

# STO User Manual

## I. STO Safety Function (Safe Torque Off)

### 1.1 Definition

STO safety function (IEC61800-5-2): STO safety function (Safe Torque Off) is the function that can shut down the motor torque safely without cutting off the power supply, but the function cannot monitor that the motor is stopped or not.

Stop type 0 (IEC60204-1): Stop the equipment by closing the energy which transport towards to the drive element. (Uncontrolled stop)

### 1.2 Function

Realize the “emergency stop” (IEC60204-1) as stop mode 0 by STO safety function.

Principle: STO safety function is activated by two input terminals SR1 and SR2. Wire the two input terminals separately to realize the character of two-channel.

The on-off operation of two input terminals SR1, SR2 must be conducted at the same time, power off the outputs and send the failure message, the motor does not produce torque, and then stops running. The motor cannot restart until “failure reset”.

### 1.3 Basic Information

<b>Danger</b> 
<p><b>Electric shock caused by improper use</b> STO safety function (Safe Torque Off) does not cause electric isolation, the DC bus voltage still exists. Please use proper appliance to cut off the power in order to achieve a voltage-free condition</p> <p><b>Failure to follow these instructions will result in death or serious injury.</b></p>

<b>Warning</b> 
<p><b>Beware of the failure of STO function.</b> A. Check if the safety function is enabled after wiring the STO port with external device. B. Improper use may result in danger because of failure of the safety function. Attention to the operating requirement of safety function.</p> <p><b>Failure to follow these instructions will result in death or serious injury.</b></p>

1.3.1 Stop mode: STO safety function is stop mode 0, driving device stops in the uncontrolled condition, users must take appropriate precautions if it is dangerous when closing to the stopping machine.

1.3.2 Vertical axis, external force: if external force which may cause dangerous accident movement (gravity etc.) affects the driving device( vertical axis), user should not run the driving device without taking necessary fall protection device.

1.3.3 Protection Level: make sure there is no conductive contaminant (pollution degree 2). The conductive contaminant may result in the safety function disabled.

1.3.4 Protected type wiring: the protected type wiring must be adopted according to the standard ISO13489-2 if there is short circuit or crosswise circuit of the signal line which

is related to the safety, and cannot be identified by the equipment in series.

Remark: If not using protected type wiring, both signal lines (2-channel) may connect to external voltage because of cable damage, and result in the safety function disabled.

1.3.5 To ensure the estimated danger failure rate, the environmental requirements of STO function refer to the user manual of inverter.

Equipment Location	In an indoor location, prevent exposure from direct sunlight, Free from dust, tanga caustic gases, flammable gases, steam or the salt-contented, etc.
Environment Temperature	-10℃~+40℃
Environment Humidity	Below 90% (no water-bead coagulation)
Vibration Strength	Below 0.5g (acceleration)
Height above sea level	1000m or below (Derate using if over 1000m)
Protection Level	IP 20

### 1.4 Safety Parameter

Service life	Years	10
Safety Failure Factor SFF(IEC61508)	[%]	67
Hardware Redundancy HFT(IEC61508)		1
Function safety class IEC61508		SIL2
Failure probability of hazard PFH(IEC61508)	[1/h]	$7.7 \times 10^{-7}$
Performance Level PL(ISO13849-1)		d

Danger and risk analysis: manufactures must make danger and risk analysis on overall system, and the analysis results must be considered when using safety function.

## 2 STO principle and Realization

### 2.1 STO Principle

The STO function is generated through cutting off the driving signal of inverter by hardware to cut off the power supply of motor and limit the torque. (Safe Torque Off: IEC61800-5-2)。

STO circuit controls the enabled port EN of gate driver to cut off the 6-channel PWM pulses which flow into IGBT, which makes the motor stop safely.

2.1.1 Principle Block Diagram

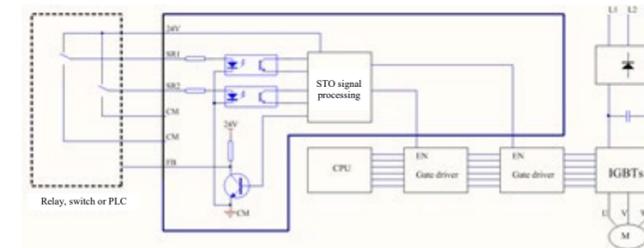


Fig 2-1 STO principle block diagram

2.1.2 Safety input connection: remove the short-circuit plug between 24V~SR1 and 24V~SR2, connect the safety input signal as the figure above.

2.1.3 Safety monitor output connection: safety monitor output (FB) is used as the feedback signal to monitor the failure of the safety function.

**Notice: Do not use FB in other functions except the failure monitor function. The FB signal is not safety output.**

### 2.2 Pin

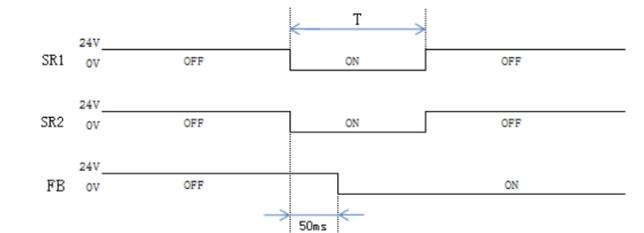
Pin Name	Definition
SR1	STO safety recommendation input: 2-channel connection 1
SR2	STO safety recommendation input: 2-channel connection 2
24V	24V control system power supply
CM	24V control system power supply reference potential: STO reference potential
FB	STO feedback output end

### 2.3 Logical specification

SR1	SR2	FB port	Display	STO circuit failure	Gate drive status	Description
0V	0V	0V	STo	No	PWM off	Cut off 6-channel PWM driving signal, no output in UVW
0V	24V	24V	STo1	Yes	PWM off	6-channel PWM drive IGBT, output in UVW, motor running.
24V	0V	24V	STo1	Yes	PWM off	
24V	24V	24V	<b>Normal</b>	STO disabled	PWM ON	

**Remark: If no need for the safety function, the input SR1 and SR2 must be connected with 24V, the inverter runs.**

### 2.4 Signal Diagram (sequence)



SR1 and SR2: low level range: 0~3V, high level range: 21~26V.

Inverter displays “STo”: delay time is 0.1S.

Remark: the effective signal time difference between SR1 and SR2 should be lower than 50mS, or else fault alarm; STO effective pulse width time T should be higher than 50mS, or else CPU cannot detect.

### 2.5 STO Debugging, Acceptance Test and Flow chart

2.5.1 To ensure the safe operation of safety function, the commissioning, inspection and debugging must be performed by final assembler to test the safety function.

2.5.1.1 The commissioning and acceptance test must be performed in either of the following situations:

- 1) First start-up of safety function;
- 2) Any modification related to the safety function (PCB, wiring, parts and setting);
- 3) Any maintenance operation related to the safety function;

Authorized personnel: The debugging and acceptance test of the safety function must be performed by the authorized personnel who received safety skill and acknowledge training. The test must be recorded and signature by authorized personnel.

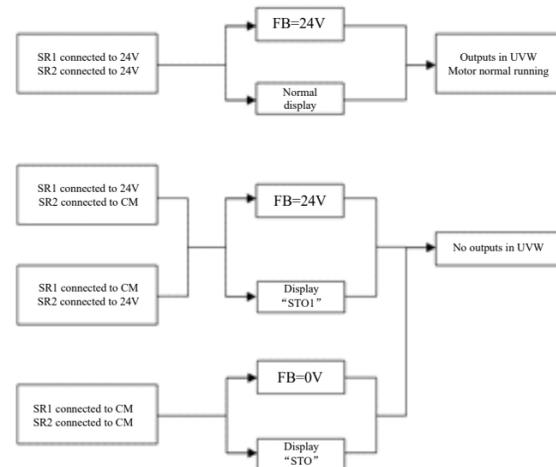
Acceptance test report: the acceptance test report with signature must be saved in the logbook of machine. This report includes related documents of start activity, test result, failure report reference and failure solution. Any new acceptance test because of modification or maintenance should be recorded in logbook.

2.5.1.2 The debugging and acceptance test should be operated according to the following requirements:

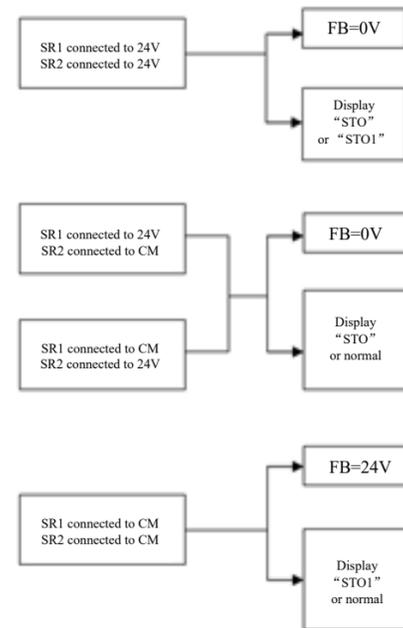
- 1) Test FB status when SR1, SR2=0V and 24V, refer to 3.3 logic specification.  
There could be failure for STO circuit or wiring if there is any inconsistent with logic specification.  
Test the system performance, press emergency stop button or let external PLC send commands if following the logic specification.
- 2) “STo” displays when the safety function works.

### 2.5.2 Debugging and Acceptance Flow Chart

A. STO function normal status



B. STO function failure status



If STO safety function is in failure status, check the wiring firstly, then check if the electronic components are damaged. The STO safe function cannot be used until troubleshooting.

2.6 External cable and terminal

2.6.1 Input Cable Specification

Shield	YES
Twisted-pair cable	Recommended

PELV	YES
Min core wire cross section	0.75mm <sup>2</sup>
Max cable length	100m

2.6.2 External terminal property:

Max wiring current	12A
Port cross section	0.5~1.5mm <sup>2</sup>
Wire stripping length	6~7mm

Notice the max allowed terminal current when connecting to several devices.  
Notice the max allowed port cross section of cable, insert the wire carefully to reach the max current load capacity and vibration resistance.

3 Maintenance and Disposal

Normal visual inspection and function test are recommended according to the followings:

- (1) Check if the module is installed correctly;
- (2) Check all connection cables and connectors regularly for damage.
- (3) Check electrical functions;

According to the industrial safety and health regulation, the device must be inspected regularly, at least once a year. See details in 2.5 for the requirements related to the debugging and acceptance test, and fill in the logbook.

Damaged or failure parts must be replaced or disposal treatment;

**Disassemble:**

Disassemble security module only in the condition of cutting off the power supply of inverter. See details in the user manual of inverter for the time requirement when cutting off the power.

Method: press on the bottom of enclosure and push it up, then bend forward slightly to disassemble.

**Disposal treatment and application:**

When STO function needs to be retired or ask for discarding application, the risk possibility to the inverter should be described; analysis and report, the analysis report, plan and evidence should be saved.

For the irreparable return goods or customer does not need this function in the maintenance process, engineer should fill in discarding notice and ask for the application.