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FINAL
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FINAL REPORT

NAS5-30549

SOFTWARE
for the
HYDRA INSTRUMENT ON THE POLAR SPACECRAFT

MODETHREE
September 29, 1996

UNIVERSITY OF CALIFORNIA, SAN DIEGO

```
c:\1\hydra\rpt\fin\fidtitle.FID
c:\1\hydra\rpt\fin\CONTENTS.FIN
c:\1\hydra\fid_0\TSKINT_0.FID
c:\1\hydra\fid_0\RSORC_0.FID
c:\1\hydra\fid_0\SOWPGM_0.FID
C:\1\HYDRA\FID\RESYNCH.INT
c:\1\hydra\fid_2\PEAKDWEL.FID
c:\1\hydra\fid_2\HVDUMPX.FID
c:\1\hydra\fid_2\SCSQ_2E.SEQ
c:\1\hydra\fid_0\DSHV100.TAB c:\1\hydra\fid_0\DFLSV001.TAB
c:\1\hydra\fid_2\B2PPA_2.FID c:\1\hydra\fid_0\APXB2PPA.FID
C:\1\HYDRA\PAS\GRIDABAB.COD
C:\1\HYDRA\FID_3\HVMON_3.FID
C:\1\HYDRA\FID_3\PHA_3.FID
c:\1\hydra\fid_0\TLM_0.FID
c:\1\hydra\fid_0\PSRL1610.FID
c:\1\hydra\fid_3\S175_3.FID
c:\1\hydra\fid_0\TIMMTX_0.FID
c:\1\hydra\fid_0\TIMLIN.FID
c:\1\hydra\rpt\fin\tlmtitle.FID
c:\1\hydra\tlmf_0\tlmall_0.fid
c:\1\hydra\tlmf_0\tlmalc_0.fid
c:\1\hydra\tlmf_0\mfofst_0.fid
c:\1\hydra\tlmf_0\tlmdd_0.fid
c:\1\hydra\tlmf_0\tlmpp_0.fid
c:\1\hydra\tlmf_0\tlmtp_0.fid
c:\1\hydra\tlmf_2\tlmsn_2.fid
c:\1\hydra\tlmf_3\tlmlb_3.fid
```

TSKINT_0.0. Task and Interrupt List for ModeZero
September 29, 1996

TSKINT_0.0.1. Nomenclature for Hydra Timing Intervals

BCI	Basis Cycle Interrupt (programmable)
BFR	Magnetometer data refresh cycle
BSP	Magnetometer sample period
DDC	DDEIS accumulation interval
DDN	DDEIS energy step interval
DSC	DDEIS energy scan period (programmable)
ET2	Experiment timing signal #2, generated internally
MJF	Major Frame Period
MNF	Minor Frame Period
PPC	PPA accumulation interval, summed in scratch RAM over some number of PPR cycles, and read out to telemetry.
PPL	The live accumulation portion of the PPR
PPR	PPA RAM refresh interval (readout and reset the 8 bit RAM on the PPA board.)
PSC	PPA energy scan period (programmable)
SEC	One NBS standard second
SPT	Tick of spin phase reference clock (4096 per sun reference pulse)
SUN	Sun reference pulse (=spin period)
TMT	Tick of the 55652 hz telemetry clock

TSKINT_0.1.0. Tasks

TSKINT_0.1.1. DDSCAN_0

Initiated after each BCI, and must complete before the next BCI. Moves 12 16-bit readings from DDHOTBUF into DD16_BUF. Determines the Control Vector for the next accumulation of the DDEIS. 1 MJF = 16 DSC. 1 DSC = 16 DDC. 1 DDC = 2000 TMT.

TSKINT_0.1.2. PPSCAN_0

Initiated after each BCI, and must complete before the next BCI. Counts PPR's and determines the Control Vector for the next PPC. Checks overflow bit, and, for no overflow, performs replace-adds of the 256 8-bit accumulations from PPHOTBUF into 256 16-bit RAM accumulators, PP16_BUF. Copies old values of theta, phi, and overflow bit from PPTHETAPHI_OLD to the appropriate two byte location in TPV_BUF. 1 MJF = 4 PPC. 1 PPC = 128 PPR. 1 PPR = 1000 TMT.

TSKINT_0.1.3. B2PPA_0

Saves previous values of theta and phi to PPTHETAPHI_OLD. Takes readings from the magnetometer reading stack, extrapolates to the time of the upcoming PPR, and computes new PPA control coordinates theta and phi. The next BCI copies these values to the PPA board for the next PPR, reads the overflow bit from the PPA board for the last PPR, and writes the overflow bit to the high order bit of PPTHETAPHI_OLD. Enabled by the PPSCAN_0 task and run right after it. It must be completed in time for the ET2 interrupt that ends the PPR.

TSKINT_0.1.4. TLM_0 (TLM0TASK)

Takes data from the holding-processing buffers, packs them, and writes the packed data into the telemetry buffer. Task TLM_0 must not read data until after PPSCAN_0 and DDSCAN_0 have completed filling half of their holding-processing buffers PP16_BUF and DD16_BUF, and it must not write data into the telemetry buffer until the telemetry task has cleared the last half. To assure these conditions, TLM_0 is started 4 times per MJF by PPSCAN_0 8 BCI's after at the end of each PPC. TLM_0 must complete by the end of the next PPC. It fills TMBUF in the order of 256 bytes (PPTPV), 150 bytes (PPTMBINS), 960 bytes (DDTM), and 4 or 3 remaining bytes for even and odd quarters, respectively.

TSKINT_0.2.0. Interrupts

TSKINT_0.2.1. Hardware Interrupts

TSKINT_0.2.1.1. BCI

Receives theta and phi from the B2PPA_0 task and delivers them to the PPA. Starts the PPA. Receives Control Vectors from the PPSCAN_0 and DDSCAN_0 tasks and delivers them to PPA and DDEIS. Unloads DDEIS accumulators. Starts PPSCAN_0 and DDSCAN_0 tasks. Initiated by BCI counter, which is clocked by telemetry clock. Period 1000 TMT. Reset by MJF.

TSKINT_0.2.1.2. ET1

Not used by Hydra in ModeZero.

TSKINT_0.2.1.3. ET2

Turns off the PPA on the fourth, second, or first ET2 within a PPR. Subdivides the PPR interval and halves it in response to overflows. On the fourth ET2 within a PPR, unloads the 256 8-bit accumulators on the PPA board into a buffer, PPHOTBUF, and sends the next HV value to the PPA. Initiated by ET2 counter, which is clocked by telemetry clock and reset by MJF. Clocked by telemetry clock. Period 200 TMT.

TSKINT_0.2.1.4. DUN

Delayed sun pulse. Resets ET1 via hardware connection. Calls for a time reading.

TSKINT_0.2.1.5. MJF

Initiated externally each major frame. Resets several pointers. Calls for a time reading.

TSKINT_0.2.1.6. MNF

Reads 23 or 22 bytes of data from the science buffer and 0 or 1 byte from the housekeeping buffer into the hardware FIFO in the proper sequence to present the proper housekeeping data for each slot in the telemetry frame. Occurs at the beginning of each minor frame and must be completed before the first telemetry word gate. Initiated externally each minor frame.

TSKINT_0.2.1.7. BXYZ

The magnetometer ISR collects the magnetometer readings and filters them. Each reading consists of 4 components, Timing/status, Bx, By, and Bz. The same filter algorithm is applied individually to Bx, By, and Bz. Initiated externally 16 times per MNF.

In ModeZero, the form of the filter is

$$O(i) = (1-a)*O(i-1) + a*Ii$$

where O represents the Output of the filter, I represents the Input to the filter, a is a fraction representing the weight given the current input (e.g.: 1/8), 1-a is a complementary fraction representing the weight given the past values (e.g.: 7/8), (i) represents the current value, and (i-1) represents the most recent value. The optimum value of a is TBD. The most compact code is produced if a = 1/2, and so it will be set to this value unless it proves unsatisfactory in operation with test data.

In higher modes, the filter is a Kalman filter as described in BLR2PPA.

TSKINT_0.2.1.8. TC

Initiated externally once per second. Reads a 4 byte Universal Time Code Word from the spacecraft timer, and places it in a UTC register.

TSKINT_0.2.2. Special Software Functions

TSKINT_0.2.2.1. Time Reading

At particular times, a time mark is obtained by reading the 4 byte UTC time mark and the 2 byte millisecond counter. Time readings are made by the MJF ISR, and the DUN ISR.

TSKINT_0.2.2.2. Scan Resynchronization

At the end of a certain number of major frames, the ddscan and ppscan routines re-execute their initialization sections to make them start over at the beginning of the scanning sequence. The proper number of major frames is called the Sequence Resynchronization Interval, and is a RAM variable. The Sequence Resynchronization Interval is chosen so that the sequence has executed a complete cycle, and it should be back at the start without being told. Thus this is only what should happen, but the resynchronization is to get back on schedule in case there are any glitches. The calculation of the Sequence Resynchronization Interval is discussed in Section SCNSEQ_0.1., SCNSEQ_0.4.3., and SCSQ_0.5. Values are given in those sections that are appropriate for the scan sequences described therein.

This is implemented as follows:

At the beginning of its power-up initialization section, the ddscan routine saves synch_mjf = the low byte of the MJF counter + synch_interval. Near the end of each execution of ddscan, it checks the BCI counter and the major frame counter maintained by the BCI and MJF ISRs, respectively. (See SOWPGM_0.0.) If it is the last BCI of a major frame, and the major frame is equal to the saved resynch frame, 'resynch' flags are set for itself and the ppscan routine, and the ddscan routine branches to its initialization code. In the initialization code, a couple of things are done differently than they would be for a true initialization because of the fact that an accumulation should be about to end and we will want to get the data next BCI. When the ppscan routine runs, it checks its resynch flag at the end, and if it is set, re-executes its initialization code, also with some slight variations from what it would do for a true initialization.

TSKINT_0.3.0. Special Hardware Functions

TSKINT_0.3.1. Telemetry Wordgate

Reads out the hardware FIFO.

TSKINT_0.3.2. DUN

Resets ET1.

TSKINT_0.3.3. MJF

Resets BCI counter and ET2 counter.

TSKINT_0.3.4. SUN

The Sun Pulse from the spacecraft resets the Delayed Sun Pulse (DSP) counter, which counts the spin clock.

RSORC_0.0. Resource Usage by Hydra Software
September 29, 1996

RSORC_0.0.1. Memory Allocation

8K x 8	PROM	Firmware
32K x 8	RAM	Rad-Hard
128K x 8	EEPROM	Software
1M x 8	RAM	Burst Memory

RSORC_0.1.0. RAM, ModeZero

In order to provide another degree of robustness, the 32K X 8 rad-hard RAM will be split into two banks, switchable upon command. ModeZero will use only one bank, allowing a redundant backup bank to be called in case of a failure in the primary RAM. Forth will reside in the backup, or secondary, half of rad-hard RAM. Because Forth builds from zero, this must be the lower half. Thus the primary half will be the upper half.

RSORC_0.1.1. Raw-Data Buffers

RSORC_0.1.1.1. Hot-Data Buffers

P_INBUF (equivalent to IN_BUF): Pointer to the start of the hot-data buffers, DDHOTBUF and PPHOTBUF. PPHOTBUF starts 28 bytes after DDHOTBUF.

DDHOTBUF: DDEIS accumulator dump. 14 channels at 16 bits per reading. Loaded by BCI when told to by DDSCAN control vector. Unloaded by the next DDSCAN into DD16_BUF. This buffer and data transfer could be eliminated if BCI loaded DD16_BUF directly. Size = 28 bytes.

PPHOTBUF: 256 X 8 bit buffer to catch the image of the 8 bit accumulators on the PPA board. Loaded by interrupt ET2. Unloaded by the next PPSCAN into PP16_BUF. Size = 256 bytes.

THETAPHI: Values of theta and phi for the next PPR. Values created by B2PPA. 2 bytes.

THETAPHI_OLD: Values of theta and phi for the last PPR, copied by B2PPA from THETAPHI. The BCI ISR writes the value of the overflow bit in the 16th bit. PPSCAN writes the 2 byte result into TPV_BUF. The following is an attempt to diagram the flow of theta, phi, the overflow bit, and some of the data.

```
                B2PPA   ...     ET2S    BCI     PPSCAN  B2PPA

PPAboard    ------------...------.         ---------------------
THETAPHI    ----\   *---...--------------/--------------\   *--
OVFbit           \      ...      *----\
THETAPHI_OLD      \-----...----------- + -------\         \----
TPV_BUF                 ...                       \-------------
PPdata      ------------...------\                  \
PPHOTBUF                ...       \--------------- OV?
PP16_BUF                ...                         \-----------
```

RSORC_0.1.1.2. Holding-Processing Buffers

DD16_BUF: DDEIS accumulator ring buffer. 12 channels for 128 DDC's at 16 bits per reading = 3072 bytes. Loaded from 12 words of DDHOTBUF by DDSCAN. Unloaded by DD2TM. Treated by DDSCAN as a ring buffer of length 128 DDC's; treated by DD2TM as a ring buffer of length 2*64, or double buffer. Size = 3072 bytes.

PP16_BUF: PPA 16 bit accumulator. PPHOTBUF is replace-added into PP16_BUF by PPSCAN. 16 bits for each of 256 bins, double buffer. Size = 1024 bytes.

TPV_BUF: PPA theta, phi, and overflow data: 2 bytes per sector, 128 sectors per accumulation, double buffer. Size = 512 bytes.

DDWILLISWAS: Not implemented in ModeZero.

PPWILLISWAS: Not implemented in ModeZero.

RSORC_0.1.2. Telemetry Buffers

RSORC_0.1.2.1. TMBUF

A buffer loaded by task DATA2TMZ and unloaded by the MNF interrupt service routine (ISR). This ISR removes 22 bytes on each MNF interrupt except the first. Since there are 250 MNF's per MJF, this is 22*249=5478 bytes per MJF, of the 5739 total science telemetry allocated to Hydra. The length of TMBUF is half of the 5478, or 2739 bytes. TMBUF is loaded in two parts, like a double buffer. Each part contains, in order,

PPTPVTM	256	bytes
PPTMBINS	150	bytes
DDTMBUF	960	bytes
Science Housekeeping	4 or 3	bytes
	1370 or 1369 bytes	

1370 + 1369 = 2739 bytes

PPTPVTM: Half, or 256 bytes, of TPV_BUF are moved at a time from TPV_BUF to PPTPVTM without any modification.

PPTMBINS: 120 bins are compressed (PSRL 16 to 10) by CS8to5 and packed into 1200 bits or 150 bytes.

DDTMBUF: 12 channels at 10 bits per reading for 64 DDC's at a time. Size = 960 bytes.

RSORC_0.1.2.2. LOOSEBYTES

The "loosebytes" are the telemetry allocation consisting of word 17 in minor frames 1-139. We have assigned these bytes for science housekeeping. They will be held in a double buffer of length 278 bytes. When the major frame counter, MJF_CNT, is even, the lower half is read out and the upper half is filled. When MJF_CNT is odd, the upper half is read out and the lower half is filled. The first byte, byte zero, of each half buffer will be written by UNH. The remaining 138 bytes will be written by UCSD. The buffer will be read out by the minor frame interrupt service routine.

RSORC_0.1.3. Total Buffer Space

	DDEIS	PPA	TVO	SHKPG	
Hot Data	28	256	4		288
Holding Data	3072	1024	512		4608
Telemetry Buffers	1920	300	512	285	3017
	----	----	----	----	----
Total	5020	1580	1028	285	7913

RSORC_0.2.0. PROM Usage

9/6/91

	DDSCAN_0	approx 605 bytes
	PPSCAN_0	approx 719 bytes
	B2PPA_0	approx 793 bytes
	DATA2TM_0	approx 735 bytes
	Descr. Tables	approx 38 bytes
Total		approx 2890 bytes

9/17/91

	DDSCAN_0		approx	274 bytes
	PPSCAN_0		approx	435 bytes
		chk_sc_es	approx	153 bytes
		next_descr	approx	127 bytes
	B2PPA_0		approx	797 bytes
	DATA2TM_0		approx	756 bytes
	Descr. Tables		approx	39 bytes
Total			approx	2581 bytes

9/19/91

Total	2479 bytes

9/25/91

	Descr. Tables		approx	39 bytes
	DDSCAN_0		approx	200 bytes
	PPSCAN_0		approx	353 bytes
		chk_sc_es	approx	140 bytes
		next_descr	approx	127 bytes
		descr_init	approx	67 bytes

	B2PPA_0	approx	705 bytes
	DATA2TM_0	approx	715 bytes
Total		approx	2346 bytes

SOWPGM_0.0. DIAGRAM OF A ROUTINE
FOR OPERATION OF THE HYDRA SCANNING ANALYZERS

MODEZERO
September 29, 1996

```
 ---------------------------------------------------
| A scanning sequence is begun by a command which    |
|   provides the starting descriptor number.         |
| The command handler saves the descriptor number,   |
|   and sets an init_flag for the scanning program.  |
| The scanning routines run once to initialize, and  |
|   then don't run again until the next MJF.         |
| Subsequently they run every BCI until another      |
|   command restarts the sequence.                   |
 ---------------------------------------------------


 -----------------------------------------------
| The BCI ISR calls the scanning routines        |
|    after each Basis Control Interrupt (BCI)    |
 -----------------------------------------------
                        |
 -------------------------------------------------------------------
| Test the init_flag to see if an external command arrived          |
|    to start a new descriptor series.                              |
 -------------------------------------------------------------------
    | No                                                       Yes |
    |        -------------------------------------------------------
    |       | DD: Calculate and save synch_mjf                      |
    |       |   = the low byte of the MJF counter + synch_interval  |
    |       | Default value of synch_interval is 63, changeable by  |
    |       |   upload.                                             |
    |        -------------------------------------------------------
    |                             |
    |                   *********************
    |                   *  RESYNCH REENTRY  *
    |                   *********************
    |                             |
    |        -------------------------------------------------------
    |       | Copy ROM descriptors to RAM                           |
    |       | Get descriptor # left by command processor            |
    |       | Get # interrupts/accumulation from descriptor and     |
    |       |   increment by 1 because this interval (i.e., next    |
    |       |   interrupt) doesn't count.                           |
    |        -------------------------------------------------------
    |                                                                 |
 -----------------------------------------------------------          |
| DD: If last BCI before MJF, and if low byte of MJF counter|         |
|        matches synch_mjf, then set PP and DD resynch      |         |
|        flags and recomputes synch_mjf.                    |         |
| PP: Enable magnetometer task                              |         |
```

```
    | PP: Replace-add 256 8-bit data words from PPHOTBUF          |
    |        into 256 16-bit bins in PP16BUF iff no overflow      |
    | PP: Move 15 bits of theta and phi + ovflow bit to TPV_BUF   |
     -------------------------------------------------------------
        |
     ---------------------------------------------------------
    | Did an accumulation end at the last interrupt?          |
     ---------------------------------------------------------
        |  No                     | Yes
        |             -------------------------------------------
        |            | DD: Complement down-count to count and    |
        |            |        move data from hot-data buffer     |
        |            |        to holding-processing buffer       |
        |            | PP: Swap double-buffer pointers           |
        |            | PP: Initialize tlm-delay counter to 8     |
        |             -------------------------------------------
        |                         |
 -------------------------------------------------------------
|       Will scan finish at next interrupt?                   |
 -------------------------------------------------------------
| No                                                    Yes  |
 -------------------------------------------------           |
| Will an energy step finish at next interrupt?    |         |
 -------------------------------------------------           |
| No             Yes   |                                     |
|    -----------------------------------------------          |
|   | PP: Copy HV to science housekeeping buffer    |         |
|   | Compute voltage index number for next energy  |         |
|   |    level, put in control vector, and turn on  |         |
|   |    new HV flag in control vector.             |         |
|    -----------------------------------------------          |
|                      |                                     |
 -----------------------------------------------             |
| Will this accumulation end at next interrupt? |            |
 -----------------------------------------------             |
| No                   | Yes                                 |
|    -------------------------------------                    |
|   | Set acc_clear bit in control vector |                   |
|   |    (affects DDEIS only)             |                   |
|    -------------------------------------                    |
|   |                                                         |
|   |         ---------------------------------------------------
|   |        | PP: Copy HV to science housekeeping buffer       |
|   |         ---------------------------------------------------
|   |                             |
|   |         ---------------------------------------------------
|   |        | Will offset cycle finish at next interrupt?      |
|   |         ---------------------------------------------------
|   |                | No                               Yes  |
|   |     ------------------------------------                |
|   |    | Increment current descriptor's     |               |
|   |    |   running offset for its next scan |               |
|   |    | Get next scan descriptor number    |               |
|   |     ------------------------------------                |
```

```
      |   |    |                                           |         |
                   -------------------------------------------
                  | Get next cycle descriptor number          |
                   -------------------------------------------
                                                           |         |
                   --------------------------------------------------------
                  | Get scans/offset cycle from descriptor                  |
                  | Re-initialize current descriptor's running offset       |
                  |    to zero                                              |
                   --------------------------------------------------------
               |                                           |
           ------------------------------------------------------
          | Get # interrupts/energy step from descriptor.        |
          | Compute # interrupts/energy scan                     |
          |   = (interrupts/Estep)*(Esteps/scan).                |
          | Initialize parameters for pyramid scan profile.      |
          | Load control vector:                                 |
          |   Set acc_clear bit (used by DD only)                |
          |   Set new_hv bit                                     |
          |   Set polarity bit (used by DD only)                 |
          | Copy scan base energy from descriptor,               |
          |   add offset base from descriptor,                   |
          |   and add running offset to obtain next HV level.    |
           ------------------------------------------------------
      |   |                        |
  ----------------------------------------------------------------
 | Check individual (DD or PP) resynch flag.  Time to resynch?    |
  ----------------------------------------------------------------
          | No                    | Yes
          |              ***************************
          |              *  GO TO RESYNCH REENTRY  *
          |              ***************************
          |
  ------------------------------------------
 | DD: Format HV index for DAC scale        |
 | Copy HV index to control vector          |
 | PP: Decrement and test tlm-delay counter.|
 |       Enable telemetry task if zero.     |
  ------------------------------------------
                     |
                  --------
                 | Return |
                  --------
```

DESCRIPTOR LIBRARY

CONTROL VECTOR

Flags (TBD bytes)

DDEIS
DDEIS Sensor Polarity @!
(1 bit action flag + 1 bit value)
Change DDEIS HV on next BCI @!
(1 bit action flag
+ 6 bits value
+ 1 bit polarity -- 0 negative, 1 positive --)
Clear DDEIS accumulators on next BCI @!
(1 bit action flag)

PPA
Change PPA HV on next ET2 @!
(1 bit action flag + 7 bit value)

HV DAC Values
DDEIS HV DAC Value @!
(64 steps, or 6 bits + range + polarity = 8 bits)
PPA HV DAC Value @!
(128 steps, or 7 bits)
These HV DAC control bytes are obtained from the HV RAM lookup tables. See SCNSEQ_0.5.

SCAN VECTORS

DDEIS SCAN VECTOR, MODEZERO

Descriptor Number	DD0	DD1	# bytes
Scan Base Level 0 <= Base <= 255 (internal scale)	127	128	1
Scan Increment	+4	-4	1
Number of HV Steps Per Scan (DDN's/DSC)	21	21	1
Offset Base (+-Levels)	0	0	1
Offset Increment (+-)	+1	-1	1
Scans Per Offset Cycle	4	4	1
# Interrupts per Energy Step (BCI's/DDN)	2	2	2
# Interrupts per Accumulation (BCI's/DDC)	2	2	2
Number of Next Scan Descriptor	DD1	DD0	1
Number of Next Cycle Descriptor	DD1	DD0	1
Sensor Polarity	+	-	1

PPA SCAN VECTOR

Descriptor Number	PP0	# bytes
Scan Base Level 0 <= Base <= 127	85	1
Scan Increment	2	1
Number of HV Steps Per Scan	18	1
Offset Base (+-Levels)	0	1
Offset Increment (+-)	1	1
Scans Per Offset Cycle	2	1
# Interrupts per Energy Step (BCI's/PPN)	128	2
# Interrupts per Accumulation (BCI's/PPC)	128	2
Address of Next Scan Descriptor	PP0	1
Address of Next Cycle Descriptor	PP0	1
Sensor Polarity	(null byte)	1

HARDWARE TIMING CONTROLS	Hex	Dec
Value in Basis Control Int. Counter (BCI)	3E8	1000
Value in 1st Expt. Timing Counter (ET1)	FF	-1
Value in 2nd Expt. Timing Counter (ET2)	C8	200
Value in Acc. Gate Counter (ACC)	BB80	48,000
Value in Sun Pulse Delay Counter (DSP)	01	1
Value in Time Code Counter	FF	-1
BCI Select MUX Setting	TM	
MIT Select MUX Setting	non-MIT	

TELEMETRY VECTOR	
Data Word Length	10 bits

@! Loaded by program in real time.

RESYNCH.0. Calculating the Resynchronization Interval

The criterion for determining the resynchronization interval is that it must contain an integer number of PPA cycles, DDEIS cycles, and telemetry cycles. Define:

F = # MJF's/resynchronization interval
Sp = # PPA cycles/resynchronization interval
S+ = # DDEIS ion cycles/resynchronization interval
S- = # DDEIS electron cycles/resynchronization interval
Sd = # DDEIS ion + electron cycles/resynchronization interval
Np = # HV steps/PPA cycle
N+ = # HV steps/DDEIS ion cycle
N- = # HV steps/DDEIS electron cycle
Nd = (N+) + (N-) = # DDEIS steps/DDEIS ion + electron cycle

We have allocated our ModeZero Code telemetry space into 256 DDEIS readings and 4 PPA readings per MJF, and we have partitioned the DDEIS readings between ions and electrons:

N- + N+ = Nd
S- = S+

The essential constraint on the sequence resynchronization interval, F, is that it must contain an integral number of both PPA scans and DDEIS scans. When this constraint is met, the resynchronization occurs seamlessly. In addition to tidiness, this prevents the resynchronization from occurring in the middle of a scan, and calling for some large step from either of the HV power supplies. This constraint (actually two constraints) gives two integer equations:

256 * F = Sd * Nd   or   2**8 * F = Sd * Nd
4 * F = Sp * Np   or   2**2 * F = Sp * Np

Eliminating F gives another integer equation which must be satisfied for integers Sp, Sd, Np, and Nd:

2**6 * Sp * Np = Sd * Nd

Given Nd and Np, this integer equation can be solved by inspection, which is easy if one first factors all integers into their prime factors.

For example, for Scan2E, the descriptors will be predicated on a value of 256 for Nd (3*43 + 3*41 + 4). The value for Np will be 36, or all the levels spanning the particle energy interval from 500 eV to 5 keV. Thus, we have

Nd = 256 = 2^8
Np = 36 = 2^2 * 3^2

and we must satisfy the following integer equation:

$2^6 * Sp * 2^2 * 3^2 = Sd * 2^8$

By inspection, this equation is satisfied if $Sd = 3^2$ and $Sp = 1$. This gives us the length of the resynchronization cycle, $F = 3^2 = 9$.

For the general case, although there may be overriding considerations, we prefer a short resynchronization interval, and the ModeZero code burned into ROM allocates only one byte for the value of F. The above demonstrates that Nd must be factored by several powers of two in order for this to be possible, and that it also helps if Nd and Np contain some prime factors in common.

PEAKDWEL.0. Strategies for Energy Dwells
September 29, 1996

PEAKDWEL.1. Dwells

Descriptors for which the Scan Base Level = -1 or 255 (Note that -1==255) are called dwell descriptors. At execution time, the code will use the offset of the peak level in place of the Scan Base Level. These are called dwell descriptors because one application is to let the voltage dwell for an extended time at the peak level from the previous scan. Because of the generality of the descriptor algorithm, it is also possible to base new scans on the peak level. In this case it is really a scan with a base level computed at run time, and dwell is probably a misleading term.

PEAKDWEL.2. Peak Seeking Scans

For each offset cycle, the scan program determines the level at which the peak weighted counting rate occurred. This is done by finding the maximum counting rate for each DDC, and comparing this value, multiplied by an optional weight, with a running maximum. The program retains the scan offset and HV control byte of the maximum. The weight is obtained from a table of length 64 indexed by the 6 LSB's of the control hexbyte.

The entries in the weight table are proportional to the energy of the particle to which the analyzers are tuned, but they are shifted somewhat to accommodate the integer arithmetic restrictions of the CPU.

Decimal Value of 6 LSB's	DDEIS Tuned Energy	Weight
0	7.07 eV	6
1	8.2	7
2	9.3	8
3	10.8	10
4	12.3	11
5	14.2	13
6	16.3	15
7	18.7	17
8	21.1	19
9	24.3	22
10	27.9	25
11	32.0	29
12	36.7	33
13	42.1	38
14	48.3	44

Decimal Value of 6 LSB's	DDEIS Tuned Energy	Weight
32	534	484
33	616	558
34	708	641
35	808	731
36	928	840
37	1065	964
38	1223	1107
39	1404	1271
40	1571	1422
41	1811	1640
42	2081	1884
43	2374	2149
44	2729	2471
45	3131	2835
46	3596	3255

15	55.3	50	47	4125	3734
16	61.9	56	48	4616	4179
17	71.5	65	49	5323	4818
18	82.2	74	50	6117	5537
19	93.6	85	51	6995	6332
20	107	97	52	8019	7259
21	124	112	53	9200	8328
22	142	128	54	10563	9562
23	163	147	55	12115	10967
24	182	165	56	13592	12304
25	210	190	57	15667	14182
26	241	219	58	17997	16292
27	276	249	59	20525	18580
28	317	287	60	23575	21341
29	363	329	61	27037	24475
30	417	378	62	31015	28076
31	479	433	63	35555	32186

Peak seeking is implemented for DDEIS scans only. PPA dwells are based upon DDEIS electron peaks. This means we need to keep separate peaks for positive and negative scans, so that the electron peak is always ready for the PPA when it needs it in its good time. Because of the arrangement of HV RAM Lookup Table DSHV900.TAB, the offset to an electron peak must lie between 127 and 63, with 63 being the highest energy. Actually, because of the limitation explained in PEAKDWEL.3.1., the offset to an electon peak should lie between 127 and 81, inclusive, corresponding to electrons in the energy range from 7.07 to 3596 eV. According to DFLSV001.2., the PPA is tuned to this energy range from steps 22 (6.91 eV) to 114 (3469 eV). Thus an algorithm for computing the PPA level corresponding to a DDEIS offset is

PPoffset = 276-2*DDoffset

However, a PPA voltage step from level 0 to any level above 96 violates that power supply's single-step limitation. Therefore, when PPA dwell descriptors are in the loop, the DDEIS electron levels should be limited to 127 to 90.

At the end of each offset cycle, write both the HV table index and the control hexbyte corresponding to the peak to a memory location to be picked up by telemetry. As long as we read out this value before the dwell is over, we get the scan base value for the dwell. Otherwise, we have no way of knowing the level at which the dwell took place. See TLMF.TLMLB_2. for the position of these values in the Science Housekeeping Loose Bytes.

PEAKDWEL.3. Restrictions in the Use of Energy Dwells

PEAKDWEL.3.1. Limits on the Ranges of Peak-Seeking Scans

Before the beginning of a dwell, the deflection power supplies are at some low level from the end of the previous scan. The next level is computed, using the peak level as Scan Base level. We are concerned lest this computed level create too large a jump for the deflection power supplies to handle safely in one step. We can restrict this jump if the peak-seeking scans include only levels that we can jump to safely. As a step of 1100 v is used by the DDEIS in SCSQ_2E, we will allow this big a jump, but no higher, for a DDEIS dwell. Thus the peak-seeking scan for a DDEIS dwell is limited to levels 0-46. These levels correspond to table offsets of 127-81 in the designated Table DSHV900.TAB. Similarly, the peak-seeking scan for a PPA dwell is limited to DDEIS offsets from 127 to 90 in Table DSHV900.TAB.

PEAKDWEL.3.2. Number of HV Steps per Accumulation Interval

During peak-seeking scans, use only one HV step per DDC so as not to confuse the position of the peak.

PEAKDWEL.3.3. HV RAM Lookup Table DSHV900.TAB

Table DSHV900.TAB is tailored for dwell descriptors. The high ranges are the only ones expected to be used, and they are arranged to be straightforward so that dwell scans take place in a reliable sequence.

Offset Range	Label	Sign Bit	Range Bit	Steps
0 - 63	L-	0	0	64 steps
64 - 127	H-	0	1	64 steps
128 - 191	H+	1	1	64 steps
192 - 255	L+	1	0	64 steps
Total Table				256 steps

Use only a pre-approved HV RAM Lookup Table during peak-seeking scans and dwells. The DDEIS table contained in file DSHV900.TAB is so designated. The designated PPA table is the identity table.

Dumping ddeis HV values in mode 2

In general, ddeis HV control-byte values are saved by the ddscan routine in sequential bytes in a 256-byte array as they are used. At startup, an offset used by the telemetry task is set to the beginning of the array, and an offset uset by the scan task for writing is set to byte 9. Once per quarter major frame, the telemetry task copies eight bytes to a telemetry dump buffer for actual dump the following quarter. The telemetry task then zeroes out the eight bytes from which it has copied and increments its offset to the next 8-byte segment. When the scan routine is about to save the first hv value of a cycle, it first advances to the beginning of the next segment (if it is not already on a segment boundary) and puts in 8 bytes of zeroes as a marker. It then writes the starting value at the beginning of the next segment. If any of these writes to the array would be in the next telemetry readout segment, there will be a full scan cycle delay before they take place.

Limitations:

The scan routine is generating HV values at the rate of 256 per major frame, assuming two BCIs per energy level. The telemetry task will read out and re-zero 32 bytes per major frame. As mentioned above, when writing collides with the next telemetry readout segment, writing is suspended for a cycle. If the cycle is long enough, telemetry readout can overtake writing and start dumping segments that it has previously zeroed. The shortest time in which this can occur will be when the writing collides with telemetry readout just before the readout takes place. Writing is suspended and immediately afterward (i.e., in the same BCI interval) the telemetry offset moves on to the next segment. It will then take 31 quarters for the telemetry offset to return to the segment it was in when the collision took place. During this time, the scan will have generated 31*64 = 1984 new values. In order for writing to have already moved out of this segment, it must have already written at least 8 values, so the maximum cycle length guaranteed to be written out without interruption is 1976. Experiments have shown that when the cycle is somewhat longer than this, telemetry can overtake the writing and dump the sections of the array that it has previously zeroed. When writing is able to resume, it picks up where it left off. If the cycle length is 2048, writing and readouts are in phase and no further values will be written to the array.

The following is a more detailed description of how this is implemented:

Variables and data structures used:

dd_hv_array	256 byte array used for storing the hv values	
dd_hv_steps	word	# of dd hv steps in a complete cycle (value set by upload)
dd_hv_cnt	word	step # in complete cycle of hv value being set up for next

		accumulation. Values range from 0 to dd_hv_steps-1.
wrt_hv_cnt	word	step # in complete cycle of next hv value to be saved in dd_hv_array. The low byte of this word, added to wrt_offset, gives the byte offset at which to save. Values range from 0 to dd_hv_steps-1 for the word and 0 to min(dd_hv_steps-1,255) for the byte.
wrt_offset	byte	byte offset in dd_hv_array of first byte of a cycle
tlm_hv_cnt	byte	offset in dd_hv_array of first byte of next segment to be read out by the telemetry task

Note: These byte values are treated as unsigned numbers ranging from 0 to 255. When two of them are added, the sum is automatically modulo 256.

Initialization:

As noted above, dd_hv_steps is initialized by upload when a new descriptor sequence is about to be commanded. At startup or descriptor command initialization, the dd scan routine sets dd_hv_cnt, tlm_hv_cnt, and wrt_hv_cnt to 0 and sets wrt_offset to 8. At re-synch time, it sets dd_hv_cnt to 0, which is what it already will be if everything is working right.

Operation:

Whenever the dd scan routine has set up a new HV value to be used on the next accumulation, including at startup or descriptor command initialization, it compares dd_hv_cnt to wrt_hv_cnt. If they are equal, it means that the HV value it has is the next one to be saved. If the next byte location to be written, indicated by wrt_offset plus the low byte of wrt_hv_cnt, is not within the next 8-byte segment to be read out by the telemetry task, it checks to see if this is the first value of a cycle, i.e, wrt_hv_cnt is 0. If it is, and if the next byte to write is not at the beginning of a segment, wrt_offset is adjusted to point to the beginning of the next segment. It then puts in 8 bytes of zeroes, and increments wrt_offset by 8. If this has not bumped it into the telemetry readout segment, or if this was not the first value in a cycle, the value is saved and wrt_hv_cnt is incremented by 1. If wrt_hv_cnt is then equal to dd_hv_steps, indicating that it has finished saving a cycle, the low byte of wrt_hv_cnt is added to wrt_offset and wrt_hv_cnt is reset to zero. The adjustment of wrt_offset is necessary to keep it moving along sequentially in the array and not jumping ahead or back. Whether it has saved a value or not, it then increments dd_hv_cnt by 1 and compares it to dd_hv_steps. If they are equal, it is at the end of a cycle, so it resets dd_hv_cnt to 0.

Once per quarter, the telemetry task copies the 8-byte segment pointed to by tlm_hv_cnt into a dump queue, zeroes those bytes in the array, and increments tlm_hv_cnt by 8.

SCSQ_2E. Candidate Deflection Voltage Sequences Compatible With ModeTwo Code September 29, 1996

SCSQ_2E.0. Summary of Characteristics

Telemetry Allocation

DDEIS

256 DDEIS readouts (DDC's)/ MJF
12 channels per readout, 16 bits each compressed PSRL to 10 bits

PPA

4 PPA readouts (PPC's)/ MJF
120 pitch angle bins per readout
Each reading compressed PSRL 16 to 10 bits

Energy Scans

DDEIS

35.9 ms/step. Alternating scans, ions/electron.
43 levels per ion scan; 41 per electron scan. Scan increment of 3 levels at low voltages, changing to 1 level at high.
1 bipolar scan of 84 levels takes 3.019 s. Two consecutive bipolar scans are identical, but shifted 180 degrees in velocity space. One pair of identical bipolar scans approximately every spin period.
Consecutive pairs offset by 1 voltage level. A cycle of 3 offsets takes 18.112 s. At the end of an offset cycle, there is a background dwell of 8 readings to let the look directions advance in velocity space. The angular shift of the next offset cycle depends on the exact spin period. If 6.00 +/- 0.06 s, then 24 +/- 11 degrees.
There are 3*2*(43+41)+8=512 DDC's, or 2 MJF's, per DDEIS cycle.

PPA

Electrons only
Four levels/MJF
18 levels/scan, with step size of 2 levels
Consecutive scans offset by 1 level. 2 scans per offset cycle.
2 scans or 36 levels altogether for each cycle.
One cycle takes 9 MJF's.

COMBINED CYCLES

Period of combined cycles: 18 MJF's.
9 DDEIS cycles/combined cycle
2 PPA cycles/combined cycle

Spacecraft Timing Factors

6.00 =/- 0.06 second spin period
9.2 second major frame period (MJF)

SCSQ_2E.1. Approach to Scan Sequences

The deflection voltages are computed by an algorithm in the DDEIS and PPA scan tasks described in SOWPGM_0. What the code computes is an offset into a deflection voltage lookup table, of length 256 for the DDEIS and 128 for the PPA. The lookup tables reside in RAM and contain the HV control bytes that are sent to the deflection supplies. The lookup tables must be uploaded from the ground, and they provide the flexibility that we need to cope with uncertainty and changes in the deflection supply characteristics. It is possible to completely rewrite a scan sequence by scrambling the table; however, we anticipate that it will be used more conservatively as a fine tuning device to provide flexibility with the detailed deflection voltages, and that the scans will be designed and changed by use of the descriptor tables.

The time profile of each scan is pyramidal, which is to say that the deflection voltage ramps up and then ramps down, so that there are no end-to-end steps. The descriptor element that we call "scan increment" specifies the size of the gaps in an entire up-down scan. Most of the time, the step size will be double the descriptor scan increment, but when the 'mid' step has just finished, defined to be half of 1 + the number of steps per scan (integer division), then a single step must be taken, going back down if number of steps per scan is odd and going up if the number of steps per scan is even. If the next step is mid + 1, set the step size back to double, but make it negative to go back down. The steps may be pictured like this (E vs. t):

```
odd:    mid                even:   mid
         |                          |
        _-                         _-  > single step
       _  -                       _  -
      _    -                     _    -
     _      -     double step{ _       -
```

SCSQ_2E.2. The DDEIS Scans

The D2EComp Scan Sequence

First column 1 from top to bottom;
then column 1 from top to bottom, again;
then column 2 from top to bottom;
then column 2 from top to bottom, again;
then column 3 from top to bottom;
then column 3 from top to bottom, again;
then column 4;
and then back to column 1.

OFS	HEX	HV	OFS	HEX	HV	OFS	HEX	HV	OFS	HEX	HV
127	9F		128	A0	0.42*	129	A1	*	159	BF	20.62*
133	A5		134	A6	*	135	A7	*	159	BF	20.62*
139	AB		140	AC	1.70*	141	AD	*	159	BF	20.62*
145	B1		146	B2	3.63	147	B3		159	BF	20.62
151	B7		152	B8	7.43	153	B9		159	BF	20.62
157	BD		158	BE	17.98	159	BF	20.62	159	BF	20.62
154	BA	10.46	155	BB		156	BC	13.68	159	BF	20.62
148	B4	4.73	149	B5		150	B6		159	BF	20.62
142	AE	2.19	143	AF		144	B0				
136	A8	1.01	137	A9		138	AA	1.31			
130	A2		131	A3		132	A4	0.65			

160	C0	2.02*	161	C1	2.32*	162	C2	2.68*
166	C6	4.64*	167	C7	5.35*	168	C8	5.99*
172	CC	10.45*	173	CD	11.99*	174	CE	13.77*
178	D2	23.47	179	D3	26.79	180	D4	30.82
184	D8	52.14	185	D9	60.12	186	DA	69.11
190	DE	119.53	191	DF	137.11	192	E0	153.13
196	E4	266.13	197	E5	305.29	198	E6	350.68
202	EA	596.60	203	EB	680.57	204	EC	782.43
208	F0	1323.89	209	F1	1526.38	210	F2	1754.10
214	F4	2300.28	215	F4	2300.28	216	F4	2300.28
220	F6	3030.62	221	F6	3030.62	222	F6	3030.62
226	F8	3900.00	227	F8	3900.00	228	F8	3900.00
232	F9	4495.88	233	F9	4495.88	234	F9	4495.88
238	FA	5165.49	239	FA	5165.49	240	FA	5165.49
244	FB	5890.72	245	FB	5890.72	246	FB	5890.72
250	FC	6771.07	251	FC	6771.07	252	FC	6771.07
253	FD	7764.20	254	FD	7764.20	255	FD	7764.20
247	FC	6771.07	248	FC	6771.07	249	FC	6771.07
241	FB	5890.72	242	FB	5890.72	243	FB	5890.72
235	FA	5165.49	236	FA	5165.49	237	FA	5165.49
229	F9	4495.88	230	F9	4495.88	231	F9	4495.88
223	F7	3476.12	224	F7	3476.12	225	F7	3476.12
217	F5	2638.52	218	F5	2638.52	219	F5	2638.52
211	F3	2000.94	212	F3	2000.94	213	F3	2000.94
205	ED	897.59	206	EE	1031.01	207	EF	1132.66
199	E7	402.76	200	E8	450.22	201	E9	519.13

193	E1	176.57	194	E2	202.94	195	E3	231.48
187	DB	78.85	188	DC	90.65	189	DD	104.03
181	D5	35.35	182	D6	40.60	183	D7	46.59
175	CF	15.81	176	D0	17.67	177	D1	20.40
169	C9	6.94	170	CA	7.97	171	CB	9.09
163	C3	3.05	164	C4	3.50	165	C5	4.02

OFS	HEX	HV	OFS	HEX	HV	OFS	HEX	HV
122	25	*	121	26	*	120	27	*
116	2B	*	115	2C	-1.43*	114	2D	*
110	31	*	109	32	-3.34*	108	33	*
104	37		103	38	-7.58	102	39	
98	3D		97	3E	-17.44	96	3F	-20.04
101	3A	-10.08	100	3B		99	3C	-13.23
107	34	-4.41	106	35		105	36	-5.84
113	2E	-1.91	112	2F		111	30	-2.48
119	28	-0.76	118	29		117	2A	-1.06
95	40	-2.01*	94	41	-2.32*	93	42	-2.64*
89	46	-4.60*	88	47	-5.30*	87	48	-5.96*
83	4C	-10.37*	82	4D	-11.90*	81	4E	-13.65*
77	52	-23.24	76	53	-26.47	75	54	-30.46
71	58	-51.56	70	59	-59.44	69	5A	-68.30
65	5E	-118.03	64	5F	-135.39	63	60	-151.16
59	64	-262.60	58	65	-301.35	57	66	-346.07
53	6A	-588.77	52	6B	-671.69	51	6C	-772.04
47	70	-1305.91	46	71	-1505.68	45	72	-1730.26
41	74	-2268.57	40	74	-2268.57	39	74	-2268.57
35	76	-2988.05	34	76	-2988.05	33	76	-2988.05
29	78	-3844.85	28	78	-3844.85	27	78	-3844.85
23	79	-4431.88	22	79	-4431.88	21	79	-4431.88
17	7A	-5091.10	16	7A	-5091.10	15	7A	-5091.10
11	7B	-5806.19	10	7B	-5806.19	9	7B	-5806.19
5	7C	-6669.12	4	7C	-6669.12	3	7C	-6669.12
2	7D	-7648.35	1	7D	-7648.35	0	7D	-7648.35
8	7C	-6669.12	7	7C	-6669.12	6	7C	-6669.12
14	7B	-5806.19	13	7B	-5806.19	12	7B	-5806.19
20	7A	-5091.10	19	7A	-5091.10	18	7A	-5091.10
26	79	-4431.88	25	79	-4431.88	24	79	-4431.88
32	77	-3427.04	31	77	-3427.04	30	77	-3427.04
38	75	-2602.55	37	75	-2602.55	36	75	-2602.55
44	73	-1978.86	43	73	-1978.86	42	73	-1978.86
50	6D	-885.79	49	6E	-1017.17	48	6F	-1166.87
56	67	-397.05	55	68	-444.39	54	69	-512.38
62	61	-174.31	61	62	-200.28	60	63	-228.52
68	5B	-77.95	67	5C	-89.59	66	5D	-102.79
74	55	-34.97	73	56	-40.12	72	57	-46.04
80	4F	-15.65	79	50	-17.52	78	51	-20.23
86	49	-6.87	85	4A	-7.90	84	4B	-9.04
92	43	-3.04	91	44	-3.49	90	45	-4.03

NOTES

Where voltage values are left blank, it is only because no calibration data were given for those levels. It is reasonable to suppose that they interpolate smoothly between adjacent calibrated levels.

Asterisks mark voltage levels probably corrupted by switching transients.

Nine descriptors produce this sequence, and they are given in SCSQ_2E.4.1.

SCSQ_2E.3. The PPA Scan

The PPA scan program calculates offsets into its deflection voltage lookup table, given in section SCSQ_2E.6.2. The lookup table has 128 elements, only one polarity, and may consist simply of an identity transformation.

The PPA cycle will concentrate on levels 085-120, which correspond nominally to 0.5 to 5 keV electrons. There are 36 deflection voltage levels in this interval, and they are covered by two staggered scans of 18 levels each. The PPA scan cycle of 36 levels is repeated 2 times in a scan resynchronization interval of 18 major frames.

First column 1 from top to bottom, then column 2 from top to bottom.

OFS	HV	OFS	HV
085	-589	086	-630
089	-771	090	-825
093	-1011	094	-1082
097	-1325	098	-1417
101	-1736	102	-1857
105	-2275	106	-2434
109	-2981	110	-3190
113	-3907	114	-4180
117	-5120	118	-5478
119	-5861	120	-6271
115	-4472	116	-4785
111	-3413	112	-3651
107	-2604	108	-2786
103	-1987	104	-2126
099	-1516	100	-1622
095	-1157	096	-1238
091	-883	092	-945
087	-674	088	-721

The time profile of each scan is pyramidal, which is to say that the deflection voltage ramps up and then ramps down, so that there are no end-to-end steps. The descriptor element that we call "scan increment" specifies the size of the gaps in an entire up-down scan. On the way up the step size is two scan increments, and on the way down it is two scan increments, but since the up-scan is interleaved with the down-scan, the overall pitch is one scan increment.

The scans were chosen to comply with the deflection supply slewing limitation of 500 volts/millisecond.

One descriptor produces this sequence, and is given in section SCSQ_2E.4.2.

SCSQ_2E.4. Descriptors

The SCSQ_2E sequence is produced by the following descriptors. The DDEIS descriptors follow one another in a loop, called D2EComp. Individual descriptors may be designated, e.g.: D2EComp-0, D2EComp-1, etc.

SCSQ_2E.4.1. DDEIS SCAN VECTORS

Sequence Name	*-----------------D2EComp-----------------*								
HV Lookup Table	DSHV100.TAB								
Coordinated PP Descriptor	PP0								
MJF's Per Resynch. Interval	18								
Nd	512								
Descriptor Number	0	1	2	3	4	5	6	7	8
Scan Base Level 0 <= Base <= 255 (internal scale)	127	160	122	95	127	160	122	95	127
Scan Increment	+3	+3	-3	-3	+3	+3	-3	-3	0
Number of HV Steps Per Scan (DDN's/DSC)	11	32	9	32	11	32	9	32	8
Offset Base (+-Levels)	0	0	0	0	0	0	0	0	+32
Offset Increment (+-)	+1	+1	-1	-1	+1	+1	-1	-1	0
Scans Per Offset Cycle	3	3	3	3	3	3	3	3	1
# Interrupts per Energy Step (BCI's/DDN)	2	2	2	2	2	2	2	2	2
# Interrupts per Accumulation (BCI's/DDC)	2	2	2	2	2	2	2	2	2
Number of Next Scan Descriptor	1	2	3	4	5	6	7	0	0
Number of Next Cycle Descriptor	1	2	3	4	5	6	7	8	0
Sensor Polarity	+	+	-	-	+	+	-	-	-

SCSQ_2E.4.2. PPA SCAN VECTOR

Descriptor Number	PP0
Scan Base Level 0 <= Base <= 127	85
Scan Increment	2

Number of HV Steps Per Scan	18
Offset Base (+-Levels)	0
Offset Increment (+-)	1
Scans Per Offset Cycle	2
# Interrupts per Energy Step (BCI's/PPN)	128
# Interrupts per Accumulation (BCI's/PPC)	128
Address of Next Scan Descriptor	PP0
Address of Next Cycle Descriptor	PP0
Sensor Polarity	(null byte)

SCSQ_2E.4.3. Related Timing Parameters

In addition to the descriptor variables, there are other parameters that must be managed in order to keep the scan and data sequences coordinated.

In order to assure that the scan sequences stay synchronized to the telemetry sequence, the scan program is resynchronized periodically. For the SCSQ_2E cases, the sequence resynchronization interval is 18 major frames (165.6 seconds). The sequence resynchronization interval F is written to a RAM variable, so that it can be updated from the ground when a change in descriptors causes a change in the resynchronization cycle.

The DDEIS scan program writes each deflection voltage control byte to a table, for telemetry to pick up. The telemetry task takes 64 bytes from the table in each major frame, cycling through the entire 256-byte length of the table in 4 major frames. As the DDEIS scan does not restart each major frame, the write pointer is cycled with the DDEIS scan cycle. The number of bytes in a cycle must be loaded into a RAM variable in order to tell the task when to restart at the beginning of the table. In loop D2EComp, the length of the DDEIS scan cycle is 512, comprised of 6 subscans of 84 each, plus a dwell of 8. The contents of this RAM variable must be updated when a change in descriptors causes a change in the cycle length.

The correct HV lookup table must be used, and is specified by the name of the FID file that describes it.

SCSQ_2E.5. Sequence Resynchronization Interval

In order to assure that the scan sequences stay synchronized to the telemetry sequence, the scan program is resynchronized periodically. The resynchronization interval is chosen so as be seamless. That is, to contain an integral number of DDEIS scans, an integral number of PPA scans, and an integral number of telemetry frames. Thus this number is acutely dependent upon the length of the scans. For the SCSQ_2E cases, the sequence resynchronization interval is 18 major frames (165.6 seconds). For other scans, the resynchronization interval must be calculated as described in file RESYNCH.INT. The sequence resynchronization interval F is written to a RAM variable, so that it can be updated from the ground when a change in descriptors causes a change in the resynchronization cycle.

SCSQ_2E.6.0. Deflection Level RAM Lookup Tables

To provide flexibility in dealing with the deflection supplies, two RAM tables (one each for the PPA and DDEIS) will be used by the scan program to look up the HV level control bytes. As determined by its descriptors, the scan program calculates a sequence of one-byte table offsets. Instead of feeding this byte directly to the HV supply, the program uses it to address the RAM lookup table, where it finds the HV level control byte in the offset location. The tables must be loaded manually after each instrument turn-on.

SCSQ_2E.6.1. The DSHV100 RAM Lookup Table for the DDEIS Deflection Supply

Table DSHV100.TAB is identical to the lookup table tailored for the SCSQ_0E ModeZero code, but we gain a better sequence by using the Scan2E descriptors. This is intended as a conservative sequence. Thus, the two highest voltage steps are not used and are absent from the table. A rolloff is applied to the high end of the high ranges in order to restrict the magnitude of any single step to a maximum of 1100 v (550 v per side), when the step size is 6 or less. To provide space for the rolloff, the high ranges are given 96 slots each. Designating the ranges by H and L, and the polarity of the particle detected by + and -, the table is allocated, in order, as shown below:

Label	Sign Bit	Range Bit	Steps
H-	0	1	96 steps
L-	0	0	28 steps
L+	1	0	36 steps
H+	1	1	96 steps
Total Table			256 steps

The L- segment of the table is shorter than L+, because there is a -2 V grid in front of the electron channeltron to suppress secondaries. This also acts as a retarding potential, rejecting electrons of energy below 2 eV. With analyzer constant of 7, this corresponds to an analyzer voltage of A-B = 4/7 V, below which there is no interesting data.

A command byte has negative polarity if MSB=1, and yields deflection voltages that analyze for positive particles. This follows because side A is connected to the outer plate.

A listing of the entire table can be found in file DSHV100.TAB.

SCSQ_2E.6.2. The PPA HV Level RAM Lookup Table

The HV level RAM lookup table for the PPA supplies may be as simple as a linear sequence running from 0 at offset 0 to 127 at offset 127. Of course, a table is not needed to create an identity operation such as this, but it offers flexibility in case the power supply characteristics change.

SCSQ_2E.7.0. Available Deflection Voltage Values

The deflection voltage supplies are expected to run from + or - 0.1 to + or - 5,000 V for the DDEIS, and from - 1.9 to - 10,000 V for the PPA. The DDEIS deflection supply has two polarities, and two ranges, from about 0.1 to 10 V, and 1 to 5000 V. Actual voltage values are given in file DFLSV001.TAB based on calibration data from the SN001 supplies taken at ambient temperature, Sept-Oct, 1992.

The energy/voltage conversion ratios are 7.07 for the DDEIS and 0.83 for the PPA, in units of eV/V.

DSHV100.0. The DSHV100.TAB RAM Lookup Table for the DDEIS Deflection Supply

The table given below is tailored for the ModeZero code, using Scan0E descriptors, and can be used by similar descriptors. This is intended as a failsafe mode. Thus, the two highest voltage steps are not used and are absent from the table. A rolloff is applied to the high end of the high ranges in order to restrict the magnitude of any single step to a maximum of 1100 v (550 v per side), when the step size is 6 or less. To provide space for the rolloff, the high ranges are given 96 slots each. Designating the ranges by H and L, and the polarity of the particle detected by + and -, the table is allocated, in order, as shown below:

Label	Sign Bit	Range Bit	Steps
H-	0	1	96 steps
L-	0	0	28 steps
L+	1	0	36 steps
H+	1	1	96 steps
Total Table			256 steps

The L- segment of the table is shorter than L+, because there is a -2 V grid in front of the electron channeltron to suppress secondaries. This also acts as a retarding potential, rejecting electrons of energy below 2 eV. With analyzer constant of 7, this corresponds to an analyzer voltage of A-B = 4/7 V, below which there is no interesting data.

A command byte has negative polarity if MSB=1, and yields deflection voltages that analyze for positive particles. This follows because side A is connected to the outer plate.

The high voltage values are based on calibration data from the SN001 supplies taken at ambient temperature, Sept-Oct, 1992.

Decim. Offset	Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
0	0	1	61	7D	-7648.35	3.88
1	0	1	61	7D	-7648.35	3.88
2	0	1	61	7D	-7648.35	3.88
3	0	1	60	7C	-6669.12	3.82
4	0	1	60	7C	-6669.12	3.82
5	0	1	60	7C	-6669.12	3.82
6	0	1	60	7C	-6669.12	3.82
7	0	1	60	7C	-6669.12	3.82
8	0	1	60	7C	-6669.12	3.82
9	0	1	59	7B	-5806.19	3.76
10	0	1	59	7B	-5806.19	3.76
11	0	1	59	7B	-5806.19	3.76
12	0	1	59	7B	-5806.19	3.76
13	0	1	59	7B	-5806.19	3.76
14	0	1	59	7B	-5806.19	3.76
15	0	1	58	7A	-5091.1	3.71
16	0	1	58	7A	-5091.1	3.71
17	0	1	58	7A	-5091.1	3.71
18	0	1	58	7A	-5091.1	3.71
19	0	1	58	7A	-5091.1	3.71
20	0	1	58	7A	-5091.1	3.71
21	0	1	57	79	-4431.88	3.65
22	0	1	57	79	-4431.88	3.65
23	0	1	57	79	-4431.88	3.65
24	0	1	57	79	-4431.88	3.65
25	0	1	57	79	-4431.88	3.65
26	0	1	57	79	-4431.88	3.65
27	0	1	56	78	-3844.85	3.58
28	0	1	56	78	-3844.85	3.58
29	0	1	56	78	-3844.85	3.58
30	0	1	55	77	-3427.04	3.53
31	0	1	55	77	-3427.04	3.53
32	0	1	55	77	-3427.04	3.53
33	0	1	54	76	-2988.05	3.48
34	0	1	54	76	-2988.05	3.48
35	0	1	54	76	-2988.05	3.48
36	0	1	53	75	-2602.55	3.42
37	0	1	53	75	-2602.55	3.42
38	0	1	53	75	-2602.55	3.42
39	0	1	52	74	-2268.57	3.36
40	0	1	52	74	-2268.57	3.36
41	0	1	52	74	-2268.57	3.36
42	0	1	51	73	-1978.86	3.30
43	0	1	51	73	-1978.86	3.30
44	0	1	51	73	-1978.86	3.30
45	0	1	50	72	-1730.26	3.24
46	0	1	49	71	-1505.68	3.18
47	0	1	48	70	-1305.91	3.12

Decim. Offset	Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
48	0	1	47	6F	-1166.87	3.07
49	0	1	46	6E	-1017.17	3.01
50	0	1	45	6D	-885.79	2.95
51	0	1	44	6C	-772.04	2.89
52	0	1	43	6B	-671.69	2.83
53	0	1	42	6A	-588.77	2.77
54	0	1	41	69	-512.38	2.71
55	0	1	40	68	-444.39	2.65
56	0	1	39	67	-397.05	2.60
57	0	1	38	66	-346.07	2.54
58	0	1	37	65	-301.35	2.48
59	0	1	36	64	-262.60	2.42
60	0	1	35	63	-228.52	2.36
61	0	1	34	62	-200.28	2.30
62	0	1	33	61	-174.31	2.24
63	0	1	32	60	-151.16	2.18
64	0	1	31	5F	-135.39	2.13
65	0	1	30	5E	-118.03	2.07
66	0	1	29	5D	-102.79	2.01
67	0	1	28	5C	-89.59	1.95
68	0	1	27	5B	-77.95	1.89
69	0	1	26	5A	-68.30	1.83
70	0	1	25	59	-59.44	1.77
71	0	1	24	58	-51.56	1.71
72	0	1	23	57	-46.04	1.66
73	0	1	22	56	-40.12	1.60
74	0	1	21	55	-34.97	1.54
75	0	1	20	54	-30.46	1.48
76	0	1	19	53	-26.47	1.42
77	0	1	18	52	-23.24	1.37
78	0	1	17	51	-20.23	1.31
79	0	1	16	50	-17.52	1.24
80	0	1	15	4F	-15.65	1.19
81	0	1	14	4E	-13.65	1.14
82	0	1	13	4D	-11.90	1.08
83	0	1	12	4C	-10.37	1.02
84	0	1	11	4B	-9.04	0.956
85	0	1	10	4A	-7.90	0.898
86	0	1	9	49	-6.87	0.837
87	0	1	8	48	-5.96	0.775
88	0	1	7	47	-5.30	0.724
89	0	1	6	46	-4.60	0.663
90	0	1	5	45	-4.03	0.605
91	0	1	4	44	-3.49	0.543
92	0	1	3	43	-3.04	0.483
93	0	1	2	42	-2.64	0.422
94	0	1	1	41	-2.32	0.365
95	0	1	0	40	-2.01	0.303

Decim. Offset	Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
96	0	0	63	3F	-20.04	1.30
97	0	0	62	3E	-17.44	1.24
98	0	0	61	3D		
99	0	0	60	3C	-13.23	1.12
100	0	0	59	3B		
101	0	0	58	3A	-10.08	1.00
102	0	0	57	39		
103	0	0	56	38	-7.58	0.880
104	0	0	55	37		
105	0	0	54	36	-5.84	0.766
106	0	0	53	35		
107	0	0	52	34	-4.41	0.644
108	0	0	51	33		
109	0	0	50	32	-3.34	0.524
110	0	0	49	31		
111	0	0	48	30	-2.48	0.394
112	0	0	47	2F		
113	0	0	46	2E	-1.91	0.281
114	0	0	45	2D		
115	0	0	44	2C	-1.43	0.155
116	0	0	43	2B		
117	0	0	42	2A	-1.06	0.025
118	0	0	41	29		
119	0	0	40	28	-0.76	-0.12
120	0	0	39	27		
121	0	0	38	26		
122	0	0	37	25		
123	0	0	36	24	-0.39	-0.41

Decim. Offset	Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
124	1	0	28	9C	0.31	-0.51
125	1	0	29	9D		
126	1	0	30	9E		
127	1	0	31	9F		
128	1	0	32	A0	0.42	-0.38
129	1	0	33	A1		
130	1	0	34	A2		
131	1	0	35	A3		
132	1	0	36	A4	0.65	-0.19
133	1	0	37	A5		
134	1	0	38	A6		
135	1	0	39	A7		
136	1	0	40	A8	1.01	0.004
137	1	0	41	A9		
138	1	0	42	AA	1.31	0.117
139	1	0	43	AB		
140	1	0	44	AC	1.70	0.230
141	1	0	45	AD		
142	1	0	46	AE	2.19	0.340
143	1	0	47	AF		
144	1	0	48	B0	2.76	0.441
145	1	0	49	B1		
146	1	0	50	B2	3.63	0.560
147	1	0	51	B3		
148	1	0	52	B4	4.73	0.675
149	1	0	53	B5		
150	1	0	54	B6		
151	1	0	55	B7		
152	1	0	56	B8	7.43	0.871
153	1	0	57	B9		
154	1	0	58	BA	10.46	1.02
155	1	0	59	BB		
156	1	0	60	BC	13.68	1.14
157	1	0	61	BD		
158	1	0	62	BE	17.98	1.25
159	1	0	63	BF	20.62	1.31

Decim. Offset	Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
160	1	1	0	C0	2.02	0.305
161	1	1	1	C1	2.32	0.365
162	1	1	2	C2	2.68	0.428
163	1	1	3	C3	3.05	0.484
164	1	1	4	C4	3.50	0.544
165	1	1	5	C5	4.02	0.604
166	1	1	6	C6	4.64	0.667
167	1	1	7	C7	5.35	0.728
168	1	1	8	C8	5.99	0.777
169	1	1	9	C9	6.94	0.841
170	1	1	10	CA	7.97	0.901
171	1	1	11	CB	9.09	0.959
172	1	1	12	CC	10.45	1.02
173	1	1	13	CD	11.99	1.08
174	1	1	14	CE	13.77	1.14
175	1	1	15	CF	15.81	1.20
176	1	1	16	D0	17.67	1.25
177	1	1	17	D1	20.40	1.31
178	1	1	18	D2	23.47	1.37
179	1	1	19	D3	26.79	1.43
180	1	1	20	D4	30.82	1.49
181	1	1	21	D5	35.35	1.55
182	1	1	22	D6	40.60	1.61
183	1	1	23	D7	46.59	1.67
184	1	1	24	D8	52.14	1.72
185	1	1	25	D9	60.12	1.78
186	1	1	26	DA	69.11	1.84
187	1	1	27	DB	78.85	1.90
188	1	1	28	DC	90.65	1.96
189	1	1	29	DD	104.03	2.02
190	1	1	30	DE	119.53	2.08
191	1	1	31	DF	137.11	2.14
192	1	1	32	E0	153.13	2.19
193	1	1	33	E1	176.57	2.25
194	1	1	34	E2	202.94	2.31
195	1	1	35	E3	231.48	2.36
196	1	1	36	E4	266.13	2.43
197	1	1	37	E5	305.29	2.48
198	1	1	38	E6	350.68	2.54
199	1	1	39	E7	402.76	2.61
200	1	1	40	E8	450.22	2.65
201	1	1	41	E9	519.13	2.72
202	1	1	42	EA	596.60	2.78
203	1	1	43	EB	680.57	2.83
204	1	1	44	EC	782.43	2.89
205	1	1	45	ED	897.59	2.95
206	1	1	46	EE	1031.01	3.01
207	1	1	47	EF	1132.66	3.05

Decim. Offset	Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
208	1	1	48	F0	1323.89	3.12
209	1	1	49	F1	1526.38	3.18
210	1	1	50	F2	1754.10	3.24
211	1	1	51	F3	2000.94	3.30
212	1	1	51	F3	2000.94	3.30
213	1	1	51	F3	2000.94	3.30
214	1	1	52	F4	2300.28	3.36
215	1	1	52	F4	2300.28	3.36
216	1	1	52	F4	2300.28	3.36
217	1	1	53	F5	2638.52	3.42
218	1	1	53	F5	2638.52	3.42
219	1	1	53	F5	2638.52	3.42
220	1	1	54	F6	3030.62	3.48
221	1	1	54	F6	3030.62	3.48
222	1	1	54	F6	3030.62	3.48
223	1	1	55	F7	3476.12	3.54
224	1	1	55	F7	3476.12	3.54
225	1	1	55	F7	3476.12	3.54
226	1	1	56	F8	3900.00	3.59
227	1	1	56	F8	3900.00	3.59
228	1	1	56	F8	3900.00	3.59
229	1	1	57	F9	4495.88	3.65
230	1	1	57	F9	4495.88	3.65
231	1	1	57	F9	4495.88	3.65
232	1	1	57	F9	4495.88	3.65
233	1	1	57	F9	4495.88	3.65
234	1	1	57	F9	4495.88	3.65
235	1	1	58	FA	5165.49	3.71
236	1	1	58	FA	5165.49	3.71
237	1	1	58	FA	5165.49	3.71
238	1	1	58	FA	5165.49	3.71
239	1	1	58	FA	5165.49	3.71
240	1	1	58	FA	5165.49	3.71
241	1	1	59	FB	5890.72	3.77
242	1	1	59	FB	5890.72	3.77
243	1	1	59	FB	5890.72	3.77
244	1	1	59	FB	5890.72	3.77
245	1	1	59	FB	5890.72	3.77
246	1	1	59	FB	5890.72	3.77
247	1	1	60	FC	6771.07	3.83
248	1	1	60	FC	6771.07	3.83
249	1	1	60	FC	6771.07	3.83
250	1	1	60	FC	6771.07	3.83
251	1	1	60	FC	6771.07	3.83
252	1	1	60	FC	6771.07	3.83
253	1	1	61	FD	7764.20	3.89
254	1	1	61	FD	7764.20	3.89
255	1	1	61	FD	7764.20	3.89

DFLSV001.0. Deflection Supply Voltage Tables, SN001

The following are the voltages available with our power supplies.

DFLSV001.1. DDEIS Deflection Supply

The following table is based on calibration data from the SN001 supplies taken at ambient temperature, Sept-Oct, 1992.

A command byte has negative polarity if MSB=1, and yields deflection voltages that analyze for positive particles. This follows because side A is connected to the outer plate. Note that the step size on the log(HV) scale approximates a uniform 0.06 across both ranges. This can be compared with the analyzer resolution, given by log((E+deltaE)/E) = log(1.08) = 0.033.

Positive Polarity, Low Range

Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
0	0	63	3F	-20.04	1.30
0	0	62	3E	-17.44	1.24
0	0	61	3D		
0	0	60	3C	-13.23	1.12
0	0	59	3B		
0	0	58	3A	-10.08	1.00
0	0	57	39		
0	0	56	38	-7.58	0.880
0	0	55	37		
0	0	54	36	-5.84	0.766
0	0	53	35		
0	0	52	34	-4.41	0.644
0	0	51	33		
0	0	50	32	-3.34	0.524
0	0	49	31		
0	0	48	30	-2.48	0.394
0	0	47	2F		
0	0	46	2E	-1.91	0.281
0	0	45	2D		
0	0	44	2C	-1.43	0.155
0	0	43	2B		
0	0	42	2A	-1.06	0.025
0	0	41	29		
0	0	40	28	-0.76	-0.12
0	0	39	27		
0	0	38	26		
0	0	37	25		
0	0	36	24	-0.39	-0.41
0	0	35	23		
0	0	34	22		
0	0	33	21		
0	0	32	20	-0.17	-0.77
0	0	31	1F		
0	0	30	1E		
0	0	29	1D		
0	0	28	1C	-0.07	-1.2
0	0	27	1B		
0	0	26	1A		
0	0	25	19		
0	0	24	18		
0	0	23	17		
0	0	22	16		
0	0	21	15		
0	0	20	14	0.05	-1.3
0	0	19	13		
0	0	18	12		
0	0	17	11		
0	0	16	10		
0	0	15	0F		

0	0	14	0E		
0	0	13	0D		
0	0	12	0C		
0	0	11	0B		
0	0	10	0A		
0	0	9	09		
0	0	8	08		
0	0	7	07		
0	0	6	06		
0	0	5	05		
0	0	4	04		
0	0	3	03		
0	0	2	02		
0	0	1	01		
0	0	0	00	0.12	-0.92

Positive Polarity, High Range

Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
0	1	63	7F	-10058.06	4.00
0	1	62	7E	-8773.63	3.94
0	1	61	7D	-7648.35	3.88
0	1	60	7C	-6669.12	3.82
0	1	59	7B	-5806.19	3.76
0	1	58	7A	-5091.1	3.71
0	1	57	79	-4431.88	3.65
0	1	56	78	-3844.85	3.58
0	1	55	77	-3427.04	3.53
0	1	54	76	-2988.05	3.48
0	1	53	75	-2602.55	3.42
0	1	52	74	-2268.57	3.36
0	1	51	73	-1978.86	3.30
0	1	50	72	-1730.26	3.24
0	1	49	71	-1505.68	3.18
0	1	48	70	-1305.91	3.12
0	1	47	6F	-1166.87	3.07
0	1	46	6E	-1017.17	3.01
0	1	45	6D	-885.79	2.95
0	1	44	6C	-772.04	2.89
0	1	43	6B	-671.69	2.83
0	1	42	6A	-588.77	2.77
0	1	41	69	-512.38	2.71
0	1	40	68	-444.39	2.65
0	1	39	67	-397.05	2.60
0	1	38	66	-346.07	2.54
0	1	37	65	-301.35	2.48
0	1	36	64	-262.60	2.42
0	1	35	63	-228.52	2.36
0	1	34	62	-200.28	2.30
0	1	33	61	-174.31	2.24
0	1	32	60	-151.16	2.18
0	1	31	5F	-135.39	2.13
0	1	30	5E	-118.03	2.07
0	1	29	5D	-102.79	2.01
0	1	28	5C	-89.59	1.95
0	1	27	5B	-77.95	1.89
0	1	26	5A	-68.30	1.83
0	1	25	59	-59.44	1.77
0	1	24	58	-51.56	1.71
0	1	23	57	-46.04	1.66
0	1	22	56	-40.12	1.60
0	1	21	55	-34.97	1.54
0	1	20	54	-30.46	1.48
0	1	19	53	-26.47	1.42
0	1	18	52	-23.24	1.37
0	1	17	51	-20.23	1.31
0	1	16	50	-17.52	1.24
0	1	15	4F	-15.65	1.19

0	1	14	4E	-13.65	1.14
0	1	13	4D	-11.90	1.08
0	1	12	4C	-10.37	1.02
0	1	11	4B	-9.04	0.956
0	1	10	4A	-7.90	0.898
0	1	9	49	-6.87	0.837
0	1	8	48	-5.96	0.775
0	1	7	47	-5.30	0.724
0	1	6	46	-4.60	0.663
0	1	5	45	-4.03	0.605
0	1	4	44	-3.49	0.543
0	1	3	43	-3.04	0.483
0	1	2	42	-2.64	0.422
0	1	1	41	-2.32	0.365
0	1	0	40	-2.01	0.303

Negative Polarity, High Range

Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
1	1	0	C0	2.02	0.305
1	1	1	C1	2.32	0.365
1	1	2	C2	2.68	0.428
1	1	3	C3	3.05	0.484
1	1	4	C4	3.50	0.544
1	1	5	C5	4.02	0.604
1	1	6	C6	4.64	0.667
1	1	7	C7	5.35	0.728
1	1	8	C8	5.99	0.777
1	1	9	C9	6.94	0.841
1	1	10	CA	7.97	0.901
1	1	11	CB	9.09	0.959
1	1	12	CC	10.45	1.02
1	1	13	CD	11.99	1.08
1	1	14	CE	13.77	1.14
1	1	15	CF	15.81	1.20
1	1	16	D0	17.67	1.25
1	1	17	D1	20.40	1.31
1	1	18	D2	23.47	1.37
1	1	19	D3	26.79	1.43
1	1	20	D4	30.82	1.49
1	1	21	D5	35.35	1.55
1	1	22	D6	40.60	1.61
1	1	23	D7	46.59	1.67
1	1	24	D8	52.14	1.72
1	1	25	D9	60.12	1.78
1	1	26	DA	69.11	1.84
1	1	27	DB	78.85	1.90
1	1	28	DC	90.65	1.96
1	1	29	DD	104.03	2.02
1	1	30	DE	110.53	2.04
1	1	31	DF	137.11	2.14
1	1	32	E0	153.13	2.19
1	1	33	E1	176.57	2.25
1	1	34	E2	202.94	2.31
1	1	35	E3	231.48	2.36
1	1	36	E4	266.13	2.43
1	1	37	E5	305.29	2.48
1	1	38	E6	350.68	2.54
1	1	39	E7	402.76	2.61
1	1	40	E8	450.22	2.65
1	1	41	E9	519.13	2.72
1	1	42	EA	596.60	2.78
1	1	43	EB	680.57	2.83
1	1	44	EC	782.43	2.89
1	1	45	ED	897.59	2.95
1	1	46	EE	1031.01	3.01
1	1	47	EF	1132.66	3.05
1	1	48	F0	1323.89	3.12

1	1	49	F1	1526.38	3.18
1	1	50	F2	1754.10	3.24
1	1	51	F3	2000.94	3.30
1	1	52	F4	2300.28	3.36
1	1	53	F5	2638.52	3.42
1	1	54	F6	3030.62	3.48
1	1	55	F7	3476.12	3.54
1	1	56	F8	3900.00	3.59
1	1	57	F9	4495.88	3.65
1	1	58	FA	5165.49	3.71
1	1	59	FB	5890.72	3.77
1	1	60	FC	6771.07	3.83
1	1	61	FD	7764.20	3.89
1	1	62	FE	8916.89	3.95
1	1	63	FF	10224.04	4.08

Negative Polarity, Low Range

Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
1	0	0	80	0.13	-0.89
1	0	1	81		
1	0	2	82		
1	0	3	83		
1	0	4	84		
1	0	5	85		
1	0	6	86		
1	0	7	87		
1	0	8	88		
1	0	9	89		
1	0	10	8A		
1	0	11	8B		
1	0	12	8C		
1	0	16	8D		
1	0	14	8E		
1	0	15	8F		
1	0	16	90		
1	0	17	91		
1	0	18	92		
1	0	19	93		
1	0	20	94	0.18	-0.74
1	0	21	95		
1	0	22	96		
1	0	23	97		
1	0	24	98	0.23	-0.64
1	0	25	99		
1	0	26	9A		
1	0	27	9B		
1	0	28	9C	0.31	-0.51
1	0	29	9D		
1	0	30	9E		
1	0	31	9F		
1	0	32	A0	0.42	-0.38
1	0	33	A1		
1	0	34	A2		
1	0	35	A3		
1	0	36	A4	0.65	-0.19
1	0	37	A5		
1	0	38	A6		
1	0	39	A7		
1	0	40	A8	1.01	0.004
1	0	41	A9		
1	0	42	AA	1.31	0.117
1	0	43	AB		
1	0	44	AC	1.70	0.230
1	0	45	AD		
1	0	46	AE	2.19	0.340
1	0	47	AF		
1	0	48	B0	2.76	0.441

1	0	49	B1		
1	0	50	B2	3.63	0.560
1	0	51	B3		
1	0	52	B4	4.73	0.675
1	0	53	B5		
1	0	54	B6		
1	0	55	B7		
1	0	56	B8	7.43	0.871
1	0	57	B9		
1	0	58	BA	10.46	1.02
1	0	59	BB		
1	0	60	BC	13.68	1.14
1	0	61	BD		
1	0	62	BE	17.98	1.25
1	0	63	BF	20.62	1.31

DFLSV001.2. PPA Deflection Supply

The following provisional PPA deflection voltage levels were calculated from the formula 7.78*exp(0.135194*(N-21)/2.0).

N	Volts	eV	N	Volts	eV
0	-1.88	1.56	64	-142.34	118.14
1	-2.01	1.67	65	-152.30	126.41
2	-2.15	1.79	66	-162.95	135.25
3	-2.30	1.91	67	-174.34	144.70
4	-2.47	2.05	68	-186.53	154.82
5	-2.64	2.19	69	-199.58	165.65
6	-2.82	2.34	70	-213.54	177.24
7	-3.02	2.51	71	-228.47	189.63
8	-3.23	2.68	72	-244.45	202.89
9	-3.46	2.87	73	-261.54	217.08
10	-3.70	3.07	74	-279.83	232.26
11	-3.96	3.28	75	-299.40	248.51
12	-4.23	3.51	76	-320.34	265.88
13	-4.53	3.76	77	-342.75	284.48
14	-4.85	4.02	78	-366.72	304.37
15	-5.19	4.30	79	-392.36	325.66
16	-5.55	4.61	80	-419.80	348.43
17	-5.94	4.93	81	-449.16	372.80
18	-6.35	5.27	82	-480.57	398.87
19	-6.80	5.64	83	-514.18	426.77
20	-7.27	6.04	84	-550.14	456.61
21	-7.78	6.46	85	-588.61	488.55
22	-8.32	6.91	86	-629.77	522.71
23	-8.91	7.39	87	-673.82	559.27
24	-9.53	7.91	88	-720.94	598.38
25	-10.20	8.46	89	-771.36	640.23
26	-10.91	9.05	90	-825.30	685.00
27	-11.67	9.69	91	-883.02	732.91
28	-12.49	10.36	92	-944.77	784.16
29	-13.36	11.09	93	-1010.84	839.00

30	-14.30	11.87	94	-1081.54	897.67
31	-15.30	12.69	95	-1157.17	960.45
32	-16.36	13.58	96	-1238.10	1027.62
33	-17.51	14.53	97	-1324.68	1099.49
34	-18.73	15.55	98	-1417.32	1176.38
35	-20.04	16.64	99	-1516.44	1258.65
36	-21.45	17.80	100	-1622.49	1346.67
37	-22.95	19.04	101	-1735.96	1440.85
38	-24.55	20.38	102	-1857.36	1541.61
39	-26.27	21.80	103	-1987.26	1649.42
40	-28.10	23.33	104	-2126.23	1764.77
41	-30.07	24.96	105	-2274.93	1888.19
42	-32.17	26.70	106	-2434.02	2020.24
43	-34.42	28.57	107	-2604.25	2161.52
44	-36.83	30.57	108	-2786.37	2312.69
45	-39.40	32.71	109	-2981.23	2474.42
46	-42.16	34.99	110	-3189.72	2647.47
47	-45.11	37.44	111	-3412.79	2832.62
48	-48.26	40.06	112	-3651.46	3030.71
49	-51.64	42.86	113	-3906.83	3242.66
50	-55.25	45.86	114	-4180.05	3469.44
51	-59.11	49.06	115	-4472.37	3712.07
52	-63.25	52.50	116	-4785.14	3971.67
53	-67.67	56.17	117	-5119.79	4249.42
54	-72.40	60.10	118	-5477.84	4546.60
55	-77.47	64.30	119	-5860.92	4864.57
56	-82.88	68.79	120	-6270.80	5204.76
57	-88.68	73.61	121	-6709.34	5568.75
58	-94.88	78.75	122	-7178.55	5958.20
59	-101.52	84.26	123	-7680.58	6374.88
60	-108.62	90.15	124	-8217.71	6820.70
61	-116.21	96.46	125	-8792.41	7297.70
62	-124.34	103.20	126	-9407.30	7808.06
63	-133.04	110.42	127	-10065.19	8354.11

BLR2PPA.0 Hydra Magnetometer Task BLR2PPA
September 29, 1996

BLR2PPA.1. Outline

1. Collect magnetometer data in ring buffer.
2. Get spin_phase time marker fixed wrt the BLR2PPA task.
3. Start BLR2PPA task and run filter on new magnetometer data.
4. Condition time variables and compute projection time.
5. Project Bx, By, and Bz to tT.
6. Convert Bx, By, and Bz to Theta, Phi.
7. Add zero to Phi to rotate to PPA reference frame, and condition Theta and Phi to range (null operation).
8. Compute new value of Kex using autoregressive filter and Bsq lookup table.

BLR2PPA.2. Detail

BLR2PPA.2.1. Collect magnetometer data in ring buffer.

1. The magnetometer ISR collects the magnetometer data, which arrives one component at a time, with a complete reading every 9.2 ms. A complete reading is four components, [tS Bx By Bz]. The readings are stored in a ring buffer, or circular queue, that is 8 readings in circumference, so that it has a size of 8x4 2-byte words. This function is asynchronous to the PPA RAM refresh interval, called a PPR, which has a period of 18.0 ms.

2. The Bxyz interface is defined -- muddily -- by Figure 24 of the GIIS. This is a screwy figure. The way I interpret it, the bit-naming convention is contrary, the signal timing is not drawn to scale, and the jitter is drawn incorrectly, too. Namely, common usage and the rest of the Hydra instrument nomenclature follows the convention that the LSB of any item is Bit 0 and the MSB of a 16 bit word is bit 15; however Figure 24 of the GIIS clearly labels the bits the other way around, so that bit 15 is the LSB. Further, the SYNC/Scale, Bx, By, and Bz words should take only 16/55652=288 microseconds, which is about 10% of the interval between Enable Gates. Also, both of the 1 ms jitters are drawn outside the 9.2 ms interval, as if they delay the average time between samples, which I might then expect to be 9.2+0.5 ms. I believe the left arrow on the 9.2 ms bar should extend to the left-hand timing mark labelled "1 mS jitter."

3. As shown in Figure 24 of the GIIS, the first component of each reading is a 2 byte timing and ranging word. Using the GIIS convention, the 12 LSB's (let's call them GIIS-bits 4-15) are the 12-bit spin phase count at the time of the

Bxyz sample. This number counts upward after being reset by the Spin Clock once per spacecraft revolution. GIIS-bit 3 is labeled Cal/Flipper Mode, or Snapshot Mode, and doesn't matter to us. GIIS-bits 0-2 designate which magnetometer the reading is from, and the gain, as shown below.

GIIS-bits 0-3 (as a hex nibble)	8 or 9	a or b	4 or 5	6 or 7
Range Word GIIS-bit 0	1	1	0	0
Range Word GIIS-bit 1	0	0	1	1
Range Word GIIS-bit 2	0	1	0	1
Magnetometer Selection	inboard	inboard	outboard	outboard
Gain or Sensitivity	low	high	low	high
Unipolar Range, nT	45,000	5,625	5,400	675
Expected Measurement Noise, nT	4.1	2.6	0.16	0.14

Extract GIIS-bits 0-3 and insert them in a four-bit status field PPBSTAT. Overwrite this field each time BLR2PPA is called. The most recent value will be picked up four times a major frame by the science housekeeping telemetry.

4. The magnetic field readings Bx, By and Bz are 16-bit signed integers using the two's complement sign convention, and the full scale reading corresponds to the unipolar range shown above. In each case the total magnetometer range is + and - the unipolar range. For the outboard magnetometer, the measurement noise is expected to be sensor noise, and for the inboard magnetometer, the measurement noise is expected to be system noise.

BLR2PPA.2.2. Get spin_phase time marker fixed wrt the BLR2PPA task.

The BCI before the BLR2PPA task reads tR1 from ET1 register and inserts the value in variable location "spin_phase". ET1 is reset by the delayed sun pulse, and clocked by the spin clock.

This feature is not implemented as of April, 1993. Instead, we use an average projection time as described in section BLR2PPA.2.4. steps 6 and 13.

BLR2PPA.2.3. Start BLR2PPA task and run filter on new magnetometer data.

The BLR2PPA task is enabled by the PPSCAN task and run right after it. It must be completed at the end of the PPR, or PPA RAM refresh interval, in time for the ET2 interrupt that stops the PPA and initializes the PPA service task.

Each time the BLR2PPA task is entered, it must first identify all new magnetometer readings that have arrived since the last BLR2PPA task, and run them through a filter algorithm.

The filter code is contained in a subroutine called from the BLR2PPA task. Since the BLR2PPA task and the magnetometer ISR are asynchronous, the number of new readings may vary. It is important to keep the readings in sets and not to mix components of different readings.

The filter is first-order, or linear, in a despun reference frame. An autoregressive (AR) algorithm is used for the three components Bx, By, and Bz. Bx and By are coupled in order to despin the reference frame; Bz is independent.

BLR2PPA.2.3.1. The Despun Linear Filter Algorithm

The quantities that are needed by the BLR2PPA task are the components of the six-vector [Bxplus Bxdotplus Byplus Bydotplus Bzplus Bzdotplus]' and time tS. Quantities are carried in double precision (4 byte integers) up to the point where projected values are computed. The conversion to Theta and Phi is done in single precision.

(0) Initialize the predicted values,

```
Bzminus = 0
Bzdotminus = 0
Bxminus = 0
Bxdotminus = 0
Byminus = 0
Bydotminus = 0
BsqBar = 0
```

All RAM locations are zeroed at power up. This is all the initialization needed, as the filter converges from any initial position.

(1) Calculate Residues.

For each new reading, [Bxmeas Bymeas Bzmeas]', form the residues,

```
Rx = Bxmeas - BxOffs - Bxminus
Ry = Bymeas - ByOffs - Byminus
Rz = Bzmeas - BzOffs - Bzminus.
```

The quantities BxOffs, ByOffs, and BzOffs represent empirical offsets which may need to be applied after launch. They should reside in the program as variables, whose nominal values are 0 so as to produce a null operation upon being added to Bxmeas, etc, but which can be changed by poking values into their storage locations. As there must be a different set of offsets for each magnetometer sensor and range, there are actually 12 values which reside in a table indexed by the magnetometer range identification.

(2) Compute the corrected values.

```
Bxplus = Bxminus + K1*Rx
```

```
Bxdotplus = Bxdotminus + K2*Rx
Byplus = Byminus + K1*Ry
Bydotplus = Bydotminus + K2*Ry
Bzplus = Bzminus + K1*Rz
Bzdotplus = Bzdotminus + K2*Rz
```

The values of K1 and K2 are of the form 1/2^N, so that the multiplications can be performed by N right shifts of the quantities Rx, Ry, and Rz. K1 and K2, called the filter gains, are discussed below.

(3) Associate result with tS.

Associate the time tS of the last measurement with the six-vector, [Bxplus Bxdotplus Byplus Bydotplus Bzplus Bzdotplus]' for the projection computation performed later in the BLR2PPA task. This set of 7 readings must be used together.

(4) Compute the next predicted values.

$$\begin{vmatrix} \text{Bxminus} \\ \text{Bxdotminus} \\ \text{Byminus} \\ \text{Bydotminus} \\ \text{Bzminus} \\ \text{Bzdotminus} \end{vmatrix} = \begin{vmatrix} 1 & 1 & S & S & 0 & 0 \\ 0 & 1 & 0 & S & 0 & 0 \\ -S & -S & 1 & 1 & 0 & 0 \\ 0 & -S & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{vmatrix} \begin{vmatrix} \text{Bxplus} \\ \text{Bxdotplus} \\ \text{Byplus} \\ \text{Bydotplus} \\ \text{Bzplus} \\ \text{Bzdotplus} \end{vmatrix}$$

This computation can be organized as follows.

```
Bxboth = Bxplus + Bxdotplus
Byboth = Byplus + Bydotplus
Bxminus = Bxboth + S*Byboth
Bxdotminus = Bxdotplus + S*Bydotplus
Byminus = Byboth - S*Bxboth
Bydotminus = Bydotplus - S*Bxdotplus
Bzminus = Bzplus + Bzdotplus
Bzdotminus = Bzdotplus
```

The rotational sine factor, S = 0.00963, and is well approximated by

$$S = 1/2^7 + 1/2^9 = 0.00977 = \sin(2*\pi*0.0092/5.9192)$$

Thus these multiplications can be accomplished by two shift operations and an add operation. It may be advantageous to do the 1/2^7 shift, duplicate the 1/2^7 result, do a 1/2^2 shift on the 1/2^7 result to form the 1/2^9 result, and add the 1/2^7 result to the 1/2^9 result.

(5) End loop.

If there is another new reading, go to (1) and run it through the filter. If there is no new reading, proceed to the projection section of the task.

The computational burden of the prediction-correction filter is approximately 14 shift operations, 20 add operations, and 26 move operations.

BLR2PPA.2.3.2. The Filter Gains

The filter gains, K1 and K2, are taken from a table which is addressed by an index, Kex. The default values can be computed from Kex by the following formulas:

K1 = 1/2^Kex
K2 = 1/2^(2*Kex+1)

Other values of K1 and K2 may be uploaded from the ground. The index Kex is computed adaptively in flight as described in BLR2PPA.2.8. The range of useful values is 0 to 7. The lower values of Kex give a more aggressive filter that does a better job of following a varying signal, but is susceptible to measurement noise. The higher values of Kex are useful when the measurement noise is higher, but they cannot follow such a rapidly varying signal. Note that, since the filter despins the reference frame, we are talking about signal variations in a despun reference frame.

BLR2PPA.2.4. Condition time variables and compute projection time.

The projection to the target time, tT, in the middle of the PPR, involves several contributions.

1. First there is the phase lag of the magnetometer filters. Before the reading receives its timing mark there is a phase lag of 7 ms for UCLA's digital filter plus about 2 ms for the analog circuitry. Thus the reading is already 9 ms old at the time it is labeled with the spin phase count of the Bxyz sample. At the nominal spin period of 6 s, this is 6.1 SPT's.

2. Plus the time required to feed the four components to our instrument. The reading is available to the Bxyz interface at the instant it is tagged with the spin phase count. There is a jitter of 0 to 1 ms before the first word gate of the sample, 2 ms between word gates, and 0.3 ms for each word gate. That's an average delay of 0.5 + 3*2 + 0.3 = 6.8 +or- 0.5 ms before our instrument has all of it.

3. Because the magnetometer readings occur at discrete intervals, every 9.2 ms, there is on the average a wait before the BLR2PPA task picks up the most recent value. This is 4.6 +or- 4.6 ms.

4. Add the constant value of tT-tR, which is the time between the BCI interrupt which initiates the BLR2PPA task, and the target time of the PPA reading. In ModeZero tT-tR = 1.4*1000 ticks of the telemetry clock (1400 TMT's) which translates to 1400/55652 = 0.0252 s, or about 17.2 ticks of the spin clock (17.2 SPT's).

5. Subtract the time between tR, the BCI interrupt which initiates the BLR2PPA task, and the moment when the task picks up the most recent value. This time is about 3 ms, and is subject to refinement as we test and change the code.

6. All of the above adds up to (9 + 6.8 + 4.6 + 25.2 - 3) +or- (0.5 + 4.6). This is to say
42.6 +or- 5.1 ms,
29.1 +or- 3.5 SPT's,
4.63 +or- 0.55 BSP's.
If we are willing to live with this much uncertainty, we can project by the average time given here. A way to eliminate this uncertainty is given in steps 7-12 below.

7. We can eliminate the major uncertainty if we make use of the time tag that comes with the magnetometer reading. The key to doing this is the spin_phase time marker named in BLR2PPA.2.2. This gives us the spin phase clock reading 17.2 SPT's before the reading is to be used. Then, each time the BLR2PPA routine is called, we can obtain the particular value of the variable delay tR-tS, between tS, the time label of the last magnetometer sample, and tR, the time of the BCI interrupt which initiates the BLR2PPA task. There is jitter over an envelope of 9.2 ms or 6.3 SPT's in this quantity, since the magnetometer sample time is not synchronized with the BCI. Sometimes tS may even be later than tR, depending upon the time between the BCI and the execution of the BLR2PPA task. It must be conditioned as follows.

8. Obtain the value of tR1 from location "spin_phase" and complement it (because ET1 is a down-counter). The result, called tR1bar, should follow the pattern: if tR1=ffff, tR1bar=0000; if tR1=fffe, tR1bar=0001; etc. (For tR1, see BLR2PPA.2.2.)

9. Add sun pulse delay tD to tR1bar. Put tR == tD+tR1bar on an ascending scale corresponding to 0 immediately after the sun pulse. Note that the total value for tR may be >4095, which only means that tR is referred to a prior sun pulse, and the most recent sun pulse is still propagating through the sun pulse delay counter.

10. Obtain tS from the most recent magnetometer reading (See BLR2PPA.2.3.1., step (3)). The spin phase counter we get from the magnetometer is contained in the 12 LSB's of the magnetometer synch/scale word, on an ascending scale from 0 to 4095, beginning with 0 immediately after the sun pulse.

11. Form the difference tR-tS. Subtract 4096 if tR-tS > 4096. Add 4096 if tR-tS < -512. Note that tR-tS may by slightly negative if the magnetometer interrupt occurs between the BCI and BLR2PPA; that's fine. However, tR-tS may also be very negative if the sun pulse and delayed sun pulse occur before the first magnetometer interrupt following the sun pulse; this is the case for which we add 4096.

12. The projection interval tJSPT is thus:

```
tJSPT =   6.1           age before time tag is applied
        + 17.2          tT-tR
        + tR-tS         variable calculated in step 11
      = 23.3 + (tR-tS) SPT's
```

The unit of time used by the filter is the magnetometer sample period, BSP = 9.2 ms. At the nominal spin period of 6 s, there are 6.28 SPT/BSP. Thus

```
tJBSP = 3.7 + (tR-tS)/6.28 BSP's
```

In section BLR2PPA.2.5. below, we approximate tJBSP by

```
tJ = 4 + (5*(tR-tS)-9)/32
```

where tR-tS is in SPT units and tJ is in BSP units.

13. In the absence of a spin_phase time marker, we can use 6 for the value of tR-tS. This gives the average projection time given above in step 6. Note that this value errs by as much as 0.55 BSP's.

BLR2PPA.2.5. Project Bx, By, and Bz to tT.

Compute the projected values.

```
|Bxproj|     | 1    tJ      SJ   tJ*SJ   0   0 |   |Bxplus   |
|Byproj|  =  |-SJ  -tJ*SJ   1    tJ      0   0 |   |Bxdotplus|
|Bzproj|     | 0    0       0    0       1   tJ|   |Byplus   |
                                                   |Bydotplus|
                                                   |Bzplus   |
                                                   |Bzdotplus|
```

SJ = tJ*S, where S is given in BLR2PPA.2.1.1.

Although this is a straightforward calculation, we can probably make it faster on our fixed point cpu by being devious. In BSP units, write

```
        tJ = 4 + tJ'
and     tJ^2 = 16 + 8*tJ' (+ error term = (tJ')^2)
```

where tJ' = (5*(tR-tS)-9)/32, and tR-tS is in SPT units as it was calculated above. We don't compute tJ' yet. Now,

```
|Bxproj|     |  1   4S   0|   |Bxplus + 4*Bxdotplus|
|Byproj|  =  |-4S    1   0|   |Byplus + 4*Bydotplus|
|Bzproj|     |  0    0   1|   |Bzplus + 4*Bzdotplus|

             | 0    1     S   8S   0   0 |   |Bxplus   |
   + tJ' *   |-S   -8S    0    1   0   0 |   |Bxdotplus|
```

```
| 0     0     0     0    0    1 |     |Byplus    |
                                      |Bydotplus |
                                      |Bzplus    |
                                      |Bzdotplus |
```

```
with    S  = 1/2^7 + 1/2^9
        4S = 1/2^5 + 1/2^7
```

The calculation can be organized in a sequence similar to that in BLR2PPA.2.1.1., section (4). Form

```
Bx4 = Bxplus+4*Bxdotplus          (1 shift and 1 add)
By4 = Byplus+4*Bydotplus          (1 shift and 1 add)
Bz4 = Bzplus+4*Bzdotplus          (1 shift and 1 add)
Bx8 = Bxplus+8*Bxdotplus          (1 shift and 1 add)
By8 = Byplus+8*Bydotplus          (1 shift and 1 add)
tJ'num = (5*(tR-tS)-9)            (1 mul and 1 add)
BxJ' = (Bxdotplus+S*By8)*tJ'num/32 (1 mul, 2 adds, and 3 shifts)
ByJ' = (Bydotplus-S*Bx8)*tJ'num/32 (1 mul, 2 adds, and 3 shifts)
Bxproj = Bx4 + 4S*By4 + BxJ'      (3 adds and 1 shift)
Byproj = By4 - 4S*Bx4 + ByJ'      (3 adds and 1 shift)
Bzproj = Bz4 + Bzdotplus*tJ'num/32 (1 mul, 1 add, and 1 shift)
```

Total cost is approximately 4 mul, 17 adds, 14 shifts, and TBD moves, plus all the fooling around with time lines, and lack of transparency in the coding.

BLR2PPA.2.6. Convert Bx, By, and Bz to Theta, Phi.

In the following, read Bxproj for Bx, etc. Quantities are given as 16 bit integers.

```
        1.  Theta and Phi are defined by
        Theta = arctan(Bz/(sqrt(Bx**2+By**2))
        Phi = arctan(By/Bx)
They are computed from
        Theta = arcsqtan(Bz**2/(Bx**2+By**2))
        Phi = arcsqtan(By**2/Bx**2)
where arcsqtan(X**2) == arctan(X)
        2.  Compute Bx**2, By**2, Bz**2, and Bx**2+By**2.
        3.  For Theta:
        (a)  Determine the octant of Theta.  Octants 5-8 are
unavailable for Theta.
                (i)  If Bz > 0, octants 1 or 2
                     If Bz < 0, octants 3 or 4
                (ii) If Bz**2 < (Bx**2+By**2), octants 2 or 3
                     If Bz**2 > (Bx**2+By**2), octants 1 or 4
        (b)  Compute the indexing integer INDINT, (0 <= INDINT
<= MULT):

        INDINT = INT(MULT*Bz**2/(Bx**2+By**2)) for octants 2 & 3
        INDINT = INT(MULT*(Bx**2+By**2)/Bz**2) for octants 1 & 4
```

where MULT is an integer which may have the value 31528 decimal (31528 worked on my spreadsheet.) MULT was chosen to use the range of a 16 bit integer with best resolution between the angle quanta chosen by VanDiver for the PPA board inputs.

(c) Using the index INDINT, search for the index angle in a table of length 32. The values of the index angle progress from 0 to 31 as shown in Appendix APXB2PPA. This is a search, not a straight indexed lookup. It may be a binary or linear search, depending upon the speed in the pipeline of the processor.

(d) Derive Theta from the index angle:
For octant 1, Theta = index angle
For octant 2, Theta = 63 - index angle
For octant 3, Theta = 127 - index angle
For octant 4, Theta = 64 + index angle

Appendix APXB2PPA shows the desired results in decimal notation.

4. For Phi:

(a) Determine the octant of Phi from By and Bx.

(b) Compute the indexing integer, INDINT:

```
INDINT = INT(MULT*(By**2/Bx**2)), octants 1, 4, 5, and 8
INDINT = INT(MULT*(Bx**2/By**2)), octants 2, 3, 6, and 7
```

where MULT is the same as used to obtain Theta.

(c) Using the index INDINT, look up the index angle in the same table used for Theta.

(d) Derive Phi from the index angle:
For octant 1, Phi = index angle
For octant 2, Phi = 63 - index angle
For octant 3, Phi = 64 + index angle
For octant 4, Phi = 127 - index angle
For octant 5, Phi = 128 + index angle
For octant 6, Phi = 191 - index angle
For octant 7, Phi = 192 + index angle
For octant 8, Phi = 255 - index angle

Appendix APXB2PPA shows the desired results in decimal notation.

BLR2PPA.2.7. Add zero degrees to Phi to rotate to PPA reference frame, and condition to range. This became a null operation when the PAS incorporated this rotation.

0. This information is left in the document in case I ever need to review it.

1. VanDiver defined the PPA x-axis to go through the "B" codacon, with Phi increasing counterclockwise around the xy plane from the x-axis.

2. In spacecraft coordinates, the Xsc-axis goes through the magnetometer boom, and the spin axis is the positive Zsc-axis, so that the Xsc-Ysc plane is the spin equator.

3. We get our magnetometer data in spacecraft coordinates.

4. At the CDR in March, 1990, a figure showed "PPA#2" to be at an angle of 70 +- 1 degrees measured counterclockwise from the spacecraft x-axis in the spacecraft x-y plane.

However, GSFC Drawing 1308201 dated 9/22/90 shows PPA#2 to be at an angle of 249 degrees measured in the spacecraft x-y plane counterclockwise about the spacecraft z-axis. This drawing was based on GE drawings number 23002009 and 23001010 which were received by GSFC 9/11/90.

This represents a switch between #1 and #2 and a shift of 1 degree, which was within the original tolerances. We will suppose the latter information supercedes the former.

5. The pin assignments for the codacon connectors confirm that the B codacon is in PPA#2. Then add 111 degrees to Phi to put it in the PPA reference frame. That is, add 79 (78.9) to the digital representation for Phi computed in BLR2PPA_0.2.6.

6. In October, 1991, John Keller issued a memo defining coordinates, and Jim VanDiver incorporated this rotation in the PAS board. Therefore, we feed the PAS board magnetometer theta and phi values in spacecraft coordinates, and no further rotation is needed to change between spacecraft and detector coordinates. The PAS board knows how the codacons are oriented. I am leaving this section in my FID just in case I ever need to review the basis of our coordinates.

7. At this point, the ranges for Theta and Phi should be 0-127 and 0-255, respectively. Neither should need conditioning at this point, because they were created in range and never changed. Further, Phi is a one byte word, and would overflow gracefully, anyway.

BLR2PPA.2.8. Compute new value of Kex using autoregressive filter and Bsq lookup table.

1. Compute Bsq = Bx^2+By^2+Bz^2, from elements which were computed in BLR2PPA.2.6. step 2.

2. Compute BsqBar = BsqBar*(1-2^-5) + Bsq*2^-5.

3. Using current value of Kex, magnetometer select, and magnetometer sensitivity (See BLR2PPA.2.1.0.), look up max and min limits from Bsq lookup table. If BsqBar exceeds max, decrement Kex by 1. If min exceeds BsqBar, increment Kex by 1. If min < BsqBar < max, leave Kex as is. Note limits to Kex are 0 and 7 (the table should cover these limits), and note that Kex changes by no more than 1 each time.

4. The updated value of Kex will be used the next time BLR2PPA is called.

5. Tables of Critical Values for B and B^2 for Selected Value of Kex

Kex	Crit N/S	(inboard, low), (8 or 9) Range=45000 nT, N=4.1 nT Crit (nT)	Sig int	Crit S^2 integer (lo,	hi)	(inboard, high), (a or b) Range=5625 nT, N=2.6 nT Crit (nT)	Sig int	Crit S^2 integer (lo,	hi)
7			0	0	1584		0	0	40780
6	.11	37	27	736	5052	24	138	18957	130039
5	.075	55	40	1584	11368	35	202	40780	292589
4	.042	98	71	5052	26907	62	361	130039	692519
3	.028	146	107	11368	110035	93	541	292589	2831978

2	.0182	225	164	26907	843819	143	832	692519	21717422
1	.009	456	332	110035	13498276	289	1683	2831978	347449600
0	.00325	1262	919	843819	1073676289	800	4660	21717422	1073676289

K e x	Crit N/S	(outboard, low), (4 or 5) Range=5400 nT, N=0.16 nT Crit (nT)	Sig int	Crit S^2 integer (lo, hi)		(outboard, high), (6 or 7) Range=675 nT, N=0.14 nT Crit (nT)	Sig int	Crit S^2 integer (lo, hi)	
7			0	0	167		0	0	8211
6	.11	1	9	77	534	1	62	3817	26183
5	.075	2	13	167	1202	2	91	8211	58912
4	.042	4	23	534	2845	3	162	26183	139437
3	.028	6	35	1202	11636	5	243	58912	570212
2	.0182	9	53	2845	89239	8	373	139437	4372755
1	.009	18	108	11636	1425636	16	755	570212	69956496
0	.00325	49	299	89239	1073676289	43	2091	4372755	1073676289

APPENDIX APXB2PPA: See File APXB2PPA.FID.

File APXB2PPA.FID

APPENDIX APXB2PPA
September 29, 1996

From B2PPA.CAL
1.41deg = 2*pi/256 rad = Q, the Angular Quantum

Angle (degrees) > Index				Index > Angle (VanDiver quanta)				Decimal Representation of Vandiver Scale	
Mltiplier= 31528									
		Mltplr *	Mltplr *						
Min	Max	TrgSqMn	TrgSqMx					Tht	Phi
0	1.41	0	18.9999	0	18	0	1.000003	0	0
1.41	2.81	18.9999	76.0912	19	75	1.000003	1.998803	1	1
2.81	4.22	76.0912	171.550	76	171	1.998803	3.003919	2	2
4.22	5.63	171.550	305.839	172	305	3.003919	4.001045	3	3
5.63	7.03	305.839	479.614	306	479	4.001045	5.001991	4	4
7.03	8.44	479.614	693.728	480	693	5.001991	6.001157	5	5
8.44	9.84	693.728	949.244	694	948	6.001157	6.999119	6	6
9.84	11.3	949.244	1247.44	949	1246	6.999119	7.998622	7	7
11.3	12.7	1247.44	1589.83	1247	1589	7.998622	9.000457	8	8
12.7	14.1	1589.83	1978.18	1590	1977	9.000457	9.999554	9	9
14.1	15.5	1978.18	2414.53	1978	2414	9.999554	11.00103	10	10
15.5	16.9	2414.53	2901.18	2415	2900	11.00103	11.99965	11	11
16.9	18.3	2901.18	3440.80	2901	3440	11.99965	13.00036	12	12
18.3	19.7	3440.80	4036.37	3441	4035	13.00036	13.99941	13	13
19.7	21.1	4036.37	4691.28	4036	4690	13.99941	14.99959	14	14
21.1	22.5	4691.28	5409.35	4691	5408	14.99959	15.99953	15	15
22.5	23.9	5409.35	6194.87	5409	6194	15.99953	17.00016	16	16
23.9	25.3	6194.87	7052.68	6195	7052	17.00016	18.00036	17	17
25.3	26.7	7052.68	7988.22	7053	7987	18.00036	18.99978	18	18
26.7	28.1	7988.22	9007.62	7988	9007	18.99978	20.00036	19	19
28.1	29.5	9007.62	10117.8	9008	10117	20.00036	21.00018	20	20
29.5	30.9	10117.8	11326.5	10118	11326	21.00018	22.00038	21	21
30.9	32.3	11326.5	12642.6	11327	12642	22.00038	23.00027	22	22
32.3	33.8	12642.6	14076.1	12643	14075	23.00027	23.99995	23	23
33.8	35.2	14076.1	15638.2	14076	15637	23.99995	24.99988	24	24
35.2	36.6	15638.2	17341.8	15638	17341	24.99988	26.00009	25	25
36.6	38.0	17341.8	19201.7	17342	19201	26.00009	27.00016	26	26
38.0	39.4	19201.7	21234.5	19202	21234	27.00016	28.00022	27	27
39.4	40.8	21234.5	23459.6	21235	23459	28.00022	29.00016	28	28
40.8	42.2	23459.6	25899.2	23460	25898	29.00016	29.99994	29	29
42.2	43.6	25899.2	28578.7	25899	28578	29.99994	31.00011	30	30
43.6	45	28578.7	31528	28579	31527	31.00011	32	31	31
45	46.4	31528	28578.7	31528	28578	32	31.00011	32	32
46.4	47.8	28578.7	25899.2	28579	25898	31.00011	29.99994	33	33
47.8	49.2	25899.2	23459.6	25899	23459	29.99994	29.00016	34	34
49.2	50.6	23459.6	21234.5	23460	21234	29.00016	28.00022	35	35
50.6	52.0	21234.5	19201.7	21235	19201	28.00022	27.00016	36	36
52.0	53.4	19201.7	17341.8	19202	17341	27.00016	26.00009	37	37
53.4	54.8	17341.8	15638.2	17342	15637	26.00009	24.99988	38	38
54.8	56.3	15638.2	14076.1	15638	14075	24.99988	23.99995	39	39

56.3	57.7	14076.1	12642.6	14076	12642	23.99995	23.00027	40	40
57.7	59.1	12642.6	11326.5	12643	11326	23.00027	22.00038	41	41
59.1	60.5	11326.5	10117.8	11327	10117	22.00038	21.00018	42	42
60.5	61.9	10117.8	9007.62	10118	9007	21.00018	20.00036	43	43
61.9	63.3	9007.62	7988.22	9008	7987	20.00036	18.99978	44	44
63.3	64.7	7988.22	7052.68	7988	7052	18.99978	18.00036	45	45
64.7	66.1	7052.68	6194.87	7053	6194	18.00036	17.00016	46	46
66.1	67.5	6194.87	5409.35	6195	5408	17.00016	15.99953	47	47
67.5	68.9	5409.35	4691.28	5409	4690	15.99953	14.99959	48	48
68.9	70.3	4691.28	4036.37	4691	4035	14.99959	13.99941	49	49
70.3	71.7	4036.37	3440.80	4036	3440	13.99941	13.00036	50	50
71.7	73.1	3440.80	2901.18	3441	2900	13.00036	11.99965	51	51
73.1	74.5	2901.18	2414.53	2901	2414	11.99965	11.00103	52	52
74.5	75.9	2414.53	1978.18	2415	1977	11.00103	9.999554	53	53
75.9	77.3	1978.18	1589.83	1978	1589	9.999554	9.000457	54	54
77.3	78.8	1589.83	1247.44	1590	1246	9.000457	7.998622	55	55
78.8	80.2	1247.44	949.244	1247	948	7.998622	6.999119	56	56
80.2	81.6	949.244	693.728	949	693	6.999119	6.001157	57	57
81.6	83.0	693.728	479.614	694	479	6.001157	5.001991	58	58
83.0	84.4	479.614	305.839	480	305	5.001991	4.001045	59	59
84.4	85.8	305.839	171.550	306	171	4.001045	3.003919	60	60
85.8	87.2	171.550	76.0912	172	75	3.003919	1.998803	61	61
87.2	88.6	76.0912	18.9999	76	18	1.998803	1.000003	62	62
88.6	90	18.9999	0	19	0	1.000003	0	63	63
90	91.4	0	18.9999	0	18	0	1.000003	127	64
91.4	92.8	18.9999	76.0912	19	75	1.000003	1.998803	126	65
92.8	94.2	76.0912	171.550	76	171	1.998803	3.003919	125	66
94.2	95.6	171.550	305.839	172	305	3.003919	4.001045	124	67
95.6	97.0	305.839	479.614	306	479	4.001045	5.001991	123	68
97.0	98.4	479.614	693.728	480	693	5.001991	6.001157	122	69
98.4	99.8	693.728	949.244	694	948	6.001157	6.999119	121	70
99.8	101.	949.244	1247.44	949	1246	6.999119	7.998622	120	71
101.	103.	1247.44	1589.83	1247	1589	7.998622	9.000457	119	72
103.	104.	1589.83	1978.18	1590	1977	9.000457	9.999554	118	73
104.	105.	1978.18	2414.53	1978	2414	9.999554	11.00103	117	74
105.	107.	2414.53	2901.18	2415	2900	11.00103	11.99965	116	75
107.	108.	2901.18	3440.80	2901	3440	11.99965	13.00036	115	76
108.	110.	3440.80	4036.37	3441	4035	13.00036	13.99941	114	77
110.	111.	4036.37	4691.28	4036	4690	13.99941	14.99959	113	78
111.	113.	4691.28	5409.35	4691	5408	14.99959	15.99953	112	79
113.	114.	5409.35	6194.87	5409	6194	15.99953	17.00016	111	80
114.	115.	6194.87	7052.68	6195	7052	17.00016	18.00036	110	81
115.	117.	7052.68	7988.22	7053	7987	18.00036	18.99978	109	82
117.	118.	7988.22	9007.62	7988	9007	18.99978	20.00036	108	83
118.	120.	9007.62	10117.8	9008	10117	20.00036	21.00018	107	84
120.	121.	10117.8	11326.5	10118	11326	21.00018	22.00038	106	85
121.	122.	11326.5	12642.6	11327	12642	22.00038	23.00027	105	86
122.	124.	12642.6	14076.1	12643	14075	23.00027	23.99995	104	87
124.	125.	14076.1	15638.2	14076	15637	23.99995	24.99988	103	88
125.	127.	15638.2	17341.8	15638	17341	24.99988	26.00009	102	89
127.	128.	17341.8	19201.7	17342	19201	26.00009	27.00016	101	90
128.	129.	19201.7	21234.5	19202	21234	27.00016	28.00022	100	91
129.	131.	21234.5	23459.6	21235	23459	28.00022	29.00016	99	92
131.	132.	23459.6	25899.2	23460	25898	29.00016	29.99994	98	93

132.	134.	25899.2	28578.7	25899	28578	29.99994	31.00011	97	94
134.	135	28578.7	31528	28579	31527	31.00011	32	96	95
135	136.	31528	28578.7	31528	28578	32	31.00011	95	96
136.	138.	28578.7	25899.2	28579	25898	31.00011	29.99994	94	97
138.	139.	25899.2	23459.6	25899	23459	29.99994	29.00016	93	98
139.	141.	23459.6	21234.5	23460	21234	29.00016	28.00022	92	99
141.	142.	21234.5	19201.7	21235	19201	28.00022	27.00016	91	100
142.	143.	19201.7	17341.8	19202	17341	27.00016	26.00009	90	101
143.	145.	17341.8	15638.2	17342	15637	26.00009	24.99988	89	102
145.	146.	15638.2	14076.1	15638	14075	24.99988	23.99995	88	103
146.	148.	14076.1	12642.6	14076	12642	23.99995	23.00027	87	104
148.	149.	12642.6	11326.5	12643	11326	23.00027	22.00038	86	105
149.	150.	11326.5	10117.8	11327	10117	22.00038	21.00018	85	106
150.	152.	10117.8	9007.62	10118	9007	21.00018	20.00036	84	107
152.	153.	9007.62	7988.22	9008	7987	20.00036	18.99978	83	108
153.	155.	7988.22	7052.68	7988	7052	18.99978	18.00036	82	109
155.	156.	7052.68	6194.87	7053	6194	18.00036	17.00016	81	110
156.	158.	6194.87	5409.35	6195	5408	17.00016	15.99953	80	111
158.	159.	5409.35	4691.28	5409	4690	15.99953	14.99959	79	112
159.	160.	4691.28	4036.37	4691	4035	14.99959	13.99941	78	113
160.	162.	4036.37	3440.80	4036	3440	13.99941	13.00036	77	114
162.	163.	3440.80	2901.18	3441	2900	13.00036	11.99965	76	115
163.	165.	2901.18	2414.53	2901	2414	11.99965	11.00103	75	116
165.	166.	2414.53	1978.18	2415	1977	11.00103	9.999554	74	117
166.	167.	1978.18	1589.83	1978	1589	9.999554	9.000457	73	118
167.	169.	1589.83	1247.44	1590	1246	9.000457	7.998622	72	119
169.	170.	1247.44	949.244	1247	948	7.998622	6.999119	71	120
170.	172.	949.244	693.728	949	693	6.999119	6.001157	70	121
172.	173.	693.728	479.614	694	479	6.001157	5.001991	69	122
173.	174.	479.614	305.839	480	305	5.001991	4.001045	68	123
174.	176.	305.839	171.550	306	171	4.001045	3.003919	67	124
176.	177.	171.550	76.0912	172	75	3.003919	1.998803	66	125
177.	179.	76.0912	18.9999	76	18	1.998803	1.000003	65	126
179.	180	18.9999	0	19	0	1.000003	0	64	127
180	181.	0	18.9999	0	18	0	1.000003		128
181.	183.	18.9999	76.0912	19	75	1.000003	1.998803		129
183.	184.	76.0912	171.550	76	171	1.998803	3.003919		130
184.	186.	171.550	305.839	172	305	3.003919	4.001045		131
186.	187.	305.839	479.614	306	479	4.001045	5.001991		132
187.	188.	479.614	693.728	480	693	5.001991	6.001157		133
188.	190.	693.728	949.244	694	948	6.001157	6.999119		134
190.	191.	949.244	1247.44	949	1246	6.999119	7.998622		135
191.	193.	1247.44	1589.83	1247	1589	7.998622	9.000457		136
193.	194.	1589.83	1978.18	1590	1977	9.000457	9.999554		137
194.	195.	1978.18	2414.53	1978	2414	9.999554	11.00103		138
195.	197.	2414.53	2901.18	2415	2900	11.00103	11.99965		139
197.	198.	2901.18	3440.80	2901	3440	11.99965	13.00036		140
198.	200.	3440.80	4036.37	3441	4035	13.00036	13.99941		141
200.	201.	4036.37	4691.28	4036	4690	13.99941	14.99959		142
201.	203.	4691.28	5409.35	4691	5408	14.99959	15.99953		143
203.	204.	5409.35	6194.87	5409	6194	15.99953	17.00016		144
204.	205.	6194.87	7052.68	6195	7052	17.00016	18.00036		145
205.	207.	7052.68	7988.22	7053	7987	18.00036	18.99978		146
207.	208.	7988.22	9007.62	7988	9007	18.99978	20.00036		147

208.	210.	9007.62	10117.8	9008	10117	20.00036	21.00018	148
210.	211.	10117.8	11326.5	10118	11326	21.00018	22.00038	149
211.	212.	11326.5	12642.6	11327	12642	22.00038	23.00027	150
212.	214.	12642.6	14076.1	12643	14075	23.00027	23.99995	151
214.	215.	14076.1	15638.2	14076	15637	23.99995	24.99988	152
215.	217.	15638.2	17341.8	15638	17341	24.99988	26.00009	153
217.	218.	17341.8	19201.7	17342	19201	26.00009	27.00016	154
218.	219.	19201.7	21234.5	19202	21234	27.00016	28.00022	155
219.	221.	21234.5	23459.6	21235	23459	28.00022	29.00016	156
221.	222.	23459.6	25899.2	23460	25898	29.00016	29.99994	157
222.	224.	25899.2	28578.7	25899	28578	29.99994	31.00011	158
224.	225	28578.7	31528	28579	31527	31.00011	32	159
225	226.	31528	28578.7	31528	28578	32	31.00011	160
226.	228.	28578.7	25899.2	28579	25898	31.00011	29.99994	161
228.	229.	25899.2	23459.6	25899	23459	29.99994	29.00016	162
229.	231.	23459.6	21234.5	23460	21234	29.00016	28.00022	163
231.	232.	21234.5	19201.7	21235	19201	28.00022	27.00016	164
232.	233.	19201.7	17341.8	19202	17341	27.00016	26.00009	165
233.	235.	17341.8	15638.2	17342	15637	26.00009	24.99988	166
235.	236.	15638.2	14076.1	15638	14075	24.99988	23.99995	167
236.	238.	14076.1	12642.6	14076	12642	23.99995	23.00027	168
238.	239.	12642.6	11326.5	12643	11326	23.00027	22.00038	169
239.	240.	11326.5	10117.8	11327	10117	22.00038	21.00018	170
240.	242.	10117.8	9007.62	10118	9007	21.00018	20.00036	171
242.	243.	9007.62	7988.22	9008	7987	20.00036	18.99978	172
243.	245.	7988.22	7052.68	7988	7052	18.99978	18.00036	173
245.	246.	7052.68	6194.87	7053	6194	18.00036	17.00016	174
246.	248.	6194.87	5409.35	6195	5408	17.00016	15.99953	175
248.	249.	5409.35	4691.28	5409	4690	15.99953	14.99959	176
249.	250.	4691.28	4036.37	4691	4035	14.99959	13.99941	177
250.	252.	4036.37	3440.80	4036	3440	13.99941	13.00036	178
252.	253.	3440.80	2901.18	3441	2900	13.00036	11.99965	179
253.	255.	2901.18	2414.53	2901	2414	11.99965	11.00103	180
255.	256.	2414.53	1978.18	2415	1977	11.00103	9.999554	181
256.	257.	1978.18	1589.83	1978	1589	9.999554	9.000457	182
257.	259.	1589.83	1247.44	1590	1246	9.000457	7.998622	183
259.	260.	1247.44	949.244	1247	948	7.998622	6.999119	184
260.	262.	949.244	693.728	949	693	6.999119	6.001157	185
262.	263.	693.728	479.614	694	479	6.001157	5.001991	186
263.	264.	479.614	305.839	480	305	5.001991	4.001045	187
264.	266.	305.839	171.550	306	171	4.001045	3.003919	188
266.	267.	171.550	76.0912	172	75	3.003919	1.998803	189
267.	269.	76.0912	18.9999	76	18	1.998803	1.000003	190
269.	270	18.9999	0	19	0	1.000003	0	191
270	271.	0	18.9999	0	18	0	1.000003	192
271.	273.	18.9999	76.0912	19	75	1.000003	1.998803	193
273.	274.	76.0912	171.550	76	171	1.998803	3.003919	194
274.	276.	171.550	305.839	172	305	3.003919	4.001045	195
276.	277.	305.839	479.614	306	479	4.001045	5.001991	196
277.	278.	479.614	693.728	480	693	5.001991	6.001157	197
278.	280.	693.728	949.244	694	948	6.001157	6.999119	198
280.	281.	949.244	1247.44	949	1246	6.999119	7.998622	199
281.	283.	1247.44	1589.83	1247	1589	7.998622	9.000457	200
283.	284.	1589.83	1978.18	1590	1977	9.000457	9.999554	201

284.	285.	1978.18	2414.53	1978	2414	9.999554	11.00103	202
285.	287.	2414.53	2901.18	2415	2900	11.00103	11.99965	203
287.	288.	2901.18	3440.80	2901	3440	11.99965	13.00036	204
288.	290.	3440.80	4036.37	3441	4035	13.00036	13.99941	205
290.	291.	4036.37	4691.28	4036	4690	13.99941	14.99959	206
291.	293.	4691.28	5409.35	4691	5408	14.99959	15.99953	207
293.	294.	5409.35	6194.87	5409	6194	15.99953	17.00016	208
294.	295.	6194.87	7052.68	6195	7052	17.00016	18.00036	209
295.	297.	7052.68	7988.22	7053	7987	18.00036	18.99978	210
297.	298.	7988.22	9007.62	7988	9007	18.99978	20.00036	211
298.	300.	9007.62	10117.8	9008	10117	20.00036	21.00018	212
300.	301.	10117.8	11326.5	10118	11326	21.00018	22.00038	213
301.	302.	11326.5	12642.6	11327	12642	22.00038	23.00027	214
302.	304.	12642.6	14076.1	12643	14075	23.00027	23.99995	215
304.	305.	14076.1	15638.2	14076	15637	23.99995	24.99988	216
305.	307.	15638.2	17341.8	15638	17341	24.99988	26.00009	217
307.	308.	17341.8	19201.7	17342	19201	26.00009	27.00016	218
308.	309.	19201.7	21234.5	19202	21234	27.00016	28.00022	219
309.	311.	21234.5	23459.6	21235	23459	28.00022	29.00016	220
311.	312.	23459.6	25899.2	23460	25898	29.00016	29.99994	221
312.	314.	25899.2	28578.7	25899	28578	29.99994	31.00011	222
314.	315	28578.7	31528	28579	31527	31.00011	32	223
315	316.	31528	28578.7	31528	28578	32	31.00011	224
316.	318.	28578.7	25899.2	28579	25898	31.00011	29.99994	225
318.	319.	25899.2	23459.6	25899	23459	29.99994	29.00016	226
319.	321.	23459.6	21234.5	23460	21234	29.00016	28.00022	227
321.	322.	21234.5	19201.7	21235	19201	28.00022	27.00016	228
322.	323.	19201.7	17341.8	19202	17341	27.00016	26.00009	229
323.	325.	17341.8	15638.2	17342	15637	26.00009	24.99988	230
325.	326.	15638.2	14076.1	15638	14075	24.99988	23.99995	231
326.	328.	14076.1	12642.6	14076	12642	23.99995	23.00027	232
328.	329.	12642.6	11326.5	12643	11326	23.00027	22.00038	233
329.	330.	11326.5	10117.8	11327	10117	22.00038	21.00018	234
330.	332.	10117.8	9007.62	10118	9007	21.00018	20.00036	235
332.	333.	9007.62	7988.22	9008	7987	20.00036	18.99978	236
333.	335.	7988.22	7052.68	7988	7052	18.99978	18.00036	237
335.	336.	7052.68	6194.87	7053	6194	18.00036	17.00016	238
336.	338.	6194.87	5409.35	6195	5408	17.00016	15.99953	239
338.	339.	5409.35	4691.28	5409	4690	15.99953	14.99959	240
339.	340.	4691.28	4036.37	4691	4035	14.99959	13.99941	241
340.	342.	4036.37	3440.80	4036	3440	13.99941	13.00036	242
342.	343.	3440.80	2901.18	3441	2900	13.00036	11.99965	243
343.	345.	2901.18	2414.53	2901	2414	11.99965	11.00103	244
345.	346.	2414.53	1978.18	2415	1977	11.00103	9.999554	245
346.	347.	1978.18	1589.83	1978	1589	9.999554	9.000457	246
347.	349.	1589.83	1247.44	1590	1246	9.000457	7.998622	247
349.	350.	1247.44	949.244	1247	948	7.998622	6.999119	248
350.	352.	949.244	693.728	949	693	6.999119	6.001157	249
352.	353.	693.728	479.614	694	479	6.001157	5.001991	250
353.	354.	479.614	305.839	480	305	5.001991	4.001045	251
354.	356.	305.839	171.550	306	171	4.001045	3.003919	252
356.	357.	171.550	76.0912	172	75	3.003919	1.998803	253
357.	359.	76.0912	18.9999	76	18	1.998803	1.000003	254
359.	360	18.9999	0	19	0	1.000003	0	255

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GRID FOR UP SIDE DOWN DETECTOR A                                                                          PHI    PHI    PHI     PHI
Dots represent pixel centers.  Use 132 columns to print this table.                                       Degrees Measured from Xs/c
File C:\HYDRA\PAS\GRIDABAB.COD,  June 17, 1992                                                            Elec.  Look   BINARY  GRAYGRAY
                                                                                                          Velo.  Dir.   CODE    CODECODE
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   264.5  84.5  00000   00000  0
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   263.5  83.5  00001   00001  1
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   262.5  82.5  00010   00011  3
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   261.5  81.5  00011   00010  2
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   260.5  80.5  00100   00110  6
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   259.5  79.5  00101   00111  7
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   258.5  78.5  00110   00101  5
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   257.5  77.5  00111   00100  4
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   256.5  76.5  01000   01100  C
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   255.5  75.5  01001   01101  D
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   254.5  74.5  01010   01111  F
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   253.5  73.5  01011   01110  E
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   252.5  72.5  01100   01010  A
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   251.5  71.5  01101   01011  B
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   250.5  70.5  01110   01001  9
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   249.5  69.5  01111   01000  8
. . . . . . . . . . . . . . . .><. . . . . . . . . . . . . . . .  248.5  68.5  10000   11000 18
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   247.5  67.5  10001   11001 19
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   246.5  66.5  10010   11011 1B
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   245.5  65.5  10011   11010 1A
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   244.5  64.5  10100   11110 1E
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   243.5  63.5  10101   11111 1F
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   242.5  62.5  10110   11101 1D
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   241.5  61.5  10111   11100 1C
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   240.5  60.5  11000   10100 14
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   239.5  59.5  11001   10101 15
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   238.5  58.5  11010   10111 17
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   237.5  57.5  11011   10110 16
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   236.5  56.5  11100   10010 12
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   235.5  55.5  11101   10011 13
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   234.5  54.5  11110   10001 11
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   233.5  53.5  11111   10000 10
                                                    1 1 1 1 1 1    E  V     THETA
7 7 7 7 7 7 8 8 8 8 8 8 8 8 8 8 9 9 9 9 9 9 9 9 9 9 0 0 0 0 0 0    L  E
4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5    E  L  Velocity Vector
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .    C  O   Measured from
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5    .  .       Zs/c

1 1 1 1 1 1                                                         L        THETA
0 0 0 0 0 0 9 9 9 9 9 9 9 9 9 9 8 8 8 8 8 8 8 8 8 8 7 7 7 7 7 7    O  D
5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4    O  I  Look Direction
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .    K  R   Measured from
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5           Zs/c

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0    B
1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0    I  C
1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0    N  O
1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0    A  D
1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0    R  E
                                                                    Y
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0    G  C     THETA
0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0    R  O
0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0    A  D
0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0    Y  E
0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0    G  C
                                                                    R  O
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1                                     A  D
0 1 3 2 6 7 5 4 C D F E A B 9 8 8 9 B A E F D C 4 5 7 6 2 3 1 0    Y  E
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GRID FOR RIGHT SIDE UP DETECTOR B                                 PHI   PHI   PHI    PHI
Dots represent pixel centers.  Use 132 columns to print this table.  Degrees Measured from Xs/c
File C:\HYDRA\PAS\GRIDABAB.COD, June 17, 1992                     Elec. Look  BINARY GRAYGRAY
                                                                  Velo. Dir.  CODE   CODECODE
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   53.5 233.5 00000  00000  0
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   54.5 234.5 00001  00001  1
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   55.5 235.5 00010  00011  3
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   56.5 236.5 00011  00010  2
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   57.5 237.5 00100  00110  6
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   58.5 238.5 00101  00111  7
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   59.5 239.5 00110  00101  5
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   60.5 240.5 00111  00100  4
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   61.5 241.5 01000  01100  C
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   62.5 242.5 01001  01101  D
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   63.5 243.5 01010  01111  F
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   64.5 244.5 01011  01110  E
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   65.5 245.5 01100  01010  A
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   66.5 246.5 01101  01011  B
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   67.5 247.5 01110  01001  9
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   68.5 248.5 01111  01000  8
. . . . . . . . . . . . . . . .><. . . . . . . . . . . . . . . .   69.5 249.5 10000  11000 18
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   70.5 250.5 10001  11001 19
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   71.5 251.5 10010  11011 1B
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   72.5 252.5 10011  11010 1A
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   73.5 253.5 10100  11110 1E
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   74.5 254.5 10101  11111 1F
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   75.5 255.5 10110  11101 1D
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   76.5 256.5 10111  11100 1C
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   77.5 257.5 11000  10100 14
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   78.5 258.5 11001  10101 15
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   79.5 259.5 11010  10111 17
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   80.5 260.5 11011  10110 16
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   81.5 260.5 11100  10010 12
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   82.5 262.5 11101  10011 13
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   83.5 263.5 11110  10001 11
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .   84.5 264.5 11111  10000 10
1 1 1 1 1 1                                                        E V      THETA
0 0 0 0 0 0 9 9 9 9 9 9 9 9 9 9 8 8 8 8 8 8 8 8 8 8 7 7 7 7 7 7    L E
5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4    E L   Velocity Vector
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .    C O    Measured from
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5    . .        Zs/c

                                                    1 1 1 1 1 1    L        THETA
7 7 7 7 7 7 8 8 8 8 8 8 8 8 8 8 9 9 9 9 9 9 9 9 9 9 0 0 0 0 0 0    O   D
4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5    O   I  Look Direction
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .    K   R  Measured from
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5            Zs/c

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0    B
1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0    I   C
1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0    N   O
1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0    A   D
1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0    R   E

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0    G   C     THETA
0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0    R   O
0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0    A   D
0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0    Y   E
0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0    G   C
                                                                   R   O
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1                                    A   D
0 1 3 2 6 7 5 4 C D F E A B 9 8 8 9 B A E F D C 4 5 7 6 2 3 1 0    Y   E
```

HVMON_3.0. DDEIS and PPA High Voltage Monitoring
September 29, 1996

HVMON_3.1. The Design Problem in HV Monitoring

The code described here monitors the deflection HV levels directly through a 10-bit A/D converter, and performs this task in the background during normal scientific operation of the instrument. Note that we don't want to sample the HV when it is on a transient; and we don't want our HV sampling period to be commensurate with the scan sequence in such a way as to repeat some samples without getting the others. In order to solve these timing problems, the scan program (DDSCAN and PPSCAN) controls the timing of the sample.

To avoid transients, the sample is requested on the second BCI of a HV step, assuming each HV step is two or more BCI's long.

In order to sample every possible level, the HV monitor code in the scan program steps slowly through all 256 permutations of a byte and seeks a match with the current HV control byte. THe HV monitor dwells on each permutation for 8 MJF's for the DDEIS and 32 MJF's for the PPA, in order to cover a complete scan of all available values. Thus it takes 5.2 hours to complete a cycle of every possible level for the DDEIS, and 20.9 hours for the PPA. Note that some HV levels may not be available if they are not included in the scan sequence; in this case the telemetry returns all bits on. For levels that occur more than once during a search, only the first occurrence is recorded, and the A/D converter is not exercised subsequently.

HVMON_3.2. Overview

The DDSCAN and PPSCAN routines will periodically ask the BCI ISR to sample the Analog to Digital converter to get the value of the high voltage for their respective instruments. In each case, the values returned consist of four bytes, with bits 0-9 of each of the two-byte words containing the 10-bit readback from one of the sides of the instrument. We don't know which of the four bytes are from which side of the instrument, but we presume Jerry Needell knows.

HVMON_3.3. Code in DDSCAN and PPSCAN:

The following discussion applies to both the DDEIS and the PPA. Where there are differences between the instruments, the main text is for the DDEIS, and changes for the PPA are given in square brackets.

After power-up or a new descriptor command, initialization for HV monitoring is performed. This consists of saving bits 3-10 [PPA: 5-12] of the major frame count as the HV control byte value to watch for. Pointers are set to the scan and telemetry halves of a readback double buffer, the scan half is cleared, and the telemetry half is set to an invalid value by turning all bits on.

At the start of the scan routine when not initializing, the major frame count is first checked to see if it is time to begin looking for a new HV value. If it is, a 'match-found' flag is checked (and simultaneously cleared) to see if there has been a match on the old value. If there has not, the scan readback buffer is set to all ones indicating invalid. Next, whether or not there has been a match, the scan and telemetry pointers to the readback buffer are swapped, and the new scan half is cleared.

If no match has yet been found on the present value being sought, it is compared to the HV control byte representing the value to which the instrument has just been set. If they are the same, a flag is set telling the BCI ISR to do the A-to-D conversion the next time it runs, and the 'match found' flag is set.

HVMON_3.4. Code in the telemetry task:

In the 'sub1' routine of the telemetry task, which executes in the third quarter of the major frame, a single byte of the HV readback values is copied to the science housekeeping loose byte buffer, byte 135; the data analyst must assemble four occurrences of byte 135 from 4 MJF's in order to make a complete sample. In assembling samples, bits 0-2 of the major frame counter determine which byte it is. When bit 2 is 0, the byte is from the ddeis, and when it is 1, it is from the ppa. In either case, the other two bits indicate which byte it is of the four returned by the BCI ISR, with 00 being the byte with the lowest address, and 11 the highest.

PHA_3.0. Pulse Height Analysis
September 29, 1996

Pulse height analysis is accomplished by code distributed through the MJF ISR, DDSCAN routine, and TLMTASK task. The sequencer is a triple-nested loop taking 8 or 9 hours to complete. The loop heirarchy is:

(i) Deflection HV: 32 foreground levels + 1 background level
(ii) CEM #: 12 pairs
(iii) Discrimination level: 16 levels

The outer, or slowest, loop scans through the HV deflection levels in 32 steps. The steps are specified in detail in Section PHA_3.5. below. The background loop uses any HV level which has polarity opposite to that of the CEM.

The middle loop scans through the 12 CEM's in each of the 2 EIS pods, 6 ion CEM's and 6 electron CEM's. The two pods are handled simultaneously so that each CEM is paired with its opposite.

The inner loop scans the levels of the PHA discriminator. Although the discriminator provides 256 levels, 16 seem enough. Again, the desired levels are named in a lookup table, which can be reloaded by ground command if desired.

PHA_3.1. Code in TLMTASK

Each quarter of an MJF, TLMTASK must collect part of the PHA data and the science housekeeping data and insert them into the appropriate telemetry buffers. PHA data occur in the following bytes of the loose bytes telemetry: offsets 12-15, 29-32, 46-49, and 63-65. See TLMF.TLMLB_3. for an enumeration of the loose bytes housekeeping telemetry.

PHA_3.2. Code in the MJF ISR

The MJF ISR picks up the PHA selection vector prepared by DDSCAN, and immediately sets the new discrimination level by writing to the DPUII (the same for both EIS's). It also writes to the DPUII whenever a flag indicates that there is a change in CEM selection, to attach the PHA discriminator to the new CEM.

PHA_3.3. Code in DDSCAN

The first run of DDSCAN in each MJF creates the PHA selection vector for the next major frame interval. If the CEM selection has changed, a flag is set for the MJF ISR.

Each time the accumulators are read out, DDSCAN checks the associated "was" CEM polarity against the PHA CEM selection polarity. If they match, DDSCAN compares the deflection HV as detailed in PHA_3.5. If they match, DDSCAN keeps the accumulator readouts for both the two PHA discriminators (one from each EIS), and also from the two matching duty accumulators. These readings are replace-added into four 32-bit words in the DDSCAN half of a double buffer shared with TLMTASK. At the beginning of each MJF, the DDSCAN and TLMTASK pointers to this buffer are swapped, and the DDSCAN portion of the buffer is zeroed. For instance, in a scan identical to one in ModeZero, with 8 ion scans and 8 electron scans per MJF, the result at the end of the MJF will be the sum of the accumulations from 8 occurrences of the matching inputs. In other modes the number of accumulations producing a match may vary.

PHA_3.4. PHA Input Selection

On each side a single A111 PHA amplifier is fed through a MUX by the analog signal output of 12 A150 preamps belonging to the individual electron multipliers (CEM's). Selection of the PHA channel is done by poking a 16 bit serial input word through the DPUII interface as described in the DPUII address map. The 16 bit word consists of an 8 bit address and an 8 bit instruction. The high nibble of the instruction byte selects the PHA channel, and the low nibble selects the A/D converter channel. Note that, when selecting either the A/D converter input or the PHA input, one must remember and preserve the input to the other MUX in the other nibble. The following table tells the CEM channels selected by each value of the PHA nibble.

PHA selection nibble	Side 1 top of top shelf	Side 2 bot of bot shelf	Accumulator offset Side 1	Side 2
0X	E1	E2	0	7
2X	E3	E4	2	9
4X	E5	E6	4	B
8X	E7	E8	6	1
AX	E9	E10	A	5
CX	E11	E12	8	3
	PHA output	PHA output	C	D
1X	I1	I2	0	7
3X	I3	I4	2	9
5X	I5	I6	4	B
9X	I7	I8	6	1
BX	I9	I10	A	5
DX	I11	I12	8	3
	PHA output	PHA output	C	D

Nibbles 6X, 7X, EX, and FX are not used, and these inputs to the MUX are connected to ground.

The outputs of the 12 active A150 preamp/discriminators are fed to the 82C54 registers, and the outputs of these registers are collected once per DDC and appear as a stack of 12 16 bit words for collection by the telemetry task. The output of the PHA registers also appear as the thirteenth and fourteenth words on the stack. The above table gives the offset into the table for the accumulators attached to each of the input CEM's, and discloses which of the A150's is matched to any selected input to the A111's.

One of the objectives of our background PHA scheme is to collect the outputs of the A111 PHA preamps and the matched A150 preamps simultaneously for comparison. The above table gives the information needed to make the match. The above information was drawn from Jerry Needell's "Hydra CEM - Accumulator Map" of 4/11/93, and from Jim Lobell's checkout command file described as "AMP1_CHK.ICL, 10:39 AM, 6/4/93". They are stored in directory c:/hydra/fid_3 as files "CEMMAP PHA 3284 12-29-93 4:19p", and "LOBELFIL PHA 10010 12-21-93 11:30a".

In the above table, the CEM's are designated by an alphabetic character, E or I, and a number, 1-12. E or I obviously designates electrons or ions, and the number selects the analyzers. Jim Lobell has assured me that the analyzer designation is the same used in the mechanical drawings and used by Jack Scudder.

PHA_3.5. Deflection Voltage Selection

The outer, or slowest, loop scans through the HV deflection levels in 32 steps. Eight levels of ion data, and 24 levels of electron data, for a total of 32 levels when you add together the two polarities. The asymmetry is because the 2000 v post-analysis acceleration on the ion side gives the lowest energies analyzed nearly the same energy at the CEM. Although there are more HV levels for each polarity, the CEM response is not expected to differ enough from step to step to require that much resolution. Eight and 24 steps are enough.

The match criteria used by the DDSCAN code for the HV deflection steps should be loaded into a table of depth 32 (or, if you please, two tables of depth 8 and 24.) The contents of the table can be varied by ground command to provide some flexibility. Each entry of the table should be a byte with the 2 lsb's equal to zero. This is compared with a byte formed from the 6 msb's of the HV control byte and 2 zero lsb's. Thus only the 6 msb's of the HV control byte count in making the match, and so any of 4 deflection levels within 3 steps (50% in energy) above the nominal level is accepted. The following are the deflection supply levels that will be the targets for PHA analysis. These values are based on calibration data from the SN001 supplies taken at ambient temperature, Sept-Oct, 1992.

PHA_3.5.1. Electron CEM's: 24 Levels

Positive Deflection Polarity, Low Range

Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
0	0	60	3C	-13.23	1.12
0	0	56	38	-7.58	0.880
0	0	52	34	-4.41	0.644
0	0	48	30	-2.48	0.394
0	0	44	2C	-1.43	0.155
0	0	40	28	-0.76	-0.12
0	0	36	24	-0.39	-0.41
0	0	32	20	-0.17	-0.77
0	0	28	1C	-0.07	-1.2

Positive Polarity, High Range

Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)
0	1	60	7C	-6669.12	3.82
0	1	56	78	-3844.85	3.58
0	1	52	74	-2268.57	3.36
0	1	48	70	-1305.91	3.12
0	1	44	6C	-772.04	2.89
0	1	40	68	-444.39	2.65
0	1	36	64	-262.60	2.42
0	1	32	60	-151.16	2.18
0	1	28	5C	-89.59	1.95
0	1	24	58	-51.56	1.71
0	1	20	54	-30.46	1.48
0	1	16	50	-17.52	1.24
0	1	12	4C	-10.37	1.02
0	1	8	48	-5.96	0.775
0	1	4	44	-3.49	0.543

PHA_3.5.2. Ion CEM's: 8 Levels

Negative Deflection Polarity, High Range

Pos Neg	Range Select	Level	Control HexByte	HV A-B	Log ABS(HV)	Ion Energy at CEM, eV
1	1	36	E4	266.13	2.43	2941
1	1	40	E8	450.22	2.65	3592
1	1	44	EC	782.43	2.89	4766
1	1	48	F0	1323.89	3.12	6680
1	1	52	F4	2300.28	3.36	10131
1	1	56	F8	3900.00	3.59	15787
1	1	60	FC	6771.07	3.83	25936

Negative Deflection Polarity, Low Range

Pos Range Control HV Log

Neg	Select	Level	HexByte	A-B	ABS(HV)	
1	0	44	AC	1.70	0.230	2006

Remember that a command byte has negative polarity if MSB=1, and yields deflection voltages that analyze for positive particles. This follows because side A is connected to the outer plate. The step size on the log(HV) scale approximates a uniform 0.06 across both ranges, and the step size for PHA selection is typically 4 levels, or a nominal 0.24 on the log(HV) scale.

TLM_0.0 Hydra ModeZero Task TLM_0
September 29, 1996

Takes data from the holding-processing buffers, packs them, and writes the packed data into the telemetry buffer. Task TLM_0 must not read data until after PPSCAN_0 and DDSCAN_0 have completed filling half of their holding-processing buffers PP16_BUF and DD16_BUF, and it must not write data into the telemetry buffer until the telemetry task has cleared the last half. To assure these conditions, TLM_0 is started 4 times per MJF by PPSCAN_0 8 BCI's after at the end of each PPC. TLM_0 must complete by the end of the next PPC. It fills TMBUF in the order of 256 bytes (PPTPV), 150 bytes (PPTMBINS), 960 bytes (DDTM), and 4 or 3 remaining bytes for even and odd quarters, respectively. The following subtasks describe the task in more detail.

TLM_0.1. PP2TM

The PPA data for each PPC consists of 256 16-bit accumulations saved in a double buffer, PP16BUF, of length 1024 bytes. At the end of each accumulation, these 256 bins are mapped, or rebinned, into 120 bins, and compressed PSRL 16 to 10 into 150 bytes in the telemetry buffer PPTMBINS. In case of overflow in the rebinning operation, a flag, PPAOV2, will be set.

There is also sector information generated throughout the scan, consisting of 128 sectors of 2 bytes each, where the 2 bytes are 1 overflow bit, 7 theta bits, and 8 phi bits. These data are saved in PPTPVBUF, a ring buffer of length 512 bytes.

TLM_0.2. DD2TM

The DDEIS data for each DDC consists of 12 channels of 16-bit accumulations. These are saved in a ring buffer, DD16BUF, which holds 128 DDC's, or half an MJF. DD2TM is initiated at the same time as PP2TM and compresses the last 64 DDC's data PSRL 16 to 10 into 15 bytes per DDC or 960 bytes, which are stored in the telemetry buffer DDTMBUF, of length 1920 bytes.

TLM_0.3. PP120BIN

Half of PP16BUF is merged from 256 to 120 bins by PP2TM. The 120 channels will be mapped from 256 accumulators as follows (Note that there is even symmetry, and the coding algorithm is very strange.)

Degrees	Bins	Re-bin Ratio	Accumulator ID	
0- 20	0-27	1 to 1 or 28 to 28	0-54	even #'s

20- 29	28-34	1 to 2	or 7 to 14	56-82	even #'s
29- 80	35-52	1 to 4	or 18 to 72	84-226	even #'s
80- 90	53-59	1 to 2	or 7 to 14	228-254	even #'s
90-100	60-66	1 to 2	or 7 to 14	255-229	odd #'s
100-151	67-84	1 to 4	or 18 to 72	227-85	odd #'s
151-160	85-91	1 to 2	or 7 to 14	83-57	odd #'s
160-180	92-119	1 to 1	or 28 to 28	55-1	odd #'s
	Total Bins	120	256		

TLM_0.4. CS8to5

ModeZero data are conveniently compressed and stacked by taking 4 16-bit data words, compressing them PSRL 16 to 10 bits each, and packing them into 5 bytes. Each DDEIS readout can be handled by repeating this subtask 3 times, and each PPA readout by repeating this subtask 30 times.

TLM_0.5. PSRL16to10

Pseudo-Root with Linear Segment compression of a 2 byte data word into a 10 bit word.

PSRL1610. Pseudo-Root with Linear Segment Compression Format

16bit to 10bit Psuedo-Root with Linear Segment compression. The bits of the original word are labelled q15 --> q0, with q15 being the high-order bit. (Say "aqqumulator.")

If the most significant bit is in this position

Then the 10 bits of the compressed word are as follows with E/O R/S

q15	q15	q14	q13	q12	q11	q10	q09	q08	0	0
q14	q14	q13	q12	q11	q10	q09	q08	q07	1	0
q13	0	q13	q12	q11	q10	q09	q08	q07	0	0
q12	0	q12	q11	q10	q09	q08	q07	q06	1	0
q11	0	0	q11	q10	q09	q08	q07	q06	0	0
q10	0	0	q10	q09	q08	q07	q06	q05	1	0
q09	0	0	0	q09	q08	q07	q06	q05	0	0
<q09	q08	q07	q06	q05	q04	q03	q02	q01	q00	1

S175_3.0. Science Status and Housekeeping Data for ModeThree
September 29, 1996

MODIFICATIONS

07-20-92 11:00 am rwf: Resynch interval referred to in sections .5.4.1. thru .5.4.3. was changed to a variable with default value of 63 MJF's on April 1, 1992.
10-29-93 rwf: Update from ModeZero to ModeTwo.
10-29-93 rwf: Update from ModeTwo to ModeThree.

S175_3.1.0. Flags and Status

S175_3.1.1. PPAOV1

There was an overflow upon replace-adding the 8 bit PPA RAM PP8_BUF into 16 bit PPA RAM PP16_BUF. Not needed if there are fewer than 256 replace-adds.

S175_3.1.2. PPAOV2

There was an overflow upon rebinning the PPA accumulators in task PP2TM.

S175_3.1.3. PPBSTAT

A four bit field corresponding to the magnetometer scale and special mode fields given to us by the magnetometer. The most recent value of this field is telemetered. This alerts us to changes in scale, which may be an error condition, and also gives us an idea of the S/N ratio of the magnetometer.
This field must be associated with the data from its own PPC, and there must be 4 of them per MJF.

S175_3.2.0. Pulse Height Spectral Information

Not implemented in ModeZero, ModeOne, or ModeTwo

HV deflection voltage monitor 2 bytes + 2 bytes
CEM bias level monitor Check with Jerry. I think he does it.
PHA input MUX 4 bits
Duty accumulator number (1-6 or 12)
Ion/Electron CEM
PHA discrimination level 8 bits
Deflection bias level 1 byte
Reading of duty accum 3 bytes + 3 bytes
Reading of PHA accum 3 bytes + 3 bytes

Summation:
Data 12 bytes
Identification 3 bytes
Voltage monitors + 4

Total for 2 HEIS's	19 bytes

S175_3.3.0. Mode and Descriptor Information

There are 8 DDEIS and 4 PPA descriptors in the descriptor table. The entire table is telemetered, at the rate of one PPA and one DDEIS descriptor per MJF. That is, each MJF we get:

DDEIS descriptor	13 bytes
DDEIS descriptor offset	1 byte
PPA descriptor	12 bytes

The DDEIS descriptor offset is counted linearly from the start of the descriptor table. Since the DDEIS descriptors are 13 bytes long, and the table is 8 descriptors long, the offset values = N*13, where N=0-7, and N is the descriptor address used to determine the descriptor sequence (e.g.: address of next descriptor). The address of the PPA descriptor is derivable from that of the DDEIS, and is simply N/2.

DDEIS	
Scan Base Level 0 <= Base <= 127	1 byte
Scan Increment	1 byte
Number of HV Steps Per Scan (DDN's/DSC)	1 byte
Offset Base (+-Levels)	1 byte
Offset Increment (+-)	1 byte
Scans Per Offset Cycle	1 byte
# Interrupts per Energy Step (BCI's/DDN)	2 bytes
# Interrupts per Accumulation (BCI's/DDC)	2. bytes
Address of Next Scan Descriptor	1 byte
Address of Next Cycle Descriptor	1 byte
Sensor Polarity	1 byte

PPA	
Scan Base Level 0 <= Base <= 127	1 byte
Scan Increment	1 byte
Number of HV Steps Per Scan	1 byte
Offset Base (+-Levels)	1 byte
Offset Increment (+-)	1 byte
Scans Per Offset Cycle	1 byte
# Interrupts per Energy Step (BCI's/DDN)	2 bytes
# Interrupts per Accumulation (BCI's/DDC)	2 bytes

Address of Next Scan Descriptor	1 byte	
Address of Next Cycle Descriptor	1 byte	
Sensor Polarity (space holder)	1 byte	
Values for control registers BCI, ET1, ET2, ACC, DSP		10 bytes

S175_3.4.0. Sampling Sequence States

Piggyback on PHA sequence. See PHA output.
Voltage monitors.
PP CEM bias
DD ion CEM bias
DD electron CEM bias
PP deflection bias, 128 levels
DD deflection bias, +- 64 levels

Not implemented in ModeZero, ModeOne, or ModeTwo.

S175_3.4.1. PPA HV level

One byte included in the 4,3,4,3 part of the output buffer. Each accumulation is labeled by its HV level.

S175_3.5.0. Timing and Reference Marks

The spacecraft provides a universal time code consisting of 32 bits of data including: 15 bits of "Truncated Julian Day (TJD)" data, and 17 bits of "Seconds of Day". The most significant bit of the TJD is transmitted first, and the LSB = 1 second. This UTC is received by the TIM interrupt and stored.

The spacecraft also provides a Time Code Clock, which runs continuously at 1.000+/-0.004 kbps. This clock feeds the 16 bit Time Code Clock (TCC) register, which is reset by the Time Code Enable pulse, which occurs once for every UTC word. Thus, the TCC register counts milliseconds between UTC words.

Time is defined to a millisecond by reading the UTC code (4 bytes) and the TCC register (2 bytes), and putting them together for a 6 byte field, which we can call MSTIM. This is the straightforward way of providing a time mark.

S175_3.5.1. DDCYCTIM, 4 bytes

Each time a new DDEIS offset cycle begins, the spacecraft time is read, and written to memory with the present and previous descriptor numbers. These numbers are read out to telemetry once per MJF to create a timing reference in the scan sequence. Since the 2 most significant bytes will be the same as for MJFTIM, 6 bytes are truncated to the least significant 4 bytes.

See TLMLB_2.FID for the byte assignments in telemetry.

Not implemented in ModeZero.

S175_3.5.2. DUNTIM, 4 bytes

Time read at the arrival of a DUN interrupt. Since the 2 most significant bytes will be the same as for MJFTIM, 6 bytes are truncated to the least significant 4 bytes.

S175_3.5.3. MJFTIM, 6 bytes

Time read at the arrival of a MJF pulse from the spacecraft (6 bytes).

S175_3.5.4. Synchronization Markers

S175_3.5.4.1. MRCD_NUM, 1 byte

Most recently commanded descriptor number. This identifies the most recently commanded DDEIS descriptor by its offset value. Every resynchronization interval, the program is reinitialized to this descriptor.

S175_3.5.4.2. PPMRCD_NUM, 1 byte

Most recently commanded descriptor number. This identifies the most recently commanded PPA descriptor by its offset value. Every 63 MJF's, the program is reinitialized to this descriptor.

S175_3.5.4.3. RESYNCH_MJF, 1 byte

The value of the low byte of the major frame counter, at which the next resynchronization occurs. Resynch occurs after this number of MJF's.

S175_3.5.4.4. MJF_CNT

The major frame counter maintained by the MJF ISR. The counter itself is one word, or 2 bytes, but only the least significant byte is telemetered, as this is the only one that matters modulo 8.

S175_3.6. Task Scheduler/Tables

A block of bytes to monitor the operation of the task scheduler.

S175_3.7. Memory Dump

A block of bytes to slowly go through memory and read it out.

*

TIMMTX_0.0. Timing Relationships Among Hydra Intervals

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To print this text, use 132 columns

TIMMTX_0.1. Nomenclature

BCI	Basis Cycle Interrupt (programmable)
BFR	Magnetometer data refresh cycle
BSP	Magnetometer sample period
DDC	DDEIS accumulation interval
DDN	DDEIS energy step interval
DSC	DDEIS energy scan period (programmable)
ET2	Experiment timing signal #2, generated internally
MJF	Major Frame Period
MNF	Minor Frame Period
PPC	PPA accumulation interval, summed in scratch RAM over some number of PPR cycles, and read out to telemetry.
PPL	The live accumulation portion of the PPR
PPR	PPA RAM refresh interval (readout and reset the 8 bit RAM on the PPA board.)
PSC	PPA energy scan period (programmable)
SEC	One NBS standard second
SPT	Tick of spin phase reference clock (4096 per sun reference pulse)
SUN	Sun reference pulse (=spin period)
TMT	Tick of the 55652 hz telemetry clock

TIMMTX_0.2. Spacecraft Signals

# of THESE	in THAT	SPACECRAFT SIGNALS			
	TMT	MNF	SEC	SUN	MJF
TMT	1	2048	55652	333912	512000
MNF	.00049	1	27.1738	163.043	250
SEC	.00002	.036800	1	6	9.200029
SUN	3.0e-6	.006133	.166667	1	1.533338
MJF	2.0e-6	.004	.108695	.652172	1

TIMMTX_0.3. Control Values

# of THESE in THAT CONTROL VALUES

	TMT	SPT	ET2	BSP	BCI	PPL	PPR	BFR	DDC	DDN	MNF	DSC	SEC	PPC	SUN	MJF	PSC	
TMT	1		200		1000		1000	1000			2048		55652					TMT
SPT		1													4096			SPT
ET2			1			4												ET2
BSP				1							4							BSP
BCI					1				2	2								BCI
PPL						1	1											PPL
PPR							1											PPR
BFR							1	1										BFR
DDC									1			16						DDC
DDN										1								DDN
MNF											1					250		MNF
DSC												1						DSC
SEC													1		6			SEC
PPC														1		4	16	PPC
SUN															1			SUN
MJF																1		MJF
PSC																	1	PSC
	TMT	SPT	ET2	BSP	BCI	PPL	PPR	BFR	DDC	DDN	MNF	DSC	SEC	PPC	SUN	MJF	PSC	

TIMMTX_0.4. Hydra and Spacecraft Signals

# of THESE in THAT HYDRA AND SPACECRAFT SIGNALS

	TMT	SPT	ET2	BSP	BCI	PPL	PPR	BFR	DDC	DDN	MNF	DSC	SEC	PPC	SUN	MJF	PSC	
TMT	1	81.52	200	512	1000	800	1000	1000	2000	2000	2048	32000	55652	128000	333912	512000	2048000	TMT
SPT		1		6.281	12.27		12.27	12.27					682.67		4096			SPT
ET2			1			4												ET2
BSP				1				1.953			4		108.70			1000		BSP
BCI					1				2	2		32	55.652	128		512		BCI
PPL						1	1				2.048			128		512	2048	PPL
PPR							1	1			2.048		55.652	128		512	2048	PPR
BFR							1	1			2.048		55.652	128		512	2048	BFR
DDC									1			16		64		256		DDC
DDN										1								DDN
MNF	.0005										1	15.625	27.174		163.043	250		MNF
DSC												1				16		DSC
SEC	2e-5	.0015		.0092	.0180	.0144	.0180	.0180	.0359		.0368	.57500	1	2.30001	6	9.20003	36.80012	SEC
PPC														1		4	16	PPC
SUN	3e-6										.0061		.16667	.383335	1	1.53334		SUN
MJF	2e-6										.004		.10870	.25	.652172	1		MJF
PSC																	1	PSC
	TMT	SPT	ET2	BSP	BCI	PPL	PPR	BFR	DDC	DDN	MNF	DSC	SEC	PPC	SUN	MJF	PSC	

```
*
TIMLIN.0.  ModeZero Information Generation Timing
             September 29, 1996
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BCI Count (0-512) within each MJF (512 BCI's and 4 PPC's per MJF)
                     1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4 5 5
   1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
                                                                                                     MJF
 MJF
 p                       p0                        p1                        p2                      p3
P                        P                         P0                        P1                      P2
mmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmm
vvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvv
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
dddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddddd
D                        D                         D                         D                         D

Pl
Ex
RO
HP
TM

BCI Count (0-127) within each PPC (4 PPC's per MJF)                                           1         1         1      1
          1         2         3         4         5         6         7         8         9         0         1         2      2
 0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,.7.
 MJF
                                                                                                                               p0
 p                                                                                                                             P
P
mmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmmm
vvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvv
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
 d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d d
                                                                                                                               D
D

Pl
Ex
RO
HP
TM

                                                                                               1         1         1
TMT Count after an MJF
          1         2         3         4         5         6         7         8         9         0         1         2
          0         0         0         0         0         0         0         0         0         0         0         0
          0         0         0         0         0         0         0         0         0         0         0         0
 0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,....0....,....0..
 MJF
 p
P
 b    b    b    b    b    b    b    b    b    b    b    b    b    b    b    b    b    b    b    b    b    b    b    b
```

m0	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12
v	v0	v1	v2	v3	v4	v5	v6	v7	v8	v9	v10	v11
M	M	M0	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
d		d0		d1		d2		d3		d4		d5
D												
Pl												
Ex												
RO												
HP												
TM												

p	Table of 256 PPC bins is finished replace-adding, and ready to rebin and compress. The alternate buffer starts repla
P	Previous table of 120 PPC bins is finished compressing and ready for TM (150 bytes 4 times per MJF).
b	Magnetometer sample (4 x 16 bits) received (BSP).
m	Magnetic field direction (15 bits) generated (BFR).
v	Overflow datum (1 bit) generated (PPR).
M	Magnetometer and Overflow data (16 bits) combined and ready for TM (2 bytes 512 times per MJF).
d	DDEIS accumulators read into buffer (14 X 16 bits)
D	DDEIS accumulator buffer (64 X 12 X 10 bits) compressed, transferred, and ready for TM (15 bytes 256 times per MJF).
S	Science status data (175 bytes 1 time per MJF)

The generation sequence can be written
S + 4*(P + 64*(2*M + D))

generating the following number of bits per MJF:
175 + 4*(150 + 64*(2*2 + 15)) = 5639

Combining notations,
S175 + 4*(P150 + 64*(2*M2 + D15))

which can also be written,
S175 + 4*(P150 + 64*(2*M2)) + 256*D15 = 175 + 4*406 + 3840

The telemetry frame will be staged in three sections or buffers, corresponding to data from the science status buffer, the PPA buffer, and the DDEIS buffer. There is also a fourth source, namely engineering housekeeping, but as this will be handled totally by UNH, we can ignore it.

PPA Data

The PPA data consists of 120 channels of 16 bit accumulations compressed 16 to 10 to 150 bytes, plus 128 sectors of 2 bytes each, where the 2 bytes consist of 1 overflow bit, 7 theta bits, and 8 phi bits.

Description of Telemetry Allocations

for

ModeThree Operation of the

Hydra Instrument on the Polar Satellite

September 29, 1996

TLMF.ALL_0. Description of Telemetry Allocation

Introduction

The Polar telemetry frame contains 250 minor frames (mf) numbered 1-250 each of which contains 256 bytes numbered 0-255. Hydra gets word 12 in mf's 26, 32, 38, etc., through 248 for a total of 38 bytes, which are to be used for engineering housekeeping only. Hydra gets word 17 in minor frames 1-139 which are collectively referred to as the "loose bytes". Additionally, Hydra gets words 20, 28, etc. for a total of 22 bytes in all minor frames. Thus the frame looks like:

Minor Frame	Byte 0	12	17	20	28	...	255
1			x	x	x	xxx	
.							
.							
26		x	x	x	x	xxx	
.							
.							
32		x	x	x	x	xxx	
.							
.							
139			x	x	x	xxx	
140		x		x	x	xxx	
.							
.							
248		x		x	x	xxx	
249				x	x	xxx	
250				x	x	xxx	

The submatrix of words used by Hydra looks like

```
Minor
Frame
  1        h h h h h h h h h h h h h h h h h h h h h h h
  .        s x x x x x x x x x x x x x x x x x x x x x x
  .        s x x x x x x x x x x x x x x x x x x x x x x
 26      e s x x x x x x x x x x x x x x x x x x x x x x
  .        s x x x x x x x x x x x x x x x x x x x x x x
  .      e s x x x x x x x x x x x x x x x x x x x x x x
  .        s x x x x x x x x x x x x x x x x x x x x x x
  .      e s x x x x x x x x x x x x x x x x x x x x x x
139        s x x x x x x x x x x x x x x x x x x x x x x
140      e   x x x x x x x x x x x x x x x x x x x x x x
  .          x x x x x x x x x x x x x x x x x x x x x x
  .      e   x x x x x x x x x x x x x x x x x x x x x x
  .          x x x x x x x x x x x x x x x x x x x x x x
248      e   x x x x x x x x x x x x x x x x x x x x x x
249          x x x x x x x x x x x x x x x x x x x x x x
250          x x x x x x x x x x x x x x x x x x x x x x
```

The bytes have been allocated as follows:

- e engineering housekeeping, assigned by UNH, 38 bytes
- h science housekeeping, assigned by UNH, 23 bytes
- s science housekeeping, assigned by UCSD, 138 bytes
- x science data, assigned by UCSD, 5478 bytes

Note: The bytes assigned by UCSD = 138 + 5478 = 5616. The bytes assigned by UNH = 23 + 38 = 61.

UCSD Allocated Bytes

Note: In the information that follows, the data designation word refers to 16-bit words while the designation byte refers to 8-bit words.

This is a description of the usage of the 5616 bytes of telemetry (tlm) allocation that are filled by the TLM0TASK. The other 61 bytes (out of 5677) are filled by code associated with the ISR's for mode 0. TLM0TASK is called four times per major frame by the PPASCAN task. It executes just "after" the two data collection tasks (SCAN and PPASCAN) have gathered enough data to fill about one-quarter of the space available for tlm.

```
                                                n+1             major frame #
 n                                                              quarter #
        0           1           2           3            0
 |            *           *           *           |         *
               ^           ^           ^           ^         ^
execution for: 0           1           2           3         0
```

When TLM0TASK executes it will process 128 words of theta/phi data, 256 words of PPA data (re-binned to 120 words) and 768 words of DDEIS data. The PPA and DDEIS data will be compressed using a psuedo-root with linear segment 16 to 10 bit compression scheme (PSRL16-10). In the course of execution of an entire major frame TLM0TASK also places data into a 138 byte buffer which is the UCSD portion of the "loose bytes" buffer.

As mentioned before, TLM0TASK splits the tlm into two buffers. The first can be thought of as the Science Data (SD) buffer and the second as the Science Management (SM) buffer. The SD buffer is actually only 2739 bytes long and is filled twice per major frame. The SD buffer is further split into two pieces each of which corresponds to a quarter of the major frame. Each piece has the one of the two following forms

```
Quarters 0 and 2
       A            B                        C                         D
[                |           |                              |                ]
 0          255 256     405 406                        1365 1366       1369

Quarters 1 and 3
       A            B                        C                         D
[                |           |                              |                ]
 1370      1625 1626   1775 1776                       2735 2736       2738
```

A = Theta / Phi data, 256 bytes = 128 words, uncompressed
B = PPA data, 150 bytes = 256 bytes re-binned to 120 words compressed with PSRL16-10
C = DDEIS data, 960 bytes = 768 words, compressed with PSRL16-10
D = 4 (quarters 0 and 2) or 3 (quarters 1 and 3) bytes of science housekeeping data

The SM buffer is 138 bytes long. It is divided into 5 pieces, a so called Fixed section and 4 Quarter sections. Each of the Quarter sections contains identically formatted, though distinct, data while the Fixed part contains information that is only required once per major frame.

TLMF.ALC_0. Allocation of Hydra's Words in the Polar Telemetry Matrix

	12	17	20	28	36	52	60	68	76	84	92	100	108	116	124	132	140	148	156	164	172	180	188	198
mf # 1		nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh	nh
mf # 2		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 3		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 4		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 5		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 6		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 7		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 8		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 9		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 10		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 11		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 12		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf # 13		sh	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	pp	pp	pp	pp	pp	pp	pp	pp
mf # 14		sh	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf # 15		sh	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf # 16		sh	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf # 17		sh	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf # 18		sh	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf # 19		sh	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf # 20		sh	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 21		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 22		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 23		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 24		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 25		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 26	eh	sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 27		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 28		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 29		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 30		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 31		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 32	eh	sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 33		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 34		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 35		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 36		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 37		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 38	eh	sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 39		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 40		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 41		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf # 42		sh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
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mf #198		tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf #199		tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp	tp
mf #200	eh	tp	tp	tp	tp	tp	tp	tp	tp	tp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf #201		pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf #202		pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf #203		pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf #204		pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf #205		pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf #206	eh	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp	pp
mf #207		pp	pp	pp	pp	pp	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #208		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #209		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #210		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd

mf #211		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #212	eh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #213		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #214		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #215		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #216		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #217		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #218	eh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #219		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #220		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #221		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #222		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #223		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #224	eh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #225		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #226		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #227		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #228		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #229		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #230	eh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #231		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #232		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #233		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #234		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #235		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #236	eh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #237		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #238		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #239		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #240		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #241		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #242	eh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #243		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #244		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #245		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #246		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #247		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #248	eh	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #249		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd
mf #250		dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	dd	s3	s3	s3

The bytes have been allocated as follows:

eh	engineering housekeeping, assigned by UNH, 38 bytes
nh	science housekeeping, assigned by UNH, 23 bytes
sh	science housekeeping, also known as the "loose bytes" buffer, assigned by UCSD, 138 bytes
tp	theta/phi science data, assigned by UCSD, 1024 bytes
pp	ppa science data, assigned by UCSD, 600 bytes
dd	ddeis science data, assigned by UCSD, 3840 bytes
sn	n=0-3, science housekeeping associated with each quarter of the science data buffer, assigned by UCSD, 14 bytes

TLMF.MFOFST_0. Minor Frame Offset List

The following is a cheat sheet to help programmers locate bytes within the Hydra telemetry display.

minor frame #		dec	hex		
mf # 1	starting offset =	0	0000		17 20-198
mf # 2	starting offset =	23	0017		17 20-198
mf # 3	starting offset =	46	002E		17 20-198
mf # 4	starting offset =	69	0045		17 20-198
mf # 5	starting offset =	92	005C		17 20-198
mf # 6	starting offset =	115	0073		17 20-198
mf # 7	starting offset =	138	008A		17 20-198
mf # 8	starting offset =	161	00A1		17 20-198
mf # 9	starting offset =	184	00B8		17 20-198
mf # 10	starting offset =	207	00CF		17 20-198
mf # 11	starting offset =	230	00E6		17 20-198
mf # 12	starting offset =	253	00FD		17 20-198
mf # 13	starting offset =	276	0114		17 20-198
mf # 14	starting offset =	299	012B		17 20-198
mf # 15	starting offset =	322	0142		17 20-198
mf # 16	starting offset =	345	0159		17 20-198
mf # 17	starting offset =	368	0170		17 20-198
mf # 18	starting offset =	391	0187		17 20-198
mf # 19	starting offset =	414	019E		17 20-198
mf # 20	starting offset =	437	01B5		17 20-198
mf # 21	starting offset =	460	01CC		17 20-198
mf # 22	starting offset =	483	01E3		17 20-198
mf # 23	starting offset =	506	01FA		17 20-198
mf # 24	starting offset =	529	0211		17 20-198
mf # 25	starting offset =	552	0228		17 20-198
mf # 26	starting offset =	575	023F	12	17 20-198
mf # 27	starting offset =	599	0257		17 20-198
mf # 28	starting offset =	622	026E		17 20-198
mf # 29	starting offset =	645	0285		17 20-198
mf # 30	starting offset =	668	029C		17 20-198
mf # 31	starting offset =	691	02B3		17 20-198
mf # 32	starting offset =	714	02CA	12	17 20-198
mf # 33	starting offset =	738	02E2		17 20-198
mf # 34	starting offset =	761	02F9		17 20-198
mf # 35	starting offset =	784	0310		17 20-198
mf # 36	starting offset =	807	0327		17 20-198
mf # 37	starting offset =	830	033E		17 20-198
mf # 38	starting offset =	853	0355	12	17 20-198
mf # 39	starting offset =	877	036D		17 20-198
mf # 40	starting offset =	900	0384		17 20-198
mf # 41	starting offset =	923	039B		17 20-198
mf # 42	starting offset =	946	03B2		17 20-198
mf # 43	starting offset =	969	03C9		17 20-198
mf # 44	starting offset =	992	03E0	12	17 20-198
mf # 45	starting offset =	1016	03F8		17 20-198
mf # 46	starting offset =	1039	040F		17 20-198

mf # 47	starting offset = 1062	0426		17	20-198
mf # 48	starting offset = 1085	043D		17	20-198
mf # 49	starting offset = 1108	0454		17	20-198
mf # 50	starting offset = 1131	046B	12	17	20-198
mf # 51	starting offset = 1155	0483		17	20-198
mf # 52	starting offset = 1178	049A		17	20-198
mf # 53	starting offset = 1201	04B1		17	20-198
mf # 54	starting offset = 1224	04C8		17	20-198
mf # 55	starting offset = 1247	04DF		17	20-198
mf # 56	starting offset = 1270	04F6	12	17	20-198
mf # 57	starting offset = 1294	050E		17	20-198
mf # 58	starting offset = 1317	0525		17	20-198
mf # 59	starting offset = 1340	053C		17	20-198
mf # 60	starting offset = 1363	0553		17	20-198
mf # 61	starting offset = 1386	056A		17	20-198
mf # 62	starting offset = 1409	0581	12	17	20-198
mf # 63	starting offset = 1433	0599		17	20-198
mf # 64	starting offset = 1456	05B0		17	20-198
mf # 65	starting offset = 1479	05C7		17	20-198
mf # 66	starting offset = 1502	05DE		17	20-198
mf # 67	starting offset = 1525	05F5		17	20-198
mf # 68	starting offset = 1548	060C	12	17	20-198
mf # 69	starting offset = 1572	0624		17	20-198
mf # 70	starting offset = 1595	063B		17	20-198
mf # 71	starting offset = 1618	0652		17	20-198
mf # 72	starting offset = 1641	0669		17	20-198
mf # 73	starting offset = 1664	0680		17	20-198
mf # 74	starting offset = 1687	0697	12	17	20-198
mf # 75	starting offset = 1711	06AF		17	20-198
mf # 76	starting offset = 1734	06C6		17	20-198
mf # 77	starting offset = 1757	06DD		17	20-198
mf # 78	starting offset = 1780	06F4		17	20-198
mf # 79	starting offset = 1803	070B		17	20-198
mf # 80	starting offset = 1826	0722	12	17	20-198
mf # 81	starting offset = 1850	073A		17	20-198
mf # 82	starting offset = 1873	0751		17	20-198
mf # 83	starting offset = 1896	0768		17	20-198
mf # 84	starting offset = 1919	077F		17	20-198
mf # 85	starting offset = 1942	0796		17	20-198
mf # 86	starting offset = 1965	07AD	12	17	20-198
mf # 87	starting offset = 1989	07C5		17	20-198
mf # 88	starting offset = 2012	07DC		17	20-198
mf # 89	starting offset = 2035	07F3		17	20-198
mf # 90	starting offset = 2058	080A		17	20-198
mf # 91	starting offset = 2081	0821		17	20-198
mf # 92	starting offset = 2104	0838	12	17	20-198
mf # 93	starting offset = 2128	0850		17	20-198
mf # 94	starting offset = 2151	0867		17	20-198
mf # 95	starting offset = 2174	087E		17	20-198
mf # 96	starting offset = 2197	0895		17	20-198
mf # 97	starting offset = 2220	08AC		17	20-198
mf # 98	starting offset = 2243	08C3	12	17	20-198
mf # 99	starting offset = 2267	08DB		17	20-198
mf #100	starting offset = 2290	08F2		17	20-198

mf #101	starting offset = 2313	0909	17	20-198
mf #102	starting offset = 2336	0920	17	20-198
mf #103	starting offset = 2359	0937	17	20-198
mf #104	starting offset = 2382	094E	12 17	20-198
mf #105	starting offset = 2406	0966	17	20-198
mf #106	starting offset = 2429	097D	17	20-198
mf #107	starting offset = 2452	0994	17	20-198
mf #108	starting offset = 2475	09AB	17	20-198
mf #109	starting offset = 2498	09C2	17	20-198
mf #110	starting offset = 2521	09D9	12 17	20-198
mf #111	starting offset = 2545	09F1	17	20-198
mf #112	starting offset = 2568	0A08	17	20-198
mf #113	starting offset = 2591	0A1F	17	20-198
mf #114	starting offset = 2614	0A36	17	20-198
mf #115	starting offset = 2637	0A4D	17	20-198
mf #116	starting offset = 2660	0A64	12 17	20-198
mf #117	starting offset = 2684	0A7C	17	20-198
mf #118	starting offset = 2707	0A93	17	20-198
mf #119	starting offset = 2730	0AAA	17	20-198
mf #120	starting offset = 2753	0AC1	17	20-198
mf #121	starting offset = 2776	0AD8	17	20-198
mf #122	starting offset = 2799	0AEF	12 17	20-198
mf #123	starting offset = 2823	0B07	17	20-198
mf #124	starting offset = 2846	0B1E	17	20-198
mf #125	starting offset = 2869	0B35	17	20-198
mf #126	starting offset = 2892	0B4C	17	20-198
mf #127	starting offset = 2915	0B63	17	20-198
mf #128	starting offset = 2938	0B7A	12 17	20-198
mf #129	starting offset = 2962	0B92	17	20-198
mf #130	starting offset = 2985	0BA9	17	20-198
mf #131	starting offset = 3008	0BC0	17	20-198
mf #132	starting offset = 3031	0BD7	17	20-198
mf #133	starting offset = 3054	0BEE	17	20-198
mf #134	starting offset = 3077	0C05	12 17	20-198
mf #135	starting offset = 3101	0C1D	17	20-198
mf #136	starting offset = 3124	0C34	17	20-198
mf #137	starting offset = 3147	0C4B	17	20-198
mf #138	starting offset = 3170	0C62	17	20-198
mf #139	starting offset = 3193	0C79	17	20-198
mf #140	starting offset = 3216	0C90	12	20-198
mf #141	starting offset = 3239	0CA7		20-198
mf #142	starting offset = 3261	0CBD		20-198
mf #143	starting offset = 3283	0CD3		20-198
mf #144	starting offset = 3305	0CE9		20-198
mf #145	starting offset = 3327	0CFF		20-198
mf #146	starting offset = 3349	0D15	12	20-198
mf #147	starting offset = 3372	0D2C		20-198
mf #148	starting offset = 3394	0D42		20-198
mf #149	starting offset = 3416	0D58		20-198
mf #150	starting offset = 3438	0D6E		20-198
mf #151	starting offset = 3460	0D84		20-198
mf #152	starting offset = 3482	0D9A	12	20-198
mf #153	starting offset = 3505	0DB1		20-198
mf #154	starting offset = 3527	0DC7		20-198

mf #155	starting offset = 3549	0DDD		20-198
mf #156	starting offset = 3571	0DF3		20-198
mf #157	starting offset = 3593	0E09		20-198
mf #158	starting offset = 3615	0E1F	12	20-198
mf #159	starting offset = 3638	0E36		20-198
mf #160	starting offset = 3660	0E4C		20-198
mf #161	starting offset = 3682	0E62		20-198
mf #162	starting offset = 3704	0E78		20-198
mf #163	starting offset = 3726	0E8E		20-198
mf #164	starting offset = 3748	0EA4	12	20-198
mf #165	starting offset = 3771	0EBB		20-198
mf #166	starting offset = 3793	0ED1		20-198
mf #167	starting offset = 3815	0EE7		20-198
mf #168	starting offset = 3837	0EFD		20-198
mf #169	starting offset = 3859	0F13		20-198
mf #170	starting offset = 3881	0F29	12	20-198
mf #171	starting offset = 3904	0F40		20-198
mf #172	starting offset = 3926	0F56		20-198
mf #173	starting offset = 3948	0F6C		20-198
mf #174	starting offset = 3970	0F82		20-198
mf #175	starting offset = 3992	0F98		20-198
mf #176	starting offset = 4014	0FAE	12	20-198
mf #177	starting offset = 4037	0FC5		20-198
mf #178	starting offset = 4059	0FDB		20-198
mf #179	starting offset = 4081	0FF1		20-198
mf #180	starting offset = 4103	1007		20-198
mf #181	starting offset = 4125	101D		20-198
mf #182	starting offset = 4147	1033	12	20-198
mf #183	starting offset = 4170	104A		20-198
mf #184	starting offset = 4192	1060		20-198
mf #185	starting offset = 4214	1076		20-198
mf #186	starting offset = 4236	108C		20-198
mf #187	starting offset = 4258	10A2		20-198
mf #188	starting offset = 4280	10B8	12	20-198
mf #189	starting offset = 4303	10CF		20-198
mf #190	starting offset = 4325	10E5		20-198
mf #191	starting offset = 4347	10FB		20-198
mf #192	starting offset = 4369	1111		20-198
mf #193	starting offset = 4391	1127		20-198
mf #194	starting offset = 4413	113D	12	20-198
mf #195	starting offset = 4436	1154		20-198
mf #196	starting offset = 4458	116A		20-198
mf #197	starting offset = 4480	1180		20-198
mf #198	starting offset = 4502	1196		20-198
mf #199	starting offset = 4524	11AC		20-198
mf #200	starting offset = 4546	11C2	12	20-198
mf #201	starting offset = 4569	11D9		20-198
mf #202	starting offset = 4591	11EF		20-198
mf #203	starting offset = 4613	1205		20-198
mf #204	starting offset = 4635	121B		20-198
mf #205	starting offset = 4657	1231		20-198
mf #206	starting offset = 4679	1247	12	20-198
mf #207	starting offset = 4702	125E		20-198
mf #208	starting offset = 4724	1274		20-198

mf #209	starting offset = 4746	128A		20-198
mf #210	starting offset = 4768	12A0		20-198
mf #211	starting offset = 4790	12B6		20-198
mf #212	starting offset = 4812	12CC	12	20-198
mf #213	starting offset = 4835	12E3		20-198
mf #214	starting offset = 4857	12F9		20-198
mf #215	starting offset = 4879	130F		20-198
mf #216	starting offset = 4901	1325		20-198
mf #217	starting offset = 4923	133B		20-198
mf #218	starting offset = 4945	1351	12	20-198
mf #219	starting offset = 4968	1368		20-198
mf #220	starting offset = 4990	137E		20-198
mf #221	starting offset = 5012	1394		20-198
mf #222	starting offset = 5034	13AA		20-198
mf #223	starting offset = 5056	13C0		20-198
mf #224	starting offset = 5078	13D6	12	20-198
mf #225	starting offset = 5101	13ED		20-198
mf #226	starting offset = 5123	1403		20-198
mf #227	starting offset = 5145	1419		20-198
mf #228	starting offset = 5167	142F		20-198
mf #229	starting offset = 5189	1445		20-198
mf #230	starting offset = 5211	145B	12	20-198
mf #231	starting offset = 5234	1472		20-198
mf #232	starting offset = 5256	1488		20-198
mf #233	starting offset = 5278	149E		20-198
mf #234	starting offset = 5300	14B4		20-198
mf #235	starting offset = 5322	14CA		20-198
mf #236	starting offset = 5344	14E0	12	20-198
mf #237	starting offset = 5367	14F7		20-198
mf #238	starting offset = 5389	150D		20-198
mf #239	starting offset = 5411	1523		20-198
mf #240	starting offset = 5433	1539		20-198
mf #241	starting offset = 5455	154F		20-198
mf #242	starting offset = 5477	1565	12	20-198
mf #243	starting offset = 5500	157C		20-198
mf #244	starting offset = 5522	1592		20-198
mf #245	starting offset = 5544	15A8		20-198
mf #246	starting offset = 5566	15BE		20-198
mf #247	starting offset = 5588	15D4		20-198
mf #248	starting offset = 5610	15EA	12	20-198
mf #249	starting offset = 5633	1601		20-198
mf #250	starting offset = 5655	1617		20-198

TLMF.TLMDD_0. The DDEIS Data Buffer

This is a description of a single DDEIS data buffer from the Hydra Mode 0 telemetry. There are 4 of these buffers per major frame. There are 960 bytes per buffer, representing 768 16-bit words of DDEIS data.

Each set of 5 bytes represents 4 compressed 16-Bit words. Each word uses 10 bits, derived from the 16-10 Psuedo-Root with Linear Segment compression algorithm. The following diagram shows which bits of each byte to use for each word.

```
     Byte#          4        3        2        1        0
                33333333 33222222 22221111 11111100 00000000
```

Each set of 5 bytes is referred to here as a "compression set" since for the purposes of deconstruction the 5 bytes are turned into 4 words.

```
 Offset
    0    Words      0-3, Compression Set  0, Byte 0
    1    Words      0-3, Compression Set  0, Byte 1
    2    Words      0-3, Compression Set  0, Byte 2
    3    Words      0-3, Compression Set  0, Byte 3
    4    Words      0-3, Compression Set  0, Byte 4
    5    Words      4-7, Compression Set  1, Byte 0
    6    Words      4-7, Compression Set  1, Byte 1
    7    Words      4-7, Compression Set  1, Byte 2
    8    Words      4-7, Compression Set  1, Byte 3
    9    Words      4-7, Compression Set  1, Byte 4
   10    Words     8-11, Compression Set  2, Byte 0
   11    Words     8-11, Compression Set  2, Byte 1
   12    Words     8-11, Compression Set  2, Byte 2
   13    Words     8-11, Compression Set  2, Byte 3
   14    Words     8-11, Compression Set  2, Byte 4
                          .
                          .
                          .
    F    Words 4*N to 3+4*N, Compression Set N, Byte F-5*N
 where   F = Offset, (0 <= F <= 959)
         N = INT(F/5), (0 <= N <= 191)
                          .
                          .
                          .
  945    Words 756-759, Compression Set 189, Byte 0
  946    Words 756-759, Compression Set 189, Byte 1
  947    Words 756-759, Compression Set 189, Byte 2
  948    Words 756-759, Compression Set 189, Byte 3
  949    Words 756-759, Compression Set 189, Byte 4
  950    Words 760-763, Compression Set 190, Byte 0
  951    Words 760-763, Compression Set 190, Byte 1
  952    Words 760-763, Compression Set 190, Byte 2
  953    Words 760-763, Compression Set 190, Byte 3
  954    Words 760-763, Compression Set 190, Byte 4
  955    Words 764-767, Compression Set 191, Byte 0
```

956 Words 764-767, Compression Set 191, Byte 1
957 Words 764-767, Compression Set 191, Byte 2
958 Words 764-767, Compression Set 191, Byte 3
959 Words 764-767, Compression Set 191, Byte 4

TLMF.TLMPP_0. The PPA Data Buffer

This is a description of a single PPA data buffer from the Hydra Mode 0 telemetry. There are 4 of these buffers per major frame. There are 150 bytes per buffer, representing 120 16-bit words of PPA data. These 120 words are the 120 Bins of PPA data representing 0-180 degrees produced by the TLM0 Task.

Each set of 5 bytes represents 4 compressed 16-Bit words. Each word uses 10 bits, derived from the 16-10 Psuedo-Root with Linear Segment compression algorithm. The following diagram shows which bits of each byte to use for each word.

```
     Byte#            4        3        2        1        0
                  33333333 33222222 22221111 11111100 00000000
```

Each set of 5 bytes is referred to here as a "compression set" since for the purposes of deconstruction the 5 bytes are turned into 4 words.

```
 Offset
    0     Bins     0-3, Compression Set  0, Byte 0
    1     Bins     0-3, Compression Set  0, Byte 1
    2     Bins     0-3, Compression Set  0, Byte 2
    3     Bins     0-3, Compression Set  0, Byte 3
    4     Bins     0-3, Compression Set  0, Byte 4
    5     Bins     4-7, Compression Set  1, Byte 0
    6     Bins     4-7, Compression Set  1, Byte 1
    7     Bins     4-7, Compression Set  1, Byte 2
    8     Bins     4-7, Compression Set  1, Byte 3
    9     Bins     4-7, Compression Set  1, Byte 4
   10     Bins    8-11, Compression Set  2, Byte 0
   11     Bins    8-11, Compression Set  2, Byte 1
   12     Bins    8-11, Compression Set  2, Byte 2
   13     Bins    8-11, Compression Set  2, Byte 3
   14     Bins    8-11, Compression Set  2, Byte 4
                        .
                        .
                        .
    F     Bins 4*N to 3+4*N, Compression Set N, Byte F-5*N
where    F = Offset, (0 <= F <= 149)
         N = INT(F/5), (0 <= N <= 29)
                        .
                        .
                        .
  135     Bins 108-111, Compression Set 27, Byte 0
  136     Bins 108-111, Compression Set 27, Byte 1
  137     Bins 108-111, Compression Set 27, Byte 2
  138     Bins 108-111, Compression Set 27, Byte 3
  139     Bins 108-111, Compression Set 27, Byte 4
  140     Bins 112-115, Compression Set 28, Byte 0
  141     Bins 112-115, Compression Set 28, Byte 1
  142     Bins 112-115, Compression Set 28, Byte 2
  143     Bins 112-115, Compression Set 28, Byte 3
  144     Bins 112-115, Compression Set 28, Byte 4
```

145 Bins 116-119, Compression Set 29, Byte 0
146 Bins 116-119, Compression Set 29, Byte 1
147 Bins 116-119, Compression Set 29, Byte 2
148 Bins 116-119, Compression Set 29, Byte 3
149 Bins 116-119, Compression Set 29, Byte 4

TLMF.TLMTP_0. The Theta-Phi Buffer

This is a description of a single theta/phi buffer from the Hydra Mode 0 telemetry. There are 4 of these buffers per major frame, with 128 16-bit words per buffer.

```
 Offset  Description
    0     Theta/Phi word#  0 LSB
    1     Theta/Phi word#  0 MSB
    2     Theta/Phi word#  1 LSB
    3     Theta/Phi word#  1 MSB
    4     Theta/Phi word#  2 LSB
    5     Theta/Phi word#  2 MSB
                  .
                  .
                  .
    F     Theta/Phi word#  N LSB
    F     Theta/Phi word#  N MSB
where    F = Offset, (0 <= F <= 255)
         N = INT(F/2), (0 <= N <= 127)
                  .
                  .
                  .
  250     Theta/Phi word#125 LSB
  251     Theta/Phi word#125 MSB
  252     Theta/Phi word#126 LSB
  253     Theta/Phi word#126 MSB
  254     Theta/Phi word#127 LSB
  255     Theta/Phi word#127 MSB
```

TLMF.TLMSN_2. Quarterly Science Housekeeping Bytes

This is a description of the the Science Housekeeping bytes allocated by UCSD that are associated with each quarter of the science data buffer. They are designated sn in the master telemetry list.

Name	Byte#	Description
s0	0	Error Flags, Scale Bits for this quarter
s0	1	HV value of PPA data in this quarter
s0	2	Not Used
s0	3	Not Used
s1	0	Error Flags, Scale Bits for this quarter
s1	1	HV value of PPA data in this quarter
s1	2	Not Used
s2	0	Error Flags, Scale Bits for this quarter
s2	1	HV value of PPA data in this quarter
s2	2	Not Used
s2	3	Not Used
s3	0	Error Flags, Scale Bits for this quarter
s3	1	HV value of PPA data in this quarter
s3	2	Not Used

Modes 0-1:

Byte 0	bits	0-3	magnetometer scale
	bit	4	PPAOV2

Mode 2:

Byte 0	bits	0-3	magnetometer scale
	bit	4	PPAOV2
	bit	5	Flag to indicate an external command occurred for a new DDEIS descriptor
	bit	6	Flag to indicate an external command occurred for a new PPA descriptor

TLMF.TLMLB_3. Science Housekeeping Loose Bytes

This is a description of the the Science Housekeeping bytes allocated by UCSD. They are also called the "loose bytes" telemetry, but UCSD does not use the first of the true loose bytes (those bytes occurring at word 17 in the telemetry list) as UNH has a use for it. These offsets are therefore relative to the UCSD buffer only.

MODIFICATIONS:

```
12-02-91  1:14:50 pm rdb: added ddeis hv dump and re-arranged everything else.
12-16-91  2:20:56 pm rdb: added 2 byte mode number at offset 136
 4-01-92  1:34:52 pm rdb: changed name of init_mjf_mod8 to synch_mjf to
                          correspond to changes made in code.
 7-20-92              rwf: added explanatory footnotes 5-7.  Clarified note 2
                          and items 80-83.
 7-21-93              rdb:
 10-20-93             rdb and rwf: Change to ModeTwo assignments
 10-21-94             rdb and rwf: Change to ModeThree assignments
 08-21-96             rdb and rwf: Correct footnote 1
 09-27-96             rdb and rwf: Add item 66, pha match count
```

	Offset	Description
*	0	DDEIS High Voltage Setting #j+0
	1	DDEIS High Voltage Setting #j+1
	2	DDEIS High Voltage Setting #j+2
	3	DDEIS High Voltage Setting #j+3
	4	DDEIS High Voltage Setting #j+4
	5	DDEIS High Voltage Setting #j+5
	6	DDEIS High Voltage Setting #j+6
	7	DDEIS High Voltage Setting #j+7
	8	DDEIS HV table index of last electron peak
	9	DDEIS HV table index of last ion peak
	10	DDEIS HV control byte of last electron peak
	11	DDEIS HV control byte of last ion peak
	12	Side 2 PHA accumulator counts from previous MJF, byte 0
	13	Side 2 PHA accumulator counts from previous MJF, byte 1
	14	Side 2 PHA accumulator counts from previous MJF, byte 2
	15	PHA HV control byte
*5	16	LSB of BCI Count at Start of PPA Accum == pp_bcicnt
	17	DDEIS High Voltage Setting #j+8
	18	DDEIS High Voltage Setting #j+9
	19	DDEIS High Voltage Setting #j+10
	20	DDEIS High Voltage Setting #j+11
	21	DDEIS High Voltage Setting #j+12
	22	DDEIS High Voltage Setting #j+13
	23	DDEIS High Voltage Setting #j+14
	24	DDEIS High Voltage Setting #j+15
	25	DDEIS HV table index of last electron peak
	26	DDEIS HV table index of last ion peak
	27	DDEIS HV control byte of last electron peak
	28	DDEIS HV control byte of last ion peak
	29	Side 1 duty accumulator counts from previous MJF, byte 0
	30	Side 1 duty accumulator counts from previous MJF, byte 1
	31	Side 1 duty accumulator counts from previous MJF, byte 2

	32	PHA discriminator setting
*5	33	LSB of BCI Count at Start of PPA Accum == pp_bcicnt
	34	DDEIS High Voltage Setting #j+16
	35	DDEIS High Voltage Setting #j+17
	36	DDEIS High Voltage Setting #j+18
	37	DDEIS High Voltage Setting #j+19
	38	DDEIS High Voltage Setting #j+20
	39	DDEIS High Voltage Setting #j+21
	40	DDEIS High Voltage Setting #j+22
	41	DDEIS High Voltage Setting #j+23
	42	DDEIS HV table index of last electron peak
	43	DDEIS HV table index of last ion peak
	44	DDEIS HV control byte of last electron peak
	45	DDEIS HV control byte of last ion peak
	46	Side 2 duty accumulator counts from previous MJF, byte 0
	47	Side 2 duty accumulator counts from previous MJF, byte 1
	48	Side 2 duty accumulator counts from previous MJF, byte 2
	49	PHA CEM MUX or-byte for current MJF
*5	50	LSB of BCI Count at Start of PPA Accum == pp_bcicnt
	51	DDEIS High Voltage Setting #j+24
	52	DDEIS High Voltage Setting #j+25
	53	DDEIS High Voltage Setting #j+26
	54	DDEIS High Voltage Setting #j+27
	55	DDEIS High Voltage Setting #j+28
	56	DDEIS High Voltage Setting #j+29
	57	DDEIS High Voltage Setting #j+30
	58	DDEIS High Voltage Setting #j+31
	59	DDEIS HV table index of last electron peak
	60	DDEIS HV table index of last ion peak
	61	DDEIS HV control byte of last electron peak
	62	DDEIS HV control byte of last ion peak
	63	Side 1 PHA accumulator counts from current MJF, byte 0
	64	Side 1 PHA accumulator counts from current MJF, byte 1
	65	Side 1 PHA accumulator counts from current MJF, byte 2
	66	PHA match count for current MJF
*5	67	LSB of BCI Count at Start of PPA Accum == pp_bcicnt
	68	MJFTIM mS LSB
	69	MJFTIM mS MSB
*6	70	MJFTIM (Spacecraft Universal Time Code, UTC) LSB
*6	71	MJFTIM (Spacecraft Universal Time Code, UTC) NLSB
*6	72	MJFTIM (Spacecraft Universal Time Code, UTC) NMSB
*6	73	MJFTIM (Spacecraft Universal Time Code, UTC) MSB
	74	DUNTIM Time == Offset Sun Time mS LSB
	75	DUNTIM Time == Offset Sun Time mS MSB
*6	76	DUNTIM (Spacecraft Universal Time Code, UTC) LSB
*6	77	DUNTIM (Spacecraft Universal Time Code, UTC) NLSB
*7	78	DDSCAN First Descriptor Number of Current DDEIS Cycle
*7	79	DDSCAN Last Descriptor Number of Previous DDEIS Cycle
	80	MRCD_num (Most Recently Commanded DDEIS Descriptor, numbered 0-7)
	81	PPMRCD_num (Most Recently Commanded PPA Descriptor, numbered 0-3)
	82	synch_mjf (LSB of mjf_cnt of next resynchronization)
	83	synch_mjf (MSB of mjf_cnt of next resynchronization)
	84	BCI Control Register LSB
	85	BCI Control Register MSB

	86	ET2 (PPA) Control Register LSB
	87	ET2 (PPA) Control Register MSB
	88	DDEIS Descriptor Byte 0
	89	DDEIS Descriptor Byte 1
	90	DDEIS Descriptor Byte 2
	91	DDEIS Descriptor Byte 3
	92	DDEIS Descriptor Byte 4
	93	DDEIS Descriptor Byte 5
	94	DDEIS Descriptor Byte 6
	95	DDEIS Descriptor Byte 7
	96	DDEIS Descriptor Byte 8
	97	DDEIS Descriptor Byte 9
	98	DDEIS Descriptor Byte 10
	99	DDEIS Descriptor Byte 11
	100	DDEIS Descriptor Byte 12
	101	PPA Descriptor Byte 0
	102	PPA Descriptor Byte 1
	103	PPA Descriptor Byte 2
	104	PPA Descriptor Byte 3
	105	PPA Descriptor Byte 4
	106	PPA Descriptor Byte 5
	107	PPA Descriptor Byte 6
	108	PPA Descriptor Byte 7
	109	PPA Descriptor Byte 8
	110	PPA Descriptor Byte 9
	111	PPA Descriptor Byte 10
	112	PPA Descriptor Byte 11
	113	PPA Descriptor Byte 12 (null byte)
*2	114	Number of the DDEIS Descriptor being dumped this MJF (see 88-113)
*3	115	Memory Dump Byte #k
*4	116	Scheduler Table Entry #n LSB
	117	Scheduler Table Entry #n MSB
	118	Status Table Entry #n LSB
	119	Status Table Entry #n MSB
	120	Address Table Entry #n LSB
	121	Address Table Entry #n NLSB
	122	Address Table Entry #n NMSB
	123	Address Table Entry #n MSB
	124	Stack Pointer Table Entry #n LSB
	125	Stack Pointer Table Entry #n NLSB
	126	Stack Pointer Table Entry #n NMSB
	127	Stack Pointer Table Entry #n MSB
	128	Error Table Entry #n 1 Byte only
*6	129	DDCYCTIM DD Scan Offset Cycle Start Time mS LSB
*6	130	DDCYCTIM DD Scan Offset Cycle Start Time mS MSB
*6	131	DDCYCTIM (Spacecraft Universal Time Code, UTC) LSB
*6	132	DDCYCTIM (Spacecraft Universal Time Code, UTC) NLSB
	133	MJF MSB
*8	134	DDEIS deflection voltage lookup table byte dump
*9	135	HV A/D readback
	136	Mode Number, LSB
	137	Mode Number, MSB

*1 Note that j = 0, 32, 64, 96, 128, 160, 192, 224 and then repeats. These values are offsets into dd_hv_array, the array of ddeis hv values saved by ddscan.
For the default descriptors, the 32 values represent one-eighth of a Major Frame. The hv values are saved in the format used by the ddeis hv DAC.

*2 Expect 0-127. Note this is different from ModeZero.
PPA descr. # = (DDEIS descr. #) mod 32 (Expect 0-31)

*3 Note that k = 0, 1, 2,..., 8176 and then repeats, since the memory dump is only of 8Kb of ROM.

*4 Note that n cycles from 0 to 15, since that is the number of entries in the task tables.

*5 Expect values of 128, 0, 128, 0 for pp_bcicnt

*6 See S175_2.5.0. thru S175_2.5.3. for description of timing and reference marks.

*7 Each time a new DDEIS offset cycle begins, the present and previous descriptor numbers are written to memory. These numbers are read out to telemetry once per MJF. With the timing mark, DDCYCTIM, given in words 129-132 and referred to in S175_2.5.1., this creates a timing reference in the scan sequence.

*8 The DDEIS deflection voltage lookup table is read out one byte per MJF. The identity of the byte is given by the LSB of the major frame counter in the UNH portion of the telemetry format.

*9 Must be decoded using the 3 lsb's of the MJF. When bit 2 (using the convention that bit 0 is lsb) of the MJF is 0, the byte is from DD; when 1, it is from PP. Low 2 bits of MJF indicate position of tlm byte 135 in the 4 byte value, with 0 being the lsbyte, 3 the msbyte. See HVMON_3.4.FID.

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