HF Controls

INFORMATION ONLY

HF CONTROLS

HFC-6000 Control System

Prudency Test Procedure

ERD921 DMR TP901-201-05 Rev B

Effective Date: 5/12/2010

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Revision History

Date	Revision	Author	Changes
4/26/10	A	J Taylor	Initial release
5/12/10	B	I. Chow	Revised for updated configuration per CR2010-0082

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1.0 PURPOSE AND SCOPE

The ERD921 Dual Mode Redundant (DMR) consists of a single redundant controller with triple redundant I/O composed from components of the HFC-6000 platform. The application of this controller is configured to perform two-out-of-three (2oo3) input voting. As part of EPRI TR-107330 qualification testing, Section 5.4 of EPRI TR-107330 stipulates that Prudency testing shall be performed at various points during qualification testing. The purpose for Prudency testing is to verify operation of a system under test under highly dynamic conditions. Section 5.4 of EPRI TR-107330 requires the following set of tests to be performed on a PLC during Prudency testing:

- **Burst of Events Test** – the intent of this test is to simulate in-service stresses by simultaneous activation of multiple input and output channels – both analog and digital (Section 5.4.A of EPRI- TR-107330)
- **Serial Port Failure Test** – the intent of this test is to introduce mechanical failures into the serial communication link with the DMR to demonstrate that system response time does not vary by more than ±10% while the fault is present. (Section 5.4.B of EPRI TR-107330)
- **Serial Port Noise Test** – the intent of this test is to inject noise signal into a serial communication channel. The DMR system responses shall not vary by more than ±10% during the test. (Section 5.4.C of EPRI TR-107330)

The scope of this document covers EPRI TR-107330 Prudency testing for the ERD921 DMR system configuration of the HFC-6000 platform. This system configuration hereafter is referred to as the "ERD921 DMR Test Specimen" or the "Test Specimen".

2.0 REFERENCES

2.1 INDUSTRY STANDARDS

EPRI TR-107330	Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants

2.2 RELATED PLANS AND PROCEDURES

VV901-300-01	ERD111/ERD921 Qualification Program, Master Test Plan, Rev B
VV901-301-02	ERD921 DMR System, Master Configuration List, Rev A
TP901-200-00	ERD111/ERD921 Qualification Program, Pre-Qualification Test Plan, Rev A

2.3 SUPPORT DOCUMENTATION

UG004-000-01	EWS User's Guide, Rev E
UG004-000-03	HAS User's Guide, Rev E
UG004-000-16	MCRT User's Guide Rev B

2.4 HFC INTERNAL STANDARDS AND PROCEDURES

QPP 5.1	Review and Approval of Quality Documents
QPP 5.2	Preparation of Procedures
QPP 11.1	Test Control
WI-ENG-003	Configuration Management
WI-ENG-205	Develop Software/Firmware Test Procedure

2.5 SPECIAL TERMS, ABBREVIATIONS, AND ACRONYMS

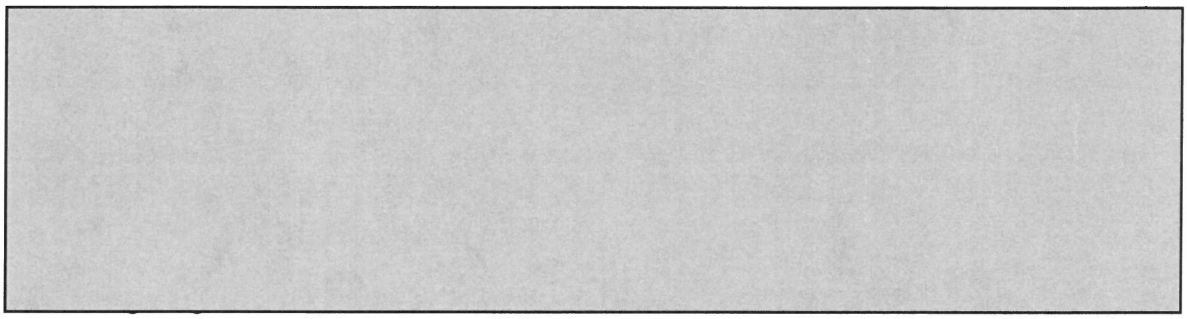
2oo3	Two-out-of-Three
AC	Alternating Current
AI	Analog Input
AO	Analog Output
BOE	Burst of Events
DC	Direct Current
DDB	Dynamic Database
DI	Digital or Discrete Input
DO	Digital or Discrete Output
EWS	Engineering Workstation
HPAT	HFC Plant Automated Tester
HAS	Historical Archiving System
HFC	Doosan HF Controls
I/O	Input/Output
MCRT	HFC Interactive Operator CRT Workstation
PC	Personal Computer
SOE	Sequence of Events
Test Specimen	A system under test consisting of control system hardware and software components along with any applicable system configuration data and support hardware.
DMR	Dual Modular Redundant
TSAP	Test System Application Program

3.0 PREREQUISITES

The following sections identify the test equipment, test environment, and setup requirements for running each of the Prudency tests. The Burst of Events (BOE) test is designed to run automatically on command from the MCRT workstation. The other Prudency tests require manual intervention and control.

3.1 EQUIPMENT REQUIRED

The following equipment and facilities will be required during performance of this test. Test personnel shall verify that all test and measuring equipment are capable of producing the level of accuracy required by the specific test being performed and that the calibration for the test and measurement equipment to be used is current.

- 

3.2 ENVIRONMENTAL CONDITIONS

Prudency testing will be conducted under various conditions of temperature and humidity. During pre-qualification testing, the test will be conducted under normal operating conditions for the Test Specimen as indicated below. During environmental qualification testing, required environmental conditions are stipulated within the procedures governing those tests.

Temperature	Ambient
Relative Humidity	Ambient

3.3 TEST PERSONNEL

The set of Prudency tests will be conducted by qualified HFC test engineers/technicians.

3.4 PRECAUTIONS

WARNING

Certain I/O circuits are energized with high voltages and may carry potentially hazardous current loads. Exercise caution whenever working around exposed terminals or circuitry.

3.5 RED-LINE POLICY

Red-lines to the test procedure shall be done in accordance with WI-ENG-815, "Red-Line Procedure". Such entries may be used to correct errors of content and procedural sequence in test documents or in engineering drawings to prevent disruption of a test in progress.

3.6 EQUIPMENT SETUP

Prerequisites prior to Prudency Testing are as follows:

1. Verify that the copy of the Prudency Test Procedure in hand is a controlled copy of the current revision according to HFC Document Control records
2. Verify that the hardware configuration of the test cabinet has been satisfactorily completed.

Validation that equipment setup is complete: _____
Name/Date

4.0 TEST PROCEDURE

The Prudency tests will be executed during the prequalification phase of testing and at specified points during the qualification tests. No fixed sequence of execution is assumed or implied by the order of specific tests in this document.

4.1 BURST OF EVENTS TEST

The BOE test for the DMR is based on the requirements of Section 5.4.A in the EPRI TR-107330 specification. As implemented for the DMR, this test will consist of the following:

- Simultaneously toggling two discrete output (DO) channels that will be looped back to separate discrete input (DI) channels. One of the DI channels will drive a third DO channel.
- An algorithm running in the DMR will drive two analog output (AO) channels with an output level switching between 10% and 90% of full scale and a 10-second dwell time at each level. The two AO channels will be connected back to separate analog input (AI) channels.

Table 1 below lists the specific combination of points used to implement this test. The BOE test is designed to run on command from the MCRT. Once started, BOE algorithms automatically generate analog and digital output signals, and the image of selected BOE signals will be logged for subsequent evaluation of equipment performance.

Table 1. BOE Point Assignments for DMR Testing

ERD921 DMR Test Specimen		
Signal Source	**Point Designation**	**Signal Rating**

4.1.1 BOE Setup Requirements

The BOE test is controlled and monitored by means of interactive graphics of the MCRT workstation and test algorithms of the TSAP executing in the Test Specimen. No software configuration beyond creation and validation of these application programs is required. All hardware configuration requirements consist of completing the cable interconnections between the Test Specimen I/O and the SOE terminals. However, before the BOE test is run for the first time, HAS and SOE loggers must be configured to record the data being generated, and the interactive graphic interface must be configured on the MCRT.

4.1.1.1 Automated Logging Utilities

Both the HAS and the SOE utilities will be used to record I/O images during execution of the Prudency tests. (Refer to TP901-201-04, Operability Test Procedure, for specific SOE and HAS point assignments.) The HPAT includes a set of 16-point input modules that can be configured for SOE logging. The HAS can be configured for both digital and analog inputs. The Operability Test Procedure provides detailed instructions for configuring both utilities.

1. Verify that SOE configuration is completed in accordance with DMR Operability Test Procedure.
2. Verify that HAS configuration is completed in accordance with DMR Operability Test Procedure.
3. The HAS time stamp is derived from the time of day clock in the EWS workstation. Ensure that this timer is set to the current date and time.

SOE and HAS setup is complete: _____

Name/Date

4.1.1.2 BOE Graphic Interface

The BOE graphic interface consists of an interactive target on an MCRT graphic page that permits on/off control of the overall test and visual status monitoring of test operation. (Refer to UG004-000-16, MCRT User's Guide.) As a minimum, configure the BOE graphic interface should include the following utilities:

- A touch target to enable/disable dynamic operation of the DMR BOE algorithms.
- 4,DO,17 through 4,DO,19 – BOE digital output images
- 4,DI,25 and 4,DI,26 – BOE digital input images
- 4,AO,7 and 4,AO,8 – BOE analog output images
- 4,AI,11 and 4,AI,12 – BOE analog input images

Graphic interface is configured and functional: _____
Name/Date

4.1.2 BOE Test Execution

Analog and digital BOE algorithms are configured as part of the DMR TSAP. After initial configuration requirements for the BOE test is complete, dynamic operation of these algorithms is controlled from the MCRT. However, the HAS.Server program must be running on the EWS workstation for the HAS to log data. (Refer to UG004-000-03, HAS User's Guide for detailed information about running the HAS logger.) Logging of SOE data is automatic, but the content of the SOE report files should be verified. The BOE test shall be allowed to run for a minimum period of 1 minute during the pre-qualification phase of testing. Test duration during an individual qualification test will be specified by the test procedure governing that test.

1. Verify that equipment setup (paragraph 3.6) and all test setup requirements (paragraph 4.1.1) are completed. _____

2. On the MCRT graphic, actuate the START button for the BOE test. Record the data and time that the test was started in attachment 6.2. _____

3. Use the MCRT displays to verify that the test algorithm produces continuous analog and digital BOE test waveforms. _____

   The digital waveform is a symmetric 0.5-Hz (one second "ON," one second "OFF") square wave. The analog waveform is shown in Figure 1.

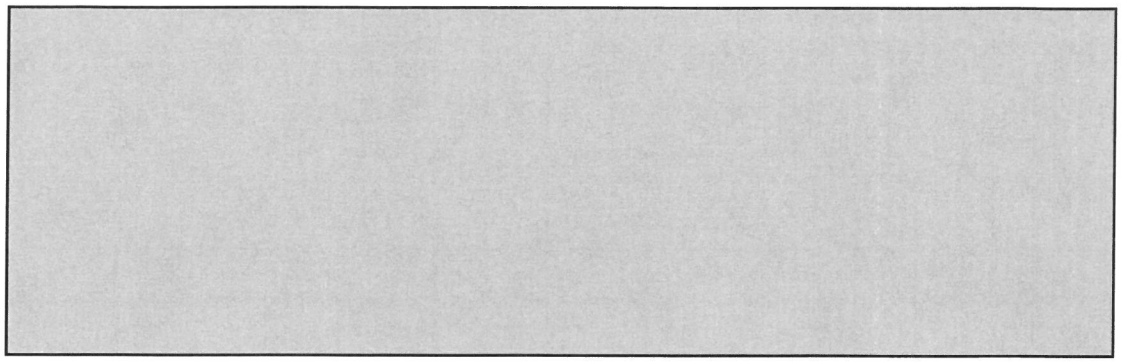


Figure 1. Algorithm for Analog BOE Test

4. After the required test period has expired, click on the STOP button to halt the BOE test. _____

5. Record the date and time that the test was stopped in attachment 6.2. _____

6. Verify that the SOE subsystem generates the report file. _____

7. Verify that the SOE report file contains the expected data, and record the file name in attachment 6.2. _____

4.1.3 Acceptance Criteria

Acceptance criteria for the digital and analog points used in this test are as follows:

DI image — Every transition is detected.
No link alarm condition is detected for DI cards in the Test Specimen.
Each transition occurs within 1.0 ± 0.15 sec.

DO image — Every transition is detected.
No link alarm condition is detected for DO cards in the Test Specimen.
Each transition occurs within 1.0 ± 0.15 sec.

AO image — Each transition (signal source) is present. The image switches between high/low levels every 10.0 ± 0.15 sec.

AI image — Each transition is detected and present in the resulting image signal.
Peak accuracy of the AI image at high and low levels is ±0.35% of the source signal (based on full span of 100%).

4.2 SERIAL PORT FAILURE TESTS

The ERD921 DMR Test Specimen includes two different types of serial communication port:

- Redundant C-Links that enable communications with external equipment.
- Redundant RS-485 Inter-Communication Links (ICL) enabling communication between the HFC-SBC06 controller and its configured I/O modules.

The following tests will record system responses to mechanical failures to the serial communication link as well as to a noise signal injected into one of the transmit signal lines.

4.2.1 C-Link Tests

4.2.1.1 Failure Test

Section 5.4.B of EPRI TR-107330 specifies three types of simulated serial communication port failures: 1) opening the transmit line for 5 to 10 seconds, 2) shorting the transmit line for 5 to 10 seconds, and 3) shorting the transmit line to the receive line for 5 to 10 seconds. All three failure conditions will be simulated for both types of communication link.

1. Configure C-Link cable A of Controller B as follows for test:
   a. Replace normal C-Link cable with breakout cable.
   b. Make sure that Controller B is operating as primary.
   c. Set the cabinet power source to 90 VAC and 57 Hz. _____
2. Use the MCRT to start the BOE test. _____
3. Verify that the breakout cable is configured without open circuit or jumper installed. Allow the system to log data for a minimum of 30 seconds. _____
4. Stop the BOE test. Verify that SOE subsystem generates an SOE report. Record the name of the report file and date/time the file was created in attachment 6.2. _____
5. **Failure 1**. Start the BOE test, and then open the transmit line (pin 3 or 6 of the breakout cable), allowing it to float. _____
6. Allow the system to log data for a minimum of 30 seconds. Stop the BOE test. Verify that the SOE subsystem generates a report file. Record the file name and date/time in attachment 6.2. _____

7. Reconnect the transmit line of the breakout cable. _____

8. **Failure 2**. Start the BOE test, and then short the transmit line (pin 3 or pin 6 of the breakout cable) to chassis ground. _____

9. Allow the system to log data for a minimum of 30 seconds. Stop the BOE test. Verify that the SOE subsystem generates a report file. Record the file name and date/time in attachment 6.2. _____

10. Disconnect the jumper to ground. _____

11. **Failure 3**. Start the BOE test, and then short the transmit line (pin 3 or pin 6 of the breakout cable) to the receive line (pin 1 or pin 2 of the breakout cable). _____

12. Allow the system to log data for a minimum of 30 seconds. Stop the BOE test. Verify that the SOE subsystem generates a report file. Record the file name and date/time in attachment 6.2. _____

13. Disconnect the breakout cable and reconnect the normal C-Link cable. _____

14. Start the BOE test, and allow the system to log data for a minimum of 30 seconds. _____

15. Stop the BOE test. Verify that the SOE subsystem generates a report file. Record the file name and date/time in attachment 6.2. _____

C-Link Failure Test is complete: _____
Name/Date

4.2.1.2 Noise Test

During this test, a large amplitude noise signal will be injected onto the communication link under test. A [XXXXXXXXX] signal at [XXXXX] with frequency modulation will be used as the noise signal for this test

1. Configure an [XXXXX] Pulse Generator as follows:

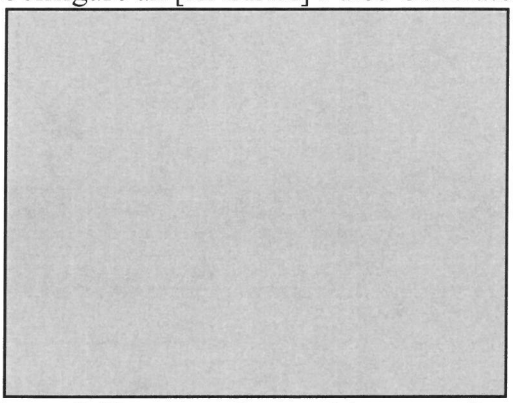


Figure 2 illustrates the resulting waveform.

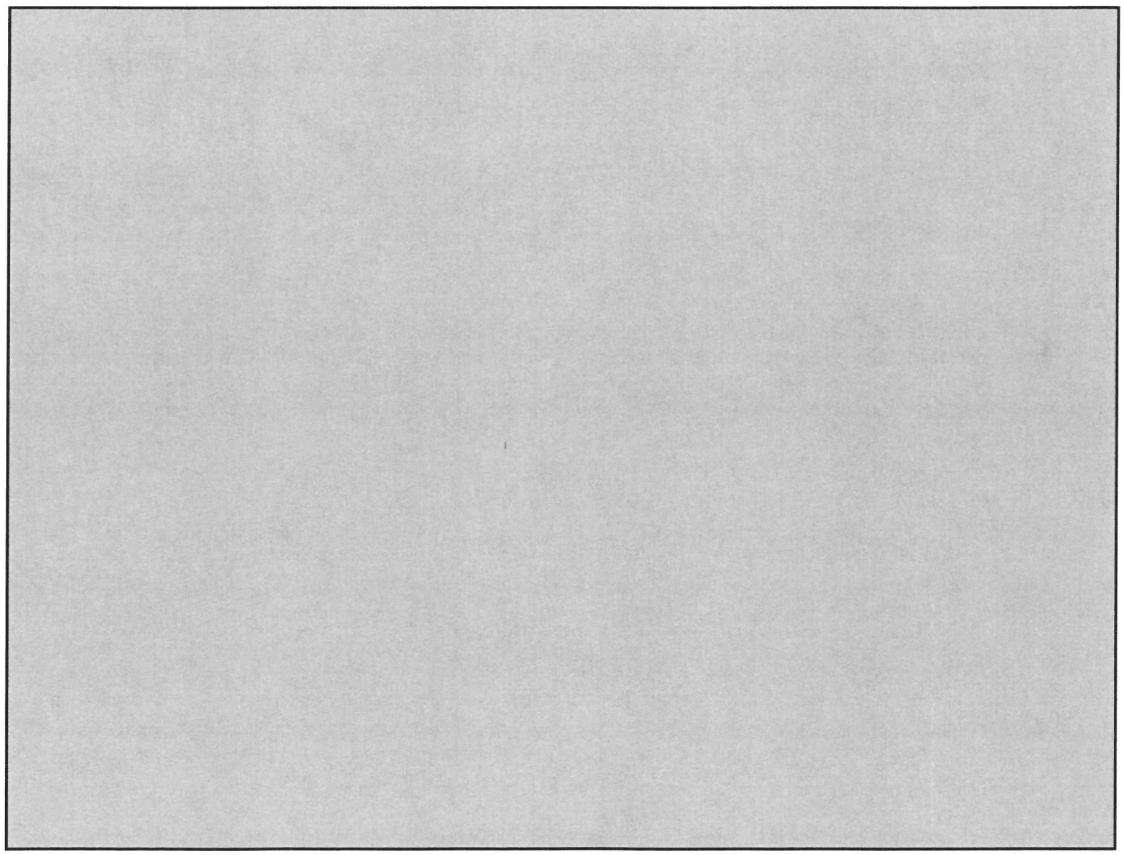


Figure 2. Noise Signal Waveform

2. Configure C-Link cable A of Controller B as follows for test:
   - Replace normal C-Link cable with breakout cable.
   - Make sure that Controller B is operating as Primary.
   - Set the cabinet power source to 90 VAC and 57 Hz.

   _____

3. Connect the probe from the pulse generator to either the RX+ or the RX- line (pin 3 or 6 of the breakout cable) of the C-Link cable. (Make sure that the noise signal is disabled.) _____

4. Start the BOE test, and then enable noise signal injection. _____

5. Allow the system to log data for a minimum of 1 minute. _____

6. Stop the BOE test. _____

7. Verify that the SOE subsystem generates a report file. Record the file name and time/date of the test in attachment 6.2. _____

8. Set the cabinet power source to 120 VAC and 60 Hz. _____

9. Reconnect the normal interface cables. _____

C-Link Noise Test is complete: _____
Name/Date

4.2.1.3 Acceptance Criteria

The test data records system response for two normal conditions (steps ***2*** and ***9***) and three abnormal (failure) conditions. Acceptance criteria for the C-Link port failure test are as follows:

Link Failure Test

- C-Link error counters (4,CO,11 or 4,CO,12 from the HAS log) may indicate an increase in errors detected for Rem 4 while faults are imposed.
- Every transition detected for the BOE test.
- Response time characteristics of the BOE signal with the fault conditions imposed on the serial port do not deviate by more than ±10% from those with no fault condition.

Noise Test

- Every transition detected for both the response time and BOE tests.
- Response time characteristics of the test signal with the fault conditions imposed on the serial port do not deviate by more than ±10% from those with no fault condition.
- Loss of communication over the C-Link channel while the noise signal is being applied does not constitute a failure of the test if the overall DMR continues operating normally.

4.2.2 ICL Tests

4.2.2.1 Failure Test

1. Configure DMR for the ICL failure test as follows:
   a. Replace the ICL cable for Link 0 inside the cabinet assembly between Rack 7 and Rack 8 with a breakout cable
   b. Set the cabinet power source to 90 VAC and 57 Hz _____
2. Start the BOE test. _____
3. Record the date and time that the test was started in attachment 6.2. _____
4. Verify that the breakout cable is configured without any jumper installed. Allow the system to log data for a minimum of 30 seconds. _____
5. Stop the BOE test. _____
6. Verify that the SOE subsystem generates a report file. Record the file name and date/time in attachment 6.2. _____
7. **Failure 1**. Start the BOE test. Disconnect the transmit line (pin 4 or pin 5 of the breakout cable). _____
8. Allow the system to log data for a minimum of 30 seconds, and then stop the BOE test. _____
9. Verify that the SOE subsystem generates a report file. Record the file name and date/time in attachment 6.2. _____
10. Reconnect the transmit line wire to the breakout cable. _____
11. **Failure 2**. Start the BOE test. Short the transmit line (pin 4 or pin 5 of the breakout cable) to chassis ground. _____
12. Allow the system to log data for a minimum of 30 seconds, and then stop the BOE test. _____
13. Verify that the SOE subsystem generates a report file. Record the file name and date/time in attachment 6.2. _____
14. Disconnect the jumper from chassis ground. _____
15. **Failure 3**. Start the BOE test. Short the two transmit signal lines (pin 4 and pin 5 of the breakout cable) together _____
16. Allow the system to log data for a minimum of 30 seconds, and then stop the BOE test. _____

17. Verify that the SOE subsystem generates a report file. Record the file name and date/time in attachment 6.2. _____

18. Remove the jumper from the Breakout cable. _____

19. Start the BOE test. _____

20. Record the test time. _____ _____

21. Allow system to log data for 30 seconds. _____

22. Stop the BOE test. _____

23. Verify SOE data is collected. _____

Validation that ICL Link Failure test is complete: _____
Name/Date

4.2.2.2 Noise Test

1. Configure the pulse generator as described in subsection 4.2.1.2, step ***1***. _____

2. Connect the probe from the pulse generator to either the TX+ or the TX- signal line (pin 4 or 5 of the breakout cable). _____

3. Make sure that the noise signal is disabled. _____

4. Start the BOE test, and then enable the noise signal on either the TX+ or the TX- line. _____

5. Allow the system to log data for a minimum of 1 minute. _____

6. Stop the BOE test. _____

7. Verify that the SOE subsystem generates a report file. Record the name of the report file and the time/date in attachment 6.2. _____

8. Reconnect the normal interface cables. _____

9. Set the cabinet power source to 120 VAC and 60 Hz. _____

ICL Noise Test is complete: _____
Name/Date

4.2.2.3 Acceptance Criteria

The test data records system response for two normal conditions and several abnormal (failure) conditions. Acceptance criteria for the ICL-Link port failure test are as follows:

ICL Failure Test

- Every transition detected for the BOE test.
- Response time characteristics of the test signal with the fault conditions imposed on the serial port do not deviate by more than ±10% from those with no fault condition.

ICL Noise Test

- Every transition detected for the BOE test.
- Response time characteristics of the test signal with the fault conditions imposed on the serial port do not deviate by more than ±10% from those with no fault condition.
- Loss of communication over the serial channel while the noise signal is being applied does not constitute a failure of the test if the overall system continues operating normally.

5.0 QA RECORDS

All data generated by execution of the tests covered by this procedure will become QA records and will be filed in accordance with the Project Quality Plan. The test data will be recorded in SOE circular memory buffers and in the HAS database while the tests are being run. Following completion of each test, an SOE report file must be generated to ensure reliable recovery of the test results. The name of the SOE report file for each test shall be recorded in the test record and stored in an appropriate folder of the EWS PC. After test completion, both the SOE reports and the HAS database volumes shall be copied to CD to provide a permanent, unchangeable record of test results for subsequent analysis.

6.0 ATTACHEMENTS

The following forms are attached to this document:

Attachment 6.1
Test Equipment Log

Test Equipment	Instrument ID	Cal Due Date

Test Reviewer/Date

Attachment 6.2
Test Record

All test results will be recorded automatically in SOE and HAS logger files. Record the file name, date and time for each test run.

Test Conducted	File Name	Date and Time of Test
Burst of Events		
C-Link Failure Test		
ICL Failure Test		
C-Link Noise Test		
ICL Noise Test		

Test Reviewer/Date