, and properly operated under the conditions described in the catalog or as otherwise agreed upon in writing between the Seller and Buyer or its customers. The Seller will provide, at its sole discretion, appropriate repair or replacement of the Product without charge at a designated facility, except as stipulated in the “Warranty Exclusions” as described below.</p> <p>However, if the Product is installed or integrated into the Buyer’s equipment or machines, the Seller shall not reimburse the cost of removal or re-installation of the Product or other incidental costs related thereto, any lost opportunity, any profit loss or other incidental or consequential losses or damages incurred by the Buyer or its customers.</p>
Warranty exclusion	<p>Notwithstanding the above warranty, the warranty as set forth herein shall not apply to any problem or damage to the Product that is caused by.</p> <ol style="list-style-type: none"> 1. Installation, connection, combination or integration of the Product in or to the other equipment or machine that rendered by any person or entity other than the Seller. 2. Insufficient maintenance or improper operation by the Buyer or its customers such that the Product is not maintained in accordance with the maintenance manual provided or designated by the Seller. 3. Improper use or operation of the Product by the Buyer or its customers that is not informed to the Seller, including, without limitation, the Buyer’s or its customer’s operation of the Product not in conformity with the specifications. 4. Any problem or damage on any equipment or machine to which the Product is installed, connected or combined or any specifications particular to the buyer or its customers. 5. Any changes, modifications, improvements or alterations to the Product or those functions that are rendered on the Product by any person or entity other than the Seller. 6. Any parts in the Product that are supplied or designated by the Buyer or its customers. 7. Earthquake, fire, flood, salt air, gas, lightning, acts of God or any other reasons beyond the control of the Seller. 8. Normal wear and tear, or deterioration of the Product’s parts, such as the cooling fan bearings. 9. Any other troubles, problems or damage to the Product that are not attributable to the Seller.
Others	The Seller will not be responsibility for the installation and removal of the inverter. Any inverter transportation cost shall be born by both Seller and Buyer.

To inverter users

The inverter described in this operation manual is used for variable-speed operation of 3-phase induction motors for general industry use.



- ▼ The inverter described in this manual is not designed and manufactured for use in equipment or a system used under the following conditions that will directly lead to death or injury: atomic energy control, aerospace equipment, traffic equipment, medical instrument and all kinds of safety devices. When our products are applied to the above equipment or system, be sure to consult us.
- ▼ Our products are manufactured under stringent quality control. However, install a safety device on the equipment side in order to prevent serious accidents or loss when our products are applied to equipment that may cause serious accidents or loss due to failure or malfunction.
- ▼ Do not use the inverter for any load other than 3-phase induction motors.
When an explosion-proof motor is selected, pay attention to the installation environment, because the inverter is not of an explosion-proof type.
- ▼ Carefully read the "Operation Manual" before use for correct operation.
Read the manual carefully also for long-term storage.
- ▼ Electrical work is necessary for installation of the inverter. Leave the electric work to specialists.

Worldwide Locations

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Specifications, dimensions, and other items are subject to change without prior notice.



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