**RBSP EFW**

**Instrument Burst Triggers**

**Specification**

RBSP\_EFW\_SYS\_016B

DRAFT

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Prepared by: John Bonnell (RBSP-EFW UCB Instrument Co-I).

John Wygant, RBSP-EFW PI, UMN.

John Bonnell, U.C. Berkeley Instrument Co-I

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

Peter Harvey, U.C. Berkeley RBSP EFW Flight Software Lead

# Document Revision Record

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| **Rev.** | **Date** | **Description of Change** | **Approved By** |
| - | 2009-4-27 | Draft; reformatting of informal document prepared by Wygant. | - |
| A | 2009-05-16 | Major revision, incorporating discussions of implementations and algorithms. |  |
| B | 2009-07-02 | Minor rev, switching UCB SysEng from DWC to MML. |  |
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**Distribution List**

|  |  |
| --- | --- |
| **Name** | **Email** |
| Michael Lullam, Sys Eng and IDPU Lead, U.C. Berkeley  Peter Harvey, Flight Software, U.C.Berkeley  John Bonnell, Instrument CoI, U.C.Berkeley  John Wygant, PI, U.Min. | mludlam@ssl.berkeley.edu  [prh@ssl.berkeley.edu](mailto:prh@ssl.berkeley.edu)  [jbonnell@ssl.berkeley.edu](mailto:jbonnell@ssl.berkeley.edu)  [jwygant@fields.space.umn.edu](mailto:jwygant@fields.space.umn.edu) |

**TBDs**

|  |  |
| --- | --- |
| **Identifier** | **Description** |
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**Reference Documents**

|  |  |  |
| --- | --- | --- |
| **Ref** | **Doc Number** | **Title** |
| [1] | RBSP\_EFW\_SYS\_001 | EFW Instrument Requirements Matrix |
| [2] | RBSP\_EFW\_SYS\_009 | Burst Operations |
| [3] | RBSP\_EFW\_DFB\_001 | DFB Specification |
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# Introduction

## This document defines the burst valuation functions (a.k.a. trigger functions), used for internal collection and management of both Burst1 and Burst2 (Interferometric) data products. It also defines similar functions used to transmit burst support requests from an EFW instrument to other instruments on the same Observatory via the instrument Shared Data words contained in the SC Time and Status message (APID 0x100).

## Burst triggers will be calculated for evaluation 4 times per second.

# Burst Trigger Function Descriptions

The purpose of each trigger function is to provide a numerical score for the current observational conditions as perceived by the EFW instrument. This score is then used to measure the relative value of the burst data being collected against data already collected, and thus allow for an on-board decision by the instrument as to whether to overwrite previous data, or discard current data. The goal of this process is the optimization of use of the limited available data volume allocated to the EFW instrument’s data products on each RBSP Observatory.

The EFW instrument shall allow for up to eight (8; TBR) burst valuation functions to be defined. A different function can be selected for each of the two burst handling tasks and the EFW status reporting task (B1, B2, and EFW\_EXT\_STATUS). These functions shall take as input the EFW Internal FilterBank data (FB\_INT, APID 0x242), External Quality Values (EQV\_ECT, \_EMFISIS, and \_RBSPICE) derived from the Instrument Status Words contained in the SC Time and Status Message (APID 0x100), and an External Quality Value derived from the EFW Conjunction and Campaign Control (CCC, a.k.a. BARREL) function.

The final set of functions shall also include members that can be used to force collection of burst data upon activation. Such forcing functions will find use in both testing, as well as in some on-orbit applications, based on previous experience with similar burst control systems on the FAST, Polar, Cluster, and THEMIS missions.

The selected set of burst trigger functions shall be evaluated 4 times per second, regardless of the cadence at which the underlying data is updated.

## Burst Trigger Data Table

The Internal FilterBank data, External Quality Values, and value of the EFW Conjunction and Campaign function are considered to form a 64-element table (IS TABLE THE RIGHT WORD HERE?) of unsigned 8-bit bytes, organized as shown in :

Table : EFW Trigger Function Data Table

|  |  |  |  |
| --- | --- | --- | --- |
| Table Indices | Description | Source | Comments |
| 0..12 | FB\_INT3\_avg[ 0..12] | DFB (APID 0x242) | Hearts |
| 13..25 | FB\_INT3\_pk[0..12] | DFB (APID 0x242) | Clubs |
| 26..38 | FB\_INT4\_avg[0..12] | DFB (APID 0x242) | Diamonds |
| 39..51 | FB\_INT4\_pk[0..12] | DFB (APID 0x242) | Spades |
| 52 | EQV\_ECT | FSW | Derived from ECT Shared Data in APID 0x100. |
| 53 | EQV\_EMFISIS | FSW | Derived from EMFISIS Shared Data in APID 0x100. |
| 54 | EQV\_RBSPICE | FSW | Derived from EMFISIS Shared Data in APID 0x100. |
| 55 | EFW\_CCC | FSW | Derived from setting of internal EFW Conjunction and Campaign Control flag. |
| 56..63 | SPARE | TBD | For expansion. |

NOTES:

The frequency bands in each block of FB\_INT data are arranged from lowest to highest frequency.

The structure and size of the trigger function data table is predicated on the FB\_INT data being set to the 13-band, full coverage setting, rather than the 7-band partial coverage setting. Behavior of the trigger functions if FB\_INT is in 7-band mode is NOT DEFINED (TBR).

The details of how the Shared Data from ECT, EMFISIS, and RBSPICE is processed into their respective EQVs is TBD, but is discussed in outline form in Section 2.3. Similarly, the details of how the EFW Conjunction and Campaign flag will be implemented and controlled are TBD, but are discussed in outline in Section 2.4 below.

## Burst Trigger Function Definitions

The EFW burst valuation functions operate on the data in the Trigger Function Data Table in order to produce the burst value data needed for on-board burst data selection. These functions are tabulated below in [RBSP\_EFW\_FSW\_005\_CTM:Triggers]:

Table : EFW Trigger Function Defintions

|  |  |  |
| --- | --- | --- |
| Function Number | Name | Formula |
| 0 | Sum1 | Sum( w0i\*TBLi\*H( TBLi – THRESH0i)) |
| 1 | Sum2 | Max( w1i\*TBLi\*H( TBLi – THRESH1i)) |
| 2 | Sum3 | Sum( w2i\*TBLi\*H( TBLi – THRESH2i)) |
| 3 | Max1 | Max( w3i\*TBLi\*H( TBLi – THRESH3i)) |
| 4 | Max2 | Max( w4i\*TBLi\*H( TBLi – THRESH4i)) |
| 5 | Max3 | Max( w5i\*TBLi\*H( TBLi – THRESH5i)) |
| 6 | Test1 | Returns TestValue LSB (located at 0xDDF9) |
| 7 | Test2 | Returns TestValue MSB (located at 0xDDFA) |

NOTES:

H(x) stands for the unit step function, with H(x) = 0 for x<=0 and H(x) = 1 if x >0.

TBLi is the i-th element of the trigger function data table.

wji and THRESHji are 8-bit unsigned bytes that are the weighting factors and thresholds for the i-th element of the data table for the j-th trigger function.

Internal arithmetic in each function is performed with 16-bit (unsigned) accuracy, with the 8-bit unsigned MSB of the result becoming the functions output.

Three instances of each of the Sum and Max functions are included in the definition. While this repetition doesn’t make much sense now, given the identical definitions of the functions, it allows for the addition of response time filtering tailored to the requirements of scoring data for the B1, B2, and EFW\_EXT\_STATUS functions.

Each of these functions can be tailored through the choice of a particular set of weighting factors to respond most strongly to a particular sort of in situ and campaign conditions.

## External Quality Values

EQV\_ECT, \_EMFISIS, and \_RBSPICE are values computed from the Shared Data provided by other instruments and suites on the same Observatory that allow EFW to respond to either environmental cues provided by those instruments (e.g. electron fluxes in a particular energy range as suggested by RBSPICE), or burst support request flags raised by those instruments (e.g. TBD). The interpretation of the Shared Data from the other instruments is not currently defined, and so the concept of the External Quality Value (EQV) has been introduced to buffer the EFW trigger function specification from the details of that definition.

The buffer functions used to compute the EQVs are detailed below. Each shall produce a single 8-bit unsigned byte representing the EQV for the given instrument or suite (in the case of ECT). The conversion functions from Shared Data to EQV for each type are TBD (originally it was thought that a simple function with masks, scale factors, and offsets might serve to define the SD->EQV conversion functions, but further reflection suggests that this is not the case, and that an actual function with logic, etc. is likely to be required.

### ECT

6 bytes (48 bits) total, TBD relevant for EFW burst valuation. Conversion function from 6 bytes of shared data to 1 byte of EQV TBD.

### EMFISIS

4 bytes (32 bits) total, TBD relevant for EFW burst valuation. Conversion function from 4 bytes of shared data to 1 byte of EQV TBD.

### RBSPICE

2 bytes (16 bits) total, TBD relevant for EFW burst valuation. Conversion function from 2 bytes of shared data to 1 byte of EQV TBD.

## EFW External Status

The EFW instrument shall produce 4 bytes (32 bits) of shared instrument data that is reported to the spacecraft for eventual distribution in the SC Time and Status Message (APID 0x100). These data are defined as shown in Table 3:

Table 3: EFW External Status Bytes Definition

|  |  |  |  |
| --- | --- | --- | --- |
| Byte/Bit Indices | Description | Source | Comments |
| 0:0..1 | EFW\_AFT\_AXB\_ILLUM | FSW | Illumination state of aft AXB sensor:  00: constantly illuminated.  01: intermittently-illuminated.  10: constantly shadowed.  11: UNDEFINED. |
| 0:2..3 | EFW\_SWEEP\_STATE | FSW | BIAS sweep state warning:  00: not sweeping.  01: U (12) axis sweeping.  10: V (34) axis sweeping.  11: W (56) axis sweeping. |
| 1:4..7 | SPARE | TBD | For expansion. |
| 2:8..15 | EFW\_EXT\_SUPPORT\_REQ | FSW | Single bit flags indicating EFW burst support requests to specific instruments (TBR):  0: ECT-HOPE  1: ECT-MAGEIS-Low  2: ECT-MAGEIS-Med1  3: ECT-MAGEIS-Med2  4: ECT-MAGEIS-High  5: EMFISIS  6: RB-SPICE  7: SPARE |
| 3:16..23 | EFW\_EXT\_STATUS\_FUNC | FSW | Configuration byte and function identifier for EFW\_EXT\_STATUS function. |
| 4:24..31 | EFW\_EXT\_STATUS\_VAL | FSW | Value reported by EFW\_EXT\_STATUS function. |

The function used to compute the EFW\_EXT\_STATUS is defined in the same way as those used for B1 and B2 scoring, with one important difference. The weighting factors for each of the EQVs shall be zero so as to avoid the possibility of positive feedback between the burst modes of different instruments, and some sort of hysterical orgy of burst requesting.

The EFW\_EXT\_SUPPORT\_REQ is a huge potential can of worms where EFW makes up for lack of computing power on the other side of the inter-instrument interface. PROPOSAL: Apply one of 8 unsigned 8-bit thresholds to the current value of EFW\_EXT\_STATUS\_VAL using the step function, H(x), defined above. Mask the resulting 8-bit word of flags with another 8-bit enable word to produce EFW\_EXT\_SUPPORT\_REQ. 7 bytes total.

# Commanding

This section describes the commands and data required to control the burst trigger function system.

## Commands

Several commands are required to implement the burst trigger function system:

1. Delayed execution (a.k.a. time-tagged) command for setting the value of the EFW\_CCC flag.
2. Delayed execution command for setting/reseting forced burst mode using FN6 or FN7.
3. Immediate and delayed commands for enabling/disabling B1, B2, and EFW\_EXT\_STATUS scoring.

## Tables and Configuration Data

Tables and configuration data that have to be uploaded to the instrument in order to completely specify the parameters required to implement the B1 and B2 trigger functions, as well as the EFW\_EXT\_STATUS function:

|  |  |  |  |
| --- | --- | --- | --- |
| Bytes | Description | Source | Comments |
| 2 | FB\_INT\_CONFIG | SDC | DFB 0x42 (???) CDI command argument, specifying analog data source, cadence, enables, etc. |
| 1 | EFW\_TRIGGER\_CONFIG | SDC | Unique Trigger Config identifier:  0x00: UNDEF.  0x01-0xEF: Flight Configs.  0xF0-0xFF: Config under development. |
| 6\*64\*2 = 768 | EFW\_TRIGGER\_W\_THRESH | SDC | Weight and threshold parameters for functions 0..5 (64 weights and 64 thresholds for each of 6 functions). |
| ??? | EFW\_EQV\_ECT\_PARAMS | SDC | Parameters required for ECT SharedData->EQV function (TBD). |
| ??? | EFW\_EQV\_EMFISIS\_PARAMS | SDC | Parameters required for EMFISIS SharedData->EQV function (TBD). |
| ??? | EFW\_EQV\_RBSPICE\_PARAMS | SDC | Parameters required for RBSPICE SharedData->EQV function (TBD). |
| 9 | EFW\_EXT\_SUPPORT\_REQ\_PARAMS | SDC | 8 8-bit thresholds, 1 8-bit enable mask (TBR). |
| 1 | CHECK\_SUM | SDC |  |
| TOTAL |  |  |  |
| >779 bytes |  |  |  |

# Burst ConOps

This section details various aspects of the concept of operations of the EFW burst trigger system, and needs further detailing!

## Enforced Burst Collection and Playback

We can through commands from the ground cause the instrument to burst during a certain time interval. We can also by ground command cause that data to be sent to the ground. This insures we have burst data to support the BARREL balloon campaign.

## Burst Disables

We will have the ability to disable bursting during EFW sweeps and during spacecraft thruster firings, during eclipses, and during eclipse transitions. The burst record mode will have the ability to be turned on or off for specific intervals of time based on commands uplinked from the ground that specify specific time intervals.

## Ground Burst Diagnostic Modes

EFW will implement burst diagnostic modes (TBD) that allow us to record and playback brief intervals of data during instrument check out and calibration.

## Reconfiguration of Burst Trigger System

## Burst trigger algorithms will be changed through time tagged commands to the instrument and will not be changed autonomously by instrument software (TBR).

# Documentation of Mode History and Purpose

The EFW-SOC-SDC shall implement a configuration-controlled list of the instrument burst modes, a log of when they were implemented, a text file which states the purpose of the mode. The EFW team will also maintain a log which contains comments by EFW team members on the effectiveness or problems of the mode.

# Appendix 1: Original Burst Trigger Function Definitions (from Rev ‘-‘).

The original burst trigger function definitions from rev – are included below, along with notes on how they map to the definitions in this rev.

|  |  |  |
| --- | --- | --- |
| Option | Burst Algorithm function | Comment |
| Option 0  Default | [A1\*FB\_INT1+A2\*FB\_INT2+A3\*FB\_INT3+  A4\*FB\_INT4+A5\*FB\_INT5+A6\*FB\_INT6+  A7\*FB\_INT7  A8\*XFACT]  Greater than T1  **THIS WOULD BE IMPLEMENTED BY AN INSTANCE OF THE SUM FUNCTION.** | Broad band signal  (Spikes) with additional weighting due to external factors: other RBSP instruments/  Barrel |
| Option 1 | (A1\*FB\_INT1+A2\* FB\_INT2+A9\*XFACT) OR (A3\*FB\_INT3+A4\* FB\_INT4+A9\*XFACT) OR (A5\*FB\_INT5\*+A6\*FB\_INT6+A9\*XFACT) OR  (A7\*FB\_INT7+A8\*EF5)  Greater than T1  **THIS WOULD BE IMPLEMENTED BY AN INSTANCE OF THE MAX FUNCTION.** | Trigger off quasi-monochromatic wave in on of each of 4 band passes (IC, KAW, LH, Whistler) includes external factors as before |
| Option 2 | [(A1\*FB\_INT1+A2\*FB\_INT2+A3\*FB\_INT3+  A4\*FB\_INT4+A5\*FB\_INT5+A6\*FB\_INT6+A7\*FB\_INT7]  Greater than T1  AND [XFACT>XTHRESH1]  **NO DIRECT MAPPING TO REVISED SET OF FUNCTIONS; revised functions don’t implement external factors as a “gate” like this would require.** | As Option 0 above but ‘AND’s additional external  Factors |
| Option 3 | [(A1\*FB\_INT1+A2\*FB\_INT2) OR (A3\*FB\_INT3+A4\*FB\_INT4) OR (A5\*FB\_INT5\*+A6\*FB\_INT6) OR  (A7\*FB\_INT7) ]  Greater than T1  AND [XFACT>XTHRESH1]  **NO DIRECT MAPPING TO REVISED SET OF FUNCTIONS; revised functions don’t implement external factors as a “gate” like this would require.** | Option 1 with AND on  external factors |