PCA Commands - Types, Sequences, Use, Configurations, Screen Functions, Verification, SOC Interface

XTE-PCA Software Module

PCA-CMD-EXP-V6.1

Build 4.5.3

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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 these deliverables 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 COMMANDING which encompasses the following areas:

- Configuration Editor
- Desired Configuration
- Measured Configuration
- Predicted Configuration
- Verification (Measured matches Predicted)

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.

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APPENDIX

PCA Macro & RTS Library Summary

IOC Plan (days 3-7) & STOL Procedures

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 commanding of the PCA experiment. It also examines the issues relating to the verification of the predicted configuration against the measured configuration.

1.1 Document History

Earlier releases of this document are tabulated below.

Version No.	Date
1.0	4 / 6 / 93
1.1	4 / 22 / 93
2.0	9 / 21 / 93
3.0	1 / 21 / 94
4.0	6 / 18 / 94
5.0	11 / 22 / 94
6.0	8 / 9 / 95
6.1	this version

1.2 Document Organization

Section 2 - describes the details of the CCSDS uplink packets.

Section 3 - describes in detail all the commands that can be sent to an individual PCU detector.

Section 4 - summarizes in a table the detector commands given in section 3 and also provides a summary table of the defaults on power up or following a reset command.

Section 5 - examines the constraints and allowed combinations of the command bits for a single detector. Some combination are not allowed and other are not sensible.

Section 6 - examines spacecraft command issues

Section 7 - describes how configurations are built and turned into useful command sequences and libraries

Section 8 - examines how time information is added to time independent configurations. The various command methods for the SOC & MOC are outlined

Section 9- examines the definitions and verification of PCA configurations

Section 10 - provides information on the commanding requirements for the in-orbit check out period and for routine operations

Section 11 - outlines a simple development plan

Section 12 - summary of commands

Section 13 - unresolved issues

1.3 Relevant Documents

Specific PCA Documents:-

PCA Instrument Commanding: Design Guide, PCA-CMD-DES-V4.0, Vikram Savkoor, August, 1995

PCA Instrument Commanding: Users Guide, PCA-CMD-MAN-V4.0, Vikram Savkoor, October 14, 1994

PCA Configuration Monitor: Measured and Predicted Configuration Design Document, PCA-CON-DES-V4.0, Vikram Savkoor, August, 1995

PCA Housekeeping Telemetry Simulator for PCA and SOC Software Testing, PCA-SIM-MAN-V5.0, Barry Giles & Vikram Savkoor, November 22, 1994

PCA Macro Library, Barry Giles, Juli Lander & Ed Lander, August, 1995

XTE Instrument Operations Users Guide, V 1.0, May, 1995

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 Housekeeping - Status, Use, Screen Functions, Recall Modes, SOC interface, PCA-HK-EXP-V6.1, 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

Relevant 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

Command Generation Public Interfaces - Leon Herreid, XTE SOC, March 26, 1993.

2.0 Uplink CCSDS Packet Structure

The format of the commands to each detector in the PCA is identical but they cannot be mixed within the same CCSDS packet. Each detector has its own destination address or APid number and all commands within the packet are for the same APid.

The CCSDS command packets do not contain any timing information. The various types of ways in which time is added are discussed in a later section.

2.1 PCU Command CCSDS Packet Structure

Each command packet has an Application Data field following the Primary and Secondary Headers. The headers take 8 bytes and since every 8 bit command has an 8 bit mask field (even if not used) the total packet length is always an even number of bytes. Most of the uplink commands consist of a single word although some commands do use several words. The details of these commands are given in the following sections.

Part	Contents	Length words	Length bytes
1	CCSDS Header	4	8
2	Applications Data	<=28	<=56
		Total:	<=64

- The applications data field of each CCSDS command packet contains a command with one to three 16 bit words for a single sub address within a single detector
- The total length of the packet must be less than or equal to 64 bytes
- The total length must be an even number of bytes
- All commands must be separated by a minimum of 31.25 milliseconds

2.2 CCSDS Uplink 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 occupies a further word (2 bytes). The secondary header contains a function code which is used to select the sub address to which the data is to be sent.

Word	Bits	Mnemonic	Contents
1	15 - 13	vernum	Version number
1	12	upordown	Type (0 for downlink)

Word	Bits	Mnemonic	Contents
1	11	secheader	Secondary header flag (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 *
4	15	reserved1	Reserved bit
4	14 - 8	functcode	Function code
4	7 - 0	checksum	Check Sum

* The packet length is defined as:

applications data + secondary header - 1 (in bytes)

The packet header information is translated by the spacecraft flight software to a Mil-Std-1773 Remote Terminal Address and sub address for the command word to be delivered to.

It has been agreed with the Mission Operation Center (MOC) that the sequence count will not be used for uplink command packets. It will be set to zero

2.3 Detector Uplink APid Values

The APid numbers for each PCU are:

PCU	APid Number
1	52
2	53
3	54
4	55
5	56

Note that these are different to the downlink housekeeping PCU APid numbers (90-94).

2.4 Function Code / Sub Address Values

Individual CCSDS command packets are directed towards a particular PCU by the APid value in the header. The sub address the commands are intended for is specified by a number placed in the Function Code space in the header and the same Function Codes are used for all five detectors. The table below relates the function codes to the sub addresses.

Function	Sub Address	Function Code	Word Count	Packet Length
Disc. setting	16	1	1	3
Disc. setting	17	2	1	3
Disc. setting	18	3	1	3
TPG control	19	4	1	3
TPG control	20	5	1	3
HV control	21	6	1	3
HV control	22	7	1	3
HV Overrides	23	8	1	3
Relay control	24	9	1	3
HRM setting	25	10	2	5
LRC	26	11	1	3
Reset RIF	28	12	1	3
RIF Diagnostics	29	13	3	7

Since each command packet can only contain commands to a single sub address of a single PCU it only contains one command word (plus mask bits). This command word may change one, several or all of its contained sub-command bit fields.

2.5 Command Packet Header Checksum

The checksum in the packet header will be calculated and inserted in the packets by the SOF (SOC) section of the Command Generation subsystem. This checksum will be re-verified at a later stage by the MOC when they receive complete binary command sequences from the SOC.

2.5.1 Checksum Definition

There has been some ambiguity in the definition of the checksum in previous documents. The following definition has been adopted:

Start with the first byte of the Primary Header and XOR successive bytes (skipping the checksum space) through the Primary & Secondary Headers and also the application data field. Take the final bytes and invert it so that 1's become 0's and 0's become 1's (ones compliment). Insert this final byte in the checksum space.

3.0 PCA Detector Commands

Each detector in the PCA has relatively few commands and these can be sorted into several functional groups. The details for these commands are shown below. A summary of the commands is given at the end of the section. The system allows multiple command changes within a single command word.

At power up or following a RIF reset command the PCA experiment is set to default conditions which are detailed below.

3.1 Command Mask Bits

All commands to a detector consist of 16 bit words. The 8 bit command data field (bits 7-0) is preceded by an 8 bit mask field (bits 15-8). The corresponding mask bit must be set to one to allow a command data bit to take effect. For mask bits set to zero the corresponding data bits within the Remote Interface Unit (RIF) box retain their current values i.e. nothing actually changes. Mask bit 15 corresponds to data bit 7 etc.

Most commands require the mask bit section but commands to sub address 24, 25 and 26 do not. Some parts of commands to sub address 29 require mask bits.

3.2 Discriminator Settings

Each of the 9 independent anode chains in each detector has an individual lower level pulse height discriminator adjustment. Each discriminator can be set to one of 4 possible values using a 2 bit section of the command word. The commands are

Command	Disc levels	VLE time window
00	LOW	SHORT ~ 12 usec
01	MED - default	MED ~ 60 usec
10	HIGH	LONG ~ 150 usec - default
11	OFF	V. LONG ~ 550 usec

Selecting a command code of 11 switches all signals from an individual anode OFF (not applicable for VLE and Dither).

3.2.1 RIF Sub Address 16

The sub address 16 command controls the ADC discriminator settings for layers 1 and 2 of the detector. The command bit structure is given in the following table.

Bit	Mnemonic	Parameter
15 - 8	-	Mask bits (4 x 2)
7, 6	cmddsR2	Layer 2 Right
5, 4	cmddsL2	Layer 2 Left
3, 2	cmddsR1	Layer 1 Right
1, 0	cmddsL1	Layer 1 Left

3.2.2 RIF Sub Address 17

The sub address 17 command controls the ADC discriminator settings for layer 3 of the detector and also for the VX and VP signals. The command bit structure is given in the following table.

Bit	Mnemonic	Parameter
15 - 8	-	Mask bits (4 x 2)
7,6	cmddsVP	Vpropane
5,4	cmddsVX	Vxenon
3,2	cmddsR3	Layer 3 Right
1,0	cmddsL3	Layer 3 Left

3.2.3 RIF Sub Address 18

The sub address 18 command controls the Alpha calibration detector ADC discriminator setting and toggles the ADC dither on/off for all PHA measurements. It also allows adjustment of the time interval of rejection applied after the detection of a Very Large Event (VLE) pulse. This could be considered as a ‘horizontal’ time discriminator. The dither circuit is a device to smooth out the non-uniformity in the ADC channels. The dither circuit is active when set to ‘1’ so its default is on. The command bit structure is given in the following table and bits 5, 6 and 7 are not used.

Bit	Mnemonic	Parameter
15 - 13	-	zero
12 - 8	-	Mask bits (1 + 2 x 2)
7 - 5	-	zero
4	cmdADCdither	Dither on/off
3,2	cmddsVLE	VLE disc. window
1,0	cmddsAlpha	Alpha det. disc. level

3.3 Test Pulse Generator (TPG) Control

Each detector has a built in 1KHz test pulse generator that can operate in a ramp or mono (multi-line) mode. The output of this generator can be directed into any one of the 9 independent anode signal chains for calibration purposes.

3.3.1 RIF Sub Address 19

The sub address 19 command directs the pulse generator signal to one of the six main xenon anode chains. A particular TPG input is activated by setting its bit to a ‘1’. The default TPG signal state is OFF. The command bit structure is given in the following table.

Bit	Mnemonic	Parameter
15 - 14	-	zero
13 - 8	-	Mask bits (6 x 1)
7 - 6	-	zero
5	cmdtpgR3	R3 TPG on/off
4	cmdtpgL3	L3 TPG on/off
3	cmdtpgR2	R2 TPG on/off
2	cmdtpgL2	L2 TPG on/off
1	cmdtpgR1	R1 TPG on/off
0	cmdtpgL1	L1 TPG on/off

3.3.2 RIF Sub Address 20

The sub address 20 command directs the pulse generator signal to the Alpha (AL), Veto Propane (VP) or Veto Xenon (VX) amplifiers. The TPG mode bit sets up a ramp profile from the pulse generator when set to ‘1’ or when set to ‘0’ a spectrum containing 14-16 roughly evenly spaced mono-energetic lines. Only perhaps 14 lines may eventually be visible as the other may be placed above the upper limit of the PHA to allow testing of the large pulse (VLE) feature. A particular TPG is activated by setting its bit to a ‘1’. The Enable TPG must also be set to ‘1’ for this and the proceeding sub address or the pulses to the selected anode chain will be inhibited. The default TPG mode is the Mono Mode and the default TPG signal state is OFF. The command bit structure is given in the following table.

Bit	Mnemonic	Parameter
15 - 13	-	zero
12 - 8	-	Mask bits (5 x 1)
7 - 5	-	zero

Bit	Mnemonic	Parameter
4	cmdtpgAlpha	Alpha TPG on/off
3	cmdtpgVP	VP TPG on/off
2	cmdtpgVX	VX TPG on/off
1	cmdtpgMode	TPG Ramp or Mono mode
0	cmdtpgEn	Enable TPG

3.4 High Voltage (HV) Control

The Xenon and Propane sections of each detector have separate high voltage supply units and each one can be set to 16 pre-defined voltages with “0000” representing the lowest and “1111” the highest setting. The lowest setting of “0000” corresponds to a very low voltage that is approximately 1000V below the nominal operating range. This is used during passages through the South Atlantic Anomally (SAA) to prevent accumulated damage to the detectors due to electron multiplication in this high radiation zone of the orbit.

In addition each HV unit can be commanded on or off. When either command cmdHVPRstate or cmdHVXEstate is sent the 3 overrides (1 pps, rates readout and HRM) are also reset to prevent any existing state from immediately turning the HV off again.

3.4.1 RIF Sub Address 21

The sub address 21 command controls the high voltage to the Propane section of a detector. The default HV state is off and the default HV command is ‘0000’. The command bit structure is given in the following table.

Bit	Mnemonic	Parameter
15 - 13	-	zero
12 - 8	-	Mask bits (1 + 4)
7 - 5	-	zero
4	cmdhvPRstate	Propane HV on/off
3-0	cmdhvPRvalue	Propane HV command

The nominal operating setting is cmd 1100 (12) at 2800 volts.

3.4.2 RIF Sub Address 22

The sub address 22 command controls the high voltage to the Xenon section of a detector. The default HV state is off and the default HV command is ‘0000’. The command bit structure is given in the following table.

Bit	Mnemonic	Parameter
15 - 13	-	zero
12 - 8	-	Mask bits (1 + 4)
7 - 5	-	zero
4	cmdhvXEstate	Xenon HV on/off
3-0	cmdhvXEvalue	Xenon HV command

The nominal operating setting is cmd 1000 (8) at 2050 volts.

3.5 Override Options & 1 Hz Timing Pulse

There are a number of conditions that must be monitored within each detector to ensure its safely by switching off the high voltage should various situations occur. Override options can be used for each of these conditions to prevent the HV being turned off. There are 3 types of rate monitoring or watchdog devices within each detectors Remote Interface Unit (RIF) electronics.

- Rate Readout Watchdog - Triggers if the Spacecraft Data System (SDS) does not readout the RIF rates after 32-48 seconds (should be every 8 seconds)
- 1 Pulse Per Second (PPS) Watchdog - Triggers if a 1 PPS pulse is not detected after ~2-3 seconds (should be a pulse every second)
- High Rate Monitor (HRM) - Triggers if any combination of the monitored rates (L1, R1, L2, R2, L3, R3, VX, VP) exceeds the HRM setting for three consecutive eight second readings (24 seconds)

3.5.1 RIF Sub Address 23

The sub address 23 command controls various override options to inhibit possible disabling event signals from automatically switching a detector off. The overrides are active when set to ‘1’ and the defaults are inactive. The “B” side 1 Hz signal is selected when Bit 0 is set to ‘1’. The default is the “A” side. The command bit structure is given in the following table.

Bit	Mnemonic	Parameter
15 - 12	-	zero
11 - 8	-	Mask bits (4 x 1)
7 - 4	-	zero
3	cmdrateov	Override Rate Read-out Watchdog
2	cmdppsov	Override 1 PPS Watchdog
1	cmdhrmov	Override HRM
0	cmdselB	Select “B” side 1 Hz

3.6 Relay Controls (ON / OFF)

The xenon and propane high voltages and the general low voltage power supplies for each detector can be completely turned on or off by command. These operations are performed by switching relays that require the on and off pulses to be supplied to separate lines.

3.6.1 RIF Sub Address 24

The sub address 24 command controls pulses to three relays to turn them on or off. The three relay functions are:

- Propane High Voltage Power Supply (HVPR) on/off
- Xenon High Voltage Power Supply (HVXE) on/off
- Low Voltage Power Supply (LVPS) on/off

The default status of all relays is off so the ‘off’ monitor lines would be set to 1. The command bit structure is given in the following table.

Bit	Mnemonic	Parameter
15 - 6	-	zero
5	cmdhvPRrlyon	Set Propane HVPS Relay ON
4	cmdhvPRrlyoff	Set Propane HVPS Relay OFF
3	cmdhvXErlyon	Set Xenon HVPS Relay ON
2	cmdhvXErlyoff	Set Xenon HVPS Relay OFF
1	cmdlvpsrlyon	Set LVPS Relay ON
0	cmdlvpsrlyoff	Set LVPS Relay OFF

These commands have NO mask bits since each has separate on/off bits. For each relay 10 & 01 commands are legal and 00 does nothing. The outcome of a 11 combination is undefined so should not be used and the PCA Command Editor prevents this.

3.7 High Rate Monitor (HRM)

The HRM threshold can be set by command for each detector although in practice all detectors would normally have the same threshold value. The commanded value is a 24 bit integer and represents the total count over an 8 second period. On power up the HRM is loaded with 65536 (equivalent to 8192 events / s) and will be active as its override is not inhibited. The HRM is compared with the rates from 8 signal anode chains within each detector. Every detector has its own HRM system and they are not interconnected. The changed HRM value is detected in the telemetry by the PCA HnS program which then adjusts the upper Yellow (HRM * 0.75) and upper Red (HRM * 1.0) limit values.

3.7.1 RIF Sub Address 25

The sub address 25 command sets the contents of the High Rate Monitor (HRM). This is sent as two 16 bit words without the use of mask bits.

Bit	Mnemonic	Parameter
31 - 24	-	zero
23 - 0	cmdhrmval	24 bit high rate monitor value

The HRM will be specified in c/sec for menu input and then multiplied by 8 for internal code use.

3.8 Latch Rate Counters

There are 14 rates that are monitored and output by the RIF. These are normally read at regular intervals of 8 seconds by the space craft but can be read at other times by the use of this command. The rate counters are actually latched by the following 1Hz pulse.

This command will not normally be sent but is retained for possible test purposes.

3.8.1 RIF Sub Address 26

The sub address 25 command latches the rate counters on the following 1 Hz pulse. This is sent as one ‘all zero’ word without the use of mask bits.

Bit	Mnemonic	Parameter
15 - 0	cmdLRC	all zero

3.9 Reset RIF Sub System

This is a ‘one shot’ command to reset all the conditions in the RIF box. It is the equivalent of a low voltage relay on command (cmdLVPSon) but avoids actual power switching.

Selecting this command produces a warning since all commandable parameters revert to their default states.

3.9.1 RIF Sub Address 28

The sub address 28 command resets the RIF box. This is sent as one ‘all zero’ word without the use of mask bits.

Bit	Mnemonic	Parameter
15 - 0	cmdResetRIF	all zero

3.10 PCU Diagnostic Commands

The RIF digital board contains two rate event counter chips (#1 & #2). Each chip has eight 24 bit counters, each with a dedicated buffer register for simplified rate sampling. In order to readout a counter it must be selected and then transferred to a chips output data register. Data can be read back by the spacecraft using "transmit commands" to either sub addresses 16 (chip #1), 17 (chip #2), or 29.(diagnostic

There are three possible uses for this diagnostic command:

- a diagnostic command for hardware verification
- a counter trouble shooting tool
- a backup means of controlling rate readout if a failure in the 1 pps signal occurs

The first two words define commands for none, one, or both of the counter chips. Typically the first word is used to select a particular counter and the second transfers it to the output data register for read back. In general, either can be used for any of the counter commands listed below. The specified counter command is issued to one or both of the chips depending on the states of bits 7 and 6.

The third word controls an on-board clock stimulus that can be applied to none, one, or both of the chips. The stimulus can be continuous (at 1MHz or 125KHz) or as a single count pulse. Any rates generated internally with this stimulus are summed with prevailing external PCU detector rates (no counts if the HV's are off).

3.10.1 RIF Sub Address 29

The sub address 29 command is sent as a group of three 16 bit words. Only bits 5-0 of the third word have mask bits. Bits 7 and 6 do not.

Word	Bit	Mnemonic	Parameter
0	15 - 8	-	zero
0	7	cmd1SEL17	Select sub add 17 to receive command #1
0	6	cmd1SEL16	Select sub add 16 to receive command #1
0	5 - 0	cmd1Counter	Counter command #1 (see below)
1	15 - 8	-	zero
1	7	cmd2SEL17	Select sub add 17 to receive command #2
1	6	cmd2SEL16	Select sub add 16 to receive command #2
1	5 - 0	cmd2Counter	Counter command #2 (see below)
2	15 - 14	-	zero
2	13 - 8	-	Mask bits (5 - 0 below)
2	7	cmdMCK17	1 = inc. counter MCKSEL on chip #2 (SEL17) if MCKGATE17 = 0 (No mask bit)
2	6	cmdMCK16	1 = inc. counter MCKSEL on chip #1 (SEL16) if MCKGATE16 = 0 (No mask bit)
2	5	cmdMCKSPEED	1 = 1 MHz, 0 = 125 KHz

Word	Bit	Mnemonic	Parameter
2	4	cmdMCKGATE17	1 = cont. clock for chip #2 (SEL17) 0 = single pulse mode
2	3	cmdMCKGATE16	1 = cont. clock for chip #1 (SEL16) 0 = single pulse mode
2	2 - 0	cmdMCKSEL	select counter N (0-7) for counting

On the actual Command Generation menus these mnemonics, which originate from the engineering design stage, have been given slightly more meaningful names. These are tabulated below in a similar layout to that of the actual diagnostics command menu.

Mnemonic	Chip #1	Mnemonic	Chip #2
cmd1SEL16	Command #1 on/off	cmd1SEL17	Command #1on/off
cmd2SEL16	Command #2 on/off	cmd2SEL17	Command #2 on/off
cmdMCK16	Increment yes/no	cmdMCK17	Increment yes/no
cmdMCKGATE16	Mode single/cont.	cmdMCKGATE17	Mode single/cont.
cmdMCKSPEED	Clock Rate	-	(same clock rate)
cmdMCKSEL	Counter N=0-7	-	(same N value)
cmd1Counter	Command #1	-	(same for chip #1)
cmd2Counter	Command #2	-	(same for chip #2)

3.10.2 Internal Counter Commands Chips #1 and #2

The two 6 bit counter commands in the previous table provide a series of options to control the operation of the counter chips. The commands are:

Command Value	Function
000000	init chip control logic (N set to 0)
110nnn (see below)	select counter ‘nnn’ (N) for subsequent commands
010000	reset counter N
010100	latch counter N to its buffer register
011000	enable counter N
011100	disable counter N
100001	transfer counter N to output data register
010001	reset all counters
010111	latch all counters to buffers

Command Value	Function
011011	enable all counters
011111	dissable all counters

3.10.3 Internal Select ‘N’ Codes Chips #1 and #2

The Select ‘N’ codes for the two chips are given in the following table.

N	CHIP #1 Contents	CHIP #2 Contents
0	Xenon L1	Propane large event VPVLE
1	Xenon R1	Xenon large event XEVLE
2	Xenon L2	2 or more
3	Xenon R2	ALPHA
4	Xenon L3	Xenon veto vle VXVLE
5	Xenon R3	Xenon good XEGOOD
6	Xenon veto VX	unused
7	Propane VP	unused

4.0 Summary of all PCA Commands & Defaults

There are a total of 39 commands that can be sent to each detector and these are summarized below. The related default conditions after power on or RESET RIF command are also summarized in the following table.

4.1 Main PCA Command Set

The full range of commands that can be sent to each detector can conveniently be summarized into ADC, TPG or HV related or in a general group labeled as others.

ADC related	ADC Defaults
cmddsL1	01 (MID)
cmddsR1	01
cmddsL2	01
cmddsR2	01
cmddsL3	01
cmddsR3	01
cmddsVP	01
cmddsVX	01
cmddsAlpha	01
cmddsVLE	10 (150 us)
cmdADCdither	1 (ON)

TPG related	TPG Defaults
cmdtpgL1	0 (OFF)
cmdtpgR1	0 (OFF)
cmdtpgL2	0 (OFF)
cmdtpgR2	0 (OFF)
cmdtpgL3	0 (OFF)
cmdtpgR3	0 (OFF)
cmdtpgVP	0 (OFF)
cmdtpgVX	0 (OFF)
cmdtpgAlpha	0 (OFF)
cmdtpgMode	0 (Mono)
cmdtpgEn	0 (OFF)

HV related	HV Defaults
cmdhvPRvalue	0000 (max 1111)
cmdhvPRstate	0 (OFF)
cmdhvPRrlyon	0 (OFF *)
cmdhvPRrlyoff	1 (OFF *)
cmdhvXEvalue	0000 (max 1111)
cmdhvXEstate	0 (OFF)
cmdhvXErlyon	0 (OFF *)
cmdhvXErlyoff	1 (OFF *)

Others	Others Defaults
cmdrateov	0 (inhibit active)
cmdppsov	0 (inhibit active)
cmdhrmov	0 (inhibit active)
cmdlvpsrlton	0 (OFF *)
cmdlvpsrlyoff	1 (OFF *)
cmdselB	0 (side A active)
cmdhrmvalue	65536
cmdLRC	no status returned
cmdResetRIF	no status returned

* Each of the 3 relays has separate ON/OFF control signals but only a single bit having a state 0 or 1 in the returned housekeeping telemetry.

4.2 Diagnostic Command Set

The set of diagnostic commands are presented here as a separate group as they do not form part of routine use. In reality the start-up situation of the diagnostic commands is not important other than the fact that “zeros” are present as shown in the lower part of the following table. This ensures that the diagnostic mode cannot interfere with normal operation following power up or RIF reset.

Command	Diagnostic Defaults
cmd1SEL17	Undefined
cmd1SEL16	Undefined
cmd1Counter	Undefined
cmd2SEL17	Undefined
cmd2SEL16	Undefined
cmd2Counter	Undefined
cmdMCK17	0 - don’t increment counter
cmdMCK16	0 - don’t increment counter
cmdMCKSPEED	0 - 125 KHz
cmdMCKGATE17	0 - single pulse mode
cmdMCKGATE16	0 - single pulse mode
cmdMCKSEL	0 - Xenon L1 & Vp VLE

4.3 Diagnostic Operating Modes

The are several ways in which the diagnostic command options can be used.

4.3.1 Normal - No Diagnostic Commands

In the normal mode no special diagnostic commands are sent from the ground and the spacecraft provides the 1 Hz strobe pulse and also reads out all the housekeeping information every 8 seconds. This results in the two counter chips being exercised in order to get their summed count values and therefore the status of some of the on-board commands assumes an undefined state.

4.3.2 Failed 1 Hz Spacecraft Pulse

Should the 1 Hz pulse into the RIF box fail for any reason the two counter chips will not operate. Their are two 1 Hz pulses available, an A & B side. If both fail it is possible to drive the rate chips by issuing the appropriate diagnostic commands to achieve the same result. These commands could probably reside as an on-board subroutine that was initiated at the required frequency to get the normal housekeeping rate.

4.4 Real Diagnostic Testing

In this mode a variety of the diagnostic commands would be used to test out the function and operation of the two counter chips. A complication here is that the spacecraft must at the same time be disabled from requesting the rates for its housekeeping package of information as this would interfere with the testing. Housekeeping should continue being returned but not the rates.

These diagnostic commands produce an immediate change in the returned data so rapid decisions and changes can be made to track down faults. This type of real time operation is therefore best suited for ground pass periods. Using these commands “blind” and waiting for returned data would be possible but is not ideal.

Diagnostic commands cannot be sent from the MOC because they have not been entered in the Project Data Base. Their structure does not have “mask” bits and therefore the mnemonic based system used by the MOC is too clumsy for practical operation. Diagnostic commands can only be constructed in the SOF using the PCA supplied command editor.

4.4.1 Diagnostic Command Strategy

The use of diagnostic commands is a non trivial affair.for several reasons. These commands are far more suited to testing of individual detectors in the lab where real time commanding and immediate response monitoring is possible. Therefore no specific strategy is outlined here since the actions required depend in detail on what is being tested and why. All the possible diagnostic commands can be generated by the PCA Command Editor so great flexibility is possible.

In any real testing situation, following some find of failure or problem, a careful test plan is required which can be implemented as a DAP insert or as a string of STOL commands. Using these commands demands care and attention to achieve the desired outcome.

The PCU’s cannot be damaged by careless or stupid use of these commands.

5.0 Command Rules & Constraints

There are a number of commands to each PCA detector that are governed by some kind of constraint. Unless specifically mentioned below there are no constraints on the other PCA commands. Often the same or similar commands will be repeated at the same time to all five detectors in the PCA.

The following aspects apply to each individual detector. Warning are defined to have three levels, Yellow, Red and RED, with RED being more important. In the following sections RED denotes "flashing" red.

5.1 Yellow Warning Constraints

There are several types of command situations that are allowed but require yellow warnings.

5.1.1 Multiple TPG signals on

When using the TPG it is possible to set any combination of the 9 signal chains to ON as there is no intrinsic loading problem with the electronics design. The ADC however can only analyze a single pulse and so the corresponding combination of Event Discriminator (ED) flags will be set but the pulse height will only apply to one of them. Which one is measured is determined by a priority system which determines the order in which pulses are processed should they arrive at the same time. This situation is not sensible from a routine detector calibration point of view. Therefore:

- Normally only one of the 9 options per PCU will be permitted on at a time
- Attempts to set more than one will be allowed but normally one will be turned off before another is turned on
- A "Yellow" warning message will be given requiring a confirm to continue response

5.1.2 TPG Enable Prompt

Setting up a TPG on for any of the 9 signal channels without also setting the TPG Enable makes little sense. The TPG Enable bit is a safety device to prevent the accidental activation of the TPG which would corrupt real science observations.

- If any TPG channels are on then the Enable should also be on
- A TPG on without enable will be allowed and vice versa
- A "Yellow" warning message will be given requiring a confirm to continue action

5.1.3 High Voltage and TPG on

The use of the TPG while the high voltages are on is not a sensible situation. Throughout the mission the TPG will almost always be off and when it is used for calibration activities the HV should be off so that "clean results" are obtained for either the ramp or mono modes.

- When the HV is on the TPG should be off and vice versa
- This situation will be allowed
- A "Yellow" warning message will be given requiring a confirm to continue action

5.1.4 Discriminators set to '11'

Setting any discriminator level (except for the VLE window - cmdVLEdisc) to '11' inhibits all events from that particular anode chain from being processed by the ADC and passed to the EDS. This "kill" option enables a noisy or broken section of the detector to be switched off to prevent the possibility of vast numbers of noise pulses from loading up the system dead time.

- Analog channels will not normally be switched off
- A "Yellow" warning message will be given requiring a confirm to continue action

5.2 Red Warning Constraints

There are several types of command situations that are allowed but require red warnings.

5.2.1 HV Inhibit Overrides

There are three signals that can cause the HV to switch off but it is possible to override each of these conditions:

1. HRM set rate exceeded
2. Rate read-out watchdog interval exceeded - spacecraft software not interrogating the RIF
3. 1 pulse per second not detected

Setting the overrides reduces the level of automatic protection available to the PCU's in the event that HV commanding during SAA passages fails for any reason. For any attempt to set the overrides:

- A "Red" warning message will be given requiring a confirm to continue action

5.2.2 Changing the HRM Setting

Any attempt to change the HRM setting needs careful consideration. If the HRM is inadvertently set to a very large value then the level of automatic protection available to the PCU's in the event that HV commanding fails during SAA passages is reduced. If the HRM is inadvertently set very low then the detector may be switched off when this was not intended and data will be lost.

For any attempt to change the HRM setting:

- A "Red" warning message will be given requiring a confirm to continue action

5.2.3 Exceeding The Nominal Detector HV Settings

The nominal detector HV command for Xenon in 8 and for Propane 12. Over time it is expected that the detector gain will increase and the HV values will be reduced. Since increasing the HV's higher than the above values appears unlikely and would increase the detectors susceptibility to various potential problems such efforts will receive warnings but will be permitted.

- A "Red" warning message will be given requiring a confirm to continue action

5.2.4 Diagnostic Commands - Conflicting Modes

Each of the 2 chips has command options to select:

- single pulse or continuous mode
- increment yes or no

There are some rules for sensible operation associated with these options but violations are allowed:

Initial State	Attempted Change	Error Message
Increment - no	Mode - single	CHIP 1 Increment not set to YES !!
	Mode - continuous	okay
Increment - yes	Mode - single	okay
	Mode - continuous	CHIP 1 Increment not set to NO !!
Mode - continuous	Increment - yes	CHIP 1 Clock not in Single Pulse Mode !!
	Increment - no	okay
Mode - single	Increment - yes	okay
	Increment - no	CHIP 1 Clock not in Continuous Mode !!

The errors for chip #2 are similar to those for chip #1.

5.3 Possible High Voltage States

All the Mandatory constraints are related to the operation of the two HV units on each PCU so it is important to review the possibilities before defining the Mandatory Operational Constraints.

5.3.1 HV - OFF State

There are several reasons why the HV may be in the OFF state:

1. The spacecraft is powering up after launch
2. It has been commanded off
3. A spacecraft safing procedure has occurred
4. One of the three possible HV veto’s has been triggered (rate readout, 1 pps and HRM) and the corresponding veto override command bit was not set

It is important to distinguish between a particular HV unit being completely OFF (0V) or being in its LOW state (command 0000) at approximately 1000V below the nominal operating voltage.

5.3.2 HV - LOW State

There are several reasons why the HV may be in the LOW state:

1. If it has been commanded there
2. The spacecraft is in the defined SAA region
3. A spacecraft safing procedure has occurred

This state will be a routine event for the periods throughout the day while the spacecraft is in the defined SAA region of its orbit. The RTS commands for SAA entry will have previously been up-linked to the spacecraft as part of its days activities by the MOC. Exit from the SAA will require another RTS command and in this case the HV will already be at its ‘0000’ LOW state and can be restored to its required value in one jump.

5.3.3 HV - Normal State (cmd > 0000)

When not in the SAA the PCU voltages will normally be within the commanded ranges (0001 to 1111) unless some other situation has occurred.

5.3.4 HV - Veto State

When an HV veto occurs (HRM, 1 PPS, Rate readout) both the high voltage units (Xe & Pr) go to zero volts (not just to the LOW state). The following conditions exist after a veto:

- The HV relay is still turned ON - telemetry shows it as on
- The commanded HV value stays where it was set - telemetry shows expected cmd value and expected HV value
- The HV command bits go OFF - telemetry shows them as OFF

The telemetry could potentially show a FALSE measured HV value. When an HV is OFF (for any reason) the A/D system in the PCU RIF will measure 0v on the +-5 volt range. For a “true” off with the command bit set to off the PCA Text Screens in the SOC will determine the true situation and put the displayed measured HV value to 0v.

This is a possible trap for the subsequent turn back on which should command the HV to LOW before turning it back on to the desired level.

Note:

All unplanned detector HV veto occurrences require detailed investigation

All detector turn on’s following an HV veto event are non-standard command situations

5.4 Mandatory Operational Constraints

There are several safety aspects to controlling the RIF unit on each PCU that are considered to be mandatory. All mandatory constraints produce RED warnings.

5.4.1 Diagnostic Commands - Multiple Commands To A Chip

Each of the 2 chips can be directed to execute command #1 & command #2. Since a single chip can only execute one or the other any attempt to set both command to On will produce an error. The 4 possible errors are:

- CHIP 1 Command 1 is already ON !!
- CHIP 1 Command 2 is already ON !!
- CHIP 2 Command 1 is already ON !!
- CHIP 2 Command 2 is already ON !!

Only one is allowed on at a time so if you want to change to the other the current one must be turned off first.

5.4.2 RIF Reset Command

This command produces a warning as it resets all the commandable PCU parameters back to their default states.

5.4.3 Simultaneous ON / OFF Commands to Power Relays

There are 3 power supply relays in each PCU:

- Low Voltage Power Supply (LVPS)
- Xenon (Xe) High Voltage Power Supply (HVPS)
- Propane (Pr) High Voltage Power Supply (HVPS)

Any of these three power supply relays could in principle be commanded on and off (to the same relay) at the same time. This will not damage anything but the outcome is uncertain. A relay could end up in the on or off state and the monitor bit would have to be examined to know which had occurred. This uncertainty must be prevented.

- The command editor ensures that only the on or off bit is set for each of these three relays
- There are no mask bits for the relay commands so it is necessary to know the state of all three before changing any one of them
- There should be a 1 second gap between each relay change - only fire 1 at a time

For any attempt to change the 6 relay control bits:

- A “RED” warning message will be given requiring a confirm to continue action

The Possible relay options allowed by the PCA command software are shown in the following table.

HEX	Xe HV	Pr HV	LVPS
15	OFF	OFF	OFF
16	OFF	OFF	ON

HEX	Xe HV	Pr HV	LVPS
1A	ON	OFF	ON
26	OFF	ON	ON
1A	ON	ON	ON

NOTE

The LVPS relay is in series with the HVPS xenon and propane relays so turning it off produces the same effect as turning them off although these two relays would still actually be on. Both HV's will go to zero volts (in one step) but both command bits would still be on, the commanded HV values would remain the same and both HV relay monitor lines would indicate the HV's were on. This is a very inconsistent situation.

If the LVPS were then turned back on the high voltages would suddenly return to their former values without a staged turn on (worse then going to zero volts).

5.4.4 Turning the LVPS Relay ON & OFF

- Ensure both HV's are completely off (Value = LOW, Cmd = OFF, Relay = OFF)
- Switch LVPS on or off

5.4.5 Turning an HVPS Relay ON & OFF

- Ensure the relevant HV unit is commanded off
- Ensure that the relevant HV unit has an command value of ‘0000’ - LOW state
- Switch HV unit relay on or off
- One relay at a time 1 second apart- at least 1 second after the LVPS change

5.4.6 HV Turn-on Command Sequence

The two High Voltage units on each PCU need to be turned on and off “slowly” to help ensure that cumulative stress to capacitors within the detector does not eventually cause them to failure. The HV has a time constant of approximately 1.5 seconds for >99% change.

Assuming that the LVPS relay is already on then:

- The HVPS relay must be off
- The HV on/off command must be off
- Set HV command value to ‘0000’ - LOW state
- Turn the HVPS relay on
- Set HV on/off command to on
- Wait for 5 seconds - for voltage to stabilize
- Set HV command to desired value ‘xxxx’ (it is not necessary to ramp up in small increments to this value)
- Wait 5 seconds - for voltage to stabilize

5.4.7 HV Turn-off Command Sequence

To turn OFF a HV unit follow the procedure below:

- Set HV command value to ‘0000’ - the LOW state. (it is not necessary to ramp down in small increments to this state)
- Wait 5 seconds - for voltage to decay
- Set HV on/off command to off
- Wait 5 seconds - for voltage to decay
- Turn the HVPS relay off

It is assumed here that the LVPS relay remains on. If it is only required to turn the HV down to its LOW state then stop after the first stage.

5.4.8 General Comments On Command Sequences

The above command sequences are sometimes difficult or impossible to enforce within the Desired Configuration Editor software alone. It is intended that a series of command sequences will be constructed for pre-prepared use which will comply with the above constraints. These will essentially be the same as RTS’s and MACRO’s.

WARNING

There is no absolute way of enforcing the sequencing of the HV controls within the PCA command editor. Individual configurations are placed on a time line within the SOC command generation system (which is quite separate software) and this is the point were it is important to know either what state the experiment (PCU) is in or what the correct series of configurations is. There does not appear to be any way around this problem but none of these commands is “really hazardous” or “critical”. They are just desirable operating procedures. Correct sequencing can be ensured in RTS’s or Macros used for SAA passages, safing and other similar aspects.

5.5 Summary Of PCU Constraints

Commanding Message Prompts:

- Ensure only the on or off bit is set for the 3 power relays
- There are no mask bits for the relay commands so it is necessary to know the state of all three before changing any one of them
- LVPS turn ON & OFF
- HVPS (Xe and Pr) turn ON & OFF
- HV turn ON sequence (two stage turn on with delays)
- HV turn OFF sequence (two stage turn off with delays)
- Diagnostic commands - multiple commands to a single chip

Red Warnings:

- HV Inhibit overrides to be queried
- Changing the HRM to be queried
- Exceed nominal detector HV settings to be queried

- Diagnostic commands - conflicting modes
- Reset RIF

Yellow Warnings:

- Normally only one of the 9 TPG options will be permitted ON at a time
- If any TPG channels are ON then the Enable should also be ON
- When the HV is ON the TPG should be OFF and vice versa
- Any attempt to select a ‘11’ value for any discriminator to be queried

6.0 Spacecraft Command Issues

There are several issues relating to the commanding of the PCU's that fall outside the direct control of the PI team software.

6.1 Spacecraft PCU ON / OFF Command

Each PCU has a separate ON / OFF relay command which is not commandable by the PI team software.

- ON switches the PCU Remote InterFace (RIF) unit on in a default power-up condition
- OFF must only be sent when the RIF unit has been commanded through its power down sequence (2 HV's low, delay, 2 HV's off, delay, 2 HV relays off, LVPS relay off - see earlier). The PCA team will provide a standard RTS to perform this for each PCU.

6.2 Spacecraft PCU Temperature Control

Each PCU has 4 temperature monitors and several heating circuits. These heaters are not commandable by the PCA team software but the temperatures are monitored by the H&S subsystem in the SOC using PCA supplied software.

6.3 Spacecraft / PCA Safe Mode Procedures

If a major problem occurs with the spacecraft it will immediately adopt a "safe" situation. The spacecraft group will therefore at some time require the safe mode commands needed by the PCA experiment.

The only requirement to safe the PCU's is

- All HV's on every detector must be turned to LOW - an RTS to achieve this is simply the same as the SAA entry RTS

If the safe mode requires that spacecraft power is conserved and the PCU's switched off then

- All PCU's will be commanded through the power down sequence

7.0 Configuration Editor & Desired Configurations

The preceding sections have described in detail the complete set of available commands, how they are constructed into CCSDS packets and some rules about their allowable sequencing. Rather than consider individual commands as the basic building blocks of the commanding activity the SOC has chosen to use the concept of instrument "configurations" and to use "delta commanding".

When commands are being formulated the scenario is to move the instrument from one configuration (the current one) to another configuration (the desired configuration) rather than think of single individual commands. A whole set of diverse commands can be changed at the same time to achieve a new desired configuration. If any commands require definite spacing in time or specific time ordering then it is necessary to move the experiment through a series of separate desired configurations.

To fully understand the PCA interaction with the main SOF command generation system requires study of the SOF design documents for this subsystem. Such a detailed review falls outside the scope of this document.

7.1 Configuration Editor

The PCA team provides a configuration editor that allows desired configurations to be created. The chief properties of the editor are:

- GUI based (TAE^+)
- Command functions grouped in suitable sub menus
- 36 parameters selected from pre-defined pull down lists
- 2 special no-parameter single shot commands (RIF reset & LRC)
- 1 HRM value typed in (range 0 - 2^{24})
- On-line help provided

7.1.1 Main Menu & Features

The editor itself is described in a users manual so this will not be repeated here. The main menu structure consists of the following elements:

- Discriminator setting commands
- Test pulse generator setting commands
- RIF diagnostic commands
- Constrained commands (high voltage & relay related)
- Configuration text summary
- Configuration text information header

In addition the following features are available:

- Default reset (to state following RIF reset or power up)
- Set to latest measured configuration

- Save / Retrieve / Delete / Printout - Configurations
- Single detector or global changes
- Browse only mode
- Rules / Constraints / Warnings built in

7.2 Use of Desired Configurations

After a configuration is constructed with the editor it is saved to disc. It then becomes available to the SOC Command Generation Subsystem software and it remains associated with its specified name for all subsequent operations within the SOC environment. It is not possible to correct or alter a configuration in the SOC environment. A new configuration, perhaps based on the previous one, must be built using the PCA Configuration Editor and re-saved. The earlier configuration is then ignored or deleted.

In general individual configurations:

- Form part of a series of configurations to get to a desired goal.
- Have names with no sensible physical meaning

The file name of a saved configuration provides a “handle” of what the configuration achieves but since this is limited in length two other methods of assistance are available. These features are available from within the SOC environment while placing configurations on a time line:

- A text information header to each configuration provides a detailed description. This field may be left blank.
- The PCA configuration editor program may be run in a browse only mode to examine actual settings if the header description is not sufficient.

Configurations are combined together in the SOC Command Generation Subsystem software to form “subroutines” known as RTS’s and MACRO’s. These will normally have meaningful names such as SAA_OFF since they can perform complete operations. All creating, editing and deleting of RTS’s and MACRO’s is done in the SOC environment.

Configurations themselves have no time information. The timing aspects are added within the SOC Command Generation Subsystem.

7.3 Delta Commands & Don’t Care Values

When a configuration is constructed with the editor only values that are being changed need to be specified. This “delta command” mode of operation means that all other parameters will be marked as “don’t care”. The don’t cares are parsed out later when the required command packets are created. In practise command configurations are dealt with only in the SOC environment since the Mission Operation Center (MOC) deals with actual commands and command packets.

- If in doubt as to the “real” present configuration it would do no harm to send up a few redundant commands.

Don’t care values are also important for the creation of predicted configurations. A complete list of parameters - defined or not, is required so that successive predicted configurations can be built up.

7.4 PCA Packet Generator

Configuration themselves are not used by the MOC so the SOC has to convert its command scripts (configuration time line) to CCSDS command packets. The code to do this for PCA packets is provided by the PI team and is called the PCA Packet Generator.

This C^{++} method is considered to be part of the PCA Configuration Editor package though it is normally executed by a program call from the SOC Command Generation Subsystem without any visible display of its results. The PCA packet generator method knows about the CCSDS packet structure, the details of the command bit patterns and also how to compute the packet checksum.

- For testing purposes the packet generator can be executed from the PCA Editor and its output examined for any given desired configuration

7.5 Conceptual Command Activity

Conceptual commanding activities will have the following outline:

- The SOC Duty Scientist constructs a series of configurations using the PCA Configuration Editor
- The SOC Duty Scientist constructs some RTS and MACROS from these new configurations (and existing ones) using the SOC Command Generation Subsystem

At this point any of the existing library Macros can be used:

- The SOC Duty Scientist can convert the Macros to a string of EOR’s and send them
- The SOC Duty Scientist can convert the Macros to STOL procedures and send them
- The SOC Duty Scientist can build a DAP or WAP and insert the appropriate Macros at the chosen times

7.6 Library of Configurations, RTS’s & MACRO’s

The building of a library of desired configurations is the starting point for the actual task of constructing real command sequences with which to form a library of:

- Execute On Receipt (EOR) - generally reserved for emergencies
- STOL Procedures - for relatively short real time command sequences
- MACROS’s - routine pre-defined PCA commanding (see later for examples). Macros can be built from Relative Time or Absolute Time commands

The PCA Macro Library is detailed in a separate document. These Macros can easily be turned into STOL or run as EOR’s though these are inappropriate for long sequences of commands as the sending procedures are somewhat cumbersome. Macros can also easily be inserted in the Daily Activity Plan (DAP) or the Weekly Activity Plan (WAP).

7.7 STOL Procedures

Although not being part of a formal library as such many of the PCA Library macros have been converted to STOL procedures for easy use.

7.8 IOC Plans

The plans for the technical part of the In Orbit Checkout (IOC) period are in an Appendix to this document. This part of IOC covers days 3-8 after launch and uses STOL and DAP commanding.

8.0 Definition and Verification of Configurations

The status of every commandable parameter in the PCA is completely described by what is know as a “configuration”. When formulating commands the scenario is to move the instrument from one configuration (the current one) to another configuration (the desired configuration) rather than think of single individual commands.

- Each configuration contains the status of all 5 PCU’s.

The C^{++} methods to handle the Measured & Predicted Configurations will be related to the Desired Configuration in order to simplify the verification process.

The PCA command subsystem Users Guide and Design Document referred to in section 1.3 provide full details on the Topics of:

- Desired Configuration
- Measured Configuration
- Predicted Configuration
- Configuration Verification
- Command Packet Builder

8.1 Configuration File Name Conventions

The file name conventions adopted are:

PCAxxxxxx.dcf for desired configurations

PCAxxxxxx.pcf for predicted configurations

PCAxxxxxx.mcf for measured configurations

- The . extension is mandatory
- The PCA can be in lower case but must start the string
- The xxxx character string can be any descriptive legend

8.2 Desired Configuration

The Desired Configurations have been described in an earlier section dealing with the Configuration Editor. A desired configuration has nothing to say about when the PCA should be in the desired state, only that it should have the desired state. The series of Desired Configurations therefore form the building block for the Predicted Configurations. The desired configuration as mentioned earlier can contain “don’t care” entries. PCA supplies the SOC with the entire C++ Desired Configuration Editor.

8.3 Measured Configuration

Housekeeping data from the PCA will arrive in the SOC at a semi-regular rate (all PCU’s every 8 seconds) but there may be some occasional sizable gaps in time. Each incoming PCU housekeeping packet will be decoded and the commandable parameters stripped out to form an updated Measured Configuration. The required parameters all have digital values so no conversions are required.

At all times the measured configuration will reflect the latest known state of all the commandable PCA parameters. The SOC will archive all changes in the "measured configuration" i.e. during long periods of unchanging conditions it will not be archived.

Normally only the latest Measured Configuration will be used for verification purposes. PCA supplies the SOC with a C++ method to construct the Measured Configurations.

8.4 Predicted Configuration

When constructing commands the scenario is to move the instrument from one configuration (the current one) to another configuration (the desired configuration). A series of sequenced commands forms a series of predicted configurations for a series of "time marks" in the future.

A new predicted configuration is formed by merging the previous predicted configuration with the commanded changes extracted from the current desired configuration (see following diagram). A specific future predicted configuration therefore is the resultant summation of a whole series of changes starting from some definitive known situation. Such an event or Master Reset could consist of commanding all the parameters to a specific desired configuration and resetting the predicted configuration to match. An equivalent situation occurs following power up or the sending of a RIF Reset command.

The following list summarizes the main factors involved with predicted configurations:

- the configuration may be different just before or just after the time mark but should have exactly the desired state momentarily after that precise time
- there may well be a whole series of predicted configurations stretching out into the future for a period of 24 hours which is the time span of the up-linked daily activity plan
- there may be no changes at all in the 24 hour period and the predicted configuration remains the last one generated
- commands within the same packet or directed at the same time to different PCU's will only require a single predicted configuration since all these changes will be considered to occur at the same time
- any unscheduled change, such as an EOR command, will require the re-generation of a new series of predicted configurations as the change must be propagated into the future

PCA supplies the SOC with the C++ Method to generate the next Predicted Configuration from the Desired Configuration and the previous Predicted Configuration.

8.5 Current Configuration vs. Best Estimated One

The SOC is charged with the task of performing a continuous check that the spacecraft is always in the state it is commanded and expected to be in. For the PCA team this means that the PCA measured configuration should always agree with the predicted configuration (the required and commanded state). This deceptively simple statement has some major problems in terms of a continuous on-going YES/NO question and result. The PCA-SOC ICD referred to in section 1.2 discusses the formal aspect to this issue.

The problems lie with the fact that there is no guarantee that the latest measured configuration (the best available known state of the PCA) is in fact the “real” currant configuration of the PCA. The housekeeping data that forms the measured configuration may not have arrived for some period of time due to any number of possible technical reasons and is therefore out of date. An invalid comparison will be being made between fresh predictions and “old” housekeeping data.

This problem can be largely overcome because for the PCA:

- the complete housekeeping data is returned every 8 seconds
- there are no multiplexed or sub-multiplexed channels
- the verification can be made only when the Measured Configuration changes

All the verification testing has to be carried out with a time quantization allowance of 8 seconds or more due to the housekeeping sampling rate even though command times can be defined to an accuracy of 1 second. Fortunately the PCA has no rapid commanding modes where fast dynamic changes might occur. In routine operation the PCA is only commanded through state changes that take place for 10’s to 100’s seconds to many days or weeks.

8.5.1 Configuration “feed forward” Requirement

Previous predicted configurations from the past are continuously “fed forward” in time and merged with desired configuration to form a new predicted configuration. If an EOR command is sent then it will cause a verification failure for all future predicted configuration since they were created without knowledge of the change just made. Therefore every single EOR sent up to the PCA must also be “fed forward” to update all future predicted configuration that exist.

8.5.2 Master Resets

Previous predicted configurations from the past are continuously “fed forward” in time and merged with desired configuration to form a new predicted configuration. Any errors therefore become “frozen in”. An occasional reset operation will be required and there are 3 basic ways of doing this:

- commanding ALL the possible parameters (all PCU’s) to a desired configuration and resetting the predicted configuration to match
- sending the RIF Reset command to all PCU’s and resetting the predicted configuration to the default power up settings
- setting the predicted configuration to a default power up state following experiment switch on

To assist the ease with which the experiment can be reset to any specific Desired Configuration it will be possible to read back into the Desired Configuration Editor:

- a previous Measured Configuration

- an existing Predicted Configuration

Command resets should seldom be required as in normal operation very few commands are sent to the PCA and therefore the “predicted configuration” and the “measured configuration” should be relatively stable.

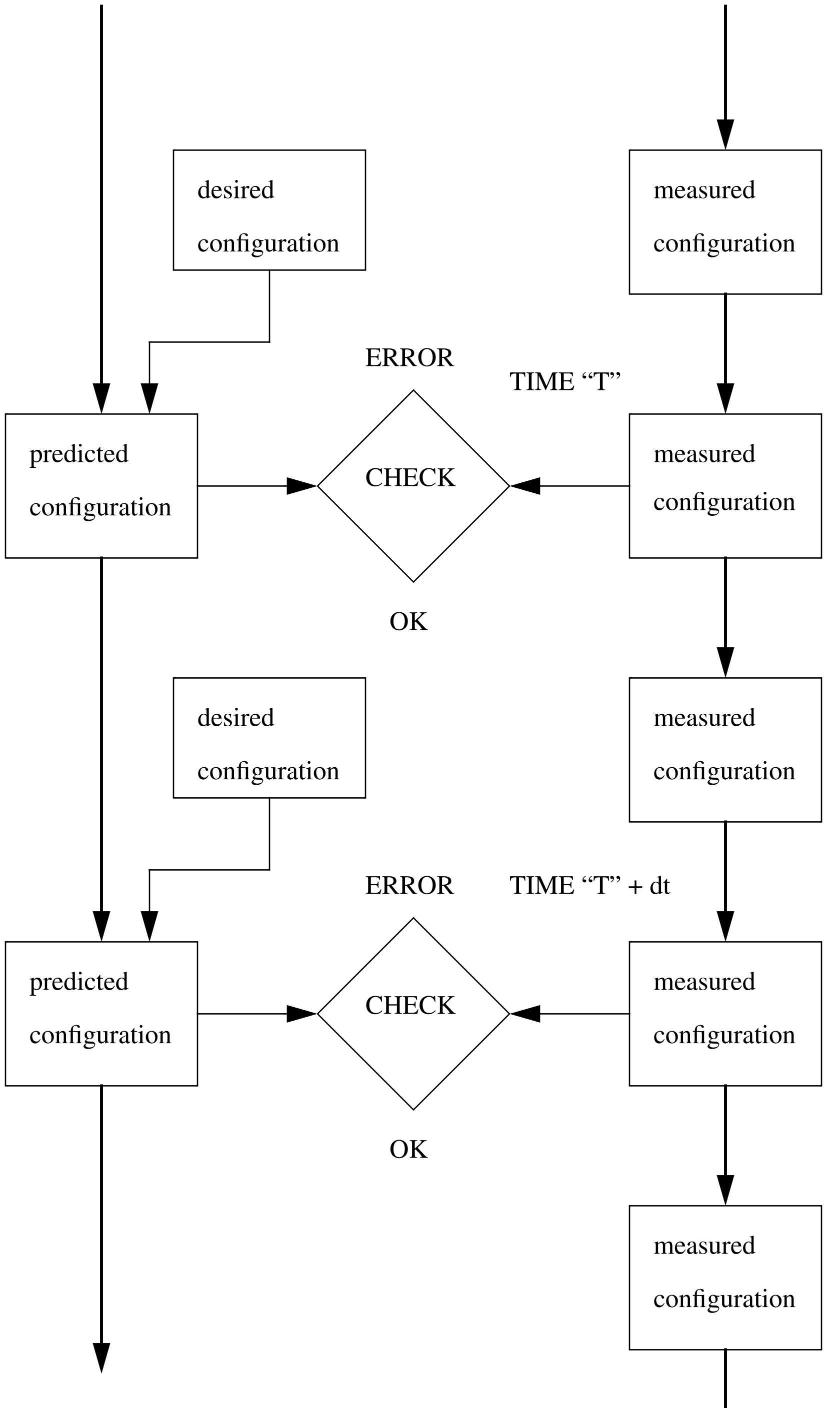
8.6 Verification Process & Results

The SOC Mission Monitoring (MM) subsystem will keep track of the MET and the Predicted Configuration time line. When a new predicted state is expected a PCA supplied C++ Method will compare the incoming Measured Configurations to check that the change has occurred (or did occur). A message protocol informs the MM subsystem of the outcome of the test.

8.6.1 Relationship Of PCA And SOF Code

The following steps describe the verification and logging process:

- Every incoming PCU packet is used to construct a Measured Configuration by PCA software. The PCU software attempts to time order the data. Normally packets from all 5 PCU’s will have arrived and a complete Measured Configuration can be passed on to the SOF subsystem. If some packets are not arriving or arriving late a time out of 16 seconds will force the transfer of an incomplete Measured Configuration to the SOF
- The SOF compare each Measured Configuration with the previous one and determine if a change has occurred. This “Has Changed” code is supplied by PCA
- If the Measured Configuration has changed then the new one is saved by the SOF as part of a permanent log
- The SOF then get the Predicted Configuration for the corresponding MET and determine if they match. The match test method itself is provided by PCA. There is no listing of differences, only a yes/no result
- The Predicted Configurations are built using PCA code. A full description can be found in the PCA Mission Monitoring Design Document



TIME FLOW OF CONFIGURATIONS

9.0 Commanding Operations

When considering the commands sent to the PCA it is convenient to divide the mission into two parts. For efficiency a number of standard command subroutines will be identified.

Additional details on the commanding operations associated with the PCA can be found in the "XTE Instrument Operations Users Guide" manual.

9.1 The First Months Operations

During the first month the PCA will be sent a large number of commands to completely check out and set up its optimum operation. This detailed plan will be the subject of a separate document.

In terms of the commanding software covered in this document it is not possible to define specific subroutines that apply to the check-out period. All commands will be specific and one-off though there may be long strings of them sent to the spacecraft on each pass.

Rather than simply write out tables and/or lists of commands the PCA team will:

- define a long series of PCA test configurations. These will be prepared on pro-forma charts after detailed discussion within the team
- these charts will be entered into the delivered software (PCA Configuration Editor) to generate configuration that will then be converted to RTS and MACROS using the SOX Command Generation Subsystem
- these sequences will be generated well in advance of the launch and should be constructed entirely from relative times so that launch slips do not entirely invalidate the prepared commands

9.2 Routine In-Orbit Operations

Once the spacecraft is fully operational the PCA group will continuously monitor the state of the five detectors. This will be largely carried out in two ways but neither of these require special PCA commanding.

- Since the weak calibration signal is always present suitable returned science data can be analyzed as a "background" activity to monitor detector gain and resolution. Guest observers data priority rights will be respected
- Some special observations of celestial targets will be requested and carried out by the PCA group for both internal and PCA/HEXTE cross calibration

In normal operation an entire days commands will be uploaded to the spacecraft in one go. The form of various classes of commands will now be examined.

9.2.1 Regular Commands - SAA Passages

Every day and on 5-6 orbits out of 15 the spacecraft passage through the South Atlantic Anomally (SAA) will require all the detector high voltages (HV's) to be turned to the LOW setting at the predicted entry time and back to their previous individual settings at the predicted exit time. Permanent on-board MACRO's will exist to turn all the detectors on or LOW at the same time. These SAA passage commands will be activated at specific absolute times.

Whenever one of the ten (2 x 5) standard HV operating values is changed due to detector ageing the spacecraft routines for SAA exit would have to be altered so that knew the new HV command to restore the detectors to.

9.2.2 Occasional Commands - Detector Adjustments

Every few month depending on the inevitable slow gas leaks from the detectors the High Voltage (HV) value for each detector may need adjustment. The EDS gain and offset parameters will also require occasional adjustment. The necessary adjustments will be computed by the PCA team but the uplink changes will be part of the EDS command system. Large accumulated changes from the initial conditions may also necessitate some discriminator adjustments.

These commands are all unpredictable and cannot be stored as subroutines. When the PCA team decide that these parameters need adjustment a special and unique command set (RTS) will be constructed. This command packet could be sent in the days command load to occur between source observations at an absolute or relative time. It might also be sent in immediate mode at the commencement of a ground pass so that the changes could be verified prior to the end of the ground contact.

9.2.3 Rare Commands - Aspect / Aperture Calibration

Perhaps twice per year the aperture response and co-alignment of the 5 detectors will be measured. These will require very little commanding to the PCA itself and may only require a simple RTS. Almost all commands will relate to spacecraft slewing and the full 'calibration' sequence would form a special guest observation.

9.2.4 Very Rare Commands - TPG Exercises

Very occasionally (< twice per year) the TPG will be exercised to calibrate the analog electronics on each detector. A series of subroutines could be constructed like those for the SAA to perform L!, L2 etc. selections for all detectors and then these would all be linked together by a suitable "master" subroutine. An exercise to perform the full TPG tests could be stored as a MACRO and might have the following form.:

1. switch all HV's Off
2. set TPG to Mono mode
3. select TPG Layer L1 and TPG Enable for all detectors
4. accumulate for some period of seconds
5. repeat steps 2 -3 for (R1, L2, R2, L3, R3, VX, VP, VA)
6. set TPG to Ramp mode
7. repeat steps 3 - 5
8. disenable TPG
9. restore all HV's at a suitable time

9.3 RTS's

There are only 5 on-board RTS's so these are all listed below.

RTS	Function
PCA_SAA_Entry	Set all PCU HV's to low command "0000"
PCA_SAA_Exit	Set all PCU HV's to observing values (see change macro below for current observing levels)
PCA_HV_off	Emergency safeing. Powers all PCU HV's to "0000", waits 5 seconds and then turns all HV's OFF
PCA_SAA_Entry_Dummy	A "dummy" SAA entry RTS that just changes the HRM value to an unusual value as a marker
PCA_SAA_Exit_Dummy	A "dummy" SAA exit RTS that just restores the HRM to the default value 8200 c/s

9.4 MACRO's

The PCA Macro Library is quite extensive and a summary is given in the Appendix. Full details can be found in the actual Library document.

10.0 Build Development Goals

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

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

All components operational except:

1. Full framework
2. Discriminator commands
3. Test Pulse Generator commands
4. Command Packet builder support for above options
5. Limited depth on-line help
6. Measured Configuration
7. Prototype Predicted Configuration

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

For this build everything (including the above items) are expected to be operational.

1. The RIF diagnostics command menu & associated pull down lists
2. The constrained command (HV) menu
3. Command Packet builder support for all commands
4. Constraints & warnings
5. Full Predicted Configuration
6. Verification of configurations
7. Configuration Editor output linked to PCA Housekeeping Telemetry Simulator

10.3 Build 3.1 (6/15/94)

Most work complete - used during 2nd Hard Line Data Flow (~6/10/94)

1. Enhance verification
2. Final polish to GUI & conform to SOC standards
3. Some on-line help in place

10.4 Build 3.2 (8/15/94)

1. Complete redesign of the Mission Monitoring subsystem
2. Some changes made to the PCU relay commanding following the 1st End to End test

10.5 Build 3.3 (11/14/94)

1. Testing of new MM design
2. More testing of commanding

10.6 Build 4.0 (11/30/94)

CM & MM subsystems complete.

1. On-line help in place
2. Comprehensive testing completed during spacecraft commanding
3. Final User Manual
4. Final Design Document

10.7 Build 4.1 Onward

Maintain

11.0 Summary of Commands for each PCU

Command	Function
cmddsR2	xenon layer 2 right disc. level
cmddsL2	xenon layer 2 left disc. level
cmddsR1	xenon layer 1 right disc. level
cmddsL1	xenon layer 1 left disc. level
cmddsVP	propane layer disc. level
cmddsVX	xenon veto disc. level
cmddsR3	xenon layer 3 right disc. level
cmddsL3	xenon layer 3 left disc. level
cmdADCdither	ADC dither on/off
cmddsVle	Very Large Event (VLE) window length
cmddsAlpha	alpha disc. level
cmdtpgR3	Test Pulse Generator (tpg) layer 3 right on/off
cmdtpgL3	tpg layer 3 left on/off
cmdtpgR2	tpg layer 2 right on/off
cmdtpgL2	tpg layer 2 left on/off
cmdtpgR1	tpg layer 1 right on/off
cmdtpgL1	tpg layer 1 left on/off
cmdtpgAlpha	tpg alpha on/off
cmdtpgVP	tpg propane layer on/off
cmdtpgVX	tpg xenon veto layer on/off
cmdtpgMode	tpg MODE Ramp or Mono (0=Mono)
cmdtpgEn	tpg Enable
cmdhvPRon	propane HV on/off
cmdhvPR	propane HV command value
cmdhvXEon	xenon HV on/off
cmdhvXE	xenon HV command value
cmdrateov	override of auto rate readout HV turn off
cmdppsov	override of auto 1 pulse per sec HV turn off
cmdhrmov	override of auto high rate monitor HV turn off
cmdselB	select side A/B for 1 PPS (0=A)

Command	Function
cmdhvPRrlyon	propane HV relay turn on
cmdhvPRrlyoff	propane HV relay turn off
cmdhvXErlyon	xenon HV relay turn on
cmdhvXErlyoff	xenon HV relay turn off
cmdlvpsrlyon	low voltage power supply relay turn on
cmdlvpsrlyoff	low voltage power supply relay turn off
cmdhrmval	set High Rate Monitor value (24 bits per 8 sec)
cmdLRC	Latch Rate Counters
cmdResetRIF	reset Remote InterFace (RIF) box
cmd1SEL17	select sub add 17 (chip #2) to receive command #1
cmd1SEL16	select sub add 16 (chip #1) to receive command #1
cmd1Counter	counter command #1 (6 bits)
cmd2SEL17	select sub add 17 (chip #2) to receive command #2
cmd2SEL16	select sub add 16 (chip #1) to receive command #2
cmd2Counter	counter command #2 (6 bits)
cmdMCK17	1=inc counter MCKSEL on chip #2 (SEL 17) if MCKGATE17=0
cmdMCK16	1=inc counter MCKSEL on chip #1 (SEL16) if MCKGATE16=0
cmdMCKSPEED	internal clock speed (1=1MHz, 0=125KHz)
cmdMCKGATE17	1=continuous clock for chip #2, 0=single pulse
cmdMCKGATE16	1=continuous clock for chip #1, 0=single pulse
cmdMCKSEL	select counter N (0-7) for counting

12.0 Notes