MITSUBISHI ELECTRIC

INVERTER FR-A800

Safety Stop Function Instruction Manual

CONTENTS

Compliance with the EU Machinery Directive – Functional Safety

⚠WARNING

- **Any misuse of safety function could lead to personal injury or death, property damage, or economic loss. To ensure that the system complies fully with requirement of safety, make a system-level risk assessment. Mitsubishi Electric Co. cannot assume responsibility for any system to comply with safety directive.**

⚠CAUTION

- **The information of this manual is merely a guide for proper installation.**
- **Mitsubishi Electric Co. cannot assume responsibility for the compliance or the noncompliance to any code, national, local or otherwise for the proper installation of this equipment.**
- **A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.**

⚠WARNING

- **To avoid an electric shock hazard, verify that the voltage on the bus capacitors has discharged before performing any work on the drive. Measure the DC bus voltage at the P(+) and N(-) terminals or test points (refer to your drive's User Manual for locations and discharging time). The voltage must be zero.**

⚠WARNING

- **The safety stop function do not isolate electrically between drive and motor. To avoid an electric shock hazard, disconnect/isolate power to the drive and verify to ensure that the voltage is zero before performing any work on the motor (refer to your drive's User Manual for discharging time).**

1 GENERAL DESCRIPTION

Features

Mitsubishi FR-A800 safety stop function prevents a drive from supplying rotational energy to motors. Dual safety channels ‘S1’ and ‘S2’ cut off the gate-drive power for IGBT to turn off.

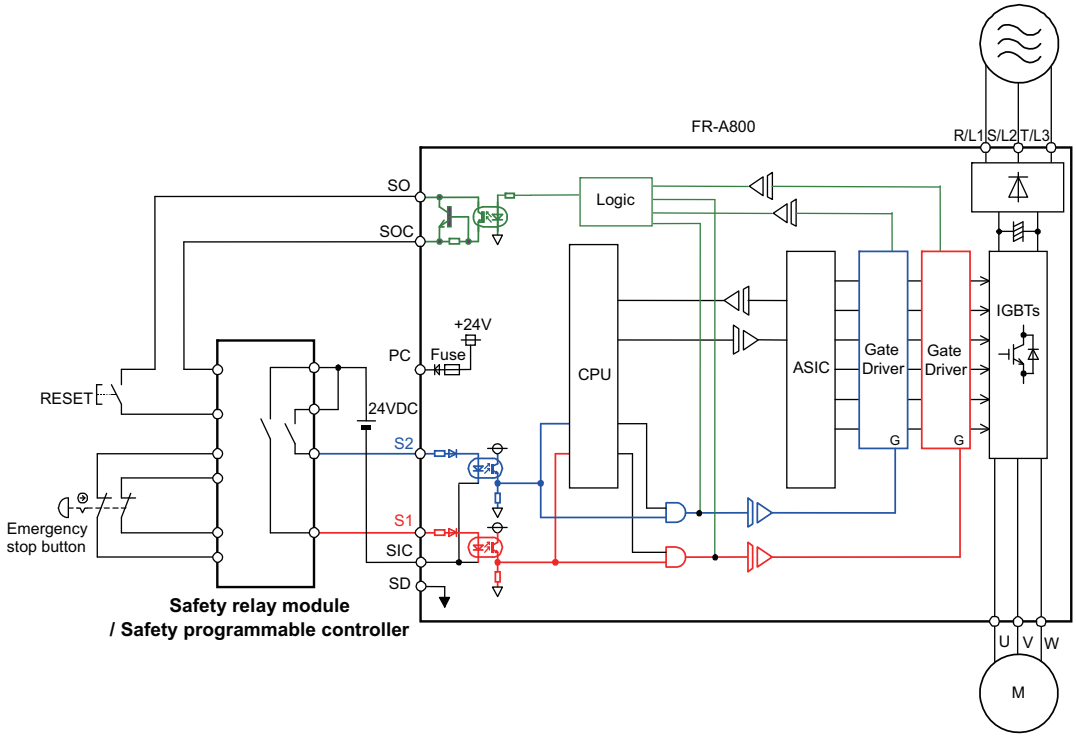

Fig.1 FR-A800 safety stop function diagram

⚠ WARNING

- **Disconnecting the power to the gate driver by the safety stop function does not isolate electrically between drive and motor. To avoid an electric shock hazard, disconnect power to the drive and verify that the main circuit capacitor voltage is zero (across P and N terminals) before performing any work on the motor (refer to your drive’s User Manual for discharging time).**

Standards

Mitsubishi FR-A800 safety stop function meets the following directives and categories.

ISO13849-1:2008 Category 3/PLd

IEC62061:2005 / IEC61800-5-2:2007 / IEC61508 SIL2

IEC60204-1:2010 / IEC61800-5-2:2007 Stop category 0

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2 INSTALLATION AND WIRING

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- **A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.**

⚠CAUTION

- **Ensure the safety relay unit and the FR-A800 unit is mounted closely in enclosure meeting IP54 and all interconnection wiring is short and protected against open and short circuit faults. Refer ISO/IEC13849-2.**

Installation

Mitsubishi FR-A800 safety stop function should be used under following condition and environment.

Table.1 The condition and environment for using safety stop function

Item		Condition
Surrounding air temperature	LD, ND (initial setting), HD	-10ºC to +50ºC (non-freezing)
	SLD	-10ºC to +40ºC (non-freezing)
Storage temperature		-20ºC to +65ºC *1
Ambient humidity		With circuit board coating: 95% RH or less (non-condensing), Without circuit board coating: 90% RH or less (non-condensing)
Vibration		5.9m/s^2 or less at 10 to 55Hz (directions of X, Y, Z axes)
Altitude		Maximum 2500 above sea level *2
Atmosphere		Indoors (free from corrosive gas, flammable gas, oil mist, dust and dirt)
Over voltage category		III or less
Pollution degree		II or less
Mounting		Wall mounting / vertical orientation

*1 Temperature applicable for a short time, e.g. in transit.

*2 For the installation at an altitude above 1,000 m (3280.80 feet) up to 2,500 m (8202 feet), derate the rated current 3% per 500 m (1640.40 feet).

⚠ CAUTION

- In order to meet safety stop, an approved safety relay unit to ISO13849-1 safety category 3 or better shall be used in conjunction with FR-A800 as shown in example. In addition, all other components with in the safety stop loop shall be 'safety approved' types.

⚠ WARNING

- To avoid an electric shock hazard, insert the magnetic contactor (MC) between power source and drive.
- Open the contact of MC and keep away from drive for discharging time (refer to your drive's User Manual for information) before performing any work on the drive. And verify that the voltage on the bus capacitors has discharged before Measuring the DC bus voltage at the P(+) and N(-) terminals or test points (refer to your drive's User Manual for locations). The voltage must be zero.

⚠ CAUTION

- To avoid systematic faults, a test even for faulty demands of the safety function has to be performed in order to check the correct function of the monitor signal. This test shall be carried out at system installation, any software changes, parameterization changes, and/or at least once per year. Refer to '4. Test and checking failure'.

●Wiring

The safety related terminals are described in Table.2 and Table.3

Table.2 The safety related terminals

Terminal symbol	Description	Rating *1
S1	For input of safety stop channel 1. S1-SIC is Open: In safety stop mode. Short: Non safety stop mode.	Input resistance: 4.7kΩ Input current : 4 to 6 mADC (In case of 24VDC input)
S2	For input of safety stop channel 2. S2-SIC is Open: In safety stop mode. Short: Non safety stop mode.	
SIC	Common terminal for S1 terminal and S2 terminal.	
SO	As output for failure detection and alarm. SO terminal type is 'Open collector output'. SO-SOC is OFF(Open): Detect failure or alarm. ON(Close): No failure detected. **Note:** This terminal cannot be used to output safety outputs in a safety system. This terminal can be used for alarm or to prevent restart only, no other safety function.	Load: 24VDC/0.1A max. Voltage drop: 3.4V max. (In case of 'ON' state)
SOC	Common terminal for SO terminal.	

*1 Specifications for conforming safety standards.

Table.3 Truth table of safety related signals

Input power	S1-SIC	S2-SIC	Internal safety circuit *1	SO-SOC	Inverter operation state
OFF	-	-	-	OFF(Open)	Drive shutoff (Safe state)
ON	Short	Short	No failure	ON(Close)	Drive enable
			Failure	OFF(Open)	Drive shutoff (Safe state)
	Open	Open	No failure	ON(Close)	Drive shutoff (Safe state)
			Failure	OFF(Open)	Drive shutoff (Safe state)
	Short	Open	N/A	OFF(Open)	Drive shutoff (Safe state)
	Open	Short	N/A	OFF(Open)	Drive shutoff (Safe state)

"N/A" denotes a condition where circuit fault does not apply.

*1 At an internal safety circuit fault, one of E.OPT, E.OP1, E.PE, E.RET, E.PE2, E.CTE, E.P24, E.SAF, E.OS, E.OSD, E.ECT, E.OD, E.MB1 to E.MB7, E.EP, E.CPU, E.5, E.6, E.7, E.13 is displayed on the operation panel. SA is displayed on the operation panel while S1 and S2 signals are both open and the safety function operates (without internal safety circuit fault).

NOTE

- The response time from safety stop signal input to drive shutoff (safe state) is faster than 8ms.
- Hold the ON or OFF status for 2ms or longer to input signal to terminal S1 or S2.
  Signal input shorter than 2ms is not recognized.

●Wire and ferrule specification

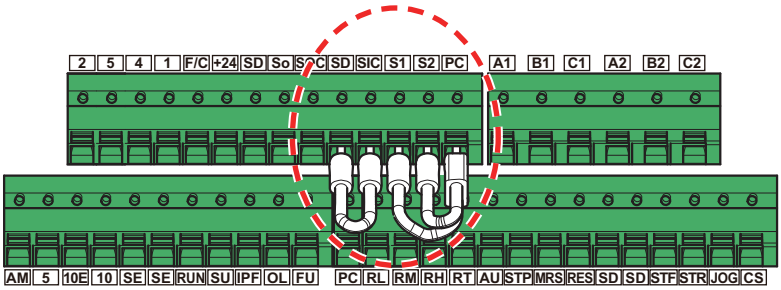
Table.4 Wire and ferrule specification

Wire size (mm^2)	Ferrule with insulation collar *1	Crimping tool name *1
0.3 / 0.5	AI 0,5-10WH	CRIMPFOX 6
0.75	AI 0,75-10GY	
1	AI 1-10RD	
1.25 / 1.5	AI1,5-10BK	
0.75 (combined 2 wire)	AI TWIN 2 X 0,75-10GY	

*1 Ferrules and tools are distributed by Phoenix Contact.

●Jumper cable

The jumper cable between S1,S2 and PC terminal between SIC and SD terminal has been installed in the factory as shown in Fig.2.



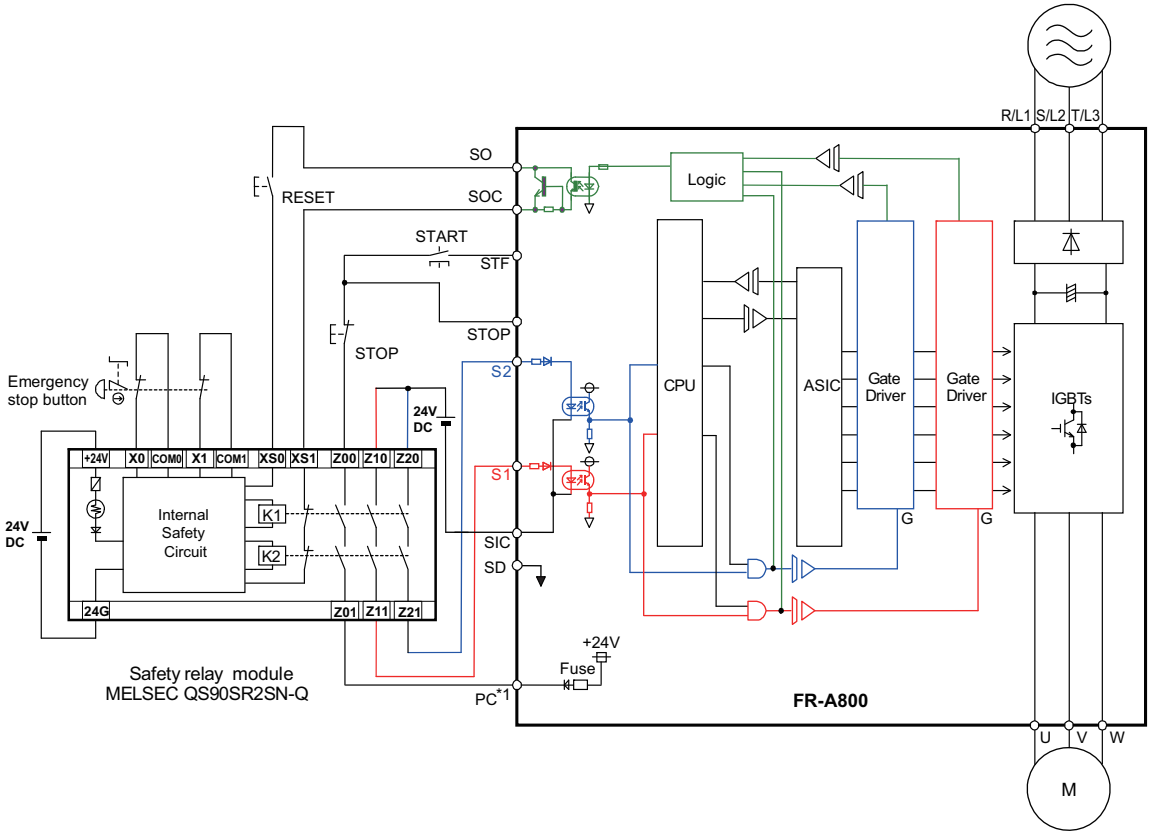
Terminal block of FR-A800

Fig.2. Short wire

Before connecting safety input wire to S1,S2 and SIC terminal, remove this jumper cable.

3 EXAMPLE OF SAFETY SYSTEM CONFIGURATION

●FR-A800 configuration example



*1 If the control logic is SINK logic, the common terminal is terminal SD.

Fig.3 Safety system example with FR-A800

NOTE

- When starting up the system's operation, press the RESET switch to reset the safety stop function first, then turn ON the START switch to run the motor.
- In the above configuration, after reset of emergency stop button, drive will be in safe-state until RESET switch is pressed.

⚠CAUTION

- **To prevent restart in case of recovering from input power loss of drive, 3-wired connection for START/STOP control is recommended. In case of 2-wire connection and using latching type switch to short between STF and SD/PC for starting, ensure the compliance with safety requirement for the restarting when the drive recover from input power loss.**

●Multiple inverter configuration example

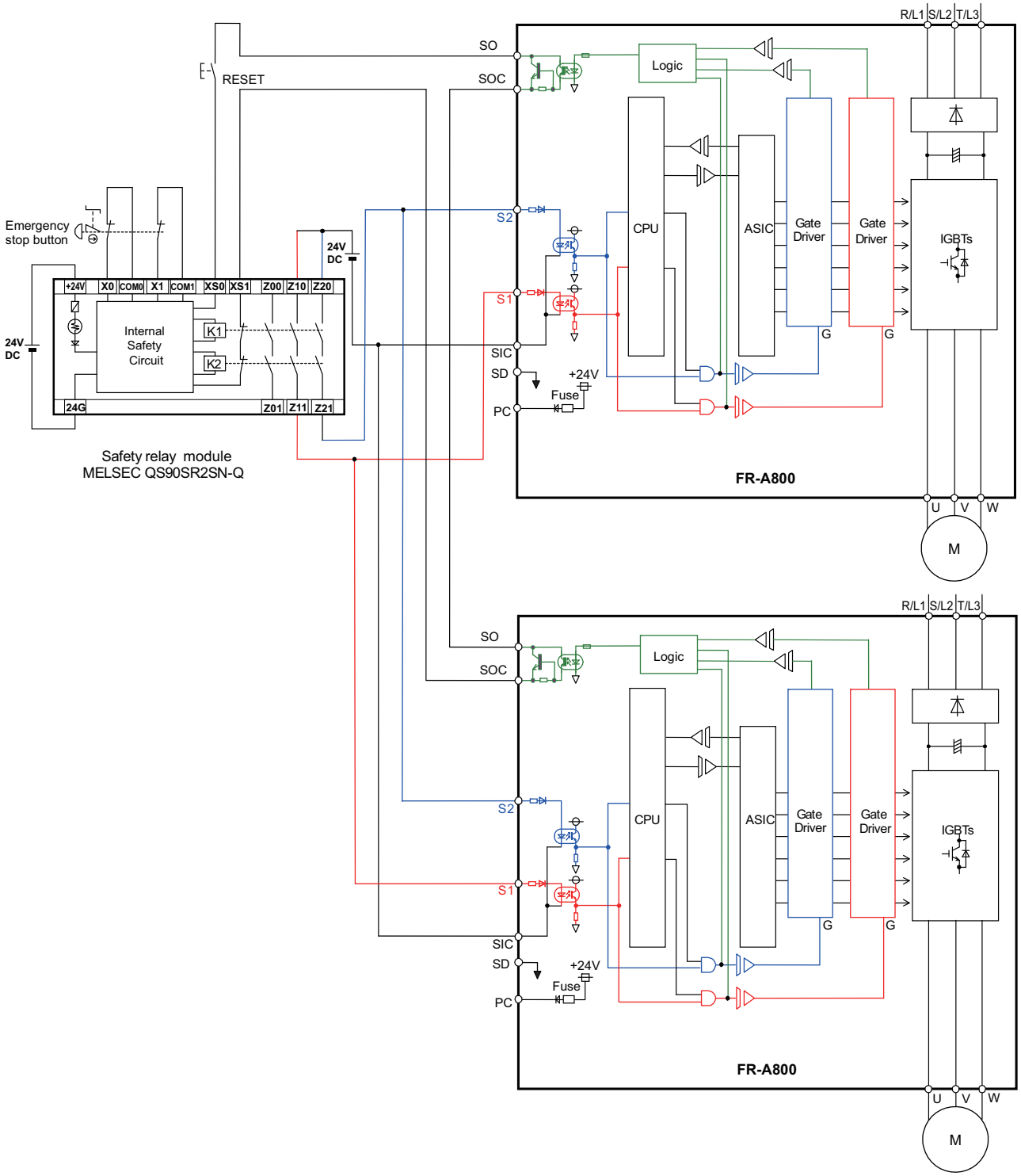


Fig.4 When using multiple safety stop function inverters (FR-A800)

NOTE

- Some models cannot be used together because their control logics are different. Refer to the **SAFETY STOP FUNCTION MANUAL** of each model.

●Safety controller configuration example

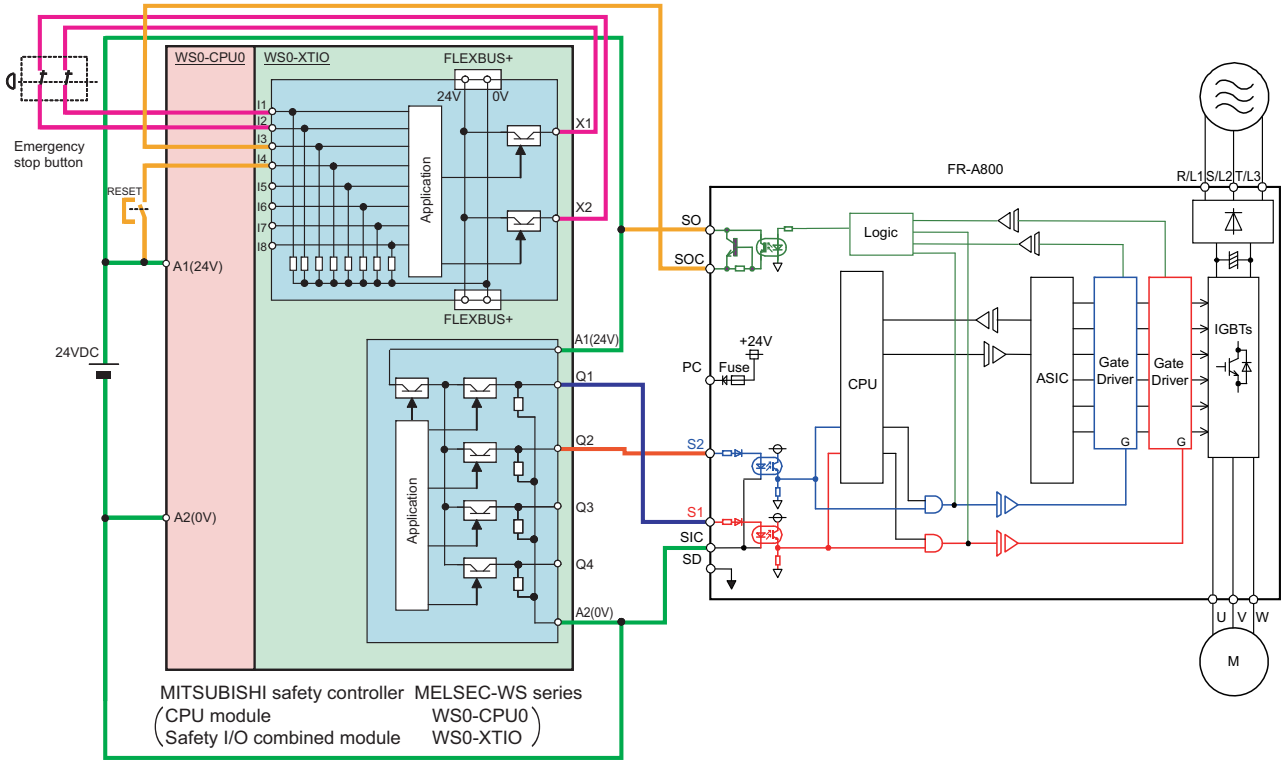


Fig.5 Safety system example with FR-A800

NOTE

- When starting up the system's operation, press the RESET switch to reset the safety stop function first.
- In the above configuration, after reset of emergency stop button, drive will be in safe-state until RESET switch is pressed.

4 TEST AND CHECKING FAILURE

⚠CAUTION

- **To avoid systematic faults, a test even for faulty demands of the safety function has to be performed in order to check the correct function of the monitor signal. This test shall be carried out at system installation, any software changes, parameterization changes, and/or at least once per year.**

I/O status and failure

FR-A800 safety related I/O status obeys the following truth table.

Table.5 Truth table of safety related signals

Input power	S1-SIC	S2-SIC	Internal safety circuit *1	SO-SOC	Inverter operation state
OFF	-	-	-	OFF(Open)	Drive shutoff (Safe state)
ON	Short	Short	No failure	ON(Close)	Drive enable
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In case of diagnostic or functionality test, check the I/O state whether it is same or not as Table.5.

Diagnostic

If the failure detected, FR-A800 output alarm signal and indicate ‘E.SAF’ at the display.

In case of FR-A800 output the alarm, please take following action.

1) Check the S1-SIC and S2-SIC input signal logic is the same. If these are different logic, collect the input signal and reset the FR-A800.
2) Disconnect the wire from S1, S2, SIC terminal, then reset or power-off and on. If the ‘SA’ letter is flashed up at display, there is failure in system except FR-A800. But, still ‘E.SAF’ is displayed and alarm output, there is malfunction on FR-A800.

Self diagnostic test

FR-A800 does the self-diagnostic test on the power-ON.

If FR-A800 output alarm (SA, E.SAF) at power-up, please take the action described in ‘Diagnostic’ at above.

Test procedure for functionality

As depicted ‘CAUTION’ in above, the test for the functionality is important.

Please do the test following procedure.

1) Please make each state of S1-SIC and S2-SIC depicted at Table.5.
2) If there is any different state from Table.5, FR-A800 has some malfunction.
3) If there is no different state from Table.5, check the systematic performance, such as, press the emergency switch, press the start/restart button at the failure detected (SO-SOC opened), and so on.
4) Finally clear the error record of the FR-A800 (see the user manual how to clear the error record).

5 SAFETY PARAMETERS OF FR-A800

The safety parameters of FR-A800 are depicted as follows.

Table.6 Safety parameters of FR-A800

Parameter	Value
PFD_{AVG}	$5.13x10^{-4}$
PFH_D	$5.85x10^{-9}$
PL	d
$MTTF_D$	674 years
DC_{AVG}	60%

REVISIONS

Print Date	Manual Number	Revision
Apr. 2013	BCN-A23228-001(E)	First edition
Jun. 2013	BCN-A23228-001-A(E)	Modification ● **Multiple inverter configuration example**

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BCN-A23228-001-A(E)(1306)MEE Printed in Japan