Summary of MELTAC Platform Equipment Qualification

Non-Proprietary

August 2017

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Signature History

	Rev.0, January 2015	Rev,1, June 2015	Rev,2, February 2016	Rev.3, October 2016
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	Rev.4, May 2017			
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Revision History

Revision	Date	Page (section)	Description
0	January 2015	All	Initial issue
1	June 2015	General (P1, 3, 4, 7, 8, 9, 10, 12, 13, 27, Appendix A, Appendix B)	Modified the typo.
		<General>	Added the description about methodology for each test.
		P1	Added explanation about this document.
		P3	Added “Test Report” to Table 1.
		P4	Added the description about the regulatory requirement applied to equipment qualification.
		P4,5	Added the revision number of the applicable regulatory and standards.
		P4,5	Modified the title of the applicable regulatory and standards.
		P6	Changed the title of section 4.2.
		P6	Modified the description of the section 4.2.
		P7	Changed the description of test condition.
		P9	Added description about “sprays” and “sprays and chemicals.”
		APPENDIX B	Updated the revision of referenced documents.
2	February 2016	P7	Corrected the error in writing.
		P30-33	Added the section 5.2 ”Qualification Test Summaries.”
		APPENDIX A	- Modified the title of APPENDIX A. - Added module information to be consistent with the Topical Report.
		APPENDIX B	- Added the list of the test reports and the list of the qualified modules.
			- Added the referenced documents. - Updated the revision number of referenced documents. - Deleted the documents based on the MRP.

Revision	Date	Page (section)	Description
3	October 2016	General	- Changed the numbering style of the Tables and the Figures.
		4, 7, 8, 9 (4.0)	- Changed the section reference to the detail of qualification test procedure and results.
		10-26 (5.1.1)	- Added the detail of environmental qualification test procedure including criteria, EUT, test instrumentation, test site, and test period.
		27-40 (5.1.2)	- Added the detail of seismic qualification test procedure including criteria, EUT, test instrumentation, test site, and test period.
		41-64 (5.1.3)	- Added the detail of EMC and ESD qualification test procedure including criteria, EUT, test instrumentation, test site, and test period.
		65-72 (5.1.4)	- Added the detail of isolation qualification test procedure including criteria, EUT, test instrumentation, test site, and test period. - Corrected the module name description. - Deleted the description about KIDJ.
		73-74 (5.2.1)	- Added the detail of environmental qualification test report including conclusion.
		75-76 (5.2.2)	- Added the detail of seismic qualification test procedure including conclusion.
		77-88 (5.2.3)	- Added the detail of EMC and ESD qualification test report including conclusion.
		89-90 (5.2.4)	- Added the detail of isolation qualification test report including conclusion.
		APPENDIX A	- Deleted the description about DPLJ, KIDJ, and KEXJ.
		APPENDIX B, 1 (2.0), 3 (3.0)	- Deleted APPENDIX B since the information of the reference document described in Appendix B has been included in the body of this document. - Deleted the sentences referring to Appendix B.
4	May 2017	73-74 (5.1.3.3.2) 106 (5.2.1.2, 5.2.1.3) 107 (5.2.1.5, 5.2.1.6) 110 (5.2.2.2) 177-178 (5.2.3.5) 180 (5.2.4.4)	Added explanation of tested conditions, deviations and exemptions.
		30-34 (5.1.1.7.5) 40 (5.1.2.3) 58-61 (5.1.2.7.2) 94 (5.1.3.9) 107 (5.2.1.4) 109 (5.2.2.1) 110 (5.2.2.2)	Clarified wording.
		11-22 (5.1.1.3)	Added EUT of Environmental Qualification Testing.
		23-24 (5.1.1.4)	Added test Instrumentation of Environmental Qualification Testing.

Revision	Date	Page (section)	Description
		25 (5.1.1.5)	Added information of Test Site and Test Period of Environmental Qualification Testing.
		35-38 (5.1.1.7.5)	Added information of Criteria of Environmental Qualification Testing.
		41-52 (5.1.2.3)	Added EUT of Seismic Qualification Testing.
		53-54 (5.1.2.4)	Added information of test Instrumentation of Seismic Qualification Testing.
		54 (5.1.2.5)	Added information of Test Site and Test Period of Seismic Qualification Testing.
		58-66 (5.1.2.7)	Added information of Criteria of Seismic Qualification Testing.
		69-78 (5.1.3.3)	Added EUT of EMC, RFI and ESD Testing.
		79 (5.1.3.4)	Added information of test Instrumentation of EMC, RFI and ESD Testing.
		80 (5.1.3.5)	Added information of Test Site and Test Period of EMC, RFI and ESD Testing.
		86-90 (5.1.3.7) 91-93 (5.1.3.8) 95 (5.1.3.9)	Added information of criteria of EMC, RFI, and ESD Testing.
		96 (5.1.4)	Deleted the sentence.
		100-104 (5.1.4.3)	Added EUT of Isolation Qualification Testing.
		105 (5.1.4.4)	Added Test Instrumentation of Isolation Qualification Testing.
		105 (5.1.4.5)	Added Test Site and Test Period of Isolation Qualification Testing.
		112-176 (5.2.3)	Added test result of EMC, RFI, and ESD Testing.
5	Aug 2017	67-96 (5.1.3)	Added test procedure of EMC, RFI, and ESD Qualification Testing.
		113-180 (5.2.3)	Added test result of EMC, RFI, and ESD Qualification Testing.
		186-195 (Appendix B)	- Changed the references to Environmental Qualification Testing. - Added the references to EMC, RFI, and ESD Qualification Testing. - Replaced double-byte character fonts with appropriate single-byte characters.

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1.0 INTRODUCTION

This summary describes the environmental equipment qualification of the Mitsubishi Electric Corporation (MELCO) Mitsubishi Electric Total Advanced Controller (MELTAC) platform. The MELTAC platform is qualified according to the regulations and standards referenced in this document. The MELTAC platform qualification testing plans, methodologies, procedures, and results are described or referenced.
This document supports the “Safety System Digital Platform - MELTAC - Topical Report” (JEXU-1041-1008) and satisfies the commitments made under Table 1 sections 1.14, 2.4, 2.5, 2.6, 2.11, 2.12, 3.4, 3.5 and 3.6 of “Mapping of MELTAC Platform Licensing Documents to the DI&C-ISG-06 Guidance” (JEXU-1041-1012).

2.0 DOCUMENTATION TREE AND CATEGORIZATION

Figure 2-1 shows the MELTAC Platform Documentation Tree. These documents are internal documents which are categorized into three groups according to the following phases: Design Phase, Qualification Phase, and V&V Phase. The scope of this summary is the Qualification documents prepared in the Qualification Phase.

The Design Phase documents are described in “Summary of MELTAC Platform Design” (JEXU-1041-1022), and the V&V Phase documents are described in “Summary of MELTAC Platform V&V” (JEXU-1041-1026).

The MELTAC platform documents corresponding to the information required by ISG-06 Enclosure B (Tier 3) are listed in Section 3.

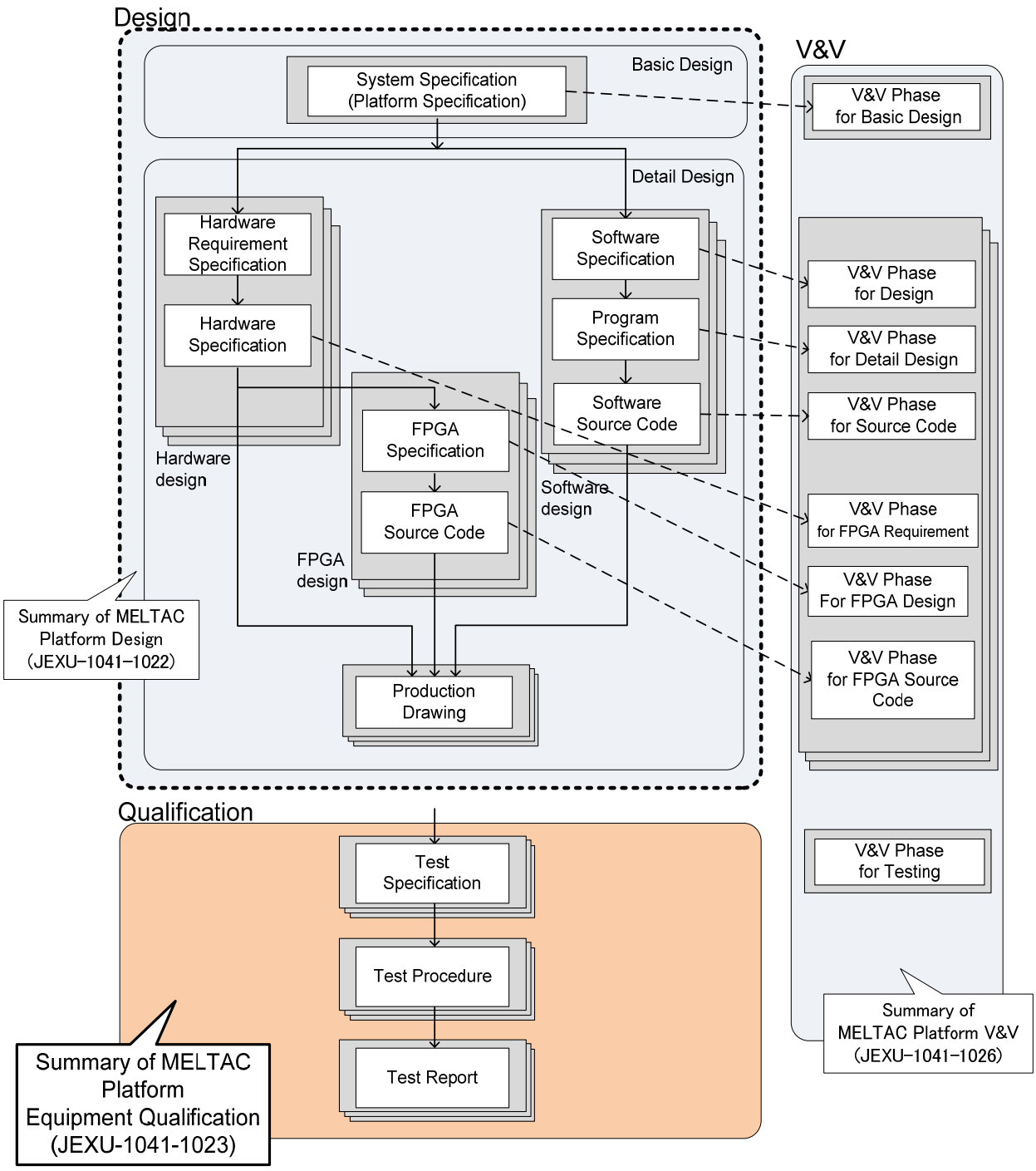

Figure 2-1 MELTAC Platform Documentation Tree

3.0 MELTAC DOCUMENTS CORRESPONDING TO THE DOCUMENTS IN ISG-06 ENCLOSURE B TIER 3

The MELTAC platform documents corresponding to the ISG-06 Enclosure B (Tier 3) documents are listed in Table 3-1.

Table 3-1 Applicable Regulatory Guides, Codes, and Standards MELTAC Platform Documents Corresponding to Documents in ISG-06 Enclosure B (Tier 3)

ISG-06 Enclosure B Tier 3 Document		Applicable ISG-06 Section	MELTAC Documents
1.14	Equipment Qualification Testing Plans (Including EMI, Temperature, Humidity, and Seismic)	D.5.2	Test Plan
2.4	Test Design Specification	D.4.4.2.4	Test Specification
2.5	Summary Test Reports (Including FAT)	D.4.4.2.4	Test Report
2.6	Summary of Test Results (Including FAT)	D.4.4.2.4	Test Report
2.11	Qualification Test Methodologies	D.5.2	Test Specification
2.12	Summary of Digital EMI, Temp., Humidity, and Seismic Testing Results	D.5.2	Test Report
3.4	Test Procedure Specification	D.4.4.2.4	Test Specification
3.5	Completed Test Procedures and Reports	D.4.4.2.4 D.5.2	Test Specification Test Report
3.6	Test Incident Reports	D.4.4.2.4	Test Report

For details, refer to Appendix B.

4.0 GENERAL DESCRIPTION FOR EQUIPMENT QUALIFICATION

4.1 Applicable Regulatory Guides, Codes, and Standards

The environmental qualification of the MELTAC platform is designed to meet the requirements given in the following 10 CFR 50 Appendix A; General Design Criteria (GDC).

GDC 2 “Design bases for protection against natural phenomena”
GDC 4 “Environmental and dynamic effects design bases”

The qualification tests and acceptance criteria applied to the MELTAC platform are intended to be bounding with regard to the design requirements at the typical United States Nuclear Power Plant.

All MELTAC platform qualification testing is designed to comply with applicable requirements of IEEE Std. 603-1991 “IEEE Standard Criteria for Safety Systems” Clause 5.4 “Equipment Qualification”. 10 CFR 50.55a (h) incorporates IEEE Std. 603-1991.

All MELTAC platform qualification testing is also designed to comply with the applicable requirements of IEEE Std. 7-4.3.2-2003 “IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations” Clause 5.4 “Equipment Qualification”. Regulatory Guide (RG) 1.152 Revisions 3 “Criteria for Digital Computers in Safety Systems of Nuclear Power Plants” endorses IEEE Std. 7-4.3.2-2003.

Table 4-1 shows the additional Regulatory Guides, Codes, and Standards applicable to each qualification test.

Table 4-1 Applicable Regulatory Guides, Codes, and Standards

Test	Reference
Environmental Qualification Testing	See 5.1.1.1 in this document
Seismic Qualification Testing	See 5.1.2.1 in this document
Electromagnetic Compatibility (EMC) and Radio Frequency Interference (RFI) Qualification Testing	See 5.1.3.1 in this document
Electrostatic Discharge (ESD) Qualification Testing	See 5.1.3.1 in this document
Isolation Qualification Testing	See 5.1.4.1 in this document

4.2 ISG-06 Guidance Overview

ISG-06 Section D5.4 (Technical Evaluation) contains guidance that the NRC staff can use to assess the environmental qualifications of a digital I&C system. This section describes the MELTAC platform qualifications applicable to the guidance in ISG-06 Section D5.4.

4.2.1 D5.4 Technical Evaluation

a) Testing Overview

Equipment qualification must demonstrate that the equipment is capable of successfully performing its intended safety functions after exposure to all normal and abnormal environmental stressors. MELTAC platform qualification testing is performed using a combination of individual module Tests and System Tests to ensure all MELTAC platform safety functions are satisfactorily tested. The MELTAC Platform System Testing is performed in a cabinet equipped with representative components of the MELTAC platform. The MELTAC platform modules mounted inside the cabinet for the System Tests are those that are deemed necessary to support the safety functions in a typical Plant Safety System (PSS).

Figure 4-1 shows the typical Plant Safety System (PSS) configuration.

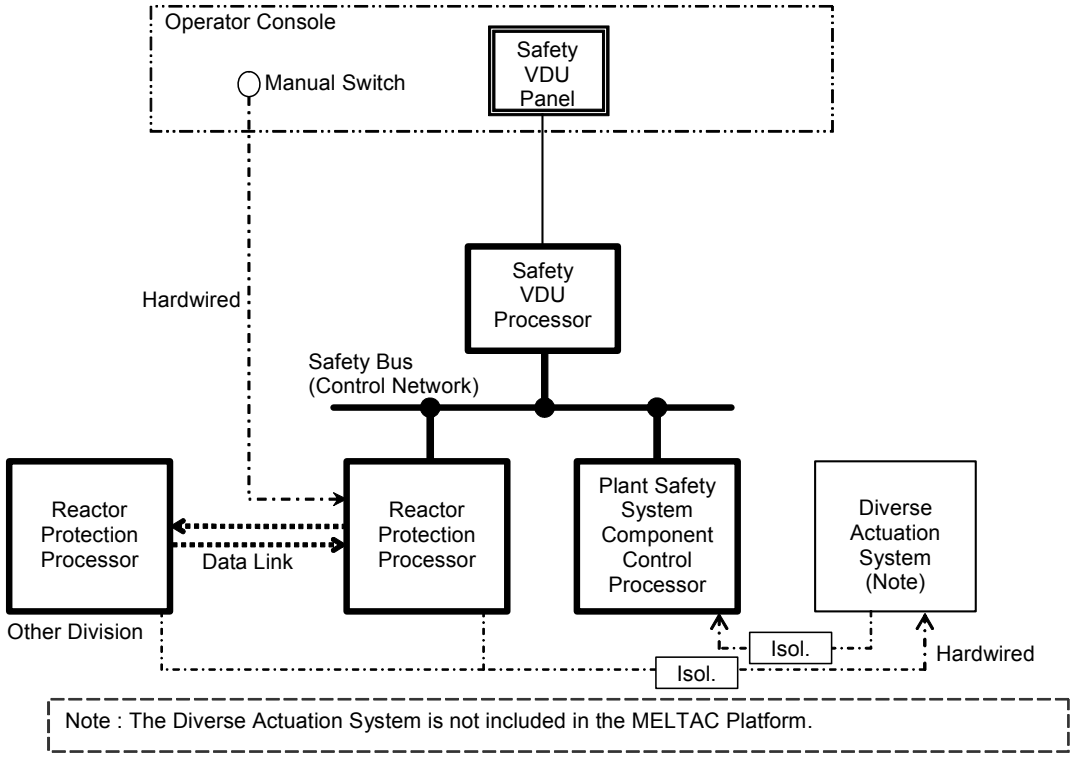

Figure 4-1 MELTAC Platform Typical Plant Safety System Configuration

The relationships between the typical MELTAC platform safety functions and the applicable qualification tests are shown in Table 4-2.

Table 4-2 Relationships between Typical Safety Functions and Qualification Tests

No.	Typical Safety Function	Qualification Test					
		Environmental Testing		Seismic Testing		EMC Testing	Isolation Testing
		System	Module	System (Cabinet)	Module		
1	Control network communication function	-	X	-	X	X	-
2	Data Link communication function	X	X	X	X	X	-
3	Analog signal input/output function	X	X	X	X	X	-
4	Digital signal input/output function	X	X	X	X	X	-
5	Isolation function	X	X	X	X	X	X
6	Display function	-	X	-	X	X	-
7	Touch panel signal input function	-	X	-	X	X	-
8	Logic processing function	X	X	X	X	X	-
9	Display data generation function	-	X	-	X	X	-
10	Self-diagnosis	X	X	X	X	X	X

The relationships between the MELTAC platform modules and the applicable qualification tests are shown in Appendix A.

b) Test Conditions

The qualification tests and acceptance criteria applied to the MELTAC platform are intended to be bounding with regard to the design requirements at the typical United States Nuclear Power Plant. Applicability of the MELTAC platform qualification tests and acceptance criteria must be evaluated against the design requirements for the specific application.

c) Aging

The MELTAC platform has aging mechanisms. MELTAC platform aging is addressed through periodic replacement schedules to maintain the equipment in a qualified condition.

4.2.2 D5.4.1 Atmospheric

The MELTAC platform Environmental Testing is in accordance with RG 1.89 and RG1.209 which endorse IEEE Std. 323.
Test items are:

- System Level Environmental Test (See Section 5.1.1.1.):
  - Temperature/Humidity Characteristic Test
  - Temperature Cycle Test
  - Hot-start Test
  - Cold-start Test

- Module Environmental Test:
  - Temperature and Humidity Characteristic Test (See 5.1.1.7.2 and 5.2.1.2)
  - Temperature/Humidity Test (See 5.1.1.7.5 and 5.2.1.5)
  - Temperature Cycle Test (See 5.1.1.7.4 and 5.2.1.4)
  - Hot/Cold Test (See 5.1.1.7.3 and 5.2.1.3)

4.2.3 D5.4.2 Radiation

The MELTAC platform is not qualified for use in a radiation environment.

4.2.4 D5.4.3 Electromagnetic Interference (EMI)/ Radio Frequency Interference (RFI)

MELTAC platform EMC qualification testing is in accordance with MIL-STD-461E endorsed by RG1.180.
Surge withstand testing is in accordance with IEC61000-4-4, 5, 12 endorsed by RG1.180.
Specific tests include:

- Susceptibility
  - Conducted Susceptibility, Low Frequency (CS101) Test for Power Leads (See 5.1.3.7.1 and 5.2.3.2.1.)
  - Conducted Susceptibility, High Frequency (CS114) Test for Power Leads (See 5.1.3.7.2 and 5.2.3.2.2.)
  - Conducted Susceptibility, High Frequency (CS114) Test for Signal Leads (See 5.1.3.7.3 and 5.2.3.2.3.)
  - Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation (CS115) Test (See 5.1.3.7.4 and 5.2.3.2.4.)
  - Damped Sinusoidal Transients (CS116) Test (See 5.1.3.7.5 and 5.2.3.2.5.)
  - Electric Field (RS103) Test (See 5.1.3.7.6 and 5.2.3.2.6.)

- Emission
  - Conducted Emissions, Low Frequency (CE101) Test (See 5.1.3.6.1and 5.2.3.1.1.)
  - Conducted Emissions, High Frequency (CE102) Test (See 5.1.3.6.2 and 5.2.3.1.2)
  - Radiated Emissions, Magnetic Field (RE101) Test (See 5.1.3.6.3 and 5.2.3.1.3)
  - Radiated Emissions, Electric Field (RE102) Test (See 5.1.3.6.4 and 5.2.3.1.4.)

- Surge Withstand
  - Surge Withstand Capability, Ring Wave Test (See 5.1.3.8.1 and 5.2.3.3.1.)
  - Surge Withstand Capability, Combination Wave Test (See 5.1.3.8.2 and 5.2.3.3.2.)
  - Surge Withstand Capability, Electrically Fast Transients/Bursts Test (See 5.1.3.8.3 and 5.2.3.3.3.)

4.2.4.1 D5.4.3.1 Susceptibility

See 5.1.3.7 and 5.2.3.2.

4.2.4.2 D5.4.3.2 Interference

See 5.1.3.7 and 5.2.3.2.

4.2.5 D5.4.4 Sprays and Chemicals

The MELTAC platform is not qualified for use in an environment with sprays and chemicals. Sprays and chemicals are not part of the typical nuclear power plant I&C installation environment.

4.2.6 D5.4.5 Seismic

MELTAC platform seismic qualification testing is in accordance with IEEE Std. 344-2004 endorsed by RG 1.100.

One Safe Shutdown Earthquake (SSE) after five Operating Basis Earthquakes (OBEs) is required by IEEE Std. 344-2004.
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5.0 QUALIFICATION TESTING

5.1 Qualification Test Procedure

5.1.1 Procedure of Environmental Qualification Testing

The tests are performed to demonstrate that the MELTAC platform will continue to operate without loss of functions under the identified abnormal environmental conditions (e.g., temperature, humidity).

The MELTAC platform System Environmental Testing is performed in a cabinet equipped with representative components of the platform.

The MELTAC platform System Environmental Testing is in accordance with RG 1.89 which endorses IEEE Std. 323-1974.
Tests are performed as shown in “Safety System Digital Platform - MELTAC - Topical Report” (JEXU-1041-1008).

5.1.1.1 Applicable Regulatory Guides, Codes, and Standards

See Table 5-1 for applicable regulatory guides, codes, and standards.

Table 5-1 Applicable Regulatory Guides, Codes, and Standards

Name	Title
RG 1.89 Revision 1	Qualification for Class 1E Equipment for Nuclear Power Plants
RG 1.209 Revision 0	Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants
IEEE Std. 323-1974 IEEE Std. 323-2003	IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations

5.1.1.2 Test Item

See Table 5-2 for test items. As in the introduction of 5.1.1, tests are performed shown in Topical Report and EPRI TR-107330.

Table 5-2 Test Items for Environmental Tests

Test Item	Reference
Burn-In	5.1.1.7.1
Temperature and Humidity Characteristic Test	5.1.1.7.2
Hot/Cold Start Test	5.1.1.7.3
Temperature Cycle Test	5.1.1.7.4
Temperature and Humidity Test (shown in EPRI TR-107330)	5.1.1.7.5

5.1.1.3 Equipment Under Test (EUT)

Testing is scheduled to be performed in 7 groups or parts. This section describes the respective EUT groupings.

5.1.1.3.1 Test Subject

Test subject groups are shown in Table 5-3 through 5.8.

Table 5-3 Test Subjects of Environmental Qualification Test (Part 1)

Table 5-4 Test Subjects of Environmental Qualification Test (Part 2)

Table 5-5 Test Subjects of Environmental Qualification Test (Part 3)

Table 5-6 Test Subjects of Environmental Qualification Test (Part 4)

Table 5-7 Test Subjects of Environmental Qualification Test (Part 5)

Table 5-8 Test Subjects of Environmental Qualification Test (Part 6)

Table 5-9 Test Subjects of Environmental Qualification Test (Part 7)

5.1.1.3.2 EUT Layout

EUT layouts are shown in Figure 5-1 through Figure 5-7.

Figure 5-1 EUT Layout of Environmental Qualification Test (Part 1)

Figure 5-2 EUT Layout of Environmental Qualification Test (Part 2)

Figure 5-3 EUT Layout of Environmental Qualification Test (Part 3)

Figure 5-4 EUT Layout of Environmental Qualification Test (Part 4)

Figure 5-5 EUT Layout of Environmental Qualification Test (Part 5)

Figure 5-6 EUT Layout of Environmental Qualification Test (Part 6)

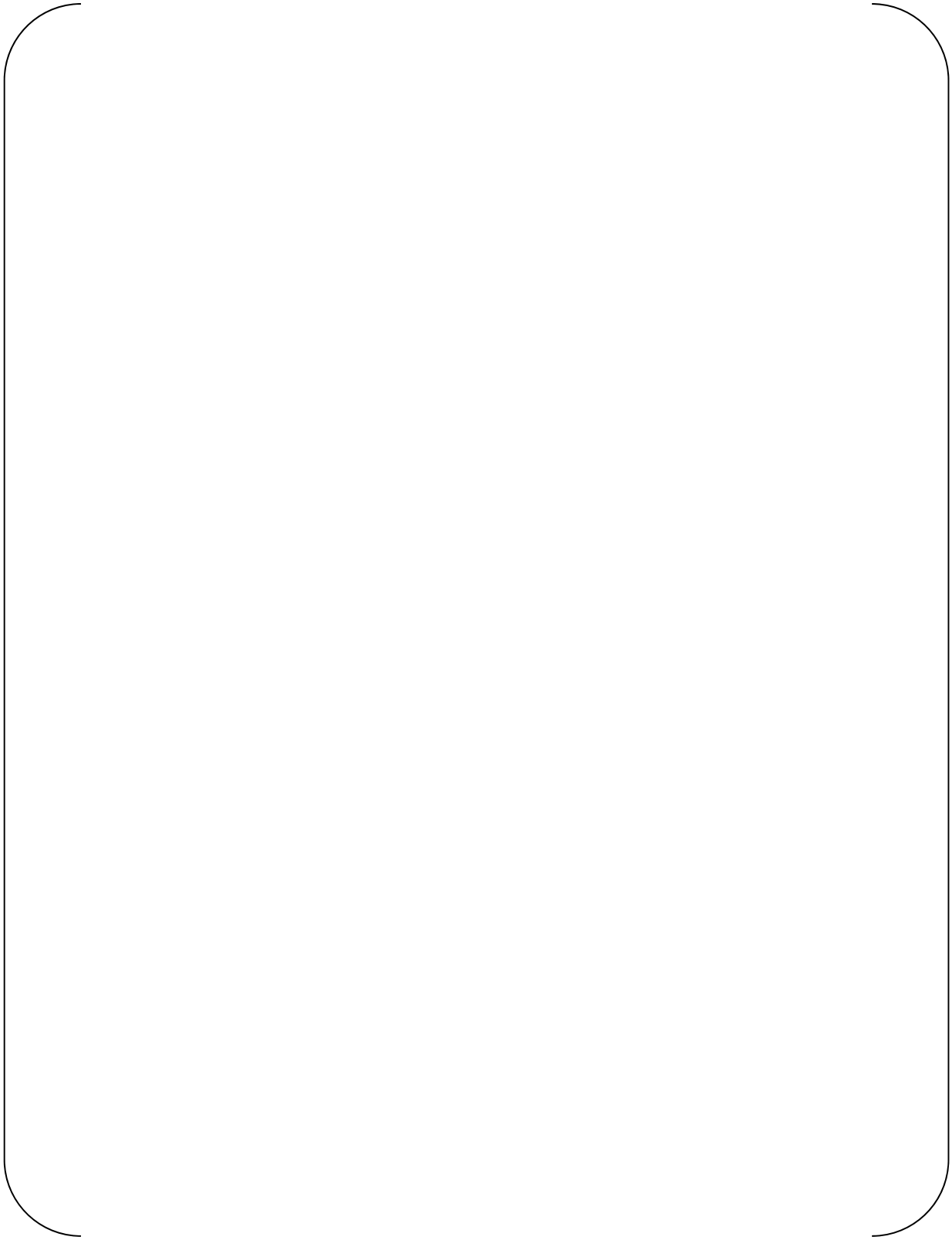

Figure 5-7 EUT Layout of Environmental Qualification Test (Part 7)

5.1.1.3.3 EUT Configuration

EUT Configuration is shown in Figure 5-8 through Figure 5-14.

Figure 5-8 EUT Configuration of Environmental Qualification Test (Part 1)

Figure 5-9 EUT Configuration of Environmental Qualification Test (Part 2)

Figure 5-10 EUT Configuration of Environmental Qualification Test (Part 3)

Figure 5-11 EUT Configuration of Environmental Qualification Test (Part 4)

Figure 5-12 EUT Configuration of Environmental Qualification Test (Part 5)

Figure 5-13 EUT Configuration of Environmental Qualification Test (Part 6)

Figure 5-14 EUT Configuration of Environmental Qualification Test (Part 7)

5.1.1.4 Test Instrumentation

Test instrumentation is shown in Table 5-10 through Table 5-16.
Since the test is scheduled to be performed in 7 parts: Part 1 through Part 7, this section describes EUT information in respective part.

Table 5-10 Test Instrumentation of Environmental Qualification Test (Part 1)

Table 5-11 Test Instrumentation of Environmental Qualification Test (Part 2)

Table 5-12 Test Instrumentation of Environmental Qualification Test (Part 3)

Table 5-13 Test Instrumentation of Environmental Qualification Test (Part 4)

Table 5-14 Test Instrumentation of Environmental Qualification Test (Part 5)

Table 5-15 Test Instrumentation of Environmental Qualification Test (Part 6)

Table 5-16 Test Instrumentation of Environmental Qualification Test (Part 7)

5.1.1.5 Test Site and Test Period

Mitsubishi Electric Corporation Energy Systems Center
From Jun. 9, 2015 to Aug. 25, 2015 (Part1 to 3)
From Jan 11, 2017 to Apr 3, 2017 (Part4 to 7)

5.1.1.6 Detail of the System Level (Cabinet) Environmental Test

a) Purpose
The MELTAC modules mounted inside the cabinet for the System Environmental Tests are selected as those that are deemed necessary to confirm the safety function of a typical reactor protection system, including the bi-stable operation and the trip signal output.

b) Test Subject

The Cabinet Seismic Resistance Test is performed with a MELTAC cabinet fully loaded with MELTAC components.

c) (1) Method
For the System Environmental Tests, a cabinet equipped with the MELTAC modules interconnected and powered in a test configuration is placed inside a thermostatic chamber. The test configuration produces the worst case expected temperature rise across the module chassis and across the cabinet. Before, during, and after each test, it is confirmed that there are no equipment failures or abnormal functions such as erroneous bi-stable operation or erroneous trip signal output, etc. To determine whether any functional abnormalities occurred, the output signals are recorded on a chart recorder to capture any erroneous output during the test. In addition, the test confirms that the Self-diagnosis function of the MELTAC platform detects no abnormalities during the test. The test also confirms that the Self-diagnosis function is still operating at the end of the test.

d) (2) Acceptance Criteria

For the System Environmental Test, the correct performance of the system is confirmed during the following tests.

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5.1.1.7 Detail of the Module level Test

5.1.1.7.1 Burn-in

a) Purpose
To confirm that there is no initial failure.

b) Test Subject
See 5.1.1.3 for test subjects.

c) Method
Test subject are energized for 100 hours or more at 60°C shown in the minimum time for deterioration described in IEEE323.
Operation is confirmed by the method shown in Table 5-18.

d) Acceptance Criteria
Criteria for operability test shown in Table 5-20 are satisfied.

5.1.1.7.2 Temperature and Humidity Characteristic Test

a) Purpose
To confirm the characteristics of the subject to temperature and humidity.

b) Test Subject
See 5.1.1.3 for test subject.

c) Method
Test is performed in the following condition. Operation of the test subject is confirmed by the procedure shown in 5.1.1.7.5 (Table 5-18).
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d) Acceptance Criteria
Criteria shown in 5.1.1.7.5 (Table 5-20) are satisfied.

5.1.1.7.3 Hot/Cold Start Test

a) Purpose
To confirm that the test subjects exposed to a high-temperature and low-temperature environment is started when the test subjects are applied with power.

b) Test Subject
See 5.1.1.3 for test subject.

c) Method
1. Expose the test subjects to the temperature of test condition in unenergized state. (low-temperature only)
2. Apply a rated power to the test subjects to confirm that tests subjects are started.
3. Change the power supply voltage (minimum/maximum) and perform the check of No. 2 above.

d) Acceptance Criteria
Normally started without loss of functions.

5.1.1.7.4 Temperature Cycle Test

a) Purpose
To confirm the suitability of the test subjects when it is subjected to repeated temperature changes.

b) Test Subject
See 5.1.1.3 for test subject.

c) Method
1. Confirm that it has specified functions and accuracy. (Performed in Temperature and Humidity Cycle Test.)
2. Perform a specified cycle of temperature change in the pattern as shown below.

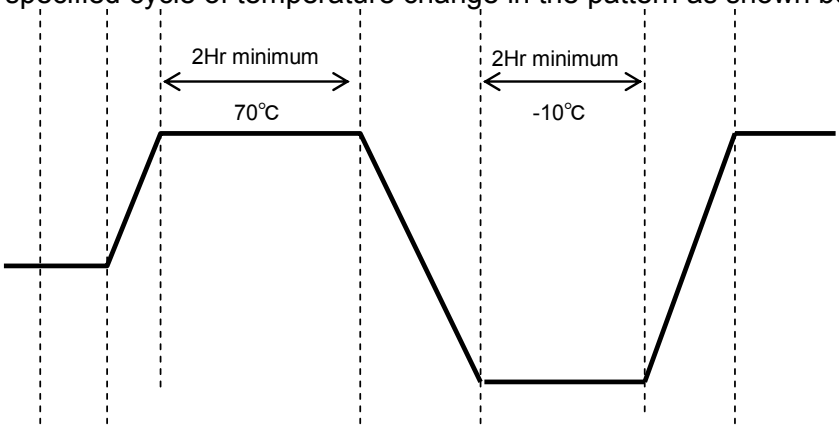

Figure 5-15 Temperature and Humidity Profile for Temperature Cycle Test

3. After the specified cycle is completed, restore the test subjects to the standard ambient condition (normal temperature and humidity) to make it stabilized.
4. Confirm the appearance and structure and electric characteristics of the test subjects in the same way as 1 above to check for anomaly or change in the characteristics from the initial value.

d) Acceptance Criteria
No error occurs during cycle testing.
Operability test is satisfied after cycle testing.

5.1.1.7.5 Temperature and Humidity Test (shown in EPRI TR-107330)

a) Purpose

Perform testing under the conditions of high-temperature and high-humidity, low-temperature and low-humidity, and ambient temperature and humidity, referring to the profile of temperature and humidity and test method shown in EPRI TR-107330 (Figure 4-4).

As shown in Figure 5-16, temperature and humidity testing consists of five tests: Test 1 to Test 5. The five tests have the at least one following sub item: initial calibration, operability test, and prudency testing. Details of initial calibration, operability test, and prudency testing is mentioned in section (c).

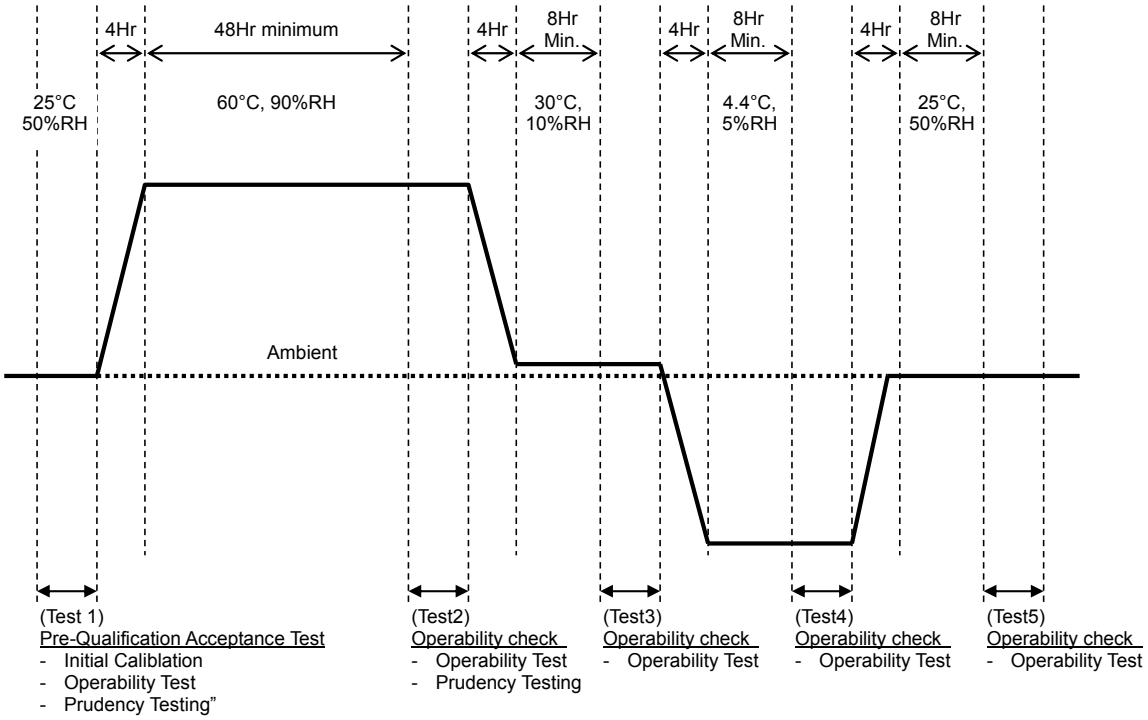

Figure 5-16 Temperature and Humidity Profile

b) Test Subject

See 5.1.1.3 for test subject.

c) Method

c.1) Pre-Qualification

Procedure of initial calibration indicated in Figure 5-16 (Test 1) is shown in Table 5-17.

Table 5-17 Pre-Qualification

Test Item	Procedure
Initial Calibration	Confirm the following: - accuracy of AI module satisfies the criteria - output voltage of power supply module satisfies the rated output voltage.
Operability tests	See Table 5-18
Prudency tests	See Table 5-19
Burn-in test	Confirm that there is no initial failure

c.2) Operability Test
Procedure of operability test indicated in Figure 5-16 (Test 1 to 5) is shown in Table 5-18. Operability test consists of the following confirmation: accuracy, response time, discrete output operability, timer, failure to complete scan detection, failover operability, and loss of power.

Table 5-18 Operability Test

Figure 5-17 Response Time Test for Analog Input to Digital Output

c.3) Prudency Test
Procedure of operability test indicated in Figure 5-16 (Test 1 and 2) is shown in Table 5-19.

Table 5-19 Prudency Test

Test Item	Procedure
Burst of Events	Input the analog and digital signals and confirm the following: - All input waveforms are observed and the signals are within the range of criteria. - The frequency of pulse output satisfies the criteria.
Faults Simulation	To simulate failure mode, disconnect the communication interface to a bus master module and I/O chassis to confirm that the system transits to failure mode successfully.

d) Acceptance Criteria

Following criteria derived from the hardware specification shall be satisfied.

Table 5-20 Criteria (Part 1 to 3)

Table 5-21 Criteria (Part 4)

Table 5-22 Criteria (Part 5)

Table 5-23 Criteria (Part 6)

Table 5-24 Criteria (Part 7)

5.1.2 Procedure of Seismic Qualification Testing

The seismic qualification testing confirms that the MELTAC platform maintains structural integrity and correct functional operation during and after a design basis seismic vibration. Seismic testing is part of the overall system seismic qualification which ensures there is no negative effect on the safety protection function of the equipment in case an earthquake occurs during plant operation.

5.1.2.1 Applicable Regulatory Guides, Codes, and Standards

See Table 5-25 for applicable regulatory guides, codes, and standards.

Table 5-25 Applicable Regulatory Guides, Codes, and Standards of Seismic Qualification Test Procedure

Name	Title
RG 1.100 Revision 3	Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants.
IEEE Std. 344-2004	IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.

5.1.2.2 Test Item

The two test items below are to be performed in this test according to IEEE Std.344-2004.

Table 5-26 Test Items of Seismic Qualification Test

Test Item	Reference
Resonance Sweep Test	5.1.2.7.1
Sine Beat Wave Test	5.1.2.7.2

A platform integrity check test is performed to confirm the maintenance of functions during and after seismic testing. See Table 5-35, Table 5-36 and Table 5-37 for details.

5.1.2.3 Equipment Under Test (EUT)

5.1.2.3.1 Test Subjects

See Table 5-27 for test subjects.

Table 5-27 Test Subjects of Seismic Qualification Test (Part 1)

Table 5-28 Test Subjects of Seismic Qualification Test (Part 2)

Table 5-29 Test Subjects of Seismic Qualification Test (Part 3)

Table 5-30 Test Subjects of Seismic Qualification Test (Part 4)

Table 5-31 Test Subjects of Seismic Qualification Test (Part 5)

Table 5-32 Test Subjects of Seismic Qualification Test (Part 6)

5.1.2.3.2 EUT Layout and Assembling

See Figure 5-18 through Figure 5-23 for EUT layout, and Figure 5-24 for assembly drawing.

Figure 5-18 EUT Layout of Seismic Qualification Test (Part 1)

Figure 5-19 EUT Layout of Seismic Qualification Test (Part 2)

Figure 5-20 EUT Layout of Seismic Qualification Test (Part 3)

Figure 5-21 EUT Layout of Seismic Qualification Test (Part 4)

Figure 5-22 EUT Layout of Seismic Qualification Test (Part 5)

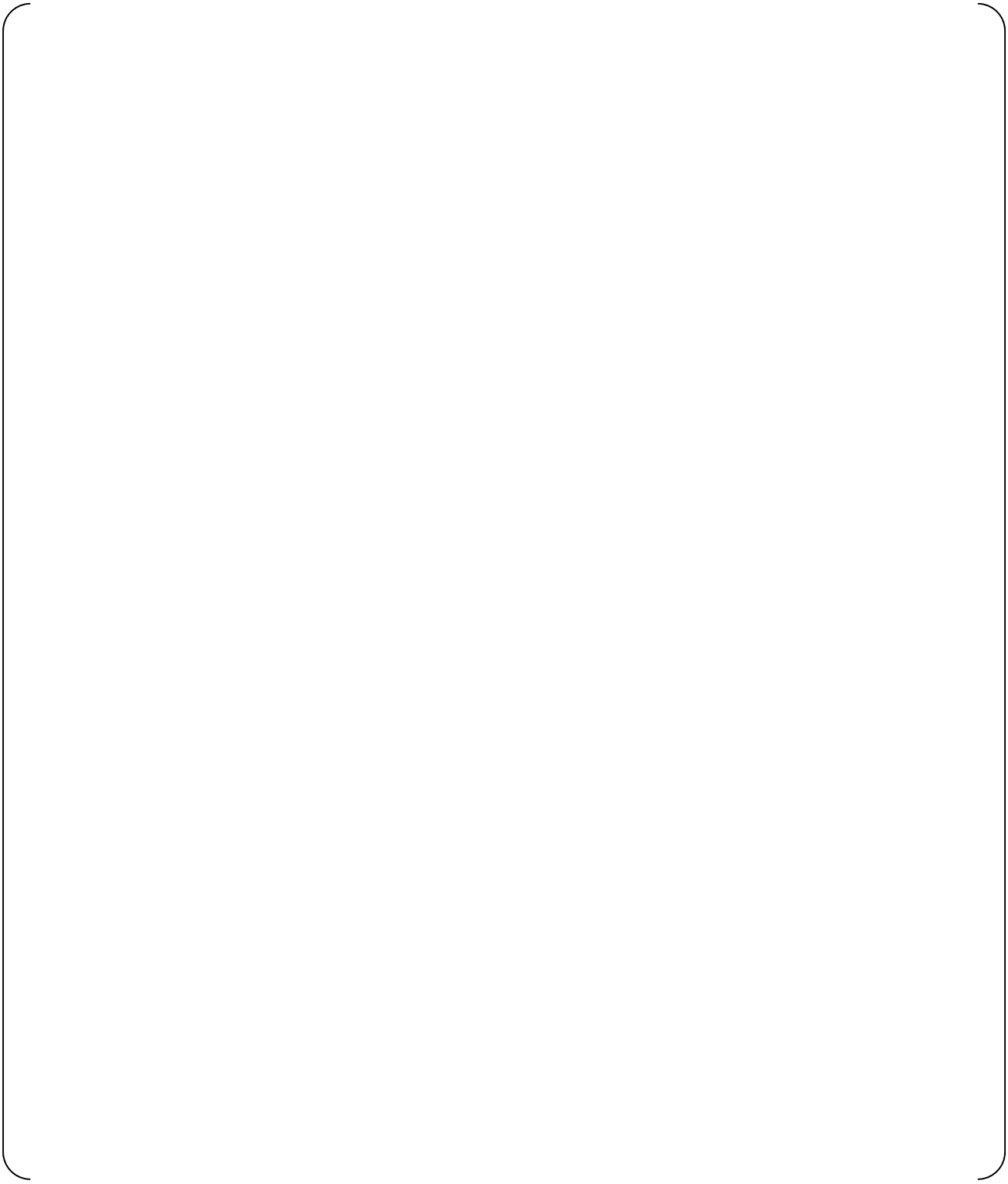

Figure 5-23 EUT Layout of Seismic Qualification Test (Part 6)

Figure 5-24 Example of Assembly Drawing of EUT of Seismic Qualification Test

5.1.2.3.3 EUT Configuration

See Figure 5-25 through Figure 5-30 for EUT configuration.

Figure 5-25 EUT Configuration of Seismic Qualification Test (Part 1)

Figure 5-26 EUT Configuration of Seismic Qualification Test (Part 2)

Figure 5-27 EUT Configuration of Seismic Qualification Test (Part 3)

Figure 5-28 EUT Configuration of Seismic Qualification Test (Part 4)

Figure 5-29 EUT Configuration of Seismic Qualification Test (Part 5)

Figure 5-30 EUT Configuration of Seismic Qualification Test (Part 6)

5.1.2.4 Test Instrumentation

See Table 5-33 and Table 5-34 for test instrumentation.

Table 5-33 Test Instrumentation of Seismic Qualification Test (Part 1 through 6) (1/2)

Table 5-34 Test Instrumentation of Seismic Qualification Test (Part 1 to 6) (2/2)

5.1.2.5 Test Site and Test Period

Seismic Test Equipment in Mitsubishi Electric Corporation Energy Systems Center
(Table Size: 1000mm x 1000mm, Available Seismic Frequency Range: 1-2000Hz)

From Nov. 2, 2015 to Nov. 26, 2015(Part1)
From Feb.20, 2017 to May. 15, 2017 (Part2 to 6)

5.1.2.6 Detail of System Level (Cabinet) Test

For the Cabinet Seismic Resistance Test, a specimen that simulates a fully loaded safety protection system cabinet is prepared. The loading configuration represents the worst case expected stress on internal mounting hardware. The MELTAC modules for the Cabinet Seismic Resistance Test are shown in Appendix A.
For module types with similar circuit electronics whose differences will have no impact on environmental test results, such as NO vs. NC contacts or differences in input ranges, one typical module type is selected.
[

]

5.1.2.7 Detail of the Module Level Test

5.1.2.7.1 Resonance Sweep Test

a) Purpose
To confirm any vibration amplifications due to resonance in the test subject, the components are vibration-excited under the following conditions and the characteristic frequency is confirmed.

b) Test Subject
See 5.1.2.3 for test subject.

c) Method
[

]

Figure 5-31 Vibration Frequency (X-Axis)

Figure 5-32 Vibration Frequency (Y-Axis)

Figure 5-33 Vibration Frequency (Z-Axis)

d) Acceptance Criteria

[

]

5.1.2.7.2 Sine Beat Wave Test

a) Purpose
To confirm the sine beat wave resistance of the test subjects.

b) Test Subject
See 5.1.2.3 for test subject.
The cabinet is vibration-excited with the sine beat wave of multiple single frequencies.

c) Method
[

]

Table 5-35 Test Items for Pre-Qualification Testing of Seismic Qualification Test

Test item	Procedure
Initial calibration	Initial calibration of I/O modules and power supply.
Operability tests	See Table 5-36.
Prudency tests	See Table 5-37.
Burn-in test	Confirm that there is no initial failure

Table 5-36 Test Items for Operability Tests of Seismic Qualification Test

Figure 5-34 Response Time Test for Analog Input to Digital Output

Table 5-37 Test Items of Prudency Tests of Seismic Qualification Test

Test Item	Procedure
Burst of Events	Input the analog and digital signals and confirm the following: - All input waveforms are observed and the signals are within the range of criteria. - The frequency of pulse output satisfies the criteria.
Faults Simulation	To simulate failure mode, disconnect the communication interface to a bus master module and I/O chassis to confirm that the system transits to failure mode successfully.

[

]

Table 5-38 Criteria of Seismic Qualification Test (Part 1)

Table 5-39 Criteria of Seismic Qualification Test (Part 2)

Table 5-40 Criteria of Seismic Qualification Test (Part 3)

Table 5-41 Criteria of Seismic Qualification Test (Part 4)

Table 5-42 Criteria of Seismic Qualification Test (Part 5)

Table 5-43 Criteria of Seismic Qualification Test (Part 6)

5.1.3 Procedure of Electromagnetic Compatibility (EMC) and Radio Frequency Interference (RFI) and Electrostatic Discharge (ESD) Qualification Testing

The EMI/RFI emission and susceptibility tests are performed for the MELTAC platform shown in the methods and acceptance criteria of RG 1.180. The EMC qualification to RG 1.180 is confirmed for the MELTAC platform. The tests are performed with a MELTAC cabinet fully equipped with a typical configuration of the MELTAC components required for the safety protection system.
The ESD test is performed under IEC 61000-4-2 with test level-2, in accordance with Annex A (maximum charge voltage is 8 kV, 15 kV). This maximum charge voltage is considered from the MELTAC cabinet being installed on the floor using antistatic materials or concrete.
To avoid any special ESD maintenance precautions for US applications, an additional ESD test is also performed to level-4. This section describes the test and acceptance criteria.

5.1.3.1 Applicable Regulatory Guides, Codes, and Standards

See Table 5-44 for applicable regulatory guides, codes, and standards.

Table 5-44 Applicable Regulatory Guides, Codes, and Standards of EMC, RFI and ESD Qualification Test Procedure

Name	Title
RG 1.180 Revision 1	Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems
RG 1.204 Revision 0	Guidelines for Lightning Protection of Nuclear Power Plants
MIL-STD-461E	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
ANSI Std.62.41-1991	IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
ANSI Std. 62.45-1992	IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits
IEEE Std. 472-1974	IEEE Guide for Surge Withstand Capability (SWC) Tests
IEC 61000-4-4 2004	Testing and measurement techniques – Electrical fast transient/burst immunity test
IEC 61000-4-5 2005	Testing and measurement techniques – Surge immunity test
IEC 61000-4-12 2006	Testing and measurement techniques – Ring wave immunity test
IEC 61000-4-2 1999	Testing and measurement techniques – Electrostatic discharge immunity tests. Basic EMC publication

5.1.3.2 Test Item

The specific test methods used for the EMI/RFI emission and susceptibility tests are described in Table 5-45 as specified by MIL-STD-461E.
An Oscillatory Wave Test related to surge withstand capability is performed for the MELTAC modules with considering IEEE Std. 472. The following test parameters are applied: a frequency range of 1 MHz, first peak voltage range of more than 2.5 kV and repetitive rate of more than 50 tests per second for a period of more than 2 seconds.
[

]

Table 5-45 Test Items of EMI, RFI and ESD Tests of EMC, RFI and ESD Qualification Test Procedure

Test Item	Description	Reference
CE101	Conducted emissions, low frequency, 120 Hz to 10 kHz	5.1.3.6.1
CE102	Conducted emissions, high frequency, 10 kHz to 2 MHz	5.1.3.6.2
RE101	Radiated emissions, magnetic field, 30 Hz to 100 kHz	5.1.3.6.3
RE102	Radiated emissions, electric field, 2 MHz to 1 GHz, 1 GHz to 10 GHz	5.1.3.6.4
CS101	Conducted susceptibility, low frequency, 120 Hz to 150 kHz	5.1.3.7.1
CS114	Conducted susceptibility, high frequency, 10 kHz to 30 MHz	5.1.3.7.2 5.1.3.7.3
CS115	Conducted susceptibility, bulk cable injection, impulse excitation	5.1.3.7.4
CS116	Conducted susceptibility, damped sinusoidal transients, 10 kHz to 100 MHz	5.1.3.7.5
RS103	Radiated susceptibility, electric field, 30 MHz to 1 GHz, 1 GHz to 10 GHz	5.1.3.7.6
IEC 61000-4-12	Surge Withstand Capability, Ring Wave	5.1.3.8.1
IEC 61000-4-5	Surge Withstand Capability, Combination Wave	5.1.3.8.2
IEC 61000-4-4	Surge Withstand Capability, Electrically Fast Transients/Bursts	5.1.3.8.3
IEC 61000-4-2	ESD Test	5.1.3.9

5.1.3.3 Equipment Under Test (EUT)

The test is performed with the MELTAC cabinet fully equipped with a typical configuration of the MELTAC components required for a safety protection system.

5.1.3.3.1 Test Subject

Test subjects are listed in Table 5-46 and Table 5-47.Performance check is done for the all specimen.
For module types whose differences will have no impact on EMC test results, such as NO vs. NC contacts or differences in input ranges, one typical module type is selected.

Table 5-46 Test Subjects of EMC, RFI and ESD Test (Part 1)

Table 5-47 Test Subjects of EMC, RFI and ESD Test (Part 2 and 3)

5.1.3.3.2 EUT Layout

The equipment under test (EUT) is comprised of 2 cabinets as shown in Figure 5-35: the CPU cabinet fitted with the CPU Chassis, E/O Converter Chassis, Optical Switch and Power Supply Modules, and the I/O cabinet fitted with the I/O Chassis, Power Interface Chassis, Isolation Chassis and Power Supply Modules. In order to attain the cabinet layout similar to the actual cabinet layout, the 2 cabinets are placed side by side with no space in between, thus acquiring the integral configuration. The cabinets are tested with the doors open to duplicate worst case conditions expected during testing and maintenance. The EUT also includes the safety VDU panel that is placed separately from the cabinet.
The power to the safety VDU panel is supplied from the CPU cabinet and connected with the power cable and the signal cable. The EUT includes the module types required for safety protection system, as shown in Appendix A.

Figure 5-35 EUT Layout (Part 1)

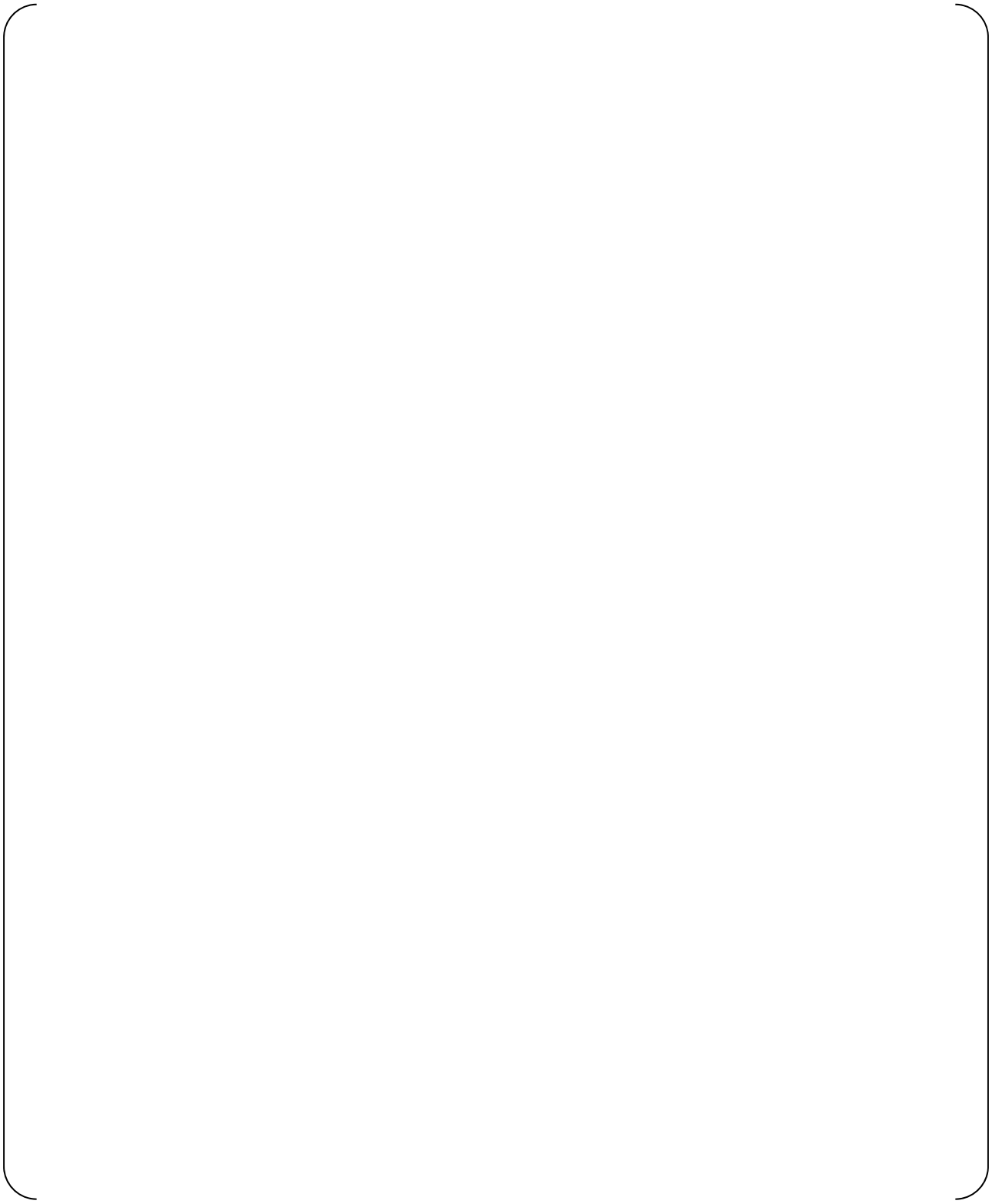

Figure 5-36 EUT Layout (Part 2 and 3)

Figure 5-37 Layout of Modules on CPU Module Chassis (Part 1)

Figure 5-38 Layout of Modules on CPU Module Chassis (Part 2)

Figure 5-39 Layout of Modules on I/O, PIF, Isolation Module Chassis (Part 1)

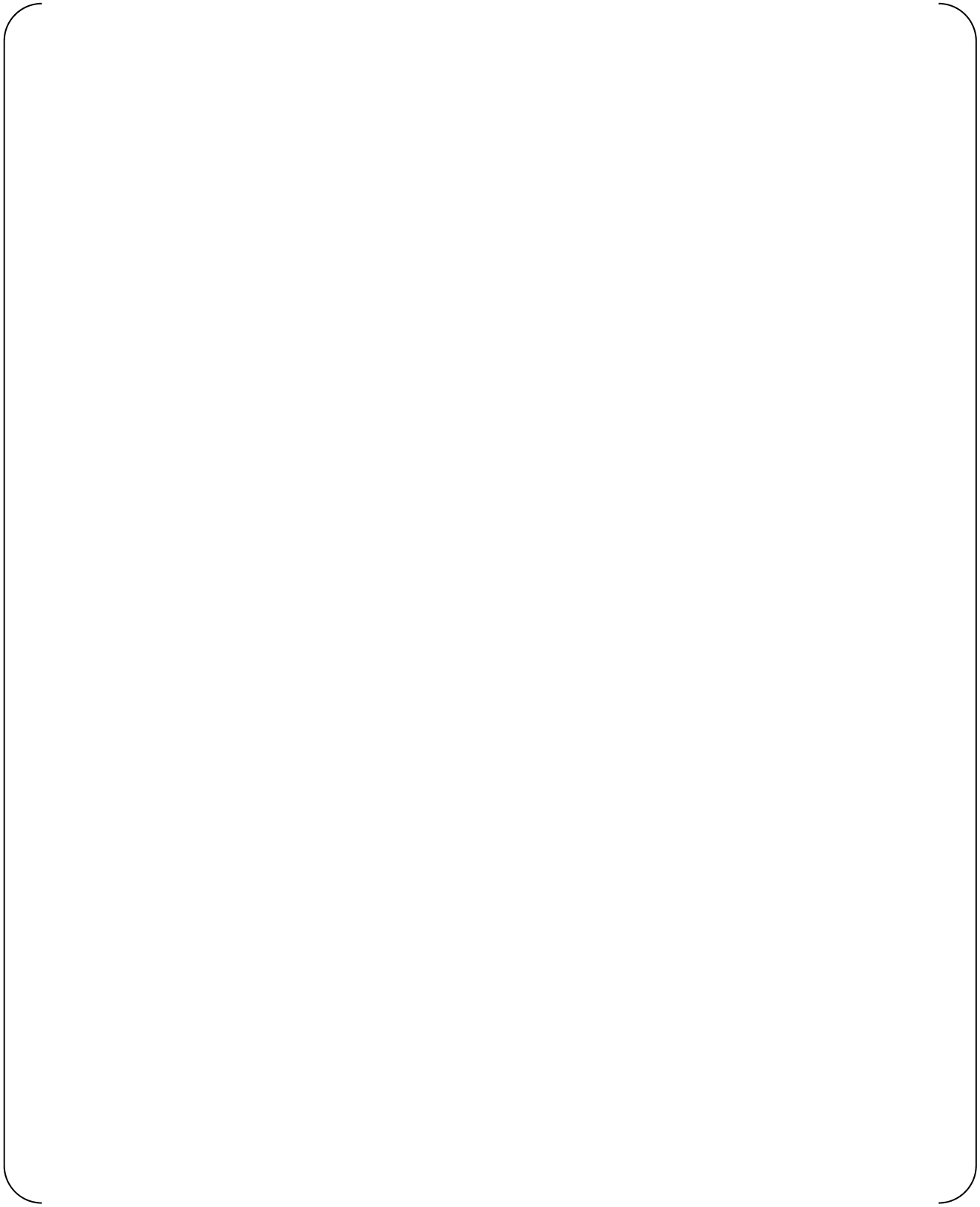

Figure 5-40 Layout of Modules on I/O, PIF, Isolation Module Chassis (Part 2)

5.1.3.3.3 EUT Configuration

Block diagram of EUT signal line connection and transmission are shown in Figure 5-41 and Figure 5-42.

Figure 5-41 EUT Block Diagram (Signal Line Connection) (Part 1)

Figure 5-42 EUT Block Diagram (Signal Line Connection) (Part 2)

Block diagram of EUT power supply is shown in Figure 5-43 and Figure 5-44.
The AC power to the EUT is supplied from 2 systems: main and standby. Since both power sources with the EUT have the same configuration, the tests for AC input power line of CE102, CS101, CS114 and IEC 61000-4 are performed for each AC power cable.
The difference between Test Part 2 and 3 is the configuration of AC power source beyond LISN (Line Impedance Stabilization Network), which MIL-STD-461E does not specify. This difference is explained in the later section (5.2.3.5, Figure 5-51 and Figure 5-52)

Figure 5-43 EUT Block Diagram (Power Supply Connection) (Part 1)

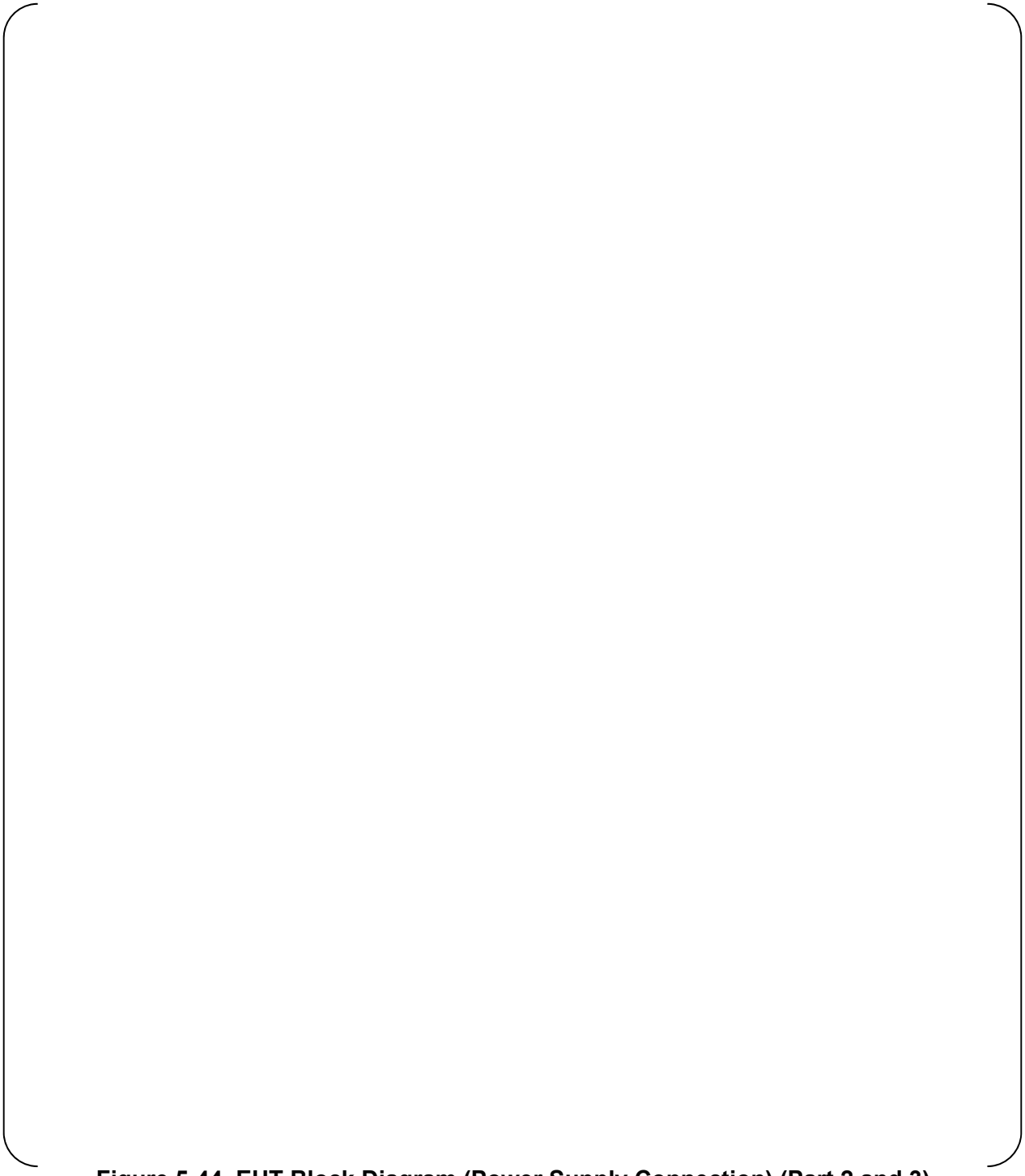

Figure 5-44 EUT Block Diagram (Power Supply Connection) (Part 2 and 3)

5.1.3.4 Test Instrumentation

Test instrumentation used in the test is shown in Table 5-48 and Table 5-49.
All instrumentations are calibrated and the calibration records are traceable to the authenticated calibration organization.

Table 5-48 Test Instrumentation (Part 1)

Table 5-49 Test Instrumentation (Part 2 and 3)

5.1.3.5 Test Site and Test Period

[

]

5.1.3.6 Detail of the Test (Emissions)

5.1.3.6.1 Low Frequency (CE101) Test

The test is performed according to the method set forth in MIL-STD-461E, as follows:

a) Purpose
The conducted emissions from the input power lead cable of the EUT are confirmed that the electromagnetic conducted emissions from the EUT do not exceed the specified value.

b) Test Subject
The test subject is the AC input power lead cable including the return and ground cable of the EUT.

c) Method
Connect a current probe with EUT on a location 5 cm from LISN and turn on the EUT and allow sufficient time for stabilization. Turn on the EUT and allow sufficient time for stabilization.
Scan the measurement receiver over the applicable frequency range, using the bandwidths and minimum measurement times specified in Table II of MIL-STD-461E.

d) Acceptance Criteria
[

]

5.1.3.6.2 High Frequency (CE102) Test

The test is performed according to the method set forth in MIL-STD-461E, as follows:

a) Purpose
The conducted emissions from the input power lead cable of the EUT are confirmed to confirm that the electromagnetic conducted emissions from the EUT do not exceed the specified value.

b) Subject
The test subject is the AC input power lead cable including the return and ground cable of the EUT.

c) Method
Connect the EMI Test receiver to the 20dB attenuator on the signal output port of the LISN and turn on the EUT and allow sufficient time for stabilization.
Scan the measurement receiver over the applicable frequency range, using the bandwidths and minimum measurement times specified in Table II of MIL-STD-461E.

d) Acceptance Criteria
[

]

5.1.3.6.3 Magnetic Field (RE101) Test

The test is performed according to the method set forth in MIL-STD-461E, as follows:

a) Purpose
A loop sensor is placed on the surface of the object EUT to confirm that the magnetic field radiated emissions from the EUT do not exceed the specified value.

b) Subject
The test subjects are the EUT enclosure, the electrical cable interface and the safety VDU panel. The 4 surfaces are scanned for 360 degrees with the loop sensor positioned at the center of the location (height) where the module is mounted.

c) Method
Locate the loop sensor 7cm from the EUT face and scan the measurement receiver over the applicable frequency range, using the bandwidths and minimum measurement times specified in Table II of MIL-STD-461E.

d) Acceptance Criteria
[

]

5.1.3.6.4 Electric Field (RE102) Test

The test is performed according to the method set forth in MIL-STD-461E, as follows:

a) Purpose

Antennas are placed at the position specified for each frequency range from the border of the setup environment including the interface cable in order to confirm that the electric field radiated emissions from the EUT do not exceed the specified value.

b) Subject

The test subjects are the EUT enclosure, all interface cables, and the safety VDU panel.

c) Method

Position antennas 1m from the front edge of the EUT. Position 104cm rod antenna on floor ground plane and the others 1m, 1.5m and 2m above floor ground plane in consideration of tall EUT enclosure. Above 30MHz, orient the antennas for both horizontally and vertically polarized fields. Scan the measurement receiver over the applicable frequency range.

d) Acceptance Criteria

[

]

5.1.3.7 Detail of the Test (Susceptibility)

5.1.3.7.1 Low Frequency (CS101) Test for Power Leads

According to Section 4 of RG 1.180, the CS101 test is mentioned as the MIL-STD-461E test method that can be applied for testing the conducted EMI/RFI susceptibility of power leads. This test method is not applied to the signal lead.
The test is performed according to the method set forth in MIL-STD-461E, as follows:

a) Purpose
Confirm that the EUT can withstand the signal connected to the AC input power lead.

b) Subject
The test subject is the AC input power lead to the EUT.

c) Method
Set the signal generator to the lowest test frequency. Increase the signal level until the required voltage level is reached on the power lead. Scan through the required frequency range at a rate no greater than specified in Table. III of MIL-STD-461E

d) Acceptance Criteria
[

]

5.1.3.7.2 High Frequency (CS114) Test for Power Leads

The CS114 test is applicable to all interconnecting leads including the power leads of the EUT. This section describes the CS114 test that is applied to the power and control lines described in Section 4.1.2 of RG 1.180.
The test is performed according to the method set forth in MIL-STD-461E, as follows:

a) Purpose
Confirm that the EUT can withstand the RF signals coupled onto the EUT associated cabling.

b) Subject
One each of the AC input power cables and the control cables (input and output cables of the Digital I/O Modules and Power Interface Module) to the EUT.

c) Method
Set the signal generator to 10kHz with 1kHz pulse modulation, 50% duty cycle, and apply the forward power level to the injection probe while monitoring the induced current.
Scan the required frequency range in 4.3.10.4.1 and Table III of MIL-STD-461E.

d) Acceptance Criteria
[

]

5.1.3.7.3 High Frequency (CS114) Test for Signal Leads

The CS114 test is applicable to all interconnecting leads including the power leads of the EUT. This section describes the CS114 test that is applied to the signal line described in Section 4.2 of RG 1.180.
The test is performed according to the method set forth in MIL-STD-461E, as follows:

a) Purpose
Confirm that the EUT can withstand the RF signals coupled onto the EUT associated cabling.

b) Subject
One of each of the signal cables (input and output cables of the Analog I/O Modules, the Isolation Modules and the RGB cables) to the EUT.

c) Method
Set the signal generator to 10kHz with 1kHz pulse modulation, 50% duty cycle, and apply the forward power level to the injection probe while monitoring the induced current. Scan the required frequency range in 4.3.10.4.1 and Table III of MIL-STD-461E.

d) Acceptance Criteria
[

]

5.1.3.7.4 Bulk Cable Injection, Impulse Excitation (CS115) Test

According to Section 4.2 of RG 1.180, the CS115 test is mentioned as the MIL-STD-461E test method that can be applied as the conducted EMI/RFI susceptibility test along the signal leads. This test method is not applied to the power lead.
The test is performed according to the method set forth in MIL-STD-461E as follows:

a) Purpose
Confirm that the EUT can withstand the impulse signals coupled onto the EUT associated cabling.

b) Subject
One of each of the signal cables (input and output cables of the Analog I/O Modules, the Digital I/O Modules, the PIF Module, the Isolation Modules and the RGB cables) to the EUT.

c) Method
Adjust the pulse generator for the amplitude setting determined in calibration to make current level 2A and apply the test signal at the pulse repetition rate and for the duration specified in the requirement. Monitor the EUT for degradation of performance.

d) Acceptance Criteria
[

]

5.1.3.7.5 Damped Sinusoidal Transients (CS116) Test

According to Section 4.2 of RG 1.180, the CS116 test is stated as the MIL-STD-461E test method that can be applied as the conducted EMI/RFI susceptibility test along the signal cables. This test method is not applied to the power lead.
The test is performed according to the method set forth in MIL-STD-461E as follows:

a) Purpose
Confirm that the EUT can withstand the damped sinusoidal transients coupled onto the EUT associated cabling.

b) Subject
One each of the signal cables (input and output cables of the Analog I/O Modules, the Digital I/O Modules, the PIF Module, the Isolation Modules and the RGB cables) to the EUT.

c) Method
Set the damped sine generator to a test frequency and apply the test signals to each cable of the EUT sequentially. Monitor the EUT for degradation of performance.

d) Acceptance Criteria
[

]

5.1.3.7.6 Electric Field (RS103) Test

The test is performed according to the method set forth in MIL-STD-461E as follows:

a) Purpose
Confirm that the EUT can withstand the electric field emitted from the antenna.

b) Test Subject
The test subjects are the EUT enclosure, all interface cables, and the safety VDU panel.

The EUT enclosure is placed above the floor as in actual plant conditions to make its height 7.55 ft (2300 mm). Then the emission of the radiated electric field to the EUT enclosure comes from 4 horizontal directions because the top and the bottom parts are not likely to be affected by the electric field.

c) Method
Set the signal source to 1kHz pulse modulation, 50% duty cycle, and using appropriate amplifier and transmit antenna, establish an electric field at the test start frequency. Scan the required frequency ranges in accordance with the rates and durations specified in Table III of MIL-STD-461E.

d) Acceptance Criteria
[

]

5.1.3.8 Detail of the Test (Surge Withstand)

5.1.3.8.1 Ring Wave Test

The test is performed according to the method set forth in IEC 61000-4-12 as follows. For the withstand voltage of the test, the B Medium Exposure is selected out of the location categories described in IEEE Std. C62.41-1991 (RG 1.180 Table 22), and the corresponding surge voltage level is applied.

a) Purpose
Confirm that the EUT withstands the transient damped phenomenon (Ring Wave) generated by the low-voltage power network applied to the input power lead cable.

b) Test Subject
The test subject is the AC input power lead to the EUT.

c) Method
Set the Ring wave generator to a test voltage of 4kV and an interval of 10 seconds at an impedance 12Ω and an interval of 6 seconds at an impedance 30Ω. Inject Ring wave to each port of the EUT for 5 times. Ring wave should be injected for each of the power phase angles of 0°, 90°, and 270°.

d) Acceptance Criteria
[

]

5.1.3.8.2 Combination Wave Test

The test is performed according to the method set forth in IEC 61000-4-5 as follows. For the withstand voltage of the test, the B Medium Exposure is selected out of the location categories described in IEEE Std. C62.41-1991 (RG 1.180 Table 22), and the according surge level is applied.

a) Purpose
Confirm that the EUT withstands the unidirectional surge generated by the over-voltage due to the transient phenomenon of switching and lightning applied to the input power lead cable.

b) Subject
The test subject is the AC input power lead to the EUT.

c) Method
Set the Combination wave generator to open-circuit voltage with 4 kV peak voltage and the short-circuit current with 2 kA peak current. Inject surge noise to each port of the EUT for 5 times. Surge noise should be injected for each of the power phase angles of 0°, 90°, and 270°.

d) Acceptance Criteria
[

]

5.1.3.8.3 Electrically Fast Transients/bursts Test

The test is performed according to the method set forth in IEC 61000-4-4 as follows. For the withstand voltage of the test, the B Medium Exposure is selected out of the location categories described in IEEE Std. C62.41-1991 (RG 1.180 Table 22), and the corresponding surge voltage level is applied.

a) Purpose
Confirm that the EUT withstands the electrical fast transient/burst: EFT/B applied to the input power lead cable.

b) Test Subject
The test subject is the AC input power lead to the EUT.

c) Method
Set the EFT/B generator to test voltage of 4kV/2kV and repeated frequency of 5kHz. Inject EFT/B to each port of the EUT. The duration of injected EFT/B is 1 minute per test.

d) Acceptance Criteria
[

]

5.1.3.9 Detail of the Test (Electrostatic Discharge Qualification)

The test is performed with the MELTAC cabinet fully equipped with a typical configuration of the MELTAC components required for a safety protection system.

The MELTAC modules for the ESD test are shown in Appendix A
For module types where differences will have no impact on environmental test results, such as NO vs. NC contacts or differences in input ranges, one typical module type is selected.

For equipment that can be accessed only during maintenance, the only acceptance criteria is to ensure no equipment damage.

The ESD test is performed according to the method set forth in IEC 61000-4-2 as follows:

a) Purpose
Confirm that the EUT can withstand the ESD, where personnel can contact, such as the human-machine interface, during normal operation and when the equipment is out of service during maintenance.

b) Subject
The following equipment areas are likely to be accessible by personnel during normal operation.

- The touch panel of the safety VDU panel and the surrounding area
- The front/rear door handles of the cabinet and the surrounding area
- The switches of the Status Display Module, and the surrounding area
- The switches and fuses of the fans, and the surrounding area
- The front panel of the Power Supply Modules and Analog Output Modules

Other human-machine interface areas of the equipment are expected to be accessed only during maintenance.

c) Method
Set the ESD generator to the test voltage of 8 kV (contact discharge) and 15 kV (air discharge) and inject ESD to each human-machine interface points of the EUT for 10 times.

d) Acceptance Criteria
[

]

5.1.4 Procedure of Isolation Qualification Testing

[

]

5.1.4.1 Applicable Regulatory Guides, Codes, and Standards

See Table 5-50 for applicable regulatory guides, codes, and standards.

Table 5-50 Applicable Regulatory Guides, Codes, and Standards for Isolation Qualification Testing Procedure

Name	Title
RG 1.75 Revision 3	Criteria for Independence of Electrical Safety Systems
IEEE Std. 384-1992	IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits

5.1.4.2 Test Item

This test performs testing in accordance with Section 5.5 Isolation Qualification Testing of Safety System Digital Platform - MELTAC -Topical Report (JEXU-1041-1008 (R0)).

Table 5-51 Test Items of Isolation Qualification Testing Procedure

Test Item	Reference
Initial test	5.1.4.2.1
Differential mode injection for Non-Class 1E connection line	5.1.4.2.2
Common Mode injection for Non-Class 1E connection line	5.1.4.2.3

5.1.4.2.1 Initial Test

a) Purpose
Confirm the input accuracy of MPIJ-11 and the pulse output waveform of KIPJ-11 before starting the test.

b) Test Subject
See 5.1.4.3 for the test subject.

c) Method
Monitor the input accuracy of the MPIJ modules on the online monitor of the engineering tool PC during testing.

d) Acceptance Criteria
[

]

5.1.4.2.2 Differential Mode Test

a) Purpose
To confirm that the function electrically isolating signal on the non-protected side and signal on the protected side satisfies the specifications when differential mode noise is applied.

b) Test Subject
See 5.1.4.3 for the test subject.

c) Method
Connect the power supply system to TU and apply test condition voltage values. After the temperature rise of SPD of the test object module is saturated, confirm the minimum and maximum input values of MPIJ-11 on the online monitor of the engineering tool.
SPD may be damaged, ignite, or generate smoke depending on the applied voltage; continue applying voltage until temperature is saturated even in such a case.

d) Acceptance Criteria
[

]

5.1.4.2.3 Common Mode Test

a) Purpose
To confirm that the function electrically isolating signal on the non-protected side and signal on the protected side satisfies the specifications when common mode noise is applied.

b) Test Subject
See 5.1.4.3 for the test subject.

c) Method
Connect the power supply system to TU and the ground and apply test condition voltage values. After the temperature rise of SPD of the test object module is saturated, confirm the minimum and maximum input values of MPIJ-11 on the online monitor of the engineering tool. SPD may be damaged, ignite, or generate smoke depending on the applied voltage; continue applying voltage until temperature is saturated even in such a case.

d) Acceptance Criteria
[

]

5.1.4.3 Equipment Under Test (EUT)

5.1.4.3.1 Test Subject

See Table 5-52 and Table 5-53 for test subjects.

Table 5-52 Test Subjects of Isolation Qualification Testing Procedure (Part 1)

Table 5-53 Test Subjects of Isolation Qualification Testing Procedure (Part 2)

5.1.4.3.2 EUT Layout

See Figure 5-45 and Table 5-46 for EUT layout.

Figure 5-45 EUT Layout of Isolation Qualification Testing Procedure (Part 1)

Figure 5-46 EUT Layout of Isolation Qualification Testing Procedure (Part 2)

5.1.4.3.3 EUT Configuration

See Figure 5-47, Figure 5-48 for EUT configurations.

Figure 5-47 Configuration of Isolation Qualification Testing (CPU) (Part 1)

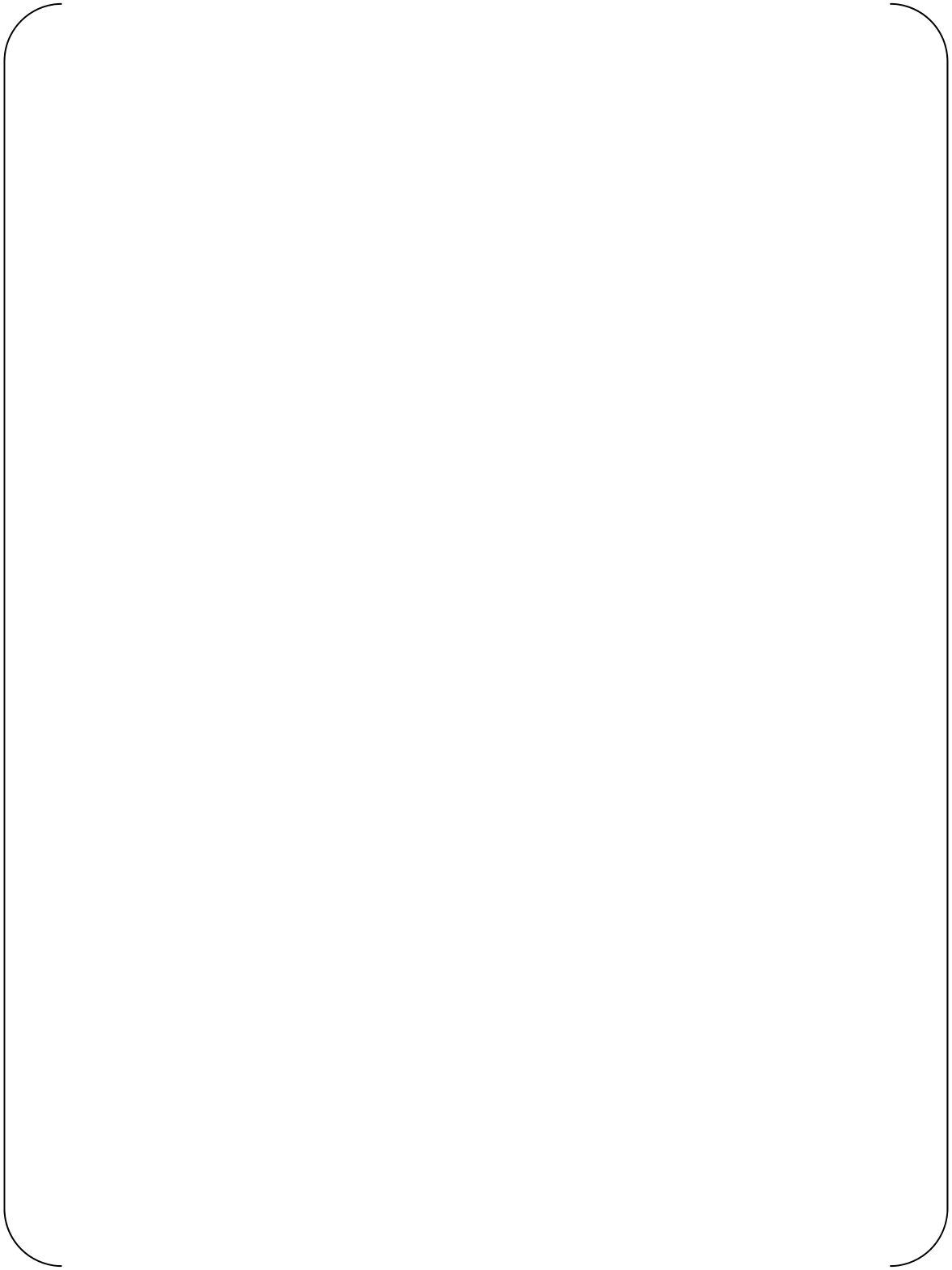

Figure 5-48 Isolation Test Configuration of Isolation Qualification Testing (I/O) (Part 1)

Figure 5-49 Configuration of Isolation Qualification Testing (I/O) (Part 2)

5.1.4.4 Test Instrumentation

See Table 5-54 and Table 5-55 for test instrumentation.

Table 5-54 Test Instrumentation of Isolation Qualification Testing Procedure (Part 1)

Table 5-55 Test Instrumentation of Isolation Qualification Testing Procedure (Part 2)

5.1.4.5 Test Site and Test Period

PART1
Mitsubishi Electric Corporation Energy Systems Center
On Nov 17, 2015

PART2
Mitsubishi Electric Corporation Energy Systems Center
From Mar. 31, 2017 to Apr. 7, 2017

5.2 Qualification Test Results

This section describes the results of each qualification test.

5.2.1 Results of Environmental Qualification Testing

[

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Table 5-56 Test Results of Environmental Qualification Test

Test Item	Result	Reference
Temperature and Humidity Test	Passed	5.2.1.5 in this document.
Temperature and Humidity Characteristic Test	Passed	5.2.1.2 in this document.
Hot/Cold Start Test	Passed	5.2.1.3 in this document.
Temperature Cycle Test	Passed	5.2.1.4 in this document.

5.2.1.1 Burn-in

Criteria for operability test shown in Table 5-20 are satisfied.

5.2.1.2 Temperature and Humidity Characteristic Test

In this test, it was confirmed that the resulting accuracy of the Operability Test satisfies the criteria and specification of the module **[**
].

5.2.1.3 Hot/Cold Start Test

[

]

1. In the high-temperature environment and low-temperature environment, it was confirmed that tested modules start up normally.
2. In Operability Test after the modules start up normally, it was confirmed that basic functions (analog input accuracy, output operation) satisfies the operability Test criteria described in Table 5-12.

5.2.1.4 Temperature Cycle Test

With changing the temperature and humidity based on the temperature profile according to the test conditions, monitoring for anomalies in self-diagnosis is performed during a cycle and Operability Test. Prudency Testing is performed after a fixed cycle is finished.
1. In the high-temperature and low-temperature cycle change environment, it is confirmed that anomalies did not occur in the test subject module.
2. After the cycle is finished, it was confirmed that Operability Testing and Prudency Testings satisfies the criteria.

5.2.1.5 Temperature and Humidity Test

With changing the temperature and humidity based on the temperature profile according to the test conditions, Pre-qualification, Operability, Prudency Test were performed under the Test Condition.
Figure 5-25 shows the actual Temperature and Humidity Test profile attainable in the Ambient Chamber in Mitsubishi Electric Corporation Energy Systems Center.

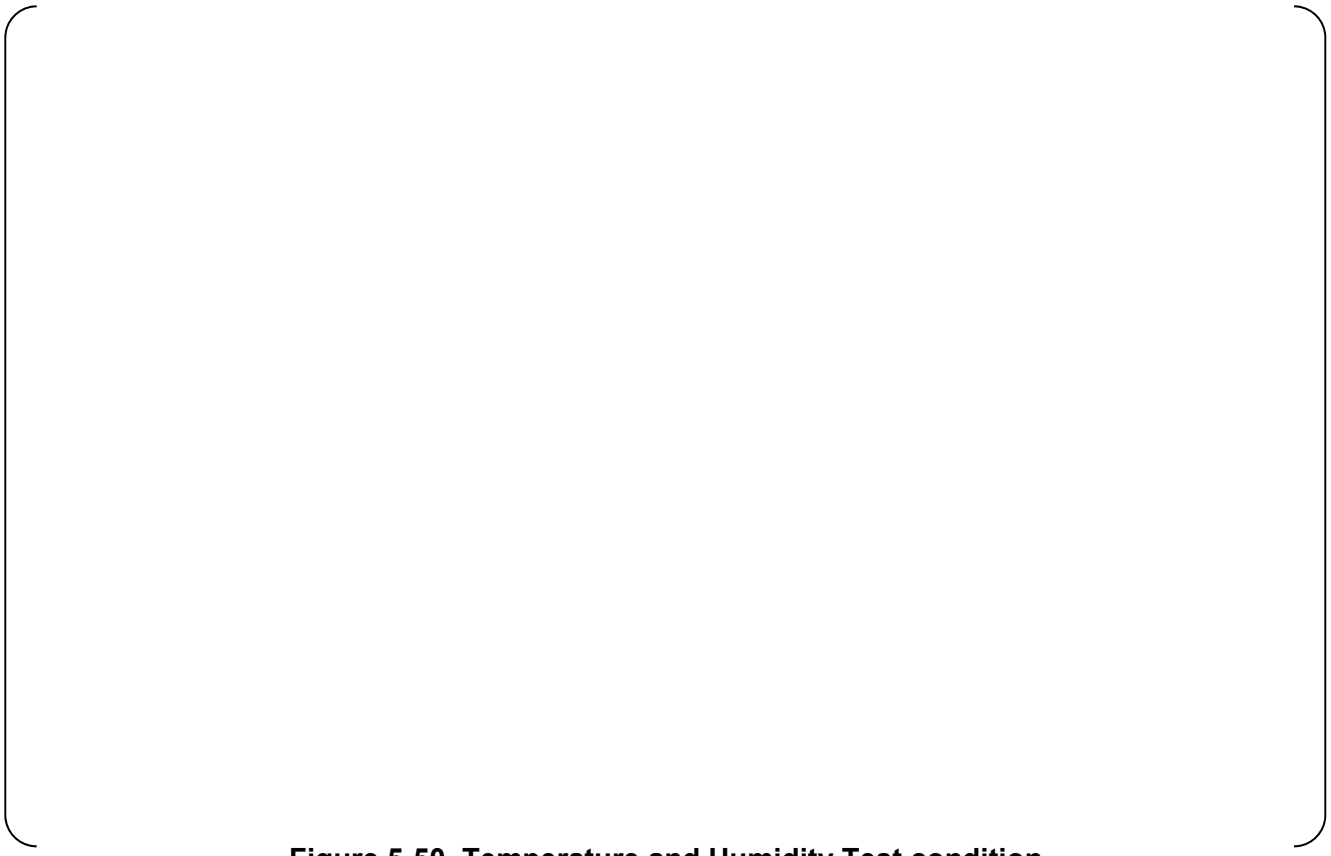

Figure 5-50 Temperature and Humidity Test condition

[

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5.2.1.6 Conclusion

From the results of this test, it is confirmed that the tested module maintains functional and performance soundness **[ ]**

5.2.2 Results of Seismic Qualification Testing

[

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For the system level (cabinet) tests, results will be added to this section upon test completion.

Table 5-57 Test Results of Seismic Qualification Test

Test Item	Result	Reference
Resonance Sweep Test	Passed	5.2.2.1 in this document.
Sine Beat Wave Test	Passed	5.2.2.2 in this document.

5.2.2.1 Resonance Sweep Test

The result of the response sweep test confirmed that there was no natural frequency **[**

]

The result of the response sweep test confirmed that there was no breakage in the unit or disconnection/looseness of the joint areas in X, Y, and Z directions for all the test subject modules.

Table 5-58 Results of Resonance Sweep Test

5.2.2.2 Sine Beat Wave Test

The result of the sine beat test confirmed that there is no breakage in the unit or disconnection/looseness of the joint areas in X, Y, and Z directions for all the test subject modules.
Confirmed that the CPU operated normally without error before, during, and after the sine beat test for all the test subject modules.

Table 5-59 Results of Sine Beat Wave Test

[

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5.2.2.3 Conclusion

The test results showed that all the test modules maintain the functional and structural integrity **[**

]

5.2.3 Results of Electromagnetic Compatibility and Radio Frequency Interference and Electrostatic Discharge (ESD) Qualification Testing

The test is performed in accordance with MIL-STD-461E.
For EUT configuring redundant parallel or redundant standby system, redundant power supply lines are used. All Emission/Immunity tests for power leads tests both power leads one by one.
As shown in Table 5-60, results of all test items are acceptable.

Table 5-60 Test Results (Part 1)

Table 5-61 Test Results (Part 2)

Table 5-62 Test Results (Part 3)

5.2.3.1 Emissions

5.2.3.1.1 Low Frequency (CE101) Test

The MELTAC platform passed the high frequency emission test performed in accordance with MIL-STD-461E, CE101.
[

]

Table 5-63 Result of Low Frequency Test (CE101) (Part 1)

Table 5-64 Result of Low Frequency Test (CE101) (Part 2)

5.2.3.1.2 High Frequency (CE102) Test

The MELTAC platform passed the high frequency emission test performed in accordance with MIL-STD-461E, CE102.

[

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Table 5-65 Result of High Frequency Test (CE102) (Part 1)

Table 5-66 Result of High Frequency Test (CE102) (Part 2)

Table 5-67 Result of High Frequency Test (CE102) (Part 3)

5.2.3.1.3 Magnetic Field (RE101) Test

The MELTAC platform passed the magnetic emission test performed in accordance with MIL-STD-461E, RE101.

[

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Table 5-68 Result of Magnetic Field Test (RE101) Part 1

Table 5-69 Result of Magnetic Field Test (RE101) Part 2

5.2.3.1.4 Electric Field (RE102) Test

The MELTAC platform passed the electric field emission test performed in accordance with MIL-STD-461E, RE102.
[

]

Table 5-70 Result of Electric Field Test (RE102) Part 1

Table 5-71 Result of Electric Field Test (RE102) Part 2

5.2.3.2 Susceptibility

5.2.3.2.1 Low Frequency (CS101) Test for Power Leads

The MELTAC platform passed the low frequency susceptibility test for power lead performed in accordance with MIL-STD-461E, CS101.
[

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Table 5-72 Result of Susceptibility Test (CS101) Part 1

Table 5-73 Result of Susceptibility Test (CS101) Part 2

5.2.3.2.2 High Frequency (CS114) Test for Power Leads

The MELTAC platform passed the High frequency susceptibility test for power lead performed in accordance with MIL-STD-461E, CS114.
[

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Table 5-74 Result of Susceptibility Test (CS114, Power Leads) (Part 1)

Table 5-75 Result of Susceptibility Test (CS114, Power Leads Main) (Part 2)

Table 5-76 Result of Susceptibility Test (CS114, Power Leads Standby) (Part 2)

5.2.3.2.3 High Frequency (CS114) Test for Signal Leads

The MELTAC platform passed the high frequency susceptibility test for signal lead performed in accordance with MIL-STD-461E, CS114.
[

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Table 5-77 Result of Susceptibility Test (CS114, Signal Leads) (Part 1)

Table 5-78 Result of Susceptibility Test (CS114, Signal Leads) CABLE1 (Part 2)

Table 5-79 Result of Susceptibility Test (CS114, Signal Leads) CABLE2 (Part 2)

Table 5-80 Result of Susceptibility Test (CS114, Signal Leads) CABLE3 (Part 2)

Table 5-81 Result of Susceptibility Test (CS114, Signal Leads) CABLE4 (Part 2)

Table 5-82 Result of Susceptibility Test (CS114, Signal Leads) CABLE5 (Part 2)

Table 5-83 Result of Susceptibility Test (CS114, Signal Leads) CABLE6 (Part 2)

Table 5-84 Result of Susceptibility Test (CS114, Signal Leads) CABLE7 (Part 2)

Table 5-85 Result of Susceptibility Test (CS114, Signal Leads) CABLE8 (Part 2)

Table 5-86 Result of Susceptibility Test (CS114, Signal Leads) CABLE9 (Part 2)

5.2.3.2.4 Bulk Cable Injection, Impulse Excitation (CS115) Test

The MELTAC platform passed the impulse excitation test performed in accordance with MIL-STD-461E, CS115.

[

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Table 5-87 Result of Susceptibility Test (CS115) (Part 1)

Table 5-88 Result of Susceptibility Test (CS115) CABLE1 (Part 2)

Table 5-89 Result of Susceptibility Test (CS115) CABLE2 (Part 2)

Table 5-90 Result of Susceptibility Test (CS115) CABLE3 (Part 2)

Table 5-91 Result of Susceptibility Test (CS115) CABLE4 (Part 2)

Table 5-92 Result of Susceptibility Test (CS115) CABLE5 (Part 2)

Table 5-93 Result of Susceptibility Test (CS115) CABLE6 (Part 2)

Table 5-94 Result of Susceptibility Test (CS115) CABLE7 (Part 2)

Table 5-95 Result of Susceptibility Test (CS115) CABLE8 (Part 2)

Table 5-96 Result of Susceptibility Test (CS115) CABLE9 (Part 2)

5.2.3.2.5 Damped Sinusoidal Transients (CS116) Test

The MELTAC platform passed the damped sinusoidal test performed in accordance with MIL-STD-461E, CS116.
[

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Table 5-97 Result of Damped Sinusoidal Transients Test (CS116) (Part 1)

Table 5-98 Result of Damped Sinusoidal Transients Test (CS116) CABLE1 (Part 2)

Table 5-99 Result of Damped Sinusoidal Transients Test (CS116) CABLE2 (Part 2)

Table 5-100 Result of Damped Sinusoidal Transients Test (CS116) CABLE3 (Part 2)

Table 5-101 Result of Damped Sinusoidal Transients Test (CS116) CABLE4 (Part 2)

Table 5-102 Result of Damped Sinusoidal Transients Test (CS116) CABLE5 (Part 2)

Table 5-103 Result of Damped Sinusoidal Transients Test (CS116) CABLE6 (Part 2)

Table 5-104 Result of Damped Sinusoidal Transients Test (CS116) CABLE7 (Part 2)

Table 5-105 Result of Damped Sinusoidal Transients Test (CS116) CABLE8 (Part 2)

Table 5-106 Result of Damped Sinusoidal Transients Test (CS116) CABLE9 (Part 2)

5.2.3.2.6 Electric Field (RS103) Test

The MELTAC platform passed the electric field test performed in accordance with MIL-STD-461E, RS103.
[

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Table 5-107 Result of Electric Field Test (RS103) (Part 1)

Table 5-108 Result of Electric Field Test (RS103) (Part 2)

5.2.3.3 Surge Withstand

5.2.3.3.1 Ring Wave Test

The MELTAC platform passed the combination wave test performed in accordance with **[**

]

Table 5-109 Result of Ring Wave Test (Part 1)

Table 5-110 Result of Ring Wave Test (Part 2)

5.2.3.3.2 Combination Wave Test

The MELTAC platform passed the combination wave test performed in accordance with IEC 61000-4-5. It was confirmed that the EUT met the susceptibility acceptance criteria defined in section 5.1.3.3.2, **[**

]

Table 5-111 Result of Combination Wave Test (Part 1)

Table 5-112 Result of Combination Wave Test (Part 2)

5.2.3.3.3 Electrically Fast Transients/bursts Test

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Table 5-113 Electrically Fast Transients/bursts Test (Part 1)

Table 5-114 Electrically Fast Transients/bursts Test (Part 2)

5.2.3.4 Electrostatic Discharge

[

]

This test demonstrated that the electrostatic discharge tests demonstrated that the MELTAC platform would continue to perform as designed under all expected electrostatic discharge conditions.

5.2.3.5 Conclusion

The test results showed that the test subject module maintains the integrity of functions and performance in all the EMC/RFI/ESD conditions described in 5.1.3 as follows.

[

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[

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Figure 5-51 Power Supply Connection on Test Site (Part 2)

Figure 5-52 Power Supply Connection on Test Site (Part 3)

[

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5.2.4 Results of Isolation Qualification Testing

The MELTAC platform passed the isolation qualification test performed in accordance with IEEE Std. 384-1992.

5.2.4.1 Initial Test

Criteria shown in 5.1.4.2.1 are satisfied.

5.2.4.2 Differential Mode Test

Table 5-115 Results of Differential Mode Test

5.2.4.3 Common Mode Test

Table 5-116 Results of Common Mode Test

[

]

5.2.4.4 Conclusion

The test results showed that the function of the test subject module electrically isolating Non-Class 1E signals and the Class 1E signals meet the design specifications as follows.

[

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6.0 QUALIFICATION BY ANALYSIS

The following modules are not tested in the Equipment Qualification tests described in Chapter 5.0. This is because modules are represented by other modules tested, or modules are application specific items.

Table 6-1 Modules not tested in the Equipment Qualification tests

APPENDIX A APPLICABLE QUALIFICATION TESTS

APPENDIX B REFERENCES

It is not possible to test all modules at once. Modules are tested in phases. If module modification affecting EQ qualification are made after EQ test or will be made (e.g. to fix other test failure), the module is not considered as EUT. If modules has not passed the EQ tests and fixed later, Re-test for modules has been done. This appendix identifies which test finally covers which module as EUT.

