DOOSAN

HF Controls

HFC-6000 Control System

ERD1192 – Control System Qualification Project

Prudency Test Procedure Remote 03 FPC08

TP901-301-08 Rev A

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[XXXXXXXXXXXX]

Revision History

Date	Revision	Author	Changes
11/9/11	A	R. McClanahan	Initial Release

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1.0 PURPOSE AND SCOPE

The ERD1192 FPC08 is a configuration of the HFC-6000 platform. 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 impose highly dynamic conditions on a system during qualification testing. The Prudency tests covered by this document are as follows:

- **Burst of Events Test** – the intent of this test is to simulate in-service stresses by simultaneous activation of multiple analog and digital I/O channels (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 FPC08 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 a noise signal into a serial communication channel. The FPC08 system responses shall not vary by more than ±10% during the test (Section 5.4.C of EPRI TR-107330).
- **Fault Simulation Test** – This test covers introduction of a simulated failure condition to trigger failover from the primary to the secondary controller. The intent of this test is covered by the Failover Operability test (TP901-301-06) and will not be duplicated in this test procedure.

The scope of this document covers EPRI TR-107330 Prudency testing for the FPC08 system configuration of the HFC-6000 platform. This system configuration hereafter is referred to as the FPC08 Test Specimen or the Test Specimen. This system consists of one chassis which includes two HFC-FPC08 controllers and multiple analog and digital I/O modules.

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, December 1996

2.2 RELATED PLANS AND PROCEDURES

TP901-301-02	ERD1192 Integration Test Procedure, Rev. B
TP901-301-06	ERD1192 Operability Test Procedure Remote 3 FPC08, Rev. A
VV901-300-02	ERD1192 Master Test Plan, Rev. A
VV901-304-01	ERD1192 Master Configuration List, Rev. A
VV901-304-03	ERD1192 Test Specimen Design Specification Remote 3 FPC08, Rev. A
UG004-000-16	MCRT User's Guide, Rev C

2.3 SUPPORTING DOCUMENTATION

500620-01	ERD1192 Remote Loop Layout, Rev. E
500621-01	ERD1192 Power Distribution, Rev. C
500633-01	ERD1192 TSAP Schematic Wiring Diagrams Remote 1, Rev. B
500640-03	ERD1192 HPAT Logic Diagrams Remote 3, Rev. B

2.4 HFC INTERNAL STANDARDS AND PROCEDURES

QPP 5.1	Review and Approval of Quality Documents, Rev G
QPP 5.2	Preparation of Procedures, Rev M
QPP 11.1	Test Control, Rev H
WI-ENG-003	Configuration Management, Rev E
WI-ENG-205	Develop Software/Firmware Test Procedure, Rev B

2.5 SPECIAL TERMS, ABBREVIATIONS, AND ACRONYMS

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
FOT	Fiber-Optics Transmitter
HAS	Historical Archiving System
HPAT	HFC Plant Automated Tester
HFC	Doosan HF Controls
I/O	Input/Output
MCRT	HFC Interactive Operator CRT Workstation
PC	Personal Computer
SOE	Sequence of Events
Test Specimen	A specific combination of hardware and software components to be subjected to specified test conditions
FPC08	HFC Flat panel controller (HFC-FPC08)

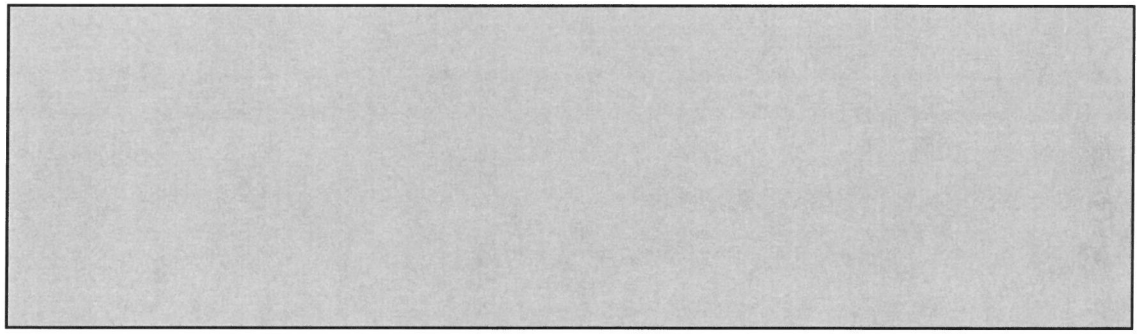
TSAP	Test System Application Program

3.0 PREREQUISITES

The following paragraphs 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.

- 

Record the IDs for the test equipment used during the test in attachment 6.1.

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	50 deg to 104 deg F
Relative Humidity	7% to 90% non-condensing

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

The HFC policy for entering red-line corrections into a test procedure is presented in Paragraph 2.6.2 of HFC document VV901-300-02. 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 TP901-301-04, ERD1192 TSAP Validation Test Plan Remote 3 FPC08, has been successfully completed.
3. Verify that hardware configuration for the test cabinet has been completed.

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

Section 5.4.A of EPRI TR-107330 defines the Burst of Events Test as a combination of analog and digital algorithms whose purpose is to provide a significant level of background activity. The implementation of the BOE test for the FPC08 Test Specimen will consist of the following combination of algorithms and I/O signals:

- A digital algorithm will be configured to produce a free-running square wave that is "ON" for one second and "OFF" for one second. This algorithm will drive two DO channels that are 180 degrees out of phase with one another.
- The two DO signals will be hard-wired to two separate DI channels. One of these DI channels will be used to control a pass-through DO signal.

- An analog algorithm will be configured to produce a signal that switches between 10% and 90% of full scale with a 10-second dwell time at each level. This algorithm will drive two AO channels that are 180 degrees out of phase with one another.
- The two AO channels will drive separate 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 FPC08 Testing

Signal Source	Point Designation	Signal Rating
	Rem3	

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 TP901-301-06, ERD1192 Operability Test Procedure Remote 3 FPC08, for specific SOE and HAS point assignments.) The SOE logger has a time resolution of ±1 ms, and the test support equipment includes a set of 16-point DI modules that can be configured for logging digital data. The HAS operates on a PC workstation and has a 1-second update rate, but it 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 FPC08 Operability Test Procedure.
2. Verify that HAS configuration is completed in accordance with FPC08 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.
4. Synchronize the SOE controller with the EWS workstation.

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. As a minimum, configure the BOE graphic interface should include the following utilities:

- A touch target to enable/disable dynamic operation of the FPC08 BOE algorithms.
- Visual indication that the BOE algorithm is running

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 FPC08 TSAP. After initial configuration 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 following completion of each test. 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 EWS workstation ensure that the HAS server program is running. _____
3. Use the MCRT to start the BOE test. Record the data and time that the test was started in attachment 6.2. _____
4. 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. _____

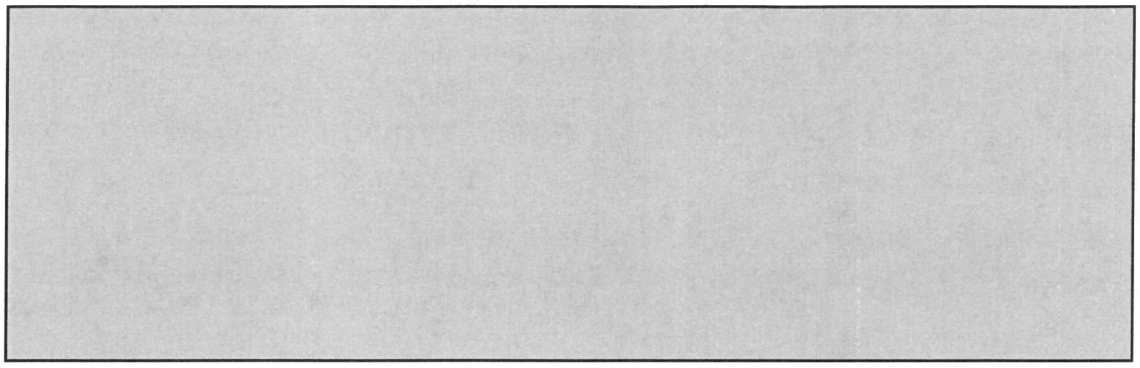


Figure 1. Algorithm for Analog BOE Test

5. Allow the test to run for a minimum of 1 minute, then use the MCRT to stop the test. _____

6. Verify that the SOE logger generates report file automatically. Open the SOE report file and verify that it contains the expected data. _____

7. Record the time and date that the test was run and the name of the SOE report file 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 detected. Averaged TSAP AO signal accuracy at each level remains within ±0.32% of source signal (based on full span of 100%).

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 PRUDENCY TESTS

The test cabinet contains the FPC08 test specimen and redundant HFC-SCG06 controllers. The FPC08 Test Specimen includes an interface with a redundant C-Link and a redundant ICL. The HFC-SCG06 is connected to the other end of the C-Link as well as the common data highway connected to external equipment. Each of these links will be subjected to two different Prudency tests:

- Serial Port Failure Test simulates three operational failures: (1) Open transmission line, (2) Transmit line shorted to ground, (3) Transmit/receive lines shorted together.
- Noise Test injects a large amplitude noise signal onto the communication link under test. A [XXXXXX] signal at [XXXXX] with frequency modulation will be used as the noise signal for this test.

4.2.1 C-Link

The C-Link extends from the C-Link ports of the FPC08 controller to the B0/B1 ports on the front panel of the SCG06 controllers.

4.2.1.1 Failure Test

1. Configure C-Link cable A as follows for test:
   - Replace normal C-Link cable with breakout cable. _____
2. Use the MCRT to start the BOE and response time tests. Record the starting date and time of this test in attachment 6.2.2. _____
3. Verify that the breakout cable is configured with open circuit jumpers installed. Allow the system to log data for a minimum of 30 seconds. _____
4. Stop the BOE and response time tests to mark a transition in this test. _____
5. **Failure 1**. Start the BOE and response time tests, and then open the transmit line (pin 1of the breakout cable), allowing it to float. _____
6. Allow the system to log data for a minimum of 30 seconds. Stop the BOE and response time tests to mark a transition in this test. _____
7. Reconnect the transmit line of the breakout cable. _____
8. **Failure 2**. Start the BOE and response time tests, and then short the transmit line (pin 1 or pin 2 of the breakout cable) to chassis ground. _____
9. Allow the system to log data for a minimum of 30 seconds. Stop the BOE and response time tests to mark a transition in this test. _____
10. Disconnect the jumper to ground. _____
11. **Failure 3**. Start the BOE and response time tests, and then short the transmit line (pin 1 or pin 2 of the breakout cable) to the receive line (pin 3 or pin 6 of the breakout cable). _____
12. Allow the system to log data for a minimum of 30 seconds. Stop the BOE and response time tests to mark a transition in this test. _____

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

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

15. Stop the BOE and response time tests. Record the time and date at which the test was completed in attachment 6.2.2. _____

16. Verify that the SOE logger generates the SOE report file automatically. Open the file to verify that it contains the expected data. _____

17. Record the name of the SOE report file for this test in attachment 6.2.2. _____

4.2.1.2 Noise Test

1. Configure an [XXXXXXX] Pulse Generator as follows:
   -
   -
   -
   -
   -
   -
   -
   -
   -
   -

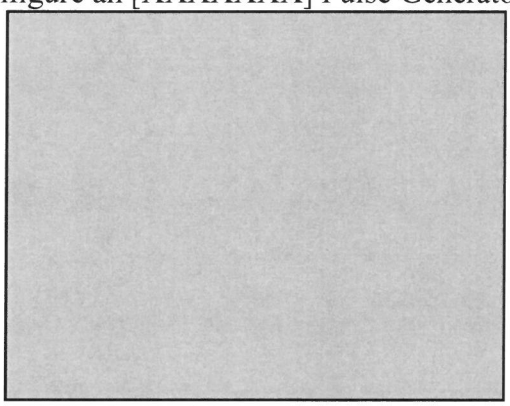


   Figure 2 illustrates the resulting waveform. _____

2. Configure C-Link cable A as follows for test:
   - Replace normal C-Link cable with breakout cable. _____

3. Make sure that the noise signal is disabled, and then start the timer and BOE tests. Record the starting time and date of the test in attachment 6.2.3. _____

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

5. Stop the BOE and timer tests to mark a transition in this test sequence. _____

6. Start the BOE and timer tests, and then inject the noise signal on either the RX+ or the RX- line (pin 3 or 6 of the breakout cable with reference on pin 5, 24 VDC – of the breakout cable) of the C-Link cable. _____

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

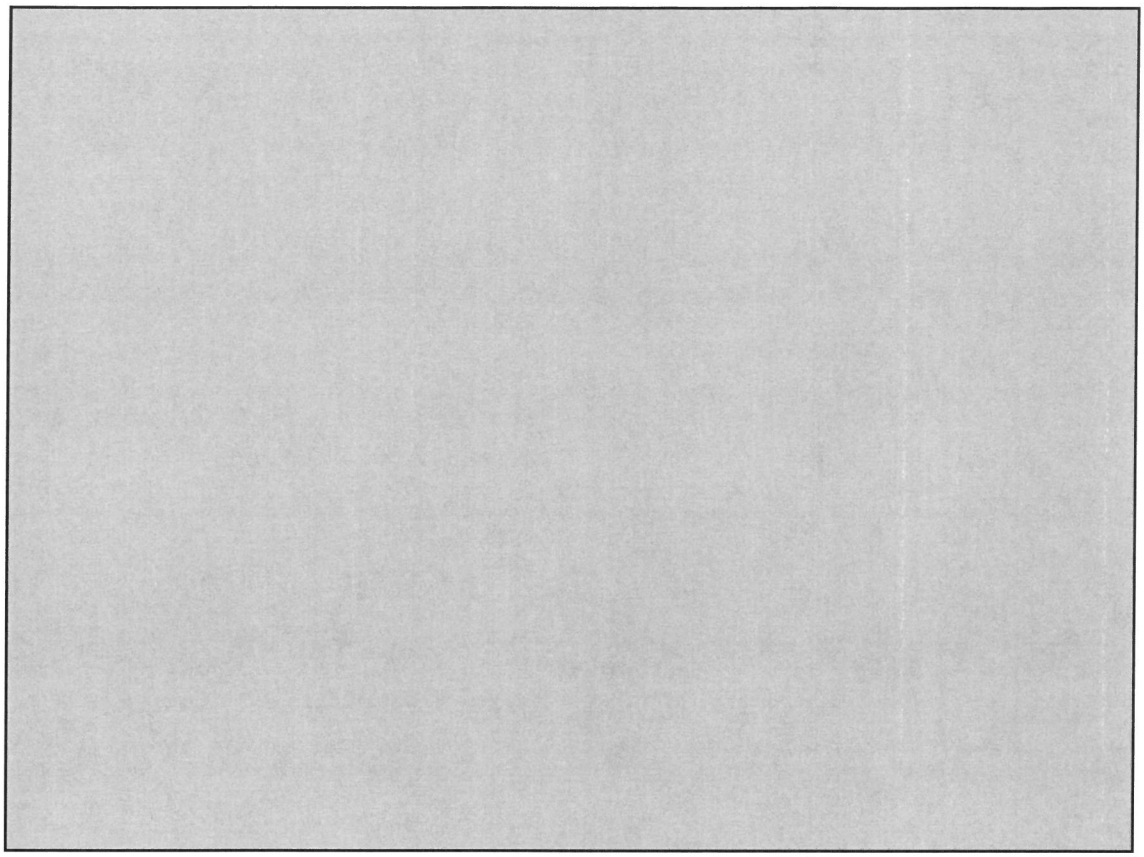


Figure 2. Noise Signal Waveform

8. Stop the BOE and timer tests. Record the time at which the test was concluded in attachment 6.2.3 _____

9. Reconnect the normal interface cables. _____

10. The SOE logger generates the SOE report file automatically. Open the report file and verify that it contains the expected data. _____

11. Record the name of the SOE report file and the time when the test was executed in attachment 6.2.3. _____

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

4.2.2 ICL

The link faults will be imposed by installing a breakout connector to the ICL Link 0 connector on the back of the backplane. Because the controller is not connected to any extension chassis, the open transmit line failure will not be simulated.

4.2.2.1 Link Failure Test

1. Configure for test as follows:
   - At the rear of the backplane, connect an ICL breakout cable to the connector for ICL link 0. _____
2. Start the response time and BOE tests. _____
3. Record the date and time that the test was started in attachment 6.2.4. _____
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 and response time tests to mark a transition in this test. _____
6. **Failure 1**. Start the BOE and response time tests, and then short the transmit line (pin 4 or pin 5 of the breakout cable) to chassis ground . _____
7. Allow the system to log data for a minimum of 30 seconds, and then stop the BOE and response time tests to mark a transition in this test. _____
8. Disconnect the jumper from chassis ground. _____
9. **Failure 2**. Start the BOE and response time tests, and then short the two transmit signal lines (pin 4 and pin 5 of the breakout cable) together. _____
10. Allow the system to log data for a minimum of 30 seconds, and then stop the BOE and response time tests to mark a transition in this test. Remove the jumper. _____
11. Start the BOE and response time tests and allow the system to log data for a minimum of 30 seconds. _____
12. Stop the BOE and response time tests. Record the date and time at which the test was completed in attachment 6.2.4. _____
13. The SOE logger generates the SOE report file automatically. Open the report file and verify that it contains the expected data. _____
14. Record the name of the SOE report file in attachment 6.2.4. _____

4.2.2.2 Noise Test

1. Configure an [XXXXX] Pulse Generator as described in section 4.2.1.2 step *1*. _____

2. Ensure ICL breakout cable is installed on the ICL link 0 connector on the backplane. _____

3. Make sure that the noise signal is disabled, and then start the response time and BOE tests. Record the starting time and date of the test in attachment 6.2.5. _____

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

5. Stop the BOE and response time tests to mark a transition in this test sequence. _____

6. Start the BOE and response time tests, and then inject the noise signal on either the RX+ or the RX- line (pin 4 or 5 of the breakout cable with reference on pin 5, 24 VDC – of the breakout cable) of the C-Link cable. _____

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

8. Stop the BOE and response time tests. Record the time at which the test was concluded in attachment 6.2.5. _____

9. Remove the breakout cable. _____

10. The SOE logger generates the SOE report file automatically. Open the report file and verify that it contains the expected data. _____

11. Record the name of the SOE report file and the time when the test was executed in attachment 6.2.5. _____

ICL Noise Test is complete: _____
Name/Date

4.2.3 Acceptance Criteria

C-Link

Link Failure Test

- C-Link error counters (3,CO,11 or 3,CO,12 from the HAS log) may indicate an increase in errors detected for FPC08 while faults are imposed.
- Every transition detected for both the response time and BOE tests.
- 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 timer test 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 FPC08 continues operating normally.

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 serial channel while the noise signal is being applied does not constitute a failure of the test if the overall FPC08 continues operating normally.

ICL

Failure Test

The test data records system response for two normal conditions (steps ***2*** and ***11***) and two abnormal (failure) conditions. Acceptance criteria for the ICL-Link port failure test are as follows:

- Every transition is 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.

Noise Test

The test data records system response for normal conditions in step ***2***; steps ***4*** and *7* record test data while the noise signal is being injected. Acceptance criteria for the serial link failure test are as follows:

- 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 serial channel while the noise signal is being applied does not constitute a failure of the test if the overall FPC08 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, SOE report files 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 ATTACHMENTS

The following forms are attached to this document:

Attachment 6.1	Test Equipment Log
Attachment 6.2	Test Record
Attachment 6.2.1	BOE Test
Attachment 6.2.2	C-Link Failure Test
Attachment 6.2.3	C-Link Noise Test
Attachment 6.2.4	ICL Failure Test
Attachment 6.2.5	ICL Noise Test

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.

6.2.1 BOE Test

Start Date/Time: _____ Stop Date/Time: _____

SOE Report File Name(s): _____

6.2.2 C-Link Failure Test

Start Date/Time: _____ Stop Date/Time: _____

SOE Report File Name(s): _____

6.2.3 C-Link Noise Test

Start Date/Time: _____ Stop Date/Time: _____

SOE Report File Name(s): _____

6.2.4 ICL Failure Test

Start Date/Time: _____ Stop Date/Time: _____

SOE Report File Name(s): _____

6.2.5 ICL Noise Test

Start Date/Time: _____ Stop Date/Time: _____

SOE Report File Name(s): _____

Test Engineer _____ Date _____