Project:	TRICON v10 NUCLEAR QUALIFICATION PROJECT

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EMI/RFI
TEST REPORT

Document No: 9600164-527

Revision 2

April 30, 2008

	Name	Signature	Title
Author:	Steve Landas	See attached	R&D Engineer
Reviewers:	Ravindar Baskaran	See attached	Independent Review Engineer
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2	04/30/08	Added Supplement 1. Revised Reference 9.29 in response to NUPIC audit corrective action (Reference CAR 2528-1).	S. Landas

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1.0 EXECUTIVE SUMMARY

The TRICON v10 Nuclear Qualification Project Electromagnetic Interference / Radiofrequency Interference (EMI/RFI) Test was performed on February 16 to April 17, 2007 at National Technical Systems (NTS) Laboratories in Boxborough, Massachusetts. As required by Triconex Document No. 9600164-500, "Master Test Plan," (Reference 9.1), the EMI/RFI Test was executed to demonstrate acceptable performance of the TRICON v10 Programmable Logic Controller (PLC) in accordance with the EMI/RFI criteria specified in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.180, Revision 1, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," (Reference 9.2).

MPR Procedure No. 9600164-510, "EMI/RFI Test Procedure," (Reference 9.3) was developed in accordance with the requirements of NRC RG 1.180 (Reference 9.2), EPRI TR-107330, "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants," (Reference 9.4), Triconex Document No. 9600164-500 (Reference 9.1), and Triconex Document No. 9600164-002, "Nuclear Qualification Quality Plan," (Reference 9.5). The procedure included steps to direct: 1) proper setup of the TRICON-Under-Test (TUT) and test system prior to testing, 2) measurement of EMI/RFI emissions from the TUT components, 3) application of EMI/RFI disturbance signals to the TUT components, 4) acquisition of TUT operational parameters during testing, and 5) evaluation of acceptable TUT performance during testing. The TUT executed a verified and validated Test Specimen Application Program (TSAP) throughout EMI/RFI Testing. The TSAP revision used was "V10_TSAP_REV_0". EMI/RFI Testing was performed by MPR certified Project Test Engineers and witnessed by Triconex Project Quality Assurance.

Triconex Drawing No. 9600164-100, "TRICON v10 Nuclear Qualification Project TRICON-Under-Test, General Arrangement," (Reference 9.6), shows the basic configuration of the TUT components for EMI/RFI Testing.

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The following EMI/RFI emissions tests were performed in accordance with Department of Defense Interface Standard MIL-STD-461E, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment," (Reference 9.7):

- MIL-STD-461E, Test Method CE101, Conducted Emissions, 30 Hz to 10 kHz
- MIL-STD-461E, Test Method CE102, Conducted Emissions, 10 kHz to 2 MHz
- MIL-STD-461E, Test Method RE101, Radiated Emissions, 30 Hz to 100 kHz
- MIL-STD-461E, Test Method RE102, Radiated Emissions, 2 MHz to 1 GHz

The following EMI/RFI susceptibility tests were performed in accordance with the referenced International Electrotechnical Commission (IEC) Standards:

- IEC Standard 61000-4-3, "Electromagnetic Compatibility (EMC), Part 4-3: Testing and Measurement Techniques, Radiated, Radio-Frequency, Electromagnetic Field Immunity Test," (Reference 9.8), 26 MHz to 1 GHz
- IEC Standard 61000-4-6, "Electromagnetic Compatibility (EMC), Part 4-6: Testing and Measurement Techniques, Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields," (Reference 9.9), 150 kHz to 80 MHz
- IEC Standard 61000-4-8, "Electromagnetic Compatibility (EMC), Part 4-8: Testing and Measurement Techniques, Power Frequency Magnetic Field Immunity Test," (Reference 9.10)
- IEC Standard 61000-4-9, "Electromagnetic Compatibility (EMC), Part 4-9: Testing and Measurement Techniques, Pulse Magnetic Field Immunity Test," (Reference 9.11)
- IEC Standard 61000-4-10, "Electromagnetic Compatibility (EMC), Part 4-10: Testing and Measurement Techniques, Damped Oscillatory Magnetic Field Immunity Test," (Reference 9.12)
- IEC Standard 61000-4-13, "Electromagnetic Compatibility (EMC), Part 4-13: Testing and Measurement Techniques, Harmonics and Interharmonics Including Mains Signaling at A.C. Power Port, Low Frequency Immunity Tests," (Reference 9.13)
- IEC Standard 61000-4-16, "Electromagnetic Compatibility (EMC), Part 4-16: Testing and Measurement Techniques, Test for Immunity to Conducted, Common Mode Disturbances in the Frequency Range 0 Hz to 150 kHz," (Reference 9.14)

The EMI/RFI emissions test results demonstrate that the Triconex TRICON v10 PLC does not fully comply with the allowable emissions levels of NRC RG 1.180 (Reference 9.2) for MIL-STD-461E, CE101 and CE102 testing. The Triconex TRICON v10 PLC does fully comply with the allowable emissions levels of NRC RG 1.180 for MIL-STD-461E, RE101 and RE102 testing.

The EMI/RFI susceptibility test results show that the TRICON v10 PLC system complies with the minimum susceptibility levels required by NRC RG 1.180 (Reference 9.2). The main processors continued to function correctly throughout testing. The transfer of input and output data was not interrupted. There were no interruptions or inconsistencies in the operation of the system or the software.

The EMI/RFI susceptibility test results show that the following TRICON v10 PLC input/output hardware does not fully comply with the minimum susceptibility thresholds required by NRC RG 1.180 (Reference 9.2) for the listed susceptibility tests:

IEC Standard 61000-4-3 Testing

- RTD Signal Conditioning Module 1600083-600 (threshold levels determined)
- RTD Signal Conditioning Module 1600083-200 (threshold levels determined)
- RTD Signal Conditioning Module 1600024-030 (threshold levels determined)
- RTD Signal Conditioning Module 1600024-020 (threshold levels determined)

IEC Standard 61000-4-6 Testing

- RTD Signal Conditioning Module 1600081-001 (no threshold levels determined)
- Digital Output Module 3601T (115 VAC) w/ ETP 9663-610N (threshold levels determined)

IEC Standard 61000-4-16 Testing

- Digital Input Module 3503E (24V AC/DC) w/ ETP 9563-810N (threshold levels determined)
- Digital Output Module 3625 (24V DC) w/ ETP 9662-810N (threshold levels determined)
- Digital Output Module 3625 (24V DC) w/ ETP 9662-610N (threshold levels determined)

NOTE: The susceptibility test results given above are contingent on a TRICON v10 PLC installation design that separates and isolates the 24 VDC field power supplies to the discrete and analog input and output module circuits.

The specific TRICON v10 PLC hardware which was tested (chassis, power supplies, modules, external termination assemblies and interconnecting cabling) is identified in Triconex Document No. 9600164-540, "Master Configuration List," (Reference 9.15).

2.0 PURPOSE

The purpose of this test report is to summarize the results of EMI/RFI Testing of the TRICON v10 Nuclear Qualification Project TRICON-Under-Test (TUT) to meet the requirements of NRC RG 1.180 (Reference 9.2). The format of this test report conforms to Section 8.3.(4) of IEEE Standard 323-1974, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," (Reference 9.16).

Details regarding the performance and results of the EMI/RFI Testing are recorded in the completed MPR Procedure No. 9600164-510, "EMI/RFI Test Procedure," (Reference 9.17). Conclusions from the EMI/RFI Testing are provided in Section 8.0 of this test report.

3.0 TEST OBJECTIVE

NRC RG 1.180 (Reference 9.2) states that EMI/RFI Testing is required to demonstrate compliance with NRC regulations on testing to address the effects of EMI/RFI and power surges on safety-related instrumentation and control systems. Appendix 8 of Triconex Document No. 9600164-500 (Reference 9.1) states that EMI/RFI Testing shall demonstrate acceptable performance of the TRICON v10 Programmable Logic Controller (PLC) in accordance with the EMI/RFI criteria specified in NRC RG 1.180. MPR Procedure No. 9600164-510 (Reference 9.3) states that EMI/RFI Testing shall demonstrate the suitability of the TRICON v10 PLC for qualification as a safety-related device with respect to EMI/RFI emissions and susceptibility levels.

4.0 DESCRIPTION OF TEST SPECIMEN

The equipment tested consists of four TRICON v10 PLC chassis populated with selected main processor, input, output, communication, chassis interface and chassis power supply modules. The tested equipment also includes external termination panels (ETPs) provided for connection of field wiring to the TRICON v10 input and output modules, and interfacing cable assemblies for connection of the ETPs to the TRICON v10 chassis and for interconnection of the TRICON v10 chassis.

Triconex Drawing No. 9600164-100 (Reference 9.6), shows the basic configuration of the TUT components for EMI/RFI Testing. Triconex Drawing No. 9600164-103, "TRICON v10 Nuclear Qualification Project System Block Diagram," (Reference 9.18), shows the general arrangement and interconnection of the TUT chassis. Triconex Document No. 9600164-541, "TRICON v10 Nuclear Qualification Project, System Description," (Reference 9.19), provides an overview and description of the TUT and test system. A detailed identification of the tested equipment is provided in Triconex Document No. 9600164-540 (Reference 9.15).

During testing, the TUT was executing a Test Specimen Application Program (the TSAP) developed specifically for the qualification project and designed to support the test procedures, which demonstrate the functionality of the TUT during all phases of qualification testing. Requirements for operation of the TSAP are defined in Triconex Document No. 9600164-517, "Test Specimen Application Program (TSAP) Software Requirements Specification (SRS)," (Reference 9.20). The completed MPR Procedure No. 9600164-510 (Reference 9.17) identifies the TSAP revision used during this testing as "V10_TSAP_REV_0". Triconex Document No. 9600164-540 (Reference 9.15) identifies the revision level of all TUT firmware.

5.0 TEST SETUP AND INSTRUMENTATION

The following sections describe the setup of the TUT during EMI/RFI Testing, the instrumentation used to generate and measure the applied EMI/RFI test conditions, and the instrumentation used to measure TUT performance during and after testing. The TUT setup is documented in the completed MPR Procedure No. 9600164-510 (Reference 9.17). Specifications for test instrumentation supplied by NTS Laboratories are included in NTS Test Procedure No. TP62987-07N-EMI, "Test Procedure for EMI/RFI Testing of the TRICON v10 Nuclear Qualification Project TRICON-Under-Test," (Reference 9.21).

5.1 TRICON-Under-Test Mounting

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5.2 TRICON-Under-Test Chassis and Module Configuration

Section 4.0 above describes the general arrangement of the TUT which was maintained throughout all of the qualification testing. Chassis configurations for EMI/RFI Testing are documented in Triconex Document No. 9600164-540 (Reference 9.15).

5.3 TRICON-Under-Test Power Supply and Wiring Configuration

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5.4 NTS Instrumentation

NTS provided the test instrumentation for generating, applying, and monitoring the EMI/RFI Test signals. NTS also provided instrumentation for measuring temperature and relative humidity inside the anechoic test chamber during EMI/RFI Testing. These instruments are identified in NTS Test Report No. TR62987-07N-EMI (Reference 9.29).

5.5 Triconex and MPR Instrumentation

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Details on the identification, configuration and calibration of the test instrumentation described above are included in the completed MPR Procedure No. 9600164-510 (Reference 9.17), and the completed Pre-EMI/RFI Testing Run No. 3.6 of Triconex Procedure No. 9600164-502, "System Setup and Checkout Procedure," (Reference 9.31). The completed MPR Procedure

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5.6 Instrument Calibration

All tests were performed using calibrated test instruments. Calibration certifications are held by NTS, MPR and Triconex. NTS Test Report No. TR62987-07N-EMI (Reference 9.29) documents the calibration status of the test instrumentation used by NTS. The completed MPR Procedure No. 9600164-510 (Reference 9.17) documents the calibration status of the test instrumentation used by MPR. The completed Triconex Procedure No. 9600164-502 (Reference 9.31) documents the calibration status of the test instrumentation used by Triconex.

6.0 TEST PROCEDURES

EMI/RFI Testing of the TUT was performed to the requirements of Sections 3 and 4 of NRC RG 1.180 (Reference 9.2). Section 3 of NRC RG 1.180 addresses EMI/RFI emissions testing. Section 4 of NRC RG 1.180 addresses EMI/RFI susceptibility testing. Each section endorses both Military Standard MIL-STD-461E series and IEC 61000 series EMI/RFI test methods. The qualifier has the option to use either series of test methods, although NRC RG 1.180 stipulates that for emissions or susceptibility testing, the chosen series of test methods must be applied in its entirety (i.e., there should be no selective application or mixing of the MIL-STD and IEC test methods).

EMI/RFI emissions testing of the TUT included both radiated and conducted emissions testing done to the MIL-STD-461E series test methods (Reference 9.7) specified in Section 3 of NRC RG 1.180 (Reference 9.2). EMI/RFI susceptibility testing of the TUT included both radiated and conducted susceptibility testing done to the IEC 61000 series test methods (References 9.8 through 9.14) specified in Section 4 of NRC RG 1.180, Rev. 1 (Reference 9.2).

The following sections describe the approach to satisfying the requirements of the referenced documents for EMI/RFI Testing of the TUT. The test procedure used by NTS to perform EMI/RFI Testing of the TUT is NTS Test Procedure No. TP62987-07N-EMI (Reference 9.21). The test procedure used by MPR to perform EMI/RFI Testing of the TUT is MPR Procedure No. 9600164-510 (Reference 9.3).

6.1 Test Sequence

Figure 2 of Triconex Document No. 9600164-500 (Reference 9.1) shows the sequence of qualification testing performed on the TUT. In accordance with the test sequence shown in Figure 2, EMI/RFI Testing was performed after Radiation Exposure, Environmental, and Seismic Testing, and prior to Electrical Fast Transient Testing, Surge Withstand, Electrostatic Discharge and Class 1E to Non-1E Isolation Testing.

6.2 Test Method

Section 3 of NRC RG 1.180 (Reference 9.2) includes the requirements for EMI/RFI emissions testing of safety-related instrumentation and control (I&C) systems. EMI/RFI emissions testing of the TUT included both radiated and conducted emissions testing done to the following MIL-STD-461E series test methods (Reference 9.7):

- MIL-STD-461E, Test Method CE101, Conducted Emissions, Low Frequency (30 Hz to 10 kHz), AC and DC Power Leads
- MIL-STD-461E, Test Method CE102, Conducted Emissions, High Frequency (10 kHz to 2 MHz), AC and DC Power Leads
- MIL-STD-461E, Test Method RE101, Radiated Emissions, Magnetic Field (30 Hz to 100 kHz), TUT Surfaces and Leads
- MIL-STD-461E, Test Method RE102, Radiated Emissions, Electric Field (2 MHz to 1 GHz), Antenna Measurement

Section 4 of NRC RG 1.180 (Reference 9.2) includes the requirements for EMI/RFI susceptibility testing of safety-related instrumentation and control (I&C) systems. EMI/RFI susceptibility testing of the TUT included both radiated and conducted testing done to the following IEC series test methods:

- IEC Standard 61000-4-3, Radiated Susceptibility, High Frequency (26 MHz to 1 GHz), Antenna Exposure (Reference 9.8)
- IEC Standard 61000-4-6, Conducted Susceptibility, Radio Frequency (150 kHz to 80 MHz), Power and Signal Leads (Reference 9.9)
- IEC Standard 61000-4-8, Radiated Susceptibility, Power Line Frequency (60 Hz) Magnetic Field, Helmholtz Coil Exposure (Reference 9.10)
- IEC Standard 61000-4-9, Radiated Susceptibility, Pulsed Magnetic Field, Helmholtz Coil Exposure (Reference 9.11)

- IEC Standard 61000-4-10, Radiated Susceptibility, Damped Oscillatory Magnetic Field (100 kHz and 1 MHz), Helmholtz Coil Exposure (Reference 9.12)
- IEC Standard 61000-4-13, Conducted Susceptibility, Harmonics and Interharmonics (16 Hz to 2.4 kHz), Power Leads (Reference 9.13)
- IEC Standard 61000-4-16, Conducted Susceptibility, Common-Mode Disturbances (15 Hz to 150 kHz), Power and Signal Leads (Reference 9.14)

6.3 Test Levels

The following lists the EMI/RFI Testing emissions acceptance levels and applied susceptibility test levels from the applicable figures and tables of NRC RG 1.180 (Reference 9.2).

EMI/RFI Emissions Test Method	NRC RG 1.180, Rev. 1 Acceptance Level
MIL-STD-461E, CE101	Figure 3.1
MIL-STD-461E, CE102	Figure 3.2
MIL-STD-461E, RE101	Figure 3.3
MIL-STD-461E, RE102	Figure 3.4

EMI/RFI Susceptibility Test Method	NRC RG 1.180, Rev. 1 Test Level
IEC Standard 61000-4-3	Sect. 4.3.3: 10 V/m
IEC Standard 61000-4-6	Sect. 4.1.2: Power Leads, 140 dBμV
IEC Standard 61000-4-6	Table 15: Signal Leads, 130 dBμV
IEC Standard 61000-4-8	Table 19: Continuous, 30 A/m
IEC Standard 61000-4-8	Table 19: Short Duration, 300 A/m
IEC Standard 61000-4-9	Table 19: 300 A/m
IEC Standard 61000-4-10	Table 19: 30 A/m
IEC Standard 61000-4-13	Table 10: See Table 10
IEC Standard 61000-4-16	Table 11: Power Leads, See Table 11
IEC Standard 61000-4-16	Table 11: Signal Leads: 3/10 of Power Leads

6.4 TRICON-Under-Test Operation

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6.5 TRICON-Under-Test Performance Monitoring

Appendix 7 of Triconex Document No. 9600164-500 (Reference 9.1) and Section 6.6 of this test report list the EMI/RFI Test acceptance criteria. Appendix 7 states that monitoring of normal TUT operation during EMI/RFI Testing will demonstrate satisfaction of the acceptance criteria. In order to clarify the definition of normal operation, Appendix 7 provides the following additional EMI/RFI Testing acceptance criteria adapted from Section 4.3.7 of EPRI TR-107330 (Reference 9.4):

i.) The main processors shall continue to function.
ii.) The transfer of I/O data shall not be permanently interrupted.
iii.) The applied EMI/RFI disturbances shall not cause the discrete I/O to change state.
iv.) Analog I/O levels shall not vary more than 3% (of full scale).

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6.6 Test Acceptance Criteria

The following EMI/RFI Test acceptance criteria are as given in Appendix 7 of Triconex Document No. 9600164-500 (Reference 9.1), and Section 4.3.7 of EPRI TR-107330 (Reference 9.4).

a) The TUT shall meet allowable equipment emission limits as specified in Section 3 of NRC RG 1.180 (Reference 9.2) for the following MIL-STD-461E Emissions Test Methods:

CE101 – Conducted Emissions, 30 Hz to 10 kHz (NRC RG 1.180, Figure 3.1)
CE102 – Conducted Emissions, 10 kHz to 2 MHz (NRC RG 1.180, Figure 3.2)
RE101 – Radiated Emissions, 30 Hz to 100 kHz (NRC RG 1.180, Figure 3.3)
RE102 – Radiated Emissions, 2 MHz to 1 GHz (NRC RG 1.180, Figure 3.4)

b) The TUT shall operate as intended during and after application of the EMI/RFI test levels specified in Section 4 of NRC RG 1.180 (Reference 9.2) for the following IEC Standard Susceptibility Test Methods:

IEC 61000-4-3 – Radiated Susceptibility, High Frequency, 26 MHz to 1 GHz
IEC 61000-4-6 – Conducted Susceptibility, Radio Frequency, 150 kHz to 80 MHz
IEC 61000-4-8 – Radiated Susceptibility, Magnetic Field, 60 Hz
IEC 61000-4-9 – Radiated Susceptibility, Pulsed Magnetic Field
IEC 61000-4-10 – Radiated Susceptibility, Damped Magnetic Field, 100 kHz and 1 MHz
IEC 61000-4-13 – Conducted Susceptibility, Harmonics/Interharmonics, 16 Hz to 2.4 kHz
IEC 61000-4-16 – Conducted Susceptibility, Common Mode Disturb., 15 Hz to 150 kHz

Evaluation of normal operating performance data (inputs, outputs and diagnostic indicators) shall demonstrate operation as intended, including the following specific operational performance from Section 4.3.7 of EPRI TR-107330 (Reference 9.4):

i.) The main processors shall continue to function.
ii.) The transfer of I/O data shall not be interrupted.
iii.) The emissions shall not cause the discrete I/O to change state.
iv.) Analog I/O levels shall not vary more than 3%.

7.0 TEST RESULTS

This section summarizes the results of EMI/RFI Testing of the TUT. This section also discusses performance or data anomalies which were observed or recorded during the testing.

7.1 EMI/RFI Test Setup and Checkout Testing

Triconex Procedure No. 9600164-502, "System Setup and Checkout Procedure," (Reference 9.32) directs setup of the TUT for the different qualification tests to be performed, and verifies proper operation of the TUT and test system prior to start of testing. EMI/RFI Testing of the TUT was performed following Seismic Testing and upon completion of the Pre-EMI/RFI Testing Run No. 3.6 of Triconex Procedure No. 9600164-502 (Reference 9.31).

Results of Reference 9.31 show that the system was operating correctly prior to start of EMI/RFI Testing.

7.2 EMI/RFI Testing

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Table 7.1: Summary of IEC Standard 61000-4-16 Final Test Results

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7.3 Post-EMI/RFI Operability and Prudency Tests

Section 5.5 of EPRI TR-107330 (Reference 9.4) requires Operability and Prudency testing to be performed during EMI/RFI Testing.

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As reported by Triconex, the completed Performance Proof Test Run No. 3.7 of Triconex Procedure No. 9600164-503, "Operability Test Procedure," (Reference 9.38) and the completed Performance Proof Test Run No. 3.4 of Triconex Procedure No. 9600164-504, "Prudency Test Procedure," (Reference 9.39) performed at the completion of all qualification testing demonstrate acceptable system performance following EMI/RFI Testing.

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8.0 CONCLUSIONS

8.1 Test Methodology

EMI/RFI Testing of the TUT was performed in accordance with the applicable requirements of NRC RG 1.180 (Reference 9.2). The following EMI/RFI Tests were performed on the TUT:

- Radiated Magnetic Field Emissions from 30 Hz to 100 kHz (MIL-STD-461E, RE101)
- Radiated Electric Field Emissions from 2 MHz to 1 GHz (MIL-STD-461E, RE102)
- Low Frequency Conducted Emissions from 30 Hz to 10 kHz (MIL-STD-461E, CE101)
- High Frequency Cond. Emissions from 10 kHz to 2 MHz (MIL-STD-461E, CE102)
- High Frequency Radiated Susceptibility from 26 MHz to 1 GHz (IEC 61000-4-3)
- Radio Frequency Conducted Susceptibility from150 kHz to 80 MHz (IEC 61000-4-6)
- Magnetic Field Radiated Susceptibility at 60 Hz (IEC 61000-4-8)
- Pulsed Magnetic Field Radiated Susceptibility (IEC 61000-4-9)

- Damped Magnetic Field Radiated Suscept. at 100 kHz and 1 MHz (IEC 61000-4-10)
- Harmonics and Interharmonics Conducted Susceptibility (IEC 61000-4-13)
- Common Mode Disturb. Conducted Suscept., 15 Hz to 150 kHz (IEC 61000-4-16)

The specific TRICON v10 PLC hardware which was tested (chassis, power supplies, modules, external termination assemblies and interconnecting cabling) is identified in Triconex Document No. 9600164-540 (Reference 9.15).

Section 5.5 of EPRI TR-107330 (Reference 9.4) requires Operability and Prudency testing to be performed during EMI/RFI Testing. The test system as configured for EMI/RFI Testing did not support Operability or Prudency Testing (see Section 6.5 of this test report). The normal operating performance data recorded during EMI/RFI Testing demonstrates system performance during EMI/RFI exposure.

8.2 Emissions Testing

a. The TUT fully complies with the allowable equipment emissions levels defined in NRC RG 1.180 (Reference 9.2) for MIL-STD-461E, RE101 and RE102 testing.

b. The TUT does not fully comply with the allowable equipment emissions levels defined in NRC RG 1.180 (Reference 9.2) for MIL-STD-461E, CE101 and CE102 testing. Sections 7.2.1 and 7.2.2 of this test report provide a detailed description of the non-compliances in emissions which were measured during CE101 and CE102 testing.

   An understanding of the electromagnetic emissions from a device is necessary to minimize the potential for the device to adversely affect the operation of other equipment that is physically located near the device, shares common electrical connections with it, or has wires or cables routed in close proximity to it. Therefore, prior to installing the TRICON v10 PLC in a nuclear safety-related or non-safety related application, an evaluation of the device emission levels should be made to determine whether the emission levels are acceptable for the planned application, or if mitigating actions would be required. The TRICON v10 PLC EMI/RFI emissions testing documented in this report provides the data required to perform such an evaluation. The TRICON v10 PLC was tested without the benefit of a secondary enclosure, additional cable and wire shielding, or installed power line filtering. Mitigating actions to address the non-compliances in measured emission levels would likely incorporate these common in-plant installation features.

8.3 Susceptibility Testing

NOTE: The following susceptibility test results are contingent on a TRICON v10 PLC installation design that separates and isolates the 24 VDC field power supplies to the discrete and analog input and output module circuits.

a. The TUT successfully passed all of the EMI/RFI susceptibility tests listed in Section 8.1. The main processors continued to function correctly throughout testing. The transfer of input and output data was not interrupted. There were no interruptions or inconsistencies in the operation of the system or the software.

b. The TUT main processor, chassis power supply, remote extender, and communication modules fully comply with the minimum susceptibility thresholds required by NRC RG 1.180 (Reference 9.2) for all of the EMI/RFI susceptibility tests listed in Section 8.1.

c. The EMI/RFI susceptibility test results show that the following TUT discrete and analog input/output hardware does not fully comply with the minimum susceptibility thresholds required by NRC RG 1.180 (Reference 9.2) for the EMI/RFI susceptibility tests listed in Section 8.1:

IEC Standard 61000-4-3 Testing

- RTD Signal Conditioning Module 1600083-600
- RTD Signal Conditioning Module 1600083-200
- RTD Signal Conditioning Module 1600024-030
- RTD Signal Conditioning Module 1600024-020

IEC Standard 61000-4-6 Testing

- RTD Signal Conditioning Module 1600081-001
- Digital Output Module 3601T (115 VAC) w/ ETP 9663-610N

IEC Standard 61000-4-16 Testing

- Digital Input Module 3503E (24V AC/DC) w/ ETP 9563-810N
- Digital Output Module 3625 (24V DC) w/ ETP 9662-810N
- Digital Output Module 3625 (24V DC) w/ ETP 9662-610N

Sections 7.2.5, 7.2.7 and 7.2.11 of this test report provide a detailed description of the module susceptibilities which were measured during each of the tests listed above, and the results of threshold testing which was performed. Module susceptibilities included spurious changes in the state of the discrete inputs and outputs, and variations in RTD input levels of greater than ± 3% of the expected levels.

d. An understanding of the electromagnetic susceptibility of a device is necessary to ensure that its operation will not be adversely affected by EMI/RFI levels already present or permitted in the area where the device will be located. Therefore, prior to installing the TRICON v10 PLC in a nuclear safety-related application, an evaluation of the input, output and communication module susceptibilities should be performed. An evaluation of the module susceptibilities should also be performed for non-safety related applications if there is a potential for the PLC to impact plant reliability and availability. The TRICON v10 PLC EMI/RFI susceptibility testing documented in this test report provides the data required to perform such an evaluation.

   To address the impact of the TRICON v10 PLC input and output module EMI/RFI susceptibilities for a specific plant application, one or more of the following approaches may be pursued:

   i. Demonstrate that the EMI/RFI levels at which the PLC modules are susceptible are not credible threats at the point of installation.

   ii. Demonstrate that the type of susceptibility failures that occurred during the EMI/RFI Testing will not adversely affect the safety function of the PLC or plant operation. For example, variations in analog input and output levels in excess of ± 3% may not impact the safety-related function of the PLC or adversely affect plant operation.

   iii. Implement actions to mitigate unacceptable EMI/RFI sources. The TRICON v10 PLC was tested without the benefit of a secondary enclosure, additional cable and wire shielding, or installed power line filtering. Mitigating actions to address module susceptibility levels would likely incorporate these common in-plant installation features. Mitigating actions might also include administrative controls on the EMI/RFI sources.

e. Tables 8-1 and 8-2 included at the end of this section provide a summary of the EMI/RFI conducted and radiated susceptibility test results for each module installed in the TUT. The purpose of the tables is to identify a set of modules which demonstrated acceptable susceptibility performance at the required test levels specified in NRC RG 1.180 (Reference 9.2).

8.4 Post-EMI/RFI Operability and Prudency Testing

As reported by Triconex, the completed Performance Proof Test Run No. 3.7 of Triconex Procedure No. 9600164-503, "Operability Test Procedure," (Reference 9.38) and the completed Performance Proof Test Run No. 3.4 of Triconex Procedure No. 9600164-504, "Prudency Test Procedure," (Reference 9.39) demonstrate acceptable system performance following EMI/RFI Testing.

8.5 Test Anomalies

Several test anomalies were encountered during EMI/RFI Testing as described in Section 7.5 of this test report. Each of the test anomalies was dispositioned for its impact on the validity of the test results. Test system revisions were made and/or repeat testing was performed as necessary to correct any negative impact the test anomalies may have had on the validity of the test results.

TABLE 8-1: SUMMARY OF EMI/RFI CONDUCTED SUSCEPTIBILITY TEST RESULTS

Module Model No.	ETP Model No.	Module Type	IEC 61000-4-6 Radio Frequency 150 kHz - 80 MHz	IEC 61000-4-13 Harmonics and Interharmonics	IEC 61000-4-16 Common-Mode Dsturbances
3008	- - -	Main Processor	Pass	Pass	Pass
8310	- - -	Power Supply, 115 VAC	Pass	Pass	Pass
8311	- - -	Power Supply, 230 VAC	Pass	Pass	Pass
8312	- - -	Power Supply, 24 VDC	Pass	Pass	Pass
4200	- - -	Remote Extender	Pass	Pass	Pass
4201	- - -	Remote Extender	Pass	Pass	Pass
4352A	- - -	Communication	Pass	Pass	Pass
3511	9794-110N	Pulse Input	Pass	Pass	Pass
3708E	9782-110N	Thermocouple Input	Pass	Pass	Pass
3501T	9561-810N	Digital Input, 115 VAC	Pass	Pass	Pass
	9561-110N	Digital Input, 115 VAC	Pass	Pass	Pass
3623T	9664-810N	Digital Output, 120 VDC	Pass	Pass	Pass
3603T	9664-810N	Digital Output, 120 VDC	Pass	Pass	Pass
3601T	9663-610N	Digital Output, 115 VAC	**Susceptible**	Pass	Pass
3503E	9563-810N	Digital Input, 24 VDC	Pass	Pass	**Susceptible**

TABLE 8-1: SUMMARY OF EMI/RFI CONDUCTED SUSCEPTIBILITY TEST RESULTS

Module Model No.	ETP Model No.	Module Type	IEC 61000-4-6 Radio Frequency 150 kHz - 80 MHz	IEC 61000-4-13 Harmonics and Interharmonics	IEC 61000-4-16 Common-Mode Dsturbances
3625	9662-810N	Digital Output, 24 VDC	Pass	Pass	**Susceptible**
	9662-610N	Digital Output, 24 VDC	Pass	Pass	**Susceptible**
3636T	9668-110N	Relay Output	Pass	Pass	Pass
3607E	9667-810N	Digital Output, 48 VDC	Pass	Pass	Pass
3502E	9562-810N	Digital Input, 48 VDC	Pass	Pass	Pass
3701	9795-610N	Analog Input, 0-10 VDC	Pass	Pass	Pass
	9783-110N	Analog Input, 0-10 VDC	Pass	Pass	Pass
3703E	9790-610N	Analog Input, 0-10 VDC	Pass	Pass	Pass
	9783-110N	Analog Input, 0-10 VDC	Pass	Pass	Pass
3805E	9860-610N	Analog Output, 4-20 mA	Pass	Pass	Pass
3721	9764-310N	RTD, No. 1600083-600	Pass	Pass	Pass
		RTD, No. 1600083-200	Pass	Pass	Pass
		RTD, No. 1600024-040	Pass	Pass	Pass
		RTD, No. 1600024-030	Pass	Pass	Pass
		RTD, No. 1600024-020	Pass	Pass	Pass
		RTD, No. 1600024-010	Pass	Pass	Pass
		mV, No. 1600082-001	Pass	Pass	Pass
		RTD, No. 1600081-001	**Susceptible**	Pass	Pass
3721	9783-110N	Analog Input, 0-5 VDC	Pass	Pass	Pass
	9790-610N	Analog Input, 0-5 VDC	Pass	Pass	Pass
	9783-110N	Analog Input, 0-5 VDC	Pass	Pass	Pass

TABLE 8-2: SUMMARY OF EMI/RFI RADIATED SUSCEPTIBILITY TEST RESULTS

Module Model No.	ETP Model No.	Module Type	IEC 61000-4-3 High Frequency 26 MHz - 1 GHz	IEC 61000-4-8 60 Hz Magnetic Field	IEC 61000-4-9 Pulsed Magnetic Field	IEC 61000-4-10 Oscillatory Magnetic Field
3008	- - -	Main Processor	Pass	Pass	Pass	Pass
8310	- - -	Power Supply, 115 VAC	Pass	Pass	Pass	Pass
8311	- - -	Power Supply, 230 VAC	Pass	Pass	Pass	Pass
8312	- - -	Power Supply, 24 VDC	Pass	Pass	Pass	Pass

TABLE 8-2: SUMMARY OF EMI/RFI RADIATED SUSCEPTIBILITY TEST RESULTS

Module Model No.	ETP Model No.	Module Type	IEC 61000-4-3 High Frequency 26 MHz - 1 GHz	IEC 61000-4-8 60 Hz Magnetic Field	IEC 61000-4-9 Pulsed Magnetic Field	IEC 61000-4-10 Oscillatory Magnetic Field
4200	- - -	Remote Extender	Pass	Pass	Pass	Pass
4201	- - -	Remote Extender	Pass	Pass	Pass	Pass
4352A	- - -	Communication	Pass	Pass	Pass	Pass
3511	9794-110N	Pulse Input	Pass	Pass	Pass	Pass
3708E	9782-110N	Thermocouple Input	Pass	Pass	Pass	Pass
3501T	9561-810N	Digital Input, 115 VAC	Pass	Pass	Pass	Pass
	9561-110N	Digital Input, 115 VAC	Pass	Pass	Pass	Pass
3623T	9664-810N	Digital Output, 120 VDC	Pass	Pass	Pass	Pass
3603T	9664-810N	Digital Output, 120 VDC	Pass	Pass	Pass	Pass
3601T	9663-610N	Digital Output, 115 VAC	Pass	Pass	Pass	Pass
3503E	9563-810N	Digital Input, 24 VDC	Pass	Pass	Pass	Pass
3625	9662-810N	Digital Output, 24 VDC	Pass	Pass	Pass	Pass
3636T	9668-110N	Relay Output	Pass	Pass	Pass	Pass
3607E	9667-810N	Digital Output, 48 VDC	Pass	Pass	Pass	Pass
3502E	9562-810N	Digital Input, 48 VDC	Pass	Pass	Pass	Pass
3701	9795-610N	Analog Input, 0-10 VDC	Pass	Pass	Pass	Pass
	9783-110N	Analog Input, 0-10 VDC	Pass	Pass	Pass	Pass
3703E	9790-610N	Analog Input, 0-10 VDC	Pass	Pass	Pass	Pass
	9783-110N	Analog Input, 0-10 VDC	Pass	Pass	Pass	Pass
3805E	9860-610N	Analog Output, 4-20 mA	Pass	Pass	Pass	Pass
3721	9764-310N	RTD, No. 1600083-600	**Susceptible**	Pass	Pass	Pass
		RTD, No. 1600083-200	**Susceptible**	Pass	Pass	Pass
		RTD, No. 1600024-040	Pass	Pass	Pass	Pass
		RTD, No. 1600024-030	**Susceptible**	Pass	Pass	Pass
		RTD, No. 1600024-020	**Susceptible**	Pass	Pass	Pass
		RTD, No. 1600024-010	Pass	Pass	Pass	Pass
		mV, No. 1600082-001	Pass	Pass	Pass	Pass
		RTD, No. 1600081-001	Pass	Pass	Pass	Pass
3721	9783-110N	Analog Input, 0-5 VDC	Pass	Pass	Pass	Pass
	9790-610N	Analog Input, 0-5 VDC	Pass	Pass	Pass	Pass
	9783-110N	Analog Input, 0-5 VDC	Pass	Pass	Pass	Pass

9.0 REFERENCES

Note: Triconex qualification project documentation and hardware are configuration controlled under the Triconex Quality Assurance Program. Triconex Document No. 9600164-540, "Master Configuration List," (Reference 9.15) provides a record of the currently applicable revision level of all Triconex documents, procedures and drawings throughout performance of the qualification program. As recorded in the completed MPR Procedure No. 9600164-510 (Reference 9.17), Triconex Document No. 9600164-540, Rev. 10 was in effect at the start of EMI/RFI Testing.

9.1 Triconex Document No. 9600164-500, "Master Test Plan," Rev. 4

9.2 U.S. Nuclear Regulatory Commission Regulatory Guide 1.180, Revision 1, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," October 2003

9.3 MPR Procedure No. 9600164-510, "EMI/RFI Test Procedure," Rev. 0

9.4 EPRI TR-107330, "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants," Final Report dated December, 1996

9.5 Triconex Document No. 9600164-002, "Nuclear Qualification Quality Plan," Rev. 3

9.6 Triconex Drawing No. 9600164-100, "TRICON v10 Nuclear Qualification Project TRICON Under Test - General Arrangement," Rev. 1

9.7 Department of Defense Interface Standard MIL-STD-461E, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment," August 20, 1999

9.8 IEC Standard 61000-4-3, "Electromagnetic Compatibility (EMC), Part 4-3: Testing and Measurement Techniques, Radiated, Radio-Frequency, Electromagnetic Field Immunity Test," September 2002

9.9 IEC Standard 61000-4-6, "Electromagnetic Compatibility (EMC), Part 4-6: Testing and Measurement Techniques, Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields," November 2004

9.10 IEC Standard 61000-4-8, "Electromagnetic Compatibility (EMC), Part 4-8: Testing and Measurement Techniques, Power Frequency Magnetic Field Immunity Test," March 2001

9.11 IEC Standard 61000-4-9, "Electromagnetic Compatibility (EMC), Part 4-9: Testing and Measurement Techniques, Pulse Magnetic Field Immunity Test," March 2001

9.12 IEC Standard 61000-4-10, "Electromagnetic Compatibility (EMC), Part 4-10: Testing and Measurement Techniques, Damped Oscillatory Magnetic Field Immunity Test," March 2001

9.13 IEC Standard 61000-4-13, "Electromagnetic Compatibility (EMC), Part 4-13: Testing and Measurement Techniques, Harmonics and Interharmonics Including Mains Signaling at A.C. Power Port, Low Frequency Immunity Tests," March 2002

9.14 IEC Standard 61000-4-16, "Electromagnetic Compatibility (EMC), Part 4-16: Testing and Measurement Techniques, Test for Immunity to Conducted, Common Mode Disturbances in the Frequency Range 0 Hz to 150 kHz," July 2002

9.15 Triconex Document No. 9600164-540, "Master Configuration List," Rev. 18

9.16 IEEE Standard 323-1974, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations"

9.17 Completed MPR Procedure No. 9600164-510, "EMI/RFI Test Procedure," Rev. 0, MPR Review and Approval Dated July 16, 2007

9.18 Triconex Drawing No. 9600164-103, "TRICON v10 Nuclear Qualification Project System Block Diagram," Rev. 2

9.19 Triconex Document No. 9600164-541, "TRICON v10 Nuclear Qualification Project, System Description," Rev. 0

9.20 Triconex Document No. 9600164-517, "Test Specimen Application Program (TSAP) Software Requirements Specification (SRS)," Rev. 3

9.21 National Technical Systems Test Procedure No. TP62987-07N-EMI, "Test Procedure for Electromagnetic Compatibility Qualification of the TRICON v10 Nuclear Qualification Project TRICON-Under-Test," Rev. 0

9.22 Triconex Drawing No. 9600164-201, Sheets 1 and 2, "TRICON v10 Nuclear Qualification Project - Power Distribution Wiring Diagram," Rev. 1

9.23 Triconex Drawing No. 9600164-202, Sheet 1, "TRICON v10 Nuclear Qualification Project - Test Chassis #1 Power Distribution Wiring Diagram," Rev. 0

9.24 Triconex Drawing No. 9600164-203, Sheets 1 and 2, "TRICON v10 Nuclear Qualification Project - Test Chassis #2 Power Distribution Wiring Diagram," Rev. 0

9.25 Triconex Drawing No. 9600164-204, Sheets 1 and 2, "TRICON v10 Nuclear Qualification Project - Test Chassis #3 Power Distribution Wiring Diagram," Rev. 0

9.26 Triconex Drawing No. 9600164-205, Sheets 1 and 2, "TRICON v10 Nuclear Qualification Project - Test Chassis #4 Power Distribution Wiring Diagram," Rev. 2

9.27 Triconex Drawing No. 9600164-206, Sheet 1, "TRICON v10 Nuclear Qualification Project - Simulator Chassis #5 Power Distribution Wiring Diagram," Rev. 0

9.28 Triconex Drawing No. 9600164-207, Sheet 1, "TRICON v10 Nuclear Qualification Project - Simulator Chassis #6 Power Distribution Wiring Diagram," Rev. 0

9.29 National Technical Systems Test Report No. TR62987-07N-EMI, "Test Report for Electromagnetic Compatibility Qualification of the TRICON v10 Nuclear Qualification Project TRICON-Under-Test," Rev. **1**

9.30 Triconex Document No. 9600164-700, "TRICON v10 Nuclear Qualification Project Wiring Schedule," Rev. 3

9.31 Completed Pre-EMI/RFI Testing Run No. 3.6 of Triconex Procedure No. 9600164-502, "System Setup and Checkout Procedure," Rev. 4

9.32 Triconex Procedure No. 9600164-502, "System Setup and Checkout Procedure," Rev. 4

9.33 Triconex Qualification Project Anomaly Report (QPAR) No. 045, "Isolation Ground Resistance (Chassis 3 and Chassis 4)"

9.34 MPR Nonconformance Report NCR-2007-04 dated March 9, 2007, "Incorrect Configuration of TRICON-Under-Test Analog I/O Circuits"

9.35 MPR Document No. 0449-0602-RWP-001 dated March 9, 2007, "Rework Procedure for the TRICON v10 Nuclear Qualification Project TRICON-Under-Test (TUT)," Rev. 0

9.36 Triconex Qualification Project Anomaly Report (QPAR) No. 044, "Load Fuse Errors on Module 3623T"

9.37 Triconex Letter 9600164-025T dated February 6, 2007 to MPR Associates, "Internally Generated Frequencies - TRICON v10 EMI/RFI Testing"

9.38 Completed Performance Proof Run No. 3.7 of Triconex Procedure No. 9600164-503, "Operability Test Procedure," Rev. 3

9.39 Completed Performance Proof Run No. 3.4 of Triconex Procedure No. 9600164-504, "Prudency Test Procedure," Rev. 1

9.40 Triconex Qualification Project Anomaly Report (QPAR) No. 055, "3636T Relay Output Module IEC 61000-4-16 Analysis"

10.0 ATTACHMENTS

Attachment 1: Example Plots of TUT Normal Operating Data

11.0 SUPPLEMENTS

Supplement 1: Supplemental Testing to IEC 61000-4-16, Short Duration Disturbance at 0 Hz (DC)

Document:	9600164-527	Title:	EMI/RFI TEST REPORT: ATTACHMENT 1		
Revision:	2	Page:	1 of 14	Date:	05/10/08

ATTACHMENT 1

a

Document:	9600164-527	Title:	EMI/RFI TEST REPORT: ATTACHMENT 1		
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Document:	9600164-527	Title:	EMI/RFI TEST REPORT: ATTACHMENT 1		
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Document:	9600164-527	Title:	EMI/RFI TEST REPORT: ATTACHMENT 1		
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Project:	TRICON v10 NUCLEAR QUALIFICATION PROJECT

EMI/RFI
TEST REPORT

Supplement 1

Supplemental Testing to
IEC 61000-4-16, Short Duration Disturbance at 0 Hz (DC)

Document No.: 9600164-527

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

The TRICON v10 Nuclear Qualification Project Electromagnetic Interference / Radiofrequency Interference (EMI/RFI) Test was performed on February 16 to April 17, 2007 at National Technical Systems (NTS) Laboratories in Boxborough, Massachusetts. During that testing, the following Digital Input and Digital Output modules had shown susceptibilities during IEC 61000-4-16 testing for Conducted Susceptibility, Short Duration Disturbance at 0 Hz (DC). (Specifically, the susceptible points were detected as being on by Trilogger when in fact they were off.)

- **Digital Input Module 3503E (24V AC/DC) with ETA 9563-810N**
- **Digital Output Module 3625 (24V DC) with ETA 9662-810N**
- **Digital Output Module 3625 (24V DC) with ETA 9662-610N**

Due to time constraints at the test facility this problem was not investigated during the original qualification testing. Instead, this problem was investigated during supplemental testing in Irvine. The digital inputs are optically isolated and should be resilient to common mode disturbances well beyond the 30V disturbances of the short duration test. Therefore, Triconex performed supplemental testing in order to duplicate and troubleshoot the failures.

As required by Triconex Document No. 9600164-800, "Supplemental Test Plan," (Reference 9.11), the Supplemental EMI/RFI Test (i.e. "Supplemental Test") to IEC 61000-4-16, Testing for Conducted Susceptibility, Short Duration Disturbance at 0 Hz (DC), was executed to demonstrate acceptable performance of the TRICON v10 Programmable Logic Controller (PLC) in accordance with the acceptance criteria specified in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.180, Revision 1, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," (Reference 9.2).

The Supplemental Test was performed at the I-T facility from January 15 to January 18, 2008. The supplemental testing validated that the aforementioned modules are not susceptible to IEC 61000-4-16, Testing for Conducted Susceptibility, Short Duration Disturbance at 0 Hz (DC).

2.0 PURPOSE

The purpose of this supplement is to summarize the results of supplemental testing to IEC 61000-4-16; Testing for Conducted Susceptibility, Short Duration Disturbance at 0 Hz (DC), of the TRICON v10 Nuclear Qualification Project TRICON-Under-Test (TUT) to meet the requirements of NRC RG 1.180, Revision 1 (Reference 9.2).

Conclusions and details regarding the performance and results of the Supplemental Testing are provided in Section 8.0 of this supplement.

3.0 TEST OBJECTIVE

The supplemental testing was performed to determine the cause of and to duplicate and troubleshoot the failures that had occurred previously at the National Technical Systems (NTS) Laboratories.

4.0 DESCRIPTION OF TEST SPECIMEN

The equipment tested consists of the same four TRICON v10 PLC chassis populated with selected main processor, input, output, communication, chassis interface and chassis power supply modules that had undergone testing previously. The tested equipment also includes the same external termination panels (ETPs) provided for connection of field wiring to the TRICON v10 input and output modules, and interfacing cable assemblies for connection of the ETPs to the TRICON v10 chassis and for interconnection of the TRICON v10 chassis.

No changes or modifications were made to the general arrangement and interconnection of the TUT chassis or test system. A detailed identification of the tested equipment is provided in Triconex Document No. 9600164-540 (Reference 9.8).

During testing, the TUT was executing the same Test Specimen Application Program (the TSAP) developed specifically for the qualification project and designed to support the test procedures, which demonstrate the functionality of the TUT during all phases of qualification testing.

5.0 TEST SETUP AND INSTRUMENTATION

The following sections describe the setup of the TUT during Supplemental Testing, the instrumentation used to generate and measure the applied Supplemental test conditions, and the instrumentation used to measure TUT performance during and after testing. The

TUT setup is documented in the completed Setup and Checkout Procedure No. 9600164-502 (Reference 9.20).

5.1 TRICON-Under-Test Mounting

For Supplemental Testing, the TUT was located at the I-T (Invensys-Triconex) **facility. The TUT was mounted in two metal frame instrument cabinets (with all sides removed) as follows:**

- **Cabinet 1: TUT Chassis No. 1 and 2, with external termination panels**
- **Cabinet 2: TUT Chassis No. 3 and 4, with external termination panels**

This is the same configuration that was used at the National Technical Systems (NTS) Laboratories. However, since it was not necessary for the specific tests performed, Cabinets 1 and 2 were not located in an anechoic test chamber.

Grounding of the TUT was in accordance with approved project documents and duplicated the previously tested configuration as detailed on Triconex Drawing Nos. 9600164-201 through 9600164-207 (References 9.13 through 9.19).

5.2 TRICON-Under-Test Chassis and Module Configuration

Section 4.0 above describes the general arrangement of the TUT which was maintained throughout all of the qualification testing. Chassis configurations for EMI/RFI Testing are documented in Triconex Document No. 9600164-540 (Reference 9.8).

5.3 TRICON-Under-Test Power Supply and Wiring Configuration

a, b

5.4 Instrumentation

Details on the identification, configuration and calibration of the test instrumentation described above are included in the completed Setup & Checkout Procedure (9600 164-502), Pre-Supplemental 4-16 Test (Run ID: 3.2, Supp 4-1 6) (Reference 9.20).

5.6 Instrument Calibration

All tests were performed using calibrated test instruments. Calibration certifications are held by Triconex. The completed Triconex Procedure No. 9600164-502 (Reference 9.20) documents the calibration status of the test instrumentation used by Triconex.

6.0 TEST PROCEDURES

The Supplemental Testing of the TUT was performed to the requirements of Section 4 of NRC RG 1.180, Revision 1 (Reference 9.2). Section 4 of NRC RG 1.180 addresses EMI/RFI susceptibility testing.

The following sections describe the approach to satisfying the requirements of the referenced documents for Supplemental Testing of the TUT. The same test procedures used by MPR and NTS to perform EMI/RFI Testing of the TUT were utilized (MPR Procedure No. 9600164-510, Reference 9.3, and NTS Test Procedure No.TP62987-07N-EMI, Reference 9.12). Only the applicable portions to IEC 61000-4-16 of the procedures were implemented.

6.1 Test Sequence

Requirements for conducting testing activities were duplicated from previous testing during the V10 Nuclear Qualification Project. Three categories of tests were conducted to satisfy the supplemental testing requirements in order to show qualification in accordance with IEC 61000-4-16 Testing for Conducted Susceptibility, Short Duration Disturbance at 0 Hz (DC):

(1) Pre-qualification tests conducted prior to qualification testing to determine that the system operates correctly and to provide baseline data on equipment performance, and

(2) Qualification tests to demonstrate compliance with specification requirements and suitability of equipment while subject to stress conditions

(3) Performance Proof tests conducted at the Invensys Triconex facilities upon conclusion of all testing to confirm satisfactory operation after being subjected to Qualification test conditions. Performance proof tests are merely a repeat of selected pre-qualification baseline tests to identify any changes in equipment performance. a, b

6.2 Test Method

Section 4 of NRC RG 1.180, Revision 1 (Reference 9.2) includes the requirements for EMI/RFI susceptibility testing of safety-related instrumentation and control (I&C) systems. The Supplemental susceptibility testing of the TUT included conducted testing done to IEC Standard 61000-4-16, Conducted Susceptibility, Common-Mode Disturbances (15 Hz to 150 kHz), Power and Signal Leads (Reference 9.7). Testing was for Short Duration Disturbance at 0 Hz (DC) only.

6.3 Test Levels

The following lists the Supplemental Testing applied susceptibility test levels from the applicable figures and tables of NRC RG 1.180 (Reference 9.2).

EMI/RFI Susceptibility Test Method	NRC RG 1.180, Rev. 1 Test Level
IEC Standard 61000-4-16	Table 11: Signal Leads: 3/10 of Power Leads

6.4 TRICON-Under-Test Operation

6.5 TRICON-Under-Test Performance Monitoring

During Supplemental Testing, operation of the TUT was monitored and recorded by the DAS and the Trilogger/TriStation Console interface. The recorded data was evaluated for time periods before, during and after each Supplemental Test. Section 7.3 of this test report includes a set of figures showing the normal operation of the data points which were monitored during Supplemental Testing. The data was monitored for deviations or trends from the normal operation shown in the figures.

6.6 Test Acceptance Criteria

The following EMI/RFI Test acceptance criteria are as given in Appendix 7 of Triconex Document No. 9600164-500 (Reference 9.1), and Section 4.3.7 of EPRI TR-107330 (Reference 9.4).

The TUT shall operate as intended during and after application of the EMI/RFI test levels specified in Section 4 of NRC RG 1.180, Revision 1 (Reference 9.2) for the following IEC Standard Susceptibility Test Methods:

IEC 61000-4-16– Conducted Susceptibility, Common Mode Disturb., 15 Hz to 150 kHz

Evaluation of normal operating performance data (inputs, outputs and diagnostic indicators) shall demonstrate operation as intended, including the following specific operational performance from Section 4.3.7 of EPRI TR-107330 (Reference 9.4):

i.) The main processors shall continue to function.
ii.) The transfer of I/O data shall not be interrupted.
iii.) The emissions shall not cause the discrete I/O to change state.
iv.) Analog I/O levels shall not vary more than 3%.

7.0 TEST RESULTS

This section summarizes the results of supplemental EMI/RFI Testing of the TUT. This section also discusses performance or data anomalies which were observed or recorded during the testing.

7.1 Supplemental Test Setup and Checkout Testing

Triconex Procedure No. 9600164-502, "System Setup and Checkout Procedure," (Reference 9.21) directs setup of the TUT for the different qualification tests to be performed, and verifies proper operation of the TUT and test system prior to start of testing. In accordance with Attachment 1 of the Supplemental Test Plan (Reference 9.11) only applicable portions of the procedure were implemented (10.1, 10.2, 10.5, 10.6, 10.8, 10.14, 10.15, 10.16, and 10.17). Supplemental Testing of the TUT was performed upon completion of the Setup & Checkout Procedure (9600164-502), Pre-Supplemental 4-16 Test (Run ID: 3.2, Supp 4-1 6). Results of Reference 9.20 show that the system was operating correctly prior to start of Supplemental Testing. Prior to performing Triconex Procedure No. 9600164-502, "System Setup and Checkout Procedure," it was discovered that a chassis power supply had failed. QPAR 056 (Reference 9.26) was written and the power supply was replaced with a spare. Testing was then continued.

7.2 Pre-Qualification Testing

Triconex Procedure No. 9600164-503, "Operability Test Procedure" provides instructions for operability and power quality tolerance testing to be performed on the TUT. In accordance with Attachment 2 of the Supplemental Test Plan (Reference 9.11) only applicable portions of the procedure were implemented (Section 1 – General Overview, Section 4 – Discrete Input Test, Section 5 – Discrete Output Test). Results of Executed Operability Test Procedure 9600164-503 Run 3.1, Supp4-16 (Reference 9.22) indicate that all acceptance criteria were satisfied.

Triconex Procedure No. 9600164-504 provides instructions for Prudency testing to be performed on the TUT. In accordance with Attachment 3 of the Supplemental Test Plan (Reference 9.11) only applicable portions of the procedure were implemented (Section 1 – General Overview
Section 2 – Burst of Events Test). Results of Executed Prudency Test Procedure 9600164-504 Run 3.1, Supp4-16 (Reference 9.23) indicate that all acceptance criteria were satisfied.

7.3 Supplemental Testing

Supplemental Testing of the TUT was performed in accordance with Attachment 4 of the Supplemental Test Plan, 9600164-800. This included Sections 10.7.147 thru 10.7.173 as

applicable to Table 7.1, Tests 7.7.b, 7.8.b, and 7.9.b, including TERR #17of MPR Procedure No. 9600164-510 (Reference 9.3), and applicable portions of Section 7.7.4, and Figure 5 of NTS Test Procedure No. TP62987-07N-EMI (Reference 9.12). All testing was performed with the TUT energized and operating under control of the executing TSAP software. Prior to execution of the 61000-4-16 test, the test setup was verified to meet the requirements of 61000-4-16.

a, b

Table 7.1: Summary of IEC Standard 61000-4-16 Supplemental Test Results

	Cont. DC (3 V)	Short Dur. DC (30 V)*	Cont. 60 Hz (3 Vrms)	Short Dur. 60 Hz (30 Vrms)	Frequency Sweep	Threshold Testing Required?
Discrete Input/Output Modules						
Module 3-2T	---	**Test 136(1)**	---	---	---	**No**
Module 3-3T	---	**Test 138(1)**	---	---	---	**No**
Module 3-3B	---	**Test 140(1)**	---	---	---	**No**

Note (1): Tests replace test no. 118, 121, and 126 of previous tests, respectively.

a, b

a, b

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a, b

a, b

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a, b

a, b

a, b

7.4 Performance Proof Testing

Triconex Procedure No. 9600164-503, "Operability Test Procedure" provides instructions for operability and power quality tolerance testing to be performed on the TUT. In accordance with Attachment 2 of the Supplemental Test Plan (Reference 9.11) only applicable portions of the procedure were implemented (Section 1 – General Overview, Section 4 – Discrete Input Test, Section 5 – Discrete Output Test). Results of Executed Operability Test Procedure 9600164-503 Run 3.7, Supp4-16 (Reference 9.23) indicate that all acceptance criteria were satisfied.

Triconex Procedure No. 9600164-504 provides instructions for Prudency testing to be performed on the TUT. In accordance with Attachment 3 of the Supplemental Test Plan (Reference 9.11) only applicable portions of the procedure were implemented (Section 1 – General Overview
Section 2 – Burst of Events Test). Results of Executed Prudency Test Procedure 9600164-504 Run 3.3, Supp4-16 (Reference 9.25) indicate that all acceptance criteria were satisfied.

Therefore, the aforementioned operability and prudency testing demonstrate acceptable system performance following Supplemental Testing.

7.5 Procedure Deviations

There were no significant procedural deviations taken during Supplemental Testing. A portion of the testing was repeated when the TUT initially failed the susceptibility testing. It was determined that the DAS ground was tied to earth in the DAS, thereby causing the common mode disturbance to be seen differentially by the digital input. This occurrence is discussed in detail in Section 7.2.

a, b

7.6 Test Anomalies

8.0 CONCLUSIONS

8.1 Test Methodology

Supplemental Testing of the TUT was performed in accordance with the applicable requirements of NRC RG 1.180, Revision 1 (Reference 9.2). The following EMI/RFI Test was performed on the TUT:

- **IEC 61000-4-16 testing for Conducted Susceptibility, Short Duration Disturbance at 0 Hz (DC)**

The specific TRICON v10 PLC hardware which was tested (chassis, power supplies, modules, external termination assemblies and interconnecting cabling) is identified in Triconex Document No. 9600164-540 (Reference 9.8).

8.2 Susceptibility Testing

The TUT successfully passed the Supplemental susceptibility tests. The main processors continued to function correctly throughout testing. The transfer of input and output data was not interrupted. There were no interruptions or inconsistencies in the operation of the system or the software.

Table 8-1 provides a summary of the Supplemental conducted susceptibility test results for Discrete Input/Output modules installed in the TUT. The purpose of the table is to identify that the Digital Input Module 3503E (24V AC/DC) w/ ETP 9563-810N,
Digital Output Module 3625(24V DC) w/ ETP 9662-810N, and Digital Output Module 3625 (24V DC) w/ ETP 9662-610N have been shown to demonstrate acceptable susceptibility performance at the required test levels specified in NRC RG 1.180, Revision 1 (Reference 9.2).

8.3 Post-Supplemental Test Operability and Prudency Testing

The completed Operability Test Procedure 9600164-503 Run 3.7, Supp4-16" (Reference 9.23) and the completed Prudency Test Procedure 9600164-504 Run 3.3, Supp4-16 (Reference 9.25) demonstrate acceptable system performance following Supplemental Testing.

8.4 Test Anomalies

Four test anomalies were encountered during Supplemental Testing as described in Sections 7.1, 7.3, and 7.6 of this test report. The test anomalies were dispositioned for their impact on the validity of the test results. Test system revisions were made and/or repeat testing was performed as necessary to correct the conditions identified by anomaly reports.

TABLE 8-1: SUMMARY OF SUPPLEMENTAL EMI/RFI CONDUCTED SUSCEPTIBILITY TEST RESULTS

Module Model No.	ETP Model No.	Module Type	IEC 61000-4-6 Radio Frequency 150 kHz - 80 MHz	IEC 61000-4-13 Harmonics and Interharmonics	IEC 61000-4-16 Common-Mode Disturbances
3503E	9563-810N	Digital Input, 24 VDC	(Not Tested)	(Not Tested)	PASS
3625	9662-810N	Digital Output, 24 VDC	(Not Tested)	(Not Tested)	PASS
	9662-610N	Digital Output, 24 VDC	(Not Tested)	(Not Tested)	PASS

9.0 REFERENCES

9.1 Triconex Document No. 9600164-500, "Master Test Plan," Rev. 5

9.2 U.S. Nuclear Regulatory Commission Regulatory Guide 1.180, Revision 1, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," October 2003

9.3 MPR Procedure No. 9600164-510, "EMI/RFI Test Procedure," Rev. 0

9.4 EPRI TR-107330, "Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants," Final Report dated December, 1996

9.5 Triconex Document No. 9600164-002, "Nuclear Qualification Quality Plan," Rev. 3

9.6 Triconex Drawing No. 9600164-100, "TRICON v10 Nuclear Qualification Project TRICON Under Test - General Arrangement," Rev. 1

9.7 IEC Standard 61000-4-16, "Electromagnetic Compatibility (EMC), Part 4-16: Testing and Measurement Techniques, Test for Immunity to Conducted, Common Mode Disturbances in the Frequency Range 0 Hz to 150 kHz," July 2002

9.8 Triconex Document No. 9600164-540, "Master Configuration List," Rev. 21

9.9 IEEE Standard 323-1974, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations"

9.10 Completed MPR Procedure No. 9600164-510, "EMI/RFI Test Procedure," Rev. 0

9.11 Triconex Document No. 9600164-800, "TRICON v10 Nuclear Qualification Project Supplemental test Plan," Rev. 2

9.12 National Technical Systems Test Procedure No. TP62987-07N-EMI, "Test Procedure for Electromagnetic Compatibility Qualification of the TRICON v10 Nuclear Qualification Project TRICON-Under-Test," Rev. 1

9.13 Triconex Drawing No. 9600164-201, Sheets 1 and 2, "TRICON v10 Nuclear Qualification Project - Power Distribution Wiring Diagram," Rev. 1

9.14 Triconex Drawing No. 9600164-202, Sheet 1, "TRICON v10 Nuclear Qualification Project - Test Chassis #1 Power Distribution Wiring Diagram," Rev. 0

9.15 Triconex Drawing No. 9600164-203, Sheets 1 and 2, "TRICON v10 Nuclear Qualification Project - Test Chassis #2 Power Distribution Wiring Diagram," Rev. 0

9.16 Triconex Drawing No. 9600164-204, Sheets 1 and 2, "TRICON v10 Nuclear Qualification Project - Test Chassis #3 Power Distribution Wiring Diagram," Rev. 0

9.17 Triconex Drawing No. 9600164-205, Sheets 1 and 2, "TRICON v10 Nuclear Qualification Project - Test Chassis #4 Power Distribution Wiring Diagram," Rev. 2

9.18 Triconex Drawing No. 9600164-206, Sheet 1, "TRICON v10 Nuclear Qualification Project - Simulator Chassis #5 Power Distribution Wiring Diagram," Rev. 0

9.19 Triconex Drawing No. 9600164-207, Sheet 1, "TRICON v10 Nuclear Qualification Project - Simulator Chassis #6 Power Distribution Wiring Diagram," Rev. 0

9.20 Completed Setup & Checkout Procedure (9600164-502), Pre-Supplemental 4-16 Test (Run ID: 3.2, Supp 4-1 6)

9.21 Triconex Procedure No. 9600164-502, "System Setup and Checkout Procedure," Rev. 4

9.22 Completed Operability Test Procedure (9600164-503), Rev. 3, Supplemental 4-16 Test (Run ID: 3.1, Supp 4-1 6)

9.23 Completed Operability Test Procedure (9600164-503), Rev. 3, Supplemental 4-16 Test (Run ID: 3.7, Supp 4-1 6)

9.24 Completed Prudency Test Procedure (9600164-504), Rev. 1, Supplemental 4-16 Test (Run ID: 3.1, Supp 4-1 6)

9.25 Completed Prudency Test Procedure (9600164-504), Rev. 1, Supplemental 4-16 Test (Run ID: 3.3, Supp 4-1 6)

9.26 Triconex Qualification Project Anomaly Report (QPAR) No. 056, "3636T Relay Output Module IEC 61000-4-16 Analysis"

9.27 Triconex Qualification Project Anomaly Report (QPAR) No. 057, "Isolation Ground Resistance (Chassis 3 and Chassis 4)"

9.28 Triconex Qualification Project Anomaly Report (QPAR) No. 058, "Load Fuse Errors on Module 3623T"

9.29 Triconex Qualification Project Anomaly Report (QPAR) No. 059, "Isolation Ground Resistance (Chassis 3 and Chassis 4)"