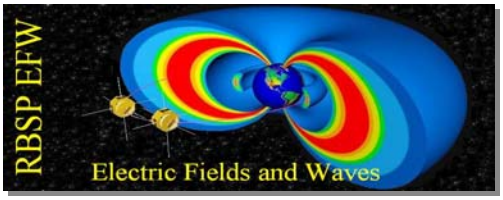

RBSP EFW
Boom Electronics Board (BEB)
Specification

RBSP_EFW_BEB_001H

Michael Ludlam
2010.03.30 16:36:01
-07'00'

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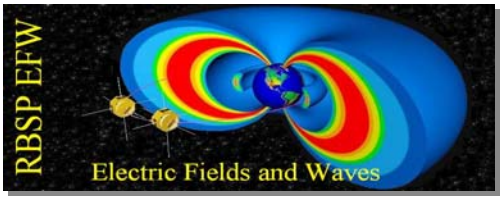


Document Revision Record

Rev.	Date	Description of Change
A	2008-3-18	Written by John Bonnell. Initial version, cribbed from thm_sys_104E_BEB-to-IDPU_ICD.doc, with mods for higher-voltage floating ground system and deletion of DBRAID system, as well as addition of EFW-EMF E-field interface and axial sensor Density Mode.
B	2008-3-20	Revised Format
C	2008-8-29	
D	2008-11-18	Updated with requirements, block diagram, pinout, HK list, commanding, board outline and corrections
E	11/21/2008	Corrections to specification and addition of CS pin to DACs
F	6/12/09	Update to DACs and connector
G	10/26/09	Corrections to specification.
H	2/26/10	Updated and added Current/power condition, Updated EMFISIS and Floating GND frequency response.

Distribution List

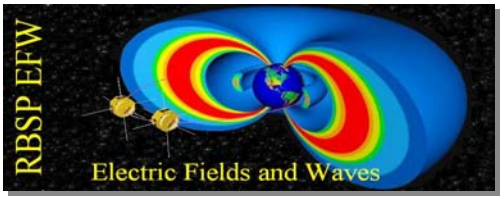
Name	Email

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_SPB_001	SPB Specification
[8]	RBSP_EFW_AXB_001	AXB Specification
[9]	RBSP_EFW_HRN_001	Harness Specification
[10]	RBSP_EFW_to_EMFISIS_ICD	EFW-to-EMFISIS Interface Control Document
[11]	7417-9018	RBSP EMC Specification
[12]	RBSP_EFW_SYS_001	EFW Requirements Matrix



1 Overview

The Boom Electronics Board (BEB) is housed in the IDPU chassis. It provides a number of functions related to the electric field measurement by the Electric Field and Waves (EFW) instrument on each Radiation Belt Storm Probe (RBSP) spacecraft (S/C). One BEB will be used in each S/C. This document primarily describes the electrical interfaces with other subsystems in the S/C, and in particular with the EFW Preamps, other subsystems in the IDPU and with the EMFISIS instrument.

1.1 Primary Requirements

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

ID	Req. Title	Subject	Priority	Requirement Body or Section Heading
EFW-36	**EFW On-Board Delivery of Signals and to EMFISIS - Spin Plane Sensor Pairs**	Each EFW Instrument	shall	be capable of providing buffered, analog probe voltage difference signals for two orthogonal pairs of spin plane electric field sensors directly to the EMFISIS instrument suite aboard its respective observatory, specified in terms of two frequency ranges, as follows: Frequency Range 1: -- frequency range: from 10 Hz to 12 kHz; -- sensitivity: 3.10-14 (V/m)2/Hz at 1 kHz; -- bandwidth: 1 Hz; -- dynamic range: 100 dB. Frequency Range 2: -- frequency range: from 10 kHz to 400 kHz; -- sensitivity: 3.10-17 (V/m)2/Hz at 100 kHz; -- bandwidth: 1 Hz; -- dynamic range: 100 dB; -- maximum signal amplitude: 30 mV/m at 1 kHz.
EFW-208	**EFW On-Board Delivery of Signals to EMFISIS - Single Pair Axial**	Each EFW Instrument	shall	be capable of providing a buffered, analog spin axis electric field measurement directly to the EMFISIS instrument suite aboard its respective observatory, specified in terms of two frequency ranges, as follows: Frequency Range 1: -- frequency range: from 10 Hz to 12 kHz; -- bandwidth: 1 Hz; -- dynamic range: 80 dB; -- sensitivity: 3.10-12 (V/m)2/Hz at 100 Hz.

				Frequency Range 2: -- frequency range: from 10 kHz to 400 kHz; -- bandwidth: 1 Hz; -- dynamic range: 80 dB; -- sensitivity: 3.10-15 (V/m)2/Hz at 100 kHz; -- maximum signal amplitude: 30 mV/m at 1 kHz
EFW-57	**EFW Spin Plane E-Field Booms**	Each EFW IDPU	shall	contain Boom Electronics Board (BEB) which will control four SPB sensors and 2 AXB sensors.
EFW-59	**EFW E-Field Buffering**	Each EFW IDPU	shall	contain circuitry to buffer differential E-Field signals to EMFISIS
EFW-75	**EFW IDPU Operational Temp Range**	The EFW IDPU	shall	perform as designed from -25 to +55C (TBR)
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-101	**EFW Axial 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	**Instrument Compliance with EM Environment Control Plan**	Each EFW Instrument	shall	comply with the requirements and constraints imposed by the RBSP Electromagnetic Environment Control Plan, APL document no. 7417-9018.
EFW-137	**EFW Quality Assurance**	Each EFW Instrument	shall	comply with the RBSP Performance Assurance Implementation Plan, as modified by the Compliance Matrix

2 Input Voltages

The following section details the BEB input voltages. 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). Reference 1 will provide peak voltages, currents and power for the BEB. The BEB shall be capable of operating within these limits at all times.
The current below represents the BEB with 5 Vsphere inputs grounded and 1 Vsphere driven with a 100Vpp load.

+5V D	+10V A	-10V A	+225V	-225V	+/-15F1	+/-15F2	+/-15F3	+/-15F4	+/-10F5	+/-15F6	VOLTAGE
0.003	0.063	0.052	.0013	.0006	0.002	0.002	0.002	0.002	0.002	0.002	*CURRENT*
0.02	0.63	0.52	0.29	0.16	0.17	0.17	0.17	0.17	0.17	0.17	*POWER*

Figure 2.1. Power Supply Voltage (V) and Currents (mA)

2.1 BEB POWER

The LVPS provides +5VD, ± 10 Volts, ± 225 Volts to be used by the BEB board. The input current shall be limited and monitored and reported to the DCB. The +5VD and ±10V will be regulated; the other voltages will be regulated by similarity. The BEB supply shall continue to operate nominally even if the DCB, DFB, or IDPU Power supply fails. Positive and negative headroom voltages are provided to operate current monitors and limiters on the PCB as needed. The +/-225 V supply may be separate from the +/-10V supply if necessary.

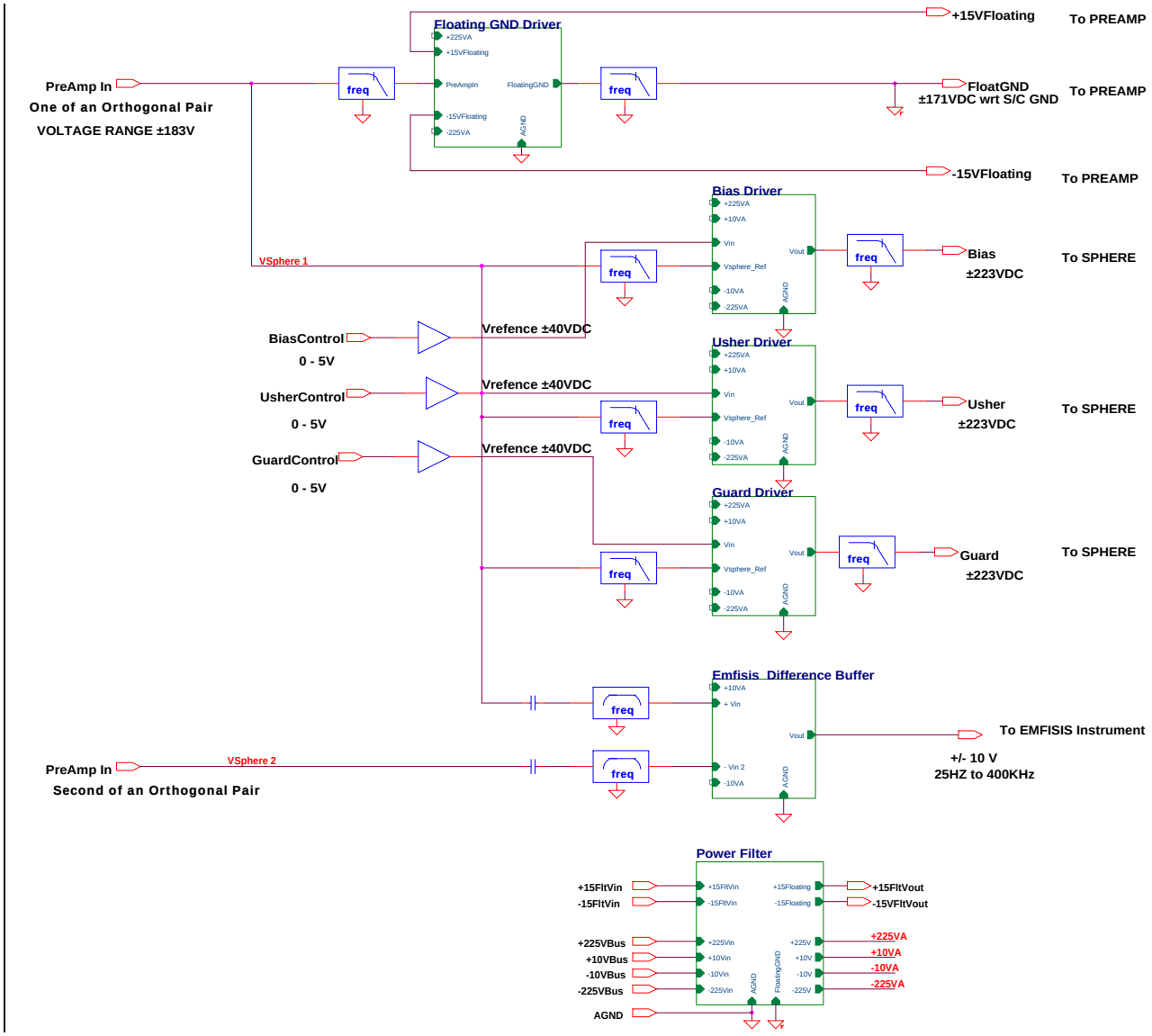
2.2 Floating Voltages

The LVPS provides for the fields instrument three pairs of ±15 Volt sets, each one of the set of ±15 has its separate return. Each pair shall be current monitored. Floating ground can be biased between +/-183V with respect to spacecraft ground on the BEB board. These voltages are derived from a separate LVPS produced supply (5V). The Floating Voltages shall continue to operate nominally even if the DCB, DFB, or IDPU Power supplies fail.

3 Block Diagram

Figure 3.1 shows an overview of the main components comprising the BEB. The BEB resides on a 6U VME board. It connects to the backplane via a female Hypertronics KA98/127 pin connector mounted edgewise, facing upwards. Power is input through the backplane connection.

Figure 3.1: BEB Block Diagram



4 Functional Description

The BEB shall provide electrical support the four (4) spin plane and two (2) axial EFW sensors. Functionally, each sensor consists of a Sensor surface, a Preamp, a Floating Ground Driver, a Sensor biasing circuit (BIAS; current-bias in E-field Mode, voltage-bias in Density Mode), and two separate voltage-bias-able surfaces (Usher and Guard).

4.1.1 Preamplifier Signal Characteristics

The electrical characteristics for this signal are as described in Table 4.1.1-1.

Element	Specification
DC voltage level	± 183 Vdc w.r.t. AGND (±(223-40) V Note 1
AC voltage level	100 Vpp (DC-100 Hz) (±150 mV/m on 100-m boom system; TBR). 26 Vpp(100Hz – 10KHz)
AC frequency band	DC-400kHz.

Table 4.1.1-1: Preamp Signal Characteristics

Note 1. Allows for full-scale Bias/Usher/Guard voltages

4.1.2 Floating Ground Driver

The BEB shall provide the reference source for each floating ground used by the EFI preamps. Table 4.1.2-1 provides the specification for this driver.

Element	Specification
Input: Preamp signal	VSPHERE
Input filter	500 Hz (3dB roll off)
Output voltage level	± 171Vdc w.r.t. SC GND
Opposing Booms matched	.1% accuracy, DC to.5Hz Note 1

Table 4.1.2-1: Floating Ground Driver Specifications

Note1: Implies gain between 0.999 and 1.001.

4.1.3 Bias, Usher, Guard Specifications

The sphere, usher and guard structures are part of the EFW sensor and each is separately biased with a programmable voltage potential. Programming is accomplished via FSW. Control of each of these voltages is done via a digital-to-analog converter (DAC), whose specification is consequently described.

Element	Specification
Reference Input	Preamp signal (VSPHERE)
Ref. Input filter	300 Hz (3dB roll off)
Output voltage level	± 223Vdc (= ± 183Vdc ± 40Vdc w.r.t. AGND), where FS DAC = Vref ± 40Vdc
Opposing Booms matched	.1% accuracy, DC to.5Hz (BIAS only) Note 2
DAC resolution	12-bits (BIAS res. requirement=1nA (E-field mode);
DAC accuracy	BIAS on opposing booms matched to better than 0.1% for a given DAC setting and Vref over the full range of each; Usher and Guard on opposing booms matched to better than 0.5%.
Gain matching	Output shall track VSPHEREn to better than 0.1% from

	DC-TBD Hz (gain between 0.999 and 1.001).
DAC step response	< 25 ms (TBR; for information only).
Noise Level	< 48u Vrms 10 to 10KHz < 35u Vrms 10K to 400KHz
AC Distortion	<-40dB THD with +/-50 VDC, +/-100Vp-p AC

Table 4.1.3-1: Bias, Usher, Guard Specification

Note2: Implies gain on Vsphere is between 0.999 and 1.001

4.1.4 ACTEST Output Specification

Element	Specification
Output voltage	$5V_{pp}$ square wave

Table 4.1.4-1: ACTEST Specification

The BEB shall forward the ACTEST signals generated by the DCB and provided over the backplane.

4.1.5 EFW - EMFISIS E-field Buffers

The BEB shall provide the analog circuits that implement the EFW-EMFISIS E-Field buffers as specified in the EFW_to_EMFISIS ICD Ref [10]. The frequency range shall be 25 Hz to 400 KHz, per discussion JWB and JRW 12/2009.

4.1.6 Contingency Operational Modes

The BEB shall be capable of providing nominal floating ground, bias, usher, and guard operations in the contingency that the EFW-IDPU is non-functional or can not otherwise command the BEB.

The BEB shall be capable of providing nominal operation of the EFW-EMFISIS E-Field buffers in the contingency that the EFW-IDPU is non-functional or cannot otherwise command the BEB.

5 Commands

The BEB board receives control line signals from the DCB on 12 lines.

Analog Mux Signals: 3 lines are used to control the enable pins on the 3 BEB muxes, and 3 lines are used to address the mux that is enabled. With polarity as measured on the backplane, a high signal (5V) on the enable pin selects a Mux, and the address pins are reverse logic (111 would select address 0 on the BEB). This allows the implementation of a single AC14 inverting buffer on the BEB for each signal.

AC Test Signal: 2 lines used to provide a test signal to the sensors pre deploy. The signal frequency is settable from 128Hz to 512 kHz and is a square wave. It is activated/deactivated on the 1Hz clock boundary to aid in timing tests during I&T.

DAC Control: 4 lines to control the BEB AD5544 Quad DACs. The BEB_DAC_CLK frequency is 1.048 MHz (20^{20}Hz) and is active only on during the transmission of DAC settings. The DACs are serially ganged together. The data is clocked in on the BEB board on the falling edge of BEB_DAC_CLK, polarity as measured on the backplane. The command to the DAC has a 2 bit address followed by 16 bits of data (MSB first). As the DACs are serially

connected together all DACs need to be programmed at once. Data is latched into the DAC registers using the CS pin. Data is latched into the registers on the falling edge of the CS pin as measured on the backplane. Once all the DACs have been loaded consecutively the BEB_DAC_LDAC line is pulsed high. The DACs update on the falling edge of this pulse, polarity as measured on the backplane.

The DACs should be commanded by the DCB in the following order:

Number	DAC #	Address Bits	Signal
1	U9	00	Guard5
2	U8	00	Usher4
3	U7	00	Bias3
4	U3	00	Not Used
5	U2	00	Not Used
6	U9	01	Bias6
7	U8	01	Guard4
8	U7	01	Usher3
9	U3	01	Bias1
10	U2	01	Bias2
11	U9	10	Usher6
12	U8	10	Bias5
13	U7	10	Guard3
14	U3	10	Usher1
15	U2	10	Usher2
16	U9	11	Guard6
17	U8	11	Usher5
18	U7	11	Bias4
19	U3	11	Guard1
20	U2	11	Guard2

Table 5.1

Note that although channels 4 and 5 are not used they need to be commanded to ensure the last DAC in the chain receives the correct configuration.

6 Analog Housekeeping

Table 6.1 provides the Analog HKP on the BEB. 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.

MUX	Channel #	HK Name
0	0	BIAS1
0	1	USHER1
0	2	GUARD1
0	3	BIAS2
0	4	USHER2
0	5	GUARD2
0	6	AGND
0	7	AGND

1	0	BIAS3
1	1	USHER3
1	2	GUARD3
1	3	BIAS4
1	4	USHER4
1	5	GUARD4
1	6	BEB TEMPERATURE
1	7	A GROUND
2	0	BIAS5
2	1	USHER5
2	2	GUARD5
2	3	BIAS6
2	4	USHER6
2	5	GUARD6
2	6	AGND
2	7	A GROUND

Table 6.1. Analog Housekeeping Returned by BEB

7 BEB Connectors

The BEB is housed in the top of the IDPU and connected by a single backplane Hypertronics KA-98 pin connector. This is a VME 96-pin connector on the ETU. Connectors to the booms are on the front panel.
Backplane: See RBSP_EFW_BPL_001_Specification.
Front Panel:
1. There are 3 DD26F connectors along the front panel that carry signals from the BEB to the Boom units. These connectors also carry the EMFISIS signals.

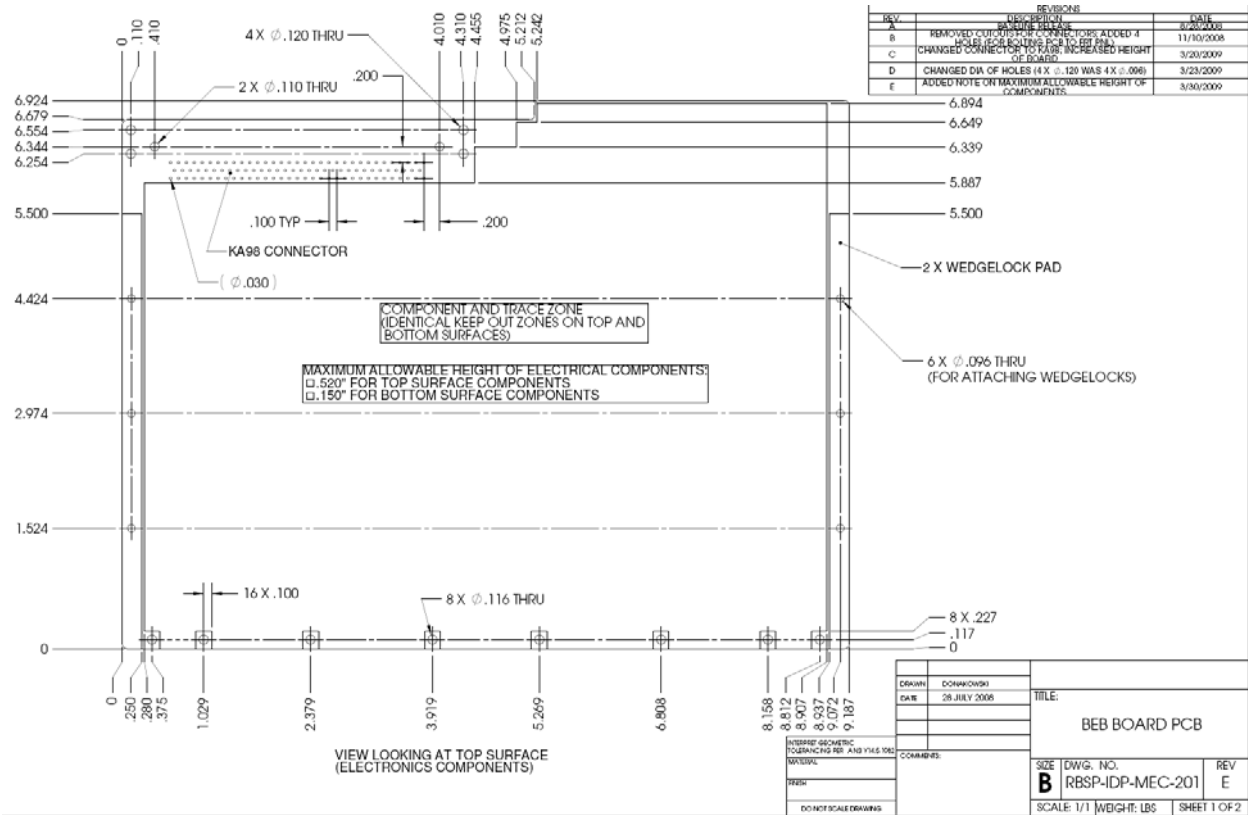
SDD26 Pin Layout				
VSPHERE2		10		
FV2_GND	1		19	AGND2
FV2_P15VA		11		
FV2_N15VA	2		20	AGND2
ACTEST2		12		
GUARD2	3		21	AGND2
USHER 2		13		
BIAS2	4		22	AGND2
(spare)		14		
EMFISIS_1_2	5		23	EMF_1-2_RET
BIAS1		15		
USHER1	6		24	AGND1
GUARD1		16		
ACTEST1	7		25	AGND1
FV1_N15VA		17		
FV1_P15VA	8		26	AGND1
FV1_GND		18		
VSPHERE1	9			

Table 7.1 Shown for J706. J707 and J708 are identical but signal names are appropriately numbered.

2. VSPHEREn signals, BEB-to-DFB (n=1..6; SMA Coax, shield to AGND at one end).

7 Packaging

The BEB will conform to the dimensions as shown in the following figure.



Taken from: RBSP-IDPU-MEC-201