



HF Controls

HFC-6000 Qualifying System

ERD921

EMI/RFI Detail Test Report

TR901-201-04 Rev. A

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HF Controls Proprietary

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**HFC-6000 Qualifying Systems – ERD921
EMI/RFI Detail Test Report**

Revision History

Date	Revision	Author	Changes
6/11/15	A	Y. Lu	Initial revision for detail EMI/RFI retests at Nemko Laboratory for ERD921 Test Specimen.

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1.0 Introduction

1.1 Purpose

An Electromagnetic Interference (EMI)/Radio Frequency Interference (RFI) test was performed on the ERD921 test specimen for the Doosan HF Controls HFC-6000 platform. This document provides detail information for the EMI/RFI tests and analyses performed on the ERD921 test specimen. Although a complete set of EMI/RFI qualifications in accordance with NRC RG 1.180 was performed, the test results described in this document are limited to the EMI/RFI tests related to the open items performed on the ERD921 test specimen. Table 1 lists the EMI/RFI tests covered in this report:

Table 1 – EMI/RFI Tests

Description	Testing Method (MIL-STD-461E)	Test Signal Range
Low Frequency Conducted Emission	CE101	60/120 Hz to 10 kHz
High Frequency Conducted Emission	CE102	10 kHz to 10 MHz
Low Frequency Radiated Emission	RE101	30 Hz to 100 kHz
High Frequency Radiated Emission	RE102	2 MHz to 10 GHz
Magnetic Field Radiated Susceptibility	RS101	30 Hz to 100 kHz
Electric Field Radiated Susceptibility	RS103	30 MHz to 10 GHz
Low Frequency Conducted Susceptibility (Power Lines)	CS101	30 Hz to 150 kHz
High Frequency Conducted Susceptibility (Power & Signal Lines)	CS114	10 kHz to 30 MHz
Conducted Susceptibility Bulk Injection (Signal Lines)	CS115	Electrical Fast Transient (EFT) Signals
Conducted Susceptibility, Damped Sinusoidal Transient (Signal Lines)	CS116	10 kHz to 100 MHz

2.0 References and Acronyms

2.1 Industry References

EPRI TR 107330	Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants, 1996
MIL-STD-461E	Department of Defense, Requirements for Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
NRC RG 1.180	Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems, 2003 R1

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2.2 HFC References

50040801	ERD111/ERD921 Power Distribution System Cabinet, Rev. D
50040901	Loop Layout Table of PCB Assemblies ERD111/TÜV, Rev. B
QPP 17.1	Quality Record
TP901-201-04	DMR Operability Test Procedure, Rev E
TP901-202-04	TMR Operability Test Procedure, Rev D
TP901-203-04	SLC Operability Test Procedure, Rev C
TP901-201-05	ERD921 DMR Prudency Test Procedure, Rev B
TP901-202-05	ERD921 TMR Prudency Test Procedure, Rev C
TP901-203-05	SLC Prudency Test Procedure, Rev B
TP901-200-05	EMI-RFI Qualification Test Procedure, Rev. C
VV901-301-02	TUV DMR Master Configuration List, Rev C
VV901-302-02	TUV TMR Master Configuration List, Rev C
VV901-303-02	HFC-SBC04A System Master Configuration List, Rev C
VV901-300-01	ERD111-ERD921 Qualification Master Test Plan, Rev B

2.3 Acronyms

DMR	Double Modular Redundancy
EFT	Electrical Fast Transient
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPRI	Electrical Power Research Institute
HFC	Doosan HF Controls/HF Controls
NRC	Nuclear Regulatory Commission
PLC	Programmable Logic Controller
RFI	Radio Frequency Interference
RTD	Resistive Temperature Detector
TMR	Triple Modular Redundancy

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3.0 Testing Information

3.1 Venue

The EMC tests were conducted at Nemko USA, an ISO/IEC 17025 certified laboratory. The laboratory is located at 802 North Kealy Street, Lewisville, TX 75057-3136

The testing period was from July 26th, 2010 until August 20th, 2010. CS116 was tested at HFC facility on September 20th, 2010.

3.2 Test Specimen Equipment List

The HFC-6000 modules installed in the ERD921 test specimen are listed in the following table.

Table 2 – ERD921 Test Specimen HFC-6000 Modules

Quantity	Modular Type	Description
2	PS, Jasper 24V	600W 24V Power Supply
1	Rack, Jasper PS	8-slot Jasper PS Rack, 19"
1	HFC-HUB06-16-01	16 Port 10/100 Hub
1	HFC-HUB06-16-02	16 Port 10/100 Hub
1	HFC-HUB06-16-EXT	Hub Extender
1	HFC-BPC01-19	Controller Chassis backplane
1	HFC-BPC03-08	3 Loop, 8 inch backplane
5	HFC-SBC06	Main Controller
4	HFC-DPM06	Dual-Ported Memory
2	HFC-SCG06	Communication Gateway
1	HFC-DPM06BP	Backplane Connected DPM06
12	HFC-DI16I	Digital Input Card with SOE
8	HFC-DO16C	Solid State Output Card
6	HFC-AI16RD	Analog Input Card (0 – 5 vdc) (DSP)
6	HFC-AO8FD	Analog Output Card (4 – 20 mA) (DSP)
3	HFC-AI8LD	Thermocouple Input Card
3	HFC-AI8MD	RTD Input Card, 100 ohm (DSP)
2	HFC-FOT06	Fiber-Optic Transmitter
4	HFC-ILR06	I/O Link Repeater/Terminator
1	HFC-BPE01-19	Expander Chassis backplane
1	HFC-SBC04A	Single Loop Controller
1	HFC-AC36FD	Analog I/O Module

(Note: Modules listed in bold-faced fonts indicate that they are listed in HFC-6000 SER.)

Figure 1 shows the layout of the modules inside the qualification cabinet.

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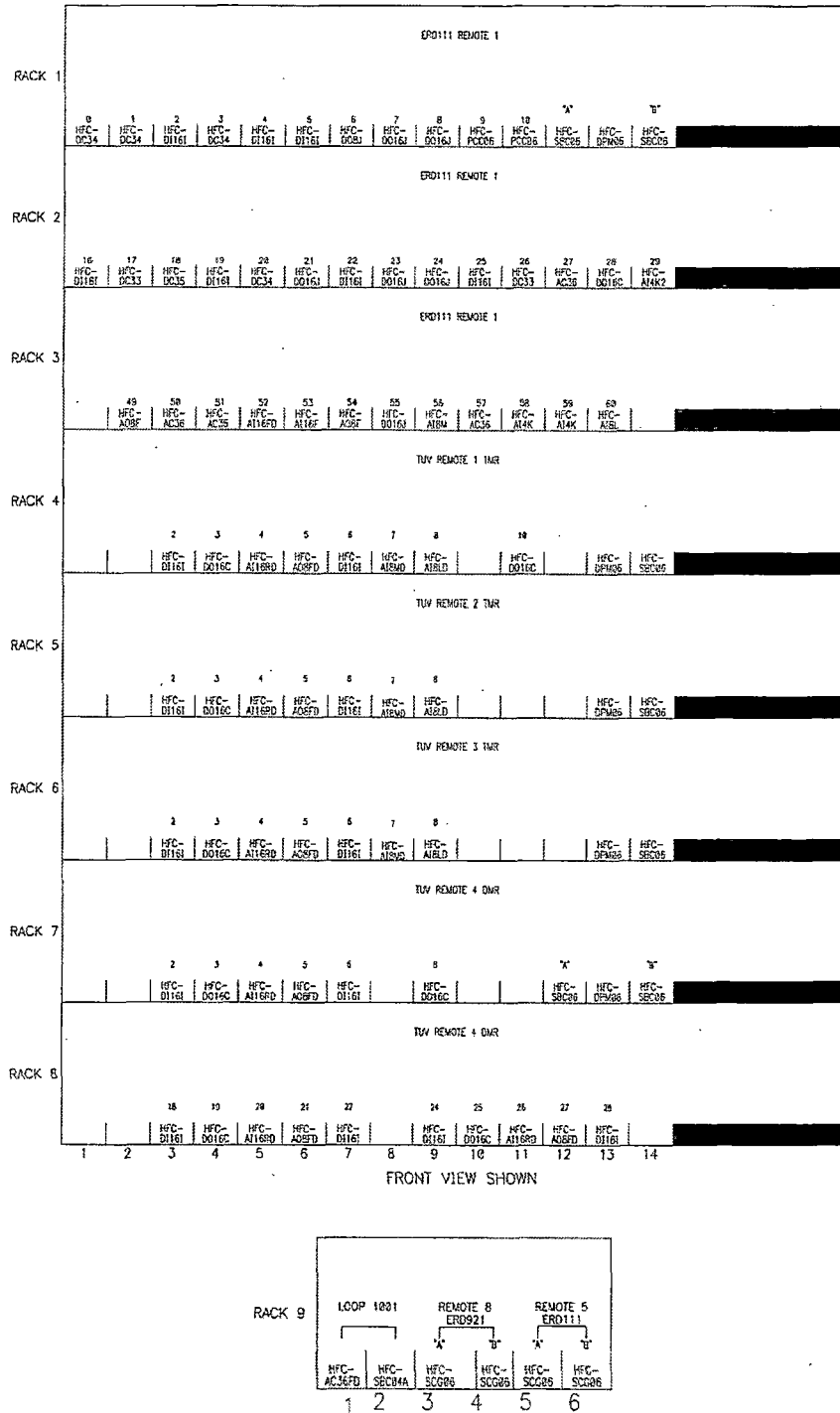


Figure 1 – Equipment Layout in the Cabinet

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3.3 Required Validation Tests

Automated operability and prudence tests developed for validating the functionality of the test specimen are used. According to EPRI TR 107330 Section 4.3.7 EMI/RFI Withstand Requirements, when the PLC modules subjected to EMI/RFI disturbances, the PLC modules shall perform as follows:

1. The main and any coprocessors shall continue to function
2. The transfer of I/O data shall not be disrupted.
3. The emissions shall not cause the discrete I/O to change state.
4. Analog I/O level shall not vary more than 3%.

In order to validate the above performance requirements, the following data from the test specimen were collected and analyzed:

A. Response Time

The response time for digital I/O and Analog I/O shall be within the manufacturer's acceptance limits. In particular, the digital response time shall be under 100ms and the analog response time shall be under 300ms.

B. Discrete I/O Operability

All states of the discrete input shall be detected and all changes of the discrete output shall occur.

C. Communication Operability

Communication performance shall meet the manufacturer's acceptance limits. No errors shall be reported for the C-Link communication. The acceptable errors for the ICL communication are 0x01 "BUSY" and 0x03 "CRC Error".

D. Timer Test

The accuracy of the timer functions shall meet the $\pm 1\%$, ± 3 scan cycles.

E. Burst of Event (BOE) Prudence Test

All transitions of the states of all channels driven by the BOE shall be detected. Analog I/O levels shall not have variations greater than 3%.

For a specific EMI/RFI susceptibility test, when the results of these tests meet the acceptance criteria, it validates the test specimen has demonstrated no susceptibility to the test signals.

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4.0 Test Results

4.1 Emission Tests

All emission tests were performed with the ERD921 test specimen powered up.

4.1.1 CE101

Conducted emission test CE101 was performed in accordance with MIL-STD-461E. The following figure shows the required test spectrum in accordance with RG 1.180.

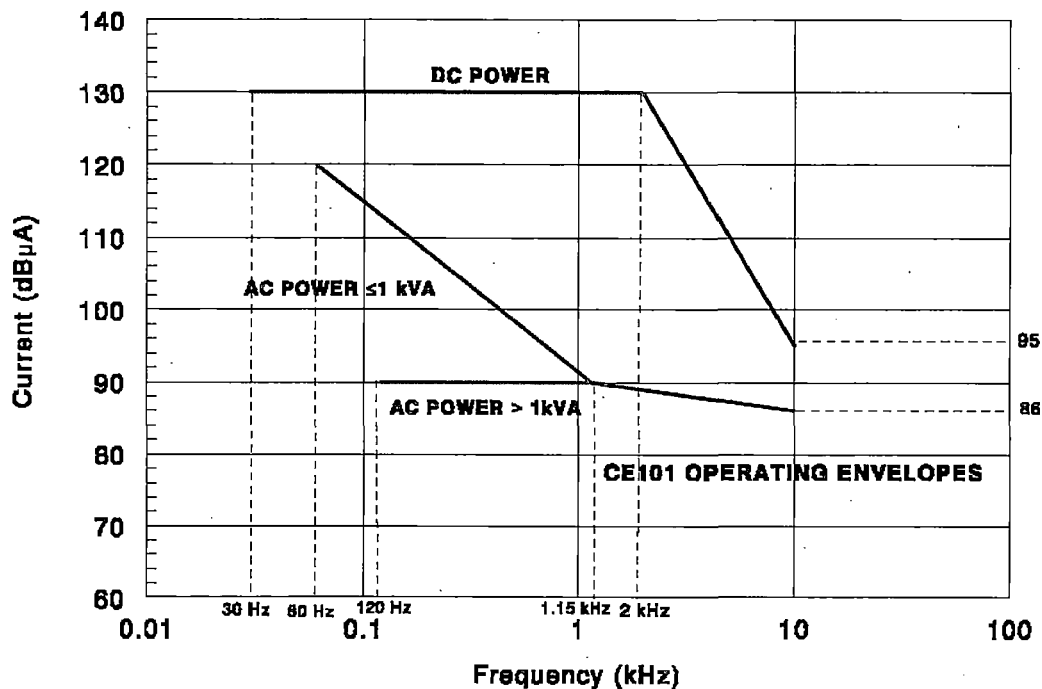


Figure 2 – CE101 Operating Envelopes

Even though the test specimen, ERD921 AC power was lower than 1kVA, the applicable starting point for the test is at the second harmonic of the power source frequency, i.e. 120Hz. Below is the direct quotation from MIL-STD-461E paragraph 5.4.1 for the applicability of CE101:

“For AC applications, this requirement is applicable starting at the second harmonic of the test specimen power frequency.”

CE101 tests were completed on August 10, 2010. The following figures show the test results of the high line and the return line tests which indicate that ERD921 test specimen pass the CE101 test.

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ERD921 120Vac High Line

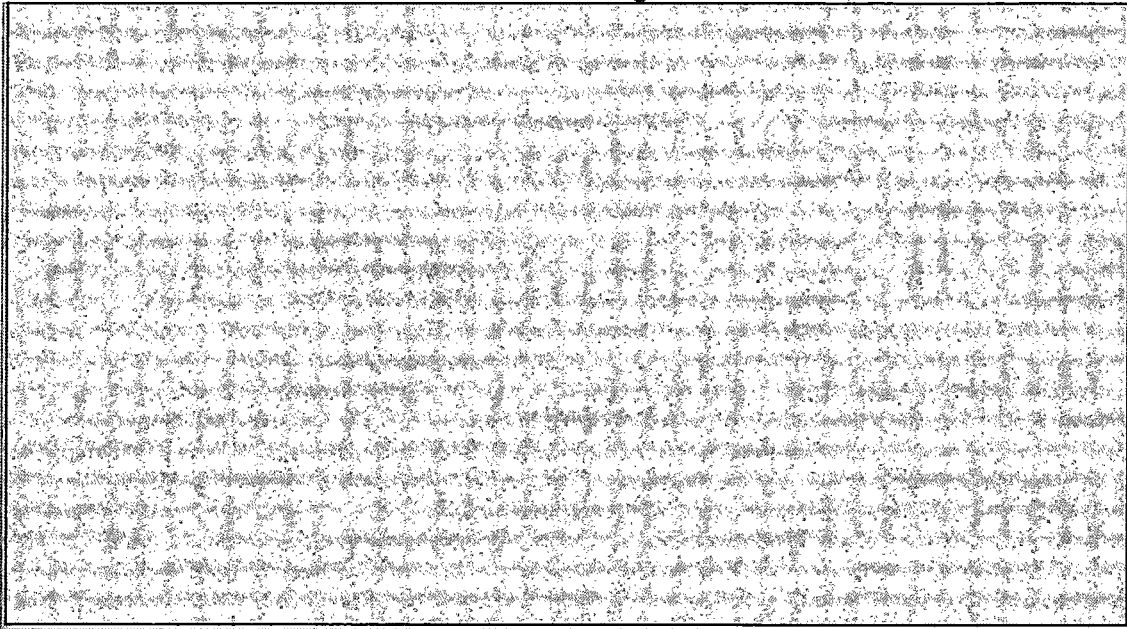


Figure 3 – CE101 High Line Test Results

ERD921 120Vac Neutral Line

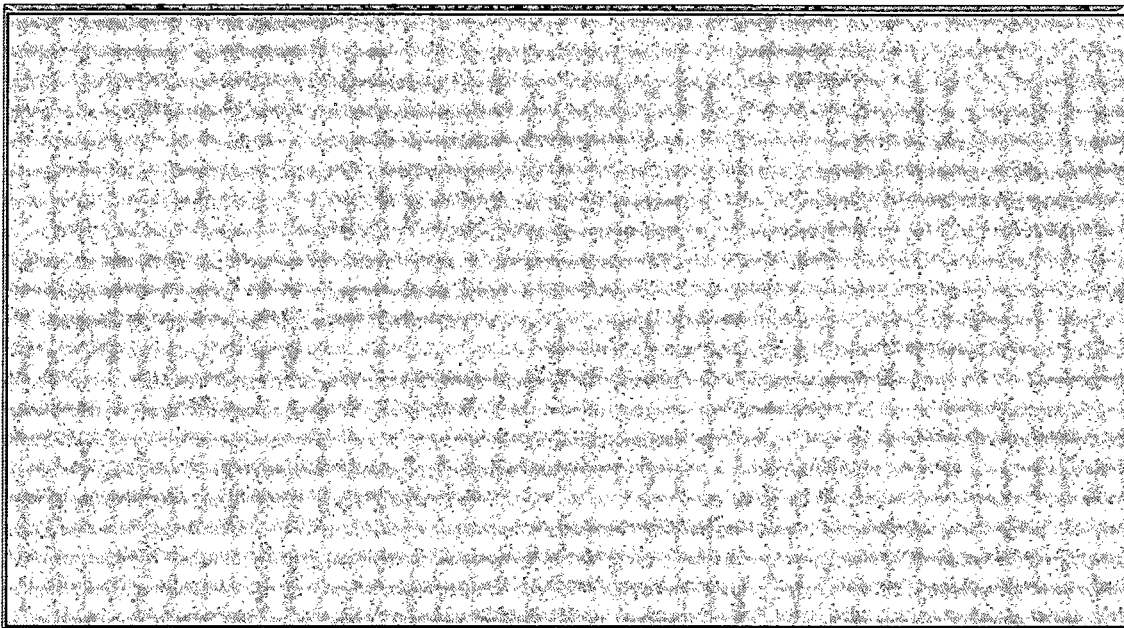


Figure 4 – CE101 Neutral Line Test Results

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4.1.2 CE102

Conducted emission test CE102 was performed in accordance with MIL-STD-461E. The following figure shows the required test spectrum in accordance with RG 1.180.

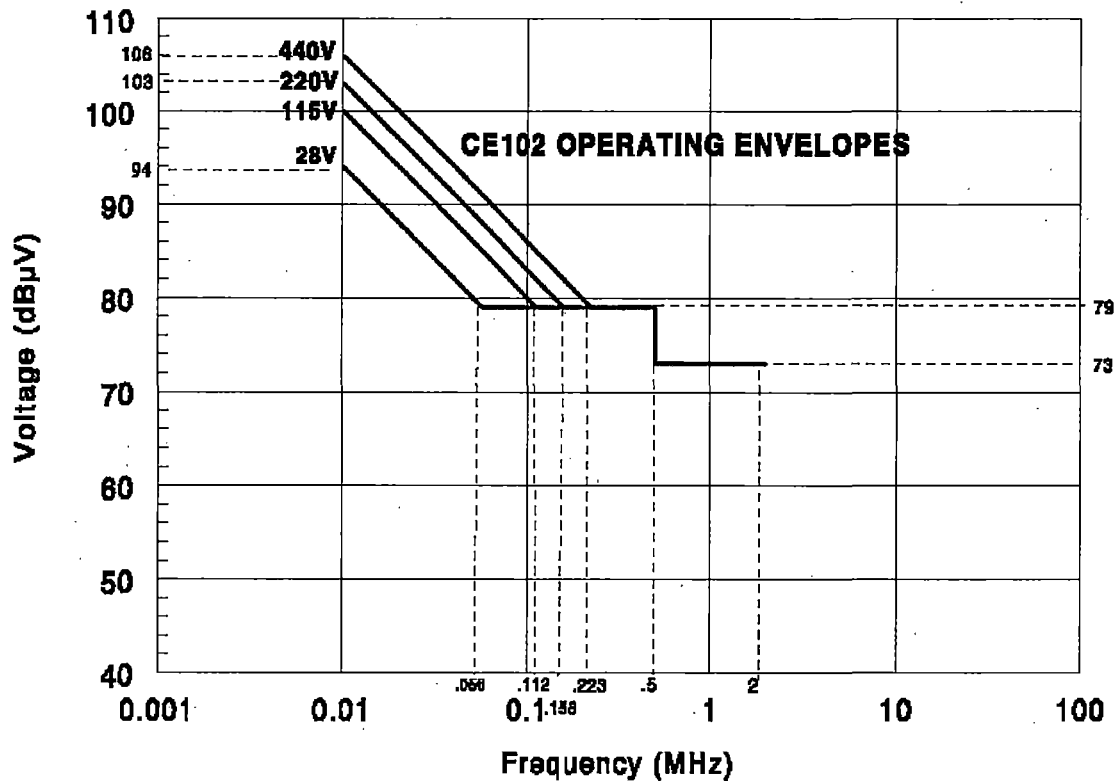


Figure 5 – CE102 Operating Envelopes

CE102 tests were completed on July 27, 2010. The following figures show the test results of the high line and the return line tests which indicate that ERD921 test specimen passed the CE102 test.

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ERD921 120Vac High Line

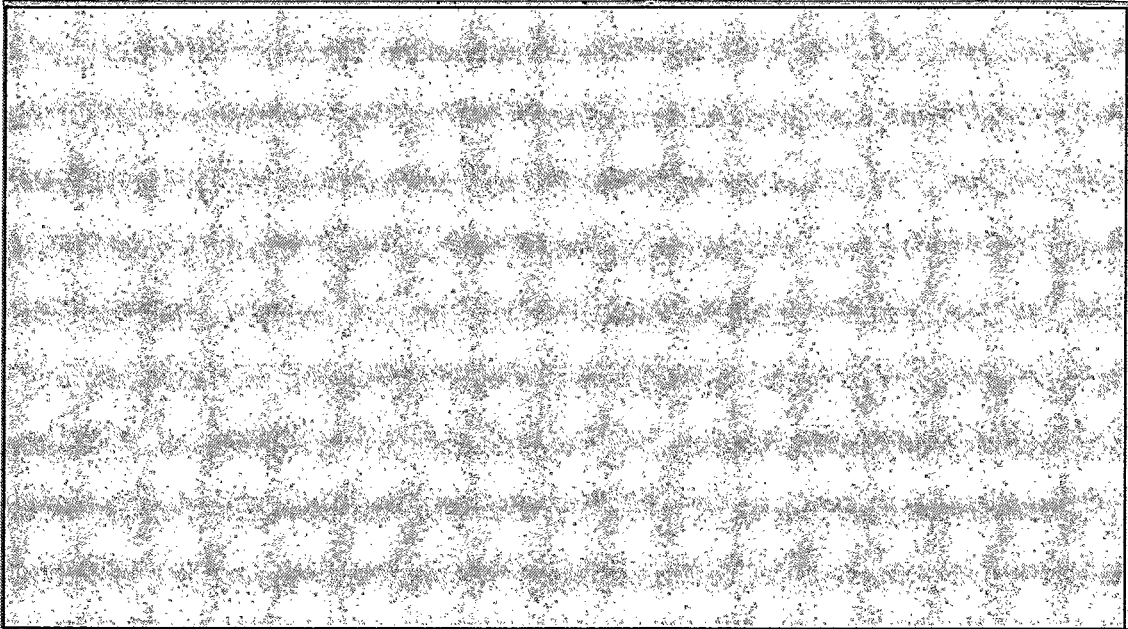


Figure 6 – CE102 High Line Test Results

ERD921 120Vac Neutral Line

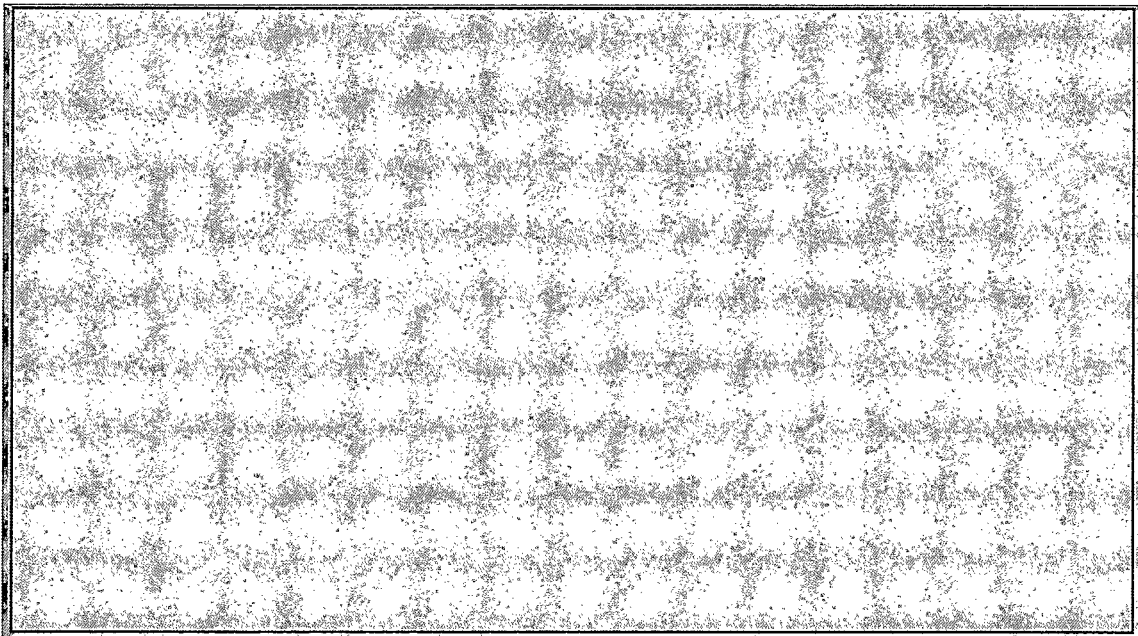


Figure 7 – CE102 Neutral Line Test Results

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4.1.3 RE101

Radiated emission test RE101 was performed in accordance with MIL-STD-461E. The following figure shows the required test spectrum in accordance with RG 1.180.

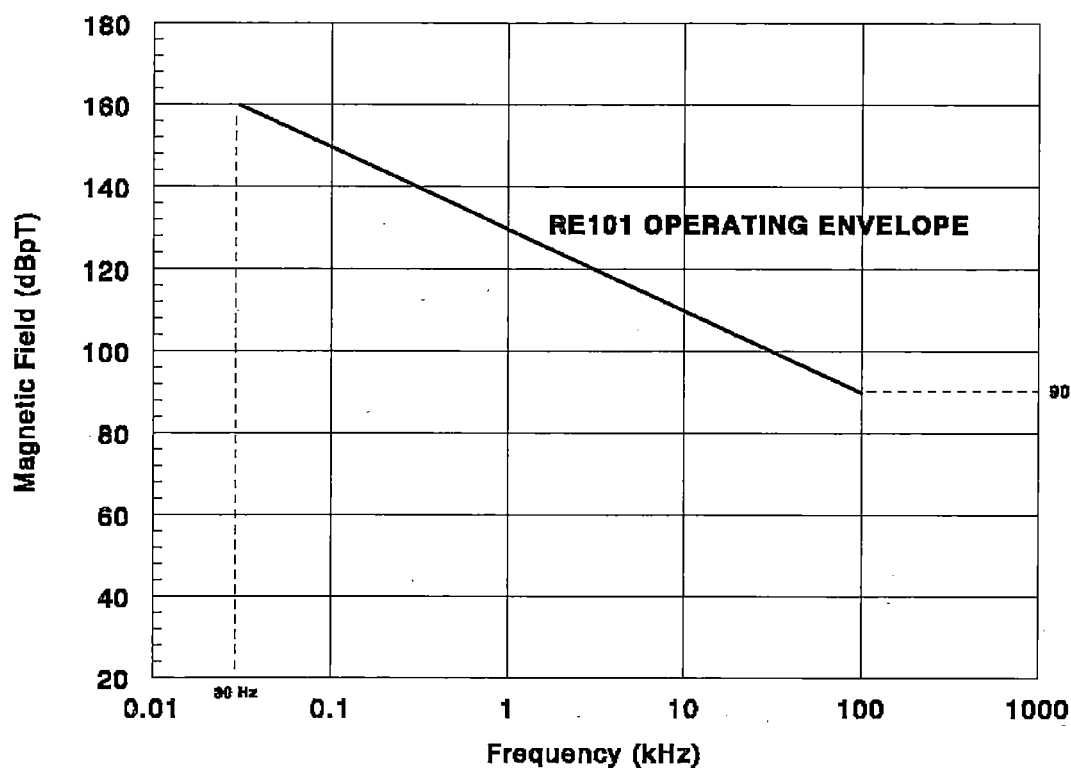


Figure 8 – RE101 Operating Envelopes

Pretest scans were performed to locate the highest radiated disturbances for the test specimen. Two locations were found and they are the left side and the right side of the mid section area around the DC power distribution terminal caps.

A full scan from 30Hz to 100kHz was performed and the detected radiated disturbances were below the RE101 operating envelop limits. The test specimen passed the test. See the following figures of the actual test results. RE101 tests were completed on July 28, 2010.

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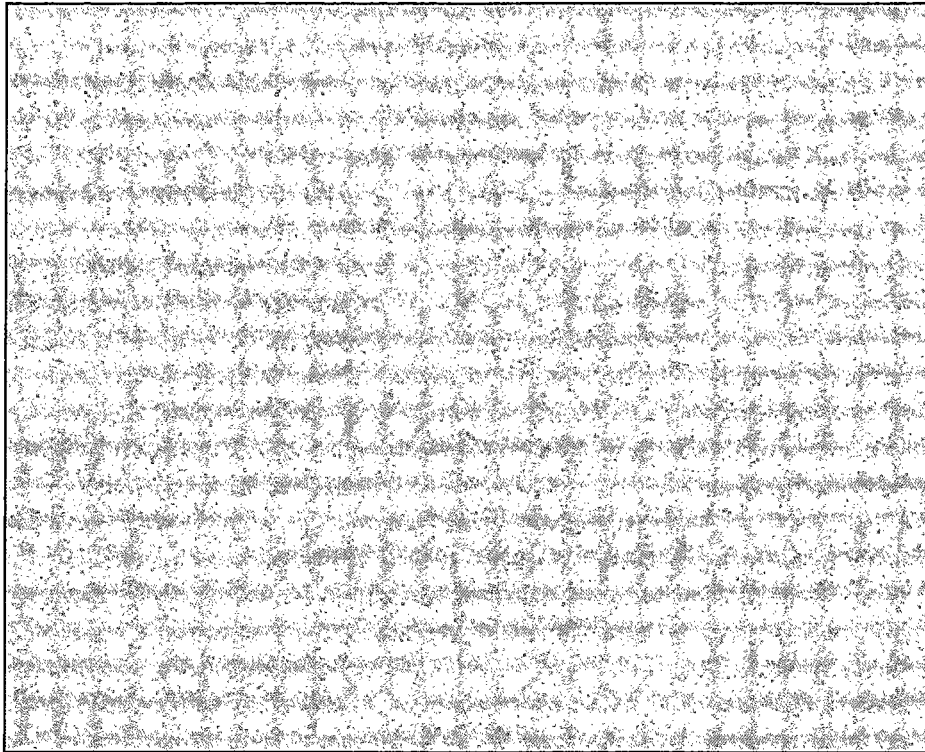


Figure 9 – RE101 Test Result 1

Nemko, Dallas TX

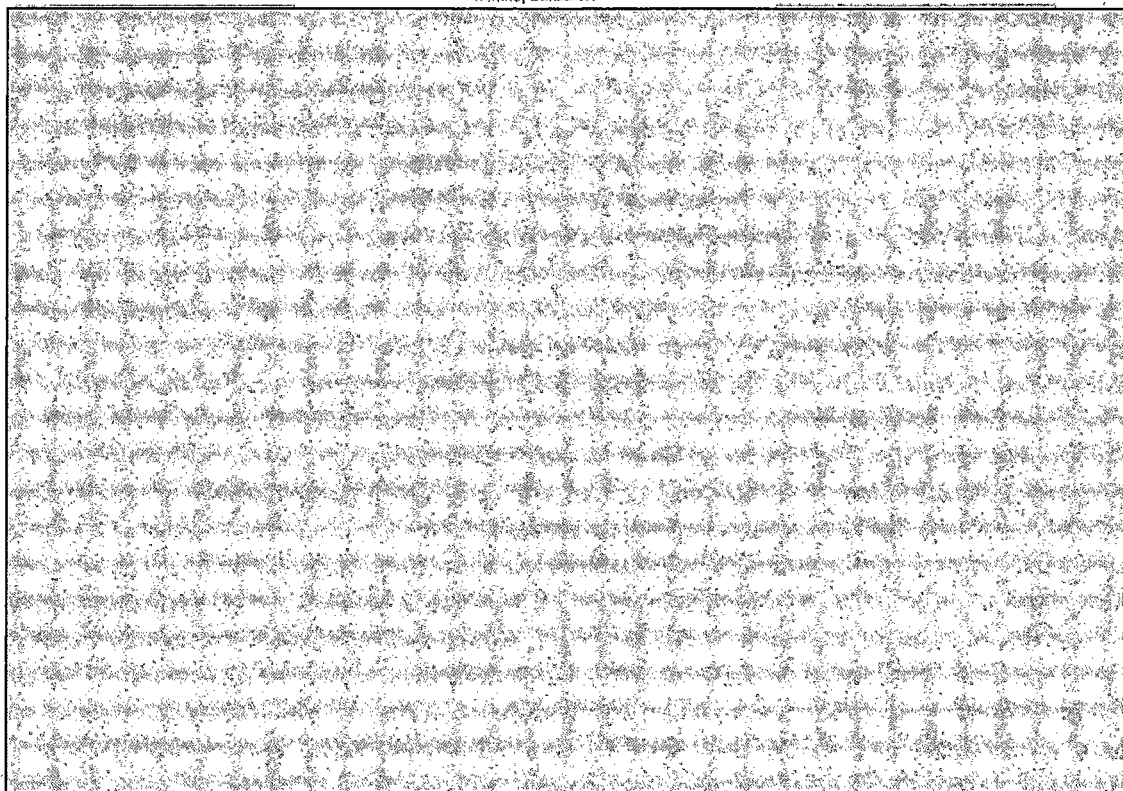


Figure 10 – RE101 Test Result 2

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4.1.4 RE102

Radiated emission test RE102 was performed in accordance with MIL-STD-461E. The following figure shows the required test spectrum in accordance with RG 1.180.

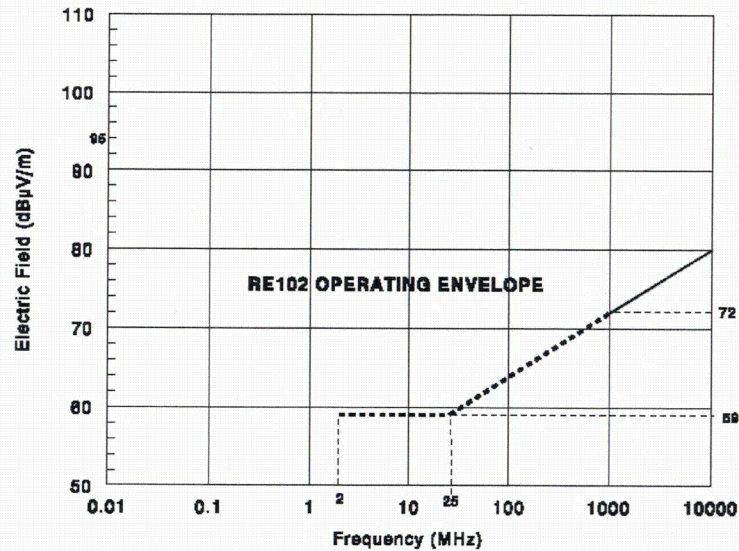


Figure 11 – RE102 Operating Envelopes

In section 6 of RG 1.180, it states that:

“The RE102 test is applicable above 1 GHz for up to 10 times the highest intentionally generated frequency within the equipment under test.”

Although there are no components in HFC-6000 platform generates 1GHz frequency, 10GHz is used as the upper limit of RE102 test as indicated in Figure 11. The location of the antenna was set at the rear side of the cabinet with the cabinet door open. See Figure 12. A pre-test scan indicated this location has the most disturbances. RE102 tests were completed on July 28, 2010.

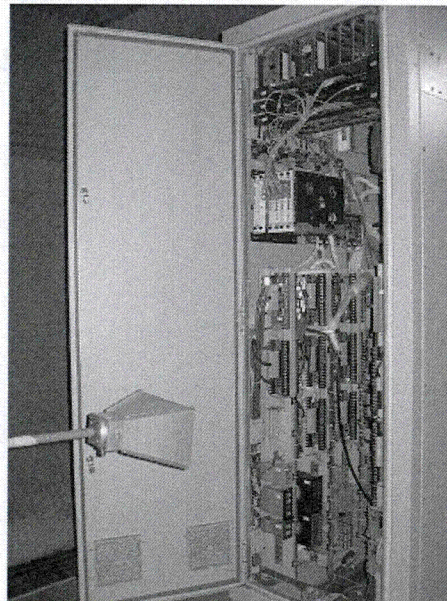


Figure 12 – Antenna location for RE102

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The following figures show that the ERD921 test specimen passed the RE102 test using Figure 11 as the operating envelope for both vertical and horizontal tests.

ERD921 TMR Horizontal

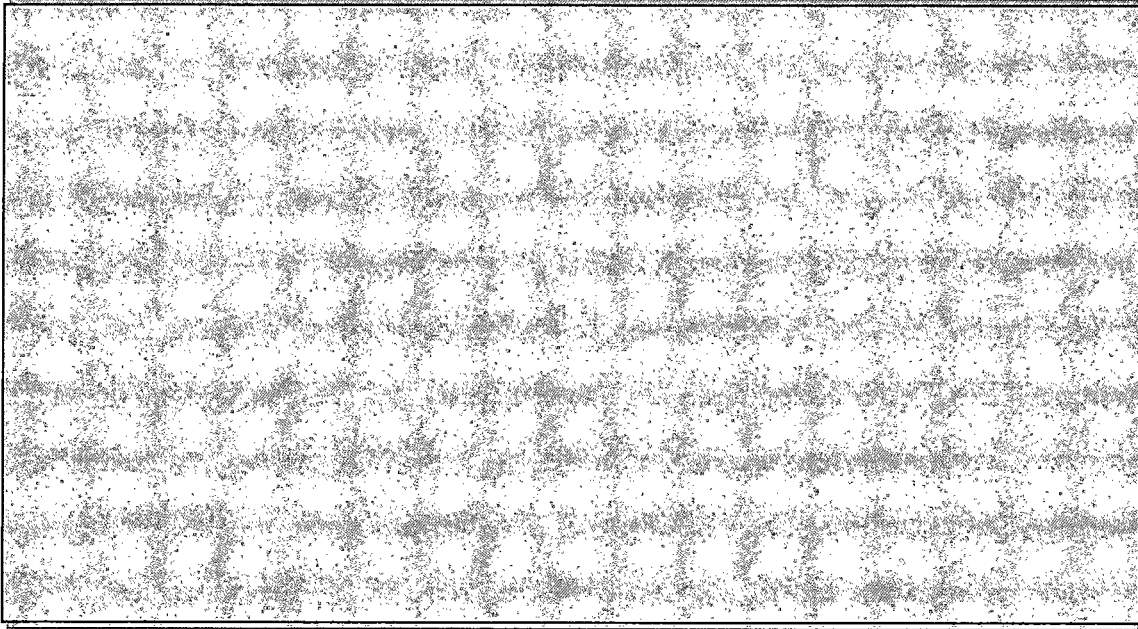


Figure 13 – RE102 Test Result (Horizontal Antenna)

ERD921 TMR Vertical

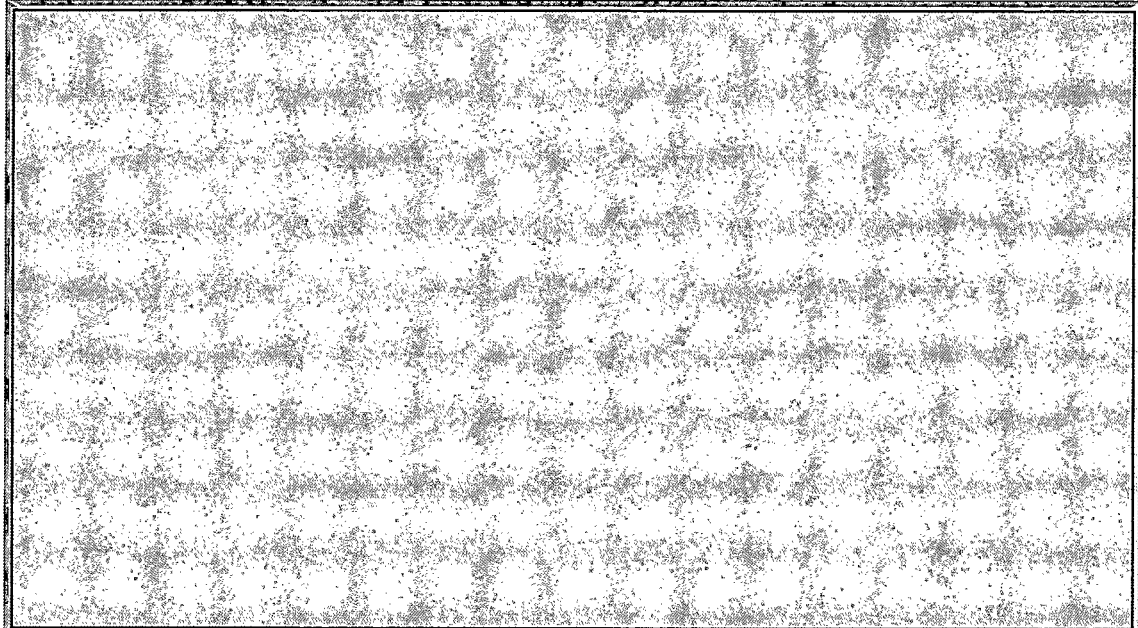


Figure 14 – RE102 Test Result (Vertical Antenna)

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4.2 Susceptibility Tests

As listed in TP901-200-05, the acceptance criteria for the susceptibility tests are:

- All test specimen microprocessors continue to function normally.
- Transfer of I/O data over serial links is not disrupted.
- Serial communication links exhibit no increase in communication error rates.
- Discrete I/O channels exhibit no spurious transitions.
- Analog I/O channels do not change by more than 3% while the EMI/RFI signal is being applied.

When performing CS114 and CS116 tests, the signal lines were grouped into 3 bundles and each bundle was tested separately. Radiated susceptibility tests RS101 and RS103 were performed on the system.

All susceptibility tests performed with the required test signals operating at 100% signal strength. The HAS data were used for validating the analog I/O channels responses and communication channel errors. The SOE data were used for calculating analog and digital response times, and timer functions of the system. In addition, the SOE data were examined to ensure no discrete I/O channels exhibit spurious transitions.

The following table describe the mapping of the SOE points and the HAS data points used in the calculation.

Table 3 – Log points

TMR Description	Output Point	Input Point	HAS Log Point
AI Test Waveform	1, AO, 1	1, AI, 5	1, AI, 5 Log 1, BL, 51
AO Test Waveform	1, AO, 1		1, AO, 5 Log 1, BL, 56
RTD Accuracy	N/A	1, AI, 17	1, AI, 17 Log 1, BL, 17
TC Accuracy	N/A	1, AI, 32 2, AI, 32 3, AI, 32	1, AI, 32 Log 1, BL, 25

For more information about the detail of the response time measurement, refer to TP0402 operability test procedure for ERD921.

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4.2.1 CS114

CS114 test verifies the ability of the test specimen to withstand RF signals coupled onto test specimen associated cabling. The following table shows the specification limits:

Table 4 – CS114 specification limits

Start Freq. (MHz)	Stop Freq. (MHz)	Test Level (dBμA)	Time Duration
0.010	1.0	49 to 89	120 minutes
1.0	30	89	

In section 4.1.2 of RG 1.180, it states the following:

“Although the CS114 test can be applied to assess signal line susceptibility, the test levels given in this section apply only to power and control lines.”

Therefore, only CS114 power line test results were analyzed.

CS114 power line tests were completed on August 6th, 2010. The followings are the test results and analyses:

4.2.1.1 System Response Time

As shown in the following table, the response times are within the acceptance ranges. No anomalies were detected.

Table 5 – System Response Time during CS114 Power Line Test

I/O Card	Average Response Time
AI16RD– AO8FD (Analog)	
DI16I – DO16C (Digital)	

4.2.1.2 Timer

As shown in the following table, the timer functions are within the acceptance ranges. No anomalies were detected.

Table 6 – Timer Accuracy during CS114 Test

CS114	1 s	5 s
(Power lines)		
Timer		

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4.2.2 RS101

The laboratory generated magnetic disturbances in accordance with RS101 at eight locations, four on each side of the cabinet. All systems continued to execute with no anomalies. See Figure 15 below for the locations of the RS101 probes. The test signal was applied in accordance with RG 1.180 as shown in Figure 16.

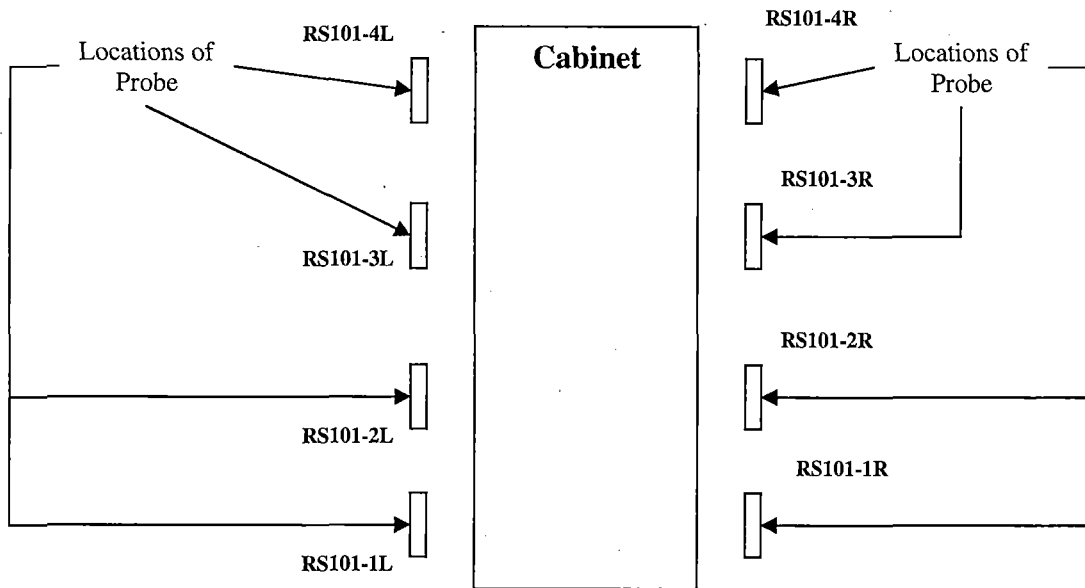


Figure 15 – Locations of RS101 Probes

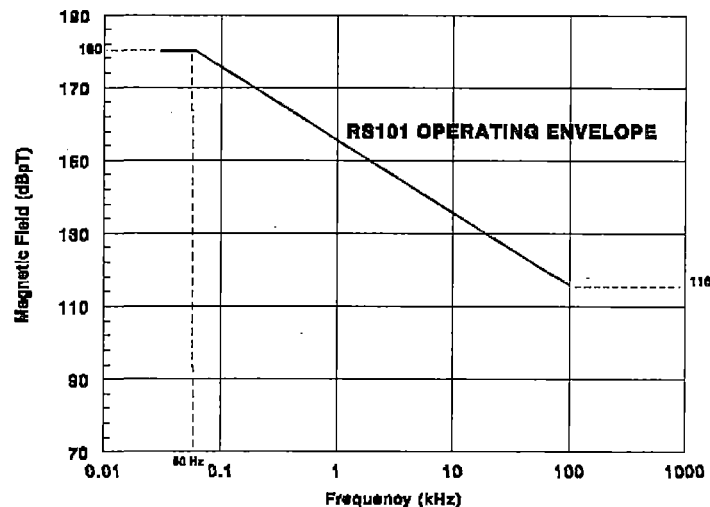


Figure 16 – RS101 Operating Envelope

RS101 tests were completed on August 6th, 2010.

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4.2.2.1 System Response Time

As shown in table below, the response times are within the acceptance ranges. No anomalies were detected.

Table 7 – System Response Time during RS101 Test

	State	Average Response Time
AI16RD– AO8FD (Analog)		
DI16I – DO16C(Digital)		

4.2.2.2 Timer

As shown in the following table, the timer functions are within the acceptance ranges. No anomalies were detected.

Table 8 – Timer Accuracy during RS101 Test

RS101	1s	5s
Timer		

4.2.3 RS103

The electric fields of frequencies from 30MHz to 10GHz at 10V/m were radiated in vertical and horizontal polarization from the rear side to the test specimens with doors opened. See Figure 17 for the antenna location.

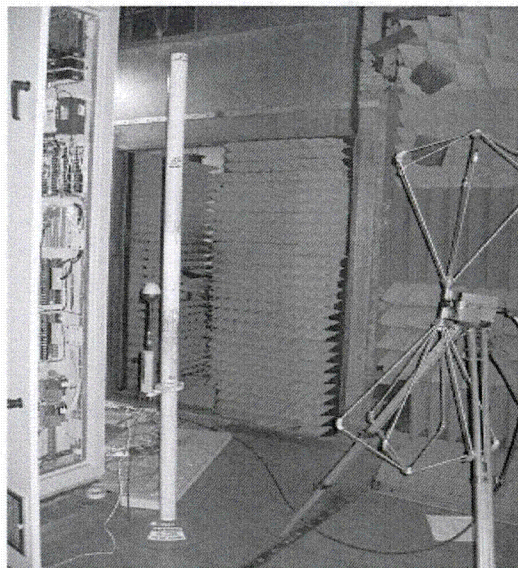


Figure 17 – Antenna location for RS103

The test lasted for two working days from August 4 to August 5th, 2010. See Table 9 for the specification limits of the test.

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Table 9 – Specification Limits of RS103

Start Frequency (MHz)	Stop Frequency (MHz)	Test Level (V/m)	Polarization
30	10000	10	Horizontal
20	10000	10	Vertical

4.2.3.1 System Response Time

As shown in Table 10, the response times are within the acceptance ranges. No anomalies were detected.

Table 10 – System Response Time during RS103 Test

	Average Response Time
AI16RD– AO8FD (Analog)	
DI16I – DO16C (Digital)	

4.2.3.2 Timer

As shown in the following table, the timer functions are within the acceptance ranges. No anomalies were detected.

Table 11 – Timer Accuracy during RS103 Test

RS103	
Timer	

4.2.4 Discrete I/O Operability

Every transition of the discrete input and output were logged. No static I/O points were excited from their original states during testing. The digital response time log data provides evidence that every transition was logged. The following table lists the SOE files/data collected for each susceptibility test:

Table 12 – SOE files for each EMI/RFI Susceptibility Test

EMI/RFI Susceptibility Test	Corresponding SOE Files
CS101	S2181431.TXT, S2181437.TXT, S2181443.TXT, S2181448.TXT, S2181454.TXT, S2181433.TXT, S2181439.TXT, S2181445.TXT, S2181450.TXT, S2181456.TXT, S2181435.TXT, S2181441.TXT, S2181446.TXT, S2181452.TXT
CS114 Power Line	S2180903.TXT, S2180914.TXT, S2180924.TXT, S2180933.TXT, S2180943.TXT, S2180952.TXT, S2180905.TXT, S2180916.TXT, S2180926.TXT, S2180935.TXT, S2180945.TXT, S2180954.TXT, S2180906.TXT, S2180918.TXT, S2180928.TXT, S2180937.TXT, S2180947.TXT, S2180956.TXT, S2180910.TXT, S2180920.TXT, S2180929.TXT, S2180939.TXT, S2180949.TXT, S2180958.TXT,

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EMI/RFI Susceptibility Test	Corresponding SOE Files
	S2180912.TXT, S2180922.TXT, S2180931.TXT, S2180941.TXT, S2180951.TXT, S2181000.TXT
CS115 Signal Line	S2211121.TXT, S2211123.TXT, S2211125.TXT, S2211127.TXT, S2211129.TXT, S2211130.TXT, S2211132.TXT, S2211134.TXT
CS116 Signal Line	S2630833.TXT, S2630933.TXT, S2631040.TXT, S2631122.TXT, S2631238.TXT, S2631323.TXT, S2631416.TXT, S2630845.TXT, S2630947.TXT, S2631042.TXT, S2631124.TXT, S2631240.TXT, S2631326.TXT, S2631418.TXT, S2630849.TXT, S2630949.TXT, S2631044.TXT, S2631125.TXT, S2631242.TXT, S2631328.TXT, S2631422.TXT, S2630852.TXT, S2630950.TXT, S2631046.TXT, S2631128.TXT, S2631244.TXT, S2631330.TXT, S2631426.TXT, S2630856.TXT, S2630952.TXT, S2631048.TXT, S2631130.TXT, S2631246.TXT, S2631334.TXT, S2631430.TXT, S2630901.TXT, S2630954.TXT, S2631050.TXT, S2631132.TXT, S2631248.TXT, S2631338.TXT, S2631432.TXT, S2630903.TXT, S2630956.TXT, S2631052.TXT, S2631134.TXT, S2631250.TXT, S2631340.TXT, S2631433.TXT, S2630904.TXT, S2630958.TXT, S2631054.TXT, S2631136.TXT, S2631252.TXT, S2631342.TXT, S2631434.TXT, S2630906.TXT, S2631000.TXT, S2631056.TXT, S2631140.TXT, S2631254.TXT, S2631344.TXT, S2631440.TXT, S2630908.TXT, S2631002.TXT, S2631058.TXT, S2631142.TXT, S2631256.TXT, S2631346.TXT, S2631444.TXT, S2630910.TXT, S2631004.TXT, S2631059.TXT, S2631215.TXT, S2631258.TXT, S2631347.TXT, S2631448.TXT, S2630912.TXT, S2631006.TXT, S2631101.TXT, S2631217.TXT, S2631300.TXT, S2631349.TXT, S2631451.TXT, S2630914.TXT, S2631008.TXT, S2631103.TXT, S2631219.TXT, S2631301.TXT, S2631351.TXT, S2631506.TXT, S2630916.TXT, S2631010.TXT, S2631105.TXT, S2631221.TXT, S2631303.TXT, S2631353.TXT, S2631508.TXT, S2630918.TXT, S2631012.TXT, S2631107.TXT, S2631223.TXT, S2631305.TXT, S2631355.TXT, S2631513.TXT, S2630920.TXT, S2631015.TXT, S2631109.TXT, S2631225.TXT, S2631307.TXT, S2631357.TXT, S2631516.TXT, S2630922.TXT, S2631017.TXT, S2631111.TXT, S2631227.TXT, S2631309.TXT, S2631359.TXT, S2631521.TXT, S2630924.TXT,

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EMI/RFI Susceptibility Test	Corresponding SOE Files
	S2631019.TXT, S2631113.TXT, S2631229.TXT, S2631311.TXT, S2631403.TXT, S2631523.TXT, S2630926.TXT, S2631033.TXT, S2631115.TXT, S2631231.TXT, S2631315.TXT, S2631405.TXT, S2630927.TXT, S2631035.TXT, S2631117.TXT, S2631233.TXT, S2631317.TXT, S2631407.TXT, S2630929.TXT, S2631036.TXT, S2631119.TXT, S2631235.TXT, S2631319.TXT, S2631412.TXT, S2630931.TXT, S2631038.TXT, S2631121.TXT, S2631237.TXT, S2631321.TXT, S2631414.TXT
RS101	S2181116.TXT, S2181117.TXT, S2181119.TXT, S2181121.TXT, S2181250.TXT, S2181252.TXT, S2181254.TXT, S2181121.TXT, S2181123.TXT, S2181125.TXT, S2181254.TXT, S2181256.TXT, S2181258.TXT, S2181300.TXT, S2181125.TXT, S2181127.TXT, S2181129.TXT, S2181131.TXT, S2181300.TXT, S2181302.TXT, S2181304.TXT, S2181306.TXT, S2181131.TXT, S2181133.TXT, S2181135.TXT, S2181306.TXT, S2181308.TXT, S2181310.TXT, S2181312.TXT
RS103	S2161109.TXT, S2161313.TXT, S2161503.TXT, S2161625.TXT, S2170903.TXT, S2171100.TXT, S2171333.TXT, S2161111.TXT, S2161315.TXT, S2161505.TXT, S2161627.TXT, S2170905.TXT, S2171102.TXT, S2171335.TXT, S2161113.TXT, S2161317.TXT, S2161507.TXT, S2161629.TXT, S2170907.TXT, S2171104.TXT, S2171337.TXT, S2161115.TXT, S2161319.TXT, S2161509.TXT, S2161631.TXT, S2170909.TXT, S2171106.TXT, S2171339.TXT, S2161117.TXT, S2161321.TXT, S2161510.TXT, S2161633.TXT, S2170911.TXT, S2171107.TXT, S2171341.TXT, S2161118.TXT, S2161323.TXT, S2161512.TXT, S2161635.TXT, S2170913.TXT, S2171109.TXT, S2171342.TXT, S2161120.TXT, S2161325.TXT, S2161514.TXT, S2161637.TXT, S2170915.TXT, S2171111.TXT, S2171344.TXT, S2161122.TXT, S2161327.TXT, S2161516.TXT, S2161639.TXT, S2170950.TXT, S2171113.TXT, S2171346.TXT, S2161124.TXT, S2161333.TXT, S2161517.TXT, S2161641.TXT, S2170953.TXT, S2171115.TXT, S2171348.TXT, S2161126.TXT, S2161335.TXT, S2161520.TXT, S2161642.TXT, S2170955.TXT, S2171117.TXT, S2171350.TXT, S2161128.TXT, S2161337.TXT, S2161522.TXT, S2161644.TXT, S2170957.TXT,

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EMI/RFI Susceptibility Test	Corresponding SOE Files
	S2171119.TXT, S2171352.TXT, S2161130.TXT, S2161338.TXT, S2161523.TXT, S2161646.TXT, S2170958.TXT, S2171120.TXT, S2171354.TXT, S2161132.TXT, S2161340.TXT, S2161525.TXT, S2161648.TXT, S2171000.TXT, S2171122.TXT, S2171356.TXT, S2161134.TXT, S2161342.TXT, S2161527.TXT, S2161650.TXT, S2171002.TXT, S2171124.TXT, S2171358.TXT, S2161136.TXT, S2161344.TXT, S2161530.TXT, S2161652.TXT, S2171004.TXT, S2171126.TXT, S2171400.TXT, S2161138.TXT, S2161346.TXT, S2161532.TXT, S2161654.TXT, S2171006.TXT, S2171129.TXT, S2171402.TXT, S2161140.TXT, S2161348.TXT, S2161533.TXT, S2170810.TXT, S2171008.TXT, S2171130.TXT, S2171404.TXT, S2161141.TXT, S2161413.TXT, S2161535.TXT, S2170813.TXT, S2171010.TXT, S2171132.TXT, S2171405.TXT, S2161143.TXT, S2161415.TXT, S2161537.TXT, S2170815.TXT, S2171012.TXT, S2171134.TXT, S2171407.TXT, S2161145.TXT, S2161417.TXT, S2161539.TXT, S2170817.TXT, S2171014.TXT, S2171136.TXT, S2171409.TXT, S2161147.TXT, S2161419.TXT, S2161541.TXT, S2170819.TXT, S2171016.TXT, S2171137.TXT, S2171411.TXT, S2161149.TXT, S2161421.TXT, S2161543.TXT, S2170821.TXT, S2171018.TXT, S2171237.TXT, S2171413.TXT, S2161151.TXT, S2161423.TXT, S2161545.TXT, S2170823.TXT, S2171020.TXT, S2171239.TXT, S2171415.TXT, S2161153.TXT, S2161424.TXT, S2161547.TXT, S2170825.TXT, S2171021.TXT, S2171240.TXT, S2171417.TXT, S2161155.TXT, S2161426.TXT, S2161549.TXT, S2170827.TXT, S2171023.TXT, S2171242.TXT, S2171419.TXT, S2161157.TXT, S2161428.TXT, S2161551.TXT, S2170829.TXT, S2171025.TXT, S2171244.TXT, S2171421.TXT, S2161159.TXT, S2161430.TXT, S2161553.TXT, S2170831.TXT, S2171027.TXT, S2171246.TXT, S2171423.TXT, S2161201.TXT, S2161432.TXT, S2161555.TXT, S2170833.TXT, S2171029.TXT, S2171248.TXT, S2171424.TXT, S2161203.TXT, S2161434.TXT, S2161556.TXT, S2170834.TXT, S2171031.TXT, S2171250.TXT, S2171426.TXT, S2161204.TXT, S2161436.TXT, S2161558.TXT, S2170836.TXT, S2171033.TXT, S2171252.TXT, S2171429.TXT,

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EMI/RFI Susceptibility Test	Corresponding SOE Files
	S2161206.TXT, S2161438.TXT, S2161600.TXT, S2170838.TXT, S2171035.TXT, S2171254.TXT, S2171430.TXT, S2161208.TXT, S2161440.TXT, S2161602.TXT, S2170840.TXT, S2171037.TXT, S2171256.TXT, S2171432.TXT, S2161210.TXT, S2161442.TXT, S2161604.TXT, S2170842.TXT, S2171039.TXT, S2171258.TXT, S2171434.TXT, S2161212.TXT, S2161444.TXT, S2161606.TXT, S2170844.TXT, S2171041.TXT, S2171300.TXT, S2171436.TXT, S2161256.TXT, S2161445.TXT, S2161608.TXT, S2170846.TXT, S2171043.TXT, S2171302.TXT, S2171438.TXT, S2161258.TXT, S2161447.TXT, S2161610.TXT, S2170848.TXT, S2171044.TXT, S2171303.TXT, S2171440.TXT, S2161300.TXT, S2161449.TXT, S2161612.TXT, S2170850.TXT, S2171046.TXT, S2171305.TXT, S2171442.TXT, S2161302.TXT, S2161451.TXT, S2161614.TXT, S2170852.TXT, S2171048.TXT, S2171307.TXT, S2171444.TXT, S2161304.TXT, S2161453.TXT, S2161616.TXT, S2170854.TXT, S2171050.TXT, S2171309.TXT, S2171446.TXT, S2161306.TXT, S2161455.TXT, S2161618.TXT, S2170856.TXT, S2171052.TXT, S2171311.TXT, S2171448.TXT, S2161308.TXT, S2161457.TXT, S2161619.TXT, S2170857.TXT, S2171054.TXT, S2171313.TXT, S2171450.TXT, S2161310.TXT, S2161459.TXT, S2161621.TXT, S2170859.TXT, S2171056.TXT, S2171315.TXT, S2171451.TXT, S2161312.TXT, S2161501.TXT, S2161623.TXT, S2170901.TXT, S2171058.TXT, S2171331.TXT, S2171453.TXT,

4.2.5 Communication

For ICL communication, only errors 0x01 (Busy) and 0x03 (CRC error) are reported. No other ICL communication errors. No C-Link communication errors were reported. The following table shows the listing of the alarm files and communication error counters:

Table 13 – Communication Error Counter and Alarm Files

Alarm Files	A07_22_2010.txt A08_23_2010.txt A08_25_2010.txt A08_27_2010.txt A07_23_2010.txt A08_24_2010.txt A08_26_2010.txt A08_28_2010.txt
Communication Error Counter	1,CO,11 C-Link Error Counter Value

No alarms were reported. C-Link error counter was zero during all susceptibility tests.

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4.2.6 Anomalies

No anomalies were found for the components listed in the SER installed with the ERD921 test specimen.

5.0 Conclusions

The validated test results have shown the test specimens meet the corresponding acceptance criteria:

1. Emissions of the systems are below the allowable limits specified by MIL-STD-461E CE101, CE102, RE101 and RE102.
2. The system is immune to radiated and conducted disturbances specified by MIL-STD-461E CS101, CS114, CS115/EFT, CS116, RS101, RS103:
 - a. All transitions of discrete I/O cards are detected and no anomalies occur.
 - b. Response time stays within the acceptance limits as compared to the measurements without EMI/RFI disturbance.
 - c. No outstanding errors in both C-Link and ICL communications.
 - d. Time functions were within acceptance limits indicating the controllers were functioning correctly throughout the susceptibility tests.
 - e. All BOE events are detected. Analog levels of I/O cards are within 3% accuracy. All transitions of discrete I/O driven by the BOE algorithm are detected.

6.0 QA Records

The test results recorded in the test documents during the tests (see section 2.2) shall be preserved in accordance with QPP 17.1 "Quality Records" as nuclear records.

7.0 Attachments

None.