

Solar Electron Proton Telescope  
Interface Control Document  
for the  
Solar Energetic Particle  
Central Electronics

**SEPT-SEP\_Central ICD**

Revision A

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## 1. Scope and Revision History

This document describes electrical hardware interfaces and timing protocols for commands, data, discrete and power signals between the SEPT sensor and SEP central electronics (SEP\_Central) as part of the SEP/IMPACT suite aboard each of the two STEREO spacecraft. SEPT sensor has two units, of which only SEPT-E is explicitly discussed here, although the same discussion applies to SEPT-NS.

For details on software-related aspects of the SEPT-SEP\_Central interface see the reference document 2.2.

For details on pyro-related aspects of the SEPT-S/C interface see the reference document 2.3.

The interfaces are conducted via external shielded harness that is terminated on both sides by MDM connectors, and split on SEPT side as shown in Appendix 8.1. Pin redundancy is not mandatory, yet highly desirable. Harness lengths vary as each SEPT unit is uniquely located on the two STEREO spacecraft.

<u>Rev.</u>	<u>Date</u>	<u>Description</u>
-	11/18/02	Initial release
A	03/19/03	Update Command and Power Interfaces and Appendices (I/F schematic, harness and power flow diagrams)

## 2. Applicable Documents

2.1 SEPT Operation Control and Data Processing Requirements  
Version 2.1

2.2 SEP Commanding and Users Manual      Document No. STEREO-CIT-007.A  
[ftp://mussel.srl.caltech.edu/pub/stereo/docs/SEP\\_CommandingUserManual\\_A.pdf](ftp://mussel.srl.caltech.edu/pub/stereo/docs/SEP_CommandingUserManual_A.pdf)

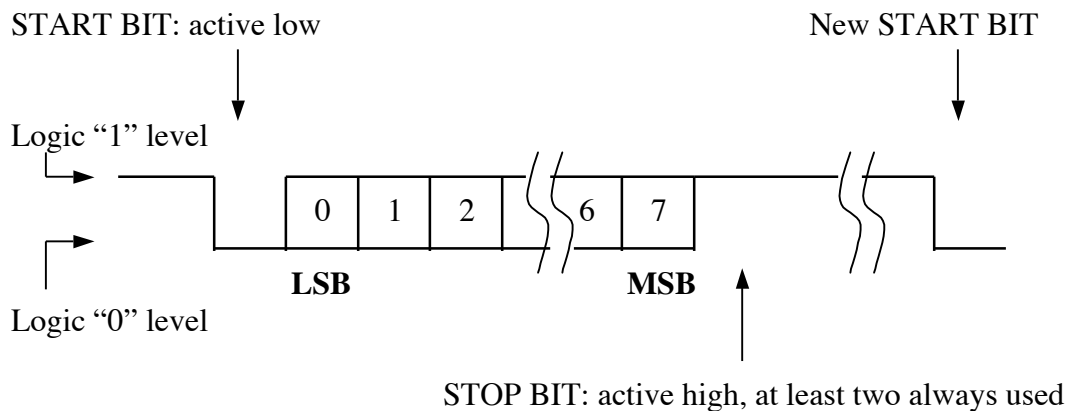
2.3 Interface Control Document (ICD) for the IMPACT Investigation  
APL Drawing No. 7381-9012, Rev. A, available at APL STEREO website

2.4 IMPACT LVPS Requirements, Rev. F  
[http://sprg.ssl.berkeley.edu/impact/dwc/ICD/LVPSRequirements\\_F.pdf](http://sprg.ssl.berkeley.edu/impact/dwc/ICD/LVPSRequirements_F.pdf)

### 3. Command Interface

The Command Interface shall be used to transfer commands from SEP\_Central to SEPT.

3.1 Protocol. Transfer of commands from SEP\_Central to SEPT shall take place according to the SEPT Serial Data/Command Protocol shown in Figure 1 below. Note that signal polarity of this Protocol is unique to SEPT-SEP\_Central I/F.



**Figure 1 – SEPT Serial Data/Command Protocol**  
(Signal polarity shown at interface connector pins)

Note: Nominal baud rate = 57.6 kbaud

High baud rate was chosen to allow boot code transfer to other, MISC-equipped, SEP sensors in a reasonably short time.

Actual rate on SEPT side = 57.69231 kbaud - generated from 18 MHz / (4\*78)

Actual rate on SEP\_Central side = 57.14286 kbaud - from 16 MHz / (8\*35)

Difference in actual baud rates shall be within 2 %. In this case it is less than 1 %.

SEPT command is 1-byte long and sometimes followed by argument 2-3 bytes long. Time separation between successive command and argument bytes shall be no longer than 1.8 ms. Otherwise, SEPT responds with < rTimeOut – 00001111 > and the

transmission shall be aborted. SEP\_Central shall then reset the communication circuit by sending [ cRstComm – 00010010 ] and shall perform TBD action.

### 3.2 Signal Description.

3.2.1 SEPT-E CMD IN. This 0 to +5 V digital signal is used to transfer commands from SEP\_Central to SEPT-E. SEP\_Central shall generate this signal. Its return line is SEPT-E MSTR RTN, which is tied to the signal ground (local chassis) on the SEP\_Central side, while on the SEPT-E side it is separated from the local signal ground (local chassis) by 50  $\Omega$ . See Appendix 8.1 for details of the I/F schematic.

## 4. Data Interface

The Data Interface is used for transfer of the following information from SEPT to SEP\_Central:

- Data (science & housekeeping)
- Command response
- Interrupt notification

4.1 Protocol. Transfer of data, command response and interrupt notification shall take place according to the Serial Data/Command Protocol described in Figure 1 and Section 3.1.

SEPT echoes back every command it receives so that SEP\_Central can verify it prior to sending the subsequent argument or command. If command verification fails, TBD action shall be taken by SEP\_Central.

SEPT shall respond to a command it does not recognize: < rUnknown – 00000011 >. SEP\_Central shall then reset the communication circuit by sending [ cRstComm – 00010010 ] and shall perform TBD action.

SEP\_Central shall use frequent polling of both SEPT units for interrupt notification. High-rate polling shall be used during the last second of the 60-second accumulation period. The polling rate is TBD.

### 4.2 Signal Description.

4.2.1 SEPT-E DATA OUT. This 0 to +5 V digital signal is used to transfer data from SEPT-E to SEP\_Central. SEPT-E shall generate this signal. Its return line is SEPT-E SUB RTN, which is tied to the signal ground (local chassis) on the SEPT-E side, while on the SEP\_Central side it is separated from the local signal ground (local chassis) by 50  $\Omega$ . See Appendix 8.1 for details of the I/F schematic.

### 4.3 Final Data Format.

SEP\_Central shall assemble SEPT science data into standard 272-byte CCSDS telemetry packet that consists of the following:

- 6-byte Primary Packet Header (byte # 0-5, inclusive)
- 5-byte Secondary Packet Header (byte # 6-10, inclusive)
- 261-byte Application Data (byte # 11-271, inclusive)

For a detailed CCSDS telemetry packet format description see Appendix 8.4. Details of the data location within the 261 bytes of Application Data will be described in the reference document 2.2.

SEP\_Central calculates checksum for each packet. Checksum Byte, the last byte of the CCSDS packet shall be such that the arithmetic sum of all 272 bytes in the packet, modulo 256, equals zero.

SEP Central shall combine HK data from all sensors to form a new SEP HK packet and shall calculate its checksum.

SEP Central shall combine beacon data from all sensors to form a SEP beacon data block and shall calculate its checksum. IMPACT IDPU shall assign the final checksum upon assembly of the IMPACT beacon packet.

SEPT science data packets carry an 11-bit APID (Application Process Identifier) in the hex range 258-261 (inclusive), or 600–609 decimal. In order to fill in the required Primary Header information (bytes # 2-3) SEP\_Central shall implement a separate 14-bit Source Sequence Counter for each unique APID that SEPT team selects to use. The APIDs can be employed to distinguish the data from SEPT-E vs. SEPT-NS, or their subsystems. Shown below are SEPT rate allocations (note that rates do not include packet headers):

- |                             |                           |
|-----------------------------|---------------------------|
| - SEPT science data (rates) | 2 packet/min, 69.6 bit/s  |
| - SEPT HK data              | 28 Fixed bytes, 3.7 bit/s |
| - SEPT beacon data          | 44 bytes, 5.9 bit/s       |

## 5. Discrete Signal Interface

5.1 Protocol. SEP\_Central shall provide a pair of connections between each of the SEPT units and the Spacecraft Thermal connector (SEP-J2) for the signals listed below. The two signals of the pair and their redundant lines shall be routed close together to avoid introduction of electric noise. In the harness they shall be routed as twisted quads.

### 5.2 Signal Description.

5.2.1 SEPT-E S/C TEMP and SEPT-E S/C TEMP RTN. These are a pair of signals that connect to a spacecraft-monitored thermistor in the SEPT-E sensor (a modified “Minco Products” model S17624, flight P/N S102212PFY72B, 1 kohm Pt ribbon RTD sensor, +/- 100 °C). The thermistor is nominally powered by the S/C, with SEP\_Central only providing a connection between the S/C and SEPT-E

sensor. Selection of the thermistor location in SEPT-E shall be coordinated with the SEP Thermal Engineer and in accordance with the reference document 2.3.

## 6. Power Interface

These signals are generated in SEP\_Central and used to provide power to the SEPT sensors.

6.1 LVPS Protocol. SEP LVPS outputs listed below are dedicated to the SEPT-E sensor and regulated to  $\pm 5\%$  (half load to full load). Another identical supply (not listed below) is dedicated to SEPT-NS sensor. High frequency (LVPS-generated) ripple on the secondary outputs shall be less than 10 mV peak-to-peak at full load, as per reference document 2.4.

LVPS switching frequency is 150 kHz on the primary and 400 kHz on the secondary side. SEPT noise-suppression circuitry shall guard against these frequencies and their higher order harmonics.

### 6.2 Signal Description.

6.2.1 SEPT-E ANA RTN. This line provides a return path for all analog power signals from SEPT-E to SEP\_Central. It is connected to the chassis in SEPT-E while floating isolated in SEP LVPS.

6.2.2 SEPT-E +5.6A. This line provides analog power at +5.6 V, primarily used in the PDFE circuit. Its maximum current draw during the steady-state operation shall not exceed 80 mA.

6.2.3 SEPT-E DIG RTN. This line provides a return path for all digital power signals from SEPT-E to SEP\_Central. It is connected to the chassis in SEPT-E while floating isolated in SEP LVPS.

6.2.4 SEPT-E +2.6D. This line provides digital power at +2.6 V, primarily used for core supply of Actel gate array. Its maximum current draw during the steady-state operation shall not exceed 12 mA. Temporary peak shall not exceed 15 mA.

6.2.5 SEPT-E +5.3D. This line provides digital power at +5.3 V, primarily used for supply of Actel gate array, SRAM, PDFA, etc. Its maximum current draw during the steady-state operation shall not exceed 20 mA. Temporary peak load shall not exceed 42 mA.

6.2.6 SEPT-E SEP STAR. This line is connected to the local chassis in both SEPT-E and SEP LVPS, therefore serving as a signal ground to which all analog and digital voltages are referenced.



6.3 SSD Bias Supply Protocol. A single negative bias supply output is used on both SEPT-E and SEPT-NS units. It is controlled by a switch located in SEP\_Central to turn SEPT bias on/off simultaneously for both sensors. For information on the detector leakage current assumptions see Appendix 8.5.

The SSD Bias Supply output ripple shall not exceed 100 mV peak-to-peak and shall be filtered locally within each SEPT unit.

At the end of detector life and at 40 °C the output of SSD Bias Supply may be allowed to droop 10% of the nominal value. This can be accomplished by the selection of current-limiting resistors in the local sensor's circuitry.

#### 6.4 Signal Description.

6.4.1 SEPT-E BIAS. Despite its unique name which signifies a unique set of harness wires, this signal is shared between two SEPT units whose eight detectors account for a total of 24 detector segments (center, guard and cross-talk ring on each detector). Its nominal value shall be set for flight around -80 V.

Inside SEPT units the current limit for each detector segment is set to 8 uA.

For the worst case of two short-circuited detectors (presumably, one in each SEPT unit) and at the end of detector life at 40 °C, the SSD Bias Supply shall be able to provide 130 uA as the short-circuited detectors draw 8 uA/segment while others draw their max. leakage current assumed for the end of detector life and at 40 °C.

6.4.2 SEPT-E BIAS RTN. This signal is also shared between two SEPT units, although on a unique set of harness wires. It provides a return path for the bias supply power from SEPT-E to SSD Bias Supply. See Appendix 8.1 for details of the I/F schematic.

## 7. Heaters

SEPT survival heater power is supplied by the STEREO spacecraft via SEP\_Central box which is only providing a connection between the spacecraft and the SEPT units. SEPT operational heater power shall be controlled by SEP\_Central, based on the HK information about SEPT thermal environment received from each of the two SEPT units via Serial Data Protocol. SEP Thermal Engineer shall actively participate in selection of the operational and survival heater type and their location in SEPT.

7.1 Protocol. SEP\_Central and SEPT shall route the signals listed below in a way that wires and traces are kept close together on the harness and PCBs to minimize the introduction of electric noise. In the harness they shall be routed as a twisted shielded 8-wire cable within the main shield. These signals carry a nominal +28 VDC voltage fed from S/C buss capable of supplying 28 +/-6 VDC. Per RFA 62 Response to STEREO S/C PDR, in order to prevent this large voltage variation (+22 V to +35 V) from affecting the design peak power of the heaters, the following design guidelines shall be followed:

7.1.1 SEPT-E operational heater shall be sized for a 75% duty cycle at 30.5 V.

7.1.2 SEPT-E survival heater shall be sized for a 100% duty cycle at 25 V.

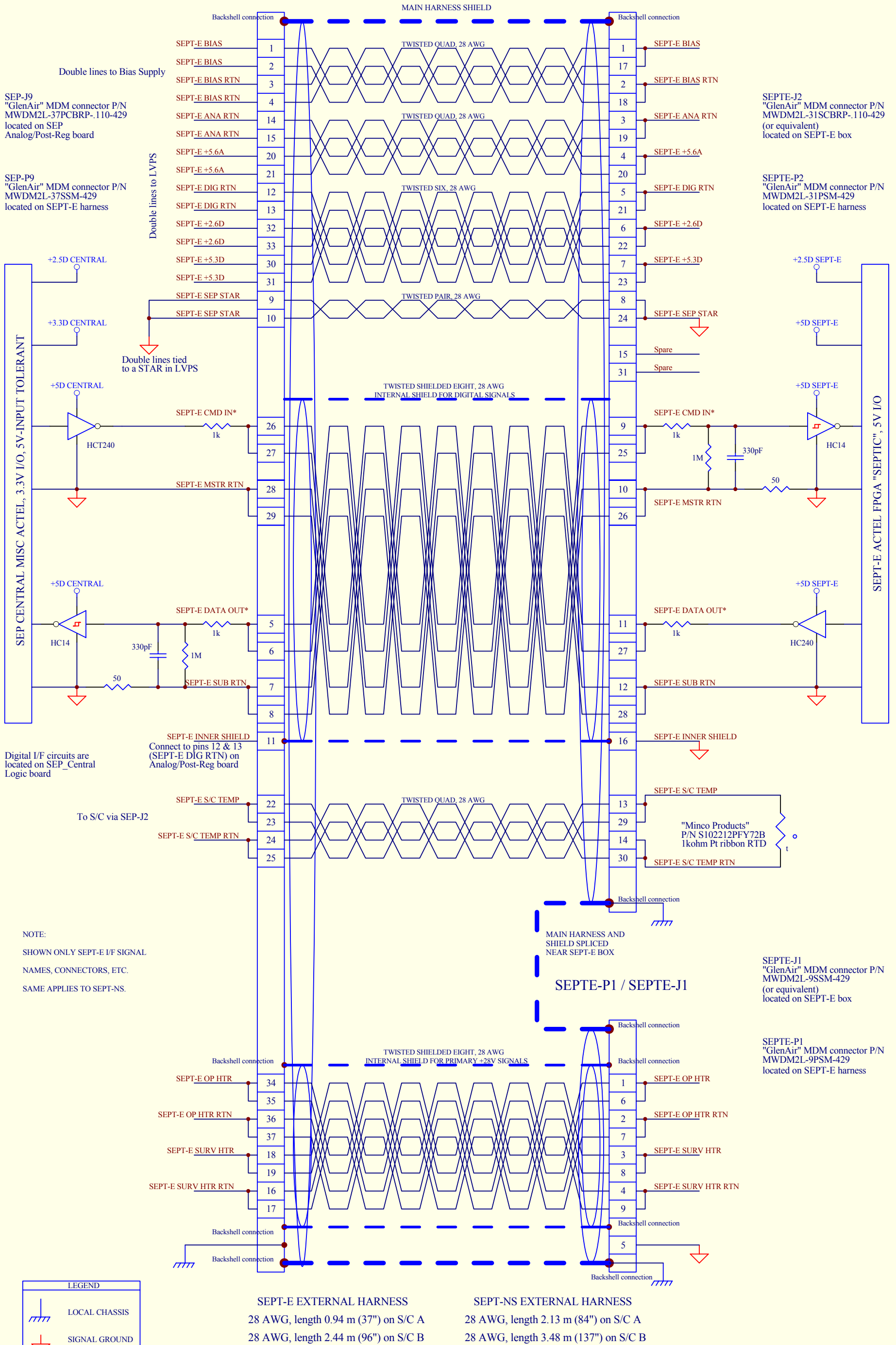
### 7.2 Signal Description.

7.2.1 SEPT-E OP HTR and SEPT-E OP HTR RTN. These are a pair of signals that supply nominal +28 VDC power to the SEPT-E operational heater when SEP power is turned on. They are fed from the same S/C power buss as the main SEP power. SEPT-E OP HTR signal shall be pulsed on and off by a heater switch located inside SEP\_Central and controlled by the SEP\_Central MISC, based on the HK\_T housekeeping variable that measures the temperature of SEPT-E electronics. The duration of pulses shall be automatically determined by an algorithm that uses a desired temperature goal set-point as an argument.

7.2.2 SEPT-E SURV HTR and SEPT-E SURV HTR RTN. These are a pair of signals that supply nominal +28 VDC power to the SEPT-E survival heater when SEP power is turned off. They are fed from a separate S/C power buss that turns on when the main SEP power is turned off. A thermostat in SEPT-E shall control SEPT-E SURV HTR signal whenever SEP is powered off.

SEP-J9 / SEP-P9

SEPTE-P2 / SEPTE-J2

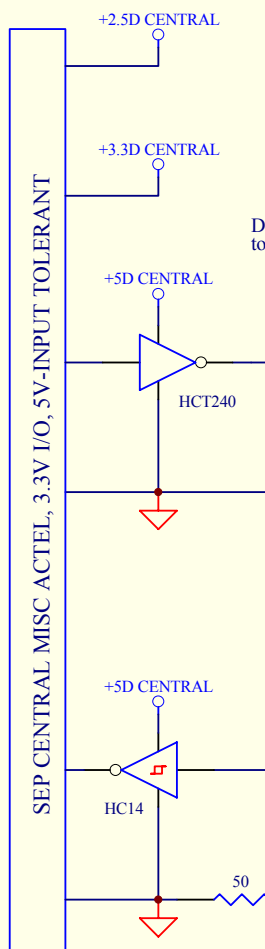


SEP-J9  
"GlenAir" MDM connector P/N  
MWDM2L-37PCBRP-110-429  
located on SEP  
Analog/Post-Reg board

SEP-P9  
"GlenAir" MDM connector P/N  
MWDM2L-37SSM-429  
located on SEPT-E harness

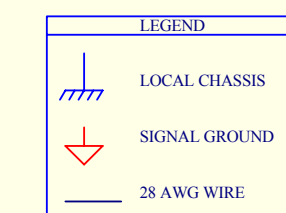
SEPTE-J2  
"GlenAir" MDM connector P/N  
MWDM2L-31SCBRP-110-429  
(or equivalent)  
located on SEPT-E box

SEPTE-P2  
"GlenAir" MDM connector P/N  
MWDM2L-31PSM-429  
located on SEPT-E harness



Digital I/F circuits are located on SEP\_Central Logic board

NOTE:  
SHOWN ONLY SEPT-E I/F SIGNAL NAMES, CONNECTORS, ETC.  
SAME APPLIES TO SEPT-NS.



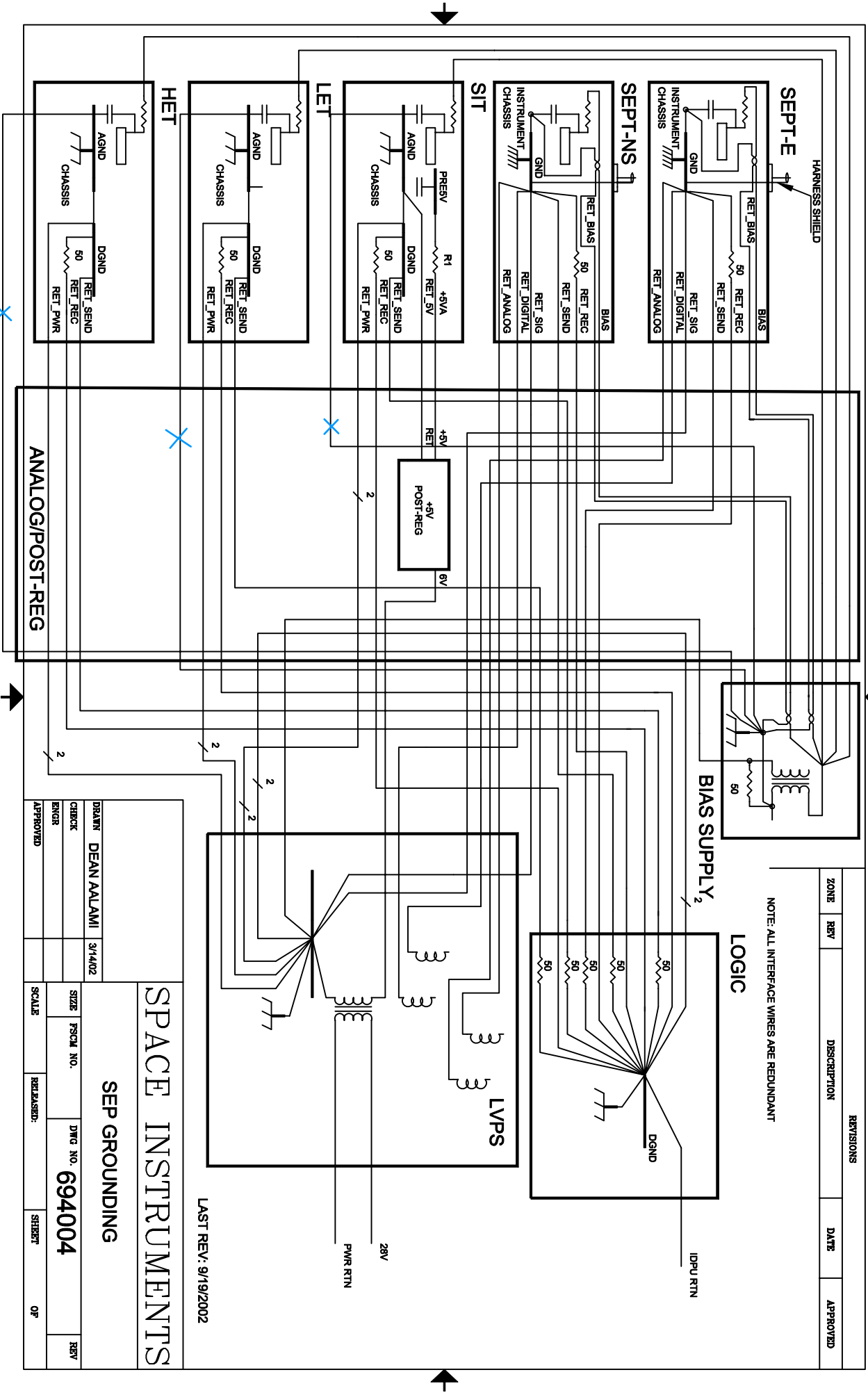
SEPT-E EXTERNAL HARNESS  
28 AWG, length 0.94 m (37") on S/C A  
28 AWG, length 2.44 m (96") on S/C B

SEPT-NS EXTERNAL HARNESS  
28 AWG, length 2.13 m (84") on S/C A  
28 AWG, length 3.48 m (137") on S/C B

Title <b>SEPT-SEP_Central I/F Schematic</b>			California Institute of Technology Space Radiation Laboratory 1201 E. California Blvd. MC 220-47 Pasadena, CA 91125	
Size:	Number: <b>100010</b>	Revision:		
Date: 14-Mar-2003	Sheet 1 of 1			
File: C:\Protel\Stereo\ICD\SEP ICD.Ddb - Documents\SEPT				

REVISIONS			DATE	APPROVED
ZONE	REV	DESCRIPTION		

NOTE: ALL INTERFACE WIRES ARE REDUNDANT



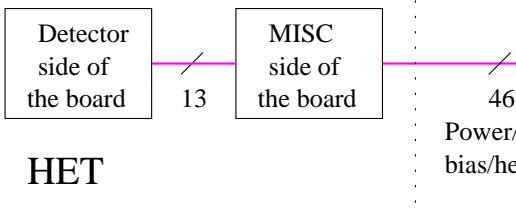
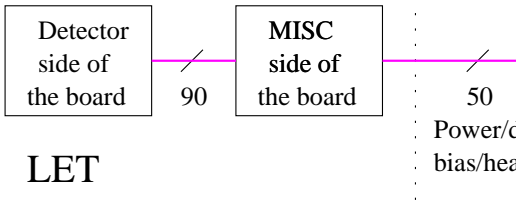
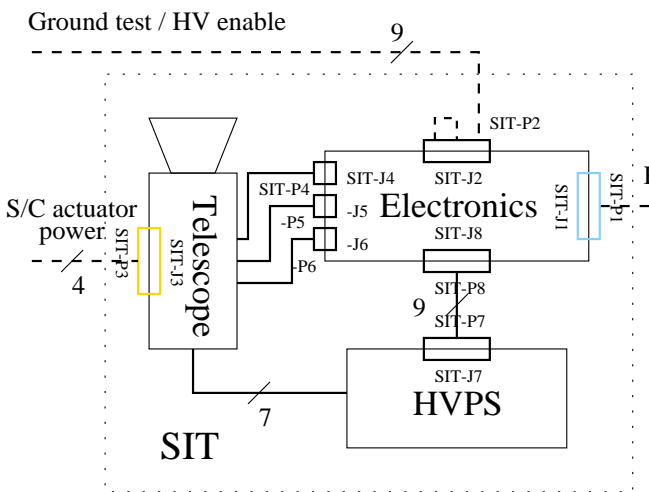
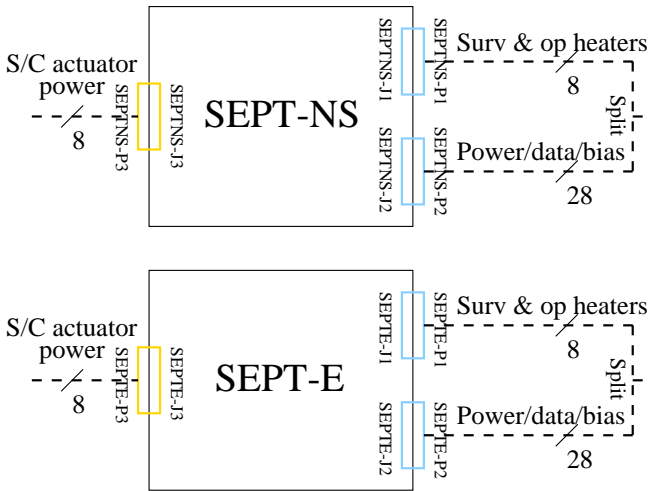
LAST REV: 9/19/2002

# SPACE INSTRUMENTS

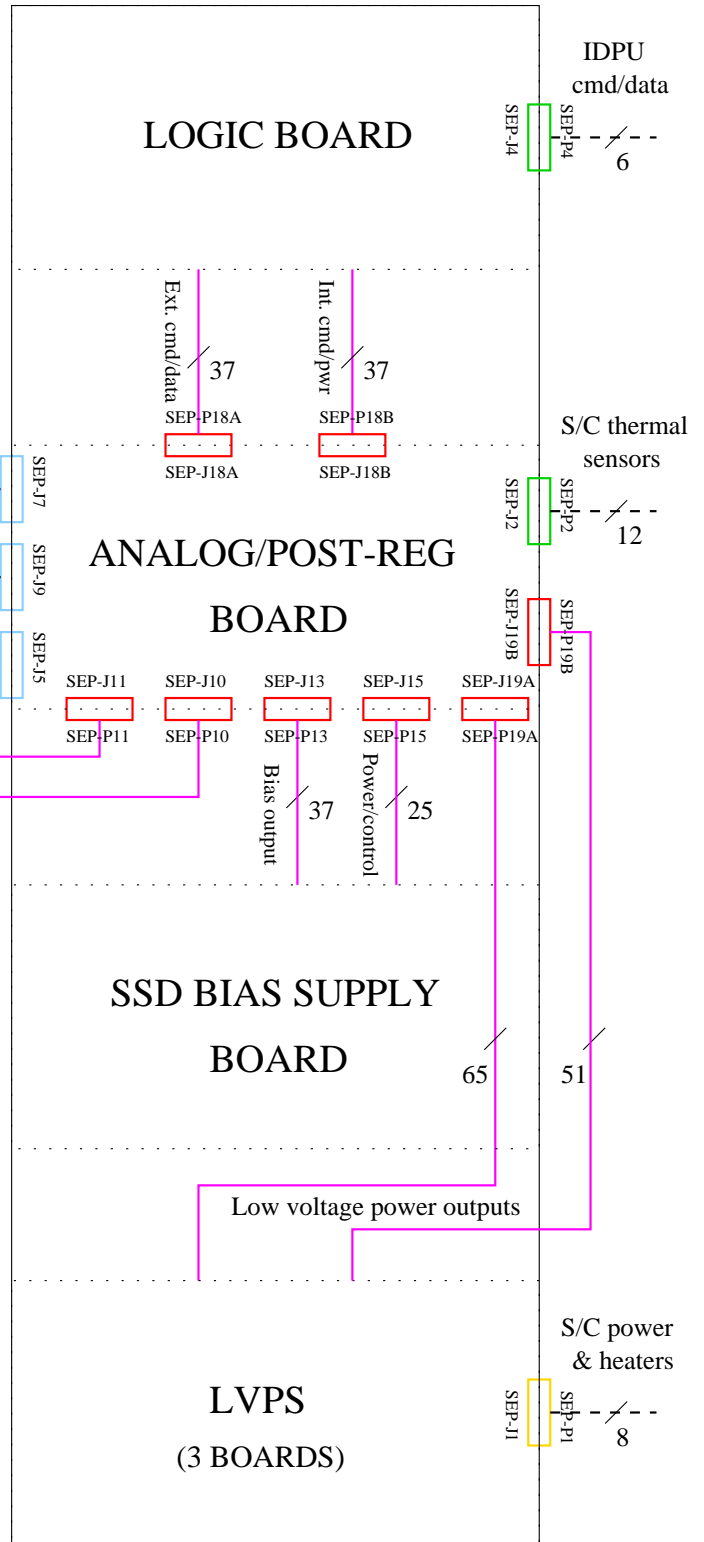
## SEP GROUNDING

DESIGN	DEAN AALAMI	3/14/02	SIZE	PSOM NO.	DWG NO.	REV
CHECK			SCALE	RELEASED:	694004	
ENGR						
APPROVED						0P

# Individual sensor boxes



# Central electronics box



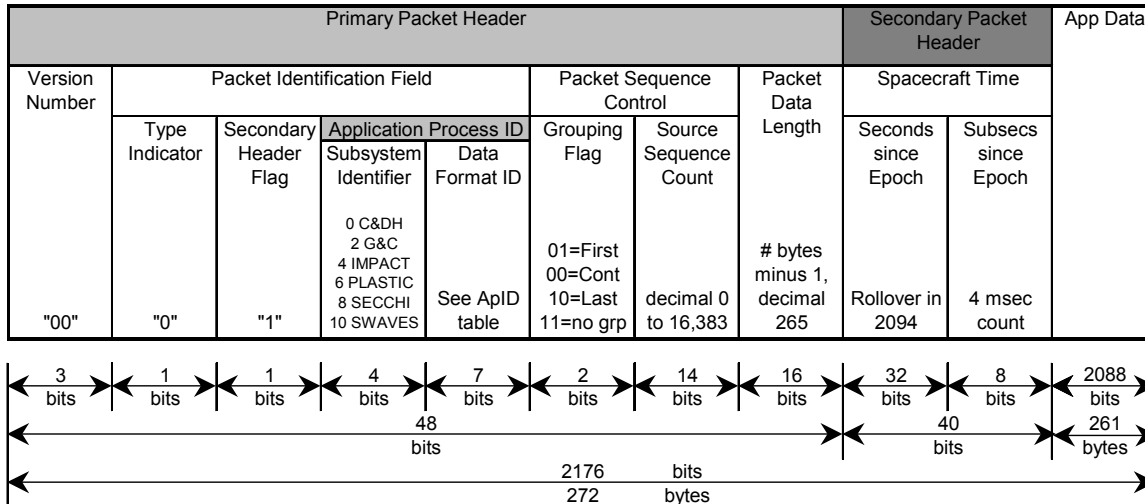
## Legend:

- |                     |  |                                     |  |
|---------------------|--|-------------------------------------|--|
| D connector pair    |  | Ext. (28 or 26 AWG, shielded)       |  |
| HD connector pair   |  | Int. harness (rigi-flex, no shield) |  |
| Nanonics conn. pair |  | Internal harness (no shield)        |  |
| MDM connector pair  |  | Connector type TBD                  |  |

# SEP Harness Diagram

BK 12/4/02

### TELEMETRY PACKET



**Figure 11. CCSDS Telemetry Packet Data Structure Diagram**

**Table 15. CCSDS Telemetry Packet Format**

CCSDS Telemetry Packet				
Contents	Size (bits)	Size (bytes)	Type	Units/Range
<b>PRIMARY PACKET HEADER</b>				
Version Number	3	0.375	Binary	"00"
<b>PACKET IDENTIFICATION FIELD</b>				
Type Indicator	1	0.125	Binary	"0" designates a telemetry packet
Secondary Header Flag	1	0.125	Binary	0 = No secondary header 1 = Secondary Header Present
<b>APPLICATION PROCESS IDENTIFIER</b>				
Subsystem ID	4	0.500	Binary	0 = 0000 = C&DH 2 = 0010 = G&C 4 = 0100 = IMPACT 6 = 0110 = PLASTIC 8 = 1000 = SECCHI 10 = 1010 = SWAVES
Data Format ID	7	0.875	Binary	See ApID table
<b>PACKET SEQUENCE CONTROL</b>				
Grouping Flag	2	0.250	Binary	01 = First Packet 00 = Cont. Packet 10 = Last Packet 11 = No grouping
Source Sequence Count	14	1.750	Binary	Decimal range = 0 to 16,383 To ensure delivery order, increment this counter
Packet Data Length	16	2.000	Binary	Number of bytes in Secondary Header Fields + Application Data Field <b>minus 1, For STEREO = (261 + 5) - 1 = decimal 265 = binary 00000000 10001001</b>
<b>SECONDARY PACKET HEADER</b>				
<b>SPACECRAFT TIME</b>				
Seconds since Epoch	32	4.000	Binary	Seconds since Epoch Jan 01, 1958 00:00:00 UTC, Rollover in 2094
Subseconds	8	1.000	Binary	Subseconds (1/256)
Application Data	2088	261	Variable	Telemetry application data
<b>TOTAL SIZE (bits &amp; BYTES)</b>	<b>2176</b>	<b>272</b>		

FSCM NO. <b>88898</b>	SIZE <b>A</b>	DRAWING NO. <b>7381-9045</b>	REV. <b>A</b>
SCALE	DO NOT SCALE PRINT		SHEET 46 of 62

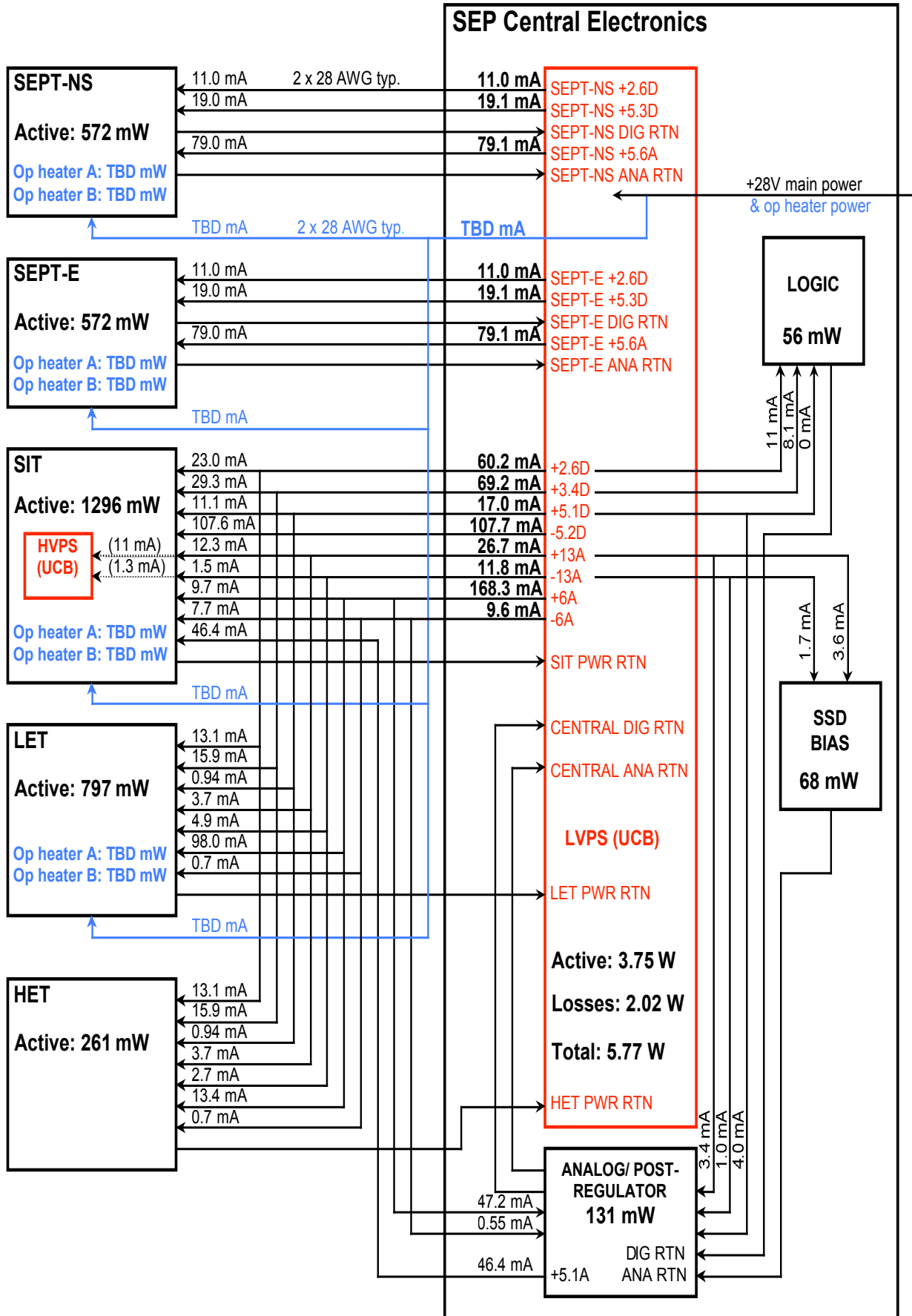
Positive supply: 300 V

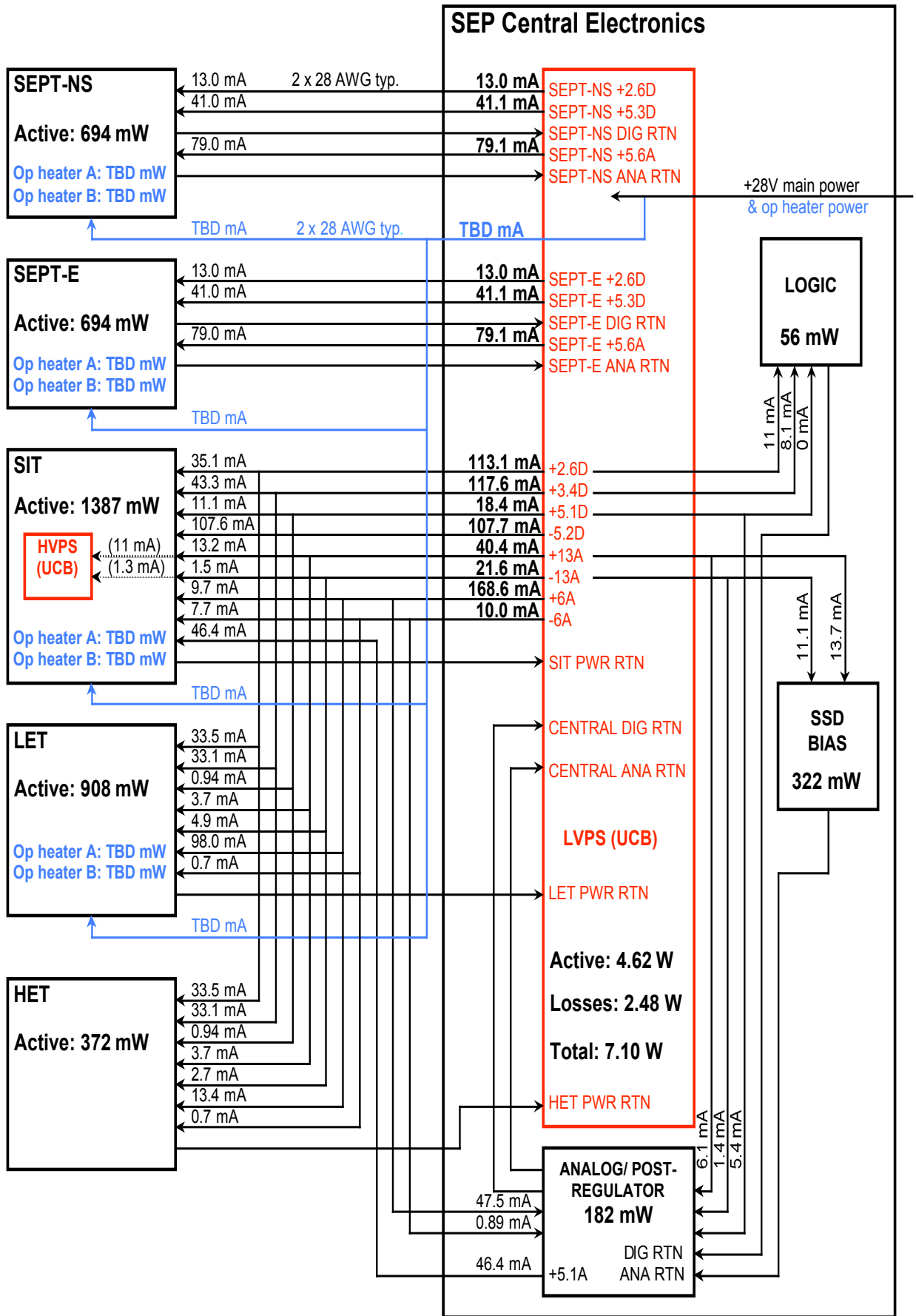
Item No.	Name	Thick (um)	Area (cm^2)	Max volts	Max curr (uA)		Factor temp	Factor time	Max curr no rad dam (uA)	Damage Coeff (uA/cm^3)	Delta rad (uA)	Max curr (uA)
					20	40						
1	L1A1	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89	
2	L1A2	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89	
3	L1A3	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89	
4	L1A4	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89	
5	L1A5	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89	
6	L2A	50	10.24	50	0.5	7.25	2	7.25	40	2.05	9.29	
7	L3A	1000	15.00	250	2	7.25	2	28.98	1	1.50	30.48	
8	L3B	1000	15.00	250	2	7.25	2	28.98	1	1.50	30.48	
9	L2B	50	10.24	50	0.5	7.25	2	7.25	40	2.05	9.29	
10	L1B1	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89	
11	L1B2	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89	
12	L1B3	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89	
13	L1B4	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89	
14	L1B5	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89	
15	H1	1000	3.14	250	1	7.25	2	14.49	1	0.31	14.81	
16	H2	1000	3.14	250	1	7.25	2	14.49	0.1	0.03	14.52	
17	H3A	1000	12.57	250	1	7.25	2	14.49	0.1	0.13	14.62	
18	H3B	1000	12.57	250	1	7.25	2	14.49	0.1	0.13	14.62	
19	H4A	1000	12.57	250	1	7.25	2	14.49	0.1	0.13	14.62	
20	H4B	1000	12.57	250	1	7.25	2	14.49	0.1	0.13	14.62	
21	H5A	1000	12.57	250	1	7.25	2	14.49	0.1	0.13	14.62	
22	H5B	1000	12.57	250	1	7.25	2	14.49	0.1	0.13	14.62	
23	H6	1000	12.57	250	1	7.25	2	14.49	0.1	0.13	14.62	
24	SIT	500	6.1	160	1	7.25	2	14.49	3	0.92	15.41	
Totals positive supply					25.00				362.29	13.24		375.53 uA
Power (mW)					7.50				108.69			112.66 mW

Negative supply: 100 V

Item No.	Name	Thick (um)	Area (cm^2)	Max volts	Max curr (uA)	Factor temp 20	Factor temp 40	Max curr no rad (uA)	Damage rad dam (uA/cm^3)	Delta rad (uA)	Max curr (uA)
1	D0	300	0.53	80	0.06	7.25	2	0.87	200	3.18	4.05
2	D1	300	0.53	80	0.06	7.25	2	0.87	200	3.18	4.05
3	D2	300	0.53	80	0.06	7.25	2	0.87	200	3.18	4.05
4	D3	300	0.53	80	0.06	7.25	2	0.87	200	3.18	4.05
5	D4	300	0.53	80	0.06	7.25	2	0.87	200	3.18	4.05
6	D5	300	0.53	80	0.06	7.25	2	0.87	200	3.18	4.05
7	D6	300	0.53	80	0.06	7.25	2	0.87	200	3.18	4.05
8	D7	300	0.53	80	0.06	7.25	2	0.87	200	3.18	4.05
9	G0	300	0.58	80	0.06	7.25	2	0.87	200	3.48	4.35
10	G1	300	0.58	80	0.06	7.25	2	0.87	200	3.48	4.35
11	G2	300	0.58	80	0.06	7.25	2	0.87	200	3.48	4.35
12	G3	300	0.58	80	0.06	7.25	2	0.87	200	3.48	4.35
13	G4	300	0.58	80	0.06	7.25	2	0.87	200	3.48	4.35
14	G5	300	0.58	80	0.06	7.25	2	0.87	200	3.48	4.35
15	G6	300	0.58	80	0.06	7.25	2	0.87	200	3.48	4.35
16	G7	300	0.58	80	0.06	7.25	2	0.87	200	3.48	4.35
Totals negative supply					0.96				13.91	53.28	67.19 uA
Power (mW)					0.10				1.39		6.72 mW
Totals both supplies					25.96				376.20	66.52	442.72 uA
Power (mW)					7.60				110.08		119.38 mW







SEP Power Flow (Max.)

02/26/03