# RBSP EFW LVPS 001
# Low Voltage Power Supply (LVPS)
# Specification
# Version K

Michael Ludlam
2011.01.18 14:39:37 -08'00'

Michael Ludlam, U.C. Berkeley RBSP EFW Systems Engineer

Selda Heavner
2011.01.18 14:33:57 -08'00'

Selda Heavner, U.C. Berkeley RBSP EFW IDPU Power Engineer

## Document Revision Record

| Rev. | Date | Description of Change | Approved By |
|---|---|---|---|
| - | | Draft | - |
| B | 2008-2-21 | Separate BEB supply, change floater source | |
| C | 2008-3-17 | Use LDO for 3.3V, 1.5V. Update backplane, Remove switching regulator option. Add 2 more switches. Change 'Turns' to 'Switch Sense' inputs | |
| D | 2008-7-8 | Update Voltage, Current requirements. Also top level requirements updates per new IRD | |
| E | 2008-8-12 | 5.5V->5V, various mods | |
| F | 2008-9-10 | Add another analog MUX for AXB temps, spares | |
| G | 2008-12-29 | Update deployment currents, LVPS currents | |
| H | 2009-01-15 | Update +/-225V peak current for saturated preamp | |
| I | 2009-04-29 | Updates to LVPS frequency, power numbers and mechanical design. | |
| J | 2009-10-22 | Updates to PCB Commands | |
| K | 2011-01-01 | Clean Up | |

## Distribution List

| Name | Email (thm_backplane) |
|---|---|
| Keith Goetz, Project Manager, U.Min | goetz@umn.edu |
| Dorothy Gordon, UCB | dag@ssl.berkeley.edu |
| Peter Berg, UCB | pcb@ssl.berkeley.edu |
| Michael Ludlam, UCB | mludlam@ssl.berkeley.edu |
| Jane Hoberman, UCB | jch@ssl.berkeley.edu |
| Paul Turin, UCB | pturin@ssl.berkeley.edu |
| Bill Donakowski, UCB | billd@ssl.berkeley.edu |

## TBDs

| Identifier | Description |
|---|---|
| | |
| | |
| | |

## Reference Documents

| Ref | Doc Number | Title |
|---|---|---|
| [1] | RBSP_EFW_SYS_004_Power | EFW Instrument Power Budget |
| [2] | RBSP_EFW_BEB_001 | Boom Electronics Board Specification |
| [3] | RBSP_EFW_DFB_001 | Digital Fields Board Specification |
| [4] | RBSP_EFW_DCB_001 | Data Controller Board Specification |
| [5] | RBSP_EFW_PCB_001 | Power Control Board Specification |
| [6] | RBSP_EFW_BPL_001 | Backplane Specification |
| [7] | RBSP_EFW_BEB_001 | Boom Electronics Board Specification |
| [8] | RBSP_EFW_SPB_001 | SPB Specification |
| [9] | RBSP_EFW_AXB_001 | AXB Specification |
| [10] | RBSP_EFW_HRN_001 | Harness Specification |
| [11] | 7417-9018 | RBSP EMC Specification |

| | | |
|---|---|---|
| [12] | RBSP_EFW_SYS_001 | EFW Requirements Matrix |
| [13] | 7417-9019 | RBSP Environmental Requirements |
| [14] | 7417-9096 | RBSP EFW Compliance Matrix |
| [15] | RBSP_EFW_BPL_001 | IDPU Backplane Specification |

# 1 Overview

The RBSP EFW IDPU Low Voltage Power Supply (LVPS) generates from the 28 Volt Spacecraft Power input the various potentials used by the RBSP EFW instrument. The regulated voltages shall be pwm regulated to ±1%, the voltages regulated by similarity shall be to ±5%. The output ripples shall be 10 mV RMS except for the +/- 225V supply and floating +/-15V supplies, which shall be filtered to 14μV RMS 10Hz-10KHz, and 0.4μV RMS 10KHz-100KHz. Some voltages, as listed below, are regulated on a ‘Not less than’ basis. The monitor ranges shall be +/-2.5V full scale for each monitored voltage or current. Each power supply shall be current limited on its primary side. Each supply is galvanically isolated primary to secondary with no less than a total of 1Mohm resistance between them.

The frequency of the IDPU and BEB converters shall be greater or equal to 199.5 kHz, the frequency of the Floater converters shall be 399kHz. They all shall be synchronized to a common crystal-controlled clock generated on the DCB and provided over the backplane as an 799kHz clock 0-5V with approximately 50% duty cycle. If the synchronization signal is absent the converters shall continue to operate using an on board 799kHz crystal oscillator, 0-5V, 50% duty cycle.

The input from the 28 Volt Spacecraft power shall be soft started and filtered to meet EMI requirements of ref [11].

## *1.1 Primary Requirements*

Primary EFW requirements can be found in ref[12]. Those related to the LVPS include:

| ID | Req. Title | Subject | Priority | Requirement Body or Section Heading |
|---|---|---|---|---|
| EFW-61 | **EFW Power Control** | Each EFW IDPU | shall | contain circuitry to open SPB and AXB doors and deploy sensors |
| EFW-62 | **EFW Low Voltage Conversion** | Each EFW IDPU | shall | contain circuitry to provide voltages to IDPU boards using the S/C-provided 28Volts |
| EFW-63 | **EFW Main Power Allocation** | Each EFW Suite | shall | not exceed the total power of 11.16 W from the EFW Main 28V Service |
| EFW-64 | **EFW Main Power In-Rush** | Each IDPU | shall | not exceed ICD values as follows:<br>10A for 100 usec;<br>5A for 100us to 1ms<br>2.5A after 1ms |
| EFW-65 | **EFW Main Power Max Voltage** | Each IDPU | shall | tolerate without damage a maximum input voltage of 40V indefinitely as defined in the ICD |
| EFW-75 | **EFW IDPU Operational Temp Range** | The EFW IDPU | shall | perform as designed from -25 to +55C |
| EFW-78 | **EFW IDPU Survival Temp Range** | The EFW IDPU | shall | survive without damage from -30 to +60C |
| EFW-88 | **EFW IDPU ICD Compliance** | The EFW IDPU | shall | comply with the requirements and constraints imposed by all relevant instrument-to-spacecraft interface control documents (ICDs). |
| EFW-98 | **EFW Illegal Power States** | The EFW IDPU | shall | not be damaged by the application of boom power while the Main power is Off. |
| EFW-99 | **EFW SPB Deployment Enable** | The EFW IDPU | shall | not deploy SPB booms or fire SPB actuators without the SPB and Main |

| | | | | |
|---|---|---|---|---|
| | | | | power ON. |
| EFW-100 | **EFW AXB Deployment Enable** | The EFW IDPU | Shall | not deploy AXB booms or fire AXB actuators without the AXB and Main power ON. |
| EFW-101 | **EFW Boom Pair Redundancy** | The EFW IDPU | shall | have separate supplies for each preamp boom axis |
| EFW-102 | **EFW Safing by subsystem** | The EFW IDPU | shall | continue to provide EMFISIS with E-Field signals on failure of DCB or DFB |
| EFW-131 | **EFW Initial Power On/Reset State** | The EFW IDPU | shall | power up in a nominal condition for measuring E-Fields without processor intervention. |
| EFW-133 | **EFW Compliance with EM Environment Control Plan** | The EFW Suite | shall | comply with the requirements and constraints imposed by the RBSP Electromagnetic Environment Control Plan, APL document no. 7417-9018. |
| EFW-136 | **Instrument Compliance with Environmental Design and Test Requirements Document** | Each EFW Instrument | shall | comply with the requirements and constraints imposed by the RBSP Environmental Design and Test Requirements Document, APL document no. 7417-9019. |
| EFW-137 | **EFW Quality Assurance** | The EFW Suite | shall | comply with the RBSP Performance Assurance Implementation Plan, as modified by the Compliance Matrix |

## 2 Specific Output Voltage Requirements

The following section details the output voltages and the characteristics of the supply. Figure 2.1 shows the voltages and nominal current requirements of the EFW system as detailed in reference [1] (refer to reference 1 for the most recent values). The LVPS shall be capable of generating peak current consumption on each supply. At power levels above the peak indicated the supply should limit. The LVPS shall produce these voltages under all environmental conditions and maintain at least a 60% efficiency ratio at average current consumption (except 225V supply, which shall have at least 25% efficiency). Power numbers for each supply (along the bottom) are on the secondary). Power numbers on the right are on the primary (including the LVPS efficiency factors).

| Calc by Voltage | Voltages | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pwr | +5V D | +1.8V D | +3.6D (1) | +5V A | -5V A | +10VA | -10VA | +5V D | +10V A | -10V A | +225V | -225V | +/-15F1 | +/-15F2 | +/-15F3 | +/-15F4 | +/-10F5 | +/-15F6 | |
| | IDPU | | | | | | | BEB | | | | | | | | | | | |
| 10.329 | 5 | 1.8 | 3.6 | 5 | 5 | 10 | 10 | 5 | 10 | 10 | 225 | 225 | 30 | 30 | 30 | 30 | 30 | 30 | *VOLTAGES* |
| *Avg* | 0.010 | 0.440 | 0.238 | 0.068 | 0.081 | 0.042 | 0.036 | 0.003 | 0.055 | 0.050 | 0.0013 | 0.0003 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | *CURRENT* |
| | 0.05 | 0.79 | 0.86 | 0.34 | 0.41 | 0.42 | 0.36 | 0.02 | 0.55 | 0.50 | 0.29 | 0.07 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | *POWER* |
| 16.974 | 5 | 1.8 | 3.6 | 5 | 5 | 10 | 10 | 5 | 10 | 10 | 225 | 225 | 30 | 30 | 30 | 30 | 30 | 30 | *VOLTAGES* |
| *Peak* | 0.018 | 0.753 | 0.556 | 0.102 | 0.121 | 0.077 | 0.058 | 0.005 | 0.055 | 0.053 | 0.0056 | 0.0056 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | *CURRENT* |
| | 0.09 | 1.36 | 2.00 | 0.51 | 0.60 | 0.77 | 0.58 | 0.02 | 0.55 | 0.53 | 1.25 | 1.25 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | *POWER* |

Figure 2.1. Power Supply Voltage and Currents (From RBSP_EFW_SYS_004J)

## 2.1 IDPU POWER

Upon application of 28VDC to the input pins, the LVPS shall provide +1.8VD, +3.6VD, +5 VD, ± 5 VA, ± 10 VA to run the DCB, DFB, and PCB cards. The input current shall be limited and monitored and reported to the DCB. The +5VD, and +5 VA will be regulated; the other voltages will be regulated by similarity..

The +1.5VD and +3.3VD required by the DCB and DFB are generated from +1.8VD and +3.6VD (not less than 1.8V and 3.6V at peak current, worst case conditions) supplies on the DCB and DFB cards using MS Kennedy LDO linear regulators. The LDOs will be located on the DCB and DFB boards. Current consumption on those boards is:

| Board Currents | 3.3V Average | 3.3V Peak | 1.5V Average | 1.5V Peak |
|---|---|---|---|---|
| DCB | 169mA | 391mA | 250mA | 373mA |
| DFB | 60mA | 118mA | 190mA | 380mA |

Figure 2-3 Remote Switching Regulator Requirements

## 2.2 BEB POWER

The LVPS shall provide +5 Volts Digital, ± 10 Volts, and ± 225 Volts to be used by the BEB board. The input current shall be limited and monitored and reported to the DCB. The +5V analog supply is regulated and supplies power to the floating voltage supplies; the other analog voltages will be regulated by similarity. The +5Volt Digital supply is used on the BEB to run digital logic and as the load is low the supply can be made from an LDO regulator if necessary. The BEB supply shall continue to operate nominally even if the IDPU Power supply fails. The +/-225 V supply is separate from the +/-10V supply.

The peak load on the +/-225V supply results from a capacitive load driven by an amplifier powered by the +/-225V supply. The worst case load takes 5.6mA peak on either supply at 100Hz. The cycle-averaged current on each supply is significantly lower, so power supply filtering can reduce this load if it can level the load at 100Hz.

## 2.3 Floating Voltages

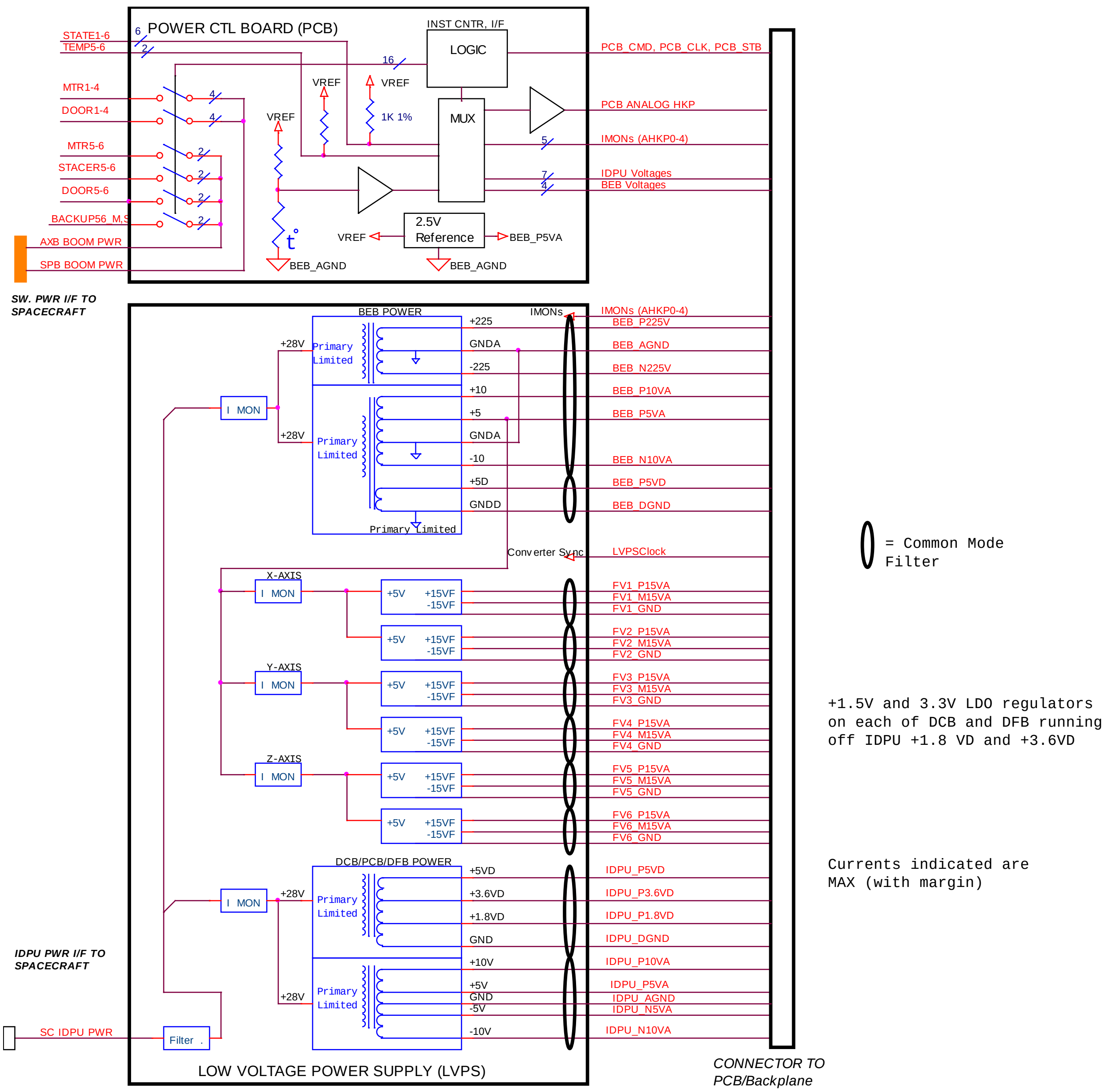
The LVPS shall provide for the fields instrument three pairs of ±15 Volt sets, each set of ±15 with its separate return. Each pair shall be current monitored. Floating ground can be biased between +/-225V on the BEB board. These voltages are derived from a BEB secondary voltage. The Floating Voltages shall continue to operate nominally even if the IDPU Power supplies fail.

The 225V supply should be proceeded by the floating supplies.

# 3 Block Diagram

Figure 3.1 shows an overview of the main components comprising the LVPS and the PCB. The LVPS resides on a 6U VME board. It connects to the backplane via a Hypertronics 80-pin connector mounted edgewise, facing upwards. Power is distributed through the backplane connection, but received from the spacecraft via a front panel male D connector. Another front panel connector takes switched deployment power and returned status signals to the boom units. The PCB is housed on the same board as the LVPS.

Figure 3.1: LVPS and PCB Block Diagram



The nominal PCB logic schematic is shown in figure 3.2

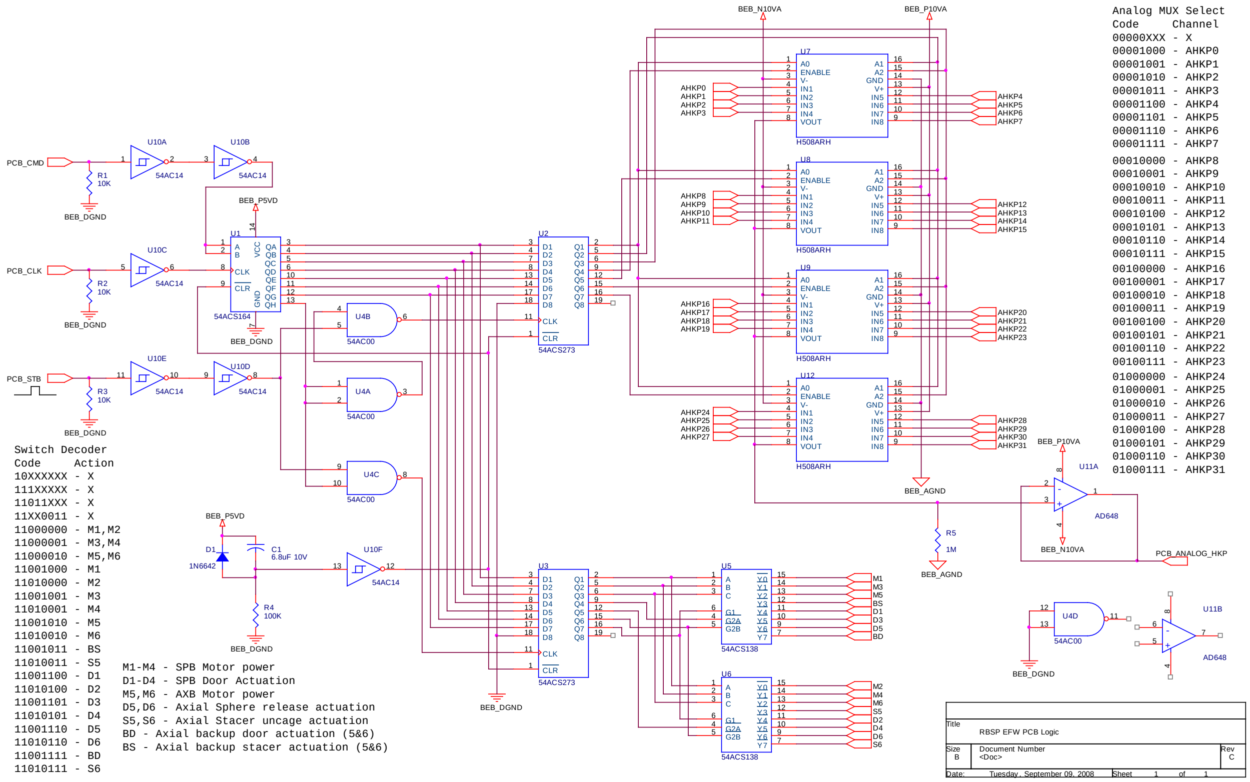



Figure 3.2 PCB Logic; switch and analog multiplexer control

# 4 Commands

The LVPS receives digital commands from the DCB via the backplane. These commands are shifted in serially and latched in parallel. The DCB shall provide PCB_CMD, PCB_CLK, and PCB_STB signals. These signals are received by inverting buffers with hysteresis (54AC14) and a pull-down resistor. Their idle state should be low. Data is shifted in on the falling edge of PCB_CLK, with PCB_CMD being shifted into Bit 0, Bit 0 shifting into Bit 1, etc. Eight data bits are shifted in. Data is transferred from the shift register to the control latch on the falling edge of PCB_STB (which should be a positive-going pulse) after the data is shifted in. There are two latches – one controls the power switches and one the analog housekeeping MUX. The state of the MSB of the data word selects which word is latched; the other latch is not affected. If the MSB is zero, the Analog Housekeeping MUX is set. If the state is one, the switch register is set. When one register is set the state of the other register is not affected.

The registers shall default to zero on power on.

## 4.1 Power Switch Register

The power switch register controls which of the power switches is enabled. Table 4.1 lists the command words associated with the various switch combinations. Following the receipt of the commands listed below only the indicated services will be powered.

| Command | Switch Name | Switch Function | Peak Current, Amps |
|---|---|---|---|
| 0x80 | IDLE | No switch actuated (power-on default) | 0 |
| 0xC0 | M1M2 | SPB Units 1 and 2 Motors ON | 3.0 |
| 0xC1 | M3M4 | SPB Units 3 and 4 Motors ON | 3.0 |
| 0xC2 | M5M6 | AXB Units 1 and 2 Motors ON | 3.0 |
| 0x D0 | M1 | SPB Unit 1 Motor ON | 1.5 |
| 0x C8 | M2 | SPB Unit 2 Motor ON | 1.5 |
| 0x D1 | M3 | SPB Unit 3 Motor ON | 1.5 |
| 0x C9 | M4 | SPB Unit 4 Motor ON | 1.5 |
| 0x D2 | M5 | AXB Unit 1 Motor ON | 1.5 |
| 0x CA | M6 | AXB Unit 2 Motor ON | 1.5 |
| 0x D4 | D1 | SPB Unit 1 Door Actuator ON | 1.9 |
| 0x CC | D2 | SPB Unit 2 Door Actuator ON | 1.9 |
| 0x D5 | D3 | SPB Unit 3 Door Actuator ON | 1.9 |
| 0x CD | D4 | SPB Unit 4 Door Actuator ON | 1.9 |
| 0x D6 | D5 | AXB Unit 1 Sphere Release Actuator ON | 1.2 |
| 0x CE | D6 | AXB Unit 2 Sphere Release Actuator ON | 1.2 |
| 0x CB | S5 | AXB Unit 1 Stacer Release Actuator ON | 1.2 |
| 0x CF | S6 | AXB Unit 2 Stacer Release Actuator ON | 1.2 |
| 0x D3 | BS | AXB Unit 1 and 2 Stacer Release Actuators ON (Backup) | 2.3 |
| 0x D7 | BD | AXB Unit 1 and 2 Sphere Release Actuators ON (Backup) | 2.3 |

Table 4.1 PCB Switch Commands

# 5 Analog Housekeeping

Table 5.1 provides the Analog HKP on the PCB. All outputs shall be scaled to be between -2.5V and +2.5V. No offset need be applied – a monitor value of zero shall typically be zero after scaling. .

| Command | HKP Channel # | HK Name | HK Function |
|---|---|---|---|
| 0x00 | - | Ground | No channel selected (power-on default) |
| 0x08 | AHKP0 | IMON_IDPU | IDPU ANALOG AND DIGITAL PRIMARY CURRENTS |
| 0x09 | AHKP1 | IMON_BEB | BEB ANALOG PRIMARY CURRENTS |
| 0x0A | AHKP2 | IMON_FVX | FVX PRIMARY CURRENT |
| 0x0B | AHKP3 | IMON_FVY | FVY PRIMARY CURRENT |
| 0x0C | AHKP4 | IMON_FVZ | FVZ PRIMARY CURRENT |
| 0x0D | AHKP5 | VMON_BEB_P10VA | BEB +10 VA VOLTAGE MONITOR |
| 0x0E | AHKP6 | VMON_BEB_N10VA | BEB -10 VA VOLTAGE MONITOR |
| 0x0F | AHKP7 | VMON_BEB_P5VA | BEB +5 VA VOLTAGE MONITOR (Runs floaters) |
| 0x10 | AHKP8 | VMON_BEB_P5VD | BEB +5 VD VOLTAGE MONITOR |
| 0x11 | AHKP9 | VMON_IDPU_P10VA | IDPU +10 VA VOLTAGE MONITOR |
| 0x12 | AHKP10 | VMON_IDPU_N10VA | IDPU -10 VA VOLTAGE MONITOR |
| 0x13 | AHKP11 | VMON_IDPU_P5VA | IDPU +5 VA VOLTAGE MONITOR |
| 0x14 | AHKP12 | VMON_IDPU_N5VA | IDPU -5 VA VOLTAGE MONITOR |
| 0x15 | AHKP13 | VMON_IDPU_P5VD | IDPU +5 VD VOLTAGE MONITOR |
| 0x16 | AHKP14 | VMON_IDPU_P3.6VD | IDPU +3.6 VD VOLTAGE MONITOR |

| | | | |
|---|---|---|---|
| 0x17 | AHKP15 | VMON_IDPU_P1.8VD | IDPU +1.8 VD VOLTAGE MONITOR |
| 0x20 | AHKP16 | TMON_LVPS | LVPS Temperature Monitor |
| 0x21 | AHKP17 | SPARE | |
| 0x22 | AHKP18 | STATE1 | SPB1 Deployment Switch Status |
| 0x23 | AHKP19 | STATE2 | SPB2 Deployment Switch Status |
| 0x24 | AHKP20 | STATE3 | SPB3 Deployment Switch Status |
| 0x25 | AHKP21 | STATE4 | SPB4 Deployment Switch Status |
| 0x26 | AHKP22 | STATE5 | AXB5 Deployment Switch Status |
| 0x27 | AHKP23 | STATE6 | AXB6 Deployment Switch Status |
| 0x40 | AHKP24 | SPARE | |
| 0x41 | AHKP25 | SPARE | |
| 0x42 | AHKP26 | SPARE | |
| 0x43 | AHKP27 | SPARE | |
| 0x44 | AHKP28 | TMON_AXB5 | AXB5 temperature monitor |
| 0x45 | AHKP29 | TMON_AXB6 | AXB6 temperature monitor |
| 0x46 | AHKP30 | SPARE | |
| 0x47 | AHKP31 | SPARE | |

Table 5.1. Analog Housekeeping Returned by LVPS/PCB

The STATE signals shall each be pulled up to a 2.5V reference signal via 6.04Kohm 0.1% resistor on the PCB. They are pulled to ground by switches to be monitored in the boom units via different resistor values such that the value of the STATE analog housekeeping measurement tells the system which switches are closed.

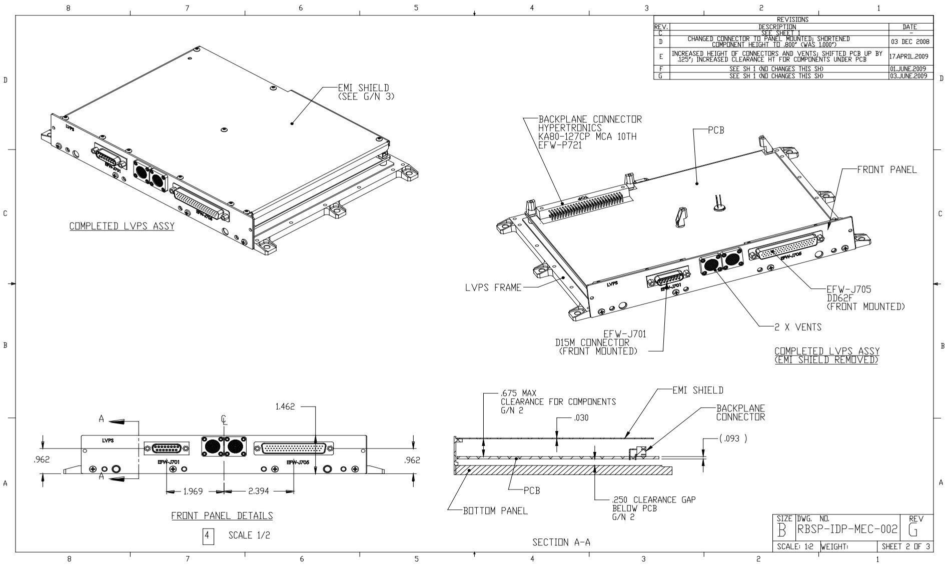
The TMON_LVPS, TMON_AXB5, and TMON_AXB6 signals are generated by a YSI thermistor, pulled up to the 2.5V reference by a 10k resistor.

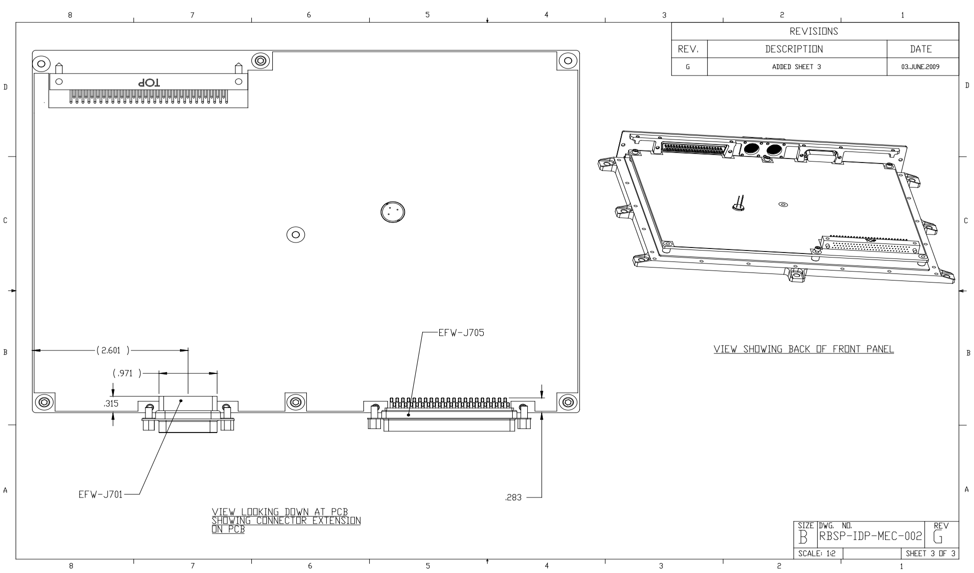
# 6 LVPS Connectors

The LVPS/PCB is housed in the bottom of the IDPU and connected to the other IDPU boards by a single backplane KA80.1-pin connector The connector to the SC Spacecraft is fitted onto the front panel. The input connector is a 311P409-1P-B-12, the output connector is a Hypertronics KA80.1/127CPFC10TABH. The connector pinout is specified in RBSP_EFW_BPL_001. Note that some of the spare signals are terminated in the LVPS, as indicated in that document. The boom deployment and boom status signals leave the board on a HD62S connector (311P407-2S-B-12) also housed on the front panel.

# 7 Packaging

The LVPS will conform to the dimensions as shown in the following figures, more detail can be found in RBSP-IDP-MEC-002.


REVISIONS
REV.
DESCRIPTION
DATE
EMI SHIELD
(SEE G/N 3)
COMPLETED LVPS ASSY
BACKPLANE CONNECTOR
HYPERTRONICS
KA80-127CP MCA 10TH
EFW-P721
PCB
FRONT PANEL
LVPS FRAME
EFW-J705
DD62F
(FRONT MOUNTED)
2 X VENTS
EFW-J701
D15M CONNECTOR
(FRONT MOUNTED)
COMPLETED LVPS ASSY
(EMI SHIELD REMOVED)
1.462
.962
1.969
2.394
FRONT PANEL DETAILS
SCALE 1/2
.675 MAX
CLEARANCE FOR COMPONENTS
G/N 2
.030
EMI SHIELD
BACKPLANE
CONNECTOR
(.093 )
PCB
BOTTOM PANEL
.250 CLEARANCE GAP
BELOW PCB
G/N 2
SECTION A-A
RBSP-IDP-MEC-002
SHEET 2 OF 3


REVISIONS
REV.
DESCRIPTION
DATE
G
ADDED SHEET 3
03.JUNE.2009
TOP
EFW-J705
(2.601 )
(.971 )
.315
EFW-J701
.283
VIEW LOOKING DOWN AT PCB
SHOWING CONNECTOR EXTENSION
ON PCB
VIEW SHOWING BACK OF FRONT PANEL
RBSP-IDP-MEC-002
SHEET 3 OF 3