SOFTWARE SPECIFICATION DOCUMENT

FOR THE

LOW ENERGY NEUTRAL ATOM (LENA) IMAGER

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LIST OF ACRONYMS AND ABBREVIATIONS

APID	Application Process Identifier
BIT	Built-in-test
CCSDS	Consultative Committee for Space Data systems
C&DH	Command and Data Handling
CIDP	Central Instrument Data Processor
HK	Housekeeping
HVPS	High Voltage Power Supply
KB	Kilobyte
LED	Light Emitting Diode
LENA	Low Energy Neutral Atom Imager
MET	Mission Elapsed Time
PROM	Programmable Read Only Memory
PSS	Position Sensing System
RAM	Random Access Memory
ROI	Region Of Interest
SCU	Spacecraft Control Unit
TOF	Time of Flight
XOR	Exclusive-Or

1. INTRODUCTION

1.1 Scope

This document describes the instrument test and flight software in detail including instrument control, commands, and telemetry data packet format. It will be used as the basis for code development, testing and verification. Information is as complete as possible. Values not yet available are indicated by TBD and values which are subject to change are indicated by TBR.

1.2 Applicable Documents

	SwRI
8089-CIICD-01	Central Instrument Data Processor (CIDP) to Instrument Interface Control Document
8089-ISLENA-01	IMAGE Instrument Specification for the Low Energy Neutral Atom (LENA) Imager
8089-ISCIDP-001	IMAGE Specification for the Common Instrument Data Processor (CIDP)
8089-SDG-001	Software Development Guidelines for the Image Program

1.3 Overview

LENA was designed to measure the composition and energy spectra of neutral atoms in the earth's magnetosphere with energies in the 10 - 300eV range. The instrument is an energy-mass-angle spectrograph and thus can display the complete range of energy, mass, and polar angle simultaneously. Angular information is obtained from a 90 degree fan-shaped field-of-view with 8x8 (TBD-8x7.33) degrees resolution. Spacecraft spin is used to obtain angular information in the orthogonal direction.

Science data will consist of 12x45 pixel images (12 polar angles and 45 spin sectors) generated once per spin (120 seconds). Each pixel includes 2 mass bins and 3 energy bins. Event and singles data are also taken. Event data is raw time-of-flight (TOF) position and energy data stored chronologically. An event includes a complete TOF start/stop pair. A "start" pulse is generated when an ion passes through the foil at the entrance of the TOF unit dislodging electrons which strike a nearby microchannelplate. A "stop" pulse is generated when an ion strikes a microchannelplate at the back of the TOF unit. Singles are individual TOF start or stop pulses. Region-of-interest data is a specified range of polar angle and energy over which events are accumulated into a TOF spectrum.

Data will be packetized and sent to the Common Instrument Data Processor (CIDP) once per spin. The data collected during a spin is transmitted after the next nadir pulse (see Section 2.2). A maximum of 16,384 bytes of data will be transferred from LENA to the CIDP per spin cycle.

2. INSTRUMENT CONTROL

2.1 Operational Sequence and Characteristics

At power-up the LENA Command and Data Handling (C&DH) system is activated and the instrument is initially in the SAFE mode. Contents of the microcontroller PROM are autonomously transferred to the C&DH 32KB RAM space. Any required program patches are then transferred from the CIDP to this RAM space. The processor boot must be verified and critical parameters must be within acceptable limits as reflected in the

housekeeping stream before LENA accepts further state transition commands from the CIDP. Default high voltage (HV) limits are stored in the RAM space and can be changed using the MEMORY command.

There are three modes of instrument operation:

NORMAL	Science and housekeeping data are accumulated in memory and reported once per spin. This mode will run during most of an orbit.
CALIBRATION	This mode allows science and housekeeping data to be reported more frequently and will be used for instrument testing and calibration.
SAFE	The High Voltage Power Supplies are commanded off. Housekeeping data will be collected.

2.2 Spin Synchronization Pulse

The instrument receives a spin synchronization signal in the form of 3600 pulses equally spaced in time between nadir pulses or, equivalently, every 0.1 degree of spacecraft rotation. The CIDP provides a double pulse (nadir) when the plane defined by the spacecraft +X axis and the +/-Z axis contains the center of the earth. A triple pulse is used to indicate solar position. The solar pulse occurs when the plane defined by the +X axis and the +/-Z axis contains the center of the sun. If the nadir and solar positions coincide, the nadir double pulse occurs first followed one sync pulse later by the solar triple pulse. Each sync pulse remains active for 1 microsecond and the time between each pulse of a double or triple pulse is 10 microseconds +/- 1 microsecond.

2.3 Power Supply Control

The power supply requirements for LENA are listed in Table 2-1. A nominal power of 15W are dissipated during normal science mode operation.

Table 2-1 Power/Voltage Requirements

Input V (Volts)	Average I (mA) @+34V	Peak I (mA) @+28V	Average Pwr (watts) @+28V	Peak Pwr (watts) @+34V
+34 +0/-12V	441 mA	500 mA	14 W	15 W

3. DATA PROCESSING

Information is transmitted to the CIDP as either a Data Package, a CIDP Request Package, or a No Data Package. The CIDP Request Package is used for issuing an instrument power off, power cycle, or data upload request. At least one package must be transmitted to the CIDP per spin. If no packages are received during two consecutive spins, the CIDP will transmit a Safe message to the instrument.

3.1 Science Mode

During the NORMAL mode of operation binned (image), event, singles, region-of-interest and housekeeping data are collected during each spin and transferred to the CIDP after the

next nadir pulse. Image data consists of a 12 (Polar) x 45 (Azimuth) pixel matrix where each pixel is comprised of 2 mass bins and 3 energy bins.

3.2 Calibration Mode

When in CALIBRATION mode, science and housekeeping data are reported more frequently. The CIDP simulator is used to vary the timing of the nadir pulse. Data packets that are normally transmitted once per spin, just after the nadir pulse, can thus be generated every few seconds. This procedure can be used to match the on-orbit spin azimuth line rate of 120/45 = 2.67 seconds. Time-of-flight and Position Sensing System (PSS) built-in test modes will be activated.

4. COMMANDING

The Command and Data Handling system will be capable of accepting at least one command every 0.1 second. Time tagging of commands will be done using CIDP Pass-Through commands. These commands contain a Mission Elapsed Time (MET) tag which indicates when the command is to be executed. The CIDP stores these commands and forwards them to the instrument when the time-tag becomes current. Commands with a MET of zero are forwarded immediately (within 100 milliseconds). The C&DH will have a macro-like capability to assemble sets of commands into a procedure which can be called by a single command from the CIDP.

4.1 Command Format

LENA commands are grouped by function and each group has a one-byte command stem unique to that group. Each command is made up of the command stem, a one-byte opcode, and may or may not have parameters which can be used to select command options. Command data can be sent to the instrument via the CIDP Pass-Through Command. The maximum size for each group of commands is 56 bytes. Additional headers are added by the CIDP with a maximum pass-through command size of 62 bytes.

4.2 Available Commands

The following is a summary of available LENA commands. A detailed description of all commands is given in Appendix A.

System Commands
- Set modes
- Reset LENA
- Reset error counter
- Enable/disable data segment type
- Request upload from CIDP
- Enable/disable internal sync signal
- Set voltage/current thresholds for HVPS

ROI Commands
- Define TOF, Polar, and Energy ranges

Performance Test Commands
- Enable low/high voltage performance test
- Enable/disable power supply tests

HVPS Commands
- Enable/disable HVPSs
- Safe/unsafe HVPSs
- Set dv/dt
- Suspend/resume dv/dt

Command HVPS output voltages
Set HVPS output voltages to 0 (reset)
TOF Commands
Set TOF state table
Enable/Disable BIT mode
Set TOF BIT strobe frequency
Define species binning intervals
Position Sensing System Commands
Set PSS channel gains
Memory Commands
Read/write memory space

4.3 Specialized Test Commands

Specialized commands will be needed to monitor testing and calibration of the instrument at the University of Denver. LabVIEW software will be used to control the gimbal mechanism which will simulate movement of the instrument on orbit. The software will record position and time information for comparison with data taken during testing.

5. TELEMETRY

5.1 Data Package Format

All science and housekeeping data are transferred to the CIDP as a Data Package. These packages are then placed into a Consultative Committee for Space Data Systems (CCSDS) Source Packet and transmitted to the Spacecraft Control Unit (SCU). The basic format for Data Packages is shown in Table 5-1. The Package Type Header is used to distinquish between the various kinds of data and to indicate whether data compression is desired. The most significant bit of the Package Type Header, if set, indicates that the data (not including the checksum) should be compressed using the Rice compression algorithm. The least significant 7 bits of the Package Type Header are used to identify the various kinds of science and housekeeping data. These same 7 bits are appended to the 4-bit Instrument Identifier (0011) to form the CCSDS Source Packet Application Process Identifier (APID). The checksum is a vertical XOR of the raw data.

Table 5-1 Data Package Format

Byte(s)	Binary (Hex)	Description	Sent to SCU
0 -- 2	(FEFA30)	Sync Pattern	No
3	11011100 (DC)	Data Package Header	No
4	CXXXXXXX	Package Type Header 7 LS bits indicate package type MS bit contains compression indicator: C=1 CIDP compresses data C=0 Data is not compressed	Yes
5,6		Byte Count (Byte 7 through & including checksum)	Yes
7 -- (N-1)		Raw Data (Max 63,980 bytes)	Yes
N		Checksum (starting at byte 7)	Yes

5.2 Science Data

Instrument science data is split into 4 types of data packages - binned, event, region-of-interest (ROI), and singles. Each of these packages can be generated once each spin (120 seconds). The formats of the science data packages are given in Appendix B.

5.2.1 Binned Data Package

The binned data are 12x45 pixel images generated from the 12 polar zones and 45 spin sectors. Each pixel includes 2 mass bins and 3 energy bins (low, medium, high) where each energy range is approximately 100% in width and ranges differ from each other by about a factor of two. The minimum and maximum energy for the ranges can be raised a factor of approximately 2.5 using the steering voltage controller. Actual values will be determined by calibration. Nominally, LENA will produce hydrogen and oxygen images with an energy range of 10-300 eV.

5.2.2 Event Data Package

Event data includes raw TOF, polar zone, and energy data stored chronologically by spin sector. A sector word count will provide the number of events included for that spin sector. Total event data volume depends on the event rate. This data is reported to the extent that data compression creates sufficient space and is used to fill the variable available telemetry rate resulting from compression of the other, higher priority, data products. In the event of a RAM overflow condition, the C&DH system will stop acquiring event data. Because the event data may be truncated, it is organized and reported in such a way as to provide an even distribution across spin azimuth. The data are reported in order of increasing spin sector bin, but the flight software will maintain a maximum limit of 460 bytes of event data per spin sector which will prevent only a few spin sector bins from filling the available telemetry space.

5.2.3 Singles Data Package

This package includes the number of start and stop singles (incomplete particle events) that occur by spin sector. All spin sectors are included.

5.2.4 Region-Of-Interest Data Package

A region-of-interest is a specified range of polar angle and energy over which particle events are accumulated into a TOF spectrum. This TOF spectrum is binned into 32 channels. A maximum of four different ROI packages can be specified and transmitted per spin.

5.3 Housekeeping Data

There are several housekeeping data packages containing information on the state of all significant LENA systems. These packages can be enabled or disabled as desired. Nominally, the Normal housekeeping package will be transmitted once per spin and the Command Record and Data Read packages are transmitted when requested. The Diagnostic and Quick Look housekeeping packets will be used primarily for early orbit and calibration activities. Four bytes of Mission Elapsed Time (MET) obtained from the CIDP's Periodic Message will be included in all housekeeping packages. The Periodic Message is sent to all instruments once per spin. The MET provided by the message is valid on the first pulse of the next Nadir double pulse.The format of these packages can be found in Appendix C.

5.3.1 Normal Housekeeping Data Package

Normal housekeeping data includes operational and commanded instrument states, power supply voltage and current monitors, error condition indicators, and subsystem temperatures.

5.3.2 Quick Look Housekeeping Data Package

The Quick Look housekeeping data contains most of the power supply and error condition information found in the Normal HK package but this package can be transmitted every several seconds. It is primarily used for instrument testing and calibration. The transmission rate for the Quick Look package is specified in a command parameter.

5.3.3 Command Record Housekeeping Data Package

This package contains a count and listing of the instrument commands sent, executed, and rejected during a spin. It is transmitted once per spin when enabled.

5.3.4 Data Read Housekeeping Data Package

The Data Read HK package is essentially a memory dump starting at the address and including the number of bytes specified in the instrument command used to enable it. The information can be transferred as a number or bytes or 16-bit words. This package is transmitted once each time it is enabled.

5.3.5 Diagnostic Housekeeping Data Package

Power supply voltage and current thresholds and an error diagnostic register are contained in this package which is transmitted once per spin when commanded. It is designed for use during calibration and early orbit activities.

6. TESTING AND VERIFICATION

Testing of all Flight and Ground Support software will be done on several levels including individual modules, subsystems, and complete programs. Peer reviews will be used on a regular basis to identify problems or suggested changes. These problems / changes will be documented and tracked until they are resolved. ComponentSoftware's RCS configuration management software will be used to identify software products and track any changes to the source code. Table 6-1 contains the Software Verification Matrix. Requirements are references from the LENA Instrument Specification Document. The codes used in the matrix refer to the level of verification: instrument (I), payload (P), Observatory (O) and the method of verification: Test (T).

Table 6-1 Software Verification Matrix

Requirement	I	P	O
3.2.2.4 Commanding Requirements	T	T	T
3.2.2.5 Data Collection Requirements	T	T	T
3.2.2.6.1 Electronics Unit Embedded Software	T	T	T
3.2.2.6.2 Software Configurations	T	T	T
3.3.3.2 Memory Load Commands	T	T	T
3.3.3.3 Serial Digital Data	T	T	T
3.3.3.4 Health and Safety	T	T	T
3.3.4.1 Data Transfer Rate	T	T	T
3.3.4.5 Instrument Control Functions	T	T	T

APPENDIX A

COMMAND DESCRIPTIONS

SYSTEM COMMANDS					
COMMAND	BYTES	OPCODE [PARAMETERS] B7-B6: en/dsbl B5-B2: cmd B2-B0: parameter		UNITS	DESCRIPTION
MODE HEADER		9A	En.cmd.param		System command stem
L_SYS_PTEST_EN	2	9A 81			Enable LENA autonomous performance test at boot (default)
L_SYS_PTEST_DSBL	2	9A 41			Disable LENA autonomous performance test at boot
L_SYS_MODE_PRAM	2	9A 71		-	LENA operational mode set to program RAM (default)
L_SYS_MODE_ROM	2	9A 44	01 0001 00	-	LENA operational mode set to ROM
L_SYS_MODE_HVD	2	9A 45	01 0001 01	-	LENA operational mode set to HV DISABLED
L_SYS_MODE_HVSF	2	9A 46	01 0001 10	-	LENA operational mode set to HV SAFE
L_SYS_MODE_NRML	2	9A 47	01 0001 11	-	LENA operational mode set to NORMAL
L_SYS_HKNRM_EN	2	9A A0		-	Enable NORMAL hk packet transmission
L_SYS_HKNRM_DSBL	2	9A 60		-	Disable NORMAL hk packet transmission
L_SYS_HKQL_EN	2	9A 89	10 0010 01	-	Enable QUICK LOOK hk packet transmission
L_SYS_HKQL_DSBL	2	9A 49	01 0010 01	-	Disable QUICK LOOK hk packet transmission
L_SYS_HKCM_EN	2	9A 8A	10 0010 10	-	Enable COMMAND RECORD hk packet transmission
L_SYS_HKCM_DSBL	2	9A 4A	01 0010 10	-	Disable COMMAND RECORD hk packet transmission

L_SYS_HKDG_EN	2	9A 8B	10 0010 11	-	Enable DIAGNOSTIC hk packet transmission
L_SYS_HKDG_DSBL	2	9A 4B	01 0010 11	-	Disable DIAGNOSTIC hk packet transmission
L_SYS_HKMEM_EN	2	9A A2		-	Enable MEMORY hk packet transmission
L_SYS_HKMEM_DSBL	2	9A 61		-	Disable MEMORY hk packet transmission
L_SYS_INST_RST	2	9A A8	10 1010 00	-	Reset LENA
L_SYS _ERR_RST	2	9A AB	10 1010 11	-	reset all error counters, registers and flags
L_SYS _BIN_EN	2	9A 8D	10 0011 01	-	Enable transmission of Binned science data packet
L_SYS _BIN_DSBL	2	9A 4D	01 0011 01	-	Disable transmission of Binned science data packet
L_SYS _EVENT_EN	2	9A 8E	10 0011 10	-	Enable transmission of Event science data packet
L_SYS _EVENT_ DSBL	2	9A 4E	01 0011 10	-	Disable transmission of Event science data packet
L_SYS _SNGLS_EN	2	9A 8F	10 0011 11	-	Enable transmission of Singles science data packet
L_SYS _SNGLS_ DSBL	2	9A 4F	01 0011 11	-	Disable transmission of Singles science data packet
L_SYS_ROI_SEL	3	9A 4C [0000 $b_3b_2b_1b_0$]	01 0011 00	-	Enable transmission of selected ROI segment(s) indicated by binary pattern [b_n]. “1" in selected field enables segment transfer. “0" disables segment transfer. b_0 - ROI 0 data (default=1) b_1 - ROI 1 data (default=0) b_2 - ROI 2 data (default=0) b_3 - ROI 3 data (default=0)

L_SYS_HKPTS_EN	2	9A B1		-	Enable performace test hk packet transmission
L_SYS_HKPTS_DSBL	2	9A B2		-	Disable performace test hk packet transmission
L_SYS_HKSTR_EN	2	9A 21			Enable transmission of hvps stripchart hk packet
L_SYS_HKSTR_DSBL	2	9A 22			Disable transmission of hvps stripchart hk packet
L_SYS_HKNMA_EN	2	9A 27			Enable transmission of normal-a hk packet
L_SYS_HKNMA_DSBL	2	9A 2D			Disable transmission of normal-a hk packet
L_SYS_UPLD_REQ	3	9A 63 P			Request upload from CIDP block P [0 <= P <= 4]
L_SYS_ISNC_EN	2	9A 95	10 0101 01	-	Enable internal sync signal
L_SYS_ISNC_DSBL	2	9A 55	01 0101 01	-	Disable internal sync signal
L_SYS_HVP_VTHR	7	9A 99 [V_{AA}] [V_{BB}] [V_{CC}] [V_{DD}] [V_{EE}]	10 0110 01	 TBD kV/bit TBD kV/bit TBD kV/bit TBD kV/bit TBD kV/bit	Set overvoltage thresholds for high voltage power supplies. Overvoltage limits V for each supply are parameterized, where 0 < V ≤ FFH. AA – MCP Start BB – MCP Stop CC – Collimator+ DD – Collimator- EE – Optics
L_SYS_NOP	2	9A 00			NOP command.

L_SYS_HVP_ITHR	7	9A 9D [I_{AA}] [I_{BB}] [I_{CC}] [I_{DD}] [I_{EE}]	10 0111 01	 TBD kV/bit TBD kV/bit TBD kV/bit TBD kV/bit TBD kV/bit	Set overcurrent thresholds for high voltage power supplies. Overcurrent limits I for each supply are parameterized, where 0 < I ≤ FFH. AA – MCP Start BB – MCP Stop CC – Collimator+ DD – Collimator- EE – Optics
L_SYS_OVCT_THR	4	9A 13 P1 P0		cnts/sec	Set start rate overcount threshold to 16-bit parameter (0xFF 0xFF default)
L_SYS_RSTR_EN	2	9A C4			Enable LENA autorestart after warm boot
L_SYS_RSTR_DSBL	2	9A C8			Disable LENA autorestart after warm boot (cold boot default)
LSYS_ACQR_EN	2	9A 5A			Enable science data acquistion (default)
LSYS_ACQR_DSBL	2	9A 5C			Disable science data acquisiton
L_SYS_STAT_SAVE	2	9A C1			Save LENA configuration state
L_SYS_STAT_RSTR	2	9A C7			Restore LENA configuration state
L_SYS_DADR_SET	4	9A 35 [$A_3A_2A_1A_0$]			Set 16-bit hex address [A3 A2 A1 A0] of data read by diagnostic register

ROI COMMANDS					
COMMAND	BYTES	OPCODE [PARAMETERS]		UNITS	DESCRIPTION
ROI HEADER		D2	sys.param		ROI Command Stem
L_ROI_CNFG_PKG0	6	D2 54 [R_{AA}] [R_{BB}] [CCCC DDDD] [0000 EEFF]	0101 0100	bin no.	Define TOF, Polar, and Energy bin ranges for Region-of-interest 0. R_{AA} = TOF Start Bin, R_{BB} = TOF Stop Bin CCCC = Polar Start Bin, DDDD = Polar Stop Bin EE = Energy Start Bin, FF = Energy Stop Bin
L_ROI_CNFG_PKG1	6	D2 58 [R_{AA}] [R_{BB}] [CCCC DDDD] [0000 EEFF]	0101 1000	bin no.	Define TOF, Polar, and Energy bin ranges for Region-of-interest 1. R_{AA} = TOF Start Bin, R_{BB} = TOF Stop Bin CCCC = Polar Start Bin, DDDD = Polar Stop Bin EE = Energy Start Bin, FF = Energy Stop Bin
L_ROI_CNFG_PKG2	6	D2 66 [R_{AA}] [R_{BB}] [CCCC DDDD] [0000 EEFF]	0110 0110	bin no.	Define TOF, Polar, and Energy bin ranges for Region-of-interest 2. R_{AA} = TOF Start Bin, R_{BB} = TOF Stop Bin CCCC = Polar Start Bin, DDDD = Polar Stop Bin EE = Energy Start Bin, FF = Energy Stop Bin
L_ROI_CNFG_PKG3	6	D2 68 [R_{AA}] [R_{BB}] [CCCC DDDD] [0000 EEFF]	0110 1000	bin no.	Define TOF, Polar, and Energy bin ranges for Region-of-interest 3. R_{AA} = TOF Start Bin, R_{BB} = TOF Stop Bin CCCC = Polar Start Bin, DDDD = Polar Stop Bin EE = Energy Start Bin, FF = Energy Stop Bin

PERFORMANCE TEST COMMANDS					
COMMAND	BYTES	OPCODE [PARAMETERS]		UNITS	DESCRIPTION
PERFORMANCE TEST HEADER		56	En.cmd.sply		PTEST command stem
L_TST_LV_EN	2	56 81		-	Enable low voltage performance test
L_TST_HV_EN	2	56 41	01 000 000	-	Enable high voltage performance test
L_TST_MSTR_EN	3	56 84 V0		-	Enable MCP start HV power supply test. Parameter V0 is max test voltage
L_TST_MSTR_DSBL	2	56 44		-	Disable MCP start HV power supply test . Parameter V0 is max test voltage
L_TST_MSTP_EN	3	56 95 V0		-	Enable MCP stop HV power supply test. Parameter V0 is max test voltage
L_TST_MSTP_DSBL	2	56 55		-	Disable MCP stop HV power supply test
L_TST_COLP_EN	3	56 96 V0		-	Enable Collimator Positive HV power supply test. Parameter V0 is max test voltage
L_TST_COLP_DSBL	2	56 56		-	Disable Collimator Positive HV power supply test
L_TST_COLN_EN	3	56 87 V0		-	Enable Collimator Negative HV power supply test. Parameter V0 is max test voltage
L_TST_COLN_DSBL	2	56 47		-	Disable Collimator Negative Positive HV power supply test
L_TST_OPT_EN	3	56 88 V0		-	Enable Ion Optics HV power supply test. Parameter V0 is max test voltage
L_TST_OPT_DSBL	2	56 48		-	Disable Ion Optics Positive HV power supply test
L_TST_STR_EN	3	56 99 V0		-	Enable Optics Steering power supply test. Parameter V0 is max test voltage
L_TST_STR_DSBL	2	56 59		-	Disable Optics Steering power supply test

HVPS COMMANDS					
COMMAND	BYTES	OPCODE [PARAMETERS]		UNITS	DESCRIPTION
HVPS HEADER		A5	En.cmd.sply		HVPS command stem
L_HVP_MSTR_EN	2	A5 80	10 000 000	-	Enable or disable MCP Start HV power supply
L_HVP_MSTR_DSBL	2	A5 40	01 000 000	-	Disable MCP Start HV power supply
L_HVP_MSTP_EN	2	A5 81	10 000 001	-	Enable MCP Stop HV power supply
L_HVP_MSTP_DSBL	2	A5 41	01 000 001	-	Disable MCP Stop HV power supply
L_HVP_COLP_EN	2	A5 82	10 000 010	-	Enable Collimator Positive HV power supply
L_HVP_COLP_DSBL	2	A5 42	01 000 100	-	Disable Collimator Positive HV power supply
L_HVP_COLN_EN	2	A5 83	10 000 011	-	Enable Collimator Negative HV power supply
L_HVP_COLN_DSBL	2	A5 43	01 000 011	-	Disable Collimator Negative HV power supply
L_HVP_OPT_EN	2	A5 84	10 000 100	-	Enable Ion Optics HV power supply
L_HVP_OPT_DSBL	2	A5 44	01 000 100	-	Disable Ion Optics HV power supply
L_HVP_GBL SAFE	2	A5 1F	01 010 111	-	limit max HVPS output to 20% of F.S.
L_HVP_GBL_USAFE	2	A5 9F	10 010 111	-	max HVPS outputs are limited to 100% of F.S.
L_HVP_MSTR_ CMD	3	A5 60 [V]	01 100 000	TBD kV/bit	Send voltage command [V_1V_0] hex to MCP Start HV power supply. $0 < V \leq FFH$
L_HVP_MSTP_ CMD	3	A5 61 [V]	01 100 001	TBD kV/bit	Send voltage command [V_1V_0] hex to MCP Stop HV power supply. $0 < V \leq FFH$

L_HVP_COLP_ CMD	3	A5 62 [V]	01 100 010	TBD kV/bit	Send voltage command [V_1V_0] hex to Collimator Positive HV power supply. 0 < V ≤ FFH
L_HVP_COLN_ CMD	3	A5 63 [V]	01 100 011	TBD kV/bit	Send voltage command [V_1V_0] hex to Collimator Negative HV power supply. 0 < V ≤ FFH
L_HVP_OPT_ CMD	3	A5 64 [V]	01 100 100	TBD kV/bit	Send voltage command [V_1V_0] hex to Ion Optics HV power supply. 0 < V ≤ FFH
L_HVP_STR_CMD	3	A5 65 [V]	01 100 101	TBD kV/bit	Send voltage command [V_1V_0] hex to Optics Steering HV power supply. 0 < V ≤ FFH
L_HVP_GBL_OFF	2	A5 6F	01 101 111	-	Execute HVPS shutdown macro (slew to 0V, safe, disable)
L_HVP_SCN_EN	2	A5 D1			Enable steering supply scan.
L_HVP_SCN_DSBL	2	A5 D2			Disable steering supply scan.
L_HVP_SCN_LD	18	A5 D7 P[15] – P[0]			Steering scan table is defined by array P[15] – P[0]. Steering supply steps through 1 command P[n] per spin.

TOF COMMANDS					
COMMAND	BYTES	OPCODE [PARAMETERS]		UNITS	DESCRIPTION
TOF HEADER		B6	en.sys.ssys		TOF command stem
L_TOF_MODE_STST	2	B6 33		-	Enable TOF start-stop mode (default)
L_TOF_MODE_STRT	2	B6 03		-	Enable TOF start-only mode
L_TOF_BIN_STRT1	3	B6 21H [P_1P_0]	01 00 0001	nsec	Define start TOF definition for species_1 binning interval. [P_1P_0] - species1 start threshold 0 < threshold ≤ FFH, for all species
L_TOF_BIN_STOP1	3	B6 22H [P_1P_0]	01 00 0010	nsec	Define stop definition for species_1 binning interval. [P_1P_0] - species1 start threshold 0 < threshold ≤ FFH
L_TOF_BIN_STRT2	3	B6 23H [P_1P_0]	01 00 0011	nsec	Define start TOF definition for species_2 binning interval. [P_1P_0] — species2 start threshold 0 < threshold ≤ FFH
L_TOF_BIN_STOP2	3	B6 24H [P_1P_0]	01 00 0100	nsec	Define stop TOF definition for species_2 binning interval. [P_1P_0] — species2 start threshold 0 < threshold ≤ FFH, for all species
L_TOF_BIT_ON	2	B6 91H	10 01 0001	-	Enable TOF built-in-test mode
L_TOF_BIT_OFF	2	B6 51H	01 01 0001	-	Disable TOF built-in-test mode
L_TOF_BIT_STRB	2	B6 52H	01 01 0010	-	Route single strobe to TOF system. Active in BIT mode only.

L_TOF_BIT_DELAY	3	B6 53H [P_1P_0]	01 01 0011	-	Define TOF BIT mode delay. Active in BIT mode only. 0 < delay ≤ FFH
L_TOF_TRSH_START	3	B6 61H [P_1P_0]	01 10 0001	-	Define TOF CFD start threshold. 0 < threshold ≤ FH
L_TOF_TRSH_STOP	3	B6 62H [P_1P_0]	01 10 0010	-	Define TOF CFD stop threshold. 0 < threshold ≤ FH

PSS COMMANDS				
COMMAND	BYTES	OPCODE [PARAMETERS]		DESCRIPTION
PSS HEADER		C7	sys.param	PSS Command Stem
L_PSS_GAIN_LOW	2	C7 11	0001 0001	Set gain of position anodes to LOW gain (default).
L_PSS_GAIN_HIGH	2	C7 12	0001 0010	Set gain of position anodes to HIGH gain.

MEMORY COMMANDS				
COMMAND	BYTES	OPCODE [PARAMETERS]		DESCRIPTION
MEMORY ACCESS HEADER		E9	dc.type.rd/wr	Memory Access Command Stem
L_MEM_WORD_RD	6	E9 0A [$A_3A_2A_1A_0$] [$N_3N_2N_1N_0$]	0000 10 10	Read LENA memory space. Transfer [$N_3N_2N_1N_0$] (hex) 16-bit words beginning at 16 bit hex address [$A_3A_2A_1A_0$].
L_MEM_WORD_WR	6+	E9 09 [$A_3A_2A_1A_0$] [$N_3N_2N_1N_0$] (data follows)	0000 10 01	Write to LENA memory space. Transfer [$N_3N_2N_1N_0$] (hex) 16-bit words beginning beginning at 16 bit hex address [$A_3A_2A_1A_0$].
L_MEM_BYTE_RD	6	E9 06 [$A_3A_2A_1A_0$] [$N_3N_2N_1N_0$]	0000 01 10	Read LENA memory space. Transfer [$N_3N_2N_1N_0$] (hex) bytes beginning at 16 bit hex address [$A_3A_2A_1A_0$].
L_MEM_BYTE_WR	6+	E9 05 [$A_3A_2A_1A_0$] [$N_3N_2N_1N_0$] (data follows)	0000 01 01	Write LENA memory space. Transfer [$N_3N_2N_1N_0$] (hex) bytes beginning at 16 bit hex address [$A_3A_2A_1A_0$].
L_MEM_PRAM_RD	6+	E9 39 [$A_3A_2A_1A_0$] [$N_3N_2N_1N_0$] (data follows)		Read program ram space. Transfer [$N_3N_2N_1N_0$] (hex) bytes beginning at 16 bit hex address [$A_3A_2A_1A_0$].

APPENDIX B

SCIENCE DATA PACKAGE DESCRIPTIONS

LENA BINNED DATA SCIENCE DATA PACKET				
BYTE	BYTES	HEX	DESCRIPTION	UNITS
0-2	3	FEFA30	Sync pattern	
3	1	DC	Data Package Header	
4	1	10	Package Type Header	
5..6	2	1960	Byte Count	
7..10	4		MET	
11..12	2		Number of valid events	counts
13..14	2		Species1 Start TOF	bin no.
15..16	2		Species1 Stop TOF	bin no.
17..18	2		Species2 Start TOF	bin no.
19..20	2		Species2 Stop TOF	bin no.
	2		Species1 counts[0,0,0]	counts
	2		Species2 counts[0,0,0]	counts
discontinuity				
	2		Species1 counts[44,11, 2]	counts
6500..6501	2		Species2 counts[44,11,2]	counts
6502	1		Checksum	

LENA EVENT DATA SCIENCE DATA PACKET						
BYTE	BYTES	HEX	DESCRIPTION			UNITS
0..2	3	FEFA30	Sync pattern			
3	1	DC	Data Package Header			
4	1	20	Package Type Header			
5..6	2		Byte Count			
7..10	4		MET			
11..12	2		Sector 0 word count			counts
13..14	2		Event0 TOF (10 bits)	Plr Sector (4 bits, 0-11)	Energy (2 bits, 0-2)	bin no. | sctr | sctr
15..16	2		Event1 TOF	Plr Sector (4 bits, 0-11)	Energy (2 bits, 0-2)	bin no. | sctr | sctr
…						
	2		Sector 44 word count			Counts
	2		Event(x) TOF	Plr Sector (4 bits, 0-11)	Energy (2 bits, 0-2)	bin no. | sctr | sctr
	*5760 – num. events		fill data (00H)			
5861	1		Checksum			

* if number of events is > 5760, the fill data does not exist.

SINGLES DATA SEGMENT FORMAT				
BYTE	BYTES	HEX	DEFINITION	UNITS
0..2	3	FEFA30	Sync Pattern	
3	1	DC	Data Package Header	
4	1	30	Package Type Header	
5	2	00B9	Byte Count	
7	4		MET	
11	2		Start Singles SpinSector0	counts
13	2		Stop Singles SpinSector0	counts
…				
187	2		Start Singles SpinSector 44	counts
189	2		Stop Singles SpinSector 44	counts
191	1		Checksum	

ROI 0 DATA SEGMENT FORMAT					
BYTE	BYTES	HEX	DEFINITION		UNITS
0..2	3	FEFA30	Sync Pattern		
3	1	DC	Data Package Header		
4	1	40	Package Type Header		
5..6	2	0045	Package Byte Count		
7	4		MET		
11 12 13 14	1 1 1 1		000AAAAA 000BBBBB CCCCDDDD 0000EEFF	TOF Start Bin TOF Stop Bin C=Polar Start Bin, D=Polar Stop Bin E = Engy Start Bin, F=Engy Stop Bin	bin no. bin no. bin no., bin no. bin no., bin no.
15	2		ROI 0 [0] (Parameterized by TOF)		counts
16	2		ROI 0 [1]		counts
…					
77	2		ROI 0 [31]		counts
79	1		Checksum		

ROI 1 DATA SEGMENT FORMAT					
BYTE	BYTES	HEX	DEFINITION		UNITS
0..2	3	FEFA30	Sync Pattern		
3	1	DC	Data Package Header		
4	1	42	Package Type Header		
5..6	2	0045	Package Byte Count		
7	4		MET		
11 12 13 14	1 1 1 1		000AAAAA 000BBBBB CCCCDDDD 0000EEFF	TOF Start Bin TOF Stop Bin C=Polar Start Bin, D=Polar Stop Bin E = Engy Start Bin, F=Engy Stop Bin	bin no. bin no. bin no., bin no. bin no., bin no.
15	2		ROI 1 [0] (Parameterized by TOF)		counts
16	2		ROI 1 [1]		counts
…					
77	2		ROI 1 [31]		counts
79	1		Checksum		

ROI 2 DATA SEGMENT FORMAT					
BYTE	BYTES	HEX	DEFINITION		UNITS
0..2	3	FEFA30	Sync Pattern		
3	1	DC	Data Package Header		
4	1	44	Package Type Header		
5..6	2	0045	Package Byte Count		
7	4		MET		
11 12 13 14	1 1 1 1		000AAAAA 000BBBBB CCCCDDDD 0000EEFF	TOF Start Bin TOF Stop Bin C=Polar Start Bin, D=Polar Stop Bin E = Engy Start Bin, F=Engy Stop Bin	bin no. bin no. bin no., bin no. bin no., bin no.
15	2		ROI 2 [0] (Parameterized by TOF)		counts
16	2		ROI 2 [1]		counts
…					
77	2		ROI 2 [31]		counts
79	1		Checksum		

ROI 3 DATA SEGMENT FORMAT					
BYTE	BYTES	HEX	DEFINITION		UNITS
0..2	3	FEFA30	Sync Pattern		
3	1	DC	Data Package Header		
4	1	46	Package Type Header		
5..6	2	0045	Package Byte Count		
7	4		MET		
11 12 13 14	1 1 1 1		000AAAAA 000BBBBB CCCCDDDD 0000EEFF	TOF Start Bin TOF Stop Bin C=Polar Start Bin, D=Polar Stop Bin E = Engy Start Bin, F=Engy Stop Bin	bin no. bin no. bin no., bin no. bin no., bin no.
15	2		ROI 3 [0] (Parameterized by TOF)		counts
16	2		ROI 3 [1]		counts
…					
77	2		ROI 3 [31]		counts
79	1		Checksum		

APPENDIX C

HOUSEKEEPING DATA PACKAGE DESCRIPTIONS

HOUSEKEEPING APID 50
(transmitted once per spin, MSBit first)

BYTE OFFSET	DESCRIPTION		BITS
0..2	FEFA30	(SYNC PATTERN)	24
3	DC	(Data Package Header)	8
4	50	(Package Header Type)	8
5..6	Byte Count		16
7..10	MET		32

ERROR CONDITIONS		
11	HVPS_MCP_START_VERR	1
	HVPS_MCP_STOP_VERR	1
	HVPS_COLLP_VERR	1
	HVPS_COLLN_VERR	1
	HVPS_OPTICS_VERR	1
	HVPS_ OPTICS_STEERING _VERR	1
	rsvd	2
12	HVPS_MCP_START_IERR	1
	HVPS_MCP_STOP_IERR	1
	HVPS_COLLP_IERR	1
	HVPS_COLLN_IERR	1
	HVPS_OPTICS_IERR	1
	rsvd	3
13	LVPS_30V_HVPS_VERR	1
	LVPS_15VP_VERR	1
	LVPS_15VN_VERR	1
	LVPS_5VP_VERR	1
	LVPS_5VN_VERR	1
	rsvd	3
14	LVPS_30V_HVPS_IERR	1
	LVPS_15VP_IERR	1
	LVPS_15VN_IERR	1
	LVPS_5VP_IERR	1
	LVPS_5VN_IERR	1
	rsvd	3
15	MEMORY_ERROR	1
	WATCHDOG_ERROR	1
	SELFTEST_ERROR	1
	TEMPERATURE_ERROR	1
	GA_CNTRL_ERROR	1
	GA_CMD_ERROR	1
	UPLOAD_ERROR	1
	PROGRAM_MODE (rom/ram)	1
SYSTEM LEVEL STATUS		
16	SW_VERSION_	5
	INTERNAL_SYNC_STATUS	1
	WATCHDOG_STATUS	1

	TOF_BIT_STATUS	1
DATA PACKET SELECTION		
17	SCI_BINNED_PACKET_STATUS	1
	SCI_DIR_EV_PACKET_STATUS	1
	SCI_SINGLES_PACKET_STATUS	1
	SCI_ROI_0_PACKET_STATUS	1
	SCI_ROI_1_PACKET_STATUS	1
	SCI_ROI_2_PACKET_STATUS	1
	SCI_ROI_3_PACKET_STATUS	1
	CMD_RECORD_HK_STATUS	1
18	QUICK_LOOK_HK_STATUS	1
	DIAGNOSTIC_HK_STATUS	1
	NORMAL_HK_STATUS	1
	MEMORY_HK_STATUS	*1*
	PERFORMANCE_TEST_HK_STATUS	*1*
	NORMAL_A_HK_STATUS	*1*
	STRIPCHART_HK_STATUS	*1*
	rsvd	1
MASS BINNING CONFIGURATION		
19	TOF_BIN1_START	8
20	TOF_BIN1_STOP	8
	TOF_BIN2_START	8
	TOF_BIN2_STOP	8
TOF SUBSYSTEM CONFIGURATION		
23	TOF_START_CFD_LEVEL	8
	TOF_STOP_CFD_LEVEL	8
	TOF_BIT_DELAY	8
HVPS CONFIGURATION		
26	HVPS_SAFE_STATUS	1
	HVPS_RAMP_EN	1
	HVPS_MCP_START_EN	1
	HVPS_MCP_STOP_EN	1
	HVPS_COLLP_EN	1
	HVPS_COLLN_EN	1
	HVPS_OPTICS_EN	1
	rsvd	1
27	HVPS_RAMP_RATE	8
	HVPS_MCP_START_CMD	8
	HVPS_MCP_STOP_CMD	8
30	HVPS_COLLP_CMD	8
	HVPS_COLLN_CMD	8
	HVPS_OPTICS_CMD	8
	HVPS_OPTICS_STEERING_CMD	8
STATUS		
34	COMMANDS_SENT	16
	COMMAND_EXECUTED	16
	COMMANDS_REJECTED	16
	PACKETS_SENT	16
	PACKETS_EXECUTED	16
44	PACKETS_REJECTED	16

46	HVPS_MCP_START_VMON	8
	HVPS_MCP_STOP_VMON	8
	HVPS_COLLP_VMON	8
	HVPS_COLLN_VMON	8
50	HVPS_OPTICS_VMON	8
	HVPS_STEERING_VMON	8
	HVPS_MCP_START_IMON	8
	HVPS_MCP_STOP_IMON	8
	HVPS_COLLP_IMON	8
55	HVPS_COLLN_IMON	8
	HVPS_OPTICS_IMON	8
	LVPS_30V_HVPS_VMON	8
	LVPS_15VP_VMON	8
	LVPS_15VN_VMON	8
60	LVPS_5VP_VMON	8
	LVPS_5VN_VMON	8
	LVPS_30V_HVPS_IMON	8
	LVPS_15VP_IMON	8
	LVPS_15VN_IMON	8
65	LVPS_5VP_IMON	8
	LVPS_5VN_IMON	8
	TEMPERATURE_T0	8
	TEMPERATURE_T1	8
	TEMPERATURE_T2	8
70	TEMPERATURE_T3	8
	TEMPERATURE_T4	8
	TEMPERATURE_T5	8
	TEMPERATURE_T6	8
	TEMPERATURE_T7	8
75	PARITY	8

COMMAND RECORD HOUSEKEEPING
APID 70
(transmitted once per spin when commanded, MSBit first)

BYTE OFFSET	DESCRIPTION		BITS
0..2	FEFA30	(SYNC PATTERN)	24
3	DC	(Data Package Header)	8
4	70	(Package Header Type)	8
5..6	Byte Count		16
7..10	MET		32
11..12	CMDS_EXEC_BYTE_COUNT		16
13	cmds exec list		Byte count * 8

DATA READ HOUSEKEEPING
APID 72
(transmitted when commanded, MSBit first)

BYTE OFFSET	DESCRIPTION		BITS
0..2	FEFA30	(SYNC_PATTERN)	24
3	DC	(Data Package Header)	8
4	72	(Package Header Type)	8
5..6	Byte Count		16
7..10	MET		32
11..12	START_ADDR		16
13	BYTE_OR_WORD_XFER | BYTE_COUNT		1 | 15
	Data follows		Byte count * 8
	…		
	PARITY		8

DIAGNOSTIC HOUSEKEEPING
APID 75
(transmitted when commanded, MSBit first)

BYTE OFFSET	DESCRIPTION		BITS
0..2	FEFA30	(SYNC_PATTERN)	24
3	DC	(Data Package Header)	8
4	75	(Package Header Type)	8
5..6	Byte Count		16
7..10	MET		32
HVPS ERROR THRESHOLDS			
11	HVPS_MCP_START_IERR_THRSHLDP		8
	HVPS_MCP_START_IERR_THRSHLDN		8
	HVPS_MCP_STOP_IERR_THRSHLDP		8
	HVPS_MCP_STOP_IERR_THRSHLDN		8
15	HVPS_COLLP_IERR_THRSHLDP		8
	HVPS_COLLP_IERR_THRSHLDN		8
	HVPS_COLLN_IERR_THRSHLDP		8
	HVPS_COLLN_IERR_THRSHLDN		8
	HVPS_OPTICS _IERR_THRSHLDP		8
	HVPS_OPTICS _IERR_THRSHLDN		8
	HVPS_MCP_START_VERR_THRSHLDP		8
	HVPS_MCP_START_VERR_THRSHLDN		8
	HVPS_MCP_STOP_VERR_THRSHLDP		8
	HVPS_MCP_STOP_VERR_THRSHLDN		8
25	HVPS_COLLP_VERR_THRSHLDP		8
	HVPS_COLLP_VERR_THRSHLDN		8
	HVPS_COLLN_VERR_THRSHLDP		8
	HVPS_COLLN_VERR_THRSHLDN		8
	HVPS_OPTICS_VERR_THRSHLDP		8
30	HVPS_OPTICS_VERR_THRSHLDN		8
	HVPS_OPTICS_STEERING_VERR_THRSHLDP		8
	HVPS_OPTICS_STEERING_VERR_THRSHLDN		8
LVPS ERROR THRESHOLDS			
	LVPS_30V_HVPS_IERR_THRSHLDP		8
	LVPS_30V_HVPS_IERR_THRSHLDN		8
35	LVPS_15VP_IERR_THRSHLDP		8
	LVPS_15VP_IERR_THRSHLDN		8
	LVPS_15VN_IERR_THRSHLDP		8
	LVPS_15VN_IERR_THRSHLDN		8
	LVPS_5VP_IERR_THRSHLDP		8
40	LVPS_5VP_IERR_THRSHLDN		8
	LVPS_5VN_IERR_THRSHLDP		8
	LVPS_5VN_IERR_THRSHLDN		8
	LVPS_30V_HVPS_VERR_THRSHLDP		8
	LVPS_30V_HVPS_VERR_THRSHLDN		8
45	LVPS_P_15VERR_THRSHLDP		8

	LVPS_P_15VERR_THRSHLDN	8
	LVPS_15VN_VERR_THRSHLDP	8
	LVPS_15VN_VERR_THRSHLDN	8
	LVPS_5VP_VERR_THRSHLDP	8
50	LVPS_5VP_VERR_THRSHLDN	8
	LVPS_5VN_VERR_THRSHLDP	8
	LVPS_5VN_VERR_THRSHLDN	8
53	ERROR_DIAGNOSTIC_REG	64
61	PARITY	8

QUICK LOOK HOUSEKEEPING
APID 60
(transmitted ~ every 2 seconds when enabled, MSBit first)

BYTE OFFSET	DESCRIPTION		BITS
0..2	FEFA30	(SYNC_PATTERN)	24
3	DC	(Data_Package_Header)	8
4	60	(Package_Header_Type)	8
5..6	Byte_Count		16
7..10	MET		32
SYSTEM_ERRORS			
11	PACKET_PARITY_ERRORS		8
12	WATCHDOG_ERROR		1
HVPS_ERROR_CONDITIONS			
	HVPS_MCP_START_VERR		1
	HVPS_MCP_STOP_VERR		1
	HVPS_COLLP_VERR		1
	HVPS_COLLN_VERR		1
	HVPS_OPTICS_VERR		1
	HVPS_MCP_START_IERR		1
	HVPS_MCP_STOP_IERR		1
13	HVPS_COLLP_IERR		1
	HVPS_COLLN_IERR		1
	HVPS_OPTICS_IERR		1
	HVPS_OPTICS_STEERING_VERR		1
LVPS_ERROR_CONDITIONS			
	LVPS_30V_HVPS_VERR		1
	LVPS_15VP_VERR		1
	LVPS_15VN_VERR		1
	LVPS_5VP_VERR		1
14	LVPS_5VN_VERR		1
SYSTEM LEVEL_STATUS			
	SELF_TEST_STATUS		1
	rsvd		*6*
15	*rsvd*		*8*
	rsvd		*8*
HVPS_STATUS			
	HVPS_RAMP_RATE		8
	HVPS_SAFE_STATUS		1
	HVPS_MCP_START_EN		1
	HVPS_MCP_STOP_EN		1
	HVPS_COLLP_EN		1
	HVPS_COLLN_EN		1
	HVPS_OPTICS_EN		1
	rsvd		2
	HVPS_MCP_START_CMD		8
20	HVPS_MCP_STOP_CMD		8
	HVPS_COLLP_CMD		8

	HVPS_COLLN_CMD	8
	HVPS_OPTICS_CMD	8
	HVPS_MCP_START_VMON	8
25	HVPS_MCP_STOP_VMON	8
	HVPS_COLLP_VMON	8
	HVPS_COLLN_VMON	8
	HVPS_OPTICS_VMON	8
	HVPS_MCP_START_IMON	8
30	HVPS_MCP_STOP_IMON	8
	HVPS_COLLP_IMON	8
	HVPS_COLLN_IMON	8
	HVPS_OPTICS_IMON	8
	HVPS_STEERING_VMON	8
LVPS_STATUS		
35	spare	8
	LVPS_30V_HVPS_VMON	8
	LVPS_15VP_VMON	8
	LVPS_15VN_VMON	8
	LVPS_5VP_VMON	8
	LVPS_5VN_VMON	8
40	spare8	8
	LVPS_30V_HVPS_IMON	8
	LVPS_15VP_IMON	8
	LVPS_15VN_IMON	8
	LVPS_5VP_IMON	8
	LVPS_5VN_IMON	8
47	PARITY	8

HK PERFORMANCE TEST APID 77

BYTE OFFSET	DESCRIPTION		BITS
0..2	FEFA30	(SYNC PATTERN)	24
3	DC	(Data Package Header)	8
4	77	(Package Header Type)	8
5..6	Byte Count		16
7..10	MET		32
11	TST_MEM_STAT*		2
	TST_CRIT_STAT		2
	TST_OVCT_STAT		2
	TST_HVP_UNSAFE_STAT		2
12	TST_TOF_STAT		2
	TST_HVP_SAFE_STAT		2
	rsvd		2
	rsvd		2
13	HVPS_STEP_NUMBER		8
14	rsvd		8
15	HVP_MSTR_VMON		8
16	HVP_MSTP_VMON		8
17	HVP_COLP_VMON		8
18	HVP_COLN_VMON		8
19	HVP_OPT_VMON		8
20	HVP_MSTR_IMON		8
21	HVP_MSTP_IMON		8
22	HVP_COLP_IMON		8
23	HVP_COLN_IMON		8
24	HVP_OPT_IMON		8
25	rsvd		8
26	PARITY		8

*Stat values: 1-not executed, 2-passed, 3-failed

NORMAL-A HK PACKET APID 53

BYTE OFFSET	DESCRIPTION		BITS
0..2	FEFA30	(SYNC PATTERN)	24
3	DC	(Data Package Header)	8
4	53	(Package Header Type)	8
5..6	Byte Count		16
7..10	MET		32
	TOF_OVCNT_THRSH (overcount threshold)		16
	CMD_SPIN_CNTR (number of commands sent during last spin)		16
	rsvd		16
	SYS_NADIR_CNTR (number of nadir pulses since LENA turn-on)		32
	SYS_ARSTR_CNTR (number of autonomous restarts since LENA turn-on)		8
	TOF_START_MODE (discrete indicating START/STOP or START ONLY mode)		8
	SYS_ARSTR_EN (autonomous state restore enable/disable)		1
	SYS_ATST_EN (autonomous test enable/disable)		1
	HVPS_STRSCN_EN (optics steering ps scan enable/disable)		1
	TOF_OVCNT_ STAT (discrete indicating overcount error)		1
	rsvd		4
	HVPS_PER_ERR (hvps performace monitor verr discrete)		1
	HVPS_THRSH_ERR (hvps threshold error discrete)		1
	rsvd		6
	HVPS_SCAN_TBL		128 (16 bytes)
	HVPS_NWDOG_CNTR (number of watchdog resets since LENA turn-on)		8
	SYS_ICMD_SENT (number of commands generated internally)		*16*
	SYS_ICMD_EXEC (number of command internally that were executed)		*16*
	SYS_ICMD_REJ (number of commands generated internally that were rejected)		*16*
	PARITY		8

HK STRIPCHART APID 56

BYTE OFFSET	DESCRIPTION (hvps commands and monitors sampled once/second)		BITS
0..2	FEFA30	(SYNC PATTERN)	24
3	DC	(Data Package Header)	8
4	56	(Package Header Type)	8
5..6	Byte Count		16
7..10	MET		32
	MSTR_CMD		960
	MSTP_CMD		960
	COLP_CMD		960
	COLN_CMD		960
	OPT_CMD		960
	STR_CMD		960
	MSTR_VMON		960
	MSTP_ VMON		960
	COLP_ VMON		960
	COLN_ VMON		960
	OPT_ VMON		960
	STR_ VMON		960
	MSTR_IMON		960
	MSTP_ IMON		960
	COLP_IMON		960
	COLN_IMON		960
	OPT_IMON		960
	STR_IMON		960
2171	PARITY		8