AbN
automation

MITSUBISHI ELECTRIC

700 series

INVERTER
FR-D700-SC-EC

Safety Stop Function Instruction Manual

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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 standards. ● 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. ● 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).

⚠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.

⚠CAUTION
● This instruction manual is compatible with FR-D700-SC-EC source-logic safety terminal model. For FR-D700-EC sink-logic safety terminal model, refer to the FR-D700 safety stop function instruction manual (BCN-A211508-000).

1. General description

Features

Mitsubishi Electric FR-D700-SC safety stop function prevents a drive from supplying rotational energy to motors. (In this Instruction Manual, the STO (safe torque off) function specified in IEC 61800-5-2 is referred to as the safety stop function.)
Dual safety channels 'S1' and 'S2' cut off the gate-drive power for IGBT to turn off.

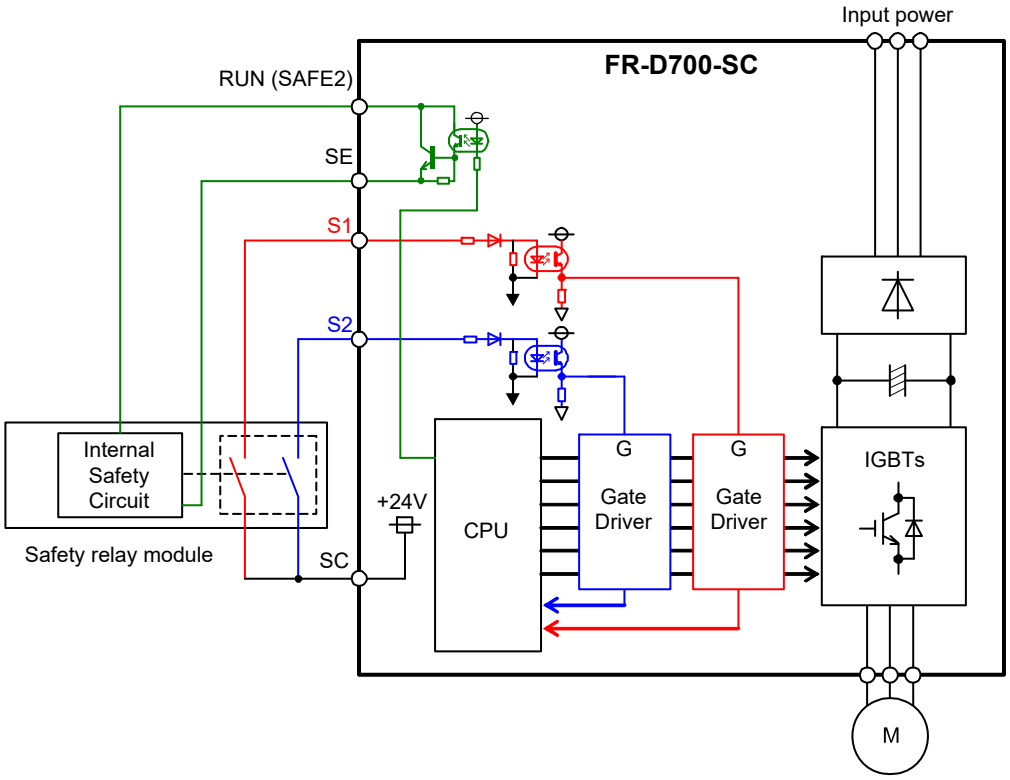

Fig.1 FR-D700-SC safety stop function diagram

⚠WARNING

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

Standards

Mitsubishi Electric FR-D700-SC safety stop function meets the following standards and categories.

ISO13849-1:2015 Category 3/PLd
IEC62061:2021 / IEC61800-5-2:2016 / IEC61508:2010 SIL2
IEC61800-5-2:2016 Stop category 0

⚠WARNING

- The misuse of safety function leads 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 standards.

2. Installation and wiring

⚠CAUTION

- The following information 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.
- Ensure the safety relay unit and the FR-D700-SC unit is mounted closely in enclosure meeting IP54 and all interconnection wiring is short and protected against open and short circuit faults.
  Refer EN/ISO13849-2.

Installation

Mitsubishi Electric FR-D700-SC safety stop function should be used under following condition and environment.

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

Item		Condition
Temperature range	Operation	-10°C to +50°C (non-freezing)
	Storage	-20°C to +65°C
Ambient humidity		90%RH maximum (non-condensing)
Vibration		5.9m/s^2 or less
Altitude		maximum 1000m
Atmosphere		Indoors (without corrosive gas, flammable gas, oil mist, dust and dirt etc.)
Over voltage category		II or less
Pollution degree		II or less
Mounting		wall mounting / vertical orientation

⚠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 Measure 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

- In order to meet safety stop, an approved safety relay unit to ISO13849-1/EN954-1 safety category 3 or better shall be used in conjunction with FR-D700-SC as shown in example1,2.
  In addition, all other components with in the safety stop loop shall be 'safety approved' types.
- 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
S1	For input of safety stop channel1. S1-SC is Open: In safety stop mode. Short: Non safety stop mode.	Input resistance:4.7kΩ Current : 4 to 6 mA (In case of shorted to SC) Voltage : 21 to 26 V (In case of open from SC)
S2	For input of safety stop channel2. S2-SC is Open: In safety stop mode. Short: Non safety stop mode.	
SC	Common terminal for S1, S2 terminals. *SC is connected terminal PC internally.	
SO (SAFE)	As output for safety stop condition. SO terminal type is 'Open collector output'. SO-SE is OFF(Open): Drive enabled, or drive shutoff (with internal circuit fault) ON(Close): Drive shutoff (no internal circuit fault) **Important:** SO terminal should be used for monitoring safety stop condition only. SO terminal cannot be used for safety function.	Load: 24VDC/0.1A max. Voltage drop: 3.4V max. (In case of 'ON' state)
RUN (SAFE2)	As output for failure detection and alarm. RUN terminal type is 'Open collector output'. RUN-SE is OFF(Open): Detect failure or Alarm. ON(Close): No failure detected. **Attention:** To use RUN terminal for monitor output of failure detection, **Pr.190 should be set 81 (Safety monitor 2).** **Note:** This terminal can be used for alarm or to prevent restart only, no other safety function.	
SE	Common terminal for safety RUN and SO terminal.	

Table.3 Truth table of Safety related signals

Input power	S1-SC	S2-SC	Internal safety circuit *1	SO (SAFE)	RUN (SAFE2) *2	Inverter operation state
OFF	-	-	-	OFF(Open)	OFF(Open)	Output shutoff (Safe state)
ON	Short	Short	No failure	OFF(Open)	ON(Close)	Drive enable
			Failure	OFF(Open)	OFF(Open)	Output shutoff (Safe state)
	Open	Open	No failure	ON(Close)	ON(Close)	Output shutoff (Safe state)
			Failure	OFF(Open)	OFF(Open)	Output shutoff (Safe state)
	Short	Open	N/A	OFF(Open)	OFF(Open)	Output shutoff (Safe state)
	Open	Short	N/A	OFF(Open)	OFF(Open)	Output shutoff (Safe state)

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

*1 At an internal safety circuit fault, one of E.SAF or E.CPU 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).

*2 To use RUN terminal for monitor output of failure detection, Pr.190 should be set 81 (Safety monitor 2).

Wire and ferrule specification

Table.4 wire and ferrule specification

Wire size (mm^2)	Ferrule with insulation sleeve *	Crimping tool name *
0.3	AI 0,34-10TQ	CRIMPFOX 6
0.5	AI 0,5-10WH	
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	

*Ferrules and tools are distributed by Phoenix Contact Co., Ltd.

Jumper cable

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

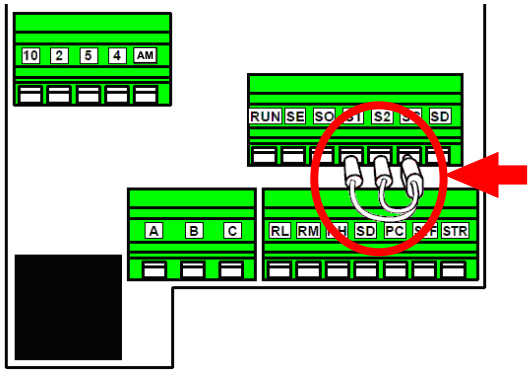

Fig.2. Short wire

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

3. Example of safety system configuration

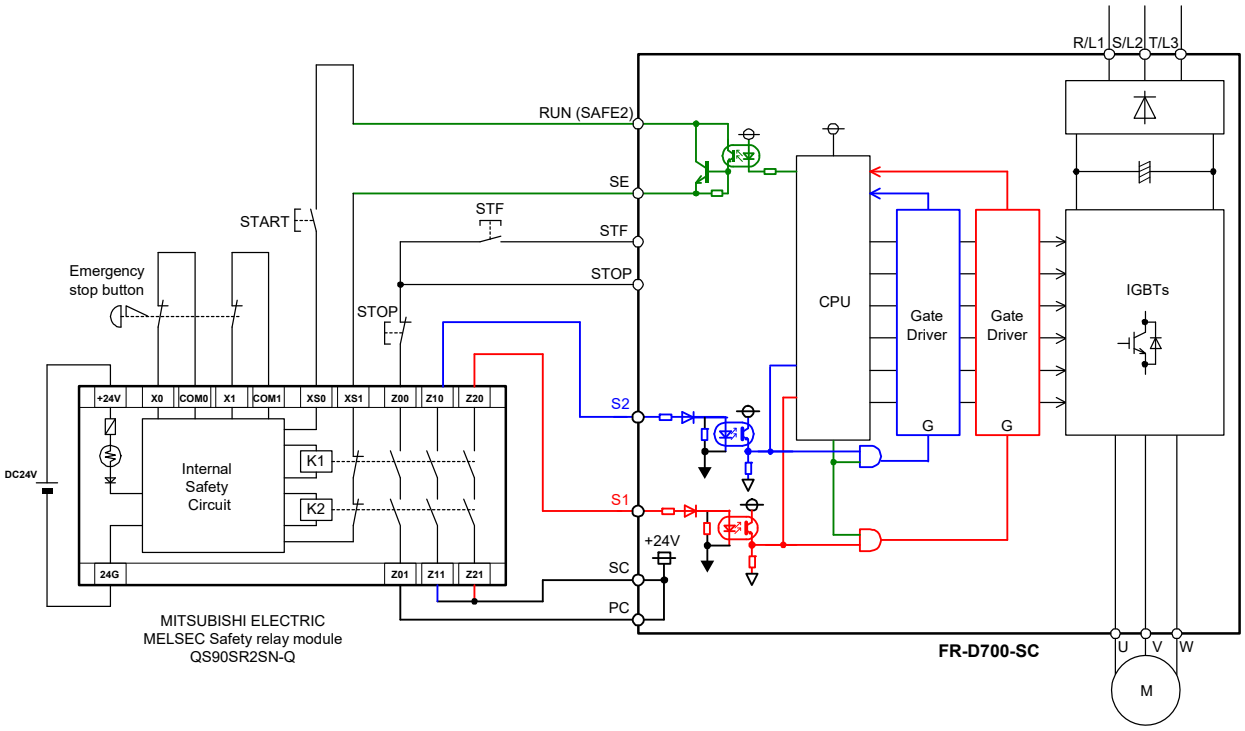

Fig.3 Safety system example – STOP synchronous with emergency stop button and fault detection through RUN output.

For safety stop, configure the wiring as shown in Fig.3 above.

NOTE

- **XS0 should be connected to RUN terminal and XS1 should be connected to SE, because polarity of XS0 is positive, XS1 is negative.**
- **Pr.190 (RUN terminal function selection) must be set to "81". This setting makes the RUN output to turn off in case of failure.**
- **The above wiring is configured to prevent restart in case of a fault.**
- **In the event of reset of 'safe-condition' the motor rotation will not occur until STF is pressed. (for normal 'non-safety' STF/STOP function, please refer to your drive's *User Manual*)**
- **After the power-up of the system, to reset the safety stop mode, press the START switch, and also press the STF switch, then start the motor rotation.**

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

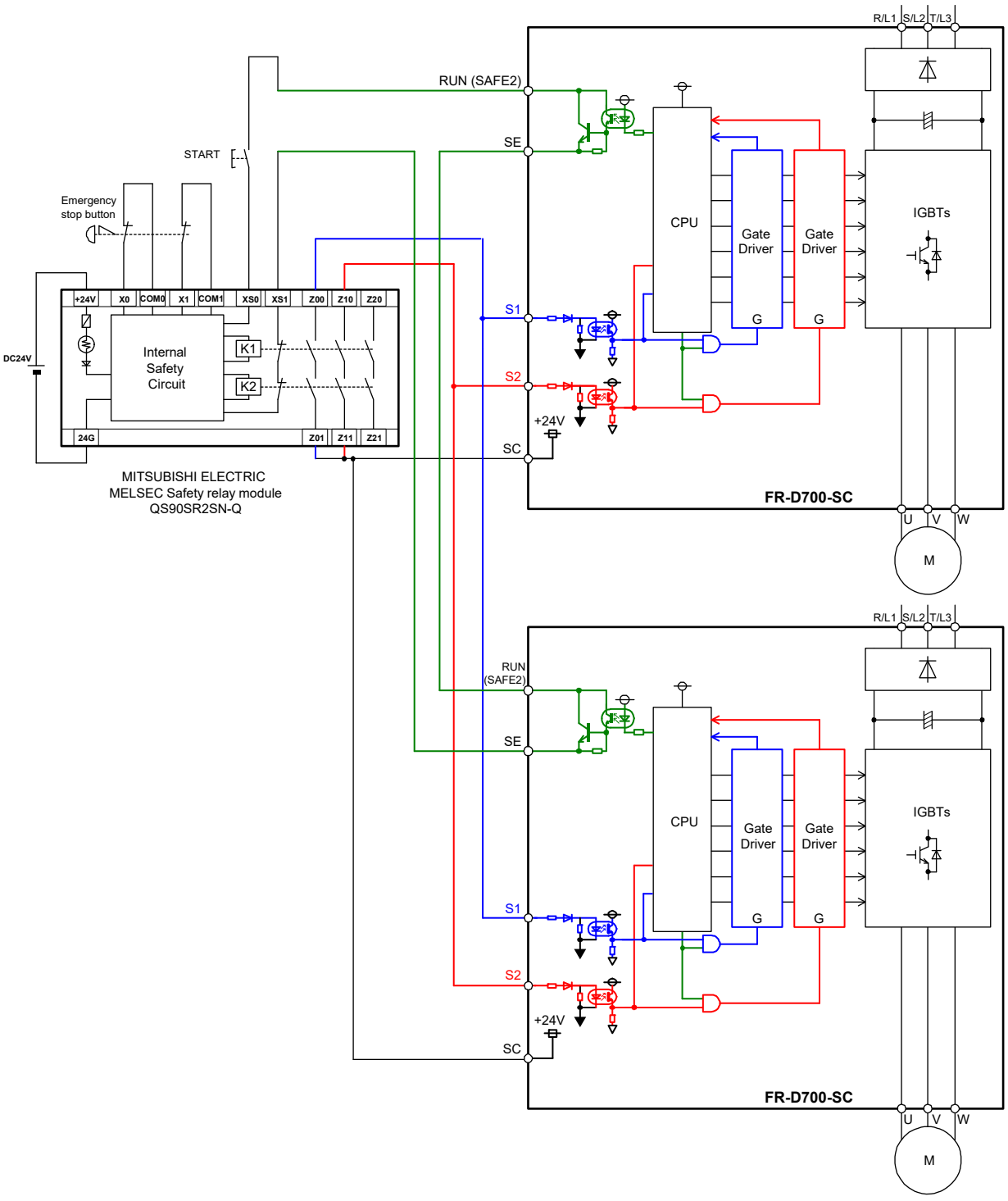

Fig.4 Example when using multiple FR-D740-SC inverters for the safety stop function

NOTE

- **Pr.190 (RUN terminal function selection) must be set to "81". This setting makes the RUN output to turn off in case of failure.**
- **Do not connect the FR-D700 (sink logic) together with the FR-D700-SC (source logic). If connected together, the safety stop function does not work properly. (Refer to page 7.)**

Inverter connection

Do not connect the FR-D700 (sink logic) together with the FR-D700-SC (source logic). If connected together, the safety stop function does not work properly.

	FR-E700-SC/NF/NC (source logic)	FR-D700-SC (source logic)	FR-D700 (sink logic)
FR-E700-SC/NF/NC (source logic)	○	○	✶
FR-D700-SC (source logic)	○	○	✶
FR-D700 (sink logic)	✶	✶	○

○: Enabled, ✶: Disabled

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-D700-SC safety related I/O status obeys the following truth table.

Table.5 Truth table of Safety related signals

Input power	S1-SC	S2-SC	Internal safety circuit *1	SO (SAFE)	RUN (SAFE2) *2	Inverter operation state
OFF	-	-	-	OFF(Open)	OFF(Open)	Output shutoff (Safe state)
ON	Short	Short	No failure	OFF(Open)	ON(Close)	Drive enable
			Failure	OFF(Open)	OFF(Open)	Output shutoff (Safe state)
	Open	Open	No failure	ON(Close)	ON(Close)	Output shutoff (Safe state)
			Failure	OFF(Open)	OFF(Open)	Output shutoff (Safe state)
	Short	Open	N/A	OFF(Open)	OFF(Open)	Output shutoff (Safe state)
	Open	Short	N/A	OFF(Open)	OFF(Open)	Output shutoff (Safe state)

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

*1 At an internal safety circuit fault, one of E.SAF or E.CPU 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).

*2 To use RUN terminal for monitor output of failure detection, Pr.190 should be set 81 (Safety monitor 2).

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-D700-SC output alarm signal and indicate ‘E.SAF’ at the display.
In case of FR-D700-SC output the alarm, please take following action.

(1) Check the S1-SC and S2-SC input signal logic is the same. If these are different logic, correct the input signal and reset the FR-D700-SC.
(2) Disconnect the wire from S1, S2, SC terminal, then reset or power-off and on, If the ‘SA’ letter is flashed up at display, there is failure in system except FR-D700-SC. But, still ‘E.SAF’ is displayed and alarm output, there is malfunction on FR-D700-SC.

Self diagnostic test

FR-D700-SC does the self-diagnostic test on the power-ON.
If FR-D700-SC output alarm at power-ON, please take the action described in ‘Diagnostic’ at above.

Test procedure for functionality

As depicted 'ATTENTION' in above, the test for the functionality is important.
Please do the test following procedure.

(1) Please make each state of S1-SC and S2-SC depicted at Table.5.
(2) If there is any different state from Table.5, FR-D700-SC 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 (RUN-SE opened), and so on.
(4) Finally clear the error record of the FR-D700-SC (see the user manual how to clear the error record).

5. Safety parameters of FR-D700-SC

FR-D700-SC safety related I/O status obeys the following truth table.

Table.6 Safety parameters of FR-D700-SC

Parameter	Value
PFD_{AVG}	$2.5x10^{-4}$
PFH_D	$2.5x10^{-9}$
PL	d
$MTTF_D$	500 years
DC_{AVG}	60%

REVISIONS

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Jan. 2012	BCN-A211508-005-A	First edition
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