

SAFE TORQUE OFF



APPENDIX

E

TABLE OF CONTENTS

Appendix E: Safe Torque Off

Safe Function Failure Rate	E-2
Safe Torque Off Terminal Function Description	E-2
Wiring Diagrams.	E-3
Internal STO Circuit	E-3
Control Loop Wiring Diagrams.	E-3
STO Parameters	E-4
Operating Sequence Description.	E-5
STO P6.71=0.	E-5
STO P6.71=0, P6.29=1	E-5
STO P6.71=1.	E-5
STL1 P6.71=1, P6.29=0	E-6
STL2 P6.71=1, P6.29=1	E-6
Error Codes for STO Function.	E-6

SAFE FUNCTION FAILURE RATE

Item	Definition	Standard	Performance
SFF	Safe Torque Off	IEC61508	Channel 1: 80.08% Channel 2: 68.91%
HFT (Type A Subsystem)	Hardware Fault Tolerance	IEC61508	1
SIL	Safe Integrity Level	IEC61508	SIL 2
		IEC62061	SILCL 2
PFH	Average Frequency of Dangerous Failure [h ⁻¹]	IEC61508	9.56×10 ⁻¹⁰
PFD_{av}	Probability of Dangerous Failure on Demand	IEC61508	4.18×10 ⁻⁶
Category	Category	ISO13849-1	Category 3
PL	Performance Level	ISO13849-1	d
MTTF_d	Mean Time to Dangerous Failure	ISO13849-1	High
DC	Diagnostic Coverage	ISO13849-1	Low
<i>For more information on the above performance levels, please refer to the appropriate standard.</i>			

SAFE TORQUE OFF TERMINAL FUNCTION DESCRIPTION

The Safe Torque Off (STO) function turns off the power supplied to the motor through the hardware, so that the motor cannot produce torque. This method of removing power from the motor is considered an emergency stop, also known as "coast to stop."

The Safe Torque Off function utilizes two independent hardware circuits to control the motor current drive signal, and thus turns off the inverter power module output in order to achieve the status of safe stop. In normal E-stop situations, both circuits will be opened (using a dual-channel safety relay, etc.). To restart the drive, the Reset input must be turned ON and the Run command must be cycled from low to high. **If only one of the circuits is opened during an E-stop, the drive considers this an STL fault and power must be cycled to the drive to clear the error** (see "Method of Reset" in the chart below).

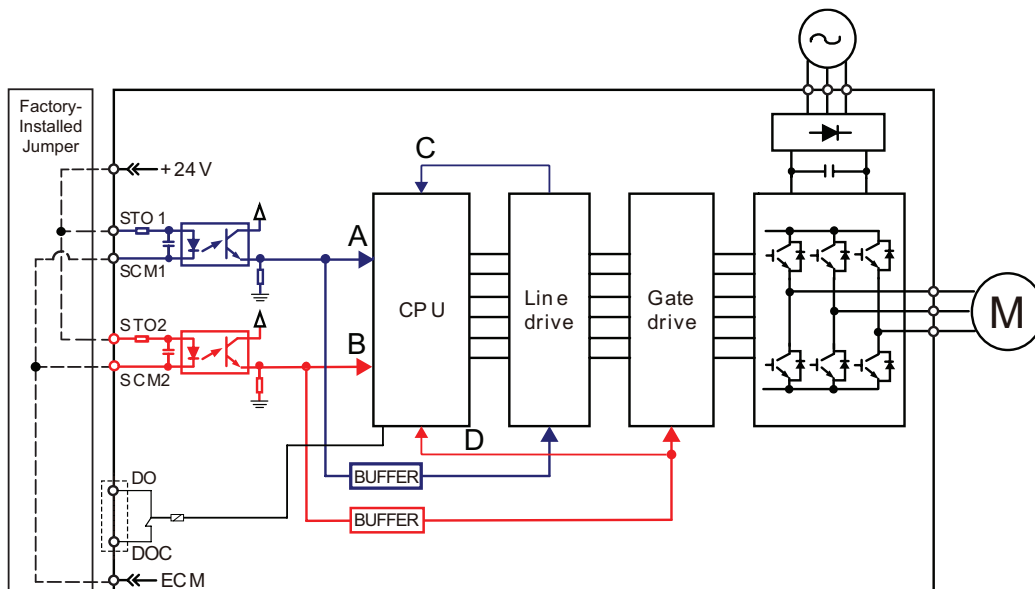
If unknown STO faults occur, the on-board +24V might be getting shorted to ground (+24V to DCM).

Operation Conditions Description						
Signal	Channel	STO Input Status				
STO Signal	STO1~SCM1	ON (High)	OFF (Low)	ON (High)	OFF (Low)	x
	STO2~SCM2	ON (High)	OFF (Low)	OFF (Low)	ON (High)	x
Driver Output Status		Ready	Normal STO Mode (Torque Output Off)	STL2 Mode (Torque Output Off)	STL1 Mode (Torque Output Off)	STL3 Mode (Torque Output Off)
Method of Reset	Step 1	n/a	Clear Fault (set both channels high)			Cannot reset; Internal Drive failure
	Step 2		Reset button	Cycle Power to Drive		
	Step 3		Cycle Run Command from low to high			
<u>Definitions</u> STO: Safe Torque Off STL1~STL3: Alarms indicate a non-standard emergency stop. STO Losses 1 and 2 (STL1, STL2) indicate only one channel of the safety circuit has been activated. STO Loss 3 (STL3) indicates an internal failure of the STO monitoring circuitry. STL3: STO1~SCM1 and STO2~SCM2 internal circuit detected abnormal. STO1~SCM1 ON(High): STO1~SCM1 has connection to a +24VDC power supply. STO2~SCM2 ON(High): STO2~SCM2 has connection to a +24VDC power supply. STO1~SCM1 OFF(Low): STO1~SCM1 has no connection to a +24VDC power supply. STO2~SCM2 OFF(Low): STO2~SCM2 has no connection to a +24VDC power supply. STO alarm is the expected method of Emergency Stop. Both channels open at the same time.						

WIRING DIAGRAMS

INTERNAL STO CIRCUIT

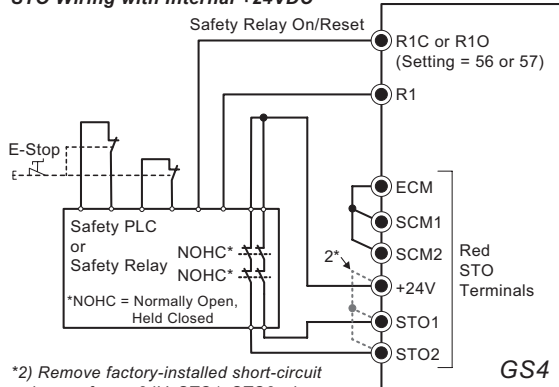
In the figure below, the factory setting for +24V-STO1-STO2 and SCM1-SCM2-ECM is short circuit



CONTROL LOOP WIRING DIAGRAMS

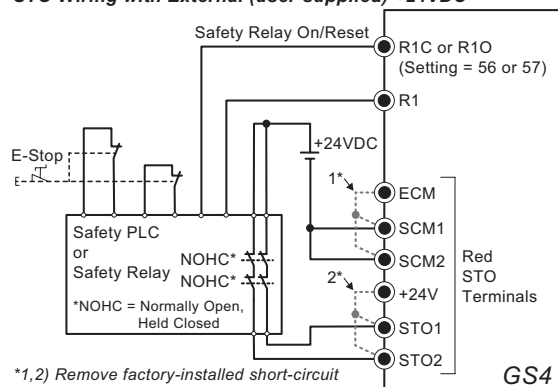
- 1) Remove the jumper from +24V-STO1-STO2 and ECM-SCM1-SCM2.
- 2) Wire the STO circuit like the diagrams below. The ESTOP contacts must be in a closed state while in a normal and safe situation for the drive to be able to run.
- 3) When the ESTOP switch is opened, the Safety PLC or Relay will open both sets of contacts. The drive output will immediately stop, and the keypad will display an STO fault.

STO Wiring with Internal +24VDC



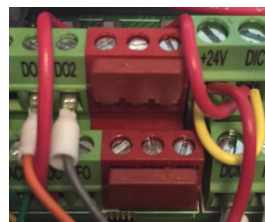
*2) Remove factory-installed short-circuit jumper from +24V-STO1-STO2 when using STO function with internal +24VDC.

STO Wiring with External (user-supplied) +24VDC

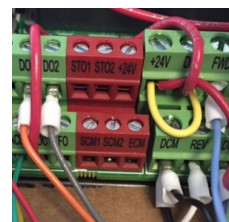


*1,2) Remove factory-installed short-circuit jumpers from red STO terminals when using STO function with external +24VDC.

- *1: Factory short-circuit of ECM-SCM1-SCM2. To use Safety Function with external power source, remove this jumper.
- *2: Factory short-circuit of +24V-STO1-STO2. To use Safety Function, remove this jumper.



STO Terminals with Jumpers



STO Terminals without Jumpers

STO PARAMETERS

	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
P6.71 STO Alarm Latch	◆R/W	0647	41608
<u>Range/Units</u>	<u>Default</u>		
0: STO Alarm Latch	0		
1: STO Alarm no Latch			

Setting Explanations:

0: STO Alarm Latch: After the reason for an STO Alarm is cleared, a Reset command is needed to clear the STO Alarm unless Fire Mode is turned ON. Once the STO Alarm is cleared, Fire Mode can run the drive without first having received a reset signal. Fire Mode will also run the drive after an STL1 or STL2 alarm is cleared without needing a power cycle.

1: STO Alarm no Latch: After the reason for an STO Alarm is cleared, the STO Alarm will be cleared automatically. Cycling the run command OFF then ON is required, even if P6.29=1 (Line Start Lockout disabled).

All of the STL1~STL3 errors are “Alarm Latch” mode. (In STL1~STL3 mode, the P6.71 function is not effective.)

	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
P6.29 Line Start Lockout	◆R/W	061D	41566
<u>Range/Units</u>	<u>Default</u>		
0: Enable start-up lockout	0		
1: Disable start-up lockout			

Setting Explanations:

0: Enable. When this parameter is enabled, the GS4 drive will not start the motor when powered up with a RUN command already applied. The drive must see the RUN command change from STOP to RUN before it will start.

1: Disable. When this parameter is disabled, the GS4 drive will start the motor when powered up with a RUN command already applied.



When Safe Torque Off (STO) alarms STL1 or STL2 are activated, a power cycle is required to reset the drive. When P6.29 is set to 1, the drive will start on power-up while performing this reset condition.

	<u>Type</u>	<u>Hex Addr</u>	<u>Dec Addr</u>
P3.17 Multi-Function Output Terminal 1 (Relay 1)	◆R/W	0311	40786
P3.18 Multi-Function Output Terminal 2 (Relay 2)	◆R/W	0312	40787

Settings Pertaining to STO Function

<u>Settings</u>	<u>Functions</u>	<u>Descriptions</u>
56	SO Logic A output	Safety Output normally-open contact
57	SO Logic B output	Safety Output normally-closed contact

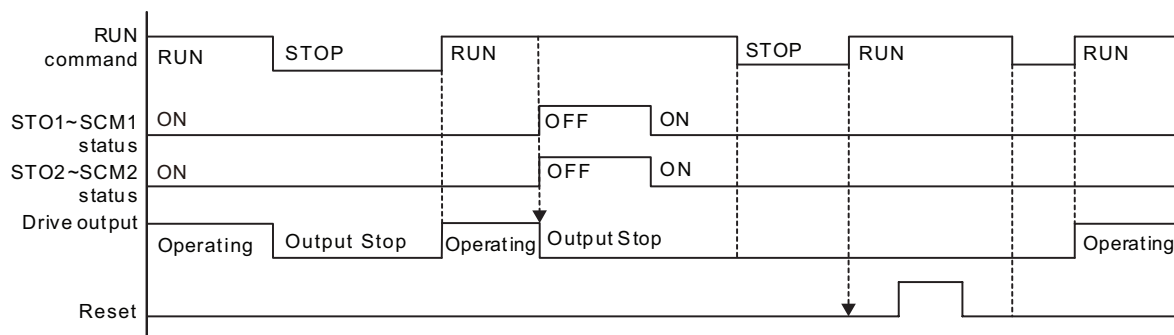
<u>Drive Status</u>	<u>Safety Output Status</u>	
–	NO (P3.17/P3.18 = 56)	NC (P3.17/P3.18 = 57)
Normal Run	open	close
STO	close	open
STL1~STL3	close	open

OPERATING SEQUENCE DESCRIPTION

NORMAL OPERATION STATUS

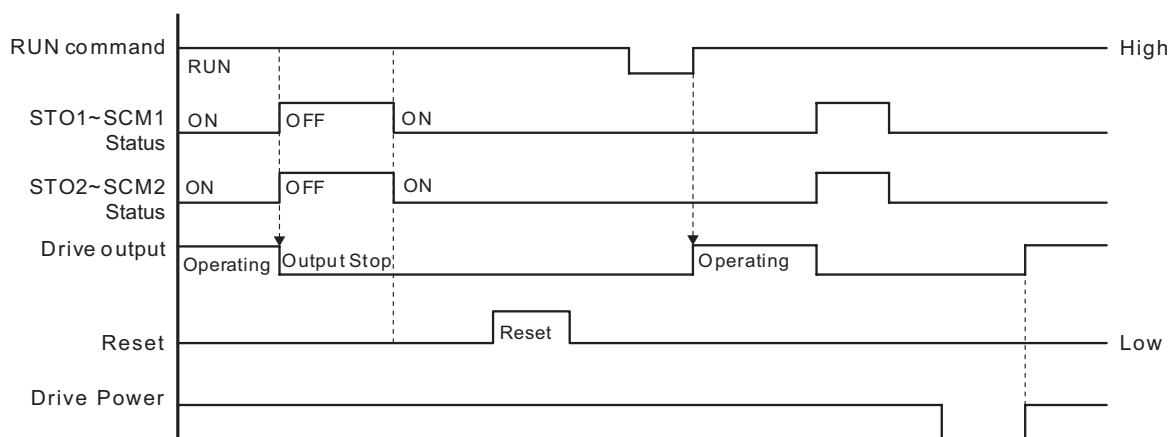
STO P6.71=0

When the STO1~SCM1 and STO2~SCM2 = ON (no STO stop signals given), the drive will execute "Operating" or "Output Stop" according to RUN/STOP command.

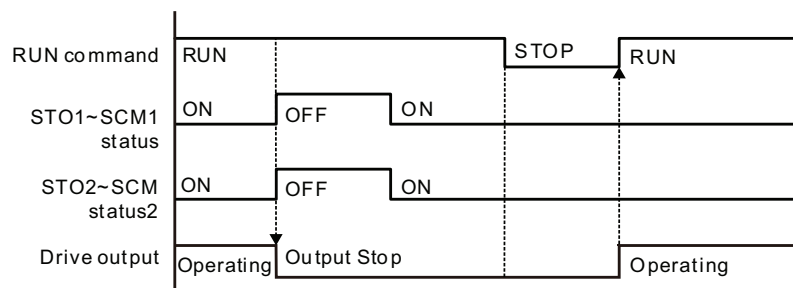


STO P6.71=0, P6.29=1

When both of STO1~SCM1 and STO2~SCM2 channels are turned off during operation, the STO function is enabled and the drive will turn off output power, "Output Stop," regardless of the Run command ON or OFF status.



STO P6.71=1



The timing diagram illustrates the sequence of events for resetting the STO (Safe Torque Off) function. The signals shown are:

- RUN command:** Starts in the 'RUN' state, transitions to 'STOP' at the first reset point, and returns to 'RUN' after the second reset point.
- STO1~SCM1 status:** Transitions from 'ON' to 'OFF' at the first reset point and returns to 'ON' shortly thereafter.
- STO2~SCM2 status:** Remains in the 'ON' state throughout the sequence.
- Driveoutput:** Transitions from 'Operating' to 'OutputStop' at the first reset point and returns to 'Operating' after the second reset point.
- DrivePower:** Remains active (high) throughout the sequence.
- Reset:** Shows two distinct reset pulses. The first pulse occurs while the drive is in the 'OutputStop' state, and the second pulse occurs while the drive is in the 'Operating' state.

Vertical dashed lines indicate the timing of the reset pulses and the corresponding state transitions for the other signals.

The timing diagram illustrates the sequence of events for resetting the STO function. The signals shown are:

- RUN command:** Starts in the 'RUN' state, transitions to 'STOP' at the first vertical dashed line, and returns to 'RUN' at the second vertical dashed line.
- STO1~SCM1 status:** Remains in the 'ON' state throughout the sequence.
- STO2~SCM2 status:** Starts 'ON', transitions to 'OFF' at the first vertical dashed line, and returns to 'ON' at the second vertical dashed line.
- Driveoutput:** Starts 'Operating', transitions to 'OutputStop' at the first vertical dashed line, and returns to 'Operating' at the second vertical dashed line.
- DrivePower:** Starts at a high level, drops to a low level at the first vertical dashed line, and returns to high at the second vertical dashed line.
- Reset:** Starts at a low level, pulses high between the two vertical dashed lines, and returns to low at the second vertical dashed line.

Vertical dashed lines indicate the timing of the first and second reset attempts. The first attempt occurs when the drive is in 'OutputStop' and power is low. The second attempt occurs when the drive is back in 'Operating' state and power is high.

	Type	Hex Addr	Dec Addr
<u>P11.04</u> <i>First Fault Record</i>	Read	0B04	42821
<u>P11.05</u> <i>Second Most Recent Fault Record</i>	Read	0B05	42822
<u>P11.06</u> <i>Third Most Recent Fault Record</i>	Read	0B06	42823
<u>P11.07</u> <i>Fourth Most Recent Fault Record</i>	Read	0B07	42824
<u>P11.08</u> <i>Fifth Most Recent Fault Record</i>	Read	0B08	42825
<u>P11.09</u> <i>Sixth Most Recent Fault Record</i>	Read	0B09	42826
<u>Error Codes Pertaining to STO Function</u>			<u>Default</u>
72: STL1 STO1~SCM1 internal hardware detect error			0
76: STO Safety Torque Off function active			
77: STL2 STO2~SCM2 internal hardware detect error			
78: STL3 STO1~SCM1 and STO2~SCM2 internal hardware detect error			