

System: SRMS

Subsystem: ELECTRICAL SUB-SYSTEM

Assembly Desc: Servo Power Amplifier

Part Number(s): S1140F1177-3

S1140F1177-5

Item:

Function: Motor Drive Amplifier Assembly

Provides motor voltage based on demand from tachometer electronics. Commutates the motor drive voltage. Provides hardware current limiting, brake drive, direct drive functions and enables backup drive. Provides BITE circuits and BITE verification for MDA.

Analog Interface Assembly

Provides Tachometer excitation, SCU signal filtering, Phase Locked Loop and tachometer counter circuits to provide measured motor speed data to inner and outer rate loops. Provides analog to digital conversion of MDA buck output voltage. EPC +5V and reference voltages for BITE.

Failure Mode: Corrupt Direct Drive signals.

HW Func. Screen Failures

Criticality: 2 1R

Mission Phase: Orbit

Cause(s): Analog Interface Assembly  
Motor Drive Amplifier Assembly

Loss of 50 KHz clock to MDA.  
Direct Drive direction prime or redundant digital filter signals fail to CCW direction.  
Direct Drive direction prime or redundant digital filter signals fail to CW direction.  
Direct Drive enable digital filter signal failed active.  
Direct Drive enable digital filter signal failed inactive.  
Direct Drive signal absent prime or redundant digital filter signals fail to signal absent.  
Direct Drive signal absent prime or redundant digital filter signals fail to signal detected.  
Loss of 50 KHz clock to MDA.

Failure effect on unit/item:

One or more of DD\_EN, SIG\_ABS1, SIG\_ABS2, DD\_DIR1 or DD\_DIR2 direct drive signals are corrupt. Direct drive BITE is set with joint brake applied when joint is commanded positive, negative or when command is released. Direct drive may be lost in one or both directions. BITE indication may or may not be latched. For DD\_EN failed inactive, no BITE indication will occur but joint will not drive in Direct.

Worst Case: Unexpected motion. In Direct Drive wrong joint direction or two joints drive. Joint Braking.

Redundant Paths: Computer Supported modes.  
Backup Drive.

Retention Rationale

Design:

The design utilizes proven circuit techniques and is implemented using CMOS logic devices. CMOS devices operate at low power and hence do not experience significant operating stresses. The technology is mature, and device reliability history is well documented. All stresses are additionally reduced by denoting the appropriate parameters in accordance with SPAR-RMS-PA.003. Special handling precautions are used at all stages of manufacture to preclude damage/stress due to electrostatic discharge.

Resistors and capacitors used in the design are selected from established reliability (ER) types. Life expectancy is increased by ensuring that all allowable stress levels are denoted in accordance with SPAR-RMS-PA.003. All ceramic and electrolytic capacitors are routinely subjected to radiographic inspection in accordance with the requirements of MSFC-STD-355.

Field Programmable Gate Arrays (FPGA's) and the Error Detection and Correction (EDAC) are semi-custom microcircuits in which design functional elements are designed by the manufacturer. The interconnection of these elements is then customized by Spar to provide the functionality of the completed microcircuit. The design utilizes proven circuit techniques and is implemented using CMOS technology. The technology operates at low power and hence the device does not experience significant operating stresses. The technology is mature, and basic device reliability is well documented. All stresses are additionally reduced by derating the appropriate parameters in accordance with SPAR-RMS-PA.003 and verified by design review.

This approach has a significant advantage in that it reduces the quantity of discrete parts required in the assembly and also the complexity of the PWB and results in significant weight and volume savings. This type of semi-custom part has been successfully used in other space applications.

The parts are qualified to the requirements of the applicable specification. They are 100% screened and burned in to the requirements of the Spar requirements document.

The SPA board is fabricated using Surface Mount Technology (SMT). This is a PWB assembly technology in which the components are soldered to the solder pads on the surface of the PWB. The significant advantage of this technology is to enable the parts on the board to be more densely packed, to reduce the overall volume and weight of the assembly.

The assembly process is highly automated. The parts are mounted on the boards using a computer controlled "pick and place" machine. Subsequent soldering operation is performed using a belt furnace, in which the time and temperature thermal profile that the PWB assembly is exposed to is tightly controlled and optimized to ensure proper part soldering attachment. The assembly is manufactured under documented procedures and quality controls. These controls are exercised throughout the assembly, inspection and testing of the unit. This inspection includes workmanship, component mounting, soldering, and conformal coating to ensure that it is in accordance with the NHB 5300 standard.

The SMT line used for the SPA PWB assembly has undergone a full qualification program, and assemblies produced on this line are used in other space programs.

The circuit board design has been reviewed to ensure adequate conductor width and separation and to confirm appropriate dimensions of solder pads and of component hold provisions. Parts mounting methods are controlled in accordance with MSFC-STD-154A, MSFC-STD-257 and SASD 2573751. These documents require approved mounting methods, stress relief and component security.

**Test:**

**QUALIFICATION TESTS** - The SPA is subjected to the following qualification testing:

**VIBRATION:** Each axis of the QM is subjected to Flight Acceptance Vibration Test (FAVT), Qualification Acceptance Vibration Test (QAVT) and Qualification Vibration Tests (QVT) in accordance with the SPA Vibration Test Procedure (826586). The level and duration for FAVT is as per Figure 6 and Table 2 of 826586; the level and duration for QAVT is as per Figure 7 and Table 2 of 826586; the level and duration for QVT is as per Figure 8 and Table 2 of 826586. At the end of the three successive random vibration test in each axis, both directions (+/-) of each axis is subjected to a shock pulse test as per Figure 9 of 826586.

**THERMAL/VACUUM:** QM TVAC Test is in accordance with Figure 5 of the SPA TVAC Test Procedure (826586), with full Functional/Parametric Test performed at levels of +60 degrees C and -36 degrees C, and non-operating at -54 degrees C. The Qualification vacuum levels during TVAC is  $1 \times 10^{-6}$  torr or less. The total test duration is 7 1/2 cycles. The QM SPA is subjected to a minimum of 100 hours of life testing and 1000 power On-Off cycles.

**EMC:** The QM is subjected to EMC Testing (tests CE01/CE03, CE07, CS01, CS02, CS06, RE02, RS02, and RS03) in accordance with the SPA EMC test Procedure (826477) based on MIL-STD-461A.

**UNIT FLIGHT ACCEPTANCE TESTS** - The FM SPA is subjected to the following acceptance testing:

**VIBRATION:** FM Acceptance Vibration Test (AVT) in accordance with the SPA Vibration Test Procedure (826586), with level and duration per Figure 6 and Table 2 of 826586.

**THERMAL/VACUUM:** FM TVAC Test is in accordance with Figure 8 of the SPA TVAC Test Procedure (826586), with levels of +48 degrees C and -25 degrees C for a duration of 1 1/2 cycles. The vacuum levels during Acceptance TVAC Test is  $1 \times 10^{-5}$  torr or less.

**JOINT SRU TESTS** - The SPA is tested as part of the joints (ambient and vibration tests only). The ambient ATP for the Shoulder Joint, Elbow Joint, and Wrist Joint are as per ATP.2001, ATP.2003, and ATP.2005 respectively. The vibration test for the Shoulder Joint, Elbow Joint, and Wrist Joint are as per ATP.2002, ATP.2004 and ATP.2006 respectively. Through wire function, continuity and electrical isolation tests are performed per TP.283.

**MECHANICAL ARM REASSEMBLY** - The SPA's/Joints undergo a mechanical arm integration stage where electrical checks are performed per TP.2007.

**MECHANICAL ARM TESTING** - The outgoing split-arm is configured on the Strongback and the Manipulator Arm Checkout is performed per ATP.1932.

**FLIGHT CHECKOUT:** PDRS OPS Checkout (all vehicles) JSC 16587.

**Inspection:**

Units are manufactured under documented quality controls. These controls are exercised throughout design, procurement, planning, receiving, processing, fabrication, assembly, testing and shipping of the units. Mandatory inspection points are employed at various stages of fabrication, assembly, and test. Government source inspection is invoked at various control levels.

EEE parts inspection is performed as required by SPAR-RMS-PA.003. Each EEE part is qualified at the part level to the requirements of the applicable specification. All EEE parts are 100% screened and burned-in, as a minimum, as required by SPAR-RMS-PA.003, by the supplier. DPA is performed as required by PA.003 on a randomly selected 5% of parts, maximum 5 pieces, minimum 3 pieces for each lot number.

code of parts received. All cavity devices are subjected to 100% FIND. Wire is procured to specification MIL-W-22759 or MIL-W-81381 and inspected and tested to NASA JSCM8080 Standard Number 95A.

Receiving inspection verifies that all parts received are as identified in the procurement documents, that no physical damage has occurred to parts during shipment, that the receiving documents provide adequate traceability information and screening data clearly identifies acceptable parts.

Parts are inspected throughout manufacture and assembly as appropriate to the manufacturing stage completed. These inspections include:

Printed circuit board inspection for track separation, damage and adequacy of plated through holes, component mounting inspection for correct soldering, wire looping, strapping, etc. Operators and inspectors are trained and certified to NASA NHB 5300.4(3A-1) Standard. Conformal coating inspection for adequate processing is performed using ultraviolet light techniques. P.C. Board Installation inspection includes checks for correct board installation, alignment of boards, proper connector contact mating, wire routing, strapping of wires etc. Post P.C. Board installation inspection includes cleanliness and workmanship (Spar/government rep. mandatory inspection point).

Unit Pre-Acceptance Test inspection, which includes an audit of lower tier inspection completion, as built configuration verification to as design etc (mandatory inspection point). A Unit Test Readiness Review (TRR) which includes verification of test personnel, test documents, test equipment calibration/validation status and hardware configuration is convened by QA in conjunction with Engineering, Reliability, Configuration Control, Supplier as applicable, and the government representative, prior to the start of any formal testing (Acceptance or Qualification). Unit level Acceptance Testing (ATP) includes ambient performance, thermal and vibration testing (Spar/government rep. mandatory inspection point).

Integration of unit to Joint SRU - Inspections include grounding checks, connectors for bent or pushback contacts, visual, cleanliness, interconnect wiring and power up test to the appropriate Joint Inspection Test Procedure (ITP). Joint level Pre-Acceptance Test inspection, includes an audit of lower tier inspection completion, as built configuration verification to as design etc. Joint level Acceptance Testing (ATP) includes ambient and vibration testing (Spar/government rep. mandatory inspection point).

Mechanical Arm Reassembly - the integration of mechanical arm subassemblies to form the assembled arm. Inspections are performed at each phase of integration which includes electrical checks, through wiring checks, wiring routing, interface connectors for bent or pushback contacts etc. Mechanical Arm Testing - Strongback and flat floor ambient performance test (Spar/government rep. mandatory inspection point)

OMRSD Offline: Power-up arm. Verify Direct Drive operating correctly.

OMRSD Online Installation: None.

OMRSD Online Turnaround: Power-up arm. Verify Direct Drive capability is as expected.

Screen Failure: A: Pass  
B: Pass  
C: Pass

Crew Training: The crew will be trained to always observe whether the arm is responding properly to commands. If it isn't, apply brakes.

Crew Action: Remove the drive command. Select any other mode.

Operational Effect: Loss of direct Drive. For a subsequent failure, when attempting to drive a single joint in Direct Drive, the joint selected plus one other joint will drive. Computer supported modes are available however the system is one failure away from a criticality one. Backup remains available.

Mission Constraints: Operate under vernier rates within approximately 10 ft of structure. The operator must be able to detect that the arm is responding properly to commands via window and/or CCTV views during all arm operations. Auto trajectories must be designed to come no closer than approximately 5 ft from structure.

Approvals:

Functional Group	Name	Position	Telephone	Date Signed	Status
Engineer	Hiltz, Michael / SPAR-BRAMPTON	Systems Engineer	4534	05Mar98	Signed
Reliability	Molgaard, Lena / SPAR-BRAMPTON	Reliability Engineer	4590	05Mar98	Signed
Program Management Office	Rice, Craig / SPAR-BRAMPTON	Technical Program Manager	4882	05Mar98	Signed
Subsystem Manager	Glenn, George / JSC-ER	RMS Subsystem Manager	(281) 483-1516	30Mar98	Signed
Technical Manager	Allison, Ron / JSC-MVS	RMS Project Engineer JSC	(713) 483-4072	09Apr98	Signed

ETP Mission Assurance CARH, DAVID / JSC-MCB RMS JUNA ENGINEER (281) 483-5899 30 APR 98 David H. Long