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

SEPT-SEP_Central ICD

Revision A

March 19, 2003

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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.

Rev.	Date	Description
-	11/18/02	Initial release
A	03/19/03	Update Command and Power Interfaces and Apendices (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

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

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.

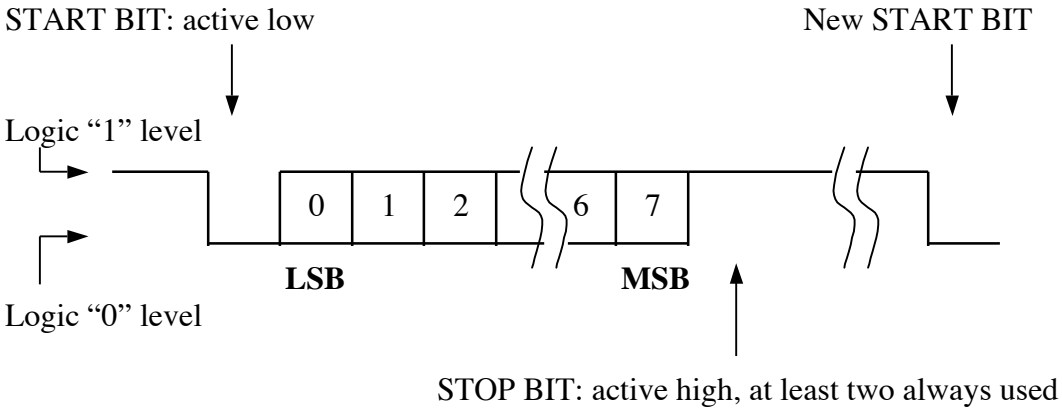


Figure 1 – SEPT Serial Data/Command Protocol
(Signal polarity shown at interface connector pins)

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 Ω. 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 Ω. 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 +/- 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 ºC 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 ºC, 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 ºC.

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 +7/-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:

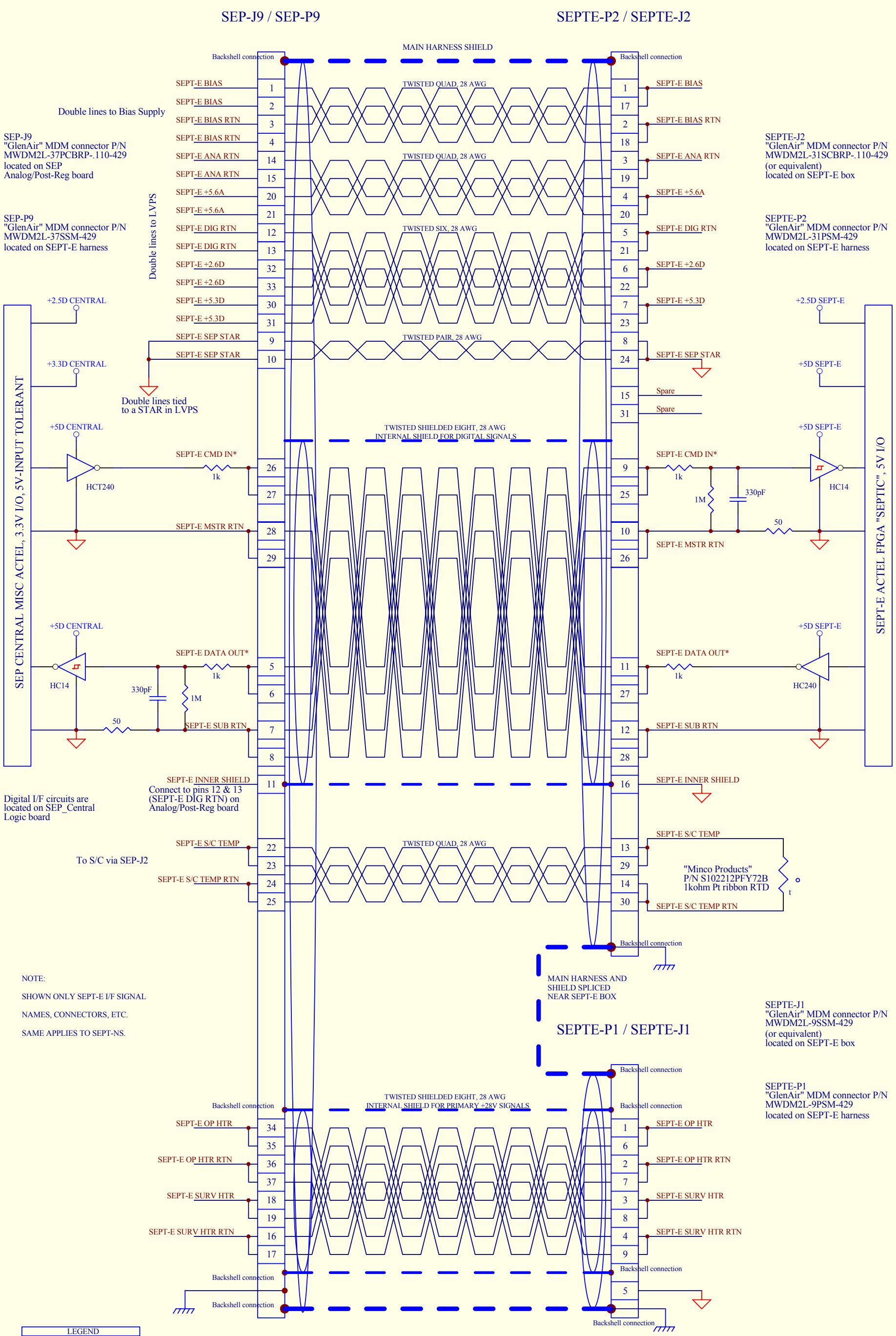
7.1.1 SEPT-E operational heater shall be sized for a 75% duty cycle at 30.5 V.

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.



Title	SEPT-SEP_Central I/F Schematic	
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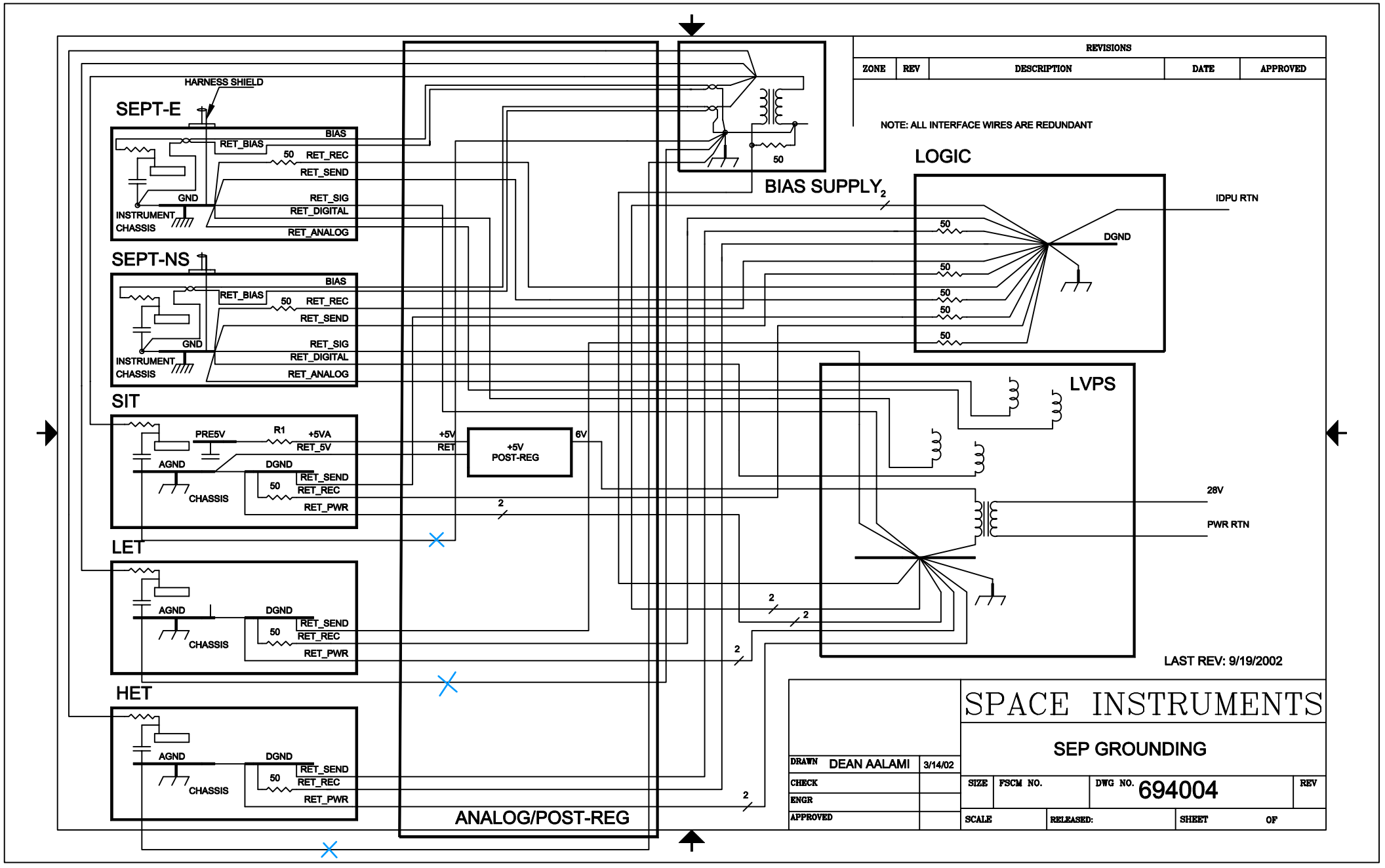
Date: 14-Mar-2003	Sheet 1 of 1	
File: C:\Protel\Stereo\ICD\SEP ICD.Ddb - Documents\SEPT		

California Institute of Technology
Space Radiation Laboratory
1201 E. California Blvd.
MC 220-47
Pasadena, CA 91125


REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
NOTE: ALL INTERFACE WIRES ARE REDUNDANT
HARNESS SHIELD
SEPT-E
BIAS
RET_BIAS
50
RET_REC
RET_SEND
GND
RET_SIG
RET_DIGITAL
INSTRUMENT CHASSIS
RET_ANALOG
SEPT-NS
BIAS
RET_BIAS
50
RET_REC
RET_SEND
GND
RET_SIG
RET_DIGITAL
INSTRUMENT CHASSIS
RET_ANALOG
SIT
PRE5V
R1
+5VA
RET_5V
AGND
DGND
RET_SEND
50
RET_REC
CHASSIS
RET_PWR
LET
AGND
DGND
RET_SEND
50
RET_REC
CHASSIS
RET_PWR
HET
AGND
DGND
RET_SEND
50
RET_REC
CHASSIS
RET_PWR
+5V
RET
+5V POST-REG
6V
2
ANALOG/POST-REG
50
BIAS SUPPLY2
LOGIC
IDPU RTN
50
DGND
50
50
50
50
LVPS
28V
PWR RTN
2
2
2
2
LAST REV: 9/19/2002
SPACE INSTRUMENTS
SEP GROUNDING
DRAWN
DEAN AALAMI
3/14/02
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REV
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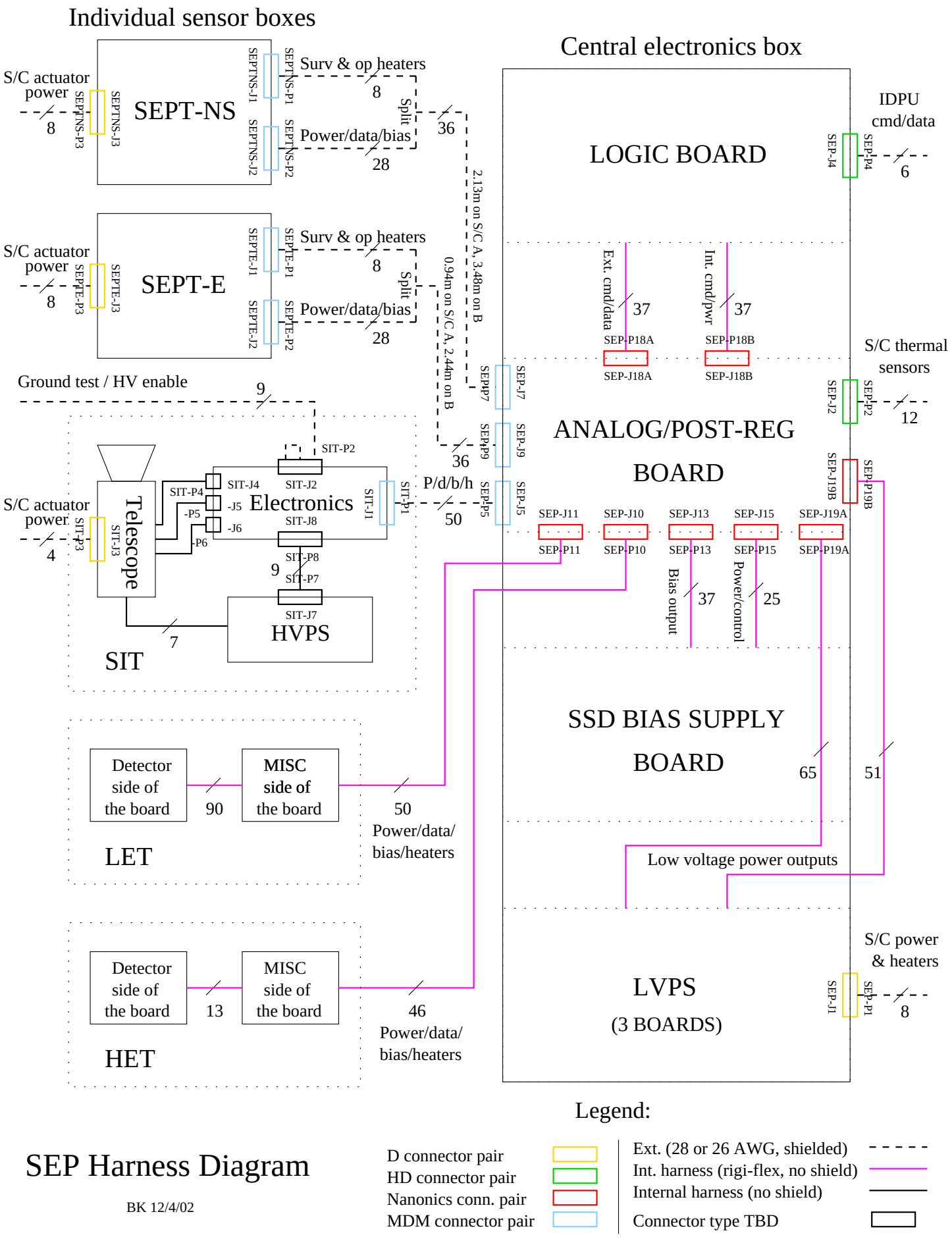
SHEET
OF



SEP Harness Diagram

BK 12/4/02

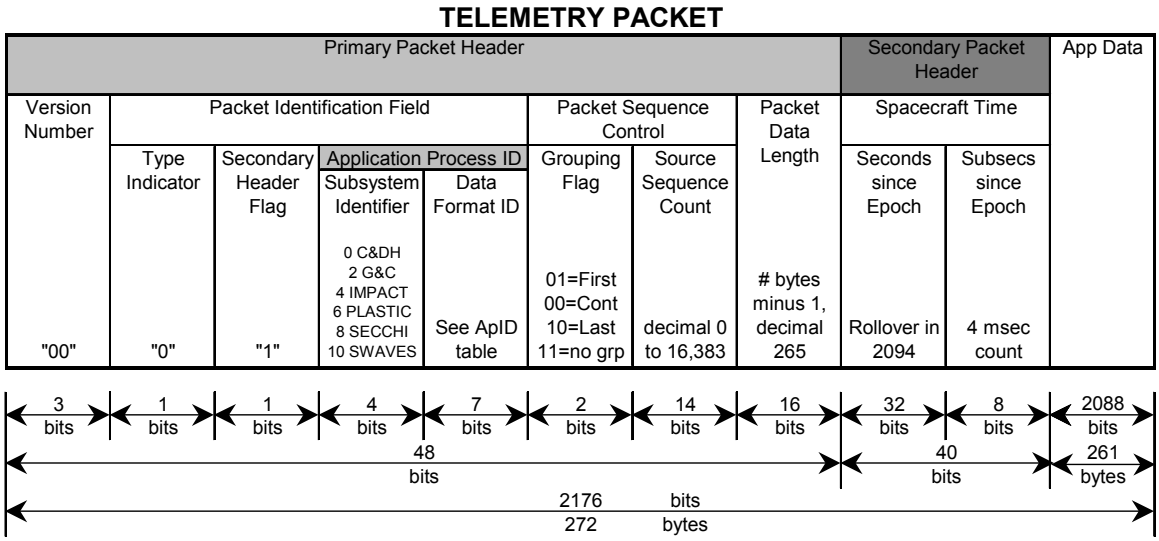


Figure 11. CCSDS Telemetry Packet Data Structure Diagram

Table 15. CCSDS Telemetry Packet Format

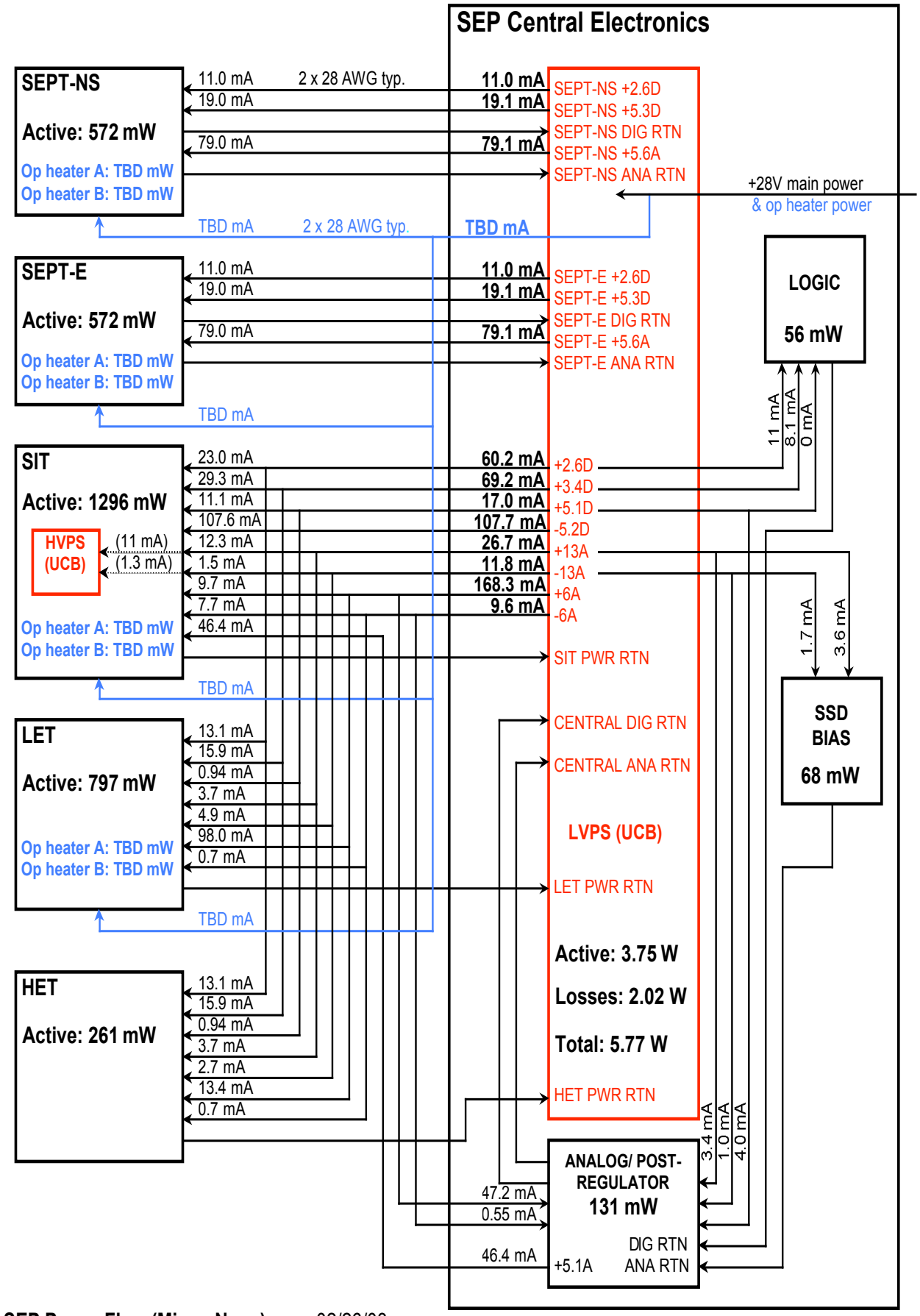
CCSDS Telemetry Packet				
Contents	Size (bits)	Size (bytes)	Type	Units/Range
PRIMARY PACKET HEADER				
Version Number	3	0.375	Binary	"00"
PACKET IDENTIFICATION FIELD				
Type Indicator	1	0.125	Binary	"0" designates a telemetry packet
Secondary Header Flag	1	0.125	Binary	0 = No secondary header 1 = Secondary Header Present
APPLICATION PROCESS IDENTIFIER				
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
PACKET SEQUENCE CONTROL				
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 **minus 1, For STEREO = (261 + 5) - 1 = decimal 265 = binary 00000000 10001001**
SECONDARY PACKET HEADER				
SPACECRAFT TIME				
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
TOTAL SIZE (bits & BYTES)	**2176**	**272**		

Positive supply: 300 V

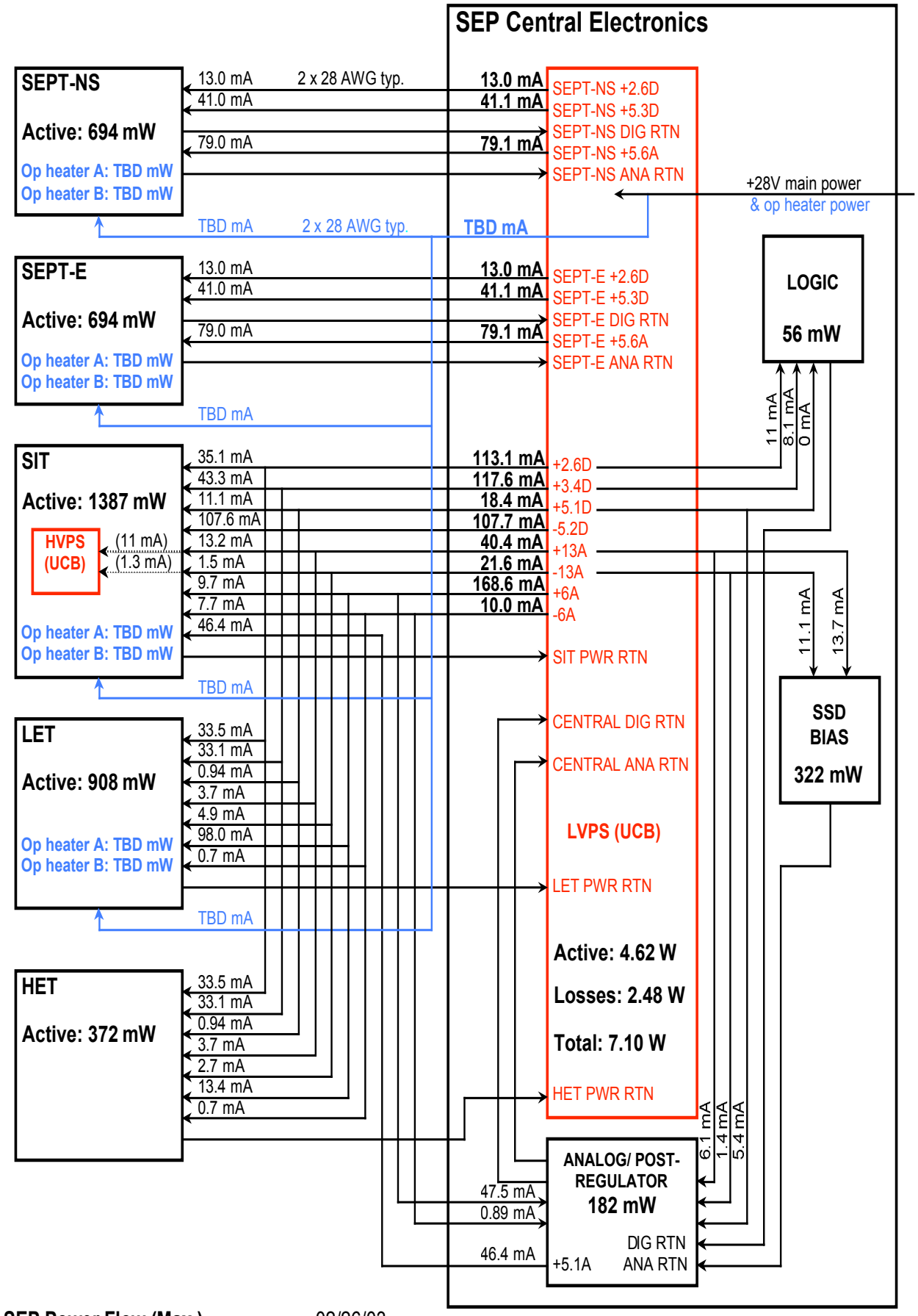
Item No.	Name	Thick (um)	Area (cm^2)	Max volts	Max curr (uA) 20	Factor temp 40	Factor time	Max curr no rad dam (uA)	Damage Coeff (uA/cm^3)	Delta rad (uA)	Max curr (uA)
1	L1A1	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89
2	L1A2	20	2.00	30	1	7.25	2	14.49	100	0.40	14.89
3	L1A3	20	2.00	30	1	7.25	2	14.49	100	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) 20	Factor temp 40	Factor time	Max curr no rad dam (uA)	Damage Coeff (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 (Min. = Nom.) 02/26/03



SEP Power Flow (Max.) 02/26/03