CLUSTER II EFW

COMMAND AND TELEMETRY DESCRIPTION

VERSION 2.1

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Revision H

Peter R. Harvey
Space Sciences Laboratory
University of California at Berkeley
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Contents

Revision History

Date	Revision Description
01/90	CLUSTER EFWCTM Start
A:10/90	Added Command Descriptions Added Sampling Plans
B:11/90	Post - EIDR ICD update
C:02/91	Telemetry Functions Definition Burst Sampling Frequencies Sample Fine-Timing Defined Deleted Self-Test Command
D:04/91	Burst Command and Telemetry Format changes FDM Burst status. Command descriptions updated. SPIN FIT format added. DSC format described.
E:10/91	Updated "EFW Telemetry Blocks" from 9x to xx Inserted user command names for qty functions. Engineering Model Telemetry Format Freeze
F:05/92	Flight Software Upgrade.
G:05/94	Additional notes post WEC testing [Burst triggering] [Burst threshold must be nonzero] [Sample Timing for tape modes] [FDM timing] [DSC invalid after reset] [Sync code decimal incrementer] [Added clock reporting] [BP34->BP12] [SCP format no longer has boom#]
H: 01/99	Update to Word 6.0 format Include Cluster II Updates to the telemetry stream. Stub has been replaced with Puck throughout the document.

1 Introduction.

The following is a description of the commands and telemetry for the Electric Fields and Waves (EFW) instrument on the four International Solar Terrestrial Program Cluster II spacecraft.

The chief purpose of this document is to guide a user in operating the EFW instrument. Associated documents are listed in EFW_LIST.DOC.

2 Commands

The Cluster EFW instrument communicates with the spacecraft electronics by a single 38.4 kbaud serial link with the University of Sheffield's DWP unit. EFW accepts commands, telemetry codes and magnetometer data from the DWP unit, and ships telemetry data in the opposite direction.

Commands are formatted with a header byte "C0" as follows:

<C0><HH><LL>

where "C0" signals the beginning of a command whose value is "HHLL".

Fluxgate magnetometer data is transferred to the EFW at **16** Hz using the format:

<BF><XH><XL><YH><YL><ZH><ZL>

Telemetry format selection as well as timing synchronization is performed by a Sync code. Each sync code is transmitted at the 1 second mark.

<F0> : Selects NORMAL mode
<F1> : Selects TAPE1 mode
<F2> : Selects TAPE2 mode
<F3> : Selects TAPE3 mode

2.1 Command Formats

The instrument decodes several internal formats for the commands. Available command format options are:

Op	Bit Structure
0	8-bit opcode, 8-bit data field
1	5-bit opcode, 3-bit address field, 8-bit data field
2	5-bit opcode, 3-bit address field, 2 4-bit data fields
3	5-bit opcode, 11-bit data field.
4	8-bit opcode, 8-bit Real-Time Quantity Descriptor.
5	8-bit opcode, 8-bit Burst Quantity Descriptor

At the GSE, the user normally allows the computer to format the command but is also allowed to input the hex command code directly. A "period" in column 1 indicates an instrument command. For example, to set GUARD 2 to 64, the user types:

".GUARD 2 64"   or in hexadecimal: ".1240"

The EFW command summary table is listed next followed by more detailed descriptions of the commands after that.

Table 1.CLUSTER ELECTRIC FIELD INSTRUMENT COMMAND ASSIGNMENTS

Op	Hex	Binary	Name	Usage
0	0000	`00000,bbb,dddddddd`	BIAS	BIAS Boom(b)= d
1	0800	`00001,bbb,dddddddd`	PUCK	PUCK Boom(b)= d
1	1000	`00010,bbb,dddddddd`	GUARD	GUARD Boom(b)= d
1	1800	`00011,bbb,-------0`	EFIELD	EFIELD Boom(b)
1	1801	`00011,bbb,-------1`	DENSITY	DENSITY Boom(b)
0	2000	`00100,000,-------x`	INFERO	INTERFEROMETER =(x)
0	2800	`00101,000,------xx`	SAMPLECTL	SAMPLECTL(x)
1	3000	`00110,bbb,-------x`	MOTOR	Set Motor(b) ON/OFF
0	4000	`01000,000,--xxxxxx`	HXFMT0	HX FMT INDEX MODE 0
0	4100	`01000,001,--xxxxxx`	HXFMT1	HX FMT INDEX MODE 1
0	4200	`01000,010,--xxxxxx`	HXFMT2	HX FMT INDEX MODE 2
0	4300	`01000,011,--xxxxxx`	HXFMT3	HX FMT INDEX MODE 3
0	4400	`01000,100,--xxxxxx`	LXFMT	LX FMT INDEX
0	4500	`01000,101,--xxxxxx`	BFMT	BURST FMT INDEX
0	4600	`01000,110,--xxxxxx`	INDEX	Format Index (i)
4	4700	`01000,111,xxxxxxxx`	QTY	Telem Qty(i++) =(x)
5	4700	`01000,111,xxxxxxxx`	BQTY	Burst Qty(i++) =(x)
3	4800	`01001,xxx,xxxxxxxx`	RAMBASE	RAM Address = (x)
0	5000	`01010,000,------xx`	FITMODE	Spin Fit Mode = (x)
0	5800	`01011,000,xxxxxxxx`	SAWOFF	SAWTOOTH Offset=(x)
0	5900	`01011,001,xxxxxxxx`	SAWDEL	SAWTOOTH Delta =(x)
0	5A00	`01011,010,xxxxxxxx`	SAWPER	SAWTOOTH Period=(x)
0	5B00	`01011,011,xxxxxxxx`	SAWDIV	SAWTOOTH Divider=(x)
0	5C00	`01011,100,----dcba`	SAWOPT	SAWTOOTH Options=(dcba)
0	5D00	`01011,101,----dcba`	SAWENA	SAWTOOTH Enables=(dcba)
0	6000	`01100,000,--xxxxxx`	SWPADR	SWEEP Address=(x)
0	6100	`01100,001,xxxxxxxx`	SWPQTY	SWEEP QTY =(x)
0	6200	`01100,010,-----ppp`	SWPREBIAS	SWEEP PREBIAS (p)
0	7007	`01110,000,00000111`	MRESET	Resets Main CPU
0	7008	`01110,000,00001000`	ADRESET	Resets A/D
0	7800	`01111,000,n--f----`	ADPOWER	A/D POWER ON/OFF

TABLE 1. CLUSTER ELECTRIC FIELD INSTRUMENT COMMAND ASSIGNMENTS (Continued)

Op	Hex	Binary	Name	Usage
0	A000	10100,000,rpvvvvaa	BTRIG	BURST TRIGGER=(rpva)
0	A100	10100,001,mmmmmmmm	BCHIRP	BURST CHIRPCTL=(m)
0	A200	10100,010,sssscccc	BPAGES	BURST PAGES=(sc)
0	A300	10100,011,tttttttt	BTHRESH0	BURST THRESH0=(t)
1	A400	10100,1rr,xxxxxxxx	BPARAM	BURST Param[r]=(x)
0	A800	10101,000,x-ss-fff	BFREQ	BURST FREQ =(xsf)
0	B000	10110,000,----psss	BSTATE	BURST STATE=(ps)
0	B800	10111,000,------xx	BPLAY	BURST PLAYBACK()
0	B000	10110,000,00000000	BSTOP	BURST STOP
0	C000	11000,000,xxxxxxxx	CMDWT	Command Wait (x) /1
0	C800	11001,000,xxxxxxxx	CMDS	Command Counter = (x)
0	D000	11010,000,--------	DEP_STOP	Deploy STOP
0	D100	11010,001,uuuuuuuu	DEP_A	Deploy A_side (u)
0	D200	11010,010,uuuuuuuu	DEP_B	Deploy B_side (u)
0	D300	11010,011,uuuuuuuu	DEP_BOTH	Deploy A&B (u)
0	D400	11010,100,mmmmmmmm	DEP_OVER	Set Override (m)
0	D500	11010,101,------pp	DEP_PAIR	Select Pair {1|3} /2
0	E800	10111,011,llllllll	ADRL	MAIN Address Low (l)
0	E900	10111,100,hhhhhhhh	ADRH	MAIN Address High (h)
0	EA00	10111,101,xxxxxxxx	LOAD	MAIN Load Byte (x)
0	EB00	10111,110,--------	EXEC	MAIN Execute Program
0	F000	11110,000,-------x	SCVMODE	S/C POT. POLARITY
0	F800	11111,000,xxxxxxxx	TEST	TEST Number (x)

Notes:

(/1) The DELAY command is used to sequence command strings loaded into the memory of the EFW instrument. See COMMAND SEQUENCING below.

(/2) The DEP_PAIR command must be issued prior to the forward deployment commands in order to select which pair of booms to deploy.

2.2 Command Descriptions

2.2.1 Bias, Puck, and Guard Commands

On all ISTP-class E-Field instruments, the electric field probes have sensors whose surface potentials can be controlled in three places. For Cluster II, these sections are called SPHERE, PUCK and GUARD.

An important capability of the instrument is that of applying bias currents to the SPHERE section. The impedance between the sensor and the plasma is a non-linear function of the current flowing between them and it exhibits a minimum at a value of bias current which depends upon the plasma conditions. Thus, the accuracy of the electric field instrument can be maximized by applying the optimum value of bias current to the sphere.

In Cluster II, the preamplifiers are located in a "hockey puck" shaped housing, affectionately termed "puck". The puck is electrostatically connected to a voltage equal to the sphere output plus or minus a small DC offset so as to force its potential to be near that of the sphere, and, thus, to minimize the perturbing effect of the puck on the plasma.

To prevent a positively charged spacecraft from attracting electrons away from the sensors, a small section (10cm), called the GUARD, is placed between the shield and the puck sections. The guard section is adjusted to be more negative than the sphere and puck sections and its potential with respect to the sphere is controlled as described below.

To set any of these DAC's, use the appropriate command:

```
.BIAS b d
.PUCK b d
.GUARD b d
```

where b is the sensor number (1 through 4), and d is a 2's complement 8-bit value (+127 to -127).

To save a lot of commanding, the IO system can command all 4 sensors at the same time. This is accomplished by setting the sensor number “b” to 7. For example, to set all 4 Pucks to 125:

```
.PUCK 7 125
```

Register#0 is handled as a no-operation, while registers #5 and #6 are pseudonyms for pairs 1&2 and 3&4, respectively.
Normally it is the responsibility of the instrument software to periodically sweep the bias current on each sensor pair and determine the optimum biasing point. Thus, the user is cautioned that the SWEEP module must be disabled prior to using the BIAS command effectively.

2.2.2 Sensor Mode Control

Unlike other ISTP instruments, Cluster EFW sensor mode control is not automatic. There is no "executive" mode command switching the sensors from E-Field to Density, and so forth.

As part of the Wave Consortium, the EFW mode is controlled directly and in concert with other WEC instruments. The sensors are individually commandable as follows:

```
.EFIELD b
.DENSITY b
```

As soon as these commands are entered, the sensors will be configured to make the appropriate measurement. During SWEEPs, the mode may be temporarily controlled by the SWP module but will be restored to the user-selected mode at the end of the sweep.

To save commanding, the IO system can command all 4 sensors into the same mode at a time. This is accomplished by setting the sensor number "b" to 7. For example, to set all 4 sensors to EFIELD mode:

```
.EFIELD 7
```

2.2.3 Differential Mode Control

All ISTP instruments measure the voltage difference between opposing sensors. Sensors 1 and 2, 3 and 4 are opposite each other and the voltage difference between them is called V12 and V34.

The EFW instrument has an additional ability to measure the difference between non-opposing spheres; i.e. the voltage between sensors 1 and 4, and sensors 1 and 3. These measurements are made when the instrument is in the INTERFEROMETRIC mode. The user may select this mode using the command:

.INFERO x

where if x = 1 selects the interferometic mode.

2.2.4 Sample Mode Control

The EFW software coordinates Real-Time sampling along with Burst (high frequency) data collections using an 80-element sampling buffer. The details of the hardware are given in the EFWHW.DOC. The total A/D rate is 36000 sample-pairs per second which fills 450 buffers per second.

EFW software must allocate samples out of this total collection rate between the real-time samples, burst samples, boom monitoring, sweep collection points, etc. The user controls how much of the samples may be used for real-time and non-burst versus how many can be used by the burst.

There are four "sample" modes available: NORMAL, SPLIT, HXONLY and NULL. In NORMAL mode, all real-time and monitoring samples are allowed while Burst operations are limited to the remaining sample-list elements (see SAMPLING.SCH drawing). While in NORMAL mode, the Burst can sample up to 9000 sample-quadruplets per second.

The SPLIT mode allows the user to push the burst frequency to 18000 sample-pairs. In this mode, the real-time samples are taken 1/18000th of a second apart instead of 1/36000th.

The NULL mode turns off real-time and monitoring and allows the Burst to take all 36000 sample-pairs. Obviously, since the real-time cannot take data, the telemetry is undefined in this mode.

To make the V12 and V34 ("HX") samples available to telemetry, there is a variation of the NULL mode. Called the HXONLY mode, this mode allows the Burst to take all 80 elements of the sampling buffer but overwrites the HX slots anyway. This means that the data in the Burst memory will actually have HX data instead of Burst data every 40 sample-quadruplets.

The user may select these modes directly using the command:

- .SAMPLECTL x

where x is 0-3 to select one of {NORMAL,SPLIT,HXONLY,NULL}.

SAMPLECTL bits are normally operated by the Burst control logic when it begins sampling. When it stops sampling, it resets the SAMPLECTL bits to NORMAL mode. Whenever these transitions occur, the sampling table is reorganized and it is expected that some real-time samples will be effected. See the BFREQ command below for the format of these bits there.

2.2.5 Telemetry Processing Commands

The ISTP E-Field instruments use tables which determine the sampling format. Two tables, called HX and LX, define the High Rate and Low Rate sampling channels profile, respectively.

The MAIN computer manages a small table (56 bytes) in order to provide flexible telemetry formatting capabilities to the user. Using the commands, INDEX, QTY, and BQTY the user can modify the table anyway he/she likes. In order to remember what was programmed and check it, the entire table is played out in the DSC every 32 seconds. The table is filled with a number of telemetry format lists, each is intended to instruct the sampling of HX, LX or Burst data. Each list ends with an End-Of-List marker. Lists can be any length, subject to the overall limit of 56 bytes.

Once the lists are established, the HX, LX and Burst sampling software must be told which list to use. Six values are defined for this purpose, four for HX, one for LX and one for Burst respectively as follows:

- HXFMT0 : Used in Mode 0 (NORMAL)
- HXFMT1 : Used in Mode 1 (TAPE1)
- HXFMT2 : Used in Mode 2 (TAPE2)
- HXFMT3 : Used in Mode 3 (TAPE3)
- LXFMT : Used in all modes
- BFMT : Used in all modes

To load the table or just part of the table, a format one uses the ".INDEX n" command which selects the starting point within the table and a series of "QTY q" or "BQTY q" which describe the format sample. The End-of-List quantity is used to end the list. For example, to load a format at the midway point of the table with alternating V12L and V34L samples:

- .INDEX 32
- .QTY V12V34L
- .QTY EOL

To select this table for LX transmission:

- .LXFMT 32

Note that the user can re-use parts of the same list by adjusting pointers cleverly, and this would mainly be used to change playback enable profiles. Once the tables are defined, the EFW will automatically switch between HXFMT's whenever commanded to change telemetry modes.

Each channel descriptor “q” can describes a set of samples which can be either MAIN multiplexor samples, RAM locations or can select one of a set of functions. To select a multiplexor pair, simply name the quantity, such as “V1V2L” or “V3V4L”.

Hx and Lx (real-time) quantity descriptors include one bit which, if enabled, allows playbacks to preempt them. To indicate that playbacks may preempt the channel, add “PLAYBACK” to the command. For example,

- .QTY V1V2L PLAYBACK

QTY DESCRIPTOR	ID	INTERPRETATION
P000 0000	V1V2L	MUX0 ADDRESS(0) & MUX1 ADDRESS(0)
P000 0001	V1V2M	MUX0 ADDRESS(1) & MUX1 ADDRESS(1)
P000 0010	V1V2H	MUX0 ADDRESS(2) & MUX1 ADDRESS(2)
P000 0011	V1V2U	MUX0 ADDRESS(3) & MUX1 ADDRESS(3)
P000 0100	V3V4L	MUX0 ADDRESS(4) & MUX1 ADDRESS(4)
P000 0101	V3V4M	MUX0 ADDRESS(5) & MUX1 ADDRESS(5)
P000 0110	V3V4H	MUX0 ADDRESS(6) & MUX1 ADDRESS(6)
P000 0111	V3V4U	MUX0 ADDRESS(7) & MUX1 ADDRESS(7)
P000 1000	V12V34M	MUX0 ADDRESS(8) & MUX1 ADDRESS(8)
P000 1001	V34V12H	MUX0 ADDRESS(9) & MUX1 ADDRESS(9)
P000 1010	SCXSCY	MUX0 ADDRESS(A) & MUX1 ADDRESS(A)
P000 1011	SCZBP12	MUX0 ADDRESS(B) & MUX1 ADDRESS(B)
P000 1100	STAT12	MUX0 ADDRESS(C) & MUX1 ADDRESS(C)

P000 1101	STAT34	MUX0 ADDRESS(D) & MUX1 ADDRESS(D)
P000 1110	ADTPWR	MUX0 ADDRESS(E) & MUX1 ADDRESS(E)
P000 1111	REF1PWR	MUX0 ADDRESS(F) & MUX1 ADDRESS(F)

(continued)

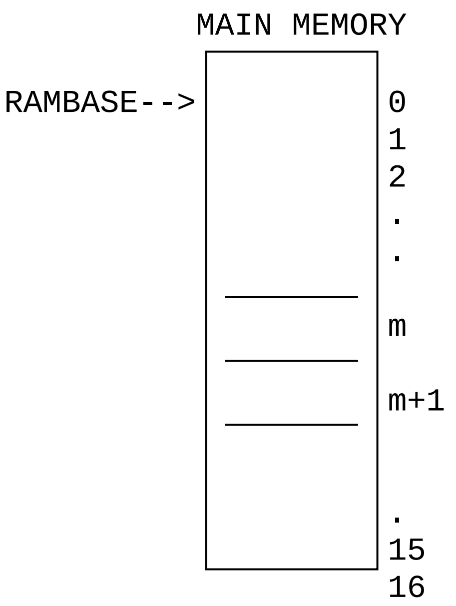
QTY DESCRIPTOR	ID	INTERPRETATION
P001 0000	V12V34L	FUNCTION "V12L & V34L"
P001 0001	V12V3L	FUNCTION "V12L & V3L"
P001 0010	V12V4L	FUNCTION "V12L & V4L"
P001 0011	V1V34L	FUNCTION "V1L & V34L"
P001 0100	V2V34L	FUNCTION "V2L & V34L"
P001 0101	BPCBP12	FUNCTION "BPC & BP12"
P001 0110	V12V3M	FUNCTION "V12M & V3M"
P001 0111	V12V4M	FUNCTION "V12M & V4M"
P001 1000	V1V34M	FUNCTION "V1M & V34M"
P001 1001	V1V2V3M	FUNCTION "V1M & V2M & V3M
P001 1010	V12V3V4M	FUNCTION "V12M & V3M & V4M"
P001 1011	V12V32V4M	FUNCTION "V12M & V32M & V4M"/1
P001 1100	V1V2V3V4M	FUNCTION "V1M & V2M & V3M & V4M"
P001 1101	V12V34V32M	FUNCTION "V12M & V34M & V32M"/1
P001 1110	V12LX25HZ	FUNCTION "V12L AT 25 HZ IN LX"/2/3
P001 1111	V32LX25HZ	FUNCTION "V32L AT 25 HZ IN LX"/2/3
P1aa aann RAM VALUE (RAMBASE+a, n+2 words)		
P=1 INDICATES CHANNEL ENABLED FOR PLAYBACK DATA		

/1: The V32 sample cannot be taken when SAMPLEMODE is "SPLIT".

/2: The "LX25Hz" functions must be the only function in the LX list, and generate 25 Hz samples plus 5 words of fill. User vectors are available to change these functions.

/3: In Version 2.1, the FUSER0 and FUSER1 programmable functions are accessed by programming their vector addresses. Until programmed, these functions return V12LX25Hz and V32LX25Hz by default.

RAM quantities (defined by a -1------ in the quantity descriptor) are simply values taken from the memory of the MAIN computer system. These are of interest mainly for diagnostic purposes when it is important to have a high bandwidth of information regarding some variables in the computer memory. Since there is a lot of RAM and only 4-bits of possible indexation, the RAM quantities use a programmable 16-bit base address called RAMBASE. The 4-bits are added to RAMBASE to produce an effective address from which data are retrieved. Two bits of the RAM definition indicate how many words are to be played (since RAM diagnostics can replace 2, 3, or 4 word qty descriptors). A code of 00 indicates 2 words, 01 = 3 words, etc.



To select a RAM quantity 0 thru 15, use the for ".QTY RAM n". To set the value of RAMBASE, use the command

.RAMBASE n

(This allows 11-bit values to be loaded into RAMBASE. For other values, use the .LOAD facility to load the RAMBASE pointer directly).

2.2.6 Spin Fit Telemetry Control

Spin fits are performed on the E-Field signal from two pairs of spin plane sensors. Samples are taken from each boom pair at 32 equal angles during each spin. Since a boom pair may be in the DENSITY mode, the fitter can be turned off by the user using the options command

.FITMODE xx

where x is the option bits which can turn on/off fits and data tranmissions. The format of x is as follows:

000000YX

x = 1 to disable V12 fits & y = 1 to disable V34 fits

2.2.7 Sawtooth Control

For diagnostic purposes, one may want to sweep the biasing voltage on the spheres. The SAWTOOTH module is available to generate sawtooth sweeps or square waves on the sphere BIAS voltages of selected sensors.

The waveforms are described by the following commands:

- .SAWOFF d : The starting BIAS value.
- .SAWDEL d : The size of each BIAS step.
- .SAWPER x : The number of steps up to the top.
- .SAWDIV x : The divider of 25 Hz to set the desired step rate.
- .SAWOPT m : Selects which sensors to control.
- .SAWENA m : Enables which sensors to control.

where d are 2's complement values, x are 8-bit unsigned values, and m is the mask for sensors {----4321}. The SAW module AND's OPT and ENA together to decide on bias enables.

For example, to produce a sawtooth with a 16 second period (8 seconds up, 8 secs down) starting at a BIAS value of -50 and going to a value of +49, using spheres 3 and 4, the user would enter:

- .SAWOFF -50 (Starting Bias Offset)
- .SAWDEL1 (Bias step size)
- .SAWPER 100 (Period = 100 steps up)
- .SAWDIV 2 (Take steps at 25/sawdiv = 12.5 Hz)
- .SAWOPT0x0C (Enable 3 and 4 probes)

See the SAWEXA.SCH drawing for more examples.

2.2.8 Automatic Bias Control

To modify the automatic bias sweep module parameters, two commands are included to change the default values. These are

- .SWPADR i Sets the relative address to load a byte
- .SWPQTY x Loads the byte

These could be implemented by using the LOAD command, etc., except that you would always have to remember the memory addresses for the SWP module variables. The list of quantities versus value is on the next page. The default index value is always 0 so that the first SWPQTY command sets the SWPSTATE reg.

The third SWP module related command is the SWEEP Rebias command. This command takes the last result calculated by the automatic bias sweep module and commands the biases to that sensor pair. This command is used internally for mode switching.

- .SWPREBIAS p

where p = sphere pair {1,3}.

The SWEEP Parameters which the user can set via the above commands fall into three sections: the overall timing control, the V12 parameters and the V34 parameters. These are described below:

The NSPINS parameter determines how often to perform sweeps, by waiting (8 * NSPINS) between sweeps. The module performs a V12 sweep, waits 8*NSPINS, performs a V34 sweep, and so forth. The default value of NSPINS is 56, so sweeps occur at 30 minute intervals.

The SWEEP STATE register is used to begin sweeps at the executive level. When the proper number of spins have occurred, the STATE will be set to a value of 1. To disable all sweeps, the user may set STATE= 2 or 3.

The OPTIONS register (for either V12 or V34) controls which types of sweeps are performed, whether the results are used and/or transmitted. The format is:

xxxxRXDE

where e = 1 enables the E-Field mode (Current biasing sweeps)
d = 1 enables the Density mode (Voltage biasing sweeps)
x = 1 enables the playback of the sweep data
r = 1 enables the calculated RESULTS to be sent to BIAS.
(r=0 selects the ALTERNATEs be sent to BIAS regs)
If neither e nor d are set, no sweep is performed.

The SUN_ANGLE register is the angle at which to begin the sweep. The angle is in units of 1.41 degree and 0 is defined by V1 pointing at the sun.

The ALGORITHM number is set when the program begins and indicates that the ROM is in control. If the user loads a program which redefines the SWEEP sequence or parameter definitions, the user should change the ALGORITHM number so that Data Analysis knows about it.

The SWEEP COLLECTION phase has 8 parameters, 4 for each collection mode (E-Field and Density). For each mode, BIAS0 defines the starting BIAS value, STEP defines the BIAS step size, RATE defines the rate at which steps are taken, and LENGTH defines the total number of steps in the sweep. Steps can be taken at a 150 Hz rate and the default RATE divider is 2 which yields a 75 Hz stepping rate. It is known that E-Field IBias sweeps should be negative in slope for the best results.

The SWEEP ANALYSIS phase requires 2 parameters which are (a) the number of points to average together when determining the slope and (b) the maximum delta-V allowed before a point is considered noise. The defaults are AVERAGE = 5 points and NOISE

LIMIT = 32. The number of points rejected from the curve is set by the SWEEP algorithm and is called NREJECT.

Sweeps alternate between sphere pairs 12 and 34. The sweep cycling (defined by #SPINS) is the delta-spins between the two sweeps, whether or not the sweeps are enabled. For example, if sweep34 is disabled, the code will wait NSPINS after sweeping 1&2 to find that sweep34 is disabled, then wait NSPINS again before running sweep12. This keeps sweep timing on a given pair the same regardless of the other pair.

ISTP E-FIELD SWEEP OPTIONS

[]	Quantity	Default/Comment
0	SWEEP STATE	3 = Inactive
1	#_SPINS TO WAIT	56 = 450 spins = 30 Minutes
2	V12 OPTIONS	7 = I,V,Transmit Enabled
3	V12 SUN ANGLE	144 = 203 Degrees
4	V12 ALGORITHM #	1 = 0.1 Version
5	V12 ALTERNATE 1	-10 = -40 nAmps
6	V12 ALTERNATE 2	-10 = -40 nAmps
7	V12 RESULT 1	0
8	V12 RESULT 2	0
9	V12 # POINTS TO AVERAGE (M)	5 = 5 Points
10	V12 NOISE PASS LIMIT (N)	32 = 32 A/D codes
11	V12 # POINTS REJECTED	0 = 0 Points
12	V12 VMODE DAC STEP VALUE	-2 = 7.8 nA
13	V12 VMODE DAC START VALUE	64 = 250 nA
14	V12 VMODE RATE	2 = 75 HZ
15	V12 VMODE LENGTH	64 = 64 Points
16	V12 IMODE DAC STEP VALUE	-8 = 2.5 V
17	V12 IMODE DAC START VALUE	64 = 20 V
18	V12 IMODE RATE	2 = 75 HZ
19	V12 IMODE LENGTH	32 = 32 Points
20	V12 Spare0	0
21	V12 Spare1	0
22	V34 OPTIONS	7 = I,V,Transmit Enabled
23	V34 SUN ANGLE	208 = 292 Degrees
24	V34 ALGORITHM #	1 = 0.1 Version
25	V34 ALTERNATE 1	-10 = -40 nAmps
26	V34 ALTERNATE 2	-10 = -40 nAmps
27	V34 RESULT 1	0
28	V34 RESULT 2	0
29	V34 # POINTS TO AVERAGE (M)	5 = 5 Points
30	V34 NOISE PASS LIMIT (N)	32 = 32 A/D codes
31	V34 # POINTS REJECTED	0 = 0 Points
32	V34 VMODE DAC STEP VALUE	-2 = 7.8 Na
33	V34 VMODE DAC START VALUE	64 = 250 nA
34	V34 VMODE RATE	2 = 75 HZ
35	V34 VMODE LENGTH	64 = 64 Points
36	V34 IMODE DAC STEP VALUE	-8 = 2.5 V
37	V34 IMODE DAC START VALUE	64 = 20 V
38	V34 IMODE RATE	2 = 75 HZ
39	V34 IMODE LENGTH	32 = 32 Points
40	V34 Spare0	0
41	V34 Spare1	0

2.2.9 Burst Sample List Definition

Burst sample lists for EFW are as easy as real-time lists. Basically, bursts use the same format list memory as HX and LX described above. The user points to an area of this memory using the ".INDEX" command and then formats the quantities desired using the ".BQTY" command. To end the list, use ".BQTY EOL". To select which list should be sampled, the user specifies the index of the start of the list (like LXFMT) as follows:

- .BFMT nn

where nn is the index of the list. To be sure what we're programming, the list is played in the DSC. An End-of-List is required to terminate the list. All burst quantity descriptors must have the MSB=1, and Burst lists must be 2**n in length. The user selects Burst quantities from the table below, pairs them up and puts them in a command list as follows:

- .INDEX 10
- .BQTY BV1M BV2M
- .BQTY BV3M BV4M
- .BQTY BSCX BSCY
- .BQTY BSCZ BV12H
- .BQTY eol

Once defined, sample formats may be selected at will by using the BFMT command; i.e. you don't have to re-define the RAM list each time you use it. You can switch around between the different formats as conditions may warrant. Upon reset, several BURST formats are defined in the formatting buffer along with the default real-time sampling lists.

The elements of the Burst lists are different than those found in the HX and LX lists. Basically, the elements are the actual bytes which are copies in the 80 element MUX buffer. Thus, they are formatted as follows:

1bbbaaaa

where a is the 4-bit multiplexor selection for AMUX0, and b is the 3-bit selection for AMUX1. The MSB of the AMUX1 is defined by the MSB of AMUX0. The uppermost bit indicates this data is to be copied to the Burst memory system. The following table lists the quantities available on these muxes to the Burst system:

BURST QUANTITIES TABLE

CHAN	A/D#0	A/D#1	COMMENT
0	BV1L	BV2L	10 HZ
1	BV1M	BV2M	170 HZ
2	BV1H	BV2H	4000 HZ
3	BV1U	BV2U	16 HZ
4	BV3L	BV4L	10 HZ
5	BV3M	BV4M	170 HZ
6	BV3H	BV4H	4000 HZ
7	BV3U	BV4U	16 HZ
8	BV12M	BV43M	170 HZ
9	BV43H	BV12H	16 HZ
A	BSCY	BSC2	4000 HZ
B	BSCX	BBP12	4000 HZ
C	BSTAT1	BSTAT2	-----
D	BSTAT3	BSTAT4	-----
E	BADTEMP	BPWR28I	-----
F	BREF	BPWRTEMP	-----

2.2.10 Burst Frequency / Sample Mode Control

The BURST software is capable of sampling a list of quantities at a number of frequencies. These frequencies are listed in the table below. It is important to observe that the frequency is for the whole list, not individual quantities, and thus the size of the sample list defines the maximum frequency at which it can be sampled.

The command which set the BURST sample frequency is

- .BFREQ x.ss.fff

where ss are the SAMPLECTL bits to use while collecting the burst, and fff is a frequency code from 0 to 6. (See the table below for the equivalent frequency.) Parameter “x” is the HX_override in the event that the user wishes the HX samples to be stored in the memory (used in the HXONLY mode).

If a frequency is requested which is greater than the maximum for a given list, the BURST software will sample at the frequency selected but with an appropriately shorter list of quantities. The frequency code is independent of the sampling lists so that one does not need to re-command the frequency when one changes lists. Also, the frequency code is not modified by the BURST software even when it describes a frequency which is impossible for a given list. Thus, one can set the frequency either before or after one defines or selects the sample list without fear that these other commands may effect the frequency.

BURST FREQUENCIES TABLE

		----- LIST LENGTH MAX PER MODE -----			
CODE	FREQ	NORMAL	SPLIT	HXONLY	NULL
6	36000	------	------	1 pair	1 pair
5	18000	------	1 pair	2 pair	2 pair
4	9000	2 pair	------	4 pair	4 pair
3	4500	4 pair	------	8 pair	8 pair
2	2250	4 pair	------	8 pair	8 pair
1	900	4 pair	------	8 pair	8 pair
0	450	4 pair	------	8 pair	8 pair
7	25	1 pair	------	------	------

(*) In HXONLY mode, the top 2 slots of the 80 element table are replaced by HX samples. See SAMPLING.SCH for details of the mux buffering.

During the period of collection, the Burst logic will instruct the BKG sample coordination to use the SAMPLECTL bits from the BFREQ register. When the collection has finished (usually during playback), the SAMPLECTL is returned to NORMAL mode.

2.2.11 Burst Collections at 25Hz

In Version 2.1, Burst Collections are able to take data at 25 Hz in sync with Magnetometer samples during the non-telemetry periods. Since the hardware collects data at a minimum of 450 Hz, flight software must be employed to collect the data. This function is implemented by having the Burst module operate at 25 Hz (up from 5 Hz). If frequency code 7 is employed, the software copies whatever the HX samples just formatted. Thus, the HX list can be used to identify what to store and it guarantees that the sample timing is the same as in real-time mode. The user must point the BFMT to a list that contains no most significant bits set.
For example,

    .INDEX 26

```
.QTY    V12V34L
.QTY    EOL
.BFMT   26
```

There are no MSB's in the list which describes V12V34L as the only quantity sampled.

2.2.12 Burst Triggering

Selecting when to start and stop Burst collections is performed by "triggering" software. A number of routines can be selected, three in ROM and one in RAM. The RAM routine is commanded from the ground. The trigger command is as follows:

- .BTRIG rpaaaatt

where r = 1 enables repeating a new burst collection following a playback; p=1 enables automatic playback after data collection; aaaa = the amount to adjust the triggering level after a collection; and tt is a routine# 0 to 3 to evaluate and rate the “value” of the current conditions. More on these below.

Whenever any of the control or algorithm parameters are going to be changed, the user should set the burst trigger to “OFF”. This keeps algorithms from being executed using partial parameters and so forth. The impact to the user is that the last command should be the setting of the burst trigger (BTRIG command).

The EFW burst logic is shown in the BURSTFSM.SCH drawing and briefly described as follows:

STARTUP: Sets the SAMPLECTL to user selection.
Compiles the Burst list into the multiplexor area.
SEARCH_PAGE = 0.

RESTART: Initializes the memory address to the SEARCH_PAGE.
Records the START_TIME of the data.
Resets EVALMAX = 0.
Turns ON Burst sampling.

SEARCH: Evaluates current conditions using EVAL().
Keeps maximum of EVAL() in EVALMAX.
When the search area is full, it compares EVALMAX

to the THRESH register. If under THRESH, it goes to RESTART state. Otherwise, it goes to COLLECT state.

COLLECT: Evaluates current conditions using EVAL(). Keeps maximum of EVAL() in EVALMAX. When the collect area is full, it records the END TIME of the data and goes to CLOSE state.

CLOSE: Sets the START_ADDRESS of data to SEARCH_PAGE. Adds the total page length to SEARCH_PAGE. Records the START and EVENT times for this data. If any of the Adapt bits are ON, it adds the value to the current THRESH register and goes to RESTART. If all Adapt bits are OFF and Playback is enabled, it goes to PLAY_WT state. Otherwise, it shuts OFF.

PLAY_WT: In this state, it waits for the EFW playback bit to be OFF. Then it sets up to output a Header block, requests a playback and goes to PLAY state.

PLAY: In PLAY state, it watches for the playback to end before continuing. If it counts to 20 minutes in this state, it drops the playback request and goes to PLAY_WT. This forces header blocks out every 20 minutes. Finally, when the playback ends, it checks the Repeat bit to see if it should go to STARTUP or OFF mode.

Key to the trigger is, of course, the EVAL() function. Basically, it checks which trigger is selected and calls it. Each trigger function must return its evaluation of the current conditions in an 8-bit unsigned form (i.e. 255 is the best, 0 the worst).

Available triggers are the following:
0 FGMTRIGGER
1 IMMEDIATE
2 ANACHECK

3 RAMCHECK

The IMMEDIATE trigger simply returns the constant 254 which is large enough to be greater than THRESH unless the user is testing the module.

The ANACHECK function is a signal averaging function whose parameters are as follows:

Parameter	Function
0	Multiplexor Address
1	Offset within A/D data [0, 2]
2	# Bits to Shift Right [0-15]
3	Summation Count

The Mux Address specifies a pair of samples to take at 25 Hz. The Offset parameter allows the user to pick which of the samples to use for the trigger calculation. The software will convert each sample to 2's complement, take its absolute value, right shift as specified in parameter #2 and add it to a 16-bit summing register. When the count of additions reaches the summation count, the summing register is latched into the result register for the function. If the summation register overflows, the result is 0xFFFF. It is worth noting that one can increase the gain in the result by dividing less and/or summing longer. Finally, burst software takes the upper 8 bits of the result register for evaluating burst collections. Note that the maximum of 254 is used for this analog trigger so that analog triggers will not overwrite FGM trigger events (evaluated at 255).
For example, to add 8 quantities together we use a summation count of 8 (parameter #3). Dividing each of the quantities by 8 is done by a shift right of 3 bits (parameter#2).

The FGMTRIGGER watches for the FGM Trigger event. Burst trigger software returns 255 if the FGM "T" bit is active, and returns the "signal averaging" trigger otherwise. With such a high evaluation, the collected FGM data will force a collection over a prior FGM collection and then stay in memory until read out. The memory will contain the last FGM-triggered collection before the playback. Note also that the signal averager trigger returns a maximum evaluation of 254, one less than the FGM trigger.

The RAMCHECK trigger uses PARAM[0] as a low part and PARAM[1] as the high part of a memory address [MA]. The memory byte is loaded, exclusive OR’d to PARAM[2] and AND’d with PARAM[3]. This is the returned value.

To change the parameter block, the user can use the PARAM command as follows:

- .BPARAM r x

where r is the register to change (0-3) and x is the value.

It is well worth noting that the ANACHECK cannot be used in HXONLY or NULL modes, since the TRG pointer cannot be given any samples. Still, the user can point the RAMCHECK at some of the Bursting data in those modes.

Also worth noting is that the threshold should be non-zero when using ANA or RAM triggers. If the evaluation meets or exceeds the threshold criteria, it will trigger. Thus, a threshold of zero is essentially a green light.

2.2.13 Burst Collection Control

The EFW burst memory totals 1 Megabyte which is organized as 16 pages of 64 Kbytes each. The software can detect the filling of pages and thus the user is allowed to control how much of the memory is assigned to searching and how much to collecting. The command which defines the Search and Collection page allotments is:

- .BPAGES ssssccc

When operating in the single collection mode, (i.e. adapt field is 0), the s and c fields can total 16 pages. The user can choose to cut down this total in order to shorten the total amount of data collected and played back.

When using the adaptive feature, the s and c fields must not total more than (16-s) since the software will begin searching as soon as a burst is taken. For example, a search area of 2 pages and a collect area of 12 pages will save 14 pages for playback, and resume searching for a bigger event in the remaining 2 pages.

Obviously, the user should try to minimize the number of search pages. The size of the search memory is more or less determined by the ability of the trigger function to evaluate conditions within the search period.

2.2.14 Burst Chirp Mode Control

The EFW instrument can rapidly pulse or “chirp” the sampling of burst data during both Search and Collect modes. The CHIRP register provides the user with control of this feature. From the beginning of the search, an 8-bit timer is increment and AND’ed with the CHIRP register. If the result is ZERO, the sampling is turned ON. If the result is non-ZERO, the sampling is turned OFF. Some examples follow:

0000000 : 100 % ON

0000001 : 0.2 seconds ON, 0.2 seconds OFF
0000011 : 0.2 seconds ON, 0.6 seconds OFF
1000000 : 25.6 seconds ON, 25.6 seconds OFF
1111111 : 0.2 seconds ON, 51.0 seconds OFF

2.2.15 Burst Playback

Bursts can be played back either automatically or manually. If the user selects the non-adaptive mode and enables playbacks in the trigger word, then playbacks will immediately follow a collection of data.

If the user has selected an adaptive mode, then EFW will never know when to stop searching and when to play back the data. The user must command EFW to play back burst data. For Cluster, a number of instruments will be dumping memory data into spacecraft tape recorders at defined times. The manual playback is compatible with this strategy. Playback is controlled using:

- .BPLAY Starts the Burst playback.
- .BSTOP Stops the Burst playback (and triggering)

The user can restart the playback as long as the searching has not begun again. Once the search has started, the memory is lost.

2.2.16 Burst Examples

For example, to define a 4-element list:

- .INDEX 18 (Pick a spot in format table)
- .BQTY BV2H BV1H (Load the 4 items)
- .BQTY BV4H BV3H
- .BQTY BP12 BSCX
- .BQTY BSCY BSCZ
- .BQTY EOF

To select a pre-defined list, select frequency and chirp:

- .BFMT 18 (Point to it)
- .BFREQ 3 (Set the frequency)
- .BCHIRP 7 (Duty Cycle = 1/8 th)

To define the type of logic, memory usage and get going:

- .BPAGES 2 12 (Search =2, Collect=12)
- .BTRIG 0x12 (Adapt = 16, Trigger=ANACHK)

2.2.17 Deployment Commands

Deployment of the spin plane booms systems is normally performed in pairs by the DEP module. The user selects which pair of booms to deploy, and then gives the deployment length. The rest is automatic. If need be, deployment of one boom at a time can be performed by either using the DEP commands below or direct MOTOR on/off commands.

Deployment software will automatically terminate the deployment if End-of-Wire / Overtension occurs, or if either Cover microswitch indicates the cover is in place. If the microswitches have failed, the software can be instructed to override them.

To deploy booms use the following command pair:

- .DEP_PAIR p
- .DEP_BOTH n

where p = {1,3} for boom pair 1,2 or 3,4 respectively; n = # clicks of the Turns microswitch, each click is 10cm.

To deploy only 1 boom, use "DEP_A n" or "DEP_B n". The A sides are 1 and 3 and B sides are 2 and 4.

If a microswitch failure occurs, one can override its effect by the command

- .DEP_OVER x

where x is the mask of bits to apply to the microswitch byte. (See Digital SubCom for boom microswitches.)

It is worth noting that the DEP_PAIR command is required in order to give the status of a given boom system in the Deployment digital subcom words. At startup, the DEP_PAIR register is cleared which disables the calculation of boom status from the STAT1-4 lines.

When the user sets DEP_PAIR to either 1 or 3, the calculation of boom microswitch bits begins.

Finally, if all else fails, the user may operate boom motors using the IO commands themselves:

- .MOTOR n m

where n = {1,2,3,4} and m = 1 for ON and 0 for OFF. These commands do not check anything so they are dangerous commands in my opinion.

2.2.18 Program Loading

One of the most important, yet simplest, pieces of the flight code is the program loader. Together with various vectors tucked away in critical places, much of the CPU operations can be changed or increased, and any location in either memory or input/output can be modified.

The available commands are:

- .CMDS n — Set Expected Command Count

- .ADRL l — Set Low byte of memory address in MAIN
- .ADRH h — Set High byte of memory address in MAIN
- .LOAD x — Load byte x into memory(h,l) in MAIN
- .EXEC — Execute program (at a fixed location) in MAIN

To load a program, one must set the high and low addresses, and then enter the series of bytes. The memory pointer increments with each load, of course.

Occasionally, commands will be rejected by the spacecraft receiving electronics which will ruin the uplink entirely. To prevent the EXEC command starting a partially loaded program and crashing the processor, the CMDS command will tell how many commands to expect. The EXEC checks this counter before beginning execution. Also, the first byte of the load must be a “AA” code to prevent an EXEC from operating without any load at all. For example, to load/execute a “C9” at 4DAAH :

- .CMDS 5
- .ADRL 0XAA

- .ADRH 0X4D
- .LOAD 0XAA
- .LOAD 0XC9
- .EXEC

Note that the final command (EXEC) must see that the command count status is zero (i.e. 4 commands expected, 4 executed) before it will execute the program.

2.2.19 Program Reset

The Main computer can be instructed to reset itself using the following command:

- .MRESET

This provides an easy mechanism for establishing a "clean slate" with all of the default settings and so forth.

2.2.20 A/D Reset

The A/D converters can also be reset using the following command:

- .ADRESET

This provides an easy mechanism for establishing a "clean slate" with the A/D's in case they get hit by an SEU, etc.

2.2.21 A/D Power Control

The A/D converters are powered through a Single Event Latch circuit in the power converter area which removes power when the A/D's are hit by an energetic particle. The user can force the action of this circuit (i.e. bring power down), can force the power ON or can leave it to its watchfull state.

.ADPOWER n..f.... Turns on/off the A/D converter.

where nf = 01 or 00 forces the A/D power on,
= 10 forces the A/D power off,

= 11 allows the SEL circuit to watch overcurrent.

For example, when the SEL circuit has tripped, "AD_POWER 0x10" will jam the power ON and keep it ON. The user should then allow the SEL circuit to sense the current by using the "AD_POWER 0x90" command. "ADPOWER 0x80" turns it OFF.

The SEL circuit will trip unless jammed ON by the AD_POWER circuit. If there is a short in the A/D secondaries, the jam ON will cause the DC/DC converter to sense the overload in approximately 40 milliseconds.

2.3 Command Lists

For the demanding user, one can load a list of commands into available main memory and then point the "CMD_LIST" variable at the list. The list must end with a "0000" command. Commands are executed from the list whenever REAL-TIME commands are unavailable. The maximum rate is 50 Hz.

Within command lists, the user can command a pause in the processing of the list. The "DELAY n" command pauses execution of the list for n/50th's of a second, so actions which must be slowed down can be implemented. For example, the Turn-on sequence delays 1 second before turning OFF motor relays in order to acquire enough relay power. This is implemented with a "CMDWT 50" command.

Once loaded into EFW's memory, the command string is started by the MACPROC (Exxx) command. The command supplies the 11-bit address of the list. It is possible to use a macro to start another macro or to create a loop by having the last command of a macro start itself over.

For example, to pulse the A/D power ON for 20 milliseconds:

- .ADRH 0X4E
- .ADRL 0X01
- .LOAD 0X10 ;AD_POWER 0X10 (SEL= JAM ON)
- .LOAD 0X78
- .LOAD 0X01 ;CMDWT 1 (WAIT .02 SECOND)
- .LOAD 0XC0
- .LOAD 0X90 ;AD_POWER 0X90 (SEL=SENSE MODE)
- .LOAD 0X78
- .LOAD 0 ;.0000 (ZERO COMMAND)

- .LOAD 0
- .ADRH 0X42 ;LOAD CMD_LIST WITH ADDRESS OF ABOVE
- .ADRL 0X03
- .LOAD 0X01 ;LOW ADDRESS FIRST
- .LOAD 0X4E ;THEN HIGH BYTE STARTS IT
- .0000

2.4 Orbit Sequencer

In version 2.1, users can specify repetitive command sequences. Each sequence is a list of time&command pairs ending in zero. The list is automatically restarted at the end of an orbit period. The basic unit of time for period and commands is 4 seconds. Thus, the minimum time between two commands is 4 seconds and the period has a 72.8 hour range. Though this process can issue only 1 command per 4 seconds, the sequence can spawn macros that operate at the internal command rate (50 Hz).

Address (Hex)	Name	Description
4240	ORBITPER	Orbit Period
4242	CMDSEQ	Address of the Command Sequence
4244	CLOCK	Orbit Clock Current Value
4246	CMDPTR	Pointer to the Current Position in Sequence

3 Sampling

3.1 Capabilities

The EFW filtering section currently has the following anti-aliasing filters and these voltages are available at the A/D converters:

QUANTITY	FREQUENCY
V1U, V2U, V3U, V4U	16 KHZ
V12H, V34H	8 KHZ
V13H, V14H	8 KHZ
V1H, V2H, V3H, V4H	4 KHZ
SCX, SCY, SCZ	4 KHZ
BP12	4 KHZ
V1M, V2M, V3M, V4M	180 HZ
V1L, V2L, V3L, V4L	10 HZ

The digital section contains a DMA channel which (1) pumps MUX requests out of memory to the multiplexors and (2) pumps converted data into memory. These two sections of memory are shown in the "DMA MULTIPLEXING AND SAMPLING" diagram.

Using these basic capabilities, the EFW computer software will format the MUX BUFFER to select the Quantities listed above. It will then collect and reformat these data for telemetry. Having listed the capabilities, it is best to decide on the baseline sampling plans and how to command them.

3.2 Implementation

A set of baseline sampling plans have been established which the EFW software can select. On the “SAMPLING.SCH” drawing, examples of the sampling opportunities are shown. HX samples are taken at the top of the mux lists. LX samples are taken at the buffer midpoint. Other sampling locations are shown as well. Burst samples are mixed in whereever needed to support the given frequency.

The EFW software implements four sampling schemes:

0. NORMAL --- Supports HX, LX, ETC and Bursts up to 9 KHz
1. SPLIT --- Supports HX, LX, ETC and Bursts up to 18 KHz
2. HXONLY --- Supports HX, no LX and Bursts up to 36 KHz (*)
3. NULL --- Supports Bursts only to 36 KHz

Note (*) that HXONLY causes HX values to be copied to the Burst memory in place of the Burst samples.

3.3 Normal Mode Timing

The rising edge of the sample clock following a SYNC or MODE byte defines the beginning of a second. Presumably the DWP instrument telemeters enough information to tell (in spacecraft time) when that occurred. Relative to that rising edge, the HX and LX samples are taken as follows:

Sample	Int	Seconds
HX0	0	.000
HX1	18	.040
LX0	26	.057

LX1	29	.064
LX2	32	.068
HX2	36	.080
HX3	54	.120
HX4	72	.160

This pattern repeats for 25 "HX" sample functions and 15 "LX" sample functions.

These data are transmitted in the following second to the DWP unit, which time-tags the packet with Universal Time. (Note: the time-tag is latched when the packet is completed, roughly 48 msecs after it began transmission from EFW.)

The timing of other data taken by the EFW software is detailed in the BKG.SCH diagram along with some description of the fine timing requirements for certain data elements. Ultimately, the EFWSW.DOC and EFWHW.DOC may be consulted for timing information.

3.4 Tape Mode Timing

In any of the three tape modes, HX data is collected at 450 Hz at the beginning of every interrupt. The normal mode HX data collection function is inhibited. The LX data collection proceeds as it did in the normal mode.

Data is transmitted at ten packets per second, as noted in the EFW TELEMETRY BLOCKS page below. Tape mode HX data is therefore approximately 0.1 second delayed from the time it is sampled to when it is transmitted, whereas normal mode HX data has a 1 second delay.

The following table shows when the 450 HX samples are taken relative to the 1-second marks coming from DWP. HX0 is defined as the first HX sample in the first EFW telemetry block in a given second.

Sample	Interrupt	Seconds
HX0 – HX44	405 – 449	.900 - .998
HX45 – HX89	0 – 44	.000 - .098
HX90 – HX134	45 – 89	.100 - .198
HX135 – HX179	90 – 134	.200 - .298
HX180 – HX224	135 – 179	.300 - .398
HX225 – HX269	180 – 224	.400 - .498
HX270 – HX314	225 – 269	.500 - .598
HX315 – HX359	270 – 314	.600 - .698

HX360 – HX404	315 – 359	.700 - .798
HX405 – HX449	360 – 404	.800 - .888
LX0, 3, 6, 9, 12	26,116,206,296,386	.057,.257,.457,.657,.857
LX1, 4, 7, 10,13	29,119,209,299,389	.064,.264,.464,.664,.864

To calculate UT for the first HX point, take the DWP time stamp for the first packet of the second. Call this "UT0". HX0 was sampled at interrupt 405 (.900 secs) of the previous second. The A/D conversion took place on the previous 1/450th interval. UT of HX0 should be UT0 - (1.000-0.900-.0022).

4 Telemetry

4.1 Transmission Blocks

The EFW sends telemetry in blocks to the DWP instrument as defined in the "WEC Internal ICD" document. The EFW collects and transmit data according to the tables on the next page "REAL-TIME TELEMETRY REQUIREMENTS".

Each data rate has its own blocking format and this is described in the "EFW Telemetry Blocks" figure. Basically, data is blocked-up for transmission differently depending upon the mode. In the Normal mode, data is transferred in a single block, once per second. Tape mode data rates would require a very long block (and lots of memory) to use this logic. Hence all tape modes send 10 blocks per second to DWP, and the size of the block just depends upon the amount of data being transferred.

The rest of the chapter is devoted to the piecemeal descriptions of data items in the telemetry. The block headers, trailers and spacecraft potential data is destined for the DWP unit only. The rest of the data is part of the EFW telemetry allocation.

4.2 Block Headers

Each transfer block to DWP has a constant “EB” code as the first byte followed by a decimal-adjusted “time” indicator as the second byte. The left nibble of “time” increments with real-time seconds and the right nibble is the “tenths-of-seconds.” This time code details when the block was sent to DWP.

4.3 Block Trailers

In the NORMAL telemetry mode, no trailer is used. During the tape modes, however, the tenth block requires some fill data as indicated in the EFW TELEMETRY BLOCKS table. Originally, this was designed as ZERO data, but this proved unneeded complication.

4.4 Spacecraft Potential

The EFW instrument calculates the spacecraft potential using either the V1/V2 pair or the V3/V4 pair. This data is converted to a 12-bit value, added to bits which indicate EFW sensor modes and sent to the DWP unit once per second. The format is given in the "Spacecraft Potential Format" figure.

4.5 Telemetry Contents

The formatting of the various data samples is described in the following pages. As a rule, all 16-bit values are transmitted low byte first, high byte second and all are 2's complement.

4.5.1 High and Low Rate Samples

The High Rate (HX) and Low Rate (LX) contents are simply buffered samples corresponding to the user requested HXLIST and LXLIST described in section 2. Sample timing is described in section 3.

4.5.2 Fast Digital Monitor

The purpose of the Fast Digital Monitor (FDM) is to indicate relatively fast mode transitions and status of the telemetry stages. For example, playbacks of recorded data are indicated by a playback bit in the FDM. See below for the bit structure.

The FDM is carefully latched internal to EFW so that the 4 bytes seen in the telemetry block correspond to one entire second of data.

The FDM is calculated internally by the instrument at .8 seconds and held in a variable called NEXT_FDM until the sampling is synchronized. This should occur at 1.0 seconds in normal mode or 0.9 seconds in tape mode. NEXT_FDM is transferred to FDM the instant that the HX is synchronized. This is also synchronous with the LX start. Thus, the FDM applies to 1 entire second of HX and LX data from start to finish.

4.5.2.1 Burst FDM Telemetry Playback Status

In Version 2.0 software, the FDM Playback bit is delayed by one second in the tape modes. This causes the data analysis to delay the processing of packets in order to get the bit from the delayed packet. The change will require all GSE programs and data analysis programs to alter the way they handle playback data, but is a relatively small change in the flight program.

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4.5.3 Spin Fit Results

The EFW instrument calculates the E-Field vector by taking 32 points at equal angles and fitting a sine wave least squares fit to the data. The best fit of the data is defined by the formula: A + B*cos() + C*sin(). The standard deviation of the fit is called Sigma, and the number of points remaining in the curve is called N.

The Spin Fit formulae are shown in the FITDIFFS.SCH drawing, and the solution matrices are shown in FITMATX.SCH.

Each of these values except N are 3-byte floating point values. N begins at 32 points and usually end between 24 and 30 by the end of the fitting process. See the diagram below.

4.5.4 Digital SubCom Data

The Digital SubCom data is a 256-byte table which is intended to telemeter very slow instrument status, verify commanding, etc. The format of this table is given in EFWDSC.SCH drawing. Below are descriptions of these data items.

Note that after a cpu reset, the first DSC cycle is not synchronized to the DSCINX value. Applications should wait for the 2nd cycle.

FORMAT_TABLE. The HX, LX and Burst lists are found in the 64-byte formatting table located in DSC[0] thru [63].

FORMAT POINTERS. The locations of active lists for HX, LX and Burst are given in DSC[64] thru DSC[69]. These values point into the FORMAT_TABLE.

RAMBASE_POINTER. The offset pointer for RAM telemetry values is given in these locations (low byte first).

FORMAT_INDEX. When loading HX, LX and Burst lists into the FORMAT_TABLE, the software uses a running index which is shown here.

EXECUTIVE_VERSION. Since users are allowed to change the EFW flight program by loading software into RAM, the EXECUTIVE_VERSION byte is used to tell data analysis which uplinked program is currently running. The 4 spare bytes are available for uplinked program options.

ROM_IDENTIFIER. The ROM identifier is used to show the default ROM configuration. The codes are as follows:
B1 : Breadboard;
E1 : Engineering Model;
Fx : Flight Model #x

TRAP_COUNTER. The very uppermost byte of RAM is never zeroed by the software and is above the 8085 stack. This byte is incremented every time the system is reset (which includes the MRESET command). Thus, the user can determine if the EFW has crashed during some non-monitored period of operation.

CLOCK. The Clock is a 5-byte counter which is in units of milliseconds. The clock is zeroed when the system is reset and is updated every 1/25th of a second. This clock is used to mark events in the Burst collections and the data analysis must determine the U.T. by justifying DSC[80] thru [84] to U.T. first. See "CLOCK REPORTING" for notes on the clock readout and corrections.

SUN_ANGLE. The sun angle is calculated by a phase locked loop routine which uses the period between successive sun pulses in order to determine the sun angle to 8 bit accuracy (1.41 degree). The low order byte is the sun angle while the high byte is non-zero only if the sun pulse has been lost. (Basically, the high byte is the number of spins since the sun pulse was last observed.) The angle is zeroed when the sun pulse is found. See the SWPORIENT.SCH for a diagram showing the sun sensor location relative to the sensors.

SUN_PERIOD. The SUN_PERIOD is a 16-bit unsigned value which is the period between the last two sun pulses. To calculate period in seconds, divide SUN_PERIOD by 150.

WHISPER_RATE. Once each second, the EFW software determines the rate at which the WHISPER instrument is operating. The rate is displayed every 32 seconds in DSC[89-90]. If this value is non-zero, a bit of the FDM is set to indicate WHISPER ON.

SCPOT. The spacecraft potential value which is calculated for the DWP unit is repeated at DSC[91-92].

CMD_REGISTERS. The user can verify the last command entered into EFW by looking at DSC[96-97]. The Good_Cmds and Bad_cmds registers are counters of accepted and rejected commands, respectively. If a command is not defined within EFW, the Bad_cmd counter is updated. Cmd_Limit is set by the "CMDS" command described in section 2. When Good_cmds matches Cmd_Limit, the FDM "command count" bit is zeroed.

MAG_REGISTERS. The Fluxgate magnetometer blocks are stored in memory and displayed in DSC[101-106]. See the DWP-EFW ICD for details on the structure of this data.

BURST_PARAMETERS. The user can verify the Burst options and parameters by viewing the DSC around [112] onward. See section 2 for details on these data patterns.

BIAS, PUCK, GUARD DACS. The commanded values of the Bias, PUCK and Guard D/A converters are shown in these locations in 2's complement form.

BIAS, PUCK, GUARD STATUS. The returned status from the boom units, sampled by the EFW software is reported in these words. Each sample is 16-bits in length but is NOT 2's complement. Instead, these values are 0 for full scale negative, and FFFF for full scale positive.

IVSTAT. IVSTAT is the status of the Current/Voltage relay returned as an analog value.

SPHERE_TEMP. Sphere thermisters are reported in these locations.

COVER STATUS. Boom deployment unit left and right covers are combined on one analog status line. The DEP software can handle the case where both covers are open or both are closed. If only one opens, these locations can be consulted to determine which one opened and which did not.

HEALTH MONITORS. DSC[188] thru DSC[195] are used to report the A/D temperature, the +27V input current monitor, the 1.2 Volt reference and the power converter temperature. These 16-bit values are 0 thru FFFF in value.

DEPLOYMENT STATUS. The deployment status bytes echo the commands listed in section 2 for "DEPLOY_PAIR",and "DEPLOY_OVERRIDE." The DEPLOY_LIMIT value is the target value (in clicks). LENGTH_A and LENGTH_B are zeroed at the start of a Deployment command and count clicks on each unit.

SAWTOOTH REGISTERS. See section 2 for the definitions of the SAWTOOTH variables.

SWEEP VALUES. The sweep options are replayed starting in DSC[208]. These are already described elsewhere in this document.

LOADER VALUES. The program load address pointer and the first four bytes of the load area are shown starting in DSC[250].

CLOCK. The 5-byte onboard clock used to mark bursts is read into telemetry in the DSC. In Version 2.0, this clock is free running. In Version 2.1, the clock is latched when seconds mod 31 is zero (the beginning of a digital sub-commutator cycle) and 80 milliseconds into the second.

REAL-TIME TELEMETRY REQUIREMENTS

NORMAL MODE	**SAMPLES**	**BYTES/SEC**
HX (V12L,V34L)	25x2	100
LX (V1L,V2L,V3L,V4L,,)	5X6	60
DIGITAL SUBCOM		8
FAST DIGITAL MONITOR		4
SPIN FIT RESULTS		8
TOTAL		**180 bytes/sec** **1440 bits/sec**

TAPE MODE 1	**SAMPLES**	**BYTES/SEC**
HX (V12M,V34M)	450x2	1800
LX (V1L,V2L,V3L,V4L,,)	5X6	60
DIGITAL SUBCOM		8
FAST DIGITAL MONITOR		4
SPIN FIT RESULTS		8
TOTAL		**1880 bytes/sec** **15040 bits/sec**

TAPE MODE 2	**SAMPLES**	**BYTES/SEC**
HX (V12M,V34M,)	450x3	2700
LX (V1L,V2L,V3L,V4L,,)	5X6	60
DIGITAL SUBCOM		8
FAST DIGITAL MONITOR		4
SPIN FIT RESULTS		8
TOTAL		2780 bytes/sec 22240 bits/sec

TAPE MODE 3	**SAMPLES**	**BYTES/SEC**
HX (V1M,V2M,V3M,V4M)	450x4	3600
LX (V1L,V2L,V3L,V4L,,)	5X6	60
DIGITAL SUBCOM		8
FAST DIGITAL MONITOR		4
SPIN FIT RESULTS		8
TOTAL		3680 bytes/sec 29440 bits/sec

NOTES:

- SPIN FITS telemetry good to 3.5 second spin
- V1L,V2L,V3L,V4L FILTERS ROLL OFF AT 10 HZ
- V1M,V2M,V3M,V4M FILTERS ROLL OFF AT 180 HZ
- Typical playback time (@ 52 bytes/sec) = 5.2 hrs

EFW TELEMETRY BLOCKS

EFW Telemetry Block Sizes

SYNC	MODE	Bits/sec	Block Size	Blocks/Sec
F0	Normal	1440	184	1
F1	Tape1 (450x2)	15040	192	10
F2	Tape1 (450x3)	22240	282	10
F3	Tape1 (450x4)	29440	372	10

EFW Telemetry Formats

NORMAL MODE (184 BYTES)						
EB	xx	SCP		LDFS	---------HX----------	
0	1	2	3	4	84	183

TAPE MODE (1ST BLOCK)							
EB	xx	SCP		LDFS	----------HX----------		
0	1	2	3	4	84	191	TAPE 1
0	1	2	3	4	84	281	TAPE 2
0	1	2	3	4	84	371	TAPE 3

TAPE MODE (BLOCKS 2-9)			
EB	xx	-----------------------------HX-----------------------------	
0	1	191	TAPE 1
0	1	281	TAPE 2
0	1	371	TAPE 3

TAPE MODE (BLOCK 10)					
EB	xx	---------------HX--------------		FILL	
0	1	2	173	191	TAPE 1

0	1	2	263	281	TAPE 2
0	1	2	353	371	TAPE 3

Note: "xx" is an incrementing block counter in which the left nibble is seconds, and the right nibble is 1/10ths of seconds.

EFW LX/DSC/FDM/SPINFIT (LDFS) FORMAT

4.	FAST DIGITAL MONITOR (4 BYTES) (See below for definition)
8.	DIGITAL SUBCOM DATA (8 BYTES)
16.	SPIN FIT DATA (8 BYTES)
24.	LX DATA (5 X 6 X 2 BYTES)
84.	

Notes:

1) Digital Subcom data is a 256-byte table which is dumped out at 8 bytes per second. See EFWDSC.SCH drawing.

2) Spin Fit data is asynchronous to telemetry and is delivered in blocks as described by the "SPIN FIT DATA FORMAT" below. When a block is not ready, this area is filled with Zeroes.

EFW SPACECRAFT POTENTIAL (SCP) FORMAT

Location:
Byte#2 = Least Significant Byte
Byte#3 = Most Significant Byte

Format:

V0bndddddddddddd

where v : "Data Valid" = 1
If v=0, EFW cannot make the measurement.

b : "Burst In Progress"
If b=1, EFW is collecting data in Burst memory.

d : "Spacecraft Potential"
7FFH = 69.560V
001H = 0.034V
FFFH = -0.034V
801H = -69.560V

n : 0 => d = +(V1+V2)/2
1 => d = -(V1+V2)/2

Notes: (1) Spacecraft Potential will not be available in certain modes of operation. (2) V1 thru V4 have Vmax of +/-69.56 Volts measureable.

EFW FAST DIGITAL MONITOR FORMAT

Format:

4.	pbbbxrwc
5	ssqiiiii
6.	aaaaaaaa
7.	mmmmeeee

p = Playback indicators
- 0: Off
- 1: Playback in Progress

x = Main/Burst playback
- 1: Main playback

bbb = Burst internal state
- 000 : Off
- 001 : Compiling List
- 010 : Turning On
- 011 : Searching
- 100 : Collecting
- 101 : Closing the file
- 110 : Playback wait
- 111 : Playing back

r = Whisper pulses present = 1
w = Sweep in Progress = 1
c = Command Counter Mismatch = 1

iiiii = DSC_index (32*8 = 256 total bytes)

q = interferometric mode
eeee = E/D mode bits units {4,3,2,1}
mmmm = Motor On/Off status {4,3,2,1}

ss = sampling mode 0-3= {NORMAL, SPLIT, HXONLY, NULL}
aaaa = Sun angle at 0.002 Sec in sampling period

EFW SPIN FIT DATA FORMAT

0.	101000x1	Format Code = A1 FOR V12 FITS, A3 FOR V34 FITS
1.	A(msb)	Result "A" in floating point.
2.	A	
3.	A(lsb)	
4.	B(msb)	Result "B" in floating point.
5.	B	
6.	B(lsb)	
7.	C(msb)	Result "C" in floating point.
8.	C	
9.	C(lsb)	
10.	S(msb)	Result "Sigma" in floating point.
11.	S	
12.	S(lsb)	
13.	N	Result N points in unsigned integer.

Each three byte floating point value is formatted as follows:

seeeeeee	Hhhhhhhh	llllllll

Where s = 1 for negative values, e is the binary exponent in excess 64 format, and [hl] are the 16-bit mantissa. There is no hidden bit in this format. Example: 1.0 is 41,80,00, 1.5 is 41,C0,00, 2 is 42,80,00.

EFW SWEEP DATA FORMAT

Format:

0.	011100x1	Format Code = E1 OR E3 (V12 OR V34)
1.	01110111	
2.	….rxde	Sweep_Options
3.	ANGLE	Sun Angle to begin sweep
4.	ALGOR.	Sweep Algorithm Code
5.	ALTER1	Sweep Bias Alternate 1 (or 3)
6.	ALTER2	Sweep Bias Alternate 2 (or 4)
7.	RESULT1	Sweep Bias Result 1 (or 3)
8.	RESULT2	Sweep Bias Result 2 (or 4)
9.	MAVG	Number of points to average
10.	NOISE	Noise Pass Limit
11.	REJECT	Number of Points Rejected by Analysis
12.	ISTEP	Voltage Mode, Current Bias Step
13.	IBIASO	Voltage Mode, Current Bias Initial
14.	IRATE	Voltage Mode, Step Rate Divider
15.	ILENG	Voltage Mode, Length of Sweep
16.	VSTEP	Density Mode, Voltage Bias Step
17.	VBIASO	Density Mode, Voltage Bias Initial
18.	VRATE	Density Mode, Step Rate Divider
19.	VLENG	Density Mode, Length of Sweep
		Spares at [20/21]
22.		Data [0] ls byte
23.		Data [0] ms byte
24.		Data [1] ls byte
25.		Data [1] ms byte
	…	(Data length default = 1024 bytes)

EFW BURST HEADER FORMAT

Format:

0.	10110010	Format Code = B2
1.	x.ss.fff	Frequency Code
2.	rpaaaatt	Trigger Selections
3.	CHIRP	Chirp Control Register
4.	sssscccc	Search and Collect Page Control
5.	THRESH	Initial Trigger Threshold
6.	P [0…3]	Parameters 0 - 3
10.	ST [0…4]	Start Time (5 bytes)
15.	VT [0…4]	Event Time (5 bytes)
20.	ET [0…4]	End Time (5 bytes)
25.	SA [0…2]	Start Address
28.	EA [0…2]	End Address
31.	LR [0…2]	Length Remaining (in bytes)
34.		Spare Word
36.	BLIST []	Burst Format List (8bytes fixed)
44.		

Notes:

(a) Burst List is always fixed at 8 bytes in length. Decoding software should check for EOL mark to determine list length.

(b) Burst samples are transmitted with the low byte first and high byte second. The value is converted to 2's complement by the EFW software.

CLUSTER EFW INSTRUMENT DIGITAL SUBCOM TELEMETRY

0	FORMAT_TABLE_0	64	HX_FMT_0	128	BIAS_DAC_1	192	VREF_L
1	FORMAT_TABLE_1	65	HX_FMT_1	129	BIAS_DAC_2	193	VREF_H
2	FORMAT_TABLE_2	66	HX_FMT_2	130	BIAS_DAC_3	194	PWRTEMP_L
3	FORMAT_TABLE_3	67	HX_FMT_3	131	BIAS_DAC_4	195	PWRTEMP_H
4	FORMAT_TABLE_4	68	LX_FMT	132	STUB_DAC_1	196	DEPLOY_PAIR
5	FORMAT_TABLE_5	69	BURST_FMT	133	STUB_DAC_2	197	DEPLOY_STATUS
6	FORMAT_TABLE_6	70	RAMBASE _POINTER_L	134	STUB_DAC_3	198	DEPLOY_SWITCHES
7	FORMAT_TABLE_7	71	RAMBASE _POINTER_H	135	STUB_DAC_4	199	LENGTH_A
8	FORMAT_TABLE_8	72	FORMAT_INDEX	136	GUARD_DAC_1	200	LENGTH_B
9	FORMAT_TABLE_9	73	EXECUTIVE_VERSION	137	GUARD_DAC_2	201	DEPLOY_LIMIT
10	FORMAT_TABLE_10	74	EXECUTIVE_SPARE_0	138	GUARD_DAC_3	202	SAWTOOTH_OFFSET
11	FORMAT_TABLE_11	75	EXECUTIVE_SPARE_1	139	GUARD_DAC_4	203	SAWTOOTH_DELTA
12	FORMAT_TABLE_12	76	EXECUTIVE_SPARE_2	140	BIAS_1	204	SAWTOOTH_PERIOD
13	FORMAT_TABLE_13	77	EXECUTIVE_SPARE_3	141		205	SAWTOOTH_DIVIDER
14	FORMAT_TABLE_14	78	ROM_IDENTIFICATION	142	BIAS_2	206	SAWTOOTH_OPTIONS
15	FORMAT_TABLE_15	79	TRAP_COUNTER	143		207	SAWTOOTH_ENABLES
16	FORMAT_TABLE_16	80	CLOCK_0	144	BIAS_3	208	SWEEP_STATE
17	FORMAT_TABLE_17	81	CLOCK_1	145		209	SWEEP_SPINMAX
18	FORMAT_TABLE_18	82	CLOCK_2	146	BIAS_4	210	SWEEP_OPTIONS_12
19	FORMAT_TABLE_19	83	CLOCK_3	147		211	SWEEP_ANGLE_12
20	FORMAT_TABLE_20	84	CLOCK_4	148	STUB_1	212	SWEEP_ALG_12
21	FORMAT_TABLE_21	85	SUN_ANGLE_L	149		213	SWEEP_ALT_1
22	FORMAT_TABLE_22	86	SUN_ANGLE_H	150	STUB_2	214	SWEEP_ALT_2
23	FORMAT_TABLE_23	87	SUN_PERIOD_L	151		215	SWEEP_RES_1
24	FORMAT_TABLE_24	88	SUN_PERIOD_H	152	STUB_3	216	SWEEP_RES_2
25	FORMAT_TABLE_25	89	WHISPER_RATE_L	153		217	SWEEP_MAVG_12
26	FORMAT_TABLE_26	90	WHISPER_RATE_H	154	STUB_4	218	SWEEP_NOISE_12
27	FORMAT_TABLE_27	91	SCPOT_L	155		219	SWEEP_REJ_12
28	FORMAT_TABLE_28	92	SCPOT_H	156	GUARD_1	220	SWEEP_ISTEP_12

29	FORMAT_TABLE_29	93	BKG_VECTOR_L	157		221	SWEEP_IBO_12
30	FORMAT_TABLE_30	94	BKG_VECTOR_H	158	GUARD_2	222	SWEEP_IRATE_12
31	FORMAT_TABLE_31	95	BKG_VECTOR_ARM	159		223	SWEEP_ILENG_12

(continued)

32	FORMAT_TABLE_32	96	CMD_REG_0	160	GUARD_3	224	SWEEP_VSTEP_12
33	FORMAT_TABLE_33	97	CMD_REG_1	161		225	SWEEP_VBO_12
34	FORMAT_TABLE_34	98	GOOD_CMDS	162	GUARD_4	226	SWEEP_VRATE_12
35	FORMAT_TABLE_35	99	BAD_CMDS	163		227	SWEEP_VLENG_12
36	FORMAT_TABLE_36	100	CMD_LIMIT	164	IVSTAT_1	228	SWEEP_SPARE_12
37	FORMAT_TABLE_37	101	MAG_REG_0	165		229	SWEEP_SPARE_12
38	FORMAT_TABLE_38	102	MAG_REG_1	166	IVSTAT_2	230	SWEEP_OPTIONS_34
39	FORMAT_TABLE_39	103	MAG_REG_2	167		231	SWEEP_ANGLE_34
40	FORMAT_TABLE_40	104	MAG_REG_3	168	IVSTAT_3	232	SWEEP_ALG_34
41	FORMAT_TABLE_41	105	MAG_REG_4	169		233	SWEEP_ALT_3
42	FORMAT_TABLE_42	106	MAG_REG_5	170	IVSTAT_4	234	SWEEP_ALT_4
43	FORMAT_TABLE_43	107	00	171		235	SWEEP_RES_3
44	FORMAT_TABLE_44	108	00	172	SPHERE_TEMP_1	236	SWEEP_RES_4
45	FORMAT_TABLE_45	109	00	173		237	SWEEP_MAVG_34
46	FORMAT_TABLE_46	110	00	174	SPHERE_TEMP_2	238	SWEEP_NOISE_34
47	FORMAT_TABLE_47	111	00	175		239	SWEEP_REJ_34
48	FORMAT_TABLE_48	112	BURST_FREQ	176	SPHERE_TEMP_3	240	SWEEP_ISTEP_34
49	FORMAT_TABLE_49	113	BURST_TRIGGER	177		241	SWEEP_IBO_34
50	FORMAT_TABLE_50	114	BURST_CHIRP	178	SPHERE_TEMP_4	242	SWEEP_IRATE_34
51	FORMAT_TABLE_51	115	BURST_PAGES	179		243	SWEEP_ILENG_34
52	FORMAT_TABLE_52	116	BURST_THRESH0	180	COVERS_1	244	SWEEP_VSTEP_34
53	FORMAT_TABLE_53	117	BURST_PARAM_0	181		245	SWEEP_VBO_34
54	FORMAT_TABLE_54	118	BURST_PARAM_1	182	COVERS_2	246	SWEEP_VRATE_34
55	FORMAT_TABLE_55	119	BURST_PARAM_2	183		247	SWEEP_VLENG_34
56	ORBITPERIOD_L	120	BURST_PARAM_3	184	COVERS_3	248	SWEEP_SPARE_34
57	ORBITPERIOD_H	121	BURST_STATE	185		249	SWEEP_SPARE_34
58	CMDSEQ_L	122	BURST_EVALMAX	186	COVERS_4	250	LOAD_ADRL

59	CMDSEQ_H	123	BURST_THRESHOLD	187		251	LOAD_ADRH
60	ORBITCLOCK_L	124	BURST_ALGOR_L	188	ADTEMP_L	252	LOAD_CHECK
61	ORBITCLOCK_H	125	BURST_ALGOR_H	189	ADTEMP_H	253	LOAD_BYTE#0
62	CMDPTR_L	126	BURST_ALGOR_ARM	190	PWR28I_L	254	LOAD_BYTE#1
63	CMDPTR_H	127	BURST_SEARCHPAGE	191	PWR28I_H	255	LOAD_BYTE#2

FREQ	0	1	2	3	4	5	5	6	(7=25Hz)
SAMPLING_MODE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	SPLIT	HXONLY	NULL	
BURST LISTS	1	2	5	10	20	40	20	40	
0	HX V1L,V2L	HX V1L,V2L	HX V1L,V2L	HX V1L,V2L	HX V1L,V2L	HX V1L,V2L	HX V1L,V2L	BUR V1U,V2U	
1	HX V3L,V4L	HX V3L,V4L	HX V3L,V4L	HX V3L,V4L	HX V3L,V4L	BUR V12H,V34H	HX V3L,V4L	BUR V3U,V4U	
2	BUR BV0,BV1	BUR BV0,BV1	BUR BV0,BV1	BUR BV0,BV1	BUR BV0,BV1	HX V3L,V4L	BUR V1H,V2H	BUR V1U,V2U	
3	BUR BV2,BV3	BUR BV2,BV3	BUR BV2,BV3	BUR BV2,BV3	BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U	
4	BUR BV4,BV5	BUR BV4,BV5	BUR BV4,BV5	BUR BV4,BV5			BUR SCX,BP34	BUR V1U,V2U	
5	BUR BV6,BV7	BUR BV6,BV7	BUR BV6,BV7	BUR BV6,BV7		BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U	
6					BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U	
7					BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U	
8							BUR SCX,BP34	BUR V1U,V2U	
9						BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U	
10				BUR BV0,BV1	BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U	
11				BUR BV2,BV3	BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U	
12				BUR BV4,BV5			BUR SCX,BP34	BUR V1U,V2U	
13				BUR BV6,BV7		BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U	
14					BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U	
15					BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U	
16							BUR SCX,BP34	BUR V1U,V2U	
17						BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U	
18			BUR BV0,BV1	BUR BV0,BV1	BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U	
19			BUR BV2,BV3	BUR BV2,BV3	BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U	
20			BUR BV4,BV5	BUR BV4,BV5			BUR SCX,BP34	BUR V1U,V2U	
21			BUR BV6,BV7	BUR BV6,BV7		BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U	
22					BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U	
23					BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U	
24							BUR SCX,BP34	BUR V1U,V2U	
25						BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U	
26				BUR BV0,BV1	BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U	
27				BUR BV2,BV3	BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U	
28				BUR BV4,BV5			BUR SCX,BP34	BUR V1U,V2U	
29				BUR BV6,BV7		BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U	
30					BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U	
31					BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U	
32	DSC0	DSC0	DSC0	DSC0	DSC0	DSC0	BUR SCX,BP34	BUR V1U,V2U	

CLUSTER ELECTRIC FIELDS AND WAVES

33	DSC1	DSC1	DSC1	DSC1	DSC1	BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
34			BUR BV0,BV1	BUR BV0,BV1	BUR BV0,BV1	DSC1	BUR V1H,V2H	BUR V1U,V2U
35			BUR BV2,BV3	BUR BV2,BV3	BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
36			BUR BV4,BV5	BUR BV4,BV5			BUR SCX,BP34	BUR V1U,V2U
37			BUR BV6,BV7	BUR BV6,BV7		BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
38					BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U
39					BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
40	LX	LX	LX	LX	LX	LX	BUR SCX,BP34	BUR V1U,V2U
41	LX	LX	LX	LX	LX	BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
42		BUR BV0,BV1		BUR BV0,BV1	BUR BV0,BV1	LX	BUR V1H,V2H	BUR V1U,V2U
43		BUR BV2,BV3		BUR BV2,BV3	BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
44		BUR BV4,BV5		BUR BV4,BV5			BUR SCX,BP34	BUR V1U,V2U
45		BUR BV6,BV7		BUR BV6,BV7		BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
46					BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U
47					BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
48	FIT V1U,V2U	FIT V1U,V2U	FIT V1U,V2U	FIT V1U,V2U	FIT V1U,V2U	FIT V1U,V2U	BUR SCX,BP34	BUR V1U,V2U
MIDWAY 49	FIT V3U,V4U	FIT V3U,V4U	FIT V3U,V4U	FIT V3U,V4U	FIT V3U,V4U	BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
50			BUR BV0,BV1	BUR BV0,BV1	BUR BV0,BV1	FIT V3U,V4U	BUR V1H,V2H	BUR V1U,V2U
51			BUR BV2,BV3	BUR BV2,BV3	BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
52			BUR BV4,BV5	BUR BV4,BV5			BUR SCX,BP34	BUR V1U,V2U
53			BUR BV6,BV7	BUR BV6,BV7		BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
54					BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U
55					BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
56	MON0	MON0	MON0	MON0	MON0	MON0	BUR SCX,BP34	BUR V1U,V2U
57	MON1	MON1	MON1	MON1	MON1	BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
58				BUR BV0,BV1	BUR BV0,BV1	MON1	BUR V1H,V2H	BUR V1U,V2U
59				BUR BV2,BV3	BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
60				BUR BV4,BV5			BUR SCX,BP34	BUR V1U,V2U
61				BUR BV6,BV7		BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
62					BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U
63					BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
64	SWP V1L,V2L	SWP V1L,V2L	SWP V1L,V2L	SWP V1L,V2L	SWP V1L,V2L	SWP V1L,V2L	BUR SCX,BP34	BUR V1U,V2U
65	TRG	TRG	TRG	TRG	TRG	BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
66			BUR BV0,BV1	BUR BV0,BV1	BUR BV0,BV1	TRG	BUR V1H,V2H	BUR V1U,V2U
67			BUR BV2,BV3	BUR BV2,BV3	BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
68			BUR BV4,BV5	BUR BV4,BV5			BUR SCX,BP34	BUR V1U,V2U
69			BUR BV6,BV7	BUR BV6,BV7		BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
70					BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U
71					BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
72							BUR SCX,BP34	BUR V1U,V2U
73						BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
74				BUR BV0,BV1	BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U
75				BUR BV2,BV3	BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U
76				BUR BV4,BV5			BUR SCX,BP34	BUR V1U,V2U
77				BUR BV6,BV7		BUR V12H,V34H	BUR SCY,SCZ	BUR V3U,V4U
78					BUR BV0,BV1		BUR V1H,V2H	BUR V1U,V2U
79					BUR BV2,BV3	BUR V12H,V34H	BUR V3H,V4H	BUR V3U,V4U

BURST LISTS

V12H,V34H	V1U,V2U	SCX,BBP34
	V3U,V4U	SCY,SCZ
		V1H,V2H
		V3H,V4H

HX	OK	OK	OK	OK	OK	OK	OK	NO
DEP	OK	OK	OK	OK	OK	OK	NO	NO
SWP	OK	OK	OK	OK	OK	OK	NO	NO
SUPPORT DSC	OK	OK	OK	OK	OK	OK	NO	NO
FIT	OK	OK	OK	OK	OK	OK	NO	NO
LX	OK	OK	OK	OK	OK	OK	NO	NO
TRG	OK	OK	OK	OK	OK	OK	NO	NO
BUR	OK 450X8	OK 900X8	OK 2250X8	OK 4500X8	OK 9000X4	OK 18000X2	OK 9000X8	OK 18000X4