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SECTION 1. SYSTEM, DESCRIPTION FORWARD INTEGRATED ELECTRONICS ASSEMBLY

The electrical system is defined by the Solid Rocket Booster (SRB) Operational Flight (O.F.) Electrical Schematic (10400- 0833). (All Failure Causes)

A. Power Distribution Circuits

To preclude the loss of orbiter power buses A, B or C orbiter power is provided in isolated redundant channels to the Forward IEA. The Forward IEA design provides one common housing with a metal wall isolating the redundant A and B channels so that no critical failure can propagate from one channel to the other. Power Bus C is routed on the same side as Power Bus B, but separated by it's shield from other IEA wiring. The IEA is pressurized with Gaseous nitrogen to prevent fire propagating between wiring. Listed failure mode could be caused by open or short circuit in the Electromagnetic Compatibility (EMC) filters, Power Bus Isolation Supply (PBIS) modules, solid state switches, wiring harnesses in the distributor or signal conditioner or short circuits in the transorb lightning suppression diode. (Only distributor wiring harness failures or transorb diode short can affect power bus C) (BI-1643)

B. Rate Gyro Circuits

To preclude the loss of power to the RGAs, redundant Orbiter A, B and C buses provide power for RGA operation. Orbiter B bus power is applied to RGA 1 in the Left SRB and Bus A to RGA 2 in the Right SRB via 3 amp 5 volt solid state switches in response to an MDM command. Orbiter C bus is hardwired to RGA 3 in the Left SRB and to RGA 4 in the Right SRB. The IEA design provides one common housing with a metal wall isolating the redundant A and B channels so that no electrical failure can propagate from one channel to the other. C bus power is physically located and isolated in the wiring harness on the A side of the IEA, and is therefore separated from A and B bus power. Loss of power to RGA #1 and RGA #2 could be caused by open or short circuits in the A and B distributor harnesses or by open or short circuits of the RGA #1 or #2 solid state switches. Loss of RGA #3 and RGA #4 could be caused by open or short in wiring harness. Applicable design documentation is listed in Component Design/Description.

C. SRM Ignition Safe/Arm Circuit

The system is designed to preclude the inadvertent safing of the SRM Ignition Safe and Arm Assembly. Series solid state switches requiring two commands in series(SRM Ignition S&A Assembly Safe-1 and Safe-2) are employed. To minimize the window of susceptibility of a double failure mode, the S&A Assembly position indication signals (Armed - ON, Safed - OFF) are monitored by the LPS (at 5 sps) from arming of the S&A Assembly to issuance of SRM Ignition fire commands by the Orbiter GPCs. The window of susceptibility is the worst case time between the last data sampled and issuance of SRM Ignition, less than two seconds. The SRM Ignition Safe and Arm Assembly can move from Armed to Safed within this time frame.

The SRM Safe and Arm Assembly Safe-1 and Safe-2 circuit uses solid state switches in the forward IEA specifically designed for shuttle SRB application to condition the MDM command outputs to the voltage and power requirements of the S&A Assembly. A 3 Amp-5V switch module is used and contains four independent, isolated, 5V control input switch circuits. Both Safe-1 and Safe-2 switches are on the same module, however, they are electrically isolated and have functions separated in the connector pin arrangement. The applicable design documentation for the solid state switches is listed in Component Description.

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D. SRM Ignition/PIC Circuit

In the SRM Ignition circuit, solid state switches are necessary as the orbiter hardwired commands are not adequate to directly operate the PICs. Two different configuration switch modules are used: (1) A channel, 0.5 Amp-Combination; and (2) B channel, 0.5 Amp-28V. The 0.5 Amp-28V switch module contains six independent, isolated, 28V control input switch circuits; the 0.5 Amp-Combination switch module is similar with 28V and three 5V control input switch circuits. All three switches (in the respective A and B channels) are on the same modules, however, they are electrically isolated and have no adjacent module connector pins.

(1) To preclude the loss of SRM ignition per listed failure mode, parallel redundant A and B channel SRM ignition circuits are provided in the Forward IEA to ensure SRM ignition occurs when commanded. The Forward IEA provides one common housing with a metal wall isolating the redundant A and B channels so that no electrical failure can propagate from one channel to the other. The SRM ignition PICs accept signals from their respective A or B ignition Arm, Fire 1, and Fire 2 solid state switches, and upon the proper sequence of commands, issue outputs to the A and B NSIs. The ignition Arm, Fire 1, and Fire 2 solid state switches are energized by hardwired commands from the Orbiter. Power to the A or B Fire 2 ignition solid state switch is provided through a Miscellaneous III card (A) or Recovery Logic III card (B) diode from the respective A or B Fire 1 solid state switch output. This design configuration assures that the Fire 2 inputs of the SRM ignition PICs cannot be activated before Fire 1 inputs, thus preventing an unscheduled internal discharge of the PICs. Loss of PIC output could be caused in either A or B channel by open SRM ignition solid state switches, open or short wiring harness, open diodes on the Miscellaneous III and Recovery Logic III cards, or PIC failures. The failure of a PIC Arm function would be detected prior to launch. The failure of a PIC Fire command cannot be detected in launch countdown. The applicable design documentation is listed in Component Design/Description.

(2) The SRM Ignition system is designed to preclude the inadvertent operating of the SRM Ignition PICs. Series commands (Arm, Fire-1 and Fire-2) with specific sequencing and timing are necessary to command SRM Ignition. The Arm command must occur at least 1 second before fire command. Fire-1 must precede or be coincident with Fire-2 at the PIC or the PIC will be discharged internally. The SRM Ignition PICs are Armed 15 seconds prior to T-O to minimize the window of susceptibility of an inadvertent SRM Ignition while allowing the required launch sequencing and vehicle monitoring to proceed to T-O.

Premature SRM Ignition can occur from either of the redundant A or B channels if Fire 1 and Fire 2 command switches or PIC Fire 1 or Fire 2 output switches fail short after PICs have been armed.

E. Forward BSM Ignition Circuit

(1) To preclude the loss of the Forward booster separation motor (BSM) Ignition, redundant A and B channel BSM ignition PICs and associated parallel circuitry is housed in the Forward Integrated Electronics Assembly (IEA). The Forward IEA design provides one common housing with a metal wall isolating the redundant A and B channels. These PICs accept signals from their respective A or B Separation Arm, Fire-1, and Fire-2 buses, and, upon the proper sequence of commands, issue outputs to the A and B forward BSM NSIs. The forward Separation Arm, Fire-1, and Fire-2 buses are energized from respective A or B channel solid state switches in the Aft IEA which are energized (turned on) by hardwired commands from the Orbiter. This failure mode could be caused by the loss of the A and B PICs or open/short in the A and B Distributor harnesses. The failure of a PIC Arm function will be detected from flight data during flight. The failure of a PIC Fire command is not detectable as flight data is lost almost simultaneously with issuing of the separation commands.

(2) The system is designed to preclude inadvertent output of the SRB Forward Booster Separation Motor (BSM) PICs. Series commands (Arm, Fire-1 and Fire-2) with specific sequencing and timing necessary to command SRB Forward BSM ignition. The Arm command must occur at least 1 second before fire command. Fire-1 must precede or be coincident with Fire-2 or the PIC will be discharged internally. The SRB BSM PICs are Armed approximately 1.7 seconds prior to separation (the PIC requires 1 second to charge), to minimize the window of susceptibility of an inadvertent SRB Forward BSM firing, but allow the required separation sequencing to proceed to SRB separation fire command. Premature SRB Forward BSM PIC output can occur from failures in either redundant A or B channels.

F. Forward Separation Thrust Pin Circuit

(1) To preclude the loss of the Forward Thrust Pin (Separation Bolt) PIC outputs per listed failure mode, redundant A and B channel Forward Thrust Pin separation PICs are housed in the Forward Integrated Electronics Assembly (IEA). The Forward IEA design provides one common housing with a metal wall isolating the redundant A and B channels. These PICs accept signals from their respective A or B Separation Arm, Fire-1, and Fire-2 buses, and, upon the proper sequence of commands, issue outputs to the A and B Forward Separation Bolt NSIs. The Forward Separation Arm, Fire-1, and Fire-2 buses are energized from their respective A or B channel solid state switches in the Aft IEA which in turn are energized by the hardwired commands from the Orbiter. This failure mode could be caused by failure of the A and B PICs or open/shorts in the A and B Distributor harnesses. The failure of a PIC Arm function will be detected from flight data during flight. The failure of a PIC Fire command is not detectable as flight data is lost almost simultaneously with issuing of the separation fire commands.

(2) The system is designed to preclude the inadvertent premature firing of the SRB Forward Separation Bolt. Series commands (Arm, Fire-1 and Fire-2) with specific sequencing and timing are necessary to command SRB Separation. The arm command must occur at least 1 second before fire command. Fire-1 must precede or be coincident with Fire-2 at the PIC or the PIC will be discharged internally. The SRB Separation PICs are Armed approximately 1.7 seconds prior to separation, to minimize the window of susceptibility of an inadvertent SRB Forward Separation Bolt firing, but allow the required separation sequencing to proceed through SRB separation fire commands.

Premature SRB Forward Separation Bolt PIC output, can occur as a result of failures in either of the redundant A or B channels.

G. Nozzle Extension Jettison Circuit

Parallel redundancy (dual redundant Separation A and B Channels) was implemented in the Forward IEA to ensure SRB Recovery Logic Sequence is initiated at SRB/ET Separation. After the Recovery Logic Sequence is initiated, a simplex circuit is utilized to ARM and FIRE the SRB Nozzle Extension Severance Pyrotechnics.

To power up and initiate the Recovery System Sequencing, redundant (A and B) Separation Fire #1 Command developed buses are input to an "OR" gate on the Recovery Logic III Card. Either A or B bus is sufficient to operate the "OR" gate and Turn "On" a Latching Switch on the Recovery Logic IA Card. The IA Card switch applies Recovery Battery Power (XD21 Bus) to a Solid State Switch on the Recovery Logic IIB Card and to a power switch supplying Recovery Battery power to the Sensor Timer Unit (STU). The Logic IA Solid State Switch output also applies XD21 Power to the OF Altitude Switch Assembly (ASA).

To "Arm" the Nozzle Extension Jettison PIC, redundant (A and B) Separation Fire #2 Command developed Buses are input to an "OR" gate on the Recovery Logic III Card. Either input is sufficient to operate the "OR" gate and turn "On" a Latching Switch on the Recovery Logic IIB card, starting a 30 Second Delay Timer. After timing out, the timer output turns on a Logic IIB Card Solid State Switch. The

output of the Solid State Switch is coupled to the "Arm" Circuit and charges the Nozzle Extension Jettison PIC in the Aft IEA. (Logic IIB Card)

The Command (Signal) to discharge (FIRE) the Nozzle Extension Jettison (NEJ) PIC is developed through the low Altitude Solid State Switch in the OF Altitude Switch Assembly (ASA). At a preset altitude, (Approximately 6,000 to 6,500 ft) the ASA Low altitude Solid State Switch turns on and applies XD21 bus power to a 18 second delay timer in the Sensor Timer Unit (STU). After the Timer timers out, the output turns on a Solid State Switch in the STU, The output of the Solid State Switch is coupled to and discharges the NEJ PIC in the Aft IEA.

For inadvertent Nozzle Extension Jettison to occur at a critical time, two failures would have to occur during the first 27 seconds of the boost phase (prior to SRB ascent reaching the Low Altitude Setting of the OF Altitude Switch Assembly (ASA)):

1.A shorted "OR" gate on the Logic III Card - or - Shorted Latching Switch on the Recovery Logic IA Card applying recovery battery power (XD21 Bus) to a Solid State Switch on the Logic IIB Card, the Altitude Switch Assembly (ASA) and Sensor Timer Unit (STU):

And

2.A Shorted Solid State Switch on the Recovery Logic IIB Card bypassing the 30 second delay timer and applying XD21 Bus power "ARMING" the Aft IEA NEJ PIC.

H. Chamber Pressure Measurement Circuit

To preclude the loss of SRM chamber pressure measurements, redundant signal paths for sensors A, B and C are provided through the Forward IEA. The B sensor output is routed via twisted, shielded wires through the B channel of the Forward IEA. The A and C sensor outputs are routed via separate twisted, shielded wire pairs through the A channel of the Forward IEA. Each sensor output is routed into and out of the Forward IEA through separate connectors. The IEAs are purged and pressurized with dry nitrogen to prevent any failure in one path from propagating to a second path. DFI monitor outputs are buffered to prevent a grounded conductor on the DFI side from affecting system operation. No two sensor outputs are routed through a common connector or within a common shield.

I. Qualification

The Fwd IEA, including specific hardware addressed for listed failure modes, was qualified to the environments specified in "Certification Test Requirements Specification" SE-019- 107-2H and qualification certified on COQ #A-E&I-2121. The COQ lists the qualification test reports which comprise the total Fwd IEA qualification effort. The qualification test environments which are most likely to induce listed failure modes are:

Vibration (Vehicle Dynamic, Lift-off, Re-entry)
Shock (Ordnance, Water Entry)
Thermal Cycling

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SECTION 2. COMPONENT DESIGN/DESCRIPTION

A. Electronic Assembly

The electrical design of the EMC filters, transorb diodes, PBISs, Miscellaneous III Cards, Recovery Logic Cards, Pyro Initiator Cards and solid state switches uses the derating factors and high reliability parts in conformance with "EEE Parts Selection and Application Guidelines for Space Shuttle External Tank and Solid Rocket Booster," MSFC 85M03936 or "NASA Standard Electrical, Electronic, and Electromechanical Parts List," MIL-STD-975. Verification of the electrical design included "Worst Case" electrical, stress, and thermal analyses, considering component tolerances and stability through end of life, and environmental range of -10 degrees C to +100 degrees C. The mechanical packaging design is conservative, employing component mounting for stress free solder connections, high temperature printed wiring boards, and conformal coating in conformance with the following design requirements: (All Failure Causes Except Wiring Harnesses) (BI-1524 R3)

DOCUMENT NO.	TITLE
MSFC-STD-136	Parts Mounting Design Requirements for Soldered Printed Wiring Board Assemblies
MSFC-STD-154A	Printed Wiring Boards (Copper Clad) Design, Documentation and Fabrication
MSFC-SPEC-278B	Terminals, Bifurcated and Turret, Swage Type: Terminals, Bifurcated and Turret, Standoff Insulated, Screw Type: Terminals, Solder Pot Swage Type
MSFC-SPEC-377C	Plastic Sheet, Laminated, Copper Clad (For Printed Wiring)
MSFC-SPEC-507	Low Solids (Thin) Conformal Coating Materials, PC Boards, Electronic and Electrical, Specification For (BI-1693 R1)
MSFC-PROC-274	Terminals, Installation of
MSFC-PROC-508	Low Solids (Thin) Conformal Coating, Application of

MSFC 50M60444	Plated Through Holes in Printed Wiring Boards, Specification For
NHB5300.4(3A/3A-1)	Requirements For Soldered Electrical Connections

B. EMC Filter

EMC filters are used at the Forward IEA power inputs to filter out electromagnetic "noise" and transients on the power lines. These filters also play a significant role in the suppression of lightning transients should they occur. All IEA power (except MDM power) passes through one of the two EMC filters (A or B). (C Bus provides No power to IEA functions and does not have a EMC Filter in the IEA) (EMC filters)

EMC filters utilized in the IEA were designed specifically for the Shuttle SRB application. The applicable design documentation is listed below: (EMC filters)

Design Document	Document Number
Design Requirements	5136100-CEI Part I
SRB Forward IEA Assembly	5080004-215
EMC Filter Assembly Drawing	5100410/5100087
EMC Filter Schematic	5110410
EMC Filter Test Specification	5130410-GTS
EMC Filter Printed Wiring Board PWB Dwg.	5107277.PO 11

(1) A short or open circuit in both filters would result in loss of power to all SRB operational electrical hardware, resulting in loss of Thrust Vector Control (TVC) during boost phase and loss of separation capability. (EMC filters)

(2) An open circuit or short circuit in one filter combined with failure in C bus would remove power from two SRM chamber pressure sensors. This would cause SRM chamber pressure measurements to go to null, and could result in improper SRB separation resulting in recontact with the orbiter/external tank. (EMC Filters)

C. Transorb Lightning Suppressor Diode

The transorb diodes are used at the EMC filter outputs to "clamp" bus power and return lines with reference to chassis ground and prevent lightning transients from over-stressing IEA internal parts. A short circuit in both positive side transorb diodes (A and B) would result in the same failures as described for EMC filter shorts. The applicable design documentation is listed below: (Transorb Diodes)

Design Document	Document Number
Design Requirements	5136100-CEI Part I
SRB Forward IEA Assembly	5080004-215
Transorb Assembly Drawing	5106985/516984
Transorb Test Specification	5136704-GTS
Transorb PWB Drawing	5106983

D. Power Bus Isolation Supplies

PBISs are used to isolate and condition power for the IEA signal conditioner section. A short circuit in the power input portion of both PBISs would result in the same failures as described for EMC filter shorts. The applicable design documentation is listed below:

Design Document	Document Number
Design Requirements	5136100-CEI Part I
SRB Forward IEA Assembly	5080004-215
PBIS Card 1 Assembly Drawing	5100384
PBIS Card 2 Assembly Drawing	5100085
PBIS Top Assembly Drawing	5106627
PBIS Schematic	5114827
PBIS Test Specification	5136521-GTS
PBIS Card 1 PWB Drawing	5105301
PBIS Card 2 PWB Drawing	5104426

E. Solid State Switches

Solid state switches are used in the Forward IEA operational system for various functions requiring current gain, power isolation, and/or noise rejection. Switches not directly associated with the recovery circuitry are powered by orbiter bus voltage. Solid state switch modules are categorized by output current (3 amp or 0.5 amp) and by control voltage (5 volt, 28 volt, or combination). The Forward IEA uses 3 amp 5 volt, 0.5 amp 5 volt, 0.5 amp 28 volt, and 0.5 amp combination solid state switches connected to Orbiter buses.

(1) Short Circuit of solid state switch to ground/return will result in loss of power Bus A or B to all SRB functions.

(2) Open solid state switch will result in loss of output to serviced functions.

(3) Internal short circuit of solid State Switch across elements may result in unscheduled output to serviced function.

The applicable design documentation is listed below:

Design Document	Document Number
Design Requirements	5136100-CEI Part I
SRB Forward IEA Assembly	5080004-215
3 amp 5 volt Assembly Drawing	5100021
3 amp 5 volt Schematic	5110021
3 amp 5 volt Test Specification	5130021-GTS
3 amp 5 volt PWB Drawing	5120021
0.5 amp 5 volt Assembly Drawing	5100022
0.5 amp 5 volt Schematic	5110022
0.5 amp 5 volt Test Specification	5130022-GTS
0.5 amp 5 volt PWB Drawing	5120022
0.5 amp 28 volt Assembly Drawing	5100060
0.5 amp 28 volt Schematic	5110060
0.5 amp 28 volt Test Specification	5130060-GTS
0.5 amp 28 volt PWB Drawing	5120060
0.5 amp comb. Assembly Drawing	5100081
0.5 amp comb. Schematic	5110081

0.5 amp comb. Test Specification	5130081-GTS
0.5 amp comb. PWB Drawing	5120081

F. Wiring Harness

The A and B sides of the Forward IEA distributor and signal conditioner wiring harnesses are physically and electrically isolated from each other by a metal wall. These wiring harnesses include wiring to distribute orbiter bus power (A, B, and C) and other signals. Included in these harness assemblies are all connectors and junction modules.

(1) A short circuit in power lines on both A and B sides would result in Loss of Bus power to all IEA functions, two rate gyro's and two SRM Pressure Transducers.

(2) Loss of wires, loss of terminal block connections, or loss of specific pins would result in the loss of one or more Bus Voltages, Measurements, or PIC outputs .

(3) A short or open circuit in C Bus distribution lines will result in loss of power to RGA #3 or #4 and one SRM Chamber Pressure Sensor for applicable SRB.

(4) A short circuit to ground or return line on functional lines/circuits in the forward IEA Wiring Harness will result in loss of that function.

The design documentation is listed below:

Design Document	Document Number
Design Requirements	5136100-CEI Part I
SRB Forward IEA Assembly	5080004-215
Distributor Wiring Harness A Assembly Dwg	5104127
Distributor Wiring Harness B Assembly Dwg	5104128
Signal Conditioner Wiring Harness A Assembly Drawing	5104124
Signal Conditioner Wiring Harness B Assembly Drawing	5104125
Distributor Wiring Harness A DITMCO Test	5114387-DTMC
Distributor Wiring Harness B DITMCO Test	5114395-DTMC
Signal Conditioner Wiring Harness A DIPMCO Test	5114324-DTMC
Signal Conditioner Wiring Harness B DITMCO Test	5114325-DTMC
Forward IEA Chassis Assembly Drawing	5104131
Forward IEA Chassis DITMCO Test	5114394-DTMC

Parts derating in wiring harness design is in accordance with "EEE Parts Selection and Application Guidelines for Space Shuttle External Tank and Solid Rocket Booster" (MSFC 85M03936) or NASA Standard Electrical, Electronic, and Electromechanical Parts List." Extensive tests and inspections occur during harness manufacture. Design requirements and specifications documents for the wiring harnesses are as follows:

DOCUMENT NUMBER	
MIL-E-45782B	Specification for Electrical Wiring

40M39513/5	Electrical Wire, Insulated, High Temperature
40M39526/5	Electrical Cable, Shielded, Jacketed, General Specification For
40M38277	Connectors, Electrical, Circular Miniature, High Density, Environmental Resisting
16A02980D	Connectors, Electrical, Circular, Miniature
MIL-B-5087B	Bonding, Electrical, and Lightning Protection, For Aerospace Systems
NHB5300.4(3A/3A-1)	Requirements for Soldered Electrical Connections (BI-1630)
40M39589	Junctions and Junction Devices, Electrical Distribution and Bussing, Specification For MSC/MSFC JD001 Crimping of Electrical Connections, Requirements For (BI-1836 R1)
1919269(PS)E	Flexible Epoxy Adhesive
10STD-0013	Retention Criteria Standard For Electrical Contacts

G. Miscellaneous III Cards

Miscellaneous III Card Design - The Miscellaneous III card provides resistors and diodes for various functions on the A side of the Forward IEA. With respect to the Forward IEA ignition function, one diode on the miscellaneous III card is utilized to provide power to the A Fire 2 ignition solid state switch. (See Recovery Logic III for B side.) This design configuration assures that the PIC Fire 2 input cannot be activated before the Fire 1 input, thus preventing an erroneous arm power removal from the A ignition PIC. An open diode from the Fire 1 solid state switch can result in the loss of ignition A Fire 2 command and loss of redundancy for SRM ignition. The design documentation is listed below: (Miscellaneous III Cards)

Design Document	Document Number
Design Requirements	5136100-CEI Part I
SRB Forward IEA Assembly	5080004-215
Miscellaneous III Card Assembly Drawing	5100525
Miscellaneous III Card Schematic	5110525
Miscellaneous III Card Test Specification	5130525-GTS
Miscellaneous III Card PWB Drawing	5120525

H. Recovery Logic Cards

(1) Recovery Logic IA - The Recovery Logic IA card utilized in the forward IEA was designed specifically for the shuttle SRB application. This card contains the +XD21 power on latching switch, activated by the Recovery Logic III card separation Fire 1 "or" gate output. This switch provides power to the Recovery Logic IIB card, Sensor Timer Unit (STU), and the Altitude Switch Assembly (ASA) baro switch. Listed failure mode addresses a logical short which effectively turns on the +XD21 latching switch. The only critical failure causes for listed failure mode are piece part failures of the +XD21 latching switch circuit itself. (Recovery Logic IA)

The applicable design documentation is listed below:

- 5136100-CEI Part I - CEI Spec Design Requirements
- 5080004-215 - SRB Forward IEA Assembly
- 5100523 - Recovery Logic IA Assembly Drawing
- 5110523 - Recovery Logic IA Schematic Drawing
- 5130523-GTS - Recovery Logic IA Test Specification
- 5120523-1 - Recovery Logic IA Printed Wiring Board Drawing

(2) Recovery Logic IIB card - The Recovery Logic IIB card utilized in the forward IEA was designed specifically for the shuttle SRB application. This card contains the NEJ Arm/+XD22 arm power latching switch and associated 30 second timer, activated by the Recovery Logic III card separation fire 2 "or" gate output. (The card also contains a 19.5 second timer and associated switch activated by a clock pulse qualified by the ASA low altitude output and associated logic circuits to perform other recovery system sequence functions.) Power for the Recovery Logic IIB card is provided by the Recovery Logic IA +XD21 power on latching switch. Listed failure mode addresses a logical short which effectively turns on the NEJ Arm/+XD22 arm power output. The only failure causes for this mode are piece part failures of the NEJ Arm solid state switch circuit itself. (Recovery Logic IIB)

The applicable design documentation is listed below:

- 5100524 - Recovery Logic IIB Assembly Drawing
- 5110524 - Recovery Logic IIB Schematic Drawing
- 5130524-GTS - Recovery Logic IIB Test Specification
- 5120524 - Recovery Logic IIB Printed Wiring Board Drawing

(3) Recovery Logic III - The Recovery Logic III card utilized in the IEA was designed specifically for the shuttle SRB application. The card contains two identical electrically isolated "or" gates which implement parallel redundancy for the Separation A and B Fire 1 and Fire 2 inputs and Recovery logic sequence initiation. The A and B separation input signals are electrically isolated from each other and from the "or" gate output circuits. The only critical failure causes for listed failure mode are piece part failures of the A or B Fire 1 "or" gate itself. (Recovery Logic III)

(4) The Recovery Logic III card provides resistors and diodes for various functions on the B side of the Forward IEA. With respect to the Forward IEA ignition function, one diode on the Recovery Logic III card is utilized to provide power to the B Fire 2 SRM ignition solid state switch. (See Miscellaneous III card for A side.) This design configuration assures that the PIC Fire 2 input cannot be activated before the Fire 1 input, thus preventing an erroneous arm power removal from the B ignition PIC. An open diode from the Fire 1 solid state switch can result in the loss of ignition B Fire 2 command and loss of redundancy for SRM ignition. The design documentation is listed below: (Recovery Logic III cards)

Design Document	Document Number
Design Requirements	5136100-CEI Part I
SRB Forward IEA Assembly	5080004-215
Recovery Logic III Card Assembly Drawing	5100559
Recovery Logic III Card Schematic	5110559
Recovery Logic III Card Test Specification	5130559-GTS
Recovery Logic III Card PWB Drawing	5120559

I. Pyro Initiator (PIC) Cards

The Pyrotechnic Initiator Controller (PIC) contains a single channel, capacitor discharge energy, pyro-firing circuit; and built-in self test circuitry for a pyrotechnic initiator resistance test, and a pyro-firing load

test. The electrical, electronic and electrical mechanical components are selected from or in accordance with the orbiter preferred parts list (OPPL) requirements. Component applications are evaluated to assure compliance with derating requirements.(BI-1445)

The PIC design consists of two double-sided printed circuit boards attached to an aluminum frame and hard wired to an output connector. The design utilizes discrete solid-state components to satisfy circuit requirements.

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SECTION 3. TESTING

A. Acceptance Test- New Forward IEA

Acceptance Test - Forward IEA Acceptance Test are Conducted per Vendor Document 5135110-GTSP. All Production Units are Subjected to 100% Acceptance Testing which includes Visual examination, Isolation/Insulation Resistance and Dielectric Withstanding Voltage Test (Wiring Harness) and Specific Functional Testing Including:

IEA Acceptance Test includes Random Vibration (Operating) and Thermal (Functional test (+30 degrees F to + 135 degrees F). (All Failure Causes)

(1) Application and redundancy of Power Buses A, B and C.

(2) Verifying Series and Parallel Redundancy of the SRB Separation A and B System ARM, FIRE-1, FIRE-2 Switches. (Includes Examination of operating Voltage, Timing, Currents, Output Wave Shapes, Loads/Circuit Resistance)

(3) Verifying Series and Parallel Redundancy of the SRM Ignition System Safe and Arm Assembly - ARM, SAFE- 1, and SAFE-2 Switches. (Includes Examination of operating Voltage, Timing, Currents, Loads/Circuit resistance)

(4) Verifying Series and Parallel Redundancy of SRM Ignition System A and B ARM, FIRE-1 and FIRE-2 Switches/ Circuits.

(5) Verifying Pyro Initiator Card (PIC) Charge and Discharge Time, Output energy and BITE Circuit operation.

(6) Verifying Bus Power Distribution to SRM Pressure Transducers and ON/OFF Switching Circuits for Rate Gyros.

(7) Verifying Series redundancy of Recovery Logic Power ON/ARM Switches and Timing/Sequencing Thresholds.

(8) Verifying Return and Measurement Circuits through Wiring Harness.

B. Recertification - Reused Forward IEA

(1) Recycled-Reused - Previously flown Forward IEAs will be processed for recertification at USA SRBE KSC Florida Operations per 10SPC-0131 and 10REQ-0051. If anomalies are noted during recertification test, the IEA will be returned to the vendor for repair/refurbishment.

(2) Repaired/Refurbished IEAs will be recertified at the vendor per document 5499296 which includes the same acceptance test per 5135110-GTSP as new IEAs.

(3) IEA's will be functionally tested prior to being placed in storage for reuse.

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C. ESD Protection

ACO OMRSD 10REQ-0021, Para 4.11 requires that grounding wrist straps be worn at all times when electrical connector pins are being contacted with anything other than the mating connector and/or the component is being handled with covers removed. In addition, LRU connectors shall have metal caps or non-metallic ESD protective caps installed when not mated to cables, and prior to removing the LRU connector protective caps for cable mating. The shell of the mating connector shall be grounded. Interconnecting cables terminated on one end to an LRU are considered an extension of the LRU and are handled in accordance with the specified procedures.

A. Electronic Assembly

The "Integrated Electronics Assembly, Inspection System Plan" (5499529) details the inspection plan for the Forward IEA. The inspections include raw materials, piece parts, subassembly, fabrication and final assembly.

Receiving Inspections: Receiving inspection is performed to the individual component source control drawings. Transistors, optical couplers, diodes, and micro-circuits are 100 percent visually inspected. Capacitors, resistors, junction devices, card connectors and environmentally sealed connectors are sample inspected (1 percent Acceptable Quality Level [AQL]). External underwater connectors are 100 percent visually inspected per Acceptance/Rejection Criteria 5136849-GMS. Solder, flux, conformal coating, wire and copper clad board material are sample inspected upon receipt. USA SRBE QAR verifies material certification and receiving inspection/test records per SIP 1177. (All Failure Causes)

Forward IEA in process inspection - All the manufacturing inspection points of the Forward IEA are contained in AICL 5080004-215. Copies of the AICL remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177 for new build hardware and for refurbishment hardware. Inspections performed include the following: (All Failure Causes)

-Witness Load per vendor AICL
-Pre-covers Visual per vendor AICL
-Pre-MCO Visual per vendor AICL
-Room Temperature MCO per vendor 5135110-GTSP
-MCO Thermal per vendor 5136203-GMC

MCO testing (Room Temperature MCO and MCO Thermal) performs the same functional tests of the MDM power redundancy as the acceptance test procedure (described below). Testing is performed at room temperature, +30 degrees F and +135 degrees F and also includes 80 hours thermal cycling from +20 degrees F to +135 degrees F. (All Failure Causes)

Forward IEA ATP inspections - All the Forward IEA acceptance inspection points are contained in AICL 5080004-215. Copies of the AICL remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177 for new build hardware and for refurbishment hardware. Inspections performed include the following: (All Failure Causes)

-ATP Thermal per vendor 5136202-GTP
-ATP Pressure Check per vendor AICL
-ATP Vibration per vendor 5136201-GTP
-Post Vibration Visual per vendor AICL
-Torque Inspection per vendor AICL
-Final ATP per vendor 5135110-GTSP
-Final Visual per vendor AICL

Critical Processes - The procedures below control the IEA critical processes:

- Solder, Hand per 5136274-GMS
- Solder, Automatic per 5126900-GMS
- Component Staking per 5136239-GMS
- Conformal Coating per MSFC-PROC-508
- Crimping per 5136588-GMS

- Staking per 1919269(PS)
- Wire Retention Test per 5136737-GMS

B. EMC Filter

The in process inspections of the EMC filter are contained in Assembly Inspection Check List (AICL) 5100410. Copies of the AICLs remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177. Inspections performed include the following: (EMC Filters)

Kit Layout per vendor AICL
Solder Visual per vendor AICL
Pre-test per vendor 5130410-GTS
Post-test Visual per vendor AICL
Staking Visual per vendor AICL
Conformal Coating Visual per vendor AICL
Module Final Test per vendor 5130410-GTS
Module Final Visual per vendor AICL

Module final test per 5130410-GTS subjects the EMC filter to more stringent performance tests over a wider range of temperature (+14 degrees F to +212 degrees F) than is required of the Forward IEA (+30 degrees F to +135 degrees F). (EMC Filters)

C. Transorb Lightning Suppressor Diode

The in process inspections of the Transorb Diodes are contained in Assembly Inspection Check List 5106985. Copies of the AICLs remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177. Inspections performed include the following: (Transorb Diodes)

Kit Layout per vendor AICL
Solder Visual per vendor AICL
Pre-test per vendor 5136704-GTS
Post-test Visual per vendor AICL
Staking Visual per vendor AICL
Conformal Coating Visual per vendor AICL
Module Final Test per vendor 5136704-GTS
Module Final Visual per vendor AICL

Module final test per 5136704-GTS subjects the Transorb Diodes to more stringent performance tests over a wider range of temperature (+14 degrees F to +212 degrees F) than is required of the Forward IEA (+30 degrees F to +135 degrees F). (Transorb Diode)

D. Power Bus Isolation Supplies

The in process inspections of the PBISs are contained in Assembly Inspection Check List 5106627. Copies of the AICLs remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177. Inspections performed include the following: (Power bus isolation Supplies)

Kit Layout per vendor AICL
Solder Visual per vendor AICL

Pre-test per vendor 5136521-GTS
Post-test Visual per vendor AICL
Staking Visual per vendor AICL
Conformal Coating Visual per vendor AICL
Module Final Test per vendor 5136521-GTS
Module Final Visual per vendor AICL

Module final test per 5136521-GTS subjects the PBIS module to more stringent performance tests over a wider range of temperature (+14 degrees F to +212 degrees F) than is required of the Forward IEA (+30 degrees F to +135 degrees F). (Power Bus Isolation Supplies)

E. Solid State Switches

The in process inspections of the Solid State Switches are contained in Assembly Inspection Check Lists as follows:

3 amp 5 volt - 5100021
0.5 amp 5 volt - 5100022
0.5 amp 28 volt - 5100060
0.5 amp comb. - 5100081

Copies of the AICLs remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177. Inspections performed include the following: (Solid State Switches)

Kit Layout per vendor AICL
Solder Visual per vendor AICL
3 amp 5 volt pre-test per vendor 5130021-GTS
0.5 amp 5 volt pre-test per vendor 5130022-GTS
0.5 amp 28 volt pre-test per vendor 5130060-GTS
0.5 amp comb. pre-test per vendor 5130081-GTS
Post-test Visual per vendor AICL
Staking Visual per vendor AICL
Conformal Coating Visual per vendor AICL
3 amp 5 volt module final test per vendor 5130021-GTS
0.5 amp 5 volt module final test per vendor 5130022-GTS
0.5 amp 28 volt module final test per vendor 5130060-GTS
0.5 amp comb. module final test per vendor 5130081-GTS
Module Final Visual per vendor AICL

Module final test per 5130021-GTS, 5130022-GTS, 5130060-GTS and 5130081- GTS subjects the Solid State Switch modules to more stringent performance tests over a wider range of temperature (+14 degrees F to +212 degrees F) than is required of the Forward IEA (+30 degrees F to +135 degrees F). (Solid State Switches)

F. Wiring Harness

The in process inspections of the IEA Distributor and Signal Conditioner Wiring Harnesses are contained in Assembly Inspection Check Lists as follows:

Distributor Wiring Harness A - 5104127
Distributor Wiring Harness B - 5104128
Signal Conditioner Wiring Harness A - 5104124
Signal Conditioner Wiring Harness B - 5104125

Copies of the AICLs remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177. Inspections performed include the following: (Wiring Harnesses)

Kit Layout per vendor AICL

Solder and Crimp Visual per vendor AICL Insulation and Continuity Test (Distributor A) per vendor 5114387-DTMC
Insulation and Continuity Test (Distributor B) per vendor 5114395-DTMC
Insulation and Continuity Test (Signal Conditioner A) per vendor 5114324-DTMC
Insulation and Continuity Test (Signal Conditioner B) per vendor 5114325- DTMC Wire Retention Test per vendor 5136737-GMS
Final Visual per vendor AICL

Forward IEA Chassis Assembly - The in process inspection of the Forward IEA Chassis Assembly is contained in AICL 5104131. Copies of the AICL remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177. Inspections performed include the following: (Wiring Harnesses)

-Chassis Harness Installation and Staking per vendor AICL
-In Process and Solder Visual per vendor AICL
-Connector Installation and Torquing per vendor AICL
-Vibration Shake Test per vendor 5136201-GTP
-Insulation and Continuity Test per vendor 5114394-DTMC
-In Process Visual per vendor AICL
-Final Visual per vendor AICL

G. Miscellaneous III Card

The in process inspection points of the Miscellaneous III Card are contained in AICL 5100525. Copies of the respective AICLs remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177. Inspections performed include: (Miscellaneous III Cards)

Kit Layout per vendor AICL
Solder Visual per vendor AICL
Miscellaneous III Card Pre-test per vendor 5130525-GTS
Post-test Visual per vendor AICL
Staking Visual per vendor AICL
Conformal Coating Visual per vendor AICL
Miscellaneous III Card final test per vendor 5130525-GTS
Module Final Visual per vendor AICL

Module final test per 5130525-GTS subjects the Miscellaneous cards to more stringent performance tests over a wider range of temperature (+14 degrees F to +212 degrees F) than is required of the Forward IEA (+30 degrees F to +135 degrees F). (Miscellaneous III Cards)

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H. Recovery Logic Cards

(1) Recovery Logic IA - All the manufacturing inspection points of the Recovery Logic I cards are contained in Assembly Inspection Check List (AICL) 5100523, CCA, Recovery Logic I Card. Copies of the respective AICLs remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177. Inspections performed include the following: (Recovery Logic I)

-Kit Layout per vendor AICL
-Solder Visual per vendor AICL
-Pre-test Visual per vendor 5130523-GTS
-Post-test Visual per vendor AICL
-Staking Visual per vendor AICL
-Conformal Coating Visual per vendor AICL
-Module Final Test per vendor 5130523-GTS
-Module Final Visual per vendor AICL

Module final test per 5130523-GTS subjects the Recovery Logic IA card to more stringent performance tests over a wider range of temperature (+14 degrees F to +212 degrees F) than is required of the Forward IEA (+30 degrees F to +135 degrees F). (Recovery Logic I)

(2) Recovery Logic IIB - All the manufacturing inspection points of the Recovery Logic II cards are contained in AICL 5100524, CCA, Recovery Logic II Card. Copies of the respective AICLs remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspection are performed to SIP 1177. Inspections performed include the following: (Recovery Logic II)

-Kit Layout per vendor AICL
-Solder Visual per vendor AICL
-Pre-Test Visual per vendor 5130524-GTS
-Post-Test Visual per vendor AICL
-Staking Visual per vendor AICL
-Conformal Coating Visual per vendor AICL
-Module Final Test per vendor 5130524-GTS
-Module Final Visual per vendor AICL

Module final test per 5130524-GTS subjects the Recovery Logic IIB card to more stringent performance tests over a wider range of temperature (+14 degrees F to +212 degrees F) than is required of the Forward IEA (+30 degrees F to +135 degrees F). (Recovery Logic II)

(3) Recovery Logic III - All the manufacturing inspection points of the Recovery Logic III cards are contained in AICL 5100559, CCA, Recovery Logic III Card. Copies of the respective AICLs remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177. Inspections performed include the following: (Recovery Logic III)

-Kit Layout per vendor AICL
-Solder Visual per vendor AICL
-Pre-Test Visual per vendor 5130559-GTS
-Post-Test Visual per vendor AICL
-Staking Visual per vendor AICL
-Conformal Coating Visual per vendor AICL
-Module Final Test per vendor 5130559-GTS

-Module Final Visual per vendor AICL

Module final test per 5130559-GTS subjects the Recovery Logic III card to more stringent performance tests over a wider range of temperature (+14 degrees F to +212 degrees F) than is required of the Forward IEA (+30 degrees F to +135 degrees F). (Recovery Logic III)

I. Pyro Initiator Controller (PIC)

The Pyro Initiator Controllers are GFE to the Integrated Electronic Assembly (IEA) vendor.

(1) PIC Vendor - The PIC vendor performs a receiving inspection consisting of visual and dimensional examination of all incoming parts. Electronic parts are functionally tested prior to release, certification records and test reports are maintained to verify materials and physical properties.

Fabrication is accomplished in a dedicated area with limited access and environmental controls. Contamination controls procedures are verified by inspection.

Quality control verifies proper maintenance of the assembly area controls. Printed circuit boards are inspected with magnification after each soldering process to verify conformance to requirements. Electrostatic discharge protection is maintained throughout the assembly and test process. Electrical terminations are verified by inspection. Measurement Standards and process equipment are verified by inspection.

(2) IEA Vendor - The "Integrated Electronics Assembly, Inspection System Plan," 5499529 details the inspection plan for the Forward IEA. The inspections include raw materials, piece parts, subassembly, fabrication and final assembly. (PICs)

a) PIC Receiving inspections: Upon receipt, Bendix QC performs a visual inspection of each PIC per 5104115 and a room temperature functional test per 5136115-GTS. USA SRBE QAR inspections are performed to SIP 1177. (PICs)

b) Manufacturing inspections - Forward IEA in process Inspection - All the manufacturing inspection points of the Forward IEA are contained in Assembly Inspection Check List (AICL), 5080004-215, SRB-FWD IEA ASSEMBLY.

Copies of the respective AICLs remain with the hardware as it is processed through manufacturing and are retained. They define the inspection points performed by vendor. USA SRBE QAR inspections are performed to SIP 1177 for new build hardware and for refurbishment hardware. Inspections performed include: (PICs)

-Witness Load per vendor AICL
-Pre-covers Visual per vendor AICL
-Pre-MCO Visual per AICL
-Room Temperature MCO per 5135110-GTSP
-MCO Thermal per 5136203-GMS

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SECTION 5. LRU (IEA) FIELD INSPECTIONS

A. ACO (USA SRBE) Inspections

(1) Forward IEA Receiving Inspection, Data Package Verification and Connector Inspection is performed per 10REQ-0021, para. 1.2.1.9.1 and 1.2.1.9.2.

(2) USA SRBE Quality Assurance verifies all ACO testing including the following: (All Failure Causes)

(a) SRB Forward IEA Power Buses A and B, RSS battery bus, and Recovery battery bus isolation and nominal voltages verification. OMRSD 10REQ-0021, para. 1.2.1.6 and 1.2.2.1.1.

(b) SRB Rate Gyro Power On, SMRD, Null, and Torque tests. OMRSD 10REQ-0021, para. 1.2.2.19.1 and 1.2.2.19.3.

(c) SRM Ignition Safe and Arm (S&A) Assembly Circuit Test. OMRSD 10REQ-0021, para. 1.2.2.9.

(d) SRM Ignition A and B Circuit Test. OMRSD 10REQ-0021 1.2.2.8.1 and 1.2.2.8.2

(e) SRB Booster Separation Motor (BSM) Ignition A and B PIC Circuit Test. OMRSD 10REQ-0021, para. 1.2.2.7.2 and 1.2.2.7.3.

(f) SRB Forward Thruster Pin (Separation Bolt) A and B PIC Test. OMRSD 10REQ-0021, Para 1.2.2.7.1 and 1.2.2.7.4.

(g) SRB Recovery/Deceleration System Test. OMRSD 10REQ-0021, para. 1.2.2.10.2.

(h) Aft IEA through circuit verifications. OMRSD 10REQ-0021 para. 2.2.2.7.4, 2.2.2.7.5, and 2.2.2.7.6

B. KSC SPC Inspections

(1) SPC Quality Assurance verifies Vehicle Level Testing and Data including the following:

(a) Orbiter to SRB Power Transfer Verifies the Forward IEA Power Buses A, B, and C. OMRSD File II, S00000.470 & S00000.475.

(b) SRB Rate Gyro Power, Polarity, and Torque Tests. OMRSD File II, Vol. I S00000.643, S00000.645, S00FF0.215, and S00FF0.230.

(c) SRM Ignition Safe and Arm (S&A) Assembly Functional Test. OMRSD File V, Vol B47SA0.070

(d) SRM Ignition A and B PIC Resistance and Arm & Fire Circuit Test. OMRSD File V, Vol. I B75PIO.011, File II, Vol. I S00000.525, S00000.510, and S00FA0.015.

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(e) SRB Booster Separation Motor (BSM) Ignition A and B PIC Resistance and Arm & Fire Circuit Test. File V, Vol. I B75PI0.011, File II, Vol. I S00000.525, & S00FA0.015

(f) SRB Forward Thruster Pin (Separation Bolt) A and B PIC Resistance and Arm & Fire Test OMRSD File V, Vol. I. B75PI0.011, File II, Vol. I S00000.525 & S00FA0.015

(g) SRB Recovery System Sequence Inadvertant Initiation Test. OMRSD File V, Vol. I B52RY0.011 CN 044

(h) SRM Chamber Pressure Sensor function. OMRSD File II, Vol. I S00000.450.

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