PCA Housekeeping - Status, Use, Screen Functions, Recall Modes, SOC Interface

XTE-PCA Software Module

PCA-HK-EXP-V6.1

Build 4.5.3

Version 6.1

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by

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Foreword

The PCA science group are responsible for providing to the SOC an agreed set of software products together with their associated documentation and test data/results. Such deliveries are governed by the details to be found in the PCA IAD and ICD documents.

In order to facilitate the production of this code and documentation a series of documents have been produced that are intended to contain as much relevant and accurate information as is available that pertains to the title and subject matter of each delivery item. This document should also present and explain the concepts and plans for the use the supplied information.

This document is concerned with the topic of PCA HOUSEKEEPING which encompasses the following areas:

- Parameter Text Screens
- Graphics parameter selection
- Packet decoding
- Limits & conversion

The PCA group will also produce additional software for its own use, in its own external environment. This software will also be provided to the SOC but is not governed by such rigorous product assurance requirements although it also requires documentation.

This document is a detailed reference for the PCA Housekeeping system from a scientific point of view. It is not intended to be in any sense a user manual. Full details on how to use the many options and features available within the PCA Housekeeping program can be found in the user manual. There is also an accompanying program design manual.

Table of Contents

APPENDIX

1.0 Introduction

The PCA team at GSFC is required to deliver a number of software modules to the Science Operations Center (SOC) for the XTE mission. This document attempts to examine and pull together all the aspects relating to the development of the software for the display of the returned PCA housekeeping data. Various screen layouts are also suggested.

1.1 Document History

Earlier releases of this document are tabulated below:

Version No.	Date
1.0	3 / 16 / 93
2.0	10 / 5 / 93
3.0	1 / 30 / 94
3.1	5 / 26 / 94
4.0	6 / 24 / 94
5.0	8 / 21 / 94
6.0	8 / 9 / 95
6.1	this version

1.2 Document Organization

Section 2 - describes the basic organization and identification of CCSDS packets for the PCA housekeeping/status data

Section 3 - summarizes the detailed structure for the 5 different sections of data that make up each packet

Section 4 - describes the spacecraft items that are required for this subsystem

Section 5 - examines the conversion factors that are required to turn some of these binary words into real physical units

Section 6 - details the physical limits, where appropriate, to these data values. Red and yellow limits are provided

Section 7 - outlines the suggested screen displays and functions. and the hierarchy of the housekeeping data

Section 8 - describes various “standard” texts screen display formats

Section 9 - describes various forms of “standard” graphics screen display modes

Section 10 - outlines testing plans using the housekeeping simulator program

Section 11 - outlines some operation and performance checking details

Section 12 - outlines a simple development plan

Section 13 - summary of PCU parameters

Section 14 - final HV command values

Section 15 - final measured VLE window values

Section 16 - detector temperature thermistor look-up table

Section 17 - final PCU address / serial No relationship

Section 18 - details unresolved issues

1.3 Relevant Documents

Specific PCA Documents:-=

PCA Housekeeping Text and Graphics Display Screens: Design, PCA-HK-DES-V4.5, Vikram Savkoor, November 15, 1995

PCA Housekeeping Text and Graphics Display Screens: Users Guide, PCA-HK-MAN-V4.5, Vikram Savkoor, October 15, 1995

PCA Housekeeping Telemetry Simulator for PCA and SOC Software Testing, PCA-SIM-MAN-V4.0, Barry Giles & Vikram Savkoor, June 8th 1994

General PCA Documents:-

Software Product Assurance Plan between the XTE Science Operation Center and the PCA Principal Investigator Team - Aileen Tousignant & Barry Giles, PCA team, February 12, 1993.

Interface Control Document for the PCA Command, Telemetry and Monitoring between the XTE Science Operation Center and the PCA Principal Investigator Team. XTE-SOC-PCA-ICD-V1.0, Rahim Choudhary et al., March, 1994

PCA Commands - Types, Sequences, Use, Configurations, Screen Functions, Verification, SOC interface., PCA-COM-EXP-V6.0, Barry Giles, December 5, 1995

PCA Calibration - General Activities & Procedures, Types, Algorithms, Response matrix, SOC interface., PCA-CAL-EXP-V1.0, Barry Giles, June 4, 1993

XTE Instrument Operation Users Guide, Version 1.0, May 1995

General SOC Documents:-

Software Development Standards - Leon Herreid, XTE SOC, November 16, 1992.

SOC Product Assurance Plan - Eunice Eng, XTE SOC, in preparation, 1993

XTE SOC Software Development Plan, SOC-STN-017, V0.2, September 7, 1993

2.0 Down-link CCSDS Packet Structure

The format of the housekeeping and status information returned from each detector in the PCA looks identical. The detector the packet refers to can be identified by the application ID (APid) number contained within the CCSDS packet header.

2.1 PCU Address & APid Number

The APid numbers for each PCU address slot are:

PCU Address	APid Number
1	90
2	91
3	92
4	93
5	94

2.2 CCSDS Packet Header

The details of the CCSDS packet header structure are shown below. It consists of a Primary Header that occupies the first 3 words (6 bytes) and a Secondary Header that contains the spacecraft (S/C) clock and occupies a further 4 words (8 bytes).

Word	Bits	Mnemonic	Contents
1	15 - 13	vernum	Version number
1	12	upordown	Type (0 for downlink)
1	11	secheader	Secondary header flsg (1 if present)
1	10 - 0	apidnumber	APid number
2	15 - 14	segflag	Segment flags (set to 11 as not used)
2	13 - 0	seqcount	Sequence count
3	15 - 0	packetlen	Packet length (135 decimal)
4	15 - 0	-	Upper 16 bits of S/C clock (sec)
5	15 - 0	SCclock	Lower 16 bits of S/C clock (sec)
6	15 - 0	-	Sub sec set to zero (not used)
7	15 - 0	-	Sub sec set to zero (not used)

- The sequence count is an incremental counter that records the order in which each packet APid is created. Each detector has an independent sequence

- The packet length is defined as the total length of the packet in bytes minus the length of the packet header (6 bytes) minus 1 byte

2.3 Spacecraft Clock Time (MET) In Packets

The definition of the time included in the CCSDS packet header is:

- The spacecraft clock field contains a 32 bit binary count of seconds since a defined Epoch. This clock time is referred to as Mission Elapsed Time (MET). The 32 bit sub seconds field will have non-zero real values which are constant. They are displayed by the program.
- The Epoch is the seconds since January 1st 1994. This is achieved on the spacecraft by jamming the clock to produce the required value since the clock itself starts from zero on S/C power up. This limited power up of S/C systems will occur some time just before launch

2.4 PCU Housekeeping CCSDS Packet Structure

Each detector produces exactly the same type of packet and the only way to differentiate between them is to examine the APid value in the packet header. The complete data structure for a PCU housekeeping packet is as follows:

Part	Contents	Sub address	Length words	Length bytes
1	CCSDS Header	-	7	14
2	8 rates used by HRM	16	16	32
3	6 rates NOT used by HRM	17	12	24
4	Command & Board Status	18	6	12
5	Analog values	19	20	40
6	Diagnostics	29	10	20
			Total:	142

2.5 Housekeeping Packet Sampling

The PCA experiment does not construct its own CCSDS packets as there are no micro-processors within the RIF boxes. The packets are constructed by the XTE CMDH subsystem software which interrogates each PCU RIF box at the appropriate time to get the parameter values it needs. The spacecraft will follow a fixed pattern of sampling for all routine PCA housekeeping. Most of the diagnostics information, although always present in the packets, is not meaningful unless specific attempts to drive the diagnostic mode are made. This is not a routine mode of operation and so is not described further here.

2.5.1 Packet Rate

The spacecraft software will produce a group of 5 housekeeping packets (one for each detector) every 8 seconds. The sampling is precisely defined using the 1 Hz pulse clock that is distributed to all PCU’s. Since there are no multiplexed or sub-multiplexed channels all data values will be updated at the same time on the ground every 8 seconds ignoring data gaps or downlink bursts following breaks in reception.

2.5.2 Parameter Sample Timing

There are a number of important timing constraints involved with the routine data sample sequencing.

- Once every 8 seconds the FDS sends to PCU #1 to #5 an all zero word to sub address #26 to request that all rates be latched at the next 1 Hertz timing signal edge. These commands must be sent at least 8 milliseconds before the next 1 Hertz pulse arrives
- For each of the PCU RIF’s the rates data (sub add #16 & #17) can then be read a minimum of 8 milliseconds after the following 1 Hertz signal but before 7 additional 1 Hertz signals i.e. none are missed.
- The commands to sub add #18 read fairly static status information
- The commands to sub address #19 to read the analog values for each RIF are made between 0.4 and 0.8 seconds after the rates are latched. These analog values (temperatures, voltages, pressures and high voltage values) are sampled at the moment they are read and are not latched at the preceding 1 Hz pulse edge
- The commands to sub add #29 read diagnostic information much of which is fairly static. When or if the diagnostics mode is being used seriously the scheme described here may not be followed
- The MET time stamps in all 5 PCU packets should be identical
- Although the spacecraft broadcast MET always refers to the time at the next 1 Hz edge the software used to construct PCA packets reads the current MET time

The following time plan illustrates the sampling strategy around a single 1 Hz pulse:

Time	Activity
-1.000	ignore 1 Hz edge
-0.328	send sub add #26 to all PCU’s (to latch on next 1 Hz)
0.000	next 1 Hz edge, all detector rates latched
0.328	idle
0.424	save MET & read PCU 1 sub add#16, 17, 18, 19, 29 & build packet
0.496	save MET & read PCU 2 sub add#16, 17, 18, 19, 29 & build packet
0.680	save MET & read PCU 3 sub add#16, 17, 18, 19, 29 & build packet
0.744	save MET & read PCU 4 sub add#16, 17, 18, 19, 29 & build packet
0.792	save MET & read PCU 5 sub add#16, 17, 18, 19, 29 & build packet
1.000	ignore 1 Hz edge

Within a packet:

- The time stamp refers to the end of the 8 second window
- Rates are integrations (8 second sums) over the preceding 8 second interval
- Analog values are instantaneous readings made just after the end of the 8 second window

2.5.3 Packet Timing (coincident PCA & EDS sampling)

The previous section described in detail what occurs close to a particular 1 Hz pulse every 8 seconds. This section describes how a decision is made as to which of the possible eight pulse to use for the latching and sampling process.

The MIT EDS samples the PCU data at 16 second intervals in its Standard Mode 2. The start and end of the 16 second windows are defined as the moment when a 1 Hz pulse causes the least significant 4 bits of the MET are all zero. In actual operation the EDS only reads and synchronizes with MET about once per orbit when it performs a quick reset of itself. For the rest of the orbit it simply counts the 1 Hz pulses and assumes that none are missed.

Two PCA 8 second windows fit exactly within one EDS 16 second one. The PCA intervals therefore begin and end when the least significant 3 bits of the MET are all zero. The following time plan illustrates the sampling strategy with respect to MET:

Spacecraft MET	Action	Packet MET
x 00 1110	idle	
x 00 1111	cmd latch on next 1 Hz	
x 01 0000	all PCU rates latched, MET’s saved, cmd read all PCU’s and build packets	x 01 0000
x 01 0001	idle	
x 01 0010	idle	
x 01 0011	idle	
x 01 0100	idle	
x 01 0101	idle	
x 01 0110	idle	
x 01 0111	cmd latch on next 1 Hz	
x 01 1000	all PCU rates latched, MET’s saved, cmd read all PCU’s and build packets	x 01 1000
x 01 1001	idle	
x 01 1010	idle	
x 01 1011	idle	
x 01 1100	idle	
x 01 1101	idle	
x 01 1110	idle	

Spacecraft MET	Action	Packet MET
x 01 1111	cmd latch on next 1 Hz	
x 10 0000	all PCU rates latched, MET's saved, cmd read all PCU's and build packets	x 10 0000
x 10 0001	idle	

All packet MET's should therefore be even and a multiple of 8.

2.5.4 Failed or Missing Packets

In normal operation with all 5 detectors working the FDS should return:

- Five packets every 8 seconds
- One packet for each detector
- Each packet has the same MET

A packet is always returned unless a detector is powered off by the spacecraft IPSDU system (there is no power to it at all).

The following possibilities exist for each individual detector:

Situation	Rates	Cmd & Status	Analog Data	Temps
Normal	Valid	Valid	Valid	Valid
HV low	All zero	Valid	Valid	Valid
HV off (+5)	All zero	Valid	Valid	Valid
HVPS off (+28)	All zero	Valid	Valid	Valid
LVPS off	All zero	Valid	Digital volts valid Analog volts invalid Det. pressures invalid Det. HV's invalid	Valid
PCU OFF	No Packets	-	-	-

2.6 Data Flow Monitor Functions

Since missing data or gaps in reception can be hard to monitor in real time two devices are available to help monitor these conditions:

- A graph of the MET for any PCU is discontinuous for missing packets
- A background task logs the work station clock time for each incoming PCU packet and produces a "No Data Arriving" check box if a time elapses greater than n*8 seconds (where n=2) since the previous packet. The check box must be cleared but data continues to be processed once it reappears.

3.0 PCA Detector RIF Status

Each detector in the PCA has a Remote Interface (RIF) box that controls the execution of received commands and also outputs housekeeping information to the spacecraft (SC). The SC builds up a full picture of the PCA status by interrogating a string of sub addresses in the RIF and storing the returned data words. All this information is then converted to the CCSDS packets and returned to Earth by the spacecraft telemetry system. A database description of the housekeeping mnemonics is given in Appendix A.

3.1 Count Rates used by HRM

The eight count rates returned in the housekeeping which are used by the High Rate Monitor (HRM) are obtained from the RIF using sub address 16. The HRM rates are those rates which can be used to switch off (if not inhibited) the detectors high voltage during passes through the South Atlantic Anomaly. The "off" state is triggered by three consecutive > HRM occasions (any combination of 3 from 8 rates).

3.1.1 RIF Sub Address 16

Sub address 16 initiates the transfer of 16, 16 bit words that contain 8 count rates. Each individual rate consists of a 24 bit counter with the MS 8 bits being transfer first and the LS 16 bits second. The order of the rates is: L1, R1, L2, R2, L3, R3, VX, VP.

Word	Bits	Mnemonic	Parameter
0	15 - 8	-	zero
0	7 - 0	-	L1 layer bits 23 - 16
1	15 - 0	evL1	L1 layer bits 15 - 0
2	15 - 8	-	zero
2	7 - 0	-	R1 layer bits 23 - 16
3	15 - 0	evR1	R1 layer bits 15 - 0
4	15 - 8	-	zero
4	7 - 0	-	L2 layer bits 23 - 16
5	15 - 0	evL2	L2 layer bits 15 - 0
6	15 - 8	-	zero
6	7 - 0	-	R2 layer bits 23 - 16
7	15 - 0	evR2	R2 layer bits 15 - 0
8	15 - 8	-	zero
8	7 - 0	-	L3 layer bits 23 - 16
9	15 - 0	evL3	L3 layer bits 15 - 0
10	15 - 8	-	zero
10	7 - 0	-	R3 layer bits 23 - 16
11	15 - 0	evR3	R3 layer bits 15 - 0
12	15 - 8	-	zero
12	7 - 0	-	VX veto bits 23 - 16

Word	Bits	Mnemonic	Parameter
13	15 - 0	evVX	VX veto bits 15 - 0
14	15 - 8	-	zero
14	7 - 0	-	VP layer bits 23 - 16
15	15 - 0	evVP	VP layer bits 15 - 0

3.2 Count Rates NOT Used By HRM

There are six additional count rates returned in the housekeeping which are not used by the High Rate Monitor (HRM). These rates are obtained from the RIF using sub address 17.

3.2.1 RIF Sub Address 17

Sub address 17 initiates the transfer of 12, 16 bit words that contain6 count rates. Each individual rate consists of a 24 bit counter with the MS 8 bits being transfer first and the LS 16 bits second. The order of the rates is: VPvle, XEvle, 2ormore, Alpha, VXvle, XEgood.

Word	Bits	Mnemonic	Parameter
0	15 - 8	-	zero
0	7 - 0	-	Pr layer very large events bits 23 - 16
1	15 - 0	evVPvle	Pr layer very large events bits 15 - 0
2	15 - 8	-	zero
2	7 - 0	-	Xe layers very large events bits 23 - 16
3	15 - 0	evXEvle	Xe layers very large events bits 15 - 0
4	15 - 8	-	zero
4	7 - 0	-	2 or more events bits 23 - 16
5	15 - 0	ev2ormore	2 or more events bits 15 - 0
6	15 - 8	-	zero
6	7 - 0	-	Alpha detector events bits 23 - 16
7	15 - 0	evAlpha	Alpha detector events bits 15 - 0
8	15 - 8	-	zero
8	7 - 0	-	Xe veto very large events bits 23 - 16
9	15 - 0	evVXvle	Xe veto very large events bits 15 - 0
10	15 - 8	-	zero
10	7 - 0	-	Xe layer good events bits 23 - 16
11	15 - 0	evXEgood	Xe layer good events bits 15 - 0

3.3 Command and Board Status

The status of commands received by each RIF/ PCU are available through sub address 18.

3.3.1 RIF Sub Address 18

Enquiries to sub address 18 produce highly compressed bit structures that have the following form. A total of six 16 bit words are output.

Word	Bits	Mnemonic	Parameter
0	15 - 14	dsR2	Xe layer 2 right discriminator level
0	13 - 12	dsL2	Xe layer 2 left discriminator level
0	11 - 10	dsR1	Xe layer 1 right discriminator level
0	9 - 8	dsL1	Xe layer 1 left discriminator level
0	7 - 6	dsVP	Pr layer VP discriminator level
0	5 - 4	dsVX	Xe veto VX discriminator level
0	3 - 2	dsR3	Xe layer 3 right discriminator level
0	1 - 0	dsL3	Xe layer 3 left discriminator level
1	15 - 13	-	zero
1	12	ADCdither	ADC dither on/off (1=0N)
1	11 - 10	dsVle	VLE discriminator “level”
1	9 - 8	dsAlpha	Alpha detector discriminator level
1	7 - 6	-	zero
1	5	tpgR3	TPG on/off layer 3 right
1	4	tpgL3	TPG on/off layer 3 left
1	3	tpgR2	TPG on/off layer 2 right
1	2	tpgL2	TPG on/off layer 2 left
1	1	tpgR1	TPG on/off layer 1 right
1	0	tpgL1	TPG on/off layer 1 left
2	15 - 13	-	zero
2	12	tpgAlpha	TPG on/off alpha detector
2	11	tpgVP	TPG on/off propane layer
2	10	tpgVX	TPG on/off Xe veto anodes
2	9	tpgMode	TPG mode to ramp or mono (0=Mono)
2	8	tpgEn	TPG enable
2	7 - 4	cmdhvXE	xenon HV command setting
2	3 - 0	cmdhvPR	propane HV command setting
3	15 - 14	-	zero
3	13	plsPRon	propane HV relay ON drive pulse
3	12	plsPRoff	propane HV relay OFF drive pulse
3	11	plsXEon	xenon HV relay ON drive pulse

Word	Bits	Mnemonic	Parameter
3	10	plsXEoff	xenon HV relay OFF drive pulse
3	9	plslvon	low voltage power relay ON drive pulse
3	8	plslvoff	low voltage power relay OFF drive pulse
3	7 - 5	-	zero
3	4	hvPRrly	propane HV relay state
3	3	hvXErly	xenon HV relay state
3	2	lvpsrly	low power supply relay state
3	1	hvPRon	status of HV cmd line to propane HV
3	0	hvXEon	status of HV cmd line to xenon HV
4	15	selB	1 Hz input to RIF box, 0 = A, 1 = B
4	14	rateov	override of rate disable to HV’s
4	13	ppsov	override of 1 pps disable to HV’s
4	12	hrmov	override of HRM disable to HV’s
4	11	rateinh	HV’s inhibited due to rate read-out timeout
4	10	ppsinh	HV’s inhibited due to 1 pps timeout
4	9	hrminh	HV’s inhibited due to triggered HRM signal
4	8	hrmflag	state of high rate monitor
4	7 - 0	-	present high rate monitor bits 23 - 16
5	15 - 0	hrmval	present high rate monitor bits 15 - 0

The four possible settings for each discriminator are termed LOW, MED, HIGH, OFF. The “11” command value turns a particular anode chain completely off.

3.4 Analog Information

Each detector has a number of analog channels that monitor various parameters using sub address 19. At present two of these rates are spare.

3.4.1 RIF Sub Address 19

Sub address 19 provides 20, 16 bit words to define temperatures, voltages and pressures on each PCU. The actual data words only occupy the lowest 12 bits since the RIF unit only contains a 12 bit ADC. The upper 4 bits of every word are therefore set to zero.

Word	Bits	Mnemonic	Parameter
0	11 - 0	tmpspare	Reserved (unused)
1	11 - 0	tmpRIF	Remote InterFace box temp
2	11 - 0	tmpADC	Analog Digital Converter box temp
3	11 - 0	tmpCSA	Charge Sensitive Amp box temp
4	11 - 0	tnpSA	Shaping Amp box temp

Word	Bits	Mnemonic	Parameter
5	11 - 0	tmpTPG	Test Pulse Generator box temp
6	11 - 0	tmpLVPS	Low Voltage Power Supply box temp
7	11 - 0	tmpHVPS	High Voltage Power Supply box temp
8	11 - 0	vap12	+12v analog
9	11 - 0	vam12	-12v analog
10	11 - 0	vap6	+6v analog
11	11 - 0	vam6	-6v analog
12	11 - 0	vdp12	+12v digital
13	11 - 0	vdm12	-12v digital
14	11 - 0	vdp5	+5v digital
15	11 - 0	vspare	Spare voltage
16	11 - 0	prsXE	Xe detector gas pressure
17	11 - 0	prsPR	Pr detector gas pressure
18	11 - 0	hvXE	Xe High Voltage direct monitor
19	11 - 0	hvPR	Pr High Voltage direct monitor

3.5 Diagnostic Status

Each detector has some diagnostic information available on sub address 29. Part of this information is always of potential interest in monitoring the status of an individual PCU while other parts are only sensible in terms of their relation to the corresponding Diagnostic Commands sent to that same PCU.

3.5.1 RIF Sub Address 29

Sub address 29 provides a total of ten 16 bit words which have the following format.

Word	Bits	Mnemonic	Status
0	15 - 0	-	Contents of chip #1 (SEL 16) bits 15 - 0
1	15 - 8	-	Contents of chip #1 bits 15 - 8 (not used)
1	7 - 0	-	Contents of chip #1 bits 15 - 8 (not used)
2	15 - 8	-	zero
2	7 - 0	c1count	Contents of chip #1 bits 23 - 16
3	15 - 8	-	zero
3	7 - 4	c1selN	select chip #1 counter register N (0000 - 0nnn)
3	3	-	Contents of chip #1 bit 15 (not used)
3	2	-	Contents of chip #1 bit 7 (not used)
3	1	c1testbit	Contents of chip #1 test bit (should=0)
3	0	c1status	status of counter N of chip #1 (1=enabled)

Word	Bits	Mnemonic	Status
4	15 - 0	-	Contents of chip #2 (SEL 17) bits 15 - 0
5	15 - 8	-	Contents of chip #2 bits 15 - 8 (not used)
5	7 - 0	-	Contents of chip #2 bits 15 - 8 (not used)
6	15 - 8	-	zero
6	7 - 0	c2count	Contents of chip #2 bits 23 - 16
7	15 - 8	-	zero
7	7 - 4	c2selN	select chip #2 counter register N (000 - 111)
7	3	-	Contents of chip #2 bit 15 (not used)
7	2	-	Contents of chip #2 bit 7 (not used)
7	1	c2testbit	Contents of chip #2 test bit (should = 0)
7	0	c2status	status of counter N of chip #2 (1=enabled)
8	15 - 14	-	zero
8	13	mckspeed	internal clock speed (1=1MHz, 0=125KHz)
8	12	mckgatechip1	status bit: gate control for chip #1 (SEL 16)
8	11	mckgatechip2	status bit: gate control for chip #2 (SEL 17)
8	10 - 8	mckselect	status bit: counter select number N
8	7 - 0	lastcmd	LS byte of last command received
9	15 - 5	-	zero
9	4	to1pps	1=1pps timeout condition detected
9	3	torate	1=rate readout timeout condition detected
9	2	waitfor1pps	1=rec. subaddr 26 command, waiting for 1pps
9	1	twohrms	1=high rate for last 2 consecutive rate periods
9	0	onehrm	1=high rate for last rate period

3.5.2 Chip #1 and #2 Select “N” Codes

In the previous table the returned value of “N” determines which counter in chip number 1 or 2 was exercised. The codes for these two chips are:

N	CHIP #1 Contents (SEL 16)	CHIP #2 Contents (SEL 17)
0	Xe layer 1 left	Pr layer vle
1	Xe layer 1 right	Xe layers 1, 2, and 3 vle
2	Xe layer 2 left	2 or more
3	Xe layer 2 right	alpha
4	Xe layer 3 right	VX vle
5	Xe layer 3 left	Xe good
6	Xe veto anodes VX	unused
7	Pr layer VP	unused

4.0 Relevant Spacecraft Telemetry

Due to the final design a number of telemetry items relevant to the PCA experiment are buried in the mass of information returned in the spacecraft packets. The detector temperatures are monitored by the spacecraft as its systems are responsible for operating survival heaters to keep the PCU's from getting too cold. This "control" loop therefore has to directly monitor the temperatures. The rest of the parameters are either direct or derived values concerning the orbital / temporal position of the detectors with respect to the Earth and its magnetic field.

These parameters are available in the spacecraft IPSDU packets. This subsystem has an A & B side one of which is the primary at any one time.

Packet	Parameter	A side ApID	B side ApID
IPSDU Quick	Currents	196	197
IPSDU Status	Relay Status, Crit. Temp	198	199
IPSDU Temp	Temperatures	200	201

Whichever side is the primary side will return packets about every 1/2 second. The secondary side will return packets every 128 seconds. Note that both sides should be both present and valid.

4.1 Spacecraft IPSDU Detector Items

The exterior of each detector body has 4 thermistors mounted on it that are measured by the spacecraft system and not by the RIF box. These readings are used to ensure detector survival by controlling heaters that are also fixed to the sides of the detector bodies. The thermistors are grouped in A & B sides with individual thermistors being termed A1, A2 & B1, B2 for each detector giving a total of 20 altogether. The Spacecraft only samples these temperatures with an 8 bit ADC.

4.1.1 Detector Temperature Data Structures

These parameters are NOT available within the PCA CCSDS packets. They are all returned in the Spacecraft IPSDU packets and therefore are handled very differently from the regular PCA data items. They are made available within the SOF environment for real time use by utilities created by the SOC who are handling a subset of the complete Spacecraft telemetry in a special way. The SOF retain a small cache memory of about 2 hours worth of measurements.

Calls to the utility for PCA detector temperatures can provide:

- The latest temperature
- The temperature closest in time before a given MET
- An array of temperatures between two given MET's

Returned values are unsigned bytes so the conversion to physical temperature is then performed by the H&S subsystem. The spacecraft sends all the temperatures every 32 seconds since the thermal time constants of the detectors are many 10's of minutes. There is no way to ensure that the temperature returned will exactly corresponds to the same 8 second data sample as the rest of the PCA data though in general they should not be far apart in time.

Within the GOF all spacecraft parameters will reside in FITS files but for convenience and processing speed a subset of them (including the detector temperatures) of special interest to the Instrument Teams will reside in a more compact and accessible FITS file structure. The access to the temperatures are made by calls to PCU_TEMP_A() or PCU_TEMP_B(). Each returns 10 unsigned bytes.

Side A   PCU_TEMP_A()

ApID	Channel	Mnemonic	Parameter
200	56	tmpDetA1	PCU 1 temp #1
200	16	tmpDetA2	PCU 1 temp #2
200	57	tmpDetA1	PCU 2 temp #1
200	17	tmpDetA2	PCU 2 temp #2
200	58	tmpDetA1	PCU 3 temp #1
200	18	tmpDetA2	PCU 3 temp #2
200	59	tmpDetA1	PCU 4 temp #1
200	19	tmpDetA2	PCU 4 temp #2
200	60	tmpDetA1	PCU 5 temp #1
200	20	tmpDetA2	PCU 5 temp #2

Side B   PCU_TEMP_B()

ApID	Channel	Mnemonic	Parameter
201	56	tmpDetB1	PCU 1 temp #1
201	16	tmpDetB2	PCU 1 temp #2
201	57	tmpDetB1	PCU 2 temp #1
201	17	tmpDetB2	PCU 2 temp #2
201	58	tmpDetB1	PCU 3 temp #1
201	18	tmpDetB2	PCU 3 temp #2
201	59	tmpDetB1	PCU 4 temp #1
201	19	tmpDetB2	PCU 4 temp #2
201	60	tmpDetB1	PCU 5 temp #1
201	20	tmpDetB2	PCU 5 temp #2

4.1.2 Detector Current Data Structures

The spacecraft IPSDU packets also contain current readings for each PCU.

Side A PCU_AMP_A()

ApID	Channel	Mnemonic	Parameter
196	2	detAsc	PCU 1 current (amps)
196	3	detAsc	PCU 2 current
196	4	detAsc	PCU 3 current
196	5	detAsc	PCU 4 current
196	6	detAsc	PCU 5 current

Side B PCU_AMP_B()

ApID	Channel	Mnemonic	Parameter
197	2	detBsc	PCU 1 current (amps)
197	3	detBsc	PCU 2 current
197	4	detBsc	PCU 3 current
197	5	detBsc	PCU 4 current
197	6	detBsc	PCU 5 current

A similar access method to that for the detector body temperatures is provided by SOF software.

4.2 Additional Spacecraft Telemetry Items

There are a number of additional spacecraft telemetry items which are required by the PCA housekeeping H&S program. These fall into two categories:

- Orbit Related
- Attitude Related

4.2.1 Orbit Related

These are listed below with their corresponding spacecraft packet mnemonic.

Parameter	Range	Spacecraft Mnemonic	ApID
Latitude (deg)	-30 to +30	ACSEARTHLAT	17
Longitude (deg)	0 to 360	ACSEARTHLON	17
Altitude (km)	0 to 600	ACSALTITUDE	21

Parameter	Range	Spacecraft Mnemonic	ApID
Earth Eclipse	IN / OUT	ACSECLIPSE (1=eclipsed)	17
SAA	IN / OUT	Obtained from SOF Mission Planning	-
Mag Field X (nT)	0 to 65535	ACSMAGFIELDX	17
Mag Field Y (nT)	0 to 65535	ACSMAGFIELDY	17
Mag Field Z (nT)	0 to 65535	ACSMAGFIELDZ	17
Total Field (nT)	0 to 65535	Computed $\mathrm{sqrt}[X^2 + Y^2 + Z^2]$	-
McIlwain L	1.0 to 2.0	Computed by PCA code	-
Spare	-	-	-
Spare	-	-	-

Most of these parameters arrive in spacecraft packets as individual items and apart from the unit conversions require little further computation. The magnetic field components selected are the “compensated” components in the 3 spacecraft body axes. These values arrive in units of micro Tesla and are multiplied by 1000 for display in nano Tesla (nT) units. The total field is just the vector sum of the 3 spacecraft vector axes components.

The McIlwain L value ranges between 1.0 and 2.0 for the XTE orbit height. The McIlwain L value is defined as the distance (in Earth Radii) from the Earths centre to the point where the field line you are on crosses the Earths Magnetic Equator.

4.2.2 Attitude Related

These are listed below with their corresponding spacecraft packet mnemonic.

Parameter	Range	Mnemonic	ApID
RA (deg)	359.99	Computed by PCA code	-
DEC (deg)	+-90.00	Computed by PCA code	-
Boresight - Sun < (deg)	180.00	ACSSUNAVOIDX	17
Boresight - Earth Limb < (deg)	180.00	Computed by PCA code	-
Slew Flag	SLEW / -	ACSMODESTAT	15
On Target Flag	ON / -	ACSMODESTAT	15
Jitter (arc sec)	0 to 3600	Computed by PCA code	-
Attitude Error (arc sec) X axis is boresight	0 to 3600	ACSATTERRY ACSATTERRZ $\mathrm{sqrt}[Y^2 + Z^2]$	15
PA +Y (deg)	0 to 360	Computed by PCA code	-

Parameter	Range	Mnemonic	ApID
Roll Bias (deg)	-180 to +180	Computed by PCA code	-
Spare	-	-	-

Several of these parameters arrive in the spacecraft packets as useful values in the correct units but others need extensive computations performed to arrive at the required result. The full algorithms are not given here but the relevant spacecraft parameters are detailed below:

- RA & DEC - uses attitude quaternions (ACSESTQ1 to Q4) to calculate the inertial boresight vector. Then transforms this to RA & DEC.
- Boresight to Sun angle - uses above inertial boresight vector and Solar position vector (ACSSUNXECI, ACSSUNYECI, ACSSUNZECI). Takes dot product.
- Boresight to Earth Limb angle - uses above inertial boresight vector and the negative of the spacecraft position vector (ACSSCPOSX, ACSSCPOSY, ACSSCPOSZ) plus the radius of the Earth (6378.16 km).
- Jitter - uses the 4 a second RA & DEC pairs to establish a max & min excursion in each "sky" axis over a fixed sampling period (16 seconds). Jitter = sqrt[(delta RA)^2 + (delta DEC)^2].
- Position Angle of +Y axis (PA +Y) - uses the RA & DEC of the boresight + a second RA & DEC pair derived from the boresight + a small increment (0.01) to the +Y boresight vector. These 2 sky positions thus define a Position Angle on the sky of the +Y axis and can be used to define the offset rocking position fields on the sky for HEXTE. Each of the 4 possible fields is 90 deg round from the previous one starting at the +Y one.
- Roll Bias - uses the Solar Vector and the spacecraft boresight. This defines a roll angle for the spacecraft with respect to the solar pointing vector. It is of relevance to the solar panel illumination and is therefore a pointing constraint. Normally the Roll Bias will be within the range -5 to +5 degrees but can be much bigger depending on the X-ray source and Sun positions (see XTE documentation for more details).

The computations involved were derived by Tod Strohmayer from information supplied by Jay Sedler (XTE spacecraft ACS team). This Fortran code was verified (by Tod) using supplied test data from Jay and then converted to C and tested again by Barry Giles. These routines were then delivered to the SOF (David Hon) for incorporation into the various subsystems principally Mission Monitoring, Science Monitoring and Health & Safety.

5.0 PCA Detector Conversion Parameters

Many of the returned binary words require knowledge of conversion parameters to turn them into meaningful ‘real world’ values. The form of these conversions is detailed in this section.

5.1 Count Rates used by HRM

The digital rates are summed counts for 8 second intervals so that they can be compared directly with the set HRM threshold value which is also expressed as an 8 second sum to give some averaging out of normal counting variability. The returned rates need to be divided by 8 to present the displayed numbers in counts per second. The numbers are displayed with one significant decimal place.

5.2 Count Rates NOT used by HRM

The returned rates need to be divided by 8 to present the displayed numbers in counts per second. The numbers are displayed with one significant decimal place.

5.3 Command and Board Status

Most of the bits in these words have simple binary count or 1/0 states. Several parameters could be decoded to give real world values.

5.3.1 High Voltage Values

The 16 possible high voltage values (0000 - 1111) for the Xe and Pr units on each detector represent real voltage values that depend on the final resistor values in the HV units. Each PCU will be calibrated on the ground and a table like the following one produced which will remain fixed. The voltage increments are about 20 volts.

Typical values for one PCU are shown below. The screen displays show values of high voltage with a resolution of 0.1 volt. A complete table of values is required by the SOC. The final or latest numerical values are given in chapter 12 and are also included in a table in the Appendix which provides a template for the actual data file delivered to the SOC.

N	Cmd Bits	Xenon HV	Propane HV
0	0000	910	1580
1	0001	1910	2580
2	0010	1930	2600
3	0011	1950	2620
4	0100	1970	2640
5	0101	1990	2660
6	0110	2010	2680
7	0111	2030	2700
8	1000	2050	2720

N	Cmd Bits	Xenon HV	Propane HV
9	1001	2070	2740
10	1010	2090	2760
11	1011	2110	2780
12	1100	2130	2800
13	1101	2150	2820
14	1110	2170	2840
15	1111	2190	2860

Note that the 0000 setting corresponds to the HV “OFF” position where the actual voltage is lowered by approximately 1000 volts relative to the next setting. This low voltage should be below that which allows electron multiplication in the detectors. The default command values are given below.

Detector	cmd	HV
Xenon	8	2050
Propane	12	2800

5.3.2 High Rate Monitor (HRM) Value

The HRM threshold is set in the RIF box as a binned sum over 8 seconds. In the housekeeping displays it is divided by 8 and shown in counts per second with one significant decimal place.

5.3.3 VLE Discriminator Settings

The VLE discriminator has a 2 bit (4 states) code that could be displayed as such in the screen displays or converted to time delays in micro seconds. The delays will be measured for each detector.

Typical values for one PCU are shown below. A complete table of values is required by the SOC. The final or latest numerical values are given in chapter 13 and are also included in a table in the Appendix which provides a template for the actual data file delivered to the SOC.

Command	00	01	10	11
Range Name	NONE	SHORT	MED	LONG
Delay micro sec	12	60	150	550

5.4 Analog Information

The 20 returned analog values can be divided into 5 groups:

- Low voltage power supply (LVPS) voltages - shown rounded to 5mV resolution
- Internal voltages - shown rounded to 5 mV resolution
- RIF temperatures - shown to 100's of a degree
- Pressures - shown to 10's of a torr
- High voltage power supply (HVPS) voltages - shown in integer volts

The HV monitors have a particularly unusual conversion factor. At present two of the 20 rates are spare. The 12 bit ADC is configured for the range -5V to +5V (10v span) giving the LSB a resolution of 2.44mV. The following sections provides typical conversion values.

Similar numerical values are included in a table in the Appendix which provides a template for the actual data file delivered to the SOC.

5.4.1 LVPS Voltage Conversions

The four LVPS voltages are all pre-scaled which results in a resolution of approximately 10mV for the +-12V ranges and 5mV for the +-6V ranges. If the conversion has the form:

Voltage (mV) = Digital Value * A + B

then typical conversion values will be

Parameter	Mnemonic	Pre-scale	A	B
+12V analog	vap12	+3V	0.00977	-20.0
-12V analog	vam12	-3V	0.00977	-20.0
+6V analog	vap6	+3V	0.00488	-10.0
-6V analog	vam6	-3V	0.00488	-10.0

5.4.2 Internal Voltage Conversions

The three internal voltages are all pre-scaled which results in a resolution of approximately 7.3mV for the +-12V ranges and 3mV for the +5V range. If the conversion has the form:

Voltage (mV) = Digital Value * A + B

then typical conversion values will be

Parameter	Mnemonic	Pre-scale	A	B
+12V digital	vdp12	+4V	0.00733	-15.0
-12V digital	vdm12	-4V	0.00733	-15.0
+5V digital	vdp5	+4V	0.00305	-6.25
spare voltage	vspare	-	-	-

5.4.3 Temperature Conversions

The seven temperatures sensors are linear devices and the ADC provides 12 bit resolution. The range is -200 to +99 degrees C with a resolution of about 0.07 degrees C. The HEASARC requires the final FITS file conversion parameters to produce temperatures in degrees Kelvin but PCA, SOF and MOC will deal with degrees C only.

Zero degrees C = 273.15 degrees K

If the conversion has the form:

Temp = Digital Value * A + B

then typical conversion values will be

Parameter	Mnemonic	Pre-scale	A	B (deg C)
spare temp	tmpspare	-	-	-
RIF box temp	tmpRIF	-	0.073	-200.0
ADC box temp	tmpADC	-	0.073	-200.0
CSA box temp	tmpCSA	-	0.073	-200.0
SA box temp	tmpSA	-	0.073	-200.0
TPG box temp	tmpTPG	-	0.073	-200.0
LVPS box temp	tmpLVPS	-	0.073	-200.0
HVPS box temp	tmpHVPS	-	0.073	-200.0

5.4.4 Pressure Conversions

The Xenon and Propane gas pressure monitors are both linear devices with a range from 0-5V of 0 - 20 psi or 0 - 1034 Torr (1 atm = 14.7psi = 760 Torr). The signal passes through an amplifier with a gain of -2.2 and an offset of 5V to produce a final resolution of 0.23 torr over the 0 - 935 Torr range. The HEASARC requires the final FITS file conversion parameters to produce pressures in Pascals but the PCA, SOF and MOC will deal with Torr only.

100 Pascals = 1 Hecto Pascal = 1 mb = 0.746 Torr (1 Torr = 133.32 Pascals)

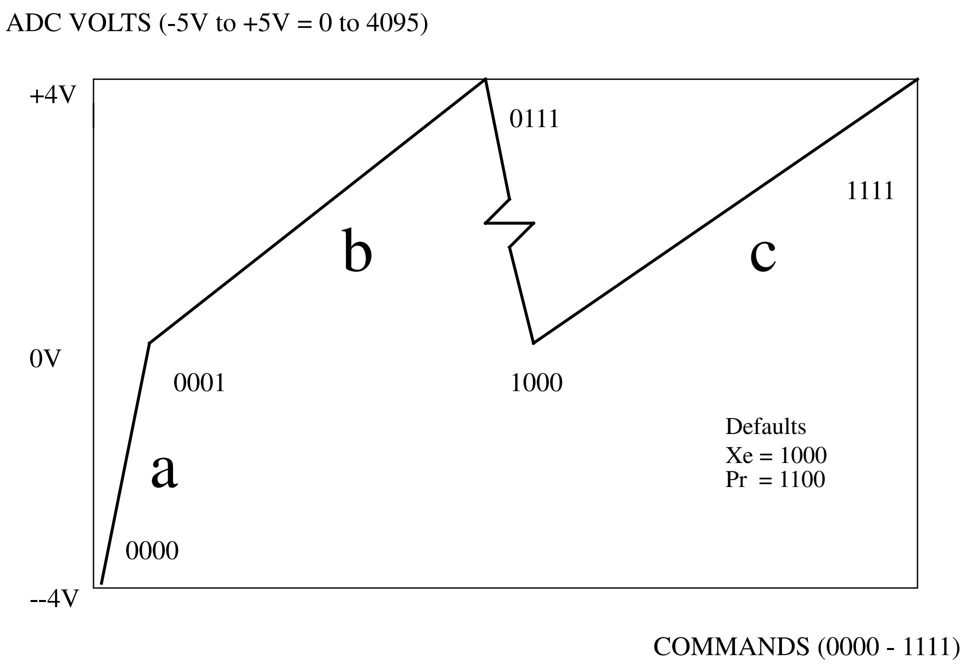
Pressure (torr) = Digital Value * A + B

then typical conversion values will be

Parameter	Mnemonic	Pre-scale	Torr A	B
Xe pressure	prsXe	-6V to 5V	-0.2295	940.0
Pr pressure	prsPr	-6V to 5V	-0.2295	940.0

5.4.5 High Voltage Conversions

The Xenon and Propane high voltage monitors have an unusual conversion profile as it consists of a double ramp form and a non-linear discontinuity at the start. It is therefore necessary to split the conversion into several parts:



The commanded HV value for Xe and Pr only has 16 positions the lowest of which is the SAA “LOW’ position (as described in section 4.3.1).

section a:- COMMAND = 0000

The command bit tells that the high voltage must be at the low position.

HV (volts) = (Digital Value * A1) + B1

where A1 = slope i.e. digital bits / HV range

and B1 = HV value for intercept of 0 bits

section b:- 0000 < COMMAND < 1000

The command bits tell that the high voltage must lie on the first ramp.

HV (volts) = (Digital Value * A2) + B2

where A2 = slope i.e. digital bits / HV range

and B2 = HV value for intercept of 0 bits

section c:- 0111 < COMMAND

The command bits tell that the high voltage must lie on the second ramp.

HV (volts) = (Digital Value * A3) + B3

where A3 = slope i.e. digital bits / HV range

and B3 = HV value for intercept of 0 bits

Taking data from a detector calibration run gives the following typical conversion tables. The final computed HV value should be shown as an integer.

Xe HV Mnemonic	**A1**	**B1**	**A2**	**B2**	**A3**	**B3**
hvXE	0.713	350.0	0.0915	1710.0	0.0914	1875.0

Pr HV Mnemonic	**A1**	**B1**	**A2**	**B2**	**A3**	**B3**
hvPR	0.607	1040.0	0.0892	2375.0	0.0890	2535.0

5.5 Diagnostic Status

There are no conversion factors associated with the diagnostic status information obtained on sub address 29. All this information is in digital form.

5.6 Spacecraft Measured Detector Temperatures

The 20 temperatures (5 detectors x 4 thermistors) monitored by the spacecraft are sampled with an 8 bit ADC and therefore have limited resolution. The HEASARC requires the final FITS file conversion parameters to produce degrees Kelvin but the PCA, SOF and MOC will deal with degrees C only.

All the thermistors are taken to have the same temperature response:

$$\text{Temp (deg C)} = a_0 + a_1x + a_2x^2 + a_3x^3 + a_4x^4 + a_5x^5$$

where x is the digital value (0 - 255) and

Parameter	Value
a_0	141.6748
a_1	-2.893541
a_2	0.3681093E-01
a_3	-0.2676768E-03
a_4	0.9687501E-06
a_5	-0.138866E-08

Rather than repeatedly compute this polynomial the PCA software contains a look up table which is reproduced in the Appendix. Typical values are:

Digital value	Deg C	1 Bit Resolution
66	50.74	0.56
113	30.88	0.37
200	-0.38	0.40
245	-29.57	1.07

The thermistors are fairly linear from 0 to 40 degrees but deviate rapidly below zero degrees.

5.7 Spacecraft Measured Detector Currents

Each PCU has an A & B side current monitor that is sampled by the spacecraft with an 8 bit ADC. The conversion factor from byte to amps is:

count (byte) x 0.01953125 = Amps

This gives a range of zero to about five amps. For the displays the current is shown in units of milliamps (mA).

Typical values are:

- Basic IPSDU power on - 98 mA
- LVPS on - 332 mA
- Both HV's on - 352 mA

The upper Yellow limit is defined as 430 mA and the upper Red as 460 mA.

5.8 HV Lookup Tables

The HV lookup tables for the Xe and Pr units in each detector have been measured prior to launch and form a table of "constants'. This HV lookup table is supplied to the SOC in the format shown in the template file given in the Appendix. The table is also shown in section 13.0 of this document. The use of this table is described in the section on limits.

5.9 Conversion Tables - SOF Access & Updates

During the development of XTE the conversion values have been changed a few times and in anticipation of this a flexible scheme has been used. This is also complicated by the fact that PCU's were moved around on the spacecraft for some time and the final flight units (5 of 6) were uncertain until early 1995.

To overcome this each detector had its own conversion table and had a file name of the form:

pcu_n_conv.dat   where n has the value 1 - 6

Depending on the PCU positions these files were delivered to the SOF with new names (see appendix) to suit their slot address or spacecraft position. These delivered files have the names:

slot_n_conv.dat   where n has the value 1 - 5

The mapping between PCU number and slot address is given in section 16.

6.0 PCA Detector Red and Yellow Limits

A number of the returned housekeeping parameters require monitoring for RED and YELLOW limits. When incoming telemetry parameters exceed these limits the system should provide several levels of warnings. The following sections provide typical limit values for each parameter.

The limit table will be supplied to the SOC in the format shown in the template file given in the Appendix.

6.1 Count Rate Limits (HRM rates)

The eight count rates returned in the housekeeping that can trigger the HRM can be provided with the following limit values. Note that all these limits are expressed in counts per second. The on-board HRM works over 8 second summations.

The limits are floating in the PCA HnS program and are related to the currant HRM threshold value:

- Upper Yellow - HRM * 3/4
- Upper Red - HRM value

The MOC cannot deal with this “floating” scheme and so uses fixed high values which in effect means that no rate limit checking is possible.

The SOF HnS program also has fixed rate limit checking at present. This may be updated later by copying the relevant part of the PCA HnS program code.

Parameter	Mnemonic	Red Low	Yellow Low	Yellow Top	Red Top
layer 1 left	evL1	0.0	0.0	48000.0	64000.0
layer 1 right	evR1	0.0	0.0	48000.0	64000.0
layer 2 left	evL2	0.0	0.0	48000.0	64000.0
layer 2 right	evR2	0.0	0.0	48000.0	64000.0
layer 3 left	evL3	0.0	0.0	48000.0	64000.0
layer 3 right	evR3	0.0	0.0	48000.0	64000.0
Xe veto	evVX	0.0	0.0	48000.0	64000.0
Pr layer	evVP	0.0	0.0	48000.0	64000.0

6.2 Count Rate Limits (non HRM rates)

The six count rates returned in the housekeeping that cannot trigger the HRM can be provided with the following limit values. Note that all these limits are expressed in counts per second. The on-board HRM works over 8 second summations.

Parameter	Mnemonic	Red Low	Yellow Low	Yellow Top	Red Top
Propane VLE	evVPvle	0.0	0.0	48000.0	64000.0
Xenon VLE	evXEvle	0.0	0.0	48000.0	64000.0
2 or more	ev2ormore	0.0	0.0	48000.0	64000.0
alpha	evAlpha	0.0	0.0	48000.0	64000.0
Xe veto VLE	evVXvle	0.0	0.0	48000.0	64000.0
Xe good	evXEgood	0.0	0.0	48000.0	64000.0

6.3 Command and Board Status Limits

The information in this section is only digital status for up-link commands and some digital status flag bits. Some of these need monitoring for possible “action” on the ground should they occur.

Parameter	Mnemonic	Red Low	Yellow Low	Yellow High	Red High
cmd. rate veto off	rateinh	0.0	0.0	0.1	0.1
cmd. 1PPS veto off	ppsinh	0.0	0.0	0.1	0.1
cmd. HRM veto off	hrminh	0.0	0.0	0.1	0.1
mon. 1PPS veto	to1pps	0.0	0.0	0.1	0.1
mon. rate veto	torate	0.0	0.0	0.1	0.1
mon. 2 previous HRM’s	twohrms	0.0	0.0	0.1	0.1
mon. previous HRM	onehrm	0.0	0.0	0.1	0.1
mon. current HRM	hrmflag	0.0	0.0	0.1	0.1

6.4 Analog Information Limits

All the parameters returned in the analog information can have limit checking performed.

Parameter	Mnemonic	Red Low	Yellow Low	Yellow Top	Red Top
spare temp	tmpspare	0.0	0.0	0.0	0.0
RIF box temp	tmpRIF	-10.00	-5.00	30.00	35.00
ADC box temp	tmpADC	-10.00	-5.00	30.00	35.00
CSA box temp	tmpCSA	-10.00	-5.00	20.00	30.00
SA box temp	tmpSA	-10.00	-5.00	30.00	35.00
TPG box temp	tmpTPG	-10.00	-5.00	30.00	35.00

Parameter	Mnemonic	Red Low	Yellow Low	Yellow Top	Red Top
LVPS box temp	tmpLVPS	-10.00	-5.00	30.00	35.00
HVPS box temp	tmpHVPS	-10.00	-5.00	30.00	35.00
+12V analog	vap12	11.800	11.850	12.150	12.200
-12V analog	vam12	-12.200	-12.150	-11.850	-11.800
+6V analog	vap6	5.840	5.880	6.120	6.160
-6V analog	vam6	-6.160	-6.120	-5.880	-5.840
+12V digital	vdp12	11.400	11.550	12.450	12.600
-12V digital	vdm12	-12.600	-12.450	-11.550	-11.400
+5V digital	vdp5	4.800	4.850	5.150	5.200
spare volts	vspare	0.0	0.0	0.0	0.00
Xe pressure	prsXE	756.0	771.0	874.0	889.0
Pr pressure	prsPR	714.0	728.0	825.0	839.0
Xenon HV	hvXE	0.0	0.0	2195.0	2200.0
Propane HV	hvPR	0.0	0.0	2865.0	2870.0
Det A1 temp	tmpDetA1	-15.0	-10.0	25.0	30.0
Det A2 temp	tmpDetA2	-15.0	-10.0	25.0	30.0
Det B1 temp	tmpDetB1	-15.0	-10.0	25.0	30.0
Det B2 temp	tmpDetB2	-15.0	-10.0	25.0	30.0

6.4.1 Nominal Detector Operating Values

The nominal operating voltage and pressure range for each detector is given in the table below. The operating temperature range is -15 to +30 C (survival -20 to +35).

Detector	Units	Xenon	Propane
Temp -15 deg C	pressure torr	756	714
Temp +15 deg C	pressure torr	845	798
Temp +30 deg C	pressure torr	889	839
Nominal HV setting	volts	2050 (cmd 1000)	2800 (cmd 1100)

6.5 Diagnostic Status Limits

There are no limits formally associated with the diagnostic functions considering them as a single block however a few monitor items are always valid and are therefore included in the previous section on “Command And Board Status Limits”. These two items are:

- two previous HRM flags set

- previous HRM flag set

6.6 Limit Tables - SOF Access & Updates

During the XTE mission the limit values may change a few times and in anticipation of this a flexible scheme has been used. Each detector had its own limit table.

These limit files were treated in the same way as the conversion files. Initially all the files contain the same limit values and will do so until anomalies in individual detectors force these values to be changed. The file names have the form:

pcu_n_limits.dat   where n has the value 1 - 6

Depending on the PCU positions these files were delivered to the SOF with new names (see appendix) to suit their slot address or spacecraft position. These delivered files have the names:

slot_n_limits.dat   where n has the value 1 - 5

The mapping between PCU number and slot address is given in section 16.

6.7 System Limit Warnings

The SOC (SOF H&S subsystem) software and the MOC system will constantly check the incoming PCA housekeeping data against the current set of stored RED and YELLOW limits. The MOC will use the data in the Project Data Base which has been provided by the PCA team. The SOF will use the files provided directly by the PCA team.

Any update provided to the SOF should also be passed on to the MOC.

6.7.1 SOF Response on Exceeding Limits

The SOC will handle all error checking (including limits) and reporting functions but the following general comments can be made. When defined limits are exceeded the system will provide a warning message. Alarm messages will always be logged to the SOC error handling system. The local message may include:

- The detector number
- The faulty parameter (text string from file) + high/low and red/yellow
- The current limit value
- The faulty parameter value

In general triggered RED limits will be more persistent and/or require more action on the part of the duty controller than that required for YELLOW limits. Limit values will also be incorporated into the PCA Housekeeping displays in the following ways:

- Text Screens - interrogate current values, change button background color
- Graphics Screens - plot horizontal limit lines

For further details see “Instrument Operations Users Guide” (ref on page 9).

6.7.2 MOC Response on Exceeding Limits

For details see “Instrument Operations Users Guide” (ref on page 9).

6.8 SOF HV Limit Checking

The HV limit checking becomes involved when all relevant aspects are taken into account to produce a robust method. The following recipe is adopted:

- If the Pr HV control bit is OFF
  - set Pr HV measured value to zero volts
  - inhibit Pr HV limit checking
- If the Xe HV control bit is OFF
  - set Xe HV measured value to zero volts
  - inhibit Xe HV limit checking
- Assuming the HV command bits are ON
  - read a measured voltage
  - read the present HV cmd setting for that voltage (0000-1111)
  - use the HV lookup table for the “expected” voltage (different for each PCU)
  - allow an error window (for yellow & red) and check which window the measured value falls within

Use

+/-25.0 for YELLOW Xenon & Propane cmd setting 0000
+/-50.0 for RED Xenon & Propane cmd setting 0000
+/-2.5 for YELLOW Xenon & Propane for cmd settings 0001-1111
+/-5.0 for RED Xenon & Propane for cmd settings 0001-1111

6.8.1 MOC HV Limit Checking

Since the MOC cannot easily introduce these types of information structures into their Data Base the PCA continues to supply them with very generous limit ranges such as 0 to 3000 volts. These large ranges still exist on the limits file passed to the SOF but the SOF will override them with the above more comprehensive scheme.

6.9 Other Special Limit Checking Conditions

It is possible to get PCA packets from the spacecraft when some data items are not yet valid for limit checking (very rare). This happens when the spacecraft has turned on a PCU’s power but its LVPS has not been turned on (by PCA command). Once spacecraft power to a PCU is on the command status bits such as LVPS are valid.

If this bit is ever a zero in a received packet then all parameters in that packet are valid except:

- The detector Pr & Xe pressures. Shown as undefined (- symbol) and limit checking inhibited
- The detector Pr & Xe HV values. Shown as zero volts and limit checking inhibited

7.0 Design Concepts & Screen Layouts

There are five detectors in the PCA so some basic repetition of displays is possible. The basic required functions can be divided into Text and Graphics screens and the means to select or build them in the graphics case.

There is no spectral information available in the PCA housekeeping packets so all data displays are concerned with time variability only.

Details of the exact implementation used for the text and graphics screens can be found in the relevant Design Document and User Manual which are listed in section 1.3.

7.1 General Design Concept

The basic design concept (as of January 1994 for Build 3) consists of the following elements (PCA only):

- A “Real Time” client front end - adapted from generic SOC code
- A ring buffer for all PCA parameters & selected spacecraft items
- Menu options to display real time incoming data on text screens or from a previous specified time in the ring buffer
- Graphics selections using the text screens to display various types of graph extracted from the ring buffer. Both specified “frozen” time spans and incoming live data in a “strip chart” mode
- Some error and warning information options on the text & graphics screens

The SOC will retain core responsibility for the overall H&S subsystem. Their role will be to:

- Continuously check all PCA experiment data against current limits
- Issue warning and error log supports to the SOC system. The PCA system outlined above does not pass error reports to the SOC therefore it does not need to run continuously
- Maintain and build the Trend data archive and its access & display methods

PCA are responsible for all calibration aspects and this includes maintaining and delivering conversion & limit files.

7.2 Text Mode Requirements

Text screens are fully defined and are not intended to be re-designed or configured on the fly. A suitable set of displays has been defined and are presented in a following section. The basic text screen requirements are:

- Show a text “Detector Screen” display for each PCU that presents ALL its housekeeping parameters in a structured layout
- Show several types of text “Combined Screens” that list sub-groups of information from all five detectors at the same time for ease of comparison

- Show a single “Combined Screen” that presents only RIF diagnostic sub frame information
- Be able to do printouts (screen dumps) of a selected table - “snapshot records”

The actual numbers presented in these frames will:

- Normally be in physical engineering units obtained from the conversion tables and the raw data
- An option will allow raw digital values to be shown to assist in testing the system

All parameters are updated every 8 seconds at essentially the same time assuming real time data flow with no gaps. The SOC part of the H&S subsystem will maintain a local short term data base in memory for all parameters extending back over a few orbits. Following reception gaps quick “bursts” of data are available essentially at the same time. Such bursts should flow into the local short term data base but a mechanism will exist that prevents them from “clogging up” the display screens. The time sample displayed will be:

- The latest data - default setting
- Data from an update moment in the past. If these are selected in MET seconds the encompassing “8 sec window” data set will be used.

Additional requirements:

- To expand the local ring buffer size from 2 hours up to say 24 hours
- The ability to save the full ring buffer contents to disc and restore it back to memory
- The ability to select information from the packet data base - a sort of “super long term” history option. The ring buffer data might automatically be saved at the start of this option and restored at the end of it
- The ability to select data from the ring buffer based on some flag option such as - SAA, Earth Occult & On-Target

7.3 Graphics Mode Requirements

The graphics screens are intended to be highly interactive in the way parameter combinations and selections are made. A base set of default selections will always be available. The basic requirements for the graphics mode are:

- Be able to select any parameter for graphical display
- Suitable axes legends to be provided in a table. Scale factors on X & Y (X is normally time) to be calculated from the time span selected or from the parameter conversion table
- Be able to select any combination of parameters for graphical display. There will be no solid upper limit but normally only a few (<6) parameters at one time will be plotted on the same graph
- Provide multiple graphs on screen
- Toggling “active or dormant” parameter groups & individual parameters for plotting

- Be able to do printouts (screen dumps) of a selected graphs

The time sample displayed will be:

- A continuous strip chart of “active parameters” - default setting
- Data from an update period in the past. If these are selected in MET seconds the encompassing “8 sec window” data start and end points will be used
- Graphs of all other parameters will be drawn as single line (point to point) plots

Additional requirements:

- Be able to “export” selected parameters as a table of ascii text numbers that can be read into any suitable analysis and display package such as ID

7.4 Additional Features

There are a number of additional useful features which are detailed below. These are all intended to provide simple and quick information about the on-going status of the PCA and the HnS information flowing from it.

7.4.1 Late Data Pop-up

In normal real time use new packets are expected from each PCU every 8 seconds. There will/may be long gaps for many reasons but on average data flow should be nearly continuous. Therefore if any packet ApID for the 5 PCU’s, has not arrived after an interval of X * 8 seconds then data is defined as overdue. The value of X is presently 1.5 so any gap greater than 12 seconds, as measured by the clock in the workstation, will result in a pop-up display:

Data Continuity Monitor	
Packet Time (UT)	16:38:56
Last Packet Arrived	14:54:49
Time Now	15:22:27
Elapsed Time	00:27:38

This display automatically disappears when fresh data arrives and reappears when another data gap occurs.

7.4.2 Auto Daily Printout

To help form a log of the performance of the PCU’s on a daily basis a special derivative of the screen printout has been devised. Assuming that the PCA HnS is running then every day at 12:00:00 local time the program will save 5 disc files, one for each of the 5 Full Screens for the PCU’s. The file names will include the date and PCU number so a sequence of files can automatically be created as each will have a unique name. It is intended that these files will be printed on a regular basis and form a quick reference set of PCA performance in book form.

Note: these files will not be saved if the program is not running

7.4.3 Missing Packet Accounting Tool

As development progressed it became clear that the stream of packets arriving at the SOF Ingest machine from PACOR might be far from complete. It was never expected to be complete and indeed the ICD specifically states that completeness is not guaranteed. PCA therefore needed a simple tool to monitor the arriving real time packets.

A sample window is shown below.

Packet Summary	**PCU 1**	**PCU 2**	**PCU 3**	**PCU 4**	**PCU 5**
Duration hh::mm:ss	12:01:10	12:01:10	12:01:10	12:01:10	12:01:10
No. In Order Packets	4191	4190	4201	4200	4191
No. Out Order Packets	10	11	0	1	10
% Out / Total	0.4	0.4	0.4	0.4	0.4

There is also a zero bottom to reset the test.

The duration period shows the interval of time since the last reset was done. Normally the top 2 boxes in each column will be the same.

8.0 Text Display Screens

The most basic form of display for incoming telemetry values is to produce a table that combines ascii legends with their associated parameters which decoded to physical values. A series of "standard screens" have been defined for the PCA experiment and these have been constructed using TAE+ as the GUI. The standard text screens fall into the two groups shown below.

Main individual detector information screens:-

- Full detector information - PCU 1
- Full detector information - PCU 2
- Full detector information - PCU 3
- Full detector information - PCU 4
- Full detector information - PCU 5

Combined text screens for detectors 1 to 5:-

- Detector information summary
- Detector count rates
- Detector discriminator settings
- RIF temperatures
- RIF voltages
- RIF test pulse generator settings
- RIF Diagnostics
- Spacecraft parameters

Each parameter field displayed on the text screens is also an active TAE+ button which can be pressed for some action on that particular parameter. The following "template" screen layouts all assume that additional information such as a heading, UTC time and local time are displayed in some kind of menu bar / header structure that is not defined here. All times shown are Universal Time (UT).

8.1 Full Detector Information Screens (x5)

This detector screen will provide a complete summary "snap shot" of the state of an individual detector. Menu options will select which of the 5 PCU's is displayed and they all have an identical screen appearance. Examples of the parameter fields (possible ranges) can be found in section 8. The x denotes a displayed parameter in the following table. A small group of "selected" spacecraft parameters are also shown on this text page.

DETECTOR INFO		RATES (HRM)		DISCRIMINATORS		TEMPERATURES	
Pr HV cmd	x	L1		L1	x	RIF	x
Pr expected HV (V)	x	R2	x	R1	x	ADC	x

DETECTOR INFO		RATES (HRM)		DISCRIMINATORS		TEMPERATURES	
Pr measured HV (V)	x	L2	x	L2	x	CSA	x
Pr pressure torr	x	R2	x	R2	x	SA	x
Pr HV relay on/off	x	L3	x	L3	x	TPG	x
Pr HV on/off	x	R3	x	R3	x	LVPS	x
Xe HV cmd	x	VP	x	VP	x	HVPS	x
Xe expected HV (V)	x	VX	x	VX	x	S/C Det A1	x
Xe measured HV (V)	x		x	Alpha	x	S/C Det A2	x
Xe pressure torr	x	HRM		VLE window	x	S/C Det B1	x
Xe HV relay on/off	x					S/C Det B2	x
Xe HV on/off	x		x				
LVPS relay on/off	x	RATES	x	TPG		VOLTS	
Select A/B	x	VP vle	x	L1	x	+12V LVPS	x
ADC dither on/off	x	XE vle	x	R1	x	-12V LVPS	x
Override rate veto	x	VX vle	x	L2	x	+6V LVPS	x
HV inhibit - rate veto	x	Alpha	x	R2	x	-6V LVPS	x
Override 1 pps veto	x	2 or more		L3	x	+12V RIF	x
HV inhibit - 1 pps veto	x	XE good		R3	x	-12V RIF	x
Override HRM veto	x		x	VP	x	+5V RIF	x
HV inhibit - HRM veto	x	MET sec	x	VX	x		
HRM Flag	x	MET sub. sec	x	Alpha	x	AMPS	
HRM for last interval	x	Packet Time UT	x	TPG Mode	x	S/C mA A	x
HRM for last 2 intervals	x	Packet Date	x	TPG Enable	x	S/C mA B	x

8.2 Combined Text Screens

There are several types of possible combined text screen which allow easy comparison of selected groups of parameters between all 5 PCU's at the same time. It is possible that the MET time stamp in each PCU packet may be different if data has been lost, arrives out of sequence or arrives late. On the spacecraft all packets built at the same "8 sec mark" contain the same packet time.

8.2.1 Detector Information Summary Screen

These parameters are obtained from several sub addresses and summarize the specific detector setup except for the discriminator settings.

DETECTORS	PCU 1	PCU 2	PCU 3	PCU 4	PCU 5
Pr HV cmd	1100	1100	1100	1100	1100
Pr expected HV (V)	2800.0	2800.0	2800.0	2800.0	2800.0
Pr measured HV (V)	2795.0	2795.0	2795.0	2795.0	2795.0
Pr pressure torr	798.0	798.0	798.0	798.0	798.0
Pr HV relay on/off	ON	ON	ON	ON	ON
Pr HV on/off	ON	ON	ON	ON	ON
Xe HV cmd	1000	1000	1000	1000	1000
Xe expected HV (V)	2050.0	2050.0	2050.0	2050.0	2050.0
Xe measured HV (V)	2048.0	2048.0	2048.0	2048.0	2048.0
Xe pressure torr	845.0	845.0	845.0	845.0	845.0
Xe HV relay on/off	ON	ON	ON	ON	ON
Xe HV on/off	ON	ON	ON	ON	ON
LVPS relay on/off	ON	ON	ON	ON	ON
Select A/B	A	A	A	A	A
ADC dither on/off	ON	ON	ON	ON	ON
Override rate veto	ON	ON	OFF	OFF	OFF
HV inhibit - rate veto	SET	SET	-	SET	SET
Override 1 pps veto	ON	OFF	OFF	OFF	OFF
HV inhibit - 1 pps veto	SET	SET	-	-	SET
Override HRM veto	OFF	ON	OFF	OFF	ON
HV inhibit - HRM veto	SET	-	-	SET	-
HRM Flag	SET	-	-	-	-
HRM for last interval	SET	SET	-	-	-
HRM for last 2 intervals	SET	-	-	-	-
MET Time Stamp (sec)	12345678	12345678	12345678	12345678	12345678
MET sub. sec.	0.424	0.496	0.680	0.744	0.792
Packet Time UT	15:14:00	15:14:00	15:14:00	15:14:00	15:14:00
Packet Date	11/14/94	11/14/94	11/14/94	11/14/94	11/14/94

8.2.2 Detector Count Rates

These will be shown as integers in counts per second so the returned telemetry rates must be divided by 8. The rates shown below are typical background rates. On the brightest source (Sco X-1) the L1 layer might register 40 - 50 thousand per second so the integer fields need a 99999.9 format.

RATES C/SEC	PCU 1	PCU 2	PCU 3	PCU 4	PCU 5
L1	10.0	10.0	10.0	10.0	10.0
R1	10.0	10.0	10.0	10.0	10.0
L2	5.0	5.0	5.0	5.0	5.0
R2	5.0	5.0	5.0	5.0	5.0
L3	5.0	5.0	5.0	5.0	5.0
R3	5.0	5.0	5.0	5.0	5.0
VP	200.0	200.0	200.0	200.0	200.0
VX	200.0	200.0	200.0	200.0	200.0
HRM value	8192.0	8192.0	8192.0	8192.0	8192.0
VP vle	15.0	15.0	15.0	15.0	15.0
XE vle	15.0	15.0	15.0	15.0	15.0
VX vle	20.0	20.0	20.0	20.0	20.0
Alpha	150.0	150.0	150.0	150.0	150.0
2 or more	20.0	20.0	20.0	20.0	20.0
XE good	50.0	50.0	50.0	50.0	50.0
Sequence #	4191	4191	4191	4191	4191
MET Time Stamp (sec)	12345678	12345678	12345678	12345678	12345678
MET sub. sec.	0.424	0.496	0.680	0.744	0.792
Packet Time UT	15:14:00	15:14:00	15:14:00	15:14:00	15:14:00
Packet Date	11/14/94	11/14/94	11/14/94	11/14/94	11/14/94

This rates screen is the only one that displays the Packet Sequence Number (Sequence #). This is a 14 bit counter in the packet header and is shown here as an addition indicator of missing packets. The sequence numbers across all 5 PCU's will normally be the same.

8.2.3 Detector Discriminator Settings

These have 2 bit binary values: 00 = LOW, 01 = MID, 10 = HIGH, 11 = OFF

DISCR.	PCU 1	PCU 2	PCU 3	PCU 4	PCU 5
L1	OFF	OFF	OFF	OFF	OFF
R1	OFF	OFF	OFF	OFF	OFF
L2	HIGH	HIGH	HIGH	HIGH	HIGH
R2	HIGH	HIGH	HIGH	HIGH	HIGH
L3	MID	MID	MID	MID	MID

DISCR.	PCU 1	PCU 2	PCU 3	PCU 4	PCU 5
R3	MID	MID	MID	MID	MID
VP	OFF	OFF	OFF	OFF	OFF
VX	HIGH	HIGH	HIGH	HIGH	HIGH
Alpha	HIGH	HIGH	HIGH	HIGH	HIGH
VLE window	MID	MID	MID	MID	MID
MET Time Stamp (sec)	12345678	12345678	12345678	12345678	12345678
MET sub. sec.	0.424	0.496	0.680	0.744	0.792
Packet Time UT	15:14:00	15:14:00	15:14:00	15:14:00	15:14:00
Packet Date	11/14/94	11/14/94	11/14/94	11/14/94	11/14/94

8.2.4 RIF & Detector Temperatures

These will be shown with a resolution of 0.05 degrees C for the RIF temperatures and 0.1 degrees C for the spacecraft IPSDU monitored detector temperatures.

Temperature C	PCU 1	PCU 2	PCU 3	PCU 4	PCU 5
RIF box	20.05	20.00	20.00	20.00	20.00
ADC box	15.35	15.30	15.30	15.30	15.30
CSA box	-4.35	-4.30	-4.30	-4.30	-4.30
SA box	5.55	5.50	5.50	5.50	5.50
TPG box	2.35	2.30	2.30	2.30	2.30
LVPS box	19.95	19.90	19.90	19.90	19.90
HVPS box	21.55	21.50	21.50	21.50	21.50
S/C Det A1	20.6	20.6	20.6	20.6	20.6
S/C Det A2	19.9	19.9	19.9	19.9	19.9
S/C Det B1	21.5	21.5	21.5	21.5	21.5
S/C Det B2	21.1	21.1	21.1	21.1	21.1
MET Time Stamp (sec)	12345678	12345678	12345678	12345678	12345678
MET sub. sec.	0.424	0.496	0.680	0.744	0.792
Packet Time UT	15:14:00	15:14:00	15:14:00	15:14:00	15:14:00
Packet Date	11/14/94	11/14/94	11/14/94	11/14/94	11/14/94

8.2.5 RIF Voltages

These will all be shown in Volts to a resolution of 5mV except the +5V line which will be shown to 2mV.

Voltages V	PCU 1	PCU 2	PCU 3	PCU 4	PCU 5
+12V LVPS	12.045	12.040	12.040	12.040	12.040
-12V LVPS	-12.035	-12.030	-12.030	-12.030	-12.030
+6 LVPS	5.965	5.960	5.960	5.960	5.960
-6 LVPS	-6.015	-6.010	-6.010	- 6.010	-6.010
+12V RIF	12.045	12.040	12.040	12.040	12.040
-12V RIF	-11.975	-11.970	-11.970	-11.970	-11.970
+5V RIF	5.012	5.014	5.010	5.008	5.010
S/C mA A	350.0	351.0	349.5	350.4	350.2
S/C mA B	349.0	349.5	349.8	349.7	349.9
MET Time Stamp (sec)	12345678	12345678	12345678	12345678	12345678
MET sub. sec.	0.424	0.496	0.680	0.744	0.792
Packet Time UT	15:14:00	15:14:00	15:14:00	15:14:00	15:14:00
Packet Date	11/14/94	11/14/94	11/14/94	11/14/94	11/14/94

8.2.6 RIF Test Pulse Generator Settings

These are simply shown as On or OFF.

TPG	PCU 1	PCU 2	PCU 3	PCU 4	PCU 5
L1	OFF	OFF	OFF	OFF	OFF
R1	ON	ON	ON	ON	ON
L2	OFF	OFF	OFF	OFF	OFF
R2	OFF	OFF	OFF	OFF	OFF
L3	OFF	OFF	OFF	OFF	OFF
R3	OFF	OFF	OFF	OFF	OFF
VP	OFF	OFF	OFF	OFF	OFF
VX	OFF	OFF	OFF	OFF	OFF
Alpha	OFF	OFF	OFF	OFF	OFF
TPG Mode	MONO	RAMP	MONO	MONO	MONO
TPG Enable	ON	OFF	OFF	OFF	OFF
MET Time Stamp (sec)	12345678	12345678	12345678	12345678	12345678
MET sub. sec.	0.424	0.496	0.680	0.744	0.792
Packet Time	15:14:00	15:14:00	15:14:00	15:14:00	15:14:00
Packet Date	11/14/94	11/14/94	11/14/94	11/14/94	11/14/94

8.2.7 RIF Diagnostics

This screen will only be used for monitoring tests on the RIF boxes if a problem is suspected. Refer to section 3.5.1 for further details of parameters.

Diagnostics	PCU 1	PCU 2	PCU 3	PCU 4	PCU 5
rate chip # 1	2334.0	2334.0	2334.0	2334.0	2334.0
selected N chip # 1	Xe L1 *	Xe L1	Xe L1	Xe L1	Xe L1
chip # 1 test bit	1	0	0	0	0
chip # 1 status	Enabled	-	-	-	-
gate control chip # 1	1	1	1	0	1
rate chip # 2	1021.0	1021.0	1021.0	1021/0	1021.0
selected N chip # 2	Xe vle *	Xe vle	Xe vle	Xe vle	Xe vle
chip # 2 test bit	0	1	0	0	0
chip # 2 status	Enabled	-	-	-	-
gate control chip # 2	1	1	1	1	0
clock speed	125 KHz	1 MHz	125 KHz	125 KHz	125 KHz
status select N	5	5	5	5	5
last cmd LS byte	A7	A8	A9	B0	B1
1 pps timeout det.	SET	-	-	-	-
rate r/o timeout det.	-	SET	-	-	-
waiting for 1 pps	-	-	SET	-	-
HRM last rate	-	-	-	SET	-
HRM last 2 rates	-	-	-	-	SET
MET Time Stamp (sec)	12345678	12345678	12345678	12345678	12345678
MET sub. sec.	0.424	0.496	0.680	0.744	0.792
Packet Time UT	15:14:00	15:14:00	15:14:00	15:14:00	15:14:00
Packet Date	11/14/94	11/14/94	11/14/94	11/14/94	11/14/94

* legends for chips #1 and #2 for N (0000 - 0111) are given in section 3.5.2

8.2.8 Spacecraft Parameters - Orbit & Attitude Related

Parameter	Value
ORBIT RELATED	
Latitude (deg0	-11.1
Longitude (deg)	147.3

Parameter	Value
Altitude (km)	600
Earth Eclipse	OUT
SAA	OUT
Mag Field X (nT)	23000
Mag Field Y (nT)	45000
Mag Field Z (nT)	35000
Total Field (nT)	61473
McIlwain L	1.23
Spare	
Spare	
ATTITUDE RELATED	
RA (deg)	123.5
DEC (deg)	-30.3
Boresight - Sun < (deg)	110.1
Boresight - Earth Limb < (deg)	97.3
Slew Flag	NO
On Target Flag	ON
Jitter (arc sec)	3
Attitude Error (arc sec)	0
PA +Y (deg)	+50
Roll Bias (deg)	+5
Spare	

A typical set of screen parameters is shown above.

8.3 Button Functions - Pop Up Window

In addition to providing a display area for a parameter each TAE+ button has a number of other attributes. When a button is pressed a pop up window provides specific information about that parameter. The pop up window displays:

- Red & Yellow limits - if appropriate
- The present value - in its “correct” relative vertical position to the 4 limits to form a kind of “vertical gauge” display
- The conversion parameters - if appropriate
- A button to clear any set limit violation (that parameter only)
- A button to plot a graph of the parameter

8.3.1 Parameters With Limit Checking

For parameters that have limit checking performed:

- A parameter in the RED limits is shown on a red background button

- A parameter in the YELLOW limits is shown on a yellow background button
- Red has priority over Yellow

Once a limit value is exceeded and the button drawn in the appropriate warning color one of two things can happen:

- It can revert to a non limit case if the value goes down
- It could stay "latched" in the warning state until its manually cleared using the pop-up button. There is also a "global" clear limit warnings as a main menu option to clear ALL current limit warnings at the same time

Selection between these the above two modes of operation is made in a main menu selection. Another option allows all limit checking to be disabled. Attempting to do this will result in a cautionary "confirm' prompt to avoid turning this feature off by mistake.

8.3.2 Special Warning Parameters

There is a special small class of parameters which are treated in a similar way to the normal limits but are considered to be more serious.

- A "special parameter" if set (i.e. 1 not 0) produces a pop up box that must be acknowledged to clear it. The program continues running.

At present the identified members of this class are any occurrence of the 3 automatic HV veto in any PCU:

1. rate veto
2. 1 PPS veto
3. HRM veto

8.3.3 Graph Options on Pop-up Menu

The pop-up menu also contains a button to press to start up a strip chart graph of the selected parameter. Once started the graph window will continue until closed even though it is very likely to become hidden behind other display windows.

8.4 Data Export Feature

In the same way that combination graphs can be built up a string of parameters can be specified and given a file name. This set can then easily be referred to and dumped from the ring buffer to an ascii file for use in any external analysis and display program. The first parameter is always the MET by default as this is the only reliable handle on the time span of the data once the exported file is created. Some header information provides the descriptors for the following data.

A desired file layout could look like the following example but for simplicity an earlier version only may be available. This has consecutive strings of each parameter and is not laid out in a tabular form. This is due to difficulties with data across several PCU's.

Parameter 1	2	3	4	5	6
MET	evXEgood PCU 1	evXEgood PCU 2	evXEgood PCU 3	evXEgood PCU 4	evXEgood PCU 5
xxxxxxxx	xxxx.x	xxxx.x	xxxx.x	xxxx.x	xxxx.x
etc.					

8.4.1 Default Data Export Combinations

Some pre-defined standard export options exist but the design allows any combination to be created, saved and used.

No standard export options have been defined. These are left to the user to create.

8.5 Summary of Main Viewing Options

The program is intended to be run in 2 forms:

- Continuous form
- Exploratory form

8.5.1 Continuous Form

The program should be left running so that the ring buffer always contains the latest set of data. This should not be overwritten with data from the Data Base.

The features available are:

1. Text screens update every 8 seconds (per PCU) as each packet comes in.
2. Strip charts continue once started for any parameter selected. Plot period into past can be changed.
3. Combination parameter strip charts can be built and viewed.
4. A “snapshot” of a past update can be selected from the local ring buffer. Buffer length can be changed.
5. Any specified time span from within the ring buffer can be plotted as a static plot.
6. Combination parameters can be selected and saved to disc for “export” as an ascii file.

8.5.2 Exploratory Form

A second instance of the program should be initiated to examine specific aspects of old data from the Data Base.

The features available are:

1. The main SOF Data Base can be accessed and a time span loaded into the ring buffer.
2. All the earlier functions are then available to operate on that buffer.

9.0 Graphics Display Screens

The following tables provide summaries of the parameters available for plotting (main & diagnostic) for a single PCU.

Main Parameter Type	Type of information	No. of parameters
detector count rates + HRM setting	24 bit	15
temperatures	12 bit *	8
voltages	12 bit *	8
detector HV & pressure for Xe & Pr	12 bit *	4
detector HV command for Xe & Pr	4 bit *	2
detector disc. levels	2 bit	10
detector state monitors + dither	1 bit	20
TPG options	1 bit	11
RIF diagnostics	various items see below	18
spacecraft detector temperatures	8 bit	4

* denotes conversion parameters can be applied

The diagnostic parameters also need to be accessible in the same way. Since they will seldom if ever be needed they are detailed in a separate table.

RIF Diagnostics Parameter Type	Type of information	No. of parameters
chip #1 & #2 count rates	24 bit	2
select chip #1 & #2 counter reg. N	4 bit	2
last command	8 bit	1
select N	3 bit	1
status / mode bits	1 bit	12

Items to be plotted can consist of combination of parameters or individual parameters. For simple parameter graphs the item required is selected by pressing its button on the Text Screen display.

9.1 Single Parameter Graphs

Single parameter graphs are drawn with:

- The 4 limit lines drawn horizontally - RED in red & YELLOW in yellow
- The normal trace color to be GREEN
- The trace color to be YELLOW when in the yellow limit zone
- The trace color to be RED when in the red limit zone
- A suitable Y axis legend which defines the parameter
- A suitable Y axis scale indication

9.2 Building Multiple Parameter Graphs

To build graphs containing several parameters (combination graph) some menu options exist:

- identify the start of building a new combination
- “click” on all required parameter items
- close the build operation
- give the combination a name

Combination names can exist as a library and be shown on another selection menu where they can be switched to active or dormant. Dormant graphs are not displayed. Active graphs can run in one of the following modes:

- displaying incoming data as a strip chart
- showing a defined time span from the local history

Time range selection options for plotting will be the same as for single plotting.

9.3 Default Graph Combinations

There are a number of graphs that can be considered to be standard features that would be suitable examples for existing as default combinations.

- The 5 evXEgood (xenon good events) count rates - one for each PCU
- The 5 evVX (xenon veto layer) count rates - one for each PCU
- The 5 propane count rates - one for each PCU

No standard graph combinations have been defined. These are left to the user to create.

10.0 Testing Using the Housekeeping Simulator

The SOC have requested each Instrument Team (IT) to construct a CCSDS packet generator or Housekeeping Simulator for the ApID numbers that they are responsible for. For the PCA experiment this only means the housekeeping data for each PCU and the formats are identical for all of them.

The SOC will incorporate the PCA simulator in their Data Generation program.

10.1 Simulator Development

The Housekeeping Simulator has a development plan that takes it through 4 levels of sophistication:

Level 1 simulator - delivered Jan 93

- Builds full packet structure with headers and counters for all PCU's
- Specifies a few parameters and varies them in a controlled way

Level 2 simulator - delivered June 93

- All parameters simulated
- Most parameters have typical values
- All parameters slightly different in value (except some digital bits) to uniquely identify them for SOC subsystem testing - therefore some combinations are not realistic of a default or flight configuration

Level 3 simulator - delivered 4 / 30 / 94 (Build 3.0)

- PCA Desired Configuration Editor linked to simulator to change commands

Level 4 simulator - delivery due 6 / 30 /94

- Some intelligence added to become a PCA simulator - i.e. HV's off no counts

It was decided at an IT meeting on 6 / 13 / 94 not to continue with PCA simulator development. It become frozen at the Build 3.0 level.

10.2 Canonical FITS Test Data & Test Plan

The SOF decided in mid 1994 to request that the instrument teams (IT) provide a sample set of packets to be:

- Passed through Ingest & SOF systems
- Produce a FITS file using XFF

The IT's were then to carefully inspect the output FITS file and confirm that it matched the expected form and content for the input data packets. Such a pair of approved data & FITS files would then form a "canonical" set. The intension was that the packet data could be re-run at any time and the new FITS file compared with the old. This would be expected to be identical unless some “error” had crept into the SOF code during further development.

PCA have produced a canonical set of data packets for PCU 1 (all PCU’s are equivalent except for the APiD value). This standard set was generated using the Housekeeping Simulator program using the standard default set of parameter values. The test file consists of:

- 10 packets with constant parameter values
- 10 packets with the noise option turned on

The final XFF FITS file was checked using the FDUMP tool in the FTOOLS suite. This produces neat tabular output so that visual comparisons with the input values can be made. It is important that the simulator run generating the test packets uses the same set of conversion parameters as does the PCA accessor when XFF creates the FITS file. Changing some conversion values or moving detector addresses can lead to problems unless the file usage is consistent. Any such change invalidates the option of a simple yes/no file comparison between the new and old FITS files. Also a precise match with the default values in the simulator default file is not possible for any parameter that uses conversion terms (not a simple count or binary value). A match should exists however at about the 1 bit resolution level. All integer or binary values should be identical.

10.3 FITS Test History

The history of the PCA canonical FITS testing is shown in the following table.

Test Date	Comments
11 / 3 / 94	Miss match with conversion files Temperature conversion parameters were old (wrong) Many text changes suggested for FITS header block
7 / 3 / 95	Legend changes had been made but all integers came out wrong as XFF had been updated to conform to FITS standards and did not allow the 24 bit unsigned integers. The PCA accessor needs changing to make them signed integers. Three minor legend changes to make. Also the addition of the packet sequence number into the FITS file.
8 / ** / 95	Final pre-launch test. File verified for regular use.

11.0 Operational Aspects Of The PCA

These are several operational aspects of the PCA that require specific mention.

11.1 Internal Failure Detection

The PCA has very limited internal failure detection capability as the PCU's contain no microprocessor. There is no automatic internal correction ability. There are three failure modes detected independently by each PCU. Each of these is characterized by its parameter changing from 0 to 1 and the concerned PCU high voltage command line going from 1 to 0 so that no X-ray counts are seen. The 0 to 1 change of the inhibit lines is considered to be a move to the upper red limit within the MOC and the SOF PCA housekeeping system.

- rateinh

This occurs when the spacecraft fails to interrogate a PCU RIF unit within 32 - 48 seconds. It should interrogate each PCU every 8 seconds to build housekeeping packets.

- ppsinh

Each RIF unit needs the 1 Hz spacecraft distributed clock pulses in order to accurately align its integration rate sampling. If this 1 Hz is absent for a 2 - 3 second period the inhibit is initiated.

- hrminh

Each PCU monitors 8 internal count rates and compares them with the current value of its HRM threshold. If any of the 8 rates exceeds this limit for 3 consecutive 8 second periods the HRM inhibit is initiated. Over threshold events for only one or two periods can be monitored in the diagnostic part of the housekeeping packet. An HRM trip would normally occur due to:

1. The PCU being on in the SAA (SAA entry command failed or boundary wrong)
2. The target X-ray source being much brighter than expected and the HRM threshold not being raised high enough
3. HV breakdown in a detector

11.2 Instrument Science Data Monitoring

The PCA Housekeeping data contains some count rate information but no spectral data. The rates are monitored by defining a very high yellow and red upper limit (both the same, lower limits are zero). Apart from an observation of Sco X-1 or a very bright transient source no target could approach or exceed these rates so any excursions above the limit will typically indicate HV break down problems.

The following comments apply to the SOF only and cover both the PCA Health & Safety (housekeeping) subsystem and the Science Monitoring subsystem. Full details on the option and features in these programs can be found in the respective user manuals.

11.2.1 Expected Values

It is not possible to define expected values as the targets are very variable.

11.2.2 Rates

It is not possible to define rates as the targets are very variable. The PCA count rates are available in the PCA housekeeping display screens where some graphical capability also exists. These data are only available in 8 second samples. For faster sampling and more detailed examination the PCA/EDS Standard Mode 1 science display options can be used.

11.2.3 Spectra

Interpretation of the spectra requires some experience of X-ray astronomy. Proportional counters produce a characteristic spectral shape which might be defined as:

- a peak at the low energy end
- a higher energy exponential tail
- a fairly smooth profile (consistent with counting statistics) without sharp spikes or holes

The PCA/EDS Standard Mode 2 science display program can be used to integrate up the data to reduce the counting noise and thus more clearly show anomalies.

11.2.4 Background

There is no easy way to access in real time the residual background in the detector unless the PCA is deliberately pointed at a region of blank sky. In this case both the PCA housekeeping display program and the Standard Mode 1 & 2 science displays show aspects of the background rates.

The non-vetoed background rates within the PCU's can be monitored on the PCA housekeeping displays and in options available within the Standard Mode 1 science displays.

11.3 How To Decide If PCA Is Functioning Correctly

This assessment can be taken quite a long way very rapidly but there is always the potential for "low level" effects that only become apparent on detailed examination. Such studies will typical use large amounts of data and be conducted in the GOF (FITS & FTOOLS) environment.

The following applies whether XTE is viewing an x-ray source or not.

Housekeeping Aspects:-

1. Is data present from all PCU's
2. Are the count rates for each PCU in the housekeeping text pages similar
3. Do graphs of the rates look noise free
4. Are any parameters in the limits

Spectral Science Aspects:-

1. Using the Standard Mode 2 displays do the spectra in each layer of each PCU look similar
2. Are the spectral profiles about normal in shape - no spikes or holes
3. Using the Standard Mode 2 displays do the calibration spectra displays for each PCU look acceptable
4. Using the Spectral Science derivatives from Standard Mode 2 do the current PCU gain & offset values produce an acceptable co-aligned summation

Temporal Science Aspects:-

1. Using the Standard Mode 1 displays do the temporal profiles for each PCU look consistent with counting statistics (0.125 sec time sampling)
2. Using the Spectral Science derivatives from Standard Mode 1 do the FFT options reveal any unexpected periodic signatures

12.0 Build Development Goals

To maintain the SOC Build development schedule the following goals have been defined for the PCA Housekeeping Module:

12.1 Build 2 (End to End - 12/31/93)

1. All limits and operations on them in place
2. All conversions and operations on them in place
3. Some form of error alarm (limits) indication
4. Several Text Screens operational (current data & past selection)
5. FITS file generator complete

12.2 Build 3 (Mission Critical - 5/31/94)

1. Dedicated PCA H&S Real Time client established
2. Two (maybe one) orbit ring buffer created
3. ALL text screens operational
4. Single parameter Graphics Screen selection modes operational and linked to Text Screen selection method
5. Interface from Text Screens to warning control & limit value display

12.3 Build 4 (11/31/94)

1. Build of multi-parameter Graphics Screen selection modes
2. Access to packet data base
3. Access to spacecraft telemetry items
4. Export of data

12.4 Build 4.4 (8/4/95)

The “Software Freeze” for PCA HnS took effect on 1st June 1995.

Almost a flight version:

1. Tidy loose ends based on operation performance
2. Complete passage of 5 outstanding DR’s/EDP’s through the CCB system
3. Add 2 “new additions” (a) packet sequence summary table (b) daily printout summary option
4. Then maintenance Only

13.0 Summary of Parameters for each PCU

Command	Function
evL1	event rate xenon layer 1 left
evR1	event rate xenon layer 1 right
evL2	event rate xenon layer 2 left
evR2	event rate xenon layer 2 right
evL3	event rate xenon layer 3 left
evR3	event rate xenon layer 3 right
evVX	event rate xenon veto layer (VX)
evVP	event rate propane layer (VP)
evVPvle	event rate propane layer very large event (VLE)
evXEvle	event rate xenon layer VLE
ev2ormore	event rate 2 or more
evAlpha	event rate Alpha
evVXvle	event rate xenon veto layer VLE
evXEgood	event rate xenon good
dsR2	discriminator level xenon layer 2 right
dsL2	discriminator level xenon layer 2 left
dsR1	discriminator level xenon layer 1 right
dsL1	discriminator level xenon layer 1 left
dsVP	discriminator level propane layer
dsVX	discriminator level xenon veto layer
dsR3	discriminator level xenon layer 3 right
dsL3	discriminator level xenon layer 3 left
ADCdither	ADC dither on/off (1=ON)
dsVle	VLE discriminator level (time window)
dsAlpha	alpha detector discriminator level
tpgR3	test pulse generator on/off Xe layer 3 right
tpgL3	test pulse generator on/off Xe layer 3 left
tpgR2	test pulse generator on/off Xe layer 2 right
tpgL2	test pulse generator on/off Xe layer 2 left
tpgR1	test pulse generator on/off Xe layer 1 right
tpgL1	test pulse generator on/off Xe layer 1 left

Command	Function
tpgAlpha	test pulse generator on/off Alpha
tpgVP	test pulse generator on/off propane layer
tpgVX	test pulse generator on/off Xe veto layer
tpgMode	test pulse generator mode to Ramp or Mono (0=Mono)
tpgEn	test pulse generator enable
cmdhvXE	xenon high voltage setting command value
cmdhvPR	propane high voltage setting command value
plsPRon	propane HV relay ON drive pulse monitor
plsPRoff	propane HV relay OFF drive pulse monitor
plsXEon	xenon HV relay ON drive pulse monitor
plsXEoff	xenon HV relay OFF drive pulse monitor
plslvon	low voltage relay ON drive pulse monitor
plslvoff	low voltage relay OFF drive pulse monitor
hvPRrly	propane HV relay status
hvXErly	xenon HV relay status
lvpsrly	low voltage power supply relay status
hvPRon	status of HV cmd. line to Propane HV supply
hvXEon	status of HV cmd. line to Propane HV supply
selB	side of 1 Hz signal, 0 = A, 1 = B
rateov	override watchdog rate from disabling HVPS
ppsov	override 1 pps watchdog from disabling HVPS
hrmov	override HRM from disabling HVPS
rateinh	HV inhibited due to rate read-out timeout
ppsinh	HV inhibited due to 1 pps timeout
hrminh	HV inhibited due to HRM
hrmflag	state of HRM
hrmval	setting of HRM threshold
tmpspare	spare temperature
tmpRIF	Remote InterFace (RIF) box temperature
tmpADC	Analog Digital Converter (ADC) box temperature
tmpCSA	Charge Sensitive Amp (CSA) box temperature
tmpSA	Shaping Amp (SA) box temperature
tmpTPG	Test Pulse Generator(TPG) box temperature
tmpLVPS	Low Voltage Power Supply (LVPS) box temperature
tmpHVPS	High Voltage Power Supply (HVPS) box temperature

Command	Function
vap12	+12V analog LVPS
vam12	-12V analog LVPS
vap6	+6V analog LVPS
vam6	-6V analog LVPS
vdp12	+12 digital internal RIF
vdm12	-12V digital internal RIF
vdp5	+5V digital internal RIF
vspare	spare voltage
prsXE	xenon gas pressure monitor
prsPR	propane gas pressure monitor
hvXE	xenon HV monitored value
hvPR	propane HV monitored value
c1count	contents of chip #1
c1selN	select chip #1 counter register N (0000-0nnn)
c1testbit	contents of chip #1 test bit (should=0)
c1status	status of counter N of chip #1 (1=enabled)
mckgatec1	status bit for chip #1 (0=single pulse, 1=continuous)
c2count	contents of chip #2
c2selN	select chip #2 counter register N (0000-0nnn)
c2testbit	contents of chip #2 test bit (should=0)
c2status	status of counter N of chip #2 (1=enabled)
mckgatec2	status bit for chip #2 (0=single pulse, 1=continuous
mckspeed	internal clock speed (1=1MHz, 0=125KHz)
mckselect	status word, counter select number N
lastcmd	LS byte of last command received
to1pps	1=1pps timeout condition detected
ptorate	1=rate readout timeout condition detected
waitforpps	1=rec. subadd 26 command, waiting for 1 pps
twohrms	1=high rate for last 2 rate periods
onehrms	1=high rate for last rate period

14.0 Final HV Command Values

The final measured HV command values for the Xenon & Propane sections of each detector (serial number, not addresses) are shown in the following tables:

Xenon:-

PCU No. (slot)		1	2	3	4	5	-1
PCU Ser. No.		005	003	004	001	002	006
N	CMD.						
0	0000	1030.0	991.7	1010.0	1000.8	958.0	1007.4
1	0001	1910.3	1910.0	1906.2	1907.1	1908.2	1911.6
2	0010	1930.1	1929.8	1925.8	1927.0	1927.9	1931.6
3	0011	1950.1	1949.8	1945.9	1947.0	1947.9	1951.4
4	0100	1970.2	1969.7	1965.9	1967.0	1967.8	1971.7
5	0101	1990.2	1989.5	1985.9	1987.1	1987.8	1991.8
6	0110	2010.0	2009.5	2005.7	2006.8	2007.4	2011.5
7	0111	2030.0	2029.5	2025.7	2026.9	2027.3	2031.6
8	1000	2050.8	2050.3	2046.5	2047.5	2048.0	2052.5
9	1001	2070.9	2070.4	2066.5	2067.6	2068.0	2072.6
10	1010	2090.7	2090.0	2086.2	2087.3	2087.6	2092.4
11	1011	2110.7	2110.2	2106.2	2107.4	2107.5	2112.5
12	1100	2130.8	2130.0	2125.8	2127.4	2127.4	2132.5
13	1101	2150.5	2150.0	2145.9	2147.4	2147.3	2152.6
14	1110	2170.6	2170.0	2165.5	2167.1	2167.0	2172.4
15	1111	2190.5	2189.8	2185.6	2187.1	2187.0	2192.2

Propane:-

PCU No. (slot)		1	2	3	4	5	-1
PCU Ser. No.		005	003	004	001	002	006
N	CMD.						
0	0000	1433.3	1483.5	1450.7	1482.8	1430.0	1477.6
1	0001	2573.6	2575.4	2571.6	2578.3	2578.9	2573.6
2	0010	2593.0	2595.2	2591.6	2598.1	2598.7	2593.5
3	0011	2613.0	2615.2	2611.8	2618.2	2618.7	2613.7
4	0100	2632.9	2635.1	2631.6	2638.0	2638.6	2633.5
5	0101	2652.8	2655.0	2651.9	2658.1	2658.6	2653.4
6	0110	2673.0	2674.8	2671.4	2677.8	2678.3	2673.0
7	0111	2692.4	2694.8	2691.4	2697.8	2698.4	2693.1

PCU No. (slot)		1	2	3	4	5	-1
PCU Ser. No.		005	003	004	001	002	006
N	CMD.						
8	1000	2713.1	2715.4	2712.0	2718.5	2719.0	2714.1
9	1001	2733.0	2735.4	2732.0	2738.5	2739.0	2734.0
10	1010	2752.6	2755.1	2751.7	2758.2	2758.7	2753.8
11	1011	2772.6	2775.1	2771.7	2778.2	2778.7	2773.6
12	1100	2792.4	2795.0	2791.6	2798.1	2798.6	2793.5
13	1101	2812.3	2814.9	2811.6	2818.1	2818.7	2813.5
14	1110	2832.0	2834.6	2831.3	2837.8	2838.4	2833.1
15	1111	2851.9	2854.6	2851.3	2857.9	2858.4	2852.9

15.0 Final Measured VLE Window Values

Each detector has discrete resistors which define the exact duration of the Very Large Event (VLE) window. The nominal values given earlier in the text have been precisely measured during the final calibration activities before delivery to the spacecraft. The VLE settings have the following durations in micro seconds:

PCU No. (slot)	1	2	3	4	5	-1
PCU Ser. No.	005	003	004	001	002	006
CMD.						
00	12.1	11.9	11.67	12.47	12.25	12.21
01	62.5	60.3	62.7	62.95	57.7	60.18
10	143.7	143.0	140.75	144.0	137.0	149.9
11	546.0	540.0	526.6	519.4	496.0	561.4

16.0 Detector Thermistor Look-up table

Each of the 5 detectors has 4 thermistors which provide temperature readings that are returned in the spacecraft telemetry packets as 8 bit numbers in the range 0 - 255. On the ground these raw values are converted to real temperatures in degrees C using the following look-up table. Value 0 = 141.7 and value 255 = -42.1

141.7	138.8	136.0	133.3	130.7	128.1	125.6	123.1
120.7	118.4	116.2	114.0	111.8	109.7	107.7	105.7
103.8	101.9	100.1	98.3	96.5	94.8	93.2	91.6
90.0	88.5	87.0	85.6	84.2	82.8	81.5	80.2
79.0	77.8	76.6	75.4	74.3	73.2	72.1	71.1
70.0	69.0	68.1	67.1	66.2	65.3	64.5	63.6
62.8	62.0	61.2	60.4	59.7	58.9	58.2	57.5
56.8	56.2	55.5	54.9	54.2	53.6	53.0	52.4
51.9	51.3	50.7	50.2	49.7	49.1	48.6	48.1
47.6	47.1	46.6	46.2	45.7	45.2	44.8	44.3
43.9	43.4	43.0	42.6	42.1	41.7	41.3	40.9
40.5	40.1	39.6	39.2	38.8	38.5	38.1	37.7
37.3	36.9	36.5	36.1	35.7	35.4	35.0	34.6
34.2	33.9	33.5	33.1	32.7	32.4	32.0	31.6
31.2	30.9	30.5	30.1	29.8	29.4	29.0	28.7
28.3	27.9	27.6	27.2	26.8	26.5	26.1	25.8
25.4	25.0	24.7	24.3	23.9	23.6	23.2	22.8
22.5	22.1	21.8	21.4	21.0	20.7	20.3	20.0
19.6	19.2	18.9	18.5	18.2	17.8	17.5	17.1
16.7	16.4	16.0	15.7	15.3	15.0	14.6	14.3
13.9	13.6	13.2	12.9	12.5	12.2	11.8	11.5
11.1	10.8	10.5	10.1	9.8	9.4	9.1	8.7
8.4	8.0	7.7	7.3	7.0	6.6	6.3	5.9
5.6	5.2	4.9	4.5	4.1	3.8	3.4	3.1
2.7	2.3	1.9	1.6	1.2	0.8	0.4	0.0
-0.4	-0.8	-1.2	-1.6	-2.0	-2.4	-2.9	-3.3
-3.8	-4.2	-4.7	-5.1	-5.6	-6.1	-6.6	-7.1
-7.6	-8.1	-8.7	-9.2	-9.8	-10.4	-10.9	-11.5
-12.2	-12.8	-13.4	-14.1	-14.8	-15.5	-16.2	-16.9
-17.7	-18.5	-19.2	-20.1	-20.9	-21.8	-22.6	-23.6
-24.5	-25.4	-26.4	-27.4	-28.5	-29.6	-30.7	-31.8
-33.0	-34.2	-35.4	-36.7	-38.0	-39.3	-40.7	-42.1

17.0 Detector Address / Serial No Relationship

Six detectors have been built and each one carries a serial number (001 - 006). Only five PCU's will fly and the relationship between their numbers and the XTE wiring loom address slots (to the EDS) has varied with time. The table below forms a record of the major changes.

The values in the table body are the PCU serial numbers (001 - 006).

		PCU No. (slot)				
Date	**Test**	**1**	**2**	**3**	**4**	**5**
March 94	1st Hard Line Data Flow	-	-	5	3	2
6 / 22 - 6 / 29	Science Performance Test	6	1	5	3	2
7 / 10 - 7 / 12	2ndt Hard Line Data Flow	6	1	5	3	2
9 / 14 - 9 / 15	1st End to End	6	-	5	3	2
10 / 11 - 10 / 14	Comprehensive Test - side A	4	1	5	3	2
10 / 31 - 11 / 4	Comprehensive Test - side B	4	1	6	3	2
Feb 95	2nd End to End	6	3	4	1	5
March 13th	Mission Sim 1 - block 1	6	3	4	1	5
March 17th	Mission Sim 1 - block 2	6	3	4	1	5
March 20th	Mission Sim 1 - block 3	6	3	4	1	5
March 23rd	Mission Sim 1 - block 4	6	3	4	1	5
March 30th	Mission Sim 1 - block 5	6	3	4	1	5
April 22-25	Mission Sim 2	6	3	4	1	2
May 16 - 18	Mission Sim 3	6	3	4	1	2
July 18 - 19	Mission Sim 4	5	3	4	1	2
Sept 25/26	Mission Sim 5	5	3	4	1	2
Dec 10th	Launch	5	3	4	1	2

18.0 Notes