



FSC Product Safety Manual

RadICS

(Radiy FSC — FPGA-based Safety Controller)

Document D11.1

Version V4, Revision R2

October 2020

Table of Contents

1	Introduction	6
1.1	Scope and Purpose of this Document	6
1.2	Applicability and Version Information	6
1.3	Reference Standards	7
1.4	Specific Definitions and Acronyms	7
1.5	Other Definitions and Acronyms	8
2	Certification	10
3	Management of Functional Safety with the FSC	12
4	Failure Rate Data for Application Selection and SIL Verification	14
4.1	Defined Safe State	14
4.2	Failure Rate Data	15
4.3	Time Domain Data	18
4.4	Using the Failure Rate Data for a Specific SIF	19
4.5	Low Demand Mode of Operation.....	21
4.5.1	Criteria for Low Demand Mode	21
4.5.2	General Requirements for Low Demand Mode.....	21
4.5.3	Proof Test Coverage (PTC) Considerations.....	22
4.5.4	Recommended Proof Test Procedures	23
4.6	High Demand Mode of Operation.....	27
4.7	Common Cause Failure Considerations.....	27
4.8	Operating Limits	28
4.8.1	Product Life.....	28
4.8.2	Environmental Conditions	28
4.8.3	EMI and Surge Withstand Ratings	29
4.8.4	Signal Ranges and Voltage & Current Limits	31
5	Operation	37
5.1	Theory of Operation	37
5.1.1	General	38
5.1.2	FSC Modes of Operation	40
5.2	Local Indications of FSC Modes and Status.....	44
5.3	Safety OverRide (SOR).....	44
5.4	Response to Detected Failures	46
5.4.1	Concept.....	46
5.4.2	Automatic Response of the FSC.....	46
5.4.3	User Application Logic (UAL) Decisions.....	47
6	Wiring of Inputs and Outputs	48
6.1	FSC Physical Chassis: Use of Modules and Chassis Slots.....	48
6.2	Module I/O Capacities	49
6.3	Redundancy Options.....	50
6.4	EMI/Surge Protection Filters for I/O.....	51
6.5	Chassis Connectors	52
6.6	Power Supply Wiring.....	53
6.7	I/O Wiring	53
6.7.1	Wiring of SOR Inputs	54
6.7.2	Wiring of Logic Module.....	56
6.7.3	Wiring of AIM Analog Inputs.....	57
6.7.4	Wiring of DIM Discrete Inputs	59
6.7.5	Wiring of DOM Discrete Outputs.....	61
6.7.6	Wiring of AOM Analog Outputs	62
6.7.7	Wiring of AIFM Analog Inputs	64

6.7.8	Wiring of OCM Fiber Opto transceivers and RS-232/485 Outputs* ...	64
6.7.9	Wiring of chassis fans control and diagnostic	65
6.7.10	Wiring of RIM Analog Inputs	65
6.7.11	Wiring of TIM Analog Inputs	67
	Important note: TIM does not provide means for cold junction temperature compensation so it's End User responsibility to read this value and make calculations for compensation using UAL. To get cold junction temperature value additional analog input (TIM or AIM) shall be used.....	69
6.7.12	Wiring of WAIM Analog Inputs	69
6.8	Wiring to Accommodate Periodic Proof Tests and Logic Changes	70
6.9	Wiring for the Safety OverRide (SOR).....	71
6.10	Detection of Field Faults in Input Circuits	73
6.10.1	AIM Failed Analog Transmitters or Wiring.....	73
6.10.2	Detecting Shorted Field Wiring	75
6.10.3	AIFM Failed Analog Transmitters or Wiring	76
6.10.4	RIM Failed Analog Transmitters or Wiring	76
6.10.5	TIM Failed Analog Transmitters or Wiring.....	77
6.10.6	WAIM Failed Analog Transmitters or Wiring	77
6.11	Wiring for the 'Armed' Contact for Tuning and Testing	77
7	Installation.....	77
7.1	Installation of the FSC chassis	77
7.2	Installation of FSC Modules.....	78
7.3	Installation of EMI/Surge Protection Modules.....	82
7.4	Installation of LM Unique Address connector	84
7.5	Connections to the FSC	86
7.6	Authentication of the FSC Version	88
8	Maintenance, Calibration, Periodic Testing	88
8.1	FSC Module HMI.....	89
8.2	LED Indications on FSC Modules.....	89
8.3	4-Character Matrix Display on FSC Modules	89
8.3.1	Display Tiers	89
8.3.2	Temporary Display Values During Startup.....	91
8.3.3	Identifying Specific Failure Details Using the Display	93
8.3.4	Determining the Specific Fault with a Blank Display	93
8.4	Routine Maintenance Activities	93
8.4.1	Periodic Inspection.....	94
8.4.2	Proof Tests.....	95
8.4.3	Routine Maintenance	95
8.5	Maintenance in Response to Detected Failures	95
8.5.1	Overview Procedure.....	95
8.5.2	Detailed Diagnostic Procedure.....	96
8.6	Calibration	103
8.6.1	AIM Calibration	105
8.6.2	AOM Calibration.....	106
8.6.3	AIFM Calibration	107
8.6.4	RIM Calibration	107
8.6.5	TIM Calibration.....	109
8.6.6	WAIM Calibration	110
8.7	Personnel Safety	111
8.8	Inspection and Test Records.....	111
8.9	General Maintenance Issues.....	111

8.10 UpLoad Station (ULS)	112
9 Tuning of Application Parameters	112
10 Design and Installation of Application Logic	112
10.1 User Application Logic Required for Compliance to IEC 61508	113
10.1.1 Verification of Chassis Configuration	113
10.1.2 Verification of I/O Channel Status	114
10.1.3 Mitigation of Failures of Safety-Critical I/O Channels	114
10.1.4 Allowances for Analog Signal Tolerance	116
10.1.5 Setting the SOR to Reach a Safe State	117
10.1.6 Latching Trip Decisions	118
10.1.7 Monitoring Module Temperature	118
10.1.8 User Logic Tests Required for the AIFM	119
10.1.9 Redundancy in User Wiring of I/O	119
10.1.10 UAL Requirements to Mitigate Output Module Failures	120
10.1.11 Behaviour of OCLs in RUN(SAFE) and FAULTED Modes	122
10.2 Use of RPCT to Design Application Logic	122
10.3 Installing a Logic Configuration in an FSC Logic Module	122
11 Security	125
11.1 Physical Security	125
11.2 Application Logic Configuration	125
11.3 Cyber Security	125
12 Product Forum	126
Annex A List of FSC modules fault codes	127
Annex B RadICS Platform Components List	128

Figures

Figure 1-1 Radly FSC Chassis Partially Filled with I/O Modules	7
Figure 4-1 Illustration of the Impact of PTC < 100%	23
Figure 4-2 Illustration of the AIFM data processing path	26
Figure 5-1 Theory of Operation of the FSC	37
Figure 5-2 Timeline of FSC Operating Modes	40
Figure 6-1 FSC Chassis Slots	48
Figure 6-2 Time delays affecting inter-chassis SIFs in multi-chassis configurations	50
Figure 6-3 FSC Chassis Showing Location of Optional EMI Filters	51
Figure 6-4 Module compliance label on IOPM	52
Figure 6-5 Rear of FSC Chassis Showing Connectors	53
Figure 6-6 FSC Chassis Power Supply Connections	53
Figure 6-7 FSC I/O Slot Connector Pinout Designations	54
Figure 6-8 AIFM Slot Connector Pinout Designations	54
Figure 6-9 OCM Slot RS-232/485 Connector Pinout Designations	54
Figure 6-10 FSC Discrete I/O Pinout Polarities	56
Figure 6-11 FSC Analog I/O Pinout Polarities for Current	58
Figure 6-12 FSC Analog I/O Pinout Polarities for Voltage	58
Figure 6-13 Single DI pinout with “diagnostic” resistor	60
Figure 6-14 FSC Analog Output Pinout Polarities for Current	62
Figure 6-15 FSC Analog Output Pinout Polarities for Voltage	63
Figure 6-16 FSC Analog Input Pinout Polarities for Neutron detector connection	64
Figure 6-17 Wiring to Facilitate Proof-Testing and Tuning	71
Figure 6-18 Example of Wiring of SOR for Selected DOMs	72

Figure 6-19 Use of 225 Ω Input Resistor with Analog Inputs	74
Figure 6-20 Extrapolation in ‘Shoulder’ Regions with 225 Ω Input Resistor	74
Figure 6-21 Diagnostic Field Resistor Used to Detect Shorted Field Circuit	75
Figure 7-1 Installation of the FSC Chassis.....	78
Figure 7-2 Locking Brackets for Chassis Installation	78
Figure 7-3 Installing/Removing an FSC Module	80
Figure 7-4 The pegs in the bottom rail	81
Figure 7-5 The pegs for plug-in modules	81
Figure 7-6 The pegs in the bottom and top horizontal rail	81
Figure 7-7 Slots and rails for EMI/Surge Protection module.....	83
Figure 7-8 Installation EMI/Surge Protection module into the rails and slots.....	83
Figure 7-9 Installed EMI/Surge Protection module	84
Figure 7-10 Installed Connector with Pre-Installed Jumpers	85
Figure 7-11 Empty slot for Address Connector	86
Figure 7-12 Power Cable Connections.....	87
Figure 7-13 Connector XG2 with dust cap	87
Figure 8-1 FSC Module Local HMI.....	89
Figure 10-1 Monitorable Signals of FSC Modules	113
Figure 10-2 LM Input Ports to Set the SOR.....	118

Tables

Table 1-3 Failure Modes	8
Table 1-4 Failure Rates	8
Table 1-5 Parameters Related to Proof Testing.....	8
Table 4-1 FSC Failure Rates at MSL (Relative Flux = 1).....	16
Table 4-2 FSC Failure Rates at Relative Flux = 4.5	17
Table 4-3 FSC Response Times	18
Table 4-4 Example: Calculating the PF of the FSC for a SIF – step 1	19
Table 4-5 Example: Calculating the PF of the FSC for a SIF – step 2	20
Table 4-6 FSC and Cabinet Environmental Limits	28
Table 4-7 EMI and Surge Withstand Ratings	29
Table 6-1 SOR Pinouts.....	55
Table 6-3 Analog Input Module I/O Pinouts.....	59
Table 6-8 Discrete Output Module I/O Pinouts	61
Table 6-9 Analog Output Module I/O Pinouts	63
Table 6-11 Pinouts for OCM RS-232/485 Outputs.....	64
Table 6-12 Fan Control Board I/O Pinouts	65
Table 6-6 Resistance Inputs Module I/O Pinouts.....	67
Table 6-5 Thermocouple Inputs Module I/O Pinouts	68
Table 6-4 Wide Range Analog Inputs Module I/O Pinouts	69
Table 8-2 Temporary Error Codes Optionally Displayed During Startup on the LM	92
Table 8-3 AOM Calibration Signal Levels	106
Table 8-4 RIM Calibration Signal Levels	108
Table 8-5 TIM Calibration Signal Levels	110