EPI-Hi

LVPS Requirements Specification

Revision C

May 6, 2013

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Approval Signatures

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Rick Cook, Caltech Date

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Alan Cummings, Caltech Date

Document Revision Record

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1. Introduction

The Energetic Particles Instrument for High Energy (EPI-Hi), part of ISIS suite of cosmic-ray instruments on Solar Probe Plus spacecraft, comprises two Low Energy Telescopes (LET1 and LET2), High Energy Telescope (HET), and supporting electronics as shown in the EPI-Hi block diagram below (Figure 1-1).

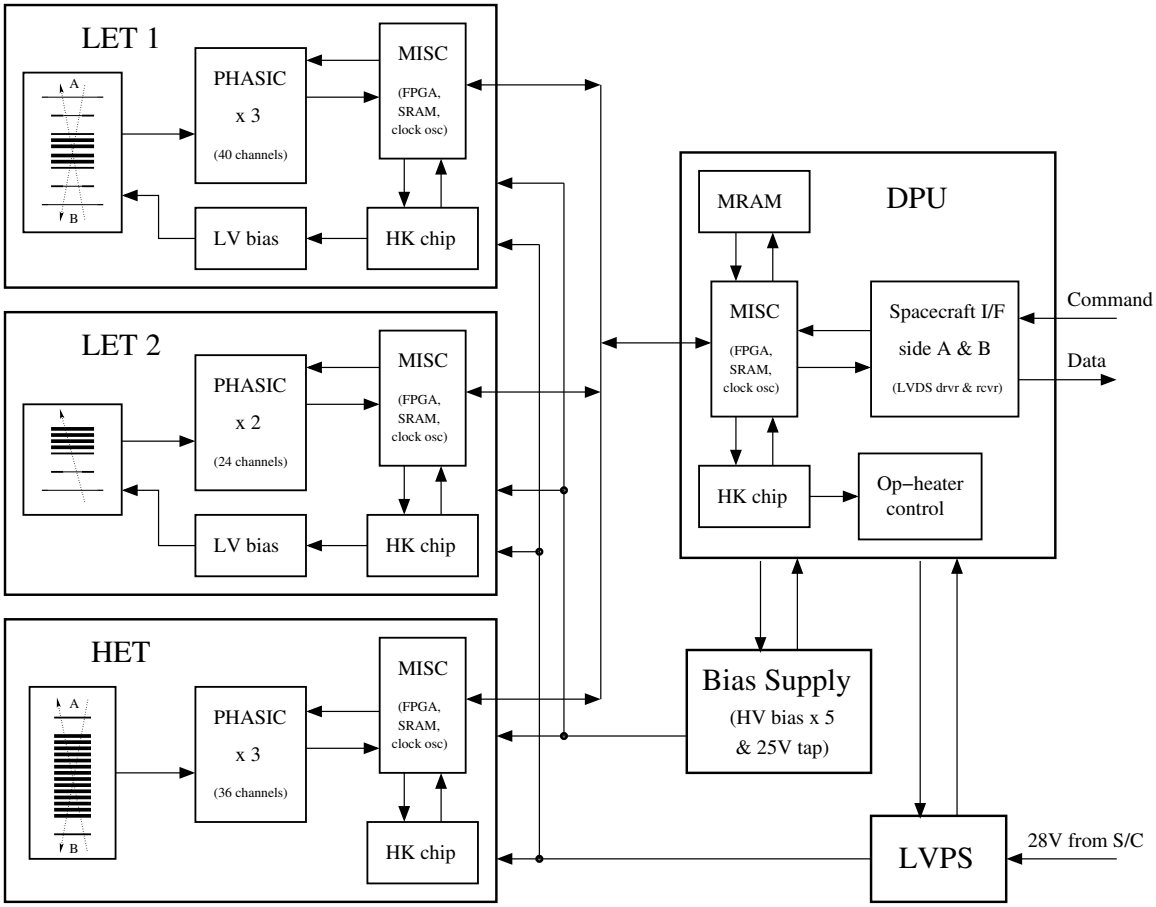

Figure 1-1 EPI-Hi Block Diagram

This document specifies design requirements for the Low Voltage Power Supply that will be designed and built by APL.
The three EPI-Hi telescopes are extremely sensitive to electronic noise, so every effort shall be made to make this LVPS as quiet as possible.

The LVPS requirements specified herein are based on the information currently available (mid-Phase B) and may evolve as the telescope designs mature. APL shall design electronic schematics and printed circuit board layout according to these requirements. Procurement of the electronic parts, printed circuit boards and the board assembly shall be the responsibility of APL. Testing of one EM and one flight board shall first take place at APL, then continue at Caltech after the delivery. Mechanical packaging design for the LVPS and manufacturing of its RF shield is the responsibility of GSFC.

EPI-Hi instrument is very constrained in terms of mass and power, and special attention must be paid to optimizing the use of these resources in the design and fabrication of the LVPS.

Current schedule for LVPS design, fabrication and test is as follows:

Deliver EM board to Caltech	Jan. 23, 2014
Deliver flight board to Caltech	April 7, 2015

Above dates are subject to change. APL and Caltech shall strive to beat the current schedule by about two months in order to keep the Earned Value parameters in good shape.

Other important Project milestones:

EPI-Hi Peer Review	June 12, 2013
EPI-Hi Preliminary Design Review	Nov. 15, 2013
EPI-Hi Critical Design Review	Feb. 10, 2015

1.1 *Document Conventions*

In this document the acronym TBD (to be determined) means that no data currently exists. A value followed by TBR (to be resolved) means that it is preliminary. In either case, they may be followed by institution name indicating who is responsible for providing the data.

1.2 *Applicable Documents*

The following reference documents shall apply in the design, fabrication and testing of the EPI-Hi LVPS. It is assumed that they will be available on SwRI Wiki site or APL SPP SharePoint site in due time.

1. NASA EEE-INST-002: Instructions for EEE Parts Selection, Screening, Qualification and Derating

2. SPP EMC requirements

3. SPP spacecraft to EPI-Hi ICD

4. SPP environmental specifications

5. SPP safety and mission assurance requirements

2. EPI-Hi Harness Diagram

EPI-Hi harness diagram in Figure 2-1 shows the manner in which the LVPS will be connected to the rest of the instrument via internal flexi-strip harness. LVPS connector type on the primary side will be defined in reference 3 most likely as a lightweight Micro-D connector type.

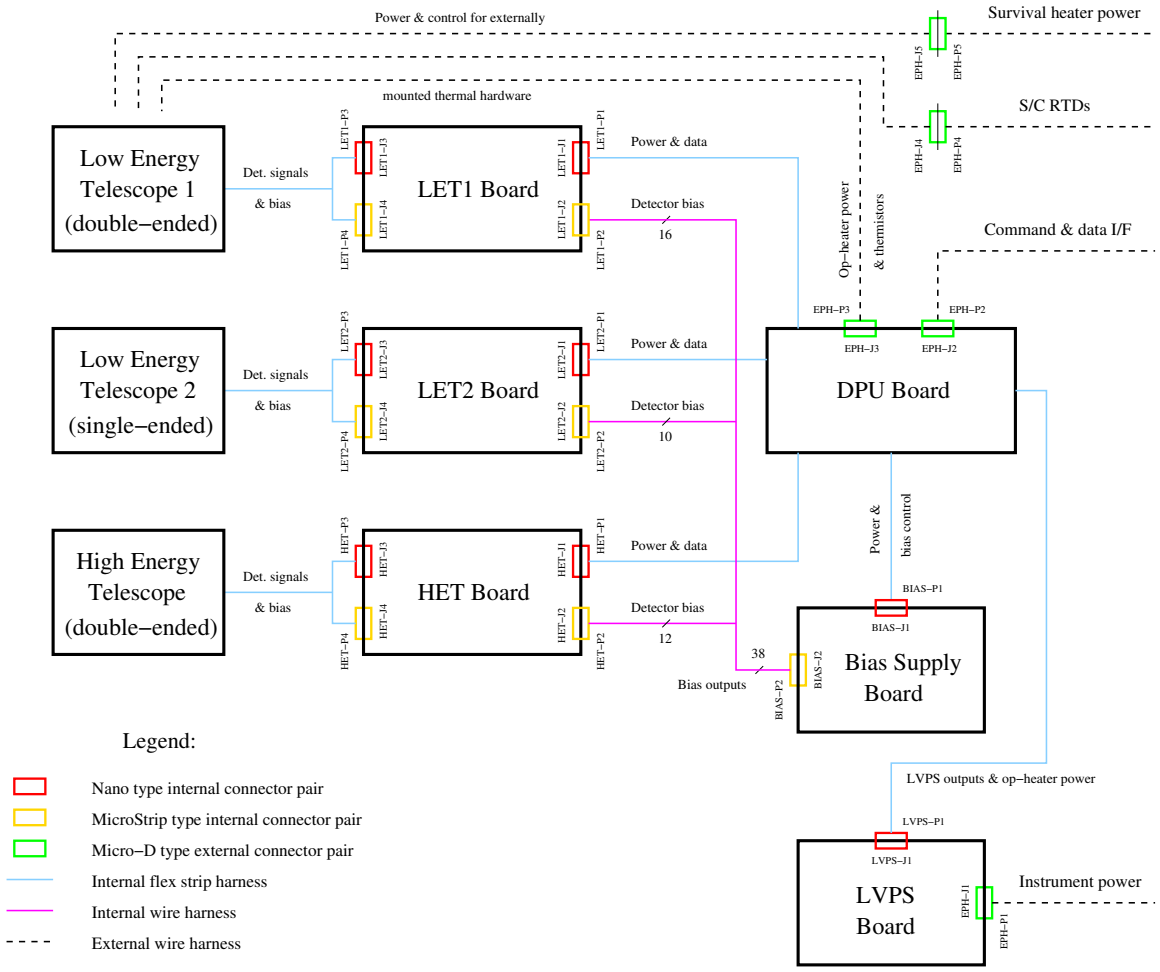

Figure 2-1 EPI-Hi Harness Diagram

3. Electrical Requirements

3.1 *Primary Voltage and Current*

The LVPS shall have a separately switched spacecraft service as indicated in reference 3. In its current draft form the main instrument power and the operational heater power share the same 28V line. They may be split into two separate services eventually if there are enough switches on the S/C side.
The survival heater service was removed from the LVPS input connector, so its size has been reduced from 15 to 9 positions.
The characteristics of the spacecraft 28V supply and ground isolation requirements will be defined in references 3 and 4.

From data in Table 3-1 the maximum EPI-Hi power without operational heaters is 5.98W (at the end of life), while the nominal or minimum power is 5.17W (beginning of life and ground testing). At 28V the maximum primary current is 0.214A, while the nominal or minimum current is 0.185A.

Assuming the average op-heater power of 0.33W for all three telescopes, at 28V the maximum combined current is 0.225A, while the nominal or minimum combined current is 0.196A.

3.2 *EMC Requirements*

The LVPS shall be designed in full compliance with the EMC requirements given in reference 2.
They currently include a requirement that the LVPS be clock-synchronized to a frequency multiple of n*50kHz where n>2. The clock provided by EPI-Hi MISC upon power-up will be 300kHz and will get divided by the PWM in the LVPS to 150kHz. The 300kHz clock is derived from the 58.9824MHz clock in the DPU FPGA.

3.3 *Analog and Digital Grounds*

The analog supplies shall have separate returns from the digital supplies. Both of these returns shall be tied together in the LVPS. There will be a “dirty” +12A return coming from the switching Bias Supply. It shall not be combined with the rest of the analog returns. It shall have its own traces going from the secondary output connector to the common secondary GND point in the LVPS.

3.4 *Secondary Voltages and Currents*

• The LVPS shall convert primary spacecraft 28V into secondary voltages as indicated in Table 3-1.
• The secondary voltages shall be 0.1V higher than implied by output name, e.g. +1.5D shall be 1.6V, etc. This difference has been accounted for and is reflected in Table 3-1 below.
• Analog secondary voltages (+12, +6 and -6V) shall be regulated to +/- 5% from half load to full load.
• Digital secondary voltages (+1.5, +1.8 and 3.3V) shall have tighter regulation, per Table 3-1, which assumes the low-pass filter info provided in Section 3.5.
• LVPS-generated high frequency ripple on the secondaries shall be less than 10mV p-p at max current.
• The nom/min and max currents in Table 3-1 have +/- 10% margin of error. They are identical in most cases except for +12 and -6V, which differ from beginning to end of life. Max current applies to EOL.

LVPS Output	Min Voltage [% or V]	Max Voltage [% or V]	Nom/Min Current [mA]	Max Current [mA]	Nom/Min Power [mW]	Max Power [mW]
+12A	-5%	+5%	17.2	64.2	208.5	777.2
+6A	-5%	+5%	347.5	347.5	2119.6	2119.6
-6A	-5%	+5%	12.6	12.6	76.6	76.6
+1.5D	1.49V	1.61V	100	100	160	160
+1.8D	1.75V	1.92V	40	40	76	76
+3.3D	3.24V	3.71V	287	287	975.8	975.8
Subtotal	active	power:			3616	4185
LVPS	losses	@ 70%	Efficiency:		1550	1794
Total	power:				5166	5979

Table 3-1 EPI-Hi Secondary Voltages and Currents

3.5 *Capacitive Loads*

The capacitive loads on the EPI-Hi secondary voltages are shown in Table 3-2 (has not been updated in this revision). These loads are tantalum and ceramic capacitors used with 1Ω or 2Ω resistors in low-pass filters on EPI-Hi boards.

LVPS Output	Bias Sup. [uF]	LET1 [uF]	LET2 [uF]	HET [uF]	DPU [uF]	Total [uF]
+12A	75	20	20	20	20	155
+6A	-	20	20	20	10	70
-6A	75	20	20	20	-	135
+1.5D	-	50	50	50	50	200
+1.8D	-	50	50	50	50	200
+3.3D	-	150	150	150	200	650

Table 3-2 EPI-Hi Capacitive Loads

3.6 *Monitoring Signals*

The LVPS shall provide two analog monitoring signals: the primary current of the instrument (w/o the op-heater contribution) and the LVPS board temperature to the EPI-Hi DPU board as defined in the connector pinout for LVPS-J1. The full scale of the primary current monitoring signal shall be 0.2A at +5V, referenced to secondary ground. The thermistor signal does not require any conditioning. Both monitoring signals will be read out with 14-bit resolution in the HK chip located on the DPU board.

The thermistor in the flight LVPS shall be Measurement Specialties P/N S311P18-09S7R6. It has a value of 30kΩ at 25°C. The EM thermistor P/N is 44008RC. The thermistors, their data sheet and the calibration table shall be provided by Caltech.

4. Mechanical Requirements

4.1 *Form Factor and Dimensions*

Given that EPI-Hi instrument is highly constrained in terms of mass resources, the LVPS board shall be designed to fit in the smallest volume possible. The layout of components on the board shall be efficient and if necessary double-sided. The proposed board area is 12 cm x 14 cm with a small corner cutout to facilitate field of view for one of the telescopes. The nominal thickness of the board shall be 1.5 mm.

Appendix 1 shows LVPS preliminary board outline with keep-out areas and connector locations. The primary component side is sunward facing. Appendix 2 shows EPI-Hi instrument configuration with the three telescopes and electronics boards stacked side-by-side. The LVPS board is at the end of the stack. It is smaller than the rest of the boards and is connected to the adjacent DPU board with a flex strip.

5. Connector Types

LVPS connectors are described in Table 5-1. The following notation is used:
- MDM is Micro-D connector per MIL-DTL-83513.
- Nano is Glenair Series 89 Nanominiature connector per MIL-DTL-32139.
- TH is through-hole mount connector on rigid PCB or PCB tab at the end of a flex strip.

PCB or PCB tab thickness is 0.062" (1.5 mm).

Connector type is defined by terms "pin" (P) and "socket" (S). Example: Nano 25S is a 25-socket (female).

By convention, harness connector on the free end has P reference designator as part of its name, while its mate which is typically mounted either on a box or a bracket carries J in its name.

LVPS Connector Name	Connector Purpose	LVPS Conn. Type	LVPS Connector - Part Number - Mount Type, Panel Thickness	Harness Connector - Part Number - Mount Type, Entry - Backshell P/N
EPH-J1	Instrument & oper heater power from S/C	MDM9S	MWDM2L-9SCBRR2-.110-429 PCB, Right angle Rear panel 0.047" thick	MWDM2L-9NSB-429 Harness, Round top 507T088XM15H08S
LVPS-J1	Second. outputs, oper. heater & mon. signals	Nano 51P	891-008-51PSBRT1T-429 TH, Right angle	891-007-51SSBST1J-429 TH on flex strip, Straight

Table 5-1 LVPS Connector Types

6. Connector Pinouts

6.1 EPH-J1 - Primary Instrument & Operational Heater Power

This is a preliminary pinout as the S/C interface has not been yet defined in the ICD. The instrument power and operational heater power may be combined into one power service from S/C, or they may be split into two as shown below. This pinout was proposed by the lead S/C harness engineer at a time when two separate power services were under consideration.

Pin	Signal Name
1	+28V INST RTN
2	+28V INST RTN
3	Spare (not floating)
4	+28V OP HTR RTN
5	+28V OP HTR RTN
6	+28V INST
7	+28V INST
8	+28V OP HTR
9	+28V OP HTR

6.2 LVPS-J1 - Secondary Outputs & Monitoring Signals

Pin	Signal Name
1	+6A
2	+6A
3	+6A
4	+6A
5	+6A
6	+12A
7	+12A
8	+12A
9	+12A PWR RTN
10	LVPS TEMP+
11	LVPS TEMP+
12	+1.5D
13	+1.5D
14	+1.5D
15	DIG PWR RTN
16	DIG PWR RTN
17	DIG PWR RTN
18	DIG PWR RTN
19	PRIM I MON+
20	PRIM I MON+
21	+28V OP HTR
22	+28V OP HTR
23	+28V OP HTR

24	+28V OP HTR
25	Spare (not floating)
26	300 KHZ CLK
27	ANA PWR RTN
28	ANA PWR RTN
29	ANA PWR RTN
30	ANA PWR RTN
31	ANA PWR RTN
32	-6A
33	-6A
34	-6A
35	+12A PWR RTN
36	LVPS TEMP-
37	LVPS TEMP-
38	+1.8D
39	+1.8D
40	+1.8D
41	+3.3D
42	+3.3D
43	+3.3D
44	PRIM I MON-
45	PRIM I MON-
46	+28V OP HTR RTN
47	+28V OP HTR RTN
48	+28V OP HTR RTN
49	+28V OP HTR RTN
50	Spare (not floating)
51	300 KHZ CLK

Found on the following pages only in PDF version of this document.

NOTES-
UNLESS OTHERWISE SPECIFIED:

1. MATERIAL: SEE B.O.M..

2. THIS DRAWING CONTAINS INFORMATION FOR THE DESIGN OF PWB. ALL ARTWORK AND PWB RELATED DRAWINGS SHOULD REFERENCE THIS DRAWING.

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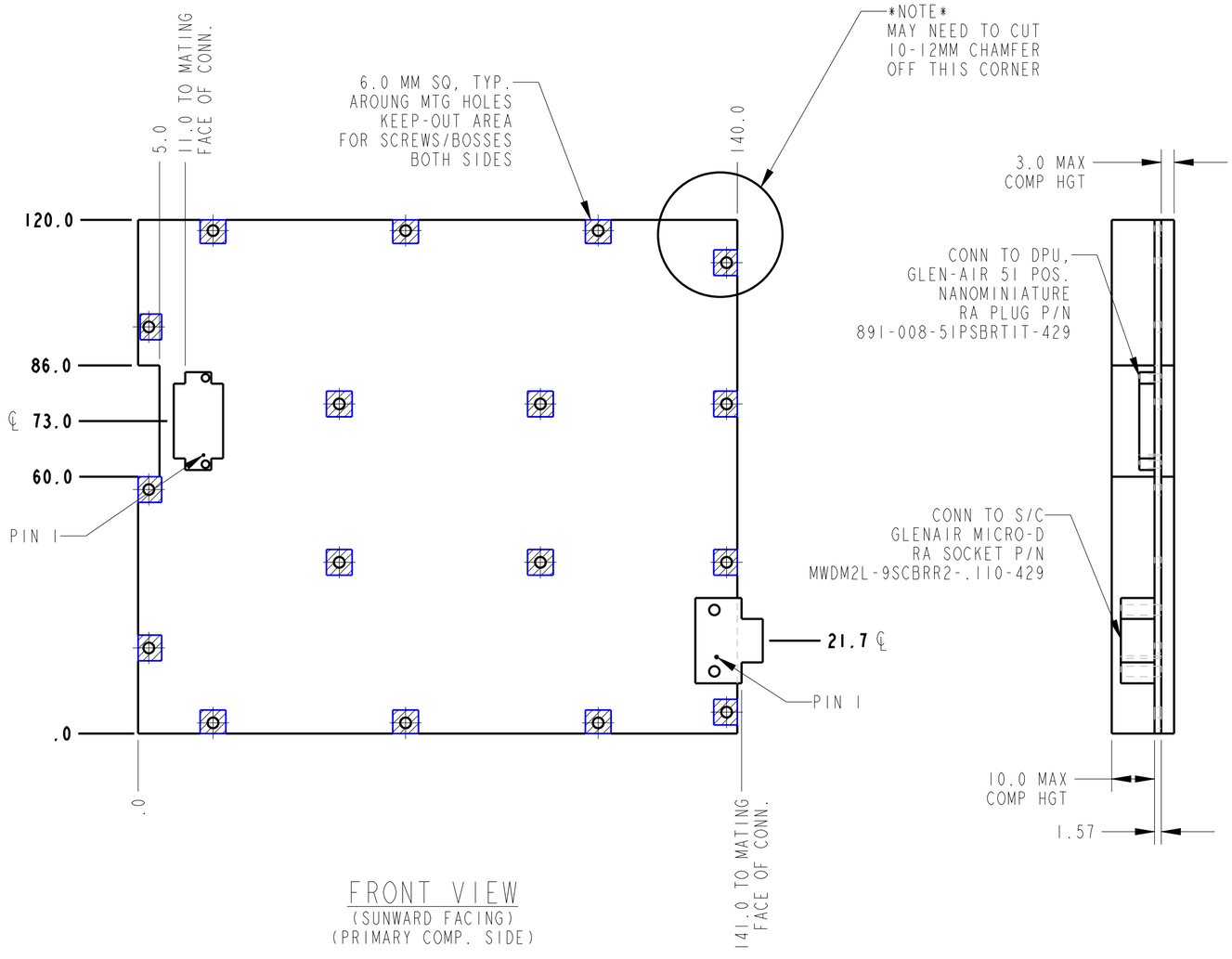
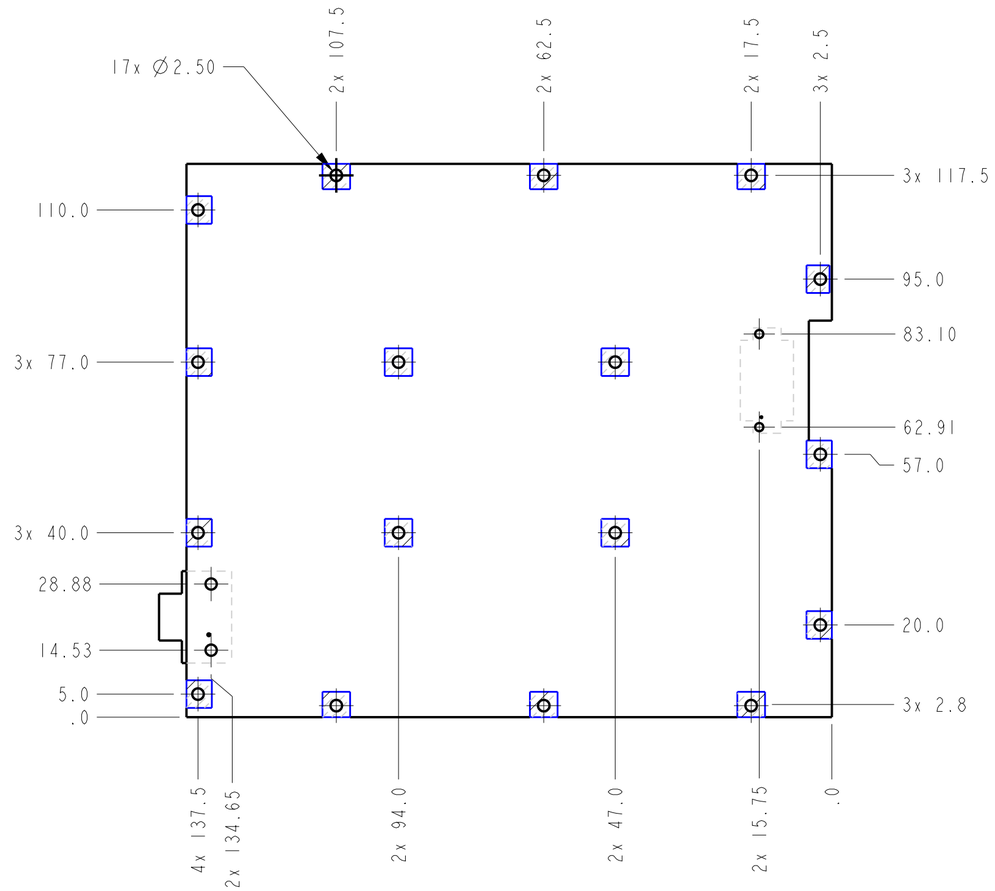
-	-	-	-	-



FRONT VIEW
(SUNWARD FACING)
(PRIMARY COMP. SIDE)



FOLD LINE

DWG. NO. 2190766 REV -

PRELIMINARY
16-APR-2013

ITEM NO.	REQD	REQD	PART NO.	DESCRIPTION	MATERIAL	MAT'L SPEC OR CAGE CODE
-		X	2190766	MULTILAYER PCB	POLYIMIDE	-

LIST OF MATERIAL

THIRD ANGLE PROJECTION

HARDWARE CLASSIFICATION: A

INCH — UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN
HYBRID — UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MM [IN]
METRIC — UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE MM

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R.010
TOLERANCES FOR INCHES:
.XX ±.01 .XXX ±.005 X/X ±1/16 ∠ ±.5° FINISH IN µIN ✓

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R0.25
TOLERANCES FOR METRIC:
X.XX ±0.08 X.X ±0.15 X ±0.2 ∠ ±0.5°
XX ±0.3 XXX ±0.8 XXXX ±1.5
FINISH IN µM ✓

SOFTWARE:	Pro/ENGINEER WF5.0
FILE LOCATION:	\SOLAR-PROBE
DRAWING FILE:	2190766 REV -
MODEL FILE:	2190766 REV -

NEXT ASSY	USED ON
-	SPP\EPI-HI\LVPS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION — Goddard Space Flight Center — GREENBELT, MD [X] WALLOPS ISLAND, VA [ ]

DRAWING INTERPRETED PER 500-PG-8700.2.5

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DRAWN S. SHUMAN		
CHECKED -		
APPROVED -		
APPROVED - ELEC-ENGINEER R. COOK		
APPROVED - SYS-ENGINEER B. KECMAN		
APPROVED - PDL T. vonROSENVINGE		

TITLE
OUTLINE DRAWING, LVPS BOARD, EPI-HI INSTRUMENT

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SCALE: 1.000 SHEET: 1 OF 1

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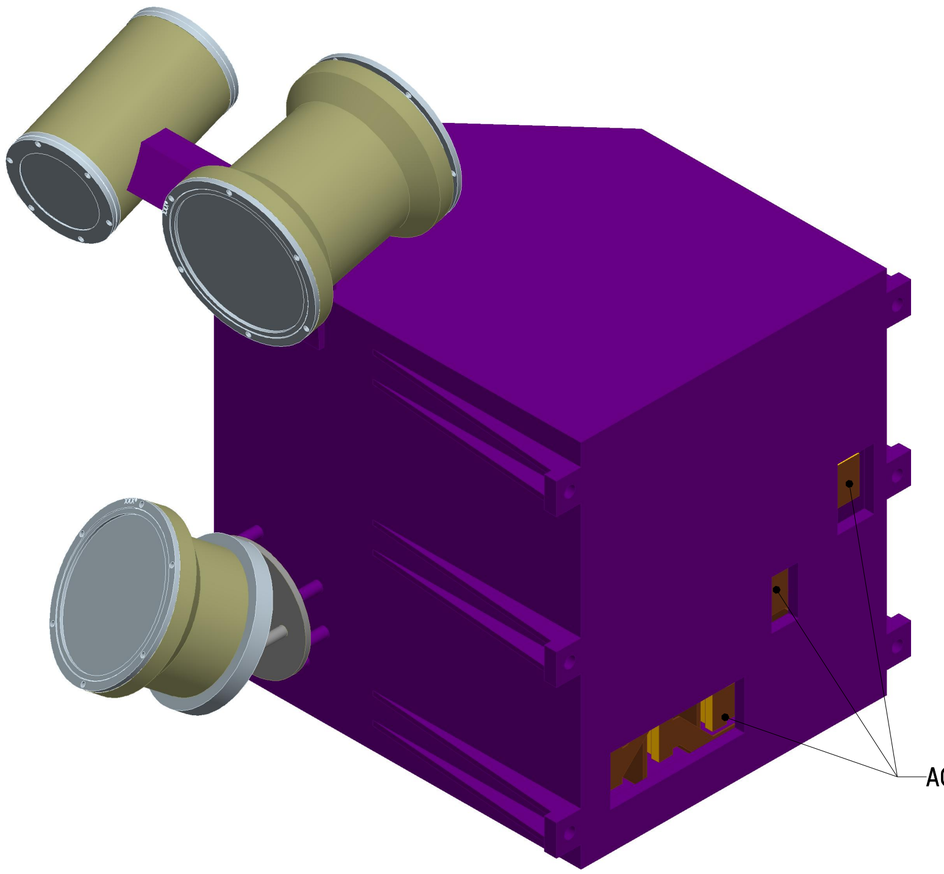

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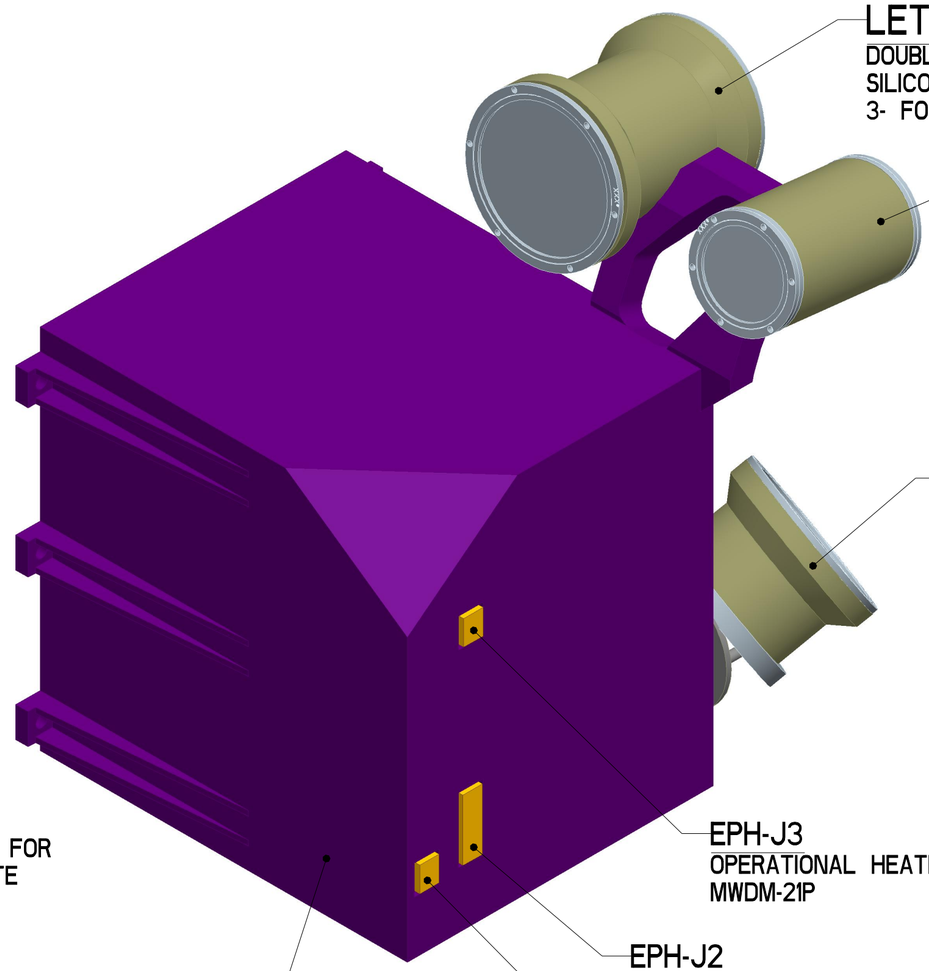
MATE/DEMATE



LET-1 TELESCOPE
DOUBLE-ENDED APERTURE
SILICON DETECTOR STACK
3- FOILS EACH END

HET TELESCOPE
DOUBLE-ENDED APERTURE
SILICON DETECTOR STACK
2- FOILS EACH END

LET-2 TELESCOPE
SINGLE-ENDED APERTURE
SILICON DETECTOR STACK
3- FOILS ONE END ONLY

EPH-J3
OPERATIONAL HEATER
MWDM-21P

EPH-J2
S/C COMMAND & DATA
MWDM-15S

EPH-J1
S/C POWER
MWDM-95

EPI-HI ELECTRONICS
ENCLOSURE- ALUMINUM
6 MOUNTING FEET
MOUNTS TO ISIS BRKT

EPI-HI INSTRUMENT CONFIGURATION

09-MAY-2013